RE-EMERGING DESIGNER-MAKER ROLES IN DIGITAL DESIGN AND CONSTRUCTION WITH TIMBER

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Abstract. The contemporary timber building design and procurement process has fragmented expertise creating numerous risk, knowledge and management interfaces. Fragmentation can lead to conservatism in design, material specification and material use. The university-educated and office-based designer is severed from construction practices and tactile material experiences. Opportunities to increase diversity and efficiency through digital design and fabrication processes from tree to completed building should seek to reconnect the designer with construction: concatenating the fragmented process into the designer-maker role. Contract tendering procedures often require generic solutions to be developed to prevent favouring one system or contractor over another which can stifle the partnering and collaboration that is required to maximise the benefits of the integrated designer-maker. This paper proposes that a multi-disciplinary team working under one contract best serves the emerging designer-maker role in timber. Educating and training designers and makers to be involved in the digital design and fabrication process requires exposure throughout the overall project process from conception, through design, fabrication to erection. This paper proposes a pedagogical approach for the contemporary design-maker and presents a case study in which a timber structure was designed, prototyped, interrogated, fabricated, and erected.

Keywords. Timber, digital design, digital fabrication, designer-maker, pedagogical, learning-by-making.

1. Introduction

Timber buildings were traditionally designed, fabricated, and erected by a master carpenter, the ‘designer-maker’. Contrastingly, contemporary building design and construction requires input from multiple stakeholders and
consultants; fragmenting the process, requiring greater coordination and risk management between disciplines. This paper speculates that the direct nature of the digital design and fabrication process in timber requires a recombining of designer and maker disciplines to produce complete building solutions.

2. Role of traditional designer-maker

Architecture, and the construction industry generally, is a material based practice that requires highly considered material application in both the design and fabrication phases. Traditionally these two roles were combined, with a master-builder assuming control in all aspects of design and construction. When compared to the current construction industry this role has long disappeared. The industrial revolution marked the beginning of role separation within the industry with the favouring of mass production. Over time designers, builders, craftsmen, and manufacturers became more segregated, fragmenting technical specialisation and knowledge (Henriques 2009). This facilitated rapid advancement of each area independently, but in isolation from other fields of specialisation. Within this environment material choice and selection is vast, but actual understanding of material properties and performance is reduced.

![Figure 1. Great Coxwell Barn, 13th Century. Image: Michael Parrott LRPS](image)

Diminishment of material understanding is particularly significant in the case of timber, which as a natural, organic material requires a higher level of understanding of the intrinsic properties in order to maximise its usage when compared to manufactured, engineered material such as steel or concrete. A
traditional master-carpenter, the designer-maker, was able to oversee the entire building process from timber growing, harvesting, selection, and preparation, through to placement, erection and fixing within their own design. Within this process, the carpenter fully owned the risk associated with their craft; there was no standardisation of supply lines and timber grading. This required a high level of specific material knowledge that allowed for the successful construction of buildings and structures with efficient material use but without a standardised material palette.

3. The demise of traditional designer-maker

The separation of the building design and construction professions has lead to a significant disassociation of knowledge across the disciplines which, along with an increase in litigation and the need for risk management, has created an environment in which architects have diminished the importance of their own involvement in the act of construction (Kolarevic, B. 2005). In simple terms, this means that it is rare for architects (or allied fields) to venture outside of their own knowledge pool and speciality, resulting in construction techniques being driven by product manufacturers or specialist contractors.

Parallel to this, the timber construction industry has moved towards a standardised approach in which traditional timber-framing systems and wood product manufacturing have become more tightly controlled and restricted, reducing the level of material knowledge required by the designers.
and minimising the requirement for skilled labour. In today’s building industry, contemporary building design and construction is typically compartmentalised, with designers and makers (as well as allied design fields) working separately. This scenario consequently diminishes the understanding of material origins, characteristics and capabilities as designers focus on standardised systems and construction or grading standards while contractors lose the input into the design stage where their knowledge could influence the outcome of a design significantly.

4. The emerging designer-maker

The industrialisation and mass-production of items for the construction industry has seen the adoption of computer numerically controlled (CNC) fabrication tools that are beginning to bridge the gap between design and construction processes. When partnered with advanced computational methodologies, CNC fabrication is facilitating the reestablishment of the relationship between design and making, especially in terms of material engagement. In comparison to other manufacturing industries, the construction industry has been slow to adopt digital methodologies as means of production. Recent growth in CNC fabrication that is evident in the construction industry is primarily driven by collaborative groups of designers comfortable with computer and software tools in their daily work.

