New Dunedin Hospital
PIKI TE ORA

RCP

Assessment of Buildability

in relation to Cadbury façade retention

Issue Date: November 2019

Project name:	New Dunedin Hospital
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VERSION 2.0	**08 November 2019**	**Information**	**Final**	**M Allen**

1. Executive Summary

RCP has been engaged by the Ministry of Health as Design and Project Managers for the New Dunedin Hospital development. It is our responsibility to provide guidance and recommendations to the Ministry during the hospital's development. This report provides a recommendation to the Ministry in relation to the feasibility of retaining the heritage buildings and/or facades on the former Cadbury Buildings.

Taking into account the various specialist reports and technical opinions provided to the Ministry in relation to this matter, it is our considered opinion that retention of the existing buildings or facades (other than the Dairy Building) would unreasonably compromise the Ministry's ability to provide the region with a modern, state of the art hospital that incorporates significant healthcare technology and hosts modern models of care.

In reaching that position we have taken into account technical inputs from the following industry specialists to analyse buildability within key building/design parameters:

- CCM Architects who have provided information regarding effects on hospital design.
- WSP-Opus who have provided structural advice regarding retention of the existing building facades.
- Rider Levett Bucknall (RLB), the project Quantity Surveyors who have provided pricing of the façade retention options outlined by WSP Opus.
- Stantec who have produced a Traffic Management Strategy (TMS) that sets out the likely NZTA requirements related to traffic management associated with the retention options.

Our analysis reaches the conclusion that the costs to the project in terms of time, resource allocation and compromising of the ultimate built outcome are such that an application for resource consent to demolish the buildings and facades should be progressed.

2. Brief description of facade retention options

Reproduced below is a table created by WSP-Opus identifying façade retention options. A "RAG" (Red, Amber & Green) format has been used to visually demonstrate how the options compare against each other, with each item assessed against the options identified on the left side of the table and the New Hospital used as the Baseline. The following assumptions are used:

- Both options 1[1], assume a hospital built right up against the façade.
- Both options 2[2], assume a separate structure to the facades, seismically separated from a new structure.
- Both options 3, assume a separate structure to the façade but seismically joint to the new structure.
- Option 4 assumes deconstruction & reconstruction of the façade.
- Option 5 assumes replacement of the existing façade with a lightweight Glass Reinforced Concrete replica.

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

Image 1: WSP-Opus – RAG table Façade retention options.

[1] Options a & b indicate the side of the façade the structural supports are located
[2] As above

3. Analysis of Foundations Works Required

The following section outlines practical matters that will need to be taken into account in assessing the various options.

Underpinning

Underpinning is a method of stabilisation in which the ground under the structure needs to be reinforced to properly support the structure above. With underpinning, the ground underneath the edge of the structure needs to be removed (exposing the underside of the existing foundation) so that the ground around it can be stabilised and reinstated. Depending on how deep the existing foundations are, there may be a need to introduce sheet piling or benching to provide safe working spaces. Sheet piling creates a temporary cantilevered retaining wall, where interlocking steel sheets (about 300 wide) are mechanically driven into the ground, and the soil on one side is excavated providing a lowered working platform. Benching works in a simpler way, by excavating down in stages some distance apart creating safe working levels. Benching however requires more space and may not be a viable option on constricted sites.

In some cases where ground conditions are poor there may be evidence of the building slumping (typically identified by diagonal cracking of exterior claddings), in which case the existing foundations need to be jacked up lifting the structure to its original location prior to reinstating the underside of the foundations. Moreover, depending on the condition of the ground, piling may be required to provide sufficient bearing to the foundations. Underpinning needs to happen in stages along the foundation (often referred to as "Hit and Miss") to ensure there is still sufficient bearing to the structure and no undermining occurs. Undermining is a very real risk associated with these works and safety procedures and protocols need to be carefully followed.

