

An Anthropology of Engineering

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Thesis Abstract

This dissertation considers the place in anthropology of ‘production’ generally, and ‘engineering’ specifically, by asking the simple question: How do people make things?

Scholars of material culture have until recently focused on issues of consumption, especially the consumption of commodities (Miller), and considered production only in the abstract. Other theoretical approaches are therefore drawn upon to act as a framework for the thesis, including network theory (Law and Latour), and environmental relationism (Ingold).

A methodology of ‘parallel fieldwork’ was developed (from Bourdieu), to situate myself as an experienced engineer carrying out anthropological fieldwork. Work in a ‘familiar’ environment (the Didcot Railway Centre, UK) was used to provoke thoughts about engineering in my primary fieldsite (the Kelabit highlands, Borneo). Data from the UK thus helped frame my analysis of Kelabit engineering, presented here in four parts.

First, using the construction of two bridges as a case study, I suggest that a **design** can be seen as the revelation of a potential future, rather than a complete plan, as is suggested by design researchers such as Lawson and Norman. Then, by looking at changing traditions of house-building, I demonstrate the intimate relationship between **materials** and environment, even as the environment becomes more industrialised (Tsing), and consider this example in the light of debates about materiality (Miller; Ingold).

Personal involvement in the conception and building of a new suspension bridge allowed me to investigate in some depth the act of **construction**. As a communal project, this incorporated aspects of individual skill, in the way that Ingold has described, but also the organization of people, tools and materials, akin to Law’s ‘heterogenous engineering’. This leads me to conclude that a theory of engineering might come from due consideration of both these approaches to relational thinking.

Finally, I describe an abandoned longhouse and trace its **deconstruction**, suggesting that this is an example of creative destruction (Colloredo-Mansfeld), and re-materialization (Gregson). The dissipation of the material parts of the building shows that engineered objects should be seen as an ongoing process of material creation and disposal, and not a unified whole.

In conclusion, my hope is that this dissertation contributes to ideas about the place and nature of material culture, and advocates a more prominent place for ‘production’ within anthropology.

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INTRODUCTION



Figure 1: A site for engineering and anthropology

An Anthropologist Looks at Engineering

Surely very little in human cultural life can be so ubiquitous as the use of technologies. Indeed, in the evolution of our species, tool-use is often seen as one of its defining features, different from the technologies of other animals and somehow special (Wynn 2002). And whilst technology can be a cultural marker (Lemonnier 1993) or the result of social trends (Dobres and Hoffman 1999; Bijker, Hughes and Pinch 1987), it is also a very practical activity, one that depends on physical interaction with the environment, often resulting in material change. This project investigates the creation of material objects through technical production, what we might call ‘engineering’, and in particular, large and complex objects. Anthropology has remained reticent to delve in any great measure into the world of engineering (Sigaut 2002), and has largely limited its scope of concern to

technology as social, and production as artistic. I aim to offer a look into some of the issues surrounding engineering, from the privileged perspective of an engineer turned anthropologist, asking the simple question: How do people make things?

Defining Engineering

More specifically, my question is ‘how do people *engineer* things?’ since I draw a distinction between the actions required to go about engineering, as opposed to production more generally. A focus on ‘engineering’ leads to the question of what that actually is, and whether we can go about investigating such an activity in different cultural contexts.

Little has been written on engineering outside the Western context, and one of the aims of this project is to show that it can be a fruitful avenue of further investigation. Barley (2005) offers a detailed review of approaches to engineering, placing it firmly within a scheme of ‘technical occupations’, along with scientists, programmers and the like. Considering ‘technical work’ from a sociologist’s perspective, he begins by acknowledging that despite studies of the scientific workplace, this has been “interested primarily in epistemological issues...” and that “...technical workers remain an ‘invisible’ workforce” (2005: 377). His descriptions of the Columbia studies of the 1980s (Barley 2005: 387-389) show that the status and practices of engineering vary according to nationality, industry and function, and to define them is problematic. What seems to be a major obstacle is the correlation of engineering with design. Studies that purport to have a focus on engineering tend to concentrate on design, rather than the complete act of production. Henderson for example gives a good insight into the social processes that shape an engineering project as seen by the designers (Henderson 1991), and Bucciarelli, in describing the social processes of engineering states “My goal in this book is to probe the function of the discrepancies between the social process of design as I have observed it...and the ideal image of an instrumental process according to which participants claim to work” (1994: 13). Bucciarelli sees the uncertainty and ambiguity of engineering, and portrays it as a continual process of social negotiation and, primarily, conception. Sheppard *et al.*

are typical of this perception, when asking ‘What is engineering practice?’ – they suggest that “... a central (if not *the* central) activity of engineering work is solving problems” (2006: 430, emphasis in original). This reduces the act of engineering to a mental process, aimed at identifying and resolving problems, at least on paper or on screen, largely ignoring the physical acts of production carried out on the shop floor or construction site.

Whilst design is undoubtedly an important activity, and one that will be explored further in a later chapter, these accounts, and others outlined in Barley (2005: 391-392) still do not consider how design interacts with skilled production. Any consideration of production is done at an abstract level of machine efficiencies and so on, and not the individual acts that come together to produce an artefact. The practice of engineering to my mind is one that is fundamentally based on production, on making things, and to ignore this is to miss a vital and interesting aspect of humanity. Trevor Marchand is a notable exception to this fixation with ‘design’, writing of the production practices of Mali masons (2009). Although his focus is on issues of knowledge and learning, he describes working practices in some detail and goes so far as to note that “Even when basic drawings and specifications are furnished, the activities of design, problem solving, and construction unfold together, requiring an on-going process of improvisation and subtle innovation” (2009: 10). Similarly, in Suchman’s ‘Embodied practices of engineering work’ (2000), while she concentrates on the use of objects in design, and not the productive side of engineering, she suggests that “we take practical activity – including its unruliness, its ‘ad hocery’ and its endless detail – as just the fundamental phenomenon that we as students of human activity are out to recover”, a recommendation I wholly endorse.

Engineering projects can be characterised by their size and/or complexity, and depend on the assembly of a range of components and materials. In many cases, and in those cases described below, the process of construction is also communal, being carried out by several individuals simultaneously. Indeed an engineering project could not be completed by one person, since it requires considerable force

to manipulate materials, and a variety of skills to operate tools and enact techniques. This forms the basis of what I refer to as engineering: technical production of large-scale or complex objects, by groups of people. In both my field-sites – the Kelabit highlands of rural Borneo, and the Didcot Railway Centre in the UK - this definition is a fair reflection of how the people doing the work (hence the ‘engineers’) saw the projects in which they were involved. These things together – the range of different parts and the number of people – produce a context that is ripe for the creation of new socio-material bonds. In essence, the route through an engineering project becomes a path along which people develop their skills and gain new experiences, modify their concepts of the environment, reflect on their past and create a vision for the future.

Incorporating Experience into Fieldwork

As an experienced engineer, investigating these themes has required a reflexive approach, in a way that allows me to use a certain amount of technical knowledge in a culturally sensitive way. However, the dangers of complacency in conducting fieldwork in a familiar ‘culture’ (if there is an engineering ‘culture’), have been pointed out by Strathern (1987b: 17). First, she says, we assume that having fewer cultural barriers to overcome allows for a greater depth of insight, and secondly, applying anthropological techniques to a familiar environment is liable to expose the academic tendency to see the mundane as extraordinary. Therefore, I wanted to hold up a mirror to my experience and see how those beliefs stood up to scrutiny.

My engineering background comes from 12 years working in three different UK companies, each producing different objects, which provides me with some understanding of the technicalities of manufacturing and assembly, as well as the sort of skills required. Most of this work dealt with bespoke products, designed according to the customers’ needs, and with their input, before being passed on to specialists to detail the design, source components, draw up production instructions, assemble and test. As with many modern UK engineering companies, there was constant competition from low-wage overseas producers, forcing my

employers to streamline their product range into relatively hi-tech manufacturing, using the so-called 'knowledge-based economy' as their advantage. The objects I am familiar with are therefore relatively complex, made up of many parts and materials, often experimental and produced as a collaboration of customers, desk-based designers, shop floor technicians and external sub-suppliers. Some of these were fairly large objects, such as filtration systems for the oil industry - objects the size of a small house,¹ and others were much smaller but more intricate, such as mechanical handling devices, made up of hundreds of components.² With this background I have experienced the creativity of designing, the frustrations of acquiring usable parts, the practical skills needed to translate designs into working products, and the dynamics of technical teams.

My belief is that through my experience in engineering, I would be able to offer an interesting contribution to the description and analysis of technical production. In essence, this project is about the act of engineering in the context of Kelabit culture, rather than about Kelabit culture as a whole.³ Drawing on my past experiences represents something of a problem however, since it raises the twin dilemmas of either direct comparison or abstract distancing. In the first case, cross-cultural comparisons ignore the specificity of social and environmental conditions, and in the second, to gain any level of detailed insight into engineering practices meant becoming an active participant, and not a passive observer. To make a direct comparison between the engineering in rural Borneo and my experience of industrial engineering in the UK would be at best anecdotal, and yet there is something to be said for bringing such past expertise and knowledge into the field and applying it to similar situations. Incorporating my past experiences and technical inclinations to an anthropological study therefore meant devising a re-assessment of my own position to balance these difficulties.

¹ Manufactured by Plenty Ltd. of Newbury, UK, and used in the petrochemical and water industries.

² Such as the 'Ultraline' range of pneumatic rodless cylinders, manufactured by KV Ltd. of Milton Keynes.

³ More detailed information of Kelabit cultural life generally can be found in Harrison 1959; Yahya 1979; Lian-Saging and Bulan 1989; Janowski 2003.

To see if I did indeed gain greater insights into engineering through being an ‘insider’, or the extent to which I erected anthropological contrivances to support my beliefs, I divided my fieldwork into two distinct sites. The first was in the Kelabit Highlands of rural Borneo, and the second in the UK, at the Didcot Railway Centre (DRC). As will be described below, there are superficial similarities between these two sites – their population size, organization, the objects produced and so on, which suggests the potential for cross-cultural comparison, but drawing on Bourdieu this is something I avoid. Instead, fieldwork in the Railway Centre was set up as a way of reflecting on my experiences in engineering and seeing some of the practices again, but with an anthropologist’s eye.

George Marcus, in his seminal article *Ethnography in/of the world system* reflected on ethnographic methods for studying an increasingly global and yet partially connected world, through ‘multi-sited ethnography’ (1995). As the subjects of anthropological study have become more mobile, widely spread, and intricately connected, the traditional ethnographic approach to detailed documentation at a micro (local, or individual) level, loses the larger macro (global) view. Marcus developed a series of ‘tracking strategies’ to combine the detailed data-gathering philosophy of single-site ethnography, with the problems encountered in studying the “macro-constructions of a larger social order, such as the capitalist world economy” (1995: 95). Tracking the various diasporas of objects, communities, expertise, capital and so on, meant adopting fieldwork which was itself itinerant, and followed one or other moving subject. Engineering could be seen in this light – a material, idea or technique travelling from one place to another, and it may be that one could devise a methodology to track such a thing. However, my concern is not so much with the movement of the concept, but the practices involved in its performance. In a later development of the original article, Marcus offers a potential solution as he tackles the problem of disjunction between fieldsites (Marcus 2006 [1999]). His suggestion is to identify a primary fieldsite and reflect on it through regular visits to a secondary fieldsite: “The functioning of one site (the more strategic one) depends on a very specific

imagining of what is going on elsewhere” (2006: 619), requiring an ‘intervention’ to bring back the second site to the first. Whilst my objective is not to find a ‘multi-sited’ ethnographic methodology, Marcus suggests that to appreciate the workings of one cultural context, it is plausible to adopt a dual site approach, and use a second site to provide insights into the first.

Parallel Fieldwork Methodology

Cross-cultural comparisons have been viewed with suspicion almost for as long as anthropology has been an academic subject. Boas (1896, 1920) rejects the assumption that traits can be compared between cultures, unless it could be shown that those traits were the effects of the same causes. Moreover, since the opaqueness of history renders the sources contentious, he doubts whether such links can ever be proven, or even be true. In effect, by making comparisons between cultures, he contends we are drawing the conclusion that there is some universal human psychology that drives similar needs to similar ends. While anthropology has come to recognise the futility of such sweeping generalizations, the concept of cross-cultural comparison has persisted. Strathern has been one of the strongest and most eloquent critics, without denying the presence of similarities between disparate societies, but to adequately bridge those similarities, she argues, requires the construction of an elaborate supporting artifice (1991: 108). Any attempts at a more detailed comparison spiral downwards to a reductionist position where the data become a convenient ethnographic slice, selected by the investigator for the purposes of showing that similarities exist. Strathern convincingly suggests that there is nothing to be gained from seeking detailed comparisons in specific social activities. Juxtaposition does nothing more than create fictional imitations (1991: 13).

Pierre Bourdieu was explicit in his use of parallel fieldwork in Algeria and France as a way of gathering data that can be analysed in a way that offers primacy to neither. His Algerian fieldwork stems from his military service in the late 1950s (Silverstein and Goodman 2009), when he recorded demographic data on displaced Algerian refugees. On his return, his growing interest in social science

led him to question the structuralist method, epitomised by the work of Claude Lévi-Strauss (1972; Bourdieu 1990b: 9, 271-283). To develop his critique, he returned to his childhood roots in rural France, and repeated his Algerian methodology:

“I had attempted to revise a study I had carried out in 1960 in a village in Béarn (south-west France), which I had consciously conceived as a kind of reverse test of my experience, as an anthropologist, of familiarization with an alien world” (Bourdieu 1990b: 16).

The key point to bear in mind is that Bourdieu used his fieldwork experience as a counterpoint for his own position. Furthermore, he suggests that it is *essential* to go through this process of reflexivity (Bourdieu 2003), and that the way to do so is to engage in the same activities in an environment with which you are more or less encultured. When considering his Algerian fieldwork, he bore in mind how he would interpret that information if he were in France. When he was in France, he thought back to his naivety in Algeria and the effect that had on his interpretation of what he was seeing. These reflexive insights ultimately led to his concept of ‘participant objectivation’ (Bourdieu 1993). He is suggesting *a way of thinking about* different societies, not by directly comparing them,⁴ but taking a position distant from each, and looking at both in the light of knowledge of yourself, denying the assumption that you ‘know’ a society from the outset. “I think it’s rather unwise to pretend to propose a universal paradigm and I was careful not to do so starting from the two – actually rather similar – cases that I studied...” (1990a: 71).

Moments of insight in a familiar culture are exposed by experiences in attempting to understand an unfamiliar one, and vice versa, the everyday in a familiar culture, which may go un-noticed, becomes less comfortably secure and more open to question. The parallels Bourdieu drew upon in his two field-sites were based on notions of displaced peasanthood, through war in Algeria and mechanisation in Béarn (Reed-Danahay 2009). Recognising that he had become a ‘de-peasanted

⁴ Reed-Danahay, a noted Bourdieu scholar, gives one example of Bourdieu using direct comparison in a footnote in a 1965 article (2009: 141). However, even that one example citing Bourdieu directly comparing the Béarn and Kabyle sense of honour (Bourdieu 1977: 94) contains no comparison.

peasant' through his intellectual and physical move to Parisian academia, he considering himself to still have some of the 'primary habitus' of rural Béarn, whilst adopting a 'secondary habitus' in his life in Paris. Thus although he was no longer a resident of Béarn (at the time his mother still was), he was still able to 'fit in'. This influenced the approach he took to his Kabyle fieldwork, but not in the way you might expect: he did not assume he had a close affinity with the peasants of Kabylia, but saw instead an increased difference:

“Perhaps because I had a less abstract idea than some people of what it is to be a mountain peasant, I was also, and precisely to that extent, more aware that the distance is insurmountable, irremovable, except through self-deception...the distance lies perhaps not so much where it is usually looked for, in the gap between cultural traditions, as in the gulf between two relations to the world, one theoretical, the other practical.” (1990b: 14)

Strathern, studying several societies in the Papua New Guinea Highlands, focuses on the relations between them, rather than as with Bourdieu, the relations between anthropologist and society. In considering the relationships between societies, she concludes that similarities are a result of their proximity and consequential exchange, but are superficial and do not provide a satisfactory route to explanation. Comparative explanations seem reasonable and interesting, but when exposed to the contextual detail, they struggle to convince. So whilst the societies could be thought of as

“extensions of one another...eclipsing or turning one kind of world into another...comparability is lost in that eclipse, but a kind of compatibility remains. Analogy remains possible. The turn is, in fact, one that the anthropologist routinely replicates when he or she writes on one society with a further society in mind.” (Strathern 1991: 54)

Strathern's argument is that in attempting to assume the perspective of one society for the purpose of gaining a closer insight into its relative, the anthropologist is confusing analytical comparison with interesting analogy (1991: 107-108). Undertaking such an exercise is more likely to fill the mind with answers that

seem eminently plausible, and hence able to be convincingly argued, based on the strength of association. We need to recognise the relations between similar cultures as parallel similarities and not potential comparisons.⁵ Bourdieu accepted his place as distant from the Kabyle, by (at the same time) recognising his distance from his native culture in Béarn. Methodologically this led him to a position of ‘participant objectivation’ – recognizing his distance from the subjects of study and the importance of the influences and consequences of that distance for him, the objectified participant.

Both scholars emphasise the problems of cross-cultural comparison and conclude, in different ways, that comparison can be used as a way of thinking. Bourdieu, as a post-structuralist, reflecting on the position of the ‘inside’ observer to use fieldwork in one site as a way of opening up thoughts for another, and Strathern, critiquing the validity of cultural comparison, seeing this as an exercise in analogy – comparability is lost, but compatibility remains. Furthermore, both highlight the privileged position of the knowledgeable viewer as a way of providing interesting insights rather than equivalences or similarities. For my investigations into engineering and technical production, this means conducting parallel fieldwork in a secondary site in the UK, with which I am ‘more or less encultured’ as a way of positioning my own experiences, and providing the stimulus for questions about engineering in Borneo without prejudiced understandings of what is important or previously understood.

Primary Fieldwork: The Kelabit Highlands

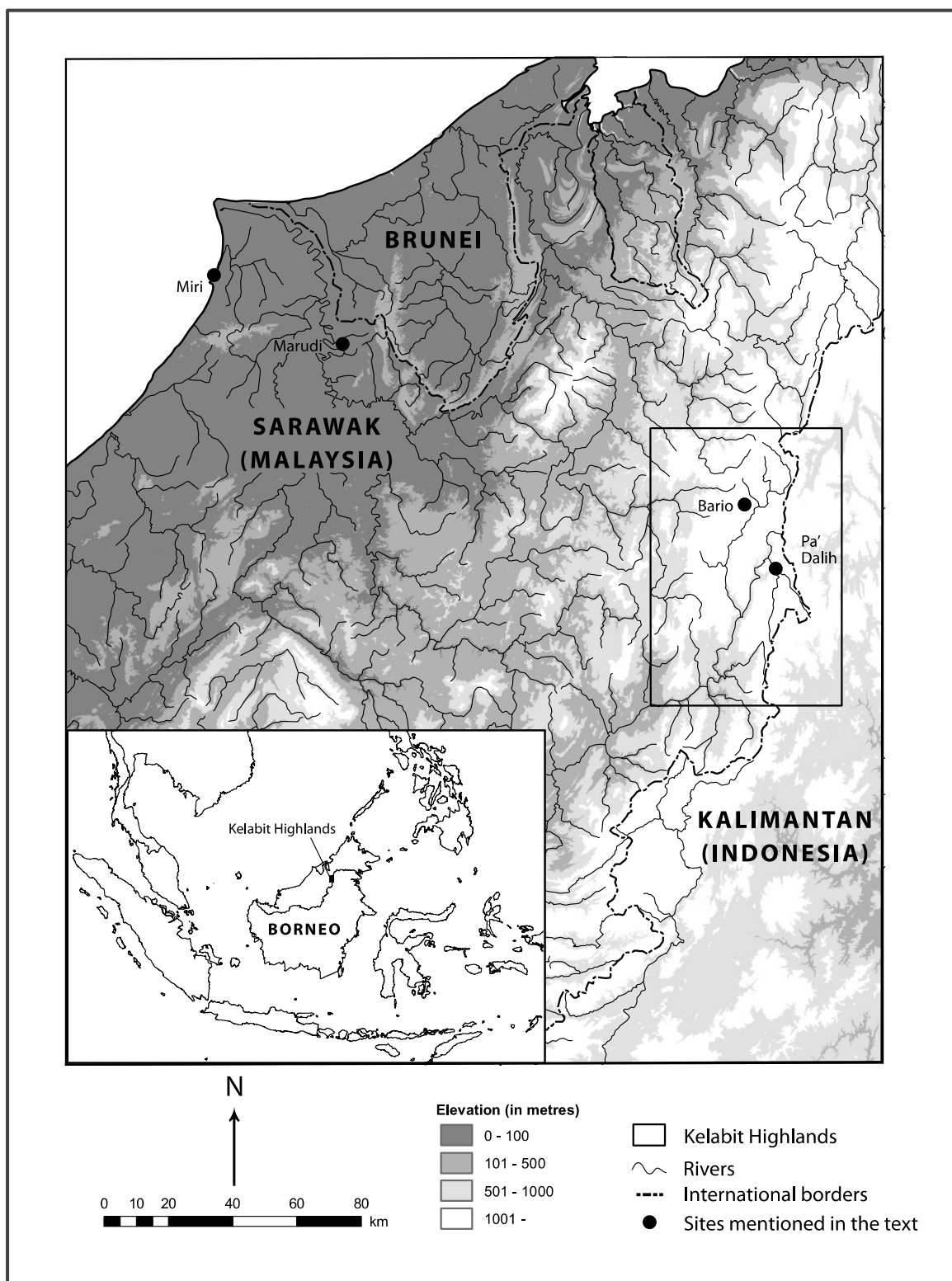
The Kelabit are a relatively small ethnic group, traditionally living in and around a highland plateau in northern Sarawak on the Malaysian side of Borneo (see Figure 2). Numbering around 5,000 in total, with many Kelabit having moved to coastal

⁵ In commenting on her work in Elmdon (Strathern, 1987b), a British village with which one assumes she may have had some fairly close cultural affinities, she notes that her place as an anthropologist was viewed with suspicion, in much the same way that she experienced her place in Melanesian villages. They both felt that she was exploiting them – in the case of Elmdon, gaining prestige with ‘their’ information, and in the case of Melanesian villages avoiding reciprocation of their information as a gift: anthropological data is assumed to have been turned into something (academic prestige, money etc.) not shared.

towns, the rural Kelabit are centred on the town of Bario in the highlands. My fieldwork was based in the Kelabit village of Pa' Dalih, a community of around 150 people, many of whom live permanently in the village and some returning periodically from work in the oil industry. My involvement with the community came about through my participation in the 'Cultured Rainforest' project an AHRC-funded archaeology and anthropology project investigating people's interaction with the environment, from prehistoric times to the present day (Barker *et al.* 2009). I made four visits to Sarawak, in July/August 2008, April/May 2009, July/August 2009 and April/May 2010, in total about 6 months. Most of this time was spent in the Kelabit highlands, but about 3 weeks was spent in Kuching, the capital of Sarawak, researching archives at the national museum and library.⁶ This was supplemented by extensive investigations into Kelabit collections in the UK, principally the British Museum, but also the Pitt Rivers Museum in Oxford.

As part of the Cultured Rainforest project, my position was less conspicuous than might have been the case, since on my first visit I was part of a team of fieldworkers, all investigating aspects of local life and interested in using local people to provide information. The archaeologists for example were interested in excavating longhouse sites and cemeteries, and so relied on the memories and stories of older people to identify potential sites from their childhood. There was consequently a framework for my own work, which rendered it less strange to the locals, and provided the associated infrastructure of guides, translators and accommodation. As a British colony until 1963, English is fairly widely spoken, and even more widely understood; maths and science for example are taught in the local school in English, and those who work in the oil industry often do so in Australia.

⁶ Subsequently published in the Sarawak Museum Journal (Ewart 2009), and the basis for the historical outline provided here.



*Figure 2: Regional Map, showing key towns
(Drawing by Lucy Farr)*

Pa' Dalih village is the site of previous anthropological investigation by another of the Cultured Rainforest team, Monica Janowski, who was able to make personal introductions to the villagers. Janowski has been particularly interested in the importance of agriculture to the Kelabit (Janowski 1988), and much of her work focuses on the symbolism of rice (Janowski 2003). She has recently begun to document the historic and mythic genealogy between living Kelabit, their named ancestors, and the more enigmatic semi-legendary figures celebrated in the landscape and recalled in stories (Barker *et al.* 2008; 2009).

I lived with one of the families in the village, either Jolly and his wife Sina Siren in the longhouse, or his brother, the headman Anderias and his wife Jane in their large detached house (see Figure 3 below, also see Figure 27 below, for a photograph of the village). This part of Borneo is becoming more aware of the potential of income from backpackers,⁷ and within each village there are typically a few individuals who have set up 'home-stays' – rooms within their house reserved for visitors. In Pa' Dalih, this is still a relatively new phenomenon, but something Anderias has been trying to develop, by accrediting individuals according to the facilities they can provide, especially new toilets and separate sleeping rooms. At the time of my visits, there were only two or three people who could provide accommodation, principally Anderias and Jolly.

⁷ The regional capital, Bario, runs a website aimed at visitors who are interested in jungle trekking, providing advice on a typical route around local villages including Pa' Dalih. See www.ebario.org accessed 1st March 2011.

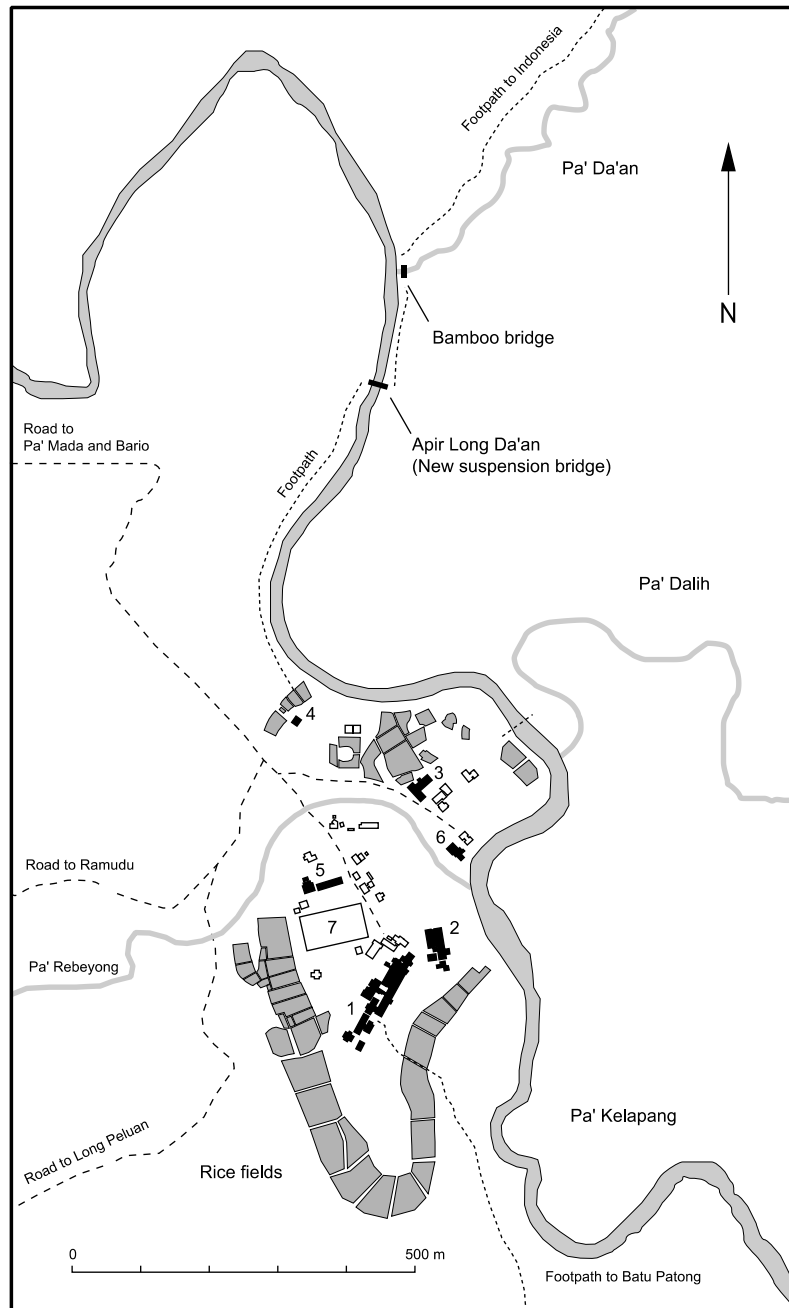


Figure 3: Pa' Dalih village, showing bridges, buildings, rice fields, rivers & paths
1 – Main longhouse; 2 – Short longhouse; 3 – Short-short longhouse;
4 – Ganang's new house; 5 – School; 6 – Anderias' house; 7 – Football pitch
(Drawing by Lindsay Lloyd-Smith)

My plan had been to investigate modern production techniques and materials, and compare them with museum objects. However, it soon became clear that the villagers make very few things themselves, buying in objects from the nomadic Penan, itinerant Indonesian traders, or from the largest Kelabit town, Bario, with its subsidised airstrip. More unusual or heavier items are brought in from coastal towns, especially Miri, by truck. Instead, I began by interviewing villagers about their possessions, homes and gardens, to try to get a feel for how objects circulate and the tools and skills still used in production.⁸ I carried out interviews with locals in Pa' Dalih and the neighbouring village of Pa' Mada, on issues of technology, construction and craft, usually with my main interpreter and helper, Ganang, in attendance. This covered for example, local uses of bamboo, and descriptions of old house-building techniques. Previous information gathered at museums, especially photographs of old Kelabit objects, was used in the interviews. In visiting farms and gardens I was able to record areas of land use, and make a study of the layout and elevations of the field irrigation system.

The Kelabit have a system of communal work parties (known as either *gotong royong* or *kerja sama*), which involve perhaps 10 or 20 people coming together to carry out a particularly laborious task. Often this was agricultural, but also included a variety of engineering projects, in which I was able to participate. There were some fairly regular maintenance tasks that I could document on several occasions, such as fixing the water supply pipe running through the forest, or repairing bridges washed away by floods. There were also some unusual projects, such as the erection of a large bamboo shelter for Malaysia Day celebrations, and a new concrete volleyball court. My participation was seen by the villagers as helpful and sometimes amusing.

As enthusiastic Christians, the Church plays an important part in organising social events, and it was usually through announcements after the service that arrangements were relayed to the community. I was able to observe and discuss a number of private projects, especially house construction, which seemed to be

⁸ Published in Barker *et al.* 2009: 127-142.

going on constantly, and surveyed and planned several houses. This included the main longhouse and two smaller longhouses at Pa' Dalih, the longhouses at Pa' Mada and Long Peluan, and several smaller individual houses (thanks to the patience and generosity of villagers who allowed me to measure and photograph their private rooms). It also included the abandoned longhouse at Batu Patong, which forms an important case study in Chapter 6, along with details of the history of the occupants and process of deconstruction. Some of the older men were also able to remember how traditional houses were constructed, and occasionally I was able to persuade them to demonstrate some of the techniques, or bring out their tools.

During fieldwork, it became clear that bridges were important to the Kelabit, since the region is interlaced by meandering rivers, and any walk through the forest meant a great deal of wading and rock-hopping. Bridges range from the very simple, a large log, to the traditional temporary bamboo and various standards of wire rope bridges (see Figure 4). I visited and surveyed several bridges of all types in and around Pa' Dalih, and made special trips to see unusual bridges in Remudu, Long Peluan and Long Banga. This culminated in me arranging financial assistance for the villagers of Pa' Dalih to buy the materials to construct their own large-scale wire rope suspension bridge, on the understanding that I would be able to record the whole process. Despite the fact that I tried on several occasions to make it clear that this money had come from a charity and not from me personally, the people of Pa' Dalih were more pleased that I had done this on their behalf than they were concerned with the source. Previous anthropological work had tended to have an academic focus on social and symbolic aspects of Kelabit culture (Janowski 2003), rather than the more practical issues and activities in which I engaged. The villagers saw my work as more useful to them directly, which, alongside their understanding of my financial assistance, affected their attitude towards me. As well as the construction of the bridge, I provided a copy of an article summarising my research into the documentary records of the Kelabit (Ewart 2009) to headman Anderias, which was widely discussed.



*Figure 4: An early wire rope hanging bridge in 1962
(courtesy of National Museum of Sarawak)*

The bridge was successfully constructed between April 2009 and April 2010. I was able to observe and participate in each stage, from initial design, to acquiring materials, assembly and construction, and many informal chats to answer questions and listen to the Kelabit men discuss how the project was progressing. Generally, I was able to involve myself in village life, helping with various projects in the village, collecting materials and food from the forest, hunting, going to church, visiting friends in the evenings, playing volleyball, arranging a sports day for the children and so on. This allowed me to build up a series of good relationships with several villagers, to get a flavour for the gossip and politics of village life, and feel comfortable in my involvement with their engineering. Information was recorded through field notes, photographs and diagrams.⁹

Through the villagers' interest in engineering, and their appreciation of the practical work that was the basis of my own interest, we each found common ground, and the basis for stimulating relationships. Sluka (2007) refers to the

⁹ The diagrams, especially those relating to house designs were given to the illustrator at the Institute of Archaeology in Oxford to convert into digital drawings.

success of ethnographic fieldwork depending on establishing ‘good rapport’, and in many ways this is what happened to me. I was able to help in certain situations, and found that this provided forums for discussions and interviews as well as their gratitude. For instance, issues of land ownership were at the forefront of villagers’ minds, since they were at the vanguard of commercial logging. One way of preventing logging was to claim water rights, signified by an active water supply pipe. This meant logging should not take place within the catchment area of the supplying rivers. I was asked to investigate why a new pipe was not working, and after trekking into the jungle and investigating, suggested reasons why this might be the case in an email to a Kelabit, who then used my information and suggestions in a reply to a government official to reinforce their claim to that area of land and prevent logging.

My position in Pa’ Dalih was therefore not neutral, but to achieve the good rapport that Sluka describes, I had to remain aware of the balance of power that local interpretation of my work and expertise provided. In some ways I had enough power to request things be done, and often they would be. I was keen that the bridge be completed for example, and in my frustration at the convoluted and slow process of communal labour, did to some extent force priority on to bridge building at the expense of other projects. My best efforts to remain impartial and patient lasted only so long, and it would certainly be true to say that my presence influenced local behaviour. I offer no mitigation for this behaviour, only an acceptance that I have contrived to erect the edifice of my own anthropological investigation. In doing so, and in the descriptions that follow, this is at the front of my mind.

Secondary Fieldwork: The Didcot Railway Centre

With the initial field-site in Borneo organised through the Cultured Rainforest project, I needed to engage in fieldwork in the UK that was in some way commensurable with the engineering in Borneo, and at the same time allowed me to reflect on my experiences as an engineer. Initial fieldwork in Borneo suggested that smaller objects, like those held in museum collections were scarcely made,

and now more often imported. It was clear then, that I would be able to obtain good data in the construction of larger objects (at that stage plans for bridge building were in their infancy, but house construction seemed to be a potentially fruitful avenue to pursue). I was also aware of the primary influence of commercialism in my engineering career, and suspected that this to be very different to engineering in a rural community. Therefore I felt that I needed to find fieldwork in a non-commercial environment, preferably manufacturing large objects.

The solution came from the Didcot Railway Centre (DRC), where I worked for six months from September 2009 to April 2010. Before beginning work at the Railway Centre, I discussed my plans with the Operations Manager, who organised a place in one of the workshop teams, and the education team. The type of engineering carried out at the DRC was much more ‘communal’ than commercial, funded largely by donations and pursued ‘not for profit’. The work is on large objects (steam locomotives), and a reasonable match for the type of engineering I saw happening in Borneo. Equally importantly however, the work at the DRC was an opportunity to expose how an anthropological approach coloured my perceptions of what it was that I was seeing.

The Didcot Railway Centre is a 20-acre site adjacent to Didcot Parkway mainline railway station with its direct connection to London. DRC is the heritage centre for the Great Western Railway (GWR), including a collection of over 20 locomotives, 40 coaches, 4 miles of rail track, a small museum and 85,000 square feet of covered space. The collection of locomotives is impressive, not least because it is one of the few places where so many are kept in running order, even those dating back to 1840 and the early days of rail travel. The collection is expanded by the acquisition of locomotives in poor condition, from scrap yards, secondary use (e.g. in Australian coal mining), or donations from collectors. This means that hugely expensive and time consuming work is done in stripping back the machine to its bare parts, and rebuilding to a virtually new state. There are a number of these locomotives in various stages of repair at any one time, usually

waiting for funds, or volunteer labour and expertise, including the one on which I worked.



Figure 5: Locomotives outside the engine sheds, Didcot Railway Centre

Locomotive 6023 'King Edward II' is one of only three survivors of the mighty 'King' class, the premier GWR express locomotives from the late 1920s onwards. One of the last mainline steam engines, it was withdrawn from service in 1962, after which it languished in a scrap yard until being rescued in 1984 when restoration began. As it now nears completion (a return to steam is planned for 2011) this means that 6023 will have been through a 25-year restoration programme. This is not an unusual length of time, and so presents its own problems: I would of course only have seen a snapshot of the work that was done, and even then, only the final stages. But my intention for this part of my fieldwork was to use this experience more as a way of examining myself as an anthropologist, and providing me with an understanding of the distance I stand from those I investigate, and the ways in which that distance affects what I do. The work that goes on in the DRC is a different cultural form of engineering to that seen in Borneo, and despite certain similarities, this was not an opportunity to

compare and contrast.¹⁰ As such, therefore, the DRC work was not one point on a comparative continuum, but stood apart as a project of self-analysis as well as an anthropology of engineering.

In some ways, the circumstances of engineering at the DRC could be considered commensurable with engineering in the Kelabit Highlands. I could draw parallels for example between Pa' Dalih as a small community which saw itself as part of the wider Kelabit ethnic group, and the DRC as a small community, itself part of the wider group of what they refer to as 'railwaymen'; the first subset describing a microcosm of a larger whole. Similarly, I could describe both work-parties as consisting of voluntary engineers, producing large and complex objects, with similar degrees of borrowed tools, techniques and skills. However, this is to ignore the differences, which become apparent when zooming in to a more detailed scale. The similarities serve in my mind to provide a degree of commensurability; close enough to provide me with a similar anthropological experience, and highlight to me what it is that I do to obtain my data and conjure up my thoughts.

Much of the DRC is run on a voluntary basis, so the work carried out in the locomotive sheds, rebuilding the engines, was done according to the hours that individuals could spare. As far as possible, I attended whenever one of these work-parties was organised, and spent the day working with the team, discussing their thoughts and ideas in an informal and largely unstructured way. The team consisted of a project leader, a core of about six who seemed to attend at every opportunity, and a further six or so who attended less frequently. My position as an anthropologist was viewed with a mixture of puzzlement and indifference, but too much questioning was frowned upon, especially by the project leader who I am sure felt it was a distraction. The two main problems for him to overcome

¹⁰ Strathern is critical of the whole idea of a 'culture' in the sense of an organised system of knowledge, something of which we can avail ourselves once we have sufficient amounts of knowledge to organise (1987b: 30-31; 1995). Culture in the popular sense of 'a common set of traits' is to Strathern no more than a way of pigeonholing a set of information (e.g. ethnography) into a preconceived framework (culture).

were getting funding and getting enough volunteer labour of the right sort: finishing the restoration project was a personal imperative.

To become more familiar with the Railway Centre environment and its people and politics I also joined the 'Education Team', whose priorities were to host school visits, and develop the Centre as a resource for the community of Didcot and railway enthusiasts more widely. To help do this I offered to produce a series of short films on some aspects of the Railway Centre which could be shown to the public in the context of 'education'. This included the work in the engine shed, which allowed me to interview some of the restoration engineers more formally and with fewer constraints, as well as drivers and firemen.



Figure 6: Locomotive 6023 'King Edward II' in the workshop

Ethnographic data from this part of my fieldwork came primarily from informal interviews with the engineers working on locomotive 6023, as well as others working on different projects. It was difficult to record comments immediately, since the environment was seen to be one where work was being done, and writing notes was not appropriate. Each day there were two tea-breaks and one

lunch-break, during which it was easier to write notes, and stimulate group conversations since the whole workforce would be gathered into one small space. As well as recording comments and writing up notes at the end of the day, I was able to make a photographic record of my time at the DRC. This included the work being done by the engineers on 6023 and other projects, the workshop environment and the site more generally. As a historic object, 6023 had been the subject of some research by one of the key members of the team, who runs a website dedicated to the locomotive, its history and on-going restoration.¹¹ He was a great source of information about the story of 6023's past, as well as the tribulations of restoration, having worked on it for over 10 years.

Being a member of the Education Team also allowed me to wander around the site and find people working on different projects away from my workshop and without the critical scrutiny of my foreman. I was able to help in maintenance tasks, such as draining the boiler of the 1840 'Firefly' locomotive, whilst talking to the engineers who had re-built and run it. Through these activities I felt I became a recognised part of the community, able to interact and communicate with the engineering and subsidiary teams in a full and open way.

The information gathered from both sites was based on the communal production of large and relatively complex objects. As a heritage centre, the work carried out at the Railway Centre was through voluntary labour, so that the engineers working on the project were of mixed backgrounds, some having been 'railwaymen' all their lives and others with no experience of engineering at all. They were few in number, and faced with work that was often new to them, normally because the technology used was now redundant, and required them to invent new methods and traditions of production. In Borneo, as a rural community, the residents of Pa' Dalih were volunteers in the sense that this work was part of their everyday life, and a form of shared responsibility. They too were of mixed abilities and similarly small in number. Some of the locals had spent time working away, and adapted their experience to new contexts, or drew on their worldly views to conceptualise

¹¹ www.6023.co.uk

new engineering projects. Acquisition of materials and components raised logistical and financial difficulties in both contexts; the railway centre relied on donations, and struggled to source old-fashioned suppliers, whilst the Pa' Dalih villagers were faced with problems of distance and transport costs. Therefore, these two sites, apparently very different, actually hold a number of similarities, suggesting that one may illuminate the other, as suggested by Marcus (2006 [1999]). However, although my investigations were of the 'engineering culture' if such a thing could be said to exist, there is no escaping the fact that these are still two very different places, and putting myself into each of them will provide a particular set of insights (Bourdieu 2003).

Organization of the Thesis

From the discussion above, the main themes of the thesis begin to emerge a little more clearly. Production generally, and technical production more particularly, represents an under-studied aspect of anthropology, and an area that can be examined more inventively, perhaps in the light of a reassessment of earlier anthropological literature, especially the economic and ecological anthropology of the 1970s (e.g. Seddon 1978; Rambo 1983; Vayda and McCay 1975). Issues of skill and development through engagement with the environment can be studied in the context of engineering, raising questions as to the relations that come about through that engagement. Having defined the focus of the thesis as being large and complex objects suggests some distinction between those things and small and simple objects, and the means of their production. One contention I make is that engineered objects are fundamentally different, and their analysis is diminished if carried out with no regard for those differences. And finally, an engineer studying engineering provides a specific perspective, which is both interesting and limiting, suggesting other perspectives also await.

After the Introduction are two chapters contextualising Kelabit ethnography and engineering as a topic for anthropology. First an overview of the region and history surrounding the Kelabit, which outlines some of the indigenous relations between the Kelabit and their neighbours, especially the Kayan and Kenyah, and

provides a summary of historic events that have contributed to local engineering culture, including the means by which new materials and ideas have altered concepts of production. There then follows a theoretical summary of the place of engineering in anthropological and sociological literature through a consideration of socio-material approaches. This section situates engineering in the context of wider studies of production and relational thinking, in particular the debates surrounding the concept of technology as a social construction, and production as a skilled activity, requiring intimate engagements with materials. Then, since the first is essentially social in its attentions, and the second tends to be material, the relationship between the two is considered, through the concept of a network of connections, or as an alternative, environmental relations. Having provided a theoretical grounding for the thesis, each of the following sections includes discussion of some of the relevant theoretical debates and approaches, as outlined below.

This is structured as an investigation of Engineering in four parts, with a series of Diversions along the way. The path through the four parts approximately follows a route through an engineering project: Design, Materials, Construction, and Deconstruction. Each relies on ethnographic data from a range of projects carried out during fieldwork in Borneo, brought together to form a body of information that can help to illustrate and illuminate the themes mentioned above. The majority of the data refers to Kelabit engineering of houses and bridges, to fit with the theme of large-scale projects.

Chapter 3: Design, uses as its main example Kelabit bridges, in particular the planning for a form of bridge relatively new to the Kelabit Highlands, based on the idea of a suspension bridge. This is supplemented by a comparative example of the same people building a more traditional bridge using locally available bamboo and rattan. The main question raised in this chapter is: To what extent does a ‘design’ represent a pre-conceived plan of action and projected future object? A traditional Western view, such as advocated by academics such as Norman and Petroski, would be that a design fossilises the future, putting down a

fixed goal that the builders work towards. Design scholars such as Cross and Lawson, similarly contend that the process of design is special, and separate from other activities, deserving particular attention. Others suggest that an object becomes created through its on-going use, and that the design represents just part of the process. Drawing on Ingold, although not without criticism, my suggestion is that a design should be seen as the starting point for the creation of new sets of relations between the builders and their environment.

Chapter 4: Materials, is based on the changing history of Kelabit houses. Documentary research from primary sources, ethnographic data collected through personal interviews and extensive building surveys, are used to paint a picture of the pattern of influences that have shaped current Kelabit houses. This collection of information provides some answers to the question of how materials are chosen and sourced, drawing on Lemonnier's notions of the arbitrariness of technical choices. This is framed by the debate about the current popularity of 'materiality' as a topic for anthropology, especially as used by Miller, and the critique of this trend as overly abstract and giving undue primacy to artefacts over materials outlined by Ingold. For the Kelabit, the consequences of Christian evangelism, international wars and commercial logging have been increased access to the wider world, and new engineering possibilities. This is reflected in physical changes to the housing stock and new attitudes to the environment. Tsing, working in a neighbouring region, provides the inspiration for a discussion on the changing place of the environment in people's lives. This leads me to describe the 'dynamic environment', emerging from the burgeoning network of logging roads and access to industrialised materials, contributing to profoundly changed relations with the forest.

Chapter 5: Construction, returns to Kelabit bridge building, and develops the ideas described in Chapter 3 on 'Design'. If a design can be seen as the catalyst for developing a new set of relations with the environment (itself a construct of the builders), then those relations come into being through the practices of making and building. Ethnographic data comes from a close involvement with the

construction of a new suspension bridge. The novelty of this bridge is particularly informative, since it provides the opportunity to see fresh relations in the making, descriptions influenced by Marchand's writings about learning through doing. Faced with an unusual and substantial task, groups of Kelabit gather, along with their experiences, skills, tools and materials in an on-going process of relation-formation: people with materials with environment. Developing the discussion put forward in Chapter 2, I suggest that a network approach, and in particular John Law's concept of heterogenous engineering, offers a way of investigating this type of complex socio-material organization. However, it is less successful at dealing with the concept of newly forming relations as nuanced and people-centred, in the way advocated by Ingold, and in particular the importance of individual skills. With aspects of both, I describe how the Kelabit bridge-builders form new relations with their dynamic environment, and continually reconstitute it in the process.

Chapter 6: Deconstruction, the final part of the engineering project, sees the construction begin to separate into its constituent parts with a corresponding fragmentation of material and social relations. This draws on recent anthropological literature critiquing the notion of the 'death' of objects, especially Colloredo-Mansfeld's ideas of the undoing of form as a creative act, and Gregson's work describing the way that objects can literally re-materialize, reverting to their original materials. The Kelabit have a historical context for issues of recycling and re-use, stemming from their recent past when longhouses were dismantled and moved every few years, carrying with them valuable parts, especially floorboards. A nearby longhouse, abandoned by the current generation, forms the primary data for the issues discussed. Interviewing villagers who lived there, and tracking the fabric of the house as it gradually dispersed throughout the area, helped to formulate the idea that a complex object is no more than a temporary coalescence of valuable parts. This was informed by Hetherington's ideas of 'conduits of disposal' as the routes that objects take to allow them to be removed from their existing social sphere. Structures, however durable, inevitably disintegrate, forming a swirling cloud of parts that re-form in a different capacity

elsewhere. The suggestion is that we need to conceive of objects as an accumulation of parts, not just a finished whole, and consider the continual creation of socio-material bonds to be as fundamental to the object as physical substances.

