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TRANSPORT ORIENTED DEVELOPMENT COST MODEL

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CASE STUDY: FARRINGDON STATION

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TAX INCENTIVES

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THOUGHT LEADERSHIP THAT ADDRESSES THE BIG ISSUES OF TODAY AND TOMORROW

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TRANSPORT-ORIENTED DEVELOPMENT

FOREWORD

With the UK housing shortage and limited space to build on in our towns and major cities, building on top of and around our bus, train and metro station transport hubs could increase housing supply, trigger wider urban regeneration and create jobs in well-connected areas. But there are a number of planning, engineering and construction complexities that come with transport-oriented development that can affect project programme, costs and therefore viability. WL

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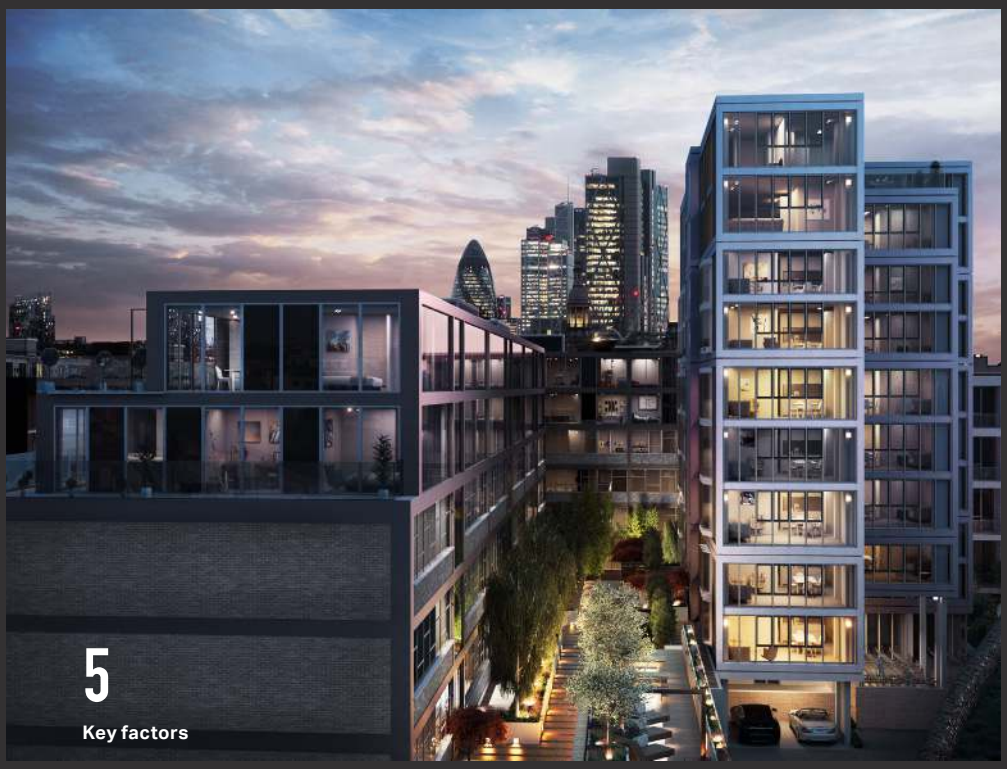
Cover image
Dalston Station - East London Line extension
The oversite development above Dalson Station created over 500 new homes and the largetst public square in London for a century.



TRANSPORT-ORIENTATED DEVELOPMENT

Building on top of and around transport hubs such as rail and bus stations can create much needed new homes in ideally connected locations, but the viability of such transport-oriented developments depends on complex factors. **Mike Pauley** and **Bernard Duffy** at AECOM evaluate the cost considerations.

INTRODUCTION

Continued investment in UK rail networks is providing significant improvements to the infrastructure itself, but it can also act as a catalyst for wider urban regeneration — think Grand Central in Birmingham and Kings Cross in London, one of the largest regeneration schemes in Europe.

Plans for major new infrastructure such as Crossrail 2, for example, include large elements of transport-oriented development (TOD) to show the wider value the proposed rail route will create.

