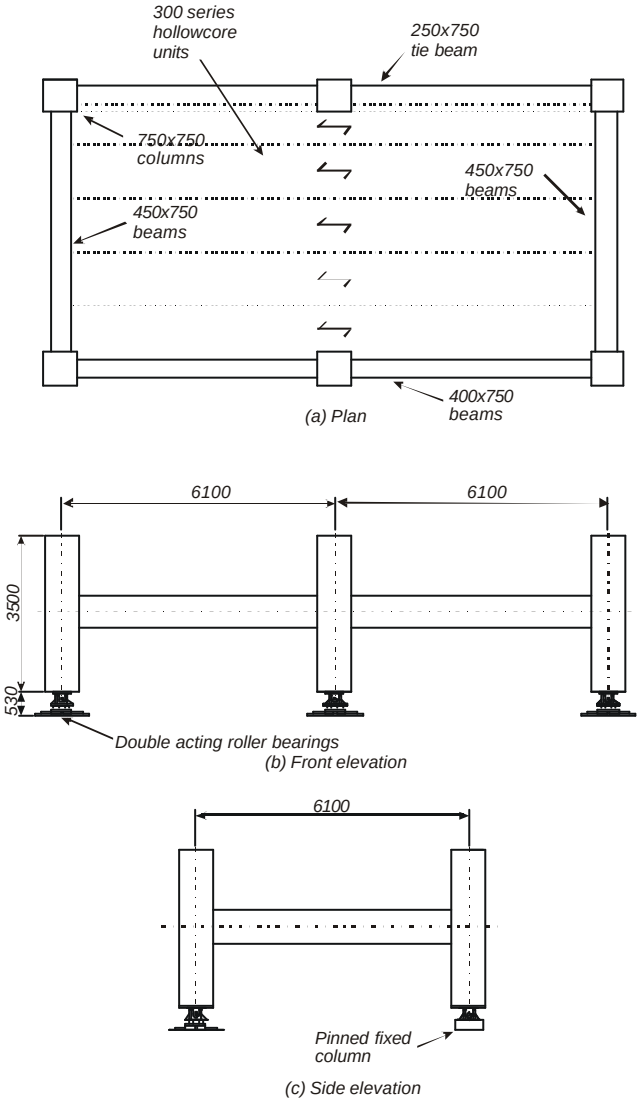
Industry Workshop on Seismic Testing of Pre-cast Flooring at University of Canterbury

Summary of Key Observations and Outcomes

The seismic load testing of a typical modern pre-cast floor and primary seismic frame assemblage is in its latter stages at the University of Canterbury. This PhD project by Jeff Matthews, supervised by Des Bull and John Mander, is of particular significance due to its size and configuration – it features two single-bay ductile frames supporting 300 series hollowcore flooring, spanning 11.8 m, with a two-bay ductile frame in the longitudinal direction (*refer figure below*).

This full-scale specimen of a 1990's building designed for Wellington forms part of a research programme undertaken in conjunction with the University of Auckland, and funded by EQC, concrete industry organisations and FRST programmes.



Industry Workshop

A workshop to discuss the issues arising from this major test was organised by the New Zealand Society for Earthquake Engineering in conjunction with the New Zealand Concrete Society and SESOC. Held on 12 April 2002 at the University of Canterbury, this workshop attracted 22 participants representing design, research and pre-cast concrete sectors, along with EQC as funding agency.

Preliminary Test Unit Performance Characteristics

The performance of the unit is described briefly in the separate pdf file.

When interpreting the images it is important to give due consideration to the following-

- The flooring units span two bays while the longitudinal seismic frame spans individual bays. The resulting double curvatures in the beams were imposed on the hollowcore unit, immediate next to these beams. This resulted in additional stresses in the unit, quite different from those envisaged for the unit, assumed to be acting as "simply supported".
- The restraint of outward movement of the central column was provided by the tensile capacity of the non-ductile mesh in the floor topping. This proved to be inadequate. No additional column tie back reinforcement was provided in the topping as suggested by 4.3.6.7 of NZS 3101.
- A mechanism explaining the damage to the seating of flooring units is presented in Appendix A. The severity of damage to seating is a function of the rotational incompatibility of the supporting beams and the flooring units. Seating damage is therefore a function of the inter-storey drift of the structure.
- Although the test specimen used hollow core flooring units, the lessons learnt are not confined to this flooring system.

Key Issues to Emerge from Testing and Workshop Discussion

Several aspects of the performance of the test unit are subject to further analysis following completion of the test loading regime at higher levels of drift parallel to the floor units. However, key issues that are of interest to designers of pre-cast flooring units are highlighted below:

- Damage to the flooring system was concentrated in the unit adjacent and parallel to the beams of the seismic frame. It is believed that this damage could be minimised by either ensuring that the one-way spanning pre-cast floor units do not end up cast longitudinally into beams and therefore acting as two-way elements, or by proving some flexibility between the precast floor units and the beam. This could potentially be achieved by placing the first hollowcore unit 700 to 800 mm away from the side of the beam, completing the floor with a 75-100 mm insitu reinforced concrete slab (using timber infills as formwork, for example).
- The damage at the seats of the hollow core units was more associated with a snapping action rather than the units sliding off (refer to appendix A). It is believed that the larger the rotation of the supporting beams relative to the floor, the greater the amount of damage to the seating. The damage is therefore more a function of inter-storey drift rather than ductility of the beams next to the hollowcore units. The consequences of the rotation of the supporting beams relative to the ends of the floor could be reduced by the use of neoprene bearing strips and permanent compressible formwork (5- 10 mm thick) to avoid the cells of the hollowcore units being filled with concrete as the beams are completed. The bearing strip and compressible backing permits the relative rotation between the supporting beam and hollowcore unit to occur, avoiding contact between the unit and beam and limiting additional stresses from being introduced in the unit.
- Interior columns of perimeter frames that are not anchored back into the building by framing beams need to have specifically designed ties provided in the floor diaphragm. Additional tie reinforcement in the topping is one way of achieving this, provided the topping thickness is adequate to accommodate the additional layer of reinforcement and its transfer of forces requirements.

Next Steps

Following completion of the test in May, analysis of the results and formal writing up will be undertaken by Jeff Matthews, Des and John. Full technical papers are likely to be presented at the New Zealand Concrete Society annual conference in October, and the Pacific Conference on Earthquake Engineering at Christchurch in February 2003.

The Department is planning to use the test set-up for another floor test in the latter part of this year. This would involve utilising the largely undamaged primary frames by removing the existing floor units and topping. Workshop participants supported the approach of having this next test based on the same flooring system but with proposed performance improvement measures such as insetting the first unit away from the beams and using neoprene seatings beneath the ends of the hollowcore planks etc.

NZSEE, NZCS and SESOC are recommending to their respective Management Committees that an industry technical advisory group on pre-cast floor systems be established. This group would work with the University of Canterbury Department of Civil Engineering to:

(i) Provide industry input into proposals for the subsequent test(s) using the same primary frames

(ii) Once the test is written up, produce 'best practice' industry guidelines for designing and detailing pre-cast floors

(iii) Communicate the issues and findings to all sectors of industry