Increasing bearing capacity and stabilising the ground

There are some options available to obtain an increased soil bearing capacity of the ground, with the main options being piling, or raft slabs. Piling involves penetrating through bad soils until a firm bearing layer is found that can support the new structure. A raft slab involves creating a solid base on top of what could be bad soil. The rafts are engineered to specific depths and have reinforcing layers throughout so that if there is subsidence underneath the slab, the strength of the raft will cause it to span over the soft spots not impacting the structure above. With raft slabs there is a chance for some settlement, but this would occur over the whole structure and would likely not be noticed.

Base Isolation / Seismic separation

The New Dunedin Hospital is required to be designed at IL4 (Importance Level 4), meaning that in a significant seismic event the hospital will still be operational. As part of this requirement the structural design consultants have adopted a base isolation approach. This allows the ground to move under the hospital while the base isolators dampen the effect and allow the building to 'slide or float' on its foundations minimising damage to the structure and its occupants

Discussion

In retaining the existing Cadbury facades, the WSP-Opus report provides options that require both underpinning and piling. To underpin the existing foundation walls, a clear space of approx. 10m (width and height) would be required. This would allow for machine access to excavate and pile as required.

Driving piles in and around existing foundations is a complex exercise. Especially if the underpinning and piles are to be driven with the structural façade frames on the inside of the existing building, this must happen in a way that takes into account coordination of the following:

a) the existing structure that is to be removed but only after the façade supports go in.
b) the temporary facade supports located in a place that is structurally supportive to the façade (i.e. not across windows) but also in a place that doesn't impact the new structure location.
c) Ensuring sufficient room for temporary foundations to support the façade frames. These foundations will need to be buried so will likely be sacrificial, the location of these need to be coordinated around the new foundation design.
d) the new structure to be installed while the façade frames are still in place, while still allowing space to disassemble and remove the frames.
e) the avoidance of all services that may be affected i.e. 33kva cables in the footpath on Castle street.

The complexity described above may reveal later in the design stage that support frames on the inside of the building may not be viable. If this is the case, support frames on the outside of the building will be the only viable option.

The proximity of the older unreinforced masonry Cadbury buildings adjacent to the Heritage listed Allied Press (ODT) building, also means that vibration caused by excavation or driving sheet piles or structural piles etc will need to be very carefully managed. Specific matters such as the vibration impacting the operation of the ODT printing press and the financial repercussions of this are also significant issues to be managed.

Further, considerable thought would need to be put into the impact of retaining facades that border neighbouring buildings when the new structure will be designed to move considerably in a seismic event. This movement would have significant effects on the neighbouring buildings, and it is not clear at this point how such effects can be managed. In order to retain the facades (that are currently fixed to the ground) and keep the base isolation approach, there needs to be a seismic separation introduced to any façade retention option. Four of the six façade retention options (1a, 1b, 3a, 3b) indicate horizontally cutting the façade to physically separate it from its original foundation. After a seismic event the separation gap would need to be checked and remedial work would be required. While the process to provide the seismic separation in this area would be hugely complex and costly, it is most likely the least onerous for future remedial work. The other two options (2a, 2b) have a seismic separation between a new frame supporting the facades and the main hospital structure. The issues that arise from this are more fully covered in Section 5.

4. Analysis of Façade Temporary Works

Installing the temporary structural façade supports on the exterior of the building (options 1a, 2a & 3a) would be the favoured option and have the least impact from a new construction standpoint. There is enough space for the foundations to be placed and the frames to be fixed in place. It allows the internal construction of the hospital to progress without the need to build in and around temporary frames. The downside with this option is the street-run services and necessary traffic management, refer sections 6 & 7 respectively.

The option to have the façade supports on the inside (options 1b, 2b & 3b) of the building creates other difficulties. All buildings have 'structure lines' typically set out in a grid type format, these structure lines are used to transfer the weight of the buildings structure. Loads come down the building from the highest level through the columns, beams and bracing systems into the foundations. Between these structure lines is where windows / doors, etc are located.

