Addendum

New Dunedin Hospital – Engineering Assessment of Existing Facades

Blocks 1 to 5 Cumberland Street
Blocks 3 to 5 Castle Street

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Introduction

WSP (formerly WSP Opus) was commissioned by the Ministry of Health to review the existing heritage facades on the Cadbury Site and to consider (from an engineering perspective) whether it was possible to retain them either independently or by way of being incorporated into the new hospital construction. That assessment is contained in *New Dunedin Hospital - Property & Building Survey Services - Engineering Assessment of Existing Façades Report.*

The assessment of the facades and options for their retention was undertaken in the context of the original Preliminary Site Masterplan which indicated a preferred location for the New Dunedin Hospital (NDH) extending across both the Cadbury and Wilsons sites. Further analysis and costing of that layout option was subsequently completed in 2019 which led to an options evaluation process. During that process, WSP was asked to consider whether relocation of the NDH entirely on the Cadbury site would result in any material difference to the findings of its original assessment. As set out in the report, no such material difference was identified.

The configuration and layout of the new Hospital has been re-evaluated and adjusted since the original report was completed. The Ministry of Health has now confirmed that the NDH will be located across both the Cadbury site and the Wilsons site but with a smaller footprint (illustrated in Appendix A). The southern portion of the Cadbury site is proposed to be used primarily for vehicle/ambulance access, circulation and parking, and plant required for the functioning of the NDH.

The Ministry of Health has asked WSP to consider whether this preferred layout would have any material impact on the findings of its original assessment. WSP's response to that request is detailed in this Addendum.

The disclaimer and limitations described in the original report apply to this addendum also.

Façade Retention Considerations

The currently proposed layout for the ground floor of the new hospital on the Cadbury site is shown in Figure A-1 below. The location of the existing heritage facades are marked with red lines to show their proximity to the proposed buildings.

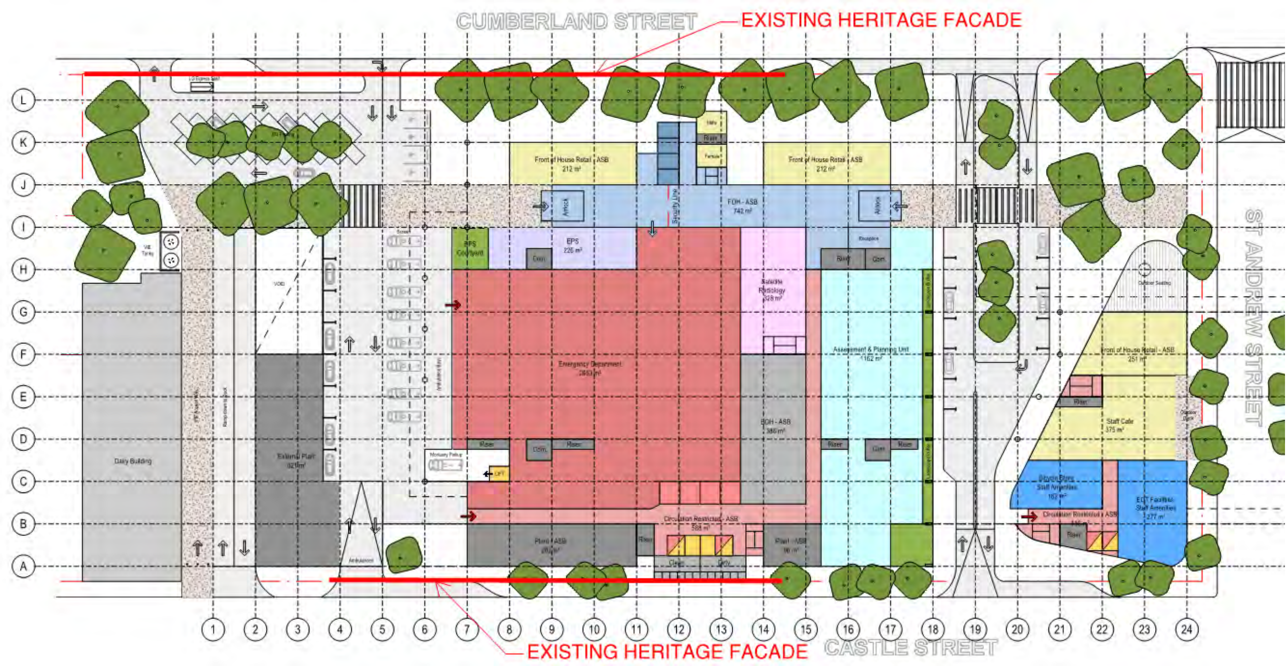


Figure A-1 : Level 00 – Block and Stack Option 5.3 with façade locations

Figure A-1 shows that the new hospital building is significantly setback from the line of the existing Cumberland St facades and setback to a lesser extent from the Castle St facades. The new laundry area between grids 11 and 14 is proposed to be built out to the street boundary, this is now the only area where the new hospital building extends to the existing façades. The existing facades cross the proposed ambulance and carpark entrance and exit points.

Option Evaluation

RAG Analysis

The Red, Amber, Green (RAG) table outputs have been reassessed considering the latest layout. The impact on each factor is discussed below.

Cost

The cost of the façade retention, both temporary and permanent, is likely to reduce marginally where the new building is significantly setback, as the complexity of the build reduces with more available space. However, this was not considered a significant enough change to affect the RAG analysis outcome.

Time

With more of the new hospital setback form the street boundary, the façade retention construction time has improved slightly for some of the options. However, it is still significantly more than the baseline of building a new hospital on a cleared site and the RAG assessment has not changed.

Impact on Heritage

Where the hospital is now setback further from the street boundary, the impact on heritage is potentially greater as it will be more obvious that the retained facades are not part of a larger building, but are instead standalone elements. This separation potentially decreases the heritage value of the retained facades. For these options (2A, 2B, 3A and 3B) the assessment has been left as "Amber", as despite the potentially increased impact, these options are still significantly better than demolition or re-construction which have been scored as "Red".

Impact on Hospital

The impact on the hospital, such as useable site area, vehicle access routes, daylight access and views from the hospital is still very significant, so the RAG assessment is unchanged.

Buildability

The buildability of the façade retention supports has improved slightly with more space to work, but again not enough to change the RAG table assessments.

Traffic Disruption

The impact on traffic remains unchanged for each option. However, it is potentially more likely that on Cumberland Street with more space for temporary bracing within the site, that one of the less intrusive options (2B, 3A and 3B) would be chosen. On Castle Street, the impact on traffic could still be significant. Again, these factors are not sufficient to change the assessments.

Seismic Resilience

The seismic resilience of the various options is unchanged.

Site wide Considerations

Both the Cumberland St carpark entrance and exit, and the ambulance bay entrance and exit, are incompatible with the existing façades. The permanent support required for the existing facades will also have a severe impact on the proposed carpark circulation and the number of carparks possible.

Setting the hospital building back from the neighbouring unreinforced masonry buildings to the south, as currently proposed, is a sensible approach to managing the seismic hazard from neighbouring sites.

RAG table options

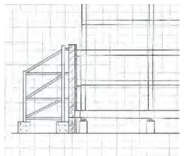
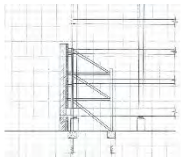
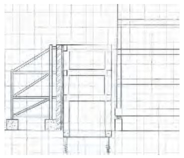
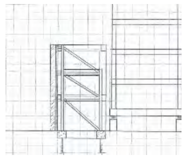
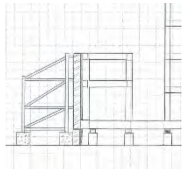
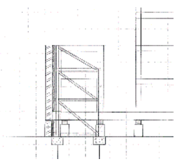
The RAG table is reproduced below in Table A-1 for reference, but has not changed as noted above.

Options 1a and 1b could now only occur in a short section along Castle Street where the new hospital will be built to the street boundary.

Options 2a and 2b – are both slightly more buildable with the additional space between the facades and the new hospital. Option 2b is still time consuming with the staging required to install the temporary bracing, allow safe demolition and the construction of the permanent frames.

Options 3a and 3b – both involve extending the isolation plane out to, and through the facades to provide the best seismic resilience. This is less practical with a greater distance to the main building.

Table A-1: Update RAG Analysis Table.

Consideration	Option								
	Baseline	1a	1b	2a	2b	3a	3b	4	5
	New Hospital 'Clear' Site							Deconstruct and Reconstruct	GRC Replica
Cost	G	A	R	A	A	R	R	R	A
Time	G	A	R	A	R	A	R	R	G
Impact on Heritage	R	A	A	A	A	A	A	R	R
Impact on Hospital	G	R	R	R	R	R	R	R	A
Buildability	G	A	R	G	R	A	R	A	G
Traffic Disruption	G	R	G	R	G	R	G	G	G
Seismic Resilience	G	A	A	R	R	A	A	A	G

Conclusion

The conclusions of the original report remain unchanged when the latest hospital layout is considered. Some minor changes to the factors were noted, but the changes were not significant enough to change the RAG table. assessments.

It is still possible to retain the façades; however, this will affect the layout and usage of the site, and both the extent and complexity of the construction work required. This will have significant cost, programme and health & safety implications.

The smaller footprint of the proposed hospital means that if the facades were retained it will become more obvious that they are standalone features. This will potentially increase the impact on their heritage value while still having a significant effect on the new hospital.

New Dunedin Hospital - Property & Building Survey Services

Engineering Assessment of Existing Façades
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Blocks 3 to 5 Castle Street

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Document History and Status

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Executive Summary

WSP Opus have been commissioned by the Ministry of Health, via RCP, to review the existing façades on the Cadbury Site from an engineering perspective and to consider if they can be retained either independently or by being incorporated into the new hospital construction.

WSP Opus have visited the site to visually inspect all the façades. An assessment of their current condition has been made. This is recorded in a summary table for quick reference, and in more detail in Appendix A.

The new hospital buildings proposed for the Cadbury site will be designed to meet the Building Code requirements for an importance level 4 (IL4) building. This includes the requirement to remain operational immediately following a 1 in 500-year earthquake and to withstand a 1 in 2500-year earthquake. This includes the hospital buildings, the services which make it operational, access ways for the public, supplies, emergency vehicles, and the helicopter service. Therefore, any façades to be retained either free standing in these areas, or as part of the hospital structure, will also need to meet these criteria.

It is possible to retain the façades, however their retention will affect the layout and usage of the site, and both the extent and complexity of the construction work required. This will have significant cost, programme and health & safety implications. From our Red/Amber/Green (RAG) analysis all the options considered had at least one 'Red' score, indicating that none of them could be considered favourable, and that all the options have at least one severe limitation.

The concept design of the hospital is currently being developed. It is therefore not possible to determine the most suitable retention treatment for each block, as the location of the hospital building footprint in relation to the facades is not known at this stage. Consequently, a range of options have been considered.

Any temporary supporting works will be substantial and if placed on the outside of the site will significantly impinge on the pavements, roads and buried services of the state highways on Cumberland and Castle Streets. To support the walls temporarily on the inside is possible as shown in the options, although this would add significant complexity, cost and time.

The method of attaching the façades to new buildings will depend on the final design chosen. It is possible to attach the facades to the new buildings; however, a significant amount of additional structure will be required to achieve this. The existing façades have many openings for windows and doors which are unlikely to line up with floor levels proposed for the new hospital which may further compromise the design.

The brickwork facades to Blocks 1 and 2 of the Cadbury site are in poor condition mainly due to their age and damp penetration over many years, and they will require significant work to improve their integrity, including upgrading the foundations to mitigate the effects of liquefaction. There may also be a residual seismic risk with these masonry facades depending on the level of resilience adopted.

In total seven options to retain the facades were considered including de-constructing the facades and rebuilding with reinforcement and erecting replica facades in lightweight GRC panels. These last two options are unlikely to be preferred due to their greater impact on the heritage fabric:

Introduction

The new Dunedin Hospital is proposed to be built on the former Cadbury factory site between Castle Street and Cumberland Street in Central Dunedin.

The configuration and layout of the new Hospital has been subject to extensive evaluation. The initial Preliminary Site Masterplan was released in December 2018 and indicated a preferred location of the Hospital which extended across the Cadbury site and onto the northern block (known as the Wilsons site). Further analysis and costing of that layout option was subsequently completed in 2019 which led to a further options evaluation process. As a result of that process, the preferred site layout now locates the new Dunedin hospital buildings entirely on the Cadbury site.

The assessment detailed in this report was undertaken in the context of the original Preliminary Site Masterplan. Following confirmation of the final preferred site layout, an update of this assessment was undertaken to determine whether that layout would result in any material differences to the findings of the original assessment. The existing buildings and façades on the Cadbury site have heritage value as outlined in the Underground Overground report.

Through RCP, WSP Opus has been requested by the Ministry of Health to review the engineering implications of retaining the existing building façades on the former Cadbury site. This included the following:

- Façade condition assessment.
- Concept design and drawings of a temporary bracing system.
- Development of façade retention options.
- Evaluation of retention options.

In developing conceptual options to retain the façades, we have considered both temporary support during partial deconstruction and construction of new buildings, and permanent support, where the façades are supported by the new hospital buildings, or independent purpose-built support structures.

Note that we have not been asked to advise on:

- The Dairy and Machine House building.
- The engineering feasibility of retaining the existing buildings on the site, although we note that Initial Seismic Assessments of the oldest buildings are approximately 20%NBS(IL2), so they would require a seismic upgrade to form part of the hospital complex.

Andrew Blacker and Simon Burrough have visited the site several times from June 2019 to September 2019 to inspect the façades of the existing buildings at each floor level internally, and from street level externally. Will Parker visited the site in September 2019.

A selection of original construction drawings and alteration drawings were available and have been reviewed.

WSP Opus have reviewed the geotechnical study prepared by Beca for Mondelez on the Cadbury site in 2017. Previous structural reports on the buildings, Block 1A, Block 2A, Block 3A and Block 5 by Hanlon and Partners have also been reviewed.

The configuration and layout of the new Hospital has been subject to extensive evaluation. The initial Preliminary Site Masterplan was released in December 2018, indicated a preferred location of the Hospital across both the Cadbury and Wilsons blocks. Specifically, the new Acute Services Building would be located on the Cadbury Site, and the new Ambulatory Services Centre would be constructed on the Wilsons Site to the north. Further analysis and costing of that layout option was subsequently completed in 2019 led to a further options evaluation process undertaken by the Ministry of Health. As a result of that process, the preferred site layout was revised, and now locates the new Dunedin hospital buildings entirely on the Cadbury site. The Acute Services Building is proposed to be on the southern end of the Cadbury Site with the Ambulatory Services Centre on the northern end of the site.

The assessment detailed in this report was undertaken in the context of the original Preliminary Site Masterplan. Following selection of the final preferred site layout (i.e. Cadbury only), a review confirmed that the change in layout would have no material impact on the findings of this assessment.

Concept design of the new Hospital buildings in accordance with that preferred site layout is now underway.

The façades in question are shown in plan in Figure 1 below and may be listed as: -

A. Cumberland Street side (Approx. North West facing)

    1. Block 1 (Cadbury World)
    2. Block 2 (Reception and Offices)
    3. Block 3A (Raw Materials and Manufacturing)
    4. Block 4A (Engineering Workshop Labs and Offices)
    5. Black 5 (Manufacturing and Packing)

B. Castle Street Side

    1. Block 3C (Raw Materials)
    2. Block 4C (Engineering and Manufacture)
    3. Block 5 (Manufacture and Packing)

Figure 1: External view of temporary propping to façade.

Structural Performance Objectives

Building Code Requirements

Hospital

The hospital buildings on the site will have emergency, surgical and post-disaster functions. The buildings will therefore be designed as Importance Level 4 (IL4) facilities in accordance with AS/NZS 1170.0. The hospital will also need to meet the serviceability limit states as prescribed by AS/NZS 1170.0. Refer Appendix D for the relevant extracts from AS/NZS 1170.0.

The Ultimate Limit State at IL4 requires that the hospital will maintain life safety in a 1 in 2500-year earthquake. The Serviceability Limit State SLS2 requires that it shall remain largely undamaged and fully operational after a 1 in 500-year earthquake.

Façades Temporary Support

The Importance Level to be adopted for the temporary support of the façades would be a minimum of Importance Level 2 (IL2 - normal buildings) but could be considered to be Importance Level 3 due to their high value to the community. This would align with the time and expense which would be required to retain the façades. The temporary support may be required for several years and a design life of 5 years has been considered for the design of temporary support.

Permanent Façade Support

If the façades are incorporated with the hospital structure, they would also be designed as IL4 structures. If the façades are separate structures but could affect the operation or access to the hospital, they would also be designed as IL4 structures. At this stage, as the layout of the site is unknown, they have conceptually been considered as IL4 structures.

Strength

There are minimum levels of strength for existing buildings prescribed by the Building Act, generally 34% New Building Standard (NBS). Guidance on levels of strength and their relative risk is also provided by the New Zealand Society for Earthquake Engineering (NZSEE). NZSEE recommend a minimum rating of 67%NBS. It should be noted that the guidance on strengthening generally treats heritage buildings on a case by case basis, and we expect that the Ministry of Health would also take this approach. The strength target that has been adopted at this stage is 100%NBS(IL4), noting that for the masonry façades, the wall capacities would be based on probable rather than dependable strengths.

Stiffness

The existing heritage façades in Block 1 and 2 are solid masonry walls which are typically at least 350mm thick. These walls are very stiff but have weak mortar. The wall strength comes from adhesion of the mortar and from the weight of masonry above. Walls acting out of plane rely significantly on the weight of the masonry above, and for this reason span vertically. They span between horizontal lines of support such as floors and the roof. This is provided there is suitable connections and the floors and roof can provide the required support.

The walls are relatively brittle. Once the wall has cracked the adhesion is lost and the only capacity available is that generated by the weight of the wall above closing the crack. After cracking, the residual strength in plane can be relied on provided that the displacements are small enough. It should also be noted that this damage may be difficult to repair.

