fib

Award for Outstanding Structures

Life Sciences Building University of Newcastle

Submitted by:

Structural Concrete Industries (Aust) Pty Ltd

Sydney AUSTRALIA

SUMMARY

Life Sciences Building – University of Newcastle

The newly completed award winning Life Sciences Building on the University of Newcastle campus has been constructed to house research and teaching laboratories together with lecture theatres and other specialist operations within the faculty schools of medical and biological sciences.

The environmental demands required the natural landscape of a very steep site beneath the building to be retained. The design and construction of the building therefore necessitated innovative architecture, demanding engineering and extreme precision in its construction. Precast concrete was chosen as the structural medium because it alone would satisfy the architectural, structural, environmental and construction requirements.

The architectural concept provides for the building to cantilever over the site in two directions - twenty-one metres out to the north on the longitudinal axis and six metres to the west on the transverse axis. Two large inclined hinged struts support the main longitudinal cantilever. These struts each carry 1200 tonnes service load and, because of their inclination, induce very large horizontal forces into the structure. These induced forces define the unique characteristic of this building that utilises concrete in tension through the entire structural spandrel facade.

Stability against collapse under these forces is provided through the unusual use of concrete tension ties. These ties transmit the large forces through the longitudinal spandrel beams back to dead end anchors at the building's south end core.

The building is constructed entirely of precast concrete. The precast structural elements were manufactured to a tolerance of +/- 2 millimetres with Class F1 finish to AS 3610 on all visible surfaces. The precast concrete structural frame presented an intricate and complex challenge with regard to interaction of the precast elements intersecting in three directions. This complexity was further amplified by the requirement for all of the structural frame elements to be only 300mm in width.

Construction of this building pushed the limits of what can be achieved with concrete. Through close tolerance precasting of these major structural elements and the repeated provision of surface finishes of the highest achievable level, a unique building with outstanding design and construction qualities has been achieved.

From the aspects of design, manufacture and erection, this building represents excellence in every respect, in the intelligent use and execution of concrete construction.

Life Sciences Building – Newcastle University

The new Life Sciences Building at the University of Newcastle is responsible in part for that Campus recently winning a prestigious Banksia Environment Award. The building is an example of innovative architecture, unusual engineering design and excellence in construction combining to achieve an environmentally responsible building comprised entirely of precast concrete.

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.

