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POWER POINT
Behind the slender glass facade, London's Shard is as tough as they come

KING OF THE HILL
The revamp of Sheffield's Park Hill estate breathes new life into a 20th-century concrete icon

SKY HIGH THAI
Bangkok's award-winning Met tower owes it all to traditional tropical housing

WELCOME

ONWARDS AND UPWARDS

There is one area of design and construction that, unlike other subdued sectors, is still attracting investment: the high-rise. Almost like a rite of passage, cities wanting to raise their profile turn to landmark high-rise buildings, the glamour of which continues to lure corporate tenants and residents.

Concrete plays a central role in high-rise design and construction. For the Shard, now towering over London, it is being used innovatively as the frame for 30 residential levels in order to provide better sound insulation and a damping effect for the entire structure. For RIBA Lubetkin Prize winner The Met in Bangkok, the thermal mass of the concrete structure is part of an intriguing passive ventilation solution inspired by tropical bungalows.

The celebration of high-rise need not be restricted to new buildings. The regeneration of the multi-storey Park Hill estate in Sheffield stripped the building to its concrete skeleton and then reinvented it to meet the aspirations of modern urban living, while still acknowledging the original intelligence of Europe's largest listed building.

High-rise design and construction presents its own skyward challenges. Concrete is more than able to rise to meet them.

Guy Thompson
Head of architecture and sustainability
The Concrete Centre

IN THIS ISSUE

On the cover: The Shard at London Bridge designed by Renzo Piano Building Workshop

mpa The Concrete Centre

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NEWS ROUND-UP

Hadid and concrete win again at Stirling Prize

The Evelyn Grace Academy in London by Zaha Hadid Architects has won the RIBA Stirling Prize 2011. This is the second year running that the practice has won the coveted prize, regarded as the most prestigious in British architecture.

Among the most notable features of the academy are the use of exposed concrete interiors and a sheer concrete chicane, which swoops over and around the racing track that runs through the school, and acts as a foil to the expanses of glazing and grey cladding.

Hadid's 2010 winner also made strong use of exposed concrete. The MAXXI Museum of 21st Century Art in Rome has been hailed for its "structural pyrotechnics", with concrete being used to create a fluid, yet monolithic presence.

Photo: Hufton Crow

ARCHIVE

RETRO CONCRETE: AUTUMN 2004

Europe's tallest residential building wins over the Swedes ... Santiago Calatrava's Turning Torso initially divided local opinion in Malmö. Based on a sculpture that explored the human body in motion, the structure is made of nine offset concrete cubes, clad in white aluminium and glass. The Swedish city had never seen anything like this twisted 190m residential tower – and neither had the rest of Europe. But as it rose rapidly over the harbour thanks to a number of innovations in concrete construction, its 152 luxury apartments began pre-selling just as fast.

Photo: Keith Hunter

Photo: Jaap Oepkes courtesy of Ramboll

'Real soul': Exposed concrete at Bennetts Associates' Potterrow Informatics Faculty Building at the University of Edinburgh (above), and Lafarge Agilia coloured concrete at David Chipperfield's Hepworth Gallery in Wakefield (below)

Conference gets in touch with visual concrete's soulful side

The aesthetic and performance potential of visual concrete is exciting designers and, increasingly, their clients. However, as delegates at the recent Specifying Visual Concrete conference heard, this potential will only be successfully achieved with leadership from designers and the early involvement of all members of the project team.

The conference heard from a number of leading architects who shared their appreciation of concrete. Alex Wraight of Allies and Morrison described it as "the Barry White of construction materials. It has real soul and is perpetually funky with lashings of disco glamour".

But it was not all about good looks. The conference discussed how exposed visual concrete can earn its keep by increasing thermal mass and decreasing the need for additional cladding and finishes. Exposed concrete helps to minimise or even negate heating and air-conditioning requirements, reducing a building's long-term environmental impact. Operational carbon dioxide emissions are far higher than those created during construction, so this can make a significant improvement to a building's overall impact.

