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The Vertical Master Plan

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Temoor Ahmad is an Associate at Grimshaw where he has been developing his field of specialty in infrastructure and the associated potential for over-site development and place making. He has worked in the UK, China, the UAE and Spain over a number of different sectors involving tall buildings where he has developed the belief that tall buildings are a key influence on a city's infrastructure. Key involvement in infrastructure projects in London include Paddington Crossrail, King's Cross Station, Euston HS2 and Waterloo Station. Temoor is also Vice-Chair of the CTBUH UK Chapter.

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Neven Sidor is a Partner at Grimshaw and is integral to the practice's established innovative reputation, he led the project which gained Grimshaw international recognition - the Eurostar terminal at Waterloo Station, London. Neven has considerable tall building experience, specifically he obtained planning consent for a 50+ storey development in the City of London in 2007 which, due to the recent recession, was finally realized as a 15-storey building. The building itself is a success but the dependency the design process had on the marketplace was a key factor in the development of the Vertical Master Plan.

Steve Watts
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Steve Watts is a Partner at alinea consulting. He has unrivalled knowledge and experience in the economics of tall buildings, having worked on many prominent towers. He has contributed to a number of studies and publications, including several High-Rise Cost Models, the BCO book: Tall Buildings – A Strategic Design Guide ('Cost' section) as well as the CTBUH's Tall Buildings Reference Book which was published in 2013. He is regularly asked to present on the economics of tall buildings at conferences. Among his many roles within the CTBUH, he is Treasurer and Trustee as well as Chair of the UK.

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Adam Miller is an Associate at Thornton Tomasetti and has worked on a number of tall buildings, his main passion, particularly in the Middle East as well as other significant infrastructure projects in the UK and Saudi Arabia. Throughout his career, he has strived to create efficient, functional and aesthetically pleasing designs with the other disciplines in a holistic manner and using modern technology to its fullest. The topic of this paper is a testimony of this philosophical aim. Adam is a Chartered Engineer and a member of the Institution of Civil Engineers and the Institution of Structural Engineers.

Abstract

With over half of the world's population now living in an urban environment, major world cities (especially) will always grow in population over time. To avoid city sprawl, urban densification will be required. This will need to happen at a steadier and more sustainable pace contrary to the "boom and bust" cycle we now take as the accepted model for economic growth.

To maximize vertical efficiencies, a framework for flexible vertical growth within an established and controlled master plan is required– a 3D vertical master plan.

The feasibility of various financial models for this approach would become apparent, making it possible for developers to realize the full plot value over time. Understanding which potential legal conflicts could arise between built and in-progress developments will also inform the outcome.

Once these realities are addressed, the concept of building vertically through long-term phased increments can hopefully be realized.

Keywords: Adaptability; Construction; Cost; Density; Mixed-Use; Vertical Urbanism

In addition to the authors credited, it should be noted that this topic required input from almost every corner of the construction industry. Since its inception, the concept of the Vertical Master Plan has been greeted with a clear understanding of what this study is attempting to unlock and, more importantly, the will to clearly set out just what the current-day issues are that would need to be addressed in order to realize the full potential of this model of building.

We would like to acknowledge the following for their input on their respective fields of expertise:

Figure 1: Clockwise from top-left, high-profile tall buildings that have been at the mercy of the marketplace: Empire State Building (New York, 1931); Centre Point (London, 1967); Sears Tower (Chicago, 1973); 1 Canada Square (London, 1992); Burj Khalifa (Dubai, 2010); 110 Bishopsgate (London, 2011);The Shard (London, 2012); 22-24 Bishopsgate (London); The Spire (Chicago) (Source: Grimshaw Architects)

- Keith Brewis and Simone Demurtas (Grimshaw) in establishing the feasibility of this study and carrying it through.
- Tanya de Hoog (Thornton Tomasetti) on the initial consultations of structural options.
- John Stopes (Vertical Transportation Studio) on lift distribution based on building use splits and phasing strategy.
- Cameron Baylis and Martin Jones (alinea) on cost comparison models for different incremental build options against current build, demolish and rebuild scenarios.
- Peter Soddy (Wirth Research) on CFD analysis for effect on wind.
- Vince Ugarow (Hilson Moran) on self-sufficient MEP implementation per building phase.
- Peter Rees (University College London & Former Chief Planning Officer, City of London) on current-day planning policy as it would affect the Vertical Master Plan.
- Yair Ginor (Lipton Rogers), Norrie Courts and Donald Horner (Network Rail) on feedback for development and commercial feasibility.
- Jim Shea (Brookfield Multiplex) on overbuild construction feasibility.

