

**BEFORE AN INDEPENDENT HEARINGS PANEL
IN CHRISTCHURCH**

TE MAHERE Ā-ROHE I TŪTOHUA MŌ TE TĀONE O ŌTAUTAHI

UNDER the Resource Management Act 1991 (the **RMA**)

AND

IN THE MATTER OF the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

**STATEMENT OF REBUTTAL EVIDENCE OF CLARA CAPONI ON BEHALF OF
CHRISTCHURCH CITY COUNCIL**

HERITAGE ENGINEERING

CITY-WIDE QUALIFYING MATTERS: HISTORIC HERITAGE

Dated: 9 October 2023

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EXECUTIVE SUMMARY

1. This rebuttal evidence comments on the new information provided by witnesses for:
 - (a) Carter Group Limited (**Carter**), submitter #824, in relation to the Blue Cottage at 325 Montral Street, Christchurch City Centre; and
 - (b) Church Property Trust (**CPT**), submitter #825, in relation to the St James Church at 65 Riccarton Road, Riccarton.

2. In respect of Blue Cottage:
 - (a) I disagree with Mr Hill that the building has already lost most of its heritage features. In my opinion the cottage retains much of its original fabric and finishes.
 - (b) I agree with Mr Fulton that most of the damage to the existing heritage fabric is due to lack of maintenance.
 - (c) The building condition assessment undertaken by Mr Brookland does not provide sufficient information to ascertain the extent and severity of the damage to the internal linings and flooring. No opening-up works have been also undertaken to confirm the current state of the internal timber structures. Therefore, Mr Brookland's conclusion that "*an almost complete replacement of all of the building components*" is required to reinstate the property is not justifiable on the basis of the data currently available.
 - (d) The cost estimation provided by Mr Chatterton assumes that complete replacement of the building fabric and internal structure is required to reinstate the cottage. I believe that this extreme resolution is not justifiable on the basis of the data and information currently available on this building.

3. In respect of St James Church:
 - (a) I agree with Mr Eggleton that minor damage has occurred to St James Church as result of deferred maintenance works. The building, however, appears still in very good condition and basic and economic repairs would address most of the issues currently causing deterioration of the building fabric.

- (b) I do not agree with Mr Eggleton regarding the level of severity assessed for the earthquake damage. In my opinion, the level of earthquake damage to the structure is nil to minor.
- (c) In my opinion considering preliminary allowance for additional strengthening work at foundation is not justifiable with the data available at this stage.
- (d) I consider the concerns raised by Mr Carney regarding the effective extent of strengthening works required if change of use is to be pursued to be premature.

INTRODUCTION

- 4. My name is **Clara Caponi** and I am a Chartered Professional Engineer specialised in Heritage Structures. I am employed at Egis NZ Limited where I hold the position of Associate Engineer.
- 5. I prepared a statement of primary evidence on behalf of Christchurch City Council (**Council**). My primary evidence is dated 11 August 2023 and it relates to site specific heritage engineering matters raised in the submissions seeking changes to the Schedule of Significant Historic Heritage Places (**Schedule**).
- 6. I have the qualifications and experience set out at paragraphs 11 – 14 of my primary evidence.
- 7. I repeat the confirmation given in my primary evidence that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023, and that my evidence has been prepared in compliance with that Code.

SCOPE OF REBUTTAL EVIDENCE

- 1. This rebuttal evidence is in relation to the Blue Cottage and St James' Church.
- 2. In preparing this rebuttal statement, I have read and considered the evidence filed on behalf of submitters, as that evidence relates to my primary evidence. Specifically, in this evidence I respond to the following witnesses:

Submission #824 (The Blue Cottage)

- (a) Mr David Hill on behalf of Carter Group;
- (b) Mr William Fulton on behalf of Carter Group;
- (c) Mr Kyle Brookland on behalf of Carter Group;
- (d) Mr Tom Chatterton on behalf of Carter Group;

Submission #825 (St James Church)

- (e) Mr Peter Carney on behalf of Anglican Church Property Trust;
- (f) Mr Peter Eggleton on behalf of Anglican Church Property Trust.

SUBMISSION #824 – THE BLUE COTTAGE

Site Inspection

- 3. The submitter’s expert evidence is based on both an internal and external site inspection. However, no access to site was provided to the Council experts at the time when our primary and rebuttal evidence was compiled. Therefore, our evidence is based on a visual site inspection of the building exteriors only and the documentation currently available.

