‘Under-over’ way speeds multilevel construction

500 Hay Street Subiaco WA

A steel-intensive approach to constructing a new medium-rise mixed use development located in the inner western Perth suburb of Subiaco is allowing for a lighter structure accommodating more works to occur simultaneously.

The main factors that spurred the change from a concrete-intensive to a steel-based design approach was mainly about limiting the number of trades onsite and the complete removal of temporary propping which allows the work to continue underneath while the concrete works happen above.

The redevelopment known as ‘Subi XO’ comprises two adjacent structures: a 10-storey building of hotel, cinema and retail space, and six-storeys of grade A office space above retail and food courts with the buildings being built over three levels of underground car parking space.

Tight site constraints ruled out open cut construction methods for the 12-metre deep excavation for the basement parking levels which opened the way for a top-down construction approach to be adopted. As the name implies, top-down construction allows a permanent structure to rise upward as the basement is excavated downward.

Basement build

In this case, the engineered design by Airey Taylor allowed construction of the building’s superstructure to commence whilst basement levels were still being excavated, which saved 12 weeks of project construction time.

Structural steel plunge columns were used in the top-down construction sequence. The steel columns were left exposed in the final conditions. This required extensive and advance finite element structural fire engineering to justify their stability during a severe fire and avoid additional passive fire protection.

One of the major advantages of the conversion to full structural steel and lightweight walls was to reduce gravity loads. With top-down construction the lighter the structure above, the more you can keep building while you are still working on the lower basements floors. With the revised scheme the builder was allowed to build the full structure while still working on the basement.

Superstructure

The superstructure consists of structural steel frame (beams and columns) and composite decking using permanent steel formwork supported by a braced steel core. It is believed to be the first steel-cored building ever constructed in Perth and is the first time that a steel framing system of this type designed for the main cores has been adopted in Australia.

The steel design approach was developed with Cooper & Oxley and the concept of the steel core drew from a series of projects Hera Engineering Managing Director, **Matteo Tirapelle** was involved with and research he did whilst based in Europe studying various projects built in the US and Europe.

The steel frame combined with a steel core allows for faster, more efficient construction methods which is carried out by one main contractor. In this project, the construction of the core using in-situ technology would have slowed down the program.

The original concrete-based design had many trades involved in the construction of the deck, walls and façade system that posed increased cost and program duration.

Mr Tirapelle said that changing to structural steel and having one major trade (Pacific Industrial Company) working on the main structure allowed for simpler site coordination.

"On the hotel alone, we reconfigured the beams and reduced the total number by approximately 60 percent and reduced the number of columns on a typical floor plate from approximately 90 to 30 with no net increase in steel quantity. This produced a 25 percent saving in both rigging and fabrication," he said.

"The main structure was constructed using mainly universal beams and columns. Almost all beams were pre-cambered.

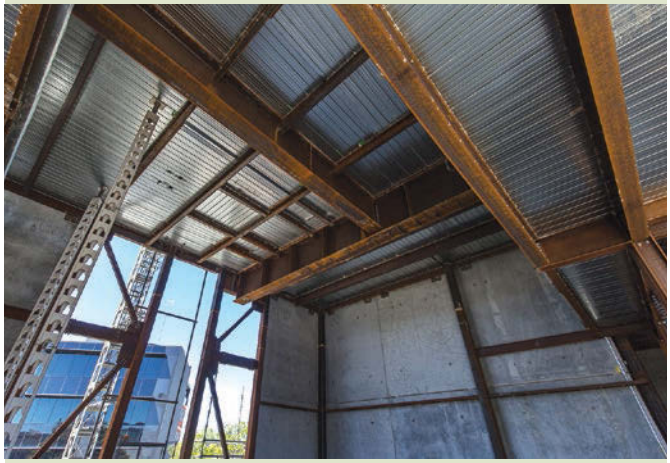
"The calculation of the pre-camber was very successful and every single beam in the project lost the full pre-camber after the pour of the deck.

"All beams and steel decking were designed to be unpropped during construction. The complete removal of all propping was a major program improvement which made the full steel solution even more attractive for the builder."

He said that in the hotel part of the structure, the first level is dedicated to cinema areas.

"Some of the load bearing columns could not continue through the cinema areas, hence large steel custom-made beams had to be designed to allow free space for the columns," he said.

"Transfer beam sections up to 1500mm deep with large moment connections had to be adopted to satisfy serviceability requirements. All connections between transfer beams and columns had to be designed as fully pinned which required particularly creative connections."