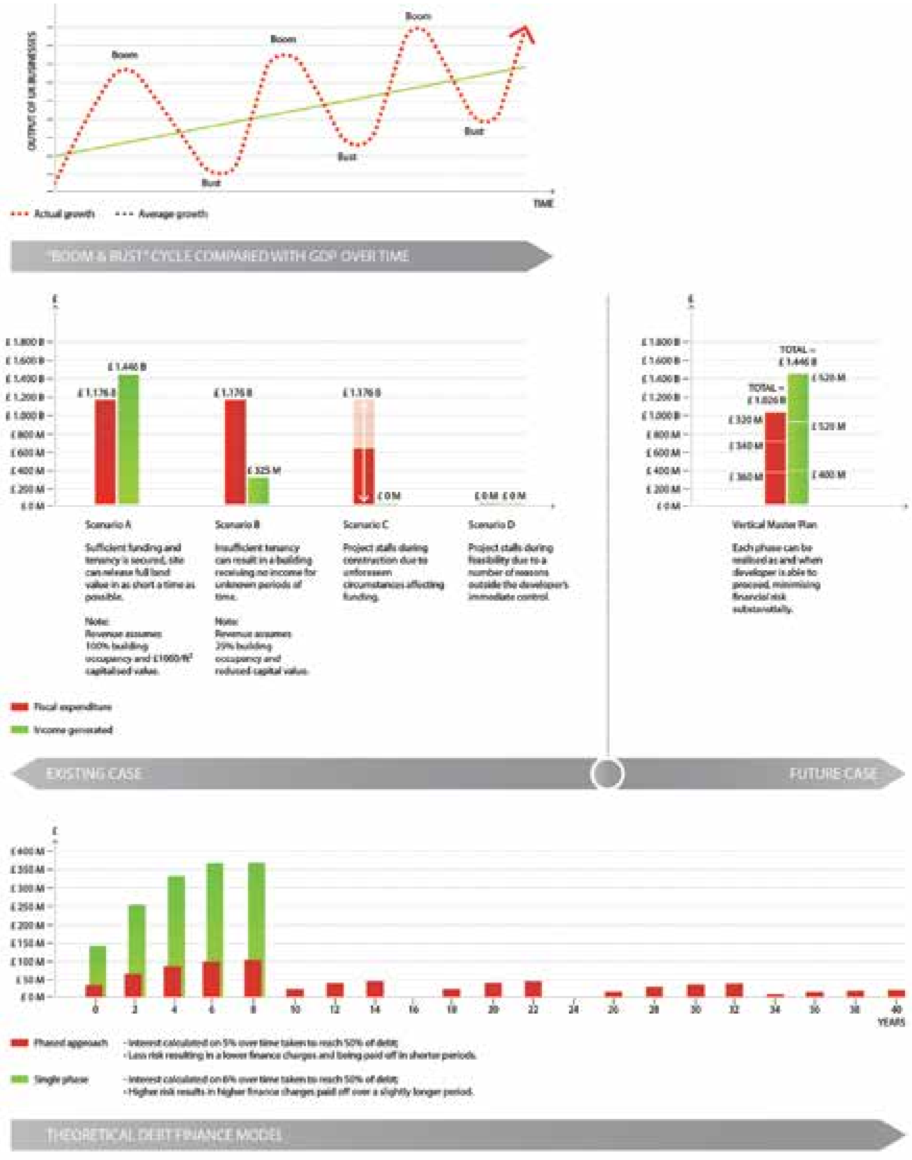

Figure 2: Three graphs which set up the proposition of the Vertical Master Plan (Source: Grimshaw Architects)

- Cecily Davis, Owen Talfan Davies and John Bowman (Field Fisher Waterhouse) on real estate litigation and the impact of incremental building on quiet enjoyment.

Relevance For Today

The timely aspect of this research relates to the recent economic downturn and how this has been a recurring feature of modern-day western society:

The Economic Downturn:

The recent economic downturn meant that developers were cautious in looking for new development opportunities. They were far more likely to look at building a mid-rise building than a high-rise one in the City. With the resulting lack of confidence and willing tenants in the market, a high-rise development was seen as high-risk. A few examples of tall buildings exposed to conditions outside of their control can be seen in figure 1.

Sustainable City Model:

The current strategy for tall building development operates on the principle of "if you build it, they will come". This is not sustainable – there is a proven history of tall buildings being completing at the beginning of a period of recession, taking years to gain occupancy. Equally, urban sprawl should be prevented – here, a tall building would in theory be valuable by increasing city densification. In reality, the manner of "sudden" provision does not help. A more steady and balanced model of supply and demand is required. The inability to build at a manageable scale prevents on-going growth at a sustainable level. The top graph in Figure 2 highlights boom and bust cycles within a context of a steady GDP growth - ideally modern economies would mirror the steady line of more predictable, lower-risk growth.

Today's thinking of developing a commercial site to its maximum potential is to proceed with various feasibility studies and concept designs finding ways to unlock a combination of added value, floor plate/core efficiencies and maximizing the permissible height. Once this is done the developer is then subjected to influences beyond their control - namely prospective tenants and project financing.

Based on the impact of these external influences, the development will either have to be scaled back to fit within the available means or risk being cancelled. If there was a way to minimize the risk, and therefore impact, of these external influences developments could be built at a much more financially sustainable rate.

The middle graph in figure 4 illustrates the current-day practices of development feasibility against how incremental overbuilding could work. The assumption which this study is based on is that this incremental expansion would be within a controlled framework - a vertical master plan. Equally, the bottom graph in Figure 6 highlights another potential advantage of how debt financing could be less onerous in shorter phases rather than one sustained commitment over a much longer period of time.

There are examples of phased construction in existence but are either on a much smaller scale or carried out on a specific case by case reason.

The Reason

Grimshaw completed a concept design, achieving planning consent for a commercial tower building which was within the City of London's commercial district, stood at a height of 217m (50 storeys) with 1,076,390m2 of net-lettable space (as shown in figure 3).

During the project, the developer encountered significant difficulties in securing the required amount of pre-let office space to justify the business case in proceeding with a building of this size. The eventual result was that the final building was 75m (15 storeys) tall and had 592,015m2 of net-lettable space. If there had been a financial and physical mechanism to allow incremental release of built office space, this might have been a different story.

This experience has been the catalyst in actively seeking to redefine the master plan design process by assuming a 3-dimensional approach. A 2-dimensional plan based study only conveys the most basic design intentions – to illustrate the proposed urban structure and distribution of land-use. With a 3-D, more holistic, approach, qualitative elements like scale, massing and even character can be investigated, allowing the social success of the master plan to be evaluated as well as urban structure and distribution of land use.

Figure 3: Grimshaw's proposal for the 50-storey tall Minerva Tower and (inset) the 13-storey tall St. Botolph Building was the eventual designed and built scheme. (Source: Grimshaw Architects)

Expected Benifits

Short-Term

- Constant growth: instead of building one super-tall building, a vertical master plan allows a range of mid-rise buildings which plug into a vertical framework.
- No letting complexities: instead of creating a mixed-use building (nearly ¾ of the current top 100 tall buildings are single-use), a vertical framework can incorporate a series of different single-use buildings.
- Developer friendly: this approach allows for a low risk approach to developments within the vertical framework.

Long-Term

- Limited urban sprawl: with flexibility in vertical growth, horizontal growth can be minimized (figure 4).
- City growth with minimized risk: much like an airport's expansion program, incremental growth in three dimensions will ensure steady growth of a city center with associated diversity of uses.
- Provision of public spaces: with each developer constructing their own building and an obligation to provide their own public space at entrance, a series of public spaces could be created rising up a vertical master plan.

The Phased Tall Building Design Process

Design Principles

The design team agreed principles with which to proceed in order to test the feasibility of this concept.

A height of approximately 90-storeys was decided on as the end condition of the phasing process. This was because a building height in the range of 300 - 400m is a common tall building height being constructed around the world. This approximate height of building is also the maximum that apparently can be constructed in London due to airspace/airport restrictions. A building taller than this would have also required a larger footprint, meaning a larger building site. In other words, the building site and footprint dimensions which we used of approximately 45 x 72 m were suitable for a building up to a height of approximately 400 m using a conventional structure and vertical transportation scheme.