Building Earthquake Damage

- 4. In Section 9 of his evidence, Mr David Hill indicated that the building “*suffered significant damage that compromised its weather tightness in the 2011 earthquakes*”. I do not agree with this statement.
- 5. From an external point of view, the structures do not show obvious signs of leaning or significant residual displacements. From an internal point of view, if the 2011 earthquakes had significantly compromised the weathertightness of the external building fabric, diffused leaking and dampness issues should have immediately arisen in the earthquake aftermath. However, in her evidence provided for the Independent Panel Hearing in 2015 (4 years after the earthquake), Ms Gilles¹ reported that:

¹ <https://chchplan.ihp.govt.nz/wp-content/uploads/2015/08/3723-CCC-Evidence-of-Jackie-Gillespie-9.3-Heritage-EIC-3-12-2015.pdf>

“There was remarkably little evidence of earthquake damage, with cracking in the lath and plaster walls and ceilings and very little damage elsewhere”.

6. Upon reviewing the photographic documentation collected by Ms Gilles and Mr Stanley during their site visit on the 9th of November 2015, I agree with that statement. The 2015 photographic documentation confirms that the building interiors had only minor cracking in a very few localised areas of the ceiling and wall linings, and none to negligible displacements of the architraves miter joints. At that time, only one minor leaking issue was identified in the entire structure, and it was limited a very small area of the corridor vaulted ceiling (space G8 in the cottage floor plan²). I have included photos of the 2015 site inspection as **Appendix B** to this evidence.
7. Based on the above observations, the earthquake damage sustained by the building in the 2011 Canterbury Earthquake sequence appears to have been minor to negligible and mainly limited to the partial collapse of the upper portion of the west chimney.
8. The post- earthquake demolition of the west chimney might have locally compromised the weathertightness of the West Elevation. However, this damage cannot be strictly considered as an earthquake related damage but, rather, a consequence of the inadequacy of the temporary covering system installed at the time and long deferred remediation works.

Deferred Maintenance Works

9. In the summary of his evidence, Mr William Fulton indicated that *“The building is in poor condition largely due to a lack of maintenance but also because it has not been used for a number of years [...]”*. I agree with this statement. In my opinion, the majority of the damage to the existing heritage fabric is due to lack of maintenance and lack of adequate ventilation for the building interiors (as the building is and has been closed off for several years). Vandalism and natural aging of the building materials represent only secondary causes and contribute just in minor part to the extent of the existing damage.

² Refer to **Appendix A**.

Original Fabric and Building Alterations

10. In Section 19 of his evidence, Mr David Hill disagreed that the cottage retains much of the original fabric and finishes as some of the original features of the building have been removed or altered. In Section 11 of his evidence, Mr Hill also provided a detailed list of all the changes and alterations made to the building over the course of time.

Internal Changes/Alterations

11. Most of the internal changes mentioned by Mr Hill regard the replacement of fireplaces, doors, ceiling cornices and other internal trim. Although important heritage features, I note that the building internal features are not currently protected by the rules.

