Hammerson & Ballymore

BISHOPSGATE GOODSYARD

Plots 8B & 8C Basis of Structural Design

XXX-X-X-XX-(01)-XX-XXX
29TH JANUARY 2020

CONFIDENTIAL

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Plots 8B & 8C Basis of Structural Design

RIBA Stage 2 schematic

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PROJECT NO. 24710919

OUR REF. NO. XXX-X-X-XX-(01)-XX-XXX

DATE: 29TH JANUARY 2020

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Plots 8B & 8C Basis of Structural Design

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2
Remarks	RIBA Stage 2 schematic		
Date	30/01/2020		
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Authorised by	P Westal		
Signature			
Project number	24710919		
Report number	XXXXXX		
File reference	XXXXXX		

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FIGURES

1 INTRODUCTION

1.1 BACKGROUND AND DESCRIPTION

The report contains design information for building Plots 8B & 8C scheme to planning submission.

Figure 1 - Proposed location of Plots 8B&8C buildings

Plots 8B and 8C consists of 4 storey hotels with restaurant and gym facilities. The structure is located on top of existing masonry arches. Main services trench runs within landscape build up zone and it is located within the building footprint.

The structure is supported by a series of reinforced concrete beams forming a grillage; these are supported by the existing brick arche piers.

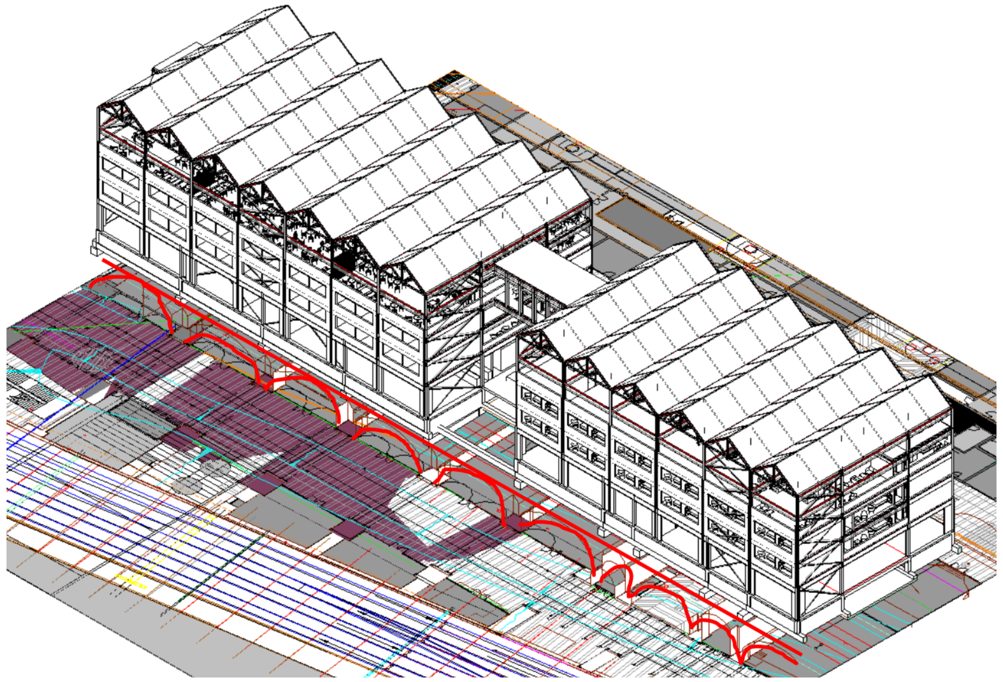

Figure 2 - Proposed plots over existing arches

1.2 PURPOSE OF REPORT

The purpose of this report is to record the development of the design at the end of Stage 2,(pre-planning submission) identifying assumptions, recording key design decisions and providing a platform for the on-going development of the design.

Comparing historic and proposed loading in addition to distribution of proposed loads to avoid arches as additional precaution measure.

1.3 WORKSTAGE OBJECTIVE, SCOPE AND DELIVERABLES

Assisting lead designer Faulkner Brown Architects with developing their planning design by providing schematic design development notes (DDNs) in form of sketches outlining structural design principles which shall be further developed in RIBA Stage 2+ to 3 design.

2 THE SITE

2.1 LOCATION AND BOUNDARIES

The site is located on the Eastern side of Shoreditch High street (A10) Shoreditch, London.

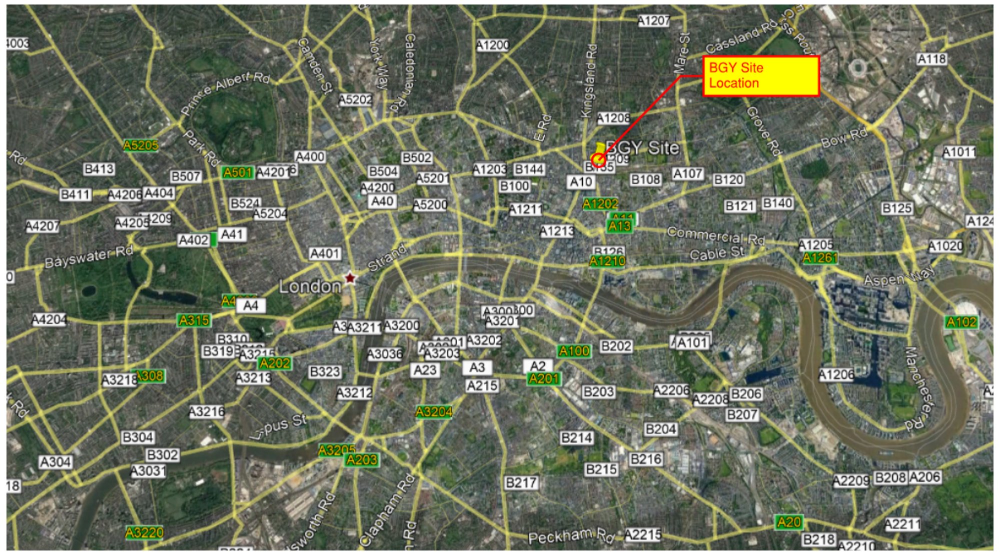

Figure 3 – BGY site location

The Northern side of the site is aligned with Sclater Street; the Southern boundary is constrained by the railway main lines into Liverpool St Station, while the Eastern boundary is adjacent to Brick lane (B134).

