

Network Rail

King's Cross Square

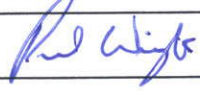
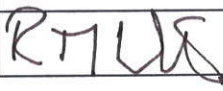
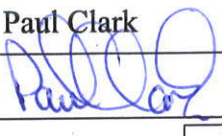
**GRIP 4 Structural Report: Southern
Facade Canopy**

ENG-REP-OAP-SFC-CSTR-0010

Rev B | September 2011

Document Verification

ARUP

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Issue Document Verification with Document

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Appendices

Appendix A

Figures and drawings

1 Name of design organisation

The design will be carried out by

Ove Arup & Partners Limited

13 Fitzroy Street

London

W1T 4BQ

2 Identification of structure

2.1 Location

The project comprises the redevelopment of the existing King's Cross Mainline Station in central London. This structural report describes the design associated with the Southern Façade canopy which will be located in King's Cross Square area of this project to the south of the existing station building.

2.2 Description

This document describes the proposed construction of a new canopy immediately adjacent to the Cubitt façade of the existing structure of the King's Cross Station. This structure is known as the Southern Façade Canopy (SFC).

3 Proposed dates of project start and completion

Complete GRIP 4	August 2011
Complete GRIP 5	February 2012
Start construction of structure:	Sept 2012, to be confirmed
Complete construction of structure:	September 2013, to be confirmed

4 Brief description of existing conditions

4.1 Site investigation reports

4.1.1 Ground Conditions

King's Cross Station is located at the junction of the former Fleet River and one of its tributaries. The ground level is currently at about +116mTD in the vicinity of the site. The river valley falls from the north-west to south-east, with the land rising either side of the former course of the river. The water formerly collected by the Fleet has been diverted and now runs in the Fleet Sewer and the Fleet Relief Sewer underneath the site.

The ground conditions at the site have been ascertained from published geological maps and memoirs; tunnelling records; reports and data held by Rail Link Engineering and Ove Arup & Partners' own records. A site specific SI was undertaken to confirm the parameters to be used in the design of the LU Northern Ticket Hall, and the interpretive report is contained in Document 57145/390.

The site is underlain by the geological sequence identified in Table 6.1.

Table 6.1: Geological sequence

Stratum		Top Level [mTD]
Made Ground		116.3
Weathered London Clay		113.5
London Clay		109
Lambeth Group (formerly known as the Woolwich and Reading Beds)	Reading Clay (cohesive)	97
	Woolwich Clay (cohesive)	97
	Reading Sand and Silts (non-cohesive)	82.5
	Upnor Formation (non-cohesive)	81.5
Thanet Sands		75
Upper Chalk		73.5

It is likely that there were once deposits of Brickearth, Gravel and re-worked London Clay in the river valley, but these have been mostly removed for use as building materials during the development of London. The nature of the remaining soils in the upper strata on the site is briefly summarised below.

4.1.2 Made Ground

The Made Ground varies between 2m and 4m in thickness across the site. Much of this material is associated with the excavation of the cut and cover railway tunnels, station facilities, sewers and building foundations in the vicinity. Prior to the development of the two railway termini, the area was used as a dumping ground for rubbish from the city, although this was also largely removed.

The Made Ground varies from soft or firm brown slightly sandy clay with a little gravel to brown clayey sand with some to much gravel. Much of the Made

Ground will have been placed in an uncontrolled fashion and its engineering properties will be highly variable.

4.1.3 London Clay

The thickness of London Clay decreases to the south of the site, and the typical thickness is about 16.5m, 12m of unweathered London Clay and 4.5m of weathered London Clay.

4.1.4 Groundwater

The groundwater profile used in the short term condition is based on piezometric data given in the LCE Design Basis Report, Feb.1997.

There are two distinct water tables at the site; an upper water table within the clay deposits and a lower one, within the Chalk.

Groundwater has been encountered within the Made Ground, generally just above the interface with the underlying London Clay. It is expected that the level at which it occurs will tend to vary across the site and seasonally. Near surface groundwater will also be influenced by leaking services, although the many tunnels and sewers may also tend to locally reduce levels. The groundwater profile assumed for short term design conditions is 70% of hydrostatic from 1m below ground level based on a conservative interpretation of the piezometric data from the King's Cross and St Pancras Underground Station Redevelopment Northern Ticket Hall ground investigation interpreted in the Arup report 57145/390.

