





# INTRODUCTION

The Shard at London Bridge is a world class building constructed in a complex urban environment. It is a mixed use high-rise building designed to accommodate retail, offices, a viewing gallery, hotel and apartments together with associated plant rooms, loading bays and ancillary facilities. The structure has been developed, in close collaboration with the client and other members of the design team, to suit the various functional requirements of the

project and. The goal has been to deliver an elegant, structurally efficient building suitable for a landmark development in one of the world's major capital cities.

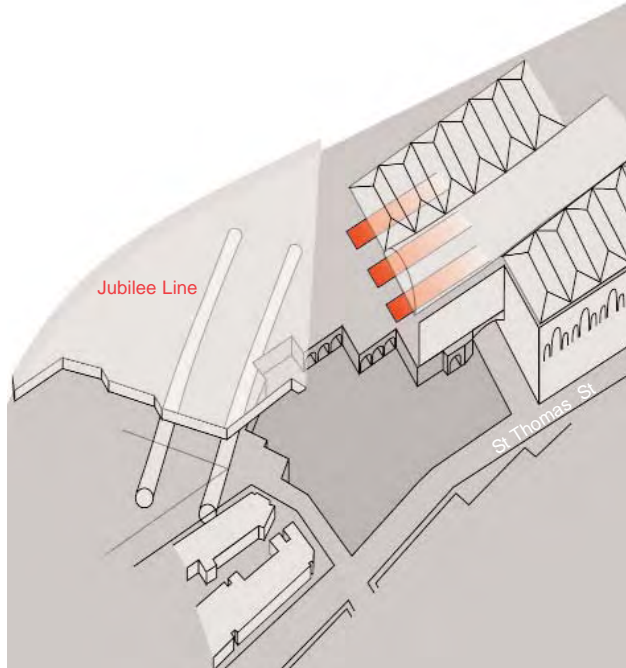
The site is adjacent to London Bridge Station and close to the Jubilee Line running tunnels. It was previously occupied by Southwark Towers, a 26 storey building founded on piles, under-reamed within the London Clay.