In the first instance, the assumed phasing was set at three phases of 30-storeys each as the assumption was that there would be a desire to keep phasing to a minimum - which is true, but the final decision was made to proceed with multiples of 18-storeys (five phases) as this mirrored the St. Botolph case study and was a reminder that in some instances, 15-storeys would be the most feasible option for the majority of developers without the backing of sovereign wealth funds. Figure 5 illustrates the overall massing proposed.

Feasibility Assessment

Two options were developed in order to start quantifying the effort and reward of a phased building as judged against a traditional base case of "build, demolish and rebuild".

The first iteration of phased construction assumed full redundancy of the first phase which was reduced as the phases progressed. This approach is the most effective in ensuring minimum disruption to phases below but the immediate concern would be how much extra this would cost compared to a traditional building of the same size. This led to the development of a minimum-redundancy option to counter this perceived weakness.

These three building models form the basis of the feasibility assessment of phased construction compared to traditional building.

Use And Amenity

In terms of mix, office, residential and hotel use was allowed for with nominal retail presence at ground floor and possibly with each phase.

Figure 6 shows the basic sequencing of how a mixed-use tower could eventually develop. Commercial office space was seen as the most onerous use to provide for if it did not have dedicated use of the ground floor plane, other uses (residential and hotel) could allow for a relatively nominal presence at ground floor with the main reception level at the base of the relevant phase. The relationship between residential and hotel would still need careful consideration but could still be considered feasible.

Through incremental building, eventually creating a building over time will be "greater than the sum of its parts". The roof of first-phase building would act as civic/public ground plane of second-phase building and so on. Equally, the provision of separate single-use buildings in a development would create a multi-use building over time making use of non-commercial spaces balanced over a whole day.

Landlord And Tenant Issues

The phased overbuild approach is intended to allow existing tenants of earlier phases to remain in occupation for the duration of the next phase(s) of construction works. As a result, the

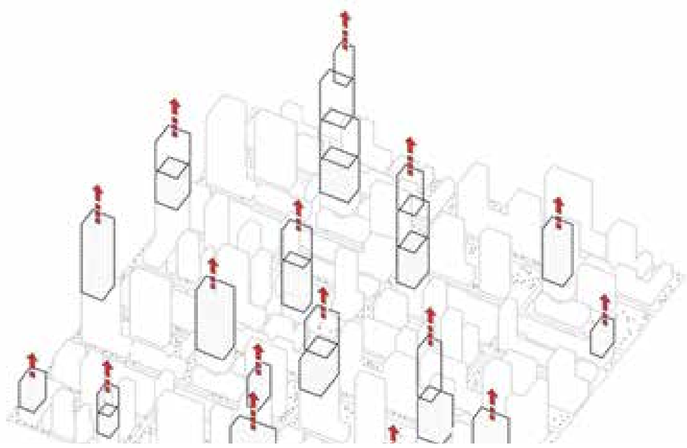

Figure 4: The vertical master plan views each building's growth as contributing to the sustainable growth of the city both financially (minimising boom and bust cycles) and physically (minimising urban sprawl and maximising density). (Source: Grimshaw Architects)

following risk factors will need to be considered.

Whilst the vertical plan model assumes that there will be no light disruption to any existing demised premises during the construction of the next phase of the development, it is anticipated that there will be noise emanation resultant from the works of construction1.

In light of this, the landlord will wish to ensure that the quiet enjoyment covenant is modified, and that it reserves to itself sufficient rights, so as to permit the proposed works of construction without triggering any liability for breach its quiet enjoyment covenant. However, this will always be a case of a balancing exercise of the landlord's and tenant's rights (both at the lease negotiation stage and at the construction stage).

Risks of claims could be mitigated by, for example:

- Limiting the hours of works of construction (e.g. outside of business hours);
- Adopting construction practices that minimize noise emanation;
- Leaving the upper floors of the constructed phase vacant during period of construction works (assuming these floor will suffer the greatest noise emanation issues).

These risks could also be managed through good estate management, for example the first phase could be let on shorter term leases without security of tenure, which can be determined easily in readiness for works of construction on the next phase and then re-let on completion of the works.

Plan Design

As this was a theoretical study, the working assumption was that the site was unrestricted on all sides. This was obviously an optimal situation and were this design model to be developed, understanding the site location and setting would be fundamental to the feasibility of the project.

The first plan iteration was to assume an efficient square shape with a central core (sized for the final phase). This worked on the assumption that the central core areas which were unoccupied by MEP or vertical transportation would be used as shafts to move construction materials up during the next phase's build process.

As the design process moved on, it became clear that minimizing redundancy within the floor plate was more attractive and reinforced a key principle of the vertical master plan - flexibility. Figure 7 illustrates the plan form that was developed going forward. With further engineering input, this plan was rationalized and became the baseline against which to test the two phased build options.

The top floor of each phase would be a permanent crash deck with a temporary fit-out to create a presentable building top while the next phase was still to be realized. Upon commencement of the relevant phase, the temporary arrangement would be removed and used as a work site and upon completion, would act as a dedicated public realm plane for its phase as seen in figure 7.

Technical Feasibility

Optimizing Construction:

Immediately, the main challenge set is of constructing a new building over an existing one or extending the height of an existing building over an extended period of time:

- Providing a permanent building-site to facilitate building without compromising quality of existing built phases.
- Structure and services built to allow for future expansion.
- Differing feasible options on extending vertical circulation.
- Optimizing prefabrication.

In terms of construction sequencing and build feasibility, in order to be viable, significant elements of the building would need to be fully prefabricated. For example, concrete risers through the building would complicate matters as logistical challenges are created at the base by the need for concrete trucks and pumps. Precast columns, walls and slabs to the maximum extent possible, or hybrid systems with steel would be recommended. Figure 8 illustrates how redundant shafts and a permanent crash-deck could aid the overbuild process.

