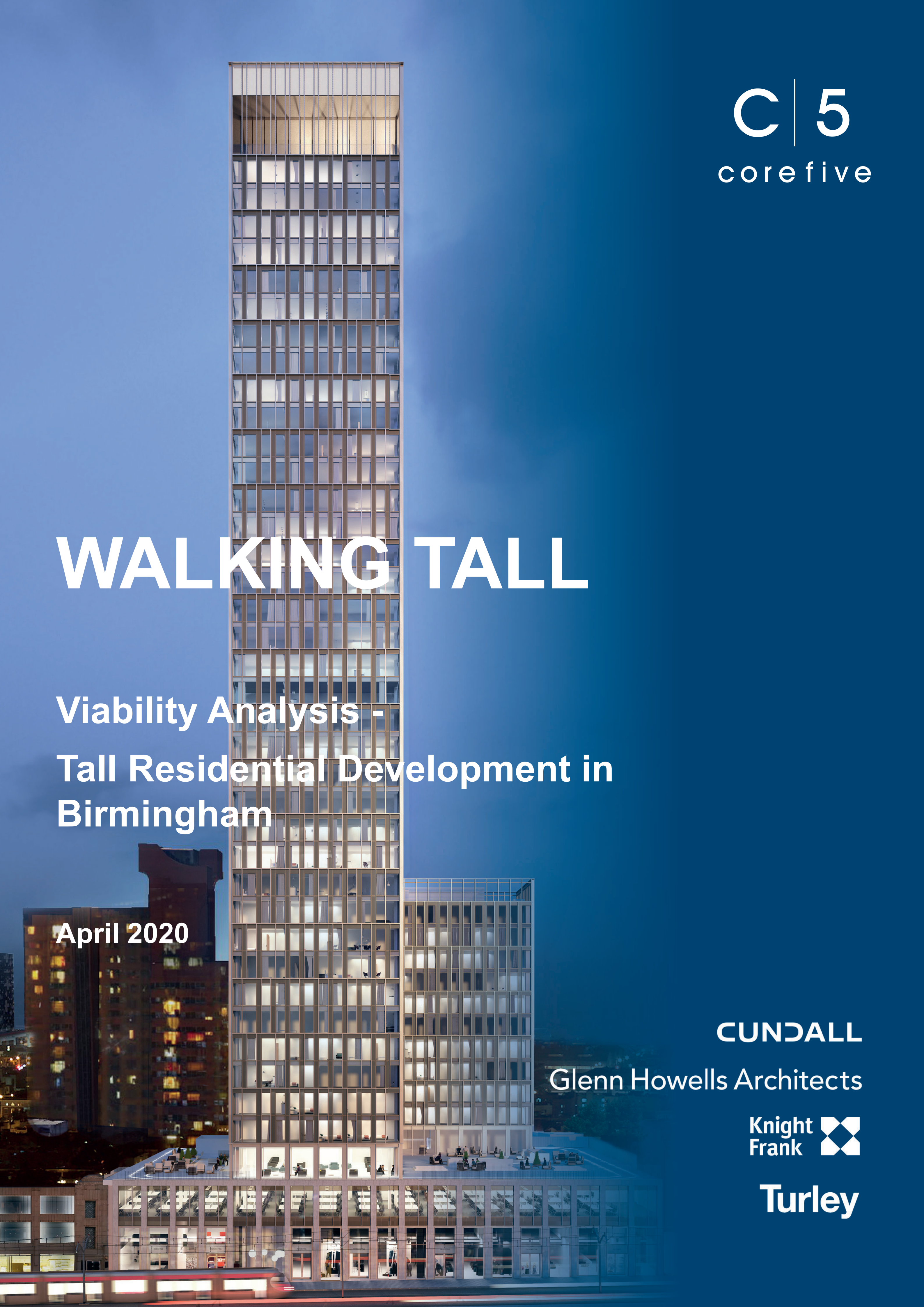

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WALKING TALL

Viability Analysis -

Tall Residential Development in Birmingham

April 2020

CUNDALL

Glenn Howells Architects

Knight Frank

Turley

VIABILITY ANALYSIS

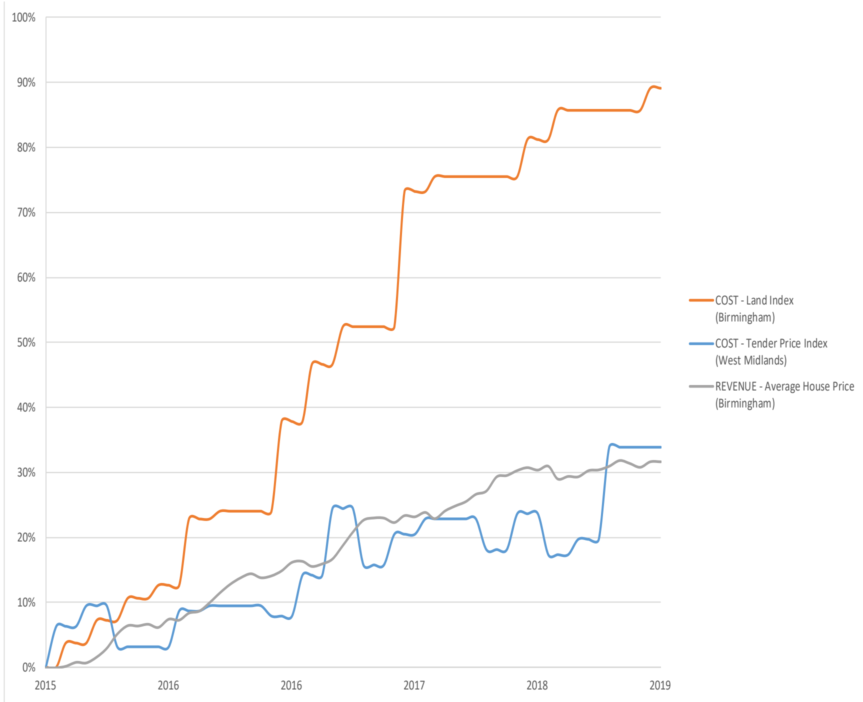
Introduction

Tall buildings are complex, risky and visible. Birmingham has a once in a generation chance to make its changing skyline a success, therefore it is imperative that the right team is in place to deliver them. At the time of writing there are 17 projects either in planning or on site that exceed 25 storeys (see Figure 2), and myriad more residing in drawing format on the desks of consultants across the city as densification gathers apace.

Yet despite the appetite for reaching further into the Birmingham sky evidently voracious, the conversion rate is low. It is not a question of endeavour or desire, but one of commercial viability coming under increasing pressure from land values and the fine margins of building tall in a regional city. Ultimately, success is reliant upon achieving a balance between revenues and cost particularly in light of the pressure being brought by increasing land rates (see Figure 1). Each of these must be met through careful consideration of quality and meeting key metrics for an efficient design.

With sales / rental values, planning requirements and end user expectations providing constraints before the design of a tall building is even considered, Figure 3 outlines the key design metrics that should be targeted in order to optimise viability during the feasibility, design and construction stages. This forms the basis of this article, with each reviewed in turn.

Figure 1 : Sales value versus input costs (land and construction costs)



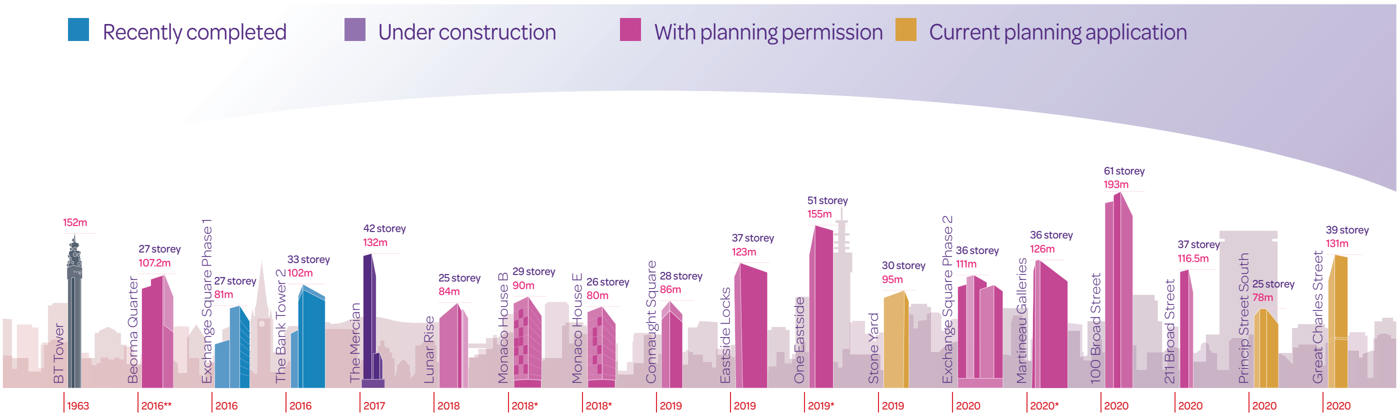
SOURCES: KNIGHT FRANK (FOR LAND DATA), RICS BUILDING COST INFORMATION SERVICE (FOR BUILD COST DATA), OFFICE OF NATIONAL STATISTICS (FOR SALES REVENUE DATA)