Throughout the conference, there were many references to the need for architects to take leadership. Early involvement of the specialist concrete contractor and full collaboration between the project team were also felt to be of particular importance.

The range of buildings examined by the conference proved that when it comes to visual concrete the only limitation is imagination.

A guidance document, "How to Achieve Visual Concrete", was launched at the conference and is now available to buy from www.concretecentre.com/publications

CONCRETE ELEGANCE LECTURE

55 Gee Street's perforated facade works with a concrete frame to provide an energy-efficient building

STEP CHANGES

Soffits and staircases will be the focus of the next Concrete Elegance evening lecture, to be held in December at The Building Centre in London.

Alfred Munkenbeck of Munkenbeck + Partners will discuss 55 Gee Street, an office and apartment building in the heart of Clerkenwell. The building has an experimental air-mixing ventilation system, combined with exposed concrete soffits for thermal mass. A perforated brick facade allows for natural cross-ventilation, which means the office space should not require cooling or heating.

Next, Tom Holbrook of 5th Studio will describe how the practice renovated a Georgian house in Kensington Church Street that had been clumsily partitioned into three properties in the mid-1980s. In-situ concrete was the material of choice for the cantilevered staircase, and 5th Studio worked closely with Sam Price of Price & Myers to create a substantial yet delicate structure.

Concrete Elegance takes place at the Building Centre, Store Street, London WC1 on Tuesday 6 December from 6.30pm. For further information and to register, go to www.concretecentre.com/events

TOUGHENED GLASS

The Shard may look like an impossibly slender glass pyramid, but at its core is 72 storeys of concrete – and for 30 floors its structure is made of nothing else. It's a solution that has required innovation, ingenuity, and one extremely powerful pump, as **Tony Whitehead** discovered

Photo: Sellar

Between the 41st and 70th floors concrete is used for all columns and floor slabs

The Shard, that 310m "vertical city" now nearing completion at London Bridge, is an extraordinary sight, and not just because of its height. Certainly, the fact that it will be easily the tallest building in the UK, beating the Canary Wharf tower by 75m, does give it a massive presence. But it is its shape – an impossibly tall, irregular pyramid of glass – that constantly draws the eye and fascinates.

You might think that such a building can only have been made possible by an alchemy of computer design and steelwork, but that is only partly true. In fact, the Shard has a highly unusual hybrid structure: predominantly steel frame up to level 40, but then changing to concrete until level 70, where it reverts to steel for the final 22 levels.

So why is this incredible building built the way it is? John Parker, technical director with the Shard's structural engineer, WSP, explains that a combination of factors drove the decision to go for a hybrid frame. The first 40 floors are supported by steelwork spanning from a central concrete core via steel columns. As the Shard rises, and spans shrink, so the number of interior columns reduces.

From the 41st floor, all columns switch to reinforced in-situ concrete and the floors are created from post-tensioned (PT) concrete slabs which, being denser than composite panel concrete, absorb more sound. They also offer excellent fire protection. "Above 40, the Shard comprises a hotel and luxury residences which need less servicing and better acoustic separation – so concrete begins to make more sense," Parker says. "The PT slabs are also lighter than ordinary reinforced concrete, can span further, and can also be thinner. Using PT has enabled us to fit another two floors into this area of the Shard."

This clearly has a big impact on the economics of the development. Less obviously, it also helps with the building's stability. "The concrete has a useful damping effect," says Parker. "As the wind blows, the building moves, and the structure absorbs a certain amount of energy. Essentially all concrete has microscopic cracks, and internal friction turns wind energy into heat which enables it to absorb more energy than other materials."

Inevitably, with such a tall landmark building, 9/11 will have been in the minds of the architect and structural engineer. In fact, the towers now being rebuilt on the World Trade Center site are designed with very robust concrete cores to enable them to withstand extreme damage and fire and offer a protected means of escape.