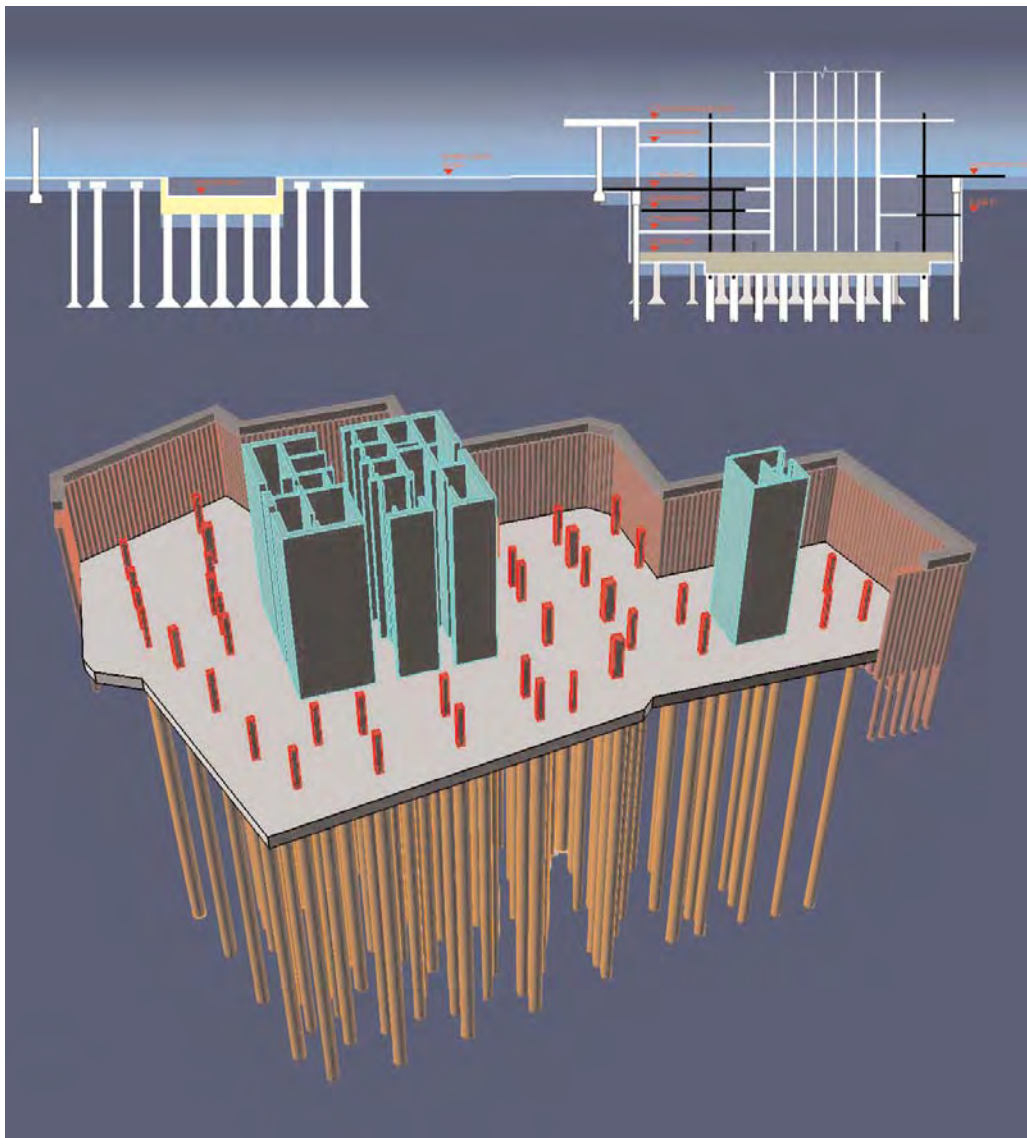


# SITE CONSTRAINTS

## Site Constraints

- Southwark Towers - the 26 storey building previously occupying the site - has been demolished
- Existing piled foundations and remains of masonry arch foundations are present across the site
- London Bridge Station borders the site to the north. It is built on a large network of masonry arches; the train shed is a Grade II listed structure. Many thousands of rail passengers use the station every day
- Jubilee Line tunnels pass on the northern side of the site
- Disused London Underground lifts and stair shafts exist within the basement perimeter on the western side of the site
- Numerous buried services are present in the roads and footpaths to the west and south





# GROUND WORKS

## Top Down Construction - Including the Main Core

- The main tower is constructed using top down techniques, beginning with the ground floor and proceeding upwards and downwards simultaneously
- The main core is constructed top down using 23 plunge columns, each 800 kg per metre
- Plunge columns for the core and external columns are strategically placed to miss existing piles
- The sequence is carefully co-ordinated between WSP and the contractor in order to ensure alignment of the plunge column capacity with the superstructure load

## Basement and Piled Raft

An extensive monitoring system, using a combination of manual and automatic measurement systems, has been specified by WSP. This is used to demonstrate that calculated movements of the ground and surrounding structures have not been exceeded, and to bring to attention movements that are approaching the limits. The monitoring system covers:

- London Bridge station - arches, escalators, tracks and other structures
- Guys hospital and Kings College
- Other buildings on St Thomas Street, Joiner Street and Stainer Street



# SUPER STRUCTURE





# THE MAIN CORE

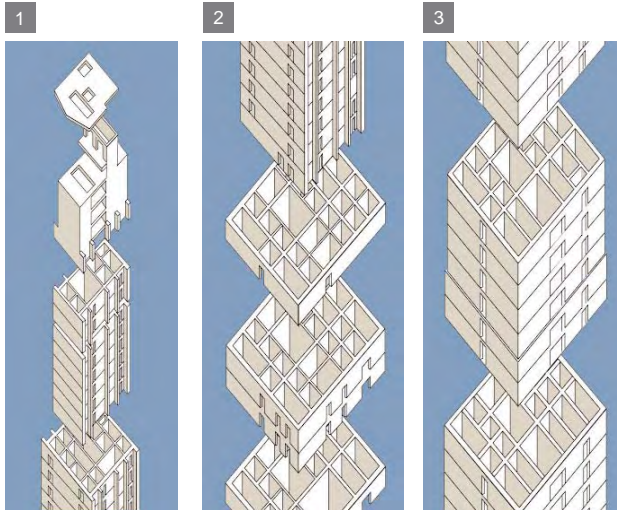
- WSP worked closely with Renzo Piano Building Workshop and other members of the design team to achieve a core that provides the required stiffness to the building, delivers optimum performance for vertical

