

Photo: British Land, courtesy of GXN



CUT OUT AND KEEP

Engineers on high-profile London projects are untangling a complex web of design, logistics, risk and responsibility. The goal: to make the harvesting and reuse of structural concrete a reality. By Nick Jones

Redundant concrete structures usually face one of two outcomes. At one end of the waste hierarchy, they are retained entirely and adapted, keeping their materials at their highest use. Otherwise, demolished structures are typically crushed and recycled in unbound applications, better than ending up in landfill, but still a substantial drop in value. Between these two extremes, there have been few options.

Where it's not viable to reuse whole structures – for example, because ceiling heights are too low – the next best alternative would theoretically be to harvest the concrete to be used again as discrete structural components, retaining as much

of its performance as possible. “Ultimately, it’s about recovering utility rather than material,” explains Adam Ozinsky, senior associate at GXN, a sustainability consultancy founded by architect 3XN. “If it’s an element that’s designed to work in bending, you want to recover that bending performance.”

To date, however, such harvesting of structural elements has rarely been achieved. Research by the Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland has identified just 77 projects across the globe over the past 60 years that include “piecewise reuse of extracted concrete in new structures”, or PRECS. None of these were in the UK, and most involved precast structures. Only six were cast solely in situ – historically the predominant concrete construction method in this country. ►

CASE STUDY: EUSTON TOWER

In 2024, British Land was granted planning permission to redevelop London's landmark Euston Tower as a science and innovation building. From the start, the developer, architect 3XN and engineer Arup were keen to reuse as much of the tower as possible. As a result, the core, basement and foundations – 31% of the structure – will be retained.

The floor slabs, however, proved more challenging. The floor-to-floor height was a restrictive 3.2m, while the slabs' ribbed span and irregular design made it difficult to insert penetrations for services. "Given those challenges, we felt the best thing to do was to install new slabs at our chosen heights, with more regularity and the ability to adapt in future," says Adam Ozinsky, senior associate at GXN, 3XN's sustainability consultancy. The original 36-storey tower was edited down to 32 floors, which would be higher and wider, increasing the building's area from 55,000m² to 80,000m².

However, this would still require the demolition and recycling of a huge quantity of structural concrete. The project team saw

an opportunity to explore the harvesting process, with the aim of developing a roadmap for reusing extracted elements.

GXN needed to find an area of structure that could be surgically extracted through the facade without disturbing the retail outlets still operating on the ground floor. With no original drawings to work from, the team relied on site inspection and scanning to help identify a 4.5m x 1.2m section of the first floor slab, above an old service corridor.

The extraction process took 15 hours in total. "That was mainly setting out and propping. The actual cutting took 15 minutes. People think of concrete as difficult to cut, but it's not with the right tools." The slab was then taken to the University of Surrey's materials lab, via demolition contractor John F Hunt's storage yard.

The testing was informed by the intended application as floor planks in a steel-framed office building. The live load strength test indicated a capacity of 43kPa, equivalent to supporting approximately 60 people/m², significantly exceeding the 3kPa of a typical

office floor. Likewise, the shear capacity of 121kN massively outstripped the required 15kN. The slab ultimately failed in shear at 269kN. Finally, the bending moment capacity was measured at 110kNm, compared with the required 17kNm. When tested to failure, it withstood 241kNm.

"When you cut it out, you essentially end up with a precast element, so it behaves differently," says Ozinsky. "For our application, it had almost an order of magnitude more capacity than needed."

GXN also measured the carbon impact of the resulting plank. This came to 135kgCO₂, largely the result of transport, additional steel connections and temporary works.

The embodied carbon of an equivalent new hollowcore plank was estimated at 337kgCO₂.

The next step is to refine the extraction method to balance cost, programme and the logistical aspects of removing slabs around a retained core. "Satisfying yourself that technically you could do this is just one element," says Ozinsky. "What we want to explore next is how it works in a system."