The availability of CNC manufacturing is greater than ever before with most medium to large construction companies having utilised some form of CNC machine in a project. With CNC fabrication becoming mainstream within construction companies, a new capacity for mass-customisation of singular building elements is becoming available, as opposed to the “off the shelf” attitude that the last 50 years has encountered. This capacity for customisation is allowing for the re-strengthening of the connection between materiality and the act of making, giving makers an advantage in the procurement of buildings as they are forming a niche knowledge base with the industry.

A disconnect remains between the designer and material. Interestingly it seems that the computer is acting as the interface allowing designers to engage with a more direct manufacturing process, but without necessarily gaining tactile exposure to material. Advanced digital tools are providing an ever-increasing level of control over the geometry and articulation of form in the design process. Designers have the capacity to develop detailed 3-D models of buildings and their components, often parametrically, which contain sufficient detail to be directly fabricated. In some cases there is a direct link between the design software and CNC machines, removing the interface
between drawings and construction - the designer and maker are re-merging. However, it is critical that pedagogy exists to provide an arena for experimentation and exposure to the process for those involved.

Figure 3. CNC fabrication using engineered wood products

5. Pedagogy for Multi-Disciplinary Design-Maker

Educating and training those to be involved in the digital design and fabrication process requires exposure throughout the overall project process from conception, through design, fabrication to erection. Multi-disciplinary learning-by-making studios are a powerful vehicle for introducing designers and makers to the overall digital design and fabrication process.

Architecture schools around the world have, for the past two decades, experimented with modes of pedagogy to develop methodologies for the integration of digital process (virtual and physical) within design-build studios. The Architecture Association’s on-going series of installations in Hooke Park, Dorset, UK, have evolved into their Design & Make Masters program based at their Hooke Park workshop, providing a base for larger traditional/digital structures to be considered (Architecture Association 2014). Significant research-based investigation at ETH Zurich has been underway for the past 10 years, as outlined in The Robotic Touch (Gramazio, Kohler & Willmann 2014), examining the potential impact of digital tools directly on the
construction of buildings. The result of both institutions’ work places the architectural profession in a strong position to regain the ‘craft’ of building in the digital age.

The Centre for Sustainable Architecture with Wood (CSAW) at the University of Tasmania, Australia has developed a Digital Fabrication with Timber Studio (DFTS) in response to the increasing desire of designers and makers to gain experience across the entire digital design and fabrication process, specifically in the area of contemporary timber construction. The DFTS event was conceived to promote a genuinely multi-disciplinary and collaborative approach to timber design and construction.

The ideal model for education and training in this context is a project run from idea-to-occupation. The Digital Fabrication with Timber Studio has been developed to provide such a project with a structure designed, prototyped, interrogated, fabricated, and erected.

The first DFTS was held over three days in January 2013 in the workshops at the School of Architecture and Design at the University of Tasmania. The studio was developed and hosted by a practicing timber engineer, a practicing architect, a competent joiner and carpenter, a workshop manager, and a computer programmer.

The studio aimed to provide hands-on engagement throughout the overall project process without interpretation of details by experienced builders or carpenters – there was no hand finishing of elements after digital fabrication. Participants were given full design freedom within a tightly defined brief developed by the studio tutors. The quality and form of finished artefact was less important than providing immersion in overall digital design and fabrication process.

Developing an understanding of timber material characteristics is fundamental to the success of a contemporary digital designer-maker. The hands-on model for the DFTS provides participants with tactile exposure to timber. To further facilitate understanding lectures covering timber material were made available on-line to participants prior to the DFTS. During the DFTS specific focus was given to discussion of timber characteristics, particularly with respect to connection development and structural performance.

The target participants for the studio were those involved in the design and construction of timber structures. Studio participants in January 2013 included architects and engineers from practice, academia and students, and a boat builder. Participants had varied experience throughout the design and fabrication process and differed in their area of focussed interest. As such, the studio was flexibly structured to allow participants to focus on particular aspects of the process with tutor support provided. For example, those interested in the computer programming aspect developed parametric routines for
the aluminium cladding of the timber structure with considerations of metalworking, machining and installation.

During the three days an eight-metre high plywood tower was conceived, modelled, prototyped, fabricated, erected, and clad. The tower form was prototyped at 1:10 with laser-cut cardboard models. Twelve versions were developed by participants and modelled. The final tower form was a concatenation of the best attributes of the twelve towers.