The internal structure of the Cadbury Buildings cannot be removed before the temporary façade restraints are in place. These restraints will need to be located as close to the existing structure lines as possible to accommodate the loads of the façade when the internal structure is gone. Importantly, the restraints cannot be located over windows / doors as the buildings hold no structural resilience in these areas. Similarly, for the construction of the new hospital to adjoin the existing facades, this will need to happen in and around the temporary restraints until it is safe for them to be removed. The complexity of making this a reality should not be underestimated, and for this reason the option of temporarily bracing the facades from the inside is not considered feasible. It then follows that the impact on the state highway and utilities beneath cannot be avoided

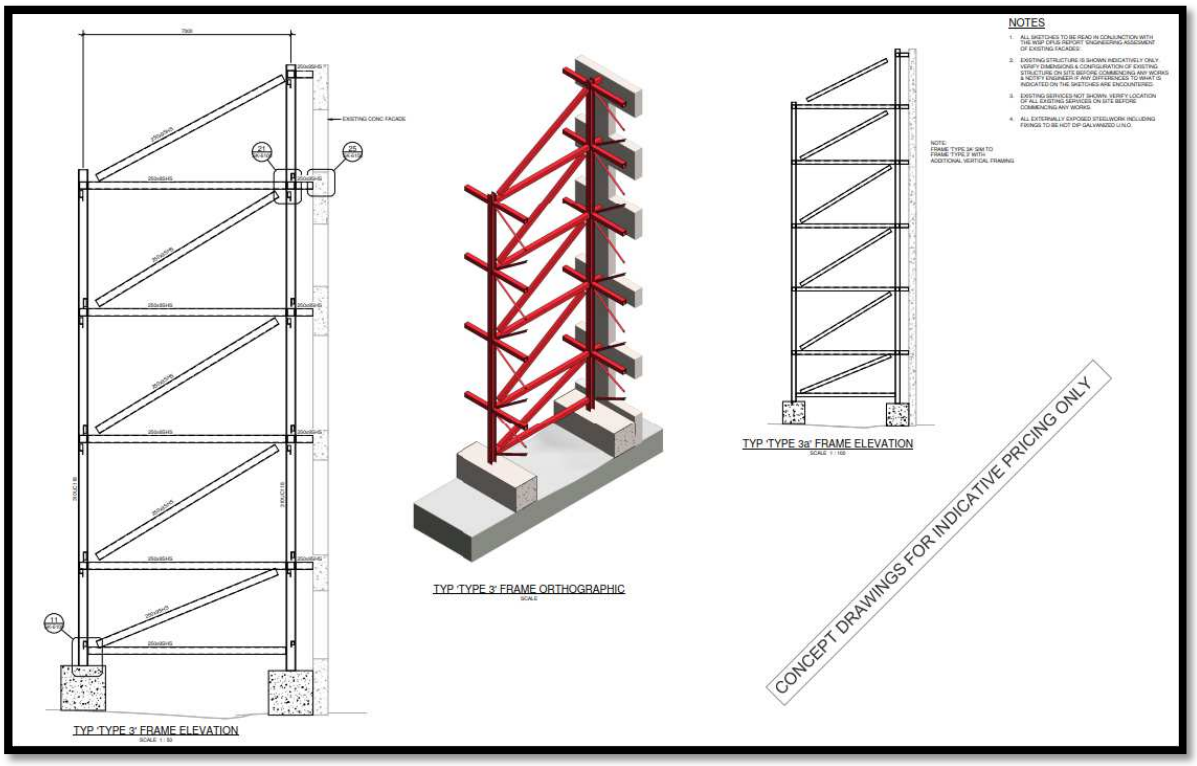

Image 2: WSP-Opus façade retention structural frame

5. Analysis of Complex Connections between Façade and New Superstructure

Establishing a connection between an existing façade and a new structure is always going to pose challenges, and it becomes even more difficult when the façade needs to be upgraded to meet an IL4 standard.

