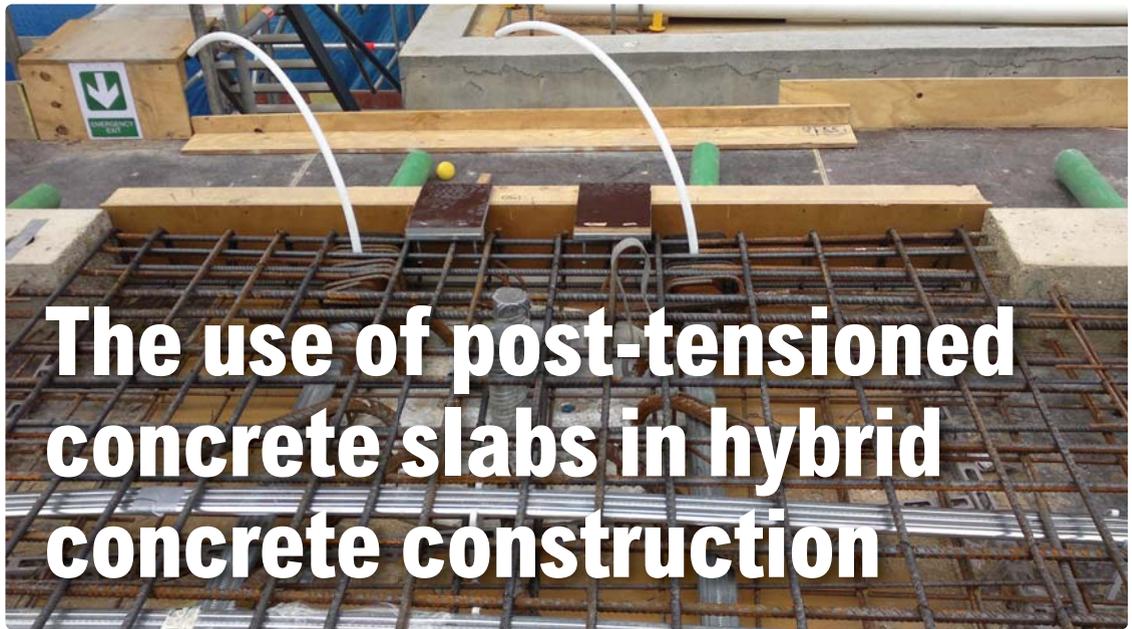


Right: CCL post-tensioning anchors located between edge beams at precast column.



The use of post-tensioned concrete slabs in hybrid concrete construction

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The use of PT in the floor slabs reduced the amount of concrete and reinforcement in comparison with a traditional reinforced concrete slab, reducing both material costs and the environmental impact of the overall frame.
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In a recent project undertaken by post-tensioning specialist CCL, in which precast columns were used in conjunction with post-tensioned in-situ floor slabs and precast edge beams, the benefits of both forms of construction were further exploited in combination. Adam Sweet of CCL reports.

Hybrid concrete construction (HCC) is the combination of construction methods, most commonly precast and in-situ, which maximises the inherent advantages of each to produce an optimised structural solution⁽¹⁾. The use of both precast and in-situ concrete can allow faster construction programmes, reduce costs, provide high-quality finishes while still delivering a considerable degree of flexibility through the design development stages, right up to construction.

Examples of more common forms of hybrid concrete construction include:

- precast column with in-situ floor slab
- precast column and floor units with in-situ beams
- in-situ columns or walls and beams with precast floor units with in-situ structural topping
- precast twin wall and lattice girder slab with in-situ concrete.

Speed of construction

A recently completed multi-storey, award-winning office development in the capital – uses exposed circular precast columns. This accelerated the construction programme by removing the need to erect column formwork, fix reinforcement cages and pour the concrete, as well as achieving a high-quality finish. The precast columns were lifted into place and connected using large-diameter internal dowel bars, which were fixed into position using high-strength grout.