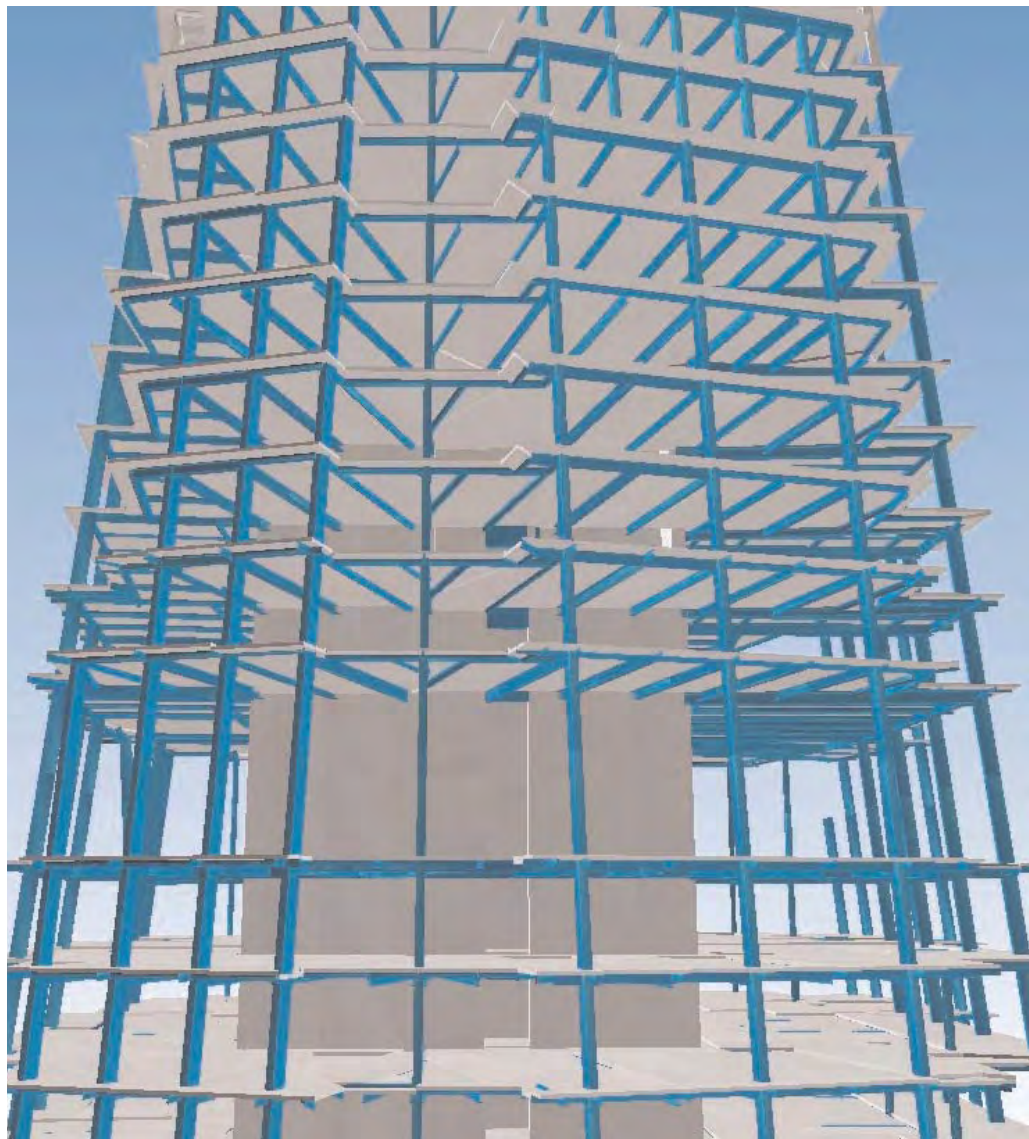
transportation and services distribution, and makes available as much floor as possible for office space.

- The core is slipformed in reinforced concrete.
- Steel beams are attached to the core using steel embedment plates, cast into the concrete as the slipform

rises.

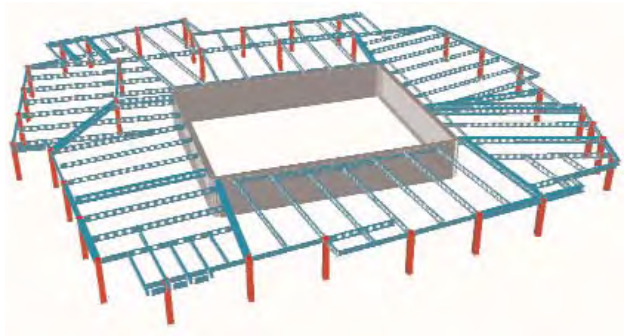
- The core reduces in size as the number of lift shafts diminishes. Intermediate columns spring from the core to limit the span - and hence the depth - of beams connected to the façade.

