Nex—

—The British Museum

King Edward Building
Basement Ventilation Tunnels Waterproofing Refurbishment
Design & Access Statement
R01

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0	23.03.2022	Draft Issue for Comment
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Contents

Introduction

This Design and Access Statement has been prepared by Nex on behalf of The British Museum to illustrate proposals for the repair and replacement of waterproofing to the ventilation and service tunnels located in the basement of the King Edward Building.

Project Location

The King Edward Building is located on Montague Place on the north side of the museum's Great Court. It is a Grade I listed building designed by Sir John Burnet & Partners, completed in 1915.

The building contains the key China and South Asia Gallery 33, along with the Galleries 33a, 67, 95, Prints and Drawings galleries, and Anthropology Library. These spaces were supplied with fresh air through the sub-basement level of the King Edward Building (KEB), commonly referred to as the KEB tunnels. This is in line with the original design of the building.

The building runs in an east-west direction with it's main elevation fronting onto Montague Place. The proposed interventions are located in the tunnels at level -2, which run along the length of the building The tunnels are accessed from back-of-house services areas via the circular stairs on the southeast and south west corners of the building. They are not accessible to members of the public, nor are they visible from the street.

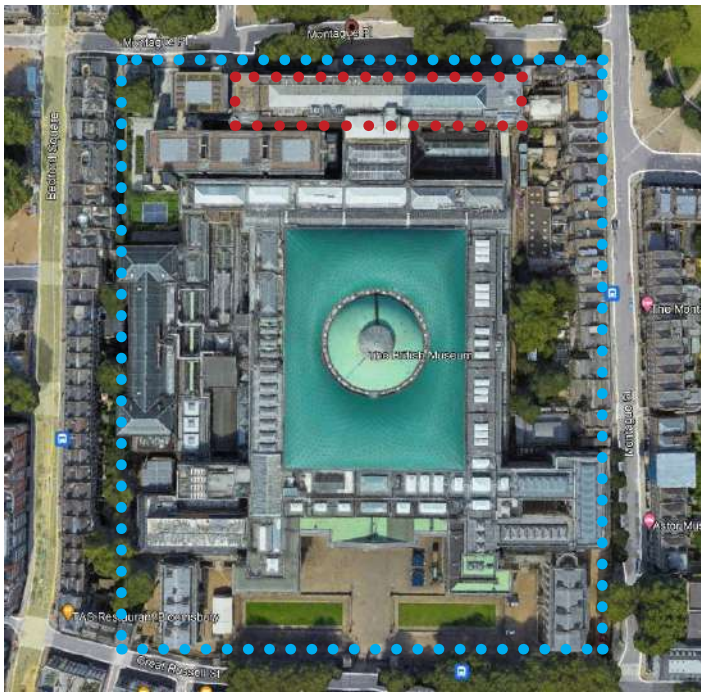
The tunnels walls and vaulted roof are constructed from London stock brick, while the floor is originally composed of asphalt and mass concrete. A detailed description of the building fabric and its significance is contained in the Heritage Impact Statement.

The interior fabric of the tunnels has been altered extensively over time:

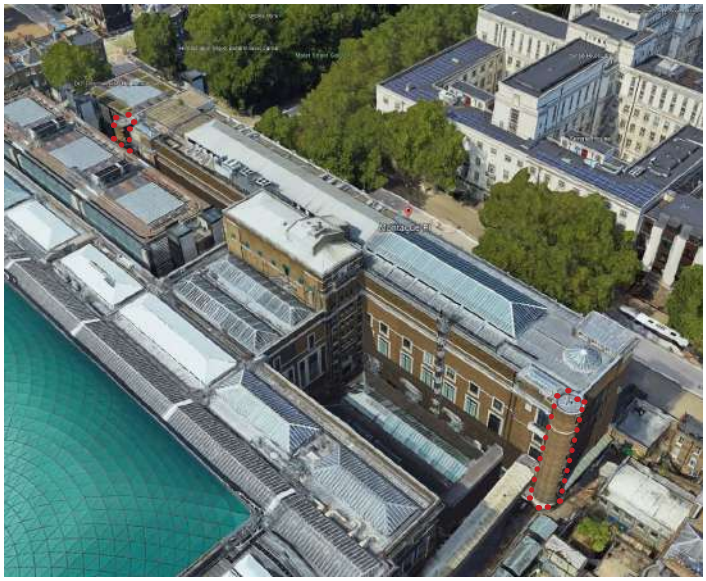
- Walls have been drilled to bear structure and containment for multiple electrical and mechanical services.
- Doors and partitions and fire curtains have been inserted to introduce fire compartmentation.
- Additional steel structure has been added along the full length of each tunnel to reinforce the vaults for increased floor loadings above.
- The walls and floors of the tunnels have been waterproofed with a Type A cementitious render.

