Structural Compliance Strategy

Cable Tram Engine House
253-263 Brunswick Road, Brunswick

Prepared for Bensons Property

04 APR 2025

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Your Partner in Engineering

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Structural Compliance Strategy	1	30 Oct 2024	JC
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1.0 Introduction

This report sets out to address Heritage Victoria's concerns in the permit application P39543 and demonstrates the structural compliance strategy of the existing building to the relevant parts of the NCC and the requirement of reg 233.

2.0 Project Overview & Building History

The project involves the development of an 6-storey high student accommodation tower at an existing cable tram engine house located at 253-263 Brunswick Road, Brunswick. The building was originally constructed in the 1880s by the Melbourne Tramways Trust and used as the cable tram engine house and substation to provide power supply for Melbourne's cable tram.

2.1 Heritage overlay

The building is heritage listed and covered under the Heritage Victoria Registry (Figure 1).

Figure 1 Heritage overlay map at the former cable tram engine house building

2.2 Proposed development to existing building

The proposed development will involve partial demolition of the former cable tram engine house, which include the internal brick walls and the northwest roof area as denoted in Figure 2 and Figure 3.

The new building structure is independent to the existing structure except for the northwest zone where the existing brick walls will be laterally restrained by the new structure as denoted in Figure 4. There is an opportunity to reuse the existing truss to laterally restraint the wall to the new structure.

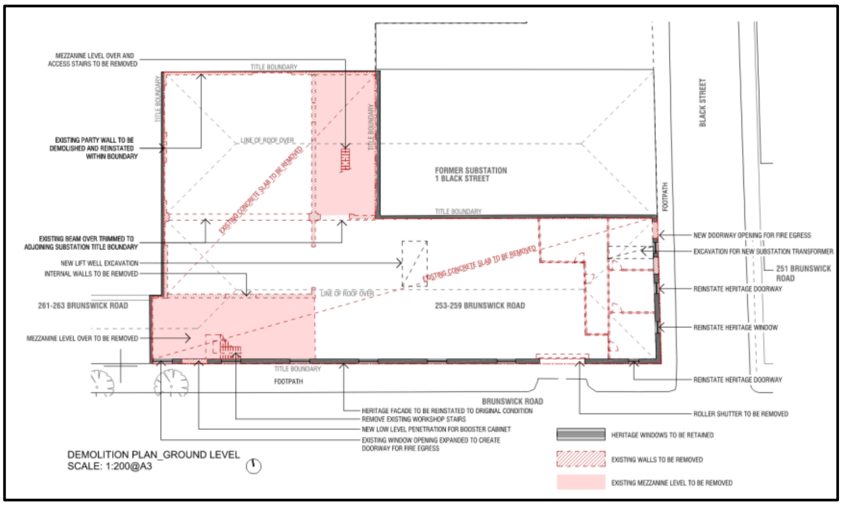

Figure 2 Proposed demolition plan at ground level - extract from 2732_Brunswick Road_Town Planning Package

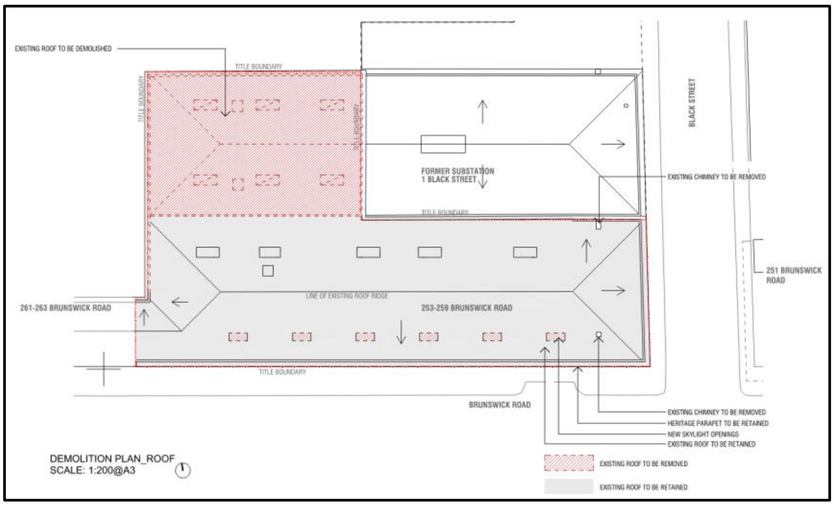

Figure 3 Proposed demolition plan at roof level - extract from 2732_Brunswick Road_Town Planning Package

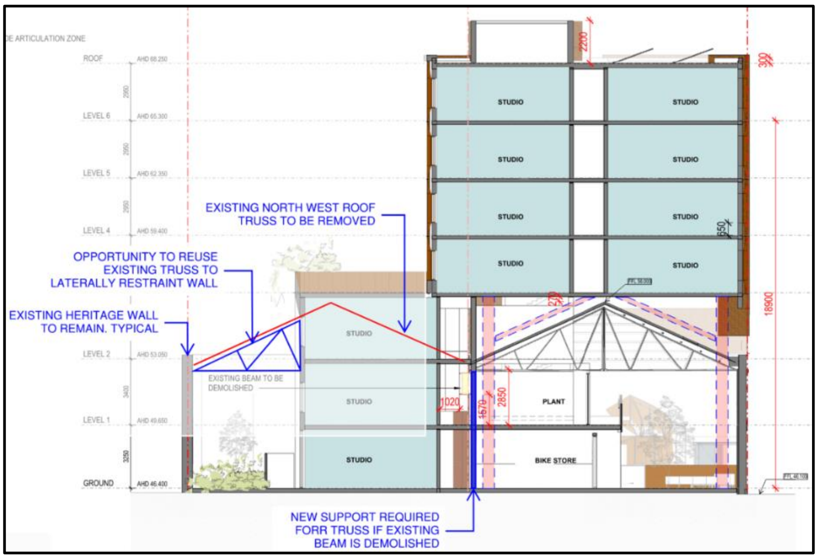

Figure 4 Building section at the west of building - extract from 2732_Brunswick Road_Town Planning Package

3.0 Existing Structural System

Limited existing information of the site has been made available to TTW (VIC) Pty Ltd at the time of preparing this report.

