Technology Feature

Living in the future

3D Modelling matures into real world construction

The way buildings evolve from first design concept to final construction has been changing across the globe over the last decade. This evolution has been driven by creativity and imagination which have forced the development of new design technologies. Two names - Disney and the architect Frank Gehry - are synonymous with both. They have not only conceived extraordinary designs but also developed the technologies to bring them to reality. These technologies are now being used in all structures across the globe and Australia is adopting the changed methodology at an ever increasing rate. Architects are now able to go beyond the past bounderies with implementation of these intelligent tools in building structures.

Major Australia projects are testament to the extent to which modelling technology is being used to execute increasing complex designs and reap construction efficiencies. The redevelopment of the historic Spencer Street Station, Stage 2 of the Melbourne Sports and Aquatic Centre, The Gold Coast Convention and Exhibition Centre, Perth Convention and Exhibition Centre and the high rise BHP Billiton and Southern Cross buildings in Melbourne and Ernst & Young Centre @ World Square in Sydney are all cases in point.

But creating the platforms, programs and protocols to take design from concept to completed structure has been a long and arduous journey.

Gehry's imagination has taken building design in new curvilinear directions. His designs for the Guggenheim Museum in Bilbao, Spain and the Walt Disney Concert Hall in Los Angeles pushed the need to move past conventional two dimensional drawings and into more sophisticated ways of detailed planning.

To build the Disney Concert Hall the contractor married the architect's computer- aided 3D images with planning software that tracks construction schedules in real time. This 4D software, developed over three and a half years by Disney Imagineering, breaks down a 3D image of a project into millions of pieces of data and reassembles then, step-by-step, in the sequence in which the structure will be built to visualise how it will come together. Without the power of computer technology this building may never have got beyond the drawing board.

From the early applications such as the simple automation of the drawing board using the computer to generate lines and objects (conventional CAD systems), that power has moved on to generate the exciting possibilities of 4D modelling building on its antecedent 3D. But 3D technology is not new.

First used in Australia in the early 1990s on projects with highly repetitive elements, such as resource processing plants, the use has flowed onto more sophisticated construction as the software has developed.

Improvement in the 3D software and the development of 4D has been paralleled by a similar progress in communication interfaces and the development of

common protocols making possible reliable and secure electronic data interchange (EDI) of technical data.

Combined, these tools enable computer generated models to be created and exchanged electronically via secure project websites by all members of the design and construction team. These powerful tools give all the parties the ability to integrate the model, extract information and input data.

3D software packages such as Tekla Structures (formally known as Xsteel) StruCad, ProSteel. BoCad and Catia together with in-house design tools from Gehry Technologies and 4D programs Common Point (the spin off software company from Disney Imagineering), Intergraph and Bentley Systems (see boxed text The 4th dimension is time) are just some of the software programs which interface with a variety of 'products' being used by architects, engineers and steel detailers to create common project models.

The software supports projects to be detailed early in the design stage concurrently with the engineering. This creates time efficiencies and eliminates double handling of information. On very large projects the software also enables data file transfer to multiple fabricators to fabricate sections of a project concurrently, maximising the industry's efficiency and capacity. (see boxed text: A new way of design development).

As working through a project model becomes more widely accepted in the steel industry the models are getting bigger, says Eddie Lewandowski, CAD Manager at PlanIt Design who detailed the AGE sign at Tullamarine and the SX1 Southern Cross Development. "In the past a large model may have been broken up into small modules but now we are more likely to work in a larger model. The software programs haven't changed much in the last couple of years but what has improved is the computers themselves which are getting bigger and more powerful with greater capability - more RAM and more hard disk space."

Highly visible showcase projects with extreme design intricacy such as the AGE sign at the entrance to the Fairfax plant at Tullamarine, the Webb Bridge over the Yarra at Docklands, and the iconic Bell Tower in Perth plus the older National Museum of Australia demonstrate the capability for sophisticated and complex design and execution using modelling technology.

These projects are fantastic illustrations of curvilinear shapes, executed in structural steel. They also represent a dramatic new approach to design and construct which has become known as building information modelling, or BIM. BIM is where where blueprints and other two-dimensional documents are replaced by 3D computer models, with each element of the design imbued with information about its real-world properties, such as how much weight a steel beam can hold.

By speeding up the design and construction sequence this technology is capable of reducing project costs and delivering greater accuracy and time savings, creating a competitive advantage for firms using the technology and, importantly increasing the appeal of the steel solution.

The numbers of architects, engineers, detailers and fabricators adopting the technology is growing and the shift is being forced on the market by new demands in the structural design process. Lead times are shorter, schedules are compressed and costs are being cut.

The technology enables many players to work on major projects from distant locations and exchange information electronically as has been the case with the design for London's Wembley Stadium, where Connell Wagner structural engineers worked from their Sydney office as part of the Mott Stadium Consortium primarily based in the UK. Using ProSteel, the Sydney team delivered the structural design for the roof, including the 300 metre span main arch and the retractable roofs panels all in 3D.

