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PRECASTER
NATIONAL PRECAST CONCRETE ASSOCIATION AUSTRALIA
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Spencer on Byron completed structure

PRECAST in New Zealand

National Precaster breaks new ground this issue by introducing the precast industry of New Zealand. As in Australia, New Zealand has a vibrant and diversified precast industry offering the building and construction market, through its twenty precast manufacturers, a sophisticated range of structural and architectural products.

Precast New Zealand Inc, a sister organisation of the NPCAA, formed in 1999, promotes, fosters and develops the interests of the precast concrete industry within New Zealand.

Industry Background

Since the early 1960's there has been a steady increase in the use of precast concrete in New Zealand for structural components. Precasters have developed skills to meet the increasing demand, using their experience with increasingly popular loadbearing and non-loadbearing cladding units. Precast flooring systems very rapidly became commonplace with the development of standard profiles, leaving insitu floor construction generally less common and uncompetitive.

Until the late 70's to early 1980's, the use of precast elements for seismic resistance in moment resisting frames and walls was the exception rather than the rule. However, with the availability of deformed reinforcing bar splice sleeves and foot and plate connectors, combined with their competent performance in hinge regions of earthquake resistant structures, precast concrete buildings could now offer the same advantage that steel buildings long held.

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During the 1980's construction boom, the popularity of hollowcore flooring systems and indeed precast component buildings in general, grew out of the requirement to build high quality cost-effective structures quickly; precast concrete flooring offers flat or ribbed soffits for architectural effect and most importantly, it has less environmental impact during construction due to the reduction of wet trades on site. Moreover, for the whole structure, off-site precasting of structural frames(cruciform elements), columns, solid beams and shell beams offered the advantage of speed of construction.

The 90's and beyond

Precast and precast prestressed concrete systems are now the preferred method of constructing suspended floors and building frames in New Zealand. In particular precast concrete has achieved floor to floor cycle times which are equal to or, in many cases, superior to, structural steelwork. This is supported by contractors who no longer consider that the erection of precast concrete frames and shear walls are on the critical path of building construction. The insitu content on building sites has been further reduced by the development of precast prestressed support beams and precast reinforced column/beam frame assemblies.

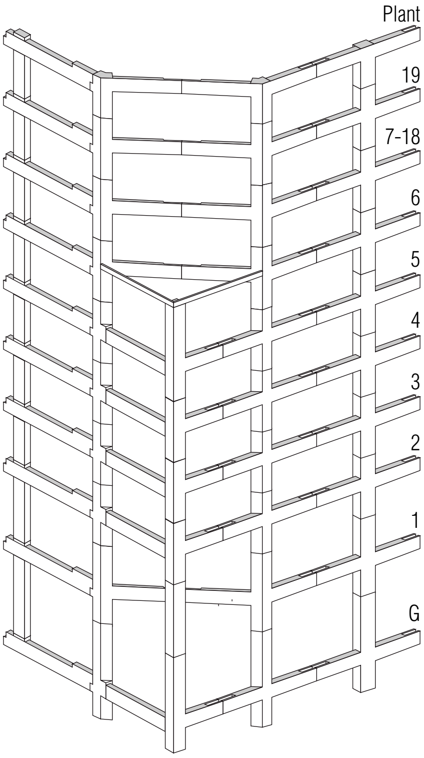
As for the future – while concrete can be customised to be all things to all people, standardisation of building elements, from manufacture, through transport to site erection and installation, should lead to the greatest economic benefits in multi-storey construction. This includes reduction in design office time, which is also a real cost of construction. Precast NZ Inc. therefore has, as one of its industry projects, a complete overhaul of the building and infrastructure markets with a view to further streamlining the speed and cost of construction through standardisation. This does not mean that innovative designers cannot continue to work with the versatility of concrete but it may mean innovative designs are more often implemented through the use of standardised components.

