Appendix A4.1
Connolly Design Report

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Executive Summary

This report was prepared for DART+ West by IDOM Consulting, Engineering, Architecture, to document the Connolly Station Design.

In the Multi-Criteria analysis developed for Connolly Station and included in the Connolly Station Options Study Report (MAY-MDC-ARC-RS02-RP-A-0002-4), three options for the new entrance to the station were analysed:

- Option 1: New entrance at Sheriff Street Lower
- Option 2: New entrance at Preston Street
- Option 3: New entrance at Seville Place

Option 2 emerged as the preferred option, after considering the main advantages it included, unlike the other two options:

- Lack of land or building acquisition requirement. However, it requires CPO to change the access rights to the Parcels Post Office building and rights to construct the new facade.
- Proximity to the ‘bunker’ building location, identified within the Dublin City Development Plan objectives as a potential DART entrance location.
- Limited impact on Cultural, Archaeological and Architectural Heritage compared to the other two options.

This report develops the Preston Street option by addressing the main constraints that the design will face:

- The urban integration
- The impact on the architectural heritage elements
- The enhancement of the passenger platforms facilities
- The new entrance to the station
- The functionality of the station
- The vaults conservation strategy
- The materials and finishes
- The MEP design
- The sustainability approach

The Connolly Station enhancement is a great opportunity for the city of Dublin and for all the stakeholders that are involved in the project. It will provide an enormous benefit for the citizens from a functional point of view but also from a ‘sense of place’ perspective.

Abbreviations, acronyms and definitions

The following definition of acronyms and abbreviations shall apply within this document:

TERM	DEFINITION
ACB	Air Circuit Breaker
BEMS	Building Energy Monitoring System
BMS	Building Management System
B&F	Buildings and Facilities
CAF	Common Appraisal Framework
CIÉ	Córas Iompair Éireann (Ireland's National Public Transport provider)
CPO	Compulsory Purchase Order
DART	Dublin Area Rapid Transit
DCC	Dublin City Council
DCDP	Dublin City Development Plan
EMC	Electromagnetic Compatibility
EMDB	Essential Main Distribution Board
FE	Functional Earthing
GDA	Greater Dublin Area
GSWR	Great Southern & Western Railway
HSS	Hollow Structural Section
HVAC	Heating, Ventilation and Air Conditioning
IÉ	Iarnród Éireann / Irish Rail
IFSC	Irish Financial Service Centre
IRCC	Irish Rail Control Centre

MCA	Multi-Criteria Analysis
MCCB	Moulded Case Circuit Breaker
MDB	Main Distribution Board
MEP	Mechanical, Electrical and Plumbing
MGWR	Midlands Great Western Railway
NTA	National Transport Authority
LSF	Life Safety
PE	Protective Earthing
ppmm	Passengers per minute per metre width
RC	Reinforced Concrete
SCADA	Supervisory Control And Data Acquisition
SET	Signalling Electrification and Telecoms
TER	Telecommunications Equipment Room
TGD	Technical Guidance Document
TSS	Train Service Specification
TSI	Technical Specifications for Interoperability
tphpd	Trains per hour per direction
TIW	Ticket Issuing Window
TVM	Ticket Vending Machine
WHO	World Health Organization
ZEB	Zero Energy Building

Codes and Standards

General Architectural

- Irish Building regulations. Technical Guidance Documents.
- CCE-TMS-312. Design Guidance Document for Accessibility of Railway Stations. TECHNICAL GUIDANCE NOTES. CCE DEPARTMENT. Iarnród Éireann. September 2020

Station design and sizing

- Station Design Guide. Iarnród Éireann. November 2004.
- Station Capacity Planning Guidance. Network Rail. November 2016.

Fire risk assessment

- Irish Building regulations. Technical Guidance Document. Part B. 2006
- Guidance for fire precautions on existing British rail surface stations. February 1993.

Accessibility

- The Disability Act: 2005;
- Irish Building regulations. Technical Guidance Document. Part M. 2010
- Technical Specifications for Interoperability (TSI) relating to accessibility of the Union's rail system for persons with disabilities and persons with reduced mobility (PRM)
- CCE-TMS-312 Design Guidance for Accessibility of Railway Stations

General MEP

- EN European Standards
- IEC International Electrotechnical Commission. Applicable if an EN does not exist for a specific matter.
- ISO International Standards. Applicable if any EN applicable for a specific matter does not exist.
- BS British Standards. Applicable if any EN and ISO applicable for a specific matter do not exist.
- IEEE Institute of Electrical Engineers. Applicable if an EN, IEC, ISO and/or BS do not exist for a specific matter.
- ETCI Electro Technical Council of Ireland. Guidelines.
- DIT Dublin Institute of Technology. Guidelines.
- BR Building Regulations Ireland.
- EEC Applicable Directives
- IS Insurance Institute of Ireland. If an EN IS exists for a specific topic it will be applied instead of the equivalent EN.
- CIBSE Chartered Institute of Building Service Engineers.
- Safety, Health and Welfare at Work Act 2005
- Any other requirements of the Industrial Inspectorate of the Department of Labour of the Irish Government.

Structure

- I.S. EN 1990:2002/A1:2005 (Eurocode 0) – Basis of the structural design.
- I.S. EN 1991-1-1:2002 (Eurocode 1, Part 1-1 and 1-2) – Actions on structures
- I.S. EN 1992-1-1:2005 (Eurocode 2, Part 1-1 and 1-2) – Design of concrete structures
- I.S. EN 1993-1-1:2005 (Eurocode 3, Part 1-1 and 1-2) – Design of steel structures
- I.S. EN 1996-1-1:2005 (Eurocode 6, Part 1-1, Part 1-2, Part 2, and Part 3) – Design of masonry structures.
- I.S. EN 1998-1:2004 (Eurocode 8, Part 1) – Design of structure for earthquake resistance
- I.S. EN 1997-1:2004 (Eurocode 7, Part 1) – Geotechnical Design – General rules.
- Technical Guidance Document A. Structure 1997 (2005).

Firefighting

- BR doc. B Fire safety

- EN 3 Portable fire extinguishers
- BS 5306 Fire extinguishing installations and equipment on premises

HVAC

- BR doc. F Ventilation
- BR doc. L Conservation of fuel and energy - buildings other than dwellings
- CIBSE Guide B Heating, ventilation, air conditioning and refrigeration
- CIBSE Guide J Weather, solar and illuminance data
- CIBSE TM 21 Minimizing pollution at air intakes

Public Health

- EN 12056 Gravity drainage systems inside buildings
- BR doc. G Hygiene
- CIBSE Guide G Public health engineering
- CIBSE Guide W Water distribution systems
- Joint HSE and DoH Working Group on legionellosis HSG (92)45 – November 1992
- HPSC National Guidelines for the control of legionellosis in Ireland, 2009-10-06
- NDSC The Management of Legionnaires' Disease in Ireland.
- HTM 04-01 and HTM 2027" Recommendations for the Prevention of Legionella"
- Solar Heating Design and Installation Guide

Gas

- IS 820 Non-domestic gas installations

Electrical Installation design

- EN 60364 Electrical installations for buildings
- BS 7671 Requirements for electrical installations. IET Wiring Regulations

Earthing&Bonding and lightning

- BS EN 62305 Protection against lightning
- BS 7430 Code of practice for protective earthing of electrical installations
- EN 50522 Earthing of power installations exceeding 1 kV a.c.
- EN 50122-1 Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock
- EN 50162 Protection against corrosion by stray currents from D.C. systems
- EN 50310 Application of equipotential bonding and earthing in buildings with information technology equipment
- IEC 61000-5-2 Electromagnetic Compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling
- IEEE 80 IEEE Guide for Safety in AC Substation Grounding

Electrical Installations

- ET 101:2008 National Rules for Electrical Installations & Amendments (2011, 2016)
- EN 60364 Electrical installations for buildings
- BS 7671 Requirements for electrical installations. IET Wiring Regulations
- EN 61439-1 Low-voltage switchgear and control gear assemblies.

Lighting

- IS EN 12464 Light and Lighting, Lighting of Workplaces; (all parts)
- CIBSE – The SLL Code for Lighting, (current edition), and applicable CIBSE / SLL Lighting Guides, (LG1 to LG12).
- ErP Directive (European Union Energy Related Products). Luminaire operating devices.
- ET 101:2008 National rules for Electrical Installations
- EN 13201-2:2003 Road Lighting Performance Requirements

- CIE 115-2010 Lighting of Roads for Motor and Pedestrian Traffic
- CIE 126-1997 Guideline for minimizing skyglow
- CIE 150-2003 Guide of limitation of the obtrusive light from outdoor installations
- BR - L2 Lighting
- ETCI Part 714 Reference document for Public Lighting Installations

Emergency lighting

- IS 3217 Code of Practice for Emergency Lighting Installations
- IS EN 1838 Lighting applications – Emergency lighting.
- IS EN 50171 Central power supply systems
- IS EN 50172 Emergency escape lighting systems.
- IS EN 62034 Automatic test systems for battery powered emergency escape lighting
- IS EN 60598-2-22 Luminaires for emergency lighting
- CIBSE LG12 Emergency Lighting Guide

Stray currents

- BS 7631 Cathodic protection. Code of practice for land and marine applications
- EN 50122-1 Railway applications – Fixed installations – Part 1: Protective Provisions Relating to Electrical Safety and Earthing
- EN 50122-2 Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 2: Provisions against the effects of stray currents caused by D.C. traction systems
- IEC 62128-2 Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems.
- EN 50162 Protection against corrosion by stray current from direct current systems

Fire alarm

- EN 54 Fire detection and fire alarm systems
- EN 3218 Code of practice for fire alarm systems (where EN 54 is not defined)
- CIBSE GUIDE E Fire Engineering

SCADA

- CIBSE Guide H Building Control Systems
- Automatic Controls Application Manual Commissioning Code C – Automatic Controls
- Applications Handbook Vols 1 & 2 Guide to BEMS Centre Standard Specification
- SMG 90c. HVCA 1992. Standard maintenance specification

1. Introduction

Connolly Station is part of the DART+ Programme[1], a transformative programme of projects which aims to modernise and improve existing rail services in the Greater Dublin Area (GDA). It will provide a sustainable, electrified, reliable and more frequent rail service to improve capacity on the rail corridors serving Dublin.

The DART+ Programme is included within the following Government policy strategies:

- The National Development Plan 2018-2027;

- Transport Strategy for the Greater Dublin Area 2016-2035; and

- The Climate Action Plan 2019.

Passenger capacity and train service frequency will be significantly increased as a result of the project. This will help to deliver a more efficient transport system, allowing more people to travel to more places in a sustainable way. The DART+ Programme will provide a viable, sustainable alternative to private car use, therefore helping users reduce their carbon footprint.

The DART+ Programme is a programme of work comprising several constituent projects to create a full metropolitan DART network with all lines linked and connected. Connolly Station is part of the DART+ West.

[1] Information obtained from DART Expansion brochure 17th August 2020.

2. Context and site

2.1 Dublin City Development Plan 2016-2022

Connolly Station is also aligned with the strategic approach of the Dublin City Development Plan 2016-2022.

One of the principles of the plan is achieving a more sustainable and resilient city by creating a connected and legible city based on active streets and quality public spaces with a distinctive **sense of place.**

From the analysis of Map E of the DCDP 2016-2022, it can be noted that Connolly Station is located in Zone Z5. The objective of that zone is to consolidate and facilitate the development of the central area to identify, reinforce, strengthen and protect its civil design character and dignity.

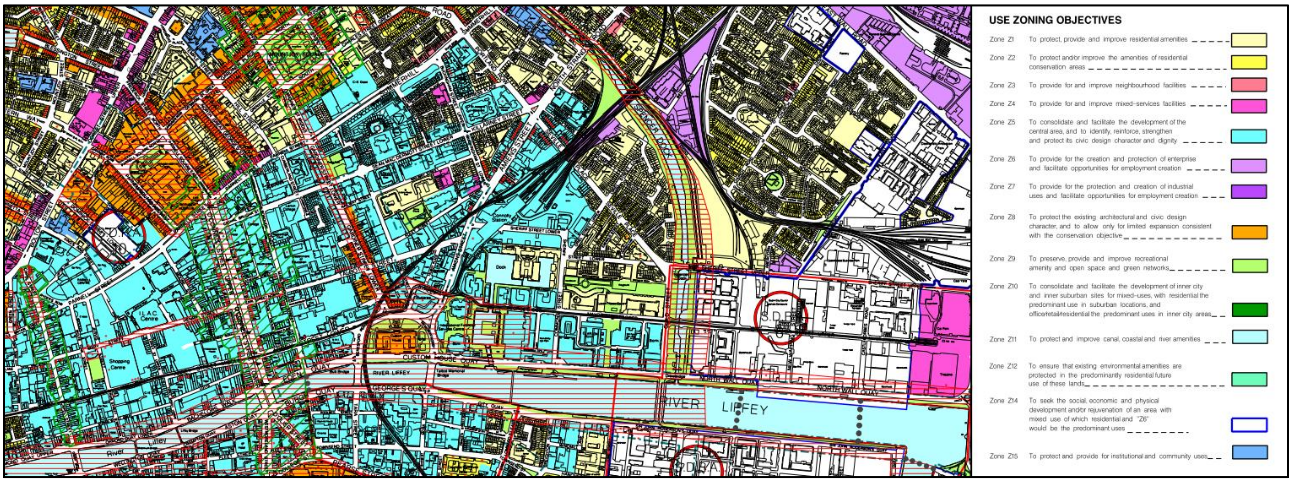

Figure 1. Extract from Map E. Dublin City Development Plan 2016-2022.

The station is one of the best-connected areas in the Dublin Region.

Despite its strategic location, there are areas around the station relatively isolated, located behind high walls and buildings, and railways infrastructure.

Dubin City Development Plan proposes to ensure the development of Connolly Station as a major transport interchange in the city. It is integrated with the sustainable redevelopment of adjacent land, including a more efficient use of land currently serving as surface parking and marshalling areas. It also proposes to secure enhanced mixed-use and vitality outside office hours on Seville Place and Sheriff Street Lower.

One of the objectives of the Dublin City Development Plan 2016 – 2022 related to Connolly Station is the following one:

- MOT5 (ii) Subject to a station layout assessment to promote the reinstatement of station entrance at Amiens Street/Buckingham Street Junction.

That location corresponds to the 'bunker' building, the former DART station entrance. This building leads to the underpass between Platform 6&7 and Platform 5. As this underpass's capacity is not capable of coping with the increased passenger demand, the 'bunker' building cannot be used as the new entrance for the station.

Figure 2. The 'bunker' building. The entrance building constructed in 1984 to provide access to the DART station.

2.2 Integration with the transport network

Connolly Railway Station provides access to rail services, including DART, Commuter and intercity routes.

The station has a wide variety of public transport services and pedestrian/cycling facilities in the vicinity: Luas, Bus Eireann and Dublin Bus services as well as a number of dublinbike stations, making the site highly accessible by more sustainable means of transport.

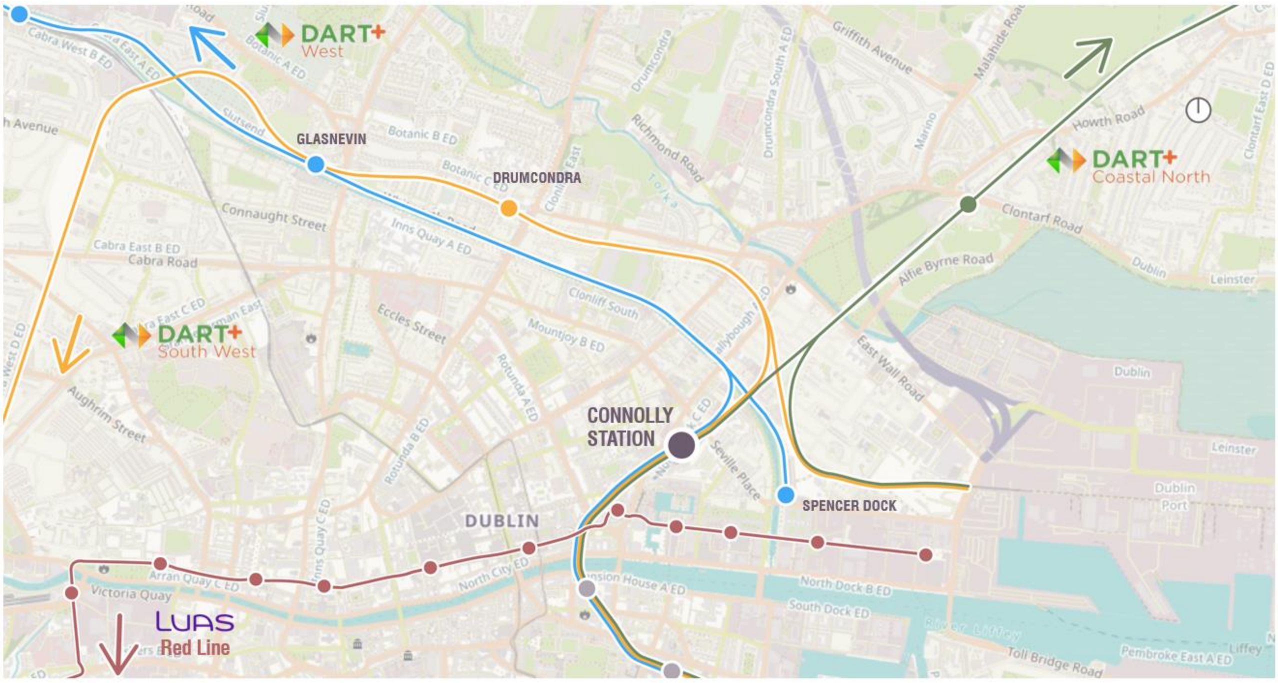

Figure 3. Integration of Connolly Station with Dublin transport Network

LUAS

The Luas Red Line commenced the operation in 2004, introducing the light rail services from Connolly Station to Tallaght and serving the city centre, Heuston Station, a number of hospitals and residential areas in the south-west of Dublin. The Red Line has provided a new high capacity public transport link and has contributed to a significant increase in the proportion of people travelling to and from Connolly by rail. The Luas is so well used that a programme to extend the Red Line trams by 10 metres was initiated to provide an additional 40% passenger capacity.

In addition, the Luas Green Line links to the Red Line at O'Connell Street, and it also has another stop 700 metres away from the main entrance of Connolly Station.

BUS

There are several Dublin Bus stops operating in the area. The routes serving the stop on Amiens Street closer to Preston Street are detailed below:

ROUTE	DESCRIPTION
14	Beaumont (Ardlea Rd.) - Dundrum Luas Station
15	Clongriffin - Ballycullen Rd.
27	Clare Hall - Jobstown
27A	Eden Quay - Blunden Drive
27B	Eden Quay - Harristown
27X	Clare Hall - UCD Belfield
29A	Lwr. Abbey St. - Baldoyle (Coast Rd.)
31	Talbot St.- Howth Summit
31A	Talbot St.- Shielmartin Rd.
31B	Talbot St.- Howth Summit
32	Talbot St.- Malahide
32X	UCD Belfield - Malahide
42	Talbot St. - Sand’s Hotel (Portmarnock)
43	Talbot St. - Swords Business Park
53	Talbot St. - Dublin Ferryport
130	Lwr. Abbey St. - Castle Ave.

Figure 4. Dublin Bus routes stopping at Preston Street

BICYCLES

The National Transport Authority (NTA) has surveyed the cycling facilities for the Greater Dublin Area (GDA) as part of the Greater Dublin Area Cycle Network Plan. An extract from this plan showing the existing facilities in the vicinity of the proposed development is shown in the plan below.

Figure 5. Extract from existing Cycle and Bus facility routes. National Transport Authority

It is to note the dublinbikes scheme, developed by DCC in an effort to provide an accessible, short term bike rental scheme across the city that would encourage and facilitate a positive modal shift in Dublin. This scheme currently allows the public access to approximately 1,500 bicycles which can be hired at 102 locations across the city centre.

There are a number of dublinbikes stations within proximity of the development site, including Talbot Street, North Wall Quay and the IFSC. A new dublinbikes station at Preston Street would be highly recommended once the new entrance to the station is constructed.

A map of the dublinbikes stations surrounding the railway station can be seen below:

Figure 6. Dublinbikes stations around Connolly Station

Furthermore, the Clontarf to City Centre Cycle & Bus Priority Project (C2CC Project) will provide a new cycle lane on Amiens Street that will pass along the Preston Street junction. It will foster the modal integration of the station.

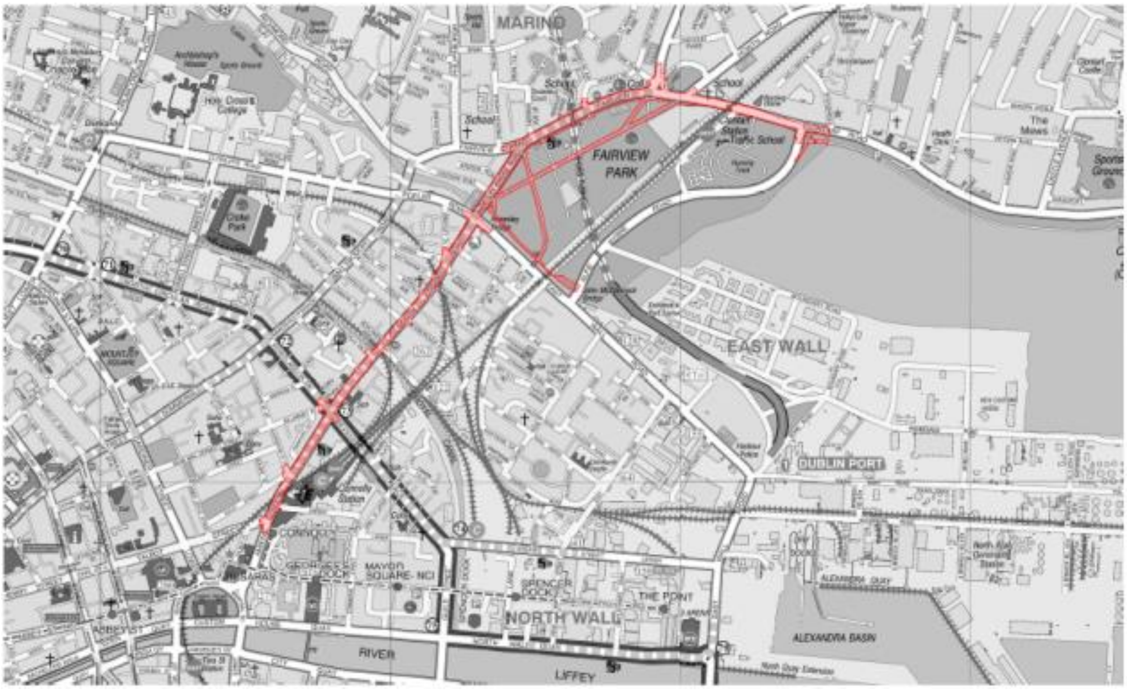

Figure 7. Clontarf to City Centre Cycle & Bus Priority Project (C2CC Project) layout

The Clontarf to City Centre Cycle & Bus Priority Project (C2CC Project) will provide segregated cycling facilities and bus priority infrastructure along a 2.7km route that extends from Clontarf Road at the junction with Alfie Byrne Road to Amiens Street at the junction with Talbot Street. The route is identified as a primary route in the Greater Dublin Area Cycle Network Plan.

Figure . C2CC Project. Detail of Amiens Street at the junction with Preston Street

PEDESTRIANS

With regard to pedestrians, there are good quality footways with dedicated pedestrian crossing facilities at all major junctions near the station, and there are numerous bridges providing pedestrian access across River Liffey, including the Samuel Beckett and Sean O'Casey bridges.

2.3 Urban regeneration

Connolly Railway Station is bounded on the northwest by Amiens Street, on the northeast by Seville place and on the south by Sheriff Street Lower. Further west of Connolly Station is Talbot Street which leads directly to O'Connell Street. Inner Dock and George Dock are located towards the south of the station, adjacent to the Financial District, the Irish Financial Service Centre (IFSC) and the Docklands Development Area. The River Liffey is located approximately 450 metres to the south.

Towards the east, there is an area of inner-city housing bounded by the Royal Canal and the railway infrastructure servicing Connolly Station and Dublin Port. The area to the north and northwest is mainly residential in character, with commercial and retail uses along the main thoroughfare of Amiens Street.

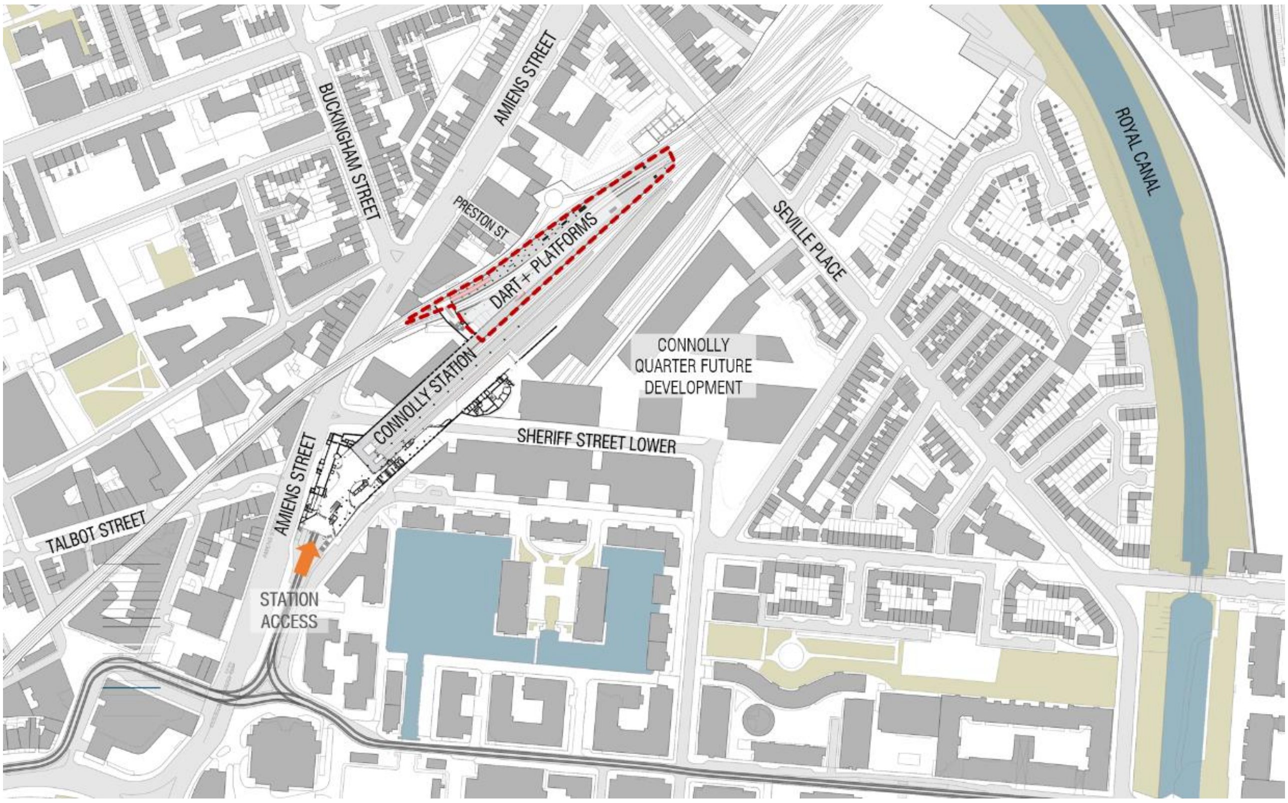

Figure 8. Connolly Station location plan

On the Southeast of the station, adjacent to Connolly Station Platform 1, there is an urban brownfield site that is currently used for ancillary facilities related to the functions carried out in Connolly Station, including a car park, railway sidings, maintenance facilities, administration facilities, telecommunication masts and ancillary storage containers. Most of the site consists of a surface car parking (approximately 390 spaces) for customers and staff of Irish Rail. In this plot, it is intended to build a new high-rise residential area and office development called Dublin Arch (formerly called Connolly Quarter development).