Scattered between the four parts of engineering, are vignettes from my UK fieldwork, labelled as Diversions. As discussed above, these serve to illustrate the analogous nature of the parallel fieldwork methodology, while at the same time demonstrating how some of the general themes in the thesis can be seen in data from different contexts. These are intended to complement rather than counterpoint the main body of ethnography, covering similar ground but in a way that requires the reader to veer off course slightly in order to gain a better view of the main path. My past experiences of engineering took place in a similar cultural context to the work at the Didcot Railway Centre, which allowed me to consider what constitutes an engineering practice, and how to approach the engineering I saw in Borneo. Adopting an anthropological mentality created the opportunity to ask naïve questions and encourage the workers to talk about their experiences in as much technical detail as they saw fit. Their stories form the basis of my Diversions, the first of which shows how aware they are that a detailed plan is not enough to be able to carry out an engineering activity. Then, their problems sourcing materials to reproduce archaic technologies led them to search further afield in an effort to cope with (from their perspective) a diminished engineering environment. Other diversions lead to a consideration of the work required to make an object appear suitable, according to social and cultural pressures, and some perspectives on the complexity of assembling together large numbers of parts and components to form a complex whole, and the fragile nature of its unity.

Taken together with the descriptions provided in the engineering chapters, written using Kelabit data, this approach has I hope gone some way to demonstrating that engineering can form the basis of an informative investigation into social production, and that the insights of an experienced practitioner can usefully enhance subsequent analysis.

1: REGIONAL CONTEXT

Historic Influences on Kelabit Engineering

The most significant data I gathered in respect of Kelabit engineering were to do with houses and bridges, which form the bulk of ethnographic information in the thesis. Issues of tradition, and the accelerating changes the Kelabit are currently experiencing formed a fundamental and recurring aspect of fieldwork. Changes to designs, access to new materials, migration to work in paid labour, the demography of those that remain in the village, the use of modern tools, attitudes to recycling old materials, and evolving perceptions of the forest, are all immediate and on-going issues for the rural Kelabit of Pa' Dalih. Earlier historic influences are also essential to the character and practices of the current generation, especially spiritual attitudes changing from animistic to Christian, past concepts of prestige in housing materials, a shift to permanent longhouse structures and regional movements of population. To understand how these issues have evolved to become contemporary and relevant to the investigation of Kelabit engineering requires an understanding of the historic events that have shaped Kelabit culture today. Included here is a summary focussing on the events most relevant to the issues discussed later in the thesis.



Figure 7a: (left) 'Kalabit Smithy' published in Hose and McDougall 1912

Figure 7b: (right) same men, unpublished picture. (courtesy of the Pitt Rivers Museum)

In the early 19th century, Sarawak, including the upper Baram region now inhabited by the Kelabit people, was nominally governed by the Sultanate of Brunei. Brunei was at the time an important port on the Indo-Chinese trade routes, and heavily influenced by both of those two countries. Direct contact with the Bornean interior was minimal however, and tribal relations were the dominant form of local politics. Exasperated by intractable tribal disputes, the Sultan gradually ceded more and more territory to the first ‘White Rajah of Sarawak’, James Brooke, from 1841 onwards. After his death in 1868, his nephew Charles Brooke succeeded James as Rajah, and continued the policy of territorial expansion by accepting from the Sultan of Brunei areas in chronic conflict and then suppressing them by military force. This included areas of Kelabit territory: in 1883-4 the Baram and Trusan river basins, and in 1890 the Limbang. Thus by 1890 the region including the Kelabit highlands had, at least nominally, switched governance from Brunei to the British run state of Sarawak.

Where Brunei had left the tribes to themselves, the Brooke regimes embarked on a plan of more systematic exploration and exploitation. For the interior tribes, this essentially meant providing forest products as tax, in return for military support, an effective way for the colonial regime to plunder the wealth of the forest. They introduced a series of reforms to persuade local people to maintain peaceful relations, including a determined assault on the practice of headhunting, frequent government sponsored raids, and various formal peace treaties between local tribes. By 1898 some Kelabit were persuaded to formally accept the terms of colonial rule, traveling to the district headquarters in Marudi to pay tax in the form of hundreds of baskets of raw rubber (Hose 1898). In 1908 the region became fully adopted after a famous peace treaty in Pa’ Mein between the Kelabit, Kenyah, Pa Kabak, Pa Brian and Pa Utak tribes, instigated by the District Resident, R.S. Douglas (Douglas 1909; 1912), in the first European visit to the Kelabit highland plateau. The ceremony was hosted by chief Ballang Maran (“a notorious headhunter” – Mjoberg 1934: 53) in which 7-800 people gathered in his longhouse, a pig was slaughtered, and the chiefs exchanged blood in the ceremony of *berpirit*, swearing to abide by the terms of the treaty (Douglas 1912: 22).

As the influence of British colonial rule spread to the Bornean interior, it brought a sense of accessibility to a range of administrators, explorers and missionaries, and from some of these we have descriptions of Kelabit longhouse life. The Torres Strait expedition skirted the edges of Kelabit territory in 1898/9, staying at a longhouse in Long Lellang (Haddon 1932: 131-213; Hose 1929); government official A.B. Ward visited the Madihit River in 1903 where he stayed in a Kelabit longhouse (Ward 1934: 86) collecting two skulls; R.S. Douglas, before his 1908 peace treaty, also visited the Seridan and Madihit rivers, staying in the newly constructed longhouse of Chief Ili Bawang, housing 200 people (Douglas 1907: 55). In 1922 the curator of the Sarawak museum Eric Mjoberg visited an area near the present day settlement of Pa' Tik and the longhouse of Tapo Boan, described as the largest longhouse he had ever seen, over 200ft in length, in a grass clearing with a small herd of buffalo (Mjoberg 1925: 418).

Until the 1930s, the relationship between the Kelabit and the wider world was primarily one of extraction. Goods were taken from the forest as tax payments, while explorers and representatives of the newly created Sarawak National Museum collected cultural objects. Some objects did make their way in the opposite direction, in particular the large *belanai* 'dragon jars' and various metal items, but the vast majority of Kelabit material culture was indigenous and relatively local. Imported ideas and objects tended to be part of a system of neighbourly relations, and those objects from further afield, such as Chinese *belanai*, were appropriated through exchange systems culminating in relatively local contacts (Rousseau 1978; St. John 1974 [1863]: 126). Reports of local cultural exchange between the Kelabit and the neighbouring Kenyah and Kayan tribes include for example, salt, rice, hairstyles, the use of leopard's fangs in the upper ear, women's leg tattoos, systems of hierarchy and so on (Pollard 1936: 5; Hose and McDougall 1912: 134; Banks 1937: 428).

This was to change in the period leading up to the Second World War. Instead of the Kelabit highlands being a place from which the outside world procured, it became a place into which they could impart new ideas and materials. The earliest

attempts were the unsuccessful attempts by missionaries to establish Christian outposts in the region in the 1930s (Lees 1979). The Borneo Evangelical Mission set up camp with the Lun Bawang (neighbours and cultural cousins of the Kelabit) in 1930, and up until the Japanese invasion in 1941, began to make headway converting the Lun Bawang and recruiting them to convert the Kelabit. Individual missionaries took their own view of the important things they needed to change to make the natives 'Christian', over and above the directly religious aspects. This included the predilection for *borak* (rice wine), consumed in great quantity (hence the title of Shirley Lees book 'Drunk before Dawn'), the lack of education, and basic hygiene.¹²

Pre-Christian religious practices were animistic, daily life governed by the behaviour of animals. In particular, birds and snakes were seen as portentous, causing work to be halted, and farms and villages to be moved (Banks 1937; Douglas 1912; Harrisson 1951). With the advent of Christian practices, this link to the surrounding forest was fractured, and the relationship between the Kelabit and the forest changed; it became, as it is today, a more prosaic environment, no longer filled with religious significance. There are however still hints of this link to the past. In August 2009, a local man was shot dead in the nearby village of Remudu. Initial rumours of foul play were soon dispelled as it turned out that the man had tripped and shot himself on a hunting trip. A few days later, whilst out collecting rattan, I discussed this privately with 3 locals (Jolly, Ganang and Isi Berawan). They surprised me by saying that they knew the area in Remudu where this had happened and considered it an area plagued by bad luck. The reason for this, they suggested, was that the old forest spirits were still strong there, holding out against the overwhelming power of the Christian God. It was not that previous generations had been mistaken in their religious beliefs, it was just that the Christian God had not yet reached them.

¹² Chong Ah Onn, a medical dresser, visited the Kelabit highlands in 1937 and described epidemics of dysentery and diarrhoea in Long Lellang, caused by unhygienic food preparation areas (1960: 117).

Whilst the Kelabit were coming to terms with a new religious environment in the 1940s, they also came face to face with a very different band of Christians in the form of British and Australian paratroopers who used the Kelabit highlands as a base for guerrilla action against the invading Japanese. Most notable among them was their commander, Tom Harrisson, subsequently curator of the Sarawak National Museum, and life-long supporter of Kelabit culture, providing the museum with large numbers of artefacts and photographs, and contributing hugely to the published literature on the Kelabit (see bibliography, and Figure 8 below). Along with the military personnel came new materials: corrugated sheeting, wire rope, steel nails, sheets of plywood, all of which were rare or new to the Kelabit. Unlike the preceding 50 years of external contact, the Kelabit were confronted with these things in a direct and explicit way that demonstrated new potentials, and new alternatives to the materials on which they had hitherto depended. Ngalun Paran, a blind man of about 80 years of age, living in the village of Pa' Mada, was keen to talk about the old days, recounting stories of youthful adventure in the days of the Japanese invasion. He talked of how locals were encouraged to begin head-hunting again, capturing Japanese skulls as trophies, and of the first time he saw a wire rope bridge and tin sheet roofing.



*Figure 8: Tom Harrisson (l)
Commander of WW2 guerilla
forces in the Kelabit highlands,
and Chief Negri Besar (r)
(courtesy of the National
Museum of Sarawak)*

The formation of the Malaysian nation in 1962 and the subsequent military confrontation with Indonesia brought another batch of British troops to the Kelabit highlands, this time to patrol the nearby international border. Villages near the border were re-settled in the village of Bario, which grew to become the Kelabit capital. Pa' Mein, famous for its salt springs, was abandoned and became the main military base, whilst Pa' Dalih was one of the few villages to refuse resettlement. Instead of the makeshift logistics of the WW2 guerilla campaign, there was now a large-scale military presence with regular supplies to provide everything the army might need: cement, roofing sheets, metal tools, nails, petrol, generators, chainsaws, clothing, and of course guns. Ngalun Paran, the blind old man from Pa' Mada, laughed as he described the villagers' ploy to get hold of some of these new materials, especially the now prized corrugated roofing sheets, nails and metal tools, by supplying chickens and fresh vegetables to the troops. As the troops were withdrawn, materials were divided up among households, with each given a section of roofing to dismantle, a few plywood sheets, and various odds and ends, such as the angle iron fence posts that every household now seems to have as the rails to support pots over the hearth.

The era of colonial rule from about 1880 to 1930 changed Kelabit lives little. The suspension of headhunting changed the nature of Kelabit relations with neighbouring tribes, and reduced the need for defensive building traditions, but did not expand the scope of external influence a great deal. This changed in the late 1940s, with the wholesale adoption of Christianity, which had a profound effect on Kelabit notions of their environment, and by the 1960s, with the second major military influx of British and Australian troops, came wider access to some of the materials the Kelabit had glimpsed. The troops may have opened up new possibilities, but it has been the logging roads, built in the last 5 years or so, which have provided the means by which villages like Pa' Dalih can make connections with the wider world more firmly, providing a conduit for people, ideas and materials to come and go over a much wider area than ever before.

Local Tribal Relations

Any discussion of the engineering of a relatively remote group such as the Kelabit needs to recognise the fallacy of the presumed isolation. Modern day links such as the logging roads, the subsidised airstrip at Bario, migration to coastal towns, and increasing access to information technology in the rural villages, are enough to dispel the idea that the Kelabit of the far highlands are particularly secluded. However, this trend of external influence is countered by an opposing current that aims to retain a cultural identity in the face of the flood of ideas entering their world. Wrestling with this paradox is a manifest part of Kelabit engineering projects and forms an on-going thread to this thesis, as ideas are translated into local dialects through the flow of materials and practices of construction.

As is clear from the historical sketch above, the process of interaction between the Kelabit and their neighbours is a long-standing one, at least as old as any documentary records allow and no doubt much more ancient than that. The nature of these relations can be seen to have changed in the last 150 years or so, and it is surely true to assume that the ebb and flow of power varied according the circumstances of the era. So whilst violent feuding may have been characteristic of 19th century tribal relations, the era of information technology now allows each group to have fairly ready access to the cultural ideas of another. The space in which Kelabit engineering is situated is therefore a mix of their own traditions, as well as those of their near neighbours and the more distant ideas of the wider world in which they are now becoming immersed.

In Chapter 4 I discuss ways in which the materials and ideas of the industrialised world are becoming more important to the Kelabit, but it should be noted that this is always tempered by local tradition, and the flow of ideas locally. Here, however, we come to something of a dead-end. Investigating Kelabit traditions of engineering has been fruitfully enlightened by their active appropriation of influences from the industrialised west, but has foundered on the rocks of ethnographic reports of their nearest neighbours. As discussed above, the Kayan and Kenyah tribes have historically been of the greatest cultural influence on the

Kelabit, and until the turn of the 20th century, their contacts were frequently violent. Indeed it has been suggested that the aggressive Kayan “a migratory and conquering people” (Southwell 1959: 40) are responsible for the movement of the Kelabit into their current highland home (St. John 1974[1863]: 123); Harrison 1954: 105; Arnold 1959: 10). Whereas the Kelabit struggled to contain the expansive ambitions of the Kayan, “only the Kenyahs were able by their superior strategy to withstand the Kayan invaders and to co-exist with them” (Southwell 1959: 42), and in recent decades both groups have tended to live in the same areas. This includes large swathes of territory around the south, east and west of the Kelabit highlands.

From reports of cultural influences (as above), and their overwhelming regional presence, the Kayan and Kenyah might therefore be expected to have played an important part in influencing of Kelabit engineering. It becomes clear when reviewing regional literature, focussing on the Kenyah and Kayan tribes, that engineering practices have proved to be of little interest to ethnographers and others working in the area. Considering housing for example, in studying the longhouse, an icon of Bornean life generally, the architecture is widely discussed, but the act of construction is not. Haddon, in his visit to Sarawak as part of the Torres straits expedition in 1899, used the longhouse as “the place for the observation of daily life” (1901: 332), and describes the layout of the Kayan longhouse in which he stayed. Essentially the arrangement of space within the longhouses of the region is similar, with a dividing wall running the length of the house, separating the open ‘veranda’ from the private ‘family’ space. Likewise, there is a typical structure of tall piles raising the floor high into the air, and a steep roof extending the eaves almost to floor level. This tends to be the extent of the detail in which various authors describe the construction (see for example King 1993: 218-219; Haddon 1901: 298; Payne *et al.* 1994: 41; Waterson 1994: 83-85). For most of these authors, the longhouse is an interesting forum rather than an interesting construction: it is the place where things happen, or a representation of something else (see Waterson 1994 for an extensive discussion of the symbolism of south-east Asian houses). Discussion of the house as a

construction tends to be limited to a few sentences: “Whereas Iban houses are usually raised a modest height from the ground and built of lighter woods and other materials such as bamboo, Kenyah and Kayan houses are massive structures, built on heavy ironwood posts with plank flooring, high off the ground” (King 1993: 220; see also Rousseau 1978: 80; Whittier 1978: 97-100; Hong 1987: 11). This is all the more surprising when some of the same publications include dramatic images of the longhouse, such as Tillema’s from the 1930s (1990: 94) showing the massive posts, carved and jointed, supporting a Kayan longhouse, or Haddon’s picture (1901: 335) of chief Aban Abit’s longhouse under construction in the Baram district (home of the Kelabit, Kayan and Kenyah).

We can see that within the context of regional practices, Kelabit longhouses are in some ways typical, as per the generic description above, but in others “look like no others” (Harrisson 1959: 60). To investigate the regional influences of engineering practices on houses and house-building practices then, the literature leaves much to be desired. When considering bridges, the situation is even less promising. Some basic bridge types are almost universal (Cruickshank 2010: 8-55), but most significant for my fieldwork are Kelabit attempts to resolve the problems of incorporating modern building materials and ideas into a local engineering context of bridge-building. The bridges of their influential neighbours, the Kayan and Kenyah have managed to avoid description or analysis, which leaves us to wonder at the extent to which Kelabit bridge-building traditions are geographically restricted. Some hints at this being true come from interviews with elderly Kelabits describing their first sight of hanging rope bridges in the 1960s (as mentioned by Ngalun Paran above), that appeared as a result of army supplies of wire rope brought into the area. The basic idea of hanging rope bridges is widespread in similar ecologies, Siegel (1982) provides a comprehensive survey of such bridges in Papua New Guinea for example. Where information is available, it suggests that traditional Kelabit bridges are at least unusual. Payne *et al.* (1994: 113) pictures a Kenyah bridge, made of bamboo and rattan, but the appearance and structural design is different from Kelabit bamboo

and rattan bridges (described in Chapter 3 below). The Kenyah bridge relies on overhanging trees to support bamboo beams, which are lashed to the branches, and supplemented by a sturdy and intricate framework of bamboo and rattan. Tillema, in his 1930s travels through Kayan territory describes two types of bridge: wooden bridges made of lashed and staked trunks and branches (1989[1938]: 96), and a picture of “a suspension bridge of rattans. This bridge links the village with rice fields” (*ibid*: 98). This ‘suspension bridge’ is more accurately a catenary, or hanging bridge, and not the same as the new Kelabit suspension bridge described below. Neither of these look like the ‘traditional’ Kelabit bamboo bridge described to me by several experienced engineers (see Figure 14 below). Furthermore, if the elderly Kelabit I interviewed were right in saying that their first sight of hanging bridges was in the 1960s, then there is a tradition of Kelabit bridge building which is difficult to trace in the literature of regional bridges.

As to why Kelabit longhouses and bridges may be significantly different from their local neighbours, we might conclude that it is a result of their radically different ecological orientation. Unlike most of the rest of Borneo, and certainly the Kayan and Kenyah, the Kelabit are people of the land, rather than people of the rivers. “In many ways the river is the lifestream of the people [of Borneo], providing them with fish, water for their domestic needs, toilet and bathing facilities, and transport using boats to get them to their farms” (Hong 1987: 3). For the Kayan and Kenyah, this means that their houses are always built on the riverbank (Haddon 1901: 298; Rousseau 1978: 80; Hong 1987: 11; Tillema 1989[1938]: 84-85; Waterson 1994: 84), and their life is dominated by the use of the boat and the development of their boating skills – they are ‘river people’ (Southwell 1959: 52). Unlike the Kelabit highlands, there was no potential for irrigated rice fields, the techniques of which were unknown to them (Tillema 1989[1938]: 98; Southwell 1959: 42, 50). Travel by river negated the need for Kayan and Kenyah bridges to the same extent as the Kelabit who travel almost exclusively on foot over their mountainous territory. For instance, Harrisson relates the story of a joint Kelabit, Kayan and Kenyah military expedition where

the Kayan and Kenyah were exhausted before reaching their planned enemies, which led them to attack another, unsuspecting and much nearer, group (1959: 91). He describes the “Kayan (river) people, folk who never walk if they need not” (1959: 20). For the Kelabit, travel up and over the slopes of their range requires them to cross rivers in order to reach their destination, often their widespread farming lands. This means on some occasions building bridges that need to be maintained to allow regular passage, unlike the Kayan and Kenyah whose preferred routes take them skilfully along rivers rather than across them.

In searching for regional engineering influences, I have therefore come up short of any substantial parallels. Their dominant neighbours, the Kayan and Kenyah, despite being far more numerous, and wielding far more regional political power, appear to have done little to affect Kelabit house and bridge construction. Kelabit houses are less permanent, built on hilltops, and with less substantial raw materials, whilst their bridges are more numerous and important, constructed more frequently, and traditionally to culturally specific designs. It seems that modern Kelabit engineering is affected more by ideas encountered in industrial societies than it has been by regional traditions.

2: THEORETICAL CONTEXT

As outlined above, this thesis is concerned with the technical production of large-scale and complex objects, and through the body of the text and descriptions of fieldwork that follow, there will be talk of techniques and materials, and the ways that these come together through social interactions. This raises important issues about the concept of relations between the engineering producers, the sources of their materials, and the structures of production. Hence to set the descriptive and analytical sections into context, I will first discuss some of the theoretical approaches that have been, and are currently used in anthropology, which examine these links and relations between people, resources, activities of production, and technical competences.

Anthropology and Production

Anthropological approaches to production have a long history, heavily influenced by Marx and dominated for many years by his concept of ‘modes of production’ (O’Laughlin 1975). For Marx, a defining characteristic of human society was its ability to produce its own means of subsistence, and most importantly the necessarily social character of the production process. This stands in contrast to the emphasis in economic anthropology and more recent trends in consumption studies to see the exchange and use of produced goods as the basis of social order (e.g. Mauss 2002 [1954]; Parry and Bloch 1989; Miller 1987). To produce goods is therefore to simultaneously produce society, since it is co-operation, although according to a variety of social relationships, that is common to all modes of production. For Marxist ‘historical materialists’ the production of material goods through technical force, and mutually consequential reproduction of social relations, represent the basis of human history and describe the dynamics of social change (O’Laughlin 1975:346-349). While Marx was primarily intent on describing the capitalist mode of production, this was set in the context of the potential for change, especially as a framework for class struggle, and hence historically specific (Copens and Seddon 1978: 38-39). In formulating an analysis of the evolution of production up to and potentially beyond the capitalist mode,

inevitably required a consideration of pre-capitalist modes of production, characterized as simpler and primitive, and seen by anthropologists as analogous of certain extant societies, in early work especially of African societies.

Meillassoux's seminal paper of 1960 "The 'economy' in agricultural self-sustaining societies" (Meillassoux 1978) used the essential Marxist historical materialist approach to critique then dominant anthropological investigations of 'primitive' societies on the basis of their economic organization. He roundly condemned the confusion of the liberal economics used by anthropology as a catchall for any type of exchange system, without differentiating between different modes of production (1978:128-131). By this reckoning, any system of exchange could be reduced to a pale imitation of Western capitalism, translating terms such as interest rates, capital accumulation, profit, supply-and-demand etc. into apparently equivalent indigenous concepts. In exposing this as contrived and over-simplified, Meillassoux then demonstrated how in a putative, but specific type of African society the economic system could be explained in terms of the social relations that reproduced and maintained the productive system. However, in doing so, he focussed almost exclusively on the 'relations of production' with little consideration of the 'technical forces of production'. This is the argument made by Graeber in a recent attempt to revitalise the concept of 'mode of production', pointing out that although "a mode of production is born of the relation between two factors, the forces of production and the relations of production ... the 'forces of production' are rarely invoked" (2006: 62-63).

In all of these works, the basis of 'production' in pre-capitalist societies was seen as subsistence – essentially agricultural production, rather than the commodity production of capitalism - and the need to reproduce a complementary set of social structures that allowed the system to be maintained or to evolve into a more complex mode of production. Devising an evolutionary model was complicated by the proliferation of apparently different modes ¹³, and the problem of identifying key criteria, usually based on systems of control over land, women and

¹³ Copans and Seddon, for example outline: hunting, lineage and segmentary, tribal-village, tributary, Asiatic and African (1978:38-39), whereas Godelier suggests: primitive, Asiatic, ancient, Germanic, feudal and capitalist ([1968] 1978:214-219).

the labour of young men. Godelier's treatment of the disputed concept of the 'Asiatic' mode of production ([1968] 1978) drew on Marx and Engels (1978: 219-230) and their description of the despotism of the Russian state. The basis of this 'mode' and the source of its controversy was the mixture of attributes when compared to more or less 'primitive' societies, including the communal ownership of land, and relations of production, alongside the emergence of a powerful State (1978: 212, 240-241). For Godelier this was a means of describing the historical transition from classless to class-based society, which required the dominance of a social class and the appropriation and exploitation of surplus labour and produce. For many other anthropologists, influenced by Wittfogel in the 1950s (Hunt and Hunt 1976: 389-390), and his 'Oriental despotism', this represented a turn to consider the 'forces of production' (and hence of interest to my project, a consideration of something large-scale and complex), since Wittfogel had based his analysis on the development of irrigated agriculture on a grand-scale as a technical feat (Kelly 1983). Continuing the theme of production as most importantly agricultural and subsistence production, irrigation could be seen as a significant expansion and complication of the relations of production, but large-scale projects such as irrigation, required equally large-scale mobilisations of labour and resources.

Hydraulic Engineering

Wittfogel's Oriental despotism hypothesis (Hunt and Hunt 1976:389-390) used the example of irrigation in Asian states to demonstrate the relationship between resource exploitation and social organization. The conditions for such large projects to be initiated were fairly specific, including the remote availability of, and the need for water, as well as a despotic (collective elite) distribution of power: in short, the large-scale re-distribution of water in an arid environment. Some of Wittfogel's conditions have been critiqued for their simplification. For example, practical requirements are far more varied and complex than he allowed, and present a more difficult unit of analysis: "irrigation is more than an act of hydraulic engineering. It requires institutional arrangements for the construction and maintenance of physical facilities and procedures for the movement and distribution of water" (Kelly 1983:880). Similarly, environmental conditions that

favour irrigation are not limited to Wittfogel's 'aridity' (Hunt and Hunt 1976: 390). Floodplains, excessive flow, highly variable rainfall, elevated field systems and so on, all require irrigation to control water flow, regardless of aridity alone. Then, the purpose of irrigation could be seen to affect its physical form and means of construction, from expansive shallow salt-flats, to hillside terraces of padi, or stagnant canals for collecting silt, to subterranean channels in Mexico (Steensberg 1976: 403). This is without accounting for the more symbolic forms of irrigation, as in the historic Kelabit highlands where *nabang* channels were cut to divert river channels and create new fields in the old river bed, but just as importantly as a form of memorialising the recently deceased.

The practical basis of irrigation therefore could be used to demonstrate more effectively the 'technical forces of production', rather than simply showing how the 'relations of production' are in some way a key determinant of the development of social history. Thus, while the construction of a substantial system may be a rare event, there are a whole host of more frequent acts that go to keep the system running, including maintenance and repair, allocation of water, resolution of disputes, or even defence (Hunt and Hunt 1976: 391). Furthermore, an understanding of the climatic conditions and ecology is necessary to both operate and benefit from irrigated agriculture. Altering one aspect inevitably has consequences, as seen by the Kelabit in their constant battles with the increasing insect and rat populations. Accordingly, the sizes of the tasks require different skills and numbers of people, and may therefore be organised at levels other than the 'despotic state'. This type of engineering project and physical resource can be devised and maintained through different forms of social organization, which may bear no relationship to a scheme of particular historical cultures. To irrigate involves organization of physical resources as well as social systems: it requires control of water sources, devising and maintaining systems of delivery, effective supply through the application of agricultural techniques and knowledge, and the expulsion of excess during or after cultivation (Kelly 1983: 881-884). That said, as the Hunts pointed out (1976), the study of irrigation systems had been overly concerned with social aspects, and only paid cursory attention to the physical system and environmental conditions. Graeber's key point in his reconsideration

of the 'mode of production' concept is that by abandoning it as flawed, economic anthropology has resorted to describing any social system as a primitive form of capitalism. Some of the more interesting points of the concept have thus been under-developed, such as the idea of technical forces of production, and the dynamism of the total system it described (2006: 61-64).

Environmental Relations

At the time that anthropologists were grappling with the ramifications of Marxist thought, an alternative view of the evolution of society was promoted on the basis of its relationship with the environment. Julian Steward's seminal *Theory of Culture Change* (1955) described how some elements of society had 'adaptive significance' to their ecological surroundings. In particular, technological evolution was seen to be more or less directly linked to effective exploitation of natural resources. Stewards' 'cultural ecology' posited the view that cultural diversity was the result of the accumulation of successful adaptive strategies to naturally occurring conditions. This formed the 'cultural core' of societies, supplemented by secondary elements assumed through the dissemination of technologies from contact with other groups. Other aspects of society such as rituals art, myth etc. are considered to be mere epiphenomena (Flannery 1972: 409), in total forming the social whole.

Steward's emphasis on technology offers some insights into the relationship between human productive activities at a practical level, and their environment, more than the social relations of production that the use of Marxist thought had offered. However, cultural ecology was dominated by the effect of ecology in shaping technologies, and took little account of the changes that were wrought by those technical adaptations (Rambo 1983: 6-8). A key paper, and often cited in this school of thought is *The cultural ecology of India's sacred cattle* by Marvin Harris (1966) and the start of his brand of 'cultural materialism'. Harris was dismissive of the idea that the reverence for cattle in India could be described as a social phenomenon based on religious beliefs. He showed that the cattle, in not being consumed, were still contributing to the agricultural well-being of the nation. This, he suggested, was through the use of their dung as fertiliser and fuel,

bullocks as draft animals, hides for a thriving leather industry, and feeding off grasses growing on waste ground or stubble left over after the harvest. As with Steward's original ideas, Harris paints a picture of a stable and resilient ecology, disregarding the environmental changes that come about through exploitative socio-technical changes. "The great weakness in Harris' argument [is that] he wholly ignores the destructive impact these animals have on the environment and the consequent lowering of the land's ability to support the total human population..." (Rambo 1983: 12).

Furthermore, this version of cultural materialism rests on assumptions it makes as to the motivations of the individuals concerned. There is an implicit suggestion of intentional rationality in decision-making, through some unidentified mechanism that guides large groups of people to the same conclusion. This despite the fact that in similar ecological situations, social and technical solutions are varied and in some cases exactly opposed to one another (e.g. Rival 1996). The etic (Western capitalist) perspective, superimposing a rational economic thought process onto actors who are seen to be attempting to maximise their productive efforts, can be criticised for missing the importance of indigenous concepts of their aims and ambitions. In *Stone Age Economics* (1972), Sahlins points out that contemporary hunter-gatherer communities (he used primarily the example of Kalahari bushmen) were oblivious to the potential problems associated with not having stored food in preparation for the hard times that might come. This was he concludes, an alien concept that was not relevant to their ecological relationships. Instead, they remained confident that the bush would provide for their needs, so that a bounty today was consumed today, and not saved for tomorrow. Surplus production is not an economic benefit but a physical burden to a transitory lifestyle, and satisfaction is achieved not through material plenty, but in developing social relationships. Not wanting more than can be personally acquired renders the unrealistic ambitions of capitalist consumerism irrelevant. Sahlins approach was therefore at odds with the cultural materialists, since he rejected the association of environmental relations with economic rationality, and saw the potential for a more varied response to similar ecological conditions,

without resorting to the strategy of analysing subsistence production as the ultimate aim of non-Western societies.

The incompleteness of cultural materialism, in its ‘calorific obsession’ (Price 1982: 720-721) and emphasis on rational choice has led to the development of a more wide-ranging ecological anthropology, with a broader ‘systems’ perspective on environmental relations (Vayda and McCay 1975; Price 1982: 725-727; Rambo 1983: 25-29) of the integrated nature of human and environmental interactions. Moving away from overtly economic interpretations of people’s activities opens up a variety of factors based on the need to flourish in an environment physically and socially. In that vein, Vayda and McCay cite an expanded analytical view of the Quechua Indians of Peru, moving from, for example, “exploiting a spatially dispersed, multiple resource base of energetically efficient crops and domestic animals” (1975: 296), to behavioural responses to their high altitude home such as coca-chewing, and physiological responses including changes to the respiratory and cardio-vascular system (1975: 299). This emphasises the dynamic interdependency of each system component on the other, as well as the influence of external social- or eco- systems, allowing a more complete view of the ways that human populations alter and engage with their environment. However, it is based on an essential division between the two, social and ecological: distinct systems each affecting and altering the other, interacting while remaining apart, humans beyond their environment instead of within it (Ingold 2000: 40-43; Latour 1993).

The use of resources, production, technology and so on, are surely as much a part of the human world as they are of the ecology that they inhabit. Conversely, the environment is not simply a place from which energy, materials and information flow into the human world, it *is* the human world, or more accurately it is *the* world, the same one that social humans belong to. However, despite this, the cultural materialist approach serves to demonstrate that relations with the environment, especially those predicated on technology are mutually constitutive, and intimately linked.

Production and Technology as Social Concepts

Whilst production has gone largely un-noticed as a recent anthropological topic, the broader sphere of 'technology' has been an important subject of study for many years. The relationship between the two is intimate, and theoretical approaches derived from studies of technology are directly relevant to a study of engineering as technical production. Large and complex objects can only be created by people responding to the materials and conditions before them, using tools, techniques and the ideas in their mind. For the social sciences, investigations into technology and tool-use have centred on their place in the wider cultural milieu, and the extent to which technology has played a part in shaping the societies we see today. 19th century anthropologists correlated technology with progress, in an explicit link between the cultural sophistication of the colonising industrialised west, and their innate superiority (e.g. Morgan 1877). The key theme for the anthropology of technology at the time was its relationship with material progress, the on-going development of ever-more sophisticated technical objects, simultaneously accruing socio-cultural benefits. However, the assumption of a link between material technologies and increasing social sophistication has proved difficult to sustain (Ridington 1994), so that more recently, sociological studies of technology have emphasised the mutual influences between technology and society.

Winner (2003:163[1980]) argued that society is governed by technology and that "...people are often willing to make drastic changes in the way they live to accord with technological innovation..." His contention that 'artefacts have politics' is illustrated by a description of government interventions in social life in order to accommodate the needs of nuclear power generation.¹⁴ The inherent environmental and military dangers are weighed against a social desire for cheap power, resulting in greater regulation of some aspects of social life. To counter this explicitly deterministic view, Pfaffenberger suggests a concept of technology as 'humanised nature', a fundamentally social phenomenon based on a shared set

¹⁴ His more famous example, of the low bridges leading to Long Island beach resorts in New York, 'designed' to keep out buses and hence the ethnic minorities who used them, has been effectively critiqued by Joerges (1999), as based on inaccurate information.

of meanings expressed through technical performances (1988:244, 249). Technology becomes the full set of relations that come about as a result of its cultural acceptance and hence technical production may be more social than material in its conception and performance.

In his introduction to *Technological Choices* (1993) Pierre Lemonnier suggests that when we see ‘social choice’, we tend to see ‘the social’ being put at odds with ‘the material’. Choices are based on a sort of competition between what might be put forward as the most efficient technical solution and what might be a different, but socially more acceptable solution. As he points out, despite problems being expressed in terms of diverse social logics, many technologies (by implication technical solutions) are cross-cultural (pottery, weaving, fishing etc.) For Lemonnier, material choices are paramount, and it is only when there are more potentials from which to choose that technical choices become predominantly social (1993:26). This leads him to advocate the *chaîne opératoire* (‘operational sequences’) method of studying technical production, analysing the physical constraints of production and use, before considering how these vary. His aim is to identify and isolate material variations and choices, to be left with social choices, and thus greater insights into social relations (1992).

Other anthropological descriptions of technical performances tend to give more authority to the social aspect at the expense of the material. Dobres (1999) describes technology as a complete chain of events, using the example of Inuit whale hunting to show that it includes not only the actual paraphernalia of the hunt, but also the pre-hunt rituals, and subsequent processing of the meat. And similarly in her joint introduction with Hoffman to their edited volume (1999), they describe technology as complicated by beliefs and social practices. However, they suggest that the scope of investigation *must* include such things, and cannot concentrate on the purely tangible and functional parts of technology. The same point is made by Ridington in discussing the introduction of new technologies into northern Athapaskan society. Whether guns or bows and arrows are used, he says, is not the point. Rather it is the complete technical performance of hunting, which

includes understanding the environment and selection of appropriate strategies. “Technologies are performances; they are the communication systems, and their styles are symbols through which communication occurs” (1999:167).

Approaches to technology that favour the social approach continue in sociology. The seminal publication edited by Bijker, Hughes and Pinch (1987), epitomised the Social Construction of Technology (SCOT) approach, based on a critique of the so-called ‘Standard View’ of technology. The Standard View linked engineering with technology by suggesting that there is an essentially pragmatic process of problem solving; natural resources are modified for utilitarian ends (see Pfaffenberger 1988 and Dobres 2001 for a fuller discussion). The endpoint to this activity is something useful, which has been preconceived and produced through manipulation of the physical world. Things are manufactured according to a planned sequence of events within the framework of overall socio-material improvement. Technological life is thus defined as a means of striving towards social improvement, making life easier and more fruitful.

The common perception of technology and engineering in the West is as science made real (e.g. Dieter 1983; Hurst 1999; Norman 2004; Petroski 1996). The concept is something like this: Nature in the raw is too complex to be fully understood, so a small part of it is analysed in detail, providing laboratory-type information. That information is then fed into the process of technology, which reconstitutes it through engineering into a revised form: nature manipulated. This is the concept that SCOT sought to undermine. By examining the compromises that had been brought about through the application of social constraints to technical activities, SCOT demonstrates that technology is not in fact coolly distant from society, but is inescapably linked. Pinch and Bijker (1987) typify the social constructivist approach with their example of the development of the bicycle: the flexibility of the artefact is first demonstrated (i.e. that there are numerous ways that the artefact could be perceived), then the artefact is stabilized through key social groups perceiving the ‘problem’ as having disappeared. So for the bicycle example, the pneumatic tyre was either to reduce vibrations, or an ugly

accessory, or made the vehicle more likely to slip, or made it less likely to slip (1987:40-46). A new form of frame (lower than the existing upright 'Penny Farthing' design) was either more or less safe, faster or slower, and more or less attractive, depending on the social group to whom it was addressed. The taller frames appealed to the machismo of male youth precisely because they were less safe. By SCOT analysis this debate reached closure through strength of rhetoric favouring the 'safety bicycle' (the design we would recognise today as a typical bicycle), and a shift in social attitudes to personal transport emphasising practicality over sportiness.

Examples of engineering, in the sense of people making things through technical production, are more common in the social constructivist approach, as illustrated by Pool (1997), and Pinch and Bijker. These however, tend to be based on a historical narrative, charting the inputs of different social groups and their rhetoric - telling a story of how things came to be, but missing out the equally important stories of failures and dead ends. The more holistic anthropological approaches such as those of Ridington and Dobres expand the remit of technology beyond engineering, to include for example 'technologies in the mind' and ceremonial performances. As Lemonnier says, this does not adequately account for the fact that there is a practical aspect to technology, producing material transformation, according to cultural concepts and relations. However, in Lemonnier's 'operational sequences', the act of production is analytically cold and clinical, separated into minute detail and seen from the outside. An investigation into technical production needs to allow for the embodied engagement of people with their materials.

Production and Craftsmanship

Keller, a practising blacksmith, effectively critiques the *chaîne opératoire* approach in his portrayal of the act of production, making the point that it is not possible to describe production through observation alone (2001). For him, the act of production is governed by his sensation of the materials, the state of the thing being made, and his mental predictions of future actions required to advance the unfinished object towards its designed outcome. The observer's account of the

process is very different from the practitioner's, missing as it does much of the internal, unspoken decision-making.

For most anthropologists, engaging in the act of production is at best difficult, and often not possible without the years of dedication that it takes to achieve a significant degree of competence.¹⁵ Even if he were able to do so, the anthropologist turned craftsman, would still remain in his own world and not that of his teacher. "Constellations of knowledge" are not shared between pupil and master through language, instead as Wynn suggests (drawing on Keller), "each [constellation] has been constructed by associations and correspondences individually recognised by each person while learning the task" (2002:153-4).

Although learning the task may help us to overcome what Gell calls our 'enchantment' with the object (1999), that is, being mesmerised by the apparent impossibility of the act of production, it can never give us complete access to the mind of the producer. MacKenzie's description of making Telefol string bags (1991) shows what an intimate knowledge of the production techniques can bring, having researched current and forgotten techniques of 'looping', and become something of an expert. Her descriptions of the process are thorough, as are her diagrams (1991:85-100), and yet there remains something intangible in her writings. Learning was done through observation and practice and to achieve competence meant being able to 'feel' the string and looping technique (1991:102). Reading the 'instructions' as written, even with the accompanying diagrams, does not provide an unambiguous set of rules for the uninitiated. Skilful production depends on a bodily engagement with the materials, and continual reproduction and honing of those skills. Ingold has also used MacKenzie's example in his comparison of human with animal production (2000:349-361), coming to the conclusion that

"...it is the pattern of regular movement, not some prespecified design, that generates the form. And the fluency and dexterity of this movement is

¹⁵ Keller is an exception to this, since his training as a blacksmith was done in collaboration with his wife, an anthropologist. Trevor Marchand, as mentioned above, has also engaged in anthropology through apprenticeship, to investigate ways of learning in traditional construction in Mali (2009), and fine woodworking in Britain (2010b).

a function of skills that are developmentally incorporated into the *modus operandi* of the organism...” (2000:360).

Anthropological accounts of production are rare, and if we were to categorise the objects produced they are generally what we might call ‘craft objects’, and the producers ‘craftsmen’. Telefón string bags are one of the best documented, others include basketry (Ingold 2000:339-348), salt (Lemonnier 1992), pottery (Malafouris 2008:19-38) and so on. Larger projects, what we might think of as truly ‘engineered’ are described and analysed for their social significance. As an example, Waterson’s analysis of houses and house building (1997), focuses on the house as a cosmological icon, and its structure as part of a system of knowledge and beliefs (see also Gell 1998:251-258), and as discussed above, irrigation systems are used as an effective example of social organization, rather than of the practicalities of their construction.

Even in accounts of Western engineering, the act of production often seems strangely missing. Engineering seems to equate with design and not production. The anonymity of machines or third world producers is usually kept away from discussions of the engineering of industrial objects. Norman (2004) asks why we love or hate everyday objects and concludes it is down to the designers, whose role is to see how things are used, more so than how they are made. Petroski (1996) asks how engineers get from thought to thing, and manages to skip straight over production! It is, he says ‘invention by design’. Even Suchman’s *Embodied practices of engineering work* (2000b), does not really discuss the embodiment of engineering, but rather sees how objects are used in designing, in a context where CAD dominates. These accounts of industrialised engineering go from design to use with hardly a mention of real people actually making things.

For anthropology, there is an enduring image of the indigenous craftsman working locally collected ‘natural’ materials, as the epitome of production. This provides the forum for investigations into skill, learning, environmental relations and so on, and is fairly readily observed, since it is possible to watch the whole process from a single vantage point. But we need to be aware of our own preconceptions of

what it is that those being observed are actually doing. By watching people ‘at work’ and setting the boundaries of that activity, we might be able to draw easy connections, but as Wallman shows (1979), the concept of work is not at all universal. Work is not just about the evaluation and control of resources, it is about social transaction as much as material production and not necessarily (or even usually) based on the exchange of labour for reward, especially money. The limits to when a person is working are hard to define if we include for example thinking and planning time, or carrying out work-like activities for personal pleasure, or being paid for essentially leisure activities (playing games or music for example). Or as Parkin describes, distinguishing the paid labour of fishing as not being the same as the ‘real work’ of (unpaid) farming (1979). Life is full of activities we might understand as valuable for their productive quality, but these are not the limits of what production is. Groups of people engaged in mundane, apparently productive activities would typically not fall inside the traditional remit of anthropological discourse. Instead, the mundane would usually be overlooked in favour of deeper social meanings and consequences. As will be discussed in the case studies below however, these mundane productive activities are as difficult to master as ‘craft’ production, despite the apparent lack of artistic intent or output. In other words, at an individual level, craftsmanship is one form of production, no different from any other, including the individual acts that combine to produce engineering.

Forms of Socio-Material Relations

As Graeber has pointed out (2006), the Marxist treatment of production, as the means by which societies have historically developed, underestimated the ‘technical forces’, which Marx himself had been keenly aware of in formulating the ‘mode of production’ concept originally. Productive activities are dependent on the social *and* technical in a complex, interactive and dynamic system (Pfaffenberger 1988). This could be developed further, and into the production of different categories of things than ‘agricultural subsistence’ in pre-capitalist (or non-industrialised) societies, or ‘commodities’ in a capitalist (or industrialised) society.

Where engineering has been considered, it has been in the context of Western industrialism, through approaches like the Social Construction of Technology (SCOT) and Science and Technology Studies (STS), with their origins in the analysis of laboratories and the scientific method. Many of the SCOT studies are fairly singular in their approach and tend to restrict their analysis to the circumstances and groups closely related to the object in question. The move to a more relational and ultimately complicated method developed with STS. Whereas SCOT described the ways in which we produce technologies that are imperfect, but with a social explanation, STS adopts a more reflexive approach, including a wider range of participants and politics.

STS builds on the constructivist philosophies of SCOT, but recognises a more significant role for the material world. Science and technology are still seen as essentially social activities, built by communities of scientists and engineers. This means they come with their ideologies and values, their competition for resources, their rhetoric, and their gender, race and nationality. But, more so than SCOT, the social realm of humans is augmented by the material world of things (such as scientific equipment, or academic politics). These non-humans are flexible or resistant, compromised by cost or availability, historicised and appropriated; in short, they play a significant part in the construction of science and technology. The result is that STS becomes a complex set of dynamic relations between the social and material worlds, merging and separating in constantly changing mixtures of people and things (most recently: Latour 2005; Law 2010).

For Latour (2005) the basis of actor-network theory (ANT) – the hallmark of STS – is a desire to do away with the differences between the social and the material worlds and treat them, analytically at least, as part of the same system. The key points that develop from this are, firstly that the world is made up of amalgams of people, objects, politics, knowledge and so on – what Latour calls ‘hybrids’ (Webmoor and Witmore (2008) use the term ‘mixtures’). Secondly, associating together in a network creates effects: “This lies at the heart of actor-network theory, and is a way of suggesting that society, organizations, agents, and machines are all *effects* generated in a patterned network of diverse (not simply

human) materials” (Law 1992:380 emphasis in original). Third, this means that analytically there can be no discrete categories; people must be treated in the same way as things. That is not to say that people and things have the same capacity to act (which Latour calls ‘absurd’ 2004:71), but that we should assume a generalised symmetry between intentional action (human) and causal relations (material) in the effects they are able to generate. Their effects are spread over the whole network (an effect may be for example a social organization) so the agency of the association – its ability to create an effect – is spread among all of the constituents, regardless of their essential character as object or person (which of course is irrelevant to an ANT practitioner). And finally, the heterogenous associations are fragile and constantly liable to break up and reform in new ways, as new materials gain association. Law (1987) gives an analysis of Portuguese exploration in the 17th century, where the network changes as new technologies of navigation are invented, allowing sailors to move further from the coast into new currents, which in turn allowed the introduction of different types of ship changing the places that could be visited. This provides a methodological tenet for ANT, which is to ‘follow the actors’ (Latour 2005:8) to see what effects they produce, and what this means to different associations.

For an anthropology of engineering, ANT emphasises the importance of relations building up and dispersing, and the inclusion of material things in creating those associations. Engineering can be considered to be about relations and not simply substances; heterogenous materials (and non-materials) accumulating and cohering at a certain time and place to form something. But engineering is also about individual skill and experience, and a mutually creative engagement with materials and the environment. Production is not always fast-moving and innovative, it is often mundane and secondary to the other social performances that are going on, and in these areas ANT fails to convince in my analysis.

Production requires some of the skills and engagements described by Ingold (2000), the environmental and bodily reactions to materials. Although he has tended to use examples of craft skill, I see no reason why the same could not be applied to engineering more generally. Rather than seeing the world as a series of

networks, each made up of a variety of people, things and hybrids, Ingold uses the analogy of 'flow'. People interacting with materials are doing so in a performative way, constantly adjusting their behaviour in accordance with the effects they sense from the materials to hand. At a micro level, this process can be seen as the craftsman minutely alters the pressure of his tool, his posture and so on in carrying out work (Ingold 2011:51-62). At a macro level, adapting to ecological conditions is a lifelong process, the actors continually attuned to their surroundings without interrupting the flow of action (Ingold 2008:214).

