# cost:

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The cost and scarcity of developable land, the permitted footprint, building bulk, quality of specification, and the time required for design, construction, occupation and use are all generic cost drivers of buildings. The cost of any particular mix of these influences the economics of a building – whether short, tall, large or small.

Optimal design solutions can identify 'appropriate cost'. When factored into a building's performance, this can have a measurable influence on the productivity of the spaces enclosed. It may or may not support the initial cost of a building (as space from which to transact business) over its operational life cycle. The creation of a landmark is a related issue.

## Procuring tall buildings

The size, complexity and duration of tall building projects means that there are a limited number of ways to design and construct them, in terms of both strategy and the range of designers, contractors and specialists with the skills, experience and resources to undertake the work. This section considers key issues in developing a successful procurement strategy for tall buildings.

Tall buildings in the City of London.
The historic street pattern of the City of London creates small, often complex footprints. The proximity of listed buildings and conservation areas influences the modelling and articulation of tall buildings. Both factors serve to produce structures of relatively high cost.
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## Speed and efficiency

One of the main opportunities of tall building design and construction is the ability to exploit the benefits of standardisation and repetition across major cost elements, such as the façades. The scale of tall buildings makes this true even when a building is bespoke. Achieving and maintaining speed is critical to successful project delivery. Procurement strategies that allow the overlapping of design, procurement and construction are essential to achieve acceptable project durations.

To optimise the programme and eliminate potential sources of delay and disruption, it is vital to invest in strategic construction planning and buildability reviews at an early stage. Key elements in programming tall building projects include:

- Management and co-ordination of trade activities on site, to maintain the cycle of floor construction
- Management of extended design and procurement programmes, to permit the maximum degree of standardisation and minimise floor construction cycles
- Optimising the use of standardised and pre-fabricated components and other measures to promote ‘buildability’.

## Specialist contractors

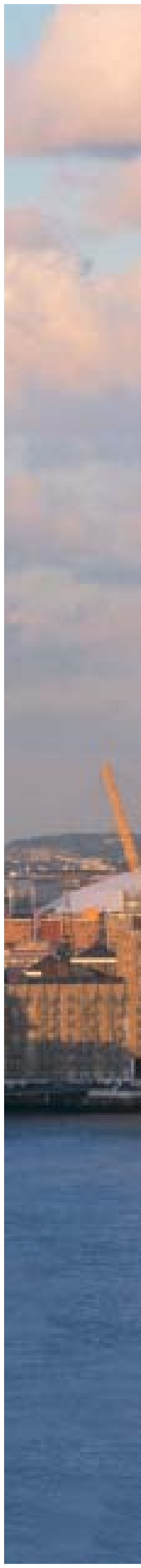
The procurement of specialist contractors is strongly influenced by the size of packages involved. It can be beneficial to bundle related trades into a single package with united management. Examples of this are core area fit-out works and services installations. The early appointment of specialist contractors is essential to provide for their early design input and co-ordination. For example, a concrete trade contractor may influence the choice of core construction method, which could result in changes to its design.

## Logistics

Provision of sufficient cranage and hoisting is critical to maintain programme. Co-ordination of deliveries, cranage slots and construction programmes is necessary to ensure that speed is maintained. Efficient transport of people and materials is crucial to achieve productive utilisation of labour. On tall structures, the added time taken to travel to and from higher level workfaces calls for attention to vertical transport during the construction period and provision for worker welfare above ground level. The location of toilets and canteens at regular intervals up the building will minimise downtime and prevent delays through unnecessary journeys in hoists.

## Health and safety

Health and safety is a major issue when working at height. The attention paid to these requirements during tall building construction in the UK means that the risk is generally well managed. One of the benefits of working on large buildings is that trades do not need to work on top of one another, with the risk of minor incidents accordingly reduced.



→ Canary Wharf, including proposals by Richard Rogers Partnership (shown to right of the cluster), reflects the relative lack of constraints on either footprint or building form, resulting in large regular blocks which are relatively cost-effective to construct.
Canary Wharf Group plc/© Miller Hare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## Cost overview

Height is not the sole criterion in the consideration of the relative cost of tall buildings. The size of the floor plate, the overall proportion of the building, its location and degree of architectural expression will all have a fundamental impact on cost. This section looks at a number of indicative construction cost models based on building designs that vary according to these criteria.

Tall office buildings: for shell and core construction costs.

