The HSBC Headquarters, Canary Wharf, London

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Introduction

The new group head office building of HSBC stands proudly in the vibrant business district of Canary Wharf, East London. Some 8000 employees occupy the 210m tall tower, making full use of the building's extensive range of facilities and services.

The decision to build a new headquarters at 8 Canada Square dates back to the mid-1990s when HSBC began a search for new premises to unite its thousands of staff in buildings across the City of London. The objective was clear: an HQ appropriate for one of the world's largest banking and financial services organizations.

Between 1995 and 1997, various options were considered, including redeveloping the former group head office at 10 Lower Thames Street in the City of London. However, only the Canary Wharf estate could provide the standard of location and volume of space necessary. Furthermore, there was the opportunity to complete the building quickly as planning permission for the estate had already been granted. In early 1998 a heads of terms agreement was reached for a 45-storey building to occupy Canary Wharf's DS2 plot, alongside the UK's tallest building at 1 Canada Square. The new building has four basement levels, five levels in the 75m square podium, and 40 floors above, each 56m square.

HSBC had successfully developed its Hong Kong headquarters building at 1 Queens Road Central in the early 1980s[1] with Arup, Foster and Partners as architect, and quantity surveyors Davis Langdon Everest. Nearly 20 years later HSBC appointed the same team for its global headquarters, with Arup providing multidisciplinary engineering services including fire, building management controls, acoustics and security design. An HSBC in-house project team was set up to ensure that all the bank's requirements would be met. In collaboration with Canary Wharf Ltd's strong development team, an unusually fast-track development for a building of this size was undertaken and successfully executed.

An additional challenge stemmed from the fact that shell and core work would overlap with fitout, under different management teams and conditions of contract. The shell and core was a design-and-build contract with Canary Wharf Contractors Ltd as contractor and the Arup/Foster design team. For the fitout Canary Wharf was the management contractor, with trade contracts being placed directly by the client. During the last year of construction, the design team co-located onto a level of the new building while the fitout works were being completed. The result reflects the enthusiastic collaboration that took place on the project, delivering a highly cost-effective design with state-of-the-art facilities and finishes.

Construction

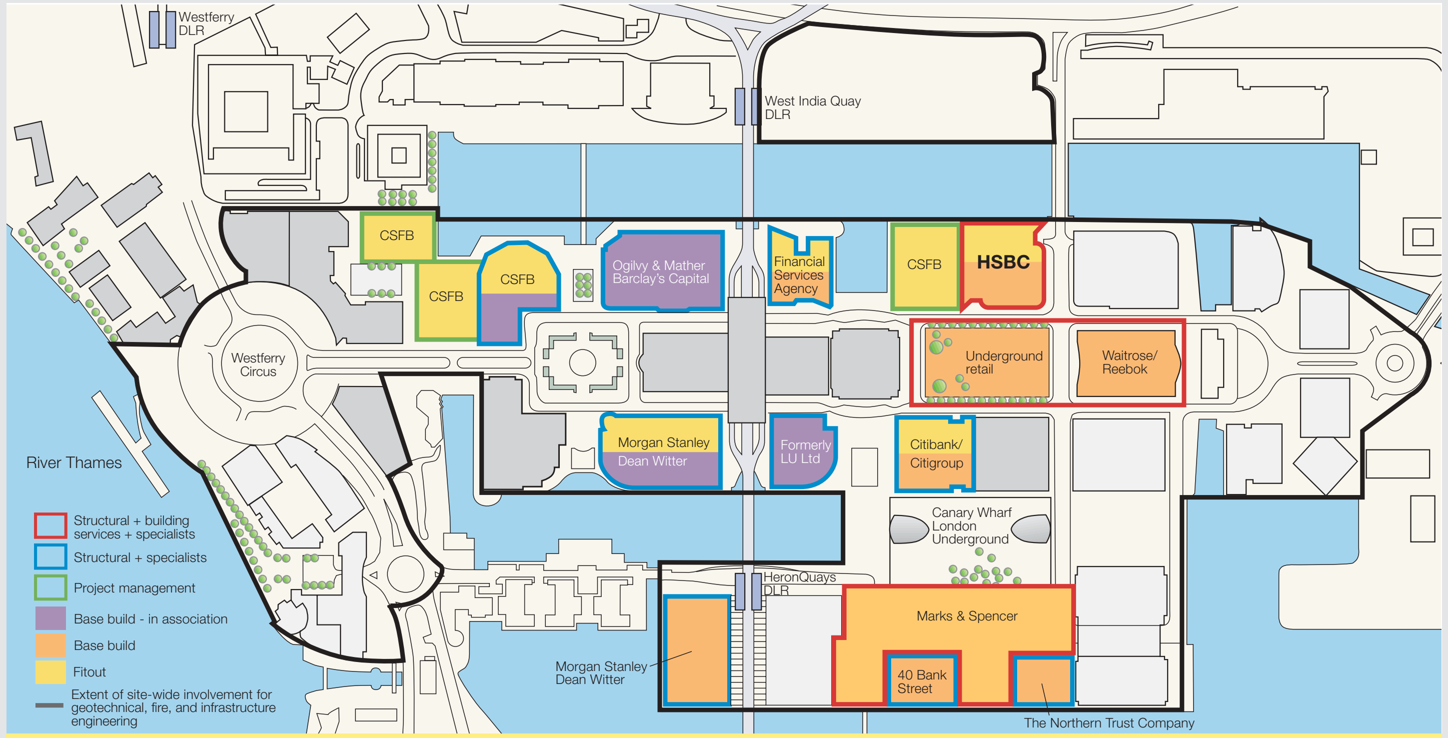
Construction began in January 1999 with the boring of the building's substantial deep pile foundations. During spring, the concrete core rose steadily with approximately 100 workers on site each day, increasing monthly by several hundred to over 1000 at the end of 1999.

The tower began to assume its current appearance in summer 2000 when work started on installing the 4900 glass panels. As the base build continued on schedule, early 2001 saw work begin on the fitout, including installation of services to the 850-seat staff restaurant and health club. In March 2001, bankers, journalists, contractors, and the design team gathered for topping out, as the final steel girder was hoisted to the top of the tower.

Within weeks another milestone arrived, as the giant hexagonal HSBC corporate signature was installed on all four sides of the building's crown. In early 2002, with the base build completed, the project moved to the final stages of the category B fitout; installation of carpets, desks, and other furniture.