Mark Sheldon of Connell Wagner's Melbourne office says the next wave of design software coming onto the market with a proliferation of design programs include Architectural Desktop (ADT) and Revit from AutoDesk, ProConcrete and Rhinoceros. A number of these new generation programs are being trialled in Connell Wagner offices around Australia. "The new programs are big on promises but not without teething problems, with some lacking the facility for reimportation to the originating architects' files." Sheldon said. "And the licences are expensive. To kit out CAD operators in all our offices will be a substantial investment so we need to be confident about which of the new generation software will become dominant."

Wayne Scott of Pacific Computing says that a lot of smaller steel detailers are now coming on board. Others however are still staying with what they have - AutoCad or the old paper based systems - because they perceive the cost of making the change as too great. A 3D modelling package can cost around $35,000 compared to about $6,000 for a two dimensional package. So unless steel detailers can see the forward benefit they are reluctant to change over. (see Technology Integration page 13)

Some large fabricators such as Samaras Structural Engineering in Adelaide and Alfasi Steel Constructions at Dandenong in Melbourne have intergrated steel detailing divisions and are not only completing detailed steel designs on their own projects but steel drafting for others also.

An increased demand for steel fabricators to meet tight time frames means some steel detailers are sending drawings direct to the steel distributors who import the files to their beamlines, cut and drill the steel and deliver it to fabricators for finish and erection. (see story page .. Technology Integration).

David Williams, Chief Executive Officer of National Engineering, one of the largest fabricators in New South Wales, cautions;

"The 3D system would work much more efficiently if the initial design was modelled on similar 3D systems or the overall model was prepared by the engineer/ architect for detailing by others. Unfortunately a lot of engineers and architects do not have this capability, in fact there are a lot of engineers/architects that still insist on hard copy drawings because there systems are such that they cannot handle large capacity electronic files,"

Mr Scott says that the reluctant section of the industry has to look beyond cost to the benefits; to the industry's focus for the future where the model delivers the BIM tools. He sees the ability BIM gives, that is to transfer information back and forth, as the biggest driving force in the industry because it gives a much clearer picture of the project at any one time. (see boxed text Building Information Modelling)

Tasmanian based fabricator Haywards are strong proponents of modelling. Managing Director, Steve Edmunds, said that they strongly believe in the new technology and are incorporating other trades into their working models. "All our drafting operators are now using this technology," he said.

Haywards have five Tekla Structures licences and have integrated the new way of working into their business. The company was one of three fabricators who delivered the spine trusses for the Spencer Street Station Redevelopment project. On Spencer Street three fabricators worked simultaneously from the same model to fabricate these trusses and ferry them on large barges over water to the landing site on the Yarra.

Other large fabricators and detailers are also seeing the benefits delivered by BIM because it gives them much greater control and they know that by integrating the model they get the information they need for that control.

However, much of the industry still operates with AutoCad because it is less expensive and is seen as a common dominator within the whole of the drafting industry. Wayne Scott observed that: "With small one person operations where the proprietor may be nearing retirement there is a reluctance to change for the short term. The push within the smaller operators is coming from the younger members who can see the productivity gains and the benefits delivered by 3D software and working with a common model."

However the big question yet to be addressed by the industry is who owns the model and who is responsible for the model. This question was raised by Don Engler, Vice President of international Operations for BDS Technical Services, when he was last in Australia for ASI. This is the big question still to be addressed by the industry. In the United States the American Institute of Steel Construction (AISC) is communicating with its members on this question through a new task force created to develop an EDI business model for steel. Don Engler says "Business models don't support EDI." But in an industry where relationships are based on contracts and prone to litigation, a new way of working is needed.

Negotiating the stumbling block

One of the early stumbling blocks to the technology was the lack of compatibility between platforms and programs. Since 1995 the International Alliance for Interoperability (IAI), a non-profit, global alliance of the building, construction and software industries has worked to develop innovative concepts that improve ways to share information over the life cycle of construction projects. They have developed forward-looking strategies, on integrated information management in planning and construction, and on the practical exchange of building information model between all project participants. This co-operative approach has led to the development of open standards such as CIMsteel Intergration Standards2 (CIS2) now established as the common translator.

A new way of working on design development

The redevelopment of the Spencer Street Station now known as Southern Cross Station scooped a pool of awards at the recent 2006 ASI Steel Awards - Victoria & Tasmania winning the Architectural Steel Design Award, the Steel Fabricators Award and the Steel Detailers Award for large projects. Commenting on the design process Peter Skene, Leighton Contractors project manager said that: "The early engagement of the steel detailer (Precision Design Australia) in the design process significantly reduced the number of unnecessary and repetitive architectural drawings. By providing early input during the design development, the steel detailer was responsible for the roof geometry and all dimensional control. This design methodology also assisted in the off-site fabrication process and the on-site survey installation, enabling the interrogation of any part of the theoretical model of the roof. With the architects and structural consultants, the steel detailer was an integral part of the design team."

Keith Cheney, Precision Design's project manager on the Spencer Street Redevelopment, said that the most challenging aspect of the project was the complex geometry. "We had to maintain the integrity of the architectural design and build the design into the software. This was a rather special project as the 3D model started from day one with the architects, Grimshaw Jackson Joint Venture, structural engineers Winward Structures and ourselves sitting around a table to realise the concept for the client."