3.1 Site observations

At the request of Bensons Property, TTW (VIC) Pty Ltd carried out a visual inspection of the former cable tram engine house building on 21/10/2024. Based on the site observations, the former cable tram engine house is expected to be comprised of:

- The former cable tram engine house building is average at 8.7m high with a L- shaped building footprint of circa 1020m^2
- The existing structure consists of internal and external brick walls. Given the age of the building, they are anticipated to be supported on a bluestone foundation as one of the common types of foundation construction across Melbourne in the 1880s.
- The roof structure appears to be a hip roof type of construction, which consists of timber planks with timber joist and steel roof trusses. The buildup thickness of the roof structure was unknown at the time of inspection. From the external view, the roof appeared to be a metal roof deck on top. Google map aerial view (Figure 5) also displays the existing roof deck to be in a newer condition in comparison with the adjacent roof condition. It was predicted that the roof sheeting has been replaced for the former cable tram engine house roof structure.
- Several roof openings can be identified across the existing roof structure
- The steel roof trusses appeared to be equally spaced at approximately 3m centres and are made of steel angle open sections and steel rods.
- At the time of inspection, part of the roof trusses structural elements can be seen to be concealed inside the internal brick walls (Figure 6). TTW anticipate these internal brick walls were built after the construction of the roof structure and considered as non-load bearing walls. An indicative location of the internal brick walls can also be referred to Figure 8 on plan
- A riveted transfer beam spanning at the east west direction which separates the northern roof and southern roof bay can be identified on site. This transfer beam is suspended over the steel columns and continues along the existing eastern brick walls (Figure 7 and Figure 8)

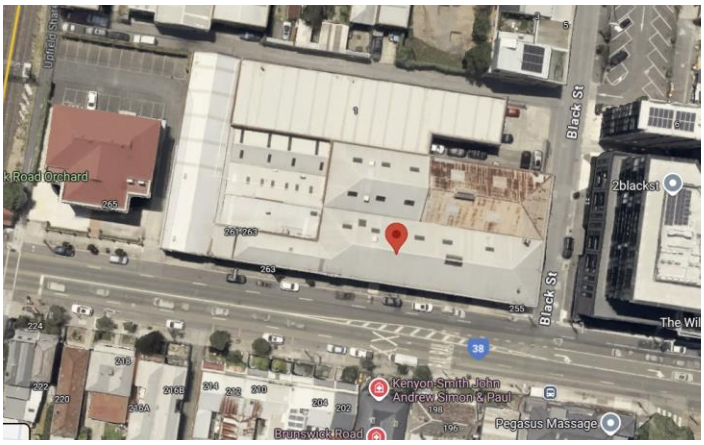

Figure 5 Aerial view of 253 Brunswick Road - snippet from Google map

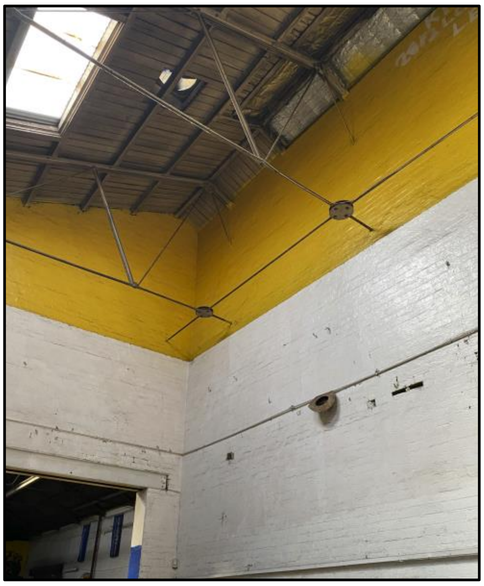

Figure 6 Roof truss bottom chord concealed inside masonry walls

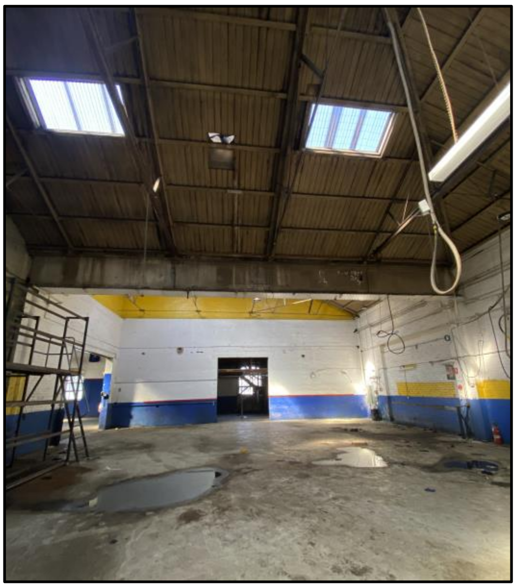

Figure 7 Riveted transfer beam

At the time of inspection, the building structure appeared to be generally in good condition, with no visible signs of cracking or foundation settlement. The arrangement of the roof structure framing can also be summarized in the existing roof plan (Figure 8)