THE AGENT'S VIEW

In 2013, we were seeing land prices averaging around £12,000 to £16,000 per unit; today we are seeing prices in excess of £36,000.

Birmingham continues to outperform many parts of the UK in house price growth, with some best in class open market developments now being priced at £450/ft² NIA. We forecast that residential property prices in the West Midlands will rise by 13% over the next five years.

Figure 2: Tall buildings in Birmingham granted planning approval since 2015



SOURCE: TURLEY

Year Planning permission granted (or application submitted, if not yet approved)

Notes

"Tall" in this context refers to buildings at least 25 storeys. Residential only (commercial excluded). Includes developments within Birmingham city centre (inside ring road).

* Resolution to grant planning permission (section 106 not yet signed)

** Extant permission

The Mercian, designed by Glenn Howells for Moda, will be one of Birmingham's tallest buildings when complete

Planning Context

The primary planning guidance for tall buildings in Birmingham is set out in 'High Places' published in 2003 by Birmingham City Council (BCC). This guidance allows tall buildings to be generally located within a defined Central Ridge Zone where development can 'emphasise the city's topography or help create a memorable skyline' (see Figure 2). The guidance also supports tall buildings that mark the sense of arrival to the city centre, terminate a key view or are nearby to major public transport interchanges.

With ambitious plans for growth and increasing pressure to densify outside of the Central Ridge Zone an updated planning and design framework is anticipated, and should be one that provides the tools to robustly promote and assess tall buildings across the city. This should give clarity to developers and provide a basis for constructive dialogue on key design matters at the pre-application stage.