Seismic Resilience

For the purposes of this report, we will use the term resilience to mean the reduction in damage to, or ease of repair of, the heritage façades in future earthquakes. This is partly covered by the Building Code requirements for an IL4 Building (refer to the following section), especially the SLS2 requirements which require the building to be operational following a 1 in 500-year earthquake.

Resilience can be incorporated by a combination of the following:

- Reducing the level of seismic demand that the façades are exposed to, for example by incorporating seismic isolation.
- Providing improved support to the façades, for example by providing additional structural elements.

When considering the retention of the heritage façades we have also attempted to develop options that will answer the following questions:

- How will any retained structural heritage fabric perform in future earthquakes?
- How can resilience be incorporated into the remedial works to limit future damage to heritage fabric?
- How can the structural intervention be effective yet be minimised?
- How can resilience be incorporated in a reversible manner?
- If resilience is reversible, how will this affect the building's aesthetics and use?

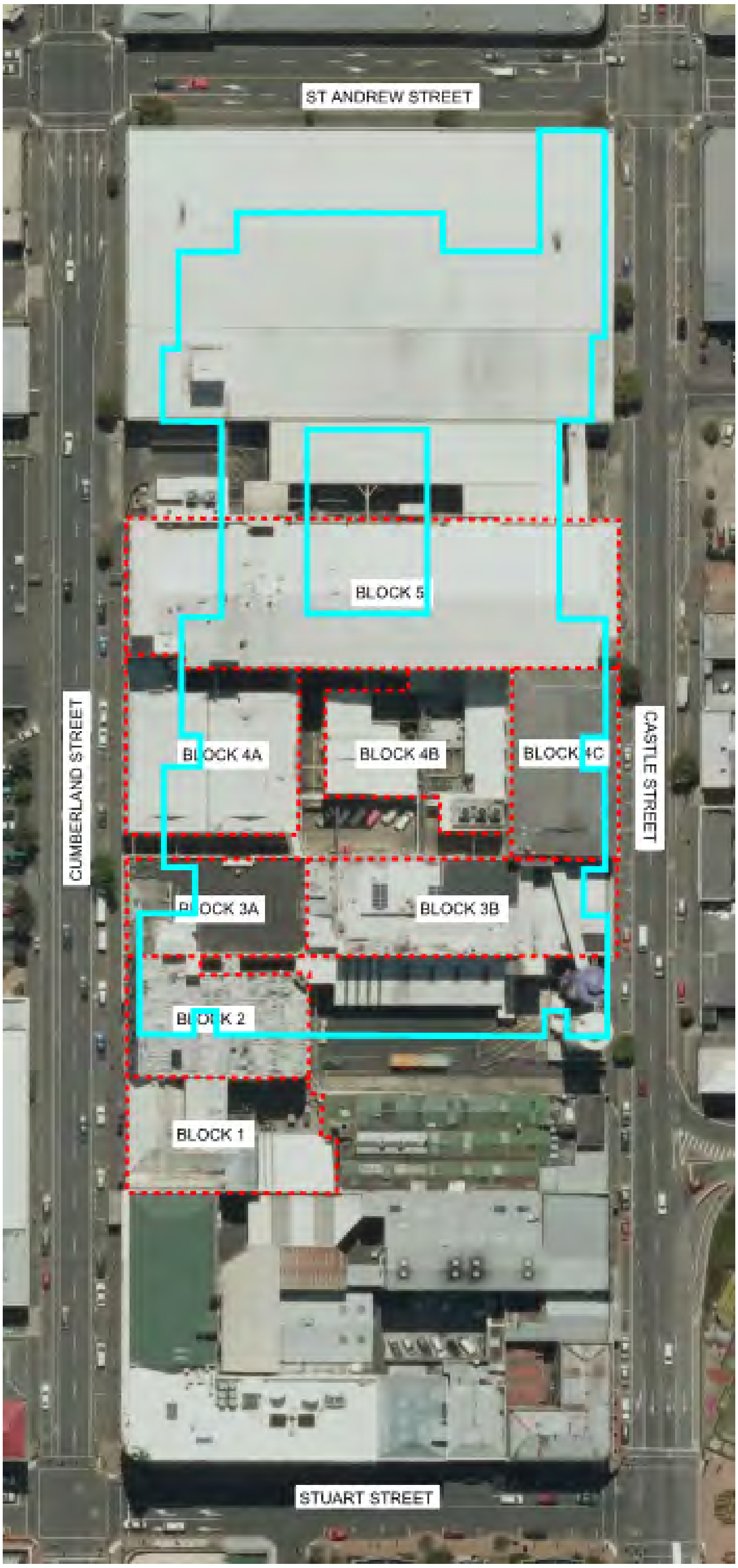


Figure 2: Aerial view of Cadbury block. New hospital outline in blue from the masterplan.

Building Façades

Each of the building façades affected by the construction of the new hospital have been reviewed and are considered below, further detail is in Appendix A & E.

Cumberland Street Elevations

Table 1: Cumberland Street Elevations 1.

			
Block	1 (Cadbury World)	2 (Offices)	3A
Date	1868	1868	1924
Material	Unreinforced masonry (URM)	Unreinforced masonry (URM)	Reinforced concrete with some URM
Condition	Rising damp and water ingress, isolated fine cracks	Rising damp	Rising damp with damp in roof and penthouse

Table 2: Cumberland Street Elevations 2.

		
Block	4A	5
Date	1960	1947
Material	Reinforced concrete	Reinforced concrete
Condition	Generally good	Some wear & tear but no signs of distress

Castle Street Elevations

Table 3: Castle Street Elevations.

			
Block	3C	4C	5
Date	1938	1947	1947
Material	Reinforced concrete	Reinforced concrete	Reinforced concrete
Condition	Rising damp and minor cracking	Some wear & tear but no signs of distress	Some wear & tear but no signs of distress

New Hospital Structure

The Hospital Buildings proposed for the former Cadbury site are currently in the early stages of concept design. The current concept indicated in figure 2 shows that the buildings will be positioned where the buildings and heritage facades are currently located, noting that there is some space at the southern end of the site. Based on information received from Holmes Consulting we understand the following key design decisions have been made that will be relevant to the façade retention:

1. The Importance Level 4 structure will be base isolated.
2. The ground floor of the ASB will be approximately 2m above street level at the St Andrew Street end, to avoid a 1 in 500-year flood event.
3. High inter-storey heights will be required to accommodate the services, structure and space required for a modern hospital.
4. The structure above the isolation level is likely to be a moment resisting frame.

Base isolation provides best practice protection against seismic hazards. It requires a significant movement allowance at the isolation level, typically in the order of ± 500mm. The existing façade cannot accommodate this movement and would need to be isolated itself and its weight supported or separated to allow for the differential movement.

Base isolation typically occurs below the ground floor level. As the ground floor will need to be raised, the isolation movement plane will be visible in the façade.

With the ASB having different floor heights to the existing buildings, the façade windows are likely to cross the floors of the new structure. When this occurs the façade windows could be blanked out to make this work visually. This means that less natural light would enter the building.

Façade Retention Considerations

Heritage & Site Planning Considerations

We have read the report on the site by Underground Overground and so have an appreciation of the heritage values of the site and existing buildings. We further understand that maintaining the buildings in their current form and use would be most desirable to minimise loss of their heritage value.

In these scenarios, the key heritage and planning considerations include:

- The heritage value of the façades without the buildings behind.
- How the façades fit with the new buildings on the site.
- How the site can be used and meet other planning objectives.

We note that these matters are outside our scope, which is limited to the structural engineering feasibility of retaining the façades, but we have endeavoured to outline conceptual options which should help inform answers to these questions.

The options developed also consider alternative techniques which have:

- Varying intrusion on the heritage fabric of the façades.
- Reversibility, for example steel frame restraint to façades is more easily removed than concrete linings.

We also note that very little information is available at this stage on the nature and extent of the new buildings including the likely structural systems. We have therefore made assumptions on building typology noting that further information and input from others will be required to define comprehensive options. These could incorporate several parts or sub-options of the conceptual options outlined in this report.

Conventional Restraint or Seismically Isolated

Conventional Restraint

The façades are currently founded on shallow strip foundations with lateral restraint provided by the existing buildings which are connected to the façades. In option 2, the façades continue to be supported on the existing footings which would be upgraded - possibly by installing piles if required to provide the appropriate level of support to prevent collapse or minimise damage to an agreed level. New structures would be constructed, likely in steel or concrete (walls or frames) to provide the lateral stability required to meet the performance objectives.

Façades Supported on Isolation System

The façade above the level of the isolation plane would be supported on the isolation plane provided for the new hospital building. We understand that the ground floor and isolation plane will be set at a level above the flood level for the site and that this is approximately 2m above ground level on St Andrews Street. The lower section of the façade would continue to be founded on the existing strip footing which would be upgraded as noted above. This section of the façade would also need an enhanced lateral support near the top, primarily because of the reduction in gravity load from the wall above.

Façade Supported by Hospital or Purpose-Built Structure

Hospital

The section of façade above the isolation plane would be supported by the hospital building, with a restraint designed to slide in the in-plane direction to allow for the much greater stiffness of the façade in this direction.

Depending on the stiffness of the hospital structure (assumed to be a seismically isolated structure with a stiff steel frame superstructure at this stage), the façade may need to be further articulated to undergo the out of plane deformations experienced in a seismic event, without significant damage. This would likely require additional support with either concrete or steel to provide the necessary support.

Façades Supported by Purpose- Built Structure

In this scenario, the supporting structure could be designed to have a stiffness compatible with the façade so that they could be connected in both directions.

Support Required to Façades

Concrete Façades

The concrete façades of buildings 3a – 5 are effectively reinforced concrete frames, although they vary in design and capacity, and have not been assessed in detail at this stage. This means they are not expected to need support over and above that provided at each floor level and by the walls or frames that abut the façades. This support would be provided by the temporary restraints, and by the permanent support structures.

Masonry Façades

The masonry façades of buildings 1 & 2a are unreinforced masonry brick. This means they have limited capacity to span between lines of supporting floors and walls, and so will require additional restraint to prevent collapse or damage in earthquake shaking.

From the Geotechnical reports the site is potentially susceptible to liquefaction. The brick façades have no reinforcing to tie them together and are very vulnerable to ground movement from liquefaction. Underpinning is likely required to ensure their stability if the ground liquefies.

The extent of restraint will be determined by the level of resilience required and the seismic demand, which will be reduced if the façades are supported on the seismically isolated building.

This restraint can be provided by a number of structural systems which would be supported by the temporary and permanent structures including:

- A grillage of steel members fixed into the masonry.
- A reinforced concrete lining cast onto the back face of the masonry with dowels connecting it to the masonry.
- A Fibre Reinforced Polymer (FRP) system likely incorporating additional masonry reinforcement, for example Helifix.

A hybrid of the above systems could also be used, and the choice of system would likely depend on the level of demand and resilience as noted above, in addition to buildability, cost, heritage and other considerations.

Temporary Bracing Exterior or Interior

Exterior

This is the most common way to temporarily support a façade that is being retained, as it essentially provides a clear workspace behind the façade to carry out the required deconstruction and new construction including any foundation work.

The main drawback with this approach is the space the braces take up outside the building, which in this case is the footpath, cycleway and road. Refer to the drawings for further detail.

Interior

This approach is much less common but has been used in the Wellington CBD on office buildings, where the floor levels can align with the original building floor levels. The main advantage with this approach is that the access to the outside of the building is relatively unaffected. There are however many drawbacks including the complexity of installing the bracing, and then carrying out the deconstruction and undertaking the new construction working around the braces. This also makes construction less efficient due to the limited access for plant and materials and the management of health & safety is more challenging.

Façade Options

Options for the temporary and permanent support of the façades have been considered and are outlined below. These are concept ideas that are subject to further design development. The likely impact and relative cost of the different types of solution are analysed in the following section.

Seven design options have been considered. With these the various options for temporary support and the transition to permanent support have been considered. Hand sketches provide a visual representation of each scheme.

Temporary and Permanent Support

Concept temporary support structures for the façades along Cumberland Street and Castle Street are shown on the sketch drawings in Appendix C.

Option 1A

This option involves:

- Façades cut and base isolated at the same level as the main structure.
- The original façade may need to have joints inserted into it to allow for articulation in the upper levels also.

The temporary support structure will be erected outside the façade and fixed through the façade before the deconstruction of the buildings behind. The existing buildings will need to be carefully deconstructed in the vicinity of the façade.

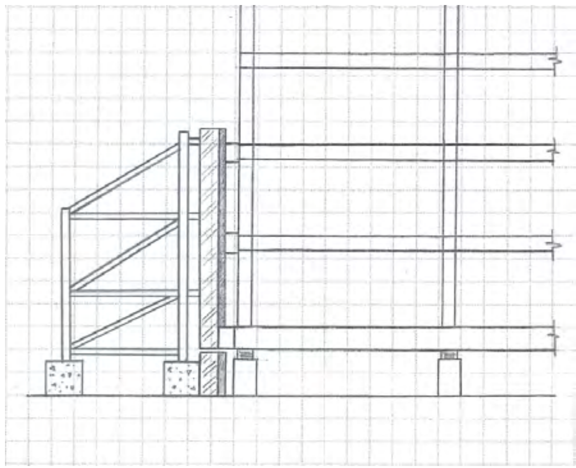


Figure 3: Option 1A

Option 1B

This option is the same as option 1A except that the temporary support structure is fixed inside the existing building before deconstruction.

This solution is possible, although the installation of the temporary support will be quite onerous.

Whilst this system is technically possible, it will create considerable construction difficulties with the sequencing required.

Refer to Appendix E for more discussion.

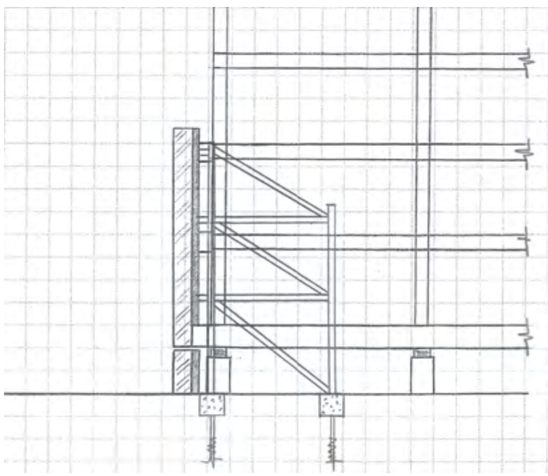


Figure 4: Option 1B.

Option 2A

<table>
<tr>
<td>
This option involves:

The façade having its own independent support structure on piled foundations
Seismic gap to be created between the support structure and the new building.

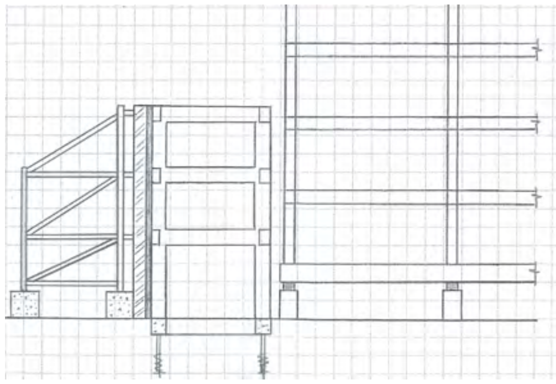
The foundations of the new support structure will have to be carefully considered to make them compatible with the façade. This is likely to involve underpinning the façade.
</td>
<td>


Figure 5: Option 2A.
</td>
</tr>
</table>

Option 2B

<table>
<tr>
<td>
This solution is the same as option 2A except that the temporary support structure is fixed inside the existing building before deconstruction.

All the consideration described above for option 2A would also apply to this solution.

Additionally, in this case the new supporting structure will have to be designed and built around the temporary support structure. Careful consideration will have to be given to the levels of main members and positions of bracing to make this possible.
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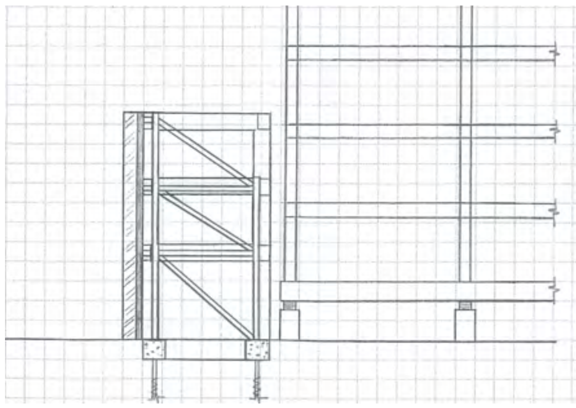
<td>


Figure 6: Option 2B
</td>
</tr>
</table>

Option 3A

<table>
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<td>
This option involves:

The façade having its own independent support structure founded on the base isolation system of the new hospital building.
Façade cut at the base isolation level.