4.1.5 Ground contamination

The potential for ground contamination, due to current and former land uses, has been assessed by URL and RLE for the CTRL works, through historical research and site investigation. The major areas of contamination identified are located to the north of St Pancras and King's Cross Stations. Where it occurs, the contamination is mostly within the Made Ground, above the London Clay.

Geochemical testing was carried out as part of geotechnical site investigations, and assessments of the test results is contained in Arup documents 57145/390 and 57145/631. There are no long-term significant risks to the fabric or users of the King's Cross Western Concourse or underlying Northern Ticket Hall due to existing ground contamination. However, during construction, particularly spoil removal, a regime for classification of material will be required and, where necessary, removal to licensed spoil tips in accordance with current UK and EU legislation.

4.2 Environmental conditions

4.2.1 General

The existing interchange at this Station is complex bringing together St Pancras and Kings Cross Mainline and Suburban services, Thameslink services and Piccadilly, Victoria, Northern, Metropolitan and Circle Underground Lines.

4.2.2 Environmental Requirements

Limitations on noise, vibration, dust and other environmental factors are imposed on the project via Section 61 conditions for planning approval (affecting operations by Network Rail). These are covered in the various preliminaries and monitoring specifications governing works by their contractors.

4.3 Proposed additional surveys or investigations

Where works impact on existing structures additional surveys and investigations will be required. For this element of work the following will be included:

- Visual, geometric and condition surveys of existing structures with removal of finishes and inspection pits including localised exposure of the existing foundations.
- Installation and monitoring of telltales and prisms on existing structures as required during excavation and construction of the foundations.

5 Description of proposed works and method of construction with reasoning

The SFC is to be built to the South of the existing station façade after removal of the existing single storey concourse structure by others. Refer to the figures 1 & 2 appendix A.

5.1 Structure

5.1.1 Existing structures

The existing façade of the grade 1 listed station is founded on brickwork piers which are supported on stepped brick foundations. At the tower locations these have been underpinned with crossed needle piles, refer figure 3 in appendix A.

5.1.2 Proposed Southern Facade structure

The new canopy structure is to be formed adjacent to the existing façade but will be structurally separated and self stable. Refer to figures 1 and 2.

The proposed primary structure of the SFC is formed from fabricated box section columns which cantilever up ~3.5m from the foundation before turning through ~90 degrees to cantilever out ~6m. This primary structure is ~0.75m forward of, and aligning with the brickwork columns of the Kings Cross façade. The primary structure is an architectural section, utilising fillets between the bottom flange and the webs to form the desired curved profile.

The primary structure supports a secondary roof structure formed from moment connected rectangular box sections. These form a stable secondary inclined plane onto which the glazing is fixed. The secondary structure spans up to 9.9m between primary supports and is formed from 3 rows of ~300mm deep fabricated rectangular box sections supported on short stub columns. Perpendicular to this the secondary structure is at ~2m centres, and is less deep (~150mm) due to the

shorter spans between the deeper rectangular box sections. The top of steel levels for the secondary structure are level for fixing the glazing to.

Stability for the SFC is from encastre supports to the primary structure, along with a moment connected secondary frame which forms a stiff diaphragm.

At the western end of the SFC, adjacent the South East Stair (SES) enclosure there is insufficient room for a final primary column. Therefore the end bay is supported from the structure of the SES enclosure. The SFC oversails the SES to hide the support connections from sight lines. Since the SFC relies on the SES enclosure for support, then should LU remove or alter the SES enclosure in the future, then it is envisaged that they would also dismantle the end bay of the SFC leaving approximately 2m of cantilevering roof over the last primary column of the SFC. A joint will be included within the structure for this purpose.

A structural gutter, formed from a fabricated box section, runs along the back of the canopy above the columns, supporting glazing, and to collect rainwater. Rain water pipes are hidden within the back of the columns with a false panel allowing access.

Between the existing Kings Cross façade and the gutter, glazing is supported from cantilevering secondary RHS's. These require batten plates over the top of the gulley to enable the secondary beams to act as back spans. A movement joint is formed between the canopy roof and the façade of the Kings Cross station.

Small openings will be required in both the primary and secondary structure in order to carry electrical conduits within the box sections.

5.2 Foundations

The foundations for the SFC will be reinforced concrete pad foundations, isolated from the foundations of the existing adjacent structure of the Kings Cross station and offset to be loaded eccentrically.