As tower fabrication commenced cladding details were resolved. Cladding panels were to be CNC routed, provide torsional bracing for the tower, and provide enclosure for part of the tower. A parametric script was developed to cut aluminium panels on the CNC router with markings to determine manual breaker bending locations. The exercise of developing the cladding details, parametric script, fabricating and installing the cladding provided an abridged version of the entire designer-maker process. For example, the designers developing the parametric script required understanding of metal working bend radii and allowances for increased panel dimensions with bending on a manual breaker; such an intimate understanding of material and fabrication is not usually required in a building design role.
Participants and tutors worked closely together. The diverse range of experience and interest of those involved in the studio led to the role of the contemporary designer-maker being addressed by the studio team. In this way fabrication, machining, and construction considerations could be addressed in the parametric digital model, at source. It is difficult to comprehend of an individual possessing the necessary expertise or experience to fulfil the requirements of the contemporary designer-maker; programmer, geometer, architect, engineer, carpenter, machinist. But through cross-discipline collaboration in a studio environment, in which all involved have appreciation across all facets of the contemporary designer-maker, all of the considerations were collated into detailed parametric models & machine file.
6. Future Role of the Designer-Maker

Leach suggests that early utilisation of digital toolsets (software and hardware) was mostly concerned with a top-down approach to design, in that “[the] objective here was simply to use the computer to make the designs of the architect realizable.” (Leach 2009). In essence, this mode saw computation as a method to realise and communicate new architectural forms in a manner that was more akin to traditional construction methods. In most cases inherent material, computational and machine-based parameters were not incorporated into the design process early enough, resulting in ambitions projects that often missed the opportunities that a combined design/make process could have offered.

As designers are coming to terms with these new digital toolsets, there is a greater appreciation and implementation evident in the work produced. The capacity for greater input in the consideration and methodology of fabrication and construction throughout the process is growing continually, with designers commonly sending files direct to a fabrication facility, bypassing a contractor completely. This brings the immediacy of making back into the design process, allowing a greater understanding of the industrialised processes. Kolarevic (2005) suggests that the inclusion and directness of these widely varying parameters offers a bottom-up approach to architectural consideration that significantly, strengthening this relationship is allowing for a closer connection between designing, making, and material understanding and inputs.

A potential impediment to the emerging designer maker is the current contractual framework operating in building projects. Contract tendering procedures often require generic solutions to be developed to prevent favouring one system or contractor over another. Such a contractual requirement can stifle the partnering and collaboration required for the benefits of the integrated designer-maker to maximised. For example in the Australian context, competitive tendering at the design stage could be based upon the ability of a collaborative team to deliver a solution similar to a Design and Construct contract. Competitive tendering at the manufacturing stage can be based upon the cost of a fabrication or machine shop to produce components directly from digital input files.

Examples exist of companies embracing the re-emerging role of designer-role with digital design and fabrication tools in the construction industry. Once such example is Oakwrights Ltd., a traditional green oak carpentry company in the UK. Oakwrights purchased a Hundegger K2 CNC timber-framing machine in 2004 to digitise as much of the design and fabrication process as possible whilst retaining the character of traditional green oak
timber framing. The team assembled to develop the digital design and fabrication of the traditional green oak timber frames encompassed the entire designer-maker spectrum and included machine operators from furniture manufacture, architectural designers, engineers, and carpenters. Traditionally trained journeymen carpenters from Germany, with detailed understanding of material and construction, were re-interpreting traditional carpentry connections to allow efficient digital fabrication without compromise to connection performance. This mode of design and fabrication sees highly skilled craftsmen fully engage with a digital design and fabrication process. Their innate knowledge is grafted into a contemporary manufacturing process enabling a traditional skillset to be revitalised and remain current in the future construction industry.

7. Conclusions

It is evident that a higher level of engagement between the various stages of design and making can enrich the built-environment. We are now seeing the development of a greater understanding and embodiment of material properties within the designer-maker role, whether in a traditional green timber carpentry workshop or a university environment. For digital design and fabrication to be fully embraced it must endeavour to blur the boundaries between material science, craft expertise and design further, in effect seeing the return of the master-builder (or designer) that has been lost. This designer-maker role is likely to be best addressed by an intimate collaborative team with appreciation across the entire design/make process supported by an appropriate contract form.

References