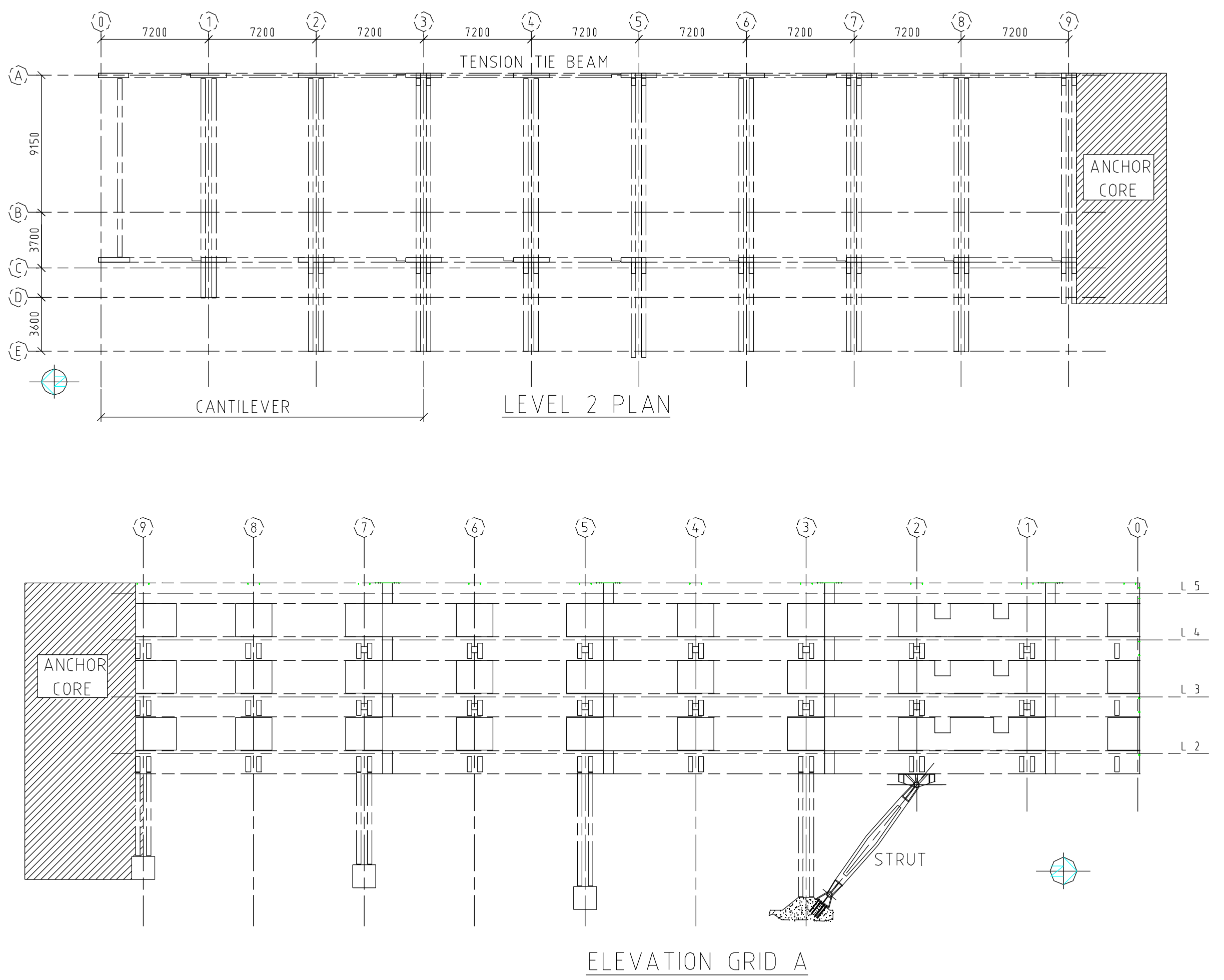


Figure 1

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 60mm 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 to provide clear, uninterrupted floor space. Precast, prestressed concrete beams span transversely across the columns, transferring the load from the hollowcore floors. 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 above 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 600mm 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 80mm 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 6m past their line of support. Precast prestressed hollowcore floor units span longitudinally between these pairs of transverse beams and when interconnected with a 60mm 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 300mm. It was only possible to construct these slender beam elements and still maintain the required 25mm cover to reinforcement because of the extremely low tolerances (+/-2mm) and precise jigging of the welded cage reinforcement developed by the precaster.

The 300mm thickness of all sections created extreme congestion of reinforcement and continuity ducts particularly at 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 240mm slump was developed to ensure proper concrete placement and 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. The attached 13 drawings, (selected from the nearly 700 that were produced to fully describe this project and the manufacturing process), demonstrate 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.

Appendix A is a selected collection of photographs and workshop drawings, which clearly show the complexity of every facet of construction of this building.

In summary, this project is worthy of the highest award for Excellence in Concrete for the following reasons:

- The site and the Architect's innovation have combined to produce a unique and outstanding building for a project of this scale.
- The use of a concrete structure has contributed towards a major Environmental Award for the building.
- Use of the Cadweld mechanical coupling system was a first in an Australian building.
- The concrete developed to manufacture the components is at the cutting edge of concrete technology.
- The manufacturing precision that was required to produce these major structural elements within a 300mm thick concrete section to +/- 2mm tolerance with consistent Class F1 surface finish was an achievement of excellence in itself.

- The completed structure is an excellent example of prefabrication in concrete.
- Utilising the most complex of pieces, it demonstrates convincingly that anything is possible of construction through the free-form qualities of concrete.
- The building is a tribute to the skills and exactness of a highly experienced precast concrete manufacturer and erector.