By this time, the number of workers on site had risen, with up to 1700 on duty each day. The first HSBC employees began work in the new building at 8 Canada Square on 2 September 2002, marking the culmination of seven years' planning, teamwork, and commitment from all involved. The phased occupation of the building was completed in February 2003 when the last of over 8000 staff moved in, with HSBC Group Chairman Sir John Bond officially opening the building as the Group's new head office on 2 April 2003.

1. View of the completed HSBC tower.



2. Site plan showing major tenants and the extent of Arup services.

The Canary Wharf location

John Brazier

Arup has been involved in Canary Wharf[2] in London's Docklands from the start in 1985, when G Ware Travelstead and a consortium of American banks proposed a new financial district there. Olympia & York took over the development in 1987 and this drove the proposals to reality. Phase 1 was built between 1987 and 1992, with Arup providing local knowledge and input to a largely American design team.

Arup's involvement in Phase 1 was:

- engineer for the enabling works, including demolition, dock wall stabilization, site investigations, and pile testing
- geotechnical consultant for most of the Phase 1 buildings
- structural engineer for the foundation platform built in the dock for four of the Phase 1 buildings
- structural engineer for one of the buildings, also in the dock, currently occupied by the Financial Services Agency
- engineering advice on the design of the temporary cofferdams for Phase 2 buildings
- engineering input into the masterplan for Heron Quay, now known as Canary Wharf South.

Olympia & York went into administration in 1992 and Canary Wharf Ltd (CWL) took over ownership of Canary Wharf, although many of the key management people remained unchanged. Between 1992 and 1996 CWL gradually let space and also marketed its Phase 2 sites. Arup involvement during this period comprised structural engineering advice on the fitout of Phase 1 buildings and assistance in assessing schemes for Phase 2 sites for potential tenants.

Phase 2 of Canary Wharf was unlocked when Citibank chose it as the home for its new building in 1996. Arup had been working with architect Foster and Partners to assess sites for Citibank and as part of the deal the consultant team was taken over by CWL to design the building to meet Citibank's requirements. Canada Square Park to the north of Citibank, as well as associated roads and utilities, had to be built to serve the Citibank building.

The park has one level of retail and three levels of car parking beneath, and Arup was structural, geotechnical, building services, infrastructure, fire and security engineer for this development.

In 1998 the HSBC took the DS2 tower site for its new headquarters, a deal quickly followed by others with major tenants, many of them financial, which has realized the original concept of Canary Wharf as a new financial centre for London.

Subsequent to HSBC, Arup has been structural and building services engineer for two major retail developments and structural engineer for three more office blocks. In addition, the firm has secured site-wide commissions for geotechnical engineering, fire engineering, and infrastructure engineering, as well as other specialist commissions for security and façades.

Arup has also provided input into the design of fitouts for several tenants, the most significant being the fitout of the four buildings that Credit Suisse First Boston occupy.

From the initial provision of some structural and geotechnical engineering advice on local practice, Arup's role has grown over the years until now the firm is one of the major consultants working on Canary Wharf, providing a wide range of services.

Sustainability aspects

The Canary Wharf estate is built on brownfield land and reclaimed land, and is served by its own dedicated Jubilee Line Underground station. This ensures that around 90% of journeys are made by public transport. The estate is also extremely large, around 35ha, with 1.2Mm^2 of lettable space already built and a further 100 000m^2 under construction. It has copious high quality open spaces for the amenity of the users of the buildings.

For the HSBC building's structure and services, flexibility in use was designed in, including allowance for a potential further floor in the podium. Before the first piece of earth was moved at the site, HSBC's commitment to the environment was tested against building guidelines from the UK government-funded body BREEAM. Management of the building, energy and water use, and health and comfort issues were all assessed, as were the choice of materials, land use, pollution, and ecological issues. The assessors gave HSBC a good rating, acknowledging that harmful materials had been avoided and that many environmentally-friendly features had been incorporated.

These include energy reclaim, treatment of kitchen grease, use of copper silver ionization to prevent bacterial growth in domestic water, and highly efficient façades with internal blinds. HSBC played its part in implementing a refuse compactor installation, reducing paper storage within the building by 70%, and installing its water bottling plant.

HSBC key features

Reception (ground floor)

With minimalist overtones, the spacious ground floor reception area (Fig 8) combines back-sprayed black glass and grey granite flooring to create a fine first impression for visitors to HSBC's new HQ. TV monitors carry rolling news feeds and a digital information board. The illuminated ceiling simulates an open natural environment which, combined with the spaciousness, feels almost like being outside.

The lighting has over 3000 luminaires, suitably positioned for even light spread. The heat generated by them and the control gear necessitated a system where return air provides cooling to the light boxes to ensure that colour, temperature, and efficacy are not affected, as well as ensuring a reduction in dust settlement. Where return air-cooling could not be achieved, direct cooling is provided by recirculating chilled water fancoils within the ceiling.

Lifts

From the entrance, four banks of lifts are accessible, serving levels 1-15, 15-25, 25-34, and 34 to the roof. Levels 15, 25, and 34 are therefore known as 'transfer floors', as to access level 29 from level 20, for example, you would travel to level 25 and transfer to another lift. The lift arrangements were a critical part of finalizing the concept for the building as they largely dictate the structural form of the core and the vertical zones for services.

The 'History Wall' (ground floor)

Unveiled in September 2002, HSBC's 6.6m high 'History Wall' (Fig 15 in Fire Safety panel on p18) marks the history, achievements, and values of the Group from the 18th to 21st centuries. Located in the ground floor lobby and designed by the Thomas Heatherwick Studio, it boasts 3743 captioned images including documents, photographs, portraits, and illustrations of staff, buildings, businesses, and events. They are arranged so that when viewed from farther away a 'magic eye' effect becomes apparent, revealing the letters 'HSBC'.

Staff restaurant (level 1)

The 850-seat staff restaurant (Fig 6) is possibly the largest of its kind in Europe, serving some 2500 meals daily. A 450m^2 servery provides some 70m of counter space. To the end of the dining area and round to the left is a food bar with a 17m long continuous marble counter top. Light refreshments and tea/ coffee are served here with a seating area that overlooks the main ground floor reception.