The façade retention options outlined within the WSP-Opus report provide different construction approaches, separated out in the analysis below.

Option 1a & 1b shows a full height hospital building built hard up against the existing façade. Both options 1 & 3 have the same façade connection / seismic separation methodology so comments made will be common to both.

While this option would be the simplest to erect, having a new hospital structure abut an existing façade does create complications. Specifically, the corresponding floor levels won't line up, which leads to existing windows being at the floor levels of the new hospital and would therefore need to be filled in.

In addition, while the physical structural connection between the existing facade and the new structure would be relatively simple, the challenge comes as to when or where the connection can take place and whether there are other items in the way.

Finally, in-ground works to allow the building to be established up against the boundaries will cause significant delays (using the complex methods outlined in section 3).

By way of positive implication, impact on new services with options 1a and 1b will be low as the façade is the only portion of the building that is fixed to the new hospital structure.

Option 3 however, does have a frame fixed to the façade with a substantial gap to the main hospital building. This will impact on the functionality of a new hospital design in that the building services (ducted, tray run, and pipe run) won't easily transfer through to the external portion of the building.

Options 2a & 2b shows a frame fixed to the façade which is seismically separated from the new hospital. This is a different approach to Options 1 & 3.

This option allows for new floor levels to be established to match the existing openings in the façade, however as the facades have differing floor levels, ramps or split-level lifts would then be required. It then becomes more complex with the connection to the new hospital building which again will have different floor to floor levels. Such changes in levels will have an impact on the hospital's new layout and how usable spaces for staff and patients are created.

As ramps are to be avoided within Hospitals where possible, split level lifts would need to be provided. This would then require separation between the split floors which will impact on natural light. The split floors also create a problem for the structure as there needs to be a seismic separation at the location of the split levels.

This option would also create difficulties in transferring building services between the split levels because there needs to be an allowance for considerable movement. Transitioning ceiling services from a single floor to split levels would be incredibly complex and create more demand on the plant required. This also makes the weathertightness transition a lot more difficult, as moving parts are harder to keep completely sealed. More precaution would be required to implement secondary and tertiary levels of defence to the ingress of moisture. More so, when any seismic event happens, the services and weathertightness areas would need to be checked and most likely require remedial action.

Finally, for all options the unreinforced masonry buildings (block 1 & 2) have multiple skins of brick that could be significantly fixed on the back face but still extremely hard to hold on the street frontage. During a seismic event there would be significant risk of bricks dislodging and falling to the footpath.

6. Analysis of Impact on Existing Street Utilities

Public services such as power, water supply, foul sewer, stormwater, reticulated gas etc within the traffic corridor will also need to be considered with the retention of the facades.

There are essential city services running inside Cumberland, Castle and St Andrew Streets. If there were façade supports to be installed along Cumberland and Castle streets, the structural frames and foundations will cover some of these services. As these frames may be in position for 6-8 years this would severely impede the ability to access them should service / repair be needed. The weight of the foundations and frames also needs to be verified to ensure they would not cause damage to the in-ground services. It is conceivable that some of these utilities will require relocation prior to façade retention works commencing to retain their underlying resilience.