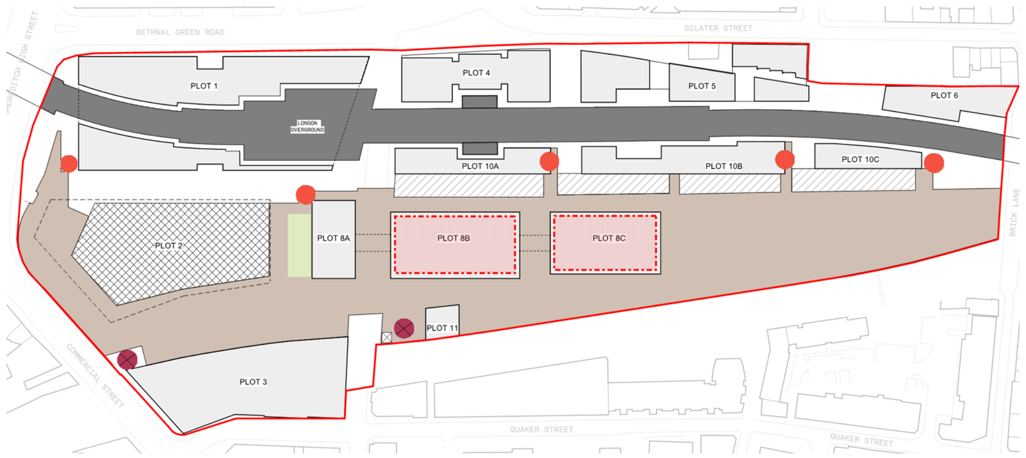

Figure 4 – Plots 8B&C location within BGY site

2.2 KEY DEVELOPMENT CONSTRAINTS FOR PLOTS 8B AND 8C AND EXISTING STRUCTURAL REPAIRS

The following constraints impact the development:

- Existing Braithwaite Arches -Listed Arches structures have the potential to carry substantial loads provided these are appropriately distributed
- Existing top fill on Braithwaite Arches: infill quality is unknown quality and substances; potential hazard of contamination shall be considered
- Braithwaite Arches repairs- generally in good conditions in a few places only locally bricks shall be removed and mortar repaired.

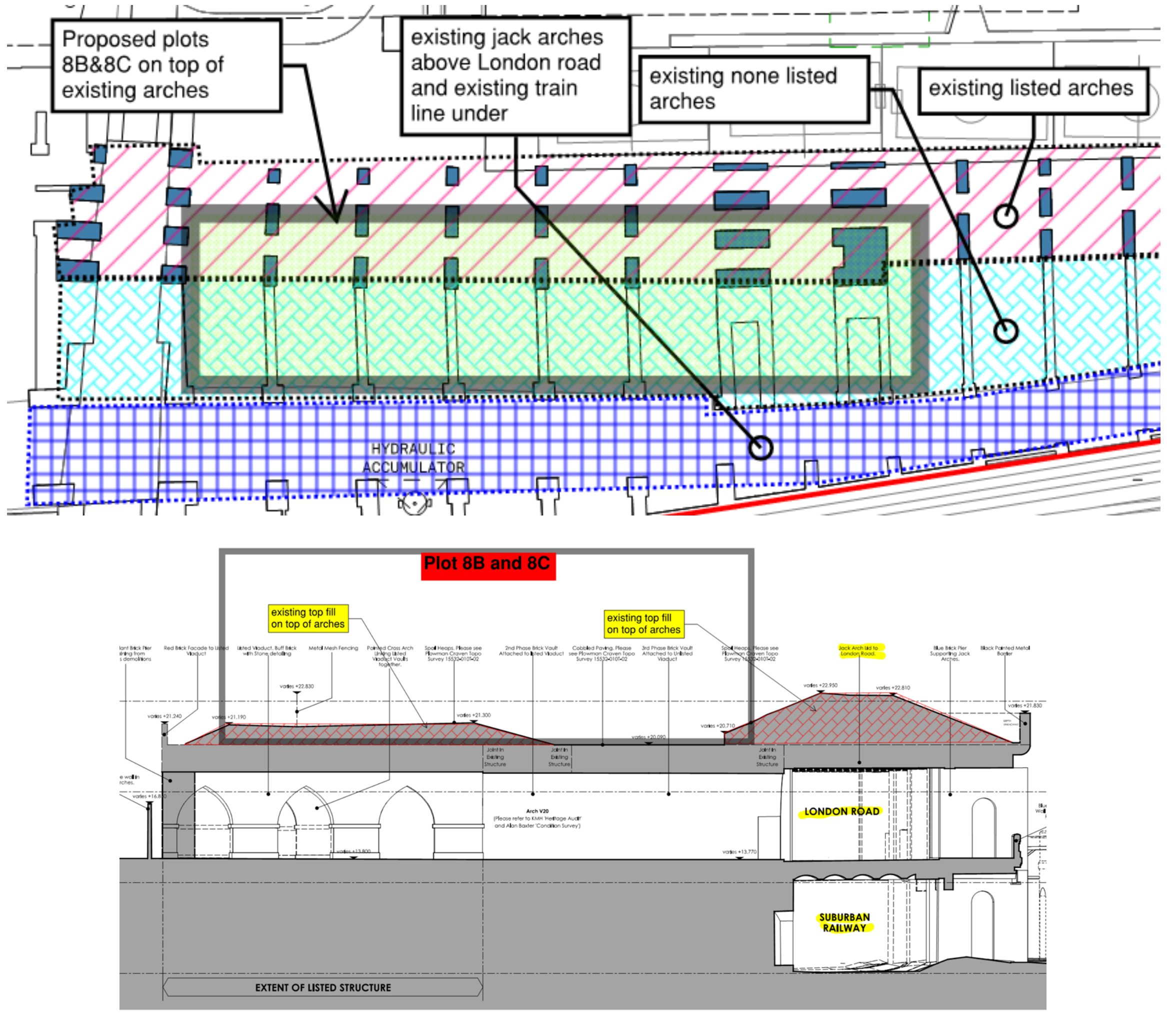

Figure 5 – Extend of plots 8B&8C site constrains

2.3 HISTORIC USE OF SITE

The site was used as Railway passenger station (1840-1867) and goods yard (1868-1964). Refer to Alan Baxter report ABA 2009 and 2013 revisions Condition report for existing brick arches. The document outlines detailed historic use of the site.

Figure 6 - Arial view of Warehouse and Goods Station burnt down in 1964.

Historically the Goods Yard included a large warehouse and goods station on the upper deck over the existing arches / viaduct with wagon lifts working the upper and lower levels allowing railway wagons to be lowered down and shunted around on tracks.