Project Team

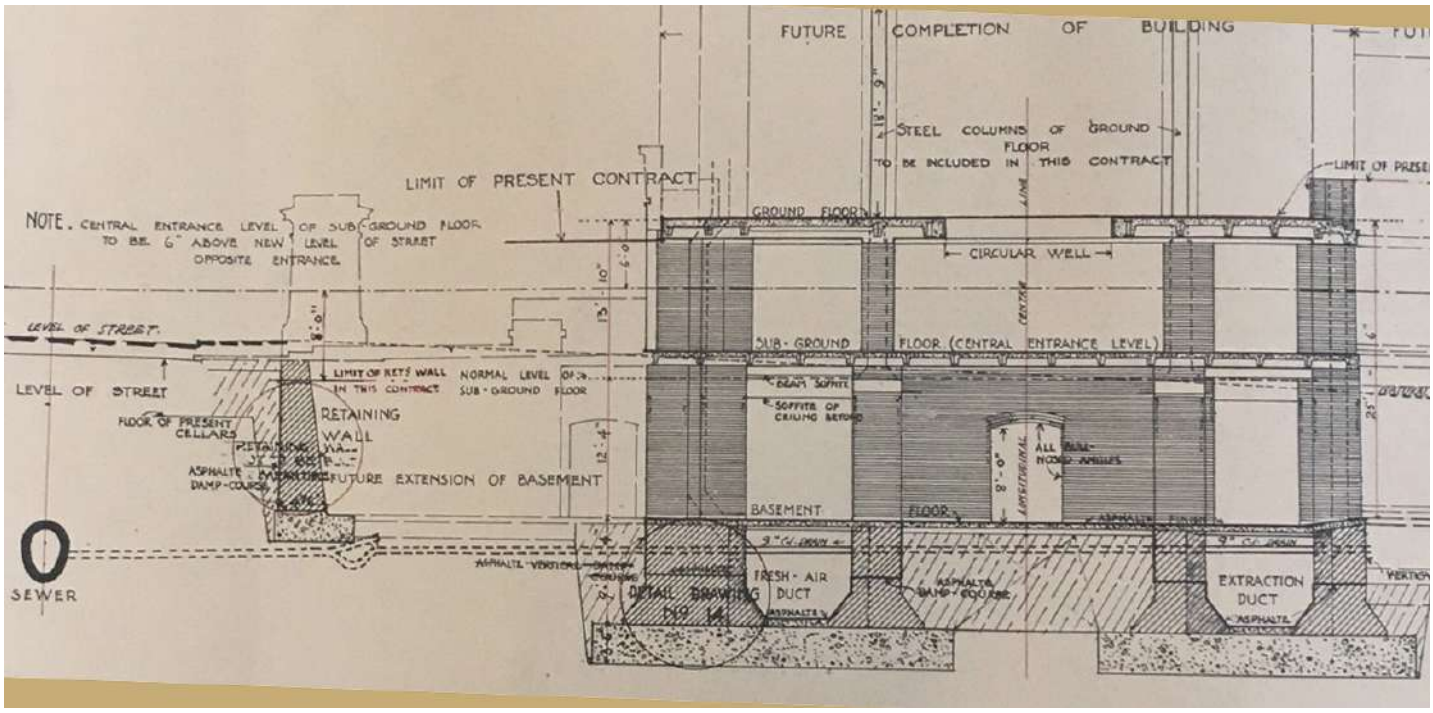
Client: British Museum
Architect: Nex
Heritage Consultant: Donald Insall Associates
Planning Consultant: The Planning Lab
Structural Engineer: Civic Engineers
MEP Engineer: Steenson Varming
Principal Designer: Steenson Varming
Project Manager: Stace
Quantity Surveyor: Stace



Aerial view of museum outlining KE building



Aerial view of south east elevation of the KEB showing the stair turrets that access the basement tunnels



Copy of original section drawing showing the construction of the basement tunnels

Project Context

The KEB tunnels are positioned within the London clay and ground water has been noted on top of this permeable layer. The two tunnels run east-west along the length of the building formed within the spaces where the base of the masonry spine walls of the building above, meet the top of the concrete foundations.

The sides walls of the tunnels are constructed of masonry, they retain backfilled made ground that was placed following the construction of the building. The tunnels are connected via a cross tunnel at their east end.

Based on the information gathered, we know that the tunnels were originally water-proofed with a ring of asphalt that lines the tunnel floors and walls internally up to just above the corbels, before turning horizontally through the masonry walls and then externally wrapping up around the tunnels and floor above.

Originally the groundwater level would have been below where the waterproofing turns horizontally through the wall however, since the construction of the KEB, groundwater levels have risen in London. It has been noted that the current groundwater level varies with rainfall.

Based on information from archives of site investigations elsewhere on the museum site, the groundwater is now roughly between 0.7m-1.4m above the top of the foundations and therefore above the potential weak point in the waterproofing layers where it turns horizontally through the wall.

No water ingress through the structure has been observed above the spring lines or on the roof of the tunnels except for the low vault area over the AHU. This is likely due to localised failure of waterproofing on the roof slab and blocked drains overhead. This will also need to be addressed as part of the proposed works.