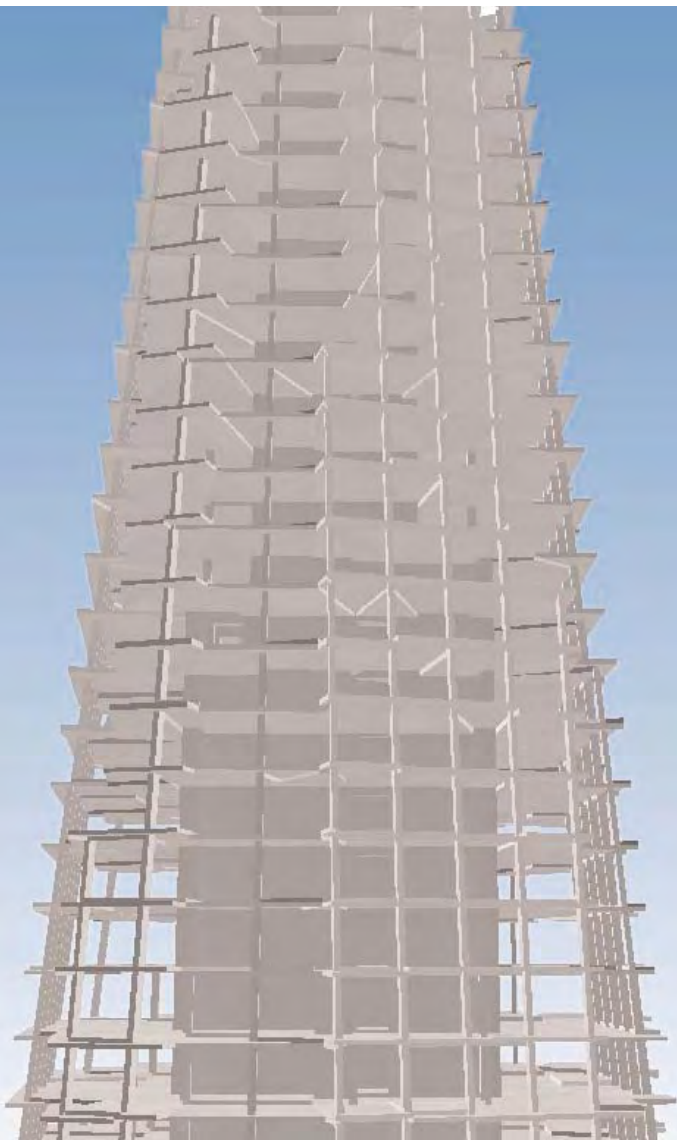




# COMPOSITE STEEL FRAMING AT OFFICE LEVELS

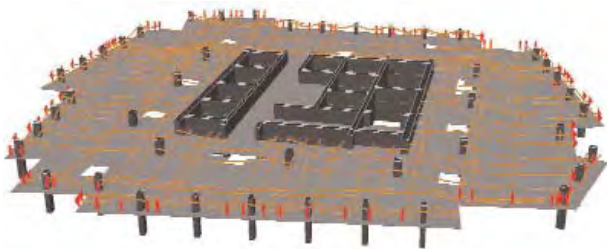
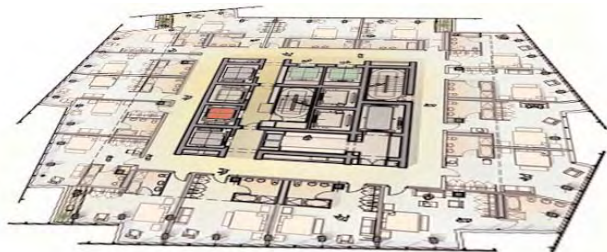
- Composite steel framing suits office occupancy
- Slabs are typically 130mm light weight concrete on metal deck, providing 2 hours fire separation
- All beams are fabricated and 500mm deep, with 300 holes at 650 centres for service penetration. This allows maximum use of the floor zone for both structure and building services
- Where large ducts are required, elongated openings are provided by connecting pairs of adjacent holes
- The steel beams guard against disproportionate collapse by providing catenary action in case of accidental column loss