Trading floors (levels 2-4)

The building includes a treasury, capital markets, and equities trading operation, all served by giant screens displaying order boards and pricing information. The treasury and capital markets operation over the whole of level 4 forms one of the world's largest trading floors, accommodating nearly 600 dealing staff and 1750 flat panel screens across 4500m^2 (Fig 5). HSBC is a leading player on international foreign exchange markets, offering a 24-hour capability with London connecting to the Group's other key dealing operations in New York and Hong Kong. Plasma screens hanging from the ceiling provide continuous market news. Equities trading and research take place on a separate floor, with settlements occupying the third large floor in the podium. The special IT requirements of the treasury and capital markets business had to be taken into account during fitout in early 2002, including the laying of some 800 000m of cable.

Health club (level 5)

This is a substantial facility with some 120 machines, 26 showers, steam rooms and saunas (Fig 4).

Client dining floor (level 6)

Accessed by two scenic lifts running up the building's east side, this floor provides 19 private dining rooms and an á la carte restaurant.

Training floor (level 14)

This includes five 30-seat conference rooms, all with audiovisual facilities, plus nine breakout rooms, six IT training rooms, and 10 small interview rooms.

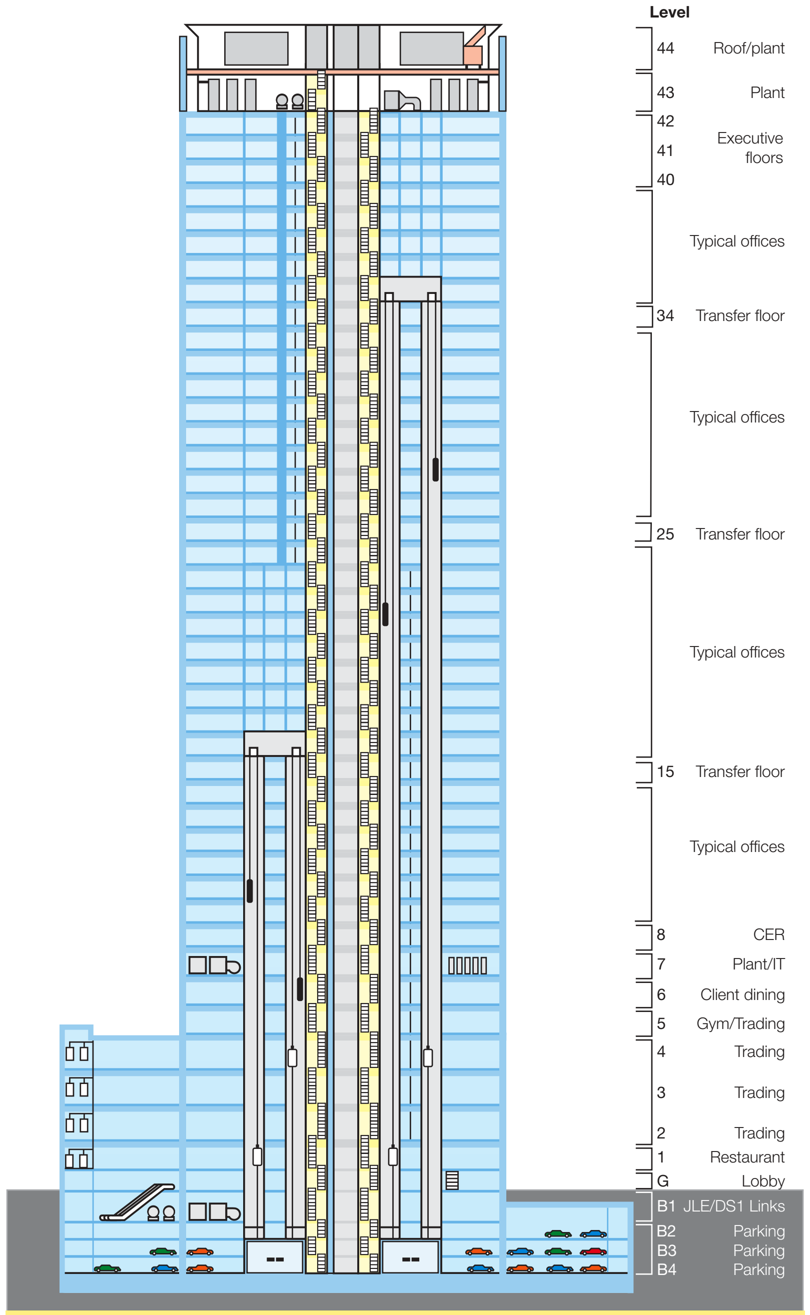
Transfer floors (levels 15, 25, 34)

At each floor where people transfer between lift banks, there is a reception area as well as a café, shop, first aid area, cash machines, and meeting rooms.

Level 15 houses medical and dental suites.

A personal banking centre on level 25 provides a range of services for staff.

Level 34 hosts a large marketing suite.



3. Elevation showing the 44 levels.

Central and satellite equipment rooms (level 8)

The central equipment room (CER) is the building's nerve centre. Occupying all of level 8, it contains the complete IT equipment required to run the building, as well as the main local computers and networking equipment that support data, voice, and video services. The two exchanges that operate the building's 10 000 telephone extensions are also here. Each floor also has pairs of satellite equipment rooms (SER), from which communications and IT wiring emanate to serve all the floor's desktops. Each SER has its own standby electrical supply as well as its own dedicated close control air-conditioning unit. Over 700 IT cabinets house equipment that required the laying of some 2Mm of cable.

Main plant floors (levels 7 and 43)

Air-handling plant is divided between these two floors. The AHUs supply treated air into a structural shaft that runs the height of the building. Level 7 also houses the plant that generates domestic hot water from gas-fired boilers to serve the level 5 gym changing facilities and the level 6 and level 1 kitchens. Also at level 7 is the uninterrupted power supply (UPS) system, which provides an instant standby electrical supply to serve the level 8 CER and the SERs throughout the building.

At level 43, access for the external 'Halo' specialist lighting for the crown of the building also acts as the air intake/ exhaust for the level 43 AHUs. The crown lighting also incorporates HSBC's hexagon symbols on the four sides of the building just below the roof, with powerful backlights (Fig 7) to illuminate the brand at night.

Boardroom (level 42)

The impressive boardroom has state-of-the-art audiovisual facilities for presentations, videos, and conference calls. Beneath its double-height ceiling it boasts, across an entire wall, a huge world map created from two-tone aluminium strips and, from its vast floor-to-ceiling window, a panoramic view across London.