The core is something of a marvel. Using slipform construction, and launched from level B (Basement) 2, the core grew by a typical 150mm per hour. "The slipform was raised in tiny jumps of about 10-20mm every 10 minutes or so," says Don

PROJECT TEAM

Developer Sellar Group
Architect Renzo Piano Building Workshop
Principal contractor Mace
Structural engineer WSP
Groundworks contractor Stent
Concrete contractor Byrne Bros
Concrete supplier London Concrete

LEFT
Despite its depth of up to 6m, the foundation slab was cast in one pour

The top-down approach

As one might expect, the groundworks and foundations to Europe's tallest building are considerable and complex. Top-down construction was used so that work could start on the core before the lower basement levels were constructed.

To achieve this, secant piles were first installed around the perimeter, and bearing piles within the basement footprint. A capping beam was then cast to link together the secant piles, and the ground-floor slab was cast, leaving an opening for the core.

The slab was supported on the capping beam and plunge columns. In the centre these had to be positioned very accurately, between piles left over from the previous building, in order to provide a stable base from which the core could be launched.

The basement was then excavated to level B2, and the core slipform launched from this level. Next, the B2 slab was cast, supported on the secant wall, plunge columns and the core, and the ground floor central opening was infilled.

Excavation then continued to level B3 and the B3 (foundation raft) slab was cast. Core walls were completed from B3 to B2. Finally, the B1 slab was cast.

Despite its size (up to 6m deep and never less than 1.5m), the foundation slab was cast in one pour. "We didn't have to do it in one go," says Houston. "But a key factor was that there was so much reinforcement, we would have had to put a stop in through seven layers of steel at the bottom and five at the top. Heat gain was also an issue, but by adjusting the mix throughout the pour we kept this to a minimum."

Some 5,500m³, or 700 truckloads, of concrete were poured over 36 hours – the largest pour London has ever seen.

Houston, project director with concrete contractor Byrne Bros. "We were doing continuous 24-hour pours for five-and-a-half days at a time. Each day we would pour around 400m³ and go up about 3m."

At the base, the core is rectangular on plan, measuring 22m x 20m with walls some 800mm thick, though this reduces in several steps at higher levels as the floor area serviced by the core shrinks.

To build a core like this successfully, says Houston, it is essential to get the concrete mix exactly right. "You need high early strength – we aimed for 30 Newtons in 24 hours, which we got," says Houston. "And to avoid drag on the forms, it also needs to be fluid and not stick."

To achieve this, Byrne Bros chose from 36 available mixes supplied from three local batching plants. "The slipform lasted a year so we were subject to every temperature and wind condition known to man," says Houston. "We had to tweak the mix depending on ambient conditions, speed of progress and what we could see happening with the concrete. We would ring up the supplier and tell them to switch from, say, mix 10 to mix 12. It required close liaison, but it worked very well."

Getting concrete up to such high levels (the core finishes at level 72) required more feats of engineering – or, as Houston puts it, "one very big pump". A monster 17.5-litre diesel pump was brought in that could push concrete up to a height of 250m at a rate of 30m³ per hour.

But even with this gargantuan kit there were challenges to overcome. Lightweight aggregate for the composite panels is not easy to pump, nor is the high-strength C80 concrete used for the perimeter columns. "Because of the cement ratio it goes off quite quickly so it can be difficult to maintain the pour," says Houston. "I don't think many people have pumped high-strength concrete that high before, but we found a mix that worked."

Of course, it was not just concrete that had to be transported up to more than a quarter of a kilometre into the sky. As Adrian Thomson, director at contractor Mace, says: "With up to 1,200 operatives on site, vertical transportation of men and materials becomes absolutely key."

Construction timeline

February 2009 Start of piling work. More than 12km of piles to be installed in total

March 2009 Full site possession

November 2009 Top-down construction commences

January 2010 Start of construction of concrete core

April 2010 5,500m³ of concrete poured over 36 hours (see box, above)

June 2010 Start of glass installation. Over 11,000 panes, or 56,000m², to be installed in total

December 2010 Concrete core complete, reaching the 72nd floor (244m). Shard becomes tallest building in the UK

2009 2010 2011

Thomson explains that while the Shard's height was obviously a challenge in this respect, its shape was an even bigger issue. "In a building with vertical sides, the external working platform, for example, can just move up the building and protect workers from wind and cold," he says. "But with every level of the Shard, the radius of the floorplan reduces by about 300mm. We did a lot of work developing a system that could cope with this."