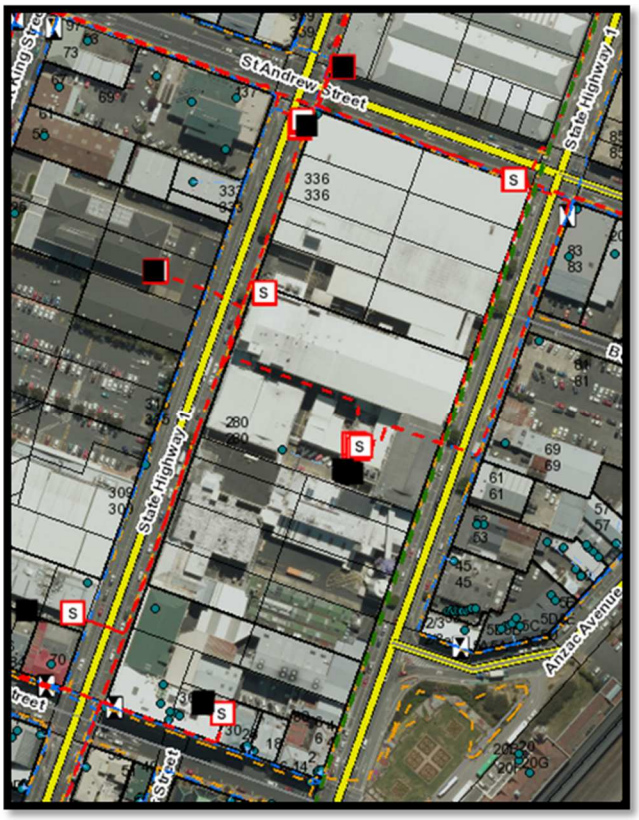

Image 3: Power services map (Aurora)

Image 4: Three Water services map (DCC)

Link to Aurora Energy online services map
http://www.arcgis.com/home/webmap/viewer.html?webmap=36c788a9848e4c869e96187e6517dacb&extent=170.4277,-45.9217,170.6092,-45.8423

Link to DCC services online map
https://dunedin.maps.arcgis.com/apps/webappviewer/index.html?id=16c606211c8441c18691a449807fb6a2

7. Analysis of Compromise to the Traffic Network

The site is located between three arterial routes of Dunedin city's traffic system - the dual carriageway one-way systems (SH1) running North (Cumberland St) & South (Castle St) on either side and St Andrew St (two way dual carriageway) running between the proposed blocks identified for hospital development. There are also separated cycleways which run on both Cumberland and Castle St closest to the Cadbury site.

An exclusion zone on the exterior of the site to protect the public will be required, It will be at least the width of the footpath, but may at times be required to extend onto the cycle ways and state highways (which will affect access to inground services). If the structural façade supports are on the outside of the building the exclusion zone would need to incorporate these areas.

The WSP Opus report identifies façade retention options (1a, 2a & 3a) that provide structural framing to the exterior of the building (on the street side). While this option would be preferred as far as buildability is concerned, (as it causes no disruption to the internal site construction), some of the structural frames protrude 8.700m out from the facade and would require closure to one lane of traffic and the cycle lane.

A Traffic Management Strategy prepared by Stantec identifies some scope to move the lanes over and away from the Cadbury site (refer Images below), but only for brief periods. This will be untenable if the structural frames were required to stand in place for 6-8 years as is anticipated.

Therefore, as it stands, there is a conflict between creating a temporary façade structure and maintaining the current flow and utility of the state highway network on both sides of the site. It is clear that retention of the heritage facades will have a significant and sustained impact on the operation of the state highways either side.

Image 5: Stantec TMS existing road layout

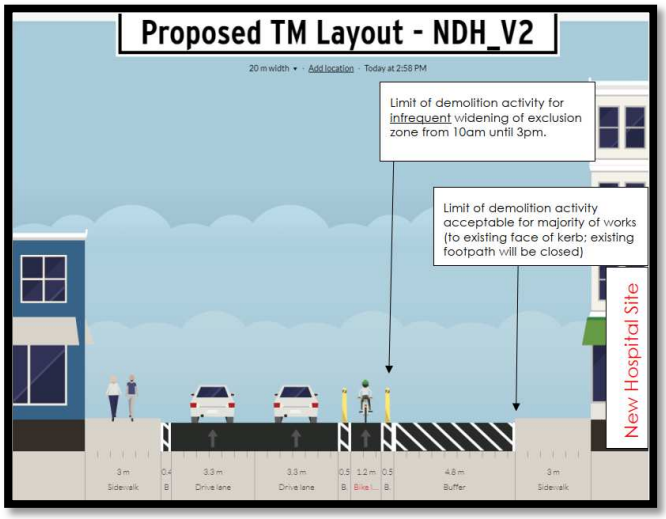

Image 6: Stantec TMS proposed road layout

8. Overall Analysis of Estimated Costs

The façade retention options below have been estimated to range from $32.6m to $74.6m.