The Braithwaite arches are in good condition and show no signs of major settlement. which is indication that structure can withstand substantially higher loads then currently are experiencing and can support up to a four storeys of light weight construction.

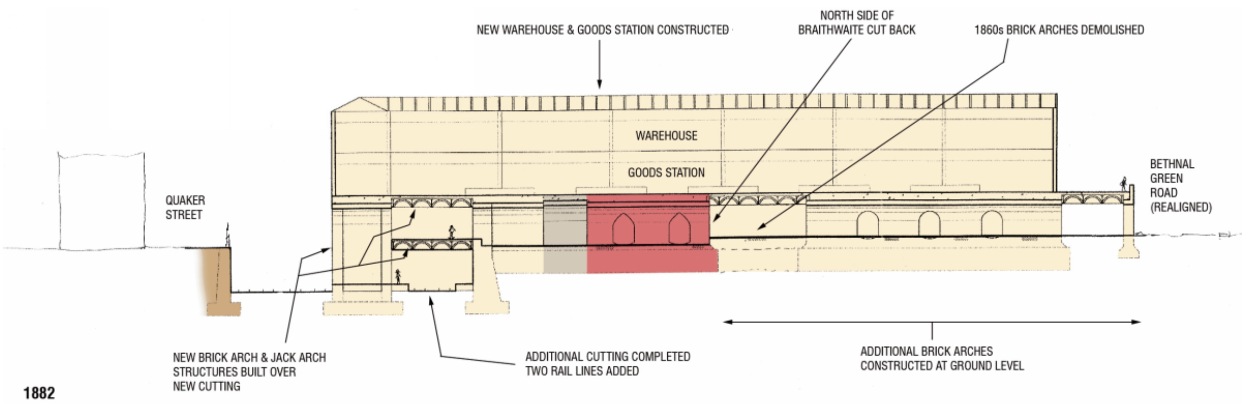

Figure 7 - Evolution Viaduct structure 1882

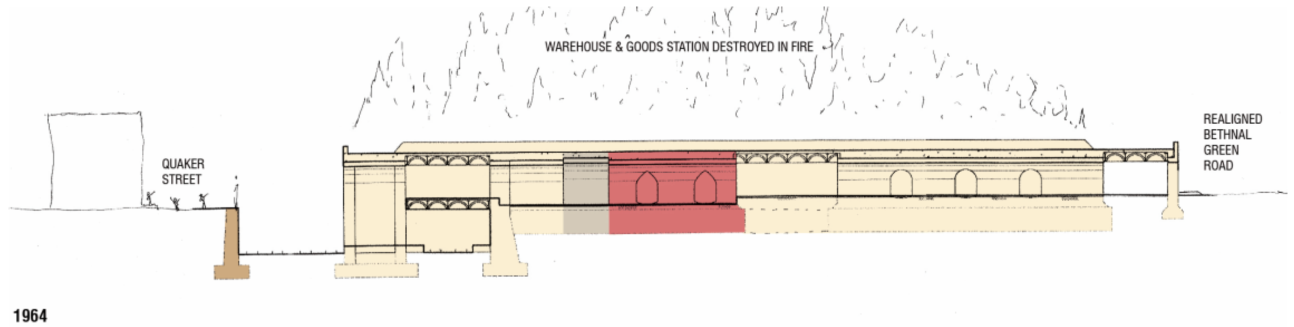

Figure 8 - Evolution Viaduct structure 1964

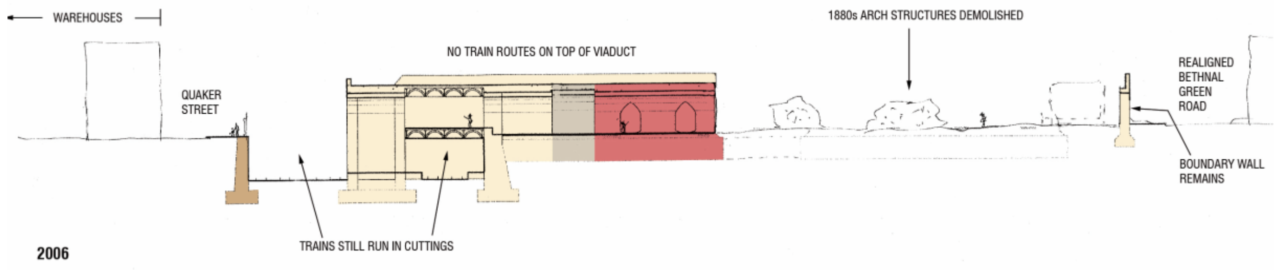

Figure 9 - Evolution Viaduct structure 2006

2.4 GROUND SITE INVESTIGATION

Referencing Arup Geotechnics Report dated January 2006, report number REP/119047/R003 combined with a review of the available information within the vicinity of the site indicates that the site is likely to be underlain by Made Ground, Head Deposits, London Clay, Lambeth Clay, Lambeth Sands and Thanet Sands.

2.5 SITE INVESTIGATION - EXISTING BRAITHWAITE ARCHES

Refer to WSP2019 Site Condition Assessment Report and Alan Baxter rev 2009 and 2013 reports for brick arches conditions. In summary Braithwaite Arches appear in good condition for their type and age.

3 EXISITING ARCHES STRUCTURAL PRINCIPLE

3.1 OVERVIEW

As previously stated the Braithwaite Arches have the potential to carry substantial loads provided these are appropriately distributed. In this section total uniform loading is derived for original (rail station) condition and compared with proposed structural frame loading values.

3.2 HISTORIC AND PROPOSED LOADING

The following calculation demonstrates the vertical design loads applied to the arches from the original 2 storey warehouse and goods station which burnt down in 1964 (refer figure 25 and 29) are in excess the loads for the proposed new 4 storey (lightweight construction) hotel on building plot 8. For this exercise the façade cladding loadings have been ignored which for the brick-built warehouse were well in excess of the loads for the proposed hotel.

The historic design live loads used in the calculations have been derived from **Dorman Long and Co Handbook 1895** (along with other relevant publications) which list Warehouses at the time being designed for between 120 to 320lbs per Sqft and machinery warehouses between 250 to 500lbs per Sqft. For calculation purposes a conservative assessment based on the historic usage has been taken of **220lbs per Sqft.** (100lbs per Sqft equates to 4.8kN/m2) The conservative historic design dead loads have been derived from construction techniques and materials used for the time and proposed usage.