The key planning challenges in Birmingham are:

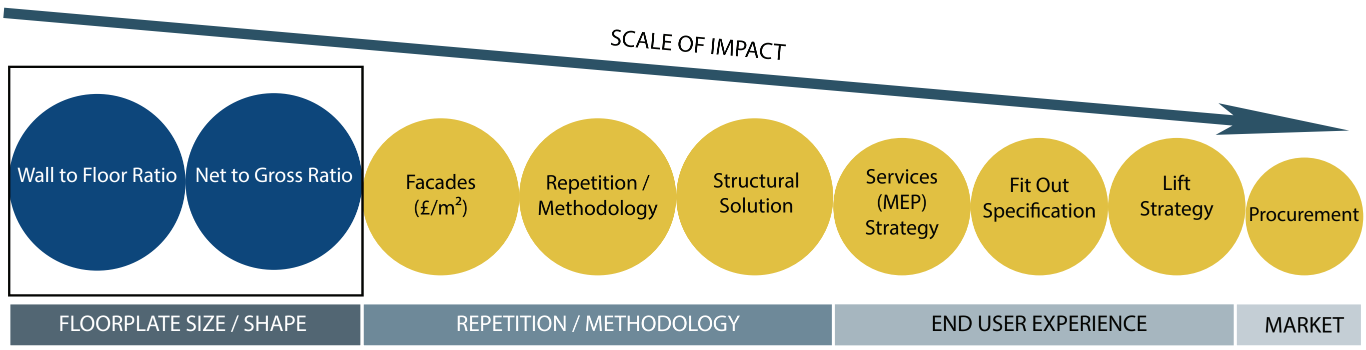
- Demonstrating design quality - relationship to viability and construction certainty, whilst ensuring a positive impact on the skyline
- Microclimate issues - modelling of wind conditions to avoid pedestrian safety concerns
- Daylight/sunlight/overshadowing - early testing to avoid later objections
- Townscape and Heritage - agreement on key views and rigorous assessment including input from Historic England (where appropriate)
- Aviation safeguarding – addressing potential interference with Birmingham Airport's radar and other systems

THE ARCHITECT'S VIEW

With the anticipated growth in Birmingham, coupled with the impact of climate change, the city needs a robust, sustainable criteria for justifying building tall. They must carefully consider their physical, social and environmental impact.

Tall buildings can be justified as locators, markers, way finders or gateways, which can start to map the dense urban fabric of Birmingham. Identifying the role and contribution of tall buildings as part of a joined-up vision for the city is needed more now than ever before.

Figure 3: Key design metrics to optimise viability, ordered by scale of impact



Wall:Floor Ratio

Wall:floor ratio – the quantity of external wall per unit of floor area – is intrinsically linked to shape, form and efficiency. A wall:floor ratio within the range of 0.40-0.55 is essential in keeping façade costs – which are typically up to 20% of construction costs for tall buildings – to an optimum.

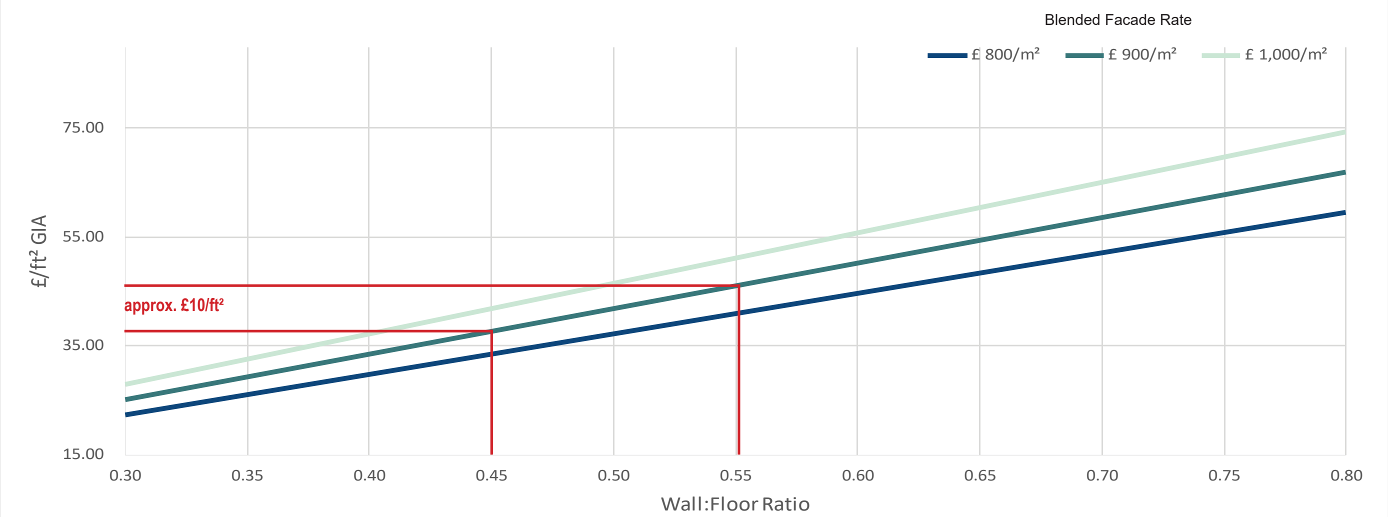
In comparison, this range could extend to 0.60+ when considering a tall building in London due to the flexibility offered by increased sales values. In Birmingham this critical design metric must be subject to finer margins in order to address the viability appraisal. (See Figure 4 below).

Storey heights

In addition to building shape and proportions, target storey heights of a maximum 3.0m are central to achieving the target wall:floor ratio. Notably, this has the supplementary benefit of reducing overall building height, affording the luxury of lowering capital costs or including additional storeys; as an example, a 0.1m decrease in storey height across 30 storeys allows for the inclusion of one additional storey, and the additional revenue this brings, for no increase in overall building height.