The Project Need

During a building inspection in December 2019, water ingress was identified within the KEB tunnels, resulting in mould and bacterial growth, and it appears that the area has been subject to historic water issues. The water ingress has also resulted in damage to electrical control systems responsible for ventilation in the tunnels and air supply to Galleries and the other KEB spaces noted above.

To mitigate the risk to health, the galleries were temporarily closed to the public following the survey. Employee access to the tunnels was also restricted until they were sanitised by a specialist contractor in early 2020 to facilitate safe entry into the space for remedial works and further surveys.

Following detailed environmental analysis by Stenson Varming of the airflow and natural air infiltration through the envelope, galleries 33 and 33a were reopened to the public winter 2021. Visitor numbers were initially limited and CO^2 levels closely monitored before open access was reinstated Spring 2022.

This proposal seeks permission for urgent repairs to the waterproofing of the tunnels, and to put in place long-term protection for the historic building fabric (vital in this location as the structural base of the building), as well as reinstate the historic use of the tunnels in ventilating the spaces above.

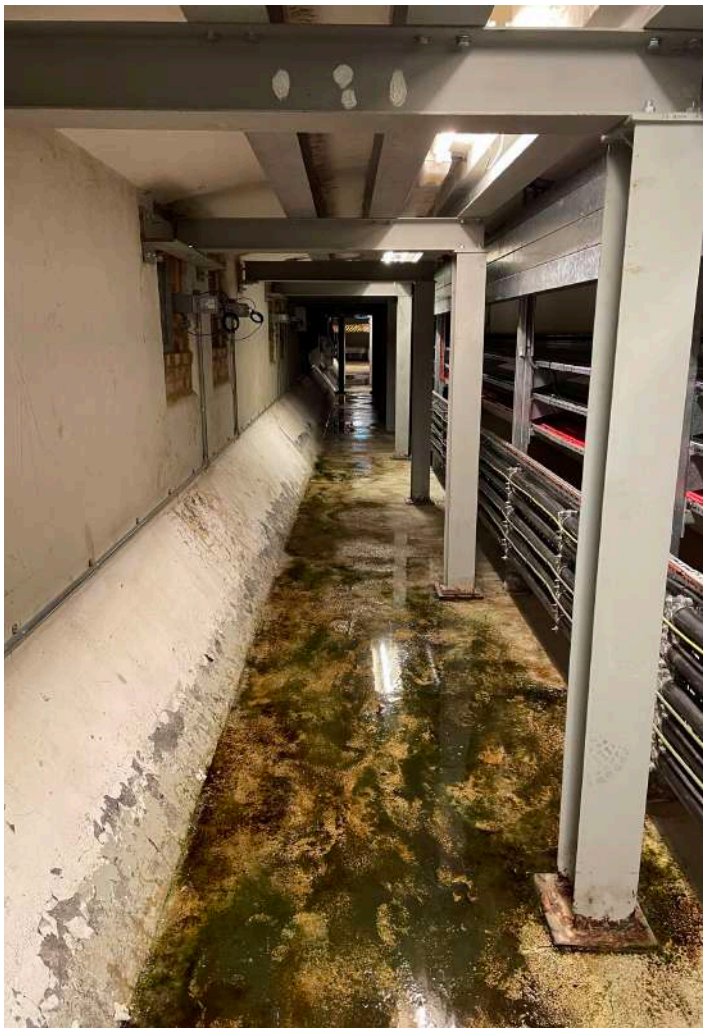


Photo of flooded KEB tunnel with mould growth on floor and walls

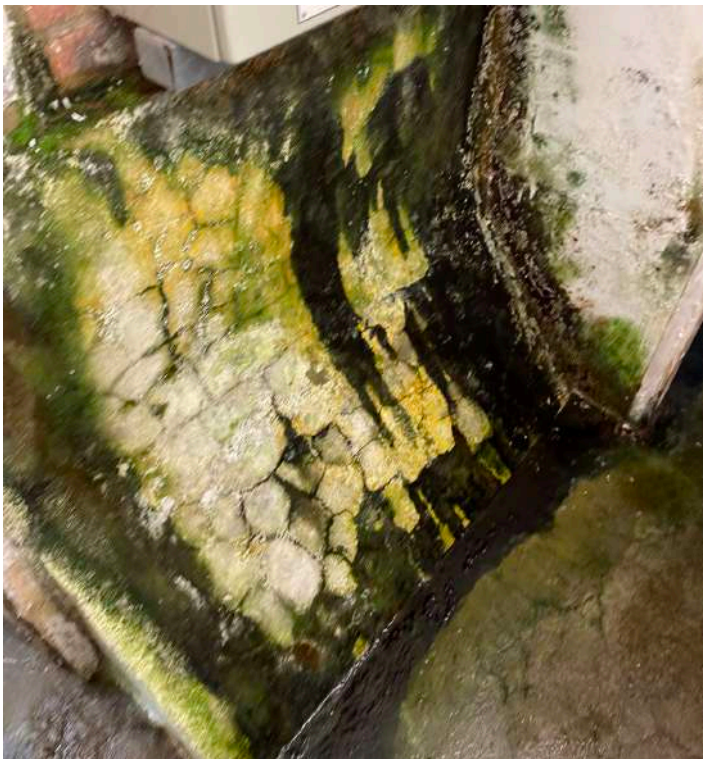
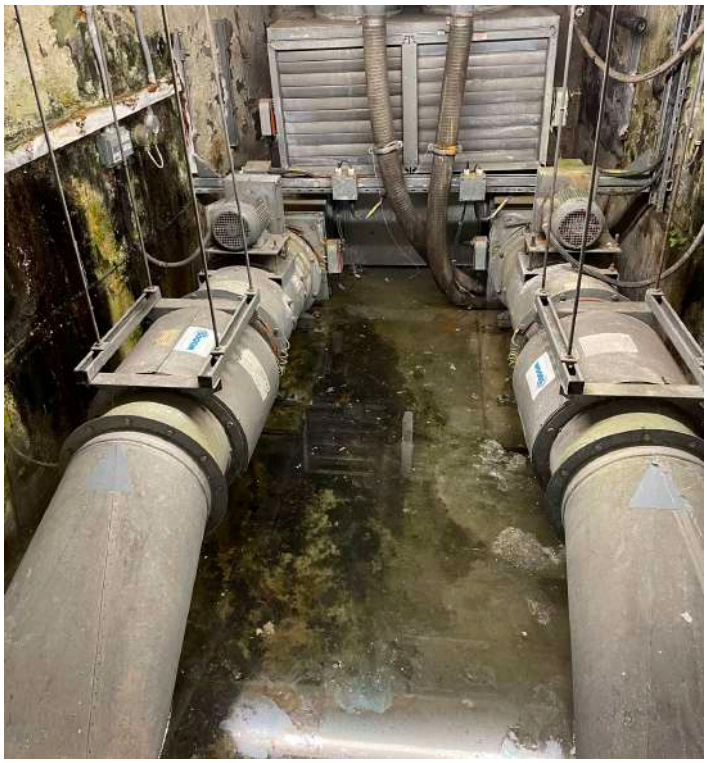
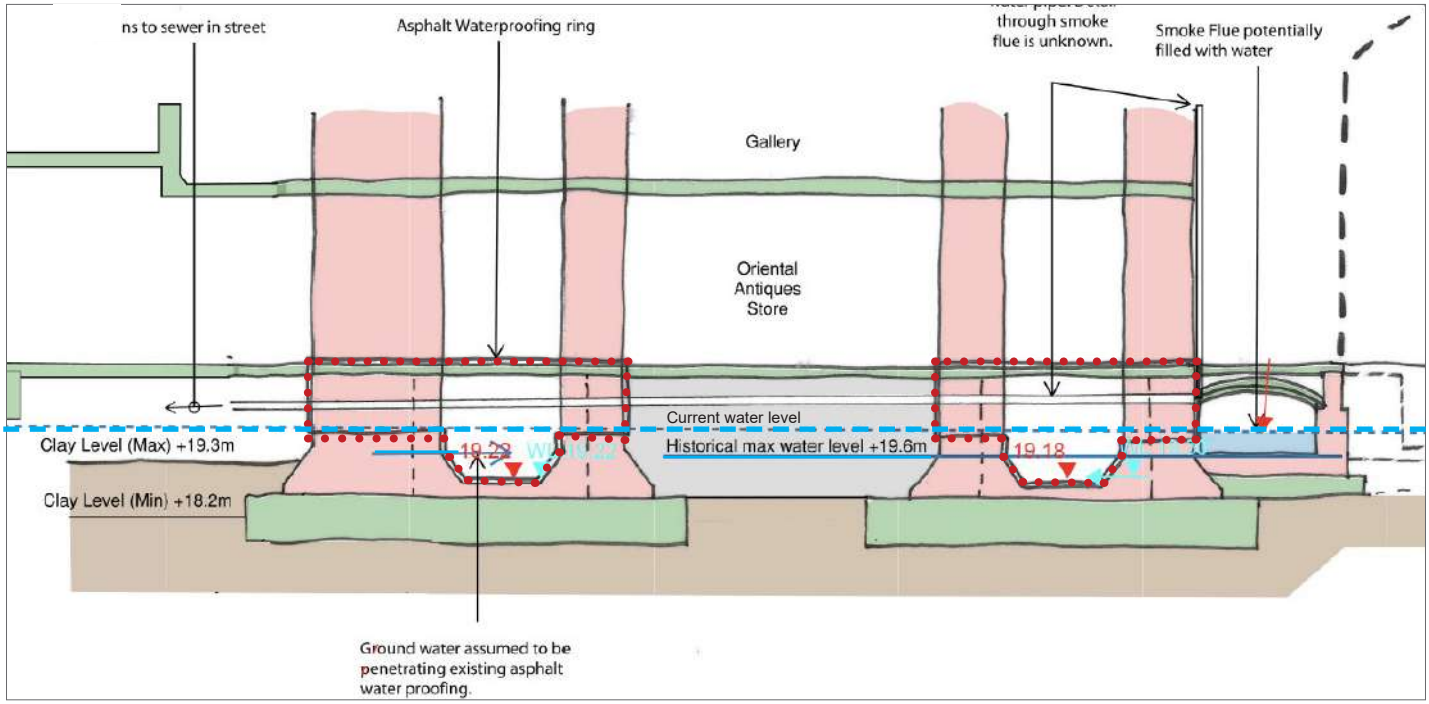