Roof (level 44)

The roof contains 14 closed circuit cooling towers, arranged as two separate heat rejection circuits to provide resilience to the building's operation. The tower pond water is treated by a silver copper ionization system that obviates the need for hazardous chemical handling and storage.


4. The gymnasium (level 5).


7. Crown lighting (at roof levels 43/44) for the HSBC symbol.

5 right. Trading floor (level 4).

6. Staff restaurant (level 1).


8. The spacious reception area (ground floor).


9. Base of chilled water risers (at B4 raft level).

Foundation design

Tim Chapman
Duncan Nicholson

Arup Geotechnics had been very involved in Phase 1 at Canary Wharf[2], so when Arup was appointed as structural consultant for the Citibank and DS2 buildings in Phase 2, there was a useful database of experience from which to draw. Plot DS2 for HSBC was the largest of the buildings and the first to be constructed in the north cofferdam.

Most of the Phase 1 buildings were constructed over the dock and founded on marine piles, which were relatively expensive and limited building heights. In 1992, two cofferdams were built to allow conventional piles to be used for the next six office buildings, and to provide basement space for car parking. They remained empty for almost a decade during the recession until a reinvigorated Canary Wharf put funding in place for Phase 2 of the development.

The foundations for Citibank in the south cofferdam were built in 1997 when the adjacent Jubilee Line station was nearing completion in its deep excavation. This had necessitated dewatering of the Thanet sand/chalk aquifer, and the Citibank piling contractor was able to take advantage of these drier soils to install his large diameter bored piles under bentonite much more quickly than expected. Canary Wharf and Arup Geotechnics saw the potential for speedier piling at DS2 and the subsequent buildings, and initiated a contract to continue dewatering of that deep aquifer. Dewatering from some six wells started in December 1998 and eventually a flow rate of 150 litres/sec was needed to draw the water level down to under -30m OD, below the deepest pile toe levels. Once the water level had dropped a flow rate of about 60 litres/sec was needed to sustain the lower water levels. Care needed to be taken that the cone of dewatering didn't cause any distress to the neighbouring buildings, including those owned by Canary Wharf. Maximum recorded settlements reached 13mm, but as the tilts were negligible, no damage of any kind was noted.

A load test to failure indicated that much higher pile capacities could be gained than conventional design approaches would allow. Accordingly, a new theory had to be devised based on fundamental soil mechanics theory to take this benefit. This was accepted by the District Surveyor and eventually published[3].

338 permanent piles were installed by Keller Ground Engineering between January and July 1999 for DS2, including two to receive the south abutment for the Great Wharf Road Bridge planned for installation once the building was complete. These piles were generally 1.5m in diameter. They started with 8m penetration into the Thanet sand but this was reduced to 5.5m once the load test results had been interpreted and the new design method agreed. This reduction in pile depth bored was very helpful as it took the toe level above the level of the water table in the deep aquifer - still being reduced by pumping. This brought all the benefits of a relatively dry pile bore and accelerated the piling programme.

To maximize pile capacity the piles were base grouted, which involves injecting grout under very high pressure through pipes cast into the pile concrete. It makes the pile performance less reliant on the presence of any soft debris that may have accumulated at the pile base. The base grouting ducts were also used for checking the pile integrity by sonic coring. Some anomalies arose during base grouting and sonic logging but most were quickly resolved with no need for further site work. However, due to defects identified by integrity testing, three piles were sufficiently poor to need replacing and because of site constraints, six replacement piles had to be provided.

In terms of cost per tonne carried, these piles proved to be some of the most economical ever installed in London, with total costs approximately half of the equivalent for piling in the City or West End. The dewatering continued for all the Phase 2 buildings, and direct savings in pile costs more than paid for the dewatering, even ignoring the significant programme advantages. In all, Arup Geotechnics went on to design the foundations for all 16 building plots completed in Phase 2, a total of more than 4000 large diameter piles, as well as several bridges and public areas. The basic foundation design and construction principles established for the HSBC tower proved very effective on subsequent buildings.

10. HSBC tower pile test.

Programme and planning

For its magnitude, the project was designed and constructed remarkably quickly. The Canary Wharf team was geared to delivering buildings rapidly; with no planning permission stage in the process and the cofferdam already in place, there were no barriers to teams delivering construction information as quickly as possible.

Also, the previous involvement of Arup and Foster and Partners in the nearby Citibank building, as well as the overall site development, meant that the team could hit the ground running.

The planning had to fit in with established cost benchmarks and meet market expectations for high quality, flexible office space with a high degree of user comfort. This constrained the project team to provide an air-conditioned building with a central core, maximizing the development potential of the site and optimizing net-to-gross floor ratios (78% was achieved). Delivery demanded production of the most economical design possible, to raise values in every area from aesthetics to ecological performance.

The double-glazed façade has high-performance coatings to maximize heat reflection and fritting, with fixed internal blinds to reduce solar gain and glare. The building is fully air-conditioned but is highly energy-efficient due to a good thermal performing façade and energy recovery measures on the services. The central-core structure, the ceiling and services layout, and a highly flexible partitioning system were designed to allow HSBC teams to reconfigure with ease and speed. The building was to set new standards in the commercial office sector.

The project team rapidly geared up to full-strength working after appointment in October 1998, and a detailed multidisciplinary scheme design was produced by the end of that year. With a very substantial piling and dewatering contract to execute, piling began in November 1998, a mere four weeks after the appointment. Thereafter, design and construction went hand-in-hand, with the major structural packages confirmed on the basis of a set of drawings in April 1999 and phased release of reinforcement and detailed drawings.

The rapid construction of the concrete and steel contracts was helped by an excellent level of definition in the April 1999 drawings package, as well as the close working relationships from the outset and on through the whole project with the management contractors, Canary Wharf Contractors Ltd, and Cleveland Bridge and Byrne Brothers, respectively the steel and concrete contractors.

11a-d:
Self-climbing core formwork construction sequence.

11a. December 1999

11b. July 2000

11c. December 2000

11d. July 2001

Structural economy

As is usual with tall buildings, operations were fast-tracked, and the hybrid built form of a concrete core with steelwork floors and perimeter columns allowed erection to proceed rapidly (Figs 11a-d).

The project's strong collaborative framework allowed buildability issues to be anticipated and the structure's efficiency to be refined.