Photography: Monad Visual

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Tirapelle said that a steel core is like a big truss sticking out of the ground in a similar fashion as a mast crane.

"For the analysis of the of the steel cores under both earthquake and wind loading, we used various 3D software to validate our assumptions and results as well as detailed hand calculations based on truss analogies," he said.

"The stability of the core is ensured by a series of diagonal bracings and moment connections where there was no possibility to introduce bracings. Between the office and hotel core there are almost 1000 connections which all have different loadings.

"We had to check most of them to avoid overdesign. For efficiency, we created an in-house software that assisted our engineers with this tedious task."

The cores' detailed design was undertaken not only using AS 4100 but various other international standards including AISC, NZS 3404, EC3, EC4.

"This allowed us to rationalise part of the design and obtain a more efficient outcome for our client," he said.

The process of prefabrication commenced with the creation of the 3D model using Tekla.

"We had to go through several iterations and revisions to get the model right but once all the shop drawings were approved, all the various members were constructed with millimetre precision in Pacific Industrial Company's workshop and delivered to site," he said.

During the detailed design of the various members, Hera Engineering took into consideration the logistics of transport to site to maximise the number of steel beams per truck and minimise the number of lifts. Hera was also responsible for the construction engineering needed during assembling of the steel.

"We ensured that the slab had adequate capacity to support the steel cradles containing the many steel members that had to be stacked on the slab during erection," Mr Tirapelle said.

"Structural steel allows constructability issues to be addressed at the design stage before site works commence so understanding the principles and detailing well is how to get the right outcome with steel design.

"With concrete in-situ structures, most of the issues appear during construction and this increases the risk of generating delays in projects. With steel the risk is low because a full 3D structure is created by the shop detailer."

During the design process, Hera also identified a good opportunity to apply project-specific structural fire engineering solutions which led to an extensive reduction of the passive fire protection required for the floor beams.

"The analysis required extensive finite element design to validate the assumptions and ensure that the building would remain structurally sound after a major fire event," he said.

"Particular attention had to be dedicated to the design of the beam connections and detailing of the suspended floors. All transfer beams and columns had to remain fire protected to ensure stability."

One-stop workshop

The work package provided by the project's prime steel contractor, Pacific Industrial Company (PIC) included shop detailing, steelwork fabrication, surface treatment, transport to site and erection of the structural steelwork.

The steelwork for the project amounted to around 1000 tonnes of structural steel and 15,400sqm worth of steel decking for the office tower with 750 tonnes of structural and 10,000sqm of steel decking for the hotel tower.

Pacific Industrial Company Client Executive – Mining, Oil & Gas, **Adam Cornelius** said that as a structural steelwork specialist, PIC continually seeks projects in which early value in engineering, cranage and screens and can help break through traditional models and deliver cost-effective benefits.

"We initially approached the main contractor, Cooper & Oxley to position a unique design concept transforming the design to a metal decking, steel frame and steel core as opposed to concrete core," he said.

"This transformation allowed for a more economical design and PIC was engaged on the project.

"The design was not overly complex and was easily accommodated by our capabilities, although every effort was made to increase the constructability of this project, allowing the site to run faster and more efficiently."

He said that the ability to be engaged early on with infrastructure projects allows PIC to assist value engineering of outline design, buildability and costings.

"Few Australian buildings have a steel core, but put simply the steel core acts similarly to its concrete counterpart extending three floors ahead of the deck construction which allows for a solid base in which to construct from," Mr Cornelius said.

"Our high-level involvement at an early stage provides an understanding of what an intense structural steel solution provides in flexibility, stabilisation and assembly hours.

"Due to the site parameters and minimal lay-down space, the 'Just in Time' delivery method was used that allowed efficient delivery of structural steel members without causing unnecessary congestion.

"The cradles of structural steel were loaded in the sequence of works in a predetermined program, allowing efficient erection of members onsite."

The project is due for completion in August 2017.

PROJECT TEAM

Client: Dradgin

Architect: Campion Design Group

Builder: Cooper & Oxley

Lead Engineer and Top-Down Construction: Airey Taylor

Structural Steel and Value Engineering: Hera Engineering

ASI Steel Fabricator: Pacific Industrial Company

Steel Detailing: Pacific Industrial Company

Steel Distributors: United Steel, BlueScope Lysaght

ASI Steel Manufacturers: OneSteel, BlueScope