Design studies, research and analysis carried out by AECOM suggest delivery of the line could trigger the development of around 215,000 homes, leading to thousands of jobs and contributing significantly to the strategic regeneration of London and the South East.

Through thoughtful TOD, stations can become destinations in themselves — places where people go not only to travel but also to shop, meet friends, work and live, creating a significant uplift in land value.

215k

AECOM's design studies, research and analysis carried out on the plans for major new Crossrail 2 infrastructure suggest delivery of the line could trigger the development of 215,000 homes, leading to thousands of jobs.

It's become a neat equation that if an area becomes a place people want to visit, and is well connected, the value of the land increases.

Understanding all the design issues surrounding TOD, producing low-cost high-value solutions and being able to cost the project accurately, have the potential to release large amounts of land for development in our cities across the UK. Costing of 'Abnormals' is the challenge as they are site specific and often complex.

KEY FACTORS

A perfect balance

From the start of a TOD project through to operation, a range of specialists are needed from architects and engineers to cost professionals, project managers and real estate experts — those who understand the planning context, the nature of the infrastructure and the potential impact of the infrastructure on the development.

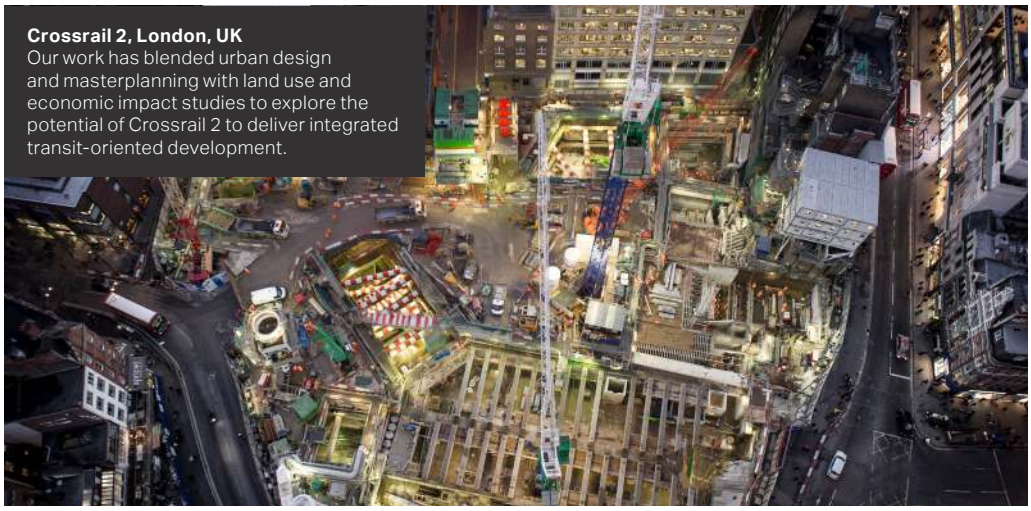
Ultimately, successful TOD delivery depends on balancing commercial viability with safety issues and the constraints of working adjacent to a live railway: understanding both the developer and the infrastructure operator is critical. Generally, transport services have to be maintained throughout construction, which means figuring out how to build something new on an existing piece of infrastructure that potentially has tens of thousands of people passing through it each day.

Harmonious design

It is imperative that oversite development doesn't denigrate or diminish the functionality of a station. This requires a depth of knowledge around what makes a commercial development viable, and how a station works. The two will ultimately add cost to each other, but there is a point that can be reached, where the total cost of the station and the oversite are the lowest they can be with the highest value outcome. Otherwise, you could end up with a cheap-to-build office or housing solution and a station that bears the brunt of the cost, or a station that has to make so many compromises that it no longer provides the public with the facilities and ease of access that is its prime reason for being there.

Planning constraints

It is vital that town planning is considered at an early stage: planning policy can restrict the development, impacting on cost and viability — for example, if the site is located within an area that does not permit tall buildings or that sits within a protected view corridor. An early due diligence planning assessment could prevent any work being aborted down the line. Where development is considered a possibility, the proposals will need to be brought forward in accordance with planning policy.



Crossrail 2, London, UK
Our work has blended urban design and masterplanning with land use and economic impact studies to explore the potential of Crossrail 2 to deliver integrated transit-oriented development.