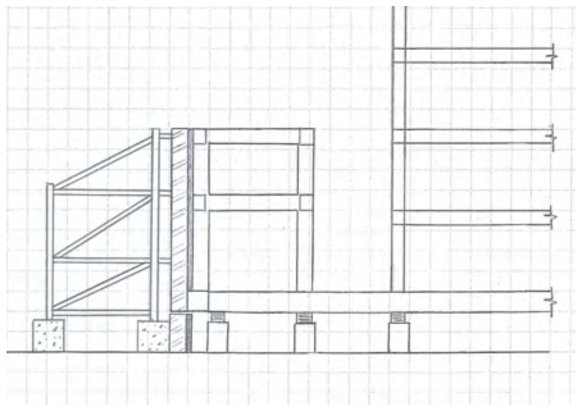
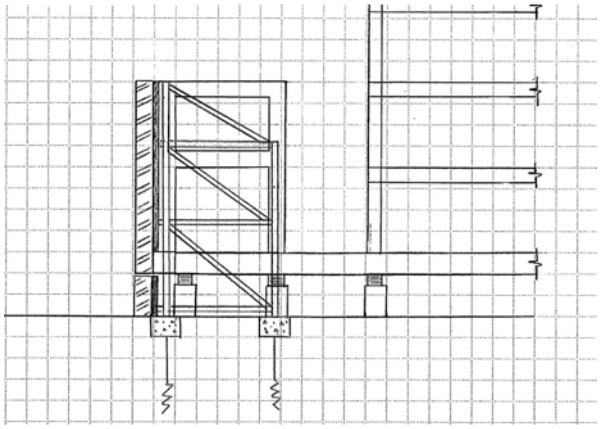
</td>
<td>


Figure 7: Option 3A
</td>
</tr>
</table>

Option 3B

This solution is the same as solution 3a except that the temporary support structure is installed inside the existing building before deconstruction.	 *Figure 8: Option 3B*

Option 4 – Deconstruct and Reconstruct

This option involves deconstructing the façade brick by brick and rebuilding them with the new structure. The rebuilt brick walls would have reinforcing in the mortar joints horizontally and in cores through the brickwork vertically to allow them to be supported. This option avoids the need for temporary support.

Option 5 - Replica Façade

This option involves:

- A Glass Reinforced Concrete (GRC) replica of a façade being made and attached directly to the new building structure.
- The GRC would be made in thin panels (approx. 20mm thick) with a steel backing frame.
- Joints in between panels allow for movement in a seismic event.
- The GRC panels would be mounted on a steel frame attached to the building.

This solution has the advantage that the replica façade is lightweight and can be attached directly to the new structure, allowing for more useable space within the new hospital building.

Option Evaluation

RAG Analysis

The following table outlines the key aspects of each option and comparatively assesses their pros and cons. This is summarised using a Red, Amber, Green (RAG) model with each factor qualitatively compared relative to the other options. Red shading indicates the least favourable option, green indicates the most favourable option and amber indicates some level of impact from the indicated factor.

This analysis provides a relative scale between options, with a range of criteria. For the baseline we have considered the new hospital as being built on a brownfield or 'clear' site. We have selected colours for each factor from our engineering knowledge and experience with input from the wider project team on other factors to be considered. The RAG analysis table can be found as Table 4 at the end of this section.

The criteria for the RAG are discussed below, noting that health and safety risk is considered in all the options, for both the temporary and permanent construction. All work needs to be carried out in a safe manner. The effect of additional health and safety precautions is factored into other criteria as appropriate. For example, where risk mitigation measures include complex construction sequencing such as installing temporary braces inside the existing building, this has been considered in the cost, time and buildability factors.

Cost

This is the cost of the façade retention, both temporary and permanent. It also considers the cost related to the increased complexity of the hospital design and additional time related costs due to the façade work on the overall project.

Time

This is the construction time relative to the baseline of building a new hospital with the site cleared.

Impact on Heritage

This is relative, and it is noted that retaining only the façade of a heritage building is a significant impact in itself. The other impacts relate to the intrusion required to introduce additional support to the façades, their connection to the heritage fabric and reversibility.

Impact on Hospital

This considers how the façade retention will reduce the useable site area available for the hospital, including vehicle access routes etc.

It also considers how the façades will impact the structure of the new hospital and the effect on daylight and views from the hospital. For example, existing façade windows could align with new floor levels, without an obscuring treatment the floor would be seen through the window.

Buildability

This considers how difficult it will be to construct both the temporary and permanent support structures, including foundations.

Traffic Disruption

This considers the disruption to vehicle, cycle and pedestrian traffic during construction as a result of the temporary façade bracing. This does not consider disruption to the operation of the hospital, as the traffic flows into and out of the site are not sufficiently understood at this stage.

Seismic Resilience

This indicates the relative seismic performance in terms of likely damage and repair required to the façade or supporting structure in a major earthquake. Refer to the section of structural performance for more detail.

Discussion of Options

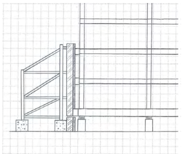
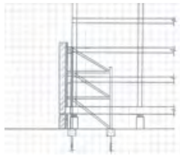
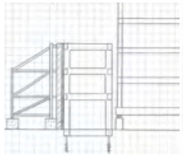
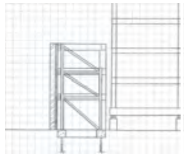
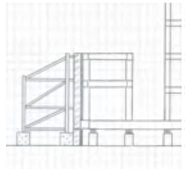
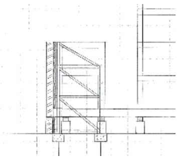
The options have been deliberately kept as general as possible so that they can be selected in whole or in part to suit any approach to the overall site or a specific building.

Sitewide Considerations

A key driver is the footprint of the new hospital building as this will define which options are feasible. We understand that the plan in Figure 2 is very preliminary in nature, however if this is indicative of what is carried forward, this will narrow the options which can be adopted. We also understand that there may be vehicles trafficking into the building below the first-floor level, this is likely to be incompatible with the existing façade where this occurs. This plan also suggests that the hospital footprint may not extend as far south as Block 1, although we understand that the design team are currently looking for more space on site. Depending on the footprint and the use of the southern area, there may be an option to strengthen this building along with the façade, noting this is outside the scope of this report.

There are unreinforced masonry walls on both sides of the boundary of Block 1 and the neighbouring ODT and Allied Press Building. Although consideration of these walls is outside the scope of this report, depending on the proposed use of this area, and any proposed upgrade of the neighbouring building, temporary and permanent restraint of this wall is likely to be required.

Table 4: RAG Analysis Table.

Consideration	Option								
	Baseline	1a	1b	2a	2b	3a	3b	4	5
	New Hospital 'Clear' Site							Deconstruct and Reconstruct	GRC Replica
Cost	G	A	R	A	A	R	R	R	A
Time	G	A	R	A	R	A	R	R	G
Impact on Heritage	R	A	A	A	A	A	A	R	R
Impact on Hospital	G	R	R	R	R	R	R	R	A
Buildability	G	A	R	G	R	A	R	A	G
Traffic Disruption	G	R	G	R	G	R	G	G	G
Seismic Resilience	G	A	A	R	R	A	A	A	G

Conclusion

We have developed this high-level report on the existing facades of the former Cadbury Factory site to consider feasibility and provide options on how the facades could be retained and incorporated into the new hospital buildings on the site.

The concept design of the hospital is currently being developed. It is therefore not possible to determine the most suitable retention treatment for each block, as the location of the hospital building footprint in relation to the facades has not been confirmed. Consequently, a range of options have been considered.

It is feasible to retain the façades; however, this will affect the layout and usage of the site, and both the extent and complexity of the construction work required, which will have significant cost, programme and health & safety implications.

The temporary supporting works will be significant and if placed on the outside of the facades will significantly impinge on the footpath, cycleway, roads and buried services of the state highways on Cumberland and Castle Streets. To support the walls temporarily on the inside is feasible as shown in the options, although this would add significant complexity, cost and time as well as an increased health & safety risk.

The methods of attaching the façades to new buildings will depend on the final design chosen. It is possible to attach the facades to the new buildings; however, a significant amount of additional structure will be required to achieve this. The existing façades have many openings for windows and doors which are unlikely to line up with floor levels proposed for the new hospital which may further compromise the design.

The brick facades to Blocks 1 and 2 of the Cadbury site are in poor condition mainly due to their age and damp penetration over many years, and they will require significant work to improve their integrity. There may also be a residual risk with these depending on the level of resilience decided upon.

From the geotechnical reports the site is potentially susceptible to liquefaction. The brick façades of Blocks 1 & 2 have no reinforcing to tie them together and are very vulnerable to ground movement, and so the foundations of these facades will require strengthening which could include underpinning.

Two other alternatives have also been considered which are unlikely to be preferred due to their greater impact on the heritage fabric:

1. Carefully de-constructing the facades and rebuilding using the original bricks incorporating reinforcement. This facade would require considerably less supporting structure.
2. Constructing replica facades in lightweight GRC panels which would require substantially less structural support.

Explanatory Notes/Limitations

This report contains the professional opinion of WSP Opus as to the matters set out herein, in the light of the information available to it during preparation, using its professional judgment and acting in accordance with the standard of care and skill normally exercised by professional engineers providing similar services in similar circumstances. No other express or implied warranty is made as to the professional advice contained in this report.

We have prepared this report in accordance with the brief as provided and our terms of engagement. The information contained in this report has been prepared by WSP Opus at the request of its client, The Ministry of Health. It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to and the assumptions made by WSP Opus.

This report has been prepared as part of the Ministry of Health's submission to the Dunedin City Council in support of its resource consent application for the Dunedin Hospital Project ('Purpose'). The report may only be used for this Purpose and may be relied on only by the Ministry of Health and the Dunedin City Council for submitting and assessing the resource consent application

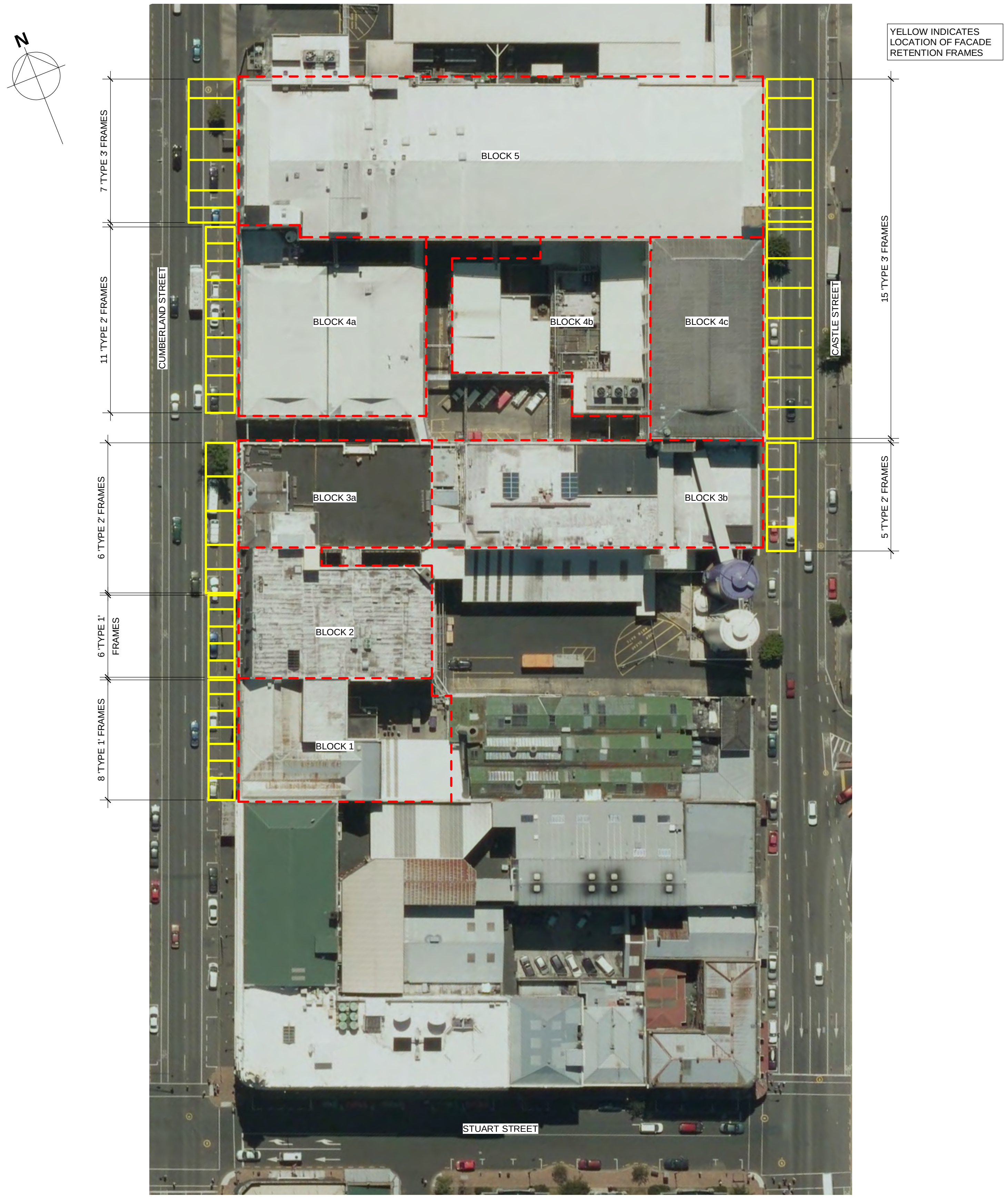
The report is also based on information that has been provided to WSP Opus from other sources or by other parties. The report has been prepared strictly on the basis that the information that has been provided is accurate, complete and adequate. To the extent that any information is inaccurate, incomplete or inadequate, WSP Opus takes no responsibility and disclaims all liability whatsoever for any loss or damage that resulting from any conclusions based on information that has been provided to WSP Opus.

Appendix A
Schedule of Façades

NDH - Cadburys Block Survey of Facades								
No.	Block No.	Description	Date Constructed	Construction	Estimated height	Assessment of present condition - see also schedule of photographs	%NBS IL2 from Hanlon IEP (for building)	
Cumberland Street Elevations								
1	1	Cadbury World Building	Earliest construction 1868	Solid Brickwork - numerous openings including large doors and window opening at ground floor level.	11.0m (From Hanlon Alteration Drawings)	Quite poor. Brickwork is damp from water penetration from the roof and also some rising damp at the bottom. Several bricks seem to be soft and the surface can be rubbed off by hand. Rendered externally - some fine to medium cracking noted.	20%	
2	2	Cadbury Reception and Offices	Unknown but a portion thought to have been constructed in 1868	From the south end (right end of picture) for five windows the construction is solid brickwork. To the north of that the façade has been altered and combined with the front of Block 3A and the link joining the buildings. Probably reinforced concrete circa 1924(?)	12.0m with the mansard roof section above that	Most of the brickwork cannot be seen as it is plastered inside and rendered outside. Rising damp affecting the plaster is seen at low level. Sign of rising damp also present on the outside. Several fine cracks in the external render.	20%	
3	3A	Raw Materials	Ground floor constructed 1922, upper floors added 1924. Penthouse added later.	Reinforced Concrete wall. Building is reinforced concrete floor on steel framing. Believed to be on shallow spread footings.	approx15.0m at penthouse. 12.0m to north.	Inside is plastered. Signs of rising damp at the bottom has affected plaster in small areas some minor rust staining. Similar at higher levels where damp either from the windows, operations or the roof have affected the plaster and there are areas where some rust staining is present. Penthouse walls are very damp and internal gutter is cracked and in very poor condition. Top of parapet is brickwork and there is a crack where it sits on the RC wall below.	About 20%. It is thought that the steel frame beam and column joints offer little resistance in the N-S direction	
4	4A	Engineering workshop at ground with offices above	1960	Reinforced Concrete on piled foundations. Pile 7.60m deep	Approx. 12.0m	The wall is plastered on the inside and rendered and painted on the outside. At the ground floor there are some signs of ware and tear but generally there are no signs of distress or problems.	Hanlons have calculated this to be 100% but it does not appear to have been a full DSA	

5	5	Chocolate manufacture and packaging	1951, additional storey added 1968.	Reinforced flat slabs on internal columns with external column and beam frames. Foundation is a cellular reinforced concrete ground slab.	Approx. 18.0m - lift tower is higher - circa 21.0m	Rendered and painted inside and out. Some signs of wear and tear but no signs of distress.	20% NBS	
Castle Street Elevations								
6	3C	Raw Materials	Building constructed 1924, Castle Street extension 1938	No drawings for this building. Probably an extension of block 3B	11.0m	Painted inside and out. Damp penetration at the bottom and at the top from the roof and around some of the windows - mould staining from condensation. Minor cracking noted particularly ion the outside. Crack at corner of window at second floor level.	20% - same issues as 3A	
7	4C	Manufacture, Storage and Packaging	1951, additional storey added 1968.	Reinforced concrete flat slabs on columns. Exterior reinforced concrete column and beam frames. Foundation cellular reinforced concrete flat slab on ground. Top floor is steel portal frames - some ties to façade.	18.0m	Painted inside and out. Tiles under windows and ground level. Large openings at ground floor filled in with blockwork. Sign of wear and tear but no particular signs of distress.	25% due to brittle nature of internal column and beam system.	
8	5	Chocolate manufacture and packaging	1951, additional storey added 1968.	Reinforced concrete flat slabs on columns. Exterior reinforced concrete column and beam frames. Foundation cellular reinforced concrete flat slab on ground. Lift shaft between blocks 4 and 5. Seismic Gap.	18.0m	Painted inside and out. Tiles under windows and ground level. Large openings at ground floor filled in with blockwork. Sign of wear and tear but no particular signs of distress.	20% lack of ductility in internal framing and possible brittle failure.	

Appendix B
Temporary Bracing Concept Drawings



SITE PLAN

SCALE 1 : 500

NOTES

1. ALL SKETCHES TO BE READ IN CONJUNCTION WITH THE WSP OPUS REPORT 'ENGINEERING ASSESMENT OF EXISTING FACADES'.
2. EXISTING STRUCTURE IS SHOWN INDICATIVELY ONLY. VERIFY DIMENSIONS & CONFIGURATION OF EXISTING STRUCTURE ON SITE BEFORE COMMENCING ANY WORKS & NOTIFY ENGINEER IF ANY DIFFERENCES TO WHAT IS INDICATED ON THE SKETCHES ARE ENCOUNTERED.
3. EXISTING SERVICES NOT SHOWN. VERIFY LOCATION OF ALL EXISTING SERVICES ON SITE BEFORE COMMENCING ANY WORKS.
4. ALL EXTERNALLY EXPOSED STEELWORK INCLUDING FIXINGS TO BE HOT DIP GALVANIZED U.N.O.
5. REFER SK-2000 & SK-2100 SERIES SKETCHES FOR FRAME ELEVATIONS U.N.O.