Principal cost drivers.
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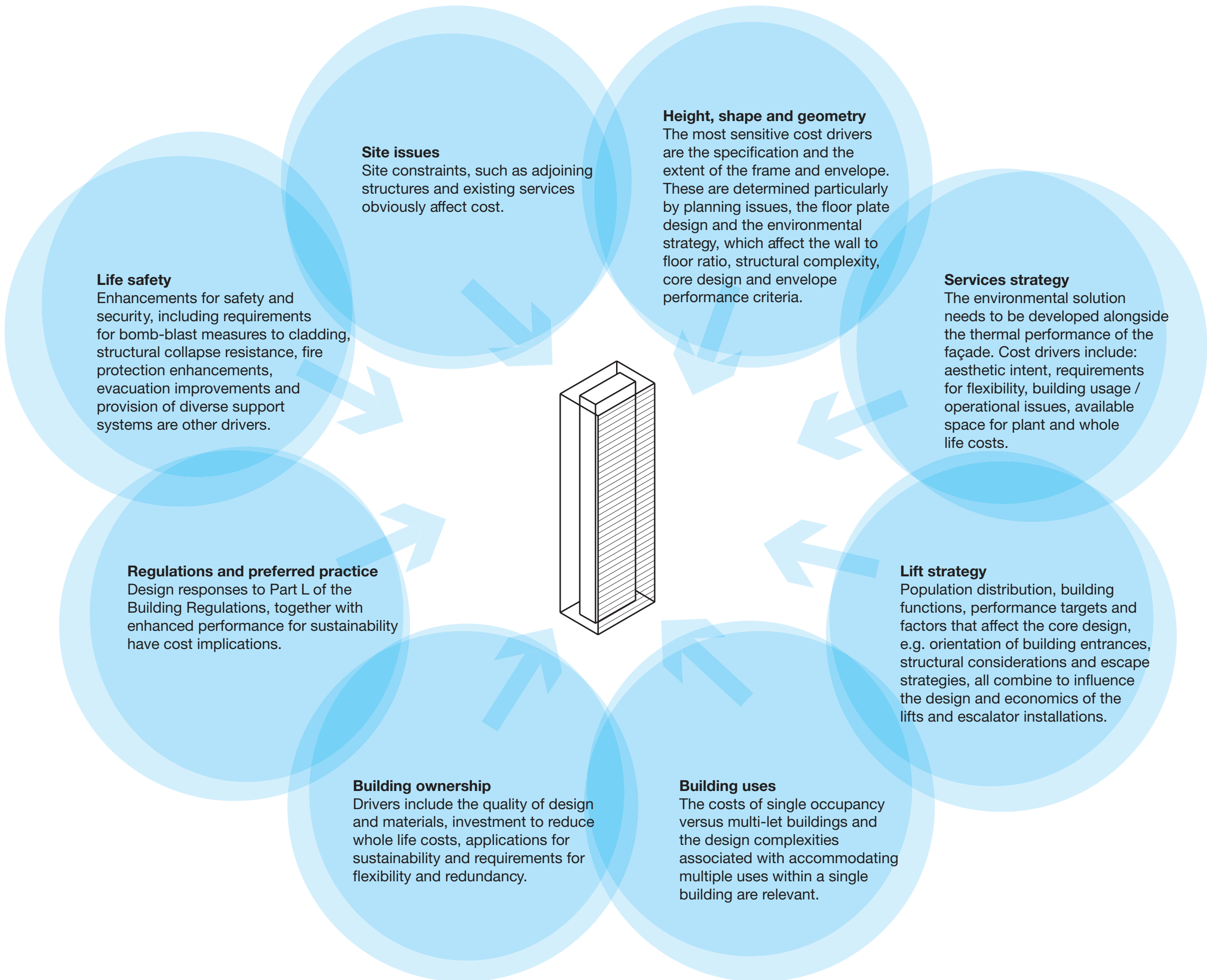
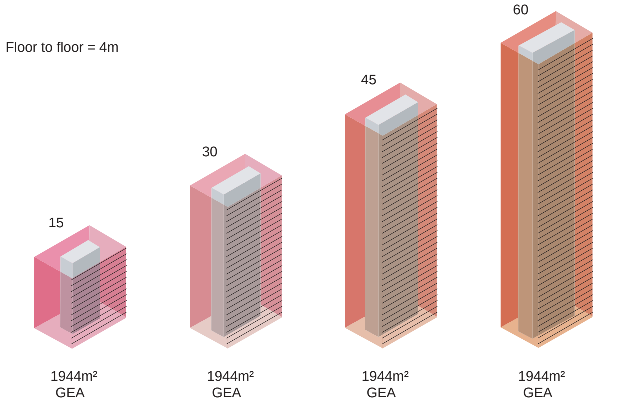


## Indicative costs

The following four models consider indicative costs based on key design variables relating to the design and construction of tall buildings.




Cost Model One: Building height

Constant plan size, varying heights.
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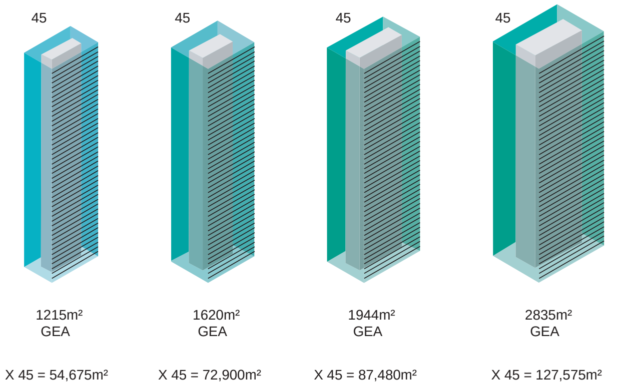


Cost Model Two: Plan size

Constant height, varying size floor plate.
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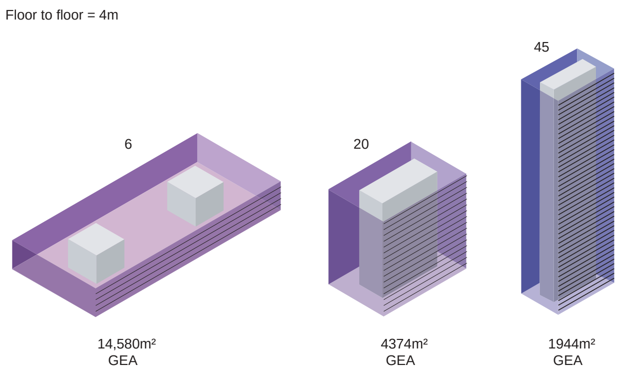


Cost Model Three: Proportion

Enclosing identical amounts of gross floor space in buildings of varying height and floor plate.
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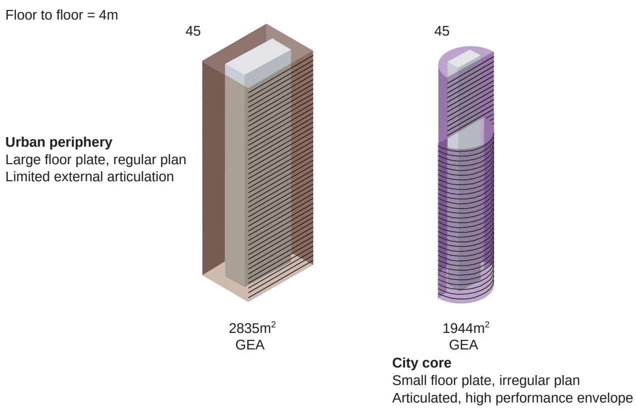
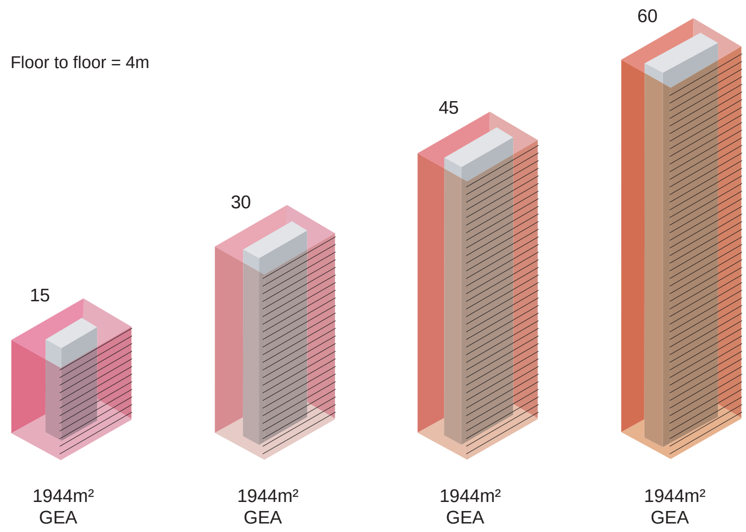