The solution involved a rig with removable sections that could be taken out by crane overnight. In places, sliding shell forms overlap like the skin of an armadillo. "It proved very effective," says Thomson, "especially in the concrete levels where the post-tensioning operatives needed to work outside the slabs."

As well as requiring this incredible shrinking platform, the sloping sides of the Shard (they incline by 6°) meant that an external double hoist, used to lift glazing into place, had to be specially designed with a parallelogram-shaped cage to accommodate the slope.

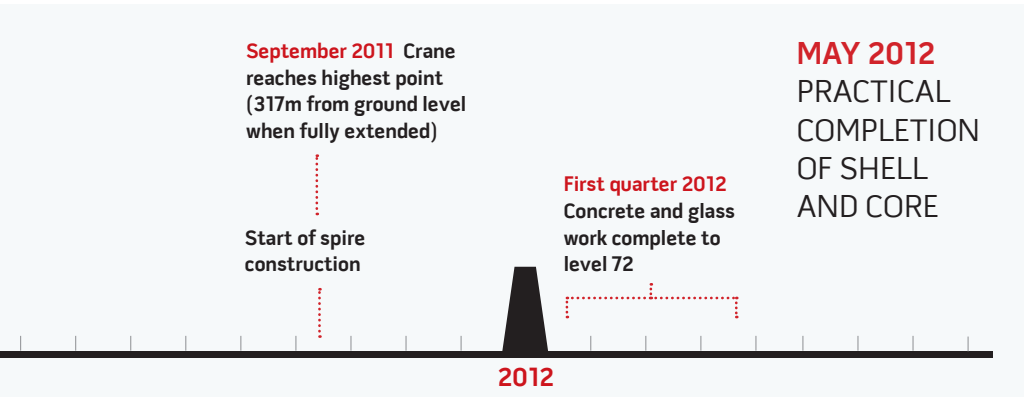
Another challenge for Mace was to ensure that the vertical transport systems would not be "overtaken" by construction, forcing work to pause while new lifting transport was arranged. Two innovations ensured this would not happen at the Shard. The first was the use of jump lifts – which use the core's actual lift shafts, but have lifting gear that can climb inside the shaft so that the lifts can always reach the desired level.

The second was the decision to place a crane on top of the slipform, rather than attaching it to the core, so no matter how fast the core grew, the crane was always above it – an innovation that Mace believes to be genuinely unique.

Despite the challenges of height and shape, construction has progressed well. "In the steel levels we were sometimes affected by wind stoppages, but in the concrete levels, we really got into a rhythm," says Thomson. "At one level there would be creation of formwork, and pouring concrete, and below that the two-stage stressing, then grouting, of the slabs. This proved very reliable. We would pour every Friday, and we hit every milestone bang on the money."

RIGHT
The concrete core rose by about 3m a day

Photos: In-Press



As CQ goes to press, the concrete elements of the building are complete. Above level 72 the structure returns to steel, but these levels are not genuine floors as such, containing only plant on the lower levels. The rest is purely aesthetic – or as Thomson puts it, "22 storeys of architectural expression".

So what has it been like working on the tallest building in Europe? "Relentless!" says Houston. "But amazing. I don't think I'll see another project like this one."

"Awesome" is Thomson's verdict. "There's such interest in it from the public, and such a buzz on site. I don't know anyone working on this building that doesn't get a kick out of it."

(FAR) HIGHER EDUCATION

Hodder + Partners' 106m-high student block will be Manchester's fourth tallest building, but has been cleverly designed to fit in with the surrounding streets

Manchester Metropolitan University's new student accommodation building takes the phrase "ivory tower" to new heights – when complete in 2012, it will be the city's fourth tallest building. Hodder + Partners' design is 106m and 37 storeys high, and will provide self-contained rooms and apartments for 520 students on the Great Marlborough Street campus.