Any increase in wall:floor ratio is compounded by a consequential impact on building services. An increased envelope area leads to increased solar gain, influencing the requirement for potentially costly solar control measures.

Figure 4: How wall-to-floor ratios affect construction costs



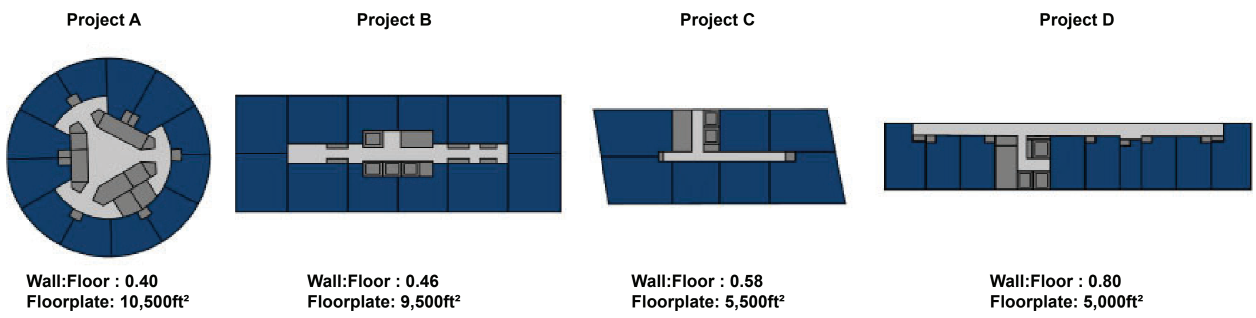
SOURCE: CORE FIVE

Floorplate size

Figure 5 below demonstrates how wall:floor ratio can vary by building shape. Circular floorplates provide the most efficient wall:floor ratio, but do not perform as well as more conventional shapes in respect of net:gross ratio and are more costly and time consuming to fit out. Floorplate size is of equal importance. Highlighting this are buildings B and C; whilst relatively similar in shape, the wall:floor ratio is significantly increased by the smaller typical floorplate size of C. As with all key design metrics, there is an optimum to be found for residential developments to ensure adequate depth of units and avoid adversely affecting the net:gross ratio through addition of inefficient core and circulation space.

In addition to influencing the wall:floor ratio, floorplate size dictates the number of apartments that can be accommodated per core. What constitutes the optimum will vary by building shape, however a sub-optimal floorplate will either struggle to accommodate the requisite number of apartments per core to achieve optimum viability, or truncate the average unit size leading to an increase in £/ft² NIA. This, in addition to giving a less efficient net:gross ratio due to the proportion of core area to floorplate, will negatively impact viability and constrain subsequent rationalisation of design.

Figure 5: How wall-to-floor ratio varies by building shape



SOURCE: CORE FIVE

Net:Gross Ratio

A number of factors influence the net:gross ratio of residential developments, however an inherent consequence of building tall is reduced floor plate efficiency; additional structure to resist wind loads, increased core sizes, lift provision, plant space and riser size requirements all impact Net Internal Area (NIA). A ratio of 80% should be targeted on a typical floorplate, though this is challenged as height increases (see Figure 6).

Beyond the 'official' skyscraper yardstick of 100m in height (circa 33 storeys), intermediate plant space is likely due to excessive vertical distribution distances, potentially losing NIA whilst adding to shell and core costs.

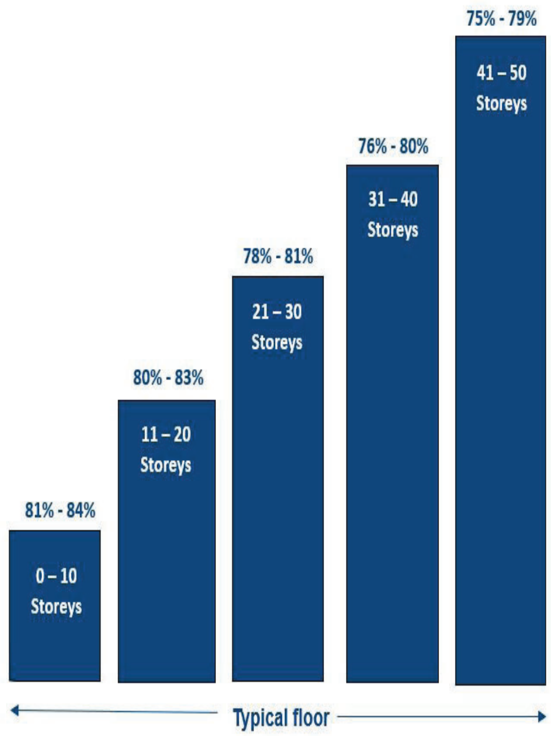
Build-to-Rent models typically see lower overall NIA:GIA than other residential schemes due to amenity provision, which whilst being central to the model increases £/ft² NIA.

It is therefore important to ensure amenity space allocation achieves the optimum balance between added value / marketability and NIA:GIA.

Further challenges to NIA may materialise in the near future as and when building regulations make the inclusion of two stair cores in tall buildings mandatory, and net zero carbon residential buildings necessitate thicker wall insulation. This may reduce NIA by 2% to 4%.

Design teams should meticulously review every element - from wall thicknesses to circulation, plant, lift and riser requirements - to maximise the NIA:GIA ratio. The magnification effect of decision making on tall buildings means it is essential to have an experienced design team able to constantly refine and optimise the design. For context, a 1% NIA improvement across 30 storeys with target sales values of £450/ft² can result in circa £1m additional income.