For Ingold, the focus shifts away from the similarities of the social and material world in creating effects, and to a more ecological view of on-going relations with the world. Interaction with the world is mediated through the application of skills, which are themselves responsive to the ever-changing environment. Production is the result of a build up of relations with the environment by people who actively engage with it. The maker is led by the materials he works with, in a creative and improvisatory flow of interaction. In Ingold's words: "Practitioners, I contend, are wanderers, wayfarers, whose skill lies in their ability to find the grain of the world's becoming and to follow its course while bending it to their evolving purpose" (2010:92). This rather abstract description is open to interpretation, but the important point to note is the relational concept linking people to their environment through their bodily skills. In terms of engineering, this of course means literally making things, but focusing on connections formed by interaction with materials, as well as the substances themselves.

As with ANT, Ingold's ecological relationalism blurs the distinctions between the social and material world, but his argument retains a specific place for the actions of people, which ANT does not.¹⁶ For Ingold, the key relationship is between the skilled producer and the environment, and how the interaction between the two is mutually constructive in a continual flow of life. Production is a way of peeking into the flow, recognising that we can only see a small part of a whole. ANT does

¹⁶ He also argues for the importance of the actions of other animals, and to a different degree plants too. People, animals and plants all forming part of the same active and creative world (2000). Inert objects such as wood, stone, nuts and bolts are the materials of interaction and, lacking 'attentiveness' do not offer the same degree of potential agency (2010).

not distinguish between the potential for influence of any part of the world, human or non-human, and thus removes the separation of people from things, for analytical purposes, in the creation of social effects.

To describe engineering, it therefore seems plausible, and desirable to combine some of the strengths of these approaches. By limiting the project to a consideration of people making things is bound to favour material effects at the expense of the wider social milieu, but in responding to Graeber, there is scope for investigations of the ‘technical forces of production’ in the context of a historical view of society, acknowledging the changes that take place over time. For the Kelabit, for example, environmental relations represent a long-standing commitment to a life in close proximity to the rainforest. From the discussion of ecological anthropology and cultural materialism, we can see that individual and communal decisions about how to respond to environmental threats and opportunities are indicative of the pressure to act differently, without assuming a successful outcome. This suggests the need for a wider consideration of how the environment and the use of resources in engineering projects are mutually affected, and hence impact on the people and their community. Systems theories, such as ecological anthropology, and the more recent science-based approaches such as ANT, go some way to describe the contextual complexities encountered in technical production, including the effects of groups of people dealing with each other, their tools, materials and the world around them. However, the attention to immediate activity, and the powerless anonymity of individuals loses the sense of the on-going lives of the human actors. It also fails to account for the nuances of individuals engaging with materials in a visceral way, which Ingold’s focus on skilled practice manages to do much more effectively. Engineering requires extended and coordinated social action, in which individuals will experience their own responses to the material world, and in that sense we need to draw on each of these approaches to successfully account for the full range of activity that this encompasses. Most importantly, where this leads is in seeing the creation of new relations through and during the creation of things.

DIVERSION: “You can’t write down everything”

Egide Walschaerts was a Belgian engineer most famous for his invention in 1844 of a new type of valve gear for steam locomotives. By the early 20th century the Walschaerts valve gear was established as the most popular system of its type, being used by virtually all locomotives, including GWR6023 ‘King Edward II’. Correctly adjusting the valve gear proved to be an unexpected problem for the refurbishment team at the Didcot Railway Centre. Here I consider why this should have been the case, and agree with one of the engineers that there is more to making something than can be put down on paper.

A steam locomotive works by producing steam in its boiler at high pressure, which is then fed into the piston chambers, driving the pistons back and forth, in turn driving the wheels through a connecting rod (con-rod). The back-and-forth motion (reciprocation) is produced by alternating where the high pressure steam goes - in front of the piston to drive it backwards, and behind the piston to drive it forwards. The steam therefore has to be directed either to the front of the piston chamber, or to the rear of the piston chamber, depending on the position of the piston. Valves control the direction of steam flow, and need to be carefully adjusted so that their timing (opening-and-closing sequence) is carefully synchronised with the position of the piston. If the timing is ‘out’ then at worst there would be no drive to the wheels, or more likely, efficiency drops dramatically. Experienced railwaymen can hear from a passing locomotive whether it is ‘on song’ (perfectly timed), or ‘out’ and steaming heavily with reduced power. To complicate matters further, there will be several pistons (on 6023 there are four), each requiring synchronisation with the others, as well as individual valve/piston timings. Walschaerts valve gear (see Figure 9 below) allowed for the adjustment of the valves in relation to piston position. By rotating the wheels and hence, through the con-rod the position of the piston, valve positions can be finely adjusted so that they open and close at just the right moment, and the set of four pistons similarly synchronised.



Figure 9: Timing gear on locomotive 6023

When 6023 was first manufactured in 1930, the Swindon engine works were turning out locomotives at the rate of 100 a year, so it was something of a surprise to learn that just to set the valves in the refurbishment of 6023 had taken nearly 3 years. A set of drawings for the original valve gear was available (Figure 10, below) and used to make new parts to replace those cannibalised during 6023's unhappy 20 years in the scrapyard. Furthermore, the setting sequence had been published by the Swindon works in some detail, and was used as the basis for setting the valve timing on 6023. Men who had previously fully rebuilt other steam locomotives, many with several decades of experience in restoring, owning and running steam locomotives, carried out this work. However, when the theoretical settings were applied, there were major discrepancies between expected performance and actual. After months of work, with data emailed to an engineer in New Zealand with direct experience of Walschaerts four cylinder valve gears, the timing sequence seems to have been

pistons and valves is so high that the scope for error is tiny. There is in fact no perfect solution, just a best compromise. In effect, setting the relative positions of wheels, valves and pistons is a matter of judgement, an in situ assessment of the state of each of the variants in the overall assembly. Listening to the sound of a running engine provides as much a marker of the accuracy of the settings as direct measurements. Those measurements and settings can act as no more than a reasonably accurate starting point, but ultimately it is down to the skills of the operators, in this case learning blind, to understand the specific mechanism and successfully come to terms with its needs.

This was first described to me over a mug of tea and a slice of home-made cake, as we sat in an old carriage used for storage and tea breaks. As one of the engineers said, somewhat philosophically, “you can’t write down everything y’know”. And this I think is a lesson learnt; he is of course quite right. How do you write down the sound of an engine ‘on song’, the feeling of a tight joint, the sense that something ‘looks about right’? A design, a plan, plays a part, and a very important part at that. But documentation can never be entirely complete, it has to be supplemented by skilled engineers engaging directly with the materials to achieve a successful result.

3: DESIGN

As the engineers in the Didcot Railway Centre were well aware, producing technical objects depends on the incorporation of existing sets of knowledge into the physical environment in which they operate. Technical objects are not simply an assembly of parts, but are continually fettled according to the senses of the people making them. Engineering begins with a plan, a design, but continues along a path strewn with obstacles, each of which needs to be overcome or circumvented. What I want to consider is the extent to which a pre-conceived idea becomes the foundation for an object, or conversely, whether the object is ‘post-conceived’ and acts as a nexus of future experiences. I put forward the suggestion that to design something is to conceptualise a forthcoming practice in a way that directs experience, and is not simply a list of parts and plan of action. A design acts as a prompt for practice, providing the makers with a particular engagement with their environment, a way of plotting a course for a journey into the future, which may or may not go according to plan. In effect I begin with design as a noun – a thought, an artefact, something tangible on a piece of paper - and end with design as a verb – a way of doing, of experiencing making.

To investigate these issues, my example is the planning done for the construction of two different bridges in the Kelabit highlands by the villagers of Pa’ Dalih. In particular, a relatively modern type of bridge intended to be built with novel imported materials, and one of the first of its kind in the region. In the course of that construction, the same men also built a traditional bamboo bridge, something they had done many times before, using locally available materials and according to a more or less standard design.

Inspiration

Ganang cocked his head to one side, his one good eye peering intently at the piece of paper he had pushed in front of me. It was small, a piece of A5 from my notebook, now decorated with a rough scribble in black biro (see Figure 11.

below). This was August 2008, and the villagers of Pa' Dalih had for some time been planning to build a new bridge over the river Kelapang to replace the traditional bamboo bridge that had been washed away several years before. Jeffrey told me that the old man who had been responsible for maintaining it had died, it had fallen into disrepair, been declared unsafe and eventually collapsed. On the other side of the Kelapang, some of the villagers had fruit trees, padi fields, and forest farms. The route to Indonesia also lay in this direction; half the village had relatives in Indonesia, in fact the traditional range of the Kelabit stretched across the international border. Cheap Indonesian labour regularly came over and was used by the more affluent, or less able, to help plant out and harvest the rice. For around 200 ringgitts (about £40), you could get an acre expertly tended. Without the bridge, getting to the village meant a half hour detour and wading across the river. This presented very little problem when shallow, but in the rainy season the river became angry and unpredictable, and access became much more hazardous. So plans had been hatched to build a new bridge, but not the traditional bamboo variety, something much more substantial and permanent - the *Apir Long Da'an* (bridge by the junction of the Da'an river) as it was named.

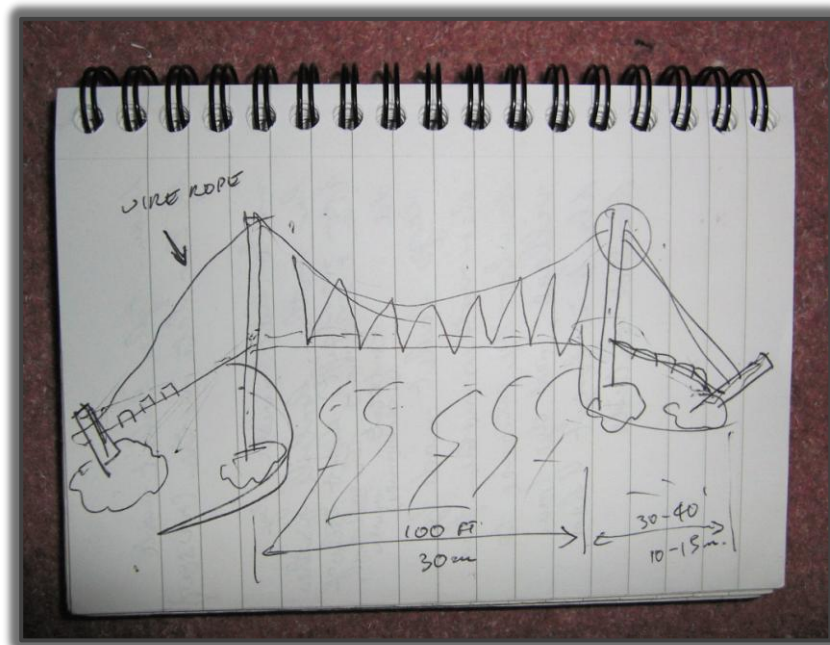


Figure 11: Ganang's plan (text and figures added by me)

Ganang had been involved with many of the larger projects in the village, and was nominally the village engineer, responsible for designing and drawing up plans. He had for example shown me a rather professional-looking plan for the proposed new house for the pastor, which he kept pinned to his wall in a clear plastic envelope. What he had pushed in front of me was his plan for the new bridge. Chief instigator for this new bridge was Jolly, son of the previous headman and occupier of the central part of the longhouse, traditionally the headman's space. Jolly worked in the oil industry, spending months at a time away from home, but earning good money, allowing him to begin to gather materials. Unusually tall and slim and with a distinctive hollow face, Jolly bore himself confidently and was someone of influence in the community. Ganang, small and wiry and eager to please, but with a steely stubbornness, complemented Jolly well. But lack of finance meant the project had stalled; the timber they needed was a non-local hardwood (*belian*) that was expensive to buy and transport up to the village. For me this provided an ideal opportunity. I was in the Kelabit highlands to look at production, and relations with the environment, and was keen to see something large and more complex being built. On my return to England after that first visit I was able to acquire funds from a charity to finance the purchase of materials,¹⁷ and with Jolly's infectious and influential enthusiasm we set the project in motion.

I had asked Ganang if I could see the plans for the bridge, and was a little surprised when he said there were none. Had they made one like this before? No, not really. How did they know what they were going to do? This was the point at which he took my pen and paper and sketched out his design. From the drawing it looked remarkably like a suspension bridge. This was unusual in the highlands, as most of the bridges were much simpler, using locally available materials where possible. There is in the nearby village of Remudu a similar suspension bridge (see Figure 12) built by a British charity in 2002, and this seems to have sparked off the interest in more substantial bridges. Trekforce, a UK based charity, organises adventure holidays and carries out voluntary work in the Kelabit region.

¹⁷ Artist's Project Earth. Project no. 118 'The Pa' Dalih Bridge Project'. www.apeuk.org accessed 02/01/11.

This bridge was brought in as a standard design, the materials procured by them and erected by the volunteers.



*Figure 12: Remudu suspension bridge built by British charity ‘Trekforce’
(compare with the Pa’ Dalih villagers’ bridge in Figures 1 above, and 60 below)*

Before this, any substantial local bridges were built to a much simpler ‘hanging’ design.¹⁸ Some time later in a visit to one of the existing hanging bridges near Pa’ Dalih, we discussed this design. I was intrigued to find out if Ganang knew the principles of a suspension bridge, or if he was simply basing his design on something he had seen and liked the look of. He had drawn inspiration from the Remudu bridge and made his own interpretation of it, the main feature of which

¹⁸ More accurately a ‘catenary’ – the shape of a hanging rope or chain supported at each end.

was the tall towers on each bank.¹⁹ The bridge came with no instructions as to its production or use, but stood as an object in the landscape. It could be used as a template, a point of reference, but this represents only a part of the design of the bridge. Other parts of the design remain hidden, for example, the number of people who could safely use the bridge at the same time – the load bearing capacity - could only be judged according to what ‘seemed safe’. On the basis that this bridge was still standing, and that its pattern of use would be similar to the bridge in Pa’ Dalih, then it seems safe to assume that the strength was at least adequate. It may of course have been hugely over-engineered, but that remained unknown. So, while it was possible to see the sizes of the wooden posts and use them as a benchmark for the Pa’ Dalih design (this bridge had 5” square posts, the size that Ganang requested, having rejected 4” posts previously bought by Jolly), it was not clear if this was a bare minimum.

As well as a lack of knowledge of the functional capacity of the bridge, there was also incomplete understanding of the process of construction. The Remudu bridge was the same height as the Pa’ Dalih bridge, with the same distance between top and bottom ropes. The wire ‘stringers’ that connect them, in places 3m overhead, need to be held taut to distribute the load. At Remudu each stringer was firmly clamped, top and bottom, whereas on our bridge, some of the stringers soon worked loose, effectively offering no distribution of load. Quite how they managed to do this at Remudu we never worked out. What was clear to the Kelabit however, was that this bridge was not designed by a Kelabit. As Anderias pointed out, the width at shoulder height was too narrow, being the same as the width of the walkway. Since the Kelabit are often carrying large baskets on their back, they need more space higher up. Most of the local hanging bridges have a narrow walkway, usually 100-150mm wide at foot level, opening out to perhaps 1m wide at shoulder height.

¹⁹ A suspension bridge works by bearing the weight of the platform on suspended load-bearing cables, strung over tall supporting towers. The platform itself is designed to bear the weight in small sections, transferred up via wire stringers to the overhead cables. A catenary, or hanging bridge, on the other hand is designed with the main supporting structure as the cables that run at the base. The upper cable is not much more than a handrail.

Other new bridges were also taking their cue from this type of bridge, the incomplete bridge at Pa' Mada was similar, although its towers were not so tall. Traditional bamboo bridges were gradually being replaced by wire rope, since they required less maintenance, a recurring theme of Kelabit engineering. The bridge at Remudu was seen as the next step in this development, it was raised higher and made of larger components and had a much more substantial appearance, it was the pride of the villagers and often referred to in conversations about development and innovation. However, as Thomas (1999) has written, new objects are not necessarily imposed on to local cultures, but become absorbed and re-interpreted, and even responsible for the creation of whole new categories. It is clear that this type of bridge represented to Anderias, Ganang and the villagers of Pa' Dalih a novelty, a challenge and a symbol of progress, and fitted with their desire to make their buildings more durable. It did not represent a better way of crossing the river, it was after all, no more durable or effective than the usual wire-rope hanging bridge, and required a good deal more effort, skill and resources.

For the villagers of Pa' Dalih, the introduction of a suspension bridge created a series of responses allowing them to build on the original form and create a novel and locally conceived object, a symbol of their skills and communal efforts. The endorsement of the suspension type of bridge, and its apparent local development at Pa' Dalih and Pa' Mada for example, is an important demonstration of Kelabit ingenuity and a desire to promote themselves as adventurous, adaptable and forward thinking.²⁰ This conversion is what de Laet and Mol call 'fluid technology' in the case of the Zimbabwe bush pump (2000). The technical object is not imposed, but introduced into existing cultural settings in a flexible way: in their example, the new pump and well would be sited with the assistance of the local water diviner. For de Laet and Mol, this is a deliberate ploy intended to encourage the use and maintenance of the water pump in rural areas for the benefit of local community health. In the case of the bridges in the Kelabit

²⁰ Historically, this attitude has come about as the result of their oppression as a minority group, eager to shed their reputation for backwardness (Amster 1999: 195; Lian-Saging and Bulan 1989: 89; Harrisson 1947: 56).

highlands, these objects were introduced for the benefit of others (the troops in the case of the original hanging bridges), or with no pretensions to demonstrate new technical possibilities (in the case of the Remudu bridge). The subsequent ‘fluidity’ and absorption has been effected by local people. The Remudu bridge, and the wire-rope hanging bridges before them, fitted in to the Kelabit traditions of innovation, keen to try out new things and make them their own. Socially, this design was readily accepted, and was seen by the villagers as an obvious symbol of engineering prowess, an orientation to the future, and proud reflection of communal effort.

Intentionality

Don Norman (2004) puts forward the view that design is a fundamental part of the outcome of an object. Indeed as he shows, modern engineering puts psychology, sociology and biology within the remit of designers. He suggests that design is more than simply a plan of production: it is possible to ‘design-in’ emotional response. In doing so, consumers will engage more completely with objects: be awestruck and reverential, or dismissive and unsentimental, for example. For Norman therefore, design is not just a way of making functional objects attractive, it is a fundamental way of conceiving objects before they are produced. Petroski (1996) also extends the remit of designers. Design does not happen in a vacuum, but is part of the wider systems of analysis, development, failure, networks, politics, society etc. But for Petroski, these things can be dealt with by the engineer. Even the cultural failure of an object happens because the engineer does not take account of the other components with which it must fit. He uses the example of airplanes needing to conform to the practices and physicality of airports and their systems of docking and unloading. ‘Good’ engineering, for Petroski, pre-empts social constructivism: users ultimately respond to the design in the way intended by the designers. Ingold, however, is fairly dismissive of the idea of a ‘designed’ object, preferring to see something ecological, growing from the mind of the maker, the influence of the materials, and the environment in which they find themselves. In the same way that the size and shape of a snail’s shell is governed by its environmental relations as much as its DNA, so too does the complexity of the relationship between maker, his materials and the context of

their coming together subvert any definitive design. His contention is that the basket weaver is guided in his movements by his instinctive and experiential responses to the materials, in the same way that the shell is formed in response to the environmental conditions around it.

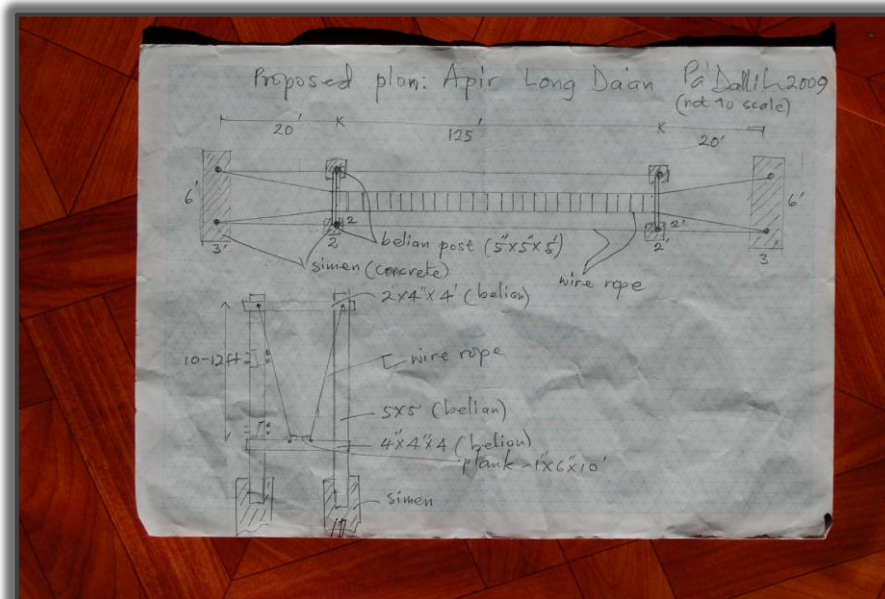
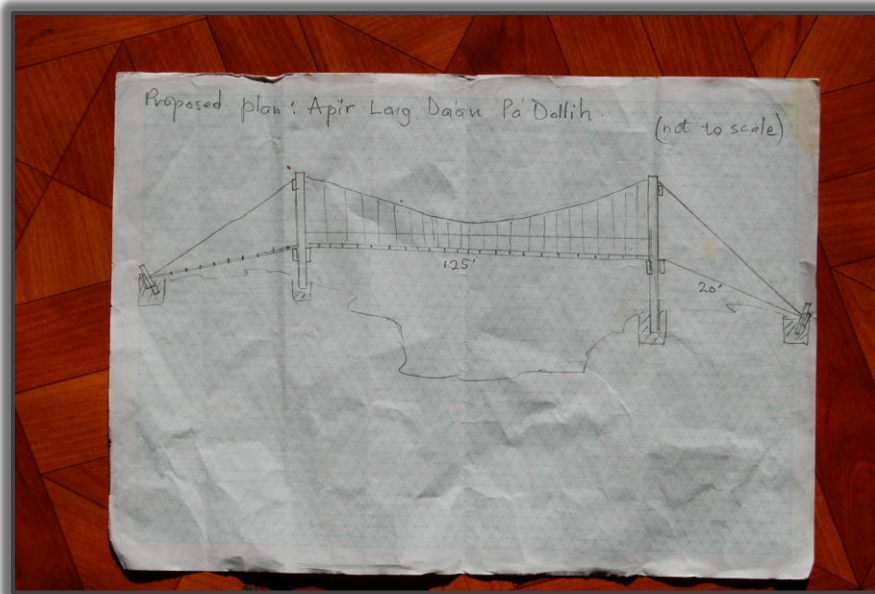
“There is, in short, no design for the spiral of the gastropod shell. Rather, the form arises through what is known technically as the ‘morphogenetic field’ – that is, the total system of relations set up by virtue of the presence of the developing organism in its environment” (2000: 344).

So, for Ingold, to give primacy to a pre-conceived idea is to ignore substantial, if not overwhelming, ecological influences and the way they affect producers and hence the production process. Intention is diluted by the restrictions of the materials and the environment, “... it is a question not of imposing forms on inert matter but of intervening in the fields of force and currents of material wherein forms are generated” (Ingold 2010: 92).

By April 2009, plans for the new suspension bridge, the *apir Long Da'an*, had advanced to the point that a more comprehensive design had been produced. Rather than sketching out an idea onto my notepad, Ganang had formalised his design by drawing it in pencil on engineering paper, rather than using pen on plain paper (Figure 13 below). The background diamond pattern seen on the paper is used as a guide for ‘isometric’ drawings, the apparently 3D shapes that engineers draw. This particular drawing is not isometric, but the regular grid on the paper acted as a way of guiding the shapes Ganang drew. Using pencil instead of pen made the drawing more easily altered, so that during the drawing process, the draughtsman is able to experiment with general shapes and proportions in the knowledge that making a mistake, or changing his mind would not leave a permanent mark. The drawing would thus be clearer and more closely represent what it was that he wanted to portray.

In a number of ways, the design is now also a result of deliberate recognition of the environment in which the bridge is intended to be sited. Ganang had made a preliminary survey of the site, and in the drawing includes several pieces of information that demonstrate his understanding that the bridge will need to be

built to accord with the circumstances on site. Most obviously, this drawing includes dimensions. The span of the bridge, is estimated at 125 feet, the distances from support towers to anchor blocks as 20 feet; some of the materials are also dimensioned, the size of the wood required for the support towers is 5 inches square and 10-12 feet high, and the foundations (“simen (concrete)”) are drawn roughly to size. The elevation (side view) also shows the bank on the left as higher than the bank on the right, something that becomes important to measure during construction.



Figures 13: Ganang's detailed plans, drawn more accurately on isometric paper

In the sense that an object does not come about purely by chance, there is bound to be some amount of determination in bringing together the rag-tag assemblage of ideas, tools, skills, components and materials to become a coherent whole. The descriptions of design by product designers such as Petroski and Norman seem to be too prescriptive, and not relevant to the type of designing that was going on here. Enough was being left out to prevent there being a complete and final design in place before production began. The Kelabit engineers, although unfamiliar with this particular object, were experienced enough to have confidence in their own abilities to resolve any difficulties that might crop up. As with Ingold's suggestion that it is impossible to specify a *complete* design, either through the DNA of the snail's shell or blueprint of the artefact, there remains a gap between what can be coded in advance and what is produced in the real world. So for Ingold, to consider a pre-conceived plan of activity as the basis for an artefactual outcome is to ignore the ecological truth of man's existence in the world at large (2000: 344).

Material properties include not only empirical devices such as strength, hardness and flexibility, but also less easily defined characteristics such as recalcitrance and surprise.²¹ Raw materials exist in a relationship with their environment, into which the maker steps and changes the potential form of some of the parts. Crucially for Ingold's argument, the environment still exists as a whole, albeit slightly different now that an intentional person has become part of the mix. That person still exists within an environmental system and remains mutually affected by it. In other words, and germane to this discussion, it is the relational environment that is responsible for the creative process, and not just the intentional person. The person is directed and formed by the act of production, as well as directing and forming the materials with which he engages.

²¹ In a classic anthropological text, Evans-Pritchard describes how one of his key Azande informants understood the same issue (1976: 20-21). Kisanga, one of the finest wood carvers in the kingdom, despite his experience and care in inspecting and choosing wood, still suffers splits and failures. He attributes this to witchcraft, which may or may not be an important factor, but demonstrates the unpredictable nature of our engagement with materials.

This is not to deny that an intentional plan exists before some action takes place, but that the degree to which that plan can be followed depends on our interaction with environmental and biological forces. However, it cannot be denied, to follow Ingold's examples, that there is a fair degree of similarity between organisms of the same DNA stock, and between a blueprint and finished artefact. The completeness of the plans, or the accuracy of the maker's interpretation of them, is less significant than the very fact that the producer does engage in a productive activity. On the other hand, industrial design, as described by Norman and Petroski, thrives on its perception of designers empathising with consumers, and being able to take into account their multitude of desires and responses. A well-designed object will allow for the users' various proclivities and inherently guide appropriate use.

These ideas are respectively argued based on examples of specific types of object. Much of Ingold's work is based on 'craftsmanship', often hand-produced objects made by skilled individuals. Industrial design such as that described by Norman and Petroski tends to focus on 'hi-tech' engineering, or mass produced commodities. Each of these objects differs from the others, and those characteristics form part of the supporting arguments. In the case of Kelabit bridges, the object overlaps and yet also misses some of these perspectives.

A Designerly Way of Doing

In his influential article *A designerly way of knowing* (1992), Nigel Cross coined the phrase and described the special way of knowing that all designers come to adopt. His suggestion is that the practice of being taught design and accumulating experiences through exposure to enough ideas created a different form of knowing, which was present to some extent in all of us. This was the necessary way that we are able to confront and solve problems through the production of suitable artefacts that satisfy our initial goals. Cross was suggesting that there are different forms of knowledge, some of which are good for designing, whilst others are more useful in other walks of life, and that by concentrating on the 'designerly' ways of knowing we are better able to design. This despite the fact that to 'design' spans a wide range of activities, with varying degrees of formality.

“The answer must surely be that there are likely to be some common features or we would never have the concept of ‘design’ in the first place” (Lawson 2004: 2).

Key academics in design research such as Cross and Lawson have come to the conclusion that to ‘design’ requires a particular mental process, which, although it can be learned, is different from other mental processes:

“It seems reasonable, therefore, to try to separate out design ability as a form of intelligence in its own right ... Design intelligence involves an intense, reflective interaction with representations of problems and solutions, and an ability to shift easily and rapidly between concrete representations and abstract thought, between doing and thinking” (Cross 2011: 136).

By emphasising the need to gain experience as a designer, to actually ‘do design’ as a key aspect of learning, there is an implicit acceptance of the importance of practice as well as abstract conceptualising. However, this seems to me to be back to front. Having accepted that a crucial part of learning to design is to engage in practices that provide a rich suite of experiences on which to draw for future inspiration, this line of thinking consistently refers back to mental and abstract design. Lawson refers variously to design protocols, events, indivisible components, episodes and so on, as the building blocks of designing, for which, among scholars of design studies, “there is now considerable consensus at a fairly general level” (2004: 17). But the design as pictured in the mind is not enough to be able to make a physical artefact, the work of designing goes on during the work of making. In Turnbull’s account of thirteenth century cathedral builders, looking at the building as a single and coherent entity makes it seem a ‘mess’ (1993: 318). This is because, he contends, that it is the result of groups of skilled craftsmen applying their own interpretations to the building ‘problem’ and continually coming up with in situ solutions. This historical case study may be dismissed as the workings of a pre-industrial culture and no longer relevant to today’s acts of designing, but in the context of rural Borneo, it is a model that holds true. To design, in other words, is about doing and not knowing or thinking, skilled

practices are responsible for the development of an object as much as the initial plans that set the process in motion.

After several days observing the goings-on at the main bridge site, I became used to the Kelabit way of working. This seemed to involve long periods during which one or two people worked whilst the others slept, chatted, tended the fire, carved bamboo or disappeared into the forest, punctuated by short periods of heavy work, when everyone helped. Often this was incredibly boring to watch, with many hours spent sitting around doing very little, until one task had been finished. Only then would the group discuss the next action required, even if it seemed fairly obvious what needed to be done.

One instance: Ganang and Anderias were busy fixing the plank flooring to the base wires, a job for which there was only space for two. Each plank had to be sawn to the same length and two holes drilled in each end, but only when they had run out of their supply of planks did someone start up the chainsaw and cut up another batch, while someone else drilled. Meanwhile Ganang and Anderias would sit and wait until they had a pile of planks ready to continue. The plank preparers would then sit down while the plank layers used up that batch, and then sit and wait before they sorted out the next batch. When boredom and frustration got the better of me, I tried to suggest what could be done while we waited, such as the planks cut and drilled all together, instead of in small batches as required, but these ideas fell on deaf ears. Some time later, talking to Robert and Ganang, I asked what they thought of my interventions. They laughed and said that if I were a Kelabit they would think me rude, but could forgive me as a Westerner. The Kelabit way of doing things was not to have someone in charge, giving orders, but to encourage input from everyone: conversations with phrases such as “it might be nice if we did this”. This went so far as to allow work to be done that the more experienced members saw as being wrong or ineffective, but were often happy to allow to go ahead. Although this seemed to create extra effort and waste time, it did allow for the possibility of new ideas, and gave the less experienced members the chance to take on some responsibility, and to learn from their mistakes. If the more experienced felt the need to intervene, this would normally be done by

wandering off quietly in pairs into the forest with a question of “do you think we might do this differently?” This was what I had interpreted as ‘men disappearing into the forest and chopping bamboo for no apparent reason’ (fieldnotes).

Designing was done ‘on the ground’ and not in accordance with a prepared template. Experiencing the difficulties in making materials fit to their proposed places was the spur for inventive thought and actions, and not the abstract images drawn on Ganang’s plans. And there were plenty of difficulties to overcome, since this was to all intents a new object, not previously experienced by the builders. Issues such as accommodating the bridge into the chosen site, the same place as the previous bamboo bridges, presented certain technical challenges. Traditional, temporary bamboo bridges (*apir bulu*) are anchored fairly close to the riverbank, ideally at a point where the river is relatively narrow and elevated above floodwater levels. Poles stretch from each side to meet in the middle where they are tied together, then rattan or wire is used to tie the base poles to overhanging trees for support. So the site used for the new *apir Long Da’an* came with some of these characteristics - there were plenty of tall trees, the bank was high above river level, and on one side there was very little flat space. For a suspension bridge, this meant that the distance between main supports and anchor point on the far side of the river was too short and created a steep angle for the wire going from the top of the tower down to the anchor point (see Figure 40 below). While the plan showed a nominally shallow angle, on the ground, the hole filled with concrete that acted as the anchor had to be placed much closer to the towers. The design as such was not a definitive plan, events that occurred during construction meant that one of those key dimensions was determined not by the ideal shape envisaged by Ganang, nor by the physics of tension in wires, but by the location and the environment. For the Kelabit, dealing with this particular environment was an everyday occurrence and so presented no particular problem. They simply moved the anchor block as far back as possible, and the tower as far forward as possible and settled on that as being an appropriate dimension.

This could of course have significant implications for a number of aspects of the bridge. The length of the main overhead wires had been calculated according to

the distance estimated from one anchor point, over the two towers and down to the anchor point on the far side, which had now changed. The foundations for the tower on that side had been moved as close as possible to the river's edge, now a distance of perhaps 2m, whereas on the near side the tower was about 5m from the edge. There happened to be an undercut where the far tower was positioned, which looked to me like a result of floodwater erosion, so the foundation was not only closer to the edge than it appeared on the surface, but also on loose ground. Jolly dismissed my fears saying that the trees were still standing and their roots would stabilise the ground, but as a precaution, extra wires were fixed from the top of the tower to nearby sturdy trees some way up the bank.

To talk of a design conjures up images of drawings, paper, perhaps computers and meetings. 'Design' as a specific set of skills and expertise, employed by a designer to undertake that initial part of the engineering project and turn ideas into the basis of reality. This suggests that there is an individual or group largely responsible for designing, distinct from a different set of people who produce, and perhaps yet another set who then use the object. In much of the literature that discusses design, there is an implicit distance between the designer and user, and little is said of the producers (e.g. Costall and Dreier 2006; Bucciarelli 2002; Henderson 1999; Suchman, 2000b; Kingery 2001).²² For the Kelabit, and I suspect for many other engineering projects, it is clear that the act of production is responsive and not prescribed, dependent on conditions and subject to change. Cross's 'designerly way of knowing' is more accurately a designerly way of doing.

Craftsmanship and Engineering

Kelabit bridges are designed to account for the use of craftsmanship and individual skills in their construction, essentially leaving some of the details to be dealt with 'on-the-ground'. They are also however, large and complex objects, requiring pre-production planning and group co-ordination, reflected in the design process carried out by knowledgeable and influential individuals.

²² For descriptions of production, see for example Keller 2001 or Lemonnier 1992. Their discussions still imply a separation between the three activities of design, production and use, focusing on these activities as processes rather than the people responsible.

Jolly and I sat at his kitchen table with Ganang and Anderias to discuss the progress of the bridge project at my request. I wanted to make sure that the money I had raised was going to be enough to finish the bridge, since this would be valuable data for my thesis and I wanted to see it through. I had been warned by experienced fieldworkers that this type of project was often boastfully promised but rarely fulfilled. Inside the longhouse it was hot and sultry; most people had retired for an afternoon nap, or sat in murmured conversation around their fire, stirring pots of steaming rice. The Kelabit are cautious consumers of alcohol, fearing a contradiction with their strict Christian ethics, but on this occasion Jolly brought out a bottle of Bacardi, which we sipped, mixed with orange squash. Ganang produced his final plan, casually placing it on the table while modestly over-emphasising, in a very Kelabit way, what he saw as its many failings. Publicly claiming any sort of virtuosity is seen as impolite in Kelabit society, even if the same person is prepared to state such claims with gusto in private. Individuals with particular skills tend to be recognised by other members of the community without being publicly lauded for them, something that becomes clear in the course of community projects, where they would willingly accept responsibility for particular tasks.

The drawing was not instructional in anything more than a cursory way (see Figure 13 above). It was a shape on a piece of paper, a pattern, an outline, an approximation; the details of construction, and any hints of the tools or techniques to be used were absent. The bridge would span 125 feet and rise about 15 feet in the air. The supporting towers would be cemented in, as would the anchor points. The shape of the hanging upper wire was drawn and the lower platform would be pulled flat, supported by about 25 stringers on each side and lined with wire netting. The arrangement of the towers and the joints required were sketched in, and a difference in elevation on each bank noted.

The significant gaps in the design as it stood depended on the group's ability to cope with the materials they gathered together to assemble into the general shape of the picture, and relied on their ingenuity to come up with solutions to the

various detailed problems as they occurred. This was a new type of structure, and although in some ways similar to other bridges or houses they had built, was bound to throw up surprises. This was of no concern and there was no particular discussion to work out the ways that different parts needed to be tackled. This project was different to others I had seen, not least because of the number and variety of components. Many of the individual components were relatively new, and relied on transferring experiences from different situations and applying them to this rather novel project. Jolly had worked in the oil industry for several years, Robert and Ganang had worked on building sites in different parts of the highlands, Anderias was adept at most forms of mechanical engineering, and Kelabit men generally were impressively skilled at improvising solutions, especially out in the forest.

Partly out of personal concerns, and partly curious, I asked several questions about the plan, and what seemed to me to be, literally, its rather sketchy nature. How did they know what ‘turnbuckles’ they needed (a device for tensioning rope)? They thought four should be enough (these were later replaced with larger ones). How would they fix the stringers to the upper cable, bearing in mind this would in some places be 4m overhead? They would use small ‘bullclamps’ (a clamp and U shaped bolt with two nuts), but were not sure how they would get up on to the wire to fix them. What kind of wire would be strong enough for the stringers? How would the top wires pass through the towers without too much friction? How would the walkway spacers fit on to the base wires? What components would need maintenance in the future?... Most of these questions were obviously not things they had thought about, since the responses were either vague, or sparked discussion. But this was a reflection of the differences between our ways of thinking more than a critique of their method. My experience as an engineer included planning as a substantial part of the activities I carried out. As Bourdieu explained (see above, p.9), my position as an engineer looking at other engineers served to highlight the differences as much as to cement a common sense of purpose “the distance lies perhaps not so much where it is usually looked for, in the gap between cultural traditions, as in the gulf between two relations to the world, one theoretical, the other practical” (1990b: 14). So the plan was laid.

Materials and components had been identified, and the basic design agreed. From it Jolly drew up a shopping list: nuts and bolts, wood, wire mesh, paint, cement, wire rope, and more besides. We agreed the costings and I was pleased to see that this left enough money for a pig for the celebratory feast.

What this design had done was to limit the range of possibilities for the bridge. It had not given a definitive view on how the bridge should be constructed, beyond the general principle that it should look like a suspension bridge. In doing so, it had begun to guide the builders along a particular path, requiring their attention to certain items and alerting them to potential difficulties. Bringing in materials from Miri was expensive and needed to be organised; construction would take some time, as it would be organised through the communal labour system of *kerja sama*; particular skills and tools would be needed, as would the support of the community. As village-life is organised around the needs of rice agriculture, taking time away from those duties could only be done occasionally, and so the bridge building project would need to claim its allocation of periodic labour over several months. As for the design, carefully drawn by Ganang in pencil on isometric paper, dimensioned up and annotated, on Day One this was put under the tin roof of our temporary on-site shelter. Once work started, the plan remained there and went largely unnoticed. On Day Two, I asked Ganang where the plan was: he didn't know. Eventually I found it, crumpled, dirty and ignored, obviously of no interest to the group. The design had acted as a guide, but no more - a shove in the right direction to get them started.

It would not be unreasonable to call the Kelabit bridge-engineers craftsmen or artisans. Craft production is indeed heavily concerned with a physical manipulation of natural materials with a sensitivity for their inherent differences and inconsistency. No two pieces of wood have the same grain pattern, but for craftsmanship, recognising this is an important consideration in the choice and use of a piece of wood, in hand-made furniture for instance (Marchand 2010a). The degree of choice in the final form of the artefact is quite significantly affected by the craftsman's interpretation of the materials. In this case, Ingold's notions of environmental relations are especially pertinent, since the course of construction

is heavily influenced by the abilities of the Kelabit to use their immediate surroundings as a resource for tools and materials. The design was of little use to the people actually doing the work, it was not a strict and complete representation of the finished object, but more an approximation to guide a group of people in the same direction.

Engineering in the Kelabit highlands requires an appreciation for material variation, honed through extensive use, since the majority of their materials of construction are not industrially produced. Wood is the most commonly used engineering material and is inherently variable, both by species and by batch. In designing bridges or houses this variation cannot be completely accounted for, and thus requires them to assume some skilful effort in coping with potential difficulties as part of the design. Industrial engineering as a form of production depends on consistency and lack of variation especially in the raw materials. Industrial and automated engineering is affected particularly badly by surprise. Ideally then, metals are standardised, wood is finished to regular sizes, fixings are tightly toleranced, techniques are established through testing and experience: as far as possible uncertainty is reduced. An engineering project runs smoothly when it is predictable. Without that tightly controlled, mechanically restricted set of materials, tools and techniques, Kelabit engineering has to adopt some of the practices of craftsmanship.

So the combination of an emphasis on predictability, a communal objective, and the substantial motivation and inertia of many people, produces a very different set of relations with the environment than that of the individual craftsman dealing personally and directly with his materials. However, what Ingold's ecologically-framed relational thinking can contribute is the notion of mutual influence of materials and environment on an engineered artefact; that the conceptual design is never going to be complete; and that the remainder, the 'gaps' (although I suspect this is not a term Ingold would use) are simply a demonstration of the dynamics of being alive. This needs to be tempered by accepting that groups of people undertaking a large-scale production project do so with an objective in mind. There is a conscious effort to manipulate materials into desired forms, overcoming

some of the difficulties posed by the word at large, according to a predetermined plan. In the case of the design for the new Kelabit bridge, a detailed plan was unnecessary since this is a group of people who are communally, and on a daily basis, craftsmen, reliant on their personal skills. However, a relatively novel and communal project such as this requires some semblance of order and pre-conception to prevent it from turning into a chaotic jumble.

Designers, Users and Producers

Questions concerning 'design' have tended to revolve around the relationship between designer and user. For the designer, the degree to which his intent is reflected in the object and limits its use; for the user, the mechanisms required to appropriate an object and bring it into being as a cultural artefact. Industrial designers (e.g. Norman 2004; Petroski 1996) adopt the view that the designer is the arbiter of his object's use. Users are guided towards the proper functions of an object through cues embedded in the design that make their way into the final object. Preston (2006) dilutes this position with a more subtle argument, suggesting that a designer's intention does not necessarily equal function, but that there is a difference between 'proper' use and 'improper' or creative use. If creative use is another form of design, then normal or proper use is implicitly uninspired, which she suggests is an arbitrary distinction and unnecessarily privileges the designer (2006: 24) at the expense of subversive users. Therefore we should consider all use as of equal stature to design, and oppose the intentionalist accounts of object function. But for Preston, all uses are derived 'proper' functions and therefore fall, even unintentionally, within the design, as an aspect of the object's materiality. In other words, most designed objects are intentionally and actually used to achieve a specific function most of the time, and those that are not are still behaviourally coerced by the design.

These concepts of design have been critiqued in consumption studies for ignoring the role of the 'active consumer' (Miller 1987; Costall and Dreier 2006). In this argument, an object can only be conceived by the designer according to a limited set of circumstances: those in which the designer places himself. There is inherently a limited degree to which the object can be designed for universal use.

Since the potential range of individual circumstances is almost limitless, it follows that there is a correspondingly large range of potential uses to which the object may be put. In fact the finished object is only the starting point, since by extending those who come into contact with the object and have authority to impose their influence, the range of potential interpretations is also extended. Crucially however, the place of the producer in these accounts is largely ignored. From the first perspective, the designer is elevated to a position of influence over the user, having created an object that governs their behaviour – the producer is seen as an automaton, able to faithfully carry out the designer's plan. From the second perspective, the object is presented to the users as an artefact from which their cultural appropriation can originate – the act of production is subsumed into the on-going life of the object, removed as a specific activity. But for any object to come into use, it must have gone through a production process of some sort. A designed object, in whatever form we think of it, remains a figment of reality until a skilled individual goes about creating it. The relationship between designer and user is mediated by the object and that object cannot exist until it has been made. To reinstate the act of production as a central tenet of an object, and to seriously consider the ramifications for this on the producers themselves, requires us to reconsider the relationship between design and production, prior to the object being used.

Commodity design literature emphasises how a designer can successfully take into account the potential use of an object and make it more widely accepted through cleverly empathetic design (Norman 2004; Petroski 1996), affording primacy to the design of the object over its use. These approaches are suited to industrial production and consumption patterns, but may not be so useful when considering circumstances where the designer, the producer and the user are much closer, and in fact may actually be the same. Consumption studies have adopted a more sympathetic view of other cultures (e.g. Miller 1987), successfully conflating the roles of user and designer, but still saying little about the participation of the producers in the cultural and physical formation of an object.

In the case of the Kelabit bridge builders, their concept of design comes about through familiarity and the *in situ* translation of the familiar into new circumstances. The designers, producers and users are essentially the same people, continually accumulating experiences that will contribute to the production and understanding of the objects they make. When a design has been practised and completed successfully a number of times, with variations that test and tweak the basic ideas, the form of the final object becomes a part of the everyday life of the producers. Repeated reproduction of a similar object acts to reinforce the validity of that design. Embodied experiences allow them to undertake work on the basis that they are familiar with the general concept and have within themselves the skills to cope with events happening on the ground during construction. The design of the bridge happens not only as a previously conceived idea, but also comes about through the interactions of the builders with their environment. Design and construction cannot be separated out as distinct phases of the performance of bridge building, since the very act of construction gradually brings to life the representation of the object, and the new perspectives that come with it.

Familiarity

Design then, reduces the infinite potential of the world to a manageable amount of possibilities, preventing the performance of production from spiralling out of control in a whirlwind of ideas and conceptualisations. The design stands as the appropriate end point, the sequence of events and a guide for required inputs; it provides a path along which the participants must travel, and restricts deviation. As the object becomes more familiar through its repeated production, the significance of the design fades and the importance of the producers' experiences and abilities takes precedence. Though the physical appearance of the object may vary, the concept of the object remains the same. Kelabit bamboo bridges are a good example of this, though each looks different, their basic principles and mode of construction is the same, and to the men who make them, they are seen as essentially the same.

The new bridge (*apir long Da'an*) as its name suggests, crossed the Kelapang river at a point near the junction (*long*) with a tributary, the Da'an, which meant that for the route to the fields and on towards Indonesia, this smaller river also needed to be crossed (see map, Figure 3 above). I had tried for some time to persuade the villagers to show me how they built a traditional bamboo bridge, and this provided the opportunity I was looking for. What I had seen as their reluctance, it occurred to me later was more like indifference: to construct a bamboo bridge was something of a repetitive chore, and of no great interest. In the course of daily life, building bridges was commonplace, and using bamboo was a well-established way of spanning medium to large streams. The use of bamboo and rattan meant that the structure only lasted for a year or two, and during that time would need to be maintained every few months. When visiting the bridge described below eight months later, most of the rattan bindings had been replaced with wire, having given way after a few months. This need for constant maintenance was something that the Kelabit wanted to avoid, a shift in philosophy from convenient and free local materials, to durable and imported materials. Within the Kelabit community, there were many who said they knew how to build bamboo bridges, so I describe below one such instance.

I had seen several bamboo bridges, but their design was confusing since maintenance was carried out ad hoc, and the result depended on what materials were easily available and the current state of repair of a particular bridge. Extra bamboo poles are attached where required, some are pushed into the bank from underneath, some fixed to any convenient tree. Extra wire or rattan lashes the whole thing together or trails up into the branches overhead, suspending you by a series of threads. The impression you get is of a mass of randomly fixed bamboo poles, bits of wood, wire, string and rattan, coming together in a haphazard and unplanned way. Crossing one of these contraptions on the verge of collapse is a nerve-racking business, treading carefully on the brown and brittle bamboo as it cracks underfoot. Anderias had reluctantly agreed to draw me a plan, but this had only served to confuse me, as much as my request seemed to confuse him. Instead, he described the design to me by resting his elbows on the table and interlocking his hands. Each forearm represented a set of bamboo poles, they were

bound together at the fingers-end with rattan, then a handrail attached and the whole thing tied for support to overhanging trees with rattan. Plans were unnecessary he had declared dismissively, these things are easy, why do we need to draw it when we can just make it!?