The building sits on a podium that addresses the sharp corner between New Wakefield Street and Great Marlborough Street with a cornice height that is in keeping with the surrounding buildings and provides continuity to the street wall. Above the podium, the building is split into four tower slices. The highest are the north-east and north-west towers, whose slender profiles will be a noted addition to the Manchester skyline.

The decision to slice the building into four elements reduces the overall impact and gives it a more interesting facade. The staggered pattern of the different shades of muted cladding echoes the sliced towers.

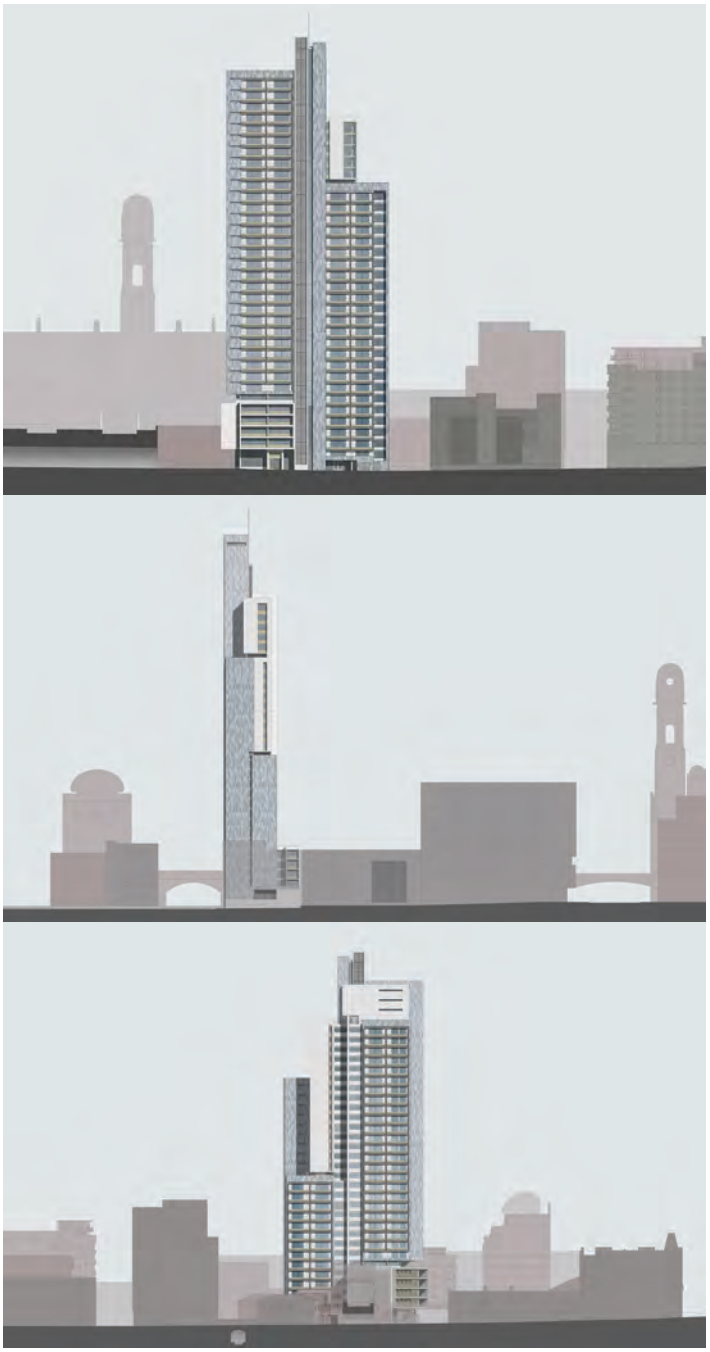
The building makes use of several innovative construction techniques, with two-storey columns that were precast on site, an enhanced climb-track system for building the core and post-tensioned concrete to provide thinner slabs. These approaches provided cost, sustainability, health and safety and programme benefits. The project is on schedule to meet its tight deadline of the start of the next academic year.

