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Modelling the Australian Lightweight House

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This paper outlines the process of making a series of highly detailed CAD models showing the form and construction of a group of contemporary award-winning houses by leading Australian architects. It discusses the issues of collecting information, clarifying details with the architects, the differences between 'as built' and 'as designed' descriptions and the organization of data.
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Introduction

There is a long history of Australian houses adopting "lightweight" construction. The recent work of many leading architects has followed this tradition in innovative ways (see, for example, the collections of work illustrated in Gollings and Mitchell, 1999; Jackson and Johnson, 2000). They are typically framed in steel or timber and clad in timber boarding, plywood, corrugated iron or fibre cement sheet. They also share approaches to environmental issues and lifestyle (Skinner, 1998; Radford, 2000). Over the last five years we have made highly detailed computer models of many of these houses (figure 1), in the process building experience of the ways in which such models are best approached and the difficulties involved. In this paper we show a few examples and outline some of that experience using the edited words of those who made the models. We shall concentrate on the initial building of the models rather than their use in animations and other purposes.

> *"In these lightweight houses, the materiality of construction becomes part of the aesthetic [and] they are exposed to a greater extent than in 'traditional' housing, which may seek to hide assemblies such as rafters and stud frames. Hence, the modeler is forced to think more about such components and how they effect both the aesthetic and structure at the same time" (Basil Genimahaliotis).*

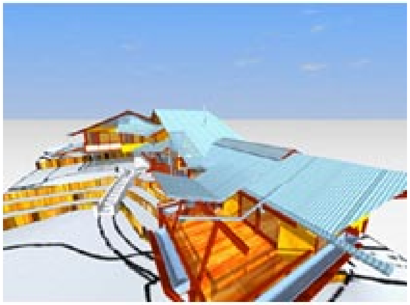

Figure 1: The Istrael house by architect Peter Stutchbury (left, model by Shannon O'Shea) and the Addison House by architect Rex Addison (right, model by Eric Lundberg)

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The modelling software used was primarily Form.Z™ or AutoCAD™ with 3D Studio™. Data transfer from Autocad™ into Form.Z™ is good. The aim was a consistent level of abstraction that indicated the materiality of the buildings without seeking photorealism. Colours broadly followed the actual colours seen in the building.

The motivations for the models

There were two main motivations for making these models. The first was to document and represent the houses in a way that would explain both their forms and the relationships between form, structure, and materials, seeking a much higher level of detail than is common in CAD building models. This complemented a parallel process of interviewing architects and clients about the designs, and the presentation of an exhibition about many of them first shown at the Telstra 2000 Adelaide Festival of Arts and later touring in Australia. The second reason was to create a resource that would be specifically useful in the teaching of house construction. This aspect was promoted by securing a major Australian grant for the enhancement of student learning. Although it did not fund the creation of the models, it did fund their use as context and focus for the creation of structured 'games' in which students digitally make and manipulate construction elements (fig 2).

Information for making the models

To make a detailed computer model requires essentially the same documentation as making the building itself. Architects provided copies of 'working drawings', but these were not always complete (with all the small details) or easy to understand.

"The greatest amount of time was spent interpreting the drawings rather than actually modelling. This was possibly because I did not have access to complete sets of drawings, but possibly also because particular details were often left a little vague, maybe to be finalised on site. To substitute for complete sets of drawings I found myself constantly referring to journal photographs of the houses, and trying to guess how parts were detailed or constructed. This raised another point: the houses often changed in many small ways from paper to reality. Even though the ways in which the houses changed in the building phase

Figure 2: The Manson House by architect Rex Addison (model by Jamie Gill)

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were minor, in such highly detailed and crafted work it can make a big difference. I also often found that I could not establish how an area or detail was constructed from plans or photographs at all, and had to make it up myself. This task I found daunting; if it had been my own work it would have been easy. However, when the houses were designed by such outstanding architects, you really don't want to get it wrong (especially if there is a chance that at some stage they will see the work themselves!)" (Jamie Gill).