External Changes/Alterations

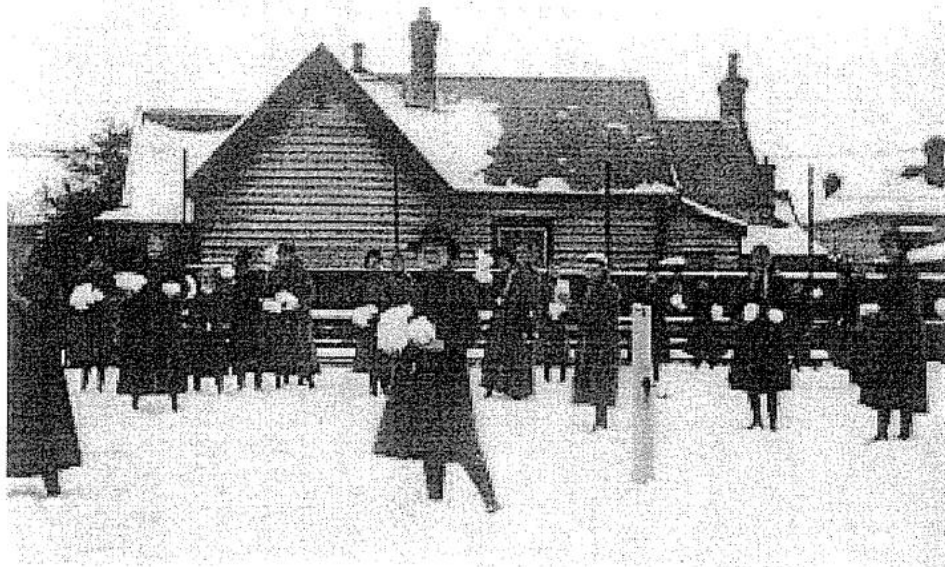


Fig 1. Early photo of the Blue cottage (325 Montreal Street, Christchurch)³

12. The external alterations mentioned by Mr Hill (and reported in my primary evidence as well) do not alter the substantial character of the building. An early photo of the building (probably circa 1900's), identifies the dwelling portrayed in the picture as the same structure on site today. This is despite

³ Photo from "The Caretaker's Cottage, Cramner Centre, Christchurch – A conservation Plan", Dave Pearson Architects Limited, January 2003. Due to the length of the report, it has not been appended but can be made available to the Panel on request.

the removal of slate roofs, chimneys, bullnose veranda and replacement of some sash windows.

13. It is worth noting that in this picture the lean-to structures added to the South-West Elevation are also portrayed. As Dave Pearson commented in his Conservation Plan ⁴, “*Although the date of these additions is not known, it is likely to have been within a few years of the original construction date as they maintain the detailing and character of the original building.*”
14. Since the cottage is believed to have been constructed around 1885, it is likely that these ancillary structures were built around or even before 1900. In my opinion, the lean-to structures added to the South-West Elevation should be then considered as an integral part of the original heritage structure and not simply later additions. Based on the above observations, I disagree with Mr Hill and I consider that the cottage still continues to retain much of its original character, fabric and finishes.

Changes/Alterations: interpretation and significance

15. More in general, it is worth noting that heritage buildings should be considered as living organisms and not objects forced to remain frozen to a certain day or time. Changes, alterations, replacements, and additions should be considered as normal attributions and enrichments of the building history and heritage value, not necessarily elements of depreciation, as per ICOMOS New Zealand Charter guidelines for the Conservation of Places of Cultural Heritage Value, 2010⁵ (Section 5. Respect for surviving evidence and knowledge).

Building Condition Assessment

Moisture Detection

16. Mr Kyle Brookland carried out a site inspection and undertook moisture-content measurements on the 25th of August 2023, during the winter season and after several years of the building being closed off. Since maintenance works have not been implemented yet, stormwater and moisture can ingress the building through the leaks in the building weathertightness envelope. Due to the lack of adequate ventilation, the stormwater and moisture are trapped

⁴ “The Caretaker’s Cottage, Cramner Centre, Christchurch – A conservation Plan”, Dave Pearson Architects Limited, January 2003.

⁵ https://icomos.org.nz/wp-content/uploads/2020/12/NZ_Charter.pdf.

inside the building with no possibility to dry out. Therefore, Mr Brookland's moisture measurements should be interpreted more as "upper-bound limits" rather than effective measurements of the building material moisture content.

17. To obtain more objective readings of the moisture levels in the building material, it would be required to address (at least temporary) the leaking issues, to re-open the building and to reinstate normal ventilation conditions for both the internal and sub-floor structures for a few months.

Extent of damage observed

18. In his building condition assessment, Mr Kyle Brookland reported signs of deterioration to the internal ceiling and wall linings due to roof leaking. Generic indications such as "*relining of the surfaces will be required due to the timber framing condition -sections of the exterior and interior framing will require replacement due to moisture damage*" were also provided as guideline for a possible remediation methodology. However, no marked-up plans or damage maps were attached to his report to confirm the effective extent of the damage observed and the relative extent of surfaces potentially affected by remediation works.
19. I note also that the readings were mainly relative to the internal ceiling and wall linings. No measurements were taken to confirm the moisture contents in the internal timber framing structures and to assess the level of damage occurred at these locations.
20. It is worth noting that there is no automatic correlation between the measurement of the moisture content on the internal linings and the severity of the possible damage occurred to the internal timber structure. Moreover, heritage timber structures were usually built using timber species exceptionally robust and usually characterised by a low susceptibility to water damage.
21. Prolonged exposure to water leaking may have caused the onset of damage in the internal timber structures. However, the extent and severity of the damage can be ascertained only undertaking opening-up works and allowing for a direct inspection of the internal timber structures.
22. In my opinion Mr Brookland's suggestion that "*the works required to return this property to a safe operational standard involves an almost complete*

replacement of all of the building components” is not justifiable on the basis of the data currently available.