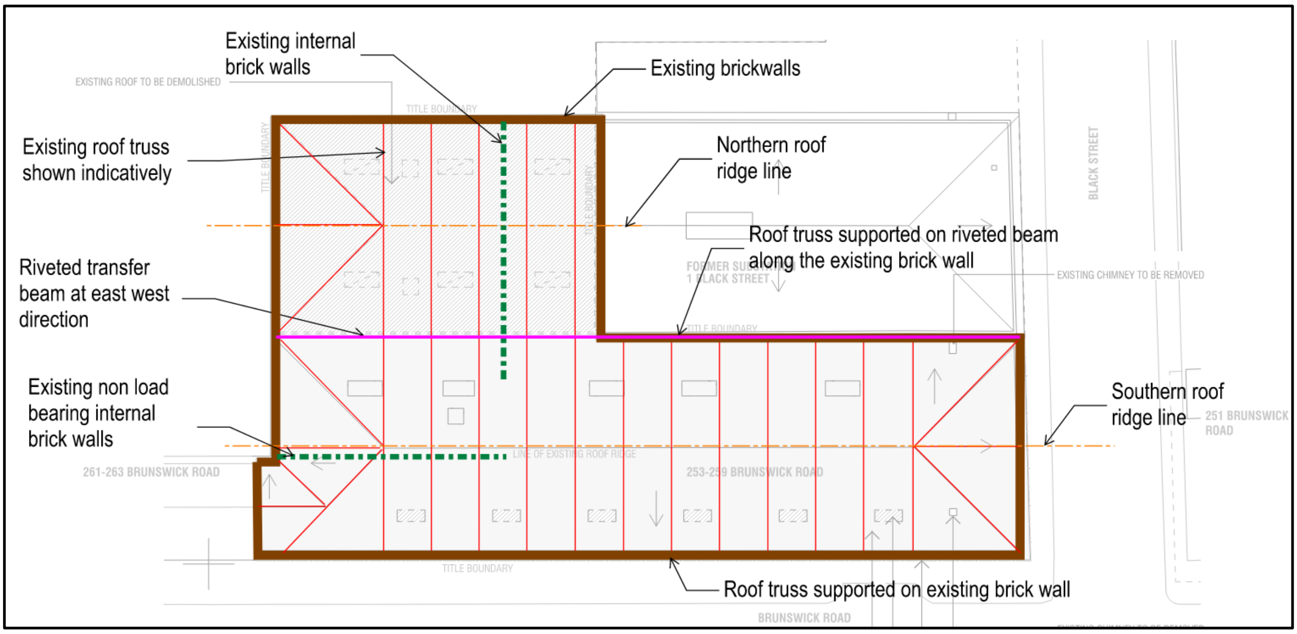

Figure 8 Indicative arrangement of roof structural framing

3.2 Forms of construction of the period

Given the age of the building, it is possible that the form of construction could vary from this. One alternative possibility is wrought-iron riveted beams. On site observation (Figure 9) also shows the form of construction to be identical to the 19th century cast-iron frame construction (Figure 10)

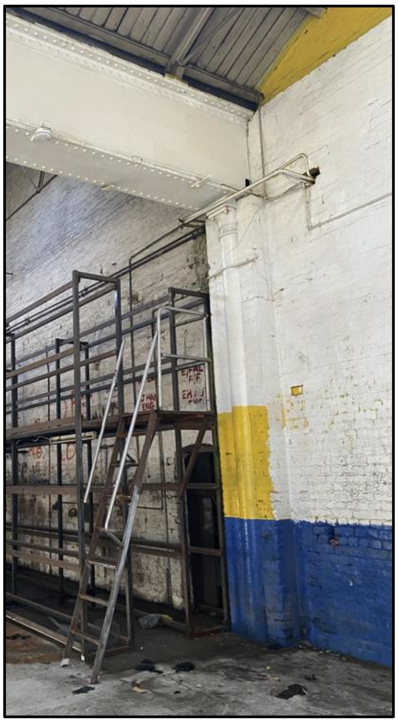

Figure 9 Site observation of riveted beam and steel column

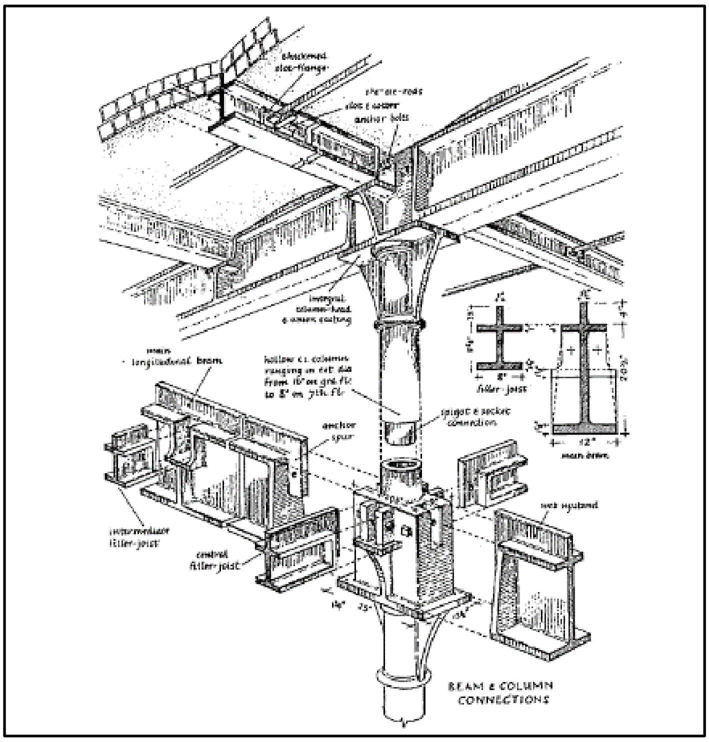

Figure 10 - Example of early 19th century cast-iron frame construction (Ref: SCI Publication 138 via 'Monuments of Industry' reproduced from the Royal Commission on Ancient and Historical Monuments in Scotland)

The exact structural details may be impossible to know without significant invasive investigations, as it is entirely possible that the construction is of bespoke wrought iron or cast-iron plate girders. The modern concepts such as seismic detailing, and vertical and horizontal tying for notional/accidental robustness loads were simply not considered in the design of buildings up until the 1970's/80's.

It should also be noted that any additional existing documentation, if obtainable, will greatly assist with design and compliance of the new structure.

4.0 Pathway for structural compliance

This section sets out how TTW will strategize to satisfy the compliance requirements to the current standard during the detailed design stage. TTW have a long history of working on heritage buildings and are familiar with the key elements to consider in the structural design of the building.