"Precision Design co-ordinated the architectural and engineering concepts into a millimetre perfect 3D model. That early collaboration and coordination saved hundreds of requests for information (RFI's) on the project, reducing these down to a mere nine RFIs over the project."

"The detailing statistics are staggering with 65,000 drawings issued with 7,200 triangular ceiling penetrations generated from a purpose written AutoCad software program. In some area Precision Design assisted the fabricators with jigging drawings."

Building Information Modelling

Building Information Modelling (BIM) refers to an approach where design information covering an entire construction project is produced and managed using a single 3D model. As the model's intelligence keeps all components reliably up to date, current information is available to all stakeholders at all times. Work duplication is minimised and many lower-level tasks are automated, allowing designers to concentrate on the essentials. Advocates of BIM claim that it delivers on the building industry expectation in the early 1980's of what might be possible from technology. The industry is now saying it helps the entire building process value chain achieve a faster, higher quality and richer design process.

Structural BIM is the subset of BIM that covers the structure of the building and the process from conceptual design to detailing, fabrication and erection. As a significant part of the information is produced during these stages, the integration of this part of the process is seen as essential to the development of any comprehensive BIM solution. With Structural BIM, engineering professionals as well as steel detailers can work simultaneously on the same design to find the best solution in efficient collaboration.

Within the last decade, key components of Structural BIM have been implemented in various design segments with convincing results. In steel design, modelling-based solutions are already an industry standard. In the US they have reached a 60 per cent share in some market areas. Worldwide, the market is dominated by the 3D steel detailing system, Tekla Structures, by the Finnish software company, Tekla Corporation.

Structural Building Information Modelling (Structural BIM) is a new, collaborative model-based way of working in structural design, providing smooth workflow and efficient information management. It enables increased productivity, higher quality and lower costs.

The early engagement of the steel detailer, Precision Design Australia, in the design process of the redevelopment of Melbourne's Spencer Street Station now known as Southern Cross Station significantly reduced the number of unnecessary and repetitive architectural drawings.

Training

Much of the industry still operates with AutoCad because it is less expensive and is seen as a common dominator within the whole of the drafting industry. The burden for training and skills development is currently being carried by the industry. The software companies offer training, but the industry bares the cost of the time. Much of the expertise is developed on the job. Although the software companies are willing to grant educational licences, the universities and TAFE collages are reluctant to pay for the time out for their people to be trained on the packages, so the onus for training stays within the industry. However this is slowly changing. One technical training institution in Port Adelaide is now training on 3D and it has a number of Tekla Structures licences.

Advantages of 3D Modelling

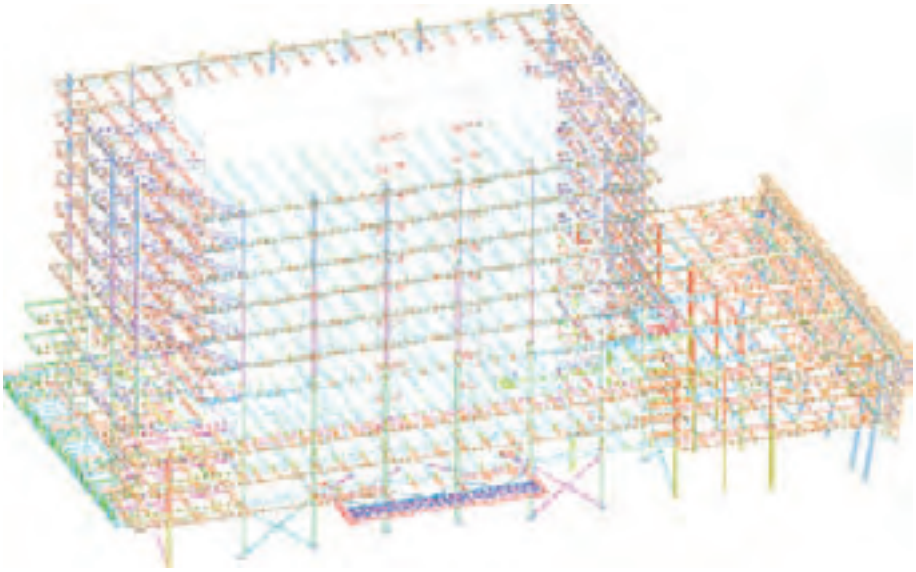
Proponents of the 3D modelling claim that it:

- enables several players to work on project from a distant location
- reduces project time with shorter lead times and compressed building schedules
- reduces project costs
- gives greater accuracy of technical data
- gives competitive advantage to firms using the technology
- increases the appeal of the steel solution

Barriers to adoption

Some of the barriers to the industry adoption include:

- early lack of compatibility between platforms and programs
- interface compatibility issues
- software license cost
- shortage of skilled operators
- time out for training
- time it takes to train proficient



The SX1 Southern Cross Hotel Development was modeled in ProSteel by the PlanIt Design Group

Colour model from Sydney Wildlife World Image of the computer generated model of the recently completed Sydney Wildlife World.