CONCEPT DRAWINGS FOR INDICATIVE PRICING ONLY

REVISION	AMENDMENT	APPROVED	DATE
A	CONCEPT DESIGN	S.R.B	2019-10-02

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MANATŪ HAUORA

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DRAWN	DESIGNED	APPROVED
K.HAMPSHIRE	M.ALEXANDER	S.BURROUGH
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
G.McGILL	S.BURROUGH	2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
SITE PLAN

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
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NOTES

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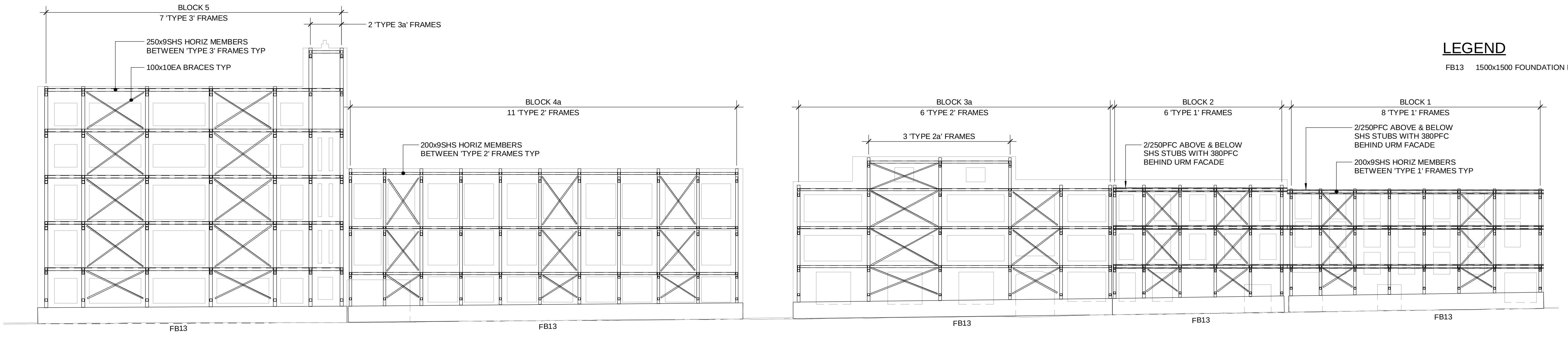
5. REFER SK-2100 SERIES SKETCHES FOR TYPE 1, 2 & 3 FRAME ELEVATIONS.

CONCEPT DRAWINGS FOR INDICATIVE PRICING ONLY

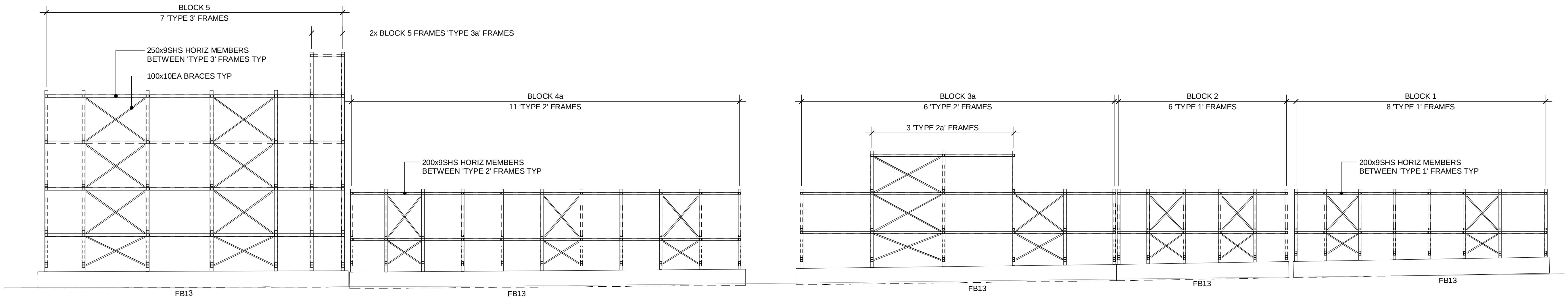
LEGEND

FB13 1500x1500 FOUNDATION BEAM.



ELEVATION AT CUMBERLAND STREET - EAST

SCALE 1 : 200



ELEVATION AT CUMBERLAND STREET - WEST

SCALE 1 : 200

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DRAWING VERIFIED: G.McGILL — DESIGN VERIFIED: S.BURROUGH — APPROVED DATE: 2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
ELEVATIONS AT CUMBERLAND STREET

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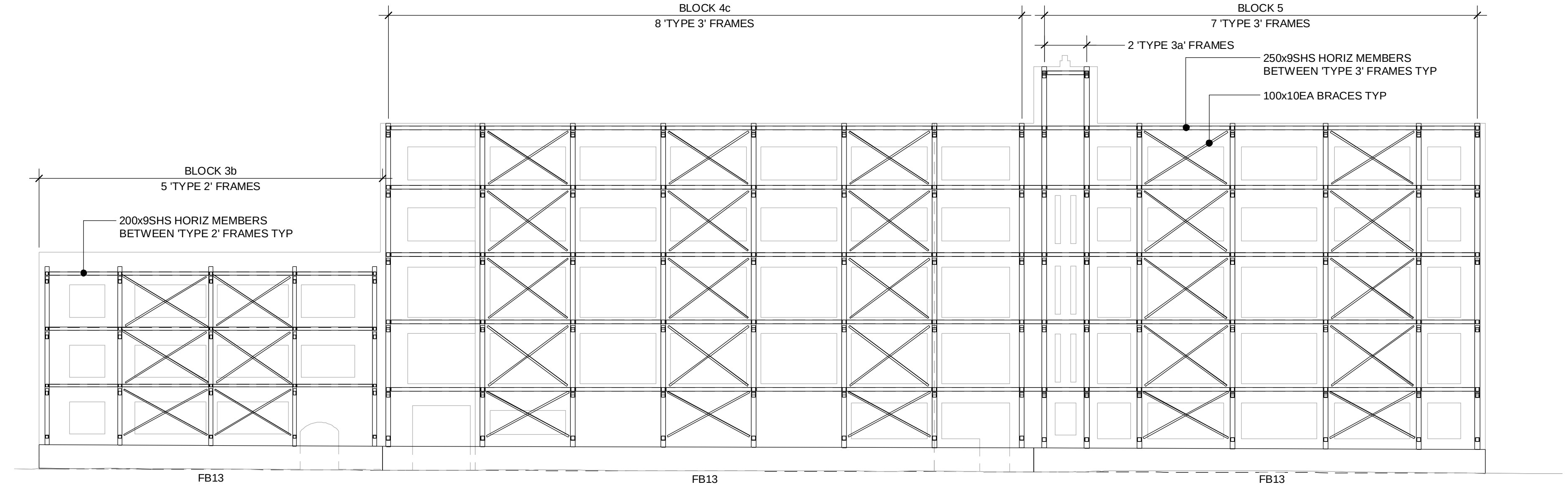
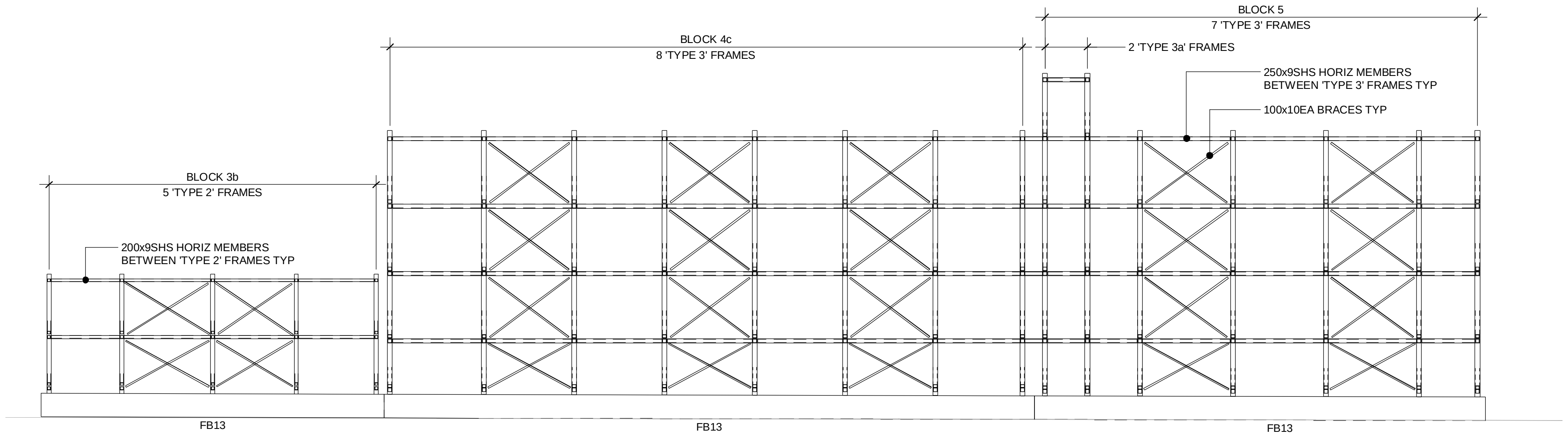


ELEVATION AT CASTLE STREET - WEST
SCALE 1 : 200



ELEVATION AT CASTLE STREET - EAST
SCALE 1 : 200

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LEGEND

FB13 1500x1500 FOUNDATION BEAM.

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ELEVATIONS AT CASTLE STREET

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
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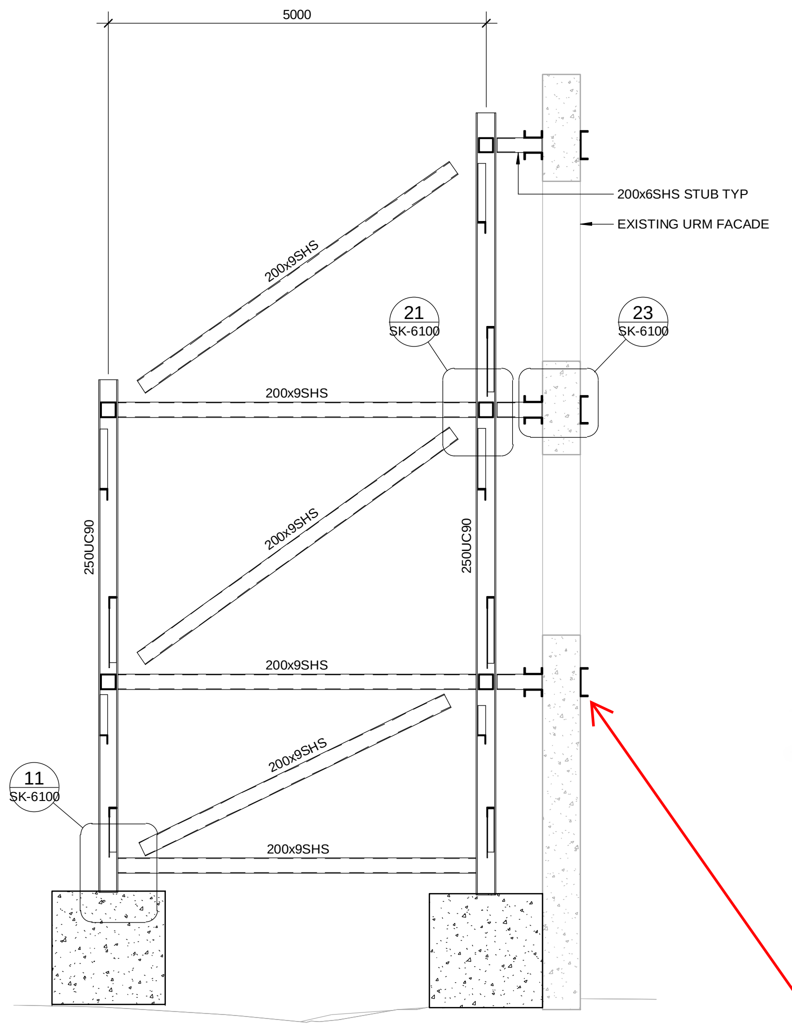
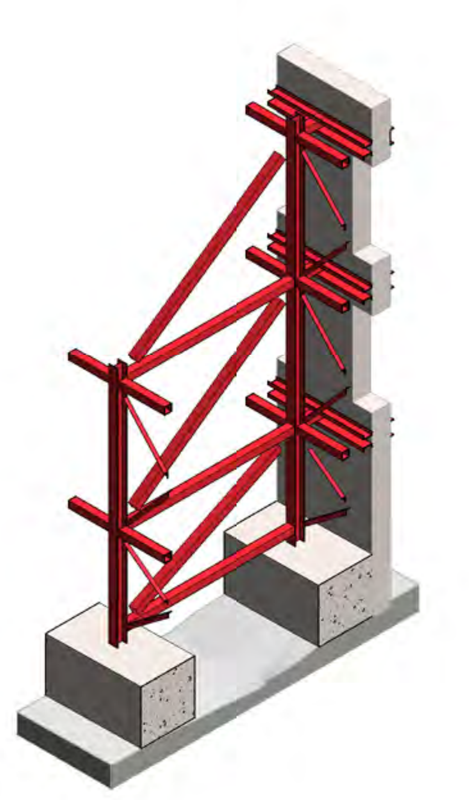


TYP 'TYPE 1' FRAME ELEVATION
SCALE 1 : 50



TYP 'TYPE 1' FRAME ORTHOGRAPHIC
SCALE

INSTALL STEEL PFC GRILLAGE BEHIND URM FACADES (50kg/m2)

CONCEPT DRAWINGS FOR INDICATIVE PRICING ONLY

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DRAWN	DESIGNED	APPROVED
K.HAMPSHIRE	M.ALEXANDER	S.BURROUGH
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
G.McGILL	S.BURROUGH	2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
TYPICAL FRAME 1 ELEVATION & ORTHOGRAPHIC VIEW

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
6-CM537.00		SK-2101	-	A

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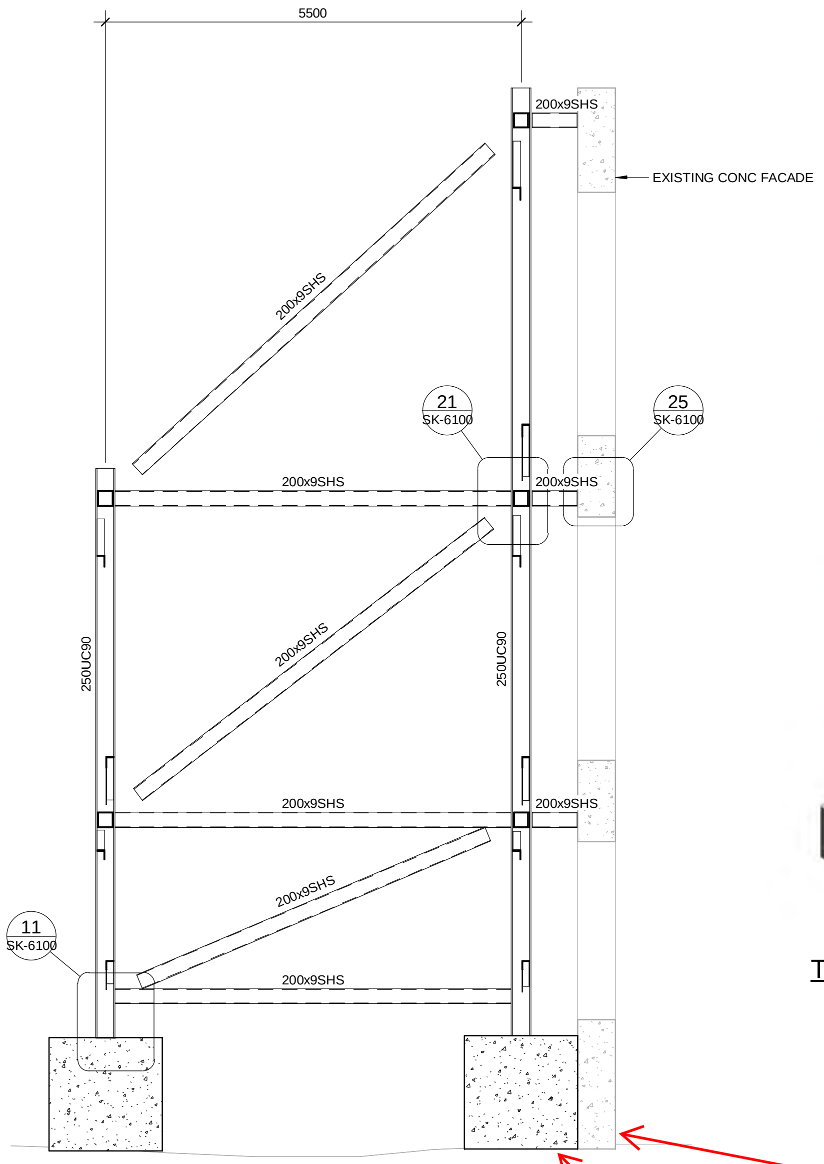
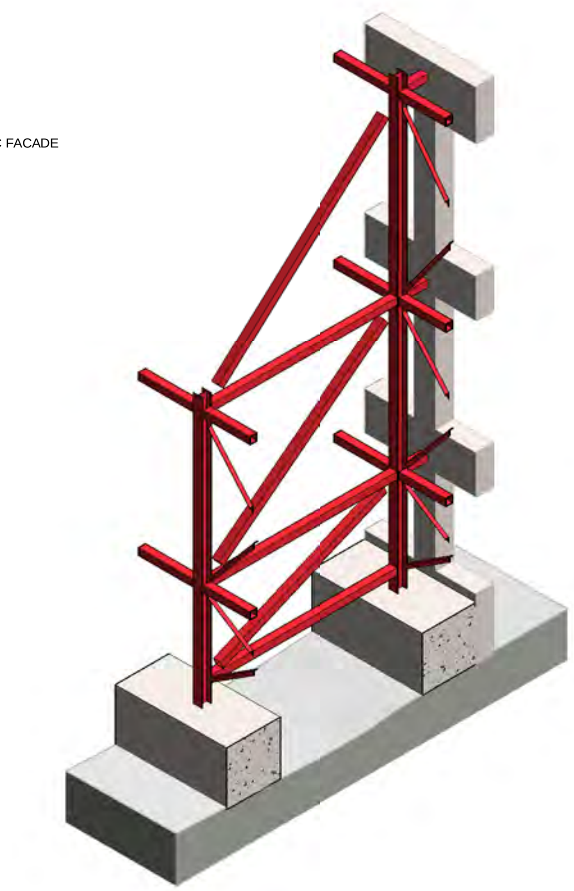
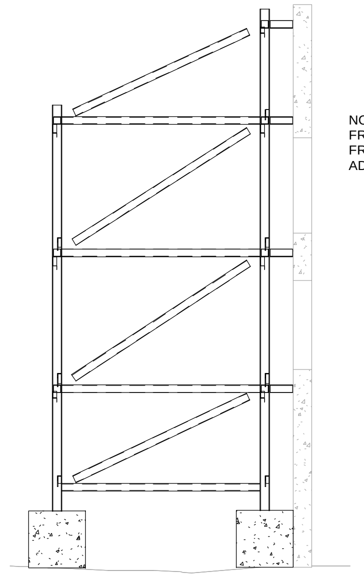


TYP 'TYPE 2' FRAME ELEVATION
SCALE 1 : 50



TYP 'TYPE 2' FRAME ORTHOGRAPHIC
SCALE



NOTE:
FRAME 'TYPE 2a' SIM TO
FRAME 'TYPE 2' WITH
ADDITIONAL VERTICAL FRAMING

TYP 'TYPE 2a' FRAME ELEVATION
SCALE 1 : 100

NOTES

1. ALL SKETCHES TO BE READ IN CONJUNCTION WITH THE WSP OPUS REPORT 'ENGINEERING ASSESMENT OF EXISTING FACADES'.
2. EXISTING STRUCTURE IS SHOWN INDICATIVELY ONLY. VERIFY DIMENSIONS & CONFIGURATION OF EXISTING STRUCTURE ON SITE BEFORE COMMENCING ANY WORKS & NOTIFY ENGINEER IF ANY DIFFERENCES TO WHAT IS INDICATED ON THE SKETCHES ARE ENCOUNTERED.
3. EXISTING SERVICES NOT SHOWN. VERIFY LOCATION OF ALL EXISTING SERVICES ON SITE BEFORE COMMENCING ANY WORKS.
4. ALL EXTERNALLY EXPOSED STEELWORK INCLUDING FIXINGS TO BE HOT DIP GALVANIZED U.N.O.

