Designing a Vertical Transportation Strategy in the Largest and Tallest Building in the City of London

John Stopes

The Vertical Transportation Studio, 70, Gracechurch Street • London, EC3V 0HR, UK

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Abstract. This paper will cover the various stages of creating the largest and tallest building in the City of London. The paper will be presented from the perspective of a specialist vertical transportation consultant.

The area around Bishopsgate and Leadenhall is the central hub for the insurance and legal professions in the City of London and over the past 10 years, it has seen substantial growth in the number of tall buildings to provide modern commercial accommodation.

The development was originally known as "The Stub" and had aspirations of being the tallest building in the City. It was properly known as the "Helter-skelter" due to its articulated top. The development failed for various reasons including being over ambitious, inefficient and poorly-funded.

A number of attempts were made to bring the project to fruition and the current professional team were able to put together a scheme which was far more appealing and responded to the reasons why the original scheme floundered.

A feasibility study for a commercial building designed to extend up to 309m in height was subsequently commissioned. As with most large projects there were extensive exchanges and discussions looking at new ideas and how they affected the core as well as the height and efficiency of the building.

It was crucial that the lifting strategy was developed at an early stage as the height and efficiency of the building would be materially affected by the design.

This paper sets out the journey through the whole design process from concept to delivery.

1 INTRODUCTION

22 Bishopsgate is on the site of the failed development which used to be known as the "The Pinnacle". The ambition, for what was to bear the nickname the "Helter-Skelter" (see Fig.1), was for it to be not only the tallest building in the City of London, but also for it to become an architectural icon. Its articulated shape at the top gave it its nickname, however, within the financial climate of London enduring at that time, it also needed to be efficient to enable the funders and developers to make enough profit. It was not only an inefficient design but also expensive to build and therefore why the original plans for the site failed. The main core had been constructed, including the basement floors, to Level 6. Yet even that progress was hesitant – being built a couple of floors at a time as the funds became available. It eventually stalled altogether and became known as "The Stump" (see Fig.2). The City of London became desperate for change.