Building Sanitary issues

23. Mr Brookland also mentioned presence of human excrement in a few rooms and suggested the replacement of the entire flooring system.
24. Based on the photographic documentation available, it appears that carpet has been installed in many rooms. In these spaces, replacement of the carpet might be sufficient to restore adequate sanitary standard inside the building, as also suggested by Mr Fulton in his evidence (Section 20). In the rooms where no carpet has been installed, biological cleaning of the flooring surfaces might be sufficient to bring the floors back into use.
25. Based on the above observations, I consider the proposed replacement of the entire building flooring system is unnecessary. The replacement should be limited to only those areas affected by severe structural damage.

Repair Scope of Work

26. In his evidence, Mr Tom Chatterton clarified that his cost estimation is based on the “*worst case scenario*” assumption that complete replacement of the entire building fabric is indeed required.
27. I note that in his evidence Mr Fulton also confirmed that a good portion of “*the remaining weatherboards and external timber trims appear sound*” appears in sound conditions. Therefore, no replacement would be required in this case but just an allowance for lead-base painting treatment.
28. As discussed in the sections above, it is not possible to ascertain at the moment the type and extent of damage to the internal timber framed structure. Therefore, in my opinion the assumption of complete replacement is not justifiable at this stage.
29. Finally, in his cost estimation Mr Chatterton allowed for the removal and replacement of a new tiled roof. It is worth noting that no tiled roof is currently present on site, as the original slate roof was removed possibly around the 1950’s when the demolition of two of the three chimneys and replacement of the internal fireplaces was undertaken. There is no requirement to reinstate a new slate roof on heritage conservation grounds, particularly as the

additional mass could result in a need to increase the seismic capacity of the building.

SUBMISSION #825 – ST JAMES

Additional Documentation provided by Submitter

30. In his evidence for CPT, Peter Carney commented and suggested amendments to an early strengthening scheme originally issued by Aurecon in 2011 and successively reviewed in 2013. This strengthening scheme, however, was not included in the documentation package lodged by the submitter in their original application and it was not available at the time the independent expert engaged by the Council were compiling their evidence.

Deferred Maintenance Works

31. In Section 12.3 of his evidence, Mr Peter Eggleton stated that “*the building has suffered (...) dilapidation due to lack of maintenance*”. I agree that the lack of maintenance and care have caused the onset of minor damage to the heritage fabric. The building, however, appears still in very good condition and basic and economic repairs would address most of the issues currently causing deterioration of the building fabric.

Earthquake damage

32. In Section 12.3 of his evidence, Mr Peter Eggleton also stated that “*the building has suffered considerable damage from Earthquakes*”. I disagree with this statement.
33. When subjected to earthquake loading, Un-Reinforced Masonry (URM) structures (such as the St. James Church) are generally susceptible to three different failure mechanisms:
- (a) Material Failure Mechanisms;
 - (b) Local Failure Mechanisms; and
 - (c) Global Failure Mechanisms.
34. An illustration and description of these three typical failure mechanisms observed on URM structures subjected to earthquake loads is provided in **Appendix C**. These typical failure mechanisms can affect the overall seismic capacity to different degrees, depending on their extent and severity.

35. None of these failure mechanisms can be observed in St James Church as a result of the significant number of 5Mw or greater earthquakes the structure went through since 2011. The 2011 Aurecon Report mentions only minor and very localised damage on the building fabric, the most relevant of which relate to the horizontal cracking of the mortar joints on the gable end walls (at eaves level) and spalling of plaster on the internal chancel arch.
36. Just as term of comparison, it would be worth considering the earthquake damage observed on St John the Baptist Church located at 324 Hereford Street (Christchurch). Please refer to the photographic documentation attached in **Appendix D**. In this case, the earthquake damage to the building structure can be considered as “*considerable*”. The church was in fact demolished after the 22nd of February 2011 Earthquake and the Christchurch transitional Anglican Cathedral built at its place.