2/M20 THREADED RODS AT EACH COLUMN LOCATION. ~600MM LONG THROUGH EXISTING WALL BASE. EPOXY INTO PRECAST BLOCK 200MIN

PRECAST CONCRETE FOUNDATION BLOCKS. 40 kg/m3 REINFORCING. 3m LONG UNITS JOINED TOGETHER WITH 4 no. STEEL BRACKETS PER JOIN (10kg PLATE + 4/M20 EPOXY BOLTS)

CONCEPT DRAWINGS FOR INDICATIVE PRICING ONLY

REVISION	AMENDMENT	APPROVED	DATE
A	CONCEPT DESIGN	S.R.B	2019-10-02

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ORIGINAL SIZE: A1

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DRAWING VERIFIED	**DESIGN VERIFIED**	**APPROVED DATE**
G.McGILL	S.BURROUGH	2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
TYPICAL FRAME 2 ELEVATION & ORTHOGRAPHIC VIEW

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
6-CM537.00		SK-2102	-	A

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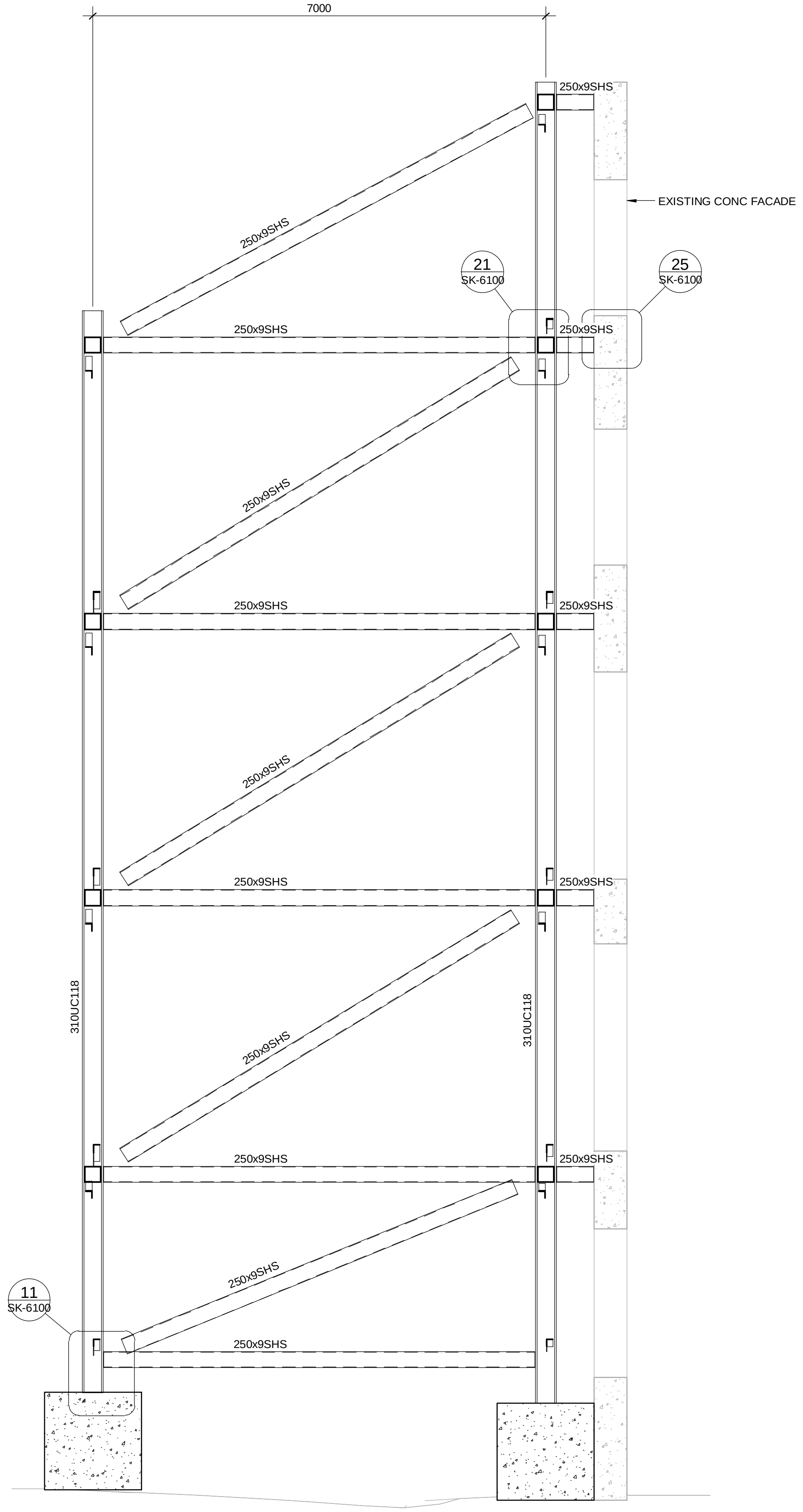

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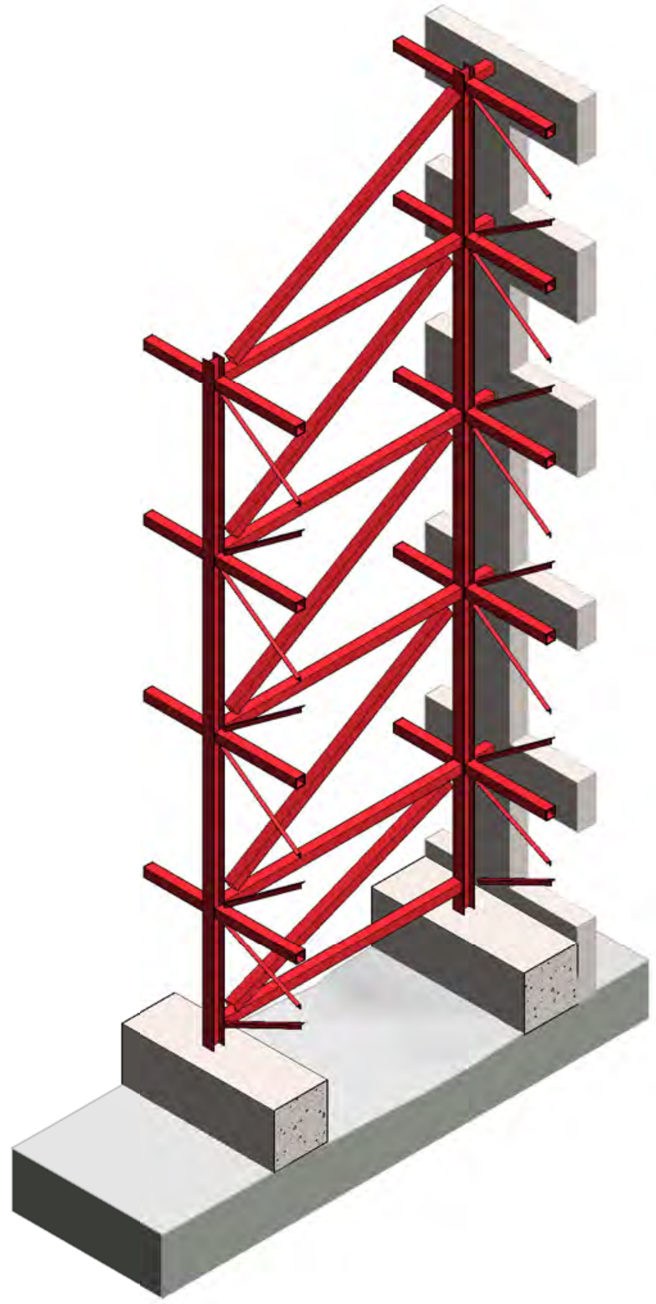
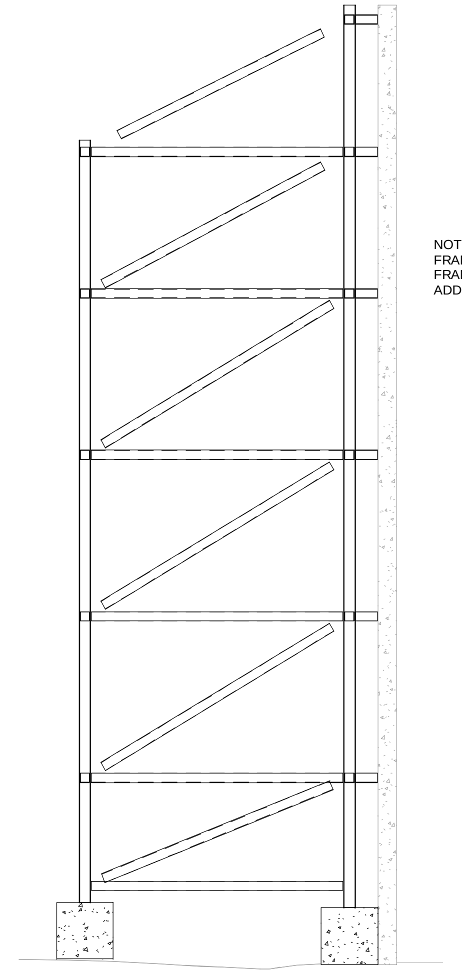
SCALE 1 : 50



TYP 'TYPE 3' FRAME ORTHOGRAPHIC

SCALE



NOTE:
FRAME 'TYPE 3A' SIM TO FRAME 'TYPE 3' WITH ADDITIONAL VERTICAL FRAMING

TYP 'TYPE 3a' FRAME ELEVATION

SCALE 1 : 100

NOTES

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K.HAMPSHIRE	M.ALEXANDER	S.BURROUGH
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
G.McGILL	S.BURROUGH	2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
TYPICAL FRAME 3 ELEVATION & ORTHOGRAPHIC VIEW

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
6-CM537.00		SK-2103	-	A

NOTES

1. ALL SKETCHES TO BE READ IN CONJUNCTION WITH THE WSP OPUS REPORT 'ENGINEERING ASSESMENT OF EXISTING FACADES'.
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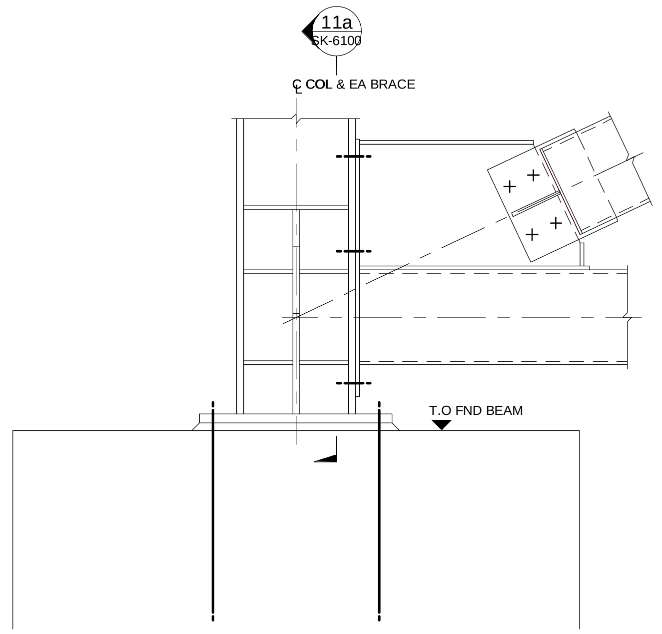
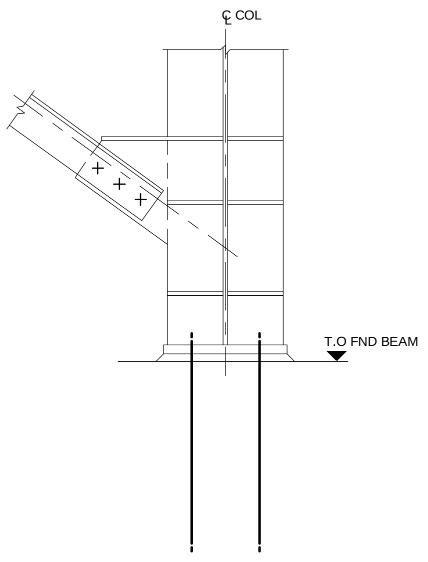
4. ALL EXTERNALLY EXPOSED STEELWORK INCLUDING FIXINGS TO BE HOT DIP GALVANIZED U.N.O.



11 DETAIL
SK-2101 SCALE 1 : 10
TYP BASE PLATE



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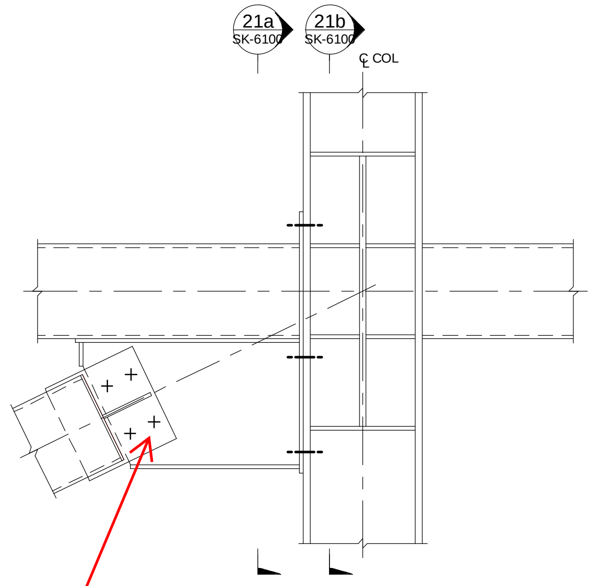

21 DETAIL
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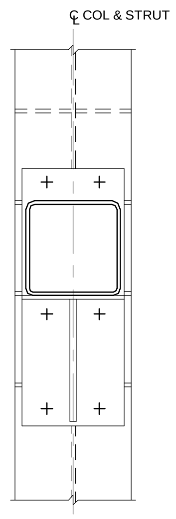
TYP BEAM/COL/BRACE



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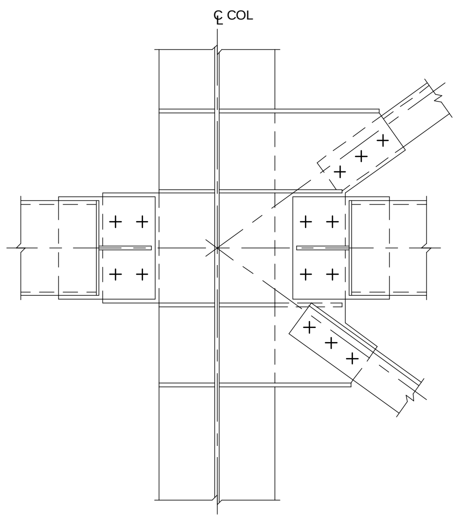

21b SECTION
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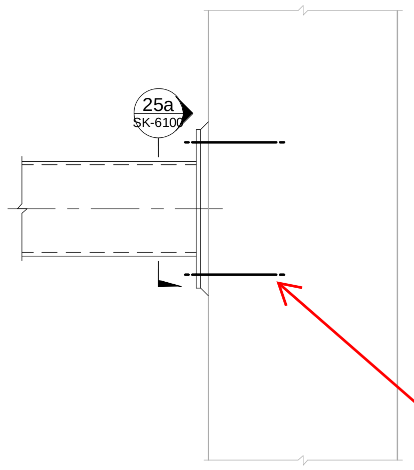
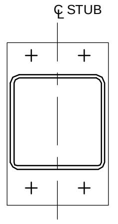
M20/8.8TB BOLTS THROUGH OUT U.N.O

M20/8.8S THROUGH BOLTS



25 DETAIL
SK-2102 SCALE 1 : 10
TYP SHS STUB/EXISTING WALL



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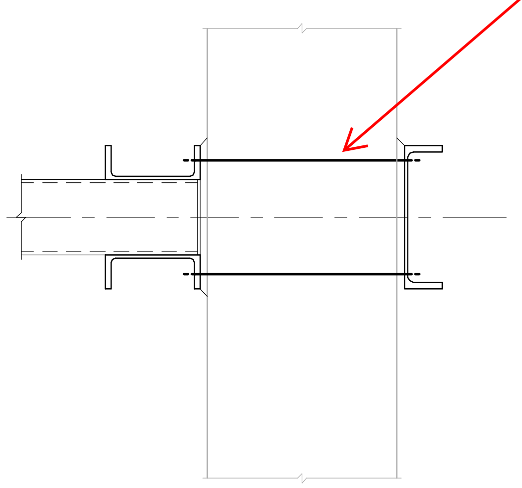

23 DETAIL
SK-2101 SCALE 1 : 10
SHS STUB/EXISTING WALL AT 'TYPE 1' FRAME

M20/8.8S EPOXY BOLTS, 150MIN EMBEDMENT

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G.McGILL	S.BURROUGH	2019-10-02

CONCEPT DESIGN

PROJECT
MINISTRY OF HEALTH
280 CUMBERLAND STREET, DUNEDIN
FACTORY FACADE RETENTION

TITLE
STEELWORK DETAILS

OPUS PROJECT NO.	PROJ-ORIG-VOL-LVL-TYPE	SHEET NO.	SUITABILITY	REVISION
6-CM537.00		SK-6100	-	A

Original sheet size A1 (841x594)   Plot date: 2/10/2019 8:08:51 a.m.   C:\Revit Local Files\Revit 2019\6CM537-OIC-01-ZZ-M3-S-0001_CENTRAL_2019_wekhh0.rvt

Appendix C
Façade Support Options – Additional Detail

Façade Options

Options for the temporary and permanent support of the façades have been considered and are outlined below. These are concept ideas that are subject to further design development. The likely impact and relative cost of the different types of solution are analysed in the following section.

