

Formwork advancements 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 world¹.

Formwork is one of the most important areas of concrete construction. It is one of the largest influences on construction speed and will usually determine success or otherwise of the project in terms of budget and schedule. One major innovative trend in formwork that has emerged in recent years is the increased use of automation. The most notable examples include self climbing jump form core systems, self climbing perimeter screen systems with the ability to attach column and perimeter beam formwork, and systemised floor formwork assemblies for floors that can be hydraulically lifted to subsequent floors up the building.



Another notable trend is the increasing use of permanent metal deck formwork for floors, principally due to favourable cost factors.

Jump form core construction

Jump form concrete core construction has become the dominant method of constructing lift and service core walls in multi-rise structures in Australia. While this fully automated technology has been in existence for some 30 years, its Australian application has witnessed many innovative refinements. These include improved hydraulics, improved set up arrangements that allow faster set up times, and material advancements. The key value points offered by this construction method include speed, reducing tower crane dependence, reducing site labour, simplification of floor construction and taking the core off the critical time path.



top: **Figure 1** Eureka Tower core formwork system showing external stairs with hanging walkways linking all work decks and lobbies to escape stairs (South Side)

above: **Figure 2** Self climbing perimeter screen on Deutsche Bank building



Figure 3 The 'skydeck' modular system by PERI is an example of the newer generation of floor form systems

The Australian industry is characterised by the willingness of building construction companies to employ new technologies, and in some cases develop systems themselves. An instructive example is provided by the 92-storey 300 m high Eureka Tower building in Melbourne built by Grocon Operations Pty Ltd.² Using their in-house developed jump form system Lubeca, the central lift core was jump formed two floors at a time, and up to 25 levels ahead of the floor construction. The double jump innovation halved the number of construction cycles and concrete pours which allowed significant time savings. It also decreased the amount of steel reinforcement required by halving the number of splices.

The Eureka Tower core was constructed ahead of the floors as quickly as possible so that the lift motor room could be installed and the building lifts made operational as early as possible. This practice is becoming increasingly popular as it allows the lifts to then be used as material hoists, facilitating rapid fit outs by following trades and further reducing the reliance on cranes.³ In areas exposed to frequent high wind days like

Melbourne that shut down safe crane operation, the reduced reliance on cranes is critical to maintain schedule. The 9 storey Ericsson House building recently completed in Melbourne is but one of many examples where automation has been well employed to avoid weather related construction risk.⁴

Self climbing perimeter screens

Self climbing perimeter screens are a far more recent trend that can be claimed as an Australian innovation. The automation generally falls into two categories – hydraulically powered automation or screw jacks that are powered by electric motors. The perimeter screen is necessitated by safety, providing a safe working area for site construction staff as well as containing materials and debris associated with the construction. Again, the priority of self climbing is to reduce crane dependence and increase materials handling speed and logistics.

A further innovation to the self climbing screen is the attachment of perimeter column, wall and perimeter beam forms, however it is dependant on the suitability of the building's perimeter shape and design. The 40 storey Deutsche Bank building in Sydney built by Bovis Lend Lease employed self climbing screens with attached column and perimeter beam edge forms. This was one of a range of innovative measures on this project which helped achieve a floor to floor cycle speed of four days.^{5,6}

On Southport Central, a project comprising three 40-storey mixed use towers, builder/developer Raptis Group have innovated to increase the safety value of self climbing perimeter screens by extending the screen two storey's below the working floor instead of the standard single storey below.⁷

Systemised floor formwork assemblies

The third area of automation involves the systemisation of floor forms to enable smaller floor panel formwork assemblies that are moved up to the next floor by hydraulic formwork hoists. This recent development represents the next generational progression from table forms which are still widely used for multi-rise floor construction. Floor panel assemblies are kept small enough to be quickly collapsible and moved to strategically located hoist locations. A project example is outlined by Williams⁸ where a modular aluminium system of 800 mm x 1600 mm pans is being used to construct the floors on a Gold Coast 20 storey tower. One of three hoists is dedicated to moving the formwork and cranes are not required for this component of work, a fact cited as beneficial in light of the prevailing windy weather on the Gold Coast.

The 9 storey Ericsson House building recently completed in Melbourne is a more conventional example that utilises compact table form assemblies for the floor formwork and allows significant materials movement by hoists rather than total crane reliance.

Permanent metal deck formwork

Permanent metal deck formwork has been gaining popularity in Australia over recent years for the construction of suspended floors in multi-rise construction. This was confirmed recently by a first of its kind costing study commissioned by CCAA that found permanent metal deck formwork to be the most cost effective formwork method for constructing concrete floors in multi-rise office buildings.¹

There are several proprietary systems currently available in Australia that all offer the following generic benefits when compared to traditional floor formwork:

- reduced labour and material handling through not having to strip conventional soffit formwork,
- reduced amount of bottom reinforcement, and
- reduced amount of propping supports provided by spanning capacity of the metal deck formwork.

Medium-rise office buildings like the recently completed 12 storey Colonial First State Properties Building in Parramatta⁹ are typical applications where permanent metal deck formwork is being used for the above mentioned reasons.

Komselis et al¹⁰ reports on research and development into new product varieties of permanent metal deck formwork with improved self spanning capacity, potentially up to 10 m. This would further improve the site productivity and construction schedule gains by allowing following trades to fit out floors quicker, unhindered by formwork propping supports.

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 concrete construction industry. A ground breaking study by international QS and cost consultants WT Partnership has confirmed that the dominance of concrete structural framing systems is underpinned by a large cost advantage over structural steel framing.

A critical component of design and construction of multi-rise concrete structures is formwork. As demonstrated by recent Australian building examples, there can be significant value gained by utilising formwork advancements and innovations.

The increased use of automation is a major trend in formwork systems for multi-rise buildings. Self climbing jump forms for service and lift core construction, self climbing perimeter screens with perimeter forms attached, and systemised floor form assemblies for suspended floor construction are examples of the growing use of automation. The major benefits of increased automation are increased speed, reduced reliance on tower cranes and increased safety for on site workers.

A notable trend in formwork for floors is the increasing use of permanent metal deck formwork, principally due to favourable cost factors as well as the potential to reduce propping requirements.



Figure 4 Permanent metal deck formwork

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