> THE DEPTH OF KNOWLEDGE AROUND WHAT MAKES A COMMERCIAL DEVELOPMENT VIABLE, AND HOW A STATION WORKS WILL ULTIMATELY ADD COST TO EACH OTHER

> THE MAJOR DIFFERENCE BETWEEN OSD AND OTHER DEVELOPMMENTS IS THE CONSTRUCTION OF A DECK THAT SEPARATES OSD FROM OPERATIONAL RAILWAYS

Environmental issues must also be considered, such as air quality, noise, ground contamination, flooding or surface water drainage, heritage or archaeology and daylight. If adverse impacts are predicted, mitigation measures would be required to reduce the impacts to an acceptable level. These measures could be costly depending on the degree of mitigation required, be it anything from full land remediation through to archaeological excavations. In some cases, mitigation may not be possible and redesign will be required, which could have implications on development capacity of the site and the project's overall cost and viability model.

Issues around requirements for social and community infrastructure can also arise. Depending on the site location, the development will need to pay a Community Infrastructure Levy and enter into a S106 agreement to mitigate the development's impacts on existing infrastructure within the area, for example, by providing funding towards a new secondary school.

Abnormals' and viability

Building on top of (oversite development, or OSD) or next to (adjacent site development, or ASD) live transport infrastructure in dense urban environments is complex and involves a number of added engineering and construction 'abnormals' compared to typical built environment projects, which can affect design, construction and operational complexity, speed to market and viability.

However, faced with a shortage of affordable housing across the UK and limited space to build on in our major cities where demand to live and work is high, developing above and around stations has become more viable as land values have increased.

TOD is now able to pay for itself, particularly when utilising the latest advances in engineering and construction, or by designing out and mitigating the issues early on in the design stages.

But TOD isn't just about tapping into opportunities to intensify our cities. Opportunities exist in rural locations up and down the country too, where derelict land often surrounds local stations, which can be converted into thriving community hubs, helping solve at least in part the housing shortage. Perhaps just as importantly, TOD can be viable along major new transport infrastructure routes, including the proposed Northern Powerhouse Rail (HS3) connecting Liverpool to Hull and East West Rail connecting East Anglia with central, southern and western England.

Land contamination

If land that is to be developed is adjacent to a railway, chances are it will have some form of contamination, be it oil or asbestos, for example. It's when you start disturbing the land to build on it that you can run into obstacles. Any remediation required will have consequences on project time and costs.

Deck to build over

A deck is the construction that separates OSD from the operational railway underneath: it is the major difference between OSD and other developments, such as a standard office block. Building the deck is intrinsically difficult because it requires building around or through existing buildings. Building the deck above a live station brings added logistical and safety challenges around the movement of people in and out of the station and surround area while works are carried out.

IF A TRANSPORT-ORIENTATED DEVELOPMENT IS BUILT ON TOP OF AN OPERATIONAL STATION, THE DESIGN NEEDS TO FACTOR IN HOW THE BUILDING WILL BE SAFELY AND EFFECTIVELY BE MAINTAINED WHILE THE STATION IS IN USE BY THE PUBLIC. MAINTAINING THE USABILITY OF STATION AND SURROUNDING AREAS DURING CONSTRUCTION IS CRUCIAL.

The provision of a deck over existing rail lines is predicated on providing a transfer deck that can span over the rail lines while being sufficiently robust to support the proposed buildings above. The transfer structure may need to be incorporated over a number of storeys. This transfer zone needs to be coordinated to allow for lift pits and other service zones which cannot penetrate below the transfer slab.

To make the transfer structure design economical it is important to identify, where possible, zones between the rail lines where piled substructure can be installed to provide support and to reduce the transfer spans. The creation of crash decks, temporary and permanent, need to be considered to reduce the extent of work that needs to be undertaken during engineering hours. However, decks are not all bad news: the OSD has a robust and well-designed platform to build off with no risks associated with ground conditions.