Photo of mould growth on floor and walls



Flooded KEB tunnel with damaged air handling unit



Sketch by Civic Engineers showing structural waterproofing and current level of ground water

Structural and Architectural Investigations

Investigation by the Design Team has included inspections of the structure, research of building archives and testing of water samples taken from within the tunnels. Our findings can be summarised as follows:

- The source of the water ingress is ground water and there is no evidence of leakage from either sewers or municipal water supply pipes.
- The original brick structure was waterproofed using a layer of asphalt. This was applied to the lower section of the tunnels on the inside and on the upper section on the outside. The asphalt was taken transversely through the structure at mid-level to connect the inside and outside layers.
- The level of this transverse layer was set above the historical maximum water level at the time of the building's construction.
- The water table has since risen significantly and now sits above the horizontal asphalt layer, which is exacerbating water penetration.
- A Type A waterproofing slurry was used to line the tunnel walls and floor approximately 10-15 years ago when additional structure was introduced to support the vault roofs.
- This Type A render has also failed and much of it has become loose and friable.

Development of Proposals

Our proposals comprise the following scope of works:

1. Cleaning, decontaminating and de-moulding of the tunnel walls and floors.
2. Local conservation repairs to the building fabric where required.
3. Installation of a permanent waterproofing treatment and its protection to create a dry and safe Grade 2 service space in the tunnels.
4. Replacement of existing basement AHU mechanical equipment to reintroduce air into the tunnels and reinstate the natural ventilation of the building.
5. Replacement of existing, non-original fire compartmentation walls, with existing fire doors retained and reinstated.

Proposals for each of these works' packages have carefully considered the impact on historic fabric, comply with historic conservation best practice and ensure that the works are wherever possible reversible with minimum damage.

1. Cleaning, Decontaminating and De-Moulding of The Tunnel Walls And Floors

The tunnels will be decontaminated and de-moulded using a spray application called 'Spore Clean'. This is a highly effective and environmentally safe chemical treatment which disinfects, removes stains, and restores surfaces from damage caused by mould and its chemical metabolites.

The chemical treatment will be applied to the walls and floors with an ultrasonic atomiser. This will make the process of mould remediation of large surface areas quick and effective, removing any requirement for abrasive treatment of listed building fabric. During application, the tunnels will be fully sealed from the rest of the building to ensure that vapour does not affect other spaces, the museum collection or staff.

2. Local Repairs to Fabric Where Required

Site surveys completed have noted that some of the existing Type 'A' tanking that is in place is defective or friable, and is likely to fall away during preparation of the surfaces for waterproofing. It is difficult at this stage to give an accurate assessment of the extent of this, and it will be investigated further when a contractor is appointed. Some local remedial repairs and plugging of the walls will be required where mortar in brick joints has decayed. This will be completed using appropriate lime-based mortars with approval of the heritage consultant.

Examples of areas of friable material and damaged brickwork that will require local repair

3. Installation of Permanent Waterproofing

The proposed waterproofing treatment will combine the use of Type A (cementitious render) and Type C (cavity drain) systems to create a Grade 2 basement that is suitable for service or plant areas. This standard of basement will have no visible areas of damp with a relative humidity range of 35-50%
The use of the Type A system will be limited to areas that are unsuitable for a cavity drain and which have already been waterproofed with a cementitious render.

3.1 Type A System

The type A system will consist of a single-component, polymer-modified, cement-based waterproofing slurry that incorporates micro silica polymer and fibre. This will be used to repair damaged render and concrete at low level, and in strips at the key junctions of the wall and floor and wall and ceiling. This will provide a reinforced waterproofing at weak joints that can withstand up to 10 bar of water pressure.

Within the circular stair wells that access the basement tunnels the existing render finishes on the bottom 1m of the stairs are also defective with cracks showing and water ingress. The walls and floor will be repaired, and a new Type A Tanking system will be applied to both walls and floor taking over lowest 10 steps.

Please refer to Nex drawing 108-Nex-XX-02-DR-A-302 for a detailed section indicating the location of the Type A system.

Examples of type A barrier waterproofing applied to wall-floor junction and sprayed on

3. Installation of a Permanent Waterproofing

3.2 Type C Cavity Drain System

This is a cavity drain membrane designed to be used internally, directly against the walls and over the floor. A Type C membrane is a waterproof management system not intended to withstand water pressure. It therefore creates no additional stress on the existing building fabric. Instead, it accepts and diverts water ingress, discharging it via newly-created channels and pumps, to give a dry, usable interior space. A Type C membrane is widely recognised and accepted for use on heritage and listed structures.