Cost Model Four: Articulation

Comparing a more architecturally expressive building, as could be required in the City of London, with the 'straight-up-and-down' form used for the base analysis that is more feasible for a peripheral site.
→ © Davis Langdon LLP/KPF




Cost Model One: the impact of changing building height on building efficiency and cost.
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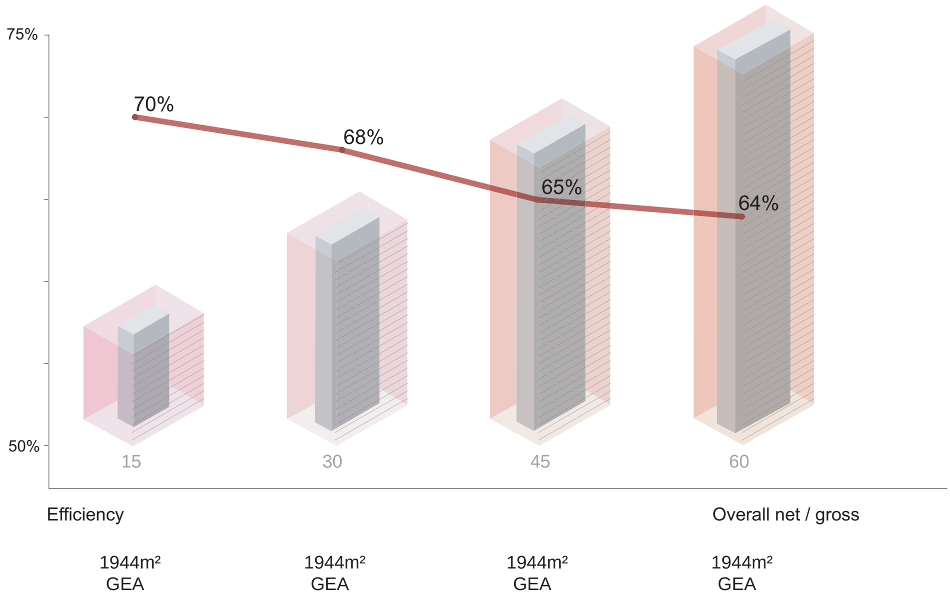
## Cost Model One: height

Irrespective of floor plate, shape, form and other factors, tall buildings cost more to construct per unit of floor area than low rise buildings, despite the opportunities they offer in terms of repetition and sequencing. This relates to:

- their increased wind loadings and heavier frames
- their vertical transportation requirements, particularly lift capacities, speed, zoning, etc.
- the larger capacities of plant and distribution systems together with the increased pressures/hydraulic breaks that are required to deal with the increased vertical distances
- the effects of their scale and complexity on the movement of materials and labour
- the risks associated with their uniqueness and the fact that these risks are exacerbated by scale and the need to access a limited pool of skills and expertise
- the potential interest in including elective security and safety enhancements in response to possible risks (although acceptable responses can be provided at relatively little additional cost).

Cost Model One provides a notional indexing analysis for 15, 30, 45 and 60 storey buildings. It shows that the principal cost drivers that differentiate the taller from the shorter buildings (with constant floorplates) are: structure, façades and vertical transportation. In contrast to a typical city centre situation in which the building is likely to be more articulated (see Cost Model Four and associated discussion), this theoretical model is constructed with constant floor plates, thereby ensuring identical wall to floor ratios and hence relatively little difference in the cost of external walls. Arguably the most important finding that Cost Model One shows is the trend for floor area efficiencies to reduce as the constant floor plate building increases in height. The actual efficiency achieved will depend on various factors including: services strategy, structural design, lift arrangements and building use.




Efficiency: the ratio of net to gross space – the building's efficiency – will decline with increased height. This reflects the larger core area required to serve a greater number of floors.
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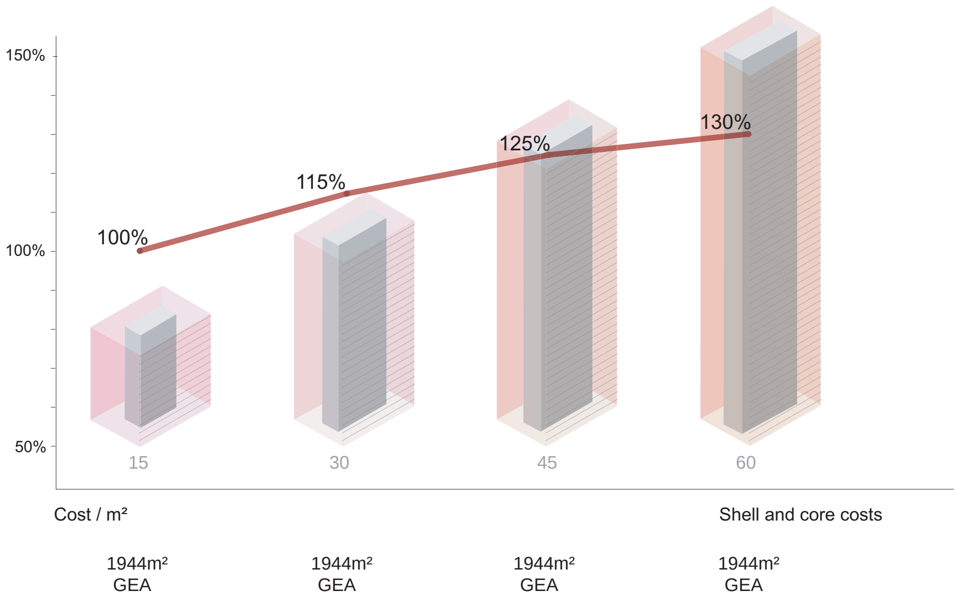


Shell and core costs: shell and core cost per $m^2$ rise with buildings of increased height.
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## Main cost drivers of tall buildings

The relative effect of the four principal cost drivers will differ in each cost model.