Figure 1: The original and dramatic Helter-Skelter vision

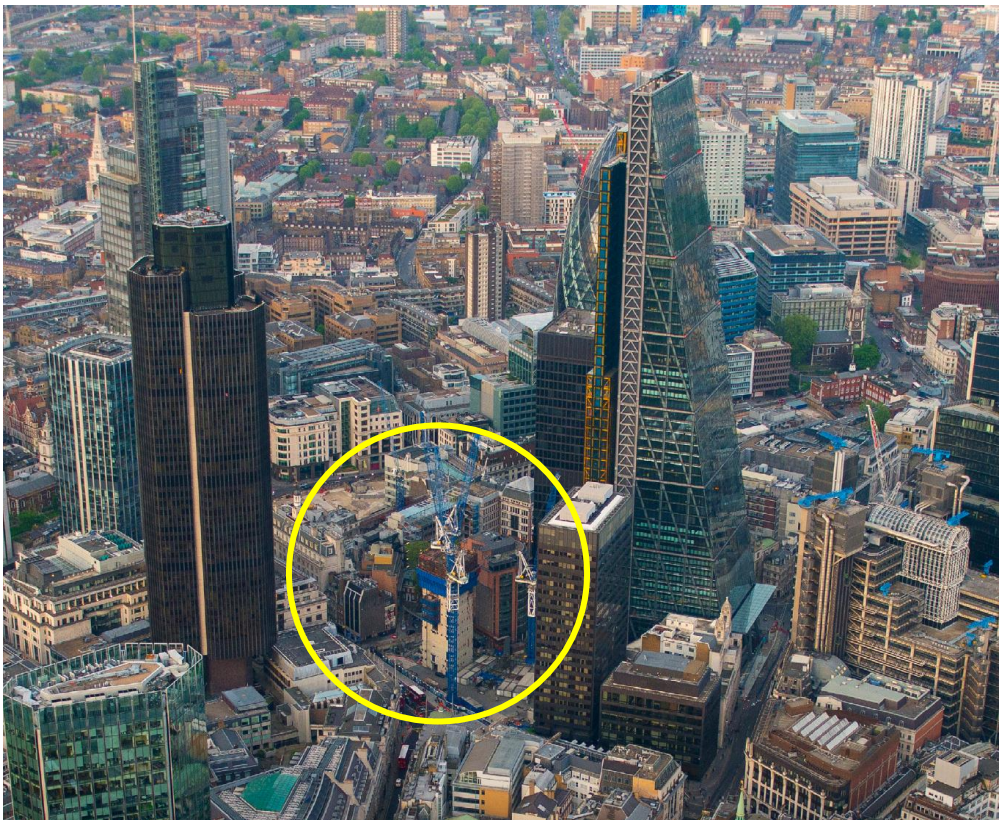

Figure 2: The Stump

A new developer became involved whose two senior partners were behind the original Broadgate scheme and who could bring an enormous amount of experience and knowledge to the project.

They courted funders and were eventually able to make a deal with the original owners, so a start was made on carrying out a feasibility study.

The original architects for the Helter-Skelter had a major split in their London practice at partner level and a new practice was formed out of the ashes. They had employed most of the original team and due to their intimate knowledge of the site and all its challenges, they were invited to look at a new scheme.

Shortly afterwards, a further company were also invited to act as multi-disciplinary engineering consultants, covering: structures, mechanical, electrical and plumbing and specialist services such as fire and life safety, façade access, environmental and of course vertical transportation (VT).

This is a journey which started in 2012 and is still is yet to be completed, however, the first occupants are beginning to move in.

2 FEASIBILITY

2.1 Setting the criteria

The project commenced by studying the existing design and aiming to make it more viable. It quickly became clear that this was not possible and as such embarked on a journey to create a new commercial office building, which might not look so distinctive, but would offer better return on investment and would be far easier to build and eventually let.

One of the most important aspects in designing tall commercial buildings, is to find a way of making the actual lettable office space as higher percentage of the overall available space as possible - having usable space on every floor and good levels of daylight.

In all tall buildings, the ratio between the total available area of a floor plate and the actual usable area which can be let to an occupier are considered. In the UK we refer normally to the Net Internal Area (NIA) and the Gross Internal Area (GIA) [1]. In very simple terms, if we can achieve a Net to Gross ratio of a minimum of 70-75%, it is seen as relatively efficient. Square and rectangular shapes are most efficient and are easier, simpler and therefore less expensive to build.

The first part in considering the form and height of a tall building, once an architectural study of the site has taken place, is to determine the parameters one can push to - looking at how much of the site can be filled. With the building itself, setting the footprint and then determining how efficient we can make the core compared to the external envelope of the building, given its target height.

Most of the core space in a tall building is taken up by lifts and their lobbies and as such there is always a challenge from developers and especially architects, to reduce the volume of the lift cores.

Finding a sweet spot in the lifting strategy will very often set the height of the building, so working closely with the developer and architect at this time is fundamental to the outcome.

In this case, the professional design team had no fees unless the building succeeded through the feasibility stage and the funders were happy with the results – then allowing the project to proceed to the design stages and Planning Application. If planning permission could be obtained, then the odds were very high it would be built. A good incentive to optimise the design you might say.

There were specific criteria the developers and funders wanted to be met:

- A population density on every office floor of one person per eight square meters (one to eight) calculated from the NIA.
- Adopting an 80% floor utilisation factor.
- Compliance with the performance recommendations of the BCO Guide 2009 (and later 2014 [2, 3]).
- The ability to board a lift in the main lobby and travel direct to your floor – considered essential in the London market.
- 309.6m is the ceiling imposed by the Civil Aviation Authority, which is set by the flight path of the aeroplanes flying in and out of City Airport

The overall site is large in comparison to others in the City. It is approximately 100m x 40m. This enables large floor plates and as such there would be a need to transport high numbers of people in the peak periods.

It immediately became evident that single deck lifts would not be able to transport sufficient numbers of people without taking up too much core space, which would deem the building unviable.

The alternatives to be considered would be:

- Sky Lobby solutions
- Double Deck [4]
- Two independent lifts in one shaft with a common motor room

Whilst sky lobby solutions are efficient in terms of core space, they do not fulfil one of the main criteria demanded in the City of London – you must be able to travel direct to your floor from the main lobby without changing lifts. This is a demand made by tenants, letting agents and seasoned developers alike.

The developer and funders were not happy with being tied into a single manufacturer to deliver what would become the largest lift and escalator contract ever placed in a commercial building in the UK. It was too much risk and as such it was decided to concentrate, for the most part, on Double Deck (DD) solutions going forward.