The existing Kings Cross structure will be monitored and not undermined. Local trial holes will be required to prove position and levels of the existing foundations. It is assumed that due to variability, the made ground may be removed to the London clay and replaced with granular material placed and compacted in layers. An assessment of the loading and existing structure will be undertaken once the existing foundations and ground conditions have been investigated. The design will ensure no adverse effects on the existing structures from the new works.

5.3 Method of construction

The foundations will be dug to the required formation, providing shoring where required and ensuring that the existing structure is not compromised in any way.

Any backfilling and compaction is carried out, again ensuring that the existing structure is not compromised in any way.

The SFC foundations will be isolated from the existing footings and then constructed.

The steel framework for the canopy will be erected traditionally with temporary works propping and a temporary stability system as required until the structure is self stable. The roof cladding will then be installed.

5.4 Special finishes or features

If the adjoining enclosure to the SES is removed or altered, then the SFC will require additional support at the western end for the end bay to remain in place and be stable.

5.5 Clearances from other structures

Foundations for the SFC will remain clear of and not below or undermining the existing stepped brick foundations and needle underpinning of the King's Cross Station southern façade.

6 Brief description of other structural forms considered and reasons for their rejection

A number of alternatives were considered including a larger canopy, and possible support from the existing King's Cross Station structure. These were rejected due to the size of the structural members and permissions required for alterations to the listed façade.

The current scheme has been chosen and developed in conjunction with the comments raised by key stakeholders including English Heritage and London Borough of Camden.

The foundations of the canopy have been chosen given the constraints of the adjacent building and loadings.

7 Design criteria

7.1 Durability

Corrosion protection will be via a paint system to achieve the required design life.

7.2 Redundancy and Bomb Blast

The canopy will be designed using the normal design code requirements for disproportionate collapse and robustness. These requirements state that the "Notional removal of any one key supporting structure shall not result in complete structural collapse". Thus, for example, if a column were to collapse as a result of the blast load, the structure will be detailed in such a way as to limit the extent of collapse to an area local to the failed column.

The stability of the SFC utilises a fully moment connected secondary level of framing supported on encastre columns. If a column should be lost under a blast load, then this has a greater robustness when compared to a structure which relies on a single braced bay for overall stability.

7.3 Material Properties

Steel grade S355, J0

Concrete grade C30/35

7.4 Soil parameters

At Grip 4 stage a safe bearing capacity of 100KN/m² has been assumed. This is to be confirmed by testing.

8 Proposed method of structural analysis

Hand calculations and appropriate validated structural analysis software such as GSA (General Structural Analysis), ADC and Adsec from the Oasys suite of programs; and geotechnical programs such as VDISP.

9 Standards and codes of practice to be used in design, including temporary works

9.1 Structure not Subject to Highway Loading

9.1.1 British Standards and Codes of Practice

BS6399: Loading for Buildings

Part 1: Code of practice for dead and imposed loads

Part 2: Code of practice for wind loads

BS8002: Code of practice for earth retaining structures

BS8004: Code of practice for foundations

BS5950: Structural use of steelwork in buildings

BS8110: Structural use of Concrete:

Part 1: Code of practice design and construction

Part 2: Code of practice for special circumstances

BS2789 Specification for Spheroidal Graphite or Nodular Graphite Cast Iron

BS5628 Code of practice for use of masonry

10 Safety considerations

The level of safety inherent in the design will be that achieved by following the load factors and material factors required by the British Standards, Codes of Practice and Department of Transport Standards as listed in Section 11.

3rd party interfaces are being consulted. Eg Network Rail, London Underground, Thames Water, other utilities providers.

11 Clearances

The foundation of the SFC will be isolated from the existing structure. The primary structure has been offset by ~0.75m from the existing façade. A movement joint is incorporated where the canopy abuts the glazing of the existing façade.

The height to the underside of the primary structure is greater than 3m.

12 Functional requirement

Both the LUL underground and King's Cross Mainline Station are to remain operational during the construction of these proposed works.

13 Design check category specified in design brief

A Category 2 check is proposed for the design.

14 Proposals for independent category 2 or 3 design checks

The Cat II design check will be carried out by Arup Edinburgh.