CASE STUDY: Spencer on Byron

Presented hereunder is an excellent example of a prestigious Auckland building, Spencer on Byron, where the project managers Multiplex Constructions(NZ) Ltd, A.D.C Architects and Stephen R Mitchell Consultant Structural Engineer, chose a totally precast skeletal frame form of construction for its landmark project on Auckland's North Shore.

This 25 storey residential building containing 249 apartments plus penthouses, with an average of 14 apartments per

Spencer on Byron building under construction



Precast cruciform beam and column layout

1000 m^2 typical floor, takes advantage of the repetitive nature of high rise building structures. Close liaison between the architect and the engineer during design development created a precast building with a minimum of component types, all of which had the architectural details incorporated into the precast components.

Spencer on Byron is fully precast with the only insitu concrete within the superstructure being the shell beam cores, precast floor topping and wall-beam stitch joints. It featured concrete topped pre-stressed hollowcore floor elements which created a structure with no internal columns, an obvious advantage for architectural planning. The building has a precast concrete shear wall core and the external frames are precast cruciform in one direction and a precast beam/column system in the other direction. The repetitive use of few moulds in the precaster's factory has permitted many advantages perhaps best summed up by the comments made by the Project Manager, Dave Heritage:

- **Ease of installation:** The configuration of the cruciform columns allowed precast components to be installed quickly, requiring minimal labour and propping systems to locate.
- **Standardised design:** All precast components were the same configuration from basement to the top of the structure. This allowed efficient utilisation of moulds and a shorter procurement period.
- **Minimised temporary support requirement:** Because the design provided the ability to take the full construction load without specialist propping, benefits were reductions in components to be relocated with each floor cycle. In turn, reducing the site labour requirements.
- **Reduced labour cost:** The configuration of the precast components negated the need for floor slab formwork and with 90% of the reinforcing requirements incorporated in the precast, again greatly reduced the requirement for site labour for floor slab preparation.
- **Short programme cycle:** Programmed floor cycle time was 7 working days. This was reduced to 6 days and fit out load in requirements still accommodated by the one on-site crane. The site team did demonstrate that when required, a structural floor cycle could be achieved in 4 days. This was solely due to the structural compact design allowing ease of installation and no requirements for a support system.
- **Early fit out access:** A further benefit from this being the service trades could commence at an earlier stage of the cycle.

National Precaster wishes to acknowledge the assistance from the following people and for the information in this article:

- **Mr Ross Cato**, Executive Officer, Precast New Zealand Inc.
- **Mr Paul Sweetman**, Precast Manager, Smithbridge Precast
- **Dr Victor Lam**, Stephen R Mitchell Consulting Engineers
- **D K Bull** – Editor *Guidelines for the Use of Structural Precast Concrete in Buildings* 2nd Edition 1999.

Completed building cantilevering full height over the site.

LIFE SCIENCES Building University of Newcastle

National Precaster *is proud to feature the new Life Sciences Building at the University of Newcastle as an example of innovative architecture, unusual engineering design and excellence in construction combining to achieve an environmentally responsible building comprised entirely of precast concrete.*

Without doubt, it thoroughly deserves to be recognised for the two distinguished awards it has recently received – the 2001 'Sulman Architectural Award' for public buildings, and the 2001 Concrete Institute of Australia 'Excellence in Concrete Award – Projects'.

The steeply sloping site and the building's twenty-one metre cantilever at its northern end provide for a singularly imposing structure. It was this cantilever that provided challenges for the design team and resulted ultimately in specifying a totally precast concrete structure. Given the site constraints, it is a credit to the flexibility and environmental soundness of concrete, as a building material, that such an elegant building solution has been achieved.