Figure 9. The first phase of the Dublin Arch Development next to Connolly Station

In the façade facing Amiens Street, there are several office buildings, a small petrol station that is going to be replaced by a hotel building, and the Parcels Post office building. This protected structure is a former railway parcels office building built in 1892.

Figure 10. Parcels Post office building

To the right of the Parcels Post office building, Preston Street makes its way linking Amiens Street to the Connolly Station vault that is proposed as the new entrance to the station.

2.4 Architectural Heritage

Connolly Station has been transformed over the years according to the railway and passengers necessities. The history of the station provides many layers that make up a vibrant heritage. The main interventions in the station are described below, with the help of some very interesting documents (sources) that are also listed at the end of the chapter.

The Main Line. 1846

The Dublin & Drogheda Railway Company was formed to connect Dublin with Drogheda. The Dublin to Drogheda Railway line was completed in 1844, comprising a single main line running between Dublin and Drogheda. Though the main terminus building for Dublin was to be located opposite the General Post Office on Sackville Street, the present Amiens Street site was later chosen due to the superior ease of its location. The station terminus building was built in 1846 following the design of the architect, William Deane Butler, and its original name of Dublin Station was later changed to Amiens Street Station. This was the first of four main stations to be built in Dublin.

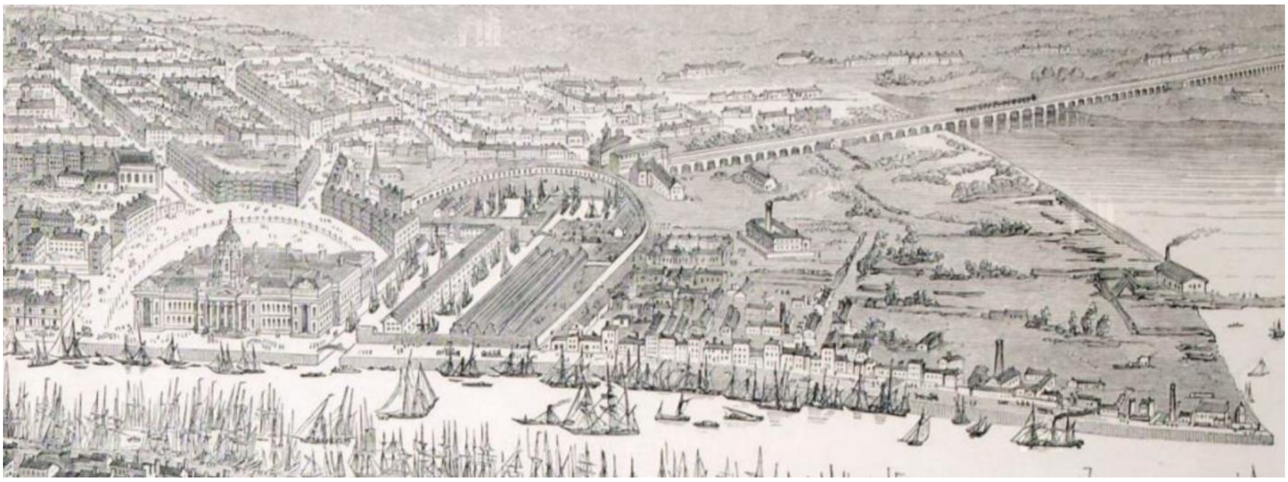

Figure 11. Engraving dated 1853 that shows the Main Line and the Dublin Station

The main station building was constructed of Wicklow granite and designed in the Italianate style at the cost of seven thousand pounds. It served as the headquarters of the Dublin and Drogheda Railway company. The main station platforms were located 22 feet above the level of the footpath on Amiens Street, and access to the platforms was by a large imposing flight of steps. A new sloped approach road was constructed in 1876, giving direct vehicular access from Store Street to the platform level to the southwest of the station building. The level of the railway above the street to carry the tracks over the Royal Canal resulted in the construction of 75 large arches running below the route of the rails, spanning over Sheriff Street and on as far as the canal.

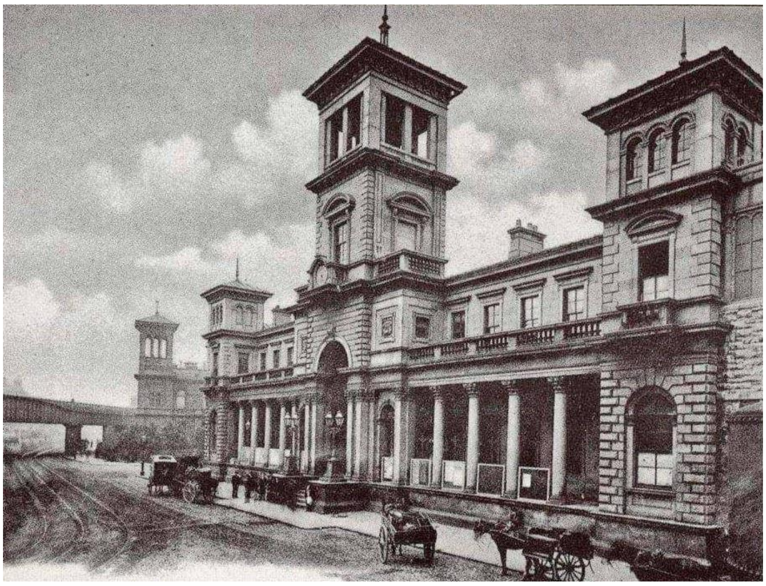

Figure 12. The Italianate style Amiens Street Station. Obtained from dublincivictrust.ie

The train shed and the Great Northern Railway headquarters. 1884

The station complex was significantly enlarged in 1884 according to the design of the railway company's engineer, W.H. Mills. Works included new running sheds located to the north of the pre-existing station building and a large passenger shed (6000 x 120 feet) housing four railway lines and their platforms built of brick with a glass and wrought iron roof. The bridge over Sherriff Street was also enlarged and remodelled at this time.

The new headquarters for the Great Northern Railway were built to the west of the main station shed following the design of John Lanyon. The new headquarters were built with red brick dressed with Dumfries sandstone.

Figure 13. Great Northern Railway headquarters building, today Connolly headquarters. Source: National Inventory of Architectural Heritage (left) and train shed over Sheriff Street Lower (right).

The Loop Line and the Amiens Street entrance. 1892

The Loop Line was constructed to connect Amiens Street station (now Connolly Station) with Westland Row station (now Pearse Station) on the south side of the river Liffey. It was opened to train traffic in 1891; however, the station facilities at Amiens Street were not completed until 1892. The design of these facilities is credited to W.H. Mills and included a separate entrance from Amiens Street to the new platforms with a footbridge linking all the platforms of the station complex with steps down to Platforms 6 & 7.

Figure 14. OS Map dated 1907 showing the Loop Line and the entrance to Platforms 6 & 7 from Amiens Street.

Connolly Station. 1966

Notable alterations within the station complex in the 20th century include the construction of a number of outbuildings and a carriage shed by the mid-1930s. The station was hit during the German bombing of Dublin in 1941. It was renamed Connolly Station in honour of James Connolly in 1966 and as part of the renaming process of major Irish railway stations to commemorate those executed after the 1916 rising.

The DART Station. 1984

The area around and below Platforms 5, 6 & 7 was altered significantly to accommodate the development of the DART system, which came into operation in 1984 which included the provision of a new entrance pavilion fronting onto Amiens Street along with a new shelter incorporating the catenary lines providing power to the new electric-powered trains that run through the Loop line.

The Luas Station. 2004

The area to the southwest of the Amiens Street terminus building was extensively remodelled and enlarged in the early 1990's, while the opening of the LUAS tram system in 2004 -with its original eastern terminus in front of the Southwest elevation of the old Amiens Street station- brought about the removal of the access ramp and its replacement with a series of canopies -together with lifts, steps and escalators- to provide a link between the train level and tram termini.

Sources:

- *The Connolly Quarter Development Architectural Heritage Assessment Report*, prepared by Clare Hogan conservation architect. May 2020

- *Connolly Station, Dublin Conservation Assessment Report,* prepared by Shane Prendergast, MRIAI. February 2015.

- *Loopline Arches, The Bunker, Connolly Station*. Architectural Heritage Impact Assessment, prepared by 7L Architects. May 2020

- *Loco Drivers Facilities, Connolly Station, Amiens Street, Dublin. Conservation method report*. Consarc Conservation. September 2007.

- *Connolly Station Vaults Inspection Report*. Roughan & O'Donovan. January 2004.

3. Station design

3.1 Required facilities enhancements

One of the DART+ West project's main objectives is to provide the required enhancements at Connolly Station to increase the number of trains per hour.

Currently, all passenger access and leave the station through the station's main concourse facing the Luas station, with numerous cross flows at peak hours. All passengers using platforms 5, 6 & 7 need to go through Platform 4 to get to the station concourse. The proposed Connolly Station enhancements will significantly reduce the number of passengers using Platform 4 to reach Platforms 5, 6 and 7.

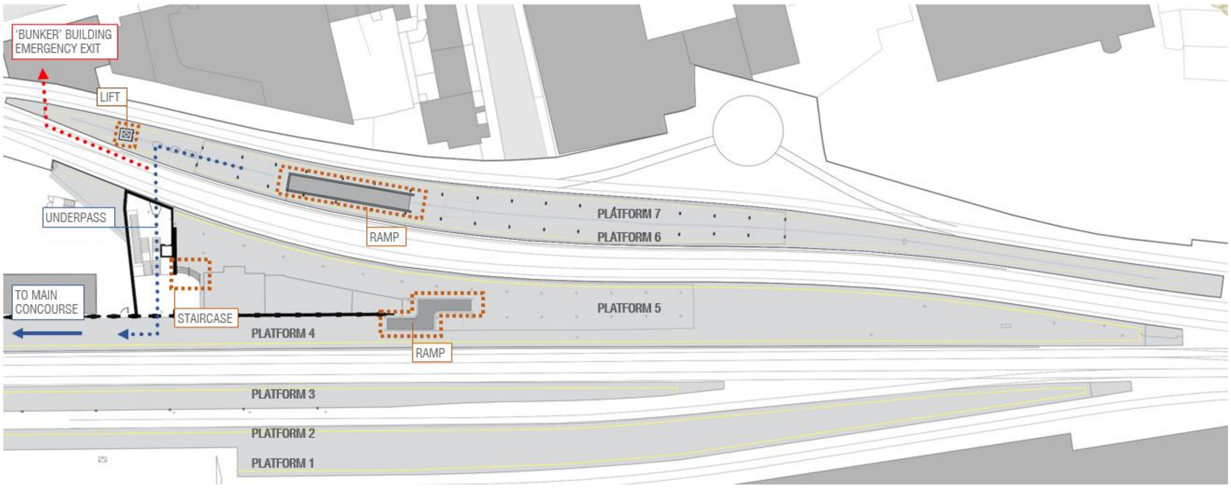

Figure 15. Platform facilities. Existing means of access to the platforms.

The analysis of the station evacuation requirements is based on the increased capacity of the trains that will serve Connolly Station as part of the DART+ West project. It is limited to the platforms that are being impacted by the increased number of passengers: platforms 5, 6 & 7. The analysis focuses on the means of egress and evacuation routes of those platforms.

Figure 16. Platforms included in the scope of the analysis

The proposed design focuses on providing a dedicated entrance for Platforms 5, 6 and 7. Providing a new entrance will guarantee a better passenger flow. It will allow passengers to orientate themselves and plan their route without obstructing those entering the station through the station's main concourse. Besides, the passengers at Platform 4 will not be disturbed by those trying to reach Platforms 5, 6 and 7. Furthermore, the routes to the desired platform will be shorter and more straightforward to avoid confusion.

According to the demand estimate for the station (see MAY-MDC-ARC-RS00-RP-A-0003_Station Capacity report), and following the accessibility requirements, the vertical communication elements to be included at the station platform are:

- Platform 5:
  - One staircase 1.60 m wide
  - One lift
  - Two escalators (they are not required in terms of capacity, but they are recommended since the difference between the ground floor and the platforms level is more than 5 metres).

- Platform 6&7:
  - Two escalators
  - One staircase 1.60 m wide
  - One lift

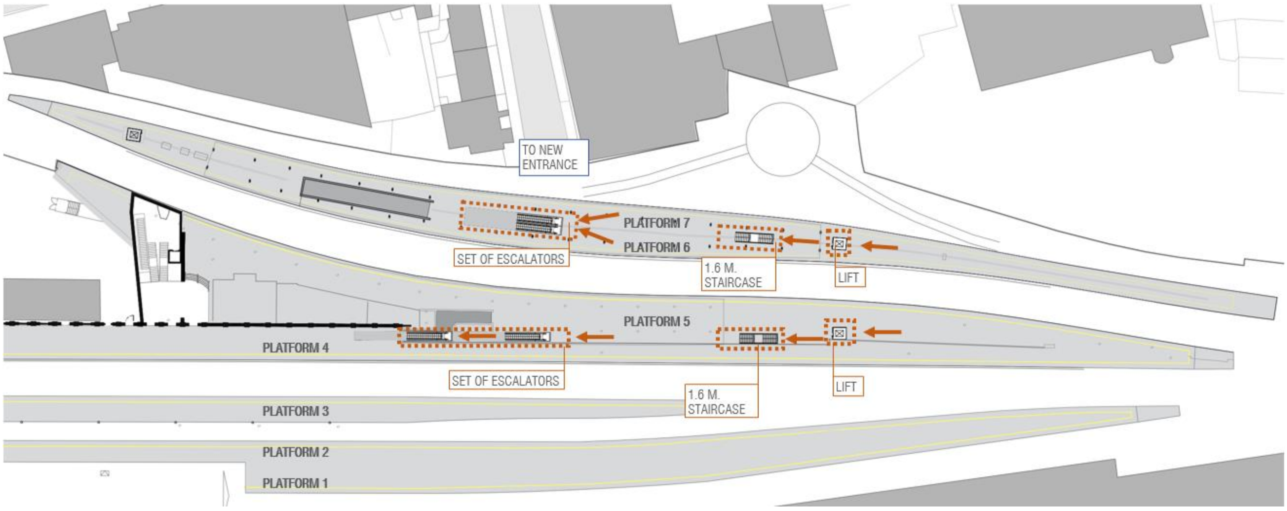

Figure 17. Platform facilities. Proposed additional means of access to the platforms

The stairwells and lifts will leave a minimum distance of 2.60 metres to the platform edge, reserving sufficient space for passengers entering and exiting the trains. The escalators are located below the existing canopies, giving access to the platform while protected from weather conditions. The lifts and the staircase at Platform 5 will be designed with shelters to ensure high-quality protection from the rain.

The above-mentioned egress elements will ensure comfortable passenger flows in the station for AM and PM peak periods and a safe evacuation of the platforms in case of fire according to local and international guidelines.

A new entrance is needed for the station to connect these new passenger facilities with the city. This entrance needs to be independent of the existing one to provide the required passenger capacity.

3.2 New entrance to the station

The proposal for a new access to the station presents Preston Street as the new access route. At the end of the street, there is an arch that will be converted into the new station entrance. From that arch, passengers will enter into a vault leading directly to the vaults area's central corridor. Part of that central corridor will be transformed into the new station's concourse.

Figure 18. Exterior and interior views of the existing arch at the end of Preston Street

The nature of Preston Street will drastically change with the opening of the new entrance and its pedestrianisation. The vehicular access will need to be limited to the users of the Parcels Post office and to the gate to access the right-of-way.

The Dublin City Council has been consulted about the pedestrianisation of Preston Street, the removal of the parking spaces on the street, and the potential access limitation of the goods vehicles to the Parcels Post Office building to specific hours (not peak hours). DCC is positive about the proposal.

A schematic design of the public realm of Preston Street has been developed, taking into consideration the access to the Parcels Post Office building.

Figure 19. Proposal for the design of Preston Street public realm

A new façade will be created at the entrance point to highlight the existence of the new access. The new Preston Street façade will also have an opening to a second vault that will house a bicycle parking, which will also have direct access to the central corridor.

Figure 20. Architectural visualization of the proposed Preston Street new entrance

Out of the 75 vaults that make up the vaults system that support the tracks and platforms, around 20 vaults need to be partially refurbished to provide the new access and concourse. The concourse area spreads through the vaults to the south of Seville place, centred on Preston Street access.

Figure 21. Vaults area to be refurbished. The new entrance to the station is located at Preston St.

There is a difference in the floor level between Preston Street and the central corridor of around 2 metres. Two actions have been undertaken to reduce that difference in height:

- A sloped surface (1:24) will be created in the entrance vault. As this slope is not considered as a ramp but a gently sloped access route in the Technical Guidance Documents, there is no need to install handrails, providing a seamless connection between the street and the concourse.
- The level of interior spaces (central corridor, concourse, retail areas, etc.) will be raised approximately 80 cm.

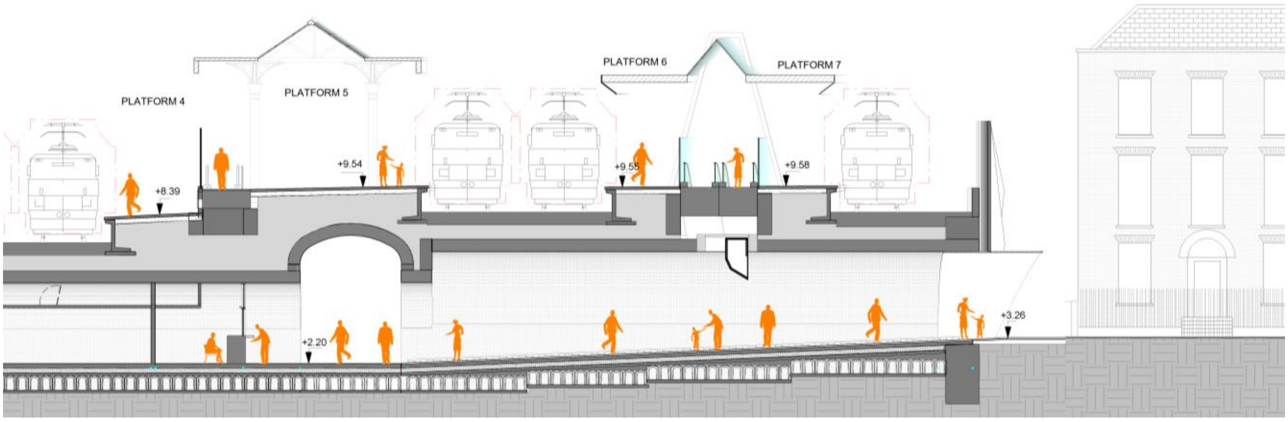

Figure 22. Section through the entrance vault that connects Preston Street with the central corridor

The entrance vault leads to the central corridor. As the corridor is only 4.2 metres wide, the facades of the different services that are located at both sides of the corridor have been recessed from the arches alignment, thus providing a broad concourse area with enough space for the passengers. The Ticket Issuing Windows (TIWs) and the Ticket Vending Machines (TVMs) will be located fronting the entrance vault.

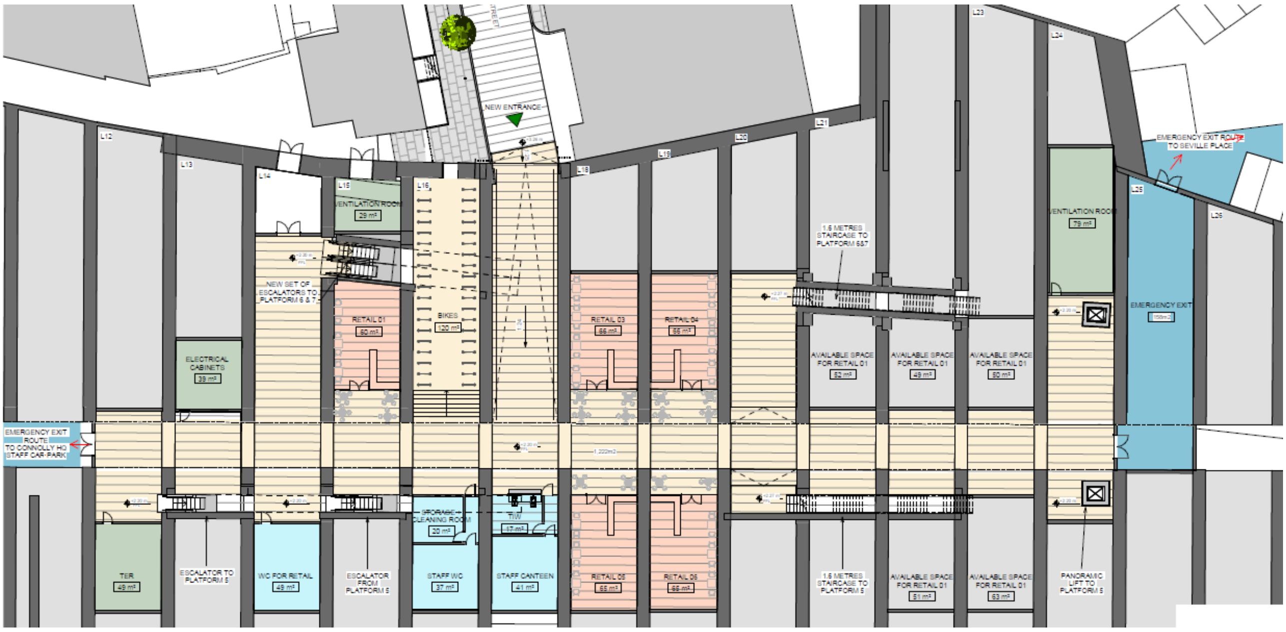

Figure 23. Connolly Station. Concourse Level

The central corridor connects towards the north with other vaults that lead to the lifts and the staircases, and to the south with the ones where the escalators are located. These vertical connection facilities will require some openings in the platforms and vaults that have been carefully studied, trying to minimise the impact on the architectural heritage.

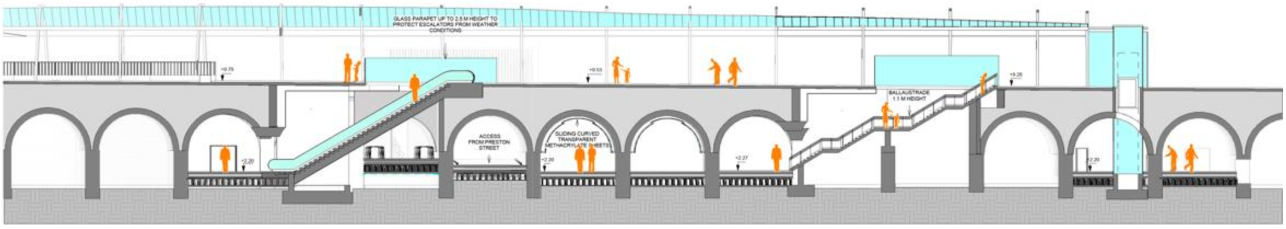

Figure 24. Section through the vertical connection facilities

The station access control system is conditioned by the geometry of the vaults, making it impossible to include the number of ticket validation gates required by the passenger demand calculations. Therefore, a smart-card-reader pole system has been proposed. The poles will be placed in the vaults that lead to the staircases, lifts and escalators.

There is potential to provide for retail units in the arches that are located on either side of the central corridor, where a high passenger flow is envisaged. The façade of the retail areas will also be recessed from the central corridor providing an area for 'exterior' terraces in the case that the retail units are provided in the future (the retail units are not part of the Railway Order application).

Two emergency exits are provided. One of them will be located at the southern end of the central corridor, leading the passengers in case of an emergency towards Amiens Street through the Connolly HQ staff car-park. The other emergency exit will be provided at the northern end of the central corridor, towards the Fáilte Ireland car-park, where there is a 'right of way' that connects with Seville Place.

In the future, the central corridor could be extended to the Rotunda building at Sheriff Street Lower to provide a connection with the Dublin Arch development.

3.3 Architectural Concept

The design, without neglecting a necessary aesthetic quality, meets strict functional and constructive criteria, allowing a harmonious dialogue with the architectural heritage.

The station proposal creates a viable new use for the existing protected structure of the Connolly Vaults. Using an existing structure is a central tenet of the architectural conservation principles. The intervention in the vaults aims to fulfil another conservation principle – *to do as little as possible but as much as necessary* – to provide a pleasant and sustainable station space. For the historic vaults, the works are limited to cleaning and refurbishing damaged parts and providing low impact interventions that will allow the historic fabric to be appreciated with a good lighting level leading to the platforms.

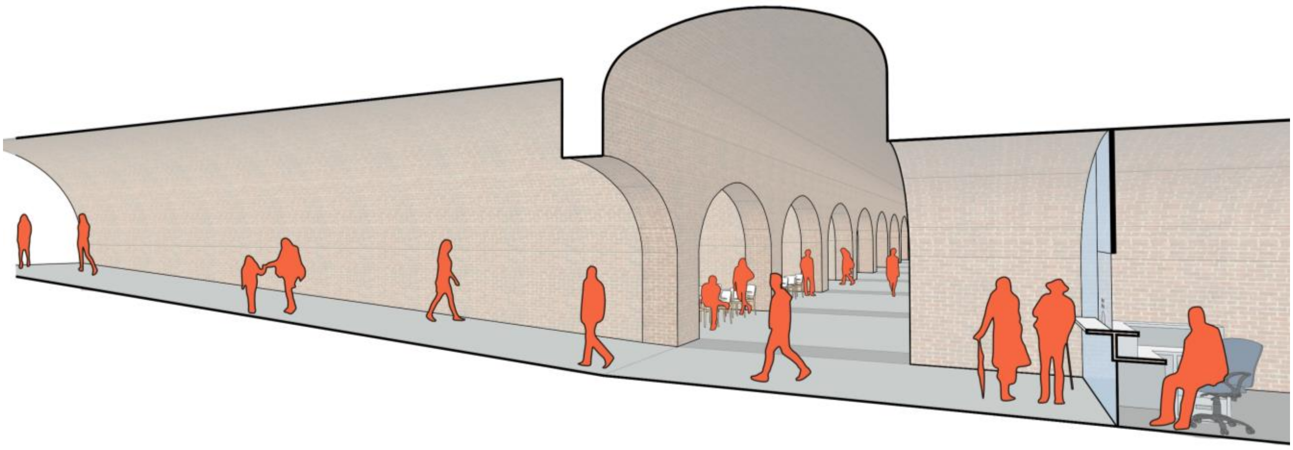

Figure 25. Sketch of the station concourse, the entrance vault and the central corridor

The objective is to keep as much as possible of the 19th Century look and feel, trying to make all the vaults visible. This is also an objective in terms of maintenance and inspection of the vaults. Where attending points or retail areas are placed, the glazing will be located two metres recessed from the inside edge of the arch, and the light in the interior of the retail units will collaborate in the lighting of the public space (in the case that the retail units are provided).

Granite tiles will be used for the floor to avoid any impact on historical structures. The pavement will have a joint when approaching the fabric walls to reduce the impact on them. This joint will be used for lighting purposes.

Quality materials will be used in a contemporary way, maintaining the original character of the station whilst providing a more modern identity. This operation will imply a new use for the existing vaults structures that are currently in a poor conservation state.

Figure 26. Architectural visualizations of the station concourse

For the façade of the new station's entrance, it is proposed to remove the free-standing wall and door on the vault facing Preston Street, leaving it open, to provide free access and exit. A new louvre façade system will be placed over the access arch and the access to the bicycle parking vault, becoming a visual landmark from Amiens Street. The louvres will be separated from the brick alignment and will include illumination of the existing brick façade.

Figure 27. New entrance elevation from Preston Street.