Arup
Scotstoun House

South Queensferry
Edinburgh, EH30 9SE

Appendix A

Figures and drawings

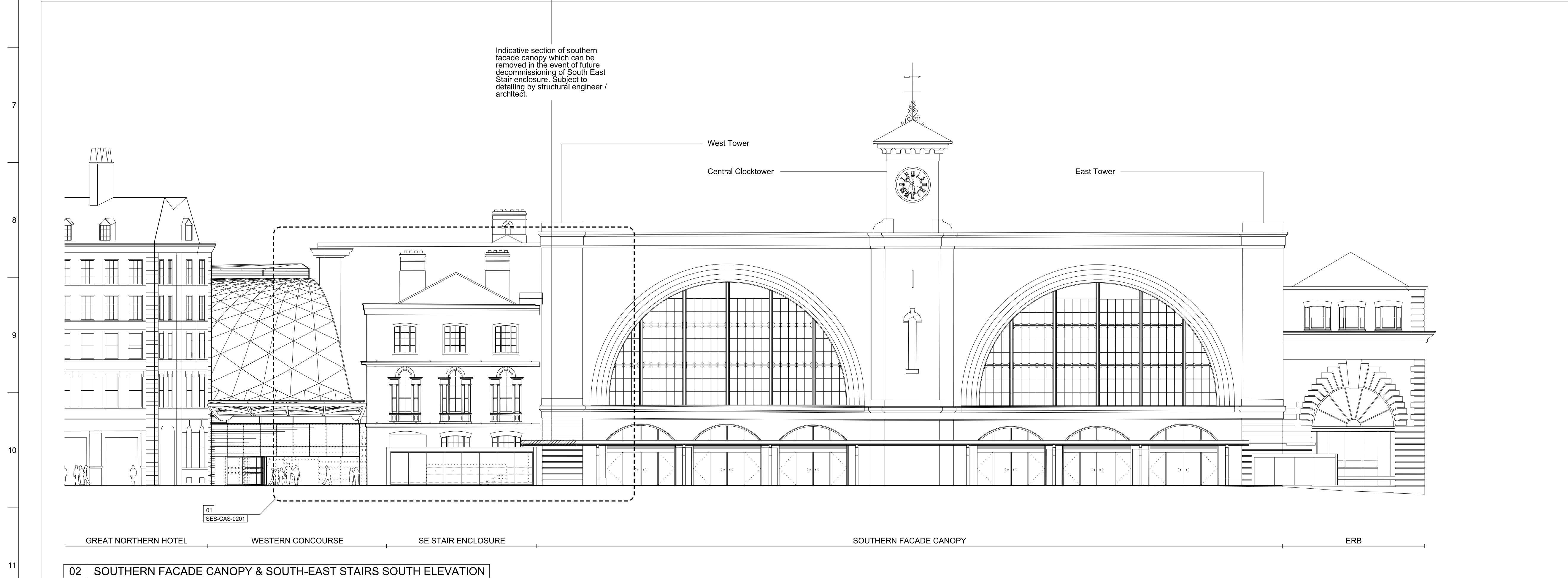
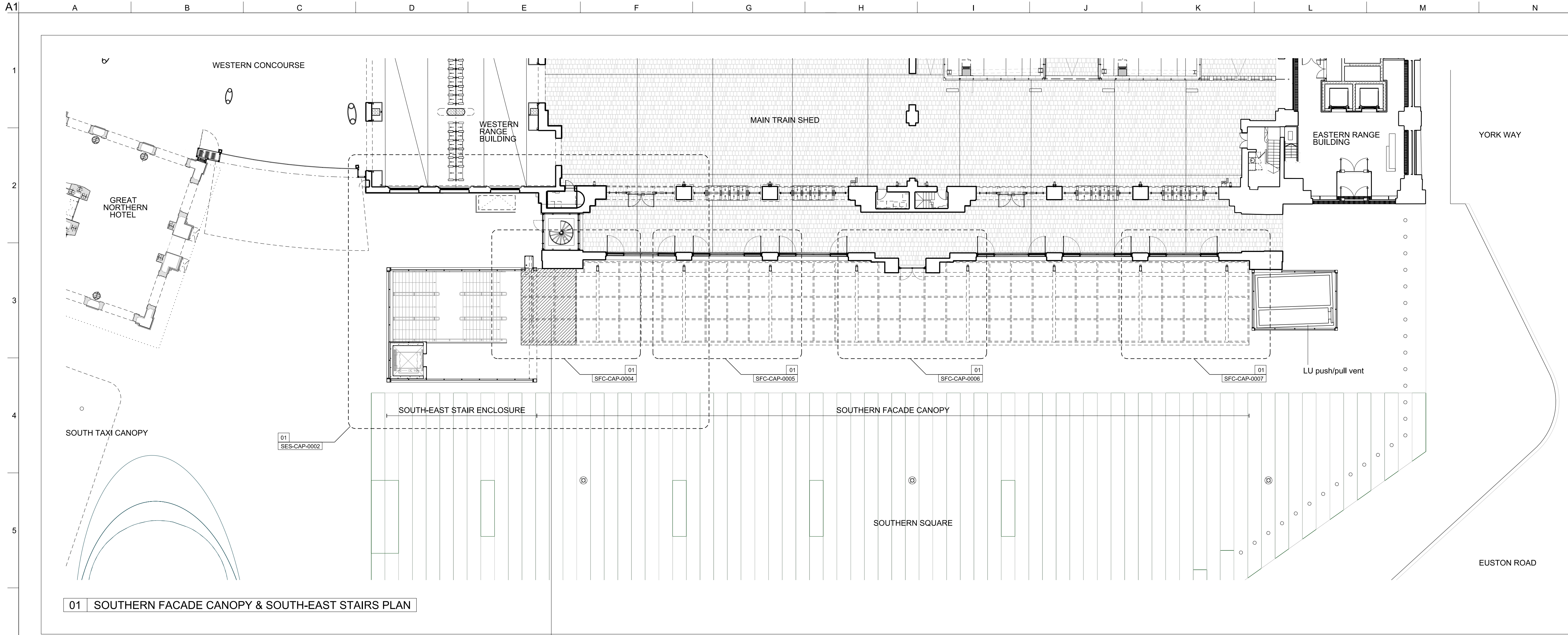
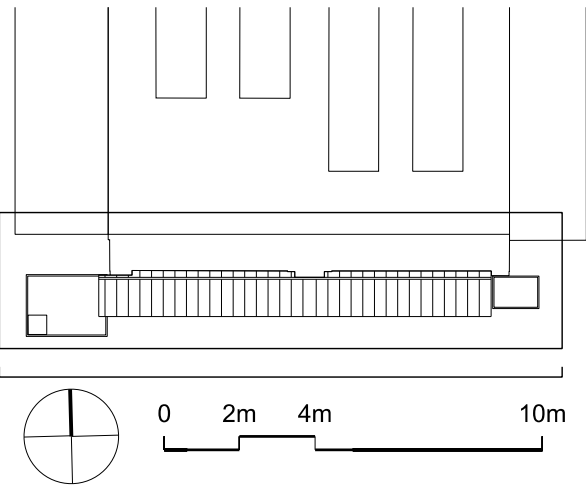