Active vibration solutions

Isolating vibrations caused by transport infrastructure is a big issue: vibrations can travel into the soil beneath and up through the foundations and structure of buildings above and nearby, which can lead to cosmetic or structural damage and be a nuisance to people's working and home lives. There are numerous methods that can be used to isolate the vibrations, such as sprung or synthetic bearings.

The building stack can be used to mitigate the impact, typically having less sensitive uses at the lower levels such as stores, plantrooms and retail, with residential introduced in the upper levels where the vibration has been dissipated. It is about determining which solution is the right fit for each building and development type.

Building core options

Core considerations are particularly relevant for buildings proposed over assets where they are situated on a transfer deck or bearing on the structure provided by the asset below. The nature of the asset will have a large influence on what can be built overhead as key criteria are loadings and spans.

The restrictions are likely to favour different building classifications — for example, the larger spans of an office building may be more efficient to construct in comparison to a residential building. Whether the core is constructed from concrete or steel will have a large bearing on the building weight and consequently the number of storeys that can be accommodated. It should be noted modular construction works well for OSD.

Logistics and the pubic

Noise, vibrations and road closures caused by TODs can be disruptive to local residents and businesses. Moving plant and equipment to and from site must be well coordinated and planned. Informing local residents, businesses and those who use the transport system about the works and engaging with them early on and throughout a project is crucial. This requires a well-thought-out public engagement strategy to ensure any concerns are addressed early on, avoiding potential project delays, to inform passengers well in advance of any track closures or delays and to ensure the development meets the needs of and benefits the community as much as possible.

Infrastructure modification

It is likely that infrastructure such as local roads and footpaths or other structures will need to be modified or demolished.

> **"STRINGENT HEALTH AND SAFETY PLANS AND PROCEDURES ARE PARAMOUNT TO ENSURING THE PUBLIC AND STATION STAFF CAN USE THE AREA AND LOCAL FACILITIES SAFELY**

Demolition is deemed to be inherently dangerous, so the requirement to keep a station open during OSD construction is an added complexity. Stringent health and safety plans and procedures are paramount to ensuring the public and station staff can use the area and local facilities safely. The local utility providers will need to be involved well in advance of any construction to ensure electricity, gas, water, sewage and telephone provisions are maintained throughout the station and to the local community. Any diversions need to be planned well in advance as do any network reinforcements.

Long-term maintenance

If a TOD is built on top of an operational station, the design needs to factor in how the building will be safely and effectively be maintained while the station is in use by the public: if you build over a rail depot and have services pipework, ducting or cables suspended above the rail tracks, how is it going to be maintained? In many instances it is not possible to include pits or any other penetrations below the deck to the transport asset and this can have an effect on the vertical transportation through the building.

Everyday maintenance of the OSD like window cleaning, through to longer term maintenance such as painting or component replacement all need to consider the existence of a live station below. Maintaining the usability of station and surrounding area during construction is also crucial. Factoring in how people will move safely and efficiently in, out and around the station during everyday operation and during an emergency is imperative. Well-thought-out plans need to be developed and in put in place with the local emergency services and station staff. Site staff need to be fully aware of the plans and how to deal with any change or emergency that may arise.

A new funding model?

In Hong Kong, the Mass Transit Railway (MTR) self-funds its rail operations, maintenance and upgrades through its unique Rail plus Property (R +P) business model where the government allows it to develop stations and land along its new rail routes.

MTR then pays the government a premium based on the price of the land before the rail infrastructure is built. MTR builds properties and creates new, well-connected neighbourhoods in partnership with developers, bringing in revenue that pays for its operations, maintenance and extensions, eliminating all tax-payer funding.

McKinsey&Company reports that buildings sit over about half of the system's 87 stations and that the model has become a critical part of Hong Kong's urban-development approach, with planners and government agencies seeking to make every new railway line or extension into a corridor where well-planned, high-quality communities can flourish. Could we see UK rail operators adopting a similar model in the future?

The Long & Waterson Apartments, Long Street, London
Based in east London's Shoreditch, these apartments were developed from disused warehouses on land beside the overground train line near Hoxton station.