Figure 6: Typical net to gross ratio per floor as number of storeys increases



SOURCE: CORE FIVE

Façades

The challenge regarding facades is to select a repetitive system with the requisite aesthetic, thermal and acoustic properties. A solid:glass ratio of 70:30 is optimal to mitigate the requirement for solar control e.g. interstitial blinds, though this isn't ideal architecturally and inhibits natural light.

Alternative options include changing building orientation, shading via window reveals or a specification of unitised façade capable of mitigating solar gain to avoid the requirement for cooling. From a cost perspective, it is important to assess the implications of increased reveal depths or façade specification against the cost of providing other means of solar control, but the solution is to mitigate through passive means i.e. building fabric rather than mechanically. Recent examples in Birmingham have seen inward-opening windows screened by perforated panels to avoid wind effects.

A sealed façade mitigates noise and air quality issues, though this can introduce the requirement for additional mechanical ventilation and removes tenant flexibility. Whilst dictated by site location, openable windows are the optimum from both a cost and end user perspective, providing a solution to avoid the impact of wind velocities at height can be identified.

Buildings with fewer than 30 storeys can consider non-unitised alternatives, whereas anything taller will typically require a fully unitised system. Whilst a unitised façade in London would be anywhere from £1,000 to £1,500/m², in Birmingham this reduces to £900 to £1,000/m².

THE MECHANICAL AND ELECTRICAL ENGINEER'S VIEW

Controlling solar gain is vital to reducing summertime thermal comfort issues, especially where noise / air quality issues exist. A 70:30 solid:glass ratio (certainly no higher than 60:40) for the east, south and west elevations is optimal. Ideally, external shading should be provided; whilst internal blinds control glare effectively, they are less effective at controlling solar gain, making external or interstitial blinds on southerly facing facades the ideal. For net zero carbon buildings the optimum glazing ratios are 25% on the southern, no more than 20% on the east/west and as little as possible on the northern elevations.

Repetition And Methodology

THE STRUCTURAL ENGINEER'S VIEW

The repetitive floor cycle defines a large portion of the critical path. Consideration needs to be given to optimise cycles. Additional blade walls off a central core provide an efficient way to improve the overall stiffness of the building, but can impact distribution of materials around a floorplate. Whilst post-tensioned slabs can be a main contractor concern with an additional trade and lengthening cycle times, typically requiring an additional day on the floor cycle, they do reduce overall storey heights.

A common barrier to building tall is programme; the additional preliminaries costs associated with lengthy build durations, delay in investment returns for funders, requirement to commit to a large number of units in one go (unlike similarly sized phased low rise developments) where a large number of units are released to market at a similar point in time and the inherent market risks of building contracts spanning across such durations can perturb many.

Whilst fully volumetric modular solutions often drive certain product (unit mix), structural and architectural compromises that are typically only acceptable for a small proportion of towers, the need for speed and repetition means that localised prefabricated solutions are often used wherever possible and the boundaries are constantly being pushed on this to find the most efficient construction methods.

The major opportunity of tall buildings is economy of scale. Design should take advantage of this through widescale repetition, speed and consistency of fit-out. Do the floorplates repeat? Does vertical distribution stack? Do the floorplate layouts minimise frame and upper floor cycle disruption? Has the façade been designed to accommodate standardised unitised panel sizes with maximum repetition? Has the building been designed to accommodate bathroom pods?

Structural Solutions

The size, proportions and external pressures on tall buildings dictate a significant structural response, which for a residential tenure is almost universally a reinforced concrete frame. Such structures are costly and, built traditionally, slow to construct; their optimisation is central to the viability of tall buildings in the Birmingham market.

From a cost perspective, shear walls are significantly more costly than columns, remove flexibility from the end user, slow floor cycles and add weight. Beyond certain tipping points in respect of height, however, they become a necessity (see Figure 7). Our research indicates that tall buildings in Birmingham should be structurally led, with architecture reacting to structural layout constraints. Where architectural layouts dictate structural design, this can lead to a sub-optimal frame solution.

Figure 7 is based on a parametric design exploring the structural configuration for a square floorplate of circa 7,000ft². This illustrates the compromise (% increase / saving in concrete volume) to be quantified and allows other factors such as floor cycle issues and imposition on the residential layout by blade walls to be assessed holistically.

For example, a core and single blade wall layout becomes more efficient than a standalone core and associated columns in terms of overall concrete volume beyond approximately 29 storeys, but any benefit may be offset by the lengthened floorplate cycle and difficulty of distributing unitised curtain walling and bathroom pods around a floorplate compartmentalised by blade walls.

THE ARCHITECT'S VIEW

A key part of this approach requires an in-depth understanding of the structural strategy from the outset. The stability provided by a central core on say a 26m x 26m floorplate with apartments wrapped around helps minimise lateral distribution of services from risers to individual units, all contributing to efficient design. Stacking services, structure and layouts creates further efficiencies and help prioritise costs in areas which add value.