APPENDIX A

Completed building cantilevering over the steep site

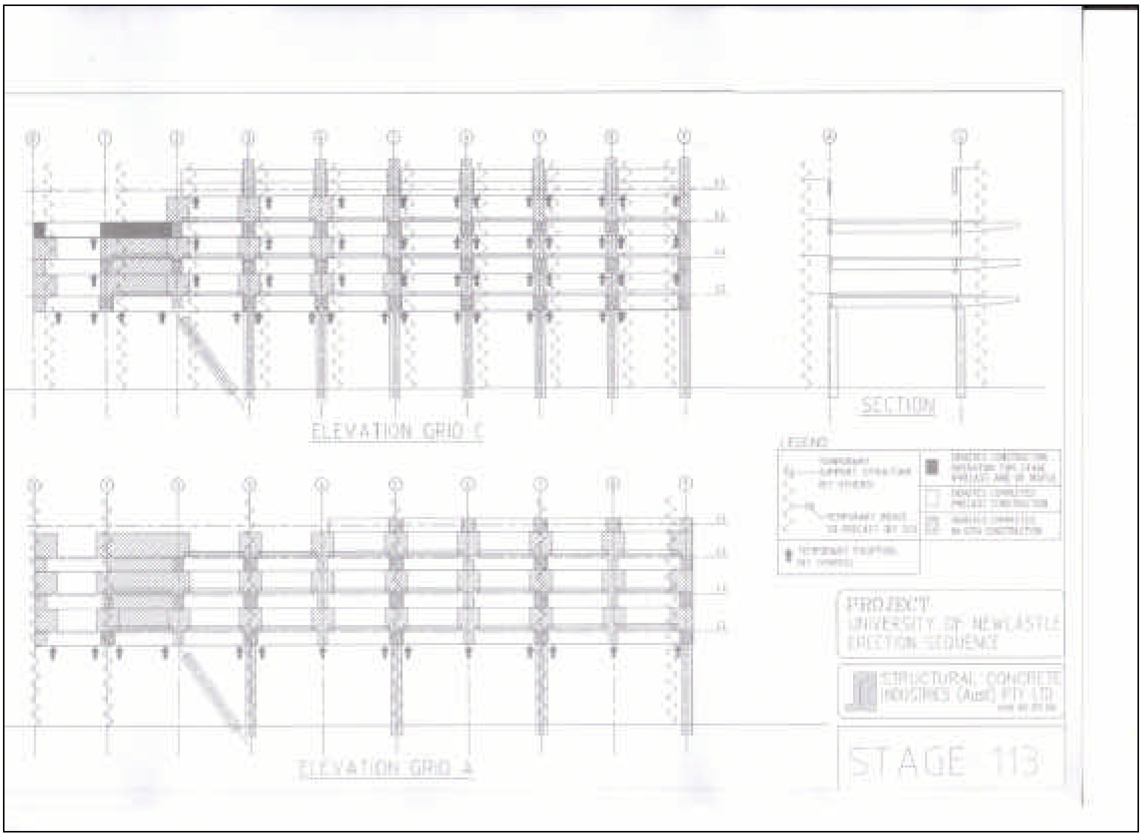
All structural elements are precast concrete

Display of Huge Cantilever and Concrete Tension Ties

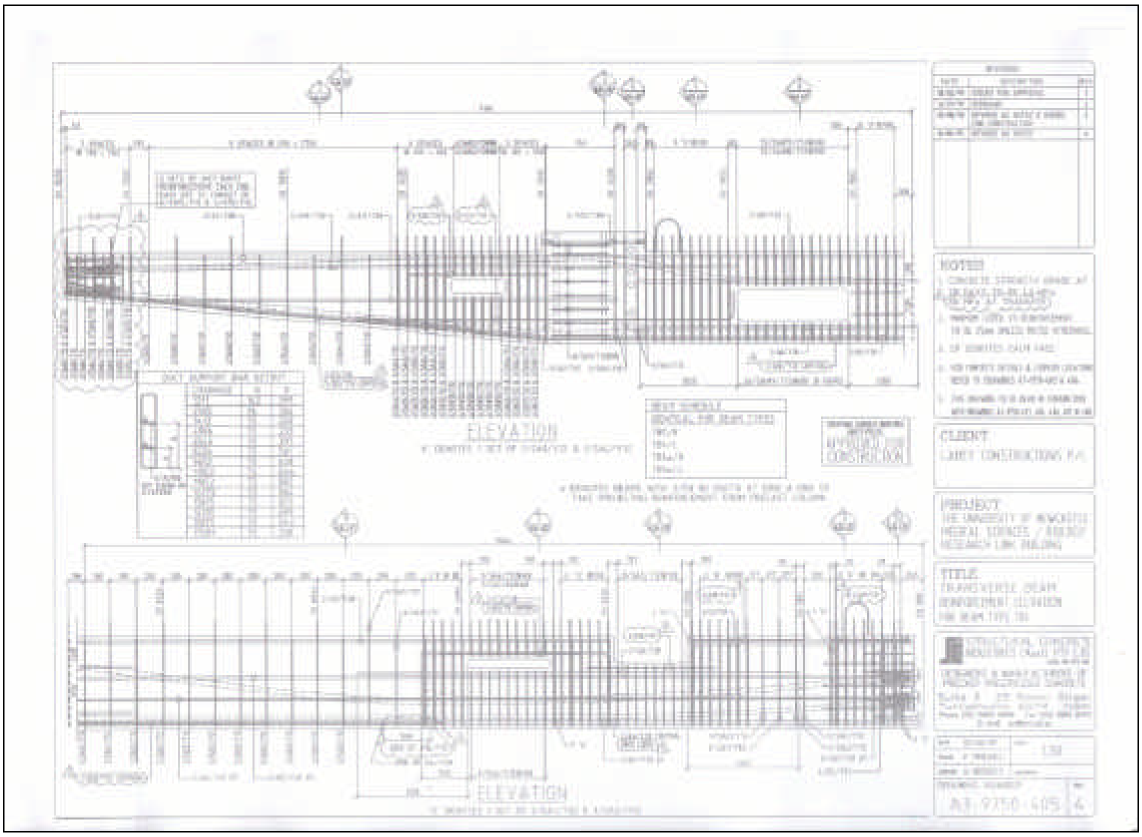
Precast element erection – tolerance on all elements +/- 2mm