The process also demonstrated the difficulty and expertise involved in translating 2D coded drawings into 3D form. Drawings rarely explicitly showed junctions and intersections, showing instead typical sections and plans. There were very few 3D drawings. The students interpreting them, and the staff assisting them, gained an increased respect for the task of builders in carrying out this same interpretation.

"The architects drawings that I received for the development of three-dimensional models could clearly have benefited greatly from the use of a more three dimensional method of design development" (Eric Lundberg).

Fortunately, like builders, we were able to ask the architects for clarification where necessary. There were several instances where images of part-completed models were faxed to architects with "what happens here?" questions pointing to parts of the images.

" Working with architectural drawings led to the assumption that documentation of all construction components would be accurate and detailed. Details left off ultimately meant that these had been constructed on site to accommodate complexities. One of the requirements of computer modelling is precise measurements to plot an object in space. In the shoes of the builder one appreciated the art of accurate detailed drawing documentation" (Shannon O'Shea).

In these experimental buildings there are numerous differences between the documentation and the built result because of changes 'on site'.

"The result of changes in its translation into three dimensions raised an interesting issue with regard to whether the computer model should maintain fidelity to the original drawings or the building itself. The resolution of this issue resulted in a hybrid response that focussed upon an abstract interpretation of the original architects intent as it might have been expressed to a city council for approval" (Eric Lundberg).

In a few cases there were no conventional working drawings at all.

"I was given enlarged photocopies of scanned images from an issue of Architecture Australia to work from. The drawings were small and as images were reasonably incoherent. In addition to these I had a number of photographs taken on a previous visit to the house, and the kind patience of [the architect's partner]" (Henry Williams).

Landscape and neighbouring buildings

A second, related, issue is the difficulty in obtaining adequate descriptions of the context in which the buildings exist. Working drawings do not show the landscape and other buildings around the house, yet these are important in adequately documenting a design. Journal articles and other publications rarely show much of the surroundings either.

"An important part of the light weight house in its overall reading is in its context. I found information through plans and photography relating to the surrounding environment was at best minimal. Without context in the model, the houses can look as if they have been presented on plinths. In terms of showing the staged construction of the house, contextual data was not as important. However, if the models were to be taken any further, to show relationships with other structures, landscaping or geography, site plans and contextual photos would aid the process" (Basil Genimahaliotis).

Modelling and data organisation

The creation of the models closely parallels the process of making a physical building, starting with

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the landscape and continuing with footings, structure and cladding (fig 3).

"I began from scratch. I scanned the terrain, which I inserted as a raster image into a blank Form.z document. The contour lines where traced and a suitable boundary defined, giving adequate geographical context to appreciate the structure's spatial relationship to the land. I was working concurrently on a 2D building 'footprint' which when complete was pasted into the terrain on the horizontal plane through the origin. The building's obvious symmetry meant that it was beneficial to define the centre of the building as the origin point. This way any part of the structure could be mirrored along the x or y axis" (Henry Williams).

"I found the best way to model the building was to work from the footings up. The model would always progress just as the construction of the actual building would: footings, stumps, bearers, joists, frame, sub-frame, cladding etc. Layers would also be named after these parts. I discovered early that this was the best way to work, and that modelling had to be detailed from the very beginning. When the project first began the original idea was to add detail to simple models (ie just the slab, walls and roof) already done by other students, a task which proved to be impossible and always ended in starting from scratch" (Jamie Gill).

"Elements were modelled as needed. A stud is made but has no reference without a base plate. One is made, and the rest are clones. These are placed in position and sliced off where necessary. Cladding is located at the face defined by the outside extents of the studs. But it has thickness. The building is assembled. There is a structural logic, even in this 'virtual' environment without gravity, material or irregularity" (Henry Williams).

Care was required to maintain consistency in the data organisation.

"The second part of the process which was to extend the time-frame for each model was the cataloguing of individual elements to make up the entire construction of a house. This was to increase the size and complexity dramatically. This was an important lesson in the art of computer modelling and data organisation, to have a plan and keep an accurate and a logical system within the process. Consistently keeping records was an unforeseeable component; however this also meant time taken to set up a system was ultimately time saved" (Shannon O'Shea).