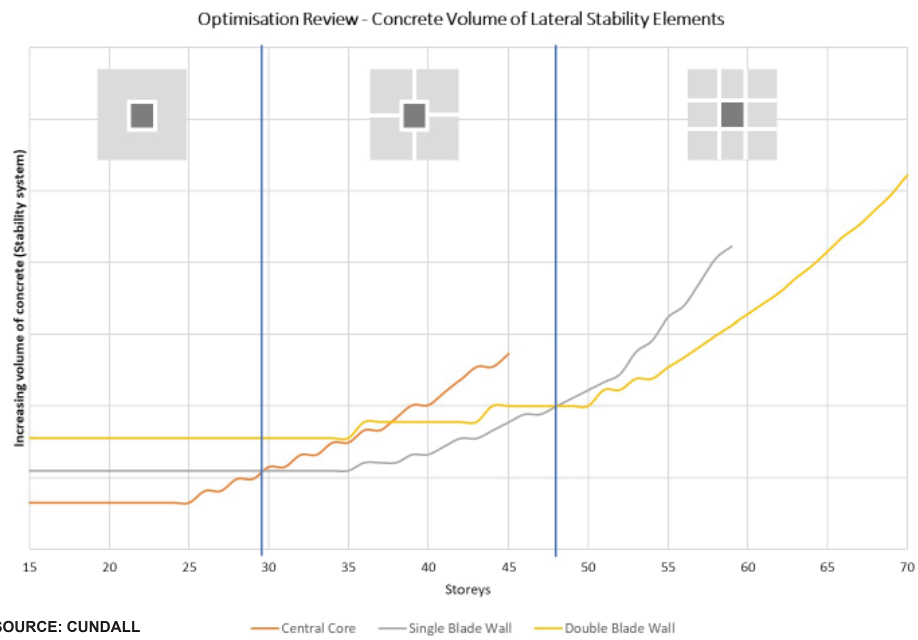
THE STRUCTURAL ENGINEER'S VIEW

A baseline of a reinforced concrete frame with a central core for a residential tower may be the optimal solution when viewed against cost,prorgramme and supply chain.

As height and slenderness increases, second order effects such as axial shortening and dynamic response to wind loads become key constraints governing design.

Efforts should be made to reduce structural mass at each floor level. This would typically be achieved through increasing strength in vertical elements, controlling floor slab spans or introducing post-tensioned slabs. Aside from reducing material volumes, reduced frame weight will have a beneficial impact on substructure costs. Birmingham benefits from shallow sandstone across large parts of the city centre, allowing for relatively efficient piled foundation designs.

Figure 7: Optimal core and shear wall layouts and associated tipping points



SOURCE: CUNDALL

Services (MEP) Strategy

With the potential for MEP services and lifts to account for circa 20-30% of total construction costs, the means of heating and cooling the building, adequately mitigating solar gain and providing ventilation where facades are potentially sealed in a noisy city centre environment suffering from air quality issues, is pivotal to a tall building being viable in Birmingham.

The major issue typically encountered is thermal comfort, though this can be overcome by introducing purge ventilation to sealed facades. Several developments are now adopting a decentralised all-electric strategy for heating, hot water and kitchen hobs, which improves net:gross efficiency, while offering some cooling to prevent overheating. Cost of electrical distribution also increases with height.

Central plant systems for buildings over 60m high (circa 20 storeys) increase in cost due to pressure breaks through hydraulic separation and a general increase in the pressure rating and relief of pipework. Typically, separation will be at circa 60m but could be as high as 100m, though this may not be cost effective. Additional cost is encountered through increased electrical distribution and enhanced protection via sprinklers and wet risers.

THE MECHANICAL AND ELECTRICAL ENGINEER'S VIEW

Traditional central plant with gas-fired CHP and boilers is being superseded by lower electric grid carbon factors. Direct electric heating however is more costly to the end user than electric heating generated via heat pumps and requires larger electrical utility infrastructure, which may be a site-specific factor if limited by available capacity. Whilst direct electric heating is currently cheaper from a capital cost perspective, heat pump technology is becoming increasingly viable and cost effective

Looking to the immediate future, localised, holistic HVAC and domestic hot water heat pumps can help meet the requirements of zero-carbon buildings on their own, without a requirement for central plant and saving riser and plantroom space. These use electric heat pumps within the MVHR unit to heat the apartment fresh air supply and domestic hot water. Whilst cooling is not ordinarily commercially viable for residential developments in Birmingham, a significant amount of cooling (or rather overheating mitigation) can be generated as a by-product of summer domestic hot water generation, thereby also mitigating solar gain issues.

This overheating mitigation can be used as a solution to apartments with noise and/or air quality issues which causes facades to be sealed, and without having to resort to full cooling solutions. This emerging technology has been market tested on Birmingham high rise schemes with such issues and has proved cost effective and capable of meeting all design targets, including summer-time thermal comfort without needing to open windows facing busy roads. Consideration will however need to be given to the façade and, in particular, air permeability.

Fit-Out Specification

Whilst differences in labour rates and issues surrounding material delivery costs see increased installation rates in London, our analysis of the London and Birmingham markets points to specification levels (and hence supply costs) being the key cost differentiator regarding fit-out.

It is therefore essential to align fit-out specification with sales / rental values in order to ensure suitability and viability for a particular market.

Examples of specification differences are shown in Figure 8 below. It should be noted that Birmingham does not currently tend to see significant cost differences in specification levels between open market and Private Rented Sector (PRS) schemes.