DD lifts are not perfect as there are several design restrictions brought about by their fixed nature, however, after presenting an analysis of the various systems looking at pros and cons, the client decided to commit to this strategy for all the main groups serving the office floors. This would be challenged from time to time and the other options reconsidered, yet it always came back to the DD strategy as being the optimum for this building.

The new building would have major entrances at the North towards Liverpool Street Station and the South towards London Bridge and East towards Fenchurch Street Stations (see Fig.3). Bank Tube station is also close to the West along with Aldgate. Additionally, there would need to be an entrance at the opposite side to Bishopsgate, where the building is facing the Aviva Building and 122 Leadenhall in a street known as Undershaft.

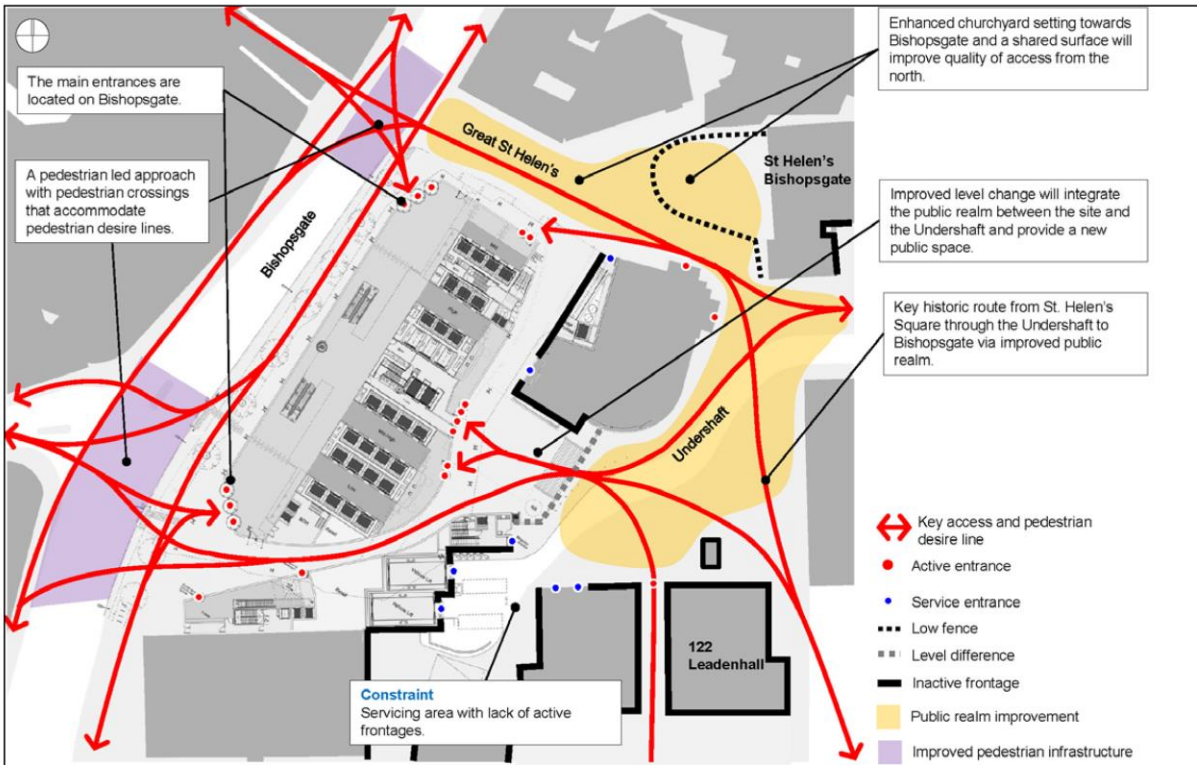

Figure 3: Pedestrian access routes – "Space Syntax Limited © 2015"

2.2 Creating Rules

From experience, it is necessary to create a set of rules which are adhered to throughout the design process so that the funder, developer and the wider team understand the engagement.

Especially in the current office environment, the way buildings are being occupied is changing. Most occupiers in major capitals, including solicitors, lawyers, insurance companies and banks, do not just sit people at desks on the office floor - they have break out areas, meeting rooms, cafes, informal relaxed areas actually on the floor. Then they might have floors dedicated to amenities or large areas devoted to such as gyms, creches, retail, food and beverage, auditoriums and many other uses.