### Structure

The building's height, volumetric shape, plan form, core location and column spacings all combine to determine the most efficient and cost-effective structural solution. Irrespective of the structural system, the mass and cost of the structural frame will increase with height. Counteracting wind loads, which increase disproportionately with height, adds significantly to loads and costs.

Both material efficiency and buildability have a greater cost impact with height. These need to be considered hand-in-hand. An important factor will be the size of the structural members. This has a bearing on buildability and speed, and a possible impact on lettable floor areas. The selection of the structural system will therefore be determined by cost, building movement, space take-up, aesthetics, buildability and speed of construction. As with the other principal elements, it is important to focus on a single solution at an early stage of the design process.

### Façades

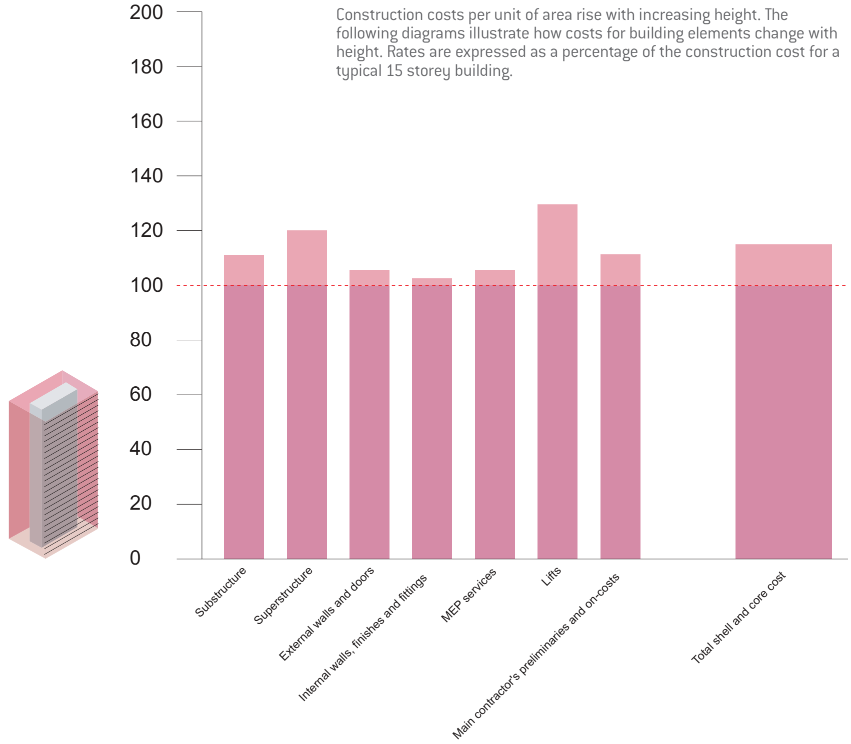
Tall buildings are typically designed with a totally sealed external envelope. The façade's contribution to environmental control is crucial. With increasing attention to carbon emissions, the design of façades and services installations needs to be developed in unison.

More often than not, tall buildings will be all-glazed and the façades will comprise double walls (triple-glazed). It will be more efficient and sustainable to use the façade to control heat gain rather than rely on cooling installations to mitigate the performance of the envelope. A number of factors will affect how this is achieved. These are principally cost, performance, operational robustness, space take-up, aesthetics and ease of construction.

Beyond the detailed performance of the envelope, the design should seek to take maximum advantage of economies of scale, both in factory production and on site. With large areas of external walling (and high wall to floor ratios), efficiency of both production and installation are critical. This can be achieved by rationalising cladding types and fixing details through maximum repetition (without compromising aesthetics), ensuring that panels can be fixed from the floors rather than having to rely on cranes, and by unitising as much of the system as possible.

As well as the environmental strategy, the façade's interaction with the structural frame is important. Tolerances and movements should be addressed at the earliest opportunity, with slab edge live loads restricted to say 12-15mm to ensure a competitive curtain wall solution.

Should the design succeed in these respects, there is every reason to expect the economies of scale to offset any potential additional costs associated with factors such as increased wind loadings and logistics. However, the cost of the external walls is still likely to show a significant increase relative to those for low buildings, when expressed per unit of floor area, because of the higher wall to floor ratios that tend to be inherent to tall buildings. Slender tall buildings will be particularly affected in this respect.




Construction costs per unit of area rise with increasing height. The following diagrams illustrate how costs for building elements change with height. Rates are expressed as a percentage of the construction cost for a typical 15 storey building.