The inherent thermal mass, fire resistance and sound insulation of the concrete structure have also contributed to a BREEAM rating of "very good".

This high-rise building was never going to go unnoticed. Despite its size, however, the design manages to harmonise with both the immediate neighbourhood and Manchester's skyline by taking into account the scale of its immediate location and of the city beyond.

PROJECT TEAM

Client Student Castle
Architect Hodder + Partners
Structural engineer WSP
Main contractor Shepherd Construction
Frame contractor Heyrod



ABOVE
Elevations showing how the building is "sliced" into four slender elements

LEFT
The height of the podium echoes surrounding buildings

THE OUTDOOR LIFE

The award-winning Met apartment building in Bangkok is a new take on high-rise living, with gardens and verandas threaded throughout its 66 storeys

The 2011 RIBA Lubetkin Prize has been awarded to a high-rise building that is not so much a tower block as a 66-storey stack of low-rise tropical housing. For The Met in Bangkok, Singapore architect WOHA has turned its back on Western models of high-rise design that aim to provide a sealed air-conditioned space protected from wind and rain. Instead, it has embraced the approach of the tropical home with a veranda that is open to the elements for natural cross-ventilation.

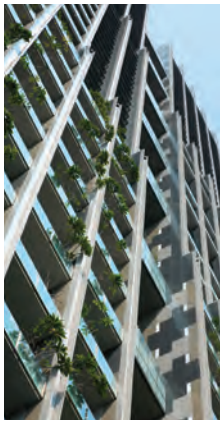
The 370 apartments are oriented north to south, and a staggered block arrangement ensures each has access and air on all four sides. Public and private terraces link the apartments to provide external spaces in the sky with outdoor gardens.

The cross-ventilation makes full use of tropical breezes to remove the need for energy-intensive air-conditioning, part of a passive sustainability strategy of which the thermal efficiency of the concrete frame plays an integral part. Other passive measures include shading by overhangs and perforated metal screens that protect the external walls from daytime sunshine and heat. Every horizontal surface is planted, and the east and west walls are covered by living plant screens, which cool the building and help to improve the air quality. Water gardens at ground level and on the recreational floors provide evaporative cooling and store rainwater.

Based on a 9m module, the structure is slender and elegant. It is, however, stronger than it looks – it must be able to withstand not only high winds but earthquakes too. There is structural bracing every five levels where the sky gardens, pools and common areas are located.

The architectural details reflect the culture and heritage of Thailand. The cladding is reminiscent of Thai temple tiles, and the effect is enhanced by the random incorporation of shiny stainless-steel panels that bring to mind the mirrors often found within temples. The staggered balconies, meanwhile, echo the panelling found on traditional Thai homes.

The Met provides a fundamental rethink of high-rise construction for the tropics. Its great trick is that although it looks radical and futuristic it is, in fact, based upon low-rise homes, and above all simple, passive strategies.



TOP
The building contains 370 apartments
ABOVE
Every apartment has external space
LEFT
There is structural bracing every five levels, where the sky gardens and common areas are located

PROJECT TEAM
Client Pebble Bay Thailand Co
Architect WOHA
Associated architect Tandem Architects
Structural engineer Worley Parsons

Photos: Tim Griffith

Built in 1957, Park Hill was the most ambitious inner-city housing development of its time

RETURN OF THE HIGH STREET

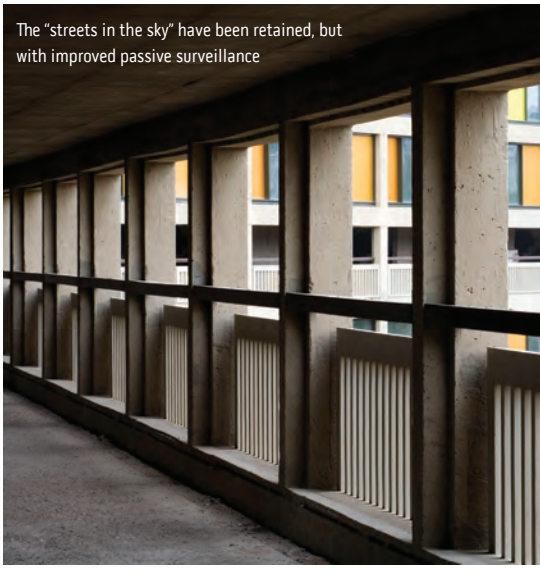
Park Hill's 'streets in the sky' were once notorious, but the Sheffield estate has now been sensitively restored – adding colour, natural light and a sense of openness, while maintaining the integrity of its imposing structure