The core formwork was self-climbing, with one central tower crane rising with the core and perimeter tower cranes left free to lift the steelwork, the floors being constructed at the rate of one per week. To start the steelwork as early as possible, the steel columns begin at pile cap level, rising through four basement levels of concrete construction before the first steelwork floor at level 1, allowing erection of the steelwork superstructure to start before the basement was completed.

Basement construction

The basement floors are typically 300mm thick concrete slabs on a 9m x 9m grid. Deflection limits were chosen to be compatible with car park use rather than to British Standard *BS8110*, yielding savings for the client.

Plant requirements resulted in deeper structural depths and double-storey heights in places. The floors act as diaphragms, transferring horizontal loads from the ground on the south and the dock on the north to the core and the perimeter retaining walls. The latter are typically 600mm thick and designed as watertight concrete in accordance with *BS8110*, which allows some seepage.

Additional protection, by inner cavity walls and external protective treatment, imparts higher grade watertightness where required.

The car parking entrance and loading dock arrangements required just one column to be transferred out at a higher level. A notable feature of the basement is that the existing dock wall, a listed heritage structure, falls directly below the building's southern perimeter. All the columns on this face were thus transferred over the wall, with the transfer structures just below ground level. Thus, in theory, were the building to be demolished, the brick dock wall would again be visible. Apart from this, all vertical structure is continuous to the basement level.

The raft foundation - in effect the pile cap - is 3.15m thick below the core and 1.85m thick at the perimeter. This raft was cast in roughly 20m x 20m pours, with concrete delivered by wagons at a rate of one every two minutes. Temperatures were carefully monitored during curing of the raft.

Structural steelwork

The columns are generally 356mm x 406mm throughout, with plating added across the flanges in the lower storeys to give a constant inside flange line, simplifying the splices and the edge beam connection to the inner face of the external flange. This detail allowed for constant cladding-to-perimeter-beam and core-wall-face-to-perimeter-beam dimensions, thus maximizing the use of standard length secondary beams.

In the basement the columns become 800mm x 800mm fabricated box sections, carrying up to 48MN and weighing over 1 tonne/m length at the lower levels - a significant craneage issue.

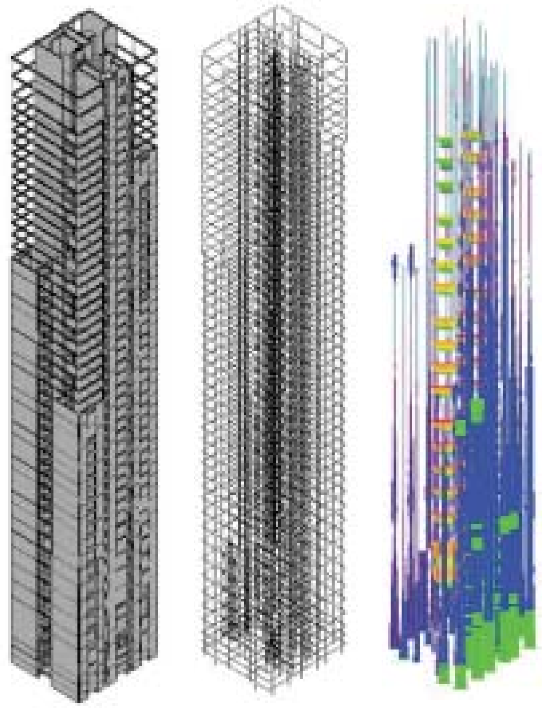
Typical spans in the tower are 10.8m-12.8m, and the 1m floor sandwich gives a 200mm raised floor and 330mm clear services zone beneath the steel beam. Deflection limits for edge beams were tightened to reduce the costs of joints in the cladding.

The 75m square podium includes 16.5m clear spans, giving vast open spaces for the trading floors. A 22m span, full storey-height, transfer beam allows unrestricted lorry access in the basement loading bay.

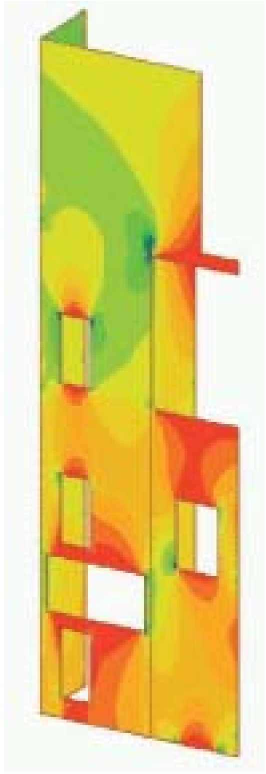
12. View up the completed HSBC tower.

'The challenge on this job was always going to be whether everyone could pull together to proactively solve problems on an extremely tight programme. Arup and Cleveland Bridge worked closely together on the structural steelwork design to anticipate just about every potential construction issue, and the tower went up very smoothly.'

Winston Huth Wallis, Construction Manager, Canary Wharf Contractors Ltd



13. Skeletal 3D GSA model.



14. Detailed finite element model.

Maximum advantage was taken of the repetitious nature of a tall building to standardize framing and detailing of connections, Arup working closely with the contractor particularly on steelwork and concrete detailing.

For non-standard areas, such as the five-storey height entrance lobby where plate girders carry escalators up through the space, standard sections were developed to minimize material waste.

X-Steel was used at Cleveland's Darlington works as the drawing and fabrication tool. Document management was electronic throughout the project using Hummingbird, with electronic red-lining of drawings by the designers.

Core wall layout

The four banks of lifts form the core's primary cells, whose walls change thickness three times over the height - from 600mm to 450mm to 300mm.

The internal walls separating stairs, lift shafts, and risers are 200mm thick throughout the height, minimizing the space-take of the core and hence maximizing lettable floor space. An 8m wide central 'street', containing vending machines, meeting rooms, multifunctional print/scanning facilities, mailroom and storage area, separates the two 'halves' of the core, its walls structurally coupled across this divide in an arrangement that gives access into the street from at least one end on any one floor. Detailing of the reinforcement for the core walls was undertaken by Arup in house, with close collaboration with Byrne Brothers.

Structural analysis and core design

The core was analyzed using the skeletal 3D OASYS GSA model to predict the response of the building to vertical and lateral loads (Fig 13); static analysis to assess element forces due to gravity, wind, and notional lateral horizontal loads, and modal analysis to assess dynamic properties. The overall 3D model was supplemented with detailed finite element models (Fig 14), to confirm behaviour in areas of local discontinuity.