The current proposals for the design of the hotel are yet to be finalised but 3 construction options are currently under review:

A. Steel framed building with a 130mm concrete slab cast on metal decking.
B. Steel framed building with cold formed 'C' sections spanning between the steel sections with 2 layers of timber boarding and finishes applied to the top of the cold formed 'C' sections.
C. Steel framed building with timber floor cassettes 47*300 joists and 18mm OSB top and bottom.

For the purposes of the calculations option A, the heavier form of construction has been used in the calculation.

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Historic Warehouse Design Loads Loading		**Proposed Hotel Design**	
Floor live loads		**Floor live loads**	
Ground Floor:	10.6 kN/m2 (220lbs/sqft)	Ground Floor:	4.0 kN/m2
First Floor:	10.6 kN/m2	First Floor:	2.0 kN/m2
Roof:	1.5 kN/m2	Second Floor:	2.0 kN/m2
		Third Floor:	2.0 kN/m2
Total live load = **22.7 kN/m²**		Roof	1.5 kN/m2
		Total Live load = **11.5 kN/m²**	

Historic Warehouse Design Loads		**Proposed Hotel Design Loading**	
Dead Loads		**Dead Loads**	
Ground Floor:		**Ground Floor:**	
400mm concrete slab:	9.6 kN/m2	400mm concrete RC slab:	9.6 kN/m2

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First Floor:		**Typical upper floor (3No):**	
300 thick Filler Joist Floor:	4.35 kN/m2	140mm concrete Holorib slab:	3.10 kN/m2
Self wt of Steel frame:	0.35 kN/m2	Self wt of Steel frame:	0.30 kN/m2
Partitions:	1.00 kN/m2	Partitions	0.50 kN/m2
Timber floor finish:	0.20 kN/m2	Floor finishes	0.35 kN/m2
Services	0.3 kN/m2	Services	0.30 kN/m2
Total Load	**6.20 kN/m²**	Suspended ceiling	0.15 kN/m2
		Total Load	**4.70 kN/m² per floor**

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Roof:		**Roof**	
Self wt Steel Frame	0.25 kN/m2	Self wt Steel Frame	0.20 kN/m2
Hot rolled steel purlins	0.15 kN/m2	Cold rolled purlins	0.03 kN/m2
Services	0.3 kN/m2	Services	0.30 kN/m2
Clay sheeting / tiles	1.10 kN/m2	Standing seam roofing system	0.72 kN/m2
Total Load	**1.50 kN/m²**	Suspended ceiling	0.15 kN/m2
		Total Load	**1.40 kN/m²**

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Summary of Warehouse Loads	**Summary of Hotel Loads**
Total Live Load = 22.70 kN/m2	Total Live Load = 11.50 kN/m2
Total Dead Load = 17.30 kN/m2	Total Dead Load = 25.10 kN/m2
Total combined Load = **40.00 kN/m²**	Total combined Load = **36.60 kN/m²**

In additional to Wearhouse loading conditions as rail station the arches were experiencing different loading conditions: referencing ''Cast metal and malleable Journal of Railways'' by M Longbridge 1838 and ''Railroad Journal VolV '' 1836 a typical train locomotive self-weight can be adopted as 4.75 tonnes for Sans Pareil, which is about 47.5kN with gauge of the railway 1,435 mm and wheel axes spaced at approximate 2.0m.

The wheel loading would have stressed the arches locally, which create greater point load conditions.

in addition, rail track build up above brick arches was approximate 1.5m or 31.5kNm^2 of gravel.

Combining the above rail station loading conditions are potentially higher the Wearhouse loading conditions described earlier

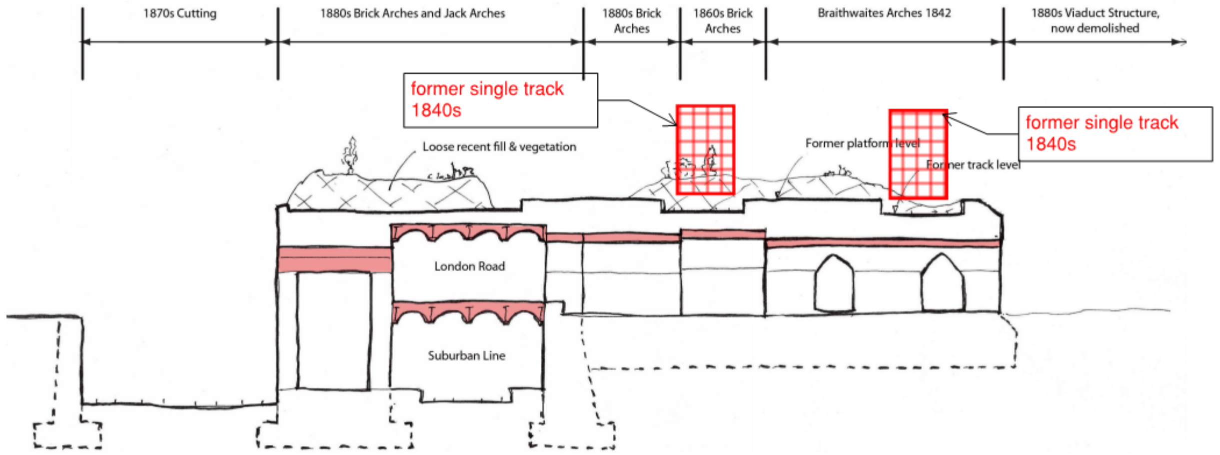


Figure 10 - Typical section through viaduct showing former platforms and train track 1840's

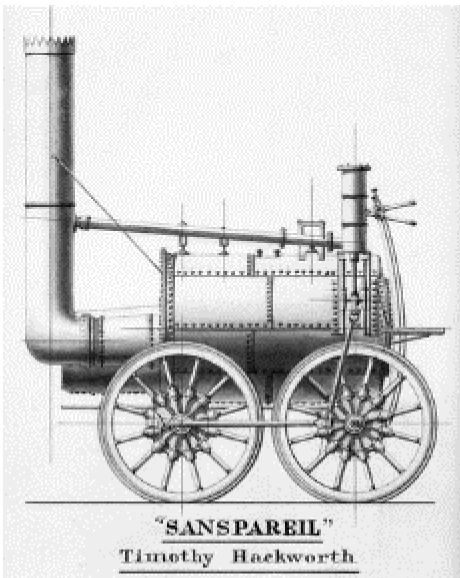


Figure 11 - Hackworth's 'Sans Pareil', 1829 (approximate weight per axle 24kN (unfactored)

3.3 HISTORIC AND PROPOSED LOAD PATH AND SUPPORT

This section outlines in brief the structural background of brick arches loading patterns and types and implication of type of loads applied. Concentrate loads lead to high stresses and potential cracks and/or movement. Uniform loading such as top fill or ground slabs effect arches in more effective way and optimize their performance and capacity while limiting movement and cracking.

