Precast concrete utilisation in multi-rise concrete buildings

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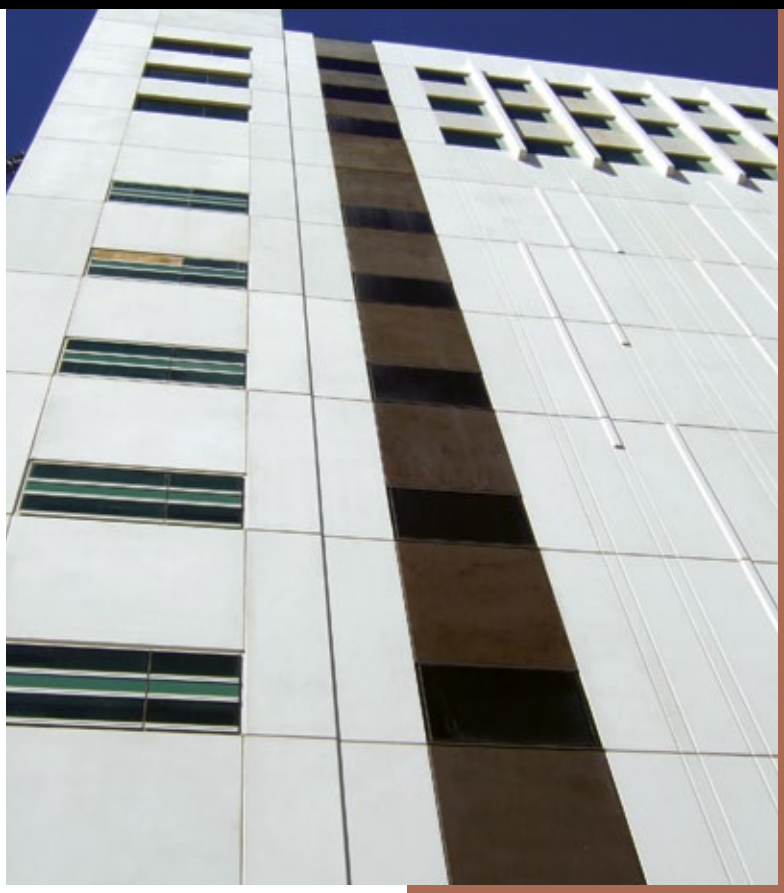
Introduction

Multi-rise buildings in Australia are overwhelmingly constructed with concrete framed structures. Recent qualitative and quantitative research by CCAA has found that the design and construction sector has utilised innovation and technology to make Australian concrete framed construction among the most cost effective and efficient in the world[1]. However most of the technology advancements in multi-rise structures have focused on the in-situ concrete construction method, and to some extent the utilisation of precast concrete has been overlooked.

Construction research undertaken by representative bodies in the United Kingdom and Europe suggest that multi-rise structures benefit from the thoughtful integration of both precast concrete and in-situ concrete. Undertaking work on behalf of the UK concrete industries, Goodchild and Glass[2] propose that "Combining the two by adopting hybrid techniques gives even greater speed, quality and overall economy."



In Australia precast is not commonly used in the framing structure of multi-rise commercial buildings over 10 storeys high. In lower height commercial buildings however, examples of precast building frames can be readily found. Hughes and Crisp[3] outline the history and growing use of such structures in Melbourne, citing the reduction of on site labour and speed advantages of off site precast manufacture as the principal drivers for this form of construction. CCAA case study based research would suggest the following reasons as best explaining these observations:

- Minimising crane time is a construction economic and speed imperative that increases with increasing building height.

top: Precast concrete facade in 12-storey District Courts building, Perth[4]

above: Precast floor soffit reduces propping and formwork requirements

top: Hollowcore floor planks being fixed into position on a multi-storey deck

above: Hollowcore floor plank units being craned into position

- Minimising crane dependence is viewed by builders as minimising risk. The risk is twofold – lost days due to high wind speeds shutting down safe crane operations, and the bottleneck effect on moving materials required for fitting out the building that are also relying on crane movement.
- Full moment connections between precast elements are time consuming and costly to construct. With increasing height, structures invariably require the columns and floors to act in frame action to resist lateral loads rather than rely totally on the service core to resist all lateral loads. In lower height structures all precast connections can be treated as simple pinned connections which are relatively faster to construct and less costly.

In multi-rise buildings of all heights precast is commonly used in the construction of facade walling which is typically non load bearing. In facade work, precast concrete has the well deserved reputation of being able to produce high quality architecturally expressive surface finishes. In residential multi-rise buildings precast is also frequently used for internal walls and columns.