The challenge VT consultants face is how to design for such uses prior to a tenant being signed up, which in a speculative building such as 22 Bishopsgate would not be until after construction was well under way on site.

This is where the density of occupation was used by the developer at one to eight on every floor of the building. In a building of this size they are convinced that not everyone will occupy to that density, more like an average of 1 to 10 and as such this becomes their buffer.

The occupational density has become a talking point in the City of London ever since the owners of the major dockland development to the east of London became involved with 20 Fenchurch Street. The Chairman had not used Double Deck lifts in one of his buildings before and he wanted a buffer to be sure there would be no performance issues. So, it was designed to one to eight on each floor. The building was marketed as such and ever since, there is competition amongst developers and letting agents to match or better that – so this was a tick in the box and perhaps the first rule.

There is always a fight for space in any building within the core and as such, the pressure is on to keep the number of lifts to a minimum necessary to meet the recommended performance targets. Targeting waiting and journey times here are very important and measures the quality of performance. The arrival rates and handling capacities needed to provide the correct quality of performance are also recommended by the BCO and CIBSE Guides [3, 5]. These are now clearer, as are the traffic profiles for use in commercial office buildings.

It was clear Destination Controls would have to be used, as with Double Decks [4] the only way to make them work in local groups with mixed traffic conditions is with this type of control.

This is the wording from BCO Guide to Specification 2014: [3]

- "Lifts should target an up-peak average waiting time across all floors served of no more than 25 seconds (s). Average waiting times (AWT) of up to 30 s may be acceptable in cases where the average time to destination is 80 s or less.
- Lifts should target an up-peak average time to destination across all floors served of no more than 90 s. Average time to destination (ATTD) of up to 110 s may be acceptable where the morning up-peak average waiting time is less than 25 s."

After discussions with the developer it was decided to target a 30 second AWT and 80 second ATTD - thinking that as this was a tall building, the journey time could be extended a little if necessary to make things work, as in practice people would expect to take a little longer to reach their destination than they might in say, an eight floor building, (bearing in mind a high density was being used as well). This became another rule to work to in producing results for each scheme going forward.

In taking this approach though, the limits were being pushed and it would leave no room for flexibility if it was needed to do "something different" in the building or if a tenant who was interested in taking space wanted to "over occupy" at a greater density still.

A simulation tool was used to carry out the traffic studies. Over the years, it has been learnt how to benchmark results against those of the major lift manufacturers, to grasp if there will be any surprises further down the line. This is a dynamic process and one which works well.

So, the settings used are very important and it is equally important that these are consistent through the design period.

2.3 Optioneering

In searching for the most optimum scheme which would satisfy not only the investors and developers but also the City Planners, English Heritage and all the other institutional bodies which seem to get involved and hold a lot of influence, an exhaustive number of options were run through over a period of 18 months.

The office floors started off with floor plates with an estimated 1500m^2 of NIA. This was for a scheme called "Interlocking", which referred to the architectural form of the building and was aimed at reusing as much of the existing basement and core as possible. The demolition costs of the basement and core were enormous and as such this appeared to make sense at the start.

The resultant building, however, was not so large and the team knew there would be more to come if demolishing the whole of the existing core was considered and then modifying the basement floors to a greater extent.

There was also a public right of way across the southern end of the site which needed to be maintained. In the "Helter-Skelter" scheme, escalators were used to transport people up and over this thoroughfare and it meant that the journey to the lifts was very truncated.

Similar concepts continued to be weighed up, known as "Carved Rectangle" and "Refined Carved Rectangle", where the main groups of lifts would start from effectively Level 2 of the building for the next few months. There were many variations on the scheme as the top half of the building also went through various changes aimed at meeting the planners' requirements. These included schemes affectionately named as "Tub Top", "Glass Top", "Magic Carpet" and others.

Escalators serving a lobby elevated up 15m from street level were considered and then shuttle lifts serving up to a lobby at Level 8 were reviewed, like the 200 West Street building. This latter concept does have advantages from a lifting point of view as it allows large uninterrupted floor plates beneath the lobby. There were, however, expensive structural solutions needed – remember the lift core is very often a major structural support for the building and most of it below Level 8 was being removed, on what was going to be a very tall building.