Seven design options have been considered. With these the various options for temporary support and the transition to permanent support have been considered. Hand sketches provide a visual representation of each scheme.

Temporary Support

Concept temporary support structures for the façades along Cumberland Street and Castle Street are shown on the sketch drawings in Appendix C.

Option 1A

This option involves:

- Façades cut and base isolated at the same level as the main structure.
- The original façade may need to have joints inserted into it to allow for articulation.

The temporary support structure will be erected outside the façades and fixed through the façade before the deconstruction of the buildings behind. The existing buildings will need to be carefully deconstructed in the vicinity of the façade.

To accommodate the significant amount of movement required at the base isolation level, the façade will also need to be separated at the same level. The upper section of the façade will be supported by beams from the new structure. The joint at the isolation level will have to be carefully filled with a waterproof filler that is flexible and can be replaced after a significant seismic event.

Smaller differential seismic movement between the upper levels of the façade and the new structure will also need to be accommodated. The façade will have a different stiffness from the new building which means it will move differently in an earthquake, especially in the direction along the façade. The connections will need to allow differential movement to take place along the façade so that neither the façade or new building is compromised. It may also be necessary to introduce joints into the old façade to give the ability to articulate and move towards the street with the new buildings without suffering a brittle failure. This will need careful consideration from both a structural and heritage standpoint.

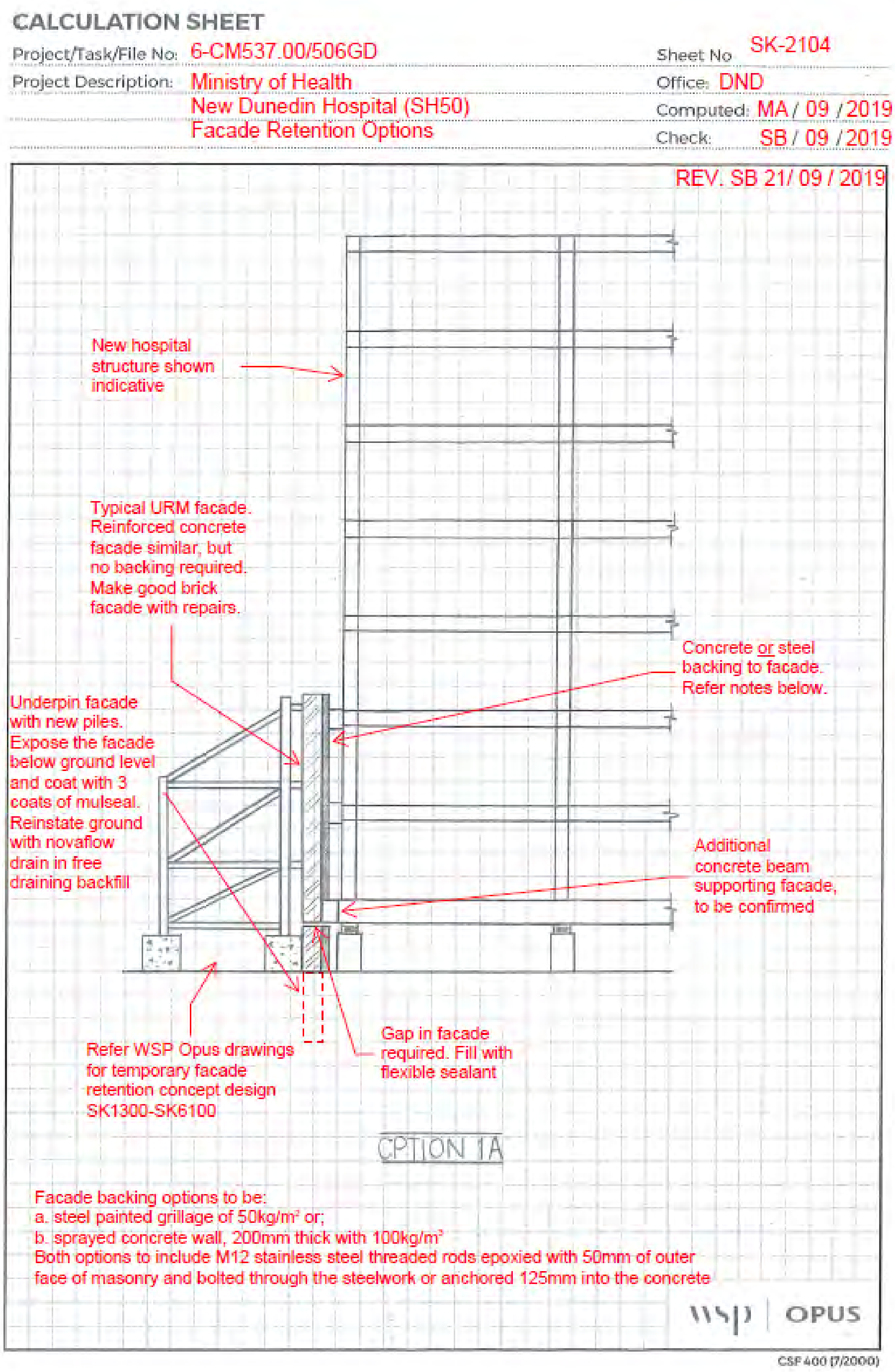

Figure 9: Option 1A.

Option 1B

This option is the same as option 1A except that the temporary support structure is fixed inside the existing building before deconstruction. The advantage is that this does not encroach on the state highway. However, scaffolding outside will be required in the short term to permit the erection and bolting through the wall as required. Pattress plates or framing may be required on the outside – particularly for the brick walls – to ensure that the façade is fully supported.

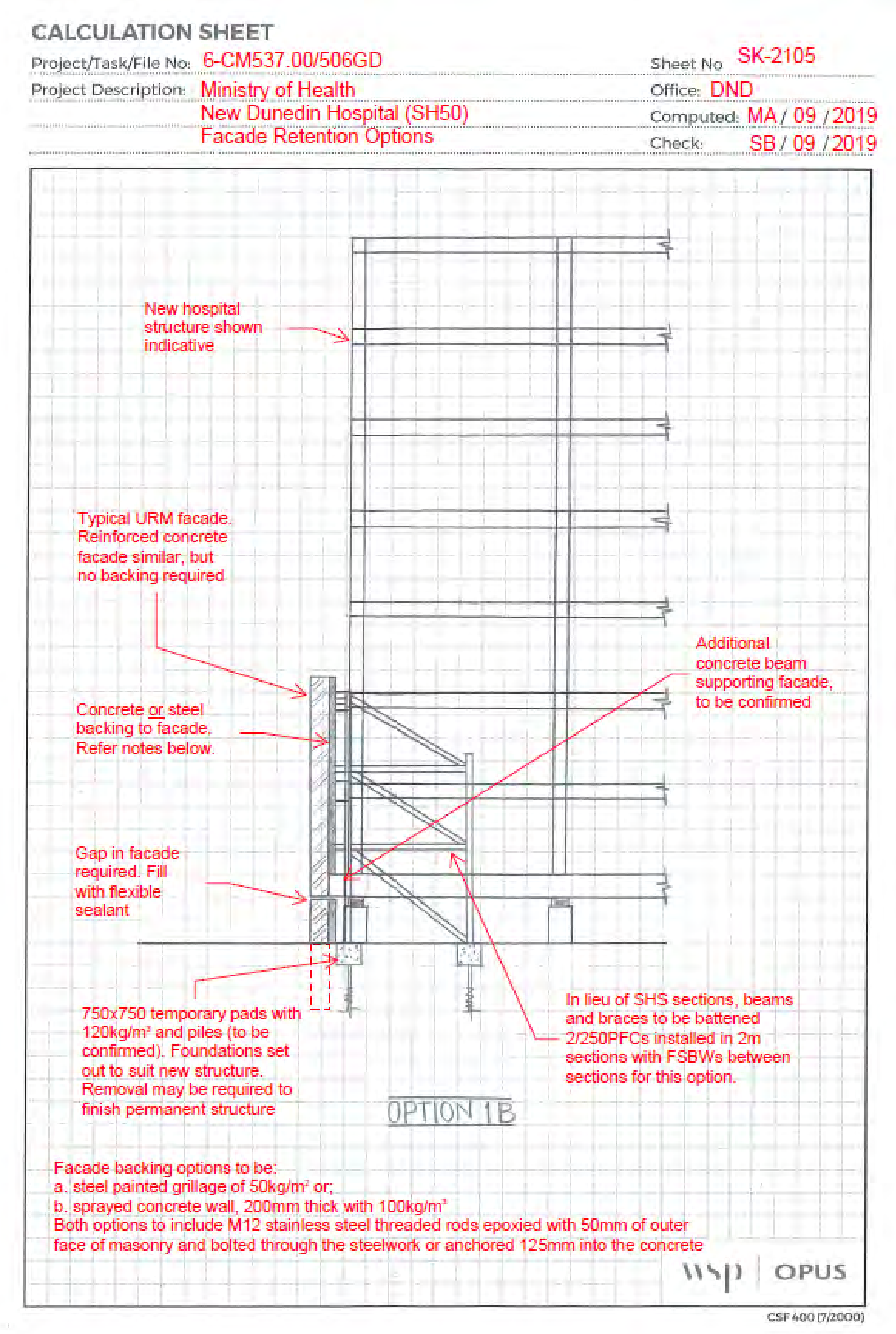

Figure 10: Option 1B.

This solution is possible, although the installation of the temporary support will be quite onerous. The following points should be noted: -

1. To install the temporary framing inside the existing building it will have to be designed in sections that can be moved into place by hand and bolted and welded together on site.
2. The installation will require holes to be made in floors to accommodate the vertical supports which would be craned through the roof. Additional support around each opening would be added as required.
3. The foundations for the façade support will have to be constructed inside the existing buildings. Installing large precast units will not be practical inside the building. Small piling rigs will be required with multiple extensions due to the lack of height inside the existing buildings. This will be time consuming.
4. The deconstruction sequence will have to consider the temporary support and not compromise it. This will mean more careful and slower deconstruction and quite often hand work to ensure the temporary supports remain undamaged.
5. Construction of the new structure will have to sequenced in such a way that it can be built around the temporary support and the connections made to the existing façade.
6. Only when the existing façade has been fully connected to the new structure can the temporary support be removed. This will have to be removed in small sections which can be manually handled within the floor space of the new building. It is expected that this will require cutting up of sections of the temporary support to allow them to be manoeuvred.

Whilst this system is technically possible, it will create considerable construction difficulties with the sequencing required.

Option 2A

This option involves:

- Façade has its own independent support structure on piled foundations
- Seismic gap to be created between the support structure and the new building.

This method envisages the façade to be temporarily supported and a new independent support structure constructed behind it. This could be in the form of a steel or concrete frame with bracing as necessary. The façade and supporting structure would be separated from the new hospital building with a seismic gap.

The foundations of the new support structure will have to be carefully considered to make them compatible with the façade. This is likely to involve underpinning the façade.

The existing façade will need to be connected to the support structure with a detail which will permit longitudinal movement to take place so that the stiffer façade is not compromised by greater movement of the new support structure behind.

CALCULATION SHEET

Project/Task/File No: 6-CM537.00/506GD — Sheet No SK-2106

Project Description: Ministry of Health — Office: DND

New Dunedin Hospital (SH50) — Computed: MA / 09 / 2019

Facade Retention Options — Check: SB / 09 / 2019

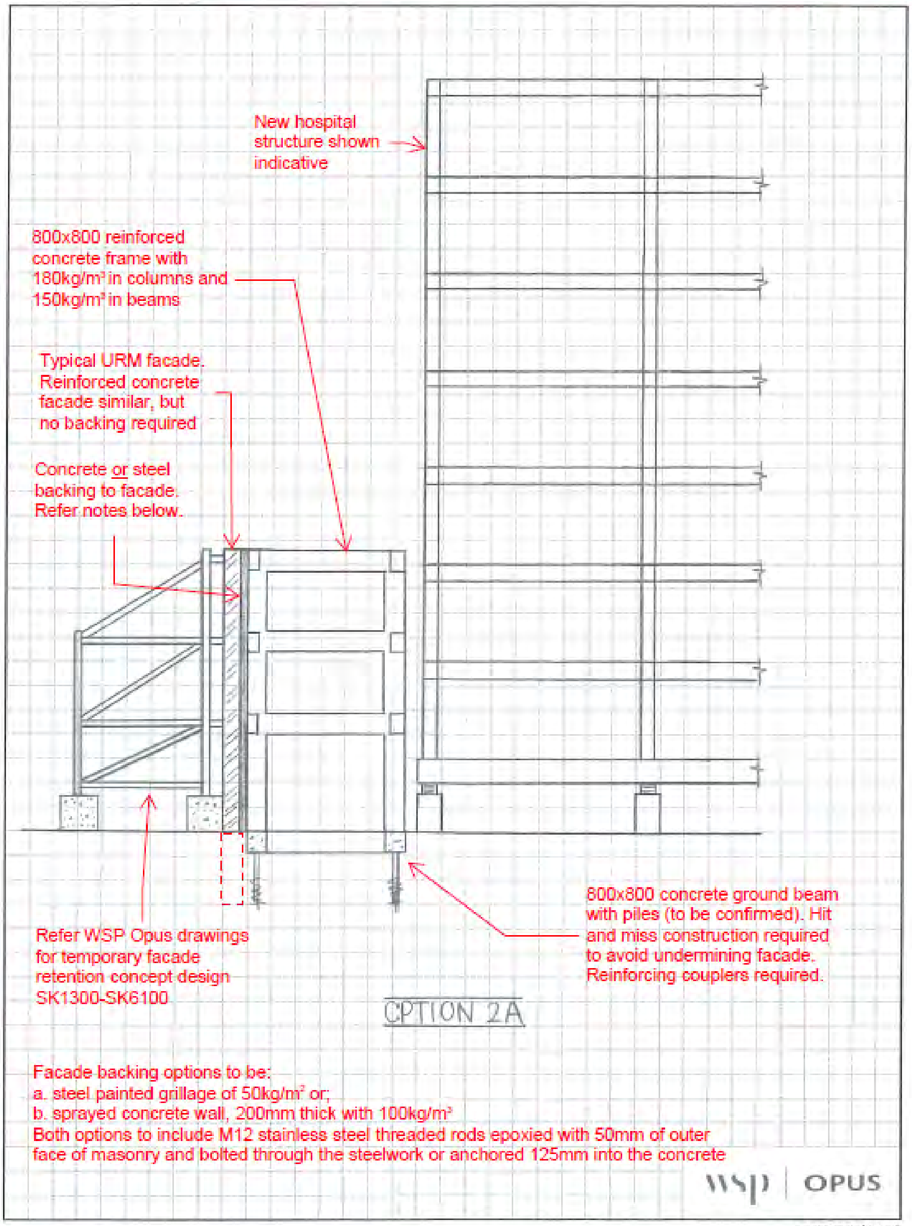

Figure 11: Option 2A.

Option 2B

This solution is the same as option 2A except that the temporary support structure is fixed inside the existing building before deconstruction.

All the consideration discussed above for option 2A would also apply to this solution.

In this case the new supporting structure will have to be designed and built around the temporary support structure. Careful consideration will have to be given to levels of main members and positions of bracing to make this possible.