Some time later, when visiting the neighbouring village of Pa' Mada, I asked Maran Balang, the headman, how he would make a bamboo bridge. His drew exactly what Anderias had described: pairs of bamboo poles anchored into the ground on each side, arcing gently up, and bound together with rattan in the middle. Poles and handrails are then supported with rattan ties to overhead trees (Figure 14 below). The construction is designed to use the flexibility of bamboo by bending in the centre as you walk across. This is obviously a well-established design and one that is common to the wider Kelabit highlands.



Figure 14: Typical Kelabit bamboo bridge (this one near Pa' Mada)

The Da'an stream was currently crossed by scrambling over a pile of flood-deposited logs, and it was agreed that they would build a relatively small bamboo bridge there. The span was about 10m, so nowhere near as much as the 40m of the new bridge across the Kelapang just upstream, and seen as a relatively simple task. A notably skilled forest-man, Isi Berawan (Robert's father), along with Robert, Ganang, and Lian a young bull of a man set off one morning to do the job, with me tagging along. The previous day Jolly, Isi and I had gone about half an

hour from the village where the rattan grew particularly long and collected several lengths, which were coiled up and carried with us. The other main material, bamboo, is widespread, growing in prolific stands and in fact right next to the site of our bridge over the Da'an stream. Some of these are truly impressive, rising up 20 or 30 metres, creaking and groaning as they sway in the wind. Bamboo is not deliberately planted, but poles are carefully chosen so as to leave some stems standing, ready for future use. Despite the ready availability of materials, having seen the confusing mass of poles that seemed to make up the bamboo bridges of any size I had seen, this still seemed to be a fairly major job. And so we set off, a home made cigarette hanging from the corner of Isi's mouth, Robert poling his canoe upriver to meet us, Ganang loping along at his own steady pace, and Lian crashing off into the forest without a word.

The work at the new bridge had dragged on for several weeks, so at the site of the bamboo bridge I was prepared for a long haul with plenty of rice and water in my backpack. But no sooner had we reached the site than everyone seemed to spring into action at once. Isi chopped down several of the huge bamboos, pushing them into the river where Robert collected them, and along with Ganang hauled them up on to the bank. As they did this, Isi fixed one bamboo horizontally across two trees on the far bank, at the same height as ground-level on my side. They slung three poles between this one and the ground on my side, and began lashing them beautifully together to form a walkway (see Figure 15 below).



Figure 15: Rattan lashings on the bamboo bridge over the Da'an stream

Meanwhile Lian reappeared noisily, carrying what looked like several enormous trees on one shoulder, trimmed the ends to stakepoints with his parang, and hammered them into the ground. (I found out later that these were a particular species of tree, known to root readily when ‘planted’ like this). Before I knew it, a handrail was fitted, an exit ramp constructed and Isi was clambering about high in the trees, fixing rattan ropes to support the centre. After three hours, including a break for lunch, the bridge was complete and Isi’s attentions were taken up with his next cigarette.

The contrast between the two projects was immediately obvious. On the one hand, the newer suspension bridge had been progressing slowly, almost painfully, beginning with that rough sketch drawn by Ganang. On the other, the traditional bamboo bridge (*apir bulu*) was thrown up without fuss, and with very little discussion, each person knowing what needed to be done and apparently able to turn their hand to it. The traditional bridge lacked the uncertainties of the new, the design was well known and shared among experienced makers. With the exception of the use of electrical wire instead of rattan in some places, and apparently more for maintenance than construction, the design itself is constant, despite some apparent differences between bridges. These differences are a function of the specifics of the location, while the essential environmental relations between bamboo, rattan and Kelabit bridge-builders remain constant. Bamboo and rattan last for a year or two and then need replacing. Even before then they may be washed away in the regular floods that inundate the highland river system during the rainy season, knocking down trees, carrying them downstream and regularly destroying light and low bridges. So the cycle of construction and reconstruction is a result of these ecological relations: Kelabit skills with bamboo and rattan, their knowledge of the specific sites where bridges are built, and the on-going seasonal rains. Although in the last few years there has been an apparent change in the severity of flooding episodes and patterns of rainfall, the concept of a bamboo bridge has remained stable in the minds of the bridge-builders. The transition from conceptual design to embodied familiarity creates a normal template expressed through repetition: This is how to build a bamboo bridge, we know about bamboo and rattan, where they grow and how to

manipulate and combine them to form this object. The design becomes a part of everyday relations with the environment.

Conclusion: A Continual Journey

The new suspension bridge is not yet familiar, but remains speculative, the object of experimentation. Its new materials are part of the larger environment that the Kelabit find themselves in. Connected to a wider world with access to turnbuckles and belian, wire rope and cement, these materials need to be manipulated to suit the forest environment. And quite how to manipulate them is part of the on-going process of engaging with the environment. The lack of knowledge and the uncertainties inherent in assembling all these things for the first time to form a bridge, direct the experiences of the builders down a new path. People had mixed cement, they had joined posts, they had even built bridges, but not in the same way as this one. Inventive people like the Kelabit, schooled in the art of improvisation, can take this in their stride, include it in their on-going accumulation of experience. They work out how to attach stringers to load bearing wire, how to squeeze anchor blocks into the forest, what size wood is needed, how to adapt house-building skills and so on. The core design is beginning to solidify, but the edges are experimental, still fuzzy and soft. The variety of potential components has massively increased over the last 5 years with the expansion of the accessible Kelabit environment to now include Miri and its Chinese hardware stores. Plans can be made, but ultimately production depends on personal engagement with this wider environment to create new sets of relations that culminate in objects like the bridge. As Lucy Suchman puts it:

“...planned purposeful actions are inevitably *situated actions*. By situated actions I simply mean actions taken in the context of particular, concrete circumstances ... because the circumstances of our actions are never fully anticipated and continuously changing around us.” (2007: 26 [1987] emphasis in original)

The design of the bamboo bridge is known through the builders’ previous experiences of it, and thus exists in a different form. Their knowledge of such a familiar object renders redundant the idea of reconceptualising each time it is

required. But there still remains a notion of pre-planning in the performance of its construction, albeit one that comes through a non-discursive and plurally embodied set of actions. Re-producing a familiar object reinforces the relations with materials and skills that have become part of the repertoire of normal life. Hence the planning phase of building a traditional bridge cannot be seen as a discrete activity, distinct and separate from the performance of its construction, or the on-going development of the builders' relations with the environment.

There is a difference between a familiar design such as the bamboo bridge, and a novelty such as the suspension bridge. To all or many of the participants, the former will not represent a challenge to their bank of knowledge, their assemblage of tools, nor to their skills and abilities. Repeated acting out of the design fixes the sets of relations between the builders and the environment that they use in its construction. Conversely, where uncertainty appears, it requires the builders to draw on their past experiences, to loop back into a place where they can draw on an existing body of knowledge, along with their neighbours and co-workers, and create a new set of relations. This is not so much gaps in knowledge as a continual process of life, emerging anew from each engagement with the environment.

Designers, in the Western sense, authorise and disseminate the concept of an object, providing producers with directions to enable them to make something. But as we have seen in the examples of the engineers at the Didcot Railway Centre, and the bridge builders of the Kelabit Highlands, the design is just the starting point. A design provides the impetus for further activity, a holistic experience for the individuals involved. Presented with a design, people begin to act according to their experiences and skills to try to bring forth the artefact represented to them. But a design does not provide an entire set of instructions needed to bring the object into existence; for the producers it acts as a catalyst for action. It requires of them that they engage with their own surroundings, bringing to bear collective knowledge, skills, techniques, tools and materials in the performance of production. It alerts them to new possibilities, and challenges them to innovate; it recreates and reinforces past relations, and suggests the route to the next leg of a continual journey.

DIVERSION: The Engineering Environment

By 1982, Great Western Railway locomotive no. 6023 'King Edward II' was languishing in the Woodham brothers scrap yard in Barry, South Wales, painted with the words "We can't save this one". When de-commissioned in June 1962, the concept of railway heritage was unheard of, and only a few enthusiasts harboured the idea that it might be worth saving some of these bastions of British engineering. Diesel power ruled the rails and steam power was consigned to the scrap heap. 6023 had survived relatively intact purely by chance, having been kept for use as a dead weight in bridge testing, along with her sister engine, no. 6024 'King Edward I'. For most, the future was bleak. Discarded locomotives were either used as a source of spare parts, or destined to be cut up and sold as scrap metal. Replacing the steam engines were a new breed of diesel powered locomotives, producing more power for the same weight, and most importantly doing away with some of the complexities of running steam. To raise a steam engine up to operating temperature requires several hours of heating from a constantly maintained coal fire, started in the early hours. When running, the steam locomotive required two skilled operators, a driver and a fireman, instead of just one driver for the diesel. Very quickly then, during the 1970s, the number of skilled steam locomotive operators dropped, as steam power became redundant.

The move to diesel had a profound effect on the engineering environment that surrounded the culture of steam power. As well as a change in the skills and numbers of operators, it required a change in the engineering skills that went to support the engines. At its peak in the 1920s and 30s at the time when 6023 was built, the main GWR engineering works at Swindon employed 14,000 people, organised around a principle of manufacturing everything in-house (Whitehouse and St. John Thomas 2002). By the time of its closure in the 1980s the workforce had dwindled to around 3,000, and the engineering infrastructure had for some time been based on external specialist supply. The differences in technology between steam and diesel meant that the skills used in the design, production and

maintenance of steam locomotives were adapted or lost in the switch to diesel. An example is the previously described skill in tuning the valve and piston timing, which was essential to the smooth and efficient running of the steam engine, but not required in the electrical system used on diesel engines. Some of the principal parts remained the same, suspension systems for example, but the shift was so fundamental that existing steam-based engineering skills were left only in the hands and minds of the last generation of steam engineers. Combined with the dissipation of skills and experience to numerous smaller engineering firms around the country, reducing Swindon to a site of assembly rather than manufacturing, the steam engineering environment became fragmented and substantially different.

Small scale engineering firms are generally set up to be flexible enough to produce a range of parts, and so many of the smaller parts could be readily sourced. In fact some, such as brass fittings and copper pipe, are now used in industry and the home much more than they were 80 years ago and are easily found. Other parts have become the victims of changing cultural attitudes to materials technology. Asbestos, for example, is a superb insulator and easy to manipulate into shape, but has been universally banned from industrial use in the UK as a health risk. Restorers of steam engines bemoan its demise, as the more acceptable modern replacements for seals do not last as long and constantly leak. In the Netherlands, where the blanket ban on asbestos has not been put in place, there are specialist manufacturers of asbestos seals for steam applications, which are highly sought after by steam engine restorers. Even in the knowledge that they are illegal in the UK, the engineers I worked with scoffed at this as ridiculous, saying more railwaymen are hurt by non-asbestos seals leaking or failing than ever were by asbestos. Some other parts would have been much less frequently built, and during their lifetime refurbished more than renewed, especially the larger parts, such as the boiler, and as was particularly significant for the restoration of 6023, the wheels.

Wheels were made to be refurbished (each has a replaceable steel tyre fitted to the main casting of hub, spokes and rim), and so were not made in large quantities, and required specialist machinery to produce. One of the significant changes in the engineering of locomotives in the switch from steam to diesel was that the wheels became much smaller. The main driving wheels on 6023 are 78" (1.98m) in diameter, whereas a typical diesel engine has wheels of around 45" (1.14m) in diameter. The machinery required to handle the larger wheels was available in the main Swindon works, but as the manufacturing process was sub-contracted at the same time that such large wheels were no longer required, the smaller engineering firms had no need for such machinery. Consequently, the tools and techniques required to produce large wheels was lost.



Figure 16: 'King Edward II' at the Woodham bros. scrapyard. Note the cut-away rear wheel, with discarded segment in the foreground (courtesy of Lionel Smith)

Whilst being moved around the scrap yard, 6023 came off the rails, and instead of lifting it back on again, the rear driving wheels were cut off. It was believed that making replacements was impossible, and the unknown practicalities and cost of doing so prevented any restoration work beginning. Each wheel is enormous, and

the main hub, spokes and rim are all cast into a single piece of steel, something not done since 1960, so finding a possible manufacturer presented a number of problems. The first was, as the project supervisor put it, “finding bad enough metal”. Alloying metals is now a precisely controlled science, catering for a diverse range of requirements, unlike the 1920s when this work was originally done. No modern steel alloy matched the metal of the existing wheels, making it difficult to produce a set that looked and performed the same as the surviving wheels. To minimize variation, the ‘worst’ available metal was used. Next, the shape of the wheel, with a large mass in the centre (the hub), relatively long slender spokes, and a thin outer rim, made contraction-cooling difficult to control (as cast metal cools it contracts – shrinks slightly. If one section cools much more quickly than the adjoining section, the contraction rates vary too much and the metal cracks). The large central mass takes longer to cool than the slender spokes, so the spokes have to be insulated and the centre cooled, to make the whole wheel contract at the same rate. Not knowing what allowance to make resulted in several failed attempts, and some guesswork on the part of the pattern maker (patterns – the mould for the molten metal - have to be made slightly oversize to allow for the shrinkage that occurs as metal cools).



Figure 17: The pattern for the new wheel casting, displayed on the workshop wall

Even having successfully cast a wheel, the problems still continue. As the wheel is much larger than modern rail wheels, the equipment needed to machine the rim was too small, so a machine had to be found in a different industry, and not one used for machining rail wheels. When made originally, all of these skills, knowledge and machinery would have been under one roof in the main workshops in Swindon. But now, each of these problems had to be overcome by finding a supplier who was willing to try to adapt their current processes, skills and machinery to a new task. Eventually this was completed in 1995, and getting 6023 back on the rails had moved a big step closer.

The restoration project environment is made up of different things to the environment in the sense of the world outside. The description above makes no mention of mountains, trees or rivers, or even of the urban environment. But there is still a set of environmental relations built up around the interaction of people with the world around them. In this case, it is an engineering environment, made up of the workshops, machinery and materials with which the engineers engage. And like the ecological environment, it too is subject to continual change. Systems of social organization affect the engineering landscape as much as they affect the environmental landscapes of animals, plants, buildings and weather. Resources are replaced and superseded, skills adapt to the needs of living in that particular world, non-human actions alter the parts and materials that make up the environment, and cultural imperatives alter the perception of the world around us. For the engineers at Didcot, building up relations with their environment meant coping with issues such as health and safety regulations, material properties, working with new tools and techniques, as well as the effects of the world on their environment, primarily in the form of rusting metal. This environment coexists as part of the ecological environment, and as with the wider world, the participants within it see only a fraction of its true extent. For the engineers, this includes the various machine shops and materials suppliers around the country that most of us would not experience, any more than we would a mountain breeze or tropical sunrise. The environment in other words is created according to the experiences of the people who inhabit it, and whose lives form part of the fluctuations that continually alter its extent.

4: MATERIALS

As described in the previous chapter, the starting point for an act of construction comes in the form of a concept, however loosely formed, of what it is that will be made. The key to the debate about how significant this concept is, revolved around the way in which makers engage with their materials. Whether they are guided by their materials, or enforce their pre-conceived ideas onto them. The conclusion I reached was that the distinction between these two approaches is too severe, and in fact a maker begins with a plan in mind and subtly alters it according to the circumstances that influence him. In this chapter I explore this in more detail, with an emphasis on the primary influence acting on the maker and his materials, namely the environment in which they are both immersed.

Environmental Imperatives

Certain materials promote within us the sense of a return to nature: wood and stone, so-called ‘natural materials’. These are deliberately used in production to generate an emotional attachment to the natural world, almost as an escape from the less-natural world of the industrial artefact: a division between ‘natural-nature and unnatural-nature’ (Ingold 2000: 41-42); an example of Latour’s ‘purification’, a futile attempt to separate out the social from the natural worlds (1993: 11). Whether the processed and industrial environment is more or less natural than the natural and raw environment is a matter of degree. After all everything was once a raw material, and everything is processed in the act of production. However, the relationship between our environment and ourselves is mediated by the materials that populate it. Some of these materials are still in their natural state and others have gone through the mill and come out in an altered form, providing us with different properties to experience. Our choice of materials in the act of production depends on our experience of the environment that we, and they, inhabit (Vayda and McCay 1975). In short, what I want to argue is that materials of production are part of the experience of the environment, and conversely, the environment

from which materials are chosen is an ever-changing mixture of physical and political limits (Rambo 1983).

To illustrate the theme of this chapter, I turn from bridges to houses in my Kelabit ethnography. In keeping with my original thesis, houses are large and relatively complex objects, and require cooperative labour. Their complexity is primarily in their size: houses are not inherently complicated or difficult to understand, but they require many parts, some quite large, which need to be assembled correctly to create the bulk of the structure. For the Kelabit, house building is held in high regard as a marker of greater personal responsibility; a young man would take great pride in the fact he had built his own house. In the village of Pa' Dalih, house building seems to be almost continual, and quite diverse (see Figure 18 below). History may prove otherwise, but one senses an era of accelerated change in house culture in the Kelabit highlands, with an on-going transition from the traditional communal longhouse to a variety of more individual buildings. Even now, if you visit the 'Cultural Village' near the regional capital of Kuching, you can indeed see a series of Bornean longhouses, traditionally constructed according to ethnic variations, and accompanied by dancing and gentle explanations. But things have changed, houses have changed and continue to do so, not only in their general layout, but also in the materials used to construct them. This process of change seems to me to be intimately tied to Kelabit relations with their environment, and the effects of greater access to resources and ideas from the industrialized world. My investigation of the Kelabit resource environment therefore considers these changes through the lens of house building, and how traditional materials and techniques have become superseded through the expansion of that environment.



Figure 18: A housebuilding project in Pa' Dalih 2009

Regional and cultural architectural variety demonstrates there are countless ways to construct a dwelling (Glassie 2000). Similarly, the choice of materials is equally immense, especially in the context of a world where global access is seen as the norm. However, for a house to act as a dwelling it needs to satisfy certain basic requirements, which in turn reduces potential choices. A house is a large load bearing structure, needed to provide protection from the elements. In general, this means heavy-duty materials used to make some sort of support, and a complementary skin capable of providing the protection the occupants see as necessary. The support system must cope with the strictures of life in all its variety, from heavy crowds to high winds, and yet remain suitable for the performance of social life in its internal space. The external skin acts as a permeable membrane, adjustable to provide a range of relationships between the environment within the building and that without. The choice of materials must account for some essential human needs: temperature, water-resistance, a place to sleep, proximity or remoteness of the animal world (human and non-human), preparation and storage of food etc. In addition, they must cope with the variety of

cultural needs – cleanliness, social separation, prestige, storage and display, hospitality and so on. And yet a house when built is not finished, it has not achieved a final state; it is at the start of a journey of deterioration and change. As the various inhabitants (people, animals and insects) make themselves at home, the building itself changes. It transforms from the solid structure that was put together, and becomes fragile and demanding. So the materials of its construction need to be able to withstand the occasional loads, and to do so over an extended period of time.

As Lemonnier (1992, 1993) has argued, technological choices are determined as much by cultural tradition as they are by physical attributes. Whilst the material nature of the world presents itself as the source of numerous technical possibilities, the choices people make are generally restricted. Problems are defined in terms of diverse social logics, resulting in culturally specific technical solutions. The same can be applied to the choice of materials for technical production: materials are not chosen on the basis of their material properties, removed from their place in social tradition, but depend on pre-existing ideas and customs. In particular, materials come from an environment, and it is from that environment that possibilities emerge – the relative availability of wood or stone would for example play a part in the cultural traditions of house building. And yet given the same ecological circumstances, different cultures choose to deal with the same problems differently, what Lemonnier refers to as ‘arbitrary choices’ (1993). He is therefore equally critical of the ecological approach (that technical choices depend on what the producer has locally available), as he is of the economic approach, (that choices are made as a logical balance between effort and rewards). Choices are made as a result of a combination of these things, mixed in with the whimsies of the social and historical background of the people doing the choosing. Materials of production are chosen for their properties, from their environment, and within their social context.

In the industrialised world, new types of materials are used to signify innovation, development, and modernity, while traditional materials are used to project values

of continuity, heritage, authenticity and so on. Cultural choice plays a significant part in narrowing down potential materials to a list that excludes many, for reasons other than the suitability of their mechanical properties. That is not to say that cultural values over-rule physical constraints. However what is the closest match to the requirements in physical properties may well be overlooked in favour of a less suitable material (see Rival 1996), cultural pressures have changed our perception of certain materials. The use of lead for example has diminished, not because it makes paint and petrol technically worse - it does the opposite - but because of the potential health hazard. As the engineers at Didcot pointed out, we have yet to find an insulating material as effective as asbestos.

Choice of materials depends on a number of factors, most obviously physical constraints, especially mechanical properties, but the vast range of potential choices created and developed through industrialized processing means this still leaves the field of choice wide open. Metal alloys, complex plastics, ceramics, processed natural materials, glass, raw materials from any and every part of the world; processing power that is becoming more widespread, more sophisticated and more powerful; the proportion of the world with access to transport links and information is now almost universal. With an ever-expanding range of materials, and greater inclusion of materials into cultural appropriate-ness, as they trickle from the more exotic uses into the more mundane, what is it that determines the materials used in any particular task? To consider this question, I describe below the material changes that have occurred in Kelabit longhouses, and the social and environmental opportunities that have acted to bring about new material choices.

The Traditional Kelabit Longhouse

The longhouse is a long-standing icon of Bornean societies,²³ and still remains relevant today. However, despite retaining some of their essential characteristics, longhouses have recently changed, especially in the period since the Second World War. Prior to this, many Kelabit longhouses were a fairly standard structure and used in a similar way, but with new forms of social organization and

²³ See King 1993 for a series of essays introducing a number of Bornean cultural groups.

a growing network of connections to the outside world, they have been transformed. As far as the villagers of Pa' Dalih are concerned, there is such a thing as a 'traditional' longhouse and from talking to a number of locals, elderly and less so, we can draw a picture of what this looked like. For the Kelabit, traditional housing means housing made using materials and techniques that were available before the processed industrial materials that started to come into the highlands in the 1940s. This was a time of massive social upheaval, brought about by the growing influence of Christianity, and the influx of British and Australian troops using the Kelabit Highlands as their base to counter Japanese invasion.

Although we can get some information on traditional Kelabit longhouse styles and construction, reports of early travel to the Highlands are dominated by the difficulties in covering the terrain as much as descriptions of the place itself. For a government official or private explorer in the early 20th century, such a journey would begin with a pleasant cruise in an official launch along the mighty Baram river from Miri on the coast, past the regional capital Claudetown (now Marudi), and as far as possible up its tributary the Tutoh.²⁴ At this point the traveller would need to disembark and shift into a series of smaller boats, poled upriver by the Kenyah, a lowland tribe used to manoeuvring around these hazardous waters. Most journeys were affected by the treacherous river system, where too much rain made the rivers impossible to navigate, and too little meant the boats had to be carried. The Tutoh thins out into the Seridan and Madihit, where R.S. Douglas passed through on the way to his 1908 peace treaty in Pa' Mein, and eventually to the foot of the Tama Abu mountains. From here, the Kelabit come into their own, far more used to the mountain slopes than they are the rivers. They would act as porters, carrying heavy loads up the sticky, greasy mud and over fallen trunks and half-hidden roots for perhaps a week of solid effort. Eventually, a month after the journey began, having coped with the rain, the leeches, and the lack of food, arriving in the Kelabit highlands. As Harrison said "the extent and scope of

²⁴ This route is taken from descriptions of the Torres Strait Expedition in 1898/9 (Haddon 1932: 131-213), Ward in 1903 (1934: 86), Hose's 1904 expedition, scuppered when his boat was damaged in rough waters (1929: 190), Moulton in 1911 (1912), Schneeberger's trip in 1939 (1945: 545) and Harrison's WW2 activities (1949).

different influences on the Kelabit highlands are complicated by the substantial efforts required to get there” (1949: 133).

The climate is less oppressive than the lowland and coastal areas, with a cool nights and a persistent breeze. The area immediately surrounding a traditional Kelabit village would have been cleared to short grass, and used for buffalo to graze, and chickens and dogs to roam. At this time, Kelabit agriculture was dominated by swidden-farming forest fields (*late lu'un*) of hill-rice and vegetables. A village would remain in one area for a period of a few years, rotating the farms in areas of the immediately surrounding forest. Each year a new area would be cleared and burnt, and the previous year's farm left to grow back. Many of these abandoned farms are left with a legacy of their previous use, so that in future years, even if the forest has regained ascendancy, there would still be a significant number of fruit trees and plants for food or building and craft materials. The forest surrounding the village would be a mosaic of re-growth, defined by the size and species of plants growing back: first ferns and bushes, then tall spindly trees with a thick carpet of undergrowth, dating back to previous use of the area perhaps 15 or 20 years earlier. There may be a series of small padi fields, planted in an old river channel, divided up by bunds of semi-rotten vegetation, a pile-up of previous years' stalks, spongy and squelching underfoot. One of the many small streams would be channelled into the fields through half-pipes of bamboo.

At this time,²⁵ small bamboo and thatch field huts are the most common building, but the dominant structure is the longhouse. From the outside, it appears as an imposing closed structure, raised 3-4m off the ground on sturdy poles and topped with a thick thatch (see Figure 19 below). In the eaves beneath the thatch, walls of plank or split bamboo are held together with rattan, the thatch extending right down, almost to floor level. Looking under the floor, past the dogs and chickens and piles of wood at the forest of supports, one can begin to make sense of the

²⁵ The following descriptions taken from: Douglas 1907, Hose and MacDougall 1912, Harrison 1959, Janowski 2003, Lian Saging 1976/7, and the photographic collection of the Sarawak Museum.

layout: the main structure is made up round poles, stripped of their bark but otherwise untouched. These are sunk into the ground, or supported on large flat stones and placed every 3m or so along the length of the house, front and back. Between these and roughly along the centre line of the structure, are sets of 4 or 6 extra poles, which support the line of hearths inside the house above. Hearths are made with a heavy stone base and an overlying wooden structure to store firewood and support cooking pots, hence the reinforcements beneath.



*Figure 19: A traditional Kelabit longhouse in the 1940s
(courtesy of the National Museum of Sarawak)*

To enter the longhouse meant climbing up the *chan*, a large log with steps chopped out, providing access to the main public space, the *tawa*. Peering into the smoky gloom, down a single corridor perhaps 100m long and 5m wide, it would be hard not to be impressed by the sheer size of the structure. On one side is a wooden wall, shielding the family area (*dalim*) from view, and concentrating the attention along the length of the busy *tawa* corridor (or public space) in front of us (see Figure 20 below). The *tawa* acted as a public open space, where visitors slept, people wandered to their neighbours, the children ran freely, possessions

were stored and displayed, and household objects were made and repaired. Hanging from the rafters are all manner of baskets, nets, mats, the odd skull or two, antlers, tusks and the like. Looking up we can see the horizontal lathes supporting the roofing thatch, pierced in places by shafts of sunlight, worn thin after a few years of heavy rains, patched up but still serviceable. The eaves are low, giving us the chance to see how the thatch has been constructed. Each leaf is about a metre long, and has been folded in half. A thin spur supports the central stem, and the folded leaf is stitched to the spur with split rattan.²⁶ The thatch is made up of a mass of these leaves, each overlapping the next by more than half. To make sure torrential rains are shed from the roof quickly, the angle of pitch is quite steep, the ridge quite high, giving plenty of storage space in the attic. Sections of roof are supported in their own small frame allowing them to be pushed up slightly, a thatched rooflight (*ikab*) to clear some of the smoke and heat.

As well as smoke, the air is filled with the general hubbub of people: murmuring and laughing as they weave baskets, fix nets and boil rice. Large *belanai* – the Chinese ‘dragon jars’ – proudly stand a metre high by the wall, no longer used for funerals or *borak* (rice wine) drinking sessions, but still remembered as a marker of status. The Christian missionaries were universally appalled by the amount of alcohol consumed by the interior tribes of Borneo (Lees 1979), and set about persuading the Kelabit to abandon this habit in the name of religious devotion. Some of the planks on the side walls can be swung down to let in more light, a long thin window on the world, and good for observing the cleared area around the house without offering too much of a target – a design relic from the times when attack by neighbouring tribes was a real threat. Children frantically race the length of the *tawa*, the whole place shaken by their banging feet, earning the disapproval of some of those trying to concentrate on their work by the window.²⁷

²⁶ This was demonstrated to me by Isi Berawan, who still occasionally made his temporary fieldhuts in the traditional way, with split bamboo walls and floor, and a thatched leaf roof.

²⁷ The headman at Pa’ Mada said this was one of the principal reasons for him to alter the layout of his longhouse in the 1980s, as he could never get any peace to work or sleep during the day.

lengthways, so it would take about two weeks for one man to chop through the length of a large trunk in two parallel channels with a narrow-bladed adze, freeing one plank from the centre, perhaps a metre wide, and 3m long.²⁸ The plank is then turned flat and the surface smoothed with a wide-bladed adze, leaving a characteristic fishscale pattern. A typical household would need about 10 of these, or else would need to rely on the much less durable split bamboo.²⁹



*Figure 21: Longhouse interior 1947, photograph by Tom Harrisson
(courtesy of the National Museum of Sarawak)*

In the centre of the longhouse, and running its entire length, is a dividing wall, separating the public *tawa*, from the family space behind (the *dalim*). Each family's section of the *dalim* is divided from the next only by low dividers, and running along the length of the longhouse on the *dalim* side is an open pathway, so people can walk from one end of the house to the other in this section as well as the much wider *tawa*. The open-plan family area, with their low walls and

²⁸ As described by Ngalun Paran, aged around 80, from Pa' Mada

²⁹ Bulan 2003: 21 says that there was a shift from split bamboo floors to wooden planks in around 1900, supported by the evidence from Douglas' visit in 1908 when several hundred (even thousand) people gathered in one longhouse. Bamboo would have struggled to support such a weight, so it is most likely that the longhouse (at Pa' Mein) would by then have had wooden floors.

connecting walkway led Tom Harrison to comment that “to the Kelabit, privacy is unknown and unwanted” (1946: 21). His Britishness may have led to an exaggerated sense of the importance of social space, but this is a peculiarly Kelabit form of architecture: other Bornean longhouses tend to have a long open public space and behind the central wall, a segmented private family space.

The ‘traditional’ Kelabit longhouse is not a fully permanent structure, as life required movement for three primary reasons: agriculture, bad omens and inter-tribal violence. Firstly, farming practices were based on cyclical planting of the hillsides, fertilized by the ash of 10 or 15 years growth of vegetation, roughly chopped and burnt, still practiced today (see Figure 22 below). Wet rice farming (*late ba’a*) was the dominant form of rice cultivation in the wetter north of the plateau (Douglas 1912: 20; Owen 1913: 107) with the associated need to remain close to the padi fields. In the south, in places like Pa’ Dalih, padi farming did not become popular until the 1970s and 80s (Janowski 1988). Without the need to remain close to the fields, a village would be set up in a place that allowed it to exploit the immediately surrounding area, and after a few seasons would be dismantled and moved.



Figure 22: An area of hillside, burnt ready for planting out: Pa’ Dalih 2009

Secondly, in the pre-Christian era up until about 1950, Kelabit relations with their environment were dominated by a system of animistic beliefs (Harrison 1954: 115). The behaviour of animals, particularly birds was seen as a portent of the future. Certain birds flying in a particular direction would be understood as offering advice on whether a journey should take place, farming carried out, or the longhouse deemed to have been cursed (Chong 1954: 188; Arnold 1953: 92; Lian Saging 1976: 46). “Before they turned to Christianity in the early 1940s, bad omens, fear of spirits and curses pronounced on the longhouse, or quarrels between residents caused whole villages to move or split” (Bulan 2003: 21). Even if the longhouse had just been built, belief in the power of the forest spirits was such that it might be dismantled and moved within a year.

The third reason for the need for a temporary structure, was the history of local violence. Reducing tribal violence was a key part of British colonial governance, and by the 1940s this had largely been eliminated following a series of local peace treaties. However, aspects of the longhouse acted as a response to the traditional need for defence against recent raids by the Kayan and Kenyah tribes, happening up until the 1920s. Raising the house on stilts and providing entrance via an easily retracted log ladder for example. Similarly, the location of the house on a ridge and in an area cleared of forest that could have been used to hide potential attackers were then, and still are to some extent, retained in the construction of a longhouse. In the event of an imminent attack, one response was to move the village from a place deemed to be less easy to defend to a more advantageous position, higher up, further away, or closer to friendly neighbours. As with the needs of swidden farming, and animistic relations with the environment described above, the threat of violence made easy dismantling and reconstruction of the longhouse at this time a priority. Materials therefore had to satisfy one of two fundamental characteristics: either they were to be easily obtained raw from the forest at the new village site, or they must be portable as components between the old and new sites.

So the materials used in the house were chosen accordingly. The thatched roof was a sacrificial component, lasting perhaps 5 years with careful maintenance, it protected the walls and floors – elements that could then be transported to the new site and re-used. Floorboards were made deliberately thin to keep their weight down for easier haulage to the new site, strapped into a basic carrying frame made of two large hooked branches and slung between the shoulders of two men. Walls were made of smaller planks, tied with rattan to allow them to be dismantled³⁰, or split bamboo, which could be left behind since it was collected easily throughout the region. Local hardwoods, stripped of their bark and used for the main structural supports lasted perhaps 10 years, eventually succumbing to the rain, heat and insects. The stones around the hearth and those used as a protective pad on which the main supports rested could be collected from the banks of one of the many nearby rivers. There would be plenty of opportunities to gather heavy stones close to the site of a new longhouse, so most of these would be left behind with the remnants of the structure to form a line of evidence for archaeologists to discover in the future (Barker *et al.* 2009: 142-152). At the site of the new longhouse, materials of construction were gathered locally and processed into longhouse components. Components deemed valuable enough to be retained from the previous site were transported, along with animals and possessions, through the forest and used in the reconstruction process.

Social practices meant that the longhouse was moved every few years, so it was only made as durable as necessary for its short existence. These structures were engineered in line with the cultural practices that had shaped them, eschewing heavy duty components and long term fixings - the construction was made as durable as required, but more importantly, easy to break down and carry.³¹ There was no need to dismantle and transport the bulk of the structure if the effort of gathering new materials is easy and convenient. The exceptions in this disposable

³⁰ Described and demonstrated to me by the village pastor during his work refurbishing an old house in the village.

³¹ This may be why Kelabit houses were sometimes seen as “flimsy” (Moulton 1912: 55) and of “a very uncertain construction” (Banks 1937: 432)

house concept were notably the floorboards, also some of the side wall planks, and on occasion some of the handsomely constructed thatch.³²

The traditional longhouse was literally a product of its environment; it was a niche product and well suited to Kelabit cultural ecology (Harris 1966). Connections to the outside world were limited by the terrain and the dangers of travel across tribal boundaries. Bringing things in from the outside meant a substantial and co-ordinated effort, drawing on the strength of local men to carry heavy loads on their backs, and the acumen of their leaders in negotiating with neighbouring tribes in a fluid political situation. Those things brought in tended therefore to be objects of political value, such as *belanai* (dragon jars) and brass gongs, rather than raw materials. The immediate forest could be transformed by skilled practices into materials and components, and used to construct and maintain the structure and fabric of the building. ‘Traditional’ Kelabit relations with the environment were dominated by their immediate surroundings, and the forest of the highlands more generally. Materials were the result of this relationship, based on a life-long knowledge of that ecology and the possibilities it presented.

The Dynamic Environment

In recent years, as discussed above, the Kelabit have become more embroiled in the global world. This has led them to develop new building practices based on the availability of industrial materials. However, in describing environmental relations I have deliberately avoided correlating environment with ecology. The environment is not only or completely the living world immediately surrounding us, but is itself contextual and created, and varies for each individual according to circumstance. I used the term ‘engineering environment’ to describe the world in which the engineers at the DRC engaged with their productive activities, and for the Kelabit, a similar concept applies. Links to the outside world have proliferated in the last 10 years or so, so that the modern Kelabit is as likely to be at home in an urban environment as in the surrounding forest. Since engineering is intimately linked with the environment, this suggests that the current Kelabit environment

³² As described by Nyimut Ulun of Pa’ Dalih.

can be seen reflected in their production practices, and as it continues to change, so too will those practices. To demonstrate this, I outline the expansion of the Kelabit environment from the traditional relations with the forest, to the global connections they now make.

The forest is not a homogenous mass, despite its appearance to the uninitiated. Some areas are obviously farmed, either now or in the recent past. Other areas are less obvious to the outsider: after a period of about 20 years, areas that had been part of the cycle of *latte lu'un* (hill farming) merge more or less into the surrounding jungle. Some hillsides around Pa' Dalih bear the marks of recent planting, most recently the burnt stumps of trees poking through low brush groundcover, and from perhaps 10 years ago, a discernible line of stunted bushes still resisting the shadowy canopy. I had in my mind a sequence of categories of forest: farmed and domesticated, recently farmed 'secondary forest', and 'primary forest' that had reverted to a natural ecological balance. With this in mind I tried to find out the Kelabit terms for these areas, but consistently failed. The question seemed to amuse or perplex locals, and the best I could do was terms such as 'small' and 'large' forest, but not standard phrases that everyone used. Then, on a long trek with Anderias into the forest to inspect damage to the water pipe, we came across a group of stones lying at the crest of a hill. He explained to me that these were the remains of the hearth of a field hut used for farming. The Kelabit often build a small hut near their fields, so that when work needs to be done over several days, they can stay there without having to walk back to the village each evening. This area of forest had been farmed by Anderias' family in his youth and was now known as an old farm, associated with his family. To me, the mix of undergrowth and trees was no different to the areas we had walked through, and not very different from the areas of 'primary forest' that we eventually walked into (see Figure 23 below). In those areas the trees were larger and the undergrowth more sparse, but the most obvious change was in the sounds of hornbills and gibbons. Anderias explained that even this area would have been farmed, but long enough ago for it to be forgotten. For the Kelabit, the forest was not divided up as crudely as my 'secondary' and 'primary'; these concepts were

essentially meaningless. Areas of forest were seen much more personally and associated with events and people, regardless of their ecology. Tsing describes the same sensation (2005: 155-202) as a blindness to anything other than apparently random green. In her example this had serious consequences, since the ‘blind’ observers were responsible for land-use planning, and failed to appreciate the managed regrowth of the forest by indigenous people.

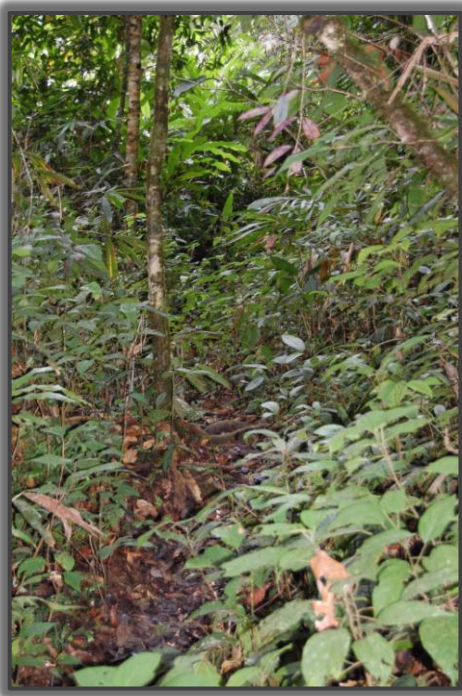


Figure 23 The site of Anderias’ old family farm: Bewildering and ubiquitous greenery.

Remote corners of the world such as the Kelabit Highlands of the 1940s are now virtually non-existent. In ways that have been well discussed (e.g. Ritzer 1993, Miller 1998), the world has become globally connected, allowing the transit of mass produced commodities to flow from one continent to another, through quick and relatively cheap long distance travel, and international communications. In the Kelabit Highlands, some of these effects are now being felt, and global connections being formed. As Anna Tsing (2005) has shown, not all forms of globalization are successful, but the creation of new forms of global connections and intercultural relations are new social forms that deserve study in their own right. She describes in shocking detail the destruction of the rainforests in Indonesian Borneo, and the new cultures that are forming around them, a peculiar form of Capitalism, a ‘Wild West’ cocktail of legal and illegal prospectors,

poisoning and pillaging the landscape in a frenzy of greed and exploitation. New ways of seeing the forest have engulfed local traditions and literally forced them to the margins, displacing indigenous people from their homes in the forest to government settlements by the roadside. The situation in Indonesia is desperate, and was not predicted – it was a different form of globalization happening away from the world centres in Euro-America or Asia. To truly study a global world, we need to give serious consideration to some of the apparently less significant incidents and connections going on in the less powerful corners of the globe. This runs counter to many of the social science studies of globalism that focus on the centres and see the effects rippling out around the world.

Tsing endorses the ethnographic fragment (2005: 271), and complicates the nature of global expansion by looking at concepts of globalism from the perspective of people on the ground. This includes more than indigenous populations, as the influx of nature tourists, geologists, immigrant workers, Japanese traders, soldiers and more, provide a rich source of ‘ethnographic fragments’ for her to try to piece together. Expanding global connections can be chaotic and uncertain, communications misinterpreted and collaborations abused. She paints a very different picture to the simplistic homogeneity of global capitalism described by authors such as Ritzer (1993), and allows a more vivid and active part for local people. No doubt influenced by the ecological catastrophe enveloping Indonesia, she deliberately shows a bleakly different view of global connections “Others have, and will tell of the pleasures of resource booms...I will tell stories of destruction” (Tsing 2005: 26). A short distance away on the Malaysian side of Borneo, things are not so severe as those described by Tsing.³³ However, the same messy creation of new relations is going on, altering local concepts of the forest and the connections between the Kelabit Highlands and the wider world. These connections can be traced in the changing materials used in house construction today, and the different position of the forest in everyday life.

³³ Her powerful descriptions of the destruction of the Bornean rainforest are based on her fieldwork in the Meratus mountain region of Indonesian Borneo (Kalimantan), about 800km south of my field site in Malaysian Borneo (Sarawak).

The influx of new materials began in earnest during the Indonesian ‘Confrontation’ of the 1960s, with the resettlement of Kelabit villages away from the border area and in to Bario, along with a supply of corrugated sheets to help building new houses. Many of the villagers I spoke to were proud of the fact that they had resisted relocation, and remained behind in potentially dangerous locations, continuing their agricultural traditions. Although the British troops of WW2 had brought some of the first non-local materials into the Kelabit Highlands 20 or so years before, they had not done so in great numbers. Very little in the way of metal sheeting for roofs had entered the Kelabit inventory, although the concept of a different way of making a roof had become firmly established. By the end of the confrontation period, the new housing stock built up in and around Bario for the resettlement of villages like Pa’ Mein, was routinely roofed with corrugated metal (see Figure 24 below). Furthermore, even those who had remained away from the new town had also been able to obtain sufficient sheeting for it to have become almost universal. Rather than the few men who had parachuted in during the 1940s and been air-dropped supplies, the extent of the logistical operations in the 1960s meant that the airstrip at Bario was extended and modernised to allow regular flights and a means of supply of non-local materials to a remote region. The environment from which the Kelabit were able to source their materials started to change and expand beyond the local and into the world serviced by the airstrip and mediated by the troops. Connections with the industrial world had spread via Bario into the interior in a material way that was reflected in the iconic longhouse.

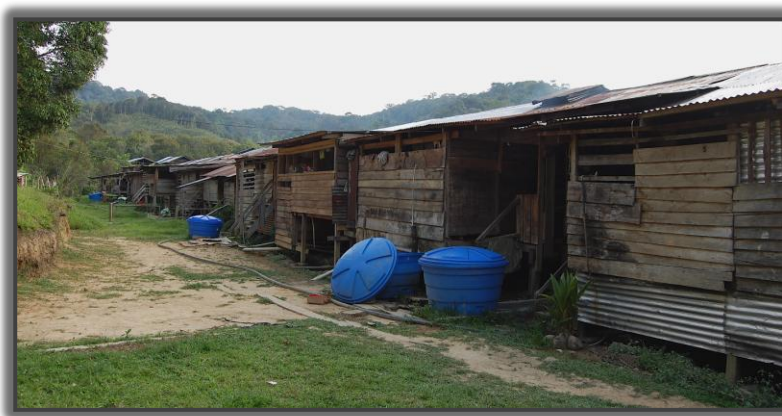


Figure 24: Rear of the longhouse at Pa’ Dalih. (the dalim, built in the 1970s using army surplus metal sheets on the roof

More significantly in recent years, the gradual encroachment of commercial logging, spreading out from the south has become more important to Kelabit connections. The Kelabit Highlands is one of the last areas to be logged, so is at the end of the Sarawak logging trail that has spread all the way from Kuching 500 miles southwest. The messy relations that Tsing describes come to the fore in the paradox of destruction merged with opportunity brought about by the provision of roads alongside the exploitation of the local environment. This is further complicated by wider climatic changes being experienced by villagers in the Highlands, affecting their agricultural cycle. Anderias described how the increasingly unpredictable rains caused problems with timing the sequence of planting out and harvesting, and was actively seeking new crops the village could grow, either for subsistence or for cash.

Years of commercial logging in the surrounding areas have raised awareness of environmental change for the rural Kelabit, and brought about a renewed interest in protecting their immediate environment. They have made a concerted effort to map and mark their 'cultural sites' showing long term occupation of the area and use of the forest environment. This was one of the main reasons why the Cultured Rainforest Project was welcomed to Pa' Dalih – it was a way of investigating the age and cultural identity of pre-Christian cemeteries, abandoned longhouses, and the iconic megalithic monuments dotted around the region. Loggers are not meant to disturb cultural sites, and although they do, morally at least the Kelabit would hold an advantage. If they could prove long-term land use and suggest a continuing need, the loggers would be required to take account of their opinions in choosing routes and areas to log. The local environment changes its place in the psyche of the Kelabit from being a place rich in resources, to a place that needs to be held on to. Cultural environment used to defend ecology and material resources.

Despite being relatively unscathed by direct logging, Pa' Dalih and its environs have been affected by the consequences of logging, and it is assumed that things will get worse. The most pressing need for the village is to secure clean and

reliable water supplies. In response to the problems of soil erosion polluting the river systems, logging licenses are contingent on giving a wide berth to sources of water used by local villages. The Department of Health is responsible for clean water supplies, officially validating sources and banning logging from within an area that might pollute the source. In Pa' Dalih a new HDPE water pipe (the same material as used in the UK) has been laid to supplement the old PVC pipes which are constantly being broken by animals and falling branches. Not only is this to supply more water, but it is also a specific ploy to have the area validated and ring-fenced as a water supply, and hence protected from logging. Unfortunately, the pipe has to be installed by the government to become an 'official' water supply, so it runs through the forest, languishing semi-connected and waiting on bureaucracy, whilst the villagers fix and maintain the existing unreliable pipe (see Figure 25 below).



Figure 25: Fixing the waterpipe, done using the forest as a source of tools and materials

These things may be enough to prevent substantial logging in the immediate area, but the paradox is that even if they want to prevent the logging, the Kelabit want the logging roads. This gives them access to local villages by truck or scooter, it makes sourcing building materials from the forest easier, demonstrated by the numerous piles of planks by the roadside, and it provides access to Miri, now a major source of materials for Pa' Dalih, as well as jobs, higher education and medical care (see Figure 26 below). But without the logging companies, the roads deteriorate at an alarming pace. One or two rainy seasons will wash away sections of the road, more than local people can repair on their own, and very quickly the road will become impassable. There is talk of bringing in the military, or regional government support to take on this responsibility, or at least the road between Bario and Pa' Dalih, but at present, maintaining the roads is down to the logging companies and local people. It may be then, that road access between Pa' Dalih and the coastal towns is only there for this window of time. Once logging is finished, the roads may well disappear, so unless access is maintained via Bario, Pa' Dalih residents would once again be limited to what they could carry. This complex assortment of relations between the Kelabit, the loggers, government health departments, the forest, patterns of rain, water pipes, and the supply of new materials and ideas all come together to provide an ethnographic fragment "...grounding one's analysis of global connection not in abstract principles of power and knowledge but rather in concrete engagements" (Tsing 2005: 267). But rather than the despair and destruction of the story in Indonesia, in the Kelabit Highlands this fragment of globalisation hints at an adaptation to the new opportunities of the global world, demonstrated by their increasing use of new materials.