Figure 3: The Istrael house by architect Peter Stutchbury with an impression of the landscape context (left, model by Jamie Gill, modified by Basil Genimahaliotis and Jared Wilson) and the frame and subframe of the Lake Weyba House by architect Gabriel Poole (right, model by Tain Patterson).

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This process was complicated by the desire to include different kinds of representations of a house for different purposes. These representations could then be selected individually, or overlaid, by turning layers on or off.

"The maintenance of a quick conceptual model, a model for presentation purposes and a model for the development of construction documentation within a single model requires the use of a hierarchical information structure in order to allow the modeller to operate with data structures at the level appropriate for the task at hand. This hierarchy should extend to the finest level of detail possible (object or below) in order to allow for a functionally efficient use of such a model" (Eric Lundberg).

Applications and representations

The house models have been used to create static images, animations, interactive QuickTime Virtual Reality (qtvr) models, a virtual reality (vrml) model used in a cave, and stereolithography (stl) models used in a rapid prototyping process to produce physical resin models. They have also been used interactively in teaching to explain construction, and as a resource in the making of web-based construction 'games' for student learning (Woodbury, Wyeld et al, 2001). Here we shall only describe two of these uses: animations and rapid prototyping.

Animation

Animations show both the final form of the house, as 'fly-by's', 'walk rounds' and 'walk throughs', and animated construction sequences showing the sequential process from footings to roof cladding. For the construction animations the model components were grouped in layers corresponding with the order in which the components of the house were to appear in the animation.

"A level of construction knowledge is required by the modeller in order to think in terms of what one would do to 'physically' build such a structure in order to arrange objects and their hierarchy during both the initial modelling phase and eventual animating stage" (Basil Genimahaliotis).

Rapid prototype models

'Rapid prototyping' is a term used in industrial design for the manufacture of resin 3D prototypes of objects. In a selective laser sintering machine, heat generated by a CO_2 laser fuses powdered material layer by layer, each layer representing a cross-section of the part. The movement of the laser is computer controlled using the data from an stl-format CAD file. Where there is a solid element the powder granules are fused to neighbouring powder granules, while where there is void in the model the powder is left loose and falls away when the object is removed from the machine at the end of the process. For physical models, the results can be highly detailed and intricate but there is a minimum thickness necessary for an element to maintain its structural integrity. The two major issues to be taken into account when a model is to be used in this process are the coherence of the model and the thickness of elements.

"In order to be used for rapid prototype modelling, the model must be a complete, unified solid with no holes in the mesh which comprises its solidity. In the CAD program the model had to be unioned together into a small number of components, between four and about ten in the houses used. To assure the components had no 'holes' in its solids, or vertices which were not unioned together, the CAD package SolidView 3.5 (by Solid Concepts™) was used, which had the ability to check if the model was valid. Once parts of the model were detected as being unusable for the .stl format, they were remodelled in Autocad R14. Particular structural components of the Israel house were remodelled in order to be thick enough to be made into a physical model and to be durable as a physical mode. These included window mullions, door frames and roof rafters" (Basil Genimahaliotis).

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Conclusion

Although time consuming and at times frustrating because of the difficulty in obtaining all the desired information, the results and process of making these models have both been valuable.

> *"Physical models (unless to a very large scale) simply cannot show the high level of detailing that a computer model can, and therefore would not have done these houses justice. The advantages of being able to put oneself inside a model, see the materiality and see how the light will fall on it are obvious" (Jamie Gill).*

> *"The reward of perhaps a much more complex task than anticipated was to see the use of the detailed models in the computing studios as a demonstration tool relating real construction elements to be manipulated (a personal frustration in earlier years of construction studios) and as an exemplar of efficient and effective computer modelling practices" (Shannon O'Shea).*

It has also led to a greater understanding and appreciation of the architecture.

> *"This is an additive architecture. Nothing is redundant. Every system is a response to a requisite of some kind, whether it be climatic, habitual or ritual. It is not, as many buildings are, a vacuous space into which comforts are added as surrogate environment. It is efficient, economical and that is beautiful. I found my appreciation of this architecture" (Henry Williams).*

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