USE OF OFF-SITE MANUFACTURE TO BUILD ON SAFEGUARDED LAND

Rail infrastructure land can be safeguarded from development: it cannot be sold or have permanent buildings built on top of it in case it is needed for future rail operations. With a number of such sites across the UK, and spare land for new homes at a premium, one solution is to use temporary, demountable accommodation, such as off-site manufactured modular housing.

This could create opportunities for local authorities, combined authorities and transport operators to come together through an agreement, where rail operators lease out the land, the local authority remediates it so it's safe for human occupation, while bodies like the Greater London Authority contributes to or pays for the modular accommodation.

The accommodation could remain on meanwhile sites until it is no longer needed and taken down and relocated elsewhere within or outside of the borough. This approach could see transport operators collaborating with local authorities to not only help meet the national housing shortage but also help close up the national infrastructure funding gap.

CASE STUDY: FARRINGDON STATION, LONDON

When the Elizabeth Line opens in 2018, Farringdon station will be one of the busiest in the UK, connecting the line with Thameslink and the London Underground — the only station where passengers can access all three networks and some of London's airports.

Farringdon incudes two platform tunnels, each over 240-metres long that link with the station's two new ticket halls: the West Ticket Hall, which connects with the new Thameslink and District and Circle Line station entrance and the East Ticket Hall, which sits adjacent to Barbican London Underground station. Both have been designed to allow future OSD.

As Framework Design Consultant for the whole station, including both ticket halls , AECOM pulled apart and value engineered the inherited scheme to 'make the complex simple', before taking it forward through detailed design to issue of construction information and handover of the finished station. This approach provided equality of routing of disabled passengers, improved buildability and OSD viability.

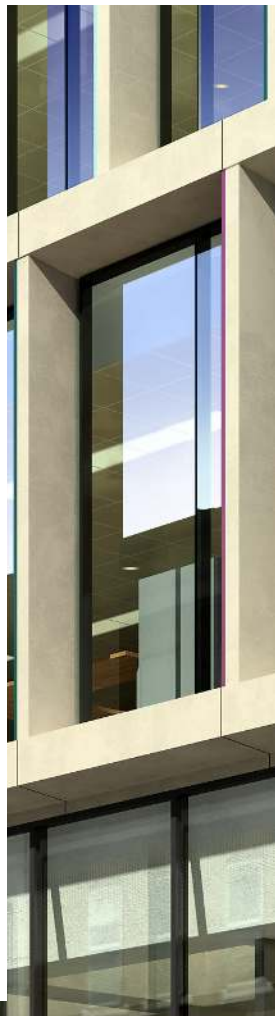
Located opposite the historic Smithfield Market, the East Ticket Hall OSD, where AECOM provided structural and MEP services, includes ground floor retail spaces and a large reception for five floors of offices above, which comprise 120,000 square feet of virtually column-free space around a central core. The development will create a well-proportioned backdrop to the listed Smithfield Market.

Bound by three conservation areas, to the west, east and north, and located among a number of listed buildings, a number of potential OSD schemes were assessed from a townscape point of view. The appropriateness of the shape, form and height of the developments were analysed using a series of computer-generated views of the each scheme. Studies were also conducted to determine how low the height of the OSD could be pushed while still achieving the maximum lettable area.

A number of huge fans are required in Farringdon station to passively address the 'piston effect' air pressure from trains, and to actively remove smoke in the event of a fire.

Turning the fans from a horizontal orientation to vertical reduced the amount of construction required for the station, increased the OSD net-lettable area and simplified the structure supporting the OSD.

A waterproofed crash deck, which forms the roof of the station, also acts to separate Farringdon from the OSD so it can continue to operate without interruption while the offices are constructed, and potentially when they're demolished and rebuilt in the future. The offices above are likely to have a shorter life than the station: Farringdon station has a 125 year design life but offices have been known to be demolished and rebuilt after around 25 years.




FARRINGDON STATION

TAX INCENTIVES

The nature of TOD can give rise to some valuable tax reliefs associated with its design and development.Where 'abnormals' tackle on-site contamination, Land Remediation Relief (LRR) can provide a deduction of 150 per cent to UK companies for qualifying expenditure, subject to satisfying certain criteria. Loss-making companies can surrender the relief for a payable credit, currently 16 per cent of the 150 per cent LRR. LRR is also available for tackling items including asbestos and Japanese Knotweed, the latter of which is a common problem with rail infrastructure.