It is evident in the estimates that the options 'A' which have the façade supports on the exterior of the building are a lesser cost than options 'B' having the supports on the inside face of the facades. The difference reflects the extra complications associated with having the façade supports on the inside face of the building. The increase in estimated price between options 1, 2 & 3 are reflective of the complex buildability of these options.

Option 4 allows for all unreinforced masonry facades (Block 1 & 2 only) to be deconstructed by hand, catalogued and stored in a warehouse until it's time to place them back in exactly the same location. This option includes the need for propping (as per Option 1A) to the remaining concrete facades.

Option 5 is for a completely new façade to be created from Glass Reinforced Concrete (GRC) to mimic the existing Cadbury facades. Sufficient information will be required / captured from the existing facades so that the new facades can be replicated almost identically. This option has the lowest estimated cost because it doesn't require the need to actually retain any facades during the construction of the new hospital and has the best outcome in respect of risks for Health and Safety. However, it is of course, not strictly retention of the heritage façade.

Option	Estimated Total Cost
Option 1A	$47,000,000
Option 1B	$58,800,000
Option 2A	$63,800,000
Option 2B	$69,800,000
Option 3A	$66,200,000
Option 3B	$74,600,000
Option 4'	$51,000,000
Option 5	$32,600,000

Image 7: Summary Cost Options from RLB Façade Retention Report October 2019

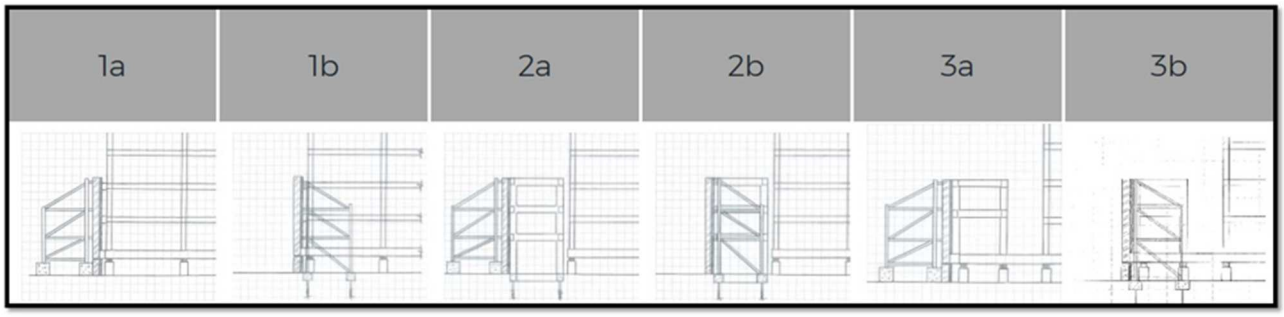

Image 8: WSP-Opus Façade retention options

9. Other Buildability Factors

There are other factors which will have an impact on buildability as set out below. These conditions are very hard to quantify yet add considerable complexity and safety risk to an already constrained site.

Some examples of these complexities include:

- No lay down areas suitable for major construction works when building up against facades that are insitu.
- Increased duration of construction and longer disruption impact on the city.
- Elevated designer and client obligation to Safety in Design principles.
- Integration from new design methodology to old construction techniques creating further complexity.
- Retention of the facades at the street boundary limit options for integration and activation of the new development at ground level, Ideally the new hospital would be articulated to allow for sufficient urban realm development.
- Frailty of the masonry will be exposed by vibration from the significant piling activities that are proposed beneath the new superstructure.