The proposed system does not require aggressive surface preparation and is reversible without causing further damage to the substrate. In summary, the heritage benefits of this system are:

- The system provides a damp proof and waterproof barrier protecting the building interior from water ingress.
- The system controls water ingress, rather than trying to stop it which can induce further stress on the structure.
- There is minimal damage caused to the substrate during installation.
- The design of the cavity system means that the historic fabric can still breath.
- The system is completely reversible.

Example of a standard Type C cavity drain

Fire resistant Type C membrane

3.3 Fixing

The membrane will be affixed mechanically to the structure every 600-800 millimetres with proprietary plastic membrane plugs that do minimal damage to the building fabric. The plugs are plastic with a watertight polymer washer that seals the hole. This is then covered by a metallic cover to provide the fire rating.

Example of fixing for fire resistant membrane

3.4 Fire Rating

Where the membrane will remain exposed to the tunnel interior, a fire rated version rated EN 13501 B-s2.d0 will be installed to meet the building fire strategy. This membrane will be installed on the floor and up to the soffit on both side walls as far as possible. The proposed membrane is reinforced on the inside face with woven fibreglass to offer a durable, tear resistant finish. Other plastic membranes were considered but rejected because they did not meet fire and durability requirements.

3.5 Strategy Selection and Alternatives

In selection of the proposed permanent waterproofing strategy, a range of options have been considered by the design team and with basement waterproofing specialists. These have been explored to weigh up their pros and cons with specific regard to; their effectiveness and longevity, their impact upon the existing fabric; any additional factors including the building's fire strategy. The key pros and cons are summarised in Table 1 below:

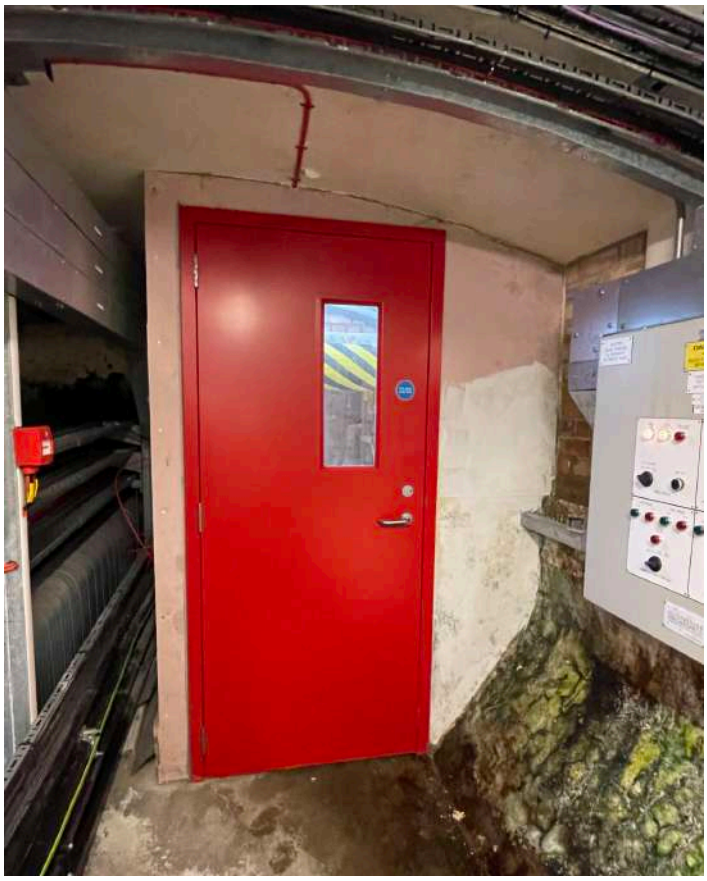
Waterproofing Type	Pros	Cons
Option 1 - Repair and expand existing Type A system (Type A only)	- Matches the existing strategy in the tunnels - Thin buildup	- Doesn't accept water ingress as part of the system, therefore any failings lead to damage and introduce need for repair - Existing Type A system installed 10-15 years ago has failed, likely to fail again if used in the same situation as the sole system - Non reversible without damage to existing fabric - Doesn't allow existing fabric to breath
Option 2 - Non FR Cavity Drain (Type C only)	- Type C system accepts water ingress as part of the system and drains away - Minimal damage caused to the substrate during installation - Allows historic fabric to breath - Fully reversible	- Lack of Type A reinforcement at joints in existing building creates weak points where water could penetrate more easily -Type C system is unsuitable for us it stair turret areas - Lack of fire rating in standard Type C systems results in them not complying with the building's fire management strategy
Option 3 - Repair exiting + FR Cavity Drain (Type A+C)	- Hybrid system uses Type A to reinforce joints and existing areas of Type A system, with Type C installed in tandem for robust system designed for long life and minimal repairs and maintenance - Type C system accepts water ingress as part of the system and drains away - Minimal damage caused to the substrate during installation - Allows historic fabric to breath - Type C system is fully reversible and areas of Type A system (the reversal of which causes damage to existing fabric) are limited - Fire Rated Type C system complies with the building's fire management strategy	

Table 1

5. Replacement of Fire Partitions

Two sections of existing, non-original partitions including fire doors, along with two fire curtains - all installed for fire compartmentation - will be removed during the works to allow for the retanking of the tunnels. The existing doors and fire curtains in these constructions will be retained and reinstated, within new, fire-rated partitions, to maintain the existing fire compartmentation of the building.