4.1 NCC compliance

The new proposed development would likely be deemed to be building class 3 for student accommodations as per NCC 2022. The following section outlines the key NCC provisions we anticipate will need to be satisfied for the building surveyor to issue a building permit, and subsequent Certificate of Occupancy

NCC compliance can be achieved through several pathways as outlined in Figure 11 below:

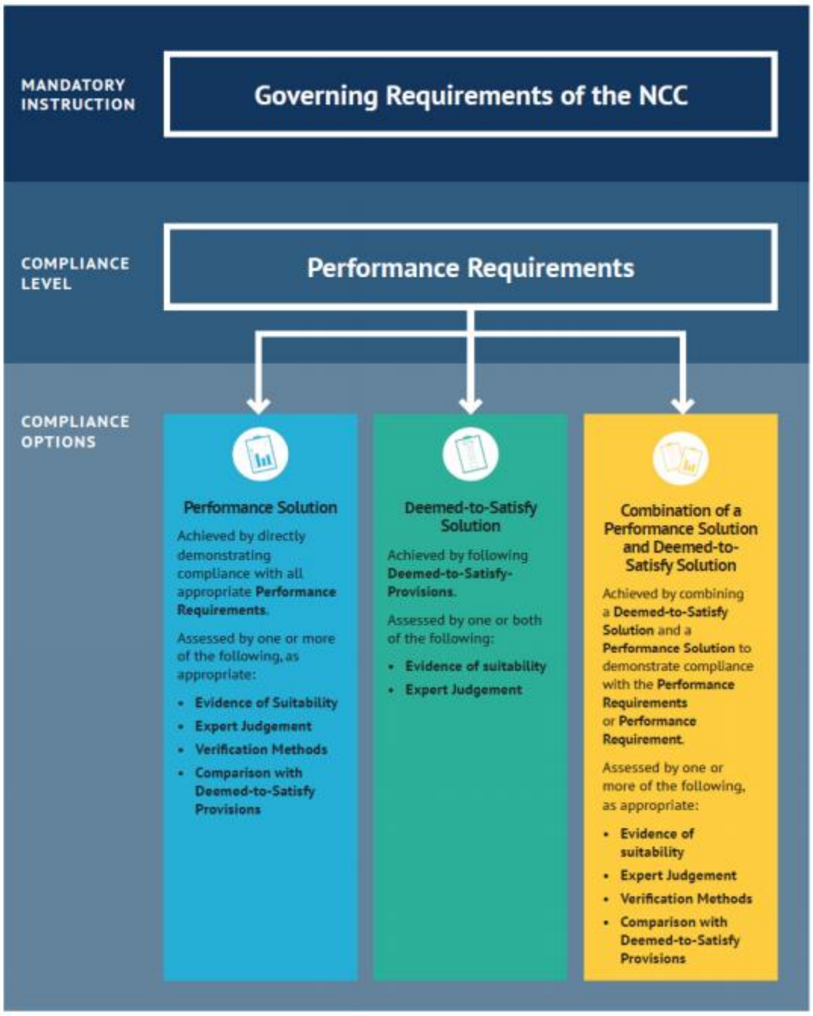

Figure 11 - Pathways to demonstrating NCC Compliance

4.2 Key Performance Requirements

The following performance requirements capture the key considerations that fall within our remit as project structural engineers.

BP1.1 Structural Reliability

(a) A building or structure, during construction and use, with appropriate degrees of reliability, must—
   i. perform adequately under all reasonably expected design actions; and
   ii. withstand extreme or frequently repeated design actions; and
   iii. be designed to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage; and
   iv. avoid causing damage to other properties, by resisting the actions to which it may reasonably expect to be subjected.

BP1.2 Structural resistance

The structural resistance of materials and forms of construction must be determined using five percentile characteristic material properties with appropriate allowance for—

(a) known construction activities; and
(b) type of material; and
(c) characteristics of the site; and
(d) the degree of accuracy inherent in the methods used to assess the structural behaviour; and
(e) action effects arising from the differential settlement of foundations, and from restrained dimensional changes due to temperature, moisture, shrinkage, creep and similar effects.

CP1 Structural stability during a fire

A building must have elements which will, to the degree necessary, maintain structural stability during a fire appropriate to—

(a) the function or use of the building; and
(b) the fire load; and
(c) the potential fire intensity; and
(d) the fire hazard; and
(e) the height of the building; and
(f) its proximity to other property; and
(g) any active fire safety systems installed in the building; and
(h) the size of any fire compartment; and
(i) fire brigade intervention; and
(j) other elements they support; and
(k) the evacuation time.

4.3 Pathway for Structural Compliance of Existing Elements

This section outlines the recommended pathway for compliance for the structural performance requirements of BP1.1 and BP1.2.

4.3.1 Vertical loads

Vertical loads are usually classified as:

- Dead loads. These are permanent loads imposed by the structure’s self-weight, floor finishes and services weight
- Live loads. These are loads imposed by people, furniture, etc, which are likely to change in position and intensity throughout the life of the structure.

The proposed 6-storey high building will be a standalone structure within the existing cable tram engine house building. It should be noted no additional vertical load will be imposed to the existing building. The main structural frame of the proposed new building consists of a combination of concrete blade columns, core filled CHS members up to the Level 3 soffit and 200 mm thick concrete slab floors.. The new structural foundation is anticipated to be bored piles and piled footings.

Further risk and recommendations of the foundation will be explained in Section 5.0.

4.3.2 Lateral loads

Lateral loads imposed on the structure are generally from external sources classified as wind and earthquake loads. The magnitude of these loads are a function of the location and geometry of the building. They are affected by the surrounding vegetation and structures, properties of the soil at the site location and etc.

Modern buildings are typically designed and detailed to resist wind and seismic loads calculated in accordance with AS 1170.2 and AS1170.4, respectively. As mentioned in 4.2.1, the proposed development will be standalone and will be designed in accordance with the latest standards in compliance with the NCC requirements. The former cable tram engine house was constructed back in the 1880’s and as such is not expected to be designed or detailed in accordance with the modern codes.

TTW anticipate that the wind load will govern the lateral design of the existing roof structure. The existing roof structure will need to be independently assessed and verified and be treated as a performance solution with allowance for additional strengthening to the existing structure

From experience, demonstrating compliance for AS1170.4 (seismic loads) is not a straightforward process. The expected nature of the construction is such that there would likely be numerous non-conformances relating to the detailing of the walls and diaphragms as well as structural capacity

In past years AS3826-1998 (Strengthening Existing Buildings for Earthquake) has been relied upon as the basis for assessing existing heritage buildings for seismic performance in Australia. Previously, this has been accepted as a pseudo DTS pathway as outlined in Figure 12, or alternatively it can be accepted as a Performance Solution.