Left: The ribbed slab section is put through its paces in the testing rig at the University of Surrey. The tests showed that the structural capacity far exceeded the required performance of a typical office floor

Opposite: The slab in the process of being removed at Euston Tower. The cutting process took just 15 minutes

Photo: British Land, courtesy of GXN

Photo: Claus Peuckert / GXN



Left: Just outside Copenhagen, 3XN and GXN designed a headquarters for demolition company Tscherning, using almost solely reclaimed materials from its projects. In collaboration with the structural engineer, Tscherning tested different extraction methods and reused hollowcore slabs as “new” walls and floors

This is where a pair of pioneering London developments come in. At British Land’s Euston Tower redevelopment, 3XN and engineer Arup have extracted a section of floor with the aim of creating an off-the-shelf precast plank (see previous page). At Derwent London’s 50 Baker Street, meanwhile, the raft foundation designed by Buro Happold will incorporate at least 1,000m³ of structural concrete taken from the floor slabs of the previous building on the site (see opposite).

This is not just about finding the best approaches to extraction and reinstallation. It means overcoming many potential barriers to adoption, including risk and responsibility. These real-life test projects are trying to untangle every link in that chain. “There is so much detail to consider, and nobody’s done it before,” says Rory O’Malley, associate

director at Buro Happold. “We are effectively establishing a whole new workflow.”

Rethinking demolition

Extracting structural concrete for reuse involves erecting internal and external support systems before the elements are lifted out by crane – an expensive process not budgeted for in conventional demolition. The pieces need to be cut out in sizes suitable for their next use, which requires a fairly advanced stage of design before demolition commences. They also need to be small enough to be removed through the existing frame and transported for storage.

“Harvesting for reuse is a lot more labour-intensive than demolition,” says Mike Brooks, technical director at Buro Happold. “With increased personnel comes increased health

“THERE IS SO MUCH DETAIL TO CONSIDER AND NOBODY’S DONE IT BEFORE. WE ARE EFFECTIVELY ESTABLISHING A WHOLE NEW WORKFLOW”

and safety risks. You also need to think about how you’re going to maintain the stability of the frame – we’ve had lengthy discussions with the enabling works contractor.”

The storage facility needs to maintain the condition of the harvested elements, with a system in place to ensure they are delivered back to site in the same state that they left. Demolition contractors may need to adapt their business model to be something more like a materials supplier – Danish firm Tscherning is in the vanguard here, trialling different extraction methods and using a range of concrete elements on its own new HQ building near Copenhagen (see photo above).

Unlocking existing sites

This level of planning adds time and cost in the critical period between a developer taking ▶

CASE STUDY: 50 BAKER STREET

At Derwent London's 50 Baker Street development, 2,000m³ of the site's existing structural concrete frames will be integrated into the new building, an office-led mixed-use scheme designed by Allford Hall Monaghan Morris (AHMM). Some will be crushed and recycled as aggregate for new structural concrete. But the aim is that over 1,000m³ will be cut out from slabs and reused as composite struts in the eight-storey building's raft foundation.

The raft is part of a low-carbon structural solution that was vital to the new development going forward. In line with the council's retrofit-first policy, structural engineer Buro Happold undertook extensive embodied carbon analysis to explore the retention of the largest of the existing buildings. However, it concluded that demolition and new construction could actually prove more carbon-efficient, at 532kgCO₂e/m² compared to 551kgCO₂e/m². This was partly due to the complicated nature of integrating new elements within a historic structure, and partly due to the efficiency of the proposed concrete frame, with regular column grids and post-tensioned slabs supported on the raft foundation.

"It was perhaps a good carbon story, but not a good circular economy story," says Mike Brooks, technical director at Buro Happold. "If in-situ retention was not really viable, what was the next step down?"

Brooks and his team had already been discussing solutions for reducing the volume of concrete in raft slabs, including bubbledeck-type systems. What if they could fill the voids between the top and bottom of the raft with carefully extracted pieces of the reinforced-concrete floors instead? This would not only lend the substructure the necessary mass to avoid heave or uplift, it could also carry loads and bending stresses, acting compositely with the reinforced top and base slabs.

The engineers spoke at length to demolition and main contractors about harvesting methodologies and the logistics of storage, testing and reinstallation.

"We were conscious that we were doing something a little bit novel," says Rory O'Malley, associate director at Buro Happold.