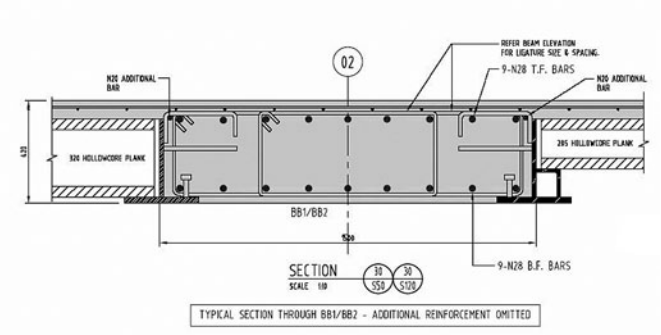
Benefits of precast concrete in multi-rise buildings

From the preceeding discussion, it follows that incorporating precast concrete into the design of a multi-rise building can add considerable value as long as its strengths are utilised while managing the potential challenges of crane time and connection detailing. The following list summarises the potential benefits of most significance to multi-rise construction:

- Construction speed gains that flow from off site prefabrication.
- Reduction of the amount of formwork required for the project which can be a construction speed constraint.
- Precast concrete floors reduce the amount of propping required, and require no formwork or the associated false work. The resultant access for following trades is improved allowing floor fit outs to be completed earlier and more efficiently.
- High quality architectural surface finishes are possible, which has most relevance to facades. (Utilising concrete's high thermal mass in the building fabric can greatly enhance the building's energy efficiency).
- For buildings that typically have a large amount of walls, for example hotels and residential apartments, there may be construction speed gains in utilising precast walls.
- In order to obtain these benefits in multi-rise construction projects, it is advisable that early consultation take place between the precast concrete supplier, builder and engineer.

PROJECT EXAMPLES

There are numerous project examples in Australia which demonstrate the value that can be provided by utilising precast concrete in multi-rise construction. The following projects are a small selection that demonstrate the benefits described above in a real project context.



Precast hollowcore – beam connection: Santos office building[5]

14 storey Santos office building, Adelaide: Precast concrete floors

The new headquarters office for Santos in Adelaide is a recently completed 14 storey office building. The structural frame consists of a mixed construction of in-situ concrete columns and core with all suspended floors designed in precast concrete. Suspended floors consist of prestressed 320 mm deep hollowcore plank units with a 75 mm in-situ concrete structural topping that span up to 15 m[5]. Innovative precast flooring connection details between planks and supporting in-situ concrete beams designed by structural engineers Wallbridge and Gilbert minimised the overall floor structure depth, and hence floor to floor height.

The precast flooring system was selected by Hindmarsh design and construct project team as the lowest cost solution to achieve the key project criteria of a 3525 mm floor to floor height and large clear floors without column intrusions. The resulting combination of in-situ concrete and precast concrete construction provided an optimal mix in terms of speed and cost for the structure.

Precast hollowcore floor planks arriving on site, Santos office building, Adelaide

12 storey Liberty Towers residential building, Adelaide: Precast concrete floors and walls

A similar example of the use of precast flooring from the residential apartment building sector is provided by Billinger and Tsoukalas[6]. The 12 storey Liberty Towers utilises a total precast concrete floor structure consisting of prestressed precast band beams supporting prestressed precast hollowcore floor planks. Extensive use of precast walls is also employed in the project, with the principal decision drivers for the use of precast being speed of construction and allowing an earlier commencement of unit fit outs. The use of precast on this project is cited as making a substantial reduction in holding costs to the developer.

40 storey Southport Central mixed use towers, Queensland: Precast concrete columns

Southport Central project comprises three 40 storey mixed use towers. Builder/developer Raptis Group opted to make all columns carrying only compression loads (about 60% of all columns) precast to assist in achieving a very high construction speed of four day floor cycles[7] (CCAA, 2007d). The speed gains resulting from this strategy were achieved by removing the forming of columns from the critical time path. A unique connection detailing system employed on the project enabled seamless precast erection. Simple and efficient connection detailing that works well in the construction phase is critical for precast concrete vertical elements to realise their potential speed gains.

Precast columns shown on 40 storey Southport Central, Queensland

Westin Hotel, 1 Martin Place Sydney: High quality precast concrete facades

Sydney's GPO building was re-developed by the Grollo Group into a mixed use commercial, hotel and retail complex and completed in mid 1999. The project was completed on time, notwithstanding the delays from unusually heavy rain. The project features 6,500 m^2 of high end architectural polished precast concrete facades which are load bearing, as well as extensive internal load bearing precast walls. A full case study is provided by Hanson Precast[8].

The key architectural feature of the facade was the polished reconstructed granite precast panels. Victorian Riverena granite was used, the final product being virtually indistinguishable from polished dimension stone at a greatly reduced cost. This project is an excellent example of the use of precast to create exterior architectural expression in multi-rise buildings while maintaining the construction key value criteria of speed and cost.

Conclusion

Research by CCAA has found that the popularity of concrete framed structures in the Australian multi-rise building sector is largely due to the presence of innovation and technology in the in-situ concrete construction industry. Precast concrete has not enjoyed the same level of utilisation in this market sector, however has many potential benefits when integrated in an optimised mixed construction philosophy. International studies in hybrid construction provide a useful framework for maximising value of the frame structure by the inclusion of precast concrete.

The use of precast concrete in the framing of multi-rise structures over 10 storeys high is expected to increase with time due to its benefits of speed, reduction of formwork and associated propping, and facilitating earlier floor fit outs. Recent project examples show that precast floor systems, columns and walls may all be value adding inclusions for particular projects.

References

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