

West Thames College – making grey green and keeping it beautiful

The redevelopment of the Isleworth campus of West Thames College involved the replacement of a series of 1960s blocks with six new buildings. These would house teaching, administration, a sports hall, a theatre, a nursery and welfare facilities for the expanding body of further education students.

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With a construction cost of £45 million, the works are phased over two years by the contractor, Osborne. The college would continue to function during this period by use of temporary accommodation on the campus, sequenced demolition and hand-over of the new buildings. As the structural and civil engineer for the project, AECOM was keen to help the college realise its ambition for a sustainable project by adopting sustainable engineering design approaches.

The first step for the structural engineer was to decide the most appropriate form of construction for the new buildings. The architect, Mackenzie Wheeler, had developed preliminary layouts with an 8m x 7m column grid and a desire for areas of exposed structure. It was essential that the new buildings provided full flexibility in partition layouts and services distribution both now and for future refurbishments. A steel frame with precast concrete slabs might be quicker and more economic to build but the network of downstands would compromise that flexibility and look somewhat utilitarian. A reinforced concrete frame with downstands would have similar problems, although could look more appealing. A concrete flat slab would satisfy the criteria and could achieve the spans required without compromising headroom. It would also offer the simplicity of construction and cost-effectiveness of a flat soffit. The sports hall and theatre both sit at irregular angles to the buildings that hold them, supported on transfer structures of storey height beams or heavily reinforced beams strips.

Lightweight concrete

The site is underlain by reasonable bearing strata so AECOM's aim was to adopt pad foundations as a cost-effective solution for the five-storey buildings. Lightweight concrete, where the coarse aggregate is replaced by a processed by-product of the power industry, was considered as a means of reducing the dead load of the structure, as it reduces self-weight by some 25%. If possible, adopting it would mean avoiding piled foundations and their caps, saving time and costs. Moreover, environmentally, a double benefit would be achieved. A waste product would be recycled that would otherwise have gone to landfill and AECOM would avoid the carbon footprint of the pile and caps, which can be around 4% of a building's construction.

While commonly used for 'crinkly tin' slabs of commercial buildings, would it be viable here for whole frames? The strength could readily be achieved and research with (among others) Lytag – the supplier of the aggregate – and The Concrete Society suggested it was practicable but costs needed consideration. Concrete suppliers charge approxi-



(Photos: AECOM)

mately 18% extra for lightweight concrete. However, AECOM's analysis showed that for a given slab thickness on the column grid the reduction in dead load meant that typically 13% less reinforcement would be required. It was concluded the premium on the frame would be more than balanced by cost and programme savings generated by the avoidance of piling.

The next issue addressed was the cement in the concrete. With cement production responsible for 6% of global carbon emissions, any reductions are worthwhile. Strength needed to be maintained so we considered replacing some of the cement with fly ash or ground-granulated blast-furnace slag (GGBS). As the most common replacements, these options again offered double environmental benefits – less Portland cement (PC) would be quarried and a waste product of the power and steel industry would be recycled and diverted from landfill. Research showed it was compatible with Lytag and delivered cost of a blended cement concrete would be 2–3% cheaper than standard mixes. Again, taking an environmental approach proved cost-negative.

Following research, AECOM decided to limit the proportion of cement replacement to around 40% for two reasons. First, the early strength gain of blended cements is slower than 100% PC, requiring extended propping periods during construction. For verticals this tends to have little impact since they are typically struck the day after casting but slabs can require propping for two or three days longer. Second, with higher proportions of replacement there is a tendency for increased bleedwater to occur at the top of pours, making good worked finishes difficult to achieve.

Overall, these were an acceptable price to pay for the financial saving and environmental benefit. The choice of cement replacement though would affect the fair-faced elements on the project; fly ash tends to darken the concrete's colour, while GGBS lightens it. Architecturally, the latter was preferable so GGBS was adopted. Accordingly, the tender documents stated that CEM II/B-S, a blend of Portland cement with up to 35% of GGBS, should be used and that contractors should account for the extended propping times in their tender considerations.

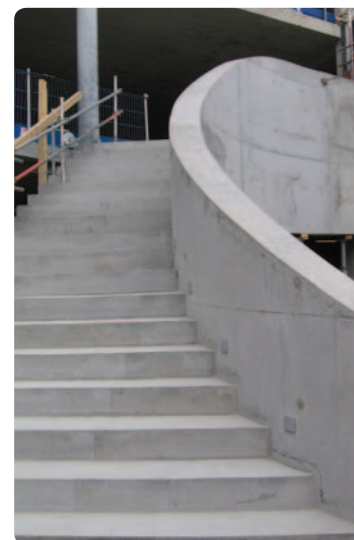


Figure 1 top: The frame of the student centre.

Figure 2 above: Fair-faced stair leading from atrium.