Other items of note are:

- Personnel and materials hoists would need dedicated shafts (redundant shafts for future phases could provide this).
- Loading bays at ground level would need to be provided.
- Centre core to side cores with transfers are ideal and work with lifting.
- Additional phases will require the MEP to be extended vertically, again best done through pre-fabricated risers and kit that can be set from crane / loaded on to the floor
- Logistically this will need to be planned with minimal disruption to building occupants, as already identified and the strategy needs to be proactive for the duration of possible development.
- The reality of urban development means that, in some instances, access will be more of a challenging constraint i.e. single or dual aspect access.
- New technology of 3D printing and pre-fabrication could very much benefit this approach of over building.

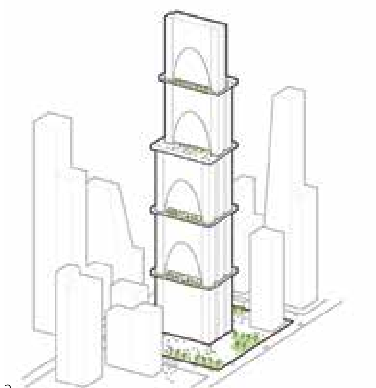
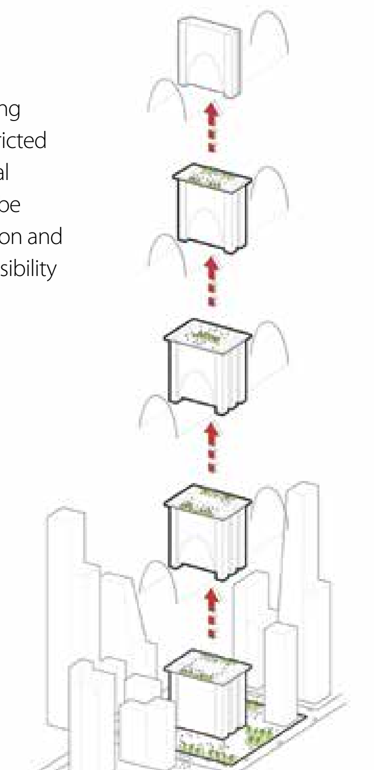
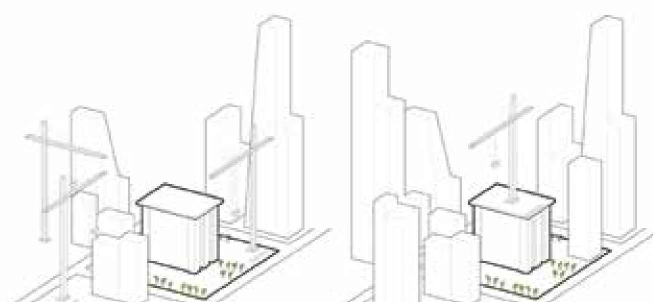
a. b. c. d.

Figure 5: From left to right: a. The building designed through the Vertical Master Plan ideology shown fully assembled; b. Exploded to highlight the five phases and relationships of one to the next via the dedicated communal spaces. c. Many city centre sites experience disruption from adjacent construction sites - this is accepted as being inevitable. d. The level of disruption above an existing development may not be as disruptive when compared to today's accepted idea of disruption. (Source: Grimshaw Architects)

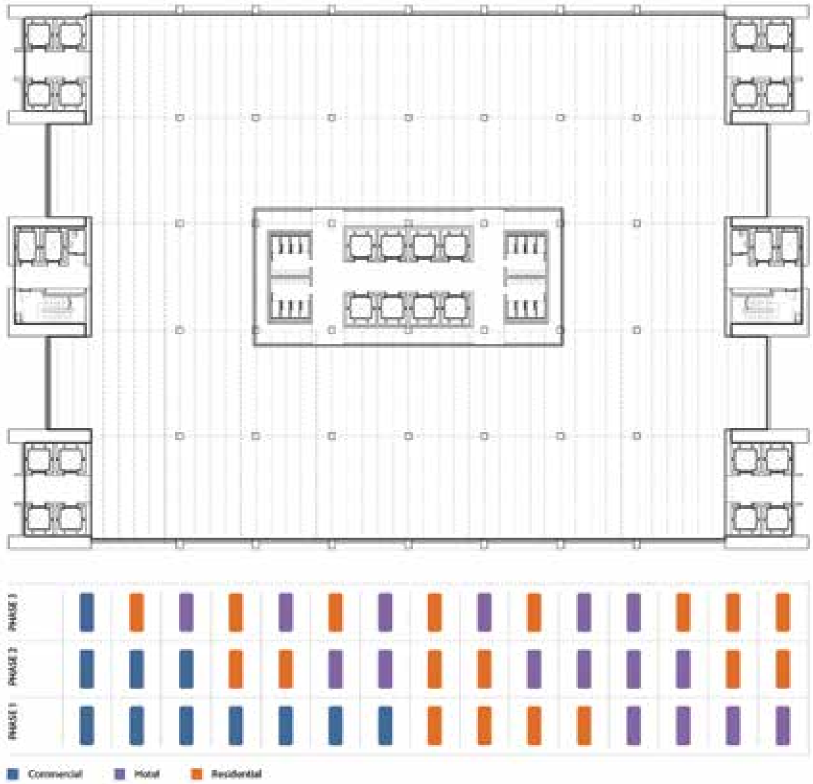

Figure 6: Diagram illustrating the various combinations of uses. Commercial space being the most restrictive. Shown over three phases for clarity when compared to use, but equally applicable to any number of phases. (Source: Grimshaw Architects)