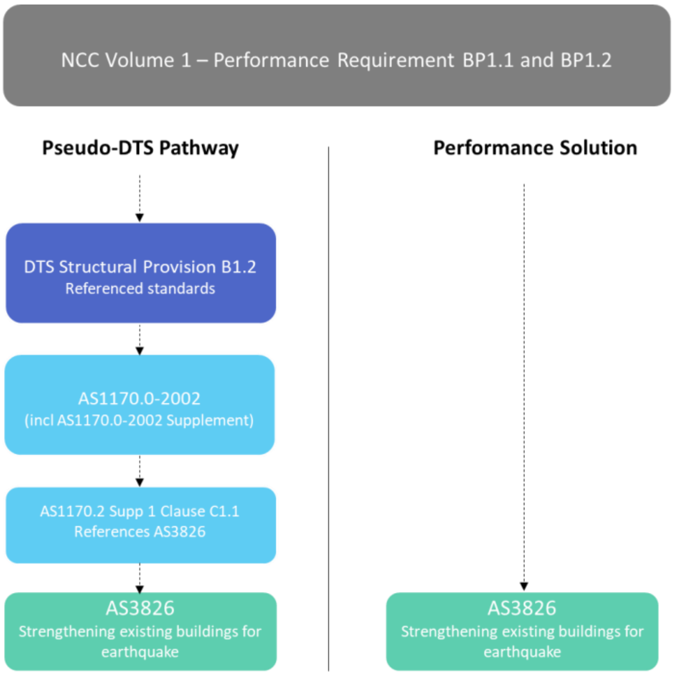

Figure 12 - Pathways for adopting AS3826

It should be noted that in June 2019, AS3826 was formally withdrawn by SAI Global. It is our opinion that the Performance Solution pathway remains a valid approach, and is our recommended pathway for building compliance, to satisfy BP1.1 and BP1.2 relating to seismic actions.

The Approach outlined by AS3826 can be described as a qualitative approach to demonstrating that the building has the ability to resist earthquake loads.

Extracts from key clauses are provided below, with relevant structural commentary outlining our typical approach. Commentary in **green** denotes clauses that are satisfied at this stage of design, commentary in **orange** denotes clauses that are pending future investigations, and commentary in **red** denotes clauses that do not satisfy the provided criteria.

AS 3826 - 1998

Clause 2.3.1 An existing building, except a building classified as Type III in AS 1170.4, shall be deemed to satisfy the requirement for having a minimum resistance to earthquake loads provided it complies with Clause 2.3.2 and the appropriate parts of Clause 2.3.3
The former cable tram engine house would be classified as a 'Type II" building in accordance with the definition in AS1170.4-1993; *'structures including buildings designed to contain a large number of people, or people of restricted mobility'*. Therefore, the provision of the 3826 code are deemed-to-be-satisfied if clause 2.3.2 and 2.3.3 are satisfied.

Clause 2.3.2 For all types of buildings, the following shall apply:

(a) The building shall be visually assessed.
TTW has conducted a site visual inspection on 21/10/2024. The building was generally in good condition with no major sign of cracks or foundation settlement. The brick walls appear to be in a serviceable condition. Further investigation work is also anticipated in accordance with the required compliance work.

(b) The original construction shall be of a high standard of workmanship.
From the site observations, the original construction appears to be of a suitable standard of workmanship and no significant defects were observed

(c) Materials, ties and connections shall be in serviceable condition
Due to height access restriction, only some of the existing roof ties and connections had been inspected and verified. All the structural connections will need to be inspected in detail to determine the compliance of the required standards.

(d) The structure of the building shall be of regular shape and shall be free from significant weaknesses.
We have assessed the building based on the available existing building plans and note that the building is of regular geometry and will satisfy this requirement.

(e) The building shall comply with the deemed-to-satisfy details set out in Appendix C. These details set out principles in detailing connections that shall be followed. They do not include other engineering or architectural details, which shall comply with the relevant material Standards and accepted building practice
Appendix C outlines the typical tie details for floors and roof to walls as illustrated in Figure 13 and Figure 14for typical floor to wall connection details as per AS3826. These typical details are to be inspected and verified on site. Where unsatisfactory, strengthening works will be required.

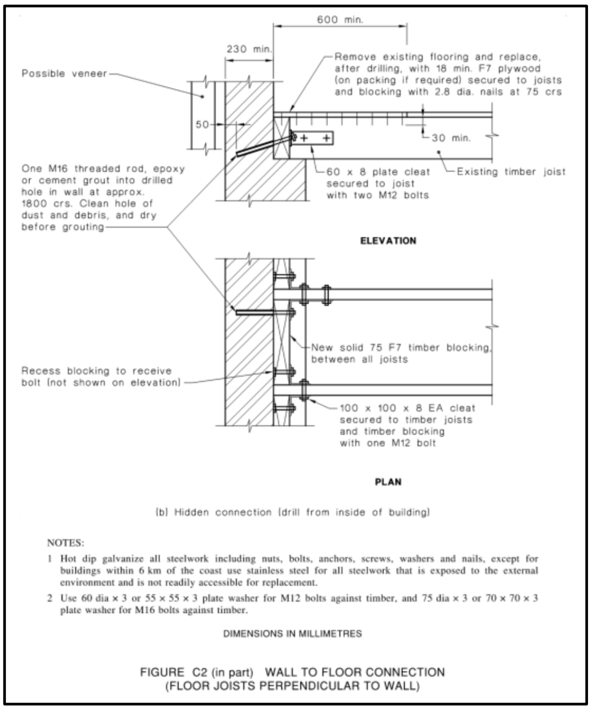

Figure 13 Extract of AS3826 Appendix C part 1

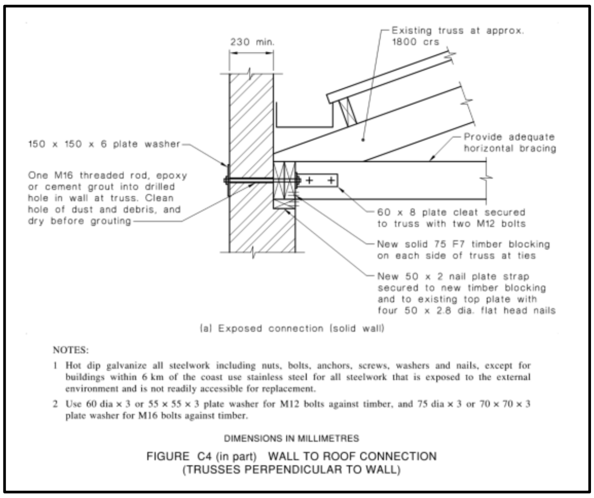

Figure 14 Extract of AS3826 Appendix C part 2

Clause 2.3.3 Predominant Structural System

2.3.3.1 General. The capacity of the predominant structural system to resist horizontal earthquake loads shall be assessed and the requirements of Clauses 2.3.3.2 to 2.3.3.4 shall be applied as appropriate.