Figure 1



Notes

Do not scale from this drawing. All dimensions are to be checked on site and any discrepancies noted in writing to the Employer's Representative. All dimensions are in millimetres unless noted otherwise.

Where there appears to be ambiguity between the drawings and other information, the Contractor shall seek the advice of the Employer's Representative for clarification.

Refer to drawing KX6-CAG-0000 for general notes and abbreviations. For detail of Architectural Specification codes (shown on drawings as 'LIN-01', for example) refer to the Technical Reference Sheet.

Drawings to be read in conjunction with the Architectural Specification and other relevant information, including the schedules and Engineer's documents. For individual repair locations, details and scope, refer to the Repair Schedule and Architectural Specification as applicable.

Half tone line work shows scope by others. Refer to detail drawings for further scope definition.

02	09/09/11	JMP	PV	HA
For Grip 4 Approval				

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Architect
Landscape Architect



Client
King's Cross Station
Redevelopment Programme
Package 7

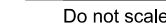
Drawing Title
Southern Facade Canopy
& South-East Stairs
Ground Floor Plan &
South Elevation

Scale at A1 1:200 @ A1

CCMS No

Approval Status
Approval in Principle/ Planning

OAP Job No	Drawing No	Rev.
1327	SES-CAP-0001	02



Do not scale from this drawing. All dimensions are to be checked on site and any discrepancies noted in writing to the Employer's Representative. All dimensions are in millimetres unless noted otherwise.

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☐ Architect

☐ Landscape Architect

Client



Job Title

King's Cross Station
Redevelopment Programme
Package 7

Drawing Title

Southern Facade Canopy Typical Section

Scale at A1 1:20 @ A1

CCMS No

Drawing Status

Approval in Principle/ Planning

OAP Job No 1327	Drawing No SFC-CAS-0202	Rev. 02
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Figure 3