Figure 8: Fit Out Comparisons (Birmingham / London)

	FINISHES	FITTINGS	TECHNOLOGY
BIRMINGHAM £350 - £450 / ft²	➢ Metal studwork with plasterboard and paint finish ➢ Proprietary primed / site painted or laminated entrance door, proprietary ironmongery, painted internal doors ➢ 50% ceramic tile coverage to bathrooms (standard range) ➢ Carpet to bedrooms, off-the-shelf laminate / timber effect vinyl flooring to other areas ➢ Plasterboard ceiling with paint finish	➢ Proprietary kitchen units, composite worktop, splashback with undermounted stainless steel sink and mixer taps ➢ Proprietary wardrobe with laminated finish doors to master bedroom only including high level shelf and hanging rail (secondary by purchaser) ➢ Proprietary vanity unit with integrated ceramic basin ➢ Mirror only, bathroom storage excluded ➢ Glass shower screen	➢ Heating via electric panel heaters with heated towel rail in bathrooms ➢ Cooling - None ➢ White plastic switches and sockets ➢ Pendant lighting generally, LED spotlights to kitchens and bathrooms only ➢ Local rocker switches ➢ Data cabling to living room only for video, TV, telephone and superfast broadband
LONDON £800 - £1,000 / ft²	➢ Metal studwork with plasterboard and paint finish ➢ Timber veneered hardwood entrance door, medium quality ironmongery, painted internal doors ➢ 100% ceramic tile coverage to bathrooms ➢ Good quality carpet to bedrooms, off-the-shelf engineered timber flooring to other areas ➢ Plasterboard ceiling with paint finish	➢ Medium-quality kitchen units, silestone worktop, splashback with undermounted stainless steel sink and mixer taps ➢ Fitted wardrobe with mirror or veneer finish doors to master bedroom only including high level shelf and hanging rail (secondary by purchaser) ➢ Porcelain vanity unit with integrated ceramic basin ➢ Overhead bathroom storage including mirror and lighting ➢ Frameless glass shower screen	➢ Wet underfloor heating with electric underfloor and heated towel rails in bathrooms ➢ Cooling - None, other than penthouses ➢ Stainless steel switches and sockets ➢ LED spotlights and downlighters throughout ➢ Local dimmer switches ➢ Data cabling to all rooms for video, TV, telephone and superfast broadband

SOURCE: CORE FIVE

THE AGENT'S VIEW

Branded appliances, kitchens and sanitaryware are not drivers for rental tenants in the same way they may be for the owner-occupier market. For the rental market, it is functionality and durability that is key; not only for convenience but also when taking into consideration the lifespan and replacement costs of these items

Lifting Strategy

The benefit of giving early consideration to a tall building's vertical transportation strategy is twofold; finding the optimum balance between the number of lifts and lift speeds will minimise capital costs whilst offering acceptable waiting times to the building populace, and will have a significant bearing on the attainability of the aforementioned target net:gross ratio of 80%.

Whilst lift traffic analysis can be used to determine the optimum number of lifts relative to waiting times, this needs to be balanced with sales values. Lifting strategy (and what is deemed to be an acceptable waiting time) needs to be considered as part of an initial brief due to the significant impact on core sizes and therefore NIA:GIA.

For example, the simulated building profile modelled in Figure 9 indicates that for this example building greater than three lifts are required typically above 35 storeys. This however is unlikely to be viable from a commercial perspective as the NIA:GIA, which already diminishes with height, is further impacted by introducing more lift cores. This could be mitigated by zoning the building into low-rise and high-rise groups of lifts. By adopting this approach, floorplate efficiency can be improved to the high-rise core by reducing the number of lifts servicing these levels.

The table (below) suggests the following approximate tipping points with regard to building height. Knowledge of such tipping points can improve viability by exploiting height within these technical parameters.

Approximate 'tipping points'	
20 storeys	Hydraulic separation i.e. pressure breaks within pipework
25 storeys	Increase from 2nr to 3nr lifts
30 storeys	Single blade wall structural layout, unitised curtain walling
33 storeys	Lift machine room required above lift shaft
37 storeys	Double blade wall structural layout
40 storeys	Possibility of 4nr lifts

THE VERTICAL TRANSPORTATION ENGINEER'S VIEW

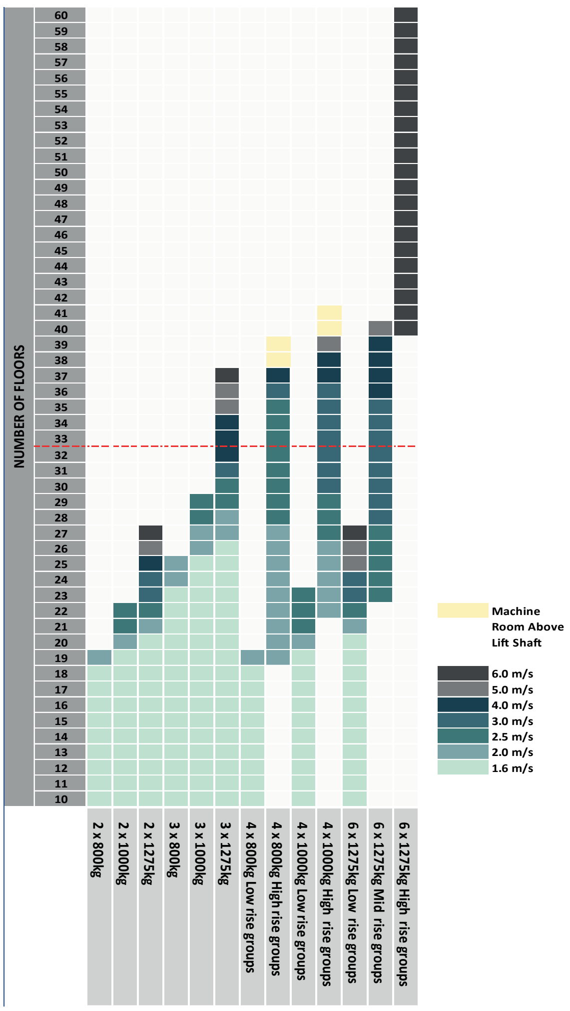
There is a common misconception that faster lifts are required for tall buildings. For the purposes of this article, a lift traffic calculation has been carried out for a theoretical building with a typical floorplate containing a mix of 10 varying sized apartments, a storey height of 3m, and following the guidance provided in CIBSE Guide D:2015 applying a number of typical assumptions. Obviously every building is different and requires its own lift analysis.