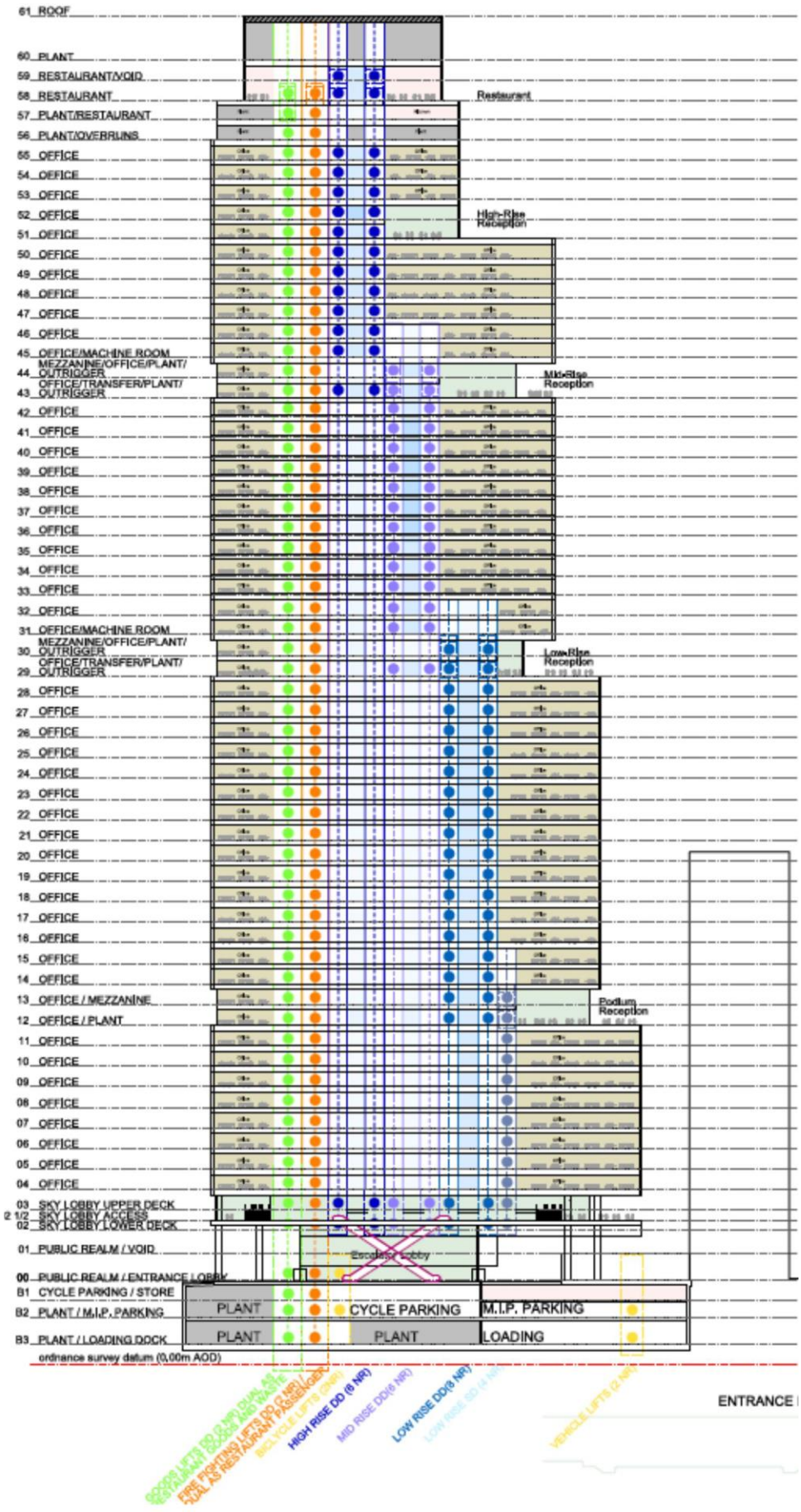

Figure 4: "Universal" Option – with the main lobby above street level

The next scheme became known as “Universal” and had larger floor plates of 2000m^2 NIA (see Fig. 4) - this was December 2013. In this scheme, escalators serving from street level to a main lobby level at Level 2, Mezzanine and Level 3, were still retained. There was a group of four low-rise DD lifts, eight car DD low mid-rise and then six car DD groups of high mid- and high-rise.