The first refurbished homes of Park Hill, the brutalist residential development that dominates the Sheffield skyline, are now on sale. Built in 1957 by Jack Lynn and Ivor Smith working with JL Womersley of Sheffield Corporation City Architects Department, Park Hill is architectural marmite. It was the most ambitious inner-city housing development of its time and at first proved to be very popular. However, from the 1980s a lack of investment and rapid social change contributed to its decline and it began to epitomise all the supposed ills of mass housing design. Now though, its regeneration has capitalised on the intelligence of the original design to successfully meet the aspirations of a new generation.

Built on a steeply sloping site with a gradient of 1:10, Park Hill has a commanding presence over the city. The building profile engages with the topography of the site, with the roof level remaining constant as the height of the residential block ranges from four to 13 storeys. The building pioneered modern design and building techniques including the "streets in the sky" which aimed to recreate the community spirit of traditional streets within a high-rise development. In recognition of its historic significance, Park Hill was granted grade II*-listed status in 1998, making it the largest listed structure in Europe.

A wide-ranging collaboration between developer Urban Splash, Sheffield City Council, Great Places Housing Group, English Heritage and the Homes and Communities Agency, together with architects Hawkins\Brown and Studio Egret West and landscape architect Grant Associates, is undertaking a £160m regeneration scheme to turn Park Hill into a vibrant place to live for the 21st century. When completed, there will be 874 apartments, one-third of which will be affordable housing, as well as new retail and leisure facilities.

The concrete structural grid of the blocks was found to be structurally sound and has been repaired and retained. New facades of brightly



The "streets in the sky" have been retained, but with improved passive surveillance

The new facades include coloured anodised panels made from the same material as the casings for Apple's iPods

coloured anodised panels, made from the same material as Apple's iPod casings, have replaced the brickwork. The famous suspended link bridges have been retained – although now there will be concierge access. Elements of the concrete structure will be left exposed within each apartment, to maintain a sense of the architectural history and importance of the building.

While the integrity of the original structure remains, some architectural interventions have been made. The north- and east-facing elevations have been opened up by inverting the solid-to-void ratio to 2/3 glazing, 1/3 solid, giving the previously dark bedroom spaces much more daylight. A four-storey cut through the north-west block provides a new, more welcoming entrance to the development, while an external mirror-finished stainless steel helical stair and glazed external lift core on the west facade of the north-west block offers another new entrance with dramatic vertical circulation and panoramic views of the city.

The original concrete balustrades have been replaced with a more slender design, cast with a higher quality finish, and new apartment hallway and landing windows open out on to the sky streets to improve passive surveillance. These alterations have helped to reduce the fortress-like impermeability of the original design, and the feeling of openness will be increased still further with the planned removal of the retaining walls that currently terrace and barrier the hill's slope. New communal landscaping and private gardens will also soften the urban landscape of Park Hill.

The regeneration of Park Hill has worked with the original concept, taking the building back to its structural skeleton and providing a new, improved version that builds on its former strengths with a deference that is intelligent and well placed.

PROJECT TEAM

Development partners
Urban Splash, Sheffield City Council, Homes and Communities Agency, Great Places Housing Group, English Heritage
Architects Hawkins\ Brown, Studio Egret West
Structural engineer
Martin Stockley Associates
Landscape architect
Grant Associates

Elements of the concrete structure have been left exposed in each apartment

Photos: Keith Collie; Daniel Hopkinson; Peter Bennett; RIBA Library Photographs Collection