The south end, four-storey core was constructed of in-situ concrete to provide a monolithic structure to which the building could be tied back to anchor the huge cantilever. Other than a 60 mm topping and some small construction joints, the remainder of the entire structure north of the core is comprised of precast concrete. Precast columns have been located on two lines of the structure only in order to provide clear, uninterrupted floor space. Precast, prestressed concrete beams span transversely across these columns, transferring the load from the precast hollowcore floors which span longitudinally between the beams. The longitudinal spandrel beam tension ties are also constructed of precast concrete. The spandrels transfer the tension loads created by the cantilever back to the anchor core. **Figure 1** depicts the primary structural elements and their structural function.

The structural design and buildability for transfer of the tension force from the cantilever and inclined strut to the anchor block was the unusual design feature of the project. A number of options were considered. These included:

- Longitudinal post-tensioning of the tension ties
- Welded structural steel plate connections between the tension ties
- In-situ pour strips with conventional lapped splices in the tension ties

After extensive consultation with the specialist precast concrete designer/supplier, the CADWELD system was adopted for mechanical coupling of the main tensile reinforcement. While this system has been used extensively in overseas projects, this was the first use of this coupling system in an Australian building. The unique advantage for its choice was the compactness of each joint, resulting in a hidden in-situ pour strip only 600 mm long at each joint. Because the precast concrete surfaces are exposed in all of the structure to provide an important visual statement, the pour strip was incorporated behind a 80 mm thick section of the spandrel. This provided for continuity and uniformity of the high class surface finish required.

Transverse beams cantilever in pairs in a westerly direction up to 6 m past their line of support. Precast prestressed hollowcore floor units span longitudinally between these pairs of transverse beams and when inter-connected with a 60 mm topping slab, each floor forms a horizontal diaphragm. This diaphragm action provides the necessary transverse rigidity for the building. For architectural considerations and interior space restrictions, all of the precast concrete elements were confined to a maximum thickness of only 300 mm. It was only possible to construct these slender beam elements and still maintain the required 25 mm cover to reinforcement because of the extremely low tolerances (±2 mm) and precise jigging developed by the precaster for the welded cage reinforcement.

The 300 mm thickness of all sections created extreme congestion of reinforce-ment and continuity ducts particularly at

Totally precast frame and floor featuring twin 18 m cantilever beams.

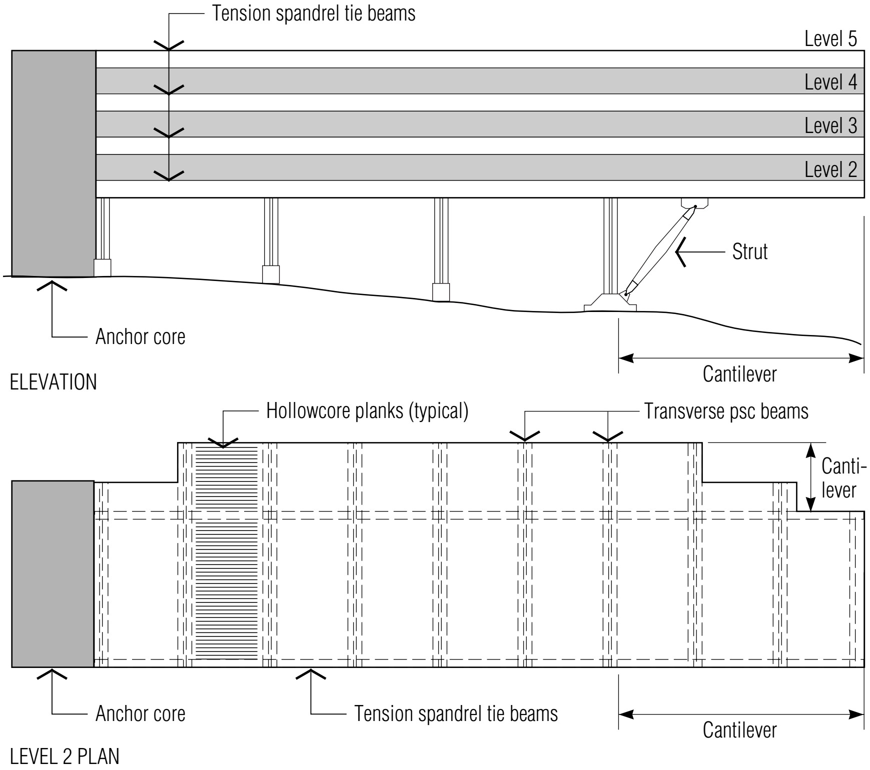
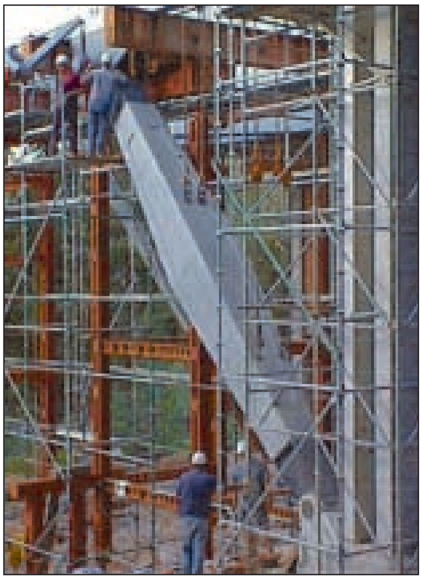