Elemental costs for a 30 storey building (baseline costs for a 15 storey building).
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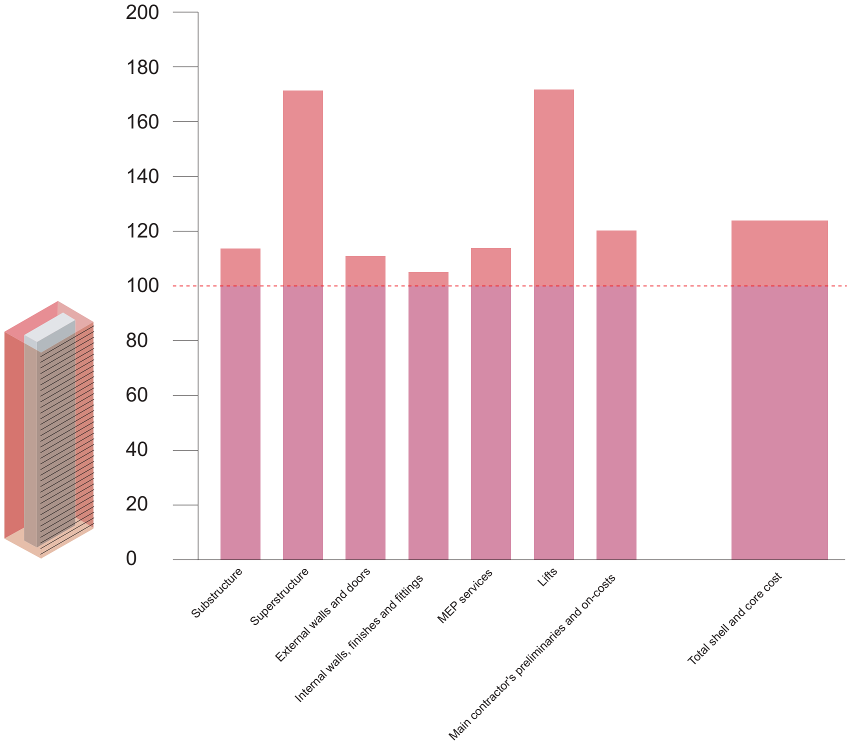


Elemental costs for a 45 storey building
(baseline costs for a 15 storey building).
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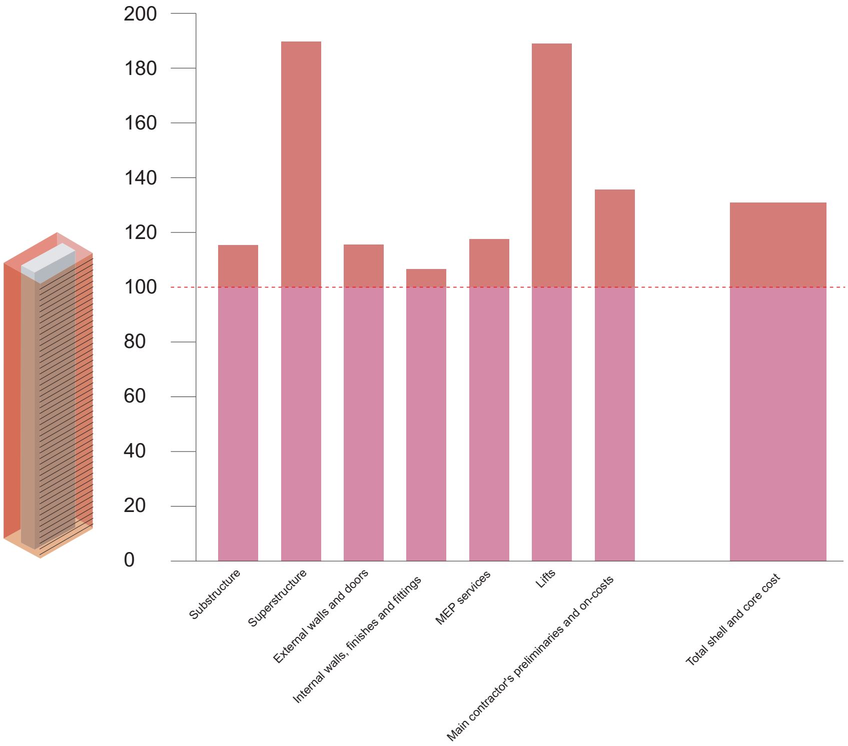


Elemental costs for a 60 storey building
(baseline costs for a 15 storey building).
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## Vertical transportation

Core design is the crucial starting point for developing the internal operation of a tall building. It determines both the building's development efficiency and its operational effectiveness. Together with structural considerations, and to a lesser extent services distribution, the design of the lift installation is a fundamental part of optimising the core arrangement.

The aim of the lift and escalator installations is to optimise travel times and waiting intervals with the building's likely population profile in mind. Achieving this involves a significant level of specialist analysis, the result often representing a balance between number of lifts, lift speeds, size of groups, zoning of the building, core size and arrangement.

With an increase in building height comes an increase in strategic options to achieve these targets economically.

The fundamental options are:

- Straightforward zoning of floors, with transfer levels
- Sky lobbies served by express lifts
- Double-deck lifts
- A combination of the above.

The use of sophisticated controls, such as destination hall call, could be incorporated to improve overall performance. A cost/benefit analysis of such options will determine their attractiveness.

## Main contractors' preliminaries/on-costs

Main contractors' preliminaries encompass a large complement of staff to manage the design and construction, and an array of accommodation, plant and equipment for use by the client, consultants, construction personnel and other site visitors. Care needs to be taken to ensure the correct quality and scope of all these items to maximise efficiencies (and avoid unnecessary duplication with trade contractors' preliminaries).

Appropriate investment in main contractors' preliminaries will mitigate the pressures on trade contractors' preliminaries, which can often be considerably greater for a tall building project, partly due to the logistics of moving people and materials to and from the workface. The time taken by operatives travelling to and between floors and welfare facilities such as canteens and toilets can take up a significant part of the day.

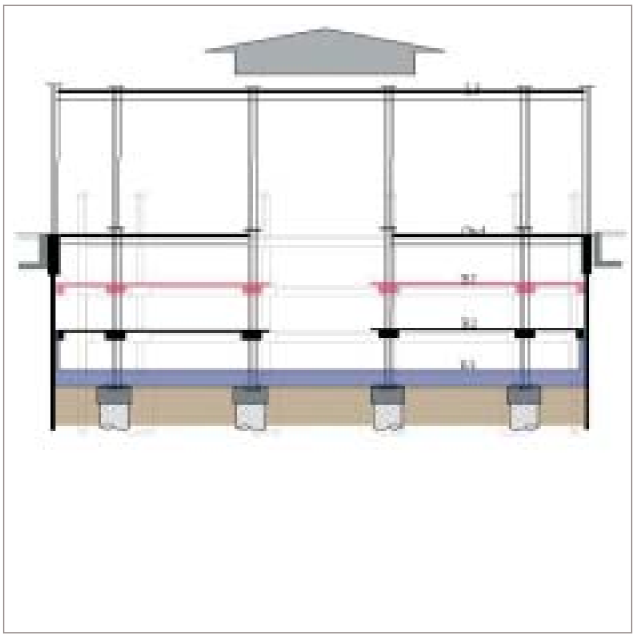
It is important to minimise these inefficiencies and manage the construction process rigorously, starting with robust and detailed planning. An appropriate procurement strategy will also help to minimise programme and financial risks.