Precast edge beams were placed between column positions and acted as permanent formwork. As a result, only minimal amounts of edge shuttering were required at column locations to allow room for the punching shear steel to be installed in-situ. Around 75% of the edge formwork was replaced by the precast edge units, vastly reducing the time to complete the pours. The beams, having been cast off-site, incorporated the required starter bars, cast-in channels for cladding and external fire escape stair fixings along with the CCL post-tensioning (PT) anchorages and associated anti-bursting reinforcement. All of the cast-in components and the edge unit dimensions were co-ordinated via BIM to ensure all trade items were accounted for and to avoid clashes.

After the beams were installed, all that remained was to fix a small number of additional PT anchors and the remaining reinforcement, which were located between the edge beams, connect the PT duct to the anchorages and push the strand through the duct.



Far right: Precast edge beams with cast-in items and CCL post-tensioning duct.





The use of an in-situ post-tensioned slab reduced the amount of reinforcement required by around 40% less than a traditional reinforced concrete slab. A reduced slab thickness maximised floor-to-ceiling heights. This had a significant impact on both fixing times and volume of concrete (and therefore environmental factors such as cement content and the number of site deliveries). Once the post-tensioned concrete gained sufficient strength and stressing had been carried out, which usually took around two to three days, the slab was self-supporting and able to accommodate construction loading. At this point the formwork could be removed and subsequent upper floors could be constructed. In traditional RC construction, tables typically remain in place until the concrete has reached two-thirds of the final design strength. This feature has been an important factor in many of the projects undertaken by CCL. The post-tensioned slabs on the 43-storey tower, Strata SE1, were completed within 50 weeks, a rate of just over one floor per week.

Quality

Installation of components within the precast elements off-site not only saved fixing time but also ensured that all components were correctly located to a higher degree of accuracy. The manufacture of the edge beams and columns within a precast factory also produced a high-quality finish for the exposed elements, which could be signed off prior to installation/erection.

Post-tensioning concrete slabs apply a compression to control cracking and deflection, maintaining the high-quality finish achieved by the precast elements.

Flexibility

An additional benefit of the in-situ scheme was the incorporation of future soft-spots in the slabs to allow areas to be removed in future, to create duplex offices, while being able to support a number of load scenarios.

As with traditional reinforced concrete, post-tensioned slabs can, in the event of unforeseen alterations, accommodate future penetrations, provided modifications that may affect the existing structure are designed by a competent engineer and are carried out by a qualified post-tensioning specialist.

Cost savings

As the edge units were repetitive, the moulds could be reused many times, reducing the amount of waste material usually associated with a full in-situ edge shutter. Only four different edge units were required on the typical levels, with small variations in the required cast-in items.

The use of PT in the floor slabs reduced the amount of concrete and reinforcement in comparison with a traditional reinforced concrete slab, reducing both material costs and the environmental impact of the overall frame. The smaller quantities of reinforcement required in turn led to a reduction in the amount of on-site labour, a common feature on post-tensioning projects, and a benefit which was further enhanced because the precast edge units acted as formwork and came preinstalled with items which are time-consuming to fix.

Benefits

HCC takes a proportion of work away from the site and into the factory, reducing the duration of operations critical to the building programme on-site, while incorporating other efficient construction techniques such as post-tensioned concrete. The precast process takes place in a controlled environment, unaffected by the elements, and allows for rigorous inspection and approval of visual elements before installation on site. Combining the two construction methods maximised the benefits of each.

Provided that careful consideration is given to the combination of construction methods at all stages of the project, HCC can maximise the benefits of both. In this instance, the judicious use of in-situ post-tensioned slabs with precast edge beams, combined with precast columns, simplified buildability, accelerated construction and reduced costs. ●

Above: Strand pushing machine.

Above left: Precast edge beams after strand installation.

Reference

1. GOODCHILD, C.H. AND GLASS, J. *Best Practice Guidance for Hybrid Concrete Construction*. The Concrete Centre, Camberley, 2004.