An assessment will be carried out to demonstrate that the building has sufficient shear walls in each direction to resist the required threshold loads in AS3826, this will not be an exhaustive study and complex 3d analysis as per the requirements of AS1170.4 and associated material standards to demonstrate ductility and post-yield behaviour.

2.3.3.2 Unreinforced Masonry or unreinforced concrete bearing walls. For buildings with a predominant structural system of unreinforced masonry or unreinforced concrete bearing walls, or both, the following shall apply:

(a) Buildings up to and including three storeys high shall have—
The former cable tram engine house building is 1 storey high.

i. a gross floor area at each level up to 300 sqm
The scaled GFA (based on existing architectural drawings) is approximately 1020 sqm. With 300sqm per storey and total 3 storey, this can be approximated to 900sqm. TTW propose that this area limit be reviewed and have successfully agreed a dispensation for this with Building Surveyors in the past

ii. horizontal load resisting walls at 8 m centres maximum in each direction
Shear walls in both directions exceed this distance. Given this is a boxed frame and lateral stability assessment will be required to demonstrate the building has sufficient shear walls in each direction to resist the required threshold loads

iii. walls course-bonded at corners or equivalently connected
To be investigated. We anticipate solid masonry construction using bonded brickwork.

iv. walls with an h/t ratio of less than or equal to 18:1
The existing brick walls are assumed to be approximately 6.75m high and 0.3m thick, h/t ratio is 22.5. This is based on unreinforced masonry assessment and further investigation can be explored in the next detailed design stage.

v. a timber-framed roof connected to walls or concrete roof bearing on walls
The existing roof structure consists of timber planks supported on steel roof trusses. The connections to the brick walls and transfer rivet beam need to be inspected and verified

vi. timber-framed first and second floors connected to walls or concrete floors bearing on walls; and
There is a mezzanine floor with a mixture of steel beams and timber planks at the northwest corner of the building. It was unclear if the mezzanine is connected to the brick walls. It was deemed to be a secondary standalone structure and does provide any lateral restraint to the adjacent brick walls.

vii. a timber-framed ground floor or concrete ground floor up to 1 m clear above ground level at any point, which need not be connected to walls
The ground floor did not appear to be higher than 1m above ground level

2.3.4 Parts of buildings The following shall apply to elements other than the main structure:

(a) Unreinforced masonry or unreinforced concrete parapets and chimneys, which have a ratio of unrestrained height above the uppermost connections to effective thickness greater than or equal to 3:1, shall be connected to the roof structure to prevent them from falling
The chimneys and parapets wall to be further investigated. The contractor should verify where the height of the parapet exceeds 1m and either trim the parapet or contact TTW for a restraint detail. A typical detail can also be referred to Figure 15.

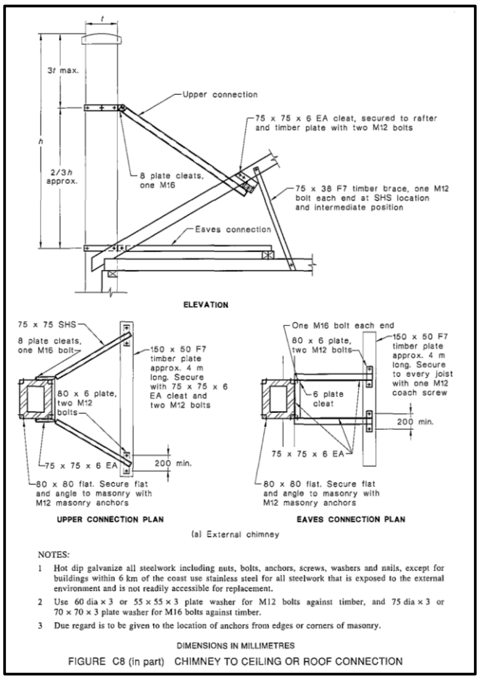

Figure 15 Extract of AS3826 chimney to ceiling or roof connection

(b) Minarets, cupolas, orbs and other similar ornamentations shall be connected to the building to prevent them from falling
The building appears to be generally free of decoration

(c) Cornices and similar projections in external walls shall project no further from the wall face than the thickness of the wall
No significant projections of cornices have been found in the site inspection. The contractor to verify if this is the case.

(d) Veneers and external leafs of cavity walls shall be tied to the supporting wall
We do not anticipate a veneer type of construction given the era of the building. The contractor to verify if this is the case. Note: specific intrusive investigations may be deferred to the contractor as these are not included with TTW's current scope.

(e) Unreinforced masonry partitions, infill panels, gables and other non-load-bearing elements shall be connected to the structure either at the top or at both side edges, and they shall have an h/t ratio less than or equal to 27:1. If they are not connected, they shall have an h/t ratio less than or equal to 6:1
The existing brick walls are tied to the roof trusses and assumed to be approximately 6.75m high and 0.3m thick, h/t ratio is 22.5

(f) Awnings shall be positively anchored to the structure and a suitable load path shall be established for the transmission of the awning forces that will be imposed on the structure. It shall not be assumed that an awning is capable of supporting masonry and other heavy materials falling from above
There are no awnings to our knowledge.

(g) Major items of plant and equipment shall be connected to the main structure
There is no plant and equipment on the existing structure to our knowledge.