3.4 Vaults conservation

3.4.1 Current condition

The information used to understand the current state of the vaults and abutments is the following:

- Inspection Report carried out by the consulting engineer Roughan & O'Donovan. January 2004.
- Arches & Vaults report presented by David Gannon from the CCE Department. May 2015
- Photos and information recollected during the site visit.

The undercroft comprises brick and limestone masonry arched vaults that generally run transversally underneath the rail lines. These are accessed from the central corridor that runs in the same direction as the tracks.

The arches involved in the proposal are:

- Vault_L13: Electrical cabinets.
- Vault_L14: New emergency exit to Amiens Street.
- Vaults_L15, L16: New escalators access to Platform 6-7, Retail area.
- Vault_L17: New access from Preston Street.
- Vaults_L18, L19: Retail area.
- Vaults_L20, L21, L22: New fixed stair access to Platform 6-7.
- Vault_L24: New lift access to Platform 6-7.
- Vault_L25: New emergency exit to Failte Ireland car-park.
- Vaults_M12: TER.
- Vaults_M13, M14, M15, M16, M17: New escalators access to platform 4, WC for Retail, Staff WC, TIW, staff cantine.
- Vaults_M18, M19: Retail area.
- Vaults_M20, M21, M22: New fixed stair access to Platform 5.
- Vault_M24: New lift access to Platform 5.

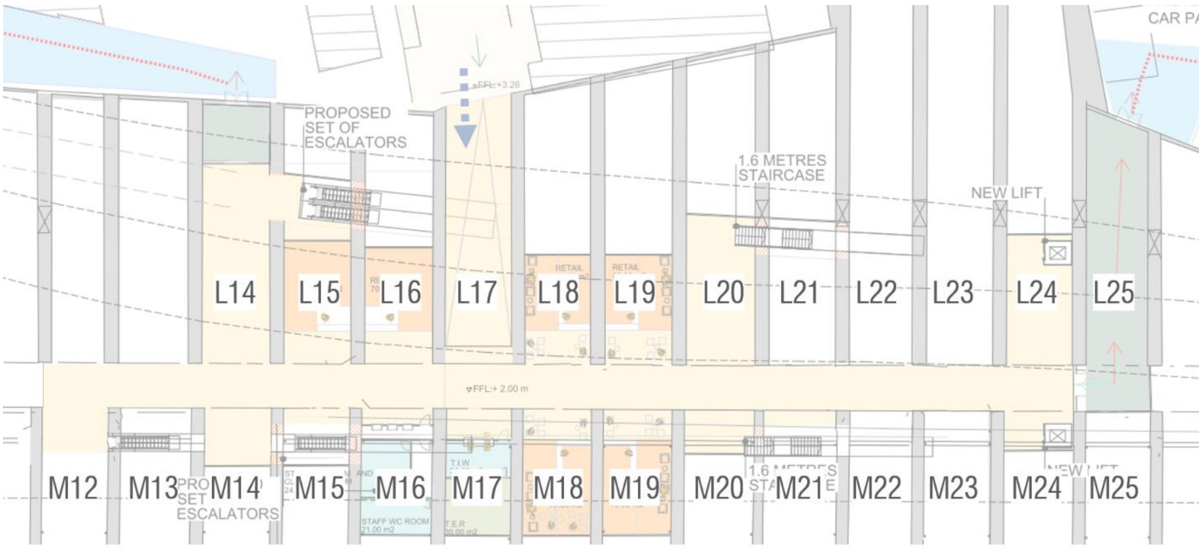

Figure 28. Vaults nomenclature

The structure of the vaults and abutments is formed by red brick, while the masonry of the walls at the end of the vaults is made of random sized limestone blocks. The vaults have a span of around 6.2 m, the abutments have a height of 2 to 2.5 metres, and the arches have a height of around 2 metres.

Figure 29. Photos of the current state of some vaults

Most of the visible pathologies in the vaults are produced by water, differential movements, and contamination. This water penetration ranges from minor seepage to constant running water.

An important area of the ground floor is covered by standing water (due to water ingress) and standing oil contamination. Some of the downpipes are corroded, show rust or are broken. Some of the arches house stalactites derived from calcite contamination.

Figure 30. Photos showing contamination in some vaults

All the brickwork surfaces close to water ingress or water seepage are covered with black contamination or white calcite coating. Most of the damages in the brickwork are caused by the washout of the mortar between bricks due to the water ingress. This process has left bricks friable at a depth of 5 mm to 50 mm, or easy to dislodge, due to the absence of infill.

DRAINAGE SYSTEM

According to the original drawings of the vaults drainage project, the existing drainage system consists of the collection of water in the upper part of the vaults formed by a pigeon-holed brick shaft. The dimension of the shafts are 18” x 18” (457mm x 457mm) on the inside, and it is covered with a stone 4” (10 cm) thick. There is rubble stone around the brick shafts. The downpipes collect water from the shaft to the general drainage system that runs under the pavement along the main corridor.

Figure 31. Section drawing of the vaults drainage original project

This drainage system has long since become totally unusable due to corrosion, silting and probably an inadequate capacity in its original design.

EXISTING RECOMMENDATIONS

The Roughan & O'Donovan Connolly Station Vaults Inspection report, developed in January 2004, provides a number of conclusions and recommendations that have been taken into account to develop the vaults refurbishment proposal.

The main conclusion is that the structural integrity of the vaults and corridors was considered to be sound with no noted significant cracking, settlement or punching. Therefore, the water penetration does not imply an imminent danger of failure of the structural integrity of the undercroft, but it is provoking a loss of brickwork, and the amount of water penetration is significant.

It was also concluded that the source of the water is either from highly rain saturated fill above the arches (or from a leaking water supply or drainage pipes) since the water dripping was continuous despite the inspection was done in a dry period. Where the water penetration has been smaller, there has been a build-up of blackened calcite contaminate.

Out of all the recommendations included in the Connolly Station Vaults Inspection report, a number of them are listed and commented below since they are considered critical to the development of the project.

The Roughan & O'Donovan January 2004 Connolly Station Vaults Inspection report recommendations:

- *It is necessary to stop water from entering the arch backfill by providing an effective drained waterproof barrier and by repairing any leaking water mains and drainage pipes. This will require access from above rather than from within.*

  Sealing the arches from within will only be a temporary solution since the intense track live loading and the hydraulic pressure will eventually result in further penetration and structural deterioration.

  A definitive solution for the vaults waterproofing would require access to the arches from above to provide an effective internal drainage system. However, due to the DART+ West project conditions, this solution is not feasible since it requires stopping the operation of the lines operating at Connolly Station.

Therefore, the proposed methodology for water collection is a mitigation measure or a short term solution that will allow passengers to use the area.

- *As a backup provision, the remains of the existing arch drainage system should be inspected and made good as far as is reasonably possible.*

A dilapidation survey will be carried out during the project's next stage to inspect the drainage system, both for the Main Line vaults and the Loop Line vaults drainage systems. The information obtained in the inspection will help provide the best solution for making good the drainage system in the later stages of the project.

- *Prior to any further inspections, consideration should be given to clearing the surfaces of the brickwork and masonry so that more comprehensive visual inspection is possible. Clearing out the vaults of all building and other debris will also allow better access for ladders, staging and access platforms*.

The dilapidation survey will also include the cleaning of some vaults and the clearing of the brickwork and masonry to allow a more comprehensive visual inspection.

- *In vaults M10, M11, M13 and M14, there was a greater extent and severity of deterioration at the construction joints across the arch at the main access corridor extension. The construction joint has opened to up to 100mm wide, and depths to mortar can be seen extending back into the brick courses by up to 300mm.*

An exhaustive inspection will be carried out at these vaults once the surface is cleaned to decide if these vaults can be waterproofed with resin injections or if they will also need polycarbonate protection below.

3.4.2 Cleaning strategy

The decision on how to perform cleaning in a historical building is one that should not be made lightly. Cleaning can have significant physical and aesthetic consequences, both positive and negative, on the building. The first step must be to undertake a detailed investigation to determine if cleaning should be performed and, if so, how it should be done. The characteristics and conditions of the masonry must be taken into account, including stone, brick and mortar, as well as the makeup of the soiling. The latter can include atmospheric depositions, paint, limewash and metal oxide staining. Each one requires a different approach. There is no single system or product that will safely and effectively remove all problems.

The goal of cleaning is to remove soiling while causing the smallest disruption to the underlying masonry. This can be extremely difficult to achieve due to the basic relationship between masonry and its soiling, as the soiling can often be embedded deeply in the substrate.

- Brickwork's characteristics to be aware of:
  - variations in the firing degree in a brick wall will affect its adhesiveness concerning deposits
  - surface texture: variations in surface hardness may also make abrasive cleaning methods difficult to use safely in many instances
  - bricks generally show a high degree of porosity, and it is probable to find a high range of different porosity degrees from one brick to another
  - heavy soiling on some brick surfaces
- Mortar joint's characteristics to be aware of:
  - lime-based mortar is comparatively soft, porous and permeable compared to its associated brickwork
  - there is a high proportion of joints in the total surface area of some brick walls. In pre-19th century brickwork, this can be as high as 30 per cent, requiring the cleaning process to be equally suitable for mortar surfaces as well as brick surfaces.

Periods of saturation related to water washing, chemical cleaning or wet abrasive cleaning can lead to the emergence of efflorescence. Inherent salts within the brick surface are dissolved and brought to the surface during the drying-out process. The efflorescence should be dry-brushed or vacuumed from the wall surface, making sure the salts are collected and not redeposited elsewhere on the masonry.

Different techniques for cleaning masonry and their effectiveness can be pointed out and examined, in order to succeed in achieving its original:

- *Air abrasive cleaning techniques:* These techniques are the most successful ones on even surfaces and consistent surface texture and hardness. An air abrasive stream cannot by its own means, regardless the used abrasive, differentiate between aiming at the removal of soiling and the removal of masonry. For brickwork, it is almost impossible to succeed in cleaning historic brickwork using abrasive blasts without causing any damage. Bricks are very intolerant to abrasive cleaning, and it is not a good choice for paint removal.

  Special attention should also be given to the effect of the cleaning process on the mortar, as traditional brickwork pointing mortars, which were based on soft mixes of lime and sand, are usually even softer than the bricks themselves.

- *Abrasive cleaning systems* are usually inappropriate for use on historic brickwork due to the nature and characteristics of the brickwork, even when the process is undertaken extremely carefully. These methods are unable to deal with the multiple variations that can be present in a brick wall. Abrasive cleaning is particularly inappropriate for paint or graffiti removal on brickwork.

- *Chemicals cleaning techniques:* cleaning chemicals must be used at low strength, applied neatly, left for short dwell times and thoroughly rinsed at non-damaging pressures. Porosity also varies, and high absorbency may eliminate or stringently define the parameters of a chemical cleaning regime.

  Chemical cleaning methods are commonly the most suitable approach since they are able to fit in variations in texture, condition and hardness, and it is undoubtedly the best method for paint removal.

Figure 32. Abrasive (left) and chemical (right) cleaning techniques

- *Low Impact Vapor Blasting strategy:* This system is a far cry from sandblasting systems. This cleaning system uses a mixture of low-pressure air, small amounts of water and a safe, inert, fine aggregate such as calcium carbonate. It gently removes paint, dirt, carbon, bitumen, limescale, graffiti and biological matter from any building finish without damaging the substrate.

3.4.3 Restoration strategy

For the restoration of brick vaults, in some cases, it will be necessary to replace bricks that have fallen off or are defective. Since part of the vaults will have to be cut in order to create the accesses to Platform 5 and Platforms 6&7, the recovery and cleaning of the original bricks is proposed to be carried out with the necessary brick replacement.

Special attention must be paid to the restoration process involving new mortars, brick replacement and the grouting of the joints washed by the water.

- The new mortar must match the historic mortar in colour, texture and tooling.
- The used sand must match the sand that is present in the historic mortar. (The colour and texture of the new mortar will usually fall into place if the sand is matched successfully.)
- The new mortar must have greater vapour permeability and be softer than the masonry units.
- The new mortar must be as vapour permeable and as soft as the historic mortar or even softer.

3.4.4 Waterproofing strategy

Some necessary steps should be carried out when starting the waterproofing strategy:

- Structural interventions and repairs.
- Removal of contamination from bricks and joints. After this, the brickwork will be repaired where necessary and repointed using an appropriate lime mortar. Finally, it will be ready for waterproofing.

The waterproofing proposal is based on acrylic injections that would only be used for the vault of the longitudinal corridor and in some cross vaults such as the access vault from Preston Street (L17) and the ones that provide vertical connection to the platforms (L14, L20, L24, M12, M14, M20 and M24).

The objective of the proposal is to remove the water from those vaults and transfer it to the adjacent ones, where the water seepage would be collected by new down pipes that will replace the existing ones. The proposed drainage system is not completely effective or everlasting since the only definitive solution would be waterproofing the vault structure from the upper side.

Additionally to the acrylic injections, the water penetration will be avoided by means of a system of removable umbrellas made of polycarbonate. In this way, the water pressure in these vaults would not be increased since the water can seep through the bricks into the vault.

A more detailed explanation of the different waterproofing systems is shown below.

- *Acrylic resin injections*

This system will be used for the vault of the concourse area, which includes the access vault (Preston St), the central corridor and its connection with the vertical communication elements (escalators, staircases and lifts).

An hydrostructural gel curtain system with injections of acrylic resins will be used to solve this type of leakage from the back of the brick vault.

The process starts off by defining a grid of perforations with a diameter ranging from 12-14 millimetres, using the brickwork joints to reach the back of the vault. Nine injection points per square meter, in parallel lines and 30 cm distance between drills, will be necessary, together with 1.5 litres of resin per injector.

Subsequently, injection packers are placed and used to pump the acrylic resin to fill the outer part of the vault.

This resin’s viscosity is similar to water’s viscosity, so it runs through any gap and, once hardened, it generates a waterproofing membrane. The packers are then removed, and the holes are sealed with mortar.

Figure 33. System involving injections of acrylic resins

- *Sliding polycarbonate umbrellas*

This system will be used in the vaults housing retail units, back-of-house areas, and technical areas.

In these vaults, water penetration will be avoided by means of a system of sliding umbrellas made of polycarbonate. In this way, the water pressure in these vaults would not be increased since the water can seep through the bricks into the vault.

Interior protection for the vault will be designed based on a very light curved metal structure, following the vault's geometry, incorporating a transparent polycarbonate protection. This new transparent vault under the existing one will be movable, fitted on simple rails supported on the metal structure, which would make tactile inspection and maintenance very easy.

This approach is very respectful with the vault since there is practically no intervention in it (only the cleaning and grouting of mortar joints). The visual effect is enhanced by incorporating LED lighting in accordance with the desired architectural characteristics.

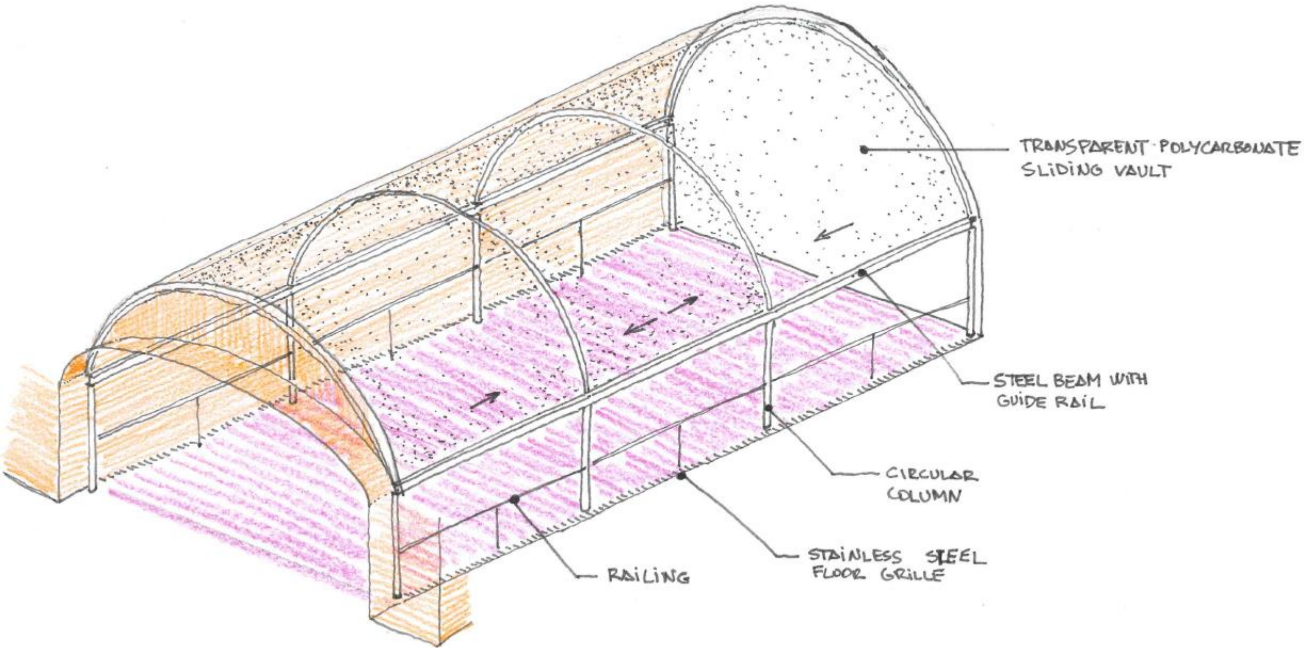

Figure 34. Sketch of the transparent polycarbonate umbrella inside the vault

This system is commonly used to cover swimming pools. It is broadly tested as many suppliers develop and provide it. It is an innovative application of the system with the confidence of a technically proved product.

Figure 35. The transparent methacrylate umbrella system is commonly used to cover swimming pools.

3.5 Materials and Finishes

This chapter explains the main finishes proposed for the intervention at Connolly Station. A minimal palette of materials is proposed for the new station entrance to convey a modern and cool aesthetic. The use of high-quality finish materials is of particular importance and will greatly improve the passenger's perception of the space, creating a safe and comfortable passenger experience.

3.5.1 Interior Finishes

The interior finishes will be chosen according to their **quality, comfort, performance, durability, low maintenance and easy cleaning**. Next, as a reference, a list of materials and finishes that, according to our knowledge and experience, we understand suitable for different areas of the building.

3.5.1.1 Entrance, lobbies, corridors

- FLOOR
  - Slip-resistant natural stone: Granite tiles, placed on a raised concrete slab with a layer of cement mortar screed. The level of the floor will be raised to solve the difference of level between the central corridor and Preston Street.
- WALLS
  - Existing brick wall with resin injections to waterproof the vaults.
- CEILING
  - Central longitudinal corridor and connection vaults: Existing brick vault with resin injections to waterproof the vaults.
  - Services and retail vaults: Movable curved transparent polycarbonate sheets. The system will consist of panels with profiled sides clipped into an adjustable suspension system which allows panels to be removed by hand individually.

3.5.1.2 Platforms

- FLOOR
  - Existing precast concrete pavers.
- WALLS
  - System with clear glass panels and stainless steel mullions to connect the lifts with the covered areas of the existing canopies and to protect stairs and elevators from weather conditions.

3.5.1.3 Technical rooms

- FLOOR
  - Electrical/ Signalling rooms: rubber flooring.
  - Cleaning Room, Trash Room and Staff toilets: ceramic tiles.
  - Other MEP rooms: traffic bearing multicomponent epoxy paint.
- WALLS
  - Acrylic paint over masonry block wall or gypsum board.
  - Cleaning Room, Trash Room and Staff toilets: ceramic tiles.
- CEILING:
  - Modular moisture resistant suspended ceiling tile to provide future access for services & modifications.

3.5.1.4 Passenger services areas

- FLOORS
  - Granite tiles over a raised floor system.
- WALLS
  - Acrylic paint on plasterboard lining.
- CEILING:
  - Movable curved transparent methacrylate sheets

The modularity of construction systems is one of the objectives of the project when selecting station finishes (e.g. partitions, raised floors, suspended ceilings, ceiling fittings, etc.). Furthermore, the availability of local and national suppliers for the proposed construction systems is also a key factor. The benefit of these criteria is that they will ease daily maintenance and repair work as well as reducing the carbon impact.

Regarding the interior illumination system, the lighting fixtures will be integrated into the edge of the methacrylate sheets. Flush linear LED lighting will provide a good level of illuminance to the vaults area. Additionally, in the central longitudinal corridor, the lighting will be provided undirectly with specific lighting points.

Wayfinding and advertising elements will be sympathetic with the station design and will be integrated into opaque wall panels suspended from the ceiling. Wayfinding and advertising elements will be backlit. They will have a powder-coated casing, with a front flushed glass cover, keeping a minimalist, clean appearance. All fixings will be concealed.

The doors giving access to 'back of the house' areas or to technical rooms will be flushed doors with concealed frames. The doors' finish should match the one of the wall where it is placed. The door giving access to the Ticket Issuing Window will be laminated tempered glass, included in a laminated curtain wall that will allow station staff to control the station entrance and provide information to incoming passengers.

3.5.2 Platforms

There are two canopies on the platforms. The canopy at Platform 6&7 integrates the adjacent track's catenary and is supported by inclined HSS square steel columns. It was constructed in 1984 for the first DART system line. The canopy at Platform 5 is a listed structure supported with circular columns decorated with capitals and circular shapes.

Both canopies do not cover the whole platform area, and they include a skylight area that allows natural light to illuminate the platform.

A new structure is proposed to connect the new lift at Platforms 6&7 with the existing canopy. At Platform 5, the access to the staircases and the lift will be protected with a 2.5 metres high glass partition and a glass roof to protect the vertical facilities from weather conditions.

3.5.3 Water ingress protection

Due to the electromechanical equipment of the lifts and escalators, they must be built with materials that are highly resistant to corrosion and ensure high resistance seals against water. That's why it is recommendable for them to be built with stainless steel profiles and plates, with a brushed finish. The possibility of having a panoramic view of the surrounding when reaching the platform requires enclosing the lift car with transparent safety glass.

The escalators are provided with 2.5 metres high vertical glass walls to protect them from any direct water ingress. Furthermore, the escalators will be specified as exterior escalators. They will be prepared with protection systems. The pit will have a drainage system connected with the general drainage of the vaults central corridor.

On the lifts, as the glass shaft contains the cabin, which acts as a piston, it must have openings that allow decompressing the air in the shaft when the lift goes up and down. The opening will also contribute to natural ventilation. The electrical mechanisms, lighting, etc., must have a high protection index against water ingress to withstand contact with wet surfaces.

The access to the lift and escalators on the platforms must be protected with a drainage pit in front of the door to prevent water from entering the lift shaft. The drainage pit will be protected with a grille to prevent people from tripping and placing their feet on the drainage pipe. The floor surface surrounding the lift shall have a slope of 1:50 to prevent the lift from being at a low point and thus avoiding water and dust ingress.

The closest glass panel to the platform level should be supported by a plinth allowing the installation of waterproofing sheets between the plinth and the floor. It shall also allow the glass panels to expand easily or to move slightly. Additionally, a roof over the lift door would reduce the amount of water significantly in the joints between the lift and the platform floor.

The lift shaft must be protected with waterproofing sheets and membranes and must have the drainage pipes connected to the general drainage network.

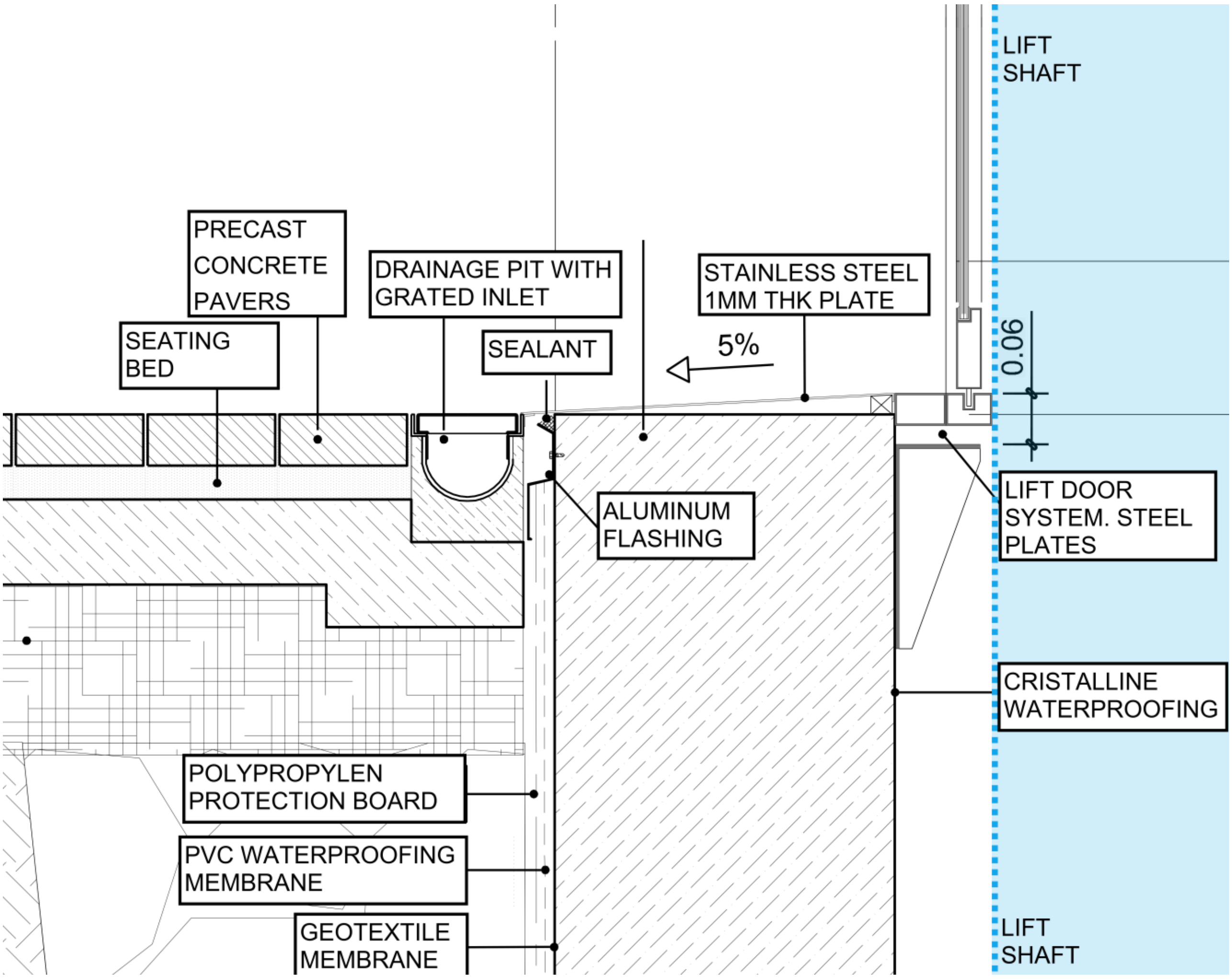

Figure 36. Waterproofing lift detail example that will be adapted to the details of the project

3.6 Schedule of uses and areas

The table below shows the main uses and net areas of the Connolly Station new entrance:

PUBLIC		**3431 m²**
Preston Street access	Street Level	134 m²
Concourse Area	Street Level	981 m²
Bicycles parking	Street Level	120 m²
Lift to Platform 5	Street Level	5 m²
Lift to Platform 6&7	Street Level	5 m²
Staircase 1	Street Level	14 m²
Staircase 2	Street Level	26 m²
Escalator 01	Street Level	15 m²
Escalator 02	Street Level	14 m²
Escalator 03	Street Level	18 m²
Platform Lift 2	Platform Level	5 m²
Platform Lift 1	Platform Level	3 m²
Platform 6&7	Platform Level	1129 m²
Platform 5	Platform Level	965 m²
RETAIL AREA (NOT PART OF THE RO)		**324 m²**
Retail unit 01	Street Level	60 m²
Retail unit 02	Street Level	67 m²
Retail unit 03	Street Level	66 m²
Retail unit 04	Street Level	65 m²
Retail unit 05	Street Level	66 m²
BACK OF THE HOUSE AREA		**164 m²**
Ticket Office	Street Level	17 m²
Staff WC	Street Level	37 m²
Staff Canteen	Street Level	41 m²
WC for retail	Street Level	49 m²
Storage & cleaning room	Street Level	20 m²
TECHNICAL ROOMS		**201 m²**
Electrical cabinets	Street Level	39 m²
TER	Street Level	49 m²
Ventilation room 01	Street Level	34 m²
Ventilation room 02	Street Level	79 m²
EMERGENCY EXITS		**285 m²**
Emergency Exit 01	Street Level	121 m²
Emergency Exit 02	Street Level	164 m²
TOTAL		**4405 m²**

4. Structural Design

4.1 Site Conditions

4.1.1 Introduction

The purpose of this preliminary geotechnical study is to provide a preliminary approach and understanding of the available historical field investigations, lab testing and ground interpretation carried out by the previous site historical GI at Connolly Station. Please note that this geotechnical study is solely for concept design purposes, therefore this a preliminary report based on initial assumptions.