Wind loads induce lateral movements that need to be assessed against criteria which describe how far occupants perceive, and tolerate, tall building motions. Preliminary assessments of these lateral accelerations were made according to NBCC (National Building Code of Canada), and wind tunnel testing was subsequently performed on a rigid force balance model at the Boundary Layer Wind Tunnel Laboratory at the University of Western Ontario (BLWTL).

Load spectra from the wind tunnel testing were combined with modal properties extracted from the 3D analysis and processed by BLWTL to give predictions of pseudo-static peak wind forces on the building and accelerations experienced by the occupants.

The maximum predicted wind displacements were building height/2600 for overall displacement and storey height/2000 for inter-storey drift. These were well within the normal limits for tall buildings (h/500 and h/300 respectively), as the core size was determined by space planning rather than structural requirements.

Building services

Planning permission for the site had been based on the then standard Canary Wharf specification of an all-electric building with fan-assisted terminal variable air volume (FATVAV) air-conditioning.

Arup looked at several alternative systems for HSBC during the concept stages, including two and four pipe fancoils, gas-fired heating, and dockwater heat rejection. The Canary Wharf standard specification was adopted by HSBC, but several innovations new to Canary Wharf were brought into the building, with cost and space benefits.

The business-critical operations HSBC aimed to locate in its new HQ demanded robust building services to support and maintain them. During the design stage Arup carried out a detailed single point of failure (SPOF) analysis. This led to two separate and independent chilled water and heat rejection systems with their own pipe risers being provided, each rated for half the building's maximum load and each with N+1 plant capacity. Dual electrical power supplies come from independent London Electricity primary sub-stations, each rated for peak building load, and 10MW of in-house power is also provided by four duty and one standby generators to support life safety and essential loads including lighting, small power, and refrigeration/chilled water. Two large and complex UPS systems with battery backup ensure that should the London Electricity supply fail, business-critical operations are maintained at all times with no loss of power. An N+1 system serves the trading floors and the SERs on all the floors. A separate 2N system serves the CER, which handles HSBC's worldwide IT and data operations.

Duplications and triplications

Resilience in the cooling and electrical systems is a theme throughout the building. At the lowest basement level are two separate and fire-compartmented chiller plantrooms, whilst two pairs of 450mm diameter chilled water and two pairs of 450mm diameter condenser water (heat rejection) pipes rise through the building; two separate cooling tower heat rejection circuits are housed on the roof.

Two AHUs on each floor (each at 75% duty) provide chilled air to the FATVAV terminal boxes. Similarly, dual generator and UPS-backed busbars rise through the building to feed essential IT services throughout.

A triplicated generator control system was specified. Although well known in aviation, these do not usually feature in commercial buildings. The system triplicates all signalling between controlling devices using different cabling and routes, so if one system fails, the power remains operative on the remaining two. The generators have five days' supply of oil, with the storage tank located in the basement. An electrical network management system (ENMS) monitors the condition of the business-critical protective devices throughout the building. It monitors power quality including harmonics and records disruptions, minimizing future malfunctions by preventative maintenance.

The CER is provided with down-flow close control air-conditioning units. These have dual coils, each fed with chilled water from different chilled water systems, thereby ensuring that cooling is maintained at all times should one chilled water system fail. Having dual coils simplifies the controls and changeover valving arrangements, again enhancing the robustness of the system.

Acoustics

Nick Boulter

Arup Acoustics' initial appointment was to develop the acoustic design of the base building, beginning with a study to assess the levels of traffic and aircraft noise and the implications this had on the building envelope sound insulation requirements. Much of the early work concentrated on services noise control issues. The original concept centred around the use of acoustic AHUs, one per floor. These have greatly enhanced casing construction compared with conventional AHUs, resulting in very low plantroom noise levels and thus minimizing the sound insulation needs. This was shown to work well in a mock-up plantroom where noise levels were low enough to allow unattenuated return openings.

The appointment was extended to cover fitout acoustic design. This involved partition design and privacy issues, although services noise and room acoustic control were also key factors in many areas. The client wanted the flexibility for future 'churn', so floor-to-ceiling relocatable partitions were the intended norm, with higher performing slab-to-slab partitions only in a few critical areas.

For relocatable partitions to be useable, noise transfer via the common ceiling void needs to be controlled, and in areas with flexible partitions, the ceiling sound insulation was upgraded.

Initial sound insulation results were lower than anticipated. Significant improvements were made by modifying the partitions, but the resulting privacy was still inadequate, due to the unexpectedly low background sound from the services in some of the internal spaces. Levels in the affected rooms were therefore artificially raised by installing a low-cost sound masking system in the ceiling void. The sound generated was derived from recordings of real ventilation services, optimized to give the most appropriate sound masking spectrum. The resulting sound is natural for an office building and therefore unobtrusive to the users, and tests after the masking system was installed showed the target privacy standards to be achieved.

A combination of sound absorbing ceilings and absorbent wall linings built into the partitions controls the internal acoustics for the various partitioned spaces. The double-height boardroom, however, presented an interesting acoustic design challenge. To work effectively for video conferencing and recording, the space needed a well-controlled acoustic. The two end walls of the boardroom have fabric-faced acoustic lining, but the floor-to-ceiling glazing could not easily be made absorptive, and this made the wall opposite particularly critical. It is covered in a large world map made from extruded aluminium sections, with the oceans in inclined T-section extrusions perforated on the hidden surface and thus absorptive. Fortunately, our globe is mostly covered with ocean!

Economizing space

Space efficiency for the building services was also a prime concern. Numerous plant arrangements were tested to ensure that equipment was optimally located and future maintenance and replacement was also possible. Arup produced a plant replacement strategy report, which detailed the maintenance/replacement frequencies of the major components and the physical routes by which this could happen. Specialist contractors and the design team collaborated on the report, which was well received.

The layouts of the various engineering systems were also designed to maximize the net lettable floor space. Again with the architect and the client's agreement, the chiller plantroom room was designed without tube withdrawal space but with knockout wall panels instead to allow chillers to be removed for maintenance. The cooling water system was meticulously designed and tested as a single pressure zone (buildings of this height are normally divided into two or three), saving plant space normally needed for pressure break heat exchangers, secondary circulating pumps, and ancillary equipment and controls. To achieve this servicing strategy, the team analyzed the stresses in the piping system at the base of the building, and reviewed and checked in detail manufacturers' pressure ratings for coils. Having a single pressure zone ensured that chilled water at 6°C could be delivered to the entire building, ensuring that all cooling coils in the building are efficiently sized.