5.0 Risks and recommendations

In addition to the pathway for the structural compliance, TTW have also identify the following risks with recommendations for design considerations. However, TTW structural and heritage engineers will carefully manage these risks during the detailed design and construction supervision.

5.1 Foundations

From the Heritage Victoria's letter, TTW also noted that under the former cable tram engine house building may contain deep underground pits, remains of underground tank and the existing footings of the chimney stack. It is important to conduct a detailed geotechnical investigation and feature underground scan prior to the next design stage. This is to avoid any intrusion to the construction of the new foundation. The alternative to the clash of existing pits or tanks with the new foundation is via a structural bridging detail (Figure 16).

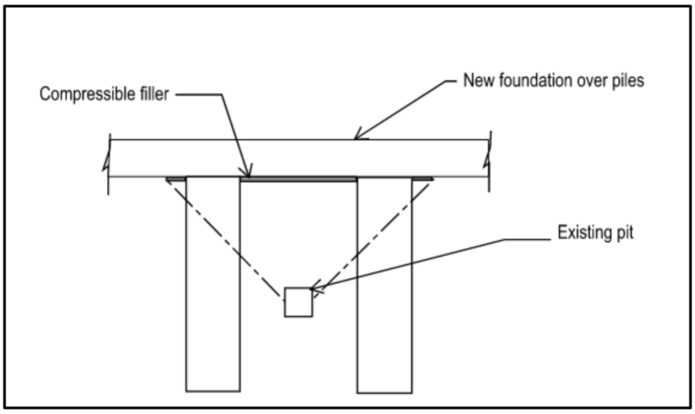

Figure 16 Structural foundation bridging detail

The current proposed foundation for the new development consists of bored piles and piled footings. We understand that the existing external walls will likely be a bluestone foundation and to avoid potential undermining of the existing footings, the column/ bored piles have been nominated at approximately 2.5m away from the external walls.

5.2 Additional roof load allowance

TTW understand the space within the former cable tram engine house will be occupied in the future and additional roof insulation is expected. From the site inspection, it can be observed that the eastern roof bay consists of steel monorails that tied under the roof truss bottom chords (Figure 17). It is assumed to support manoeuvring any heavy equipment during the operation of the building, hence there is a potential allowance for additional roof weight within this zone. The structural integrity of the roof trusses including the connection shall be further investigated to ensure the structural adequacy of any new additional roof weight.

Figure 17 Monorails at the underside of roof truss bottom chords

5.3 Building interfaces

The new proposed building is an independent structure to the existing building except the northwest zone where the existing brick walls will be laterally restrained by the new structure.

5.3.1 Existing brick walls at northwest zone

The proposed new development will require the demolition of the roof structure at the northwest zone of the former cable tram engine house building. The existing heritage walls are anticipated to be laterally restrained by the roof trusses. The removal of the existing roof trusses at the northwest zone will result the existing brick walls to be free standing. TTW propose the existing brick walls to be laterally restrained by the new structure to retain the structural load path of the existing brick walls.

5.3.2 Existing building and new structure movement gap

The building movement between the new and existing are also considered. AS1170.4 provides a guidance for building pounding effect with a limitation of 1% of structural height.

The top of the existing brickwalls is typically 6.75m above ground and this limit the building movement to 67.5mm. TTW has allowed for 100mm clearance at the building interface which is deemed to satisfy the standard requirement.

5.4 Roof penetrations through existing roof

Based on the current layout plan, the proposed building structural columns below L3 will penetrate through the existing roof. New structural steel trimmers can be introduced to support the proposed new penetrations at the existing roof. The steel trimmers can also make use of the new columns as the primary support instead of altering the existing roof truss.

5.5 Construction impact to existing building

5.5.1 Construction of new bored pile foundation

During the schematic concept design, without any detailed geotechnical investigation, TTW has taken the reference from a past project site circa 200m away from 259 Brunswick Road, and anticipated the underlying soil strata consist of silty clay at 2m below ground and weathered siltstone at 16m below ground. The proposed new 6 storey high building structure is expected to be supported on bored pile foundation and founded at the estimated weathered siltstone strata level.

TTW understand the site constraint of 6.75m head height clearance below the existing roof trusses throughout. The main site access is via the roller shutter at the southeast existing brickwalls facing Brunswick Road.

Without dismantling the existing roof and modifying the existing structure, a proposed solution to the site constraint is by adopting a smaller piling rig for the new bored pile construction. The MAIT baby bored piling rig (Figure 18) typically ranges between 2.4m to 5.4m high and is useful to work around sites with limited head height clearance. However, the single pile length of MAIT Baby bored piling rig is generally shorter than a conventional bored pile. The reduction of pile length can be compensated with group of additional piles and tied together with a pilecap. TTW can work closely with the geotechnical and piling contractor in the next design phase to ensure no structural impact to the existing building.

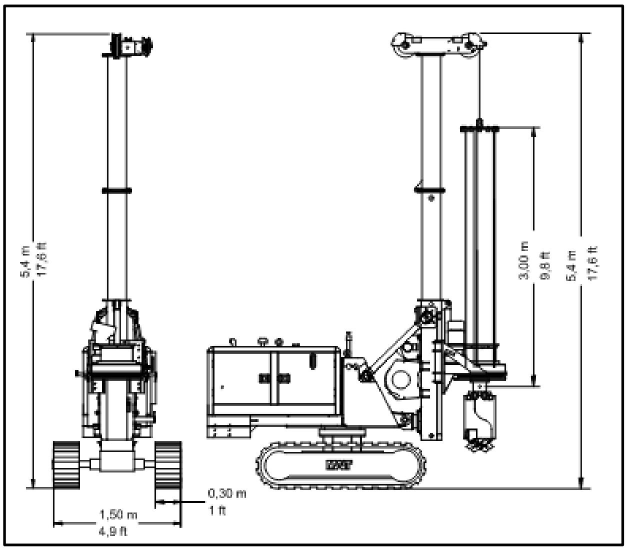

Figure 18 MAIT Baby bored piling rig - extract from MAIT baby drill brochure

5.5.2 Construction above the existing roof structure

The new L3 structure will be constructed above the existing roof structure. As discussed in Section 5.4, the proposed new building columns will penetrate through the existing roof.