Figure 26: A hardware store in Miri, used to supply parts and materials to Pa' Dalih

A journey to the Kelabit Highlands today, while lengthy, is increasingly less arduous. Government subsidies provide for a 19-seat, twin propeller aircraft to fly from Miri on the coast, to the Kelabit 'capital' Bario for a very reasonable fee, taking less than an hour. This airstrip, originally constructed by Harrison after WW2, modernised during the confrontation in the 1960s and well maintained ever since, now provides easy access to the highlands for people and limited amounts of cargo. Outside the airport building are several modern Toyota Hi-Lux 4 wheel drive pick ups, along with a host of scooters, the sort you might see buzzing around many Asian cities, but here with knobbly tyres and jacked-up suspension. And thanks to a new bridge built in 2009 over the river at Long Dano, it is now possible to drive directly from Bario to Pa' Dalih in about two hours. As long as the roads are dry, getting to Pa' Dalih is no longer the expedition it was 70 years ago. Now there is a direct link to Miri, and a Toyota 4WD can make the journey in about 10 hours, laden with half a ton of anything the world has to offer.

The environment for the Kelabit is no longer just the local forest and its resources of wood, sand and stones. *Belian* hardwood comes from Long Peluan, the airstrip at Bario brings in small quantities of almost anything, and most importantly the logging road to Miri opens up access to roofing sheets, nails and bags of cement, as well as the tools required to manipulate and transform them. Globalization for the Kelabit is fed by tenuous links to the coast, and the desire to make things more durable, as well as the proliferation of information and ideas that provide this inventive people with new ways of engaging with their expanded environment. Conversely, local materials such as rattan and bamboo, once absolutely vital to the working of the village are now only peripheral, and usually only a stop-gap. The relationship with the immediately surrounding environment changes as it becomes less important for its raw materials, and movement becomes a regional issue rather than a local one. Materials are no longer local, instead they become second- or third-hand as they come in through a series of intermediaries linking the Kelabit to the wider world. Expanding their resource environment through a combination of changing attitudes to the forest, historic circumstance, and access to new places, materials and modes of transport, destabilizes and invigorates the environment culturally as well as ecologically. The expanding environment has developed a sense of new potentials, and the possibility of new forms of production.

The Kelabit Longhouse Today

For now, the Kelabit of Pa' Dalih are able to access heavy materials, with the cost of transport the determining factor. This influences the type of longhouse that we see there today. Looking down from higher up one of the surrounding slopes, the village of Pa' Dalih has many more buildings than its counterpart of 70 years previously.

The variety of building types is also apparent: no longer is the village so obviously organised around the longhouse, instead it seems to centre on the football pitch (see Figure 27 above, and also village map, Figure 3 above). Nearest the pitch is the school quarter of the village – Pa' Dalih acts as a central

primary school for children from nearby villages, and so includes the main school building, the headmaster's and teachers' houses, the children's boarding houses and the only concrete building in the village, housing a large generator. There are three longhouses, known as the main longhouse, the short longhouse and the short-short longhouse. But these are in many ways overshadowed by the 15 or 20 other houses visible in the same area, no longer dominating the landscape as they once did.



Figure 27: The village of Pa' Dalih 2009. The school buildings (blue roofs) are bottom left, with football pitch in front. The church is on the far side of the pitch with main longhouse behind. To the right are the irrigated rice fields

The original longhouse built in the 1970s has been expanded over the years, a reminder of the change in Kelabit attitudes from portability to permanence. From the outside, facing the centre of the village and in the centre of the longhouse is an imposing modern-looking structure with planed plank walls, glass louvered windows and a new metal roof. This represents the main structural change in

longhouse design: no longer is this one building divided lengthways into public (*tawa*) and family/cooking (*dalim*) spaces (see Figure 20 above for a ‘traditional’ layout, and Figure 30 below for a plan of the current longhouse). Now the main structure is entirely *dalim*, a series of family hearths arranged along the length of the longhouse. The modern-looking structure visible from the front outside is an attached *tawa*, in the central section of the longhouse, traditionally occupied by the head-man, and here occupied by Jolly, his wife Sina Siren Paran, and their young children (see Figures 28 and 29 below). Jolly is brother of Anderias, the current head-man, both sons of the former head-man. On one side is the neighbouring *tawa* of Inan Tauh, an old lady in her 80s. Hers is still the old-fashioned type, small and closely connected to the main *dalim*, the overlapping planks stained dark with rain and age. On the other side is a new construction; Jolly’s neighbour, Judine is in the process of replacing his old *tawa*, something like Inan Tauh’s, with a new version like Jolly’s, except bigger and to be shared by two families.



Figure 28: Front of Pa’ Dalih longhouse 2009.

Jolly’s tawa is on the left, and Judine’s new tawa being built on the right.

The whole structure is raised about 2m above ground level, with the underneath used for storage, mainly of wood in the form of planks and firewood. On closer inspection, the support posts are squared, unlike the round posts of old, and not of one piece. The lower portion is the resistant *belian* hardwood, sunk into the ground and secured with concrete, then jointed to the upper part with an angled bolted lap joint (see Figure 33 below). Connecting Jolly's *tawa* and *dalim*, is a walkway about 20m long, creating a sizeable area between *tawa*, walkway and *dalim* which is planted out with vegetables, conveniently accessible from the steps leading up into the building (see Figure 30, plan of the longhouse, below).

The inside of the *dalim* is reminiscent of the traditional longhouse: rough plank walls, wide floorboards rubbed smooth by bare feet, the atmosphere heavy with smoke from the many fires. The heat is stifling, beating down from the metal roof close above, blackened by soot, rafters no longer decorated with the hanging odds and ends of everyday life, supporting instead a few fluorescent strip lights, wires straggling beneath them. Thin shafts of light pierce through the rust holes and old nail holes of the re-used sheets, illuminating the smoky mist as it swirls upwards and out of the ridgeline skylights. More light comes in from the side windows, many made from heavy army regulation plywood, still in service after 50 years. Much of the floor is covered with linoleum, marking of the owner's part of the house, to me a strange vision of 1970s Britain, beautiful natural floors covered with gaudy patterns. Lino is popular as it can be easily cleaned, more so than the floorboards with all their gaps, but only recently available since a large roll needs to be brought in by truck from Miri.



Figure 29: The dalim of the Pa' Dalih longhouse 2009

Around the hearths are woven mats, used for resting and sleeping, the same as those used in previous generations. In fact the scene around the hearth generally looks remarkably similar to that in the traditional longhouse of 70 years ago: the *tetal* (open hearth) with wood stored above, the pots and cooking utensils, the mats, the smoky darkness with people lying close by despite the heat. Sina Siren takes up her usual place by the fire, boiling water and preparing rice, occasionally blowing at the flames through a plastic pipe, and poking in another piece of wood. Behind the *tetal* is a kitchen area, with a sink and tap, a separate food preparation and storage area and another door leading to the bathroom.

CRF 08
Pa' Dalih Longhouse

- [H] Hearth (Raran)
- K Kitchen/Food preparation area
- B Bathroom (Inan Di'u)
- Stairs down
- Window
- Door
- Open wall
- Unsure of position/function
- Edge of individual household dalim (Joint in floor & structural timbers-not walls)
- Open ground
- Garden

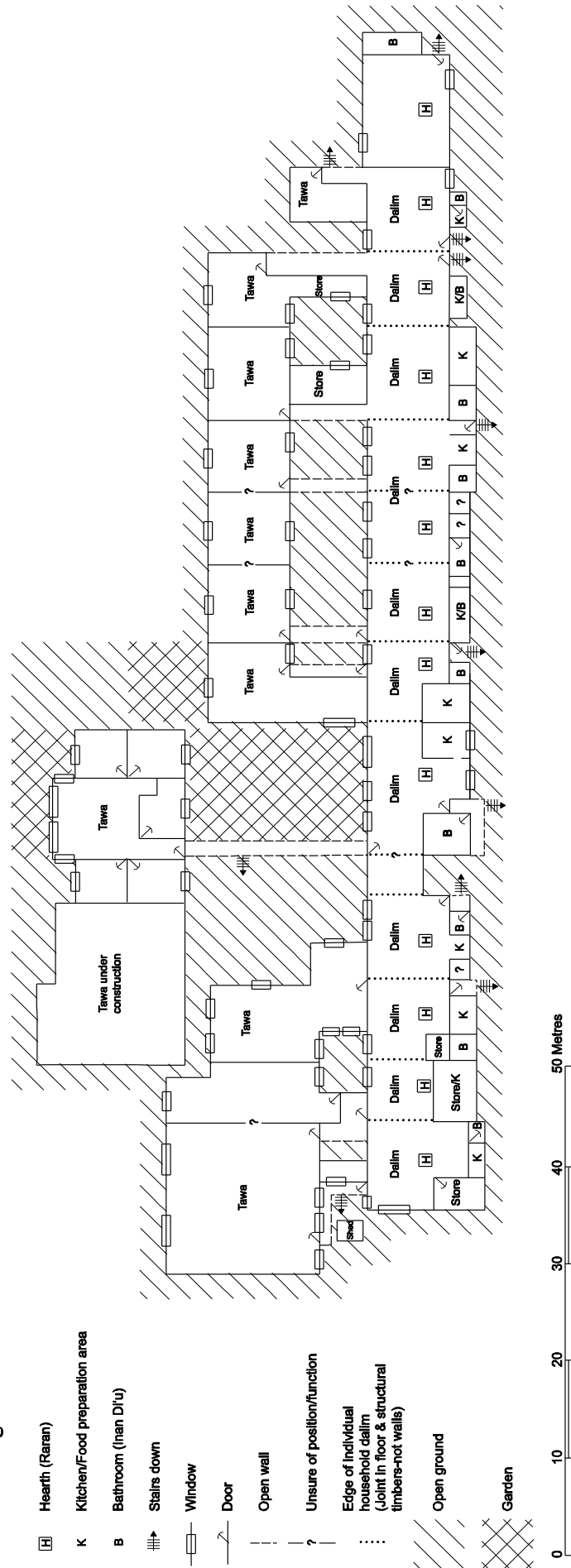


Figure 30: Plan of the current longhouse in Pa' Dalih

If the old part of the longhouse seems to have changed little, the modern *tawa* is very different. Jolly's *tawa*, when built in 2000 was a relatively grand affair in Kelabit terms. At 20m square, it is much larger than the traditional *tawa* space, but serving a similar purpose of display, albeit in a more private setting. Around the walls are photographs, certificates of achievement, decorative hats, bamboo musical instruments, and some colourful Christmas decorations still in place years after they first went up (see Figure 31 below). Leading off the central area are 5 sleeping rooms (*telong*), made separate by wooden walls and doors with locks, a major change from the 'unwanted and un-needed privacy' described by Harrison in the 1940s.



Figure 31: Inside Jolly's tawa.

Since it was built, this style has become relatively common, the size, the planed wooden planks used for walls and floor, the louvered glass windows, separate sleeping rooms. Many of these features are repeated in other buildings around the village, to the extent that one might consider this now to be a traditional Kelabit

house. That perception is illusory though, since the changes that have led to this type of design have been rapid and are on-going, this was the first *tawa* in the village to use glass louvered windows and has an experimental roof shape with false dormers. The trend is for the size of buildings to increase. These new *tawa* bulge out and dominate the old style *dalim*. Walls are getting bigger and, thanks to the dividing up of interior space, more numerous, meaning that much larger volumes of wood are required, in turn requiring more fixings such as nails, hinges and locks. The *tawa* being built next door has a suspended plywood ceiling to keep out some of the heat from the metal roof, the first I had seen in the village. There are planned to be 6 *telong* leading off from the central area, each with its own door. Its walls are planed smooth, but new tools allow them also to be half-lapped giving a flat surface, rather than each plank overlapping the one below, clinker style.

The *dalim* in many ways harks back to the past in its construction, but shows how the Kelabit have changed their concept of how to build houses. This part of the building was built in the 1970s and even though it has an air of dereliction about it, it is a permanent building, conceived of as remaining in the same place for a generation or more. A traditional longhouse would have lasted perhaps five years before being uprooted and moved on, and we can see in the materials used here some of the differences. The metal roof is a relic of army supplies of the 1960s, a time when they were based in Pa' Mein during the Indonesian Confrontation. These rusty old sheets are thick steel, highly regarded for their longevity, but their weight has led people to look for alternatives. In the end household, Henry Labang was replacing the metal sheets in his father's leaking roof and explained the alternatives to me. Tin sheets brought in from Miri are expensive due to the cost of loading up a truck, so the more you can carry in one trip, the cheaper they become. Thinner zinc sheets were popular since they were lighter and you could get more on one truck, but less durable. Recently, aluminium sheets have become popular since they are thin and light, reducing the overall cost through savings in transport. They have the disadvantage of being shiny and reflecting the strong sun, and are not really sufficiently durable in today's terms, but some villagers have

tried painting them to overcome both disadvantages. Pre-painted zinc sheets are becoming more common, although not the cheapest they last longest, and come in a variety of colours, much preferred to rust brown. In the end, and mainly for cost reasons, Henry used standard tin sheets as his best compromise.

Metal roofing sheets were one of the first, and probably the most significant change to materials used in the longhouses, and contain a very different set of properties to the thatched roofs that went before. Metal sheets are large and hard and heavy, they get very hot and radiate heat inside. When it rains, (and it rains often, and heavily) the sound is like a thunderous applause, drowning out conversation. Talking to the old folk about the palm leaf thatched roof led to animated conversations and lengthy complaints about how dirty they were, how anything stored in the rafters was covered with soot and animal droppings, and they were constantly having to repair and replace parts of the roof. The choice of materials for the roof is a stark one, and one of radical differences. The thatched roof is intricately and skilfully made, with carefully chosen local materials. The materials are still readily available, but the skills needed to make them into roofing panels are largely forgotten. It is only through skilled forest men like Isi Berawan that this continues as an activity at all, and even he only occasionally uses thatched roofs for his temporary field huts. Roofing with metal sheets is also a skilled activity, one that requires a different set of tools and competences to be able to do effectively. Robert, during the refurbishment of the old house next to the Pastor's, complained that the (metal) roof and wooden rafters were badly made, especially in the complex joints where two or more sheets met at different angles (see Figure 32 below). This was done by *kerja sama* (communal work parties) he said, and the result of different levels of skill could be seen in different parts of the roof. Tin sheets are different to palm leaves, in their size and weight, their flexibility, and the tools and skills needed to work them.

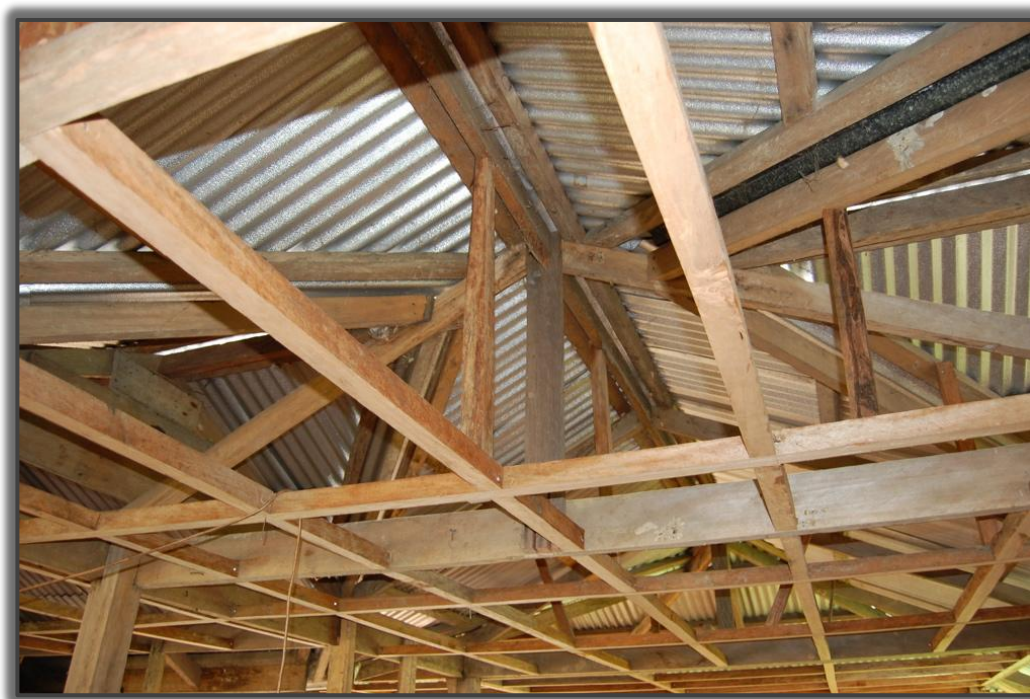


Figure 32: Complex roof supports: badly made and ill-fitting according to Robert

Metal sheets, through their very nature have an affect on people. It gets become hotter during the day and noisier at night, but you no longer have to spend so long attending to roof maintenance, since although rust holes form there remain surprisingly few leaks. At first the heat and noise of the tin roof can be overwhelming, but you learn to live with it, changing the way you approach the mid-day sun and the evening rains. The materials of the Kelabit roof are a fundamental characteristic of the longhouse: metal sheets, create a different set of effects to thatch in a simple way. The heat and noise of a tin roof can be overwhelming, whereas the dirt and insects harboured in a thatched roof impact on how possessions are stored, and frustrate attempts at cleanliness. In the heat of the midday sun, when work outside is suspended, you retire to the longhouse and swelter beneath the vast radiating panels overhead (and incidentally beside the fiery hearths and boiling pots of rice). In the torrential evening rains, communication is drowned out by the percussive roar of water on metal, and through the rusty pinpricks comes a particularly atmospheric sensation of light in the smoky longhouse interior.

Apart from the roof, the most significant change to materials used is the change from local hardwoods to the far more durable *belian*. This does not grow well in the Kelabit highlands, despite concerted efforts. In a walk through the forest, Ganang stopped and laughed as he told me the story of a rich Kelabit who had planted an area of forest with *belian*, but which had failed to grow and reverted to the more usual mix of regrowth. The nearest sources are around the village of Long Peluan, 30 km to the south, harvested and processed by local Penan into regular sized square posts, up to 12 feet in length. There is now a road to Long Peluan making the journey relatively easy, so the use of *belian* as a material has become more common. In the change from moveable to permanent housing, the most noticeable change in Kelabit attitudes to materials is in the pursuit of durability. Many immediately local materials are falling out of favour due to their relative lack of resistance to the rain and insects, bamboo in particular is only used for explicitly temporary structures,³⁴ which is a recent change, within the lifetime of the present generation of villagers. Rattan is used far less often as its expected life is even less than bamboo and is easily and cheaply replaced with nylon string or electric cable. Local wood is still a key material, sourced from the forest around the village, since it lasts several years in most applications, and the cost of replacing it is prohibitive. Most of the external and internal walls are made up with a variety of local woods, and to prolong them further, these are now sometimes treated. Robert had started to bring in large tins of varnish to paint any wood directly exposed to the weather, and Ganang in his new house had managed to acquire some green paint, which prevented insect attack on the internal joists. To keep costs down, while still getting the advantages of *belian*, the standard method of construction is to use a short length of *belian* which would be cemented into a foundation hole where it copes with the worst of the rain and rot. Fixed to this by means of a joint and bolts, would be local hardwoods making up the

³⁴ As well as in the bridges described in the previous chapter, bamboo was used to construct a temporary shelter as part of the Malaysia day celebrations of 2009, it was frequently used for fencing and occasionally used to make field huts near padi fields that were further away from the village. It was also used to make up rafts to float down river for entertainment. Many villagers remembered bamboo as a useful material in making a range of household objects, from traps to containers, but in my time in Pa' Dalih it was rare to see anyone actually still doing so.

structure above, and raised clear enough of the ground to prevent substantial deterioration (see Figure 33 below).

Ideally, the Kelabit would like to use *belian* as their default material of construction, seeing it as the epitome of progressive housebuilding, but the expense is still unwarranted. Local hardwoods require a chainsaw and some labour, and not too much cash. There are now several petrol driven chainsaws in the village, which tend to be brought out in any communal project. Most of the men are accomplished in their use, and for those who are not, such as Ganang, it is easy to find someone to do the work for a small fee. So, whilst *belian* is relatively easy to find, it is still expensive and other methods for prolonging the life of local woods, coupled with ease of access, means that they remain the most popular material.



*Figure 33: Typical structural support post at the base of the new tawa.
The lower part is belian hardwood, and the upper part local wood*

Walking the length of the longhouse, one thing that strikes you is the number of empty households: of the 14 or so, only about half are permanently occupied. This includes one household used by some of the school teachers (who are in the village on secondments lasting about 2 years), and two or three that are home to people one would describe as very elderly, and suspect may not be in residence for much longer. On my last visit, Henry Labang's elderly father, occupier of the end household where Henry was fixing the roof, was moved to the hospital in Miri with his wife in attendance. Even Jolly, in the central household, talked of moving his family to Miri for the schools and easier access to his work. Other problems of longhouse living were described to me in Pa' Mada, where internal politics has led one prominent resident to begin constructing what looked like a new village, with new houses and padi fields, just outside the village. The longhouse, it seems, is dying. But before we lament its passing, we should look at the number of other houses springing up. The demographic problems of rural life are a story in their own right, but there are plenty of new houses being built in Pa' Dalih, a process that has been going on for many years.

Modern Housing

Ganang is one of the keenest 'guides' always ready to proffer his services to any wandering visitors that pass through. As a result he is sometimes privately ridiculed for his lack of skill and effort in rice farming (he has far too many fields to cope with, scattered in all directions from the village), but does have greater access to cash than many in the village. He is now able to begin building a new house (see Figure 35 below), while still keeping his old part of the short-short longhouse. I use this as a way of describing the trend to individual houses, without suggesting that this is a typical Kelabit house. Indeed, it would be difficult to say what is 'typical' since many of the traditionally common features are now being challenged. Separating the *tawa* from the *dalim*, and joining them with a footbridge can be seen quite clearly in for example Doo Pu'un's house (see Figure 34 below), and even in Anderias' house despite its many additions, but this is no longer a prescription.



Figure 34: Doo Pu'un's house. The tawa on the right is connected to the dalim on the left by a tadur (footbridge). This is the same layout as a typical family section of a longhouse

Raising the house on stilts is common, but in the last few years, people are experimenting with a ground floor, made using concrete, a material able to withstand the rigours of rain and insect attack. Anderias, and the Pastor have both dug out under their house and are in the course of laying down a concrete slab. For Anderias this means paying 20 ringgitts (£4) per bag for 40 bags of cement, then a further 2000 (£500) for two truck journeys from Miri. Ganang, using his experience of construction “with the Chinese” (I could never find out exactly what or where that was), had taken this a stage further, and incorporated a number of new features to his house. First, the foundations were not the usual *belian* lower portion jointed to local wood upper structures, instead he had put in concrete blocks with steel plates, onto which are bolted local wood posts. He was in the process of mixing and laying a concrete base to provide a lower floor, with bags of cement from Miri, sand from the nearby river, and angular blocks of stone chosen for their size and shape, breaking off naturally at a nearby cutting made by the logging road. The layout includes an internal stairwell and upstairs landing, something familiar in the UK, but very unusual in the Kelabit highlands. The roof

is made of painted tin sheets also from Miri, set at a steeper angle than usual. He had seen a poster advertising tourism to the Swiss Alps and been taken by the shape of the alpine lodges, using them as the inspiration for his design.³⁵ When discussing later, in the company of others, he added that he was also trying to reproduce the steep roofed designs of the traditional thatched longhouse – steep to make sure that rain was shed before it could seep through.



Figure 35: Ganang's new house under construction

However, by emphasizing durability, there have been compromises made in other areas. In particular, other performance characteristics of the material are accepted despite the compromises this entails. Roofing now lasts as long as the house, and not just a few months, but metal sheets are poor insulators, unlike the traditional thatched roofs. Going back to that system was not an option however, not because the material was no longer available (palm leaves still grow in abundance in the

³⁵ Several villagers remarked independently of the beauty of the Swiss Alps, it seems that this is seen as the epitome of attractive countryside, with its snow peaked mountains and fast flowing rivers.

forest), but because of the constant maintenance it required. One compromise in material property has been replaced with another: concerns with durability and maintenance are replaced with concerns about heat insulation, convenience overriding efficiency. Having accepted this compromise for 30 years or so, the Kelabit, ever resourceful and innovative, are trying to tackle this new issue once again with the import of new materials.

In Ganang's new house, to cope with the heat generated by the metal in the blazing sun, he was experimenting with fibreglass insulation held in place with wire mesh fixed to the underside of the roofing sheets. He was also using the architecture of the steep roofline, which had the effect of raising the ridge height, so that he could leave large areas of the upper gables open, like large triangular windows near the ridge. They were protected from the worst of the elements by the overhanging roof, but would allow the wind to pass straight through, hopefully taking the warmest and smokiest of the air with it. The steep roof design was viewed by many in the village with some suspicion, but as is normal, received very little direct criticism, people preferring to hold their counsel until it was finished. Many people doubted that the fibreglass insulation would work, and would in any case become an ideal nesting place for all manner of pests. Another solution was generally seen as the best way of dealing with the problem, and that was the installation of a suspended plywood ceiling (see Figure 36 below). Sheets of plywood, as with most new materials, coming in by truck from Miri. This was the conclusion reached by Judine, Jolly's neighbour, in his new *tawa*, and was also being fitted retrospectively by Robert in his refurbishment.



Figure 36: The interior of Judine's new tawa, during the installation of a suspended plywood ceiling to reduce radiant heat from the metal roof

Ganang had made other choices based on the availability of new materials. His windows are not the traditional sliding wooden panels, nor are they the now common louvered glass type, but are wooden-framed opening windows with tinted glazing. Since he was not raising the building on stilts, he decided to make the lower part of the external skin with a few courses of hand made bricks to help protect against the weather. He had bought a brick mould and produced several hundred bricks by hand, using the same sand and cement as the concrete base. Some of the bricks were crumbling, as the proportions of the ingredients were something of a mystery and required him to experiment further. The rest of the external skin was made of planed planks, as was the flooring and internal walls, all of which came from the local forest, Ganang having commissioned villagers with chainsaws to produce them.

All of the newer houses in Pa' Dalih include various novel materials, and Ganang's, as one of the newest is a good example of the changing relations with the expanding environment. The bulk of the house is still made of locally sourced hardwoods, but now with the addition of metal plates, cement, painted roof

panels, insulation, tinted windows and the concept of a Swiss chalet, the Kelabit house is made up of a radically different set of materials to the traditional longhouse, and represents a change even from the more recent longhouses. Access to materials is no longer a significant problem as long as there is cash to pay for transport, and the skill set of people in the village has altered in tandem with the increased use of different materials.

Conclusion: Enviro-Material Relations

The series of events beginning with the Brooke regime penetrating in to the Kelabit highlands and culminating with the wholesale adoption of Christianity, radically altered the relationship between the Kelabit people and the highland environment. Traditional animistic belief systems required people to act according to the behaviour of animals and conditions in the forest, links that were strained and distorted by the new religion. Concepts of the forest were no longer dominated by their associations with omens and spirits, but became more prosaic, a place of provisions and shelter, areas to be inhabited and farmed without the old restrictions. Modern Kelabits are reluctant to talk much about pre-Christian rituals and beliefs,³⁶ but in private moments, for example after the shooting at Remudu described above, some did voice an opinion. Today, the old traditions are seen as a nuisance, preventing people from getting on with their work. Christianity has moderated the dominance of the forest in everyday life, and reduced people's dependence on it for their social wellbeing. Today, with the threat of ecological assault from logging, the forest has again become a more significant cultural environment, with the Kelabit staking claims to their heritage through marks made in the forest in previous generations. These new relations with the immediately surrounding forest have led to new working practices, based on a different concept of the suitability of the materials available there.

New materials have contributed to a change in the way that a modern Kelabit leads his life, and the declining importance of many local resources. This can be seen in material changes and continual innovations in housing brought about by

³⁶ See also Janowski 1988

the reconstitution of the dynamic environment (Rambo 1983: 23-29; Price 1982: 720-721). Today, the chief aim of a new construction such as a house is to reduce the amount of time required to maintain it: Make it permanent rather than temporary, fixed rather than portable. This is an objective constantly being pursued, and furthered by the introduction of different materials and techniques. When talking to villagers as they build or re-build their houses, this is an explicit point of pride in their work. The demands of the agricultural lifestyle and its links to the increasingly fickle weather patterns make for a precarious and continually laborious routine. Through access to longer lasting materials, the Kelabit are now able to produce houses that are durable enough for frequent maintenance issues to be a thing of the past. This frees them up to carry out farming duties – largely to do with raising padi, and makes them more flexible in their working patterns. Padi fields are widespread, in the north of the highland region as they have always been, but since the 1980s further south into villages like Pa' Dalih.³⁷ But having emerged as one of the driving forces behind the turn to permanent village settlement, and the consequent adoption of more durable materials, rice farming, whilst a traditional and socially important aspect of Kelabit life (Janowski 2003), is itself increasingly being questioned. Food is available easily and relatively cheaply from Bario and Miri, and the increasing difficulties of growing rice in villages like Pa' Dalih because of rainfall patterns and the explosion of the rat population,³⁸ is forcing the villagers to consider new ways of farming. At present, wet rice fields dominate agricultural life, the old river channel running around the longhouse supplemented by various fields dotted around the surrounding area, over the new bridge at Long Di' it, at Batu Patong, towards the old grass airstrip, and further afield through the forest. But the dominance of wet rice farming over cyclical hill farming is a relatively recent phenomenon, reducing the need to rely on the forest as a source of food and focussing attention back to the village and its

³⁷ Janowski's description of farming in the 1980s concentrated on dry farming, saying that reliance on rainfall meant that wet rice fields were difficult to maintain productively (1988).

³⁸ A side issue of the logging roads is that by stripping the undergrowth, and disturbing the soil, they have unwittingly created the ideal habitat for rats alongside the roads. Anderias, in one of his church sermons, implored the villagers to build better defences against this marauding invader: "Last year," he said, "we planted 3 fields of rice - two for the humans and one for the rats. This year we planted three fields of rice - one for the humans and two for the rats. Next year we will be nothing but rat farmers."

immediate surroundings. The forest is less important as a source of food than it has been in the past, and even if farming practices move away from padi fields and the centrality of the village, it seems unlikely they will return to shifting agriculture instead of accepting further dependence on imported foods (Harris 1966). The idea of permanence seems to have taken hold, and the shifting village and its associated requirements for local materials is a thing of the past. Instead durability is the key attribute for the Kelabit engineers, and access to industrial products has reduced the variety taken directly from the forest.

As cultural traditions change and the concept of communal living in a longhouse loses out to the newer traditions of detached individual houses, the demand for locally sourced hardwoods has increased. The footprint of a detached house such as Ganang's is much larger than that of the family unit in the traditional longhouse, as is the area of the internal and external walls. Most of that extra wood comes from the surrounding forest, as does the majority of the sand and stones. Nymut Ulun, an old man who lives in the short longhouse, complained that people now go into the forest and chop down whatever they like. Logging roads, four wheel drive trucks, chainsaws and petrol give the Kelabit greater access to their locally available building materials.³⁹ Whereas in the past, there was a need to extract a wide range of raw materials for construction from the forest, including especially rattan and bamboo, as well as wood and palm leaves, most of these materials are now sourced from a newly expanded environment. Thus it is more important now for a Kelabit to gain access to metal sheets, concrete, nails, tools, generators, fuel and so on, than being able to use the forest. Those tools and techniques used to acquire and process forest materials are also being replaced with a new set of skills. Very few Kelabit would be inclined, or able, to source and process the materials required to make a traditional longhouse. But there are many who are now extremely adept at using the chainsaw, and a growing minority who are able to drive through the treacherous roads after

³⁹ It should be noted that the practices of local people in gathering wood from the forest is eminently sustainable. The volume of wood required to build the whole of the village of Pa' Dalih for example would take about two years to re-grow in the area of the surrounding forest. Since the buildings are intended to be used for around 20 years, that level of use does not represent a significant ecological threat.

prolonged rain in the face of steep drops and collapsing banks. More importantly, using new materials has become a way of life for the Kelabit. Tin roofs are manipulated no less skilfully than thatched palm leaves. They are materially different in their weight, insulation and means of fixing, and because of this they are in part creating the new environment in which the Kelabit now live. In a literal way in the longhouse, where ambient heat and noise has changed, and in a broader sense by allowing for new forms of housing to emerge.

Beyond the forest, the Kelabit's living environment has been stretched along logging roads and through the air from the Bario airstrip, to include a host of new places and possibilities. Getting to Miri no longer requires an expedition, which opens up global connections and the realistic potential of access to industrialised materials. There is an intimate relationship between the environment and the people who use it, something not limited to the apparently 'natural' world of the forest and forest materials. The Kelabit who used parangs, bamboo and rattan in such a successful way prior to their extensive contact with modern materials were doing the same as Kelabit in the modern environment that includes chainsaws, petrol and metal sheets. Materials are a product of the environment and in turn help people to construct their environment in a continuous process of engagement and mutual creation.

DIVERSION: The Constructed Appearance of a Steam Locomotive

Steam locomotives in the UK are usually portrayed in a particular way, a historically specific time often thought of as the 'golden age of steam', in the period leading up to the Second World War. This was the zenith of steam powered travel, a time when speeds exceeded 100mph, passenger numbers and comfort were increasing, access to the far corners of the country became affordable, and rail companies were making money and employing thousands (Whitehouse and St. John Thomas 1992). Locomotives were fast moving, technologically advanced, and powerful – mechanically and socially, opening up areas of the country to more and more of the population (see Figure 37 below).

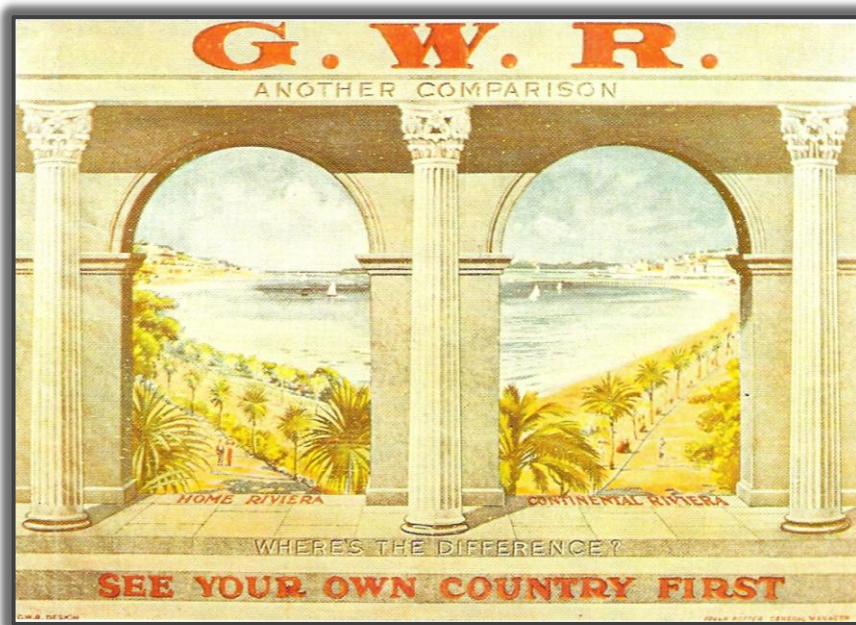


Figure 37: GWR poster promoting the novelty and excitement of travel in the UK

Rail travel today has lost much of this glamour. Visiting the 'Home Riviera' no longer holds the same mystery in an age of mass car ownership and cheap air travel. In the rush to diesel power, many steam locomotives were scrapped, but fortunately not all, leaving us with a stock of engines able to provide a limited recreation of some of the sense of the past. Removing steam power from regular service meant that travelling 400 miles from London to Edinburgh was a political and moral responsibility that fell to diesel power and the revised transport

infrastructure. The essence of steam travel comprised a new set of values, with a fundamental shift in character. Old steam trains became objects of fantasy, eliciting and creating memories as they ran up and down a few miles of country track, depending for their authority on the enthusiasts who restored and maintain them. As seen today, steam locomotives are no longer the technological marvels of the 1930s, nor are they the scrap metal of the 1970s. Instead they have become a symbol of nostalgia, an icon of a better age, steam billowing from the chimney against a backdrop of home-county green. Getting to that new ontology has taken a lot of work: changing the objects themselves through physical restoration, and repositioning the objects within a new scheme of responsibilities. Going from scrap metal to nostalgic icon required a shift in perceptions driven by circumstance.

Through this complex interaction of mediating influences acting to produce the steam locomotive, we now have a particular sort of object. The current view of steam travel as a heritage industry has created a drive for authentic recreation of an experience harking back to the 'golden age'. That time has itself been commandeered by certain agents (engine restorers, the media, commercialism like Thomas the Tank engine and Harry Potter's 'Hogwarts Express' etc.) to become a window into a constructed set of values: times when things were simpler and less stressful, when soot coming in through the windows was a good thing, and dirty overalls were a sign of honest hard work. And key to the relationship of the steam locomotive with the current set of values is an obsession with accuracy of appearance. I avoid the word 'authenticity' since the objects now produced are as close as possible in appearance to the originals, but their performance is compromised. Within the set of agents creating the essence of steam locomotives today, are the self-appointed guardians of accuracy, the so-called 'rivet counters'. This group of people represent an important attitude of conformity to the perception of appropriate behaviour, namely that things should appear to be indistinguishable from the original. By comparing the smallest detail between original and restoration (such as the number of rivets holding sheets of metal together), and publishing their work in specialist magazines, they act to reinforce the importance of appearance.

In accordance with these fundamentals, restoring 6023 has been a painstaking process. Replacing the copper oil pipes, for instance, to carry lubricant to the dozens of oiling points, has taken two men 18 months to complete. This could have been done much more quickly by using a modern pipe-bending machine to form the complex shapes required for each pipe. However, a modern pipe-bending machine, of the sort used when installing household central heating, creates a distinctive bulge at each side of the bend. Despite the fact that most of the pipes are buried within the framework and hidden from view, this was deemed unacceptable, so the original method was employed. To do this, the part of the pipe needing to be bent was heated with a gas blowtorch until red-hot, bent around one of a series of custom-made jigs to get the approximate angle, then cooled and tried in place. The pipe would then be heated and bent again to align it more accurately and this process repeated until it fitted. To look at a bent copper pipe, you could see which had been machine-bent, and which had been heat-bent, but the difference is small, especially on the scale of an elaborate 20m long machine, and both would work equally well. But to the restoration team, and the rivet counters, this type of detail is important in restoring 6023.



Figure 38: Part of 6023's lubrication system, made with hand-bent copper piping.

But whilst accurate recreation of appearance is sacrosanct, accuracy of performance is not. Usually this is by way of introduction of newer technologies to improve the performance of the locomotive, either to make it more reliable or to satisfy legal requirements. For example, to use a locomotive to carry passengers requires it to be passed by the Railway Inspectorate. One check would be to the braking systems, which must operate on a failsafe system, typically a vacuum produced by the engine holding the brakes off, so that in the event of any sort of failure, the vacuum is lost and the brakes are applied. In the Didcot Railway Centre collection is a replica of one of the first passenger locomotives from the 1840s – ‘Firefly’. This would originally have had wooden brakes, or been slammed into reverse to stop, so a new system had to be installed before it could run with passengers on the DRC demonstration line. The engineers ingeniously used a lever that was originally part of the water supply system as a brake lever. That lever was no longer required since the water supply system was also changed to incorporate (relatively) modern steam injectors hidden under the framework to make the engine more efficient.



Figure 39: Accuracy of appearance: Replica of the 1840 ‘Firefly’ locomotive.

The same approach applies to the installation of electronic warning systems, modern headlights and horns and so on. As far as possible all these things are hidden from view whilst the redundant control levers and oil lamps are left in

place. So, while strenuous efforts are made to make the object look like the original, for various reasons the same is not true of the performance (new safety requirements, increased reliability and efficiency etc.) The newly created object is made to fit in with the current concept of its appropriateness, fulfilling needs from influences as disparate as the rail inspectorate and grandparent's nostalgia.

To carry out an engineering project is as dependent on its cultural milieu as it is on the skills of the engineers and the availability of materials. What we see today, in the case of engine 6023, resembles the object of the 1930s, in fact the primary aim of the restorers is to make it look as near as possible exactly the same as the object of the 1930s. But it is fundamentally different, as an object it has changed. The set of relations created by the structures in which they exist, including restorers, rivet counters, fans of 'Thomas the Tank Engine', steam injectors, electronic warning systems, wistful media portrayals and so on, all go to make up the thing we see as the steam locomotive. Objects such as 6023 are contingent on those fragile relations and as they break down and disperse, new sets of relations come together, driving the re-formation the object in a constant process of respecification and renewal.

5: CONSTRUCTION

Since this thesis has as its primary research question, “How do people make things?” then this chapter, where I go into detail about a group of people actually making something, could be seen as the crux of the matter. However, I hope by now that the reader will feel more comfortable in accepting that ‘making something’ is part of a larger scheme (Kelly 1983). In the previous chapter I described how the environment that provides materials of construction is in flux and subject to locally specific and complex relations created in response to globalization, following Tsing’s use of the ethnographic fragment, and debates about the nature of materials and materiality. For the Kelabit this has meant a dynamic environment that has taken them beyond their rural heartland and into the wider industrial world. The ways they have embraced this environment are reflected in the continual evolution of their housing, mediated by the fundamental characteristics and properties of the materials they now have at their disposal. I now continue the engineering process by considering how materials are used in engineering, and the act of construction more generally. In particular, this chapter draws on detailed ethnographic data gathered as part of my close involvement with the construction of the new suspension bridge introduced in Chapter 3.

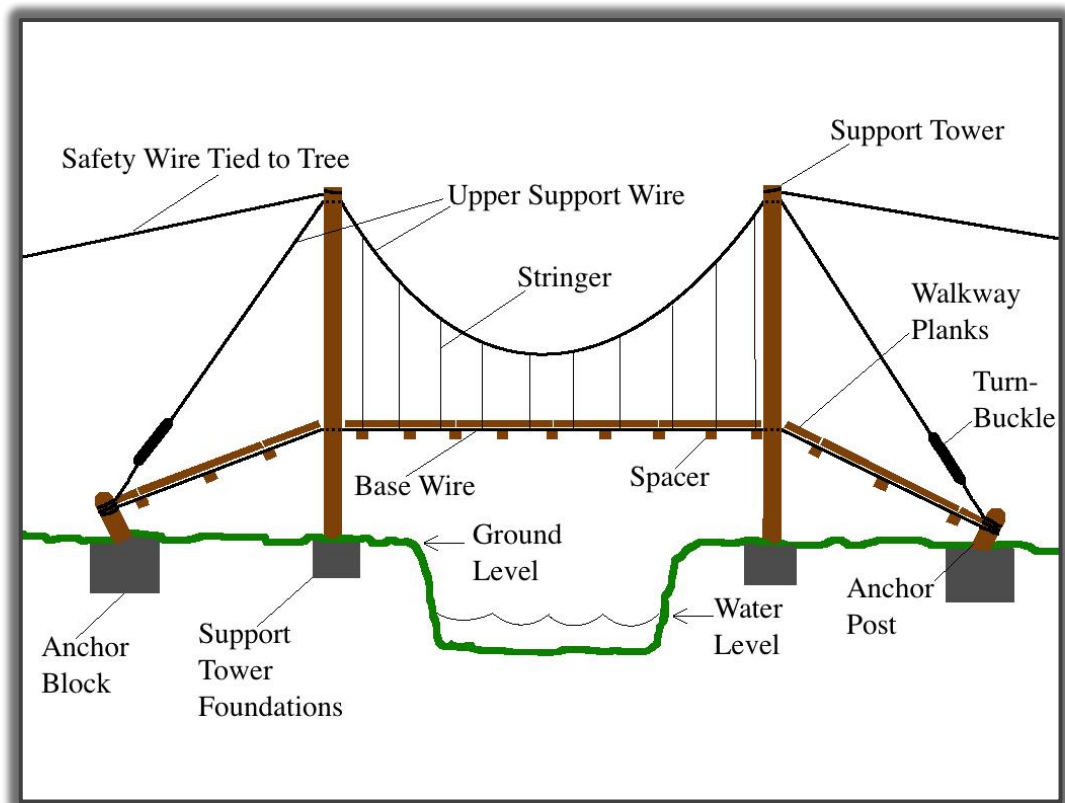
Building Bridges

The *apir long Da’an*, or bridge by the junction of the river Da’an, you may recall is a type of suspension bridge, built by the villagers of Pa’ Dalih using materials that have become available only quite recently. Most importantly, the use of wire rope as the main load bearing component is something that dates from the influx of British and Australian troops during WW2, when the troops used that material, and the ‘confrontation’ period in the 1960s, when the material became available to the local population. Army engineers erected a number of wire rope hanging bridges in the region, and these became the inspiration for a new breed of bridge that spread widely around the highlands, becoming almost ubiquitous where a long-lasting structure is required. Traditionally built bamboo and rattan bridges

are still common, but most Kelabit prefer the more durable modern materials, and given the resources would probably use them exclusively. The suspension bridge at Pa' Dalih is a newer version of the simple hanging bridge, using impressive 7m high hardwood towers on each bank to carry a pair of upper supporting cables, and a pair of lower base cables onto which is fixed the wooden walkway (for a diagram, see Figure 40 below). All four cables are then anchored into large concrete blocks set into the ground behind each tower. Most of the hanging bridges I saw were constructed by the current generation of senior men, Ganang in particular having a good deal of involvement in several local bridges. However, this bridge was different: it was larger and built to a higher specification than other bridges, and so presented the men with a number of challenges in its construction. This chapter recounts the triumphs and tribulations of the production of the *Apir long Da'an* within the context of relational thinking, especially Ingold's notions of skilled practice, and network theories of heterogenous assemblages.

The activity of production is based on the creation and emergence of material-social relations through the application of skills and knowledge (Ingold 2010). The reconstitution of the material world through acts of production is easy to see - in this case we end up with a bridge. But at the same time, going through the process of production leaves a mark on the people who are undertaking the work. Watching people making things, it is clear that they are also going through a process of transformation, in much the same way as the materials they are busy working on. Whilst materials change according to the work applied to them (through reduction or assembly), people also change through the act of production - gaining experience and becoming more knowledgeable and skilful individuals. The transformation process is mutual and lasting; the relations that are formed among workers, tools, materials, skills and so on, are durable through memories, embodiment, and physical alteration. This is similar to Bourdieu's classic ideas about *habitus*, as the inculcated bodily norms of behaviour, expressed through subconscious everyday activities (1977). The practice of these actions, especially repeatedly, fixes within the body a sense of the requirements that go to reproducing that activity. As described below, when faced with a familiar

engineering performance, experienced engineers were able to perform the required actions with little recourse to anything other than their past experiences. This is especially true of practices that appear relatively simple, but in fact need a substantial body of experience to be able to perform with virtuosity and effortlessness. So rather than considering an engineering project as the creation of an object, I see it as part of the on-going creation of relations between people and their environment, including the effect on them, and the use by them, of skills, materials and tools.



*Figure 40: Main components of the Apir Long Da'an suspension bridge
(drawing by Jasmine Ewart)*

Describing the process of production in these terms brings out two important points for consideration. First, it calls into question the assumption that the human world is separate from the natural world, since they are inextricably dependent on each other for their mutual and continual re-creation (Latour 1993; Ingold 2000). Effecting a physical transformation on the world around us requires tools and techniques, but to carry out that work brings the qualities of materials and environmental resources into play. The work to be done is determined by a

combination of the person and the environment he seeks to transform (Ingold 1987, 2000), so that the act of production demonstrates that the effects acting on each are in some way commensurable, at least methodologically, even if not actually (Law 1992).

Secondly, talking of a process of production suggests a sphere of activity delimited in some way, either temporally or spatially (Wallman 1979). But the people involved in the process come into it carrying with them a set of skills gained through previous life experiences, and leave the process with enhanced or different abilities. Their life is unlikely to be bounded by the process: they will move on, taking their new experiences with them. Similarly, the materials and components used in the project did not set out with any intention to become part of that construction, and are not destined to remain so. Wire ropes came from somewhere, will become part of the new bridge and will ultimately go on to something else in years to come. *Belian* hardwood came from the forest, became towers and planks, and will soon rot away or be re-cycled, according to the vagaries of fate. This point will be developed further in the next chapter: Deconstruction.

This represents an approximate starting point for relational thinking in the context of production. If people are not so special, but part of a larger system, then we need to pay more attention to the system and the place of people within it, rather than starting with people and seeing what effects we have on the world around us. The concept of sociality becomes redundant in the light of the expansion of relations that our place in the wider world affords us. If we are affected by our interactions with wood and wire rope, then those things need to become part of the system of relations in which we place ourselves (Law 1992, Latour 2005). This approach of course seriously complicates matters by insisting that we account for material relations in the same way that we account for social relations. However, it seems true to say that not all relations are equally important, some personal and material interactions will be fleeting and inconsequential, whilst others will prove to be more significant.