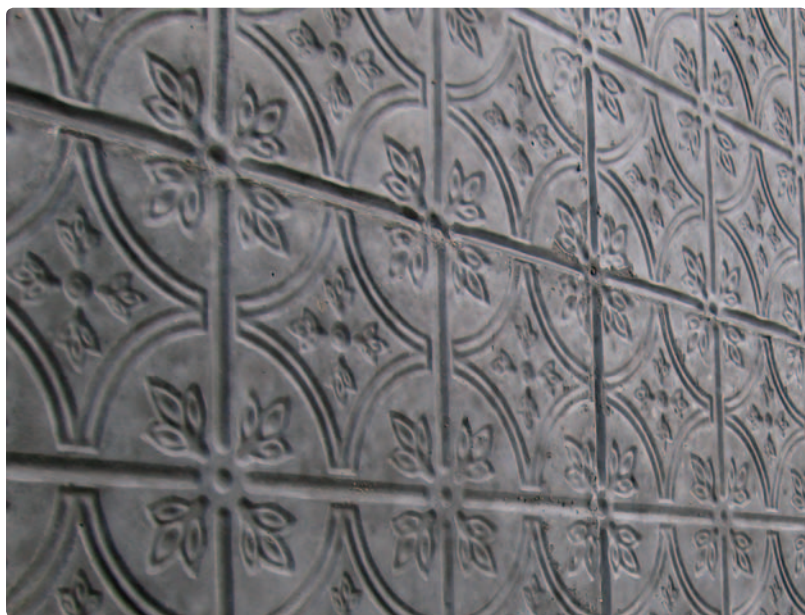


Figure 3: Embossed wall in dining area.

At this stage we also included a series of other cost-neutral environmentally beneficial clauses in the tender documentation. These would either draw procurement along a greener path or restrict site practices to limit the impact on the local environment. Many of the latter were derived from the Environment Agency's guidelines. The specification defined all reinforcement must be provided by British manufacturers, who use solely recycled steel. More generally, all materials were to be sourced locally if no significant cost impact was incurred. For construction our specification defined how site practices or storage of materials should be carried out to address run-off and debris contamination of mains drainage or groundwater.

Aside from these structural issues, the concrete was also an architectural feature in fair-faced walls, columns and slabs, but these too were influenced by our material choices. Being circular and with an average diameter of 9mm, the lightweight aggregate suggested it would lend itself well to fair-faced work through improved ability to smoothly fill detailed shuttering. Also, the GGBS in the mix meant the concrete would be lighter than normal. The design team discussed these issues with the concrete contractor, Ground Construction, and the main contractor along with the usual fair-faced issues of panelling, formwork materials, joints and tie details and arrises, all balanced between aesthetics and cost. The agreed approach was then used for a less critical area of the main frame to act as samples for the exposed elements. Although an unconventional approach to sample work, this created samples using the representative mix and reinforcement without any programme impact. These proved successful and led to the adoption of resin-faced ply formwork for the slabs and polythene-lined cardboard for the columns.

The flagship element of the fair-faced work was an 8m-long storey-height wall embossed with a pattern redolent of textured wallpaper. The formwork was a grid of embossed metal sheets on ply fixed to steel pans, with a series of samples used as alternative details for panel joints. The final choice was constructed as a single shutter, with joints and screw-heads filled with wax to minimise their expression on the finished face.

The end results for all elements were a very high standard. Finish was almost glossy, concrete colour was consistent, details were sharp and honeycombing was negligible. The wall, in particular, far exceeded expectations. The blowholes might have been little more frequent on some column pours, possibly due to the reduced head of con-

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crete during pouring created by the 300mm square column size, the moderate storey height and the reduced concrete density. Elsewhere, the track cover spacers were visible on the slab soffit in a couple of back spans of cantilevers. The buoyancy that normally lifts spacers from the soffit may not have acted so strongly here due to the dense reinforcement bar and lighter weight concrete.

The site works generally were enjoyably uneventful with two interesting exceptions. The majority of the first-floor slab was programmed for pouring during the exceptionally cold weather of January this year. Temperatures were often below the 5°C threshold, such that special measures would be required during mixing, casting and curing. The contractors took a pragmatic approach by postponing the main pours until the weather improved, as this would prove less onerous than employing the restrictive cold weather practices. They did though decide to press ahead with the verticals in adjacent areas. To address the effects of low temperatures, their first step was getting the batching plant to confirm temperatures of delivered concrete. Secondly, pours were delayed until the warmest part of the day. Once cast, frost blankets were applied to shutters to maintain core temperatures overnight. Lastly, formwork striking times were extended to account for slower strength gain. Verticals were delayed from one to two days and slabs cast in subsequent weeks were delayed to at least 11 or 12 days rather than a typical week or so.

The second issue was the effect of the blended cements on the speed of strength gain of the concrete. The slower strength gain of the CEM II mixes meant that a small number of the cube results only exceeded their 28-day design strength by 2 or 3MPa. Indeed, some 12% only achieved the required strength at 56 days, causing a few slightly apprehensive weeks on-site.

Concluding remarks

This project has been a worthwhile learning process. These days there is a responsibility to address sustainability in design. Savings on the carbon footprint of this concrete frame were readily achieved without any compromise to the structural integrity, the architectural intent or the programme. More importantly, and contrary to popular belief, this green approach actually reduced project costs.

From the outset, AECOM searched for opportunities where traditional approaches could be improved. Ultimately, green benefits were achieved without the fundamental departures from standard practice, which often attract cost premiums in tender returns. It was more a matter of recognising the environmental gains of products used for their other advantages and by combining them the company achieved an end result that was greater than the sum of its parts. Experience here shows that concrete designers can easily employ simple measures that make a difference and that is something we can all be educated on. ■

Figure 4: Fair-faced column in dining area.