Please refer to Nex drawings 108-Nex-XX-02-DR-A-401 and 108-Nex-XX-02-DR-A-402 for details of the proposed removal and reinstatement of the partitions.



Fire door within partition (top) and fire curtain (bottom)

3.6 Flooring

On the floor, the fire-resistant membrane will be covered with a fibre cement screed board, which will serve as a traffic wearing course. Please refer to Nex drawing 108-Nex-XX-02-DR-A-302 for a detailed section indicating the location of the Type C system and the cement floorboard.

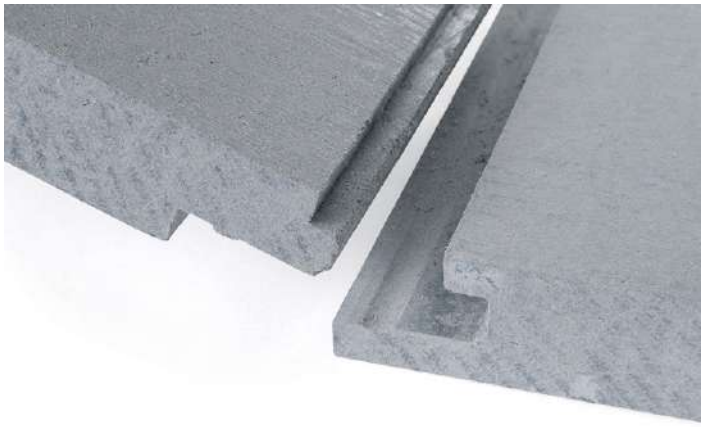
3.7 Drainage

The cavity membrane will be drained using a newly cut channel located in the centre of each tunnel that runs their full length. Water run-off from the channels will be collected in two sump pits in each tunnel and pumped towards the larger existing sump chamber in the AHU vault. From there, water will be pumped out of the building using the existing pump lines. The pumps will be powered by the building electrical supply and have a separate battery back-up and alarm in the event of a power failure.

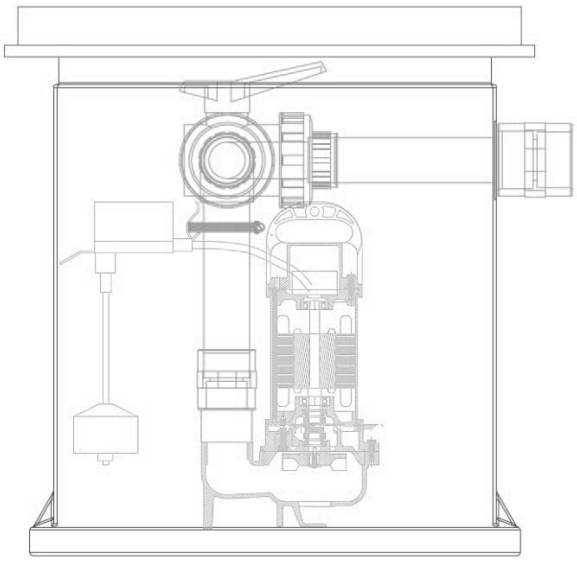
4. Fire Compartment Partitions

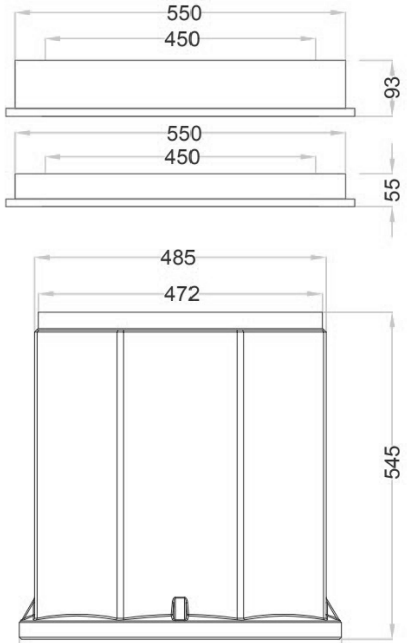
Existing fibreboard partitions that provide fire compartmentation around the stair entrances will be carefully dismantled and removed to allow the waterproofing works to proceed.

On completion, these compartments will be replaced with similar fire rated partitions lined in durable fermacell board. Fire doors will be reinstated or replaced with a like-for-like alternative. Refer to Nex drawings for full details.