These preliminary results should be contrasted with the specific site investigation designed in the GI contract, which will confirm the previous assumptions.

4.1.2 The Site

Connolly Station is located in Dublin, between Amiens St, Seville Pl, and Harbourmaster Pl having the river Liffey at the south.

The published geological maps of the local area indicate the site to be underlain by marine basinal (Tobercolleen and Lucan Fms – "Calp"), dark grey argillaceous and cherty limestone and shale. The surface deposits are anticipated to consist of made ground (of varying provenance) overlying boulder clay.

4.1.3 Sources of Information

The main source of information is the report:

- CE 5148-1 Bridge Foundation Inspections, Connolly Arches. Report on clearance, surveying and assessment works. Undertaken by CCE Technical Department. Report No. 1552-14.
- CUC 14-08 Accessibility – Connolly Platform 6 & 7, Lift – Ground Investigation Works. 19th June, 2015. Pgl priority geotechnical.
- Accessibility Project Platform 6 & 7 Connolly Station. Geotechncial Survey. Report Status: Draft. 2nd December 2014. Minerex Geophysics Limited.

4.1.4 Geophysical Information

The report No. 1552-14 covered a geophysical surveying with the use of Electrical Resistivity Imaging and Ground Penetrating Radar.

The Electrical Resistivity Imaging had the intention of analysing the sub-surface to a depth of approximately 2.75 m and 5.50 m below existing ground level. The geophysical electrical resistivity survey has generally indicated the presence of made ground / fill material, that is in tun underlain by what is anticipated to be till (boulder clay).

The extent of the made ground is expected to vary in thickness, but the data indicated that approximately 0.75 m to 2.40 m is made ground. An average depth of approximately 1.60 m made ground / fill material is anticipated to mantle the are within the arches. Generally, it appears that the made ground decreases along the south-western section of the arches (approximately 0.75 m) and increases in thickness along the structure towards Seville Place. The analysis also indicates that the till / boulder clay under the made ground is present to a depth of at least 5.50 m under the existing ground level.

The Ground Penetrating Radar indicates the presence of made ground / fill to depths of approximately 1.60 m below existing ground level.

4.1.5 Groundwater

Based on the boreholes in the surroundings of Connolly Station, the groundwater level is assumed to be deeper than 2.0 m below ground level.

4.1.6 Geotechnical Considerations

From the desk study information, the knowledge of the site and the available historic ground investigation information, the following subgrade materials may be considered for the preliminary design of this project:

i) Made ground and historical fills. These materials are unsuitable for engineering purposes.

ii) Till / Boulder Clay.

iii) Cherty Limestone

4.1.7 Foundations

According to the available information some sort of ground treatment is necessary if the foundation level is over the boulder clay stratum. For this reason all foundations in absence of more information are assumed to be loading in the boulder clay stratum. Conventional strip or pad foundations for traditional buildings can be placed on the boulder clay for allowable bearing pressure (ELS). The design of the foundations that require micropiles or piles, due to geometric limitations or higher load bearing, will be defined once the geotechnical information becomes available. According to the available information the concrete design class could be XA1.

The selection of foundation type and some others geotechnical inputs (e.g strip, raft foundations, ground improvements, drainage design, deep foundations, etc) will be defined once the site-specific data becomes available.

4.1.8 Seismic Condition

Following established engineering practice, the Republic of Ireland is deemed to be in an area of very low seismicity and as such national annexes are not considered necessary for adopted I.S. EN 1998.

In the event that I.S. EN 1998-1 is considered for the design and construction of buildings and civil engineering works in the Republic of Ireland, the recommended values for NDP´s given in I.S. EN 1998-1 should be employed.

The design seismic action, AEd, is expressed in terms of: (a) the reference seismic action, AEk, associated with a reference probability of exceedance, PNCR, in 50 years or a reference return period, TNCR.

The values considered are PNCR = 10% and TNCR = 475 years as the recommendation of the I.S. EN 1998-1:2004 and I.S. EN 1998-2:2005.

No onshore seismic zonation map with peak ground accelerations is currently available. Recently a map of seismic intensity (EMS scale) for 475 years mean return period has been published. Although the correlation between intensity and ground acceleration is rather weak. In areas with intensities less than 6 or 7 the 475-year return period PGA should not be exceeding the 0.04g, a level considered as a very low seismicity region.

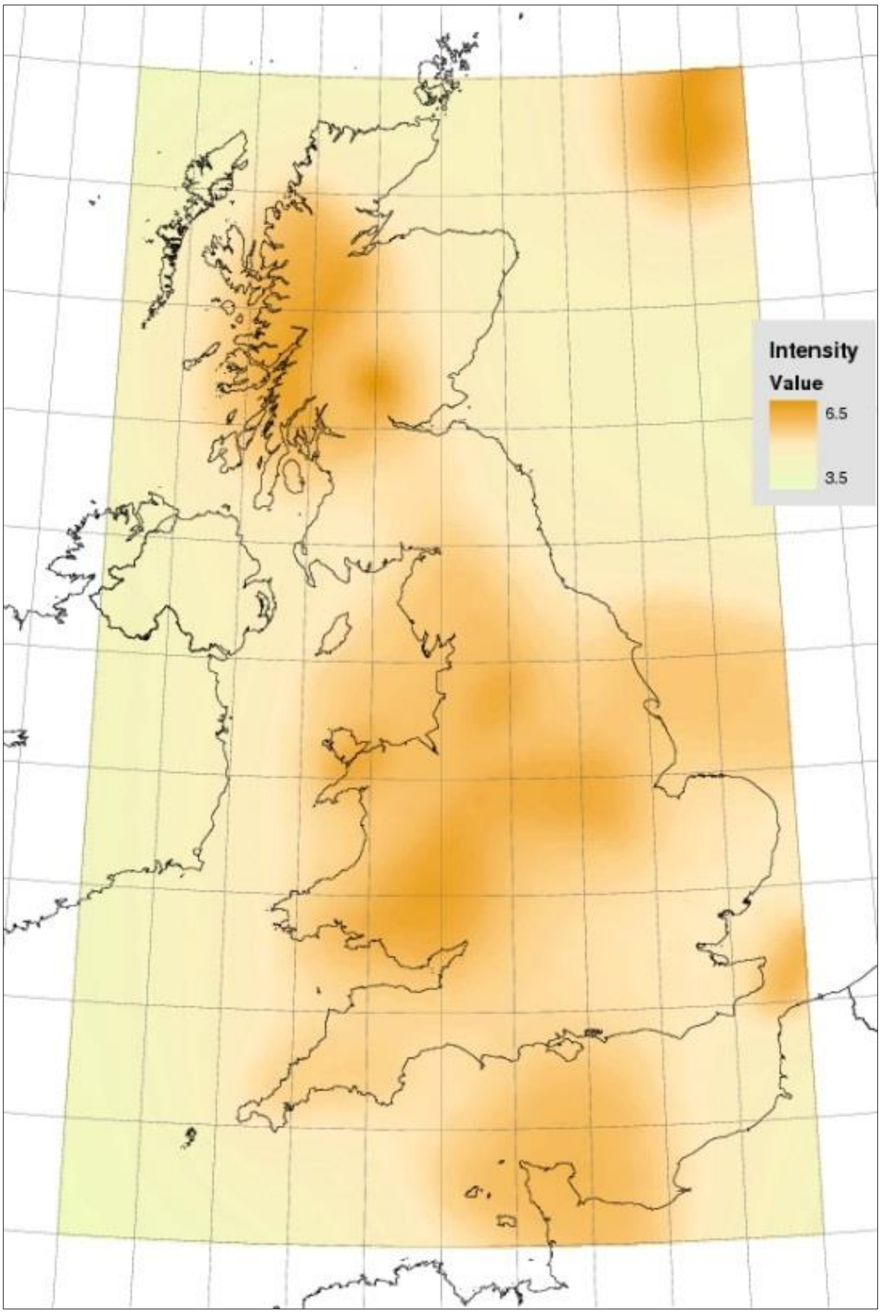

Figure 37 – The expected intensity (EMS) of earthquake shaking with a 10% probability of being exceeded over 50-year period in the UK. (Source: Musson and Winter (1996))

Another reference is the Seismic Hazard Harmonization in Europe (SHARE), supported by the EU-FP7 to deliver the first state of the art reference hazard model for Europe, replacing older maps. The SHARE hazard contributes to the Global Earthquake Model (GEM) and serves as input for risk mitigation policies such as the design of earthquake-resistant multi-storey buildings and critical infrastructures such as bridges or dams. The SHARE seismic hazard is assessed with time-independent, probabilistic approach. Models of future ground shaking are based on the history of earthquakes over the past 1000 years, on the knowledge of active faults mapped in the field, on the style and rate of deformation of the Earth´s crust from GPS measurements, and on the instrumental recordings of strong ground shaking generated by past earthquakes.

The SHARE results do not replace the existing national design regulations and seismic provisions, which must be obeyed for today´s design and construction of buildings.

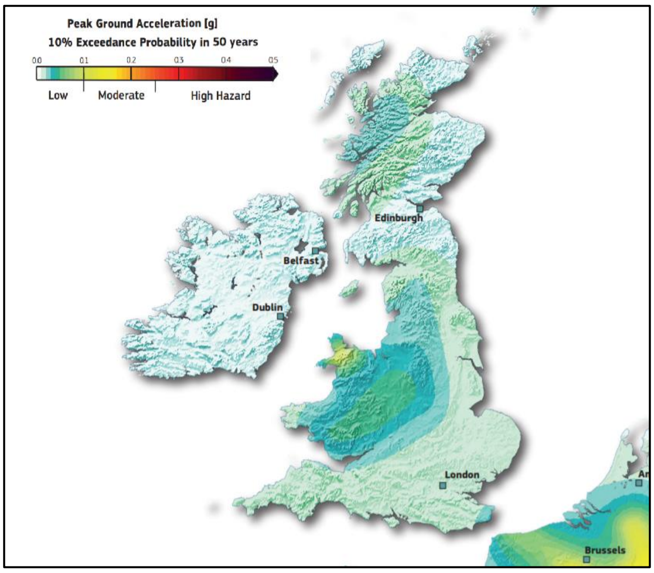

Figure 38 – Peak ground acceleration [g] 10% exceedance probability in 50 years. (Source: SHARE European Seismic Hazard Map for Peak Ground Acceleration, 10% Exceedance in 50 years)

Therefore, no special provision for seismic design is required for this project.

4.2 Materials

4.2.1 Concrete

The concrete adopted for the structural design is included in following table, depending on the element type:

Concrete specification according to I.S. EN-1992-1-1:2004				
Element type	**Exposure Class**	**f_{ck} min (MPa)**	**Max w/c**	**Min. Cement (kg/m3)**
Lean concrete	N/A	C15	N/A	N/A
Spread Footings	XC2; XA1-2-3(1)	C35/45	0,50	360
Piles Caps	XC2; XA1-2-3(1)	C35/45	0,50	360
Piles	XC2; XA1-2-3(1)	C35/45	0,50	360
Interior Columns	XC3	C35/45	0,50	360
Exterior Columns	XF1; XS1; XA1-2-3(1)	C35/45	0,50	360
Interior slabs	XC3	C35/45	0,50	360
Exterior slabs of buildings	XF4; XS1	C35/45	0,50	360
Exterior slabs of roads	XF4; XS1	C35/45	0,50	360
Interior beams	XC3	C35/45	0,50	360
Exterior beams	XF3; XS1	C35/45	0,50	360
(1) Aggressive conditions for the soil and water to be confirmed				

Table 1 – Concrete specification according to I.S. EN-1992-1-1:2004

All concrete is to be normal weight concrete. Concrete shall have low permeability, high strength, and the ability to resist chloride penetration into the concrete by diffusion, absorption, or hydraulic pressure. The exposure classes and the structural classes have been defined following the Eurocode methodology.

Concrete covers have been defined for each element according to the exposure conditions as per the following table:

Concrete specification according to NA to I.S. EN-1992-1-1:2004							
Exposure conditions							
	Class Designation	**Description of the Environment**	**Indicative Concrete Strength**	**Max. w/c**	**Min. Cement (kg/m3)**	**Min. Cover to steel (mm)**	**Nominal cover to steel**
Carbonation induced corrosion	XC1	Dry or permanently dry	C25/30	0.65	270	25	$25 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XC2	Wet, rarely dry	C28/35	0.60	290	35	$35 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XC3	Moderate humidity	C30/37	0.55	310	35	$35 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XC4	Cyclic wet and dry	C30/37	0.55	310	40	$40 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
Seawater induced corrosion	XS1	Airborne salt but no direct contact	C30/37	0.55	310	35	$35 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XS2	Wet, rarely dry	C30/37	0.55	310	40	$40 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XS3	Tidal, splash and spray zones	C35/45	0.50	360	45	$45 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
Seawater induced corrosion	XS1	Airborne salt but no direct contact	C35/45	0.50	360	50	$50 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XS2	Wet, rarely dry	C40/50	0.45	400	55	$55 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XS3	Tidal, splash and spray zones	C30/37	0.55	310	45	$45 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
Chloride induced corrosion excluding chlorides from seawater	XD1	Moderate humidity	C30/37	0.55	310	45	$45 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XD2	Wet, rarely dry	C35/45	0.50	360	50	$50 + \Delta c_{dur,\gamma} + \Delta c_{dev}$
	XD3	Cyclic wet and dry	C40/50	0.45	400	55	$55 + \Delta c_{dur,\gamma} + \Delta c_{dev}$

NOTE 1 $\Delta c_{dur,\gamma}$ = 0mm for reinforced concrete and Factory controlled prestress precast concrete where fabrication is subject to a quality assurance system and with satisfactory history of previous use. Otherwise a value of 10 mm should be adopted
NOTE 2 Δc_{dev} = 10mm or 5mm for all factory controlled precast structures. This is based on fabrication being subjected to a quality assurance system in which the monitoring includes measurement of the concrete cover
NOTE 3 For cements assumed for use in this Table; refer to Notes 1 & 2 of Table NA.5 of the National Annex to I.S. EN 206

Table 2 - Concrete specification according to NA to I.S. EN-1992-1-1:2004

Minimum cover for concrete cast against prepared ground (including blinding) should be 50mm and for concrete cast directly against soil 75mm.

Concrete cover according to I.S. EN-1992-1-1:2004 (Reinforcing Steel)		
Element type	**Exposure class**	**Nom Cover (mm)**
Lean Concrete	N/A	N/A
Spread Footings	XC2; XA1-2-3(1)	55/75
Piles Caps	XC2; XA1-2-3(1)	55/75
Piles	XC2; XA1-2-3(1)	75
Interior Piers	XC3	45
Exterior Piers of buildings	XF1; XS1	55
Exterior Piers of roads	XF2; XS1	55
Diaphragm walls	XC2; XA1-2-3(1)	75
Vertical lining walls of Underground Stations	XC2; XC3; XA1-2-3(1)	45/55
Exterior Cut and Cover vertical lining walls	XF2; XS1; XA1-2-3(1)	55
Interior slabs	XC3	45

Concrete cover according to I.S. EN-1992-1-1:2004 (Reinforcing Steel)		
Element type	**Exposure class**	**Nom Cover (mm)**
Exterior slabs of buildings	XF3; XS1	55
Exterior slabs of roads	XF4; XS1	55
Interior beams	XC3	45
Exterior beams	XF3; XS1	55

(1) Aggressive conditions for the soil and water to be confirmed

Table 3 - Concrete cover according to I.S. EN-1992-1-1:2004 (Reinforcing Steel)

4.2.2 Reinforcing Steel

Ribbed bars for concrete reinforcements will be weldable. Bars shall comply with Article 3.2 of Eurocode 2 (also according to UNE 10080), Class B or Class C and have the following characteristics:

- Characteristic yield strength of reinforcement: f_{yk} = 500MPa
- Ductile failure limit: f_s = 550MPa
- Design value of modulus of elasticity: E_s = 200,000MPa
- Rupture elongation = 12%

The nominal diameters of the corrugate bars will be selected from this series:

6 - 8 - 10 - 12 - 16 - 20 - 25 - 32mm

4.2.3 Grouting

Anti-shrinkage high resistance grout will be used over structural concrete, with a minimum characteristic compressive strength f_{ck} = 50N/mm^2.

4.2.4 Structural Steel

Structural steel to be S355 J0 in accordance with BS EN 10025, for all steel members. Channel and angle shape members to be S275 J0.

Structural general properties will be:

- Modulus of elasticity: E = 210,000N/mm^2
- Shear Modulus: G = 80,000N/mm^2
- Poisson's Ratio: ν = 0.30
- Coefficient of linear thermal expansion: ε_t = 0.000012m/m °C
- Density: ρ = 7,850kg/m^3
- British sections profile or built up sections have been considered in the design.

The design value for the resistance of structural steel is defined by the expression: f_y/γ_i

Where the strength reduction coefficient γ_i will have the following values:

- γ_{M0} = 1.05

- γ_{M1} = 1.05
- γ_{M2} = 1.25

4.3 Loads

4.3.1 Dead Load

For permanent actions, a single representative value, coinciding with the characteristic value G_k, shall be considered.

The dead load includes the weight of all walls, permanent partitions, floors, roofs, finishes, foundations and structures, and all other permanent construction including services of a permanent nature.

It includes the gravitational action of all known and permanent elements which act on the structure, including equipment loads given by the suppliers.

The following values for dead loads of structures shall be taken into consideration:

Reinforced concrete	25kN/m3
Mass Concrete	24kN/m3
Structural steel	78.5kN/m3
Arches infill	25kN/m3
Masonry	20kN/m3

4.3.2 Live Loads – Imposed

Each of the variable actions can be considered with the following representative values:

a. Characteristic value Q_k: Value of the action when acting alone.

b. Combination value $\Psi_0 \cdot Q_k$: Value of the action when it acts together with another variable action.

c. Frequent value $\Psi_1 \cdot Q_k$: Value of the action that is exceeded during a short period with respect to the life of the structure.

d. Quasi-permanent value $\Psi_2 \cdot Q_k$: Value of the action that is exceeded during a large part of the life of the structure.

The values of the coefficients Ψ are as follows:

Recommended values of Ψ factors for buildings			
Actions	Ψ_0	Ψ_1	Ψ_2
Imposed loads in buildings, category (see I.S. EN 1991-1-1)			
Category A: domestic, residential areas	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.6
Category D: shopping areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic area, vehicle weight≤ 30kN	0.7	0.7	0.6

Recommended values of Ψ factors for buildings				
Actions		**Ψ_0**	**Ψ_1**	**Ψ_2**
Category G: traffic area, 30kN<vehicle weight≤ 160kN		0.7	0.5	0.3
Category H: roofs		0.6	0.5	0.0
Railway traffic actions (LL; braking; nosing; centrifugal) (see I.S. EN 1991-2)		1.0	1.0	1)
Road traffic actions	TS; UDL; braking; skew (see I.S. EN 1991-2)	0.75	0.75	0.0
	Pedestrian and cycle-track loads	0.40	0.40	0.0
Snow loads on buildings (see I.S. EN 1991-1-3)		0.5	0.2	0.0
Horizontal earth pressure due to traffic load surcharge		0.7	0.7	0.6
Wind loads on buildings (see I.S. EN 1991-1-4)		0.6	0.2	0.0
Variable component of the water table		1.0	1.0	1.0
Temperature (non-fire) in buildings (see I.S. EN 1991-1-5)		0.6	0.5	0.0
Construction Loads		1.0	-	1.0
1) If deformation is being considered for Persistent and Transient design situations, Ψ2 should be taken to 1.00 for rail traffic actions.				

Table 4 - Recommended values of Ψ factors for buildings

The values of the imposed loads considered are as follows:

- Live load in public areas: 5 kN/ m^2

4.3.3 Load Combinations

Load combinations will be designed according to EN 1990 Eurocode 0 requirements.

- For ultimate limit state load combinations, the following have been followed:

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\Psi_{0,i}Q_{k,i} \qquad \text{(EC0 Eq. 6.10)}$$

- For permanent and variable loads the next equations have been used:

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\Psi_{0,i}Q_{k,i} \qquad \text{(EC0 Eq. 6.10)}$$

Where:

- $\gamma G_{j,sup} = 1.35$
- $\gamma G_{j,inf} = 0.9$
- $\gamma Q_{1,sup} = 1.5$
- $\gamma Q_{1,infj,inf} = 0.9$

Values of Ψ factors for buildings			
Values of Ψ factors for buildings	**Ψ0**	**Ψ1**	**Ψ2**
Imposed loads in buildings: Office areas	0.7	0.5	0.3
Imposed loads in buildings: Storage areas	1.0	0.9	0.8
Imposed loads in buildings: Roofs	0.6	0.5	0.0

Values of Ψ factors for buildings			
Values of Ψ factors for buildings	**Ψ0**	**Ψ1**	**Ψ2**
Wind load	0.6	0.2	0.0
Snow load	0.5	0.2	0

Table 5 – Values of Ψ factors for buildings

And for the serviceability limit state the next equation has been used:

$$\sum_{j\geq1} G_{k,j} \text{"+"} P \text{"+"} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{0,i} Q_{k,i} \qquad (6.14b)$$

4.4 Calculation Basis

The structure shall be designed and executed in such a way that it is able to sustain all actions and influences likely to occur during its execution and use, with appropriate degrees of reliability and in an economical way. The structure shall be designed to have adequate structural resistance, serviceability, and durability in accordance with EN Eurocodes.

To ensure the safety of the surface station structure, the Limit State design method will be used according to European Regulation. The states are classified as:

- Serviceability Limit States (SLS).
- Ultimate Limit States (ULS).

4.4.1 Serviceability Limit States (SLS)

This limit state concerns the functioning of the structure or structural members under normal use, which affects the comfort of users and the appearance of the construction works.

In the context of serviceability, the term “appearance” is concerned with criteria such as high deflection and extensive cracking, rather than aesthetics.

Serviceability limit states in buildings considers, for example, floor stiffness, differential floor level, storey sway or/and building sway and roof stiffness. Stiffness criteria may be expressed in terms of limits for vertical deflections and for vibrations. Sway criteria may be expressed in terms of limit for horizontal displacements. The following states are considered:

4.4.1.1 Deflection Limits

In general, the structures are designed to standard deflection limits indicated in British Standards and Eurocodes. The general principle for limiting deflections is to avoid damage to cladding, avoid damage or excessive and the overall appearance of the building.

The proposed limits are as follows in the table below:

Deflection limits			
Area	**Short term Imposed Load**	**Imposed and finishes load**	**Total Load**
Floors - general	Span/360	-	Span/250
Elements supporting cladding /brittle finishes	Span/500	Span/500	Span/250
Roofs – general	Span/360		Span/250
Horizontal storey drift	Storey height/300	-	Storey height/300
Horizontal building drift	Building height/300		Building height/300

Table 6 – Deflection limits

Deflections of a building shall not exceed the values that adversely affect its proper functioning or appearance. As specified in I.S. EN-1990-2002+A1-2005 A1.4.3, vertical and horizontal deformations should be calculated in accordance with I.S. EN 1992 to I.S. EN 1999, by using the appropriate combinations of actions.

4.4.1.2 Vertical deflection

Vertical deflection is represented schematically in the figure 12-70:

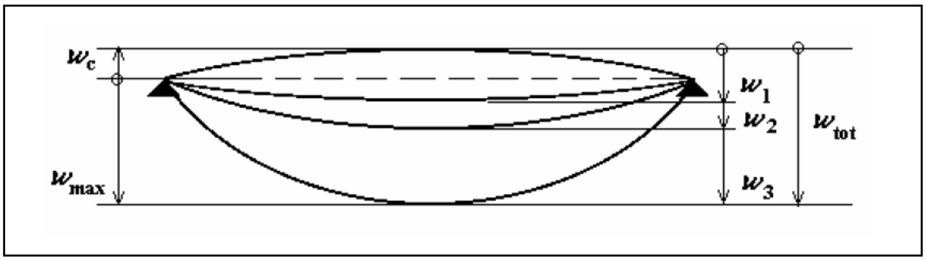

Figure 39 - Definition of vertical deflections. (Source: I.S. EN-1990-2002+A1-2005, A.1.4.)

- w_c is the precamber in the unloaded structural member.
- w_1 is the initial part of deflection under permanent loads of the relevant combination of actions.
- w_2 is the long-term part of the deflections under permanent loads.
- w_3 is the additional part of the deflection due to variable actions of the relevant combination of actions
- w_{tot} is the total deflection sum of w_1, w_2, w_3
- w_{max} is the remaining total deflection considering the precamber.

For concrete structures, as specified in I.S. EN 1992-1-1:2004 7.4.1, the appearance and general utility of the structure could be impaired when the calculated sag of a beam, slab or cantilever subjected to quasi-permanent loads exceeds span/250. The sag is assessed relative to the supports. Pre-camber may be used to compensate for some or all of the deflection but any upward deflection incorporated in the formwork should not generally exceed span/250.

Deflections that could damage adjacent parts of the structure should be limited. For the deflection after construction, span/500 is normally an appropriate limit for quasi-permanent loads. Other limits may be considered, depending on the sensitivity of adjacent parts.

In the case of steel structures, since the Irish National Annexes do not recommend any specific deflection limit, the following criteria of the British Standard National Annex (NA to BS EN 1993-1-1:2005) will be considered in this design stage. The suggested limits for calculated vertical deflections of certain members due to variable loads (permanent loads should not be included) are as follows:

- Cantilevers: Length/180
- Beams carrying plaster or other brittle finish: Span/360
- Other beams (except purlings and sheeting rails): Span/200
- Purlings and sheeting rails: To suit the characteristics of particular cladding.

If the function or damage to the structure, finishes, or non-structural members is being considered, the verification for deflections should take account of the effects of permanent and variable actions that occur after the execution of the member or finish concerned.

4.4.1.3 Horizontal displacement in building above ground

Horizontal displacements are represented schematically in the figure 12-71:

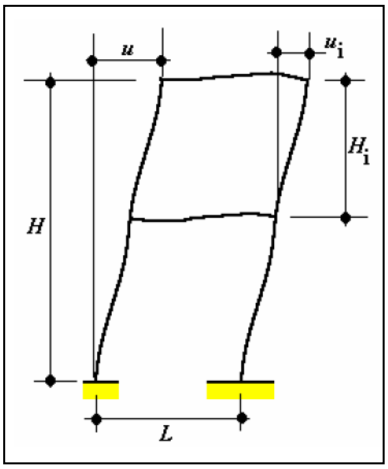

Figure 40 - Definition of Horizontal displacements. Source: I.S. EN-1990-2002+A1-2005, A.1.4.3

- u is the overall displacement over the building height H
- ui is the horizontal displacement over a storey height Hi
- In general, for control and integrity of structural and non-structural elements under the Characteristic combination the following limits shall apply:
- u < H/500
- ui < Hi/300
- When only appearance of the structure is considered under the quasi-permanent combination the relative displacement in a storey shall be ui < Hi/250.