**Heron Tower, 110 Bishopsgate, KPF: Construction sequence studies.**


Demoltions: access and cranage.
© KPF


Basement construction: access and cranage.
© KPF

To achieve all this will require a significant level of input from a constructor, employed to manage the design team and the construction and site processes, and to provide an input into planning, procurement and cost control. This will include the provision, maintenance and co-ordination of common items of plant, facilities and equipment provided for use by all trade contractors. This level of input results in higher costs, associated with staff and plant equipment levels, which will need to be provided for relatively longer periods. The inherent cost and complexity of tall buildings will inevitably also result in relatively higher design and construction contingencies, when indexed against lower buildings (though percentage allowances will not necessarily be higher).



Top down construction proposed for basements.
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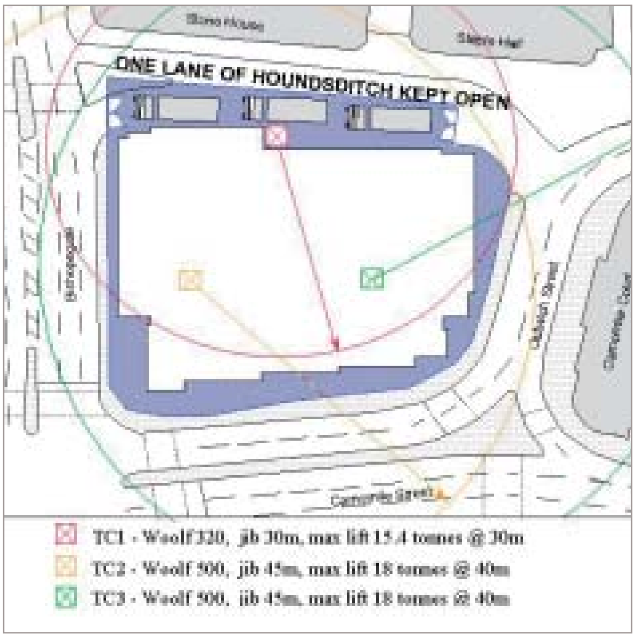


Superstructure construction: access and cranage.
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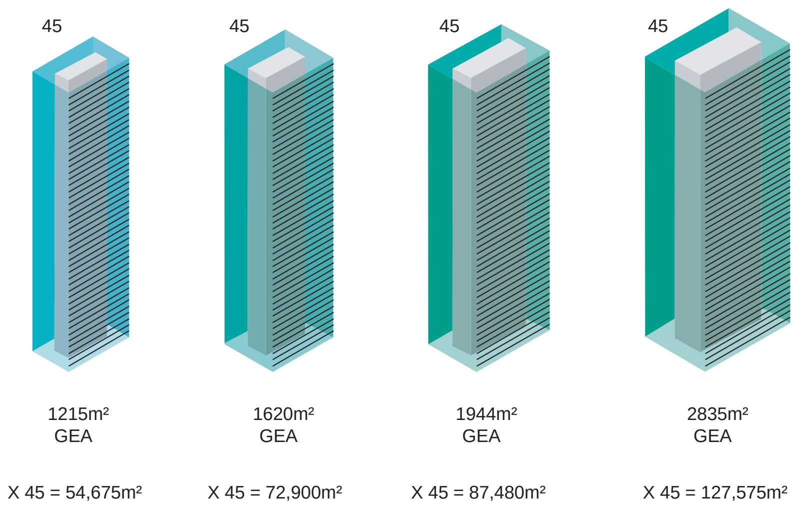


Cost Model Two:
impact of size of the floor plate on the efficiency and cost of a 45 storey tower.
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## Cost Model Two: plan size

The 45 storey building from the earlier analysis has been further reviewed to consider the effect of alternative floor plate sizes – 1,215m$^2$, 1,620m$^2$ and 2,835m$^2$ – on area and cost (re-indexed to the tall building).

The effect of varying floor plates on the shell and core cost of a tall building shows the principal cost drivers to be:

**Wall-to-floor ratios**

The significantly higher wall-to-floor ratio of a smaller floor plate will result in a greater proportion of costs being attributed to the envelope. It will also affect the services strategy, which will have to respond to an increased level of solar gain.

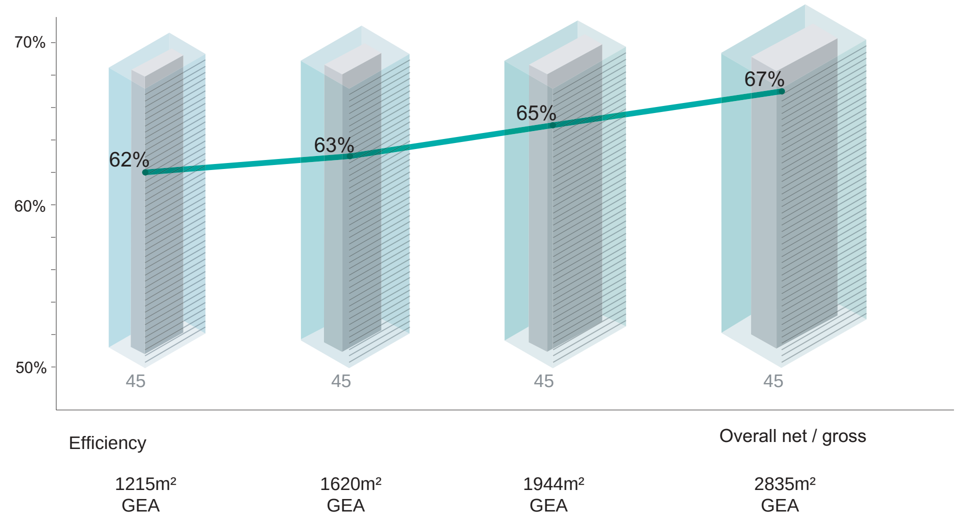
**Structure**

Slender tall buildings require stronger frame solutions for increased stiffness, to counteract the more marked effects of wind action.