Organizing People and Things

My involvement with the *apir long Da'an* bridge began in late 2008, during a chance conversation with Jolly, brother of head-man Anderias. As he works in the oil industry, Jolly is often away from the village, but is still one of the most influential members of the community. We began to talk of life in the village and his desire to improve the lot of the villagers, many of whom did not have the same access to cash and resources as he did. He mentioned his on-going plan to construct a new bridge, currently hampered by the cost of materials and transport to get them up to the Highlands. Along with Anderias he had begun to gather together some of the materials required, notably the wire rope, but was frustrated by the relative lack of progress. This was my first visit to Pa' Dalih, and I was keen to find examples of large-scale local engineering and production, more unusual than the ubiquitous house-building. I offered to explore the possibility of getting funding from the UK to help purchase materials and organise the construction, on the understanding that I would be able to document the whole process. By the time of my next visit in April 2009, a UK charity had agreed to provide funds for the bridge, after I had made a case for on-going regional problems caused by commercial logging.⁴⁰ With funding in place and a design agreed, Jolly set about acquiring the materials required for the construction of a modern bridge. Sources included Miri, with its host of Chinese hardware shops, local suppliers in the Kelabit region, and villagers' use of the immediately surrounding forest. This eclectic mix provided an equally disparate set of components and materials, to be cajoled into shape by the villagers.

Objects purchased from Miri include, from the Chung Siong (Lutong) Trading Company: 8kg of nuts and bolts, 20 shackles, 4 turnbuckles, 18kg of wire, 2 rolls of wire netting, a paint roller, 4 drill bits, a screwdriver, a cold chisel and a tapping screw. From Jiun Shun Hardware Trading: 15 bags of cement (25kg each), 2 rolls of plastic coated wire, a set of tensioning strops, and 9kg of nails. Subsequently, it was decided the turnbuckles were too lightweight, so another larger set was purchased, along with more shackles. Jolly had already acquired the

⁴⁰ Artists Project Earth, a charity that specialises in helping rural communities affected by the causes or consequences of climate change. See www.apeuk.org Project no. 118: The Pa' Dalih Bridge project. Accessed 1/3/2011.

wire rope, some of which came second-hand from a crane (a very high specification rope) and some, of a lower quality, bought new. The hardwood was supplied 'cut and squared' from a Kelabit / Penan settlement two hours drive away to the south-west: 4 pieces 5"x5"x12 feet long, 8 pieces 4"x4"x5 feet long, 140 pieces 5"x1"x6 feet long, 50 pieces 3"x2"x3 feet long. Sand was collected from beaches along the river-bank, approximately 50 x 25kg bags. Stones also came from by the river, larger ones near the site and smaller ones from various nearby natural piles, approximately 1000kg in all. These were the permanent materials, all of which were intended to be incorporated into the structure, but there was also a range of temporary materials used in the construction process and subsequently discarded. Rattan for temporary bindings; large branches and bamboo used for stakes, scaffolding and temporary support; smaller branches and bamboo used as fuel for the fire, temporary tools, cooking utensils, and to construct a shelter, along with 6 sheets of corrugated aluminium. We could also include parts of the forest in situ as building materials: large trees used as anchor points for safety back-up wires, overhanging branches used as tie-off points, the bedrock to which the anchor blocks were attached, even the space around the bridge cleared to allow access.

As a large project, construction of the bridge required the marshalling of substantial resources for such a small community. The Kelabit way of dealing with that type of requirement is through a semi-formal system of labour exchange (*kerja sama*).⁴¹ Organised through the church, this provides a means by which villagers can cope with labour intensive tasks especially in the agricultural cycle, but also for large-scale projects such as the construction of the bridge. The system is semi-formal, in that although there is a list of names taken of those present at the start of the day, an individual can opt out of the work by making a donation to the church. The amount of the donation is very small, especially for those with finances coming in from outside, and Anderias, the headman, had plans to substantially increase the amount. Within the village, it was seen as bad form for

⁴¹ The Kelabit have two terms for their communal labour system. As well as *kerja sama*, which some informants described as being organised by the church, they also use *gotong royong*, which tends to be privately organised and funded. However, to many there was no difference, and for my purpose both terms have the same meaning.

an able bodied man (or to a lesser extent woman) not to turn up to the majority of the *kerja sama* work parties.

I saw several *kerja sama* in my time in Pa' Dalih and my impression was that a core of people turned up to virtually all of the agricultural work parties, and a different group of people turned up to the 'special' non-agricultural work parties. Most of the people who laid a large concrete slab for a new volleyball pitch, also constructed a temporary shelter for the Malaysia Day celebrations, and were the same people that did most of the work on the bridge. There were a few exceptions, including Jeffrey Malang, who grew to be a good friend. When I talked to him about this, his response was that since he would never use the bridge, why should he help build it? Jeffrey and his family came from Batu Patong, in the opposite direction as the bridge⁴² and it is tempting to suggest that this was a determining factor in who attended. Soon after the new bridge was finished, in May 2010, a bridge en route to Batu Patong was washed away in heavy floods (as were several others in the village), stranding Jeffrey's elderly parents in their field-hut for several days. That section of the village complained that they were not given priority in repairing the bridge and organised their own work party to fix it. Organizing people to undertake relatively large-scale projects is not simply a technical requirement, it also depends on social and institutional arrangements (Hunt 1976; Kelly 1983), and in this case, the apparent divisions between the sectors of the village were played out in the need for bridge building and repairing.

Assembling together such a disparate set of elements to form a complex mixture⁴³ such as the bridge, is a good example of what John Law calls 'heterogenous engineering' (Law 1987; 1992), adopting an actor-network theory approach. Actor-network theory (ANT) is essentially a reassessment of the relationships

⁴² Batu Patong was abandoned in 1976, leaving the longhouse behind, which forms the case study for the Chapter 6: Deconstruction.

⁴³ And here I use the word in the sense outlined by Webmoor and Witmore, who differentiate things from objects thus: "things are an entangled aspect of what it is to be human, and that many people (materials and companion species) are always folded together into a thing" (2008:59). Conversely, 'objects' retain the intellectual and historic baggage associated with the opposition between culture and nature – a dichotomy that advocates an either/or stance and resists *mixture* (*ibid*: 60).

created by people's involvement with the world around them. For advocates of ANT, the traditional concept of sociality is the basis of a system of interpretation that fails to account for the influence of non-humans in social explanations of the world. By their account, the social element is not necessarily special, or if it is, it is not assumed to be so from the start. Relations created by the interaction of people with tools for example, are predicated on the understanding that the combination of person with tool is a different actor than either of those two things separately. The interaction of that tool-person 'hybrid' (Latour 1993[1991]: 41-43) with further things such as wood, cement and nails begins to form a network, which becomes complete when we then include other matter such as politics, ideas, transport links and so on. ANT, and the concept of heterogenous engineering outlined by Law provides a descriptive device for the analysis of relationships forged in the variety of parts that make up an effect like 'construction'. As Latour (2005: 8) says:

“Using a slogan from ANT, you have ‘to follow the actors themselves’, that is try to catch up with their often wild innovations in order to learn from them what the collective existence has become in their hands, which methods they have elaborated to make it fit together, which accounts could best define the new associations that they have been forced to establish.”

Methodologically this approach depends on investigating the hives of activity and ignoring the centrality of humans within the process – the effect comes out of a distributed agency across the whole network of people and things. “This then is the crucial analytical move made by actor-network writers: the suggestion that the social is *nothing other than patterned networks of heterogenous materials*” (Law 1992: 381, emphasis in original). Although that is not the same as suggesting that humans are the same as things, which Latour says would be an absurd symmetry between humans and non-humans (2005: 76), where both are equally ‘alive’.⁴⁴ It is instead a methodological ploy, insisting on a neutral stance, equidistant from both: this is the concept of ‘generalised symmetry’ (Latour 1993[1991]: 94-96).⁴⁵

⁴⁴ Latour dislikes the term ‘actor’ for this very reason, preferring the term ‘actant’ (1999).

⁴⁵ The point should be made that this is not to be seen as an ethical position, equating the moral standing of people with that of animals, or things: “To say there is no fundamental difference between people and objects is an analytical stance, not an ethical position... We don’t have to

So the network we could see come into being in the production of the bridge, consists equally of all those materials listed above, as well as the people who were engaged in transforming them, their tools, politics, the trees, the *kerja sama*, in fact anything which could be seen to have an effect on the activity. The construction of the bridge is one manifestation of the network of effects, and so too is technology, as is society (Law 1992). Analytically, production can be seen to be the effect distributed throughout the network of interactions between the combinations of people and things. Of course wood and wire are inanimate, but they do possess an ability to affect the people who come into contact with them, and for ANT, this is the means by which the symmetrical relationship comes to life. A person coming into contact with hardwood posts through a mediating chainsaw is the group of actors that combine to form a human/non-human 'hybrid' and it is the effect caused by the hybrid that takes its place within the network. The network is made up of these effects – large numbers of hybrids all acting to make things happen. By this analysis, the production of the bridge could be seen as an effect created by a series of interactions between the people and their tools and materials.

“...a bridge can be viewed as an arrangement of more and less effectively stabilized material and social relations. Most obviously, of course, the stability of the bridge is a matter of its materiality, based in principles and practices of structural engineering. This material stability is inseparable, however, from the networks of social practice – of design, construction, maintenance and use – that must be put into place and maintained in order to make a bridge-building project possible, and to sustain the resulting artefact over time” (Suchman 2000a: 316).

At a macro-level this seems to hold true, but construction, as one of Suchman's 'networks of social practice', is made up of individuals entering into skilled performances in a way that seems to fall outside the analytical scope of such an overarching scheme, as described below.

deny them the rights, duties, or responsibilities that we usually accord to people” (Law 1992: 383).

Mundane Skills

With the site chosen, and organization of the *kerja sama* work party in place, bridge construction began in July 2009. At 8.00 a.m. the bamboo gong sounded to let the villagers know that work was about to begin, although for most people the exact time was not too important, they would appear over the next couple of hours or so (As Wallman (1979) describes, the concept of when someone was actually working is culturally specific). On this occasion, the first *kerja sama* for the bridge, there was a definite sense of purpose as a group of 15 men walked the ten minutes along the forest path to the site, carrying their woven rattan and bamboo backpacks (*bakang dalai*) full of tools and food. When we arrived, the area had already been cleared of undergrowth and a temporary bamboo and tin shelter set up. Under the shelter were rolls of wire mesh, striped plastic bags full of large bolts, and cardboard boxes full of nails and the various fixings brought in from Miri. To one side was a neat pile of hardwood planks and posts, and several bags of cement.

Amidst a general murmur, Isi Berawan set about collecting firewood and expertly splitting it, then piling it up near the shelter. Once this was lit, the group gathered around and the Pastor said a prayer, hoping for good quality work and no accidents. The Kelabit are a devoutly Christian people, going to church almost every day, with a particularly energetic and well-attended service on Sundays. This ceremony, of the Pastor saying a prayer around the newly lit fire, was a feature of many of the subsequent work parties, and even on those occasions when the Pastor was not present one of the senior members, usually Anderias, would fill in. The religious aspect of the construction should not be overestimated however; Christianity is ubiquitous in Kelabit life, and this project, despite being unusual, was not one infused with exceptional spiritual significance. There was no sense that what the Kelabit were doing here was anything other than a practical project, and the call to the divine was a matter of everyday courtesy. Shortly after work had started, a group of women appeared, carrying pots of food, and set up around the fire ready to start cooking.

To begin the project, the first major task was to dig the foundations for the various concrete blocks: one anchor block on each side of the river, and two per support tower on each side of the river. Getting the anchor blocks finished was important, since they were about 2m long, 1m wide and 1m deep, and that volume of concrete needs several days, and preferably weeks to set completely, before it would be wise to put any strain on them. Whilst the men dug out the holes, many of the women, some quite elderly, went down to the river bank below the site carrying empty sacks and a couple of spades. They filled the sacks with sand and carried them up the bank, emptying them out in a pile next to the hole. My efforts, although appreciated, were less than effective due to the weight of the sacks and a limited ability to walk up the slippery slope, even in the plastic football boots that everyone wears. As the hole and the pile of sand beside it grew, the villagers began carrying up stones from the river, the third ingredient required in making concrete. A chain of villagers formed from the riverbank, up the slope and over to the foundation hole, a mixture of young and old, male and female, passing along stones about the size of your hand, and piling them up by the sand.

Once the hole was dug, the bags of cement and piles of sand and stones were mixed to make up the concrete. Several of the men took turns in doing this, but one stood out as having a beautiful technique, much admired by those watching. Robert was an experienced builder, having worked on a number of projects, usually houses, and because of this his semi-official role in the project was that of 'foreman'. Many men (and some women) will have some experience of mixing concrete, whether in the UK or in the Kelabit highlands, and know the basic principle of mixing sand, cement, water and stones, then pouring it out and leaving it to set. When we watch a 'craftsman' at work, we often marvel at his or her skills in creating something that we might feel is beyond us. There is a certain 'magic' involved (Gell 1999). Ordinarily, if we were to stop and stare it would be because of the beauty of the object produced, or the complexity of the activity undertaken, but to see Robert mixing concrete, and to see those around him watching was to experience the same sensation. Robert is a stocky man with large hands, and to see his enthusiastic lumbering on the football pitch contrasts remarkably with his delicacy in manual work. In his hands, the shovel is as much

an instrument of craft as the woodworker's chisel or the artist's brush. He puts a shovelful of cement into a pile of sand, and sets about mixing it. But rather than picking up a load and turning it over back on top of the pile as most men do, he flicks the shovel with a practised wrist so that the sand and cement mix in mid-air before falling back on the pile, slightly to one side. He then picks up another load and does the same, repeating the manoeuvre so that the pattern in the air is mesmerizingly consistent. Mauss, in his hugely influential discussion of 'techniques of the body' ⁴⁶ describes common activities such as swimming, running and even walking, as dependent on a cultural upbringing. He then extends the argument to include more specific uses of the body, learned through experience:

"In this case all that need be said is quite simply that we are dealing with *techniques of the body*. The body is man's first and most natural instrument. Or more accurately, not to speak of instruments, man's first and most natural technical object and at the same time technical means, is his body" (1973: 75 emphasis in original).

His famous example of the difficulties English troops had in using French digging tools during WW1⁴⁷ resonates in this discussion of Robert's use of the shovel.

Looking down at the pile of sand is to see it transform with a series of soft thuds from orange to grey remarkably quickly, as the two materials are effortlessly and completely mixed. Others, even those with experience of mixing concrete were not able to do so with the same degree of elegance or efficiency. This is still a mundane practice, not something to be overly valorised, even though it was clear to see that those looking on did so with admiration, and in Ganang's case not a little jealousy.⁴⁸ Robert with his shovel responded intuitively to the pile of sand and cement in front of him, as well as the interventions of his colleagues, the

⁴⁶ Originally published in French in 1934

⁴⁷ During a visit to the Imperial War Museum in London, I was surprised to see an archive film of English troops digging a trench during WW1. They used an implement something like a mattock, swung from the shoulder and bending the knees, giving an almost comic effect to the film as their heads bobbed up and down in the trench. This would be very different to using a 'standard' shovel, and may explain the apparently baffling idea that English troops were unable to use French digging tools.

⁴⁸ Ganang tried very hard to match Robert's skill at mixing cement and was very serious in his efforts. Because of this he was effusive in his praise, having realised more than most the level of skill involved.

smell of cooking, changes in temperature, insects landing on him, the subtleties of the materials and his bodily engagement with them. He is carrying out a mundane practice, not a set of deliberated actions, in fact much of the time he is preoccupied with what is going on around him, the act of mixing was secondary to all manner of other things, many of which I could not see.



*Figure 41: Robert mixing
cement*

Not only was this a skill learnt through practice, it was also an innate skill that he had, more so than his peers. To take an ANT perspective would talk of the man-shovel hybrid, an actant enabled to create certain effects, one node in the network of a larger set of effects created by other hybrids of human and non-human entities. This seems slightly nonsensical, ignoring the particularities of this situation, it was Robert that was performing a skill that he had learnt and embodied. Other people including Ganang, another experienced builder, and me, a sometime DIY'er, tried to copy Robert's actions, but even with his amused tuition, we failed. The concrete and the effect of providing anchorage, through the mixture of homogenous elements including sand, cement, Robert and the shovel, is surely better seen through his skilled practice than as an abstract network. Ingold has riled against this abstraction (2008, 2009), suggesting that at best it provides a bland assessment of creative relationships, and a bizarre concept of the relative powers of agency between inanimate objects, animals and people. The

key activity we can observe in this event is the skilled practice of an individual engaging with familiar materials. Through the practiced use of the shovel, he was manipulating powdery cement with coarse sand to create a homogenous whole. “And what people do with materials, as we have seen, is to follow them, weaving their own lines of becoming into the texture of material flows comprising the lifeworld” (Ingold 2010: 96). Describing the performance as such places Robert within the context of the rainforest riverside, and the creation of cement as a non-discursive revelation of the potential for those materials to become something new. The degree of mixing was not preplanned, the amount of water added was not carefully measured out, but these actions came from seeing the mixture evolve, and the feel of it through the handle of the shovel.

So far I am in agreement with Ingold, that to see the execution of skilled performance, need not be artistic, but may include the technical (Ingold 2000: 294-311), and the ‘doing’ is what is important. Similarly, as discussed in my first ‘Diversion’ – to have instructions is not enough to complete a complex task, it requires the embodied experience of skilled individuals to translate the abstractions represented in drawings, documents, verbal advice and so on, into an actual thing. But, following directly on from the quote above, it seems we have a problem:

“Out of this, there emerge the kinds of things we call buildings, plants, pies and paintings. In the very first move that isolates these things as objects, however, theorists of material culture have contrived to rupture the very flows that brought them to life” (2010: 96-97).

The jump from a skilled individual performing acts such as Robert mixing cement, to an emergent building is a leap too far. Many of Ingold’s examples of skilful production are based on accomplished craftsman (basket-weavers 2000: 339-348; bag-loopers 2000: 349-361; reindeer lasso-ists 1993a; machinists 2000: 300-301; carpenters 2011: 51-62, along with a sprinkling of musicians, train drivers, artists etc.), whose actions are both skilled and individual, and it is they, he suggests, that we rely on: “For makers have to work in a world in a world...and with materials that have properties of their own and are not

necessarily predisposed to fall into the shapes required of them, let alone to stay in them indefinitely” (2010: 93). The concept of the ‘taskscape’ is Ingold’s way of dealing with this issue (1993c), essentially a discussion of temporality and the relationship between the land and the activities that can be seen and heard within it, he describes the taskscape as an array of related activities, or using musical performance as an analogy, the “complex interweaving of very many concurrent cycles” (1993c: 66). However, an engineering construction is not the result of a group of skilled individuals each contained within their own bubble of competence; they are brought together and organised into a coherent entity. This is the misunderstanding that appears in Turnbull’s description of the builders of Chartres cathedral in the thirteenth century. “Chartres resulted from the ad hoc accumulation of the work of many men” (1993: 315) he advocates, on the basis that the architecture is filled with idiosyncrasies and even some mistakes. His argument is that the building process did not depend on plans and designs, but was essentially made-up on the spot. Without suggesting that it would have been impossible without a design, I do think it would have been impossible without a plan. Before the masons could begin, materials had to be shipped in, the site prepared, the religious and economic imperatives sorted out, as did accommodation, food, blacksmiths, labourers, scaffolding and so on and so forth; the list goes on. It was not, after all, purely by chance that the cathedral appeared. As he later describes “Along with the cathedral came not only the emergence of the role of the master mason, the master carpenter, the glazier, and the sculptor but also the lodge or guild...” (1993: 329). To describe the productive acts of engineering then requires consideration of how the skilled practitioners coalesce and their personal practices coincide to produce the large-scale or complex artefacts that I am interested in here, something that a network approach seems to so quite well.

Contra-ANT, watching Robert mixing concrete, I did not see a Robert-shovel hybrid producing an effect within a network of local sand, imported cement, divisions of labour, sand-flies and so on. What I saw was a mesmeric performance. That he was able to perform this activity was part of his engagement with the environment in which he found himself, facilitated by skills that he had

built up and embodied throughout his life. He was actively engaged with his tools, continually and minutely altering his actions according to the feel of the materials to maintain what appeared as remarkable consistency. For Robert to flick shovelfuls of sand and cement was a rhythmic process that in a small way demonstrates the poetry of life – something missing from the hybrids and effects of ANT.

However, while the concept of heterogenous engineering (Law 1992) provides a realistic, albeit slightly bland description of the assemblage of a variety of people and things to form new relationships, this is limited to a perspective based on those actants that produce effects within the scope of the network under investigation (Law 1987 – Portugese navigation, Latour 2002 - hi-tech engineering, Law and Mol 2008 - foot & mouth disease etc.). By this analysis, the effect is the result of a series of interactions between particular hybrids with an analysable outcome. The network has to be curtailed to remain manageable, otherwise it would spiral out of control, so for Law, the Atlantic currents are irrelevant until the Portugese explorers encounter them. That is not to say that the currents only came into existence then, nor that Law is denying knowledge of them before then, but it is to say that only when they come into the network are they relevant. For the sake of analysis, they are unimportant until they are able to hybridise and create an effect, through the agency distributed over the network. This idea, that the ‘effect’ is society (or organizations, or people, or machines etc. Law 1992: 380) depends on restricting the extent of the network to manageable proportions, and treating it as a separate entity. So the ‘effect’ (most controversially in my view, that means society or a person, as well as the less problematic organization or machine) is restricted to the set of materials (human and non-human) outlined by the analyst, and seen by them as being active. An understandable methodological tactic - since the alternative is a relativistic attitude implying that everything is relevant - but not entirely satisfactory.

The network is inherently human, designed to provide explanations to the workings of human life, and not for example the life of sheep (Law and Mol 2008). The influence of non-humans is conceded, but on human terms. For

example, as Jones and Cloke point out, the apparent influence of trees in creating the different environments of their examples takes place over decades, if not centuries (2008: 79-96). To see the entire performance of that event, in the tree-scale of time, could be ‘fast-moving and ever-changing’ but at a human scale is quite the opposite. Human intervention is not the only, or indeed most important, perspective, and ANT does not deal well with the concept of a mechanism that requires humans only sporadically, if at all. There seems especially to be a problem of recognising the on-going effects of non-human actants. The impatience of network analysis, driven by the emphasis on action, and only action that involves humans, leaves out the on-going and powerful actions of the world at large. The action that is going on in the creation and maintenance of these networks is thus only the action that the analysts sees and considers to be effectual, and not the complicating panoply of life as a whole (as illustrated in Rambo 1983: 26).

Relational thinking in network terms is limited by the practicalities of analysis and concepts of significance. ANT especially is a model of the world that does not seem to accord with the world as seen by the participants, despite its invocation to follow the actors. In that model, a person picking up a tool becomes a human-tool hybrid until such time as the tool is put down and the person goes about some other business. This represents a continuously staccato existence, where the hybrid is intent on one task, oblivious to the outside world, until it becomes disconnected and re-hybridised as something else. In reality, as Ingold portrays, the act of production is an on-going process, where the participants are fluid in their activities, constantly adjusting themselves to the environment, and continuing in their daily existence with no sensation of jumping into and out of the analyst’s model.⁴⁹

Adapting Skilful Practices

Largely thanks to Robert’s skill, the concrete anchor blocks were made by layering mixed cement with stones and wire mesh as reinforcement, with inset

⁴⁹ I am reminded again of Keller’s critique of the *chaîne opératoire* methodology (2001), in which he points out that the observer’s analysis is very different from the practitioner’s experience of the same activity.

belian wood posts that would act as the anchor points for the main wire ropes. These were left to set for several weeks while the rest of the bridge was erected. To do that, the first task was to fix a level across the river, a datum point used to set the height of the walkway and to ensure that both sides were loaded equally by the pull of the wires and weight of the structure. Normally this would be done with a tube of water, the height of the water at each end being level, but the distance across the river was too far. Ganang came up with a novel solution, which was to set a level between a convenient tree and a post, set in line with the tree and the opposite bank. Fixing a nail in the tree, and another in the post, levelled up with a water tube, meant there was now a level sightline. Standing behind the post, he could look along the line of the two nails and call to someone on the far bank to direct them to the same level on that side, marked there in a tree with a chop of the parang.

With a level marked on each side of the river, there was a datum from which other measurements could be taken, most importantly in the construction of the two support towers, one on each side of the river. Each support tower was made up of two pairs of 24' (7.5m) long wooden posts, connected together by a cross piece at around shoulder level, another at the top, and two posts arranged in an X shape holding it rigid (see Figure 1 above). Since it was difficult to get posts as long as 24' (7.5m) they were made up by connecting two 12' (4m) lengths, with a joint based on house-building techniques (see Figure 33 above). However, the house joint is much lower to the ground, and part of a fairly inflexible structure. As used on the bridge, the joint is 2m higher, and part of a structure that is required to flex as people walk across. The joint was being put to a use that was new to the builders, which they addressed by ordering custom-made support plates. These were intended to be fixed on either side of the joint so as to sandwich it between them, and bolted through. Unfortunately the intended bolts were too short to fit through the combined thickness of posts and a plate on each side, presenting a perceived problem in the strength of the joint (see Figure 42 below). After much discussion and experimentation, this was resolved by abandoning the reinforcing plates and focussing on the quality of the joint. The angled lap joint works by

providing a fairly large area of contact between the two posts, with commensurate amounts of friction. Ensuring that the joints were cut accurately maximised the contact area and the levels of friction keeping the two posts together. An extra bolt was also used, so the two surfaces were more effectively pressed together, adding to the effect. Whether the overall result was more or less successful than the planned reinforcing plates is unclear, but the application of substantial and varied skills and knowledges produced a result that seems to work.



Figure 42: Support tower joint, with unused reinforcing plate

Skills of housebuilding were used and extended to suit a new situation. Whilst setting the level and fixing the joint may each seem fairly trivial, the effect of having done these incorrectly would have been significant. It was noticeable that for example, many of those working at the time were surprised at the difference in levels between the two banks, and asked Ganang to go through his method so they could check the result. It was of course quite accurate, but by guesswork alone the tower on the far side would have been perhaps 2m lower than level, upsetting the balance of stress on the structure, with unknown but potentially serious consequences. The fact that this solution was arrived at without a great deal of

fuss masks its importance in the overall scheme of things; there was in that episode a great deal of ‘inaction’, it was soon forgotten and the more strenuous activity of building work continued. But it is important to note the periods of inaction, much happens of great importance in ‘inactivity’. If no easy solution had been found, and great amounts of time and energy had been expended on attempting and failing a variety of other solutions, activity would have been more noticeable and given a commensurate amount of attention and importance to the effect. That is, the combination of people, materials and skills that came together to form the level on which the bridge was subsequently based. For followers of the ANT approach, the effect (the level) would have been of greater consequence if it had been achieved through greater action, whereas in reality, the effect is the same (i.e. a level is created), it is the practice of achieving it through adaptation of experience and knowledge that is different, and thus of interest.

For a joint to have been considered as potentially suitable in the first place, there needed to be some amount of confidence in recognising the relative similarities of performance. There was no inherent need for the joint to have been an angled lap joint, nor for there to have been a supporting metal plate. Transferring the joint from housebuilding to bridge building was not too much of a leap of faith, and in the absence of other candidates was the obvious choice. Why then did the engineers deem a metal support plate to be necessary? The simple answer is that the loading on the bridge would be greater than, or different to, that experienced by a house joint, and hence required reinforcement. However, the design of this object as discussed above, was intuitive and not based on specific knowledge, so the types and values of loads were unknown. A house after all is much larger than the bridge, and subject to more frequent strains in humans moving about above, and water buffalo pushing wooden uprights from below. The consequences of failure in either situation are probably equally catastrophic and safety would be of prime importance. So it was by no means certain that a joint could be fashioned that would satisfy the engineering and social requirements of the bridge, through on-the-ground application of skill and experience. Having discarded the metal plates, the joint had to be made coherent (in Suchman’s terms, i.e. relevant to this

object), within the contexts of safety, knowledge of housebuilding, tools and skills. The problem of the joint attracted a great deal of material and human activity, lasting many hours. The custom-made metal plates had been difficult to organise since the closest equipment capable of making them was in Bario. Longer bolts would have had to come from Miri, probably taking several weeks, so a great deal of effort was put into looking for longer bolts in the village or nearby, somehow joining two bolts together, adapting the plates and the posts to reduce their overall thickness, and eventually coming up with the agreed compromise of adding in an extra bolt and making sure the joint was well made. It then became imperative that the wood was accurately shaped to allow for a reasonable degree of satisfaction in their strength and safety. The joint had already been cut prior to trying to fix the metal plates, but at this stage the fit between the two pieces of wood was not particularly accurate. The task of re-cutting the joints was given to Robert and Judine both notably skilled in the use of the chainsaw. By holding the two pieces of wood together and pressing the chainsaw down between them along the line of the join, a cut was simultaneously made on both pieces, guaranteeing a tight fit. This technique was evidently new to some of those watching, and required a fair amount of bravery since there was a chance that the wood could snatch and throw the saw or the wood itself. For the Kelabit engineers however, the resolution of this problem was routine, as was the act of cutting the wood for Judine, and ultimately, the joint was cut and the posts bolted tightly together.

A firm joint between the two major components of the most significant structural element of the bridge is obviously important, but no more so than balancing out the forces across the structure as a whole. In the two instances where these critical activities were undertaken, a similar process of gathering together skills and knowledge took place. In the first (setting the level) it was a low key and seamless movement of action that enabled the next phase of work to continue. The second (joining the posts) was an equally seamless flow of action, requiring the same activities and enabling further work to be carried out. The difference was that in the second instance the flow of work moved from one aspect of the joint to the

next, rather than from the joint on to something else. It would be wrong to see the work done to finish the joint as a rupture in the flow of activity, it was in effect part of the same process, the use of skills and knowledge in dealing with the materials and tools at hand.

Engineering the Environment

Fixing together the posts to form the uprights allowed the Kelabit engineers to continue constructing the support towers. The 24' (7.5m) long jointed posts were connected into an elongated H shape with the addition of cross pieces top and bottom, and hauled into place over the holes dug near the river bank which would act as their foundations. The towers were pushed into place by a team of men and held upright with stakes cut from branches whilst the holes were filled with concrete and stones. The extra stiffening pieces forming an X shape near the top of the tower were left off until it was upright, to keep the weight off the top and make it easier to lift into place. Once the towers were up, standing proud at a considerable height, and the concrete set, it was necessary to climb up the tower to fix these pieces, by drilling holes through and bolting them into place. Several of the Kelabit men went into the surrounding forest and returned with a small tree, chosen for its shape – thin and straight with several small branches protruding. These were trimmed to a stub, leaving enough for a foothold, so that it became a ready-made ladder. The tree ladder was strapped to the tower with rattan and two men shimmied up carrying the drill, nuts and bolts and planks of wood. After some difficulty, the wood was fixed and bolted in place and the tower finished.

Use of the forest in this way as a short-term resource was a recurring feature of Kelabit engineering. During bridge construction various parts of the forest were used as supports, ladders, temporary scaffolding, tools, fuel, entertainment and so on. On a separate occasion, when spending two days fixing the water supply pipe running from the Pa' Dalih river dam to the village this was equally apparent (see Figure 25 above). Where the pipe ran over rivers it was supported with branches of a type known to root fairly well; large vines were trimmed so they could be used, still alive, to tie the pipe up; airlocks were overcome by drilling a small hole, waiting for the air to hiss out, then plugging the hole with a sharpened stick;

branches were used as levers to push connectors together, or fixed in place as a rudimentary bridge; the list goes on. When watching the Kelabit at work, I found myself constantly wondering how they would overcome a situation, and the solution invariably involved some immediate use of the forest environment. For me this was an alien set of tools, but for the locals it represents a familiar part of their world, and one on which they can draw without difficulty. My toolkit is housed in a series of plastic boxes and stored in the garage, and in my mind those tools represent a range of potentials; even tools specifically designed for one purpose, by understanding the principles can be turned to a different use. There is a sense of continuity between the environment and its use: for me the garage and my plastic boxes, and for the Kelabit, the forest. Fixing the water pipe is a regular task for the villagers of Pa' Dalih, not least because many of the repairs they put in place are destined to fail. Sticks get knocked out of the pipe, supports get washed away, bridges rot and collapse and so on. However, for the Kelabit, making things last is an important modern trend. As described in the previous chapter, changes to house design and building practices are predicated on the notion of improving durability. So when talking to them about the repairs to the water pipe, and if these could be more permanent, I was constantly told that they were "made to last", even when accepting that they will invariably be replacing the sticks they put in the previous month. The limitations and potentials afforded by the forest form a strand in Kelabit practices of making; it is literally part and parcel of life. Their engagement with the resources they pick from the immediate environment is a result of their life-long process of making things, and trying out new ways of doing things. They create sets of relationships based on the projects they undertake, and their skilful use of the materials they find around them. Hence sticks become an integral part of the water supply system, and branches become the scaffolding around a new bridge.

For the new bridge, too many trees meant more problems, since large holes had to be dug into the ground and filled with concrete at various points – the foundations for the support towers and the large anchor blocks further back. On one side of the river there was plenty of space, but on the other side, the density of trees, and shape of the ground meant that with the anchor blocks pushed as far back as

possible, the tower foundations were perilously close to the bank. My concern was the apparent undercutting of the river exactly under the foundations, leaving what seemed to be insufficient solid ground. The Kelabit engineers discussed this at some length and decided that as long as the surrounding trees were left in place they would hold the ground together. So, a banning order was put on felling trees immediately around the tower on the far bank to keep it secure.

The potentially destructive power of the river was also evident in the high-water mark, some 3m above its level during construction. Heavy rains regularly caused flooding episodes, carrying fallen trees and large branches along on a speeding torrent, smashing into low-slung bridges and washing them away. The highest known flood level, plus a little extra, was used as the datum point for the height of the bridge. This was well above ground level, which led to Ganang telling a story of the collapse of a bridge on the road between Pa' Dalih and Bario in 2002. In heavy floods, the concrete anchor blocks were pulled from saturated and soft ground by a build up of debris in the river pushing against the bridge.⁵⁰ It would be easy to think of the bridge as an attempt by the Kelabit to triumph over the forces of nature, literally an attempt to overcome obstacles to allow them to carry on their encultured lives. But in a poignant moment visiting the completed bridge with Ganang, while taking photos, I gave him the camera and asked him to take a few photos to show how he saw it. He walked around for some time, exploring many vantage points, eventually ducking into the undergrowth halfway down the bank. Looking at his picture (see Figure 43 below) I could hardly see the bridge, surrounded and camouflaged by the forest. He was most pleased, he said, that the bridge was "part of the forest".

Kelabit relations with the forest are continually created and negotiated. In the context of the construction of a bridge, the physical properties of the forest were mixed up with other sets of meanings and attitudes to form a place suitable for

⁵⁰ Another bridge collapsed in the 1980s between Long Peluan and Remudu as a group of around thirty schoolchildren was crossing, throwing them into the river below. Fortunately none were seriously injured, but the episode still brings back strong memories and thoughts. Children have fun by running and jumping up and down on bridges, and the extra strain this put on the structure, especially over time, proved to be too much. The weight of the structure was out of balance, and the anchor posts were too slim, snapping on one side, causing a chain reaction of failures - breaking the other anchor posts, then collapsing the walkway.

building the bridge. This included the historic association of the place with a bridge, regardless of the problems of its suitability for the new type of construction. This is an important consideration in setting out to understand the entirety of the relations created in the construction process. The forest acts variously as a supporting mechanism for the bridge, in the large trees used as anchor points, it acts as a cultural support in recreating the point of crossing from the past, and reinforces the forest as the basis of temporary resources through its use directly in the construction. The environment in other words, is embraced in the construction process; it is an active part of the bridge. It is not as if certain parts of the natural environment are isolated and mined of their usefulness, providing for a bridge. Instead the environment is continually changing, of its own accord and through the influence of the human population that live there. In this sense, the concept of the forest remains intact and unchanged. The bridge is not an imposition that radically alters the environment, instead it becomes part of the ongoing flow of environmental change, wrapped in the same processes of decay and regeneration that the rest of the forest experiences.

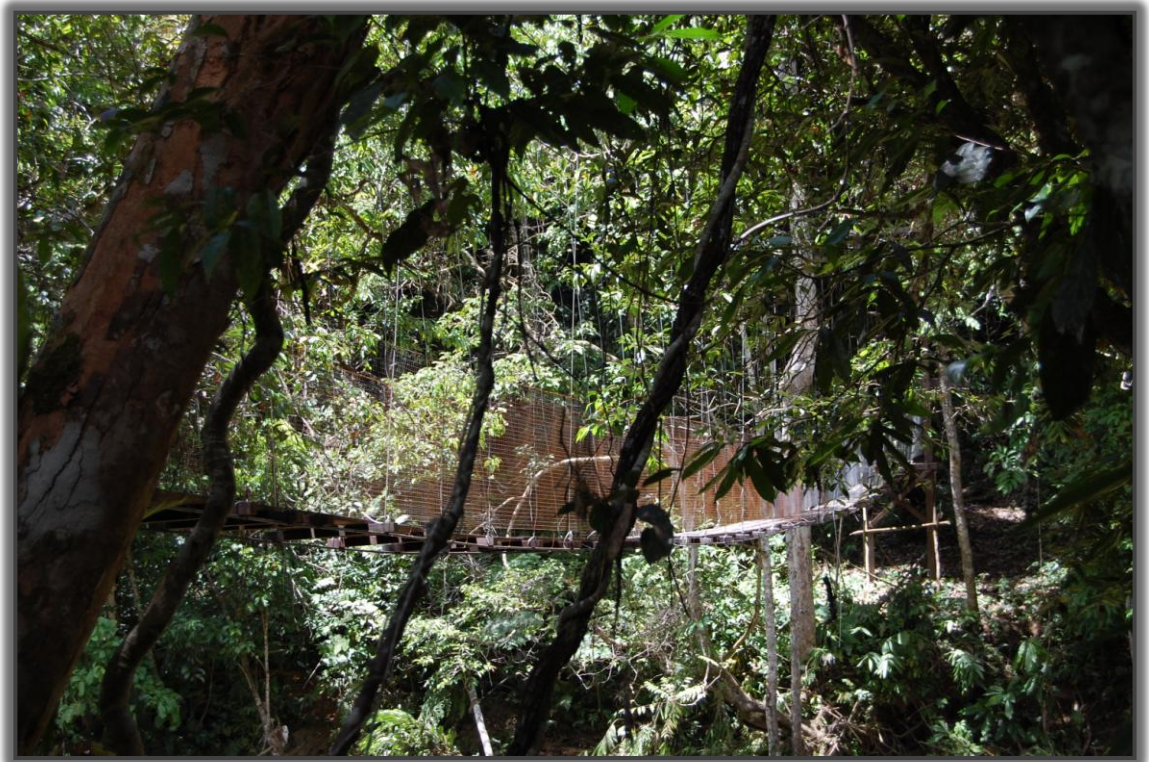


Figure 43: Ganang's photograph of the new bridge

Making by Eye

Marchand, in describing how Yemeni minaret builders surveyed an older standing building to get a feel for how to build a new one for the first time, claimed it was intuitive. Their know-how, they said, was already in their heads and just needed to be brought out. No calculations or drawings were required, it was “all in the eye” (2010a: 193). This form of engineering, predicated on experience and the ability to transfer knowledge from one context to another is, it seems, far more common than the Western scientific notions of pre-planning and detailed design (see also Turnbull’s descriptions of thirteenth century cathedral builders (1993), discussed above). As Marchand has pointed out, “the mental representations we possess as humans are not restricted to those that can be defined in language” (2010a: S102). To engineer something is based on a way of thinking that is dependent on a non-discursive reflection of analogous situations, or to put it another way making something that ‘looks about right’.

After several weeks of work, the support towers and anchor blocks on each side of the river were ready to accept the main wire ropes, a pair running over the top of the towers and another pair lower down that would act as the base of the walkway (see Figure 40 above, for a reminder of the main components of the bridge). The pair of base wires was tied to the anchors, slung across the river and pulled tight. The top wires were seen as being of greater importance, as they were to hold the main weight, and were pulled into place with more care. Each was tied to the anchor block with a turnbuckle (see Figure 44 below - a large twisting hook bolt that can adjust the tension of the wire), fed through a hole in the top of the support tower by a man sitting astride the top cross-piece, then taken by boat across the river. The wire was then hoisted to the top of the opposite tower, similarly fed through a hole and down to the anchor on that side, before being fixed with another turnbuckle. The whole process of putting the four main wires in place took two days, involving ingeniously splitting and splicing the rope into loops, fixing connectors at the top of the towers, and setting auxiliary safety lines from the top of the towers to nearby trees.



Figure 44: Anchor post with turnbuckle and spliced wire rope

For most of the men, using wire ropes like these was a new experience, and for all of them it was the first time they had used wire ropes as the basis of a suspension bridge. Ganang had made several hanging bridges, and Jolly was experienced using this type of rope in his work in the oil industry. It was clear however, that the engineering principles of suspension bridges were not a dominant consideration in the choice or fitting of the ropes - their strength easily exceeded this task, especially those ropes which came from cranes in Miri.⁵¹ Instead, the principle used to adjust the pairs of wire ropes was making something that ‘looked right’. It may be a truism to say that if something looks about right, then it probably is, and that approach would be castigated if used as the basis for building a bridge in the UK, but to know if something looks right requires a lifetime of experience in seeing things. If your life includes a significant portion of time spent dealing with engineering problems, then you tend to tune in to the topic generally

⁵¹ Each of those ropes was rated at 50 tonnes, with a factor of safety, probably of around 4. In reality therefore, each rope could have supported about 200 tonnes. The total weight of the bridge was around 2 tonnes, and the design was such that most of that strain was evenly spread over four uprights – two on each tower, and among four principal ropes. So each rope might have a load of around 0.5 tonnes.

and pick up on snippets of information, register relevant sights and events, discuss, observe, and attend to, things to do with engineering. If you have no interest in the subject then these things pass you by, and you consequently accept few responsibilities and have less involvement in engineering. So to say something is made according to whether or not it looks about right is not to say that people are proposing outrageous ideas, or hazarding a guess, it is an intuitive estimation based on the accumulation of past experience. For the bridge wires, it requires an understanding of the general shapes and forces that are at play, and an ability to associate similarities between past sights and present situation.

Essentially, this most important set of components was set up according to an estimation of equilibrium. The Kelabit engineers knew that the bridge needed to be balanced, to prevent one side being pulled over by the other, so the first objective was for the ropes to be symmetrical. The pair of base wires, forming the walkway was easier to set, since the ideal would be to have them horizontal, providing a flat surface across which to walk. The archetypal hanging bridge, with its naturally pleasing catenary shape is inherently unsuitable for a walkway, since the angle becomes more and more steep at either end and relatively flat in the middle. This means that when first stepping on to the bridge, you do so on the steepest downslope, and to exit the bridge you have to climb the steepest upslope. This effect is exacerbated by the tendency for materials to stretch over time, creating a lower depth of hang, and an even steeper entry and exit. Being a rainforest, the environment around the Kelabit highlands is often very wet, and the thick clay soil sticks to your boots in a heavy layer of frictionless mud, so coming across a sagging bridge in the rain can be fraught with potential slips and falls. Having said that, for the Kelabit, even when laden with heavy baskets, the journey through the forest over the various obstacles is no cause for concern. On many journeys walking behind them as they skip over log bridges and down steep riverbanks, I would look up from the ground, where I was busy concentrating on my feet, to see them some way off in the distance. However, the ideal walkway on a bridge is still to have it as flat as possible, with gentle entry and exit ramps.

It is not possible to pull a wire perfectly horizontal, since the force required becomes exponentially greater as the rope gets closer to the horizontal (in other words to pull a rope perfectly horizontal requires an infinite force). Pulling the ropes taut places extra strain on the anchor blocks, and is limited to the force that a group of around 10 men can exert. The only way to make the walkway flat is to support it, for example from above by means of the stringers attaching the lower walkway wires to the upper support wires. So, with the lower wires pulled as tight as possible, they were fixed in place and attention turned to the upper wires. Thanks to the turnbuckles, the top pair could be finely adjusted to bring them parallel to each other, so it was only necessary to set the shape of their slope more generally. In this case there was a problem of making the wires look right, which was that it was difficult to get to a place where you could actually see them. Several of the men, including Ganang and Jolly stood on the riverbank to the side of the bridge, slightly downstream and lower down the bank, while others, including Robert and Anderias, poled upstream in a canoe at quite a distance below the height of the bridge (see Figure 45 below). The other men took hold of the wires and pulled them around the anchors. When initially pulled taut, they looked strangely high, and had to be gradually lowered to an agreed level. From the bankside it was difficult to see the general shape, but by standing directly behind the wires at the entrance to the bridge it was possible to see whether or not they were parallel and even; from the river it was possible to see the shape, but difficult to see if the wires were even. So, after several hours of shouting and pulling, eventually the wires were fixed in place.



Figure 45: Setting the wires (view from the river)

In the act of deciding how high, and how hard to pull the ropes, judgements were made literally by eye, standing to the side of the bridge, or metres below it in a canoe, sometimes squinting or with one eye closed. My experiences of calculation and material properties were redundant in this situation; this was a combined sense of aesthetic and mechanical appreciation. Making it look right depended on a complex estimation of strains on the wires and the anchors, a realistic depth of sag according to the strength of men and the likely future stretching of the wires. At this stage of course, the wooden planks had not been fixed, so would create a further substantial load, and the effect of connecting the upper and lower pairs of wires had not been seen, so required an allowance in the overall assessment of appropriate shape. Taking these into account meant making a judgement of the effects of the next stage of engineering and how it was likely to alter the final shape to bring it into line with the shape that the engineers thought ‘looked right’. Ultimately these ambitions came together most beautifully by setting the ropes to create a balanced catenary across the river.

Making Mistakes

Fixing the ropes across the river for the first time made a physical connection across the river, so that despite the danger, men could walk on the ropes and get from one side to the other without needing a boat or swimming, and represented a significant stage in the construction process. Our next task was to fix the wooden walkway to the base wires, to create a stable platform. There was a pile of *belian* hardwood planks of different sizes, some to be cut and drilled and fixed as spacers between the base wires, and other to be cut and planed and fixed to these spacers to form the walkway itself. The 40 or 50 spacers each needed four holes drilled through, and the 150 or so planks all need to be planed to form a relatively smooth surface. A fairly recent technology to the Kelabit highlands is the introduction of electric tools, particularly drills and planes, powered by small petrol generators. Anderias had recently been given a new plane and this was the ideal opportunity to use it. He had in fact planed all of the timber for the support towers before they were assembled, he said so that they looked nice, but I suspect it was his desire to use and show off his new plane. The job of planing smooth the walkway planks was much larger and meant that several men took it in turns using the drill, the plane, and a chainsaw to cut the planks to the same length. Having spent several weeks during which most of the work was done by heaving and carrying, it was something of a shock to hear the constant noise of the generator, electric tools and chainsaws all screaming at once, and to be surrounded by a pall of smoky exhaust fumes. As far as is possible in this environment, we had strayed into the realms of the fast-moving technological ‘social’ world that Latour describes. Watching Anderias planing the wood however, what seemed most important was the way that he adjusted his movements to cope with changes in the density of the wood, how he stopped and twisted the knob to set the planing thickness, changed his stance as he grew more proficient or tired, lifted the plane and looked at the wood moving his head from side to side, kicked at the ground as the layer of wood chippings grew around him. Similarly, to watch Judine, chainsaw in hand, cigarette in mouth, eyes half closed in protection from the flying sawdust, swathed in a cloud of oily fumes as he pushed one plank next to another and cut through both, was to see a skilled production, not an abstract network.

But Judine's skill with the chainsaw, Robert's cement mixing, or Anderias with his plane masks the wider span of engineering aptitude. The Kelabit are not averse to making mistakes, indeed this is positively encouraged through the inclusion of young men in the production activity and the open discussions that continually go on around the site. It is not unusual to see a tool being picked up and work carried out by any member of the group, regardless of their apparent seniority. Any interventions tend to be by way of assistance rather than correction; as Ganang said "I knew they were doing it wrong, but I let them do it anyway. They may have a new idea we can use". No description of an engineering project would be complete without mention of some of the things that went wrong. The temptation is to be blinded by the mesmeric performances, the skilled interventions and the accomplished ingenuity, but this ignores the equivalent lack of ability, aptitude or motivation, and in some people a combination of these things. The continued work of production is created through the set of relations a group of individuals has with the tools and materials at their disposal, and the wider set of abilities found in the group as a whole.