In conclusion, in this approach, the journey into the building was thought overly complicated for the occupants. It was decided that the main entrance lobby should be firmly at ground level.

In December 2013, a concept report was created based on this scheme, however, through the next 12 months many more variants were worked up, “Moonraker”, “Refined”, “49.15”, 52, 52.1, 54, eventually coming to the basis of the scheme now being built.

The floor plates had grown to 2500m^2 up to level 30, 2100m^2 to level 42 and 1800m^2 to Level 54. The lobby was now at street level and 12 different lifting configurations were looked at in the final month in the lead up to obtaining agreement from the funders, to go ahead with designing and construction of what would be the largest speculative office building ever constructed and home to what would now potentially be 12,000 people.

Agreement was reached with the funders and at the beginning of 2014 the project became real after all the hard work the team had voluntarily contributed.

3 SCHEMATIC AND DETAILED DESIGN

Unlike just about every other project that was worked on, the traditional RIBA design stages were in fact fused together and just rolled into one.

The continual refinement was ongoing and through 2014 and 2015 more options were weighed up as the architectural, structural and services solutions were refined.

The basis of the scheme had remained the same, however it was not until June 2016 that the final configuration was settled on (see Fig. 5).

Over time with all the discussions with not only the planners but also the general contractor, who was originally appointed on the Helter-Skelter, the final height of the building had been set. It was not only a planning issue but also a buildability issue. At this time, the cranes would not be allowed to break above the 309.6m ceiling demanded by the Civil Aviation Authority for the flight paths into London City Airport – this has always been the limiting factor for London’s high-rise developments.

The lifting scheme that was settled on had now been centred around three groups of eight 2000kg (26 person) Double Deck lifts.

They fitted the core well and especially the width of the building, however, they alone would not help get it as high as desired.

The lower seven floors of the building above ground were treated differently by using a group of three 2000kg (26 person) single deck lifts. This enabled office floors as high as level 57 to be reached with the high-rise 2000kg (26 person) Double Deck lifts. [6]

These three lifts were added to the north end of the core, close to the North Entrance.