3.3.1 PRINCIPLE OF BRICK ARCH SUPPORT

Arches distribute forces to supports by compression only via the extrados formed with bricks and mortar. Arch normally is supported by a pier. Horizontal reaction balances out with adjacent arch reactions, allowing minimum lateral displacement of the whole arch system. At each end of arch system earth embankment or buttress walls are introduced to restrain lateral load from amplifications or uneven or pattern arch loading.

For an arch to be stable a minimum ''squash'' load is required on top of it to maintain the compression in place within the bricks. This load is confirmed during the detail design along with upper limit of maximum load that can be applied. In simple terms the arch would not stand up if it did not have load on top of the arch or adequate self-weight.

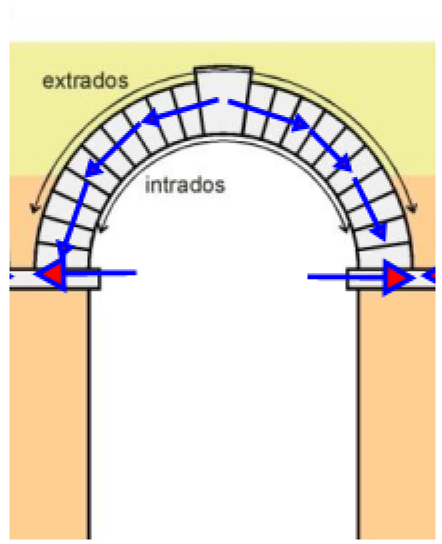


Figure 12 - Typical arch forces diagram

Arch is designed assuming 3 hinge failure mechanism,which is typical for unifrom loading; in some instances 4 hinge mechanism is created due to concetrated or uneven load path, in this instance the risk of collapse is far greater and detail assesment is essecial.

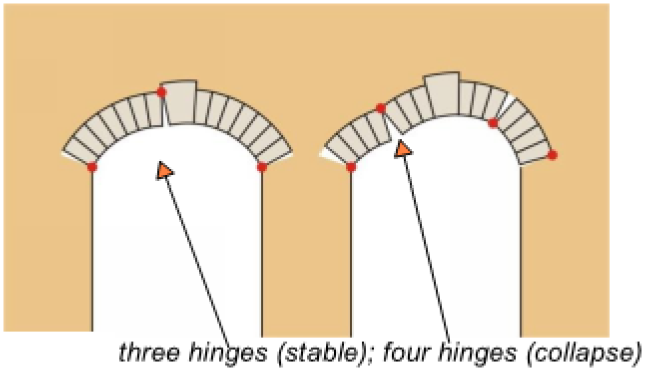


Figure 13 - Typical arch failure mechanism analysis

3.3.2 ORIGINAL/HISTORIC LOAD PATH

Recalling the train track loading which originally was applied to the arches, the sketch below indicates the load path.

The sketch demonstrates the load path of train wheels/track, as mentioned before the wheel loads are concentrated loads imparted at various points along the arches causing high stresses and the potential risk of the system being out of equilibrium.

As result of the above the horizontal destabilizing reactions are increased, which increases the stresses on the arches.

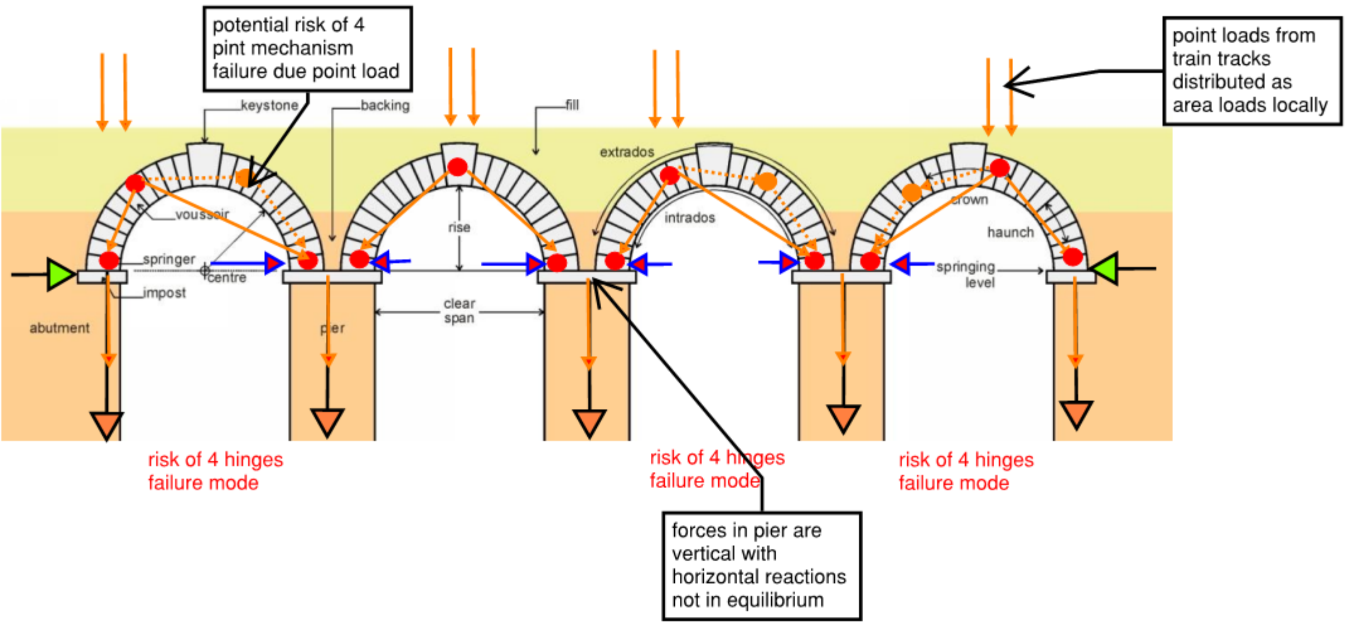


Figure 14 - Historic load path onto existing arches

The vertical piers were likely to have experienced far greater loading due to uneven reactions from adjacent arches which adds an overturning moment to these vertical elements and their foundations.