Although Judine is particularly able in using the chainsaw, he is not the only one. For the Kelabit, the chainsaw is an almost ubiquitous tool, second only to the parang, which is carried by everyone whenever they leave the house. So preparing the planks for the walkway was done in stages by various men – cut into 6 foot lengths with chainsaws and planed smooth with the electric plane. The *belian* wood spacers were fixed to the base wires three feet apart, and the planks were laid on them, nailed in place at each end and in the centre. The weight of the bridge was intended to be spread between the upper and lower wires, which meant that before the heavy walkway could be laid, the wire 'stringers' connecting the top wire with the base wire had to be fixed. The plan had been to clamp a stringer to the top rope, then pull up the base rope until it was level, and clamp it tight on that rope. This would need to be repeated about 40 times on each side, giving a total of about 80 wire stringers connecting the upper wires to the base and

supporting the weight of the walkway. This proved to be one of the most difficult, and ultimately least successful aspects of the bridge.

At the support towers, the distance between the upper and lower ropes was around 4m – too high to be able to reach, and clamp on the wire stringer. In the centre of the bridge the two ropes were much closer, but since there was no walkway, there was nothing to stand on except the base wire and the spacers. Even if they could be reached, to pull up the base wire before clamping was difficult, since you would need to stand on that very wire and would effectively have to pull yourself up at the same time. Discussions went on for some time as to how to fix the stringers, including Anderias' idea of making a small platform fixed to the upper wires and standing on that, or releasing the tension and lowering the upper wires. In the end the solution developed on site, through a series of discussions and unsuccessful attempts.

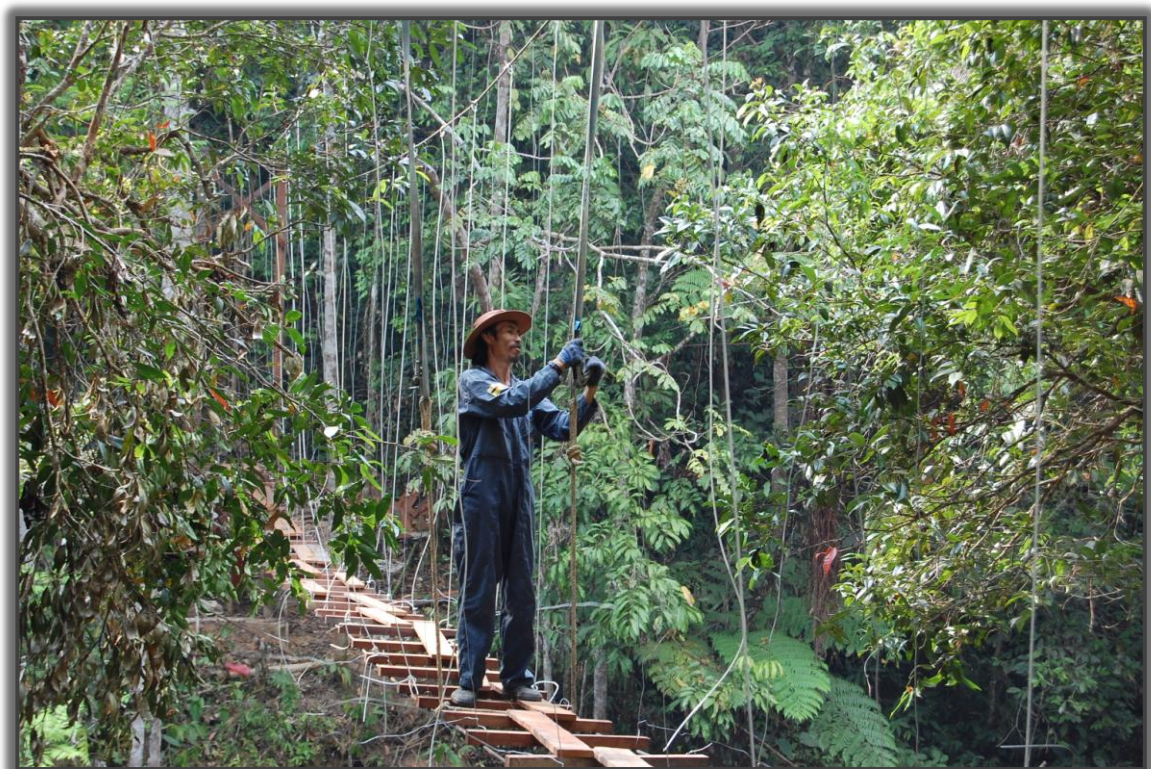


Figure 46: Jolly, fixing the stringers between upper and base wires.

At this stage the loose planks are still in place and a ratchet strop is being used

A few planks were temporarily laid, unfixed, to the centre of the bridge and two men walked precariously out to the middle. Someone climbed to the top of the tower and the wire stringers were looped over the top wire and pushed out to the centre with a long forked bamboo pole. Initial attempts to pull up the base rope by feeding the stringer underneath and jumping up whilst pulling at it, were an accident-in-waiting as the loose planks were thrown into the river, and feet slipped off the rope. Eventually the ratchet strop that had been used to tighten the main ropes was brought out again, pulling the two ropes together and allowing the stringers to be clamped at the bottom (see Figure 46 above). The constant moving and fixing made it very difficult to get the base straight and level however, and the system of looping and sliding the stringers meant that they were also able to slide down the upper rope after they had been fixed to the base, leaving them loose and ineffective. Returning to the bridge in April 2010, six months or so after it was completed, these problems were clear to see. The stringers near the towers had slid down, and some of those near the centre had worked loose as the uneven base stretched and equalised.

Methodologically, the study of failure, incompetence or laziness in an engineering project presents significant problems. On some occasions, such as when a young man struggled to cut planks to size and drill holes in them, this was accepted as part of the learning process. There were also times when the mistake was comically obvious, such as the setting of a large upright stone in the anchor block in mock homage to the Kelabit's past traditions of erecting large stone monuments. The stone was, however, right in the middle of where the sloping walkway should have been and had to be knocked out. But knowing my objective was to document the construction of the bridge, the first thing that tended to happen when something went wrong was that it would be hidden from me. This was the tactic I encountered in the case of the discarded joint support plates, when groups of men huddled around as they tried to cope with their error. Then when it became obvious that I was aware of the mistake, a series of explanations was forthcoming, unprompted: the plates were not made to our specifications, the bolts were supplied wrongly, the plates were just an idea and may never have been used

anyway, the new solution was actually better anyway and so on. Finally, if I pressed the issue and asked for more information, for example on the cases of the collapsed bridges, Anderias became very defensive and explained that he was worried that people would think of the Kelabit as incompetent, or foolish, asking me specifically not to make public any such information. Trust became a serious issue. Recording failure provides some methodological difficulties since by its very nature it is generally not something people want to be associated with, and is quickly forgotten, or becomes a political football, kicked around by those with different agendas. But failure, for whatever reason, is a valid aspect of engineering, and worthy of study, despite the difficulties it presents. There should not be lesser consideration of unskilled, novice or even incompetent production, to afford a proportionate consideration to failure and ugliness. Mistakes are part of the flow as much as skill, beauty and success.

In his discussions of his own experiences as an apprentice, Marchand has written of the ways that novices learn, using the expression ‘dynamic syntax’, an iterative process that involves seeing, doing and seeing again (2010b). In his example it was the master furniture maker that was explaining and demonstrating to a group of students how to perform a variety of acts of carpentry, then leaving each of them to try to do it themselves. His suggestion is that the student learns by watching what the ‘master’ does, and subconsciously splitting the apparently single act into a series of component parts. By re-enacting each part, mentally, physically or both, and reassembling them into a new whole, specific to that individual, the essential activity becomes learnt. Through time this is fine tuned through developing bodily knowledge such as adjustment, control and balance (2010a: S105-S114). The lack of knowledge that Marchand experienced as a novice demonstrates itself through his relative incompetence, but as his objective was to become more proficient, what is not clear is what form bodily ‘ignorance’, as opposed to competence or skill, would take (Dilley 2010: 188). Factors such as a lack of aptitude or motivation are presumably a common part of the performance of production – this seemed to be the case for some of the engineering I witnessed

– so to fully account for the communal nature of this activity we need to be aware of the disparity in competencies.

For the Kelabit bridge builders, fixing the stringers between the top and bottom ropes was a time consuming and not very successful exercise. It was difficult to discuss this with them however, since they are proud of their reputation as a capable and innovative people (which they are, and I hope that comes across in my ethnography). Anderias was keen to censor my efforts to describe the problems faced in this part of the construction process, and insisted on discussing new ideas for how they might do it differently in the future - he proposed a different pattern of stringers, with more near the centre where most of the load would be for example. Despite the problems, the walkway was eventually fixed in place and the bridge was a great success. Jolly organised a celebration in the longhouse for the whole village, at which I thanked the villagers for their patience with me, and made another unsuccessful attempt to explain the concept of charity funding. It was hoped that access to the far side of the river would provide more people with the opportunity to go hunting and start hill farms, as well as providing easier transit to friends and relatives over the border in Indonesia.

Conclusion: Continually Constructing Relations

Returning six months later, I was able to sit surrounded by the remnants of the days and weeks of work that had gone on constructing this bridge: the temporary shelter ready to collapse, scattered offcuts of *belian* and piles of sawdust, pieces of chopped bamboo and the burnt out fire. Every few minutes someone would walk up the ramp and over the bridge with a friendly nod in my direction. Ganang joined me and we sat and talked about the project, which evidently gave him a great deal of pride. He had played his part in providing the village with an impressive and useful structure, and was particularly pleased with the bridge as it stood in the landscape. As a large object, the bridge was placed into its environmental context quite comfortably. Perhaps I had been seduced, but it did look right. The colour of the wood, the space, the wires fixed to trees, the detritus of construction, all these things gathered together to form a new environment, a

new thing but one which seemed at once to belong there. After everyone had gone home, while sitting quietly in the final wisps of the fire looking across the river from between the towers, one sensed that the forest had reclaimed the space in a way that western construction sites strove so very hard to do but often failed. The photographs I had taken of the bridge emphasised its size and structure, whereas Ganang's had hidden it among the trees (see Figure 43 above). He said he wanted to show how the bridge merged with the forest, and was part of it.

This had required a substantial effort and time committed by many people, only hinted at by the debris around the site. As with any object, before it can be used, it has to be made, and the process of construction is a vibrant milieu of creative activity, impinging on people's lives in a multitude of ways. For the Kelabit, this had been a significant project, drawing on past experiences to create a specific set of actions according to individual and traditional skills and practices. The villagers were undoubtedly proud of their achievement, while recognising it as an accumulation of ordinary knowledge and abilities, scaled up, rethought and applied to a new circumstance. The people who were involved in the project were themselves altered through the process of construction, incrementally developing skills and experiences that would form part of their embodied understanding of the world around them. New relations were created with tools and materials, allowing them to carry that experience forward and apply it in a new situation. Relations with the forest were explored and renewed, reinforcing its place as a useful provider of temporary tools and materials, mistakes made and solutions invented.

I started this chapter by emphasising that construction is a part of life and could not be separated out from it (despite this thesis trying to focus only on that). The act of production is a process that creates a series of entanglements between people and their environment. For much of the time these are fleeting, Robert picking up his shovel and mixing cement, Ganang trying out different ways of fixing together lengths of wood, groups of people discussing how to tie up the wire stringers, and so on, before they move on to something else. The skills

present or absent in the process are fluid and brought to bear on a situation in an engagement with the world that continues after the activity appears complete. Completeness is an illusion based on a human perspective, which fails to adequately account for the actions of the rest of the world. The river Kelapang continues to work away at the banks, removing and re-depositing materials to support or undermine the foundations, wood rots or hardens, wire stretches, trees grow or die, insects burrow, people walk from one side to the other. The bridge becomes an integral part of the environment, important in the immediate vicinity and perhaps less so to those further away or less affected by its possibilities. The same skills, or tools, or groups of people, which came together in its production are then dissipated and brought to bear on a different situation in a continual flow of activity. The world is made up of these temporary coalescences, in which groups of things live out the part they play in the construction of the environment, whilst constantly dividing and reforming in new ways. The next chapter - 'Deconstruction' - takes this thought a stage further, by tracing a construction as it loses its coherence and begins to reform in a host of different ways.

DIVERSION: Multiple Trajectories

After WW2, a series of economic arguments and political principles led to the decision to bring rail travel into public ownership, through the inauguration of a nationalised UK rail system. Beginning with the formation in 1948 of the British Transport Commission, subsequently to morph into British Rail (BR), regional companies (such as GWR) were forced, often against their will, into a huge single new organization. However, as BR became unwieldy and costly to the taxpayer, the government appointed an advisor, Dr. Beeching, to recommend how the system could be changed. He published his seminal report in 1963 - 'The Reshaping of British Railways' (British Railways Board 1963). The recommendation, subsequently carried out in the later 1960s, was a reduction of about one third of the British rail network, condemning many local lines and introducing the public to a new perspective on what constitutes rail travel. No longer was it the means to a family holiday, instead it became a system of transport to move around the employed masses. The personality of the network was fundamentally altered from one of regional identity and individual engines to a homogenous whole – a centralised political system of control, and an anonymous and efficient fleet of diesel engines. Up until then, steam locomotives such as 6023 were the mainstay of the transport network, and for many people, the only way to travel long distances. Each was instilled with its own history and personality, according to the routes that it travelled, and for the engineers, the performance that it put in (e.g. Whitehouse and St. John Thomas 1992: 86-92). The locomotive I worked on, 'King Edward II', covered 1.5 million miles between 1931 and 1962 running from London Paddington to the West country and back, as outlined by its maintenance history (see Figure 47 below).

locomotives went ahead. By 1968, steam locomotives had been entirely replaced by diesel and electric power.⁵²



Figure 48: 'King Edward II' in the Woodham brothers scrapyard, south Wales
(painting by Richard Varley)

A steam locomotive is a complex piece of machinery made up of many thousand parts, and the process of production in the early 20th century relied on the skills of teams of engineers to effectively hand-make each locomotive. GWR pioneered a new method of production, by standardising as many parts as possible. The company had a range of engines designed to suit particular situations - long or short distance, freight or passenger, difficult gradients, poor quality coal, and so on. To make their production more efficient, many of the components were designed to be generic, and interchangeable. Some of the GWR stock managed to

⁵² In August 1968, the 'Oliver Cromwell', a Pacific class locomotive, made the final steam powered regular service from Liverpool to Carlisle.

avoid being broken up and sold as scrap, and fell into the hands of enthusiasts, or were sold to rail companies around the world,⁵³ and so the GWR engines languishing in scrapyards such as Woodham's. became a stock of useful spare parts. At first this was to satisfy the maintenance needs of the working engines, but latterly with the growing enthusiasm in rescue and restoration, the various engines around the country being saved by heritage organizations.

This was the fate that befell 6023. Many of its minor parts were stripped and re-used by several engines around the country, including the sister locomotive, GWR 6024 'King Edward I', itself restored between 1974 and 1989. Conversely, when it came to rescue and restore 6023, parts were similarly sourced from other GWR locomotives no longer in use, as well as re-made to original drawings. These are not just the fixtures and fittings used in the bowels of the machine, but also major parts such as the boiler (the most obvious part of the locomotive, stretching from the driver's cab to the front of the machine – in Figure 49 below, painted blue and black). Each boiler has a history of its own, independent of the locomotive, since they were difficult to maintain, and were regularly removed for refurbishment:

“6023 had thirteen different boilers during its working life, only two of which, 4686 (original) and 8621 (1955) were brand new. The current boiler on 6023 is 8619, originally issued to 6012 King Edward VI in 1954, and refurbished in 1956, before being removed for a total strip down in 1958, after which it was inserted in 6003 King George IV until 1960, when it was removed during a heavy general overhaul, and after re-tubing, inserted in 6023 in June 1960.” (www.6023.co.uk)

Even the boiler as it stood when entering restoration had to be substantially maintained, replacing thousands of large spacer bolts, and as described above the main driving wheels had to be re-cast and machined since the originals were cut away. Much of the driving gear was made from new, the drivers' cab had to be re-made to reduce its height and comply with current regulations, the ashpan (under

⁵³ Another locomotive at the Didcot Railway Centre was sold to an Australian coal mining company, and worked there for many years before being bought by the DRC and undergoing a complete restoration.

the boiler) was completely re-made, the piping was replaced, the vacuum system to control brakes and engine efficiency was renewed, even the tender (the coach that carries the coal just behind the driver's cab) came from a different locomotive based on the Severn Valley Railway. I asked Dennis, the project leader, just how much of what we were restoring was actually original 6023, and after much thought and wandering around he came to the conclusion that it was only the front bogie (the 4 smaller wheels and their chassis, near the front) and part of the main frame.



Figure 49: 'King Edward II' after restoration.

Virtually nothing remains of the original.

6023 thus has a complex set of intertwined histories. According to its running records, it is a named object that could be located in time and space. And yet we know that throughout its history, as with other locomotives, it would have been continually altered with different parts being repaired and replaced, including major parts such as the boiler. It then became part of a different construction project, acting as a weight to test a bridge, before moving to a scrapyard and left to rot. At that point, the process of dissipation accelerated and various parts left the object to become part of something new, resulting in something that could not

really be described as a locomotive. The long process of restoration continued the pattern of deterioration, movement and creation, as objects were gathered or formed and attached to the assembly. Many of these parts have their own biographies, such as the new wheelset described above, which makes it difficult to identify the biography of the locomotive as a whole. In effect there is no object, but a series of parts and events that come together to form something recognisable as a locomotive. But that thing is only there while the will and skill of the engineers prolong the connections between the parts. Their efforts direct the relations between environment, materials and groups of people in a particular way, but theirs is only one direction, which happens to be towards restoration and assembly rather than oxidation and dispersal. To see a large and complex object in its entirety requires us to see it not as a single thing, but instead a fleeting assemblage of parts, constantly exposed to the on-going processes of the world at large.

6: DECONSTRUCTION

Transient Durability

In the previous chapter, I described how an assemblage of people and things came together to form an object through a continual creation of relationships. In building a bridge, objects were brought in from far and wide to a single place over a short period of time and fixed in the landscape in a particular form. The act of construction depended on the use of skills and tools, sometimes in new ways, to physically manipulate the materials of construction and the site itself, so that the object could be fitted in to the environment. I finished by saying that the object thus formed could not be considered as a permanent thing, since the process of construction was only one part of the forming of the environment. Other processes continue regardless of the presence of people or their activities.



Figure 50: The on-going relations of a bridge with its environment:

A collapsed bridge near Pa' Mada

In the case of the bridge, directly attached to the living landscape, tethered to surrounding trees and straddling a powerful river, its precarious position is easily

imagined. Over the years, as floods come and go and trees grow or fall, the environment changes noticeably and the bridge has to adapt, or be adapted, accordingly. The sets of relations created through the coming together of the engineers, their tools, materials and the place in question, are on-going and continually and mutually renewed and altered. What appears at first to be sets of long-lasting relationships will inevitably fragment and dissipate, leaving a new situation for other people to engage with.

Construction depended on the accumulation of heterogeneous materials and their assembly into a form something like that set out beforehand, brought together in an 'act of persuasion' Suchman (2000a), a rhetorical exercise that renders one course of action more desirable than another. In many cases, the most likely outcome of attempts to persuade are not obvious, and it is generally only through historic analysis that the reification of the object can be traced.⁵⁴ Socially, then, as well as materially, the permanence of an object is always subject to question. Historical approaches can, by definition, only trace the course of an object up to the present - an interesting story, but one that can never be complete. While materials deteriorate over time in accordance with the processes of nature, the social stability of the object (Suchman 2000a: 316) is also subject to processes that may undermine it. Some of the politics and concepts essential to the siting and construction of the bridge in the previous chapter, such as access to farm land, a route to relatives in Indonesia, and emergent notions of durability, may subsequently become redundant and cause the bridge to fail, socially if not materially.

This chapter describes an example of social and material changes that result in the deconstruction of a large object into constituent parts. My ethnographic data relates to the on-going abandonment and re-use of a longhouse in a place called Batu Patong, an hour's walk from the village of Pa' Dalih, and introduced to me by Jeffrey. Historically the Kelabit have seen their longhouses as temporary structures, selectively re-using parts of the structure in later buildings, depending

⁵⁴ Closely following the SCOT approach, which sees the final form of an object determined after a process of rhetorical closure (Bijker *et al.* 1989)

on access to materials from the environment. More recently this has changed with the introduction of new materials, and social organization now based around a permanent village site. The longhouse at Batu Patong is part of this fluid cultural attitude towards recycling and durability. It was made up in part from previous houses when the village moved to the current site, and in part from new materials in the 1970s as part of a determined effort to produce a house in the modern image. It now stands empty and partly dismantled, with various bits used in different constructions elsewhere. This not recycling as such, but of a continual flow of existence, sweeping up and re-depositing various parts: material components of the house, the possessions, memories and emotions of inhabitants, ecological habitats and so on. All these things came together to form a house, but as Hicks points out, its permanence is illusory since they remain attracted together for a fleeting moment (whether that be seconds or years) in an ultimately fragile bond, destined to break apart, only to coalesce as a different object elsewhere.

“It is not, of course, that buildings are not undergoing constant change. Rather, they are moving at a different pace: all buildings will fall down eventually. Moreover, the pace of change in materials is contingent upon not only their maintenance by humans...but also the materials involved” (Hicks 2010: 86)

What remains at Batu Patong is materially, but not socially, recognisable as a house. No-one lives there permanently, and it has over the years shrunk as owners have seen value in the parts and taken them away. Something remains though, still immersed in the world at large, forming new relations with the animals, plants and climate (Ingold 2000: 172-188). A different object, or perhaps more precisely set of things, valued as component parts by the humans and as a whole by the non-human inhabitants.

Reincorporating Materials

My first encounter with Jeffrey was a shocking introduction to the world of ethnographic fieldwork. Arriving in Pa’ Dalih for the first time, after an arduous truck drive over the rutted and rotten logging roads in the early hours, and with a

few hours sleep under my belt, I went to meet some of the villagers. Jeffrey had been hunting the previous evening and come back with a large boar. With skill obviously borne of experience, he demonstrated the Kelabit approach to butchering; expertly hacking away at the bloody carcass with his parang, body parts strewn over a plastic sheet on the floor of the short longhouse, lumps of fat rendering in a large pan over the fire, and a meaty stink hanging in the air. I got to know Jeffrey well, his English was very good, and he usually had time on his hands. He was in his late 40s, married, his wife and daughter living in a modern house in Miri, and he spent his time between there and with his elderly parents in Pa' Dalih. His father was recovering from a stroke, and had returned to the village from hospital in Miri. Jeffrey's mother (Sina Ellie) was also a great character, a bundle of energy and laughter and the kindest and most generous spirit you could ever wish to meet. Jeffrey had moved to Pa' Dalih with his parents from the nearby village of Batu Patong, when the population there had declined to the point that the village was no longer sustainable. He recounted how, one day in 1976 aged around 14, when returning from school, he arrived at the longhouse to find his parents gone and a message telling him to go to Pa' Dalih. Along with most of the other villagers, they had decided to join up with larger villages, in response to the difficulties of life at Batu Patong due to dwindling numbers of young people.



Figure 51: The tawa of the abandoned longhouse at Batu Patong, 2010.

30 years later, parts of the village remain in Batu Patong: the rice fields are still used, and the longhouse is still there, at least in part. Some of the village has been dismantled and re-used, including as it turned out the *dalim* (family area) of the short-longhouse where Jeffrey had chopped up the boar - part of the old longhouse transported and re-used in making a new one. Intrigued to see what the longhouse looked like today, I arranged the first of several visits with Jeffrey. Setting off one morning, we reached a small hut beside some padi fields and surrounded by fruit trees and pineapple plants. His parents were inside, so we stopped for tea. They stayed in this hut when working on their farm to save themselves from walking back to the village, since their fields were still mainly in and around Batu Patong.



Figure 52: Jeffrey outside the field hut of his mother (Sina Ellie) and uncle (Baye Ribu)

The hut is quite small, about 4m square, raised off the ground on stilts about 2m high, with a metal roof, and on one side a set of stairs leading up to a wooden door (see Figure 52 above). The interior is dimly lit by two flaps, planks that swing down to form windows in the traditional way, and filled with the characteristic smokiness that comes from an open hearth. The only possessions are those that Jeffrey's parents have brought to last them the few days they will stay there: a couple of baskets, pots and a kettle, some farming tools and some food. As the hut is only used for short periods, there is plenty of dust, cobwebs and evidence of rats that have tried to rip into old rice sacks and food baskets. Jeffrey and his mother sweep the worst of it outside and sit down to tend the fire. Pinpricks of light beam down from holes in the roof, lighting up the wispy smoke and creating a hypnotic effect as it swirls gently around. As with the roof in the longhouse, the hut had been made with re-used tin sheets, originally army issue probably from the 1960s. The holes creating the peculiar lightshow were old nail holes from previous fixings. As it turned out, the previous home for these particular sheets had been the longhouse at Batu Patong. In fact, further investigation showed much of the hut was made up of the old longhouse, including its floorboards and door.

Notions of objects as having a trajectory of change are commonplace and historical in anthropological theorising, generally as a reading of social and symbolic difference, saying less about physical change, especially deterioration. Malinowski for example, famously described the circulation of *kula* objects in Melanesia (1922), in terms of the accumulation of prestige they bestowed on the politically astute.⁵⁵ In this description, and others that drew on it (especially Mauss 2002 [1954]⁵⁶), an object changes as it passes from person to person, accruing some essence of its past owners, each of which bestows extra status through association. In most of these descriptions however, the object itself actually physically changes very little, if at all. The same could be said of the biographical approach, suggested by Kopytoff and Appadurai in the seminal book *The social life of things* (1986). This set out the idea that commoditization was a process requiring things to pass through various cultural stages, analogous in some ways to a life or career, giving new meaning to the commoditised objects along the way, for example becoming more valuable as they “resist our desire to possess them” (Appadurai 1986: 3). This idea has been developed further by various writers more in the vein of material culture studies than economic anthropology. Good examples of the biographical approach as applied to the study of objects include Peers’ (1999) analysis of the history of a hand-made bag as it acquires different meanings to its new owners, and Tapsell (2000) who showed how indigenous Maori concepts of the life of an object differ radically from western ideas, through their reception of a famous carved statue as it is returned to them after many years of display in the West. Similarly, Hoskins has described how objects can act as a repository for memories (1988), and Gosden and Marshall (1999) pointed out the way that physical, as well as social changes can be important, in their example of the Fijian whale tooth’s necklace, the *tabua*, and how its value is apportioned according to the patina, a depth of colour generated through years of handling, progressively absorbing the sweat and grime of the owners. A key tenet of the approach is the focus on an object, or group of objects,

⁵⁵ However, see Campbell (1983) for a more prosaic account of the objects, and their physical make-up.

⁵⁶ Originally published in French in 1924

and their durability and links to the past. If the object were to disintegrate then its biography is effectively at an end.

Other writers such as Hetherington (2004), Colloredo-Mansfeld (2003) and Daniels (2009) have pointed out that this fails to account for the ‘social death’ of things, and the processes of value creation that are inherent in the disposal of the object. Written in the context of studies of consumption, they make the obvious but important point that consumption intrinsically involves some aspect of using up, and hence needs to turn our attention to ephemerality, disposal and forms of value that are independent of the histories of the object or its previous owners. Durability and longevity need not be the ingredients that create the most socially charged biographies, and we need to also see destruction, and “reincorporation in some other guise” as a fertile circumstance for physical and social circulation (Colloredo-Mansfeld 2003). If the same thinking is applied to engineering and production, it then becomes possible to see the deconstruction of a large object such as a longhouse as a creative process, as much as the initial organization that went into bringing it into being in the first place, or its on-going appropriation through use.⁵⁷

In the traditions of material culture studies, the durability of objects has until recently been a fundamental part of the discipline: to be able to study objects implies that there are objects to study. This chapter is intended to consider the importance of an engineered object being ‘used up’, within the context of material culture, but not as an act of consumption. As Colloredo-Mansfeld points out “...one element of material culture studies remains curiously immovable - the presumption of object durability. Meaning fades, value spills over boundaries, memorialized loyalties falter, but the thing itself endures...” (2003: 246). As discussed in the case study below of the abandoned longhouse at Batu Patong, the permanence of objects is easily questioned, which leads us to ask what are the means and implications of a lack of durability, of practices like demolition, deterioration and disposal? Even within consumption studies, the lack of adequate

⁵⁷ Consumption studies have been sympathetic to the notion of an object physically changing as it becomes appropriated by new consumer cultures (e.g. Hebdige 1983; Miller 1988)

consideration of disposal, at least until recently, is something of an oversight, as Hetherington has said, suggesting “that disposal be seen as a necessary issue integral to the whole process of viewing consuming as a social activity” (2004: 158). In other words, disposal is not an end-point for objects, but is part of a recursive sequence (Hetherington 2004: 160) including production and consumption, occurring in no particular order. Disposal is not the final state of things, in that they are henceforth ‘rubbish’, but a productive act: “The undoing of form encompasses not just destruction or consumption, but production too” (Colloredo-Mansfeld 2003: 249). In this way, we can be ‘generous to materials’ as described by Gregson *et al.* (2010) in their discussion of asbestos as a material encountered in the demolition of ships. This particular material has different properties when dormant (inert and safe) than when disturbed (mobile and dangerous), so that “...demolition, or destruction, is a transformative state in which materials stilled in the object form become animated” (Gregson *et al.* 2010: 1068). By taking apart large ships, the intervention of humans disrupts and terminates one set of associations and reconfigures materials to bring about new “associations, arrangements and conjunctures” (*ibid*). The act of demolition is thus shown to be the cause of a new set of values, in this case to do with work, safety and economics “...conduits of disposal implicated in changes of value of particular materials...” (Hetherington 2004: 165). In deconstructing a large object, the variety and quantity of materials contained within it are significant facts of its constitution. Materials are themselves made up of different properties and thus require us to take account of that variety when considering the processes that act to separate them. Instead of the simple model of an object having a biography or career, we need to reconsider the sort of objects produced in the performance of engineering. In Gregson’s example of ship’s asbestos, it would be difficult to recount a biography, not because it fails to impress us with a glorious individual history, but because it is a material and not an object. This is similar to the floorboards re-used in Jeffrey’s family field hut. It would be true to say that there are particular floorboards that individuals can relate to as objects from their past, but this happens only when pressed, and not a part of everyday discourse. Floorboards are seen as a material used in the construction of houses, and come

with their own particular traditions of prestige and recycling. In the course of dismantling houses, certain parts would be ‘re-animated’ in Gregson’s terms, especially the floorboards, which could then be productively re-used elsewhere. “While sometimes it entails material loss, at other times ephemeral practice takes place when objects lose their bounds and merge with others” (Colloredo-Mansfeld 2003: 252).

The complexities of a large object, such as the ships mentioned above, make it difficult to conceptualise as a single entity, which leads Gregson to talk of “...objects as materials made stable” (2010: 1080; cf: 1070). After around 30 years, the commercial cargo ship reaches the end of its life and goes to the breaker’s yard for what is euphemistically called in the industry ‘recycling’. At this point the ship is broken down into its material parts through

“...the violent, intensely physical work of purposefully breaking-up large, heterogenous fabricated things...[where] things - in this instance ships - are literally unbecoming, reverting to materials as the object dematerializes” (Gregson and Crang 2010: 1030).

However, the process of dematerializing is one that had been going on for all of the 30 years of the ship’s life, since the very reason why it ended up in the breaker’s yard is that it suffered wear and tear, corrosion and deterioration at the hands of the occupants and elements: materials are in a constant state of ‘animation’. In the case of the longhouse given below, this ecological recycling is perhaps more evident, since the plants and animals that are doing the dematerializing are obvious to see. Rather than separating out the human actions involved in dematerializing, it seems more appropriate to admit to the on-going interactions between materials and environment, including the various active participants, from weather to plants to animals. This provides an important point for the analysis of what is happening to the longhouse at Batu Patong, namely that instead of being an object, it is a temporary assemblage of materials. Rather than seeing the large-scale object as a single coherent entity, it is more accurately simply part of an environment, and subject to the effects of that particular environment. The breaker’s yard engages in a particular way with the assembled

materials, as do the rolling oceans, and as does the rainforest for the longhouse. The act of deconstruction is a continual one, going on regardless of the process of assembling or the perception of the nature of the materials. Environmental dematerialization occurs according to the make-up of the specific environment. In some cases that means insects, plants and rain, and in others saltwater, or humans with cutting tools.

“Asbestos, then, affirms Ingold’s (2007) point, that materials should be thought about in terms of processual and relational attributes that emerge in the flux of substances and the medium that surrounds them...Demolition emerges...as a human-orchestrated remeshing of materials in the world and as an activity that is as important to the social sciences as the more familiar couplet of production-consumption” Gregson *et al.* 2010: 1080)

Ultimately a consideration of the longhouse at Batu Patong depends on accepting these points: a large-scale object is more than a single entity, the temporary connection of disparate materials in one place, and the on-going and creative rematerialization that characterizes environmental relations between materials and the world. That requires us to shift our focus of attention away from the complexities of the whole object and look at some of the materials and components that make it up. A longhouse is a good candidate as the starting point for such an approach, since it is made up of many parts, some of which could be considered as objects for investigation in their own right (the example I use is the floorboard), but which all go to make up a site of connection.

Traditions of Recycling

As described previously, Kelabit longhouses, up to those built by the previous generation, were substantial if temporary structures, requiring the occupants to dismantle and transport parts of the house to each new site. Maran Balang, the headman in the neighbouring village of Pa’ Mada, about 8km from Pa’ Dalih, described for me his sequence of house moves as best he could remember. The current village called Pa’ Mada, as with Pa’ Dalih, has moved around the landscape over the years, but within range of the feature after which it is named.

Pa meaning river, as in Pa' Mada, *Batu* meaning stone, as in Batu Patong, and *Long* meaning a river junction. So the village of Pa' Dalih has been in different locations along the same river (the river Dalih) over the years, only becoming more permanent in the 1970s.

Maran Balang's first memory was a longhouse at Long Arur, where he was born in 1940, from there the village moved to Long Rapudun, then Batu Lumut and Lan Puan. These four places are all quite close together, separated by a short walk, as little as perhaps 5 minutes. The village remained in each location for 3 or 4 years, before packing up and moving on. In 1962, with the increasing tensions created by the Indonesian confrontation, they moved again, this time a little further, to Long Dano, where they remained until 1966 when they came to their current location at Pa' Mada. The longhouse built by the villagers at Pa' Mada was more or less to the traditional design, with a long open *tawa*, and a series of family hearths each with their own *dalim* and sleeping area, all under one zinc-sheet roof. When Maran Balang was appointed Headman he decided to knock down the old longhouse in 1985, but to remain in the same place and build a new house to a more modern design, separating the *tawa* from the *dalim*, with connecting footbridges (*tadur*) - the building that stands today. His motivation for doing this was, he said, because he could not relax with the children running up and down the *tawa*. As with other stories of house moves in Pa' Dalih, Maran Balang's house biography shows the historic tendency for migration and dispersal, often every few years, up until recent times.

To move the village meant to dismantle the longhouse and transport useful parts to the next site before reassembling it. The floorboards, having taken so much time and effort to produce, were the most important part of the transported house, traditionally cut with reduced thickness to make them lighter and easier to handle. Where other parts of the house were exposed to the elements (the roof, external walls and structural posts), or blackened by smoke from the hearths (rafters and ceiling) the floor was fairly well preserved, by being inside and often covered with mats. Parts of the house were sacrificed but the floorboards were protected, and cherished by individual family units. In rebuilding the longhouse, the size of a

person's section was determined by the length of his floorboards, generally around 4m, a tradition still visible in the Pa' Dalih longhouse where the boards from one family butt up against those of their neighbour without interlocking or overlapping. The very wide boards, made from the biggest trees and taking the most effort to produce, were (and are still) the most admired. Inside the longhouses of Pa' Dalih, people will pull up their mats to show you an exceptionally old or wide board, pointing out how thin they are, and how dark from years of use in the smoky atmosphere.

Historically, floorboards represented a significant investment of labour in their production. The technique of carving them out of a large tree trunk using a type of adze meant that one board would take up to two weeks to make. Conversations with the older men in the village suggest that these last for many generations. Nymut Ulun, aged around 70, a neighbour of Jeffrey in the short longhouse, could point out particular boards made, he thought, by his great grandfather, which would make them around 150 years old. Other adze-cut boards in the village could be dated to around 100 years: Jolly for example had kept already-old boards from a previous longhouse at Ba Siok, when his father moved to Pa' Dalih. They may not hold quite the same kudos as floorboards of old, but they represent something more than a useful resource, retaining a sense of tradition, often family specific, and still used in the construction of new houses as they are moved or rebuilt. With the introduction of large two-person saws in the 1950s more boards could be cut from one trunk, and more quickly, meaning boards became readily available and no longer required the mobilisation of substantial effort. These boards do not seem to be held in the same light as the older boards. When asking people about their houses, the constituent parts and their construction, nobody talked about the sawn boards. The only boards they talked about were the adze-cut, traditional ones, and usually it was described in the context of the efforts that had gone into their production and the number of places they had been used. Unlike the older boards, even when pressed no-one could easily identify or locate one of these sawn boards.

By the 1970s, when chainsaws became available, planks could be produced on a much larger scale. This is the method used today, and driving around the area you often see piles of dozens of planks by the side of the road, waiting for the owner to come and collect them. There are probably more chainsaws around now than there were 20 years ago, but even now there are only a few in the village, and finding fuel is regular problem. Today, most houses are made up almost entirely of this type of plank: one size fits all uses – walls, floors, even ceilings are being clad with planks, and the same thing used on bridge walkways. In woodworking tool technology, most recently Pa' Dalih has seen electric planes, and petrol generators to power them, so that today, many planks are not only chainsaw cut, but also smoothed by electric plane. Some Kelabit are even experimenting with the way that the plane is used to cut a notch along the edge of wall boards to get an interlocking tongue-and-groove effect, one board over the next. Boards in general, and new floorboards in particular have changed their status, and the way they are seen as a constituent component of Kelabit houses.



Figure 53: Interior of Pa' Dalih longhouse, late 1980s. Floorboards in the foreground have the distinctive surface finish of the adze cut boards, and are perhaps 100 years old (Photo by Kaz Janowski, © Monica and Kaz Janowski)

This rough chronology of boards manifests itself in the surface patterns created by the tools of production. The earliest adze-cut boards have a distinctive fish scale appearance, made by the multitude of small cuts to the surface as the board lay flat, to smooth it enough for walking on. The hand-sawn boards have a series of parallel marks made by the blade as it was pushed one way, then pulled the other. Chainsaws on the other hand leave a circular pattern and in places a quite rough surface. The latest planed planks are almost ubiquitous around the village, at every project I saw and in piles along the roadside. They are narrower and more uniform, smooth surfaced and square edged. The very proliferation of the modern boards seems to be partly responsible for the wave of nostalgia for the old boards. Anderias for example was experimenting with an old adze tool on chainsaw-cut planks, trying to recreate the traditional surface effect as part of his most recent house extensions.

Back in the field hut with Jeffrey and his parents, I was able to identify three of the four plank types. First by pulling back the mats and looking at the jigsaw of planks, and then more easily by looking at the floor from underneath the house after fighting off the cobwebs (as it is raised nearly 2m off the ground, this was fairly easy). The older boards with their distinctive adze marks had been shortened, because as Sina Ellie (Jeffrey's mother) explained, they had been made from part of the *dalim* (the family and cooking area) of the Batu Patong longhouse. Next to the oldest boards were a series of ad hoc sawn and chainsaw-cut boards, for which Jeffrey and his mother could not recall the source, just saying they had come from "some other house". In one small area, near the door to the hut (which was the door into their *dalim* at Batu Patong) it was possible to see the whole history of Kelabit board cutting technology, assembled together in this small field hut in the forest.

The hut was a reconfiguration of previous constructions, dismantled, and reformed in a different place and seen in a different light. It was a temporary shelter, abandoned for months at a time, and inhabited as much by rats and spiders as by humans. A field-hut is conceptually and socially different from a longhouse,

being more isolated and more limited in its use. It is far less frequently a place of social interaction than the *dalim* (family area) of the longhouse, and the objects kept there are far fewer and less treasured. In the past a field hut would have been made up of much less durable materials, usually split bamboo for the floor and walls, and woven leaves for the roof, and after being used for a season would be left to rot (see Figure 54 below, also Janowski 2003: 71 pl. 33 - note the split bamboo walls in the background).



Figure 54: Temporary fieldhut made by Isi Berawan the previous season.

Note the thatched palm leaf roof and split bamboo walls.

Jeffrey's family field hut was built in around 1980 and shows the change in significance of floorboards. The big old floorboards of the Batu Patong *dalim* were used in this much less socially charged building and conveyed none of the sense of memory, effort or prestige involved in their production and history. Sawn boards seem never to have held such associations, so the degree of change required to make them appropriate for this new assemblage was less. The hut was constructed from a combination of component parts and new attitudes. Floor

boards mix with historically contingent ideas of their worth, the entrance is built around the old door, tin sheets with their holes bring a particular quality to the interior, the relaxed demeanour of the occupants, comfortable in their acceptably chaotic internal space, all mix together to create the field hut. The hut is not just constructed from the material and immaterial parts brought together in its production, but is influenced and constructed by them. To say that you make a hut from old boards and tin sheets is a pale and inadequate notion, since the hut is an assembled mass of people and things, attitudes and properties, and part of the environment in which it has been set.

The Longhouse at Batu Patong

Past the field hut and further along the path is the site of Batu Patong, and the abandoned longhouse. Surrounded by well-tended padi fields, pineapple plantations and a beautiful orchard of fruit trees, the scene is almost idyllic. The house itself looks remarkably fresh, the side visible as you approach from Pa' Dalih painted in pale colours, standing proud and neatly square, with a lawn of short grass in front. Only a loose corrugated sheet flapping noisily in the breeze hints at the quiet emptiness within (see Figure 51 above). The modern looking building is the *tawa* (the veranda, or communal space), constructed just a few years before the house was abandoned, and to its right as we look is a much older looking *dalim* (family and cooking area). The *dalim* has the same patina as the Pa' Dalih longhouse - a dark brown weathered look to the wooden walls and a rusty roof. It has a slightly crooked, ramshackle appearance, propped by ad hoc timbers with confusing additions to stop the whole structure from slipping down. Having seen a number of Kelabit houses, I could see that there was something strange about this one. The *tawa* is longer than the *dalim*, and the *tadur* (connecting footbridge) between the two halves of the house seemed to be missing, except for a much larger central connecting room.

Climbing over a barbed wire fence, and pushing through the undergrowth, you can see an entrance into the *dalim*, a padlocked door at the top of a notched log ladder (*chan*). Opposite is an opening into the *tawa*, and by moving the ladder across and clambering up we managed to get inside. As with the outside, the first

impression of the inside of the *tawa* is a surprisingly good one. Despite being abandoned, this part of the house appeared to be in good condition. The opening led into a short corridor, with a door on both sides and one at the end. The side doors lead into a series of partitioned *telong* (sleeping rooms) about 3m square, each with walls above head height and hinged doors, all painted in now faded pale colours. The walls and floor were bare, bar a covering of dust and wind blown debris; without a trace of human occupancy, my own hesitant footsteps echoed in the silence. Going through the end door we entered the *tawa*, the communal space used for socialising and displaying personal objects. Jeffrey told me how as a child he would run the length of the *tawa*, racing the other children. Now the full length is cut short halfway along by an incongruous plank wall with wire mesh top.



Figure 55: Interior of the longhouse at Batu Patong 2010.

The wall erected by Riwad Bala cutting across the communal tawa

He explained that the wall was part of the conversion made by the headman, Riwad Bala, who remained in the longhouse after the rest of the village decided to

move elsewhere. By putting up this wall across the communal *tawa*, he partitioned off and secured his section, as he also did in the attached *dalim* (cooking area), so that he was independent of the rest of the empty building, and able to live in his own house-within-a-house (see Figure 57 below).

The walls and floor of the *tawa* were made of chainsaw-cut, hand-planed planks, structural timbers were squared off local hardwoods, neatly and expertly jointed, the outer wall made from overlapping planks with glass windows, and the roof from new-looking tin sheets, never subjected to the soot of smoky fires. Typical traces of humans are absent here, they had such a short amount of time to make their mark. In particular the familiar smoke stained ceilings and walls, and the dark wooden floors: here those surfaces are left pristine and almost new looking. Only the faintest traces remain, pinholes in the wall where pictures would have hung, a faded certificate showing that the house had been sprayed against malaria. Instead, the prominent signs of occupation are left by insects. Large black bees, burrowing thumb sized holes into the joists, had left the layer of fine dust on the floor, and where they were currently active, a dusty mist hanging in the air. In Kelabit homes, these are pests and everything is done to remove them or dissuade them from taking up residence in the first place (on his new house described above, Ganang was trying a green paint to deter them). There are two types of very similar looking bee, one with black legs and one with white legs. One of the two gives a nasty sting while the other is harmless; I could never remember which, so standing there surrounded by a low hum and constant buzzing made me a little nervous. I was now the intruder, the pest. They had indeed made themselves at home. Jeffrey lamented the gradual deterioration of the house, but not as a memento of his youth, even when pressed he seemed to have very little emotional connection to this object as a place. What did frustrate him was the amount of resources going to waste, the good quality prepared timber and the clean roofing sheets. The longhouse, as is usual, was a communal project, relying on the cultural tradition of the *kerja sama* work-party to transport materials and carry out construction. Each family is nominally responsible for their section of the longhouse, but the size of components means that the stronger do the work in

return at a future date for a reciprocal number of days labour, on their farms for example. As with the current longhouse at Pa' Dalih, improvements such as the new *tawas* being built by Jolly and Judine are done at their expense, or the exchange of equivalent days labour with someone who may be particularly adept at some part of the process. So the community who inhabit the longhouse bear responsibility for its construction and upkeep, investing into the fabric of the structure and retaining rights over their sections of the house.

This provides for a multitude of possible future trajectories for this single building, suggesting that the coherence of the thing as an object is somehow dependent on social behaviour. There are limits, in other words, as to what it would be acceptable for an individual to do with 'his' *tawa* and *dalim*, since it affects the whole of the community. As the social nature of the building breaks down, there are fewer limits on what would be acceptable, hence Riwad Bala could build a wall across the *tawa*, people could move to another village and take whole sections of the building with them, or the pattern of occupation can change to become more casual and less formal. All of these new forms of longhouse occurred at Batu Patong.

On a separate visit, once again with Jeffrey, the padlocked door to the *dalim* was open. Doo Pu'un, a swarthy man probably in his 70s had come to work on his fields in the area and stayed in the *dalim* to save the walk back to Pa' Dalih. Inside, the interior felt very similar to the longhouse at Pa' Dalih: dark, brown and black, with a lingering smokiness. Doo Pu'un had fixed up the hearth with pieces of timber to reinforce it, and stored a small amount of firewood above. Inside, he had set up a tent and brought along some food and odds-and-ends to last him the few days he would spend there. There was only one room, no separate kitchen or bathroom area. In 1976, bathrooms were in another hut outside the back door. This *dalim* was now a single unit, the neighbour's building on one side had been removed for re-use, and on the other stood another wall put up by Riwad Bala, to separate out his *dalim*, in the same way as he had walled off his *tawa* once the other villagers left. Climbing up and peering over the top of the dividing wall, I

could see into Riward Bala's home. Apparently abandoned in 2004 after his death, but still looking remarkably lived-in. Wood was stored over the fire, pots and baskets lay on the floor and tied to the rafters, a washing line was strung out with two towels hanging over it. A pile of leaves blown in through the open window was all that testified to its now disused state. The long open view that would have been there when the *dalims* were complete was curtailed to produce a claustrophobic space only suitable for occasional occupation by visitors like Doo Pu'un. As well as being used as a *daan* (field hut), this room reminded me very much of the *daan* where we had previously stopped for tea with Jeffrey's parents, unkempt and little used. In fact the most frequent visitors were the rats, searching out any left over scraps or insecure stores of rice to be raided. The rats were for now displaced by a human, complete with his tent to keep them off him at night.