**Lifts**

A higher lift density will be required to serve the needs of smaller ‘premium’ occupiers.

Additionally, where the floor plate is significantly reduced in slender tall buildings, opportunities for economies of scale may be reduced or lost. Net to gross floor area efficiences are also shown to deteriorate with a decrease in the size of the floor plate, relating to relatively larger cores on smaller floor plates.




Efficiency
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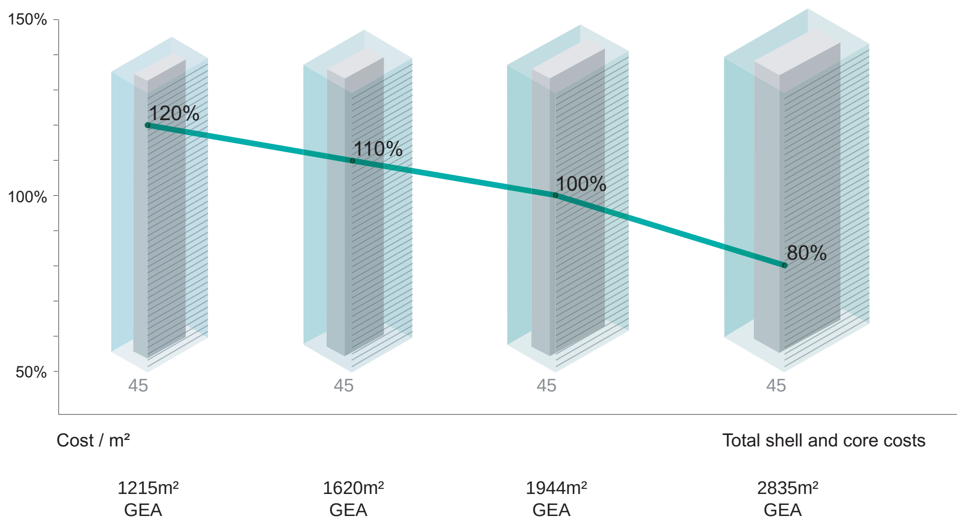


Shell and core costs
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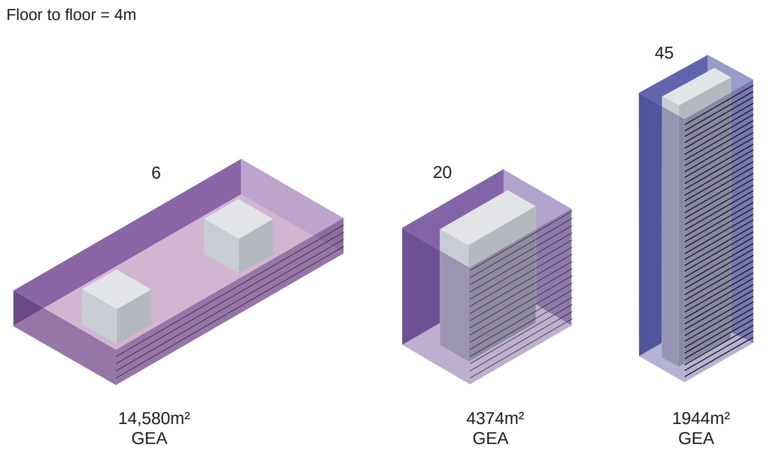
# Cost Model Three: proportion

Cost Model Three considers the choice of building form for a given amount of gross floor area. It shows three possibilities to provide around 87,000m² of total gross internal floor area: a groundscraper of 6 storeys (14,580m² floor plate), a medium-rise building of 20 storeys (4,374m² floor plate), and the 45 storey office building which was analysed previously. This comparison results in the following indicative effect upon the total cost indices.

The combination of decreasing height and increasing floor plate affords:

- Significantly improved wall-to-floor ratios
- More efficiently designed elements (such as the structural frame)
- Faster construction, with a greater proportion of the building being horizontal rather than vertical, and easier logistics
- More options in the location of components such as central plant.




Cost Model Three: impact of proportion on building cost.
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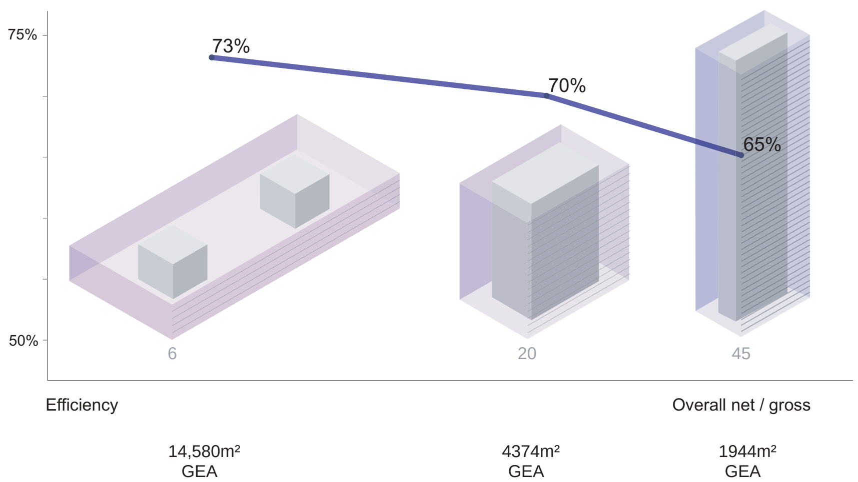


Efficiency
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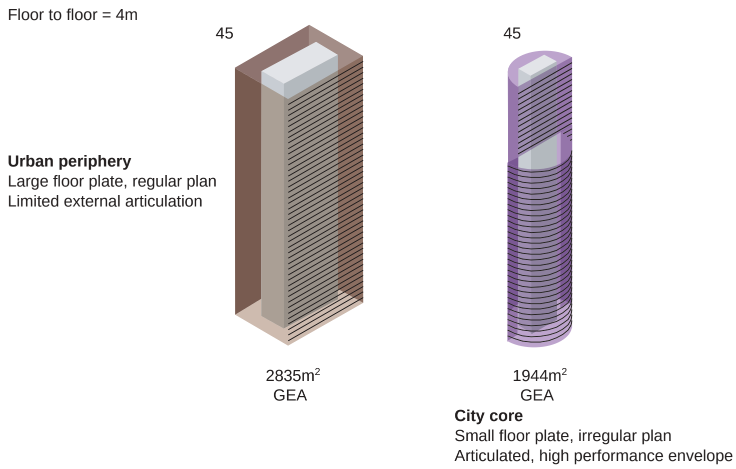
## Cost Model Four: articulation