A big talking point was the optimal panel size – both for extraction, and installation back into the raft. In the end, they opted for 2.5m x 2.5m sections, the maximum for removal by crane and transport by truck. The large format also helps to even out idiosyncrasies such as weight variation. Once at the storage facility, they will be cut into three, stacked and grouted together into a block. Each panel assembly will be 800mm wide, up to 960mm deep, with three 20mm grout interlayers to account for plank tolerances and deformities. In the raft, they will be concentrated in areas of low stress, away from the primary column loads.

Derwent London took vacant possession in March, which means Buro Happold and demolition contractor McGee can now plan the harvesting, assembly and testing processes in detail. "We will be building some prototypes, and devising

a testing methodology to prove that the interstitial bond has been met and the forces can be delivered in line with the design," says O'Malley. "We are also working with universities to prove the outcomes analytically."

The exciting thing for Brooks and O'Malley is the volume of concrete that can potentially be reused in this way without significant cost or programme implications for the client. "We want to make it easy for people to consider reuse, because a lot of the built stock is concrete frames," says O'Malley. "We're showing there is a way forward between leave-it-as-it-is and the default option of crushed demolition materials. It's about filling that gap."

Below: 50 Baker Street will be supported on a raft foundation which is planned to include over 1,000m³ of reused floor slabs



Visualisation: AHMM

Photo: Smart Living Lab



EPFL's Re:Crete footbridge uses 25 concrete blocks that were cut from the in-situ reinforced concrete structure of an existing building. The blocks were mortared and strengthened with two post-tensioned cables

vacant possession of a site and the start of construction. It may however become increasingly important for getting projects approved.

The London Plan requires planning applications to include a circular economy statement showing how material demands have been minimised and onsite reuse maximised. This places materials with high demolition rates and limited reuse options, such as concrete, firmly in the spotlight.

Although there are currently no mandatory targets for reuse, Brooks suggests this could soon have an impact on the viability of sites that contain existing concrete buildings. "If you're not able to keep that building for whatever reason, then you're basically going to be stuck with extremely low percentages of material reuse from your own site. You then have to source reused materials from elsewhere, which is difficult when the market is not that well developed."

The tightening of embodied carbon targets poses a similar

challenge to developers, particularly on schemes such as high-rise towers that rely on the performance of reinforced concrete. Harvested elements could be a game-changer here, enabling designers to avoid emissions from the manufacture of new cement and steel rebar.

A question of confidence

Other barriers to the wider adoption of PRECS focus on quality, and the complexities surrounding insurance and liability.

As the EPFL study notes, in-situ concrete can seem more complex to reuse than precast due to its "monolithic nature, the absence of explicit connection areas, and a highly customised production". There may not be surviving design drawings, and if there are, there's no guarantee that they reflect the actual building. Concrete strength, rebar layout, depth of cover and many other factors could all vary depending on the vagaries of a construction process carried out over half a century ago.

The answer, says GXN's Ozinsky, is to test, rigorously and systematically. The trial section extracted from the Euston Tower was tested for loading, bending and shear capacity, in line with its theoretical reuse as a precast plank in a steel frame system. But testing will need to go beyond such use-specific criteria if it's going to instil confidence on the demand side, he adds. "We know more about this system than we would about fresh poured concrete. But there are so many stakeholders, each with their own risk profiles. What worries them about the system? If they want to know about fire, let's fire-test it. To make this work, we need to put their questions to bed."

To satisfy insurance providers and other stakeholders, test methodologies will need to be harmonised and new standards developed, an inevitably lengthy process. GXN has identified an existing Norwegian standard for recovered hollowcore slabs that could be adapted for its precast planks, with a higher level of

"WE KNOW MORE ABOUT THIS SYSTEM THAN WE WOULD ABOUT FRESH POURED CONCRETE"

testing due to the variability of in-situ concrete. An international consortium is also working on a range of European standards focusing on circular construction, including material reuse.

The endpoint, Ozinsky says, is for PRECS to be available off-the-shelf, "so you don't need to find someone who is knocking down a building". He likens it to the car market: "You can buy a preloved car from a dealership, and you don't worry that it doesn't work because you trust them to have tested it. The vision is to get to the same place with materials: to be able to go out to concrete suppliers and for them to say, OK, this is what we have ..."