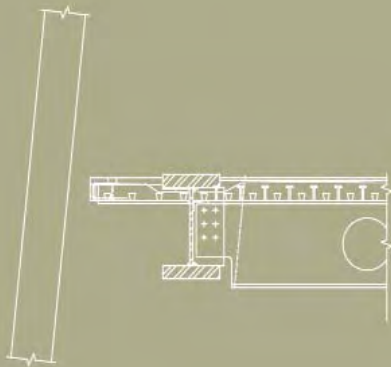
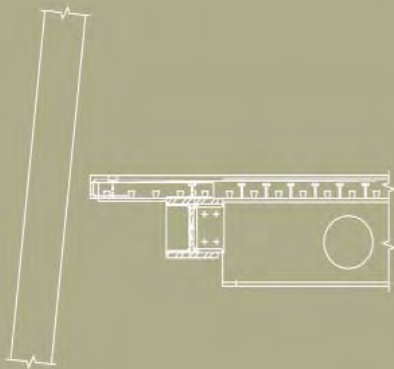
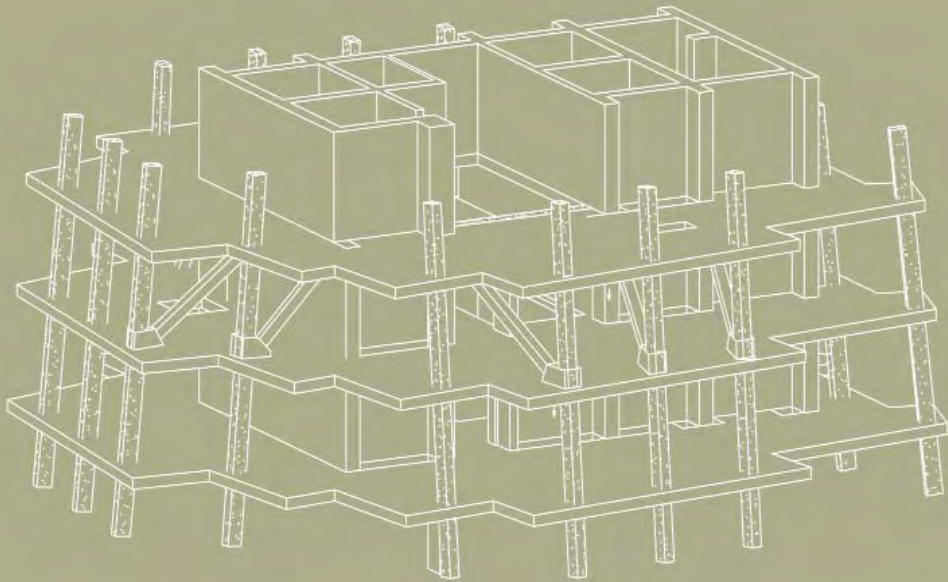
# CONCRETE POST-TENSIONS (PT) SLABS IN RESIDENTIAL LEVELS

- Concrete slabs suit residential occupancy
- Slabs are typically 200mm - 250mm deep with tendons at approx 1m centres  
Because there is less need for lateral distribution of services in residential levels, the ceiling zone can be reduced. Therefore PT offers minimum slab thickness for a given column layout
- The depth of concrete provides the required acoustic separation
- The mass and inherent damping of the concrete gives a better dynamic performance to the building overall