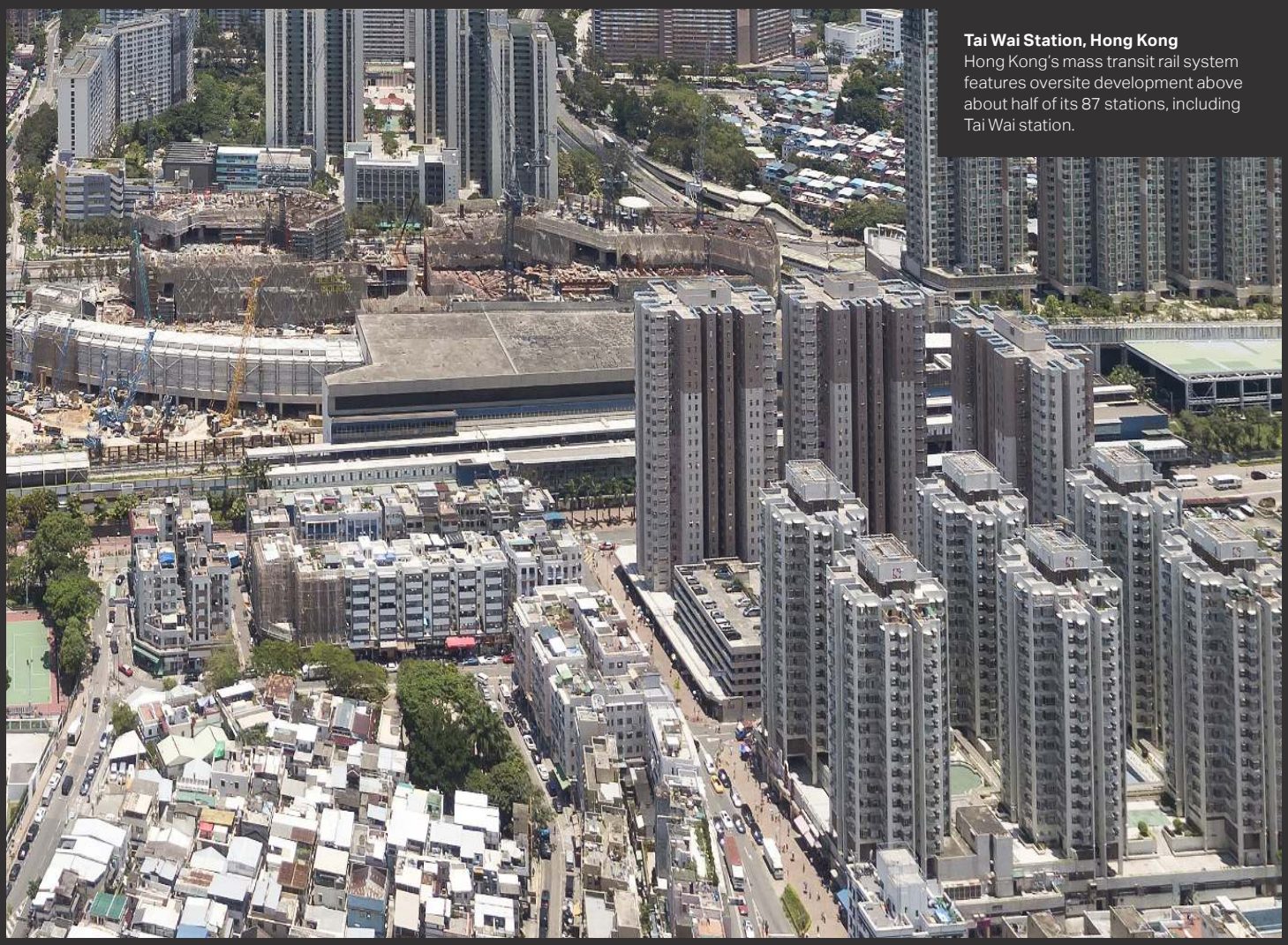
150%

LRR can provide a deduction of 150% to UK companies for qualifying expenditure, subject to satisfying certain criteria.