3.3.3 PROPOSED LOAD PATH FOR PLOTS 8B &C APPLIED TO ARCHES

The proposed current scheme applies uniformly distributed loads to the arches from the subsoil / ground floor slab (public realm) only. This nominal load applied to the top of the arch provides the load required to maintain the compression in place over the arch crown.

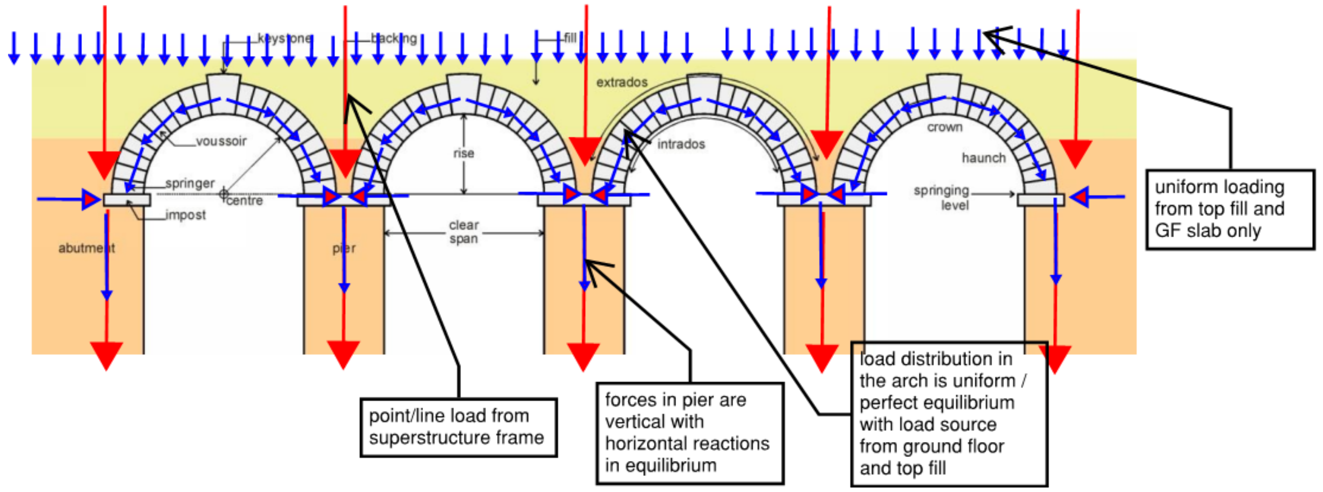


Figure 15 - Proposed load path onto existing arches

The main column and foundation loads indicated by the red arrows in the sketch above are located over the piers with the loads uniformly distributed along the length of the piers by the concrete strip footings. By locating the proposed development foundations over the existing piers less load is applied to the arches than was historically.

3.3.4 OVERALL LATERAL STABILITY OF ARCHES

The figure below shows the existing buttress wall on each end of arch system and its purpose is to restrain lateral movement caused by arches support thrust.

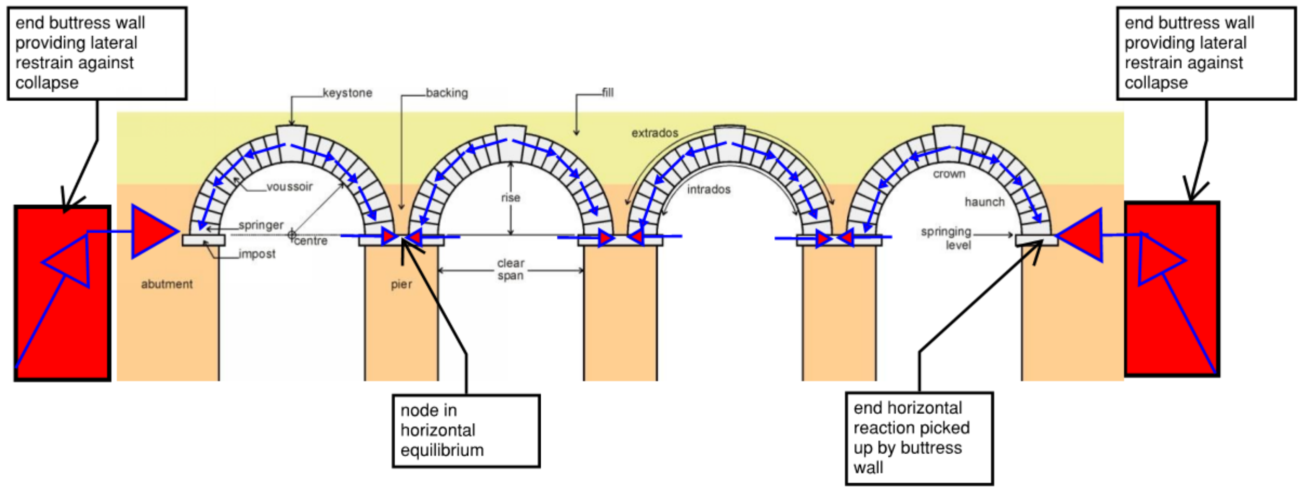


Figure 16 - Lateral stability of existing arches

3.4 CONCLUSIONS

The existing brick arches are cable of supporting the loads from the proposed 4 storey hotel construction based on the following factors:

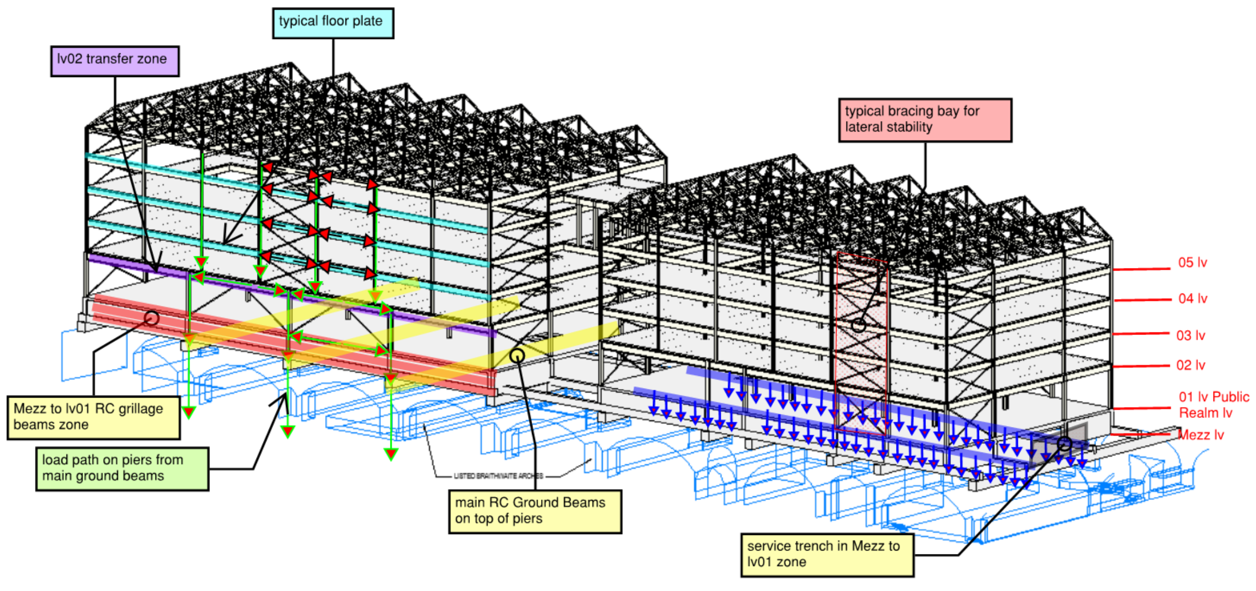
- Proposed loads are less then original applied loads
- Loads applied to the crown of the arches are substantially less than originally designed for
- Vertical Piers/ arch supports will experience less stress then originally designed for