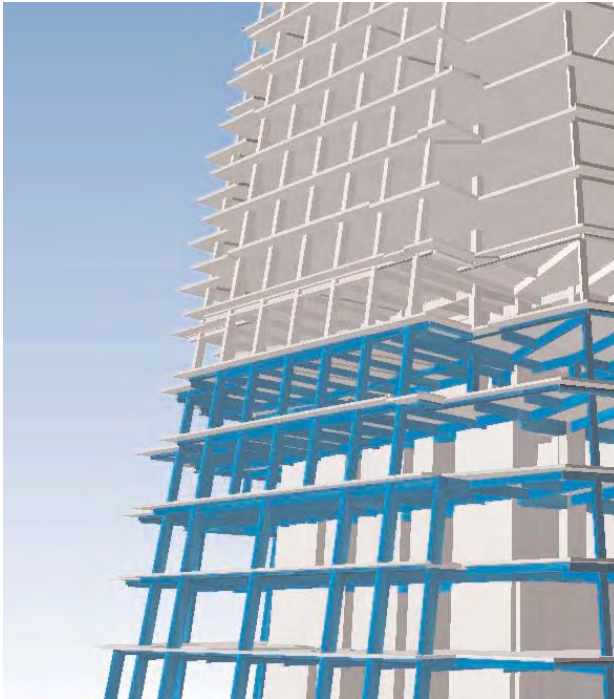




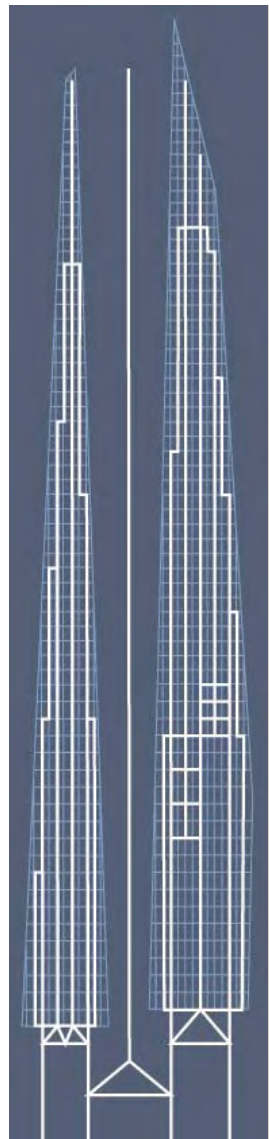




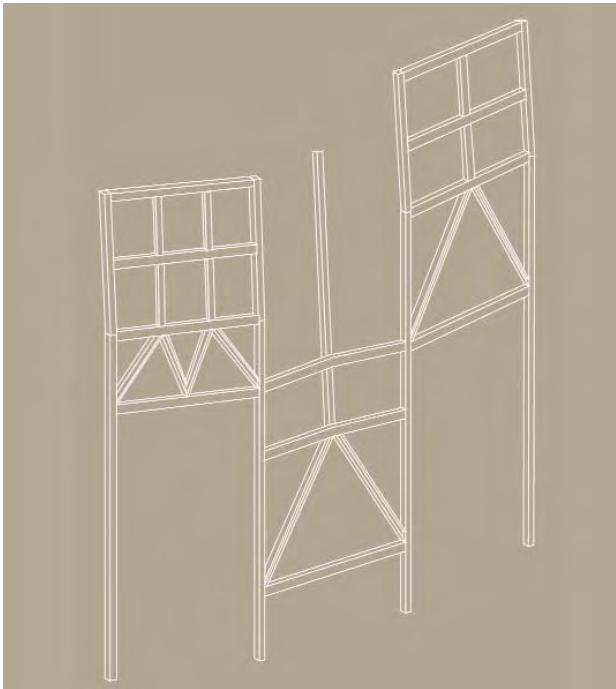
# PERIMETER COLUMNS



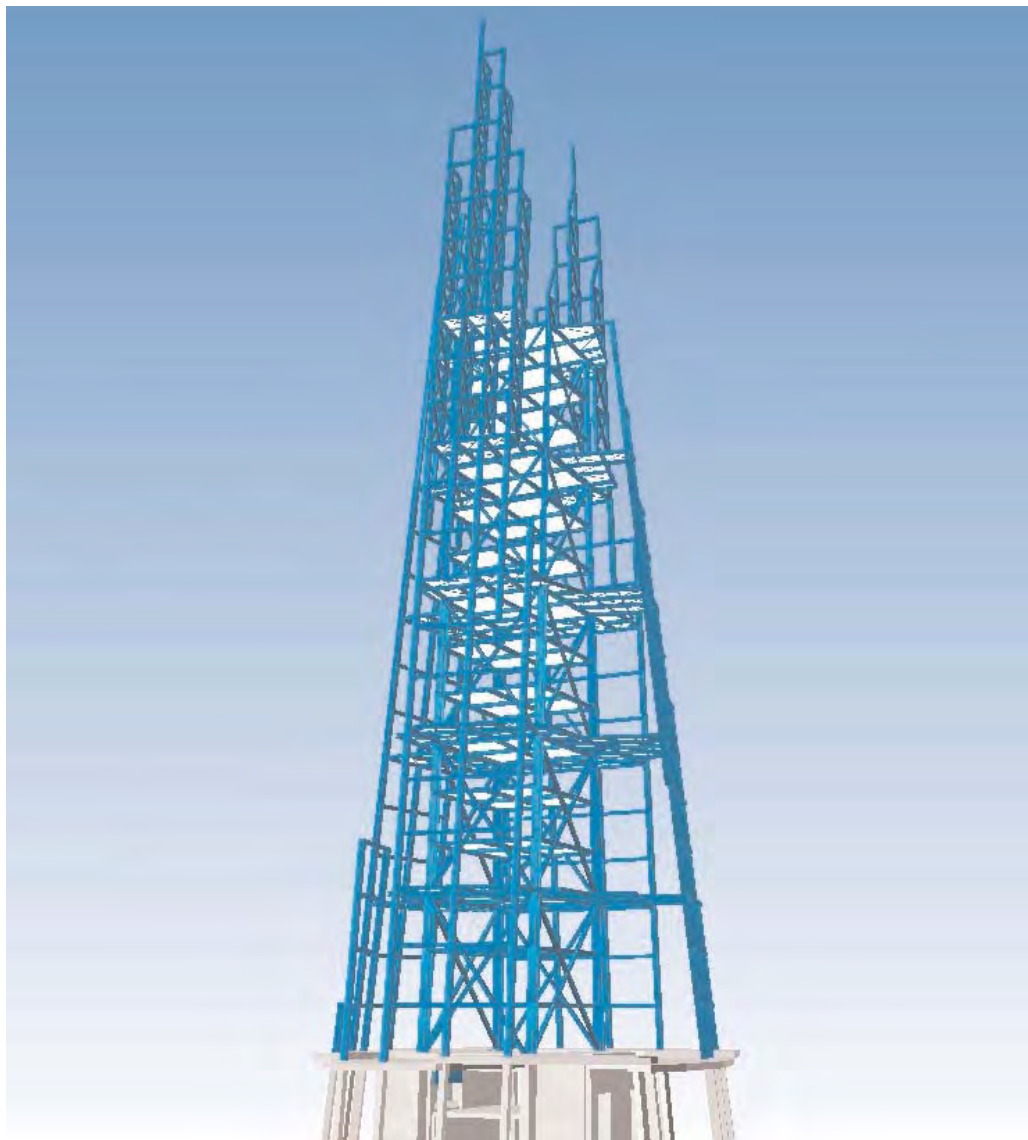
- The spacing of perimeter columns reduces from 6m at the office levels to 3m at residential levels, to 1.5m in the spire. These changes in spacing coincide with changes in material type.
- Kink points are needed where shard alignments change - eg from sloping to vertical. At these points forces are transferred back to the core.
- Transfer trusses are used in order to limit the number of columns passing through the office floors at the junction between the main tower and the backpack.



# TRANSFER STRUCTURES



- Load sharing systems transfer the forces over four floors, ensuring that no transfer beams exceeds the general edge beam depth.
- Columns stop at different levels to suit the triangular geometry of the shards



## THE SPIRE

- The Shard is surmounted by a 60m tall steel-framed 'spire' which houses building maintenance units, viewing galleries and other public spaces.