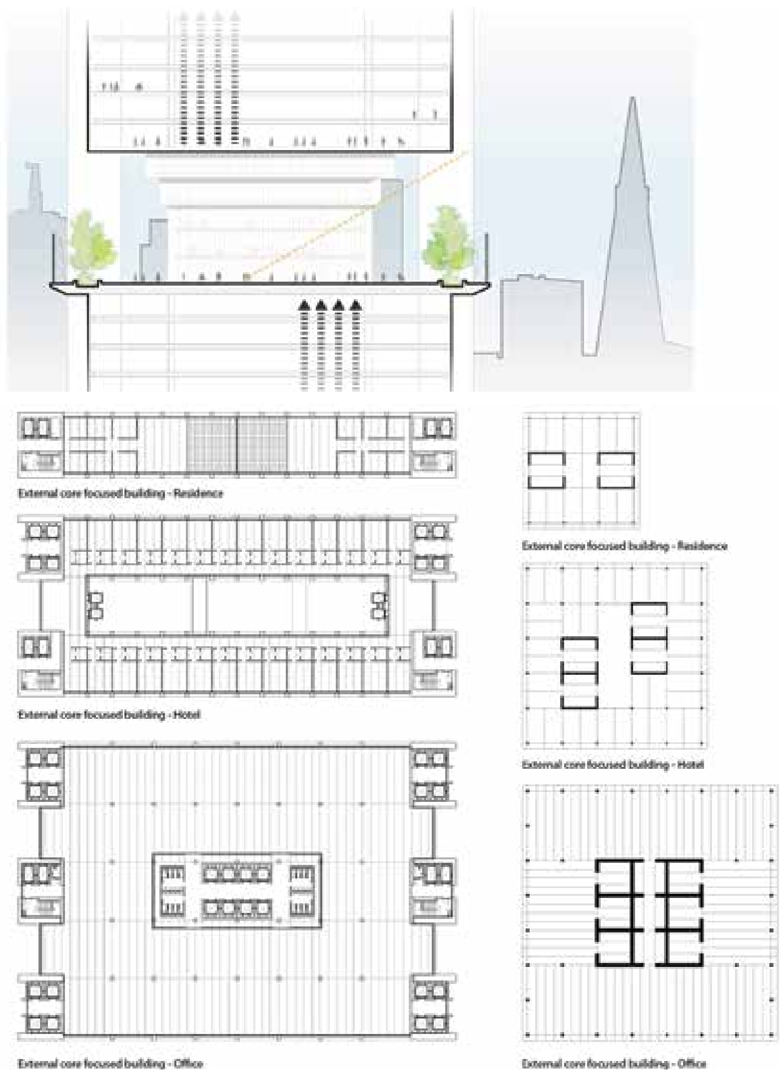

Figure 7: The early plan studies compared a centre-core plan tapering in area as it ascends (right) against an (all-phase) external-core plan with local phase-specific cores (left). Also, note the diagrammatic section of the newly created amenity space at the base of a new overbuild phase (top). (Source: Grimshaw Architects)

Pioneering Construction Methodology:

This construction methodology would be unique if it were implemented, although there have been instances of flexible vertical construction in the past but never fully capitalized on like, say, the prefabrication process. Advances in construction methodology in sensitive areas now are so commonplace that the idea of building above an existing building seems very much in reach.

Three examples of this thought process are:

- Bentall, Vancouver – originally 12-storeys (2002), now 22 (2007)
- Roanoke Building, Chicago – was 16-storeys (1915), 21-storeys (1922) now 35-storeys (1925)
- Blue Cross Shield Tower, Chicago – was 33-storeys (1997), now 57 (2007-2010)

MEP Provision

There are three fundamental MEP strategies presented each with merits and shortfalls, when considering disruption and redundancy as criteria for constructing a phased tall building (see figure 9), whilst part in occupation.

There are two common concepts which apply to all the options. These are:

Plant location: To maximize rental income, identify volumetric space for all plant items which can be accommodated in "no/low rental return" basement levels, regardless of the phase being constructed. These will include: utility intakes, HV sub-stations, generators, boilers, chillers, water storage tanks, sprinkler and wet riser tanks.

Plant capacity: design the shell & core services on a modular principle. Install modules specific to each phase, with space provision for adding further modules as and when the next phase is constructed. Allows capital cost of MEP to track the phased construction cash flow.

Vertical Transportation

In principle each phase is considered as a separate building, self-contained, but served up from grade level by express shuttles to particular sky lobbies. This is a conventional lifting method for tall buildings but by careful positioning of the shuttles and stacking of the local cores it can be achieved in a space efficient manor without interrupting the tenants of existing, occupied phases.

For this study each phase of offices is typically assumed to be 18 floors and 60,000m2 NIA over all the floors. The hotel is assumed to be a 5 or 6 star and a net occupation on each floor of 18 people.

The apartment floors are assume to have a net occupancy of 10 people per floor. Figures 10 and 11 illustrate the relationship the lifts have to their corresponding users both on plan and diagrammatically.

Cost Comparison

What now follows over the following pages is a cost comparison of the three building models and summaries comparing capital cost and income.

Base Case:

Each phase assumes that the previous phase will be demolished and the new phase will be built anew. There will become a time when the existing basement or foundations can no longer be used. In this case, the existing piles will need to be extracted prior to the scheme progressing which could have an impact of the final height of the scheme. From a financing perspective, the amount of finance charge is in the region of 20% more than a phased approach. This is a result of the finance being charged on a much higher value for the early part of the borrowing.

Minimum Disruption

It has been assumed that all foundation/ basement and external works costs relating to the 90 story building will be completed in the first phase and further works to these elements would not be required. This option also allows for all cores to be constructed in all phases whether required of not. After Phase 1 an allowance for remedial works to cover the cost of striping off the existing roof prior to construction of the next Phase has been included in each case.

Minimum Redundancy:

This option assumes the majority of the foundation/basement and external works costs relating to the 90 story building will be completed in the first phase. However, this option only allows for construction of the structure and cores required for each phase. Therefore as well as an allowance for the cost of stripping off the existing roof prior to the start of each new phase , the remedial cost for alterations / building out the additional core space to the previous phase to serve the new phase as also been accounted for.

Debt Financing

The debt finance graph in Figure 2 showed the relationship of debt financing when comparing single-build against a phased-build model. The amount of overall finance charge calculated

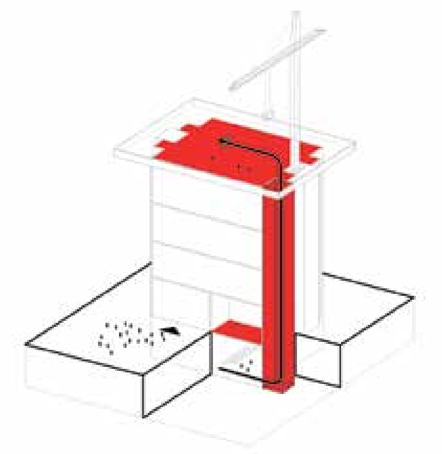

Figure 8: Building material can be passed through core shafts from a materials holding area in the basement. The use of dry building materials and a heavy focus on prefabricated construction process and DfMA would be key to expediting a quick process and minimal disruption. (Source: Grimshaw Architects)

for the single-build scheme works out at approximately 40% higher than the overall finance on the scheme carried out in phased-build. This is partly a result of there being less financial risk on a number of smaller schemes and therefore being able to obtain competitive financial rates. Even if one is able to obtain the same finance rate, the overall finance cost of the single-build approach still works out at approximately 20% higher than the overall finance cost of the phased-build approach. The reason behind this is that the single-build scheme attracts a much greater level of finance charge over the first few years when the greatest portion of the finance charge is calculated whilst