The new structural columns below the proposed Level 3 floor are steel encased concrete columns. They can be erected to the underside of the existing roof and provide support for the trimmer beams of the new roof penetrations (Figure 19).

Without dismantling the existing roof, the roof penetrations can be locally removed after the trimmer beams have been installed. This will retain the structural adequacy and performance of the existing roof structure. Any waterproofing and flashing requirement over the existing roof will be further coordinated in the next design phase.

The Level 3 floor can also take advantage of the lightweight steel framing construction with Bondek floor supported on shear studded steel beams. This can remove the requirement of conventional propping and formwork for Level 3 floor construction. Temporary platforms for scaffolding and construction workers can also be installed outside of the existing building which reduce the risk of invasive construction over the former engine house building. The detail construction sequence can also be further coordinated with the builder in the next design phase to ensure no structural impact to the existing building.

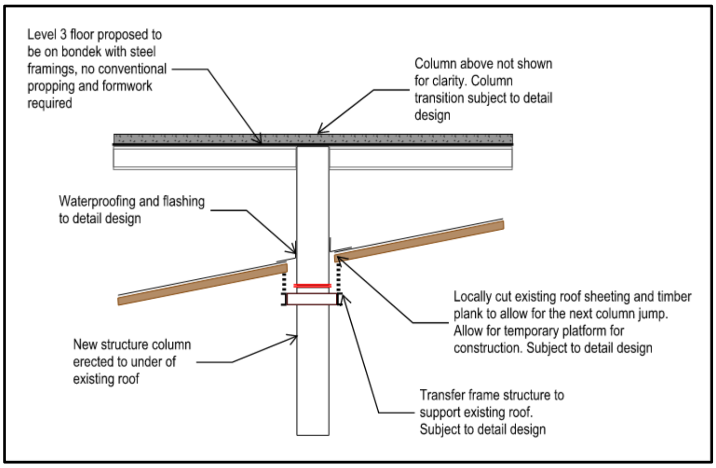

Figure 19 Proposed construction detail at roof penetration

Currently, there are two options for the Level 3 transfer structure. The first option features a 500WC transfer beam beneath the floor slab at Level 3, supported by core-filled CHS members (Figure 20). The transfer beam carries loads to the core-filled CHS via CHS struts. The transfer beam can be designed as either a double beam or a double flange beam.

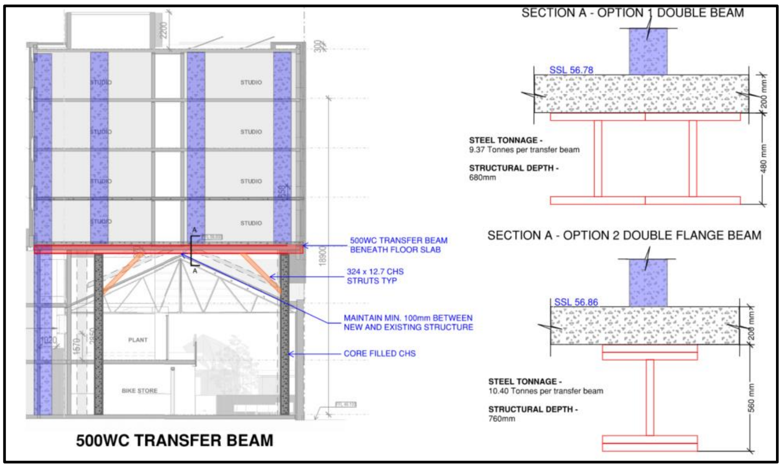

Figure 20 Proposed transfer structure at Level 3 – Option 1

The second option utilises a transfer truss, which, like the first option, transfers loads to the core-filled CHS via CHS struts (Figure 21). Blade columns within the studio wall will extend from Level 3 to the roof for Option 1 and from Level 4 to the roof Option 2.

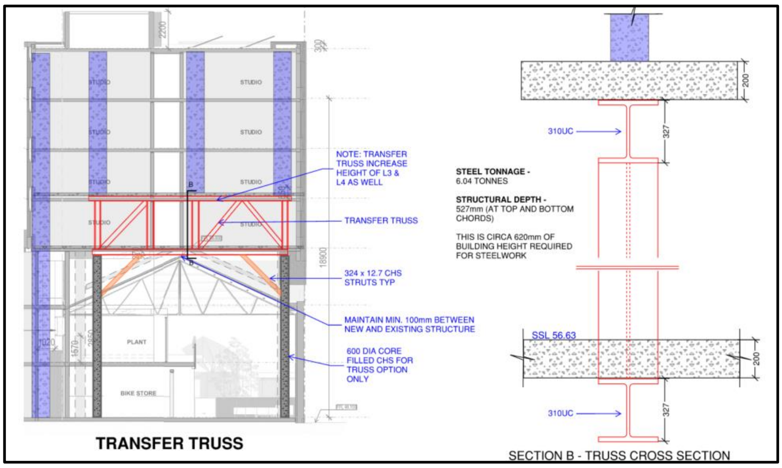

Figure 21 Proposed transfer structure at Level 3 - Option 2

5.6 Further Design Issues

The following includes a brief list of further design issues to be resolved during the next design stage:

- An agreed approach for the proposed performance solution to validate the building's structural adequacy under Reg 233 sub-regulation 4(a), and confirmation on whether the Performance-based design brief (PBDB) process is required.
- A geotechnical investigation and in ground services survey work
- A strategy is required to simplify protection works notices for adjoining owners at later stage

6.0 Conclusions

This report has set out the strategy for structural compliance with relevant provisions of the NCC, for the proposed works to be undertaken at 253-263 Brunswick Road, known as Cable Tram Engine House.

In addition to setting out the structural strategy, this document also addresses the concerns from Heritage Victoria and outlines a road map for additional items to be investigated or confirmed, by TTW and others, in order to meet the requirements of the recommended compliance strategy.

In conclusion, the former cable tram engine house building is generally in good condition based on the site observations and through careful design and engineering, the proposed new development will not impact the structural integrity of the existing structure.

7.0 Limitations

This report has been prepared for Bensons Property. TTW cannot accept responsibility for any liability arising from third party reliance on the recommendations contained herein.

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