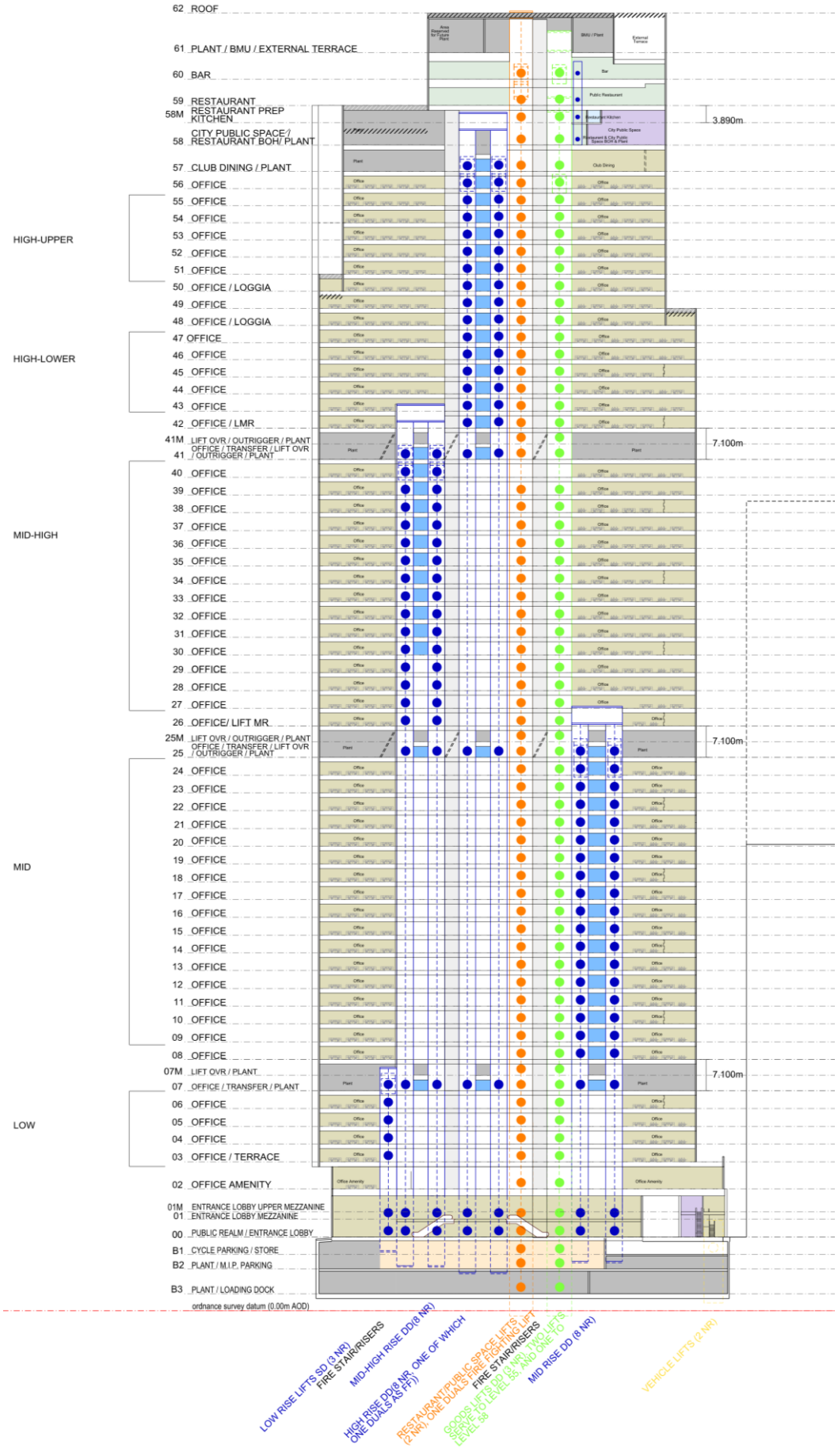

Figure 5: The basis of the final scheme

Whilst the basis was set, there were many other areas of the building that had to be designed including the goods lift service, the viewing gallery and restaurant, parking and showers for 2400 cycles in the basements and eventually the amenity spaces would start to emerge. These are all subjects in themselves and could be subject to their own papers.

3.1 Goods Lifts

There is no other commercial office building of this size in London and as such, designing the goods lift service could not be compared to anything else. Goods lift design is not well documented in the various design guides such as BCO and CIBSE. [7]

Many hours were invested in touring the other towers in London, speaking to the building managers and considering strengths and weaknesses of each design.

Generally speaking, the other tall buildings in London might have had two goods lifts as their main artery. Some buildings only had one lift serving the top floors of the building. In this case there would be no redundancy. In this type of high-quality office building, you cannot use the passenger lifts as they are too busy at peak times and you cannot risk damage.

It was settled on three 3500kg goods lifts and the aim was to have them serving every floor of the building. Initially, this was successful but as the top of the building developed the space requirements for plant, the viewing gallery and restaurant meant that at the top not all the lifts were able to serve all of those floors. This was not ideal and it also meant special buttons on the floors would be required to call particular lifts to particular floors.

Originally the electrical design demanded five large generators to be deployed at the top of the building and they were too large to fit inside a normal goods lift. After much negotiating and discussion, the electrical engineers were persuaded to switch to six smaller generators. Even now it was still needed to over rate one of the goods lifts to 7400kg, on a special operation to carry one.

These lifts are also fast at 4.0m/s in an effort to provide a good level of service within this tall building.

3.2 Viewing Gallery and Restaurant.

These floors are effectively owned and operated by a separate entity.

The original design was centred around maximising the space to accommodate as many people as possible and churn them as often as possible as the experience was going to be chargeable. The views were going to be the best in the City with uninterrupted views for 360 degrees. The most efficient way to move as many people as possible to and from those floors was assessed. There are four levels in all, served by a number of local lifts, and these were to be fed by two 2250kg (30 person) Double Deck Lifts, capable of moving in excess of 800 people per hour.

In the end, the City of London Planners changed their policy, insisting that all such viewing galleries in central must in future have free access to the general public and so the potential had diminished somewhat. The level of service had already been committed to the owner and as such that is how it remains. The two viewing gallery lifts are high speed shuttles at 8.0m/s and the top deck of one of them also functions as a firefighting lift, serving all floors from ground and above via the rear entrance. Both lifts have front and rear entrances in order to maximise and simplify traffic flow – in the same way as the lifts in some of the deeper London Underground Stations.