Figure 1 *Elevation and plan of Life Sciences Building*



Erection of precast spandrel tension tie (note temporary stability support for wall)

the cantilever support points where elements interacted in three directions.

Because of the high congestion of reinforcement in the precast components, high performance concrete of 240 mm slump was developed to ensure proper concrete placement under intense form vibration necessary to achieve uniformity of surface finish. The concrete mix was designed using the precaster's extensive experience in the use of super-plasticised concrete for complex bridge girder manufacture.

Application of this technology combined with a rigorous manufacturing procedure allowed a superior, high class F1 off-form finish to be achieved on all elements.

To ensure buildability of this challenging structure, it was necessary to prepare full size (1:1 scale) drawings which show the interaction of each reinforcing bar with interfacing elements in three dimensions at all cross sections through the entire building. This level of documentation demonstrates the high complexity of tolerance and fit of all areas of the construction. This meticulous approach to detailing ensured resolution of the many complex interface and interaction difficulties inherent within the design. All of this phase of the work was required to be complete before manufacture and erection could commence.

Utilisation of complex structural elements in this building demonstrates convincingly that anything is possible in construction through the flexibility of opportunities offered by precast concrete. It is only through the use of precision precast concrete that this building was constructed with such an outstanding end result.

The project team responsible for this remarkably innovative and outstanding building was:

- Architect **Suters Architects** and **Stutchbury and Pape**
- Structural Engineer **Northrop Engineers Pty Ltd**
- Builder **Lahey Constructions Pty Ltd**
- Precast Erector **LW Contracting**
- Precast Manufacturer and Specialist Consultant **Structural Concrete Industries (Aust) Pty Ltd.**
- Hollowcore Flooring **Rescrete Industries**

■

VENEER Construction

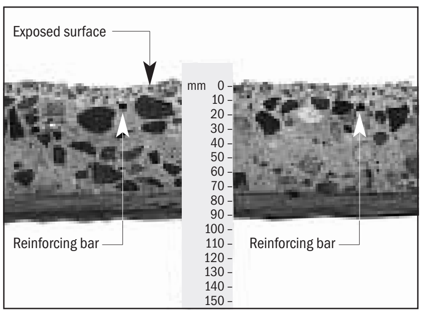
The practice of veneer construction, (also known as two-layer casting), has been a proven technique for producing an aesthetic and durable surface finish for architectural facade panels in high-and medium-rise construction,both in Australia and overseas for as long as precast concrete has been manufactured.

Veneering in this case refers to the process of casting concrete in two layers rather than to any process akin to applying timber veneers or the like. It is similar to casting concrete in layers as is done for larger structures or to the topping of insitu floors, bridge decks and the like. In practice, the second layer in the pour of an architectural panel is usually carried out within an hour of pouring the first layer.

