30 St Mary Axe, London
Norman Foster

Assignment 2: Construction and Management Plan
Course: Construction Technology 4
ARBE4100
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Date: Friday 5th June
Executive Summary

The aim of this report is to analyse the technical and management issues associated with the construction of a high rise building. The report takes a case study approach in regards to Fosters and Normans' St Mary Axe and how a similar building could be constructed in Newcastle CBD.

The report will outline issues such as building services within the high rise structure, specifications for the cladding system in regards to legal documents, legal issues and the how they comply with the BCA and Procurement Methods.

This report follows on from Assignment 1 of the structural and cost analysis of a high rise building in the Newcastle CBD area. The report also takes 30 St Mary Axe as a case study building and investigates the construction and management techniques in the high rise building.
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1. Introduction

“30 St Mary Axe, better known as the Gherkin because is floor plan resembled a sliced pickle, is located in the heart of London’s insurance district. It was originally the site of the Baltic Exchange since 1903 but was obliterated in April 1992 by the IRA. The site went under many discussions on what was to be done with it including restoring the Baltic Exchange and the proposal of an 84 storey Millennium Tower. In 1997 insurance giants Swiss Re acquired the site and commissioned Foster and Partners to design the building.

London’s first environmentally sustainable tall building stands 180m high and consists of 40 storeys. The building consumes about half the energy of most skyscrapers this size. The building gradually widens at each floor plan until it reaches the 16th where it then diminishes until it reaches its apex. This distinctive form responds to the constraints of the site: the building appears more slender than a rectangular block of equivalent size; reflections are reduced and transparency is improved; (Foster+Partners.com). The sliming of the building at ground floor maximises the public space at ground level. It helps maintain pedestrian comfort at street level as the profile reduces the amount of wind deflected to the ground compared with a rectilinear tower of similar size.” (Turner, 2009)
2. Building Services

This section provides a detailed study of the service in St Mary Axe, providing an example of how services could be integrated into a high rise building in Newcastle CBD.

2.1 Service Details

St Mary Axe building utilities are located around a circular central core (London Architecture). This allows for uninterrupted floor space for tenants and the ability to maximise daylight from every side of the building.

![Service Details Diagram](image)

2.1.1 Ventilation

30 St Mary Axe is designed to maximise daylight and natural ventilation so that it uses half the energy typically required by an office block (Glass Works). Gaps in each floor create six shafts that serve as a natural ventilation system for the entire building (Wikipedia). A double glazing effect, which insulates the office space inside is caused by air being sandwiched between two layers of glazing. These shafts pull warm air up and allow for natural ventilation throughout the building.

![Ventilation Image](image)
air out of the building during the summer and warm the building in the winter using passive solar gain. Blinds located within the cavity of the ventilated double skin facade intercept solar gain before it enters the office environment; intercepted heat can then be reclaimed or rejected depending on the requirement for heating or cooling (Swiss Re). The ventilation system is decentralised which enables occupants to supply and control mechanical ventilation on a floor by floor basis.

Windows in the facade of the wedges, which open automatically, allow for fresh air to be drawn into the building. As a result the building uses 50% less energy that a typical prestige air-conditioned office building (Swiss Re).

2.1.2 Plumbing

The building uses an electric heat-tracing system which provides “energy-efficient hot water temperature maintenance, frost protection and snow melting” (Process Heat).

Over 1000 metres of Raychem HWAT-M self-regulation heating cable has been installed. This particular type of electric heat tracing system provides instant hot water throughout the building without any re-circulation plumbing. This allows for “greater energy efficiency, lower maintenance and significant installation time/cost savings over traditional re-circulation systems (Process Heat).

2.1.3 Lighting System

The lightwells allow daylight to penetrate the building to a further distance inside the building then they would have had the floor gone all the way to the perimeter, helping to improve the internal environment. Although these lightwells reduce the need for artificial lighting some is still required.

The building has also been equipped with motion and light level sensors to prevent unnecessary lighting (Glass Works).
2.1.4 Electrical Supply

The building uses primary fuel is gas as it is one of the cleanest available.

2.1.5 Air Conditioning

Air conditioning system consists of “assumed 4 – pipe fan coil system in conjunction with ventilated facade” and “closed circuit evaporative cooling towers” for heat rejection (Great Buildings Online).