All precast elements only 30cm thick

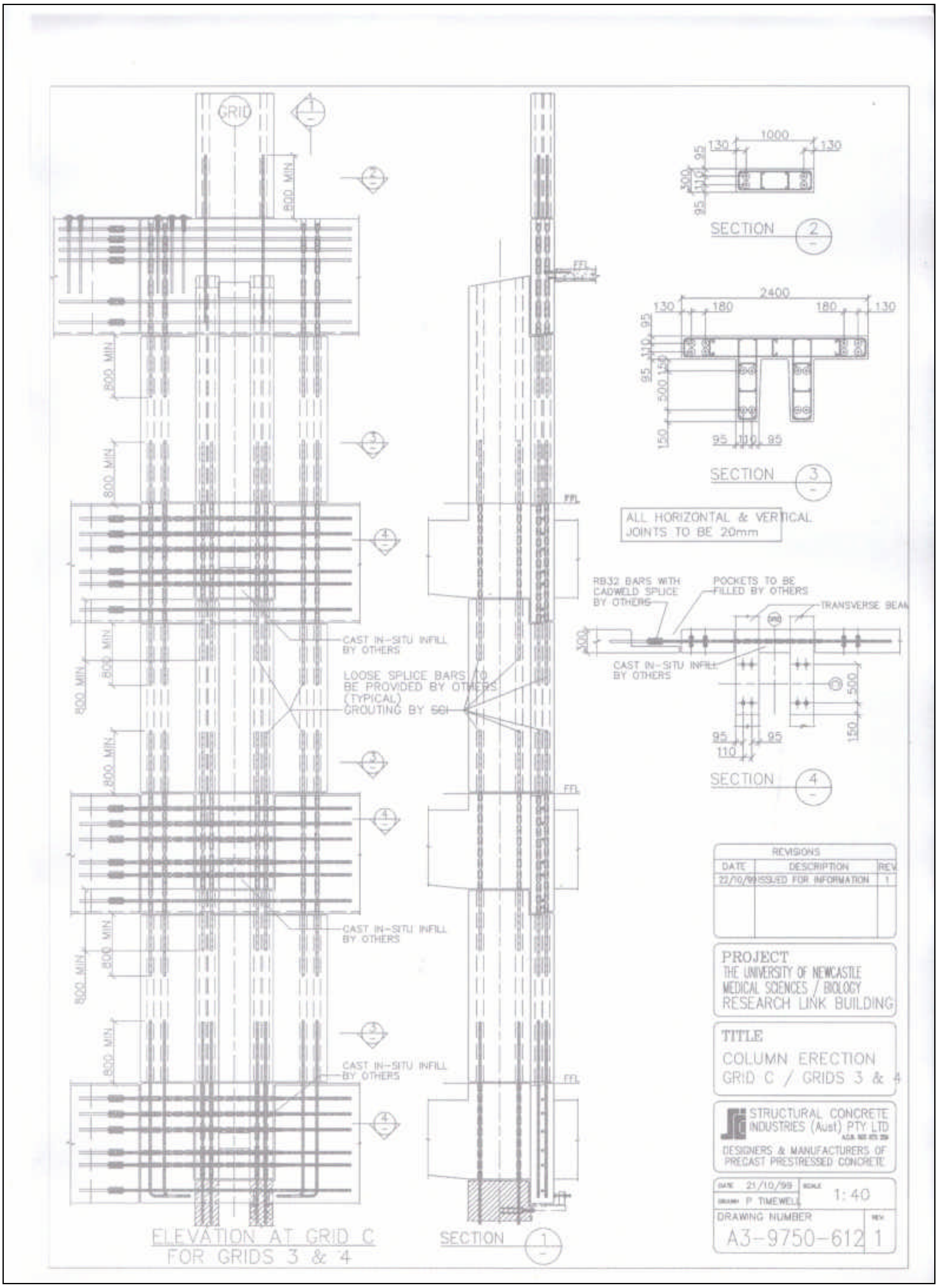
Erection of strut



Erection Methodology for the precast structure



Transverse cantilever beam details
Very high precision in every aspect of reinforcement fit



Demonstration of highly complex reinforcement in 3-D arrangement