	Option 1	Option 2	Option 3
MEP Strategy	Centralised	Centralised	Floor-by-Floor
Plant Zones	Intermediate Plant levels	Annex & Intermediate Plant levels	Fly Towers
Minimum Disruption	★ Condenser water system including roof top cooling towers require extension to next roof level. Base build central systems require extensions/additions. Change over and commissioning disruption to existing occupiers. Longer programme.	★★★ Base build central systems require extensions/additions. Change over and commissioning disruption to existing occupiers. Longer programme.	★★★ Heat pumps serve individual floors. If based on VRV refrigerant system there is no disruption to neighbouring occupied floors. Reduces significantly the scale of base build central systems requiring extensions/additions.
Minimum Redundancy	★ Primary base build central distribution systems to be sized and configured to allow plug in of future plant modules, serving progressive phases. Spare cooling towers required to be installed in early stages of phased construction at newest roof level. New roof level to be ready early to accommodate new cooling towers, whilst existing cooling towers are in operation.	★★ Primary base build central distribution systems to be sized and configured to allow plug in of future plant modules, serving progressive phases. Annex plant zones to be constructed in Phase 1 as a shell, to accommodate future plant modules.	★★★ Multiple heat pumps replace central boiler and chilled water/cooling tower systems. Heat pumps installed in fly towers on a floor-by-floor basis. Reduces significantly the scale of primary base build central distribution systems to be sized and configured to allow plug in of future plant modules, serving progressive phases.
Further comment	Construction complexity and programme implications in building "top-down" to ensure new cooling towers can be installed and operational, before existing can be de-commissioned.	Relies on larger site footprint to locate annex. Site locations with mass/height restrictions, rights of light issues, viewing corridors may work with this approach.	Requires fly towers on opposing elevations. Requires high permeability of air flow. Impacts facade design.

★★★ Best ★★ Ok ★ Not good

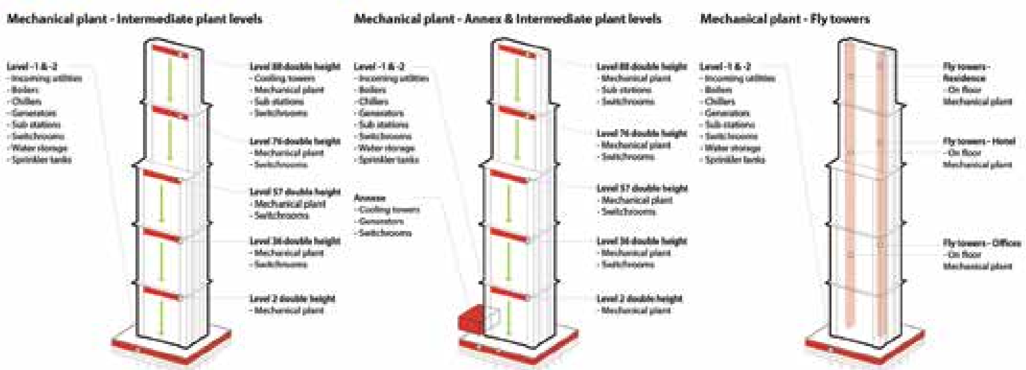

Figure 9: MEP options apllied on the tall building after the final phase highlighting how the MEP increments have been provided for per stage and a scoring matrix below showing how these 3 otions rate when cmpared to the two build options of minimum disruption and minimum redundancy. (Source: Grimshaw Architects)

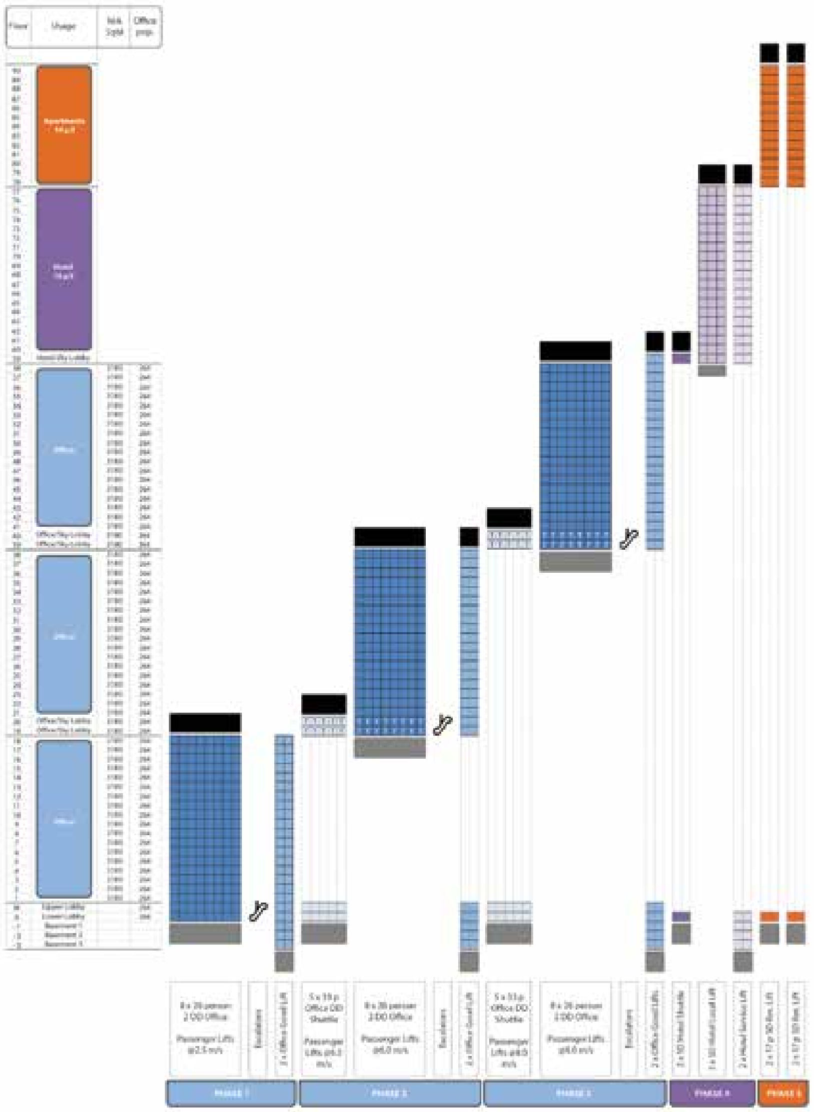

Figure 10: A layout of the plan (above) used to develop both incremental build strategies. The external cores deal with vertical master plan's lifting strategy moving between phases and the centre is dedicated for phase specific use only. Note the colour coding of the lifts corresponds to the lifting strategy (adjacent page)as laid out. The floor plan shown in this instance is a typical commercial office block. (Source: Grimshaw Architects)

the phased-build scheme attracts a number of lesser finance changes.