It is, as in all technical processes however, possible to induce failure by the use of bad practice. There has been an exaggerated reaction to a handful of apparent failures of veneer in precast construction which has led to veneering being banned by some specifiers. This has been wasteful and has demonstrated a lack of understanding of the basic technical criteria. The precast concrete industry has marvelled at the violent reaction to veneering from many quarters while large numbers of failures in insitu concrete and curtain wall construction seem to go unpunished.

In order to provide a technical rebuttal the NPCAA, in 1999, commissioned Mahaffey Associates to undertake a research study into the technology and history of veneering in precast concrete applications. The research was carried out in two stages:

- To determine the general condition of facade concrete of some 20 major buildings constructed with veneered panels over more than 35 years.



Reinforcement in perfect condition after being cut out of an acid-etched veneered precast unit exposed to a marine environment for over 25 years.

- To carry out testing to demonstrate that veneering is a safe procedure.

The study was completed in December 2000, and the findings have now been published. In summary these are:

STAGE 1 The review was limited to some 14 NSW commercial high-rise buildings ranging from 15 to 36 years of age, where maintenance records were available.

Key Findings:

- Any problems with these buildings were NOT related to the failure of the bond between the veneer and the backing concrete.
- In all cases where repairs were required, the problems were the result of poorly conceived or executed construction techniques or of the choice of alkali reactive aggregates – not the result of veneering.

STAGE 2 The testing was carried out at the factory of an established precast manufacturer, and trials completed under normal factory conditions and not in a laboratory. Trial 600 x 600 mm units were cast face-down, ie the architectural concrete was poured first and the backing concrete (the second layer) was poured later at predetermined intervals viz 1.25, 2.5, 3.5 and 4.5 hours.

Three types of testing was carried out:

- Compressive strength (veneer and backing)
- Drying Shrinkage (veneer and backing)
- Adhesion testing (veneer pull-off test)

Commonwealth Bank Building, Sydney *– an example of a high quality, durable veneered facade*

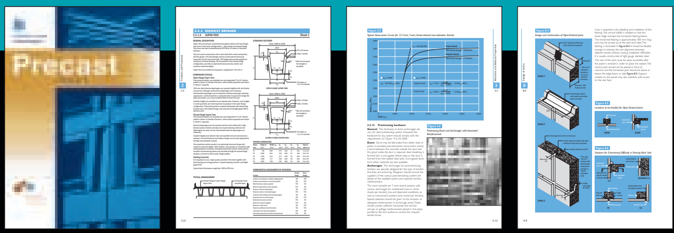
Key Findings

- Veneering of precast concrete panels, carried out in accordance with good practice, results in a composite material with a perfect bond between the veneer and the backing concrete. Pull-off testing showed failure occurred in the backing or in the veneer – not at the interface.
- The interval between casting of veneer and backing concrete affects the development of bond at interface.
- The bond between the backing concrete and veneer of steam cured panels is sufficient to resist failure at the interface for delays of up to 2.5 hours. For the normal cured panels, the delay is up to 3.5 hours.
- It is clear that veneering can be successfully carried out using either normal or steam cured concrete.

The overall conclusion of this research study is that the technique of veneering precast concrete facade panels is technically sound, and produces a high quality and durable product. Should you require more comprehensive details on this research study, please contact the NPCAA office.

In conclusion, it is worth noting that independent overseas research on bond strength achieved between unreinforced interfaces supports the findings of the Mahaffey study. For further reading on this research, please refer to BFT 4/2001 Pages 64–69, *Shear Strength – Unreinforced interfaces: precast concrete elements and in-situ topping.*

AMP Centre (Tower and St James Building), Melbourne *– an example of a veneered facade from the 1960's that has stood the test of time*



Precast

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Sasso Precast Concrete – Sydney-based supplier of wall panels.

Hallweld Bennett – Manufacturers of concrete batching equipment

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