4.4.1.4 S.L.S. of vibration

To achieve satisfactory vibration behaviour of structures and their members under serviceability conditions, the following aspects, should be considered:

1. The comfort of the user.
2. The function of the structure or its structural members (e.g. cracks in partitions, damage to cladding and sensitivity of building contents to vibrations).
3. For the serviceability limit state of a structure or a structural member not to be exceeded when subjected to vibrations, the natural frequency of vibration of the structure or structural member should be kept out of certain values which depend upon the function of the building and the source of the vibration.
4. The analysis is not usually critical in concrete structures.

4.4.1.5 S.L.S. of cracking

The cracking of the concrete due to tensile stresses may affect the durability of the structure.

A limiting calculated crack width ωmax shall be established taking account of the proposed function and nature of the structure and the cost of limiting cracking. Due to the random nature of the cracking phenomenon, actual crack widths cannot be completely predicted. However, if the crack widths calculated in accordance with the models given in the Eurocode are limited to the values indicated hereinafter, the performance of the structure is unlikely to be impaired.

The following values are considered according to the exposure class of the elements.

Recommended values of ωmax for the building and relevant combination rules. Source: NA to I.S. EN 1992-1-1:2004. Section 7.3.1		
Exposure Class	**Reinforced members and prestressed members with unbonded tendons**	**Prestressed members with bonded tendons**
	Quasi-permanent load combination	**Frequent load combination**
X0, XC1	0.3*1	0.2
XC2, XC3, XC4	0.3	0.2*2
XD1, XD2, XS1, XS2, XS3		0.2 and decompression*3
*1 For X0, XC1 exposure classes, crack width has no influence on durability and this limit is set to give generally acceptable appearance. In the absence of specific requirements for appearance this limit may be relaxed.		
*2 For these exposure classes, in addition, decompression should be checked under the quasi-permanent combination of loads.		
*3 ωmax = 0.2mm applies to parts of the member that do not have to be checked for decompression		

Table 7 - Recommended values of ωmax for the building and relevant combination rules.

Source: NA to I.S. EN 1992-1-1:2004. Section 7.3.1

The decompression limit should extend over 25mm for all parts of the bonded tendons or duct in buildings.

4.4.2 Ultimate Limit States

Design for ultimate limit states shall be based on the use of structural load models for relevant limit states.

It shall be verified that no limit state is exceeded when relevant design values for actions, material properties or product properties and geometry data are used in the models.

The verifications shall be carried out for all relevant design situations and load cases.

The requirements shall be achieved by the partial factor method.

4.4.2.1 U.L.S. of equilibrium

The global balance, due to instability for a part or the overall structure shall be ensured.

4.4.2.2 U.L.S. against bending with or without axial force, shear and torsion.

This analysis is carried out on the structural element and cross sections. The development of the results is done by means of computer calculation software and supplementary hand calculations to guarantee the correspondence between calculation and reality.

4.5 Platform operational during the works

4.5.1 Platform 6&7

The works on platform 6&7 are divided into two phases. One phase for the stairs and lift and another one for the escalators. The division of the works will enable the use of the platform during the works.

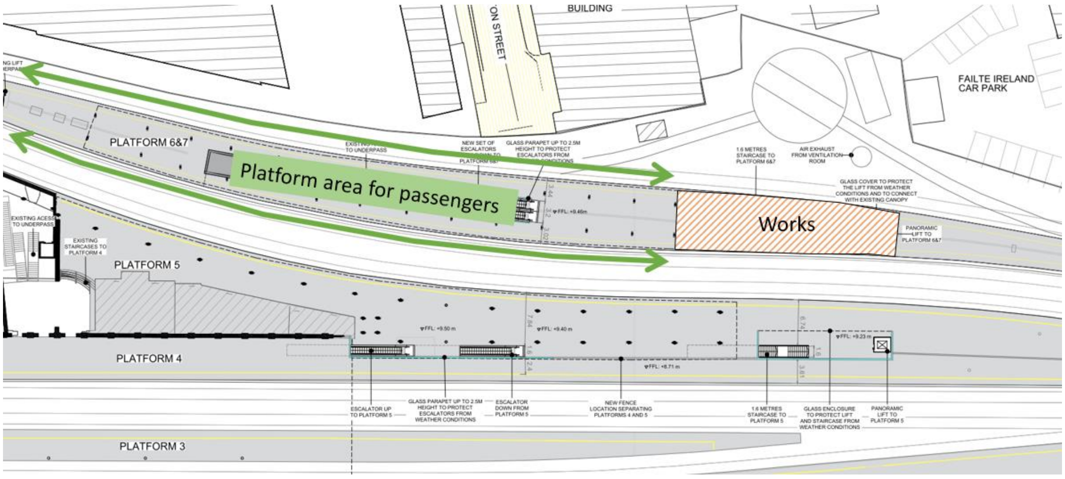

Figure 41 - Phase one: works on stairs and lift

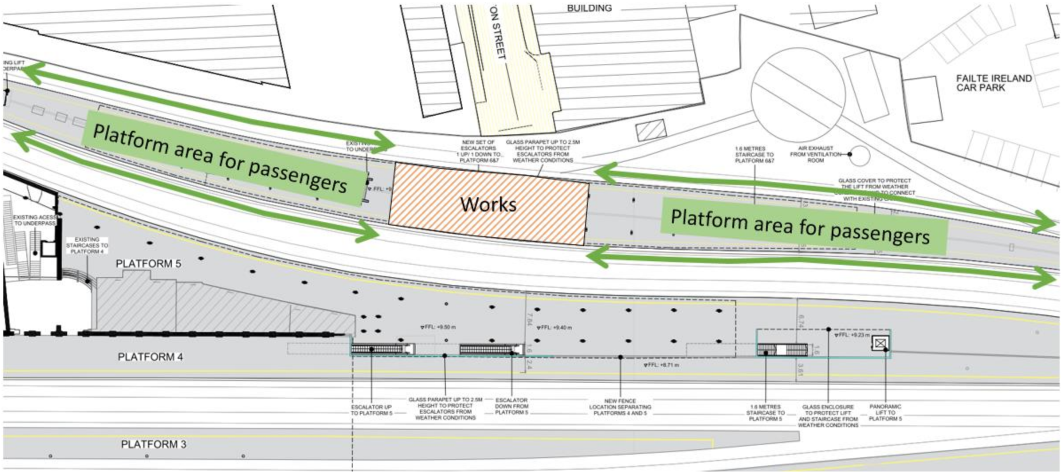

Figure 42 - Phase two: works on escalators

4.5.2 Platform 5

The operational of Platform 5 during the works is less intrusive due to the size of the works compared with the total size of the platform. The works can coexist with the platform operation.

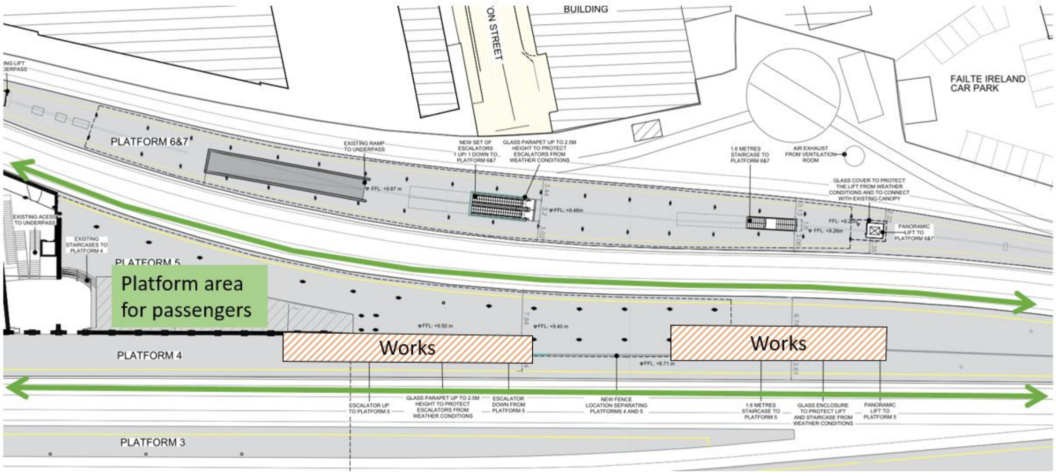

Figure 43 - Works and platform operation coexist

4.6 Structural description

The structural modifications of Connolly Station are limited to the opening of several voids in the platform to communicate the street level with the ground level.

To achieve this vertical communications, the structure in the voids has to be able to bear and transfer the horizontal loads of the arches, retain the fill between the arches and the platform, and support for the stairs when needed.

Due to the size and location of the voids, it will be necessary to implement temporary works to support the canopies of both platforms. The columns would be located on the axis of the masonry abutments and would require a foundation comprising pile caps to transfer all the loads directly to the bearing substratum. The temporary works would also include the use of formworks to bear the horizontal and vertical loads until the works are finished. The use of retaining systems could be required in order to reduce the impact on the existing structure.

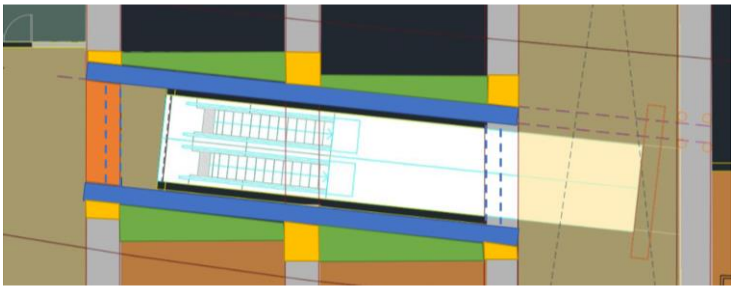

Figure 44. Sketch of a plan view of the new void

The different structure typologies can be divided into three groups: voids for stairs or escalators perpendicular to the arches, voids for stairs or escalators non-perpendicular to the arches and voids for lifts.

4.6.1 Voids perpendicular to the arches

The structure of the voids perpendicular to the arches is made of Reinforced Concrete (RC) slabs, columns, walls, and beams. The slabs will be supporting all the loads of the platform and canopy and transferring them to the new walls and the existing RC Type “S” Z-units. The RC walls containing the perimeter of the void will transfer the vertical loads of the new slab and the horizontal loads deriving from the infill directly to the columns. The columns will then transfer the horizontal forces from the arches and forces from the new wall to the foundations. The columns will be fixed to a pile cap at ground level. For voids planned to be opened in the abutments, it will be required to use an RC beam to transfer the horizontal loads from the arches to the columns.

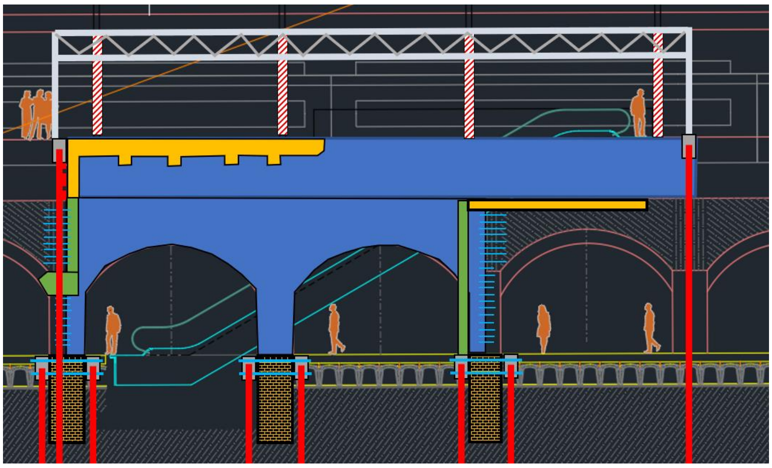

Figure 45. Sketch showing the structural solution for a void containing an escalator

4.6.2 Voids non-perpendicular to the arches

The structural proposal for the voids that are non-perpendicular to the arches is similar to the previous one shown above but adding RC slabs in the shape of the arches. These RC arches are perpendicular to the walls and will be supported in the columns and connected to the walls.

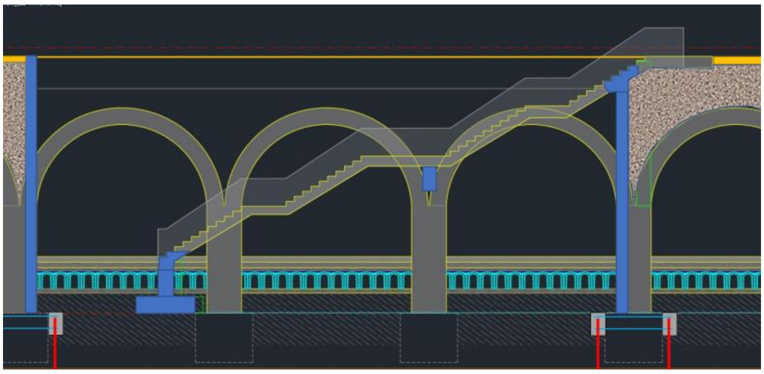

Figure 46. Sketch showing the structural solution for a void containing a staircase

4.6.3 Voids containing lifts

The structural proposal for the voids containing lifts consists of a set of RC slabs with the same shape as the arches but cast-in-place in the extrados of the arch. The RC slab is supported on pile caps founded on top of the abutment walls. The perimeter of the void is formed by an RC wall connected to the arched slab. The existing arches under the new slab will then stop bearing compression loads and will be hanged with steel connectors from the RC slab.

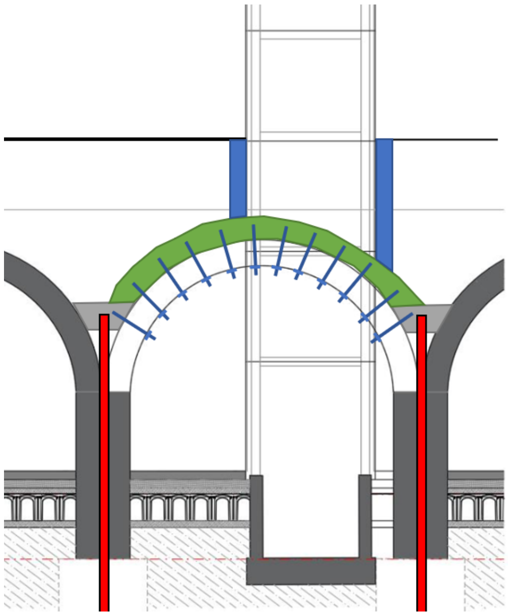

Figure 47. Sketch showing the structural solution for a void containing a lift

All the lift and escalator pits, together with stairs foundations, will be carried out with shallow foundations.

4.7 Phased construction

As an example, the constructive process of one of the platform openings is shown below: the one corresponding to the escalators that lead to platforms 6 and 7. This process is included in the report to show that it will be as respectful as possible with the vaults. It is a schematic description of the process that will be further detailed in future stages of the project.

Figure 48. Location of the analysed escalator and opening

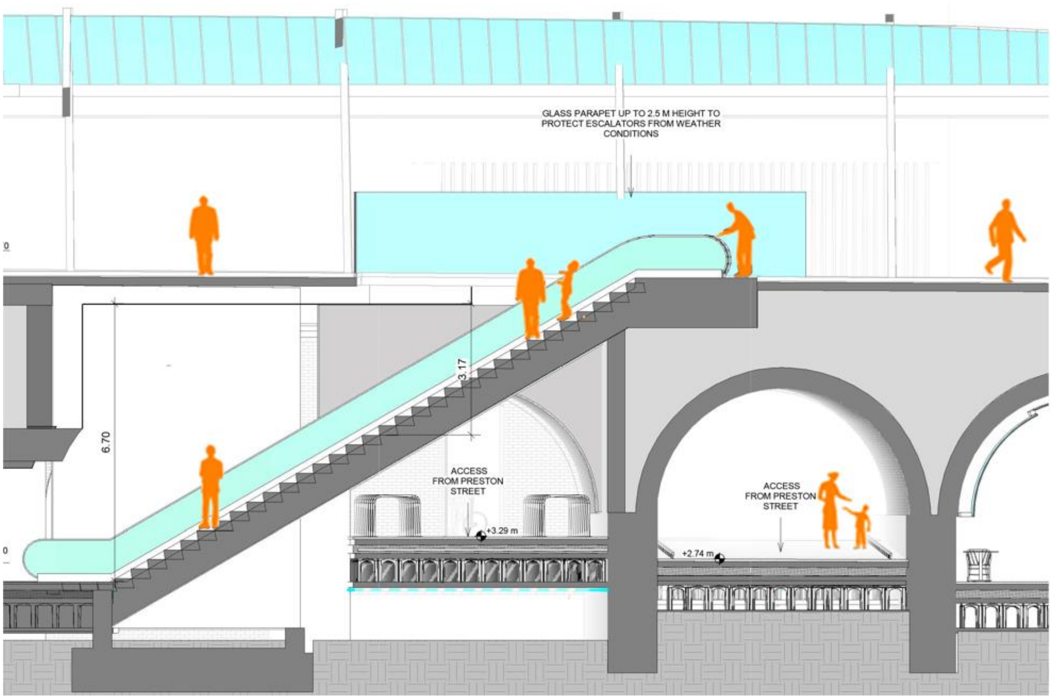

Figure 49. Section of the analysed escalator and opening

GENERAL NOTE: The stability of the structure during the ongoing works shall be ensured, together with the use of continuity steel bars in reinforced concrete items.

4.7.1 Foundations

STEP 1: In this phase, foundations for the new structure will be built using reinforced concrete pile caps with micropiles, and micropiles inside the walls. To carry out this phase, the micropiles will firstly be made inside the core of the future columns, the excavation will then continue down to the lowest level of the pile caps, and the micropiles will be built. Once they have been set, the surface will be homogenised with blinding concrete and the pile caps and the tying between them will be made.

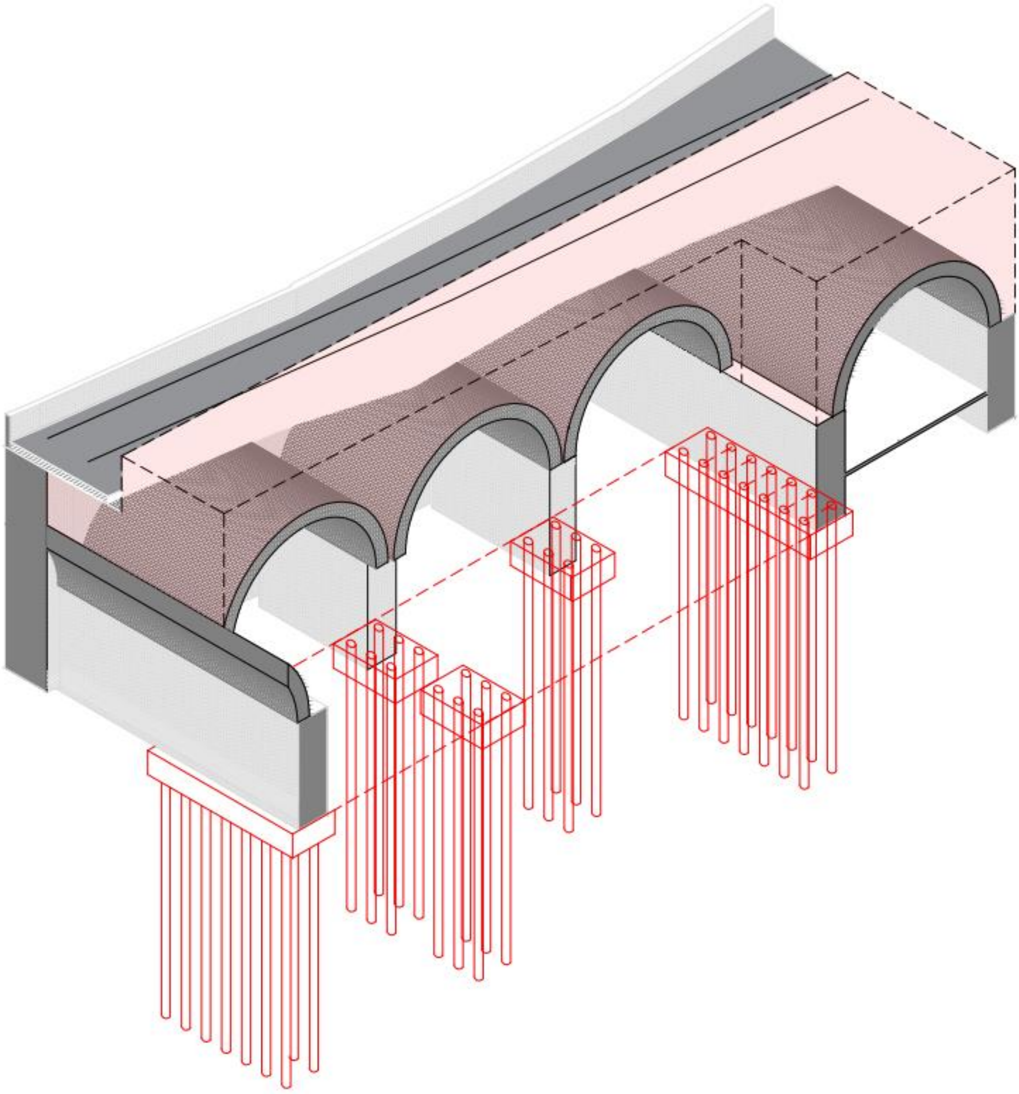

Figure 50. Axonometric view step 1, foundations.

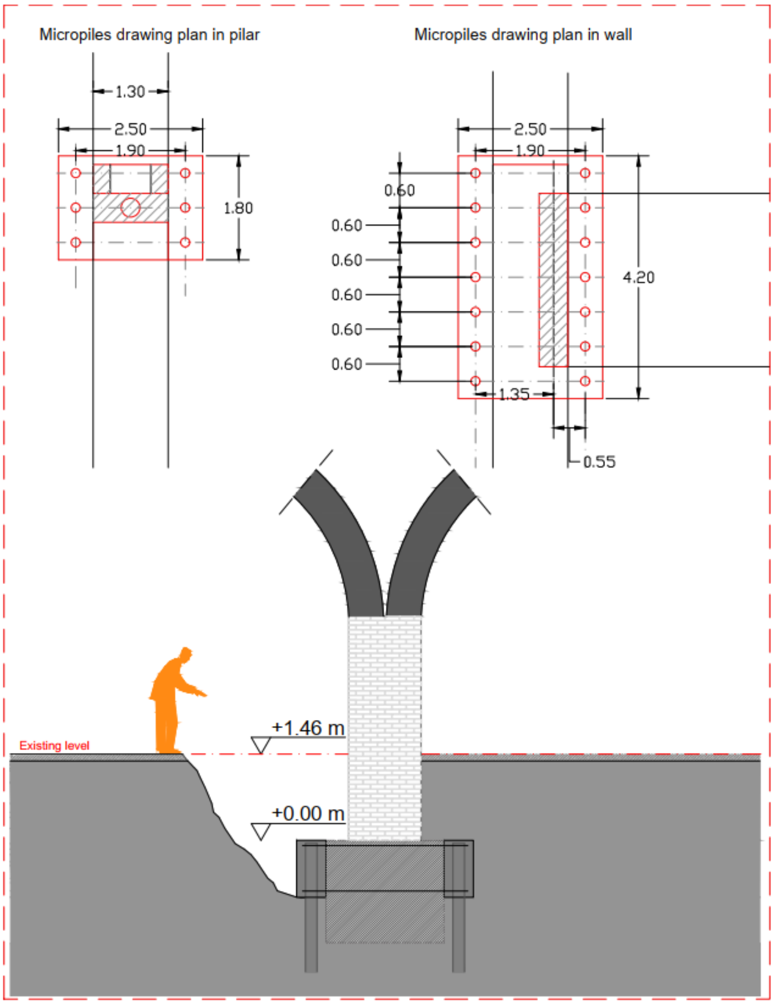

Figure 51. Elevation drawing of excavation up to base of pile cap. Plan drawing of two types of foundations.

4.7.2 Support and removal of canopy structure

STEP 2. In this phase, the temporary shoring structure of the canopy is built and the canopy structural columns are cut under the existing horizontal steel beam. In this sense, micropiles are built as foundations for the metal columns of this new temporary structure. These micropiles are built from a new concrete footing located below the platform level to the foundation level, passing through the brick walls. Once the structure is in place, the existing columns can be cut and dismantled.

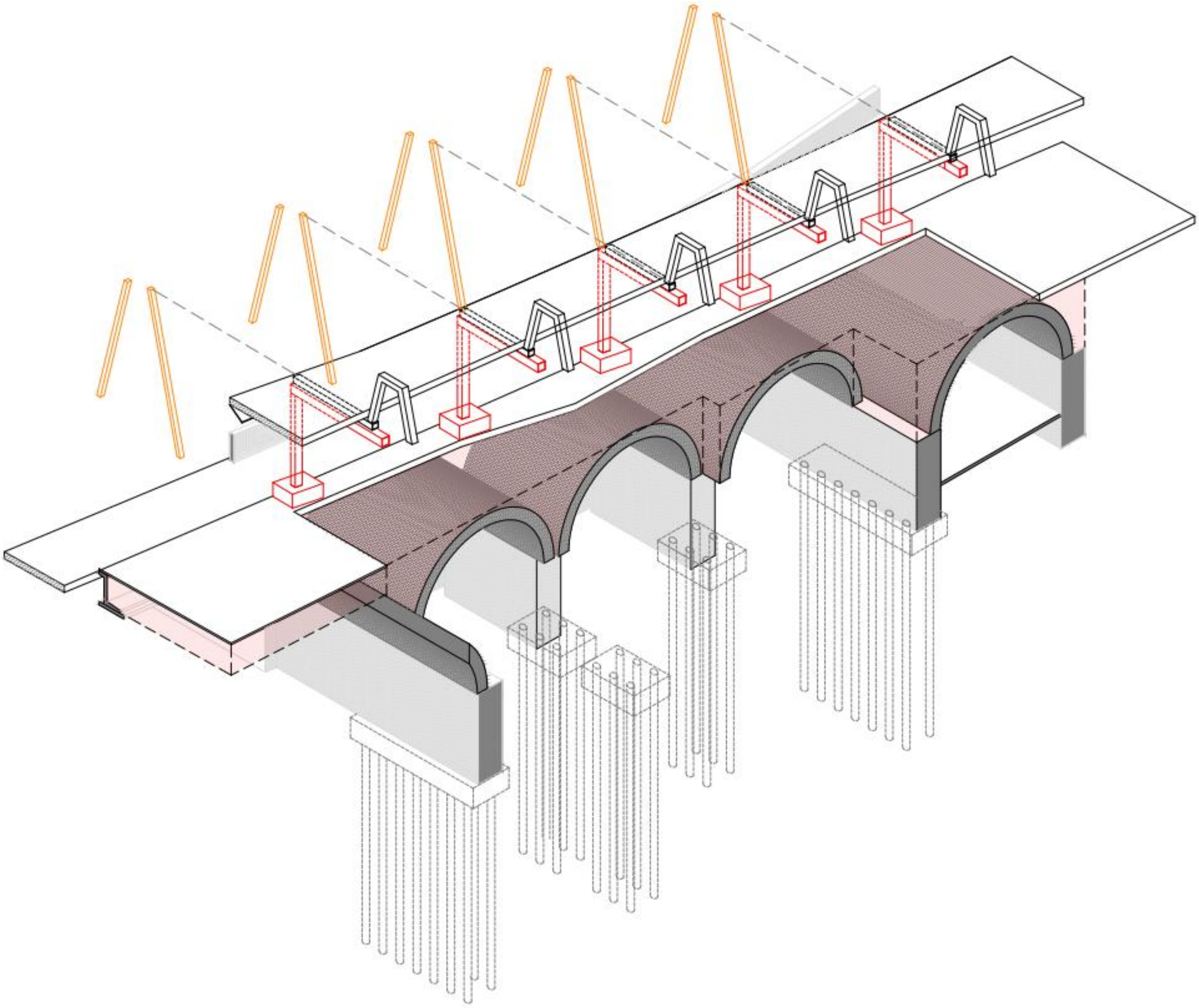

Figure 52. Axonometric view step 2.