Building Seismic Performance

37. St James Church has sustained significant seismic loading during the Canterbury earthquake sequence. Geotechnical studies have demonstrated how the seismic demands in terms of loadings and displacements were significantly above the design levels addressed in the New Zealand Loading Standard NZS1170.5 for many structures. Scientific literature has also highlighted how the Canterbury earthquake sequence was characterised by a wide spatial distribution of the earthquake epicentres and a significant number of high-magnitude events. Please refer to the documentation attached in **Appendix E** for further details.
38. Based on the severity of the seismic demands, the significant number of high-magnitude earthquakes this church has sustained and the minor level of damage occurred at the structures, I consider that St James Church has performed extremely well during the Canterbury earthquake sequence. The building heritage structures are also characterised by a high level of inherent robustness as the damage did not worsen over the earthquake swarm and following events.

Strengthening Scheme Scope of Work

39. The strengthening scheme concept proposed by Aurecon in 2013 and the additional suggestions provided by Mr Carney imply substantial works to

the building heritage fabric. This is despite the only minor earthquake damage observed on the structure.

40. Both the 2013 Aurecon strengthening scheme concept and the additional suggestions provided by Mr Carney are based on initial engineering considerations and are not supported by any structural analysis. No Detailed Seismic Assessment (as per indication provided by the 2017 MBIE guidelines "*Seismic Assessment of existing Buildings*"⁶) has been carried out to date to ascertain the effective capacity of the existing structures.
41. Numerical analysis might prove that high-level remedial strengthening solutions for the gable end walls and chancel arch might suffice to achieve an acceptable level of seismic resistant capacity when the inherent capacity of the existing structures is taken into consideration.
42. Considering the full inherent strength of the existing structures is essential to assess the current capacity of the building and minimise the extent of the strengthening works required to achieve the desired %NBS rating. This is a crucial passage to also ensure the respect of the ISCARSAH and ICOMOS guidelines which indicate that "*no actions should be undertaken without demonstrating that they are indispensable*" (Section 3.4 of the ICOMOS Charter guiding principles for the analysis, conservation and structural restoration of architectural heritage⁷).

Geotechnical Issues

43. In Section 12 his evidence, Mr Peter Carney noted "*foundation performance as a risk item that could potentially result in higher strengthening costs*". However, no geotechnical report has been lodged provided to confirm the effective geotechnical risk for this site and demonstrate that additional strengthening works at foundation level are indeed required.
44. On the other hand, site observations indicate good performance of the existing foundation system and suggest good ground conditions for the site. Considering the significant level of intensity and the number of earthquakes already sustained by St James Church, poor foundation performance or potential geotechnical issue should have already manifested.

⁶ <https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/seismic-assessment-existing-buildings/>

⁷ <https://www.icomos.org/en/about-the-centre/179-articles-en-francais/ressources/charters-and-standards/165-icomos-charter-principles-for-the-analysis-conservation-and-structural-restoration-of-architectural-heritage>

45. Based on the above observation, in my opinion considering preliminary allowance for additional strengthening work at foundation is not justifiable with the data available at this stage.

Change of Use and associated %NBS target

46. In Sections 15-20 of his evidence, Mr Carney discussed how a change of use might mean a shift in the target of the NBS percentage to be achieved for the building and, consequently, implying more intervention and structural works than what currently anticipated. This is based on Section 115 of the Building Act 2004⁸ which states (my emphasis in **bold**):

115 Code Compliance requirements: change of use

An owner of a building must not change the use of the building,—

(a) *[...]*

(b) *in any other case, **unless the territorial authority gives the owner written notice that the territorial authority is satisfied, on reasonable grounds, that the building, in its new use,—***

*(i) **will comply, as nearly as is reasonably practicable, with every provision of the building code that relates to the following:***

(A) means of escape from fire, protection of other property, sanitary facilities, structural performance, and fire-rating performance:

47. Section 115 of the Building Act 2004 certainly requires for any change of use to lead towards an upgrade of the existing building in terms of means of escape from fire, protection of other property, sanitary facilities, structural performance, and fire-rating performance. However, no predetermined target levels are defined for the upgrade, as the building in its new use is required to comply with the Building Code “*as nearly as is reasonably practicable*” only.
48. This clarification is especially important for projects involving the retrofitting of heritage building. In these cases, the historic materials, construction details and architectural arrangements might inherently preclude achieving

⁸ <https://www.legislation.govt.nz/act/public/2004/0072/latest/DLM306880.html>