4 PROPOSED STRUCTURAL FRAME

4.1 INTRODUCTION AND OVERVIEW

the structural frame comprises of steel frame with cross braces in all 4 elevations for lateral stability and composite steel deck floor plates. The column grid changes at lv 02 to lv 01 (public realm level +22.35) to align columns with foundations limitations over the arches. LV02 floor plate accommodates the transfer beams.

The foundations consist of ground beams grillage (under public realm level +22.35) allowing to avoid stressing the brick arches (specially over the crowns) and creating load path limited to the top of piers. Main Ground beams are transferring the forces on to the arch's piers vertically with minimal pressure on to the arches.

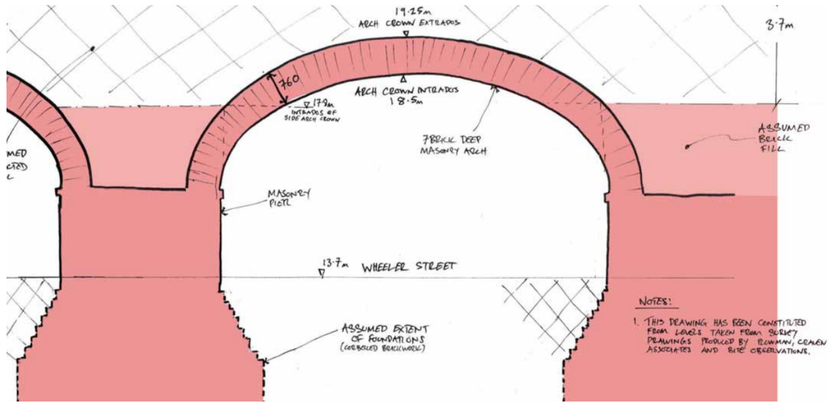


Proposed structure key elements

4.2 STRUCTURAL PRINCIPALS FOR SUPPORTING THE PUBLIC REALM

The design principles for setting the current proposed platform landscaped levels currently air on the conservative side due to unknowns ie, existing finished soft landscaped build up/levels in certain areas and arch extrados (top of arch) levels.

Whilst the intrados (underside arch) levels are generally known across the site through surveyed information the extrados levels are not, however the intrados and extrados levels of the Braithwaite Arch over Wheler street are known and this information re arch thickness etc has been adopted elsewhere to help form the current structural principals. The unknown extrados arch levels will be validated at a later stage through a series of trial pits although not seen as critical as the loads are generally applied to the piers.



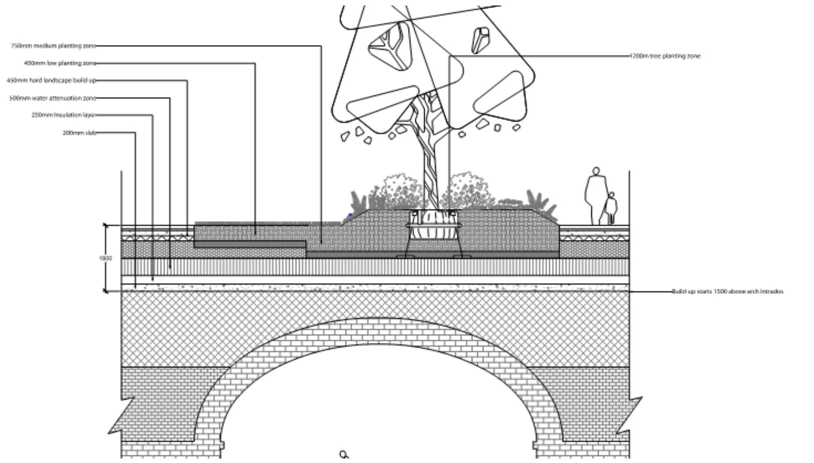


Figure 17 - Public realm build up over arches

Based on the above the following design principals have set the current proposed landscape levels indicated on Space Hub drawings / details

A. Arch extrados not to be exposed

B. A minimum of 500mm of existing soil / compacted fill to remain in place above the arch extrados

C. Where deeper existing landscaping levels exists and there is a requirement to reduce the proposed platform levels as much as possible a maximum of one third (1/3) of the existing platform build up over the arches is considered acceptable to be removed.

Any further percentage removal of material over and above the one third rule noted above or a reduction in the minimum 500mm of fill over the crown of the arch, would need to be reviewed on a case by case basis post planning during the detailed design stage of the project where intrusive works may be required.

The landscape build-up is achieved by firstly, carefully removing a minimum of 200 to 300mm of existing soft / hard landscaping to achieve the required formation level. Any soft spots / voids are infilled and along with the formation level proof rolled. The formation / sub-base level is then capped with a 200mm concrete cover protection slab from which the insulation, waterproofing, water attenuation and planting layers are installed.

The general proposed landscaping build-up does not increase the dead and superimposed design loads over the brick arch or Jack arch structures which were previously designed to support low rise structures and run goods vehicles over. There is currently extensive loose fill / materials and vegetation over the viaduct / arch structures which in areas extends over 1.5 to 2.0 metres in height.

The measures set out for forming the formation levels and the proposed landscape build up will ensure there is sufficient permanent load on the arches to ensure they do not flex / heave.