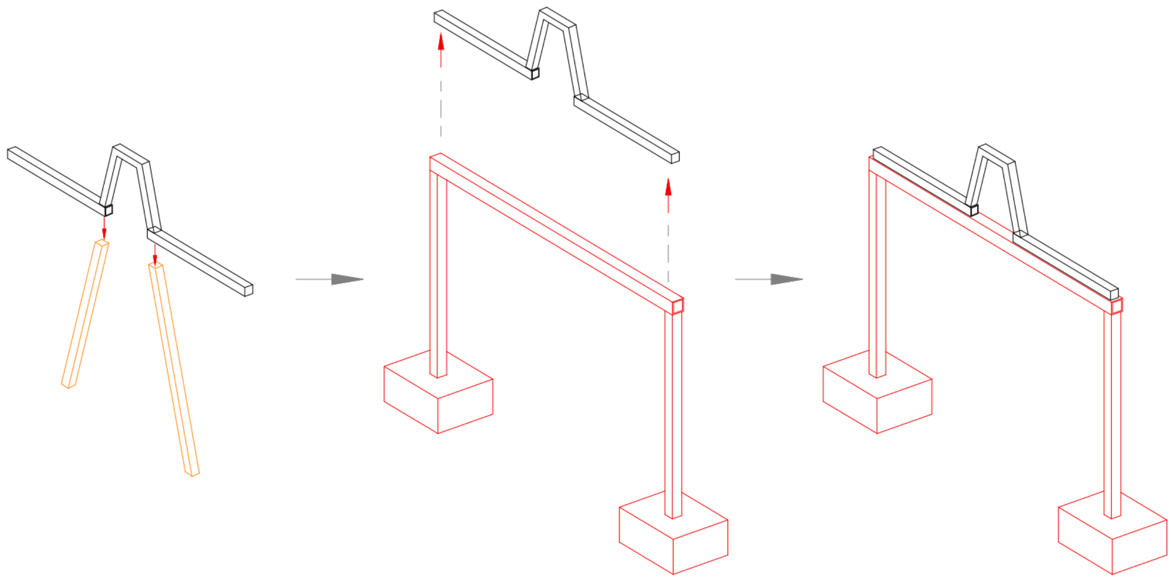

Figure 53. Cut of the existing structure. New steel structure and foundations on platform.

4.7.3 Falseworks in vaults

STEP 3. In this phase, the provisional falsework of the vaults is placed. This falsework will serve as a horizontal bracing system, as well as vertical shoring of the vaults. It will also work as formwork for the new structure.

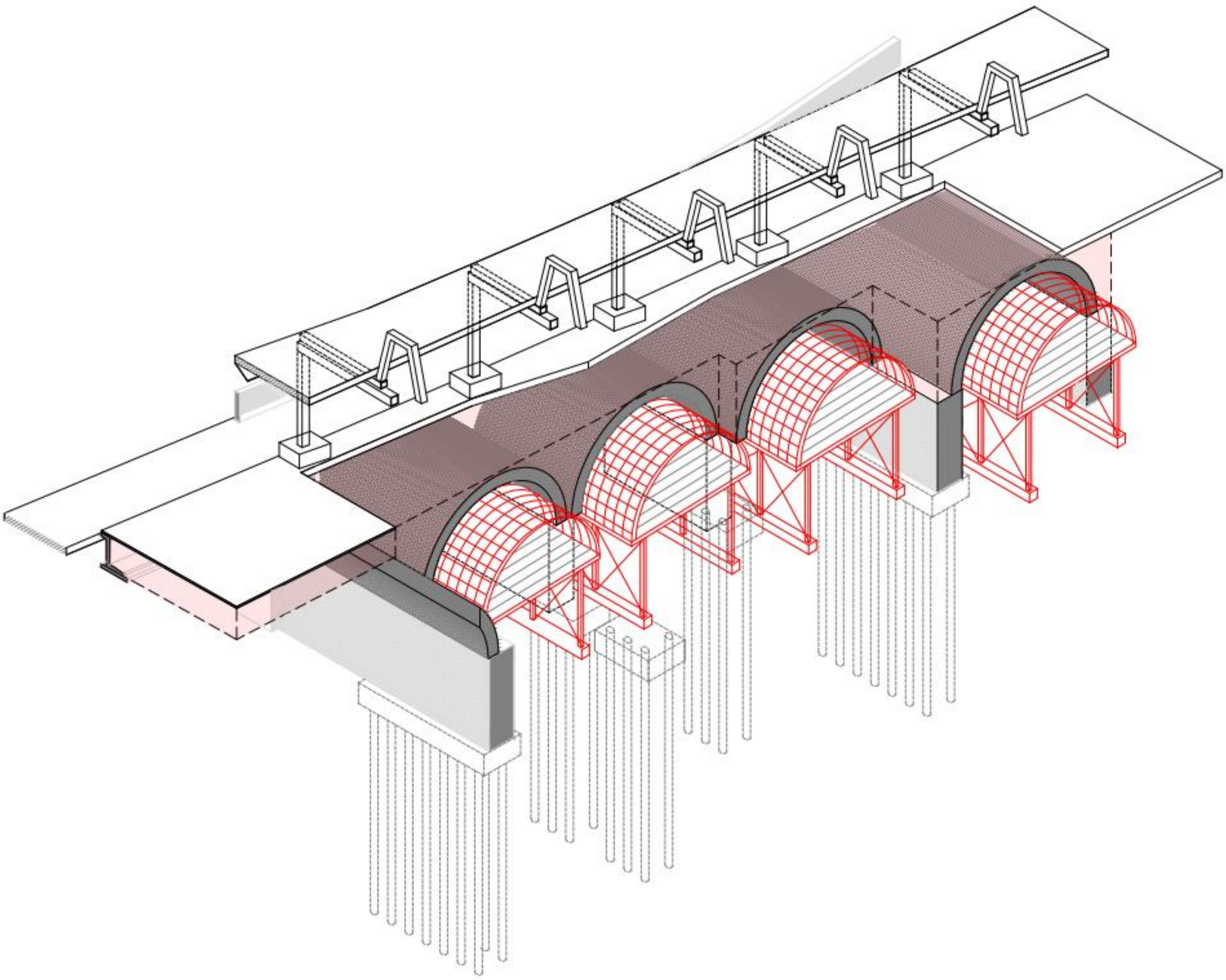

Figure 54. Axonometric view step 3.

4.7.4 Construction of columns and walls

STEP 4. In this phase, the concrete columns are constructed near the edges of the shaft. These pillars will be built following a staged excavation procedure, surrounding the micropiles and building one side of the column first, and then the other one. Afterwards, the walls will also be built as a staged construction.

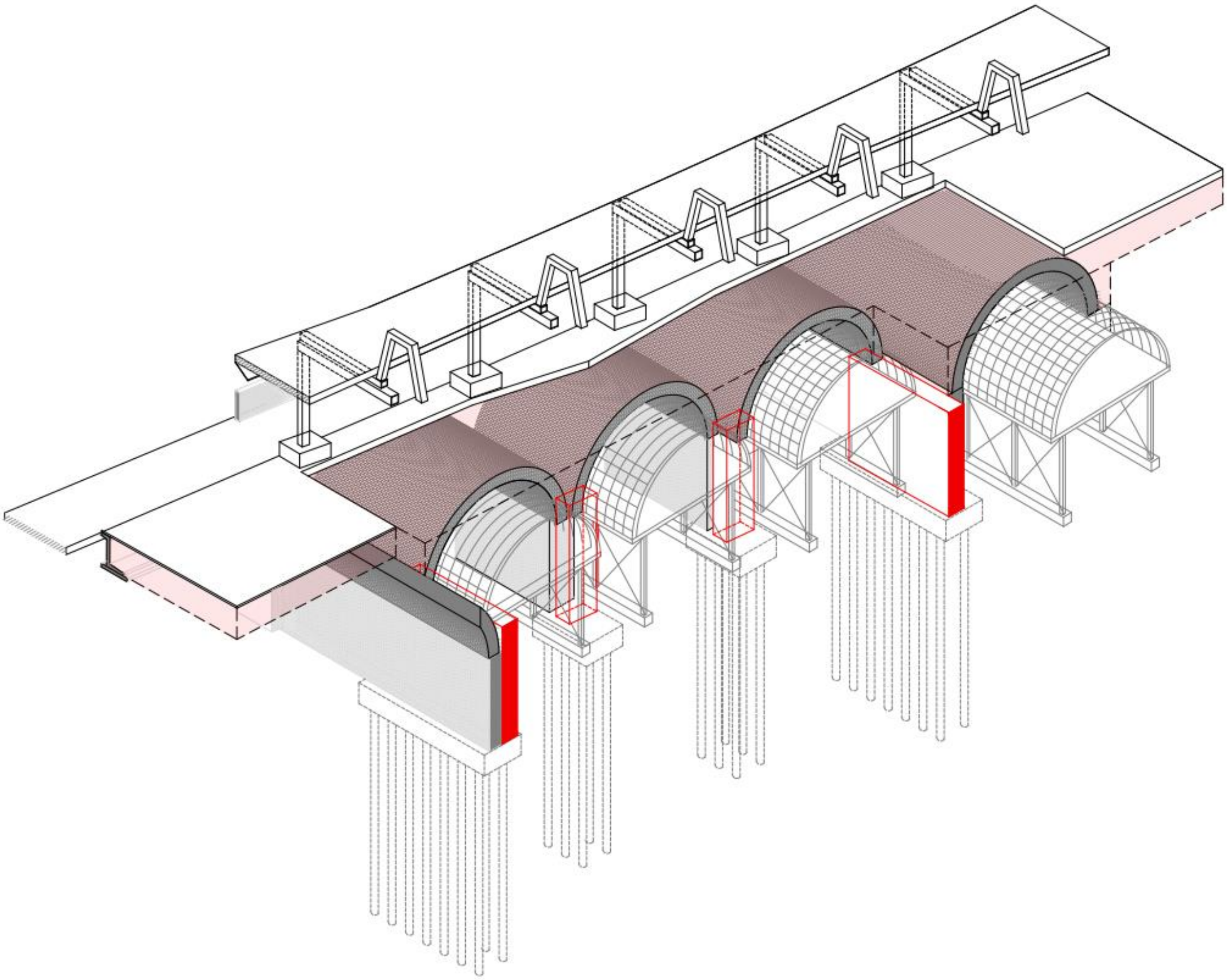

Figure 55. Axonometric view step 4.

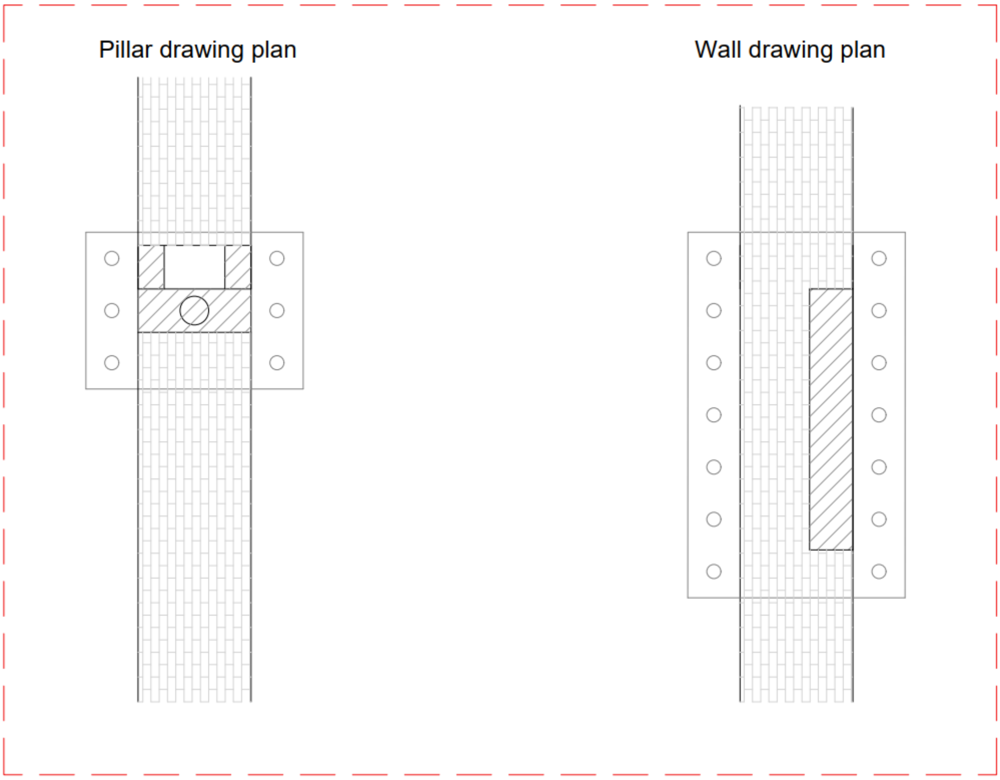

Figure 56. Axonometric view step 4.

4.7.5 Platform excavation and construction of arched beams.

STEP 5. In this phase, the excavation will be carried out from the platform level down to the falsework, in order to build the concrete arch beams.

Formwork modules will be placed to help contain the soil between the platforms and the extrados of the brick vaults.

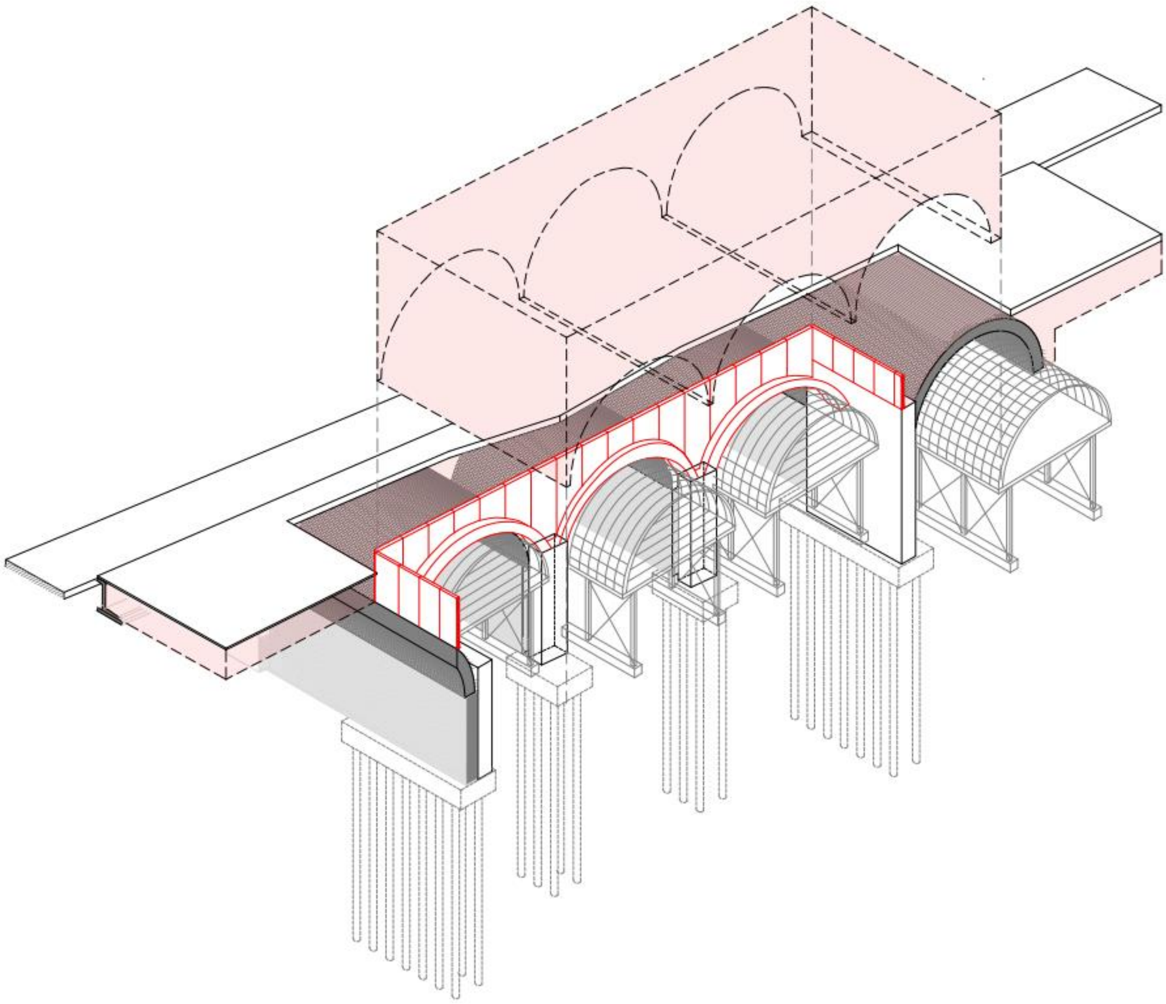

Figure 57. Axonometric view step 5.

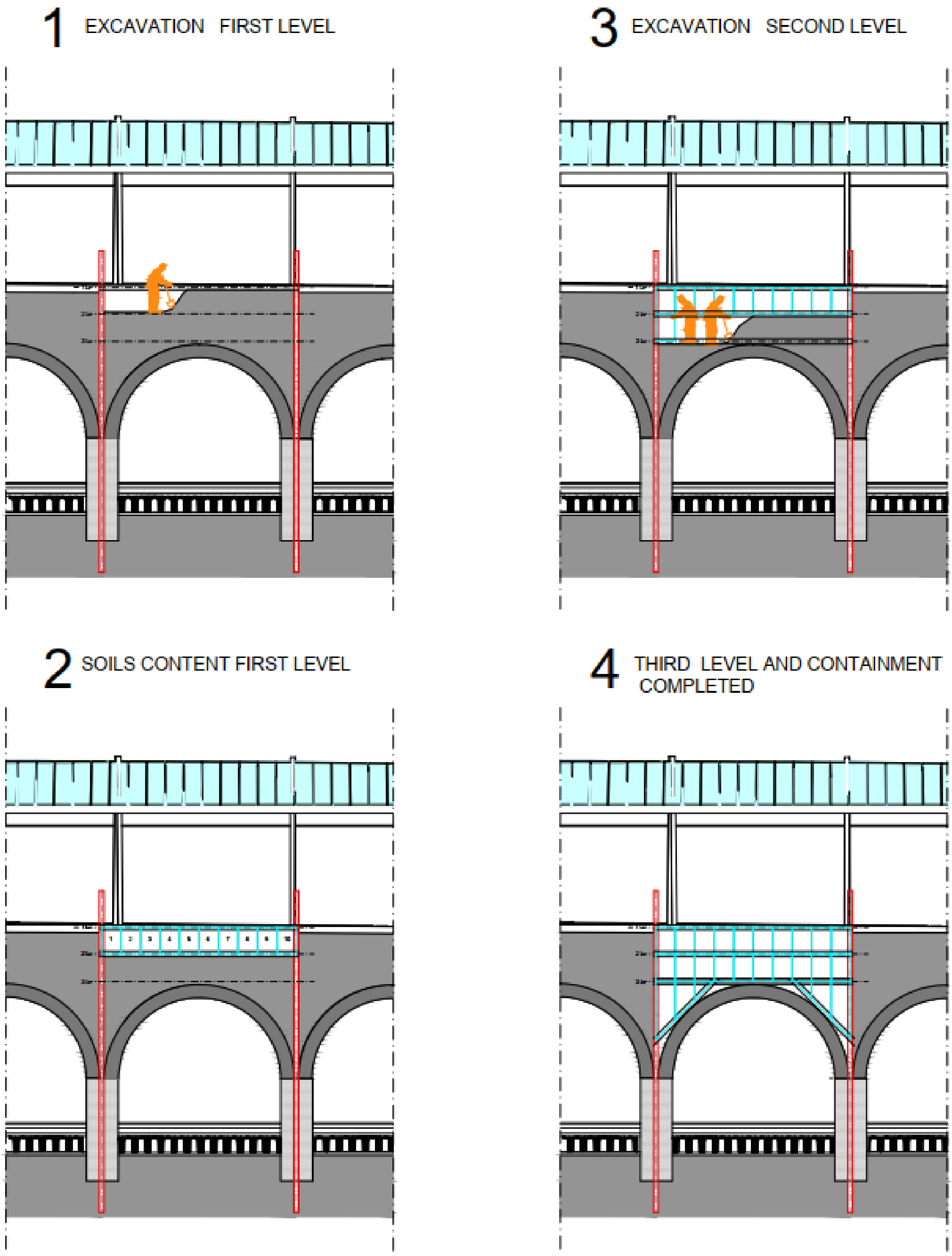

Figure 58. Excavation phases and soils contain between platforms.

4.7.6 Construction of the vertical structure over the arched beams.

STEP 6. In this phase, the construction of the vertical structure progresses from the level of the arches to the platform level.

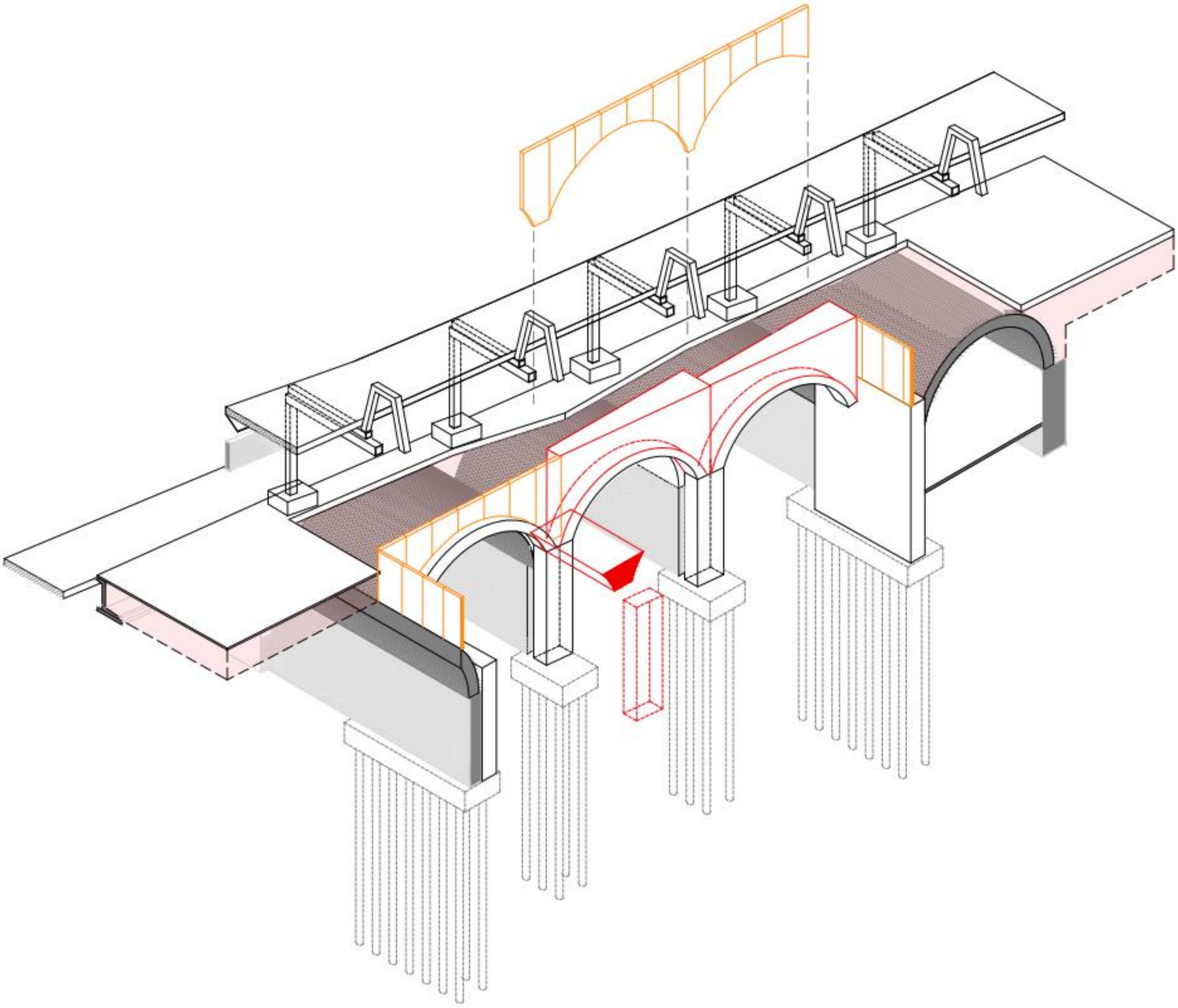

Figure 59. Axonometric view step 6.

4.7.7 Construction of vault l14

STEP 7. At this stage, the arched slab between the beam and the concrete wall is built. Involved vault: L14.

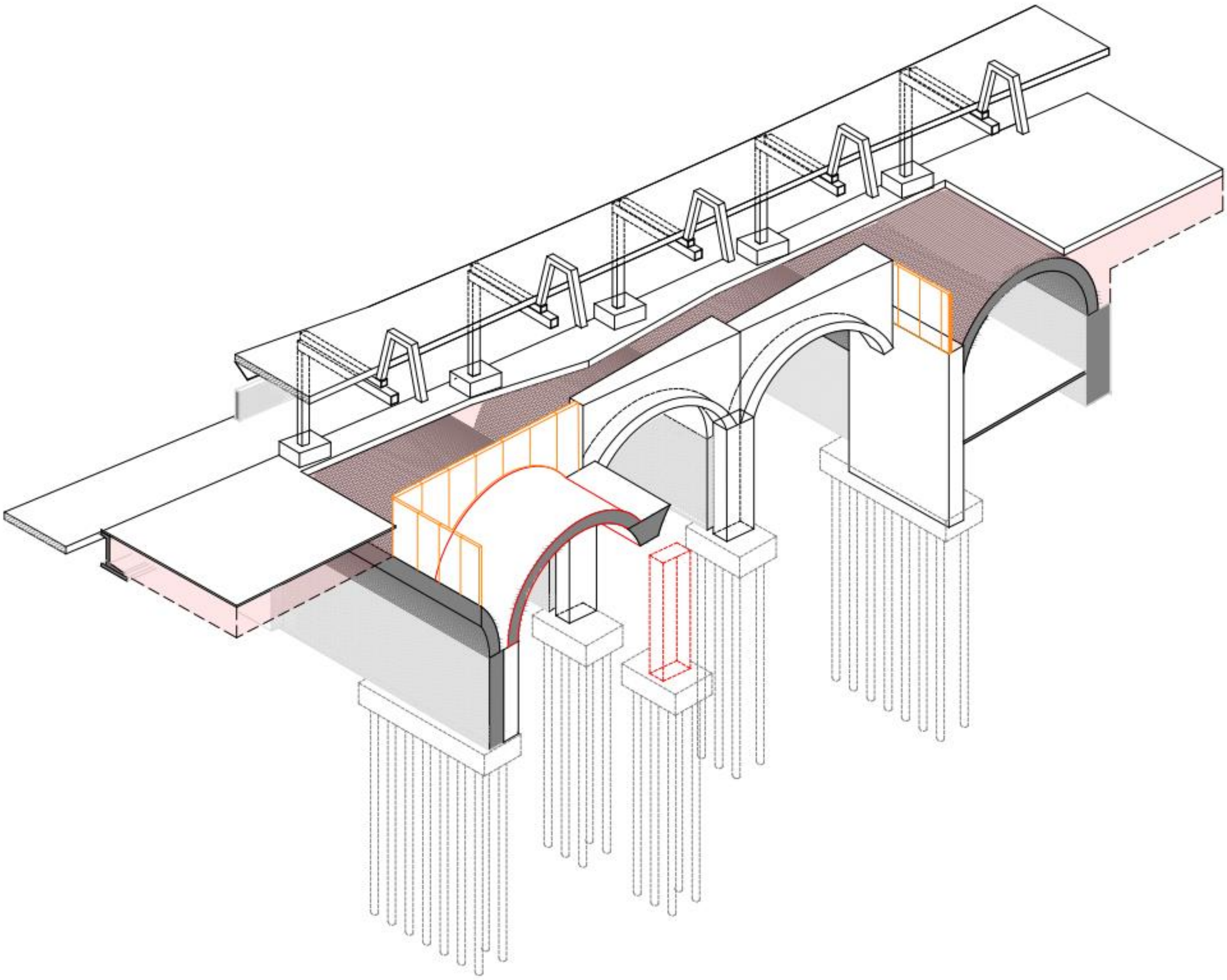

Figure 60. Axonometric view step 7.