2.1.6 Lift System

St Mary Axe consists of 23 lifts including; 16 passenger lifts (6 high rise, 5 mid rise and 5 low rise) 2 good lifts, 2 fire fighters lifts, 2 shuttle lifts for the top floor and 1 car park lift. The lifts can carry a maximum of 378 people at any one time reaching speeds of 6 metres a second.

Majority of buildings will have extensive lift equipment on the roof of the building. However seen as a bar had been planned for the 40th floor this was not possible. The architects dealt with this by having the main lift only reach the 34th floor, and then having a push-from-below lift to the 39th floor (Wikipedia, 2009).
3. External Cladding System

3.1 Overview of the Facade

The building’s exterior cladding systems consists of full glazed, double-skinned facade comprising approximately of 5,500 flat triangular and diamond shaped glass panels.(Profinder). These metal and glass prefabricated panels are fixed to the diagrid.

Fig 3.1 Cladding under construction (Munro)

The elements of the facade consist of:

- Operable glass screen
- Perforated aluminium louvers (internal sun-screen)
- A column casing of aluminium
- Facade frame of extruded aluminium

The glazing to the office areas consist of a double-glazed outer layer and a single-glazed inner screen. Sandwiched in between is a central ventilated cavity which reduces heating and cooling requirements. Its performance can be turned to maximise benefits that the prevailing internal and external environment might have to offer. The solar-control blinds intercept solar gain before it enters the office environment.
Double glazed aluminium framed facade
Ventilated cavity
Internal sunscreen of perforated louvers
Inner screen

The glazing in the lightwells consist of double-glazed panels which can be opened to allow fresh air in, while solar gain is effectively reduced through the use of grey-tinted glass with a high performance coating.

Despite the overall curvilinear shape of the building there is only one piece of curved glass which is the lens at the top of the building.

4. Specification for the Cladding System

The following section details the specification of the cladding system if 30 St Mary axe was to be built in Newcastle CBD paying particular attention to Australian Standards.

4.1 Building Description

30 St Mary Axe consists of a circular plan that widens as it rises from the ground and then tapers towards its apex. A typical floor plan has a six-leafed plan around a circular service core with triangle shaped voids acting as light wells. The cladding consists of a “double-skin energy efficient facade made of glass, with aluminium profiles and a steel frame” (Case Study Landmark building). 24,000 square metres of glass arranged in diamond-shaped panes is used to clad the building.
4.1.1 Design Life

The external cladding is to be designed and constructed to withstand the severe exposure for a realistic time period. The external cladding system is to be designed to meet BCA performance provisions listed in BCA Volume 2 – BCA 2007, Section P2.1 Structural stability and resistance to actions

The external cladding should have a minimum of:

- 30 year serviceable life, within reasonable schedule maintenance
- 50 year design life for structural integrity, this is inclusive of brackets, framings and fixings

4.1.2 Structural Capability

AS 1170.0:2002 Structural Design Actions – General Principles refers to loads in which the building must be able to withstand from. These include loads either generated from the structure or from the environment.

Dead Loads – are the loads generated from the building itself. Refer to AS 1170.1:2002 Structural Design Actions – Earthquake actions in Australia.

Wind Loads – Due to the shape of the building vortices, which can generate strong gusts at the base of the building, have been reduced. The shape also helps deflect strong winds around the building therefore causing less stress on the external cladding. The design for wind loads should meet AS 1170.2:2002 Structural Design Actions – Wind Actions.

Earthquake loads – In 1989 an earthquake hitting Newcastle, reaching 5.5 on the Richter scale, destroyed and damaged many buildings. As Newcastle is located in an area which can suffer from earth disturbance the building is to be designed to meet AS 1170.4:2007 Structural Design Actions – Earthquake actions in Australia.

Ground Water – Due to Newcastle’s CBD location being only a few meters above sea level precautions are to be taken in regards to flooding. The building shall be designed to meet AS 1170.1:2002 Structural Design Actions – Permanent, imposed & other actions.

4.1.3 Water Penetration

The external cladding system is to be designed to resist water penetration from heavy rain, windy conditions and during window cleaning. The cladding standards are to meet AS 4420.5:1996 Windows – Methods to test. Water penetration resistance test.