This graph had been calculated on the basis that the loan period would have been at approximately the midpoint of when the project breaks even at an average rent of £80/ft^2 per annum of Net Internal Area. The higher value loans are taken out over a longer period and therefore attracted a slightly higher percentage (6% in lieu of 5%) as a result of the finance risk of fixing the rate over the longer period and the larger loan value.

Summary Of Cost Models:

The result of this from a financing point of view is that the intelligent phasing results in a lower capital cost during phase 1 compared to the unintelligent option, but due to the additional remedial works required, results in an overall greater total cost of construction once all phases are complete. Compared to the single-build BASE CASE, it would seem that the more financially effective approach of MINIMUM DISRUPTION is £50M cheaper to build.

With the single build, one is left to the mercy of the marketplace. During a recession, the market is empty and during boom-time, the duration of construction can be a deterrent when so many places are on offer. The phased-build approach secures tenancies in a more low-risk manner.

The phased approach is based on the developer only proceeding with the next phase once the previous phase has broken

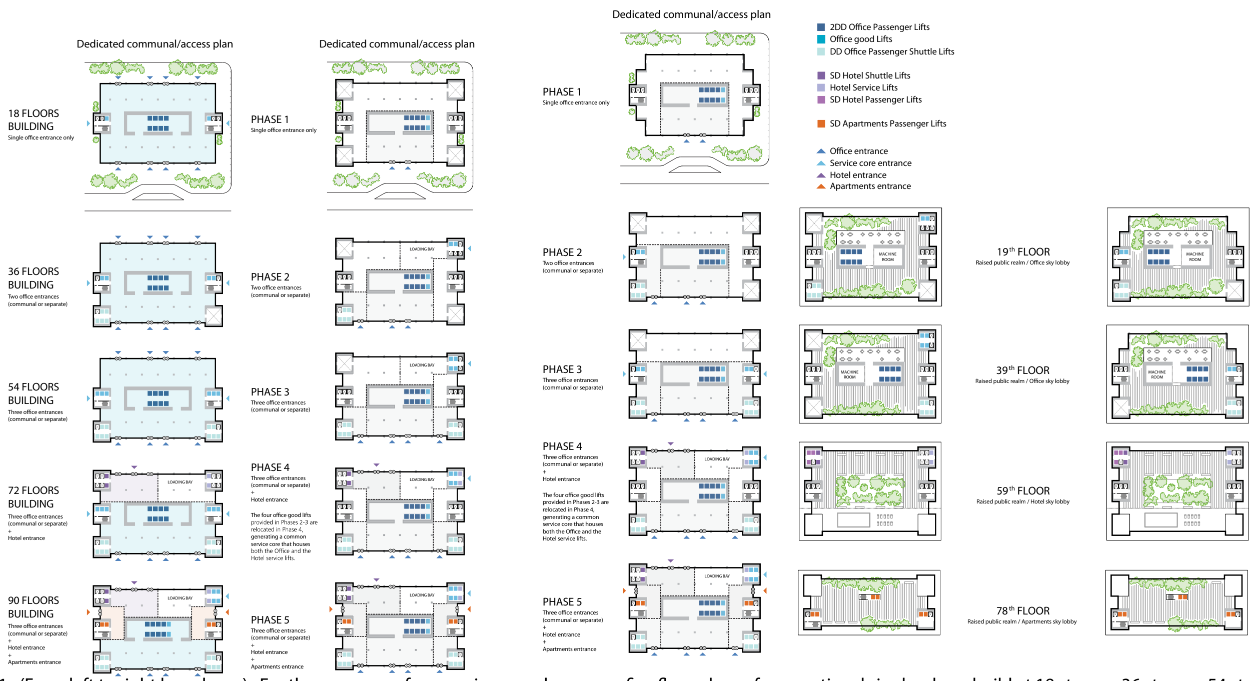

Figure 11: (From left to right by column): For the purposes of comparison as a base case, five floor plans of conventional single-phase build at 18 storeys; 36 storeys, 54 storeys; 72 storeys; and 90 storeys. Each showing the plan configuration at ground floor as each additonal building use would be added. A single phase building is purpose designed with no redundancy so therefore becomes the benchmark against which the efficiency of phasing options are measured. (Source: Grimshaw Architects)