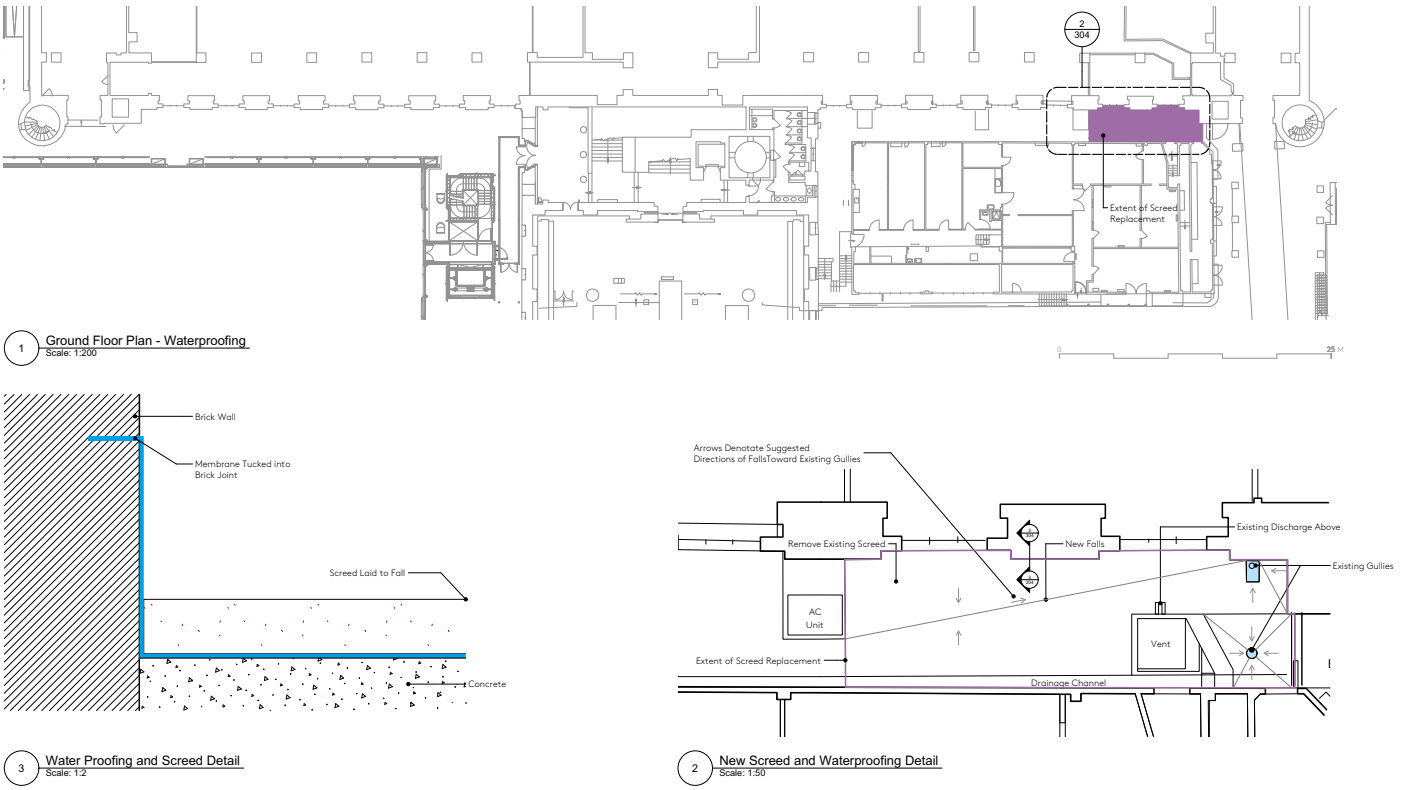


Examples of a finished screed-board floor and a detail of the interlocked board joint.





Example of Titan DTS sump pump which will be used in each tunnel.



Extract from Nex drawing 304 showing the extent of screed replacement

5. Ground Floor Slab Waterproofing

There is water penetration into the tunnels via the roof of the tunnel over the AHU units. Our inspections have lead us to conclude that this is due to the failure of the waterproofing and drainage in a small section of slab on the southeast corner of the KEB.

The problem is compounded due to the water discharge pipes from the tunnels currently pointing west, while the drainage gullies are located to the east end. The fall of the screed does not direct the water to the gullies, resulting in frequent flooding.

Our proposal is to take up the existing screed and apply a new bonded waterproofing to the structural slab. A new screed will then be laid to the correct falls to direct water to the gullies.

Photo showing area the is regularly flooded resulting in water leakage into the basement. Image shows the misalignment of the drainage gullies and water discharge pipes.

Conclusion

In summary, the proposed works have been developed in close consultation with heritage consultants and waterproofing specialists experienced in the restoration and waterproofing of listed buildings. We believe that the proposals offer an effective and long-lasting solution to reinstate natural ventilation of the KEB building spaces, create a dry service space for continued maintenance, while protecting the building and minimising further damage to historic fabric.