4.1.4 Acoustic Performance

The external cladding is required to protect the occupants from external noises entering the building and to help maintain a good acoustic atmosphere internally. The acoustic performance design is to meet AS 1055.1-1997 Acoustic – Description and Measurements of Environmental Noise – General Procedures.
4.1.5 Fire/Smoke Separation

With relation to fire separation inside the building there are various issues which need to be addressed. Fire/Smoke Separation regulations are to meet AS 4284: 1995 Testing of Building Facades as well as BCA Parts C2 Compartmentation and Separation, C2.6 Vertical separation of openings in external walls and C3 Protection of Openings.

4.1.6 Glazing

Majority of the cladding system of St Mary Axe consists of glazing. Glazing to the first 38 levels of the building are to be aluminium framed, while the domed structure on the top is to be frameless glass.

The glass used for the external cladding is to be produced and installed with good characterises in subject to wind loading, human impact, safety, security and the UV elimination.

Glazing to be used for the cladding is Solarplus® Low E Twin-Glaze unit by G.James. It is chosen for its superior thermal performance. Glass is to be clear in colour and grey glass for the atrium and dome.

Glazing is to meet the following standards:

AS 1170.4:1993 Minimum design loads on structures – Earthquake loads
AS 1288 Glass in buildings – Selection and Installation
AS 2047 – 1999 Windows in buildings – Selection and Installation
AS 4420.0 – 1996 Windows – Methods of test – General introduction and list of methods
AS/NZS 1170.1:2002 Structural Design Actions – Permanent, imposed and other actions
AS/NZS 1170.2:2002 Structural Design Actions – Wind actions
ISO 9000 Quality management and quality assurance standards

5. Legal Issues

5.1 Requirement for BCA

Buildings within Australia must be built in accordance with regulations as set out in the BCA. In the following section a case study approach has been taken in regards to requirements of the BCA in the case of Foster and Partners 30 St Mary Axe building.
5.1.1 Type of Construction Required

Part C1.1 of the BCA sets the minimum type of fire resisting construction. The Case study building (and any high rise building to be built in Newcastle) has 4 or more rises in a class 5 therefore the type of construction is A.

5.1.2 General Floor Area & Volume Limitations

Part C2.2 of the BCA states that the fire compartment or atrium must not exceed 8000m$^2$/48000m$^2$, unless sprinkled with a smoke exhaust system. See section 6.2.2 for details.

5.1.3 Separation by Fire Wall

Part C2.7 of the BCA states that fire walls must be constructed so that they meet the specified levels of fire protection.

5.1.4 Separation of Lift Shaft

Part C2.10 of the BCA requires lift shafts to be separated from the building and in an enclosed shaft. All emergency lifts must be contained within a fire-resisting shaft having a FRL of no less then 120/120/120. The floor plan below highlights the service lifts indicating that there are masonry walls constructed around the lift shaft. Therefore complies with BCA requirements.

5.1.5 Number of Lift Shafts

Part D1.2 of the BCA requires buildings over the height of 25 metres to require at least two exits from each story. As indicated in the above image St Mary Axe has the required minimum number of fire exits provided for each level and therefore complies with BCA requirements.
5.2 Fire Regulations

The spiral lightwell arrangement allows for a fire escape strategy based on a variation of phased evacuation. The building is divided into fire safety zones at every sixth then second floor. This allows for the evacuation of one area at a time as opposed to the whole building at once. A system of smoke curtains form smoke reservoirs in the lightwells. Natural ventilation is used for smoke clearance for the lightwells. (Mace) This eliminated the spread of smoke through the lightwells from lower floors.

5.2.1 When Fire-isolated Exits are required

Part D1.1 of the BCA requires every ‘required’ fire exit to be fire isolated. As shown in figure fire stairs appear to be constructed from masonry to comply with BCA standards.

5.2.2 Sprinklers

Part E1.5 of the BCA requires sprinklers to be installed in a building which has a height of more then 25 metres. In the case study of St Mary Axe a sprinkler system has been used. Lightwell based floors are protected by sprinklers on the overhanging soffits above (Mace). The sprinkler system also includes an array of window sprinklers on levels 2 and 3. However there is no sprinkler system in the dome. These were omitted on aesthetic and practical grounds. “Instead the mechanical ventilation system needed for environmental purposes has been upgraded to serve as a temperature and smoke control system” (Mace).