Specific relief around research and development (R&D) associated with design is also available. Overcoming site-specific issues such as construction over running rail lines and vibration will often require bespoke solutions that aren't readily resolved by 'off the shelf' designs.

Capturing the staff costs associated with any innovation developed can generate a 230 per cent deduction for eligible costs for small and medium-sized enterprises or a 12 per cent 'above the line' Research and Development Expenditure Credit (RDEC) for large companies.

Finally, any commercial elements of the development may generate additional relief through capital allowances for eligible plant and machinery assets. Where energy or water-saving technologies are incorporated (from approved lists or criteria), enhanced capital allowances (ECA) provide 100 per cent relief for qualifying expenditure, or a payable credit for loss-making companies.



Tai Wai Station, Hong Kong
Hong Kong's mass transit rail system features oversite development above about half of its 87 stations, including Tai Wai station.

Soho Place, London
Derwent's Soho Place scheme at Tottenham Court Road station, designed by AHMM, will feature a 350-seat theatre as well as several storeys of offices and ground-floor retail.
Image © Derwent London

THE COST MODEL

A cost model has been prepared based on a 12,000m² gross internal floor area (GIFA) commercial office building (shell, core and Category A fit-out) as the OSD. The location is central London and the cost base date is Q4 2016 updated to Q2 2018 prices.

An indicative range of abnormal costs related to the transfer deck and station related temporary works to facilitate the OSD have also been set out. This excludes the costs of any station remodelling, fit out, new equipment or rail upgrades.

An alternative to commercial offices could be residential units based in lightweight modular construction to mitigate the cost and programme implications of OSD. Typical modular residential units cost could range from £2,500/m² to £3,500/m² depending on factors such as location, access, façade upgrades, fit-out finish, and so on.

SHELL AND CORE

Substructure

Total (£)	£/m²	%
Structural steel frame: Including braced steel framed core, 90 minutes fire protection with factory applied intumescent paint; columns on anti vibration mounts		
3,423,020	285.25	11.70
Upper Floors: 140mm thick composite slab with lightweight concrete and 1.2mm Holorib metal decking, glass lense floor to lift lobby, acoustic insulation to horizontal station surfaces		
1,559,822	129.99	5.33
Roof Structure: 140mm thick composite slab, single ply membrane waterproofing, insulation, precast concrete paving (54%), brown roof (46%), lightweight compostite roof cladding and louvres to rooftop plantroom.		
979,367	81.61	3.35
Stairs and ramps: Folded steel stairs		
346,069	28.84	1.18
External walls: Frameless double glazed façade to ground floor entrance and retail; primary façade unitised double glazed units with solar shading; louvred walls to plantrooms; revolving doors to entrance; tracked BMU to roof		
7,267,290	605.61	24.84
Internal walls and partions: Blockwork walls to ground; drylined partitions to upper floors		
427,228	35.60	1.46
Internal door: Metal doors to ground, timber doors to upper floors, glazed doors to lift lobbies		
238,134	19.84	0.81

Fittings, furnishings and equipment

Total (£)	£/m²	%
General fittings, furnishings and equipment; reception desk, signage, fitting out management areas		
229,413	19.12	0.78

Internal finishes

Total (£)	£/m²	%
Wall finishes: Back painted glass to lift lobbies, painted plasterboard generally		
344,010	28.67	1.18
Floor finishes: Stone floor to ground floor reception and lift lobby; porcelain tiles to circulation areas, rubber flooring to stairs and painted finish to stores and plantrooms		
302,478	25.21	1.03
Ceiling finishes: Feature plasterboard ceiling to reception, painted plasterboard to circulation, painted concrete soffit to back of house and plantrooms		
133,070	11.09	0.45
WC fit-out: Tiled floors on raised floor, laminated wall panelling (IPS) and mirrors, plasterboard ceilings with access panels, laminated/veneered cubciles, vanity unit, fittings, with lockers etc to ground floor changing room		
638,442	53.20	2.18

Works to existing buildings

Total (£)	£/m²	%
Enabling works associated with station structure		
57,421	4.79	0.20