- The spire is stiffened by a concrete core housing the central lift shaft. The shaft and a scissor stair are enclosed in a glazed mast, framed in architectural steel.
- The topmost parts of the spire, where the shards extend upwards beyond the main structure, are stiffened with steel trusses



KAMRAN MOAZAMI  
Project Director

RON SLADE  
Design Director

JOHN PARKER  
Team Leader

RODOLFO GIANNINI  
Project Engineer

ROMA AGRAWAL  
RICHARD MAWER  
MATT GOSWELL  
Structural Engineers

DONNA OFFEN  
SIMON HEAGNEY  
CAD Technicians

JOHN BUTCHER  
Resident Engineer

MARK O'CONNOR  
Structural Fire Protection  
Special FE analysis

MATT SHARRATT  
JOHN RICHMOND  
SAKTHI SRISAKTHIVEL  
Geotechnical Engineering

MARK BEAUMONT  
MATTHEW HYAM  
Drainage Engineers

STEVE KATESMARK  
NEIL HORTON  
LEE HAILEY  
JOHN CARNE  
Traffic Engineers

DAVE MAUNDRILL  
Acoustics



WSP Group plc  
WSP House  
70 Chancery Lane  
London  
WC2A 1AF

Tel: +44 (0)20 7314 5000  
[www.wspgroup.com](http://www.wspgroup.com)