4.7.8 Construction of beams and foundations for escalators

STEP 8. At this point, the remaining parts of the structure are set, including the beams and walls supporting the escalators, as well as the foundations for the escalators' pit.

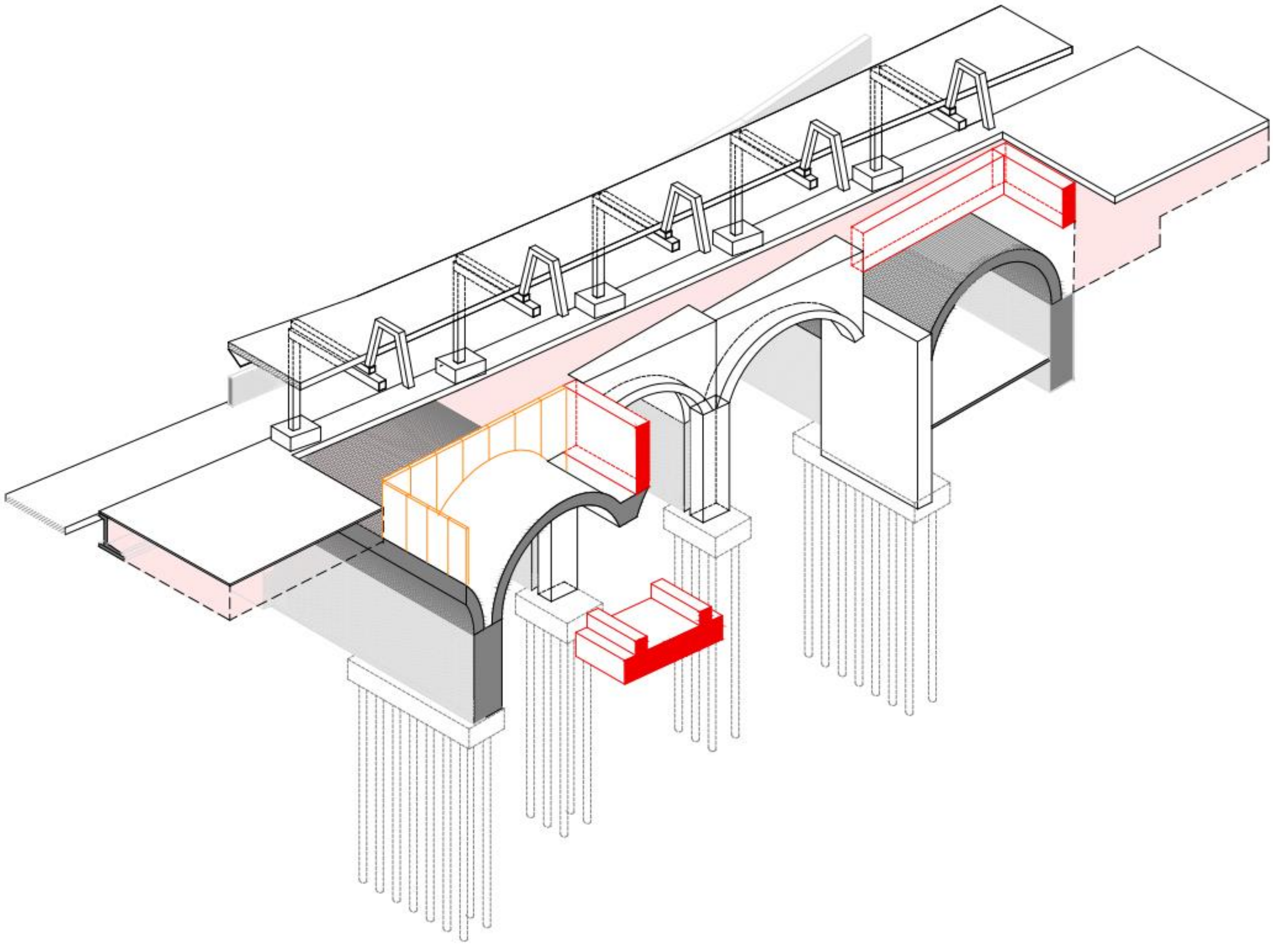

Figure 61. Axonometric view step 8.

4.7.9 Construction of floors and non-bearing walls

STEP 9. In this phase, the walls enclosing the shaft are built, together with the different layers up to the finished floor level users will walk over.

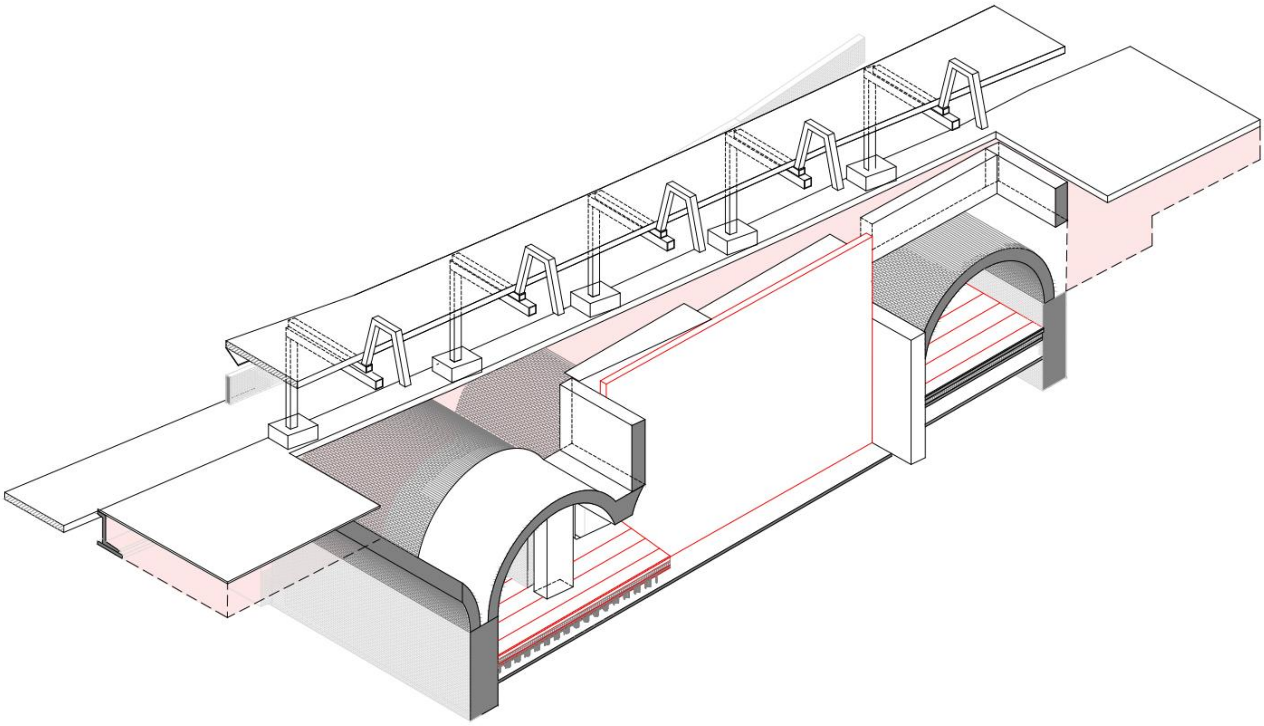

Figure 62. Axonometric view step 9.

4.7.10 Insertion and assembly of the escalators in two steps

STEP 10. The escalators' structure is assembled in two steps. The first section will be temporarily supported until it joins the second section of the escalators. The escalators will be resting over the pit and supported by the beam.

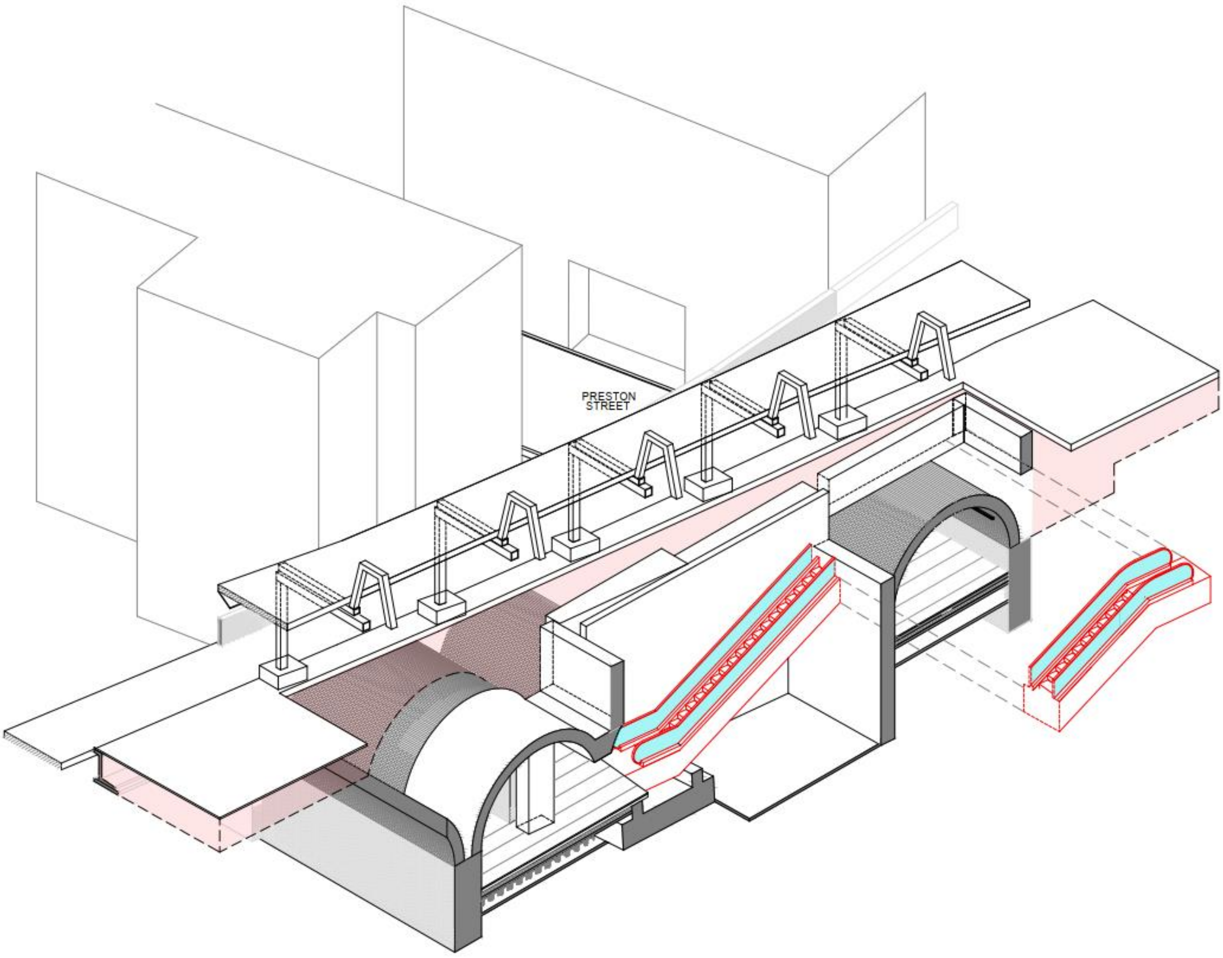

Figure 63. Axonometric view step 10.

4.7.11 Temporary structure could be retired and construction of platform structural slab.

STEP 11. Once the assembly of the escalator has been completed, the soil can be backfilled to the lowest level of the canopy foundations, while the slab can be built to partially close the open shaft. Once this level has been reached, the definitive foundations and columns of the canopy will be constructed. After the canopy rests on the definitive columns, the provisional shoring structure will be dismantled.

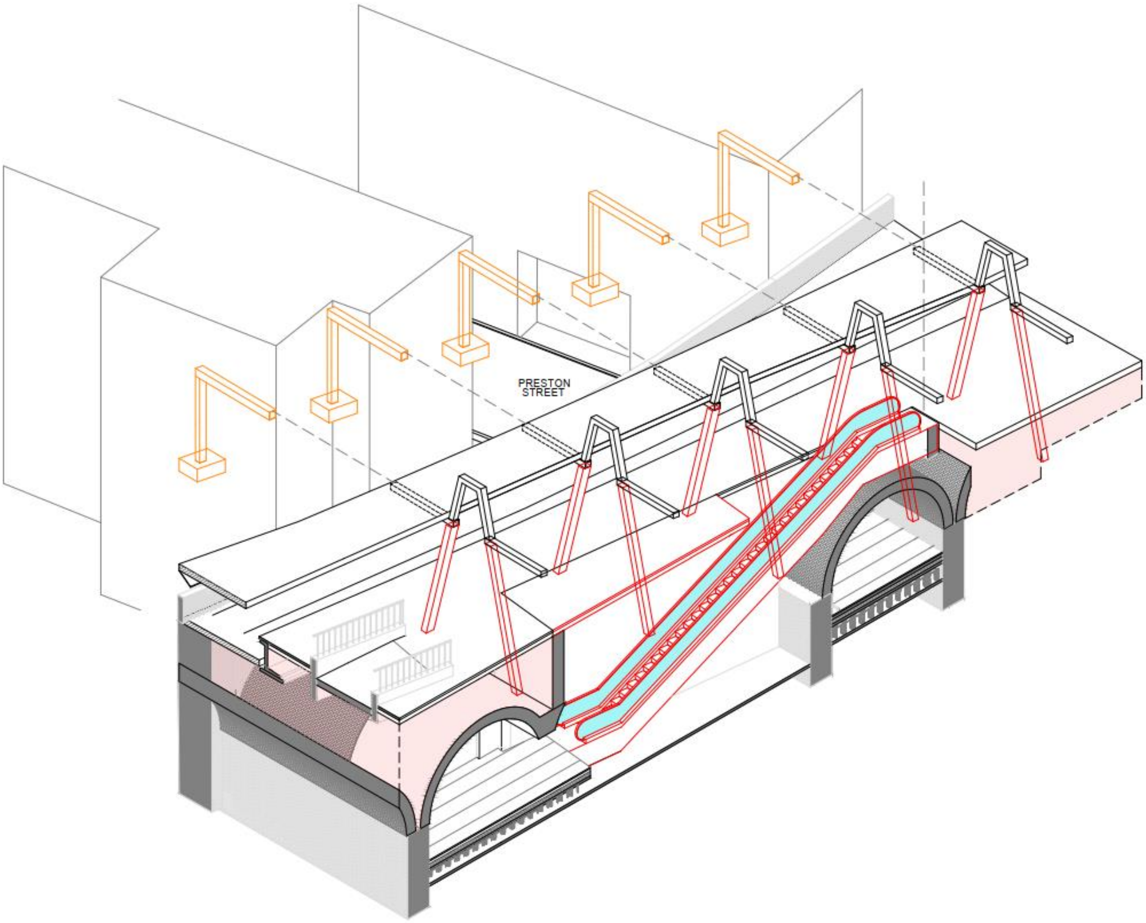

Figure 64. Axonometric view step 11.

4.7.12 Falsework removal

STEP 12. Once the structural works have been completed, the shoring structure under the vaults is removed and the finishing works can take place.

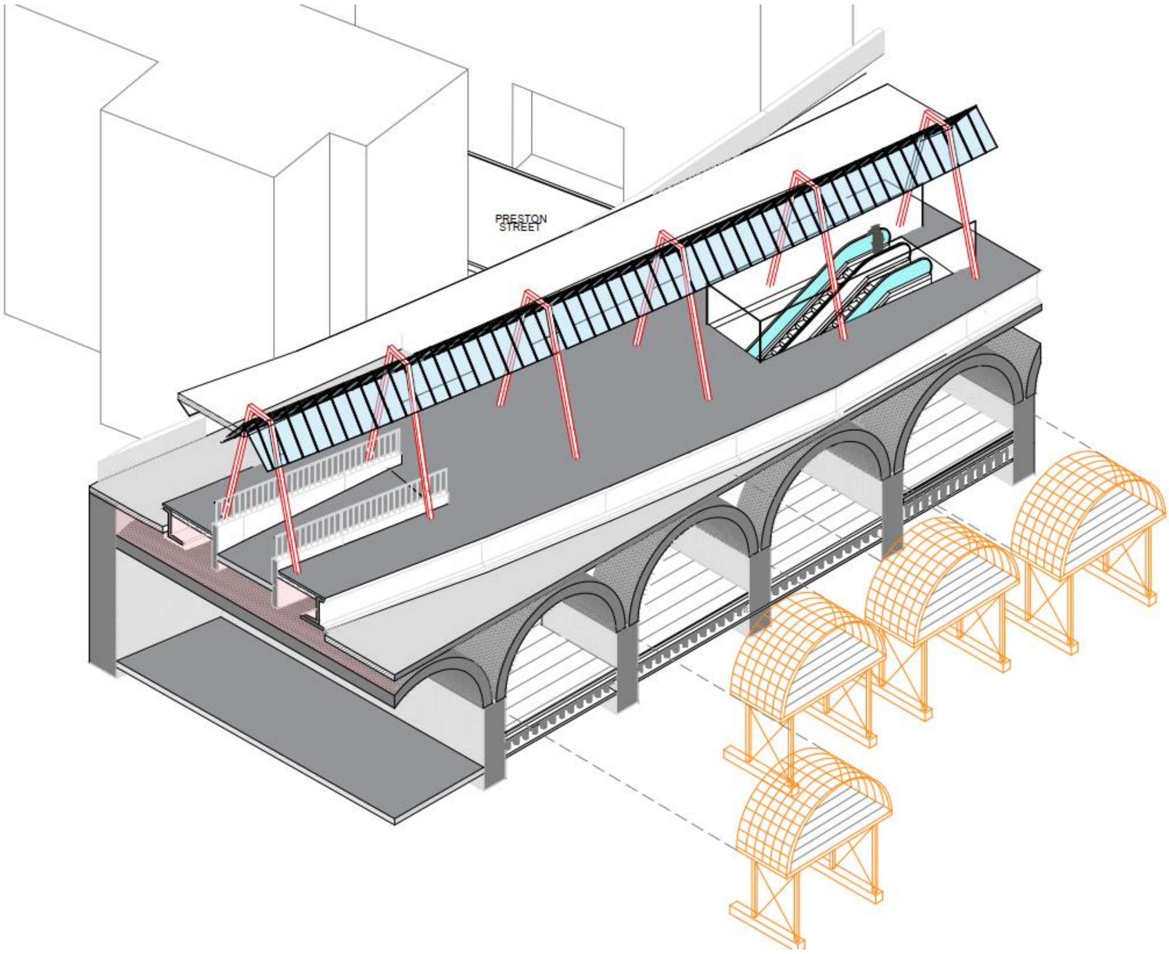

Figure 65. Axonometric view step 12.

5. MEP Design

5.1 Fire Protection System

The proposal at Connolly Station will be designed and built to achieve satisfactory protection against fire and the spread of fire. The design will be provided with appropriate means for rescuing people and for fighting fires.

5.1.1.1 Irish Building Regulations 2020 Groups

According to TGB Part B (2020), the intervention in Connolly Station will be catalogued as:

- Group 5: Assembly.

5.1.1.2 Fire extinguishers

Manual portable fire extinguishers will be provided throughout the area under study. The type of each fire extinguisher will be as follows:

- CO_2 type for electrical hazards (Electrical rooms and switchboards)
- Dry powder type for electrical and solid hazards.

5.1.1.3 Automatic Fire Detection System

An analogue addressable fire alarm system shall be provided to achieve automatic detection of fire in the projected new areas.

The station will have a Fire Alarm Control Panel located inside the TIW (Ticket Issuing Window) with a graphic interface to monitor the system. The fire alarm system shall be monitored from the current Fire Alarm Control Panel, and they shall be linked to the local fire authority's system.

A stand-alone automatic gas extinguishing system will be planned for the Telecommunications Room (TER). Gas containers shall be located inside the area to be protected behind a fence.

Inert gas will be FK-5-1-12, or other if required.

The gas to be used in this procedure should be an inert gas (e.g. FK-5-1-12). The standard used for the design and calculations is EN 15004, Part 1 & 2, "Fixed firefighting systems – Gas extinguishing systems".

5.2 HVAC, Heating, Ventilation and Cooling System

5.2.1 Ambient conditions

Design outside temperatures taken into account shall be (as per ASHRAE 2017):

- DB 21.9º / MCWB 17º in summer
- DB -2.7º in winter

Regarding the setpoint temperature in the different rooms, the station can be divided into the following uses:

- Staff areas and ticket office: Heated to no less than 20ºC
- Telecom & server rooms; between 20ºC and 24ºC and 30%-70%

5.2.2 Ventilation

Natural ventilation shall be provided with openable windows or grilles, wherever it is feasible.

Mechanical ventilation shall be provided for staff rooms, cleaning room, telecom room, retail areas and toilets.

5.2.3 HVAC system per room

HVAC design shall comply with EN 16798 and Irish Building Regulations, Technical Guidance Part F. And it shall be designed and built for energy-efficient operation. The fresh air providing ventilation will be filtered in accordance with Building Standards requirements.

The HVAC system shall consider the internal and ventilation thermal loads calculated in accordance with criteria expressed in the ASHRAE handbook of fundamentals and relevant EN standards.

	TEMPERATURE	HUMIDITY	HEATING	COOLING	MECHANICAL VENTILATION	NATURAL VENTILATION	HUMIDITY CONTROL	USE
Staff and ticket office	>20ºC	-	YES	NO	YES	NO	NO	CONTINUOUS
Telecom and server rooms	20ºC-24ºC	30%-70%	YES	YES	YES	NO	YES	CONTINUOUS

Figure 66 - HVAC requirements

The proposed systems will be selected based on a low energy consumption criterion.

5.3 Piping

5.3.1 General water treatment strategies

The following scheme explains the water treatment strategy for the area involved in the project of Connolly Station.

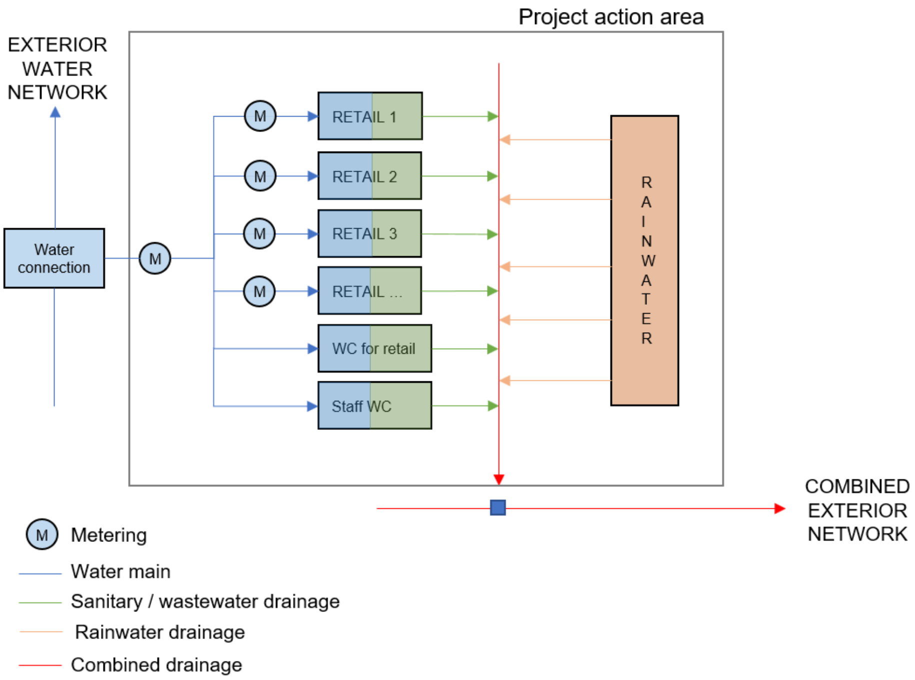

Figure 67 Water Drainage and Supply Strategy

Rainwater and sanitary drainage will share the same pipe and will discharge into an existing combined exterior network.

5.3.2 Drainage and Sewerage System

The drainage and sewerage system shall comply with Irish Regulation. Connections with the Public Utilities are defined with the Utilities Companies.

5.3.2.1 Rainwater drainage

Currently, the stormwater gathered in the various platform canopies and floor gullies is collected in a buried pipe that flows into the track. Then, all the incoming water of the track is supposed to be drained with different stacks located between each pair of vaults of the gallery to the main buried pipe which, theoretically, is under the central corridor. In order to ensure the feasibility and the “good behaviour” of the new proposal, a survey shall be done, to confirm that belief.

The new proposal aims to avoid the discharge of water collected on the platform and canopies towards the track. As an alternative, the project proposes to drain, independently, the collector buried in the platform by means of stacks that take advantage of the voids in the new escalators. Finally, this water would also be connected to the drainage main pipe under the central corridor.

The rainwater collection in the station, track, and platforms, shall be designed as a gravity system. All the pipes will be insulated against condensation.

Furthermore, so as to ensure a correct waterproofing solution of the project area, 2 different measures shall be taken:

1- Injection of waterproofing material above some of the vaults.

2- Placement of a waterproofing umbrella under some secondary arches. Then, the collected water will be connected, in the low points of the umbrella, to the general stormwater stacks/system.

This way, not only the surface water but also the infiltrated water will be properly collected and drained in the aforementioned main buried pipe to the combined exterior network.