The overwhelming impression that I came away with, after my foray into the interior, was the lack of much humanly-instigated deterioration. The short period of perhaps five years when this house was the home of the villagers of Batu Patong had not been long enough for them to alter the interior in the same way as other interiors I had seen in more established longhouses. Especially in the *tawa*, constructed from new planks, it lacked the patina, the atmosphere and the degradation present in the longhouse at Pa' Dalih, for example.

Now it was left to the rats and insects, the weeds and the trees to encroach and consume it. To the side, the surrounding vegetation has made a decent job of taking over the house, fruit trees gradually moving closer to the house as they self-propagate, so that now they lean up against the outside walls, fighting off greedy climbing plants that swamp what was once a carefully tended garden (see Figure 56 below). The shortened extent of the *dalim* is also obvious from this side, only two sections remain, but apparently not in any imminent danger of collapse, they still look quite sturdy. Steps lead up to a padlocked door, next to a sink hung outside the kitchen window - the back entrance to Riward Bala's house. At the far end of the building is a large, overgrown, but obviously flat area, which Jeffrey informed me was where the rest of the house had been. What remains is half of

the *tawa*, and a third of the *dalim*. The rest of the building has been taken away and re-used in one way or another, telling a story of social and material connections, which I will try to describe below.



Figure 56: The dalim of the Batu Patong longhouse, now overgrown by fruit trees and weeds, showing the entrance to Riward Bala's kitchen on the right

Material Dissipation

At the time of its demise in 1976, the Batu Patong longhouse held six families. The younger members of the community had begun to leave to take up jobs in Miri as government workers, or joined the organised exodus of border communities resettled in Bario from the 1960s onwards. As the age of the community grew older, they found it more difficult to cope with the demands of farming and maintenance and eventually had to leave. The house was constructed over a two year period in 1970-72, the *dalim* first, using materials taken in part from the previous longhouse, and done piecemeal, as and when villagers could

assemble the materials and labour required to construct family sections. The *tawa* was sponsored by a wealthy individual and built as a whole in 1972, hence its visible coherence on first approaching it, and the use of new planks. Shortly before its desertion, the house was laid out something like the plan below, reconstructed from discussions with Jeffrey and his parents, and observations and measurements taken on the ground. Each section is numbered to identify the owner, and described below. The intricacies of Kelabit family relations come across in this description, which can be a little overwhelming, but comparing the diagrams in Figures 57 and 58 (below) will, I hope, help make the social and material relations a little clearer.⁵⁸ The photograph in Figure 51 (above) is taken from the bottom right corner of this plan, and Figure 56 (above) taken from top left.

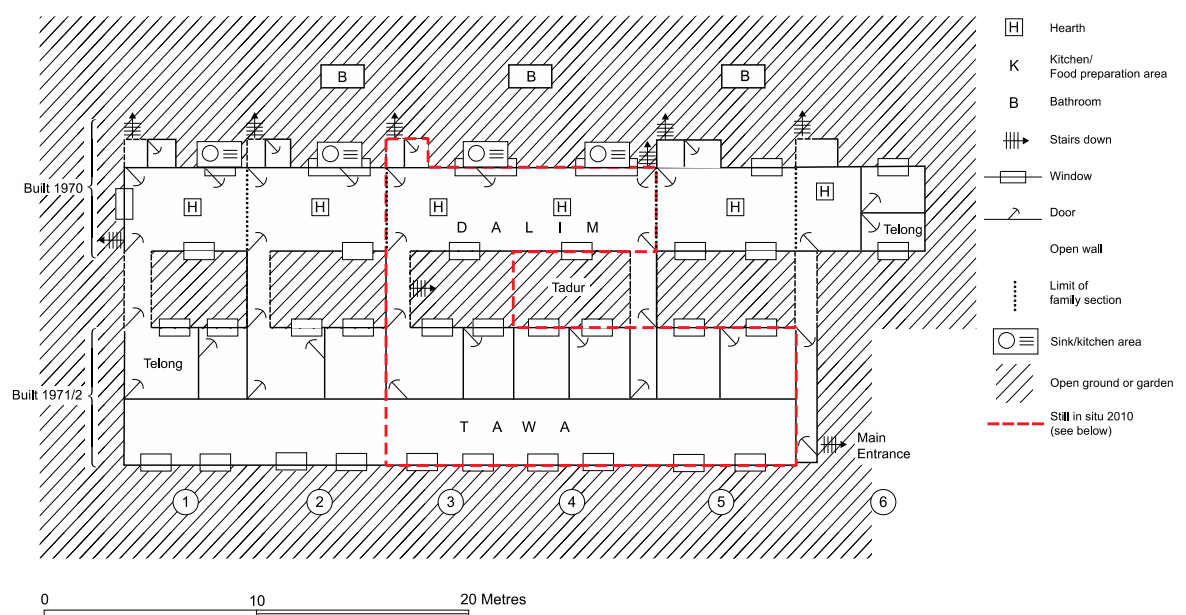


Figure 57: Reconstruction of Batu Patong Longhouse shortly before abandonment

Section 1: Ketuan Tepun lived in Batu Patong with his wife and daughter, he also had family in Miri. When the longhouse was abandoned, they split their time between Miri and the old longhouse for three or four years until Ketuan Tepun

⁵⁸ These relationships were described to me by Jeffrey and his mother Sina Ellie, and supplemented by further information from Monica Janowski (pers. comm.) who is in the process of drawing up a detailed genealogy of the Kelabit in and around Pa' Dalih.

died in Miri in 1979/80. The *tawa* was dismantled and taken to Pa' Mada (8km from Pa' Dalih) and used to construct the end section of the longhouse there. Sina Guna Ulun, Ketuan Tepun's wife's niece, now lives there. Her section is at the common entrance to the Pa' Mada longhouse and she has gained something of a reputation for hosting backpackers and occasional tourists. The old *dalim* was bought by Balan Paran (no relation to Ketuan Tepun) for a large antler, and used by him in building his part of the short-short longhouse, where he is next-door-neighbour to Ganang.

Section 2: Balang Punang was half-brother to Ketuan Tepun and married to Jeffrey's grandmother. He worked as a border scout, a post based in Bario where he moved once new houses were built there for the scouts to use. He divided his section of the house between Sina Ellie (his step daughter, Jeffrey's mother) and her brother Baye Ribu. Sina Ellie used her portion of the house to build part of the short longhouse in Pa' Dalih, while Baye Ribu built a storage hut in Pa' Dalih village. The roof, walls and floor were all re-used, five of the floorboards went into the house at Pa' Dalih, the rest of that building was made up of materials from the old pastor's house at Batu Patong. The field hut where we stopped on the way over, was made up of parts of the longhouse and "some other houses" and belongs to Sina Ellie and Baya Ribu. This section was Jeffrey's home.

Section 3: Riwad Bala was the full brother of Ketuan Tepun and half brother of Balang Punang, and headman of the village of Batu Patong. When the villagers left in the late 1970s, he decided to remain in the longhouse. To increase the space available to him, he widened the connecting bridge (*tadur*) thereby creating another room between the existing *dalim* and *tawa* to form a much larger internal space. This is the unusual construction I had seen from the outside. The sink and padlocked door seen at the side were the kitchen area and rear entrance to this house. He continued to live here until his death in around 2004. This section of the longhouse still stands, now owned by Riwad Bala's daughter who lives in Miri.

Section 4: Temagong Tepun was related to the previously mentioned three at grandparent level. Jeffrey thought their grandparents may have been siblings or cousins. Temagong moved to Pa' Dalih in 1976 and stayed for three years or so with his son Ra'an Bala before they moved to Miri. Ra'an Bala at the time owned a section of the Pa' Dalih longhouse which was where Jeffrey and his family first lived in Pa' Dalih. When Balang Punang (see above) bought the section of the Pa' Dalih longhouse from Ra'an Bala, he (Ra'an Bala) bought the Pastor's house at Batu Patong and transported the planks from there to Pa' Dalih where they were used in the initial construction of Sina Ellie's *dalim* in the short longhouse. This was later re-built with mostly new planks cut by Raja Bala. The *tawa* and *dalim* still remain at Batu Patong. Doo Pu'un from Pa' Dalih, who has padi fields in Batu Patong, uses the *dalim* as a *daan* (field hut), erecting a tent inside the derelict building, storing a few odds-and-ends, and using the hearth.

Section 5: Mili Ulun was married to Temagong's daughter, Ra'an Bala's sister (now known as Sina Mili), and also worked as a border scout. He had a new house in Bario as part of his job, and moved there when the villagers left Batu Patong. The *dalim* was bought by Nyimut Ulun, Jeffrey's neighbour in the short longhouse, and used by him to build a new *daan* (field hut) near his padi fields. Mili Ulun died about 3 years ago, and the remaining *tawa* is owned by Sina Mili and her son, still living in Bario. Jeffrey says he has tried to buy the building to use the wood, but they have so far refused.

Section 6: Tulu Bala was married to Mili Ulun's sister, and came to Batu Patong quite late. He had built a *dalim*, but not yet built his addition to the *tawa* when the villagers decided to leave, and so the space that had been cleared for this was never used. His brother Radu Ulun had planned to build a *dalim* and *tawa* next to Tulu Bala, but in the end they both moved to Bario, to work as border scouts. The flat grassy area seen on approaching the longhouse is the space left for these planned buildings. Tulu Bala died sometime before 2004, but his *dalim* was bought by Maran Guna in Pa' Mada and transported there, possibly reconstructed as a *daan*.

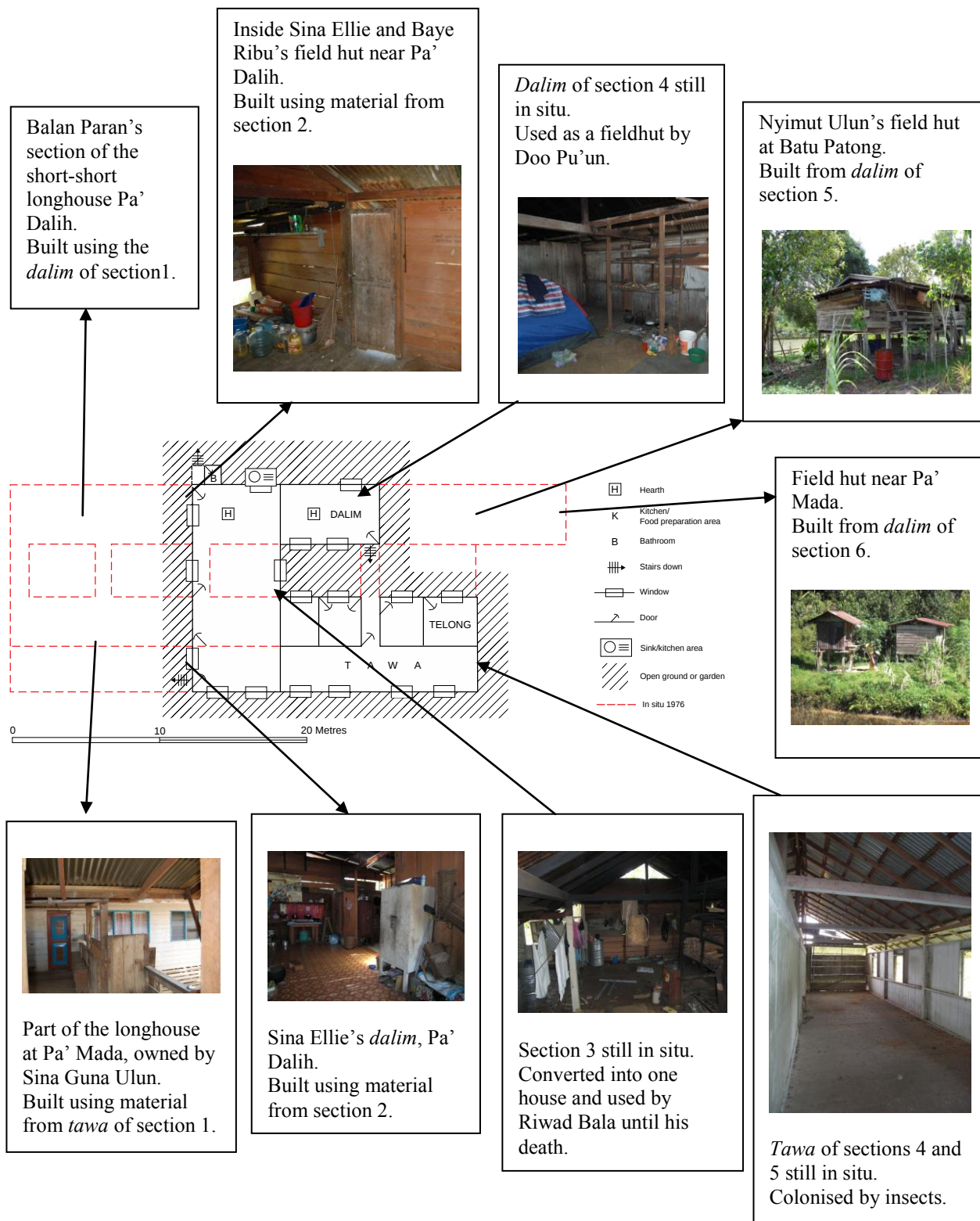


Figure 58: Batu Patong Longhouse 2010: Dispersed materials

Conclusion: A Site of Temporary Connection

Studies of exchange have demonstrated how objects can accumulate meanings and facilitate relationships, acquiring value as a result of the politics of on-going transactions, while objects considered as ‘art’ objects are instilled with value through the demonstration of rare skill that they embody. In the case of the longhouse at Batu Patong, scale plays an important part in determining its value. Objects discussed as being exchanged, or artistic, tend to have been collected, usually for museums, thus being inherently portable, and usually small. Of course not all objects in museums are small, ‘portability’ being a function of the facilities available to carry them there, but the general point holds, that small objects can be seen as complete and coherent wholes and thus easy to track. Objects such as the Batu Patong longhouse are unlikely to be collected in the same sense of the word, and hence require a different analytical approach to perceiving their value. To accord with local views, value is seen to reside in the potential of the component parts. This seems to be particularly appropriate for the sort of large-scale objects that are the focus of this thesis since they are assemblages of multiple components, and usually the result of communal activity. In their production they require a process of accumulation and manipulation to coerce sometimes reluctant materials into shape. Big objects made up of lots of things contain within them a significant resource, the wood in a house can be reused in ways that the wood in a carving, for example, cannot. The tendency is for objects such as the longhouse to retain some of their value in the materials of construction, rather than, as in the case of the carving, value retained through the labour involved in its production, or as an exchange object, through a history of ownership.

The engineering project produces an object constantly in flux, always requiring maintenance, and through its inclusion into daily activity, always changing in line with the lives of the occupants. Ingold has described two perspectives (2000: 172-188) to demonstrate the difference in conception between a house in its environment (the ‘dwelling perspective’), and a house forming a boundary between the inside and outside worlds (the ‘building perspective’). The second makes a distinction between the cultural world of the house, and depends on

human invention to be able to envisage the building, and formulate a plan for its creation. Contrary to this, the 'dwelling perspective', as originally espoused by Heidegger has been summarised by Cloke and Jones (2001: 652) as: "Dwelling is about the rich intimate on-going togetherness of beings and things which make up landscapes and places, and which bind together nature and culture over time". To 'dwell' is to live as part of the world, rather than to confront and challenge it, without a special place for the human scope of activity separate from the multitude of other activities already there and continuing regardless of human interventions or absence.

So the building perspective sees a house as 'man-made', designed according to cultural variation, and opposed to (in Ingold's example) a beaver's lodge as 'beaver-made' no more than an extension of its pre-determined phenotype (akin to a mollusc's shell, which cannot help but grow). The dwelling perspective on the other hand considers any form of constructed environment incomplete. A house for example is continually changing, as it becomes inhabited by other creatures (insects, rats, pets etc.) and altered by them, by the human inhabitants, or other parts of the surrounding ecology (plants, sun, wind etc.). "It does not begin here, with a pre-formed plan, and end there, with a finished artefact." (2000: 188). The thing we see as a longhouse is different from day-to-day, and generation-to-generation, as new fashions of living are incorporated into it and interactions with the world outside alter the constituent parts. Ingold has shown that the human perspective of objects is partial (in both senses of the word: biased, and incomplete), especially those such as the longhouse which are exposed to environmental conditions. The object is never finished as such, it is constantly morphed by the actions of the world at large – the flow of life - ranging in scale from the sun and rain, to rotting moulds. This becomes obvious when we remove the human component and see how the building became home to a series of large bees, hungry rats, and a variety of plants.

The static permanence of the building is therefore illusory, subject to constant change as a result of being exposed to the world. It is a temporary collection of

components, all of which are affected by sociality (nostalgia for floorboards) or ecology (rusting tin sheets or homely rats), and liable to split apart for social or ecological reasons and coalesce with other components in a different assemblage. It is a site of temporary connections. The object-as-seen is made up of all those individual parts, each contributing an amount to the nature of the entire thing. In the case of the longhouse, the individuals are not just the material parts that are fixed together in a particular shape – the floorboards and rafters, tin sheets and glass windows - but also include the concepts and ideas that brought them together, the possessions that people bring with them, the soot on the ceiling of the *dalim*, the bees burrowing into the rafters and the rats looking for an easy meal, the faded paint and climbing weeds. The constitution of the object is a nebulous combination of all these things and many more. The previous longhouse, other buildings, fresh timber from the forest, large stones from the river, roofing sheets from Miri, and some that had been used for perhaps 20 years in other houses, all these pieces came together through human activity to form the new object. This is what Colloredo-Mansfeld describes as the productive undoing of form (2003), the very act of taking something apart provides an opportunity, even an obligation, for the resultant pieces to become something else . Some things maintain only a tenuous grip on the object and may easily slip off, while new things stick to the edges, perhaps becoming more firmly fixed. Attitudes ebb and flow, like the current Kelabit notions of durability; components disappear and new ones materialize - modern planks replace adze cut floorboards; pictures are removed or changed; hearths deteriorate; insects move in.

The swarm of parts that congregated to form an assemblage, retained an essential core, formed around the basic idea of a longhouse. At the edges, dissident parts splinter off and break away, to gather together with different parts from here and elsewhere around a new essential core to form a new object,. At some point the whole thing disintegrated and the ‘longhouse’ ceased to exist as such. The work of holding it together as a complex and coherent object through regular maintenance tasks slowed and stopped, leaving the object to collapse and split into parts, free to

mix with other parts from the animal world, the forest, houses, possessions, the river, skills, tools, the weather, and so on, into new concepts and objects.

By 1973, a site of temporary connections had established itself at Batu Patong, in the form of a longhouse. It was made up of various fragments from houses, the forest, and the de-commissioned army camp at Pa' Mein. It included the various insects, animals and plants that were attracted to the core, and helped to create the object that was held together through the concept of what constitutes a longhouse. Not just the physical components of the longhouse, but also the notion of how the object is made up, what becomes part of the core and what breaks off: family pictures are in, but now skulls are not, dogs and bees kept out, the soot allowed to build up on the ceiling. The materials of the object also flow between the core and the friable edge: rotten posts are replaced with new ones, the old ones consumed in the fires inside, thatched roofs slip away and tin sheets get pulled in. As Gregson *et al.* say, there is a tendency for the object to re-materialize, to literally revert to its material state (2010). In 1976, when the villagers of Batu Patong decided to leave, the swarming mass of parts and concepts, humans, plants and animals, materiality and immateriality, all those things that went to make up the longhouse, began to fragment. Material parts divided up and went their separate ways, disaggregating and reforming somewhere else. Floorboards joined up with other parts to form a new house, or a ramshackle field hut. Likewise other parts not physically secured to the construction also dissipate – most obviously the people themselves and their possessions, but they also leave with their emotional energies, their plans for the future, their social morals. All these things are split apart and move on to merge with new hopes and codes of behaviour as part of the continual process of dwelling.

And what becomes of the original thing, the longhouse at Batu Patong? The concept of the object as a dwelling, a place fit for human habitation, became disconnected and reconvened in Pa' Dalih, Bario and Miri. Some of the tin sheets separated off and reformed in the longhouse of Pa' Mada. Still others reconfigured themselves with timbers from the Pastor's house and formed a

dwelling that became Jeffrey's family home at the end of the short-longhouse in Pa' Dalih. Floorboards exerted their influence as objects suitable for forming the floor of a structure, and re-assembled in fieldhuts nearby. The long-thing-where-people-live is reduced to the point where that description is no longer tenable, and it becomes filled with new purpose and new life. The death of the longhouse could be more accurately described as its redistribution (Gell 1998: 96-154). Instead of mouldering into a funereal dust, the object becomes a hive of activity. Dismantled and broken down, a whole set of new assemblages were formed. Alliances forged with other materials in a different place, and yet more growing in the forest, or on the shelves of Bario stores. Relations with insects, plants and animals are disturbed, while in new places they are invigorated. Ideas and emotions are broken down and reconfigured in the context of the next assemblage. New sites form and begin the cycle of object construction all over again.

CONCLUSIONS

The Importance of Engineering to Anthropology

I began this thesis by asking the question, “How do people make things?”, and hope to have shown some of the complexities involved in practices of production, and in particular, technical production – what I have referred to as ‘engineering’. The act of production is a fundamental part of life and yet it remains firmly in the shadow of ‘consumption’ in academic anthropology. As Dietler says (referring to Miller) “Indeed, one prominent advocate has even argued...perhaps with a hint of hyperbole, that the rise of consumption studies constitutes a fundamental transformation in the discipline of anthropology...” (2010: 209). How objects are seen to be ‘consumed’ is so broad as to defy limited definition, including for example, acts of exchange, representation and effect, use and appropriation, reflections of life histories, creation of identity, and much besides.⁵⁹ In the sense of the word commonly used in the industrialised world, consumption has come to be associated with commodities, as in ‘the consumer society’, focussing on the ever-increasing abundance of ‘Stuff’ (Miller 2009, Molotch 2003) and the part it plays in everyday life. In both cases the act of production is given limited space, either through the alienation of the object from its place of production, or the reluctance of anthropologists to enter into an alien and technical world (Sigaut 2002). Neither of which are reason enough to preclude production generally, and engineering in particular, from exposure to the anthropological gaze. Where production has been given academic consideration, it tends to be in the form of observations of craftsmanship and usually of small individually produced objects (e.g. Mackenzie 1991, Ingold 2000). So the question, “How do people make things?” is not simply an abstract philosophical research question, it is a question that most people really could not answer, and probably do not give much thought to.

⁵⁹ Although surprisingly little on *literally* consuming.

Turning specifically to engineering, which has been the focus of my discussions here, I have used a general definition of ‘technical production’, and further reduced this to the communal production of large-scale or complex objects. The anthropology of technology has, as discussed, a long history, concurrent with the birth of anthropology as an academic discipline and the idea of technology as a measure of social development (e.g. Morgan 1977), but more recently been heavily influenced by French sociology, and Science and Technology Studies. Especially important have been the works of Lemonnier and the idea of the *chaîne opératoire* methodology (1992; 1993), developed from a long tradition of French scholarship including Leroi-Gourhan (1964), who placed the issue of technology at the heart of what it means to be human, and Haudricourt, who defined technology as the science of human activity, endorsed as an approach by Sigaut (2002: 422). This tradition of an ‘anthropology of techniques’ (including Mauss (1973) and his concept of ‘techniques of the body’) has been complemented and brought into social anthropology by the adoption and consideration of social constructivist notions of technological choice (Bijker *et al.* 1987; Dobres and Hoffman 1999), and more recently STS ideas of the mutuality of the material and social world of technology (Latour 2002; Law 2010).

Herein lies the space in which this thesis aims to dwell. The rich literature on consumption fails to give adequate attention to production as its prerequisite, while the literature on production as a general topic tends to avoid issues of technical production, preferring to stick with craftsmanship and individual skills. On the other hand, technology is a current and developing field of investigation for sociologists, usually French and often interested in industrialised technologies and science in particular. If we accept the importance of production to cultural life, then the communal nature of engineering projects must surely be doubly important to anthropology. By investigating the type of practices discussed in this thesis - the technical production of large, composite objects – we can document and examine the necessarily extended and co-ordinated social relations, and the simultaneous development of socio-material and environmental connections in the process.

Parallel Fieldwork as a Way of Providing Perspective

This project was set up in the belief that personal experiences of engineering could in some way act to provide different insights into technical production. The aim was to investigate engineering as an activity, rather than the engineering activities of any particular culture. This presented me with two problems, first, the influence and bias of my own experience, and second the extent to which engineering could be seen as a generalised activity, regardless of culture. Bourdieu in particular provided a methodological ploy that served to address these problems, through his use of parallel fieldwork (1990a; 1990b) without resorting to cross-cultural comparisons of the sort that would simply identify differences of approach. My view is that technical production is an activity that forms an integral part of people's continually creative relations with their wider environment, each acting to re-form the other, and to investigate and demonstrate this requires more than a technical cultural comparison.

Fieldwork in a culture with which I am familiar provided the opportunity to situate practices in their context without having to struggle with the context, as suggested by Marcus (2006 [1999]) in proposing the idea of primary and secondary fieldsites. The Didcot Railway Centre was a place where the engineering of large and complex objects was carried out in a way that allowed me to observe the subtleties of activity. This was the first time I had observed my own engineering culture as an anthropologist, and provided the important insight that this was a particular and idiosyncratic perspective, based on personal experiences. It would have been easy to report back on those observations, but this would have been unwittingly self-centred, something which only becomes apparent when exposed to a commensurate situation, outside the familiar. This was provided by my primary fieldsite in Borneo.

Working with the Kelabit showed very clearly the holistic relations between materials, environment and skills, and served to expose in my own mind the differences from my own approach. Recognising the importance of aspects of Kelabit engineering led me to question whether I had overlooked the obvious in

considering UK engineering, for example as described in Diversion 2 (*The Engineering Environment*), the importance and concept of the culturally perceived environment. Similarly, in observing technical activities in the UK, and understanding their context, required that the same ideas were tested in Kelabit circumstances. Issues described in Diversion 1, such as lack of skills and how these were overcome through an on-going process of engagement with materials, resonated during construction of the new bridge in Pa' Dalih. This cross-fertilization of ideas and forms of analysis, has provided a useful tool in considering engineering more broadly.

Unlike the traditional anthropological approach of a complete immersion into an exotic culture, my focus remained firmly on technical production, and included only those areas of cultural life that seemed to be relevant to the engineering work that was going on. This has inherently provided a limited view of the cultures of both the Kelabit and the English, but has I believe provided a more detailed picture of the nature of engineering, freed of many of the biases of personal experience, while remaining technically sound. Parallel fieldwork has provided the method by which I have been able to adopt a reflexive approach to a familiar subject, but still ground the analysis in situated practices rather than personal idiosyncrasy.

The nature of anthropological fieldwork is changing with pressures on funding and family life, a shift away from the search for the exotic, and the increasing globalisation of communication, travel, and access to information. "Today, "the field" has broadened to include everywhere there are human beings, and every imaginable human group and context has become an actual or potential research site" (Robben and Sluka 2007: 2). Because of this huge variety of contexts, the long-standing anthropological tradition of cross-cultural comparison and generalization is increasingly difficult to sustain, and yet resorting to relativism seems to offer little in the way of genuine insight, just a series of interesting stories. My context – engineering - includes the additional difficulty of specific competency and the problem of a technical language. For many anthropological

researchers with a background in the arts and humanities, the science and mathematical content of engineering is enough to dissuade or preclude them from attempting such fieldwork. For me personally, this was not difficult since I have experience of dealing with technical production in a range of industries, but did present the problem of overcoming this upbringing when applying it to a different cultural context. This is where the methodology of parallel fieldwork (Bourdieu 1990a; 1990b) and the concept of cultural analogy (Strathern 1987a; 1991) could be more widely used within anthropological research. As a way of avoiding the twin traps of cross-cultural comparison and personal bias in specific areas of expertise (doing anthropology ‘at home’ – Strathern 1987b), this approach might provide a way forward for anthropological fieldwork that suffers from being either overly reflexive or conversely, observed from too far a distance.

A Theoretical Stance to Include Skill and Organization

In discussing the various projects used here as case studies, it has become clear that the more popular theoretical approaches to technology, production, skill etc. seem to have something to offer an anthropology of engineering and yet at the same time, some things missing. Ultimately, I have come to the conclusion that in the absence of another new theory, it has been worthwhile using aspects of network theory, material culture studies (especially debates about materiality) and ecologically-informed approaches to skilled practice, in particular the work of Tim Ingold.

Ingold has written of acts of skilled practice, and placed them in the context of an on-going flow of life (e.g. 2000: 339-348; 2010; see also Guss 1990), and usefully for this thesis, many of his examples are to do with production. Skilled practices are of course not limited to making things, we could cite sport, music, dance and so on, and one of Ingold’s points is that life itself is skilled practice; but my concern here has been with acts of production. We are used to descriptions of skill in acts of production, usually in the context of craftsmanship or artistic virtuosity, but the skills used in engineering are no less impressive. Engineering production, in the examples I have described, is a communal activity relying on the combined resources of a group of like-minded people. The size of these projects means it

would not be possible for an individual to complete them alone. In constructing a bridge, a house or a steam train, some of the separate parts are too large or too cumbersome to be manipulated by one person. More so than the need for simple brute force, technical production also demands that enough appropriate skills and tools are available.

Communal production, and the scale or complexity of an engineered object or set of practices means that quite often the skill involved is quickly hidden, lost in the mass of other materials and practices. When Robert mixed sand and cement, a group of knowledgeable men watched in appreciation. The mixture was then combined with water and stones, buried in a hole and left to set, leaving behind no trace of the skill that had gone into its production. The same could be said of the engineers at the Didcot Railway Centre, in the way they bent copper pipes, or listened to the sound of an engine. Experienced practice embodies skills within individuals, tempered or exaggerated by their personal aptitudes and physical capacities: the more you practice, the better you get. This is true for everyday activities of making as much as it is for more highbrow artistry of sculpting, painting, dance and so on, who are often seen as possessing innate or divinely-gifted abilities, beyond the scope of the ordinary person (e.g. Gell 1999). To suggest these are anything more than the mastery of everyday activities seems to me to be misguided, and it is a characteristic of engineering that the process is filled with such activities carried out by ordinary people. This insight owes much to Ingold's work, but also demonstrates a shortcoming, which is the emphasis on the skill of the individual, and especially what we might call craftsmanship.

Whilst, through Ingold, we can see engineering as a skilled practice, it is also an organised activity, one where a multitude of people, tools and materials are gathered together according to a plan. This begins to move us away from the craftsman and towards the world examined by STS, and network analysts. Knowing that the resultant engineered object comes about through the mutual interactions of people and materials, ANT suggests how we might view this happening, as Law puts it by 'heterogenous engineering' (1992). The complex

interactions among disparate components of an engineering project are difficult to trace from the standpoint of a set of individual craftspeople.

As Ingold has rightly pointed out, the tendency in material culture studies has been to ignore the materials of objects in favour of the objects themselves, as a result of the dominance of consumption as an analytical framework (Ingold 2007a; 2007b; cf Miller 2007). To consider materials, forces a consideration of production; that, after all, is what materials are for – to make things. Engineering, as a form of production, is thus dependent on materials, and the creative engagements of engineers with their materials. Any approach to engineering must allow for this, which is what I have tried to do in the case studies above. The Kelabit house-builders' history of relations with wooden floorboards for instance, demonstrates changing technical traditions and individual skills; similarly the pride taken in the railway engineers' exact shaping of copper pipes.

However, while 'materiality' in consumption studies might have lost its connection to the world of production, seeing only 'materials' dilutes our interactions with the world of things. We can thank Gell (1998) for pointing out the importance of the effect of objects, not just their meaning. Important, since an engineering project is full of objects, some of which are materials, some tools, and some simply things that happen to be there. These all go together to influence behaviour and alter the course of the project through the ways they are apprehended by the engineers. Kelabit bridge builders for example, engaged with chainsaws, wooden posts and branches in different ways, and the availability of any of these things altered their behaviour. At what point did a piece of belian wood stop being 'material' and transform into 'object'? Perhaps once it had been sawn, planed and joined to other pieces of wood and become a tower, or to other towers and rope, and become a bridge. Or perhaps it remains forever 'material'. The distinction is of course unnecessary and not of the least concern to the bridge builders. At some point, once the wood has been worked into its desired shape, through processes that resemble those described by Ingold's notion of skilled practice, it is assembled with other materials and becomes something else. Things are of course still constituted of materials (Ingold 2007b), which became clear in

my example of the disintegration of the longhouse at Batu Patong, but they are also objects.

This is where I feel we can usefully draw on some of the ideas put forward by ANT. The gathering together of these parts, along with the necessary skills and tools to engineer them into a large or complex object, resembles Law's notion of heterogenous engineering (1987; 1992), or Latour's 'sociology of associations' (2005: 9). The relations created by the association of the heterogenous parts act to create the social activity that is the engineering project. More so than Ingold, Latour in particular gives power to objects to act within the network of relations. ANT tries to free human actors from the illusion of 'the social' and natural actors from empiricism (Latour 2005: 114). Law's 'material semiotics' (2010) is more concerned with practices and the patterning of relations, and so is closer to Ingold: "Using verbs rather than nouns, and exploring how it is that processes work, it [material semiotics] talks more of mattering or materializing, than of matter or materiality" (Law 2010: 187). The 'materials', in Law's material semiotics are a much wider group of things than Ingold's, including everything that can be seen in the action during the practices that draw them together, from raw materials to component parts to tools, people, politics and so on. Whereas Ingold sees at the centre of relations the person involved in the practice of production (2011: 63-65), Law focuses on the outcome of the assembled materials, and sees practice as unavoidably variable from one activity to the next, even in the apparently controlled environment of the scientific laboratory (2010: 177-180).

Watching the Kelabit engineers building their bridges, I was struck by the appropriateness of Ingold's notion of skilled practice at an individual level, but failed to see how it translated into the social complexity of communal construction. On the other hand, a network analysis, or systems approach seemed to ignore the important individual practices that were going on, but provided a way of seeing how the variety of parts came together. Rather like Law's descriptions of Portugese expansion and the interactions of new technologies, ship design and political ambitions (1987), I saw during the bridge building an act of heterogenous engineering, literally in the techniques and effort, and socially in the

mixture of tradition, materials and ways of learning and failing. Engineering seems to straddle both these approaches, including as it does, the skilled individual, and the social and material assembly of heterogeneous parts. Where they meet is in advocating a socio-material relational approach, seeing production practices as the creation of relations between people and their environment, and this seems to me to be a good starting point for a theory of engineering.

The Mutual Construction of Engineering and Environment

The environment has been a key theme in this thesis, as the forum for individual skilled practice, and a setting for the assembly of large and varied collections of materials. I have discussed above the idea of the engineering environment as a context for these activities to take place, and described how the dynamic environment is subjected to cultural forces that cause it to change. In the case of the engineers at the DRC there was a contraction of their engineering environment as tools and techniques became obsolete, whereas for the Kelabit, engineering has been part of their incorporation into a global world, through regional transport links and information technologies. Engineering therefore produces environmental relations on two levels: the wider engineering environment, and the immediate locale. First, it links different geographic places through a common concept, and secondly a large composite object and the process of its construction has the potential to make a significant impact on its setting.

As discussed above, the engineering environments encountered by the Kelabit bridge builders, including for example the Chinese hardware stores in Miri, or the engineers at the DRC who searched long and hard for someone to make new wheels, were in effect part of a creative process. The environment in which those engineers operated grew to include new objects, ideas and possibilities. It took them beyond the places they currently inhabit and immersed them in new places, which became part of their environment. This immersion is what Ingold refers to as the 'meshwork' (2011), a flow of relations seen as a way of life. Others might call this a network of connections, bringing together people and things to form a heterogeneous assemblage that is imbued with powerful effects (Law 1992; Latour 2005). Both are attempts to go beyond individual life and place the person within

the wider world. For Ingold, the primary relation is with the environment, and for network analysts, relations between 'materials' (in Law's sense of the word) are all-encompassing and dispassionate. To see how engineering and its environment are mutually constructed, we need to embrace both senses of relationality and realize that the clinical heterogeneous assemblages are part of the same flow of life as the more poetic experiences that Ingold has described.

Tsing (2005) showed how globalism alters the concept of the environment in a myriad of ways, and demonstrated the importance of embracing the messiness at a local level to begin to understand the picture at a global level. Her example is environmental in the commonly-understood sense - the shocking and depressing destruction of the Indonesian rainforest - but the same process of environmental change has been at work in the Kelabit Highlands, in a less catastrophic way. For them, issues such as religious beliefs, notions of durability, encroachment by logging, modern materials and ideas etc. has fundamentally altered concepts of the environment, and consequently of engineering too. The idea that the environment is the 'natural world' of plants and animals is clearly unsustainable, since most clearly, as in Indonesia, the world of plants and animals is created in tandem with people. The environment in other words is that part of the world that a person inhabits, which for the engineers in my cases includes things like hardware stores and jungles, or heritage railways and workshops. These relations are created as a result of the engineering activity, and the inherently composite nature of the objects produced. A wide range of components, tools, skills and materials is unlikely to be available within a geographically close area, which leads the engineer to forge new links in different places. The engineering environment in these terms can be seen as an extended resource base that acts as the framework for further social relations to come into effect.

Which brings us to the on-site relationships between engineering and the environment. The size and complexity of engineered objects are enough to alter their location, not simply an *in situ* construction, but continuing to form part of the environment. The suspension bridge, for example, was anchored to the forest mechanically and ecologically, fitting in with the on-going processes of nature

and the human users' desire for certain shapes and appearances. The environment was altered to accept the bridge, and the bridge was engineered to fit in with the environment. To build the new bridge into place required substantial efforts to make it fit in a way that accorded with the sentiments of the builders. In doing so, they changed the forest around the bridge, installing a series of parts and materials new to the surroundings as well as to the builders. This part of the forest had never before 'seen' a suspension bridge any more than the builders had. Tall wooden towers and large concrete blocks became part of that setting, and were then subjected to the on-going use and impact of the living and climatic milieu, much as the longhouse at Batu Patong became colonized by a variety of plants and animals.



Figure 60: The Engineered Environment

Materials become the home and food of insects and animals, supports for plants, and participants in environmental cycles. Production continues, no longer dominated by people, removing the construction site from the object, and leaving

it to the forest to set a different course, transforming into rust and rot, food, habitats and supports. While this is creative for the animal world, it might not suit the humans, who still intend to use the object and rely on it to perform according to their changing social needs. As with the example of the abandoned longhouse in a constant flux of human and non-human activity, inhabitation, maintenance and cultural appropriation, the object and its materials are part of the continual passage of production. In that case, the deterioration of parts of the building and the re-use of others illustrates the complexities of the multiple journeys and the on-going sense of movement and change. As Colloredo-Mansfeld (2003) pointed out, the ‘undoing of form’ is a productive act, a process of re-materialization in Gregson’s example, literally the object reverting to materials (2010). The apparently destructive acts that cause the disintegration of an object are in themselves part of the process of creation, and hence production: we cannot distinguish between one and the other.

As a result of the act of engineering, new sets of relations start to form, based on the significance of a substantial new part of the environment to be encountered. The Kelabit bridge created paths and clearances, as people visited, crossed and stopped to chat or fish, these extended out to Pa’ Dalih in one direction, and past the farms and on to Indonesia in the other. The longhouse at Batu Patong attracted plants and animals who happily colonised the building, obscuring human traces and setting up their own pathways through the air and along the ground. And the restored ‘King Edward II’ brought people from far and wide to take photographs, discuss details and develop their own links and paths, across the internet, or on visits to some of the places associated with the engine and its restoration.

Environmental relations are therefore crucial to the engineering project. They provide the framework for an extension to the experience of the producers, by forcing them to look outside normal environmental boundaries and into new places. Geographically distant places are linked with little attention for what lies between. The common concept of engineering is the thread that holds this environment together, and not the containing boundaries of area or proximity. Furthermore, the place at which the objects and practices of engineering are

located is substantially transformed by the size and complexity of those activities. While people are being created by the embodiment of practice in the course of construction, the environment is simultaneously being created by the introduction of materials and forms.

Extended and Coordinated Social Relations

In examining objects that are large and complex, and come about through practices of engineering, I have switched focus away from symbolism and craftsmanship, and on to technical production. In the case of the two bridges described above, the same people performed different engineering practices, on the basis of their familiarity with the construction techniques and materials. The starting point, of conceiving the object and formulating a plan, depended to a large extent on the knowledge that during the construction process they could rely on their skills and experience. The competences required to successfully produce the object were contained within the group of people, and not within an individual. For engineering practices to be carried out therefore depends on extensive social relations, providing access to tools, skills and materials that are distributed among them.

There is an important point in the notion of a design as a preconception. For the engineers I studied, the idea of a plan was incomplete, what they were doing was to set off on a journey, with an end point in mind, but not necessarily knowing the entire route. They were working towards an objective by doing, rather than by thinking, which seems an obvious point to make - How can engineering be done in any other way? But this is different from ideas of industrial design, which assume a final form regardless of the activity or problems of production (e.g. Lawson 2004), and different too from descriptions of craftsmanship, which reduce planning to a by-product of material interaction (e.g. Ingold 2000). For the former, any feature or effect of an object can be preordained in the process of conception, whereas for the latter, the materials act to guide and restrict the movement of the producer, almost regardless of the initial idea. In my case studies, of the new and traditional bridges, the act of pre-conception took different forms, but in both cases acted as a template for production. In the first instance, engineering the new

bridge was guided by drawings and lists of parts, in the second the bamboo bridge was guided by previous performances, but in both cases there was a sense of setting off with a destination in mind (Suchman 2007). The men who made the bridges were able to articulate their objective, to a level of detail that was mutually understood. It may be true to say that the finished object was not necessarily exactly as conceived prior to construction, but there was certainly a coordinated and persistent effort to maintain the course of production towards that end point.

Making a large or complex object requires the engineers to deploy a range of skills, tools and materials, creating or reinforcing ideas about their potentials, and exposing them to new experiences and situations. Engineering practice requires a group of people to gather in one place at the same time, and carry out complimentary actions. An individual would not have the strength to manipulate large components, and probably not the knowledge to be able to carry out all of the tasks required to engineer a complex object (see Figure 61 below). The group is organised according to motivation, skill and knowledge, such that there is sufficient of each in every part of the project for it to be carried out.



Figure 61: Distributed competencies: Coordinated group action

For someone working on a specific task, in the same way that materials are shaped and formed, so too, through the act of production is the person. In that respect, as described by Marchand (2010b: 192), it is the most literal means of making the person, bodily changes coming about through the act of making something else. Most importantly, however, in the context of engineering, making something is not done in isolation. Examples such as mixing cement, using a chainsaw or bending copper pipe demonstrate that individual practices act as a part of the whole project, enriching the person but also the relations between the group. Individuals become renowned for particular skills of construction, traits of character, or possession of the best tools through their participation in a communal production effort – knowledge that is carried forward into the community once the day's work, or even the project, is finished.

An Engineered Object is Not a Singular Artefact

Large and complex objects are made up of many things. The list of materials used in building the bridge and the expanding range of sources discussed in Chapter 4, demonstrate the need for some sort of motivating force to hold these things together. A recurring theme in this thesis has been the attempt to show the engineered object as in some ways unusual, and deserving of special attention. In their design, it seems that large and complex objects are different to small (commodity, or craft) objects, and a simple observation is that they are also different in their constitution. The number and variety of components, and the communal nature of their construction requires a collaborative act and results in an assemblage of large and potentially re-usable parts.

Having been made by a number of people, the object may then be further complicated by the politics of group ownership. That is not to say that group ownership is unique to large objects, of course it is not, but it seems a fundamentally different mode of ownership. Many of the objects that have been the subject of anthropological study are well studied primarily due to the fact that they are portable, and find themselves in a collection. Their size has been a

unwitting attribute in the primacy given to collected objects in the academic literature. Transferring objects around or between cultural settings (such as from a source community into a museum collection) is characteristic of objects that can be easily carried and transported, typical of the descriptions of exchange systems and the prestige accrued by an object as it changes hands. Large objects such as a bridge or a house are more fixed in their setting, and as communally owned objects they cannot so easily be transferred as a complete unit from person to person. What movement that does occur is less about changing ownership, and more about function – the traditional longhouse moves for social reasons, and the steam locomotive is inherently mobile. The complexity of the engineered object renders it dependent on its engineers to maintain its intended use by the community it serves, making it difficult to break away from group ownership. So, while ownership could be multiply apportioned, the continued presence of a substantial assembly acts in a way that reduces individual determination over its future. Large objects dominate their owners, requiring special physical arrangements to transfer ownership, and relying even then on the coordinated actions of engineers to maintain them.

It seems to be the case that one of the defining characteristics of an engineering project, its need for large numbers of parts and materials, complicates the issue of its end, and the validity of its classification as an ‘object’. At what point can the object no longer be seen as materially the same as the produced object? Once made to fit into its environment, the object is released from the cossetting attentions of its producers and succumbs to the ravages of use: altered, abused and maintained by people; invaded by insects and plants; beaten upon by sun, wind and rain. The bees that bored into the rafters of the abandoned longhouse at Batu Patong were not lying in wait for a house to be built, but living in the environment where the house appeared, and were able to use it in the same way they used other things not made by people. The deterioration that was wrought on the longhouse by the surrounding ecology was as active as the acts of people as they sought to remove parts of the building to use elsewhere. So the deconstruction of an object, as with its construction, is a small part of a larger process. It seems significant to

us, as we tend to give greater attention to things we have made, and notice when they change.

At what point then, is the house no longer the house? For the Kelabit, changing from a tradition of temporality to durability meant altering the concept and materials of a house from something that lasted a few years to something that lasts a few decades. On the human scale, this might be considered a measure of longevity, but in the scheme of the forest environment, perhaps not, after all it takes trees dozens or hundreds of years to mature, and their potential for environmental change is as great as human activity (Jones and Cloke 2008). If we see the house as a part of the environment, then its production and deterioration form a relatively short episode in the context of its surroundings, or the cross-generational acts of human building. As a continually changing object, a house might be seen as a process of many parts rather than an individual thing.

The size and complexity of engineered objects make them susceptible to this kind of thinking, more so than for example craft objects or commodities. The efforts required to maintain a house or bridge are substantial and on-going, and the consequences of failure are more likely to be significant too - a collapsed bridge likely to be more serious than a broken basket. Issues of scale are important: contained within an engineered object are components and materials large enough to retain some value. Rather than for example a craft object retaining value as a repository of skill, commodities being seen as valuable for their prestige, or gifts for their history, the value in a large object is at least in part retained in its fabric. In moving a longhouse, it is worth keeping parts of it because they are usefully sizeable. It takes time and effort to make floorboards, and even if they are no longer to be used for their original purpose, there is enough in them to be able to turn them to other uses. The destruction of the abandoned longhouse at Batu Patong was actually quite creative, as it was broken down into its component parts and re-used in combination with other parts to form new things. In tracking the progress of the longhouse, it was clear to see that the act of deconstruction was an opportunity to engage in new acts of construction. Re-using floorboards and doors

to make field huts and new houses was the most obvious activity, but this was only what people tended to remember. The small things made from other parts were forgotten, like the metal fence posts used as supports for many of the hearths, or nails absorbed into a homogenous mass and re-used.

This suggests that engineering, as I have been conceiving of it, deserves different treatment in an anthropology of material culture. Objects like houses or bridges are not really ‘objects’ at all, and it is simplistic to apply typical methods of material culture studies to what is better seen as a temporary assemblage of parts, coming together in a continual interaction with the encultured environment. The floorboards described in Chapter 6 for example, force us to consider whether this is true of all objects, which I doubt, or whether there is something special about things made up of substantial numbers of different components and materials. The floorboards within the house are more than simply materials, since they may contain social memories and evidence for a history of technological change, but certainly the more recent boards lose much of this significance and revert to being a wooden component.

Seen in this way it seems clear that the type of objects produced in engineering deserve greater attention in the anthropological literature, and a more thorough consideration of the theoretical implications. The issues I have raised here, including environmental relations, the creative act of deconstruction, the links and contradictions between individual skills and group organization, are all played out in the engineering environment. As a fundamental characteristic of what it means to be human, surely the importance of production generally cannot be overstated in a study of people, and in the increasing technical opportunities offered by the spread of global industrialisation, technical production should take a central place in the future of an anthropology of production.

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