5.2.3 Fire Control Centre

Part E1.8 of the BCA states that buildings over a height of 25 metres, requires a fire control centre facility. The installed fire alarm system includes “automatic smoke/heat detection, manual call points, sprinkler flow switch activation, auto dial-up facility to London fire brigade, two-way fire fighter’s system and a central fire command centre” (Great Buildings Online).
Conclusion

This report has investigated the technical and management issues associated with the construction of a high rise building taking a case study approach with Forster and Partners’ 30 St Mary Axe building in London, UK.

As demonstrated in this example, the design and construction of a high rise building is very complex and involved process. In regards to the Vision 2020 and Newcastle City Centre LED 2008, 30 St Mary Axe could realistic meet these requirements.

As we move towards design buildings which are more environmentally friendly we are able to take the example of 30 St Mary axe and design a building which can meet the requirements of the clients without compromising the environment.
Resources

Munro, Dominic; “Swiss Re’s Building, London” retrieved 04/04/09
http://www.sbi.se/uploaded/dokument/files/Art_Swiss%20Re%C2%B4s%20Building,%20London.pdf

Buchanan, Peter; “The Tower, An Anachronism Awaiting Rebirth?” retrieved 04/04/09

Emporis.com; “30 St Mary Axe” retrieved 10/04/09

Architecture Week.com; “Swiss Re Tower by Foster & Partners” retrieved 06/04/09

Freiberger, Marianne; “Perfect buildings: the maths of modern architecture” retrieved 04/04/09

Swiss Re; “Sustainability at 30 St Mary Axe” retrieved 06/04/09

Absolute Astronomy; “30 St Mary Axe” retrieved 06/04/09

MRMCA; “Case Study 001 – 30 St Mary Axe, London” retrieved 06/04/09 www.rlrd.com

The Institution of Structural Engineers; “30 St Mary Axe, London” retrieved 10/04/09

ICON Magazine Online; “30 St Mary Axe” (September 2004) retrieved 10/04/09

Processheat; “Case Study: 30 St Mary Axe (Swiss Re Building)” (2007) retrieved 23/06/09
http://www.processheat.ltd.uk/clients/case-study1.html

Fedun, Bill; “30 St Mary Axe” retrieved 20/05/09

www.hilsommaroran.com; “Spotlight Projects – 30 St Mary Axe” retrieved 20/05/2009


www.londonarchitecture.co.uk; “30 St Mary Axe” retrieved 12/06/2009

www.wikepedia.com; “30 St Mary Axe” retrieved 12/06/2009
Appendix

The following has been taken from Dominic Munro’s report titled Swiss Re’s Building, London

Height to top of dome: 179.8 m
Height to highest occupied floor level: 167.1 m
Number of floors above ground: 40
Number of basement levels: single basement across whole site
Largest floor external diameter (lvl 17): 56.15 m
Site area: 0.57 hectares (1.4 acres)
Net accommodations areas:
➤ Office 46,450 m²
➤ Retail 1,400 m²
Office floor-floor: 4.15 m
Gross superstructure floor area (incl. lightwells): 74,300 m²

Tower Structural Steelwork
Total weight of steel (from Arup Xsteel model): 8,358 tonnes
of which:
➤ 29% is in the diagrid
➤ 24% core columns
➤ 47% beams.
Total number of primary steel pieces: 8,348
Total length: 54.56 km
Diagrid column sizes:
➤ Ground – level2: 508mm f, 40mm thick
➤ Level 36–38: 273mm f, 12.5mm thick
Hoop design tension at level 2: 7,116 kN
Perimeter column maximum design load: 15,460 kN
Core column maximum design load: 33,266 kN

Foundations
750mm diameter straight-shafted piles into London Clay
Number of piles: 333
Total length of piles: 9 km
Total design capacity: 117,000 Tonnes

Credits
Client: Swiss Re
Project Manager: RWG Associates
Architect: Foster and Partners
Structural Engineer: Arup
Building Services Engineer: Hilson Moran Partnership
Cost consultant: Gardiner & Theobold
Fire Engineering: Arup Fire
Main Contractor: Skanska
Structural Steel sub-contractor: Victor Buyck – Hollandia