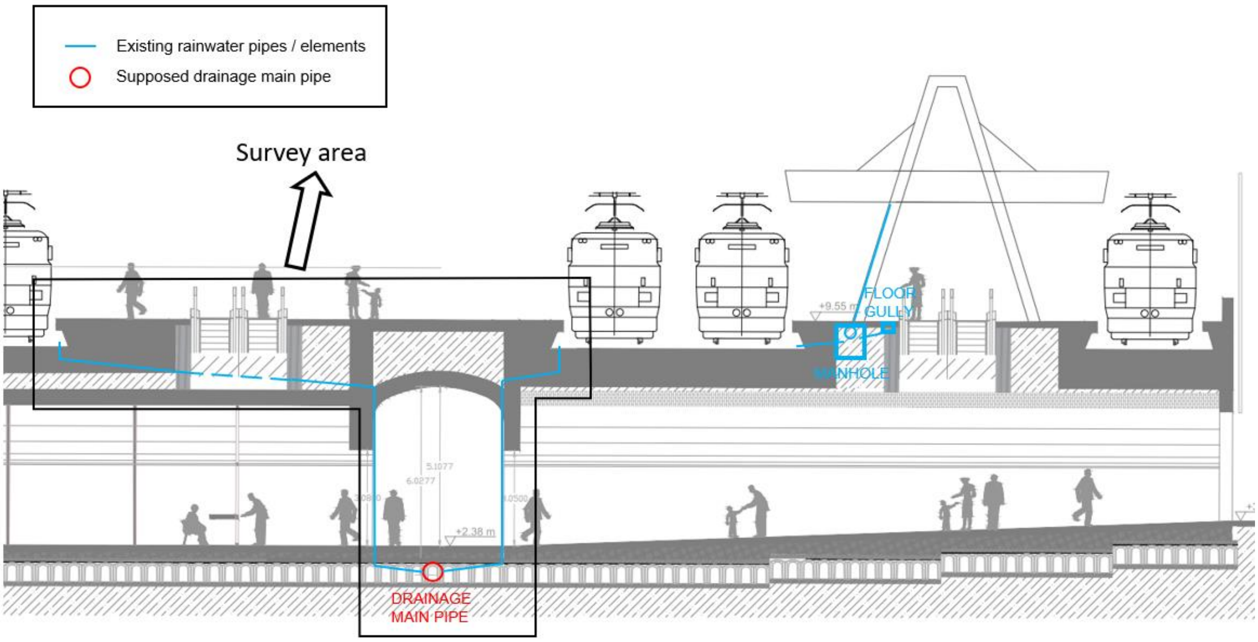

Figure 68 – Rainwater drainage system. Supposed current solution

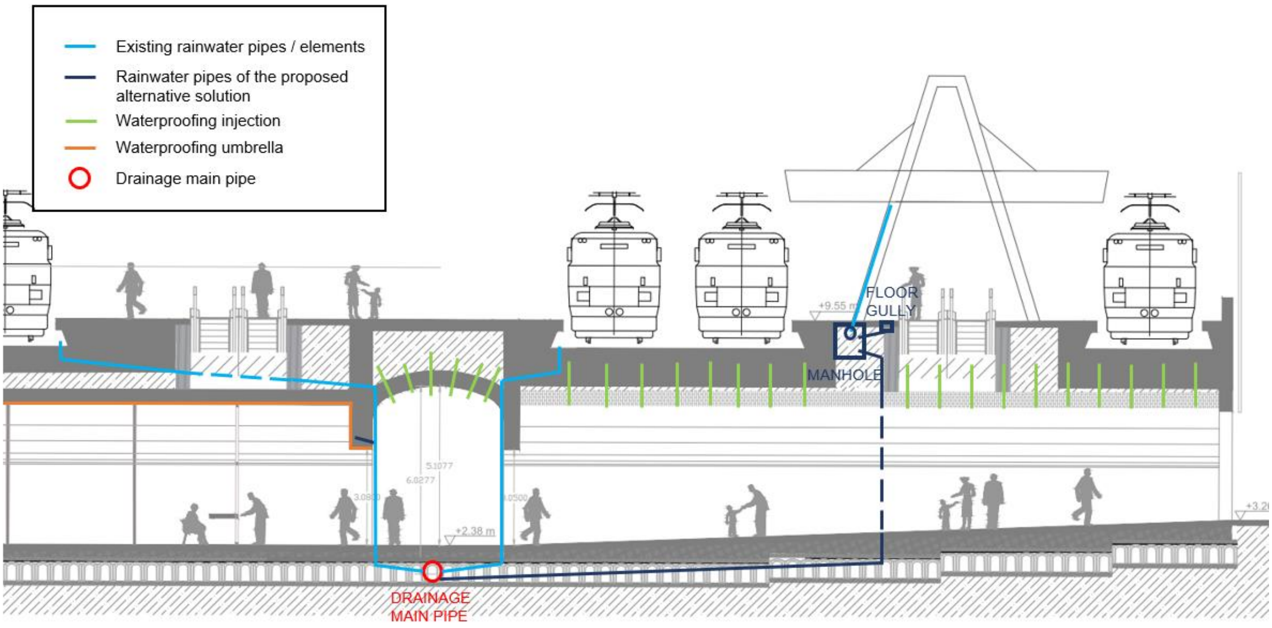

Figure 69 – Rainwater drainage system. Proposed solution

5.3.2.2 Sanitary drainage

All sanitary drainage from the different spaces will be collected and discharged into the public sewage network through the main buried pipe of the central street.

All drain stacks will have adequate venting in order to protect the trap seals from siphonage, aspiration or back-pressure. In order to size the piping for the drain distribution system, the following criteria will be followed: the slope for horizontal drainage shall ensure a self-cleaning speed.

5.3.3 Water supply

Water supply to the new Connolly Station access, retails and toilets will be provided from the existing municipal water supply.

One main Water Meter will be provided inside the corresponding water intake space. From this point, separate water flow meters will be installed up to the retails in order to determine the water consumption of the different potential renters.

The material of the water supply pipes shall be plastic polymers, properly insulated.

Water heating for the domestic hot water in the toilets shall be provided by instant electric water heaters, located within the served room. The piping shall have thermal insulation.

5.3.4 Natural Gas

Natural Gas connection will be provided to each retail unit if required.

5.4 Electricity

5.4.1 Supply

The electric supply to the new electrical loads in Connolly Station will come from the existing installations through the Main Distribution Board (CS-MDB1). To feed the new loads, the spare outlets in the MDB shall be used to supply the new Main Distribution Board (CS-MDB2) for the general services of the new station access. If necessary, new ones will be added. The new retails located in the new entrance of the station will be fed also from this Main Distribution Board (CS-MDB1). All new meters will be located in the same room that the existing ones. The capacity of the existing MDB and the ESB supply is to be confirmed by IÉ and ESB.

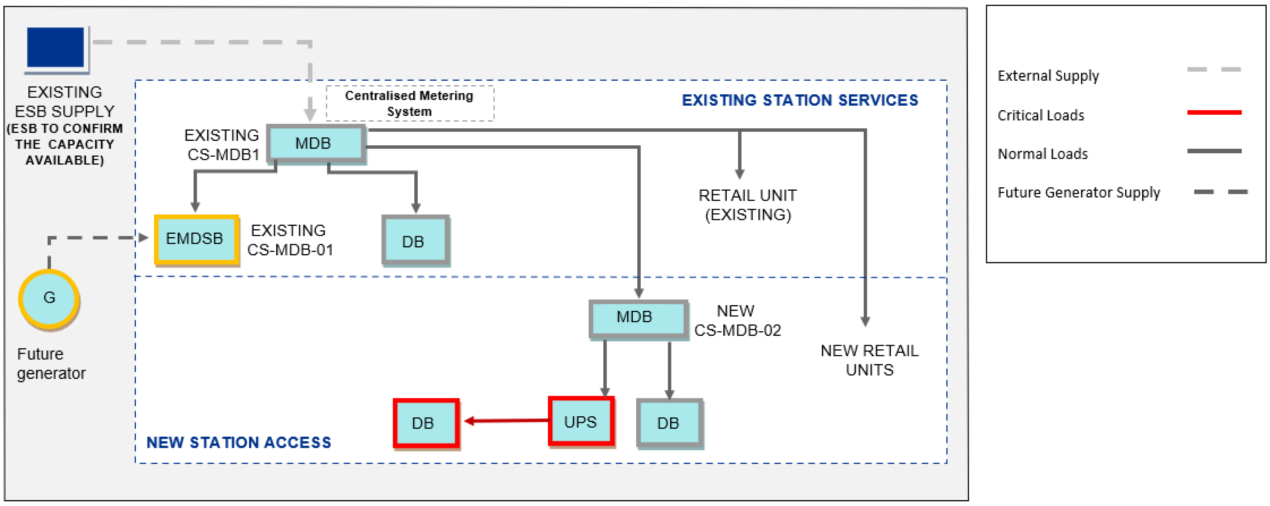

Figure 70 - Distribution scheme

Power factor capacitors

Considering the increase in electrical load and the installation of 4 escalators and 2 elevators, the existing power factor capacitor shall be revised. If necessary, the power factor correction equipment shall be enlarged or replaced to obtain a power factor of at least 0.95.

5.4.2 Type of Loads

According to their use, the new loads that can be found in Connolly Station are building loads: office and general use small power, retail small power, HVAC, internal lighting, fire safety, escalators, elevators, etc. They are fed from dedicated Distribution Boards connected to Connolly Station MDBs.

On the other hand, according to the required redundant and uninterruptible supply, the following type of loads can be defined in Connolly Station design area:

- **Critical Loads**: Power supply to loads where a power break down is considered to be critical for life and safety of people or fire strategy, or that may notably impact the activity or economics of the railway, and thus requires back up energy source.
  - Fire alarm equipment nodes/panels
  - Escalators
  - Emergency lighting
  - TER HVAC loads
  - UPS feeding critical loads
  - TER workstation and technical room small power (10 minutes autonomy)
  - Data racks, security, and BMS (10 minutes autonomy)

  These loads are fed from Uninterrupted Power Systems (UPS) connected to the CS-MDB2, with enough batteries to provide the required autonomy in each case.

- **Ordinary Loads**: Power supply to all other loads, where power loss is not considered to impact in an important way the activity, economics, or safety of the Station.
  - General use Small Power
  - General lighting
  - General HVAC
  - Tenants

5.4.3 Power demand

The power demand estimation shall consider diversity factors and the minimum available spare capacity for future expansions shall be 20%.

The building's power demand will be based on different ratios (W/m^2) taking into account the activities and uses of each area.

5.4.4 Distribution Boards

Main Distribution Boards

The Main Distribution Boards (MDB) feeding the new station services will be the already existing MDBs (CS-MDB1 and CS-MDB-01). The new retail units located at the new entrance of the station will be fed directly through the Main Distribution Board (CS-MDB1). The available capacity of the current MDBs needs to be confirmed. The new Distribution Boards (DB and CS-MDB-02) will be installed in a dedicated LV room near the new station entrance and will be connected as it is shown in the schematic of Figure 70.

The loads considered essential or critical will have the backup of the emergency supply batteries (UPS). The Ordinary Loads, however, shall be connected directly to the CS-MDB-02.

Any changes made to the MDBs shall be done following the characteristics of the existing installation: type tested, factory-built assembly complying with IS EN 61439-2 with Form 4b with withdrawable feeders (in a rack) for fast replacement and maintenance. The cubicle construction of the main switchboard will consist of high-grade sheet steel of 2mm thickness. The enclosure degree of protection will be IP54. The neutral busbar will be of the same size and rating as the phase busbars.

The main distribution board will be arranged to enable the following to be carried out in the future:

- Extension by the addition of further cubicles at either end without disturbing the existing steelwork or busbars.
- Fit and cable additional circuit protection devices to spare equipped compartments.
- Change withdrawable outgoing units without disturbing adjacent units.
- Installation and termination of an outgoing cable.
- Inspection of switching devices, conductor connections, relays, etc.
- Adjustments of the settings of relays and other control/protective devices.
- Replacement of fuses, indicator lamps, etc.

In order to allow some not foreseen supplies, 20% of spare space will be provided within every new distribution board.

All Switchboards and Distribution Boards shall be designed to verify assemblies in accordance with EN 61439. Design verified assemblies shall be verified by testing, calculation, and/or design rules in accordance with EN 61439-1 and manufacturers shall provide evidence of compliance with that standard. All boards shall be installed with a minimum clearance of 1200mm from the front and 1000mm from the sides and rear if access to the back of the assembly is required in accordance with ET 201.

The maximum ratings of MCCBs shall be 630A. Breakers above 630A shall be ACBs.

All ACBs and MCCBs shall have integral power meters with communication modules. The meters shall be networked, and the wiring brought to an appropriate connector in the terminal section of the boards. The meters shall be compatible with the Building Management System (BMS).

Distribution Boards (DB)

Distribution Boards (DB) will be connected to the MDBs, they shall feed other DB or directly the Building loads in the Station. They shall be located in LV electrical switchroom or a suitable area of the station.

DB will be form 3b in accordance with IS EN 61439-2. In order to allow some not foreseen supplies, 20% of spare space will be provided within every switchboard.

5.4.5 Cableways and Cables

Cable ladders and cable trays shall be used mainly for the ease of installation and maintenance of the electrical distribution. Any existing cableway or cable trunking system shall be used if possible for the distribution of cable related to the new electrical loads.

Separate cabling systems will be used for different systems to ensure electromagnetic compatibility (EMC), which should be:

- Medium Voltage
- Low voltage 400 V for production equipment, HVAC, small power, and lighting
- Very Low Voltage, ITC, and BMS cabling

For final or specific services, electrical conduits will be used: stainless steel or halogen-free (rigid and flexible).

There shall be at least 300mm between LV cableways and ITC cableways, according to EMC standards.

A spare space of 20% will be provided in order to allow future new circuits.

Cables

Bundles of single-core cables will be used typically for main feeders and machines, and multicore ones will be used mainly for small power and lighting. Low voltage cables to be considered shall be:

- Cables from MDB to Distribution Boards: CU/XLPE/LSZH/SWA/LSZH, 600/1000V Multicore, 90°C thermosetting insulated, armoured LSF Cu. If the installation is outdoors, CU/XLPE/PVC/SWA/PVC, 600/1000V cables shall be considered.

- Cables from Distribution Boards: Single-core or multicore, 90°C thermosetting insulated, non-arm, LSF Cu

- Cables for Life Safety Loads: Prysmian FP600S Fire resistant cable Cu

Low Smoke Fire Retardant will be used in general, and Low Smoke Fire Resistant will be used for safety feeders. In all cases, cables will be halogen-free.

Cables shall be sized considering ET101 standard fulfilling three criteria: current-carrying voltage drop below limits and short circuit withstand capability.

5.4.6 Small Power

Different small power connections shall be used depending on the area.

The sockets and electrical connections will be waterproof in wet areas, such as cleaning rooms, washrooms, outdoors, etc. Other supplies, such as fans or machinery, will be connected directly through an isolator switch beside the specific equipment. 230Vac socket circuits will be radial throughout with a maximum of eight twin sockets per circuit. The cleaner's sockets shall be wired in separate circuits.

5.4.6.1 Technical rooms:

In technical rooms, power boxes shall be installed in order to connect maintenance, cleaning or other working equipment.

Power boxes shall be protected IP54 and IK09 generally.

5.4.6.2 Staff rooms:

In staff rooms, the following socket outlets will be combined in power boxes:

- Normal supply socket outlets, switched 230Vac – 13A (3 pins) P+N+E
- UPS supply socket outlets, 230Vac – 13A (3 pins) P+N+E (red colour)
- Normal supply USB socket outlet

Additionally, the following single or double socket outlets will be installed for equipment connection and scattered along the walls for cleaning purposes:

- Normal supply socket outlets, switched 230Vac – 13A (3 pins) P+N+E

5.4.6.3 Retail areas:

In the retail areas, the small power shall be developed and installed by the tenants. A junction box with a terminal block will be provided in each retail unit.

5.4.7 Lighting

5.4.7.1 Normal Lighting

Normal indoor lighting is intended to provide a comfortable environment with high-quality optical performances and high-efficiency energy consumptions.

According to this, indoor lighting shall be LED type, with the following features:

- High CRI, over 85 (4000K minimum will be selected), providing high comfort for the environment and optical quality.

- Suitable glare control for each working area according to CIBSE, e.g. UGR19 for offices and meeting areas.

- High energy efficiency (whole luminaire over 120lm/W).

- Minimum service life 50,000h (L80/B10) at = 25°C.

- Suitable dust and waterproofing: IP44 in showers, plant rooms, risers, and maintenance workshops; IP65 outdoors and in washing and cleaning wet areas.

- The capability of regulation for spaces where it can be combined with natural lighting, and according to the presence of people.

According to applicable standards and best practices, the minimum lighting levels shall be the following (horizontal illuminance unless otherwise stated):

Lighting Levels		
AREA	**ILLUMINANCE**	**U_0**
Entrance lobbies / Waiting areas	200 lux	0.4
Corridors / Circulation area	100 lux	0.4
Stairs	100-200 lux	0.4
Reception desk	300lux	0.6
Toilets / Changing room	200 lux	0.4
Rest rooms	100 lux	0.4
Storage/Service/Support Room	100-200 lux	0.4
Offices, task areas	500 lux	0.6
Offices, general areas	300 lux	0.4
Technical rooms	200 lux	0.4
Lift car	100 lux	0.4
Comms rooms	500 lux	0.6

Figure 71 – Lighting levels

5.4.7.2 Sustainability and control

The lighting sustainability strategies main concept shall be to allow reducing the luminance levels, or switching off the circuits in areas where artificial lighting is not needed, either because no work is being carried out or because natural lighting is enough to fulfil the task requirements.

An energy-efficient lighting control philosophy shall be used. Some points to be considered in the design of the lighting shall be:

- Passive Infra-Red (PIR) occupancy detection in toilets, stairs, stores
- Switches for plant rooms, technical rooms, and utility areas where maintenance staff are responsible for switching on /off. They may also be controlled by the Lighting Control System (BEMS)
- Turning off completely lighting circuits in order to cut off voltage and not maintain the “standby mode” in the luminaire when it has been switched off. This “standby mode” state implies a very low load.
- Fully programmable time functions to maximize energy savings within each Facility via a Lighting Control System

The lighting control system shall be integrated with the existing control system of Connolly Station. It will be controlled via a fully addressable, programmable automated control system, which will be part of the Building Energy Monitoring System (BEMS). The system will use an open standard building automation lighting protocol to switch on and off the lighting in the rooms and to connect the field device to the BEMS. An open standard addressable dimming lighting control protocol will be used over it to set different scenes in rooms that require it. The combination of both protocols allows for a more robust and flexible control system.

5.4.7.3 Emergency Lighting

There will be two types of emergency lighting regarding its use:

- **Escape Lighting**: to ensure that the means of escape can be effectively identified and safely used by occupants of the building and allow a safe and organized evacuation. This can be further divided into Escape route, Open area and High-Risk Area lighting.
  Escape lighting luminaires shall be LED non-maintained, fed from a central power supply system.

- **Escape Signage:** This will mark and identify the directions of egress.
  Escape signage will be LED maintained, fed from a central power supply system.

Escape luminaires and signs shall be fed from un-switched branch circuits. Emergency luminaires will be self-contained, with an autonomy of at least 3 hours.

The schedule below shows the escape lighting levels in each space, as per the IS 3217:

Emergency Lighting Levels		
Room or area	**Type of lighting**	**Required minimum illuminance**
Defined Escape Routes (including out of the building near the exit)	Escape Route	1 lux (along the centre of the escape route) 0.5 lux (0.5 m around the centre)
Open areas over 60 m2	Anti-Panic Lighting	0.5 lux (excluding 0.5m around the perimeter)
Toilets over 8m²	Toilet Facilities	0.5 lux
Accessible Toilet or shower (any size)	Toilet Facilities	1 lux
Security and Plant Rooms	Plant Rooms	1 lux
Switchboards	Plant Rooms	5 lux (Vertical)
Disabled Refuges	Point of Emphasis	5 lux
First Aid Posts and Fire Fighting Equipment: extinguishers, alarm call points, fire panels…	Point of Emphasis	5 lux (Vertical)
Other areas as per specification (e.g. lifts)	Anti-Panic Lighting	0.5 lux
High-Risk Area	High-Risk Area	10% of the normal illuminance

Figure 72 - Emergency lighting levels

At least an exit sign must be seen from any escape route, and additionally in any place where confusion may occur. They will be generally suspended, or surface mounted between 2 and 3m, always at the same height throughout the escape route, so far as it is reasonably practicable. Escape signs shall not be fixed to doors or in places where opening doors may obscure them.

5.4.7.4 Earthing and bonding

All the earthing systems (or new elements belonging to earthing systems) resulting from the new installations in Connolly Station shall be connected to the existing earthing grid, including:

- 400 Vac Low Voltage System.

- Telecommunication System (ITC).

Also, metal and steel-reinforced structures, metal pipes, cable trays, machinery, fences, façades, lighting columns, and other conductive parts that may become live parts under fault conditions shall be connected to the earthing mesh. This way, it is ensured that all those elements are at the same potential, and touch and step voltages will be acceptable. It is necessary to ensure the safety and reliability of the electrical supplies as a result of any fault in the low voltage.

Separate earthing circuits will be used for protective earthing (PE) and functional earthing (FE), in order to prevent electromagnetic disturbances in the telecommunications and control systems. Earthing system will be designed according to IEC 61000-5-2.

5.5 BMS

The Building Management System (BMS) shall be capable of remote monitoring, supervision, and reporting on the operation and maintenance of systems and equipment. It shall also manage and control the status and performance of all the Electro & Mechanical equipment installed inside the Connolly Station intervention to optimise energy consumption whilst maintaining specified thermal comfort.

The controlled and monitored systems by BMS are the following:

- Heating, Ventilation, and Cooling System
- Electrical LV main switchboard Building Services
- Lighting System
- Emergency Lighting System
- Electricity and Water Meters
- Fire Alarm System
- UPS

The daily operation of the BMS shall be at the operator terminal, and it shall be possible to operate the BMS directly on the server. It shall be possible to access the BMS from a workstation/laptop/smartphone outside the station via a web browser. The BMS shall communicate with the SCADA.

5.6 Telecom (GroupIT, B&F)

The services managed by B&F and GroupIT in the new entrance to the station shall be integrated inside the current system, and shall be fully compatible with the existing ones.

The new ticketing points shall be provided with induction hearing loops and with an Internet connection.

The lifts shall be equipped with suitable loudspeakers with connection to the station Public Address System and the lift alarm/system must be also fitted with a hearing loop. The CCTV installed inside the lifts shall be managed by B&F and will be independent of the rest of the CCTV system which is controlled by SET.

The equipment of B&F and GroupIT shall not be located inside TER rooms which are only for SET services.

Internet services shall be provided in the retail areas where passengers spend time waiting for the connection.

The voice alarm system shall be integrated into the existing one and shall be fully compatible.

6. Sustainability Design

The greenest building may be the one you already own, according to the National Trust for Historic reservation. The building reuse projects pointed out carbon impact reductions that seemed small when considering one building but showed significant when it is extended to a bigger scale. It can take between 10 to 80 years for a new energy-efficient building to overcome, through efficient operations, the climate change impacts created by its construction. In this direction, certifications such as LEED or BREEAM, strongly recommend the reuse of an existing building.

Therefore, the proposal relies in the reuse and rehabilitation of the actual infrastructure that will enhance its comfort and functionality by means of the architectural design.

6.1 Passive architecture strategies to improve comfort conditions based on the specific climate conditions for Dublin

The first step in every sustainable building design consists of understanding the climate to adapt to its characteristics and respond to the external conditions providing design strategies capable of reducing the energy needs and maximising internal comfort.

The dominant influence on Ireland's climate is the Atlantic Ocean. Consequently, Ireland does not suffer from the extremes in temperature experienced by many other countries at a similar latitude. The warm North Atlantic Drift has a marked influence on sea temperatures. This maritime influence is more substantial near the Atlantic coasts and decreases with distance inland. The hills and mountains, many of which are near the coasts, provide shelter from strong winds and from the direct oceanic influence. Winters tend to be cool and windy, while summers, when the depression track is further north and depressions less deep, are mostly mild and less windy (Irish Meteorological Service).

The bioclimatic charts reveal that the key strategies to achieve comfort are the **maximisation of solar radiation** (when possible) and the **protection from high-speed wind** conditions. When applying these concepts to the current station, due to the specific characteristics of the station, the solar radiation will be compromised, however, the high thermal inertia that the current structure provides will minimise the external temperature fluctuations, improving the overall thermal comfort, and becoming the main bioclimatic strategy.

6.2 Towards the Near Zero Energy Buildings (nZEB)

The main energy consumptions in stations tend to be due to lighting and ventilation needs, together with the heating requirements to achieve internal comfortable thermal conditions.

The proposed design works with a different concept, that aims to minimize the energy requirements of the stations, understanding the stations as a transition area between outdoors (the street) and indoors (the train cars). This strategy will allow for the reduction of the mechanical ventilation and heating needs, with their correspondent energy consumption and the maintenance needs and costs.

The bioclimatic design will permit the improvement of the comfort conditions in the stations compared to the external conditions by reducing air draughts and providing homogeneous radiant temperature by means of thermal inertia.

Also, special focus will be put on providing an efficient lighting system based on LED technology that will dime in consonance with the daylight levels and the station occupancy and needs (light level reduction when there is no transport on the station).

6.3 Low Environmental Impact

Dublin’s 30-year vision is for a **zero-carbon city** with all energy coming from renewable energy sources. All buildings will have to be built or retrofitted to near-zero energy building standards.

As mentioned before, the proposed design is based on a deep climate analysis to provide energy savings to the stations while enhancing comfort, with the idea of achieving an exemplary transport system from a sustainable point of view.

Together with energy, there are other sustainable strategies to reduce the environmental impact of the stations:

- Water: reduce potable water needs by low consuming equipment, water recovery and reuse
- Transport: prioritise facilities and paths for pedestrians and bikes nearby the stations.
- Health: healthy environments with optimum Indoor Air Quality management, by maximising natural ventilated semi-exterior areas, and use of non-toxic and low - VOC materials
- Security: safe design with open areas and adequate lighting. Protection of pedestrians in exits and cross-sections.
- Waste Management: minimise waste and enhance the use of recyclable materials.
- Environmental friendly: use of environmentally friendly materials and provide the buildings with easy operation schemes to reduce environmental footprint.

6.4 Post-pandemic design. Passive and creative solutions

CONTACTLESS SOLUTIONS

The post-pandemic era will be faced with innovations delivering a safe environment for the passengers using contactless devices and online operations, thus providing the passengers with a feeling of safety and making them more willing to use the DART+ network:

- Contactless turnstiles.
- Automatic doors.
- Holographic information systems and pushbuttons.
- Handrail sterilisers.
- Electronic sinks and sensors for urinals and toilettes, soap/steriliser dispensers, and paper hand towel dispensers.

The open and continuous design of the station will ease the crowd management tasks. Passenger supervision and social distance control can be done by someone located in the concourse area if necessary.

USE OF TECHNOLOGY

The use of technology will play a key role in the post-pandemic era:

- The Use of Big Data to realise targeted control measures, including traffic flow, operation monitoring, passenger and freight demand forecast, passenger flow tracing analysis.
- The use of technology to improve the operation efficiency and disease control: innovations such as mobile reservation of commute, droid and smart logistics.

NATURAL VENTILATION

The best way to fight the virus is to use natural ventilation. An open and ventilated design of the station would minimise the risk of contagion.

For enclosed areas, the following recommendations from the World Health Organization (WHO) will be followed when possible:

- For mechanical systems, increase in the percentage of outdoor air, using economiser modes of HVAC operations and potentially as high as 100%.
- Increase in total airflow supply to occupied spaces.
- Improve central air filtration:
- Consider running the HVAC system at maximum outside airflow for 2 hours before and after spaces are occupied, in accordance with manufactory recommendations.
- Generate clean-to-less-clean air movements by evaluating the positioning of supply and exhaust air diffusers and/or dampers and adjusting zone supply and exhaust flow rates to establish measurable pressure differentials. Have staff work in "clean" ventilation zones.

ANTIBACTERIAL MATERIALS

During the development of the next stages of the project, materials and systems that prevent the build-up, spread and transfer of harmful bacteria and viruses will be proposed.

Copper and its alloys (brasses, bronzes, cupronickel, copper-nickel-zinc, and others) will be proposed as finishing materials within the station, since they are natural antimicrobial materials that have intrinsic properties than can destroy a wide range of microorganisms.

7. Drawing Index

FULL CODE	TITLE
MAY-MDC-ARC-RS02-DR-A-0001	Connolly Station. Station Location
MAY-MDC-ARC-RS02-DR-A-0002	Connolly Station. Platforms level plan
MAY-MDC-ARC-RS02-DR-A-0003	Connolly Station. Street level plan
MAY-MDC-ARC-RS02-DR-A-0004	Connolly Station. Cross sections
MAY-MDC-ARC-RS02-DR-A-0005	Connolly Station. Longitudinal sections
MAY-MDC-ARC-RS02-DR-A-0006	Connolly Station. Elevations
MAY-MDC-ARC-RS02-DR-A-0007	Connolly Station. Axonometric Views
MAY-MDC-LAN-RS02-DR-A-0001	Connolly Station. Landscape and Urban integration