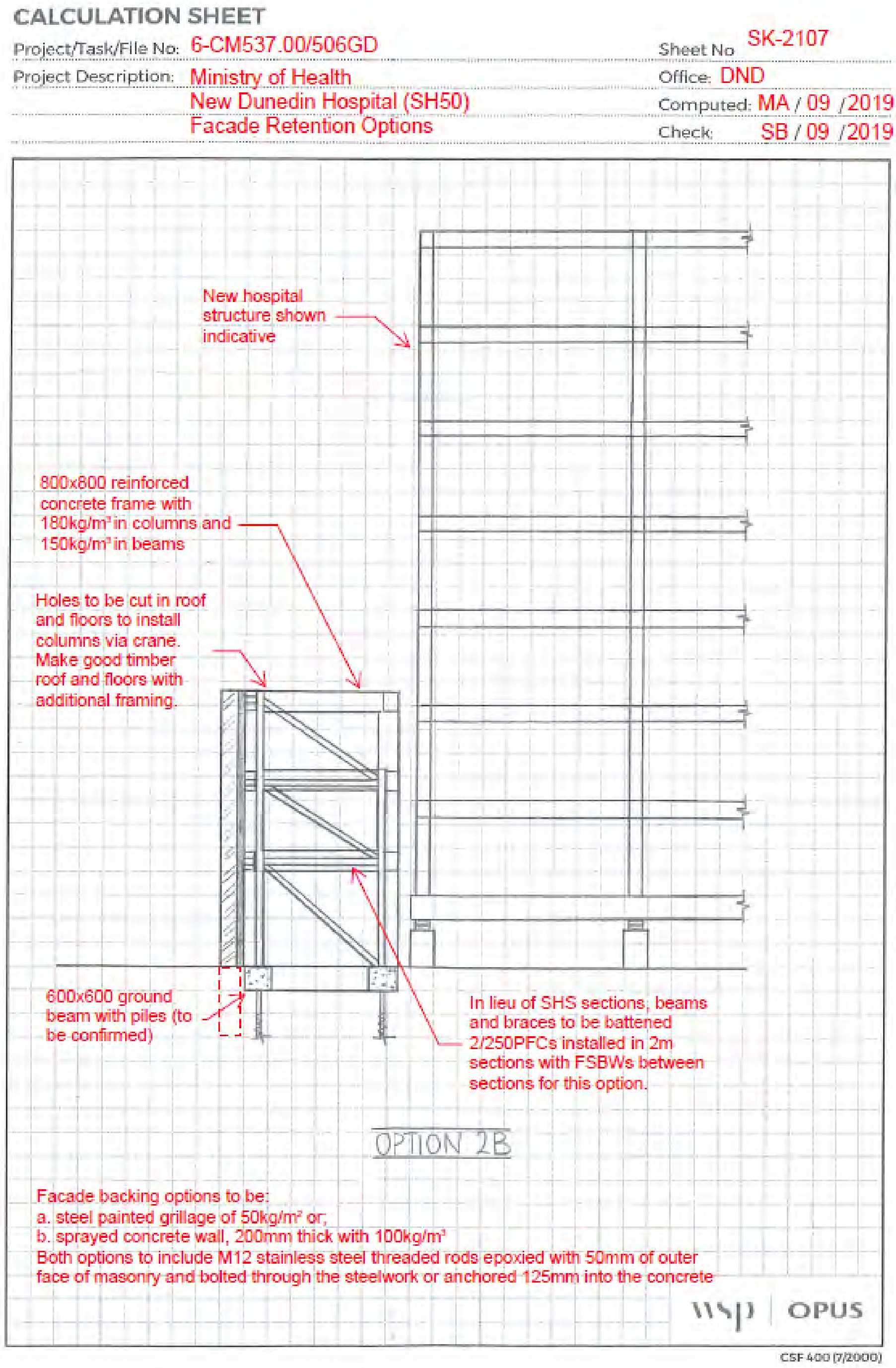

Figure 12: Option 2B.

Option 3A

This option involves:

- Façade has its own independent support structure founded on the base isolation plane of the new hospital building.
- Façade cut at the base isolation level.

This solution places the permanent façade support structure on the same base isolation plane as the new hospital buildings. This will reduce the differential movement between the structures and the seismic forces on the bulk of the façade providing a high level of hazard protection. However, the stiffness and hence movement of the façade and its support structure will be different to that of the newly designed hospital building. A seismic separation will still be required to allow for this.

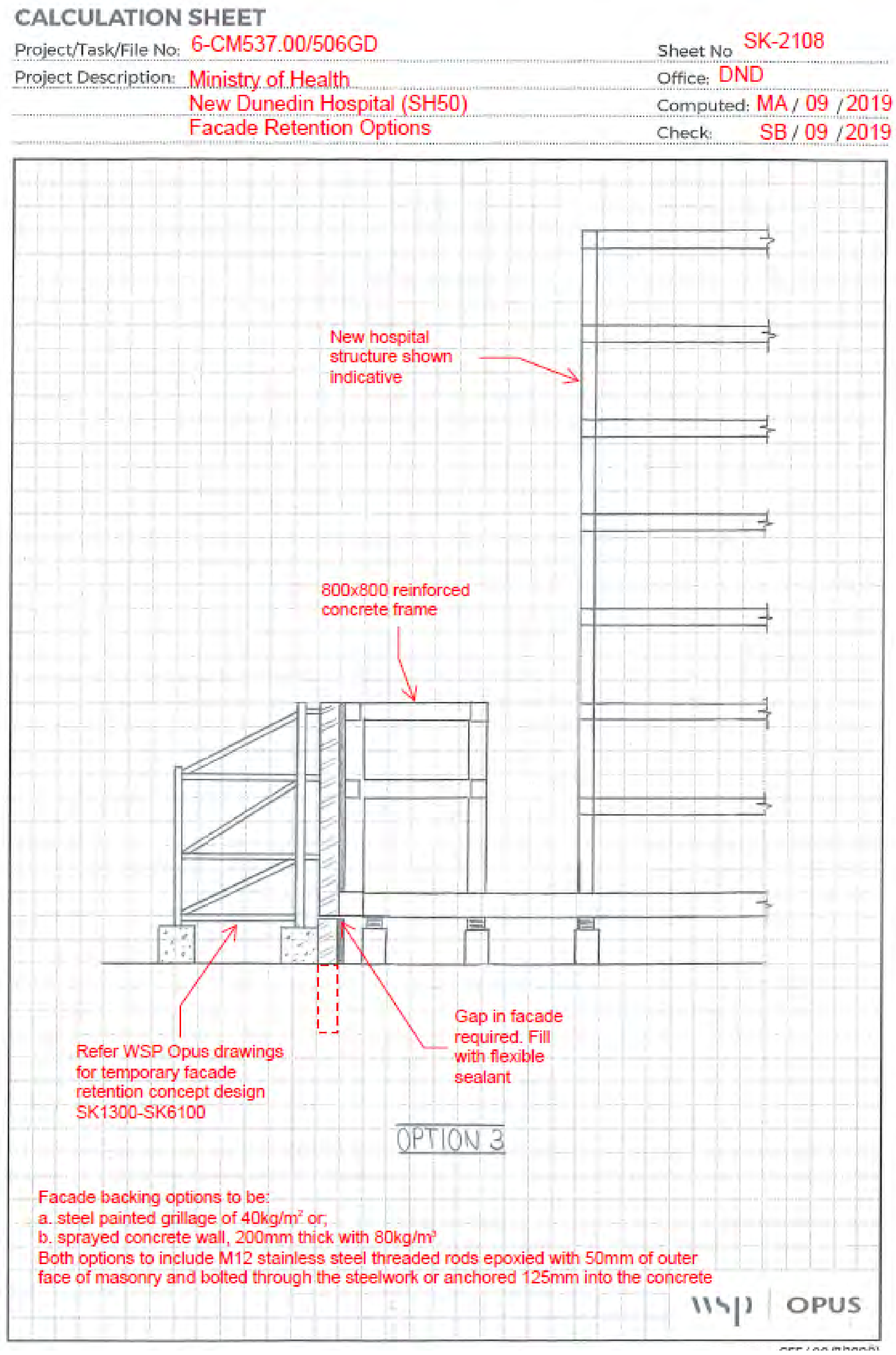

Figure 13: Option 3A.

Option 3B

This solution is the same as solution 3a except that the temporary support structure is fixed inside the existing building before deconstruction.

Placing the temporary support structure on the inside makes this build much more difficult than other solutions. The isolation plane will have to be constructed around the temporary support. The temporary support will then have to be carefully modified so that it is supported from the base isolation plane. The temporary support and façade will then have to be cut to allow the base isolation plane to become functional. After that the construction of the permanent façade structure and the new hospital building can commence above the base isolation level.

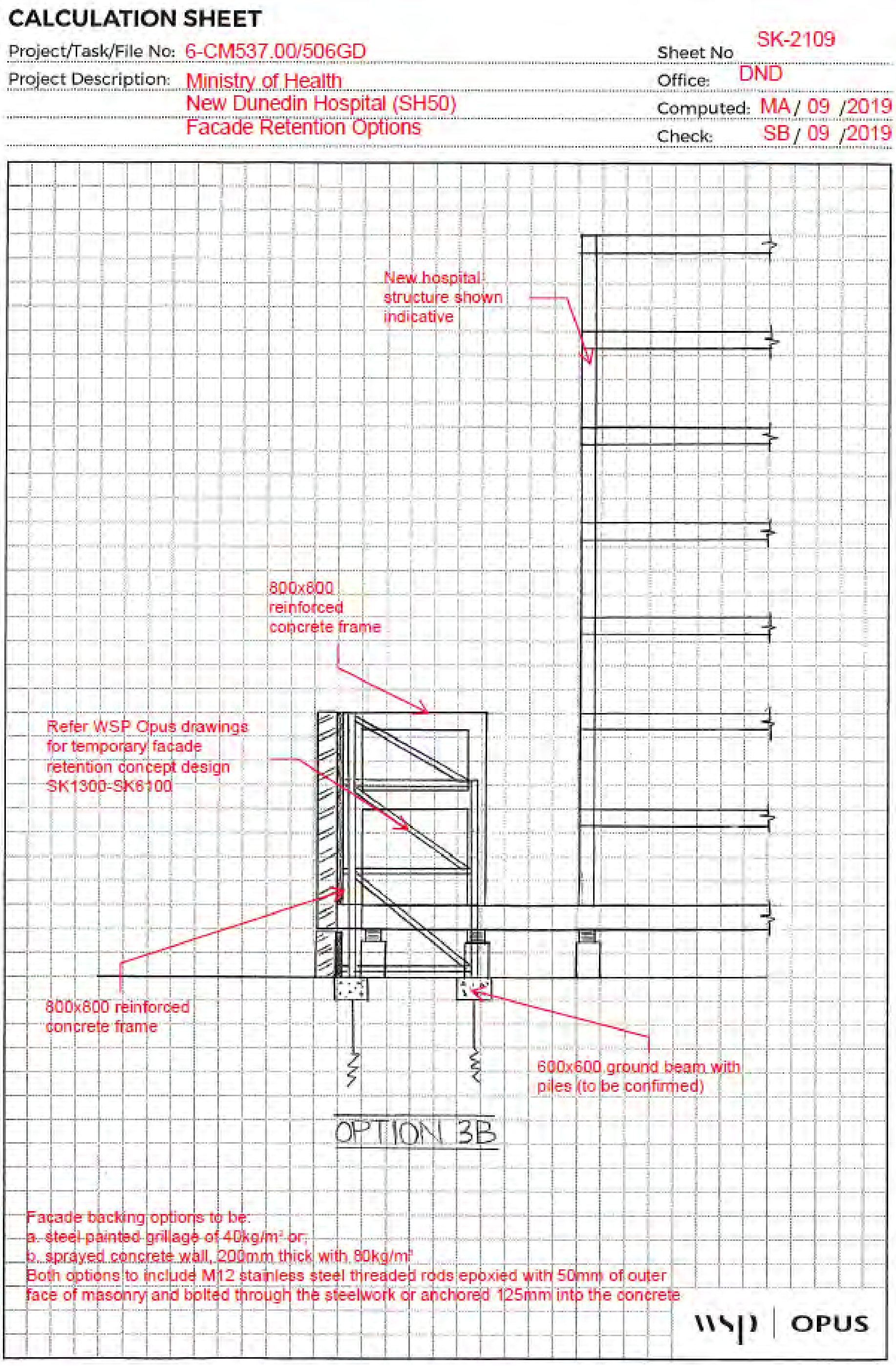

Figure 14: Option 3B.

Option 4 – Deconstruct and Reconstruct

This option involves deconstructing the façade brick by brick and rebuilding them with the new structure. The rebuilt brick walls would have reinforcing in the mortar joints horizontally and in cores through the brickwork vertically to allow them to be supported. This option avoids the need for temporary support.

Option 5- Replica Façade

This option involves:

- A GRC replica of a façade being made and attached directly to the new building structure.
- The GRC would be made in panels with joints in between to allow for movement in a seismic event.
- The GRC panels would be mounted on a steel frame attached to the building.

This solution has the advantage that the replica façade is lightweight and can be attached directly to the new structure, allowing for more useable space within the new hospital building.

Appendix D
ASNZS1170.0 Extracts

TABLE 3.2

IMPORTANCE LEVELS FOR BUILDING TYPES—NEW ZEALAND STRUCTURES

Importance level	Comment	Examples
1	Structures presenting a low degree of hazard to life and other property	Structures with a total floor area of <30 m^2 Farm buildings, isolated structures, towers in rural situations Fences, masts, walls, in-ground swimming pools
2	Normal structures and structures not in other importance levels	Buildings not included in Importance Levels 1, 3 or 4 Single family dwellings Car parking buildings
3	Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds	Buildings and facilities as follows: (a) Where more than 300 people can congregate in one area (b) Day care facilities with a capacity greater than 150 (c) Primary school or secondary school facilities with a capacity greater than 250 (d) Colleges or adult education facilities with a capacity greater than 500 (e) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities (f) Airport terminals, principal railway stations with a capacity greater than 250 (g) Correctional institutions (h) Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate more than 5000 people and with a gross area greater than 10 000 m^2 (i) Public assembly buildings, theatres and cinemas of greater than 1000 m^2 Emergency medical and other emergency facilities not designated as post-disaster Power-generating facilities, water treatment and waste water treatment facilities and other public utilities not designated as post-disaster Buildings and facilities not designated as post-disaster containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries
4	Structures with special post-disaster functions	Buildings and facilities designated as essential facilities Buildings and facilities with special post-disaster function Medical emergency or surgical facilities Emergency service facilities such as fire, police stations and emergency vehicle garages Utilities or emergency supplies or installations required as backup for buildings and facilities of Importance Level 4 Designated emergency shelters, designated emergency centres and ancillary facilities Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond the property boundaries
5	Special structures (outside the scope of this Standard—acceptable probability of failure to be determined by special study)	Structures that have special functions or whose failure poses catastrophic risk to a large area (e.g. 100 km^2) or a large number of people (e.g., 100 000) Major dams, extreme hazard facilities

3.4.2 Serviceability limit states

Serviceability limit states shall include—

(a) SLS1—the structure and the non-structural components do not require repair after the SLS1 earthquake, snow or wind event; and

(b) SLS2—the structure maintains operational continuity after the SLS2 earthquake.

For serviceability limit states for structures of importance levels 2 to 4, the annual probability of exceedance (P) for wind, snow and earthquake loads shall be determined as given in Table 3.3.

NOTE: Guidelines for limits associated with serviceability events are given in Appendix C.

TABLE 3.3

ANNUAL PROBABILITY OF EXCEEDANCE

Design working life	Importance level	Annual probability of exceedance for ultimate limit states			Annual probability of exceedance for serviceability limit states	
		Wind	Snow	Earthquake	SLS1	SLS2 Importance level 4 only
Construction equipment, e.g., props, scaffolding, braces and similar	2	1/100	1/50	1/100	1/25	
Less than 6 months	1 2 3 4	1/25 1/100 1/250 1/1000	1/25 1/50 1/100 1/250	1/25 1/100 1/250 1/1000	— 1/25 1/25 1/25	
5 years	1 2 3 4	1/25 1/250 1/500 1/1000	1/25 1/50 1/100 1/250	1/25 1/250 1/500 1/1000	— 1/25 1/25 1/25	— — — 1/250
25 years	1 2 3 4	1/50 1/250 1/500 1/1000	1/25 1/50 1/100 1/250	1/50 1/250 1/500 1/1000	— 1/25 1/25 1/25	— — — 1/250
50 years	1 2 3 4	1/100 1/500 1/1000 1/2500	1/50 1/150 1/250 1/500	1/100 1/500 1/1000 1/2500	— 1/25 1/25 1/25	— — — 1/500
100 years or more	1 2 3 4	1/250 1/1000 1/2500 *	1/150 1/250 1/500 *	1/250 1/1000 1/2500 *	— 1/25 1/25 1/25	— — — *

* For importance level 4 structures with a design working life of 100 years or more, the design events are determined by a hazard analysis but need to have probabilities less than or equal to those for importance level 3.

Design events for importance level 5 structures should be determined on a case by case basis.

Appendix E
Building Façades – More Detailed Information

Building Façades – More Detailed Information

Each of the building façades affected by the construction of the new hospital have been reviewed and are considered below.

Cumberland Street Elevations

Block 1

Block 1 comprises several interconnected buildings. The original building and building façade were constructed in many phases, the earliest being in 1868.

Figure 15: Cumberland Street façade of Block 1.

The building is three and four storeys high and is constructed of unreinforced masonry brick (URM) walls with a concrete slab at ground level. The upper storeys have timber framed floors with a screed finish and a timber framed roof. The ground floor level housed the Cadbury World facility. From this level, the supporting structure of the first floor is visible and consists of double steel RSJ beams which span between and into the URM walls. In general, the floor structure elements are set into the brick walls but were not observed to be mechanically connected to the brickwork.

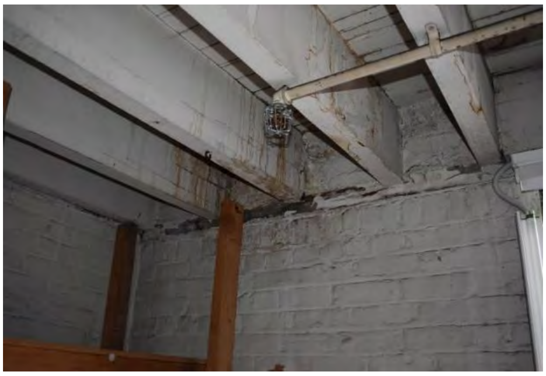
Figure 16: Underside of second floor adjacent to façade wall.