The Viewing Gallery has its own entrance to the south of the building which traverses Art Street. Access lifts are provided to an upper level where escalators are taken to the appropriate deck, whether you are travelling to the Viewing Gallery or Restaurants reception level. At a separate, dedicated exit, there are stairs and lifts.

All these lifts and escalators will effectively be in use 20 hours a day, to serve the many functions that will exist around the clock, which will place pressure on maintenance regimes.

3.3 Basements

There are four basements in all and an additional basement which had to be created to gain access to the lift pits of the high-speed lifts, where they are more than 2.5 m deep. This was expensive but very necessary.

Within the basement there are over 2400 cycle spaces, showers associated changing facilities, plant and the loading bay.

As this area was being developed, it was clear the main lifts could not serve down to the basements, due to the massive disruption it would cause to the lift service and it was quickly agreed for a separate group of lifts to be used to link the basements to the lobby. There would potentially be a lot of traffic going to and from the basement during peak times.

The cycles themselves use a stair with a runway for the cycles and this is supported by a disabled cycle lift.

The loading bay is served by two 26,000 kg hydraulic lorry lifts. These are enormous and are very specialist. They must be very reliable as they will be used intensively for periods during the day, especially mornings. By using a consolidation centre outside of London, the number of lorries is reduced but there will still be a substantial number of movements when you are serving 12,000 people.

There is a separate firefighting strategy for the basements and it is served by two dedicated firefighting lifts within the associated firefighting cores.

3.4 Additional Challenges

The whole site is on a slope with around 1000mm difference from one end of the core to the other. As Double Deck lifts were employed, it was imperative the floor to floor heights remain even through the whole building, so a series of gentle ramps were employed to even things out.

Due to the depth of the floor plates, the floor to floor heights needed to be taller in the lower floors so the floor to ceiling heights could be increased to allow more light in. All these variations had to be taken up and agreed with the architects and developers and solutions found for the various lifts.

Another firefighting lift was required in the main core and there was no room. Therefore the same principle as for the Viewing Gallery Lift was used and again, an upper deck of one of the high-rise lifts with a rear entrance opening into the firefighting core, was also used. Whilst this might have compromised the design of one of the main DD lifts, it saved substantial core area. These principles were all agreed with the City of London Building Control who had been very supportive throughout.

As the design continued to develop, it was essential that a theme for the building was developed and this became dedicated to art. One of the partners of the developers, being an avid art lover, was very influential in this decision. Hence the name given to the public thoroughfare of Art

Street and the amount of art which will be displayed in large areas in not only the main entrance lobby but the lifts themselves.

The reception will be a library and the use of leather and wood is much in evidence.

Lastly and late in the design process, it was decided to use Level 2 as an enormous amenity space. This would serve the whole building and would shape the design for the main entrance lobby. Only the three Single Deck lifts at the north end of the core were designed to serve this level as offices and there was no interconnectivity with the rest of the building.

Due to the fact the Double Deck lifts had been designed close to the limit, there was no way they could be allowed to stop at Level 2. It was also a single level, so a "two stop" of the lifts was necessary, which would add confusion and take far too much time. Therefore, an alternative had to be found.

A combination of escalators and lifts was decided on. The basement serving lifts were to be extended at the south end of the core up to Level 2 and increase their number to three.

The escalator banks in the main lobby area, serving the upper deck of the main groups, would be extended up to serve Level 2. This would provide a compromise in as much as the occupiers would have to change lifts, or lift to escalator, to travel to and from Level 2 but none the less this would work well.

There are also amenities and wellbeing centres at the transfer floors, not overly large, however they too need to be accessed.

4 BIOGRAPHICAL DETAILS

John Stopes has held senior positions working for major international lift and escalator manufacturers from the late 1970's until 2001, when he became a Consultant working for HH Angus on several million square foot buildings in Phase 2 of the Canary Wharf Development. He then went on to work at Watermans, Lerch Bates and WSP before founding The Vertical Transportation Studio at the end of 2013. John sits on the BCO Guide to Specification VT, Peer Review Committee, is a member of the CIBSE lift group and member of the CTBUH.

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