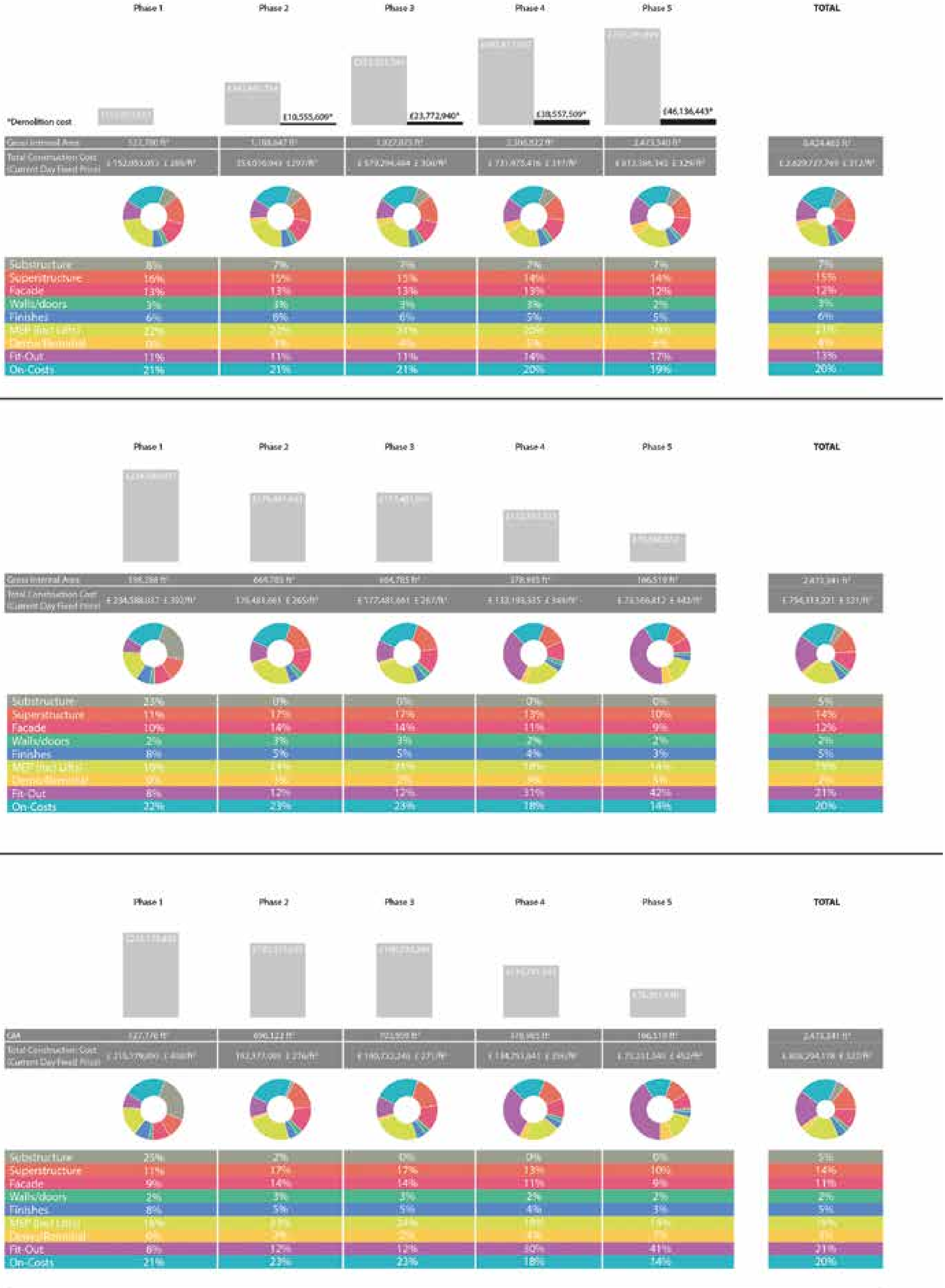

Figure 12: Each assessment scenario articulated in 3D with their associated cost analysis alongside (From top to bottom): The BASE CASE; Minimum disruption phased-build option; Minimum redundancy phased-build option Notes: Graphs show the total construction cost at current day (2015) fixed prices for each phase, including on costs, fit out costs, and external works. The demolition costs have been shown separately where applicable. Pie chart shows elemental breakdown of costs as a percentage of total construction costs for each phase. The base case is only shown as a means of comparing build costs against the phased options. In practice a build, demolish and rebuild sequence as shown would never happen. (Source: Grimshaw Architects)

Figure 13: Graph sequence demonstrating exposure to risk (Above. from top to bottom): Summary assessment of the three cost models showing both phased options performing simlarly and both being marginally cheaper that a single phased build. An income v capital expenditure comparison regarding conventional single-build. three scenarios are depicted to illustrate the profound influence market conditions have on the construction industry. A similar income v capital expenditure comparison for the phased-build approach. No fluctuations regarding market conditions are shown. (Source: Grimshaw Architects)

even. This therefore limits his financial exposure. As an example, in the single phase, after say 6 years, the developer is still exposed in the region of £1BN but in the phased approach, their exposure is limited to approximately £300M. Also, the calculated area income is based on is much smaller in the first phase and then this increases as you move to the next phase.

Conclusion

The graphs on the previous page are more a demonstration of exposure to risk more than anything else. Both methods of building (single-build and phased-build) are ultimately the same size and using similar rental rates they will break even within a similar period, however the single build approach carries a lot more risk than the other. Conversely, once phase 3 is developed, there is very little financial exposure. Reducing the risk profile of a development must go some way to a more stable growth system.

Towers are all about a 'heightened' and more intense risk-reward relationship. The scale and complexity of the larger, more iconic endeavors makes them hostages to the fortunes of time in particular. The greater the building and the longer the overall program, the more difficult it is: to secure the services of a supply chain with the necessary skills / appetite; to accurately forecast price inflation; to predict occupier demand.

Phasing a tower is a fundamental response to this dilemma, but is largely (though not completely) unprecedented, and not without some obvious challenges, not least:

- Obtaining Planning permission for an ultimate building that intentionally lacks certainty of phase timings.
- Valuation of the land, which is driven by the nature and size of the proposed development(s).
- Construction methodology that eases logistics whilst minimizing disruption to occupiers of previous phases.

Addressing these, and other difficulties are a pre-requisite to making the vertical master plan not only a practical proposition but also a viable one. And yet the increased cost of developing the tall building in increments has the potential to create a more attractive commercial development, whilst providing an inherent flexibility that can be used to counteract the vagaries of the property market.

Our analysis shows that against the status quo of building the ultimate 90-storey scheme at the outset (or demolishing and rebuilding at appropriate points in the market to eventually get there), the construction cost premium of phasing the tower is approximately 5.4% for the minimum redundancy option or 3.5% for the minimum disruption option. These additional costs are associated with:

- The 'temporary works' necessary between phases.
- The up-front investment in elements put in place for later phases.
- The complications of constructing above an existing, occupied building.

However, the premiums can be mitigated or even balanced by the lower risks of smaller, more manageable and deliverable chunks of real estate – this relative comfort revealing itself in lower finance costs, reduced void periods – and possibly lower yields.

Like everything to do with high-rise economics, success will depend on getting the fundamentals right, and backing this up with an attention to detail that de-risks through thorough planning. This theoretical phased strategy will clearly need such planning, but it is founded on such logical financial metrics to make it a compelling proposition worthy of more detailed work.