External works

Total (£)	£/m²	%
External Works; replacement paving at OSD ground level		
92,632	7.72	0.32
External Services; incoming utilties		
928,925	77.41	3.17

Services

Total (£)	£/m²	%
Sanitary appliances		
139,643	11.64	0.48
Disposal installations		
234,323	19.53	0.80
Water installations		
235,967	19.66	0.81
Heat source		
90,612	7.55	0.31
Space heating and air conditioning		
1,319,816	109.98	4.51
Ventilation systems		
322,455	26.87	1.10
Electrical installations		
1,161,681	96.81	3.97
Gas and other fuel installations		
32,496	2.71	0.11
Lift and conveyor installation		
874,878	72.91	2.99
Fire and lightning protection		
368,250	30.69	1.26
Communication, security and control systems		
425,151	35.43	1.45
Specialist installation		
287,185	23.93	0.98
Bulders work in connection with services		
274,619	22.88	0.90

Sub total

Sub total (£)	£/m²	%
22,734,397	1,895	78
Sub total shell and core	Sub total shell and core	Sub total shell and core

Main contractor's preliminaries, OH&P, design risk and contingency

Total (£)	£/m²	%
Main contractor preliminaries		
3,637,503	303.13	12.43
Design risk and contingency		
1,568,673	130.72	5.36
Main contractor OH&P		
1,318,595	109.88	4.51

TOTAL SHELL AND CORE

Total (£)	£/m²	%
29,259,169	2,438	100
Total shell and core	Total shell and core	Total shell and core

CAT A FIT-OUT COST BREAKDOWN

Wall finishes

Total (£)	£/m²	%
Column encasement with painted finish		
46,218	3.85	1.02

Floor finishes

Total (£)	£/m²	%
Raised access floor (carpet tiles to raised floor - excluded)		
378,767	31.56	8.37

Ceiling finishes

Total (£)	£/m²	%
Suspended metal tile ceiling with plasterboard margins		
568,895	47.41	12.57

Space heating and air treatment

Total (£)	£/m²	%
Four pipe fan coil air conditioning		
1,301,126	108.43	28.74

Electrical installations

Total (£)	£/m²	%
Tenant distribution boards; lighting and luminaires to office including lighting control; emergency lighting; power to mechanical (FCUs); floor boxes (one per 10m²); earthing and bonding; testing and commissioning		
827,462	68.96	18.28

Communications installations

Total (£)	£/m²	%
Analogue addressable fire alarm and detection system, BS 5839 L1, including FP200 cabling, containment and interface with landlord system; public address system; distribution and sounders		
145,649	12.14	3.22

Protective installations

Total (£)	£/m²	%
Sprinklers installation		
194,197	16.18	4.29

Special installations

Total (£)	£/m²	%
Building management system		
174,778	14.56	3.86

Builder's work in connection

Total (£)	£/m²	%
Forming holes, chases etc; allow 3%		
79,296	6.61	1.75

Preliminaries and contingencies

Total (£)	£/m²	%
Main contractor preliminaries (item £595,000.00); Design risk and contingency (item £256,784.70); Main contractor OH&P (item £215,569.40)		
810,569	67.55	17.91

TOTAL CAT A FIT-OUT

Total (£)	£/m²	%
4,526,957	377	100
Total Cat A Fit-out	Total Cat A Fit-out	Total Cat A Fit-out

ABNORMALS COST RANGE

The abnormal costs will vary significantly depending on the site/station conditions and as such is only a indicative of the potential costs to be considered. The items indicated are therefore not exhaustive.

Cost range (£)

Station related works/transfer deck Station specific surveys
100,000 – 200,000

Temporary works design approvals etc
150,000 – 250,000

Cost of possessions (depending on number and duration)
250,000 – 500,000

Crash decks and protection
750,000 – 1,250,000

Monitoring/reporting
200,000 – 300,000

Piled foundations and structures to support transfer deck
1,000,000 – 2,000,000

Reinforced concrete deck structure over station/rail lines (3000m^2); including column structures, retaining walls; antivibration pads etc
10,500,000 – 15,000,000

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