4.3 STRUCTURAL PRINCIPALS FOR SUPPORTING PLOTS 8B AND 8C

4.3.1 FOUNDATIONS

Mezzanine and public realm floors are +19.85AOD to +22.350AOD (lv Mezzanine and lv01 respectively) and comprise reinforced concrete slabs and series of beams.

The concrete slab shall be part of hotels ground floor slab and would be supported by the concrete beams' grillage with no pressure applied onto brick arches.

Within the RC beams grillage a trench is introduced for MEP services; the trench can be supported on the beams to avoid loads being applied to the arch crowns ,alternatively the trench could be ground bearing, this will need to be confirmed following a detailed assessment analysis of the arches.

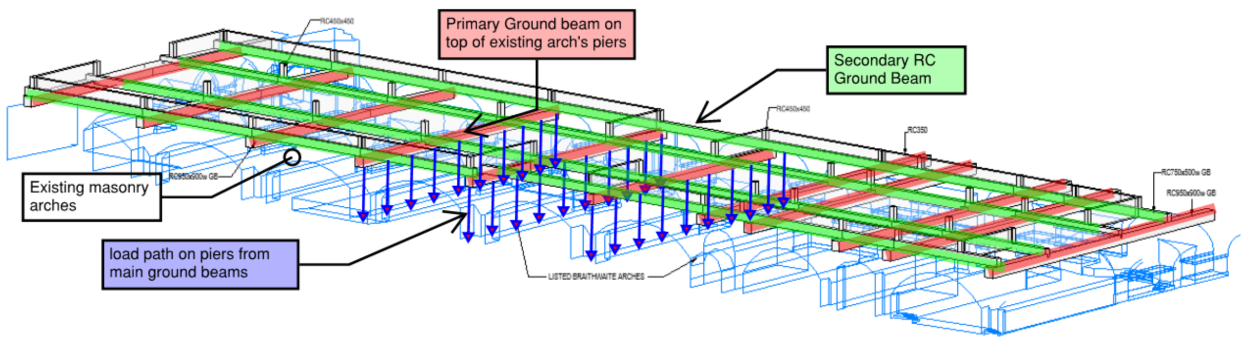


Figure 18 - Proposed foundation grillage over existing arches

Masonry piers in some places have openings; since main ground beams bear on to them there is a risk of local stress exceedance over the opening areas. This can be mitigated with void former underlaying ground beams which provides bridging over the 'openings. This concept might not be required subject to detail analysis of arches.

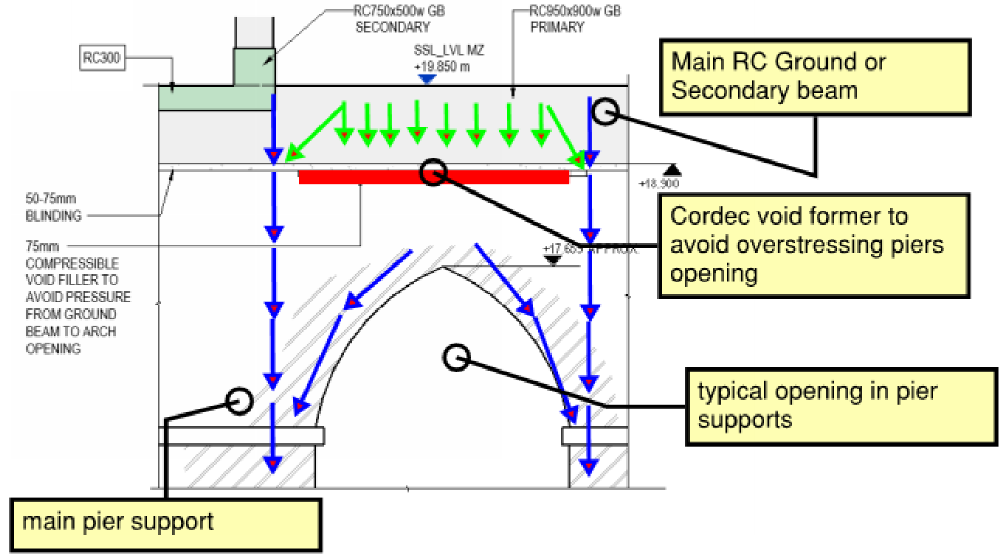


Figure 19 - Proposed main ground beams over vertical pier

4.3.2 SUPERSTRUCTURE

Superstructure based on a column grid of 7.4m x7.0m for end bays and 7.4m x 10.5 for internal bays. Steel beams in the range of UB533-610 deep would be required.

Transfer structure at level 02 is set with various column positions to align with existing arch piers but generally around 13.0m x 6.5m. Beams shall be prefabricated girders to optimize weight with depth of approx 800 to 900mm.

Supported floors are 130mm concrete on structural metal decking and act compositely with the steel beams. Assumed spacing between floor beams is 2.4m to mitigate back propping at construction stage.

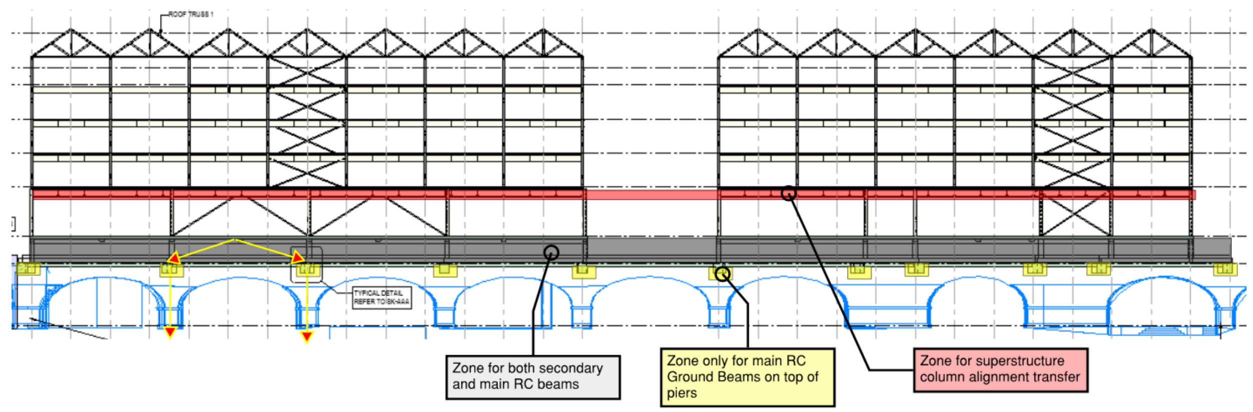


Figure 20 - Superstructure key elements zones

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