Another space-efficient design was the provision of a fresh air riser running through the building's concrete structure. Detailed analysis ensured that the structure's inherent thermal inertia did not adversely affect the treated fresh air thus supplied. The shaft was subsequently suitably finished to prevent mould growth and moisture migration into the structure. This fresh air shaft can also be used as for smoke extract in a fire.

Movement differentials

As a result of the single pressure zone design, Arup devised a way to allow for pipe thermal movement based on anchoring the two pairs of pipe risers at the base of the building on the structural raft, with expansion/contraction of the pipe risers taken up at the top of the building. This removed the need for a special structure to take up significant thrust forces normally required for anchors in a building.

As well as thermal expansion and contraction of the system, the design of all pipe risers had to accommodate differential movement of the structure as it shortens vertically after construction due to concrete creep and shrinkage. Special attention was given to how branch take-offs were made from the risers so that the horizontal pipework could take up the vertical movement of the branch. This was achieved by carefully implementing horizontal pipe loops to make use of the natural flexibility in pipework and bends to absorb the movement.

Water supply

The hydraulic static pressures arising from the building's height also impacted on the sprinkler system. Working closely with building control and the Fire Brigade, Arup negotiated a dispensation under the design codes to enable pressure reducing sets to be installed on the sprinkler systems.

Similarly, by working closely with the authorities Arup satisfied building control that with all the life safety systems of smoke extract, sprinklers, wet risers, fire and voice alarms, the hose reel installation could be omitted without prejudicing occupants' safety. The client was satisfied with this and recognized the added value that Arup had brought to the project.

Two incoming water supplies feed two potable water tanks. The potable water is purified using copper silver ionization; HSBC is believed to be the largest building in London to use such a system. Copper silver ionization is also used to treat the cooling tower pond water system in lieu of a normal chemical treatment system; this overcame any need for hazardous chemical storage and handling up to the top of the building.

Security

Simon Brimble

Arup Security Consulting was involved in designing the security installation from almost the inception of the project. The initial study was to develop a strategy for protecting the building fabric based on a threat and risk analysis. This work was later used to inform the blast commission that TPS Consult undertook through to project completion.

Following this involvement Arup was asked by HSBC's security department to provide security engineering services through the entire design period, onto site, and through to commissioning. This required a close working relationship with HSBC's security department and other members of the design team, mainly Foster and Partners, to produce an integrated approach to security. To enable this, Arup used a methodical approach, based on the client risk assessment and brief, to develop a detailed security plan that was tracked through the design process to provide an auditable trail. The security plan co-ordinated various parts of an integrated security strategy including operational procedures, physical and electronic security measures, and the planning and space requirements for security assets. One unusual but interesting aspect of the close collaboration with the client and other design team members was attending HSBC's monthly fire, safety and security working party meetings, where security was considered in the most holistic of ways.

The scheme comprised CCTV, access control, intruder detection, vehicle management, turnstiles, and control room systems.

The first security elements that most staff and visitors encounter are the pedestrian gates to control access. These were specially developed to maintain the visual objectives of the lobby design and provide an installation that would handle the total building population.

Through much discussion a sophisticated vehicle management control system was introduced to prevent vehicle tailgating.

The installation comprises 'vehicle airlocks' formed by impact-rated roadblockers, raising-arm barriers, and fast-acting speedgates. Throughout the development and implementation of the vehicle management scheme, Arup strove for a balance between the building security objectives and personnel safety, and the scheme was implemented for all vehicles including goods deliveries and private cars.

Close attention was given to integration with the building and its systems, including the use of the structured cabling system to transmit video signals, use of a common building LAN for IT, and access control through to custom-designed access controlled gate bodies, camera housings and brackets.

The successful realization of the security design was a co-ordinated effort between Arup, HSBC's security, facilities and project team, Foster and Partners, and not least the construction team of Bell Security and Canary Wharf Contractors.

Fire safety

Andrew Gardiner

Arup Fire was responsible for Category A and Category B fire strategies and also participated, as part of the design development process, in HSBC's monthly working group on fire, safety, security, and facilities management. This participation was a unique opportunity to explore how the complex operations required by modern banking integrate with design.

Questions arose from these meetings requiring a series of special studies.

Computer equipment rooms

One such study examined the fire protection needs of the very large main computer equipment rooms. They form an essential part of HSBC's business and there was much debate as to the degree of fire protection required. Arup Fire carried out a quantified risk analysis that superimposed a transient fire and smoke spread model onto a probability event tree. This allowed the consequences of success or failure of individual fire safety systems to be examined and put into context with the likely probability of these events occurring. The results were distilled down into a series of possible smoke, fire and water damage outcomes, each with a related return period.

This was then used to justify HSBC's choice of fire protection systems.

The History Wall

A more unusual study concerned the entrance lobby artwork. As part of the agreed fire strategy, the entrance lobby had to have a controlled quantity of combustible material which also had to exhibit very low surface spread of flame characteristics. Unfortunately, the artist's choice of material for the nearly 4000 perpendicularly-mounted flags in the History Wall was PVC, coated to accept a high quality photographic image.

Tests showed it to be easily combustible and with a very rapid surface spread of flame characteristic. Arup Fire and Arup Materials Consulting worked with the artist and HSBC to develop an acceptable solution.

The idea of a non-combustible aluminium substrate onto which the flags could be mounted was seen as a positive by the artist, and so a series of photographic plastics and papers were examined, not just for fire performance but also for UV stability, cleanability, and image quality. A series of fire tests eventually identified a product that satisfied all the criteria of HSBC, the artist, Arup, and the local authority.

Simultaneous evacuation

One final study, probably most important of all, arose from September 11, which occurred near the end of the shell and core construction phase. HSBC was keen to extend the standard phased evacuation procedures for fire and examine the most efficient way to evacuate the complete building simultaneously. Using a series of models, Arup explored with HSBC many different options and scenarios until one was chosen as the most practicable and efficient.

Key to the success of this was management of the evacuation and the role of the Building Emergency Co-ordinator. It was clear to HSBC that the person responsible should have a very high competency profile both technically and in decision-making during a stressful situation. HSBC's search for a person of the right qualities was successful and since occupation a series of full-scale evacuations have been carried out.

