



Westfield Sydney – Revitalising a City Centre

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Summary

Sometimes the strategic location of a site in the centre of a city and the potential of creating a valuable asset allows engineering challenges to be undertaken that would normally be discarded due to cost, complexity and risk. On Westfield Sydney, we have been fortunate to achieve our client's vision through innovative engineering solutions whilst ensuring the sequence of construction maintained the Sydney Tower in a safe and stable condition at all times. To validate this process a real-time monitoring and warning system was developed that measured structural movement against accurately predicted movement based on environmental conditions at that time.

Keywords: monitoring, concrete filled steel tubes, high-rise buildings, modernisation and refurbishment.

1. Introduction

Sydney has been transformed with the opening of Westfield Sydney, a retail and commercial precinct situated below the iconic Sydney Tower. It encompasses the Centrepont, Imperial Arcade and Skygarden sites, the re-modelled 100 Market Street and a new 27 storey commercial tower. This paper summarises a few of the structural challenges faced and explains how they were overcome.

2. Zone 1: 100 Market Street Office Tower, and Sydney Tower

The refurbishment and modification of Zone 1 to suit the revised architectural layout and vision for Westfield Sydney involved some of the most complex and difficult engineering completed by the structural team since the design of the original Sydney Tower. The proposed changes altered the lateral support for the 308 metre Sydney Tower. Construction monitoring included GPS positioning with a sophisticated predictive algorithm to ensure the behavior of the tower remained within design parameters at all times. FE modelling demonstrated that the proposed changes and increased strengthening would provide a similar performance to the original structure. We developed a comprehensive demolition and reconstruction sequence which identified critical items which could impact on the structure, along with pre- and post- requisites, which were inputted into the construction program ensuring the structure remained in a safe and stable condition at all times.

To encourage pedestrian traffic, column free entries were created at the street corners using hanging trusses at level 11. The trusses used a central column and back stay to allow the removal of the corner column at street level. A food court was included to attract visitors. To provide the necessary ceiling height a floor had to be removed and a number of columns transferred above requiring strengthening of columns and new transfers. A challenging feature was the addition of retail space beneath the building. Part of the existing structure was used as a loading dock set at a higher level to the surrounding retail. The loading dock was transferred to Zone 2, allowing the space to be utilized as retail but column footings were at a higher level so levels did not match surrounding areas. To lower the floor, columns were supported off temporary propping and the

columns, footings and surrounding floor lowered to the new level. This was a significant challenge as the columns formed part of the support structure for Sydney Tower.



Figure 1:
View on completion showing
left Sydney Tower over the
refurbished 100 Market St,
centre the new 85 Castlereagh
St Tower and right Skygardens
Tower.

providing additional lateral stiffness to the tower. In a traditional tower, the concrete lift core providing lateral stiffness continues to foundations, with a lobby at ground level. In this mixed use development the premium retail space would have been compromised by a large lobby and core structure so a sky lobby and main lift bank at Level 7 with smaller, express lifts down to ground floor was adopted. Level 6 was designed to act as a rigid diaphragm with shear transfer to substantial concrete perimeter walls leaving the premium retail space free of lift shafts and lobby area. A distinctive architectural feature of the office tower is the inclined glass roof. The roof follows the same elliptical shape of the typical floor plates but is inclined at 36 degrees to the horizontal and spans across nine levels as each successive floor reduces in length, to create the gradient.

4. Zone 3: Retail and 77 Castlereagh Street

During the project the Skygarden office tower at 77 Castlereagh Street remained fully tenanted. Key issues for the tenants included continuous access, noise and vibration. To manage this issues we assisted in the development of appropriate vibration and noise limits. Previous alterations included a deep transfer beam beneath the heritage stone façade to eliminate a number of columns. This façade was propped and the beam removed to restore the historic façade to its original configuration. To improve streetscape and anchor the redevelopment with adjacent buildings, the existing precast concrete and steel bridges across Castlereagh, Market and Pitt Street were replaced with slender glazed bridges including the first all-glass portal framed bridges to have been designed and built in Australia.

5. Conclusion

The successful opening of Westfield Sydney in 2011 is a testament to the co-operation of the design team, construction team and client to address major engineering and construction challenges with a collaborative approach. The innovative approach and the lessons learnt will be of value on future projects to ensure high level of safety can be achieved on complex projects and sensitive sites.

3. Zone 2: Retail and 85 Castlereagh Street

Zone 2 is a mixed use structure including three sub-basements, six retail levels, a sky lobby and a 27 storey elliptical office tower suspended above an open retail area. A rail corridor easement ran beneath the project site. Using 3-dimensional geotechnical analysis to model the rail tunnel, the rock properties and anticipated, applied loads Hyder demonstrated that the excavation and structure would not negatively impact upon the proposed rail tunnels. The site was bound by existing buildings and street frontages. This required hoardings with decorative architectural treatment designed to protect the public without affecting amenity and protective works to allow continual trading by the neighbours.

The elliptical shape 85 Castlereagh Street tower and its eccentric core could have led to unacceptable torsional accelerations without the introduction of a wind frame. The stiffness of the wind frame was “tuned” to minimise size and cost and to fit within the structural envelope. The innovative use of inclined, thin walled concrete-filled steel tubes allowed an elegant transition from the retail column grid and to the office whilst