The Cumberland Street façade is approx. 11 metres high and is constructed of URM with regular window openings. The wall varies in thickness from 18" (457mm) at the ground floor, to 9" (229mm) parapet at roof level, according to the drawings available. The façade wall is currently supported by the timber floor structures, as timber joists and rafters are set into the brickwork, and steel tie rods help by tying the top of the wall back to the internal structure.

Existing drawings show the original building to have shallow concrete pads of an unknown depth. Later extensions are shown to have similar foundation types.


Figure 17: External view of the façade wall to Block 1 showing plaster carks and damp at pavement level.

The wall shows many signs of damp penetration and it may be assumed that the brickwork itself is quite wet. At the bottom of the wall externally there are signs of rising damp. The external surface of the wall is plastered and there are several fine cracks in the plaster.

Hanlons carried out an Initial Seismic Assessment (ISA) of the Cadbury Factory Site. The Initial Evaluation Procedure, as part of the ISA process, is considered to be just an initial, "first stage" look at the building's seismic assessment and is used to provide an indication of the seismic rating for the building. The building in Block 1 was rated 20%NBS*(IL2)* which was based on the observation that there is no visible connection between the main elements of the building.

Block 2

Figure 18: External view of the block 2 façade looking South.

Block 2 comprises a four-storey building used for offices on the upper floors and factory staff facilities on the ground floor. The date of original construction is unknown although a portion is thought to have been constructed in 1868 along with the original building and façade of Block 1.

The external URM walls of the building are tied to reinforced concrete columns at regular centres around the perimeter. The top storey has a mansard roof structure clad with slate on the Cumberland Street façade only. The rest of the building has a flat roof which appears to be supported on timber beams. These beams are supported on intermediate timber columns throughout the building. The upper floors are timber framed with timber partitions and are supported on regularly spaced beams and columns. The first-floor structure was replaced with reinforced concrete floor slab in 1958 and the existing timber columns were encased with steel and capped to support the slab above. Further alterations to the timber partitions were made in 1982 to redevelop the office spaces.

From the drawings, the building foundations are shown to be spread footings beneath columns.

Figure 19: Internal view of the wall at ground floor level showing damp penetration.

The Cumberland Street façade wall is approx. 12m metres high (not including the mansard section), constructed of URM with regular window openings. It is shown to be 24” (610mm) thick at the first-floor level. The north end of the Block 2 façade wall is distinctively different from the south end. The decorative pattern from the Block 3A façade extends into the façade of Block 2 as a link structure connects the buildings. There is a service entrance on the ground floor level beneath the link. The mansard roof structure extends the full width of the Block. Internally, the façade wall is lined with plaster, and cladding at the higher levels and therefore is not clearly visible. No indicators of distress to the wall materials were observed.

To remove the building while retaining the façade, would require that the mansard roof be removed entirely, thus reducing the overall height of the structure. Supporting the link section of the façade would also represent a challenge.

As for Block 1, Hanlons carried out an IEP and rated the building at 20%NBS*(IL2)*. It is therefore likely to be equally as challenging to strengthen and support the Block 2 façade, as for Block 1.

Block 3A

Block 3A is situated on the Cumberland Street side of Block 3. It is a four-storey building, with a façade on Cumberland Street. There is limited information on the age and construction of the building but, it would appear that the ground floor was originally constructed in 1922 with the upper floors added in 1924. An extension towards Cumberland Street and an additional penthouse storey were added later.

Figure 20: Cumberland elevation of Block 3A.

The original building is constructed of concrete columns around the perimeter external walls with cavity brick infills beneath large windows. The ground floor has a concrete slab and the upper levels have concrete floors supported on steel RSJ beams spanning between steel RSJ columns. The steelwork is connected with riveted connections. The extension is of similar construction but with circular internal columns – thought to be steel RSJ columns encased in concrete – on the ground level supporting the slab above. The external walls have reinforced concrete columns and beams with windows and concrete infills and the building typically has a flat roof and the external walls extend above to form a parapet. There is a four storey lift shaft on the south side of the building which was observed to be a concrete frame with a mix of URM and concrete infill.

The Cumberland Street façade is approx. 16m high at the penthouse and approx. 14.8m to the north of that and is constructed of reinforced concrete columns with reinforced concrete spandrels beneath windows at each level. There are no drawings of the original building available, but the penthouse extension drawings indicate that the main wall is 300mm thick with columns on the outside which project a further 300mm. According to the drawings, there is a cavity brick parapet above the penthouse roof level.

From the drawings, the foundations are shown to be perimeter strip footings with spread footings beneath internal columns.

Damp penetration at the ground level (rising damp) was observed around the windows and at roof level. The penthouse is particularly damp the internal gutter against the façade wall has large cracks.

Hanlons IEP rates the building at 20%NBS*(IL2)* due to the lack of ductility in the framing connections.

Block 4A

Figure 21: Cumberland Street façade of Block 4A.

Block 4A is situated on the Cumberland Street side of Block 4 and was constructed in 1960. It is predominantly a reinforced concrete frame with reinforced concrete spandrels beneath large windows on the external walls. The building is three storeys high with reinforced concrete floors spanning between reinforced concrete columns at each level. The top level is constructed of steel portal frames which support the roof structure. The steel portal frames span between external concrete walls and are connected at the knee. The ground floor was used for engineering workshops and areas for glucose and melting processes. The first floor was upgraded to an office space in 1994 with timber partition walls. There is a reinforced concrete stair tower on the east side.

The Cumberland Street façade is approx. 14m high and is constructed of reinforced concrete columns with reinforced concrete spandrel infills beneath large windows. The columns are 1'9" (534mm) thick and support the edge of the concrete slab floor structures with tapered column heads. The infill spandrels are 10" (254mm) thick. The wall has a large opening at the ground floor, used as a service entrance, and many large windows. The size and number of openings in this wall may present challenges to its retention

The building foundations comprise 25ft (7.6m) deep piles which are likely to be more resilient than the strip footings but are still within the 7m layer considered as liquefiable. Careful analysis of the piles would be required to determine their performance in an IL4 seismic event. The façade wall has a ground beam type foundation which is supported on a line of piles.

Hanlons IEP has calculated the seismic rating of the building at 100%NBS*(IL2).*

Block 5

Block 5 spans the entire width of the Cadbury Factory site with façades on Cumberland Street and on Castle Street. The four-storey building was designed as a biscuit factory at the same time as Block 4C in 1947. Construction of the building was completed in 1951. An additional fifth storey was added in 1968.

Figure 22: Cumberland Street elevation of Block 5.

The building comprises regularly spaced circular concrete columns with cone shaped column heads supporting the first, second and third floor slabs while square concrete columns with concrete beams support the fourth-floor slab. The top storey is constructed of steel portal frames supporting the roof and creating a large open floor area. The external walls are constructed of reinforced concrete columns and concrete infills beneath window openings. There is a seismic gap between Block 4A and Block 5.

There is a five-storey reinforced concrete lift shaft and stair well at each end of the building which may need to be removed as part of the façade retention.

The Cumberland Street façade is approx. 22m high and is constructed of reinforced concrete columns with reinforced concrete spandrel infills beneath large windows. The columns are 1'9" (534mm) thick and support the edge of the concrete slab floor structures with tapered column heads. The infill spandrels are 10" (254mm) thick.

According to the drawings available, the building foundations comprise a reinforced concrete cellular slab structure approximately 1.4m below ground level and 2.8m below ground level in the lift shaft.

The wall is painted on both the internal and external face. Some evidence of wear and tear were observed but no signs of distress.

Hanlons IEP rated the building at 20%NBS*(IL2)* because of the general lack of ductility in the structure and the likelihood of brittle failure.

Castle Street Elevations

Block 3C

Figure 23: Castle Street elevation of Block 3C.

Block 3C is situated on the Castle Street side of Block 3. It is a three-storey building with a façade on Castle Street. The original building was constructed in 1924. It was extended in 1934 and a third storey was added. According to the drawings, the building was constructed with a temporary end and was extended towards Castle Street with a similar construction type in 1938. This building is often referred to as Block 3B, and the Castle Street extension as Block 3C. The buildings were used for raw materials and manufacturing plant. A staff cafeteria was constructed on the fourth storey of Block 3B in 1938 and was later refurbished in 1989.

The original building is constructed of concrete columns and beams around the perimeter external walls with cavity brick infills beneath large windows. The ground floor has a concrete slab and the upper levels have concrete slab floors supported on steel RSJ beams spanning between steel RSJ columns. The steelwork is connected with riveted connections. The building extension has a similar construction with concrete infills between columns on the external walls. The top storey cafeteria is constructed with a timber framed roof and URM walls with timber beams spanning between URM columns and intermediate timber posts. There is a four-storey reinforced concrete stairwell and lift shaft on the south side of the building and a three-storey blockwork stairwell at the east end, which is connected to the façade wall.

The Castle Street façade is approx. 14m metres high and is believed to be constructed of reinforced concrete with large window openings. There are no drawings of this section of building available but by site measure the façade wall is approximately 300mm thick. There are some further projections to the decorative section to the south end of the wall. There is a large opening on the found floor level which may present a challenge for retention.

The wall is painted on both the internal and external face. Damp penetration was observed at the bottom of the wall at ground level, at the top from the roof, and around some of the windows. There was also evidence of mould staining from condensation. Minor cracking was noted particularly on the external face. There was also a crack observed at the corner of a window at second floor level.

There is a straight joint between the Block 3C façade and the adjacent façade of Block 4B. Further investigation will be required however, if both façades were preserved, this may create problems of the different façades pounding against each other.

Block 4C

Block 4C is situated on the Castle Street side of Block 4 and is a five-storey concrete framed building used for workshops and packaging. The original three storey building was designed in 1947 as a biscuit factory and construction was completed in 1951. An additional two storeys were added in 1968.

The building comprises regularly spaced circular concrete columns with cone shaped column heads supporting the first and second floor slabs, and square concrete columns with concrete beams supporting the third and fourth floor slabs. The top storey is constructed of steel portal frames supporting the roof and creating a large open floor area. The external walls are constructed of reinforced concrete columns and concrete spandrels beneath window openings. The ground floor level of the building was altered in 2008 with the addition of concrete masonry block partition walls.

Block 4C was constructed at the same time as Block 5 and therefore share similar construction details, including foundations. The buildings are adjoined and there is an open accessway between blocks on each level. There is also a seismic gap between the buildings.

The Castle Street façade is approx. 22m high and is constructed of reinforced concrete columns with reinforced concrete spandrel infills beneath large windows. The columns are 1'9" (534mm) thick and support the edge of the concrete slab floor structures with tapered column heads. The infill spandrels are 10" (254mm) thick.

The wall is painted on both the internal and external face. There are tiles under the windows and on the ground level and there are large service vehicle openings which have since been filled in with concrete blockwork. There are signs of wear and tear on the wall but no particular signs of distress such as significant cracking, bulging or other damage.

Block 5

Block 5 spans the entire width of the Cadbury Factory site with façades on Cumberland Street and on Castle Street. The construction at the Castle Street side is therefore the same as Cumberland Street.

The Castle Street façade is also the same in height (approx. 22m) and construction. Note that at the north end of the building, there is an extended return and the fourth-floor cantilevers over the edge of the floor below. If the building were to be demolished, and the façade retained, this would require further review. Similar to the Cumberland Street elevation there is a service lift at the Block 4 end.

Figure 24: Castle Street elevation of Block 5.

There is evidence of some damp staining on the wall, at low level, and some minor cracks in the plaster, but overall the façade appears to be in good condition.

Appendix F
Examples of Façade Retention

Examples of Façades Retention

Wellington East Girls College

The Wellington East Girls College has a category 1 listed façade. It is unreinforced brickwork although it had previously been strengthened by cutting out sections of the brickwork and casting in reinforced concrete columns and beams.
The following photographs give an indication of the extent of the works required firstly in the temporary support stage and secondly to strengthen and tie the existing wall into the new building permanently.

Figure 25: Aerial view of the temporary support.

Figure 26: External view of the temporary propping.

Figure 27: Internal view showing the start of the strengthening works required.

Figure 28: view showing the extent of the temporary propping.

Figure 29: Internal concrete beams to reinforce and support the brickwork.

Figure 30: Internal view of the building progressing.

Figure 31: Aerial view showing the construction proceeding.

Figure 32: Extent of the strengthening work inside.

McKenzie and Willis Christchurch

The McKenzie and Willis Store in Christchurch has been rebuilt retaining the original façade. Steel bracing frames were installed on the outside of the building to temporarily hold the facades.

Figure 33: Inside view of the temporary support for the Mackenzie and Willis façade Christchurch.

Figure 34: External view of the temporary propping.

Note that there are additional internal steel columns to support the brickwork around the window openings. They are bolted through the wall at relatively close centres to connect the internal support to external raking supports. The original steel beam at first floor level and the circular columns below are braced by the supporting structure.

Externally the raking supports are required to fully support the wall. They extend out a significant distance from the wall. Concrete blocks are used for kentledge (to prevent uplift). Any supporting foundations cannot be seen.

The external supporting frames also have substantial foundations. In this case they are piled because of the adjacent retaining wall.

In this case reinforced concrete was added to the façade which was then tied into the stiff steel structure of the strengthened building.

A significant amount of strengthening works have been carried out to strengthen and support the brickwork façade form the inside.

For this development the reinforced concrete floors are connected to the façade walls to assist with fixing them in place and to distribute the seismic forces. In this case it has worked well because the original window openings have been incorporated into the design so that they align between floors. This will be more challenging for the Cadbury facades due to inconsistencies in the floor and window levels between blocks.

Replica façade – Mayfair Hotel Christchurch

It is possible to reproduce the façades by casting replica sections in GRC (Glass Fibre Reinforced Concrete). Projects have been completed with replica façades created in this way. An example of this is the Mayfair Hotel which was reconstructed in Christchurch after the original building had been demolished post-earthquake. Figure 35 below, show an elevation of the GRC façade with the panel layout on the left and the supporting steel structure behind the GRC panels on the right.

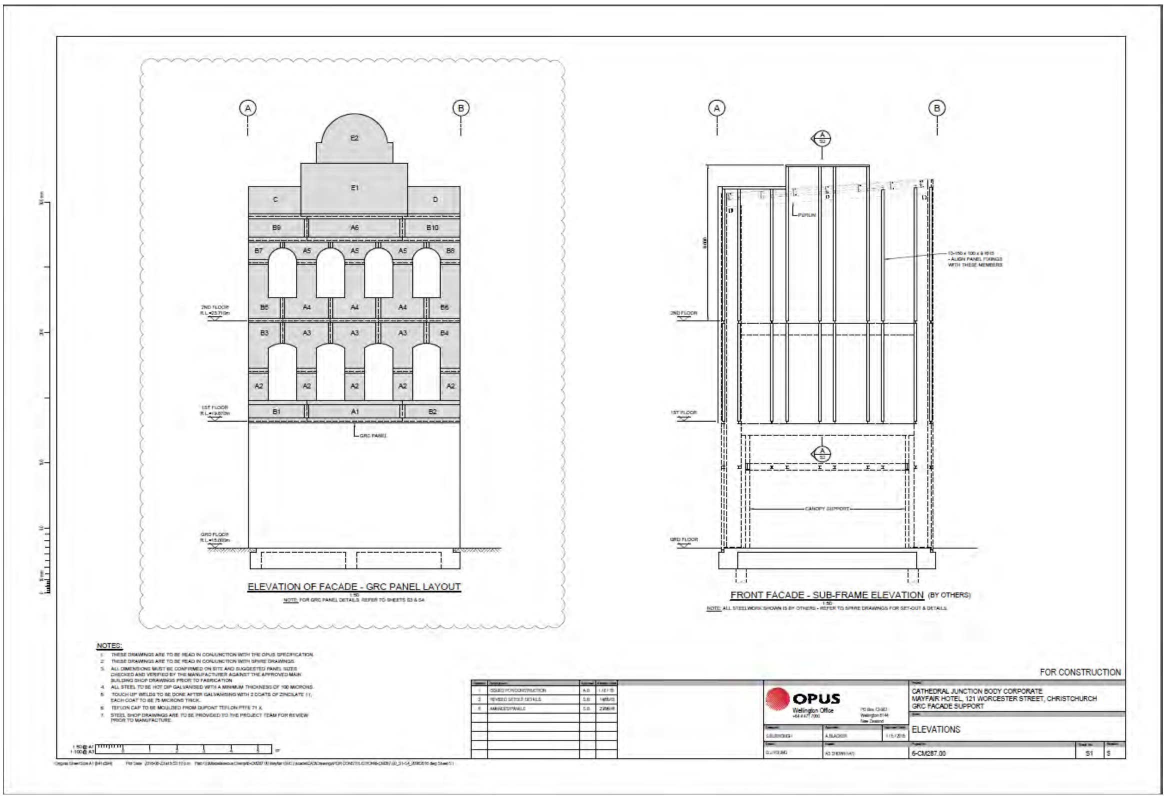

Figure 35: Drawing showing the supporting structure for the GRC panels.

The minimum standard in the building code allows for parts up to 7.5kg (i.e. an individual brick) to be unrestrained. This balances cost and risk. It may be difficult to achieve a complete and satisfactory restraint of these walls and it would not be possible to restrain every single brick. As discussed above, with the agreement of NZ Heritage a reinforced concrete wall may be designed to carry the old façade as a veneer. Whilst this is possible it has its own limitations in terms of weight and stiffness and the size of supports to accommodate it in the new buildings.
As an alternative, if it is essential to retain the brick façades it would be possible to do so by carefully demolishing them and then rebuilding them – using as many of the original bricks as possible but with building in reinforcement and ties to allow the whole wall to be restrained in a satisfactory manner.

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