When setting a lift strategy key considerations include:

- Whilst increasing lift speed can increase the height capability for a certain quantum of lifts, the increase in height offered by the increase in speed is typically only one or two additional floors before waiting times become an issue. The cost increase caused by this increase in lift speed is likely to outweigh the benefit of adding these floors.
- Buildings above approximately 33 storeys (100m) typically require a machine room above the lift shaft.
- Buildings above 40 storeys could require 4nr lifts, significantly increasing lift core size.

Figure 9 shows the lift speed required versus increasing building height e.g. two lifts could be suitable for up to 27 storeys, and three lifts up to 37 storeys.

Figure 9: Lift size/speed versus number of storeys



SOURCE: CUNDALL

Concluding remarks

Tall buildings, by their physical scale, complexity and quality requirements, are costly. Their role in acting as key way finders, attracting tourists and encouraging an increase in surrounding development are some of the primary benefits of high quality landmark buildings.

That said, beyond certain ‘tipping points’ at which additional technical considerations come into effect, the overall £/ft² of a tall building will increase and floor plate efficiency will decrease. Figure 10 outlines anticipated £/ft² GIA costs for tall residential buildings in Birmingham.

Whilst tall buildings have historically been more prevalent in London they are now more commonplace in regional cities, including Birmingham, where the challenge of achieving viability is all the greater and parameters applied to key design criteria must be tightened accordingly.

By adhering to the design principles set out within this article, considering and rationalising each at the outset of the project, inherent constraints can be mitigated to the greatest possible extent and viable tall buildings accomplished. To achieve this amid the further constraints of sales values and planning requirements in Birmingham, building tall requires an engineering led solution combined with skilful and sensitive architecture that responds to the place.

The introduction of net zero carbon targets and the regulatory implications for residential developments in a post-Grenfell world will put build costs under additional pressure, further highlighting the necessity of maximising design efficiencies and adopting an engineering led approach to maintain viability.

There is however the question of procurement when looking to further improve viability. Whilst this article has principally addressed the optimisation of tall buildings from a design and construction perspective, the procurement of tall residential buildings plays a crucial role in successfully marrying the client’s key objectives of time, cost and quality. Coupled with this, contractor pipeline, capacity and capabilities at a point in time dictates the market’s approach to risk and therefore influences the selected route.

Contractors in the region are getting to grips with building tall, and new entrants are providing alternatives to what has traditionally been a two-stage or negotiated process. Teams are now considering alternative hybrid procurement routes. Whilst allowing for early specialist input, thereby reducing design risk, a hybrid two-stage method can provide up to two thirds cost certainty at the end of the first stage, a proportion often sought by investors.

A schemes attractiveness to the market via the combination of client body, future pipeline, consultant team, equitable risk allocation, optimised design and site particulars / logistics will also ensure competition and contractor interest. Ultimately, the most appropriate procurement route will need to be determined on a project by project basis and, having already optimised the design to the greatest extent possible, procurement offers a further final opportunity to improve viability.

THE ARCHITECT’S VIEW

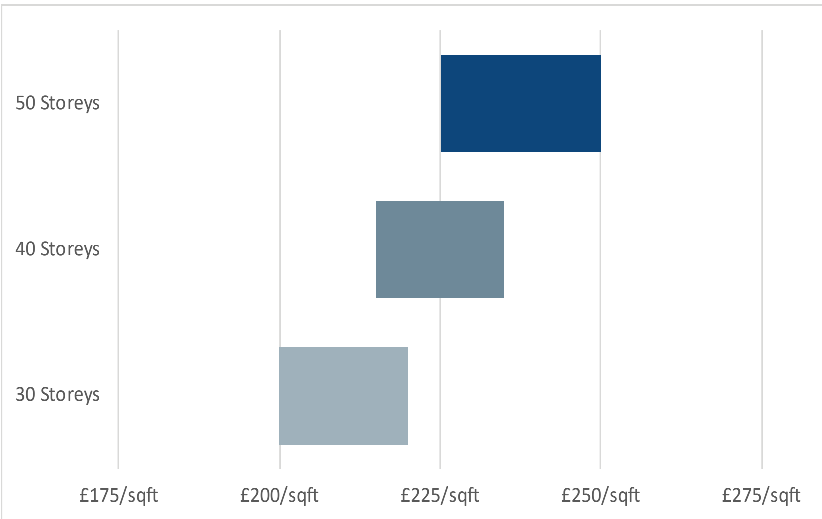
We know denser, compact cities lead to better transport accessibility; this, in turn, means better access to workplaces, reduced congestion and fewer carbon emissions, thereby providing the opportunity for more sustainable places.

Though taller buildings have an inherently higher embodied energy, they need to strive for much greater resilience, lower energy in use and last long enough to justify their need.

The delivery of tall buildings demands a holistic approach to design, and Birmingham should adapt the guidance on tall buildings from the Design Council and Historic England as part of assessing forthcoming proposals so that they may be delivered sustainably and responsibly.

Tall buildings will play a vital role in shaping Birmingham as a global city and redefining its skyline, so these research case studies will help us to address the challenges in a more informed approach.

Figure 10: GIA costs for tall residential buildings in Birmingham



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