This has allowed systems to be fine-tuned to minimize evacuation times and also to better serve staff with mobility difficulties. In doing so, HSBC has set an example for others to follow.

15. The History Wall in the ground floor entrance lobby.

Building controls

HSBC is the first large-scale installation of Invensys Building Controls' new Sigma control system, specifically selected to complement the resilient mechanical and electrical design.

HSBC's BMS installation not only uses Arup standard controls design, but also implements a distributed starter approach. Instead of relatively few large centralized motor control centres supplied by a controls specialist, there are many individual starter enclosures provided by the associated mechanical equipment suppliers.

Each incorporates all hardwire interlocks required for the safe stand-alone operation of the plant, including all fire interfaces, allowing the drives to be commissioned before the controls were installed on site.

This effectively provided a plug-and-play approach for the equipment to be controlled. To complement this philosophy, Arup designed the controls using many small controllers distributed adjacent to each starter enclosure.

As the mechanical systems were generally designed with dual duty/duty plant configurations, it was necessary for the controls to mirror this by providing dedicated controllers for each item of plant. This modularity needed far more co-ordination between contractors than under a normal contract, with Arup successfully providing much of this co-ordination.

The FATVAV box and fan coil unit controllers are connected via an ECHELON (Open protocol) data network, but communications between the main plant controllers utilize a proprietary dual redundant twisted pair network, linked to an ethernet backbone. Failure of the primary network causes an automatic changeover to the secondary standby network, creating a high-integrity, resilient data network. Similarly innovative dual flash allows firmware upgrades to the controllers to be carried out without the usual downtime ensuring continuous service while maintaining the most up-to-date software. The BMS system also interfaces with the lifts and escalators, lighting, and energy metering, to act as a gateway channeling and recording information to become the main portal for the building facilities management.

Providing for the client

For a building of its size, the design and construction of the new HSBC headquarters was efficient, cost-effective and innovative, while satisfying the client's desire to amalgamate all his 8000+ UK staff in a single building. HSBC wanted spaces to generate synergies among the staff, to reduce facilities management costs, to improve communications and to promote efficiency in central functions such as HR, Finance and IT. The design was key to improving business and providing an unrivalled working environment for the staff. Arup's design team met client requirements and the challenges of efficiency in relation to the scale of the building by applying appropriate and innovative design.

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Credits

Clients:
HSBC Holdings plc
Canary Wharf Contractors Ltd

Architect:
Foster and Partners

Project manager:
HSBC/Canary Wharf Ltd

Structural, MEP, fire, acoustics, security and building controls engineer:
Arup Mark Adams, Graham Aldwinckle, Joanna Allen, Malcolm Ashmore, Trevor Baker, Phil Barker, Richard Bartlett, Peter Berryman, Nick Boulter, James Bown, Derek Brewser, Simon Brimble, Stas Brzeski, Matthew Bumpass, Tim Casey, Tim Chapman, Dave Choy, Andrew Christie, Iain Clarke, Nigel Clift, Judy Coleman, Darren Connolly, John Coppin, Richard Coveney, Richard Cowell, Paul Cross, Daniela Dafarra, Menino Da Silva, Ismena Deacon, Peter Deane, Asha Devi, Enzo Di Ienno, David Dollman, Thomas Dossenberger, David Easter, Karen Elson, Mike Evans, David Fearon, Tony Fitzpatrick, Alan Foster, Suzanne Freed, Andrew Gardiner, Anne Gilpin, Andrea Gnudi, Jeff Green, David Gubb, Stuart Hall, Simon Ham, Andrew Harland, Steve Harris, Mike Hastings, Geoff Higgens, Ernie Hills, Peter Ho, Karen Holt, Bill Horn, Nick Howard, Rachel Hughes, Daniel Iffland, Adam Jaworski, Richard Jelbert, Ivan Jelic, Barney Jordan, Tarsem Kainth, Beijhan Keenan, Edward Lam, Ben Lawlor, Stephen Lees, Gerry Loader, Kate Longley, Paul Malpas, Jim McCarthy, Gordon McDonald, Sean McGinn, Steve McKechnie, Tony Minchinton, Steve Mitchell, Yoshiyuki Mori, Paul Morrison, Wolfgang Muller, Karen Naughton, Sohail Nazir, Duncan Nicholson, Tony Noad, Sarah O'Driscoll, Julian Olley, Andrew Painter, John Papworth, Lucy Patenall, Val Pavlovic, Garry Porter, Daryl Prasad, Henry Quek, Stuart Redgard, Simon Reynolds, Gregg Richardson, Edward Robinson, Toby Robinson, Mark Rowan, Mark Ruohonen, Eddie Scuffell, Geoff Shotter, Clem Smoothy, Les Stokes, Arra Tan, Alan Todd, John Veale, Bob Venning, Faith Wainwright, Karen Warner, John White, Adam Wildon, Jim Williams, Ben Williamson, Shaun Woodhouse, Louise Wright

Lift consultant:
Lerch Bates & Associates

Quantity surveyor:
Davis Langdon Everest

Audiovisual consultant:
CMS

Catering consultant:
GWP

IT consultant:
PTS

Management contractor:
Canary Wharf Contractors Ltd

Steel frame contractor:
Cleveland Bridge

Concrete frame contractor:
Byrne Brothers

Mechanical contractor (base build):
Crown House

Mechanical contractor (Base build/fitout):
Hotchkiss

Mechanical contractor (fitout):
Rosser & Russell

Electrical contractor (base build):
T Clarke

Electrical contractors (fitout):
PIP
RTT

Fire alarms supplier/contractor (Base build/fitout):
Siemen's (Cerberus)

Security supplier/contractor (base build/fitout):
Bell

BMS/controls supplier/ contractor (base build/ fitout):
Satchwell

Lifts supplier/contractor:
Fujitec

Illustrations
1: Peter Mackinven/VIEW
2: Denis Kirtley
3: Daniel Blackhall
4, 6, 8, 11, 15: Central
5, 7, 9, 16: Dave Choy
10, 13, 14: Arup
12: Steven Jenkins

16. Symbolic HSBC Lion brought to the new headquarters from the Hong Kong building.

'The very demanding fast track programme was only achievable because of the first rate personnel from the designers, contractors and clients who were highly committed to the project and maintained the confidence of the Bank throughout. HSBC are delighted with the completed building.'

Mike Smith, Project Manager, HSBC