This compares a predominantly functional, well detailed but essentially plain building form, such as HSBC at Canary Wharf, with a more complex, articulated building typical of the City of London. The comparison illustrates key implications of designing and procuring a tall building in a sensitive city centre location. These include:

- Complex substructures to avoid existing obstructions and deal with boundary conditions
- A more complicated shape and form, particularly in response to planning considerations (e.g. the tapered shape of the proposal for 122 Leadenhall Street, predominantly to avoid a viewing corridor to St Paul's Cathedral)
- The higher quality of design and materials
- The increased pressures to incorporate an attractive interaction between the building and the streetscape, an architectural statement at its pinnacle, and more demanding planning requirements
- More complex construction issues resulting in extended construction programmes.

By far the biggest impact on costs will be the more complex building form, a simplified illustration of which is shown in Cost Model Four (noting that real examples of this exist, e.g. the Heron, Minerva and London Bridge Towers).

Floor area efficiencies are also likely to be reduced, possibly through a less straightforward core design and more impact of structure on the floor plate.




Cost Model Four: articulation
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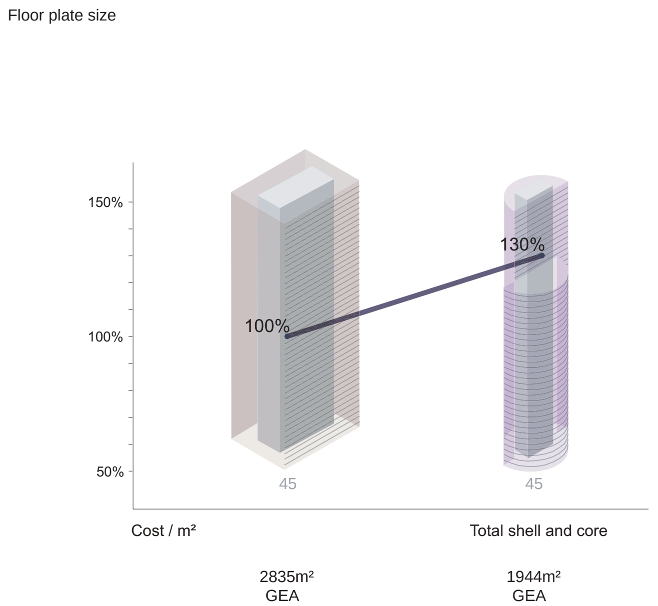



Shell and core costs
© Davis Langdon LLP/KPF

## Cost and height

The following principles are involved:

- For a constant floor plate, costs per $m^2$ of floor area increase with height, whilst overall net to gross floor area efficiencies are reduced.
- The cost/height relationship is characterised by step changes, due to various technical thresholds which occur at different heights and floor plate dimensions. The full cost progression depends on the specific aggregation of the component costs in any given design.
- Larger floor plates are more economic, mainly due to their superior net to gross floor area efficiencies and improved wall to floor ratios.
- City schemes constructed in high value locations involve a trade-off, with reduced floor area efficiencies and higher cost, because of their more articulated façades, more complex forms and the other implications of a constrained, sensitive location.
- Groundscrapers can provide more net area for the same overall gross area provision, at significantly lower construction costs, but involve less intense – and potentially less sustainable – use of high value land.

### Risk

Cost-effective enhancements can promote safety in tall buildings, addressing evacuation, structural collapse and bomb-blast resistance. With building management and occupant training, these measures offer economically viable inputs to risk assessment.

## A question of value

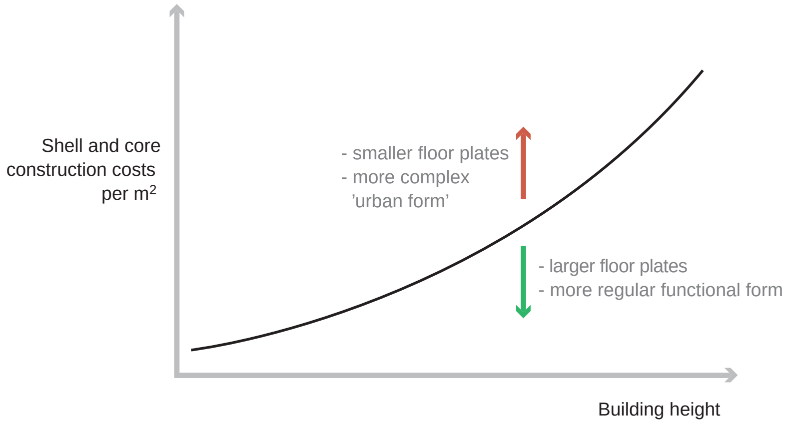
With many factors at play, the cost indices provided here are necessarily indicative.

Because of the increased unit costs and decrease in floor area efficiency with taller buildings, net space is disproportionately more expensive. The viability graph (opposite) illustrates this by plotting the cost in accordance with net internal floor area.

Irrespective of floor plates, landmark status, form and proportion, development costs per $m^2$ of gross floor area increase with height. To be viable, the value of tall buildings per $m^2$ must also be higher, and market evidence suggests that it is possible for tall buildings to provide an acceptable long-term return.

The economics of tall buildings on both a macro and micro scale will vary according to their location. The values and costs associated with a tall building in the Far East are different to one in London. London is a 'young market' for tall buildings. With the increased knowledge and experience that comes as more proposals are developed, the cost and efficiency premiums may be reduced. The distinctiveness of quality tall buildings may also represent a valuable form of diversification within the office sector.

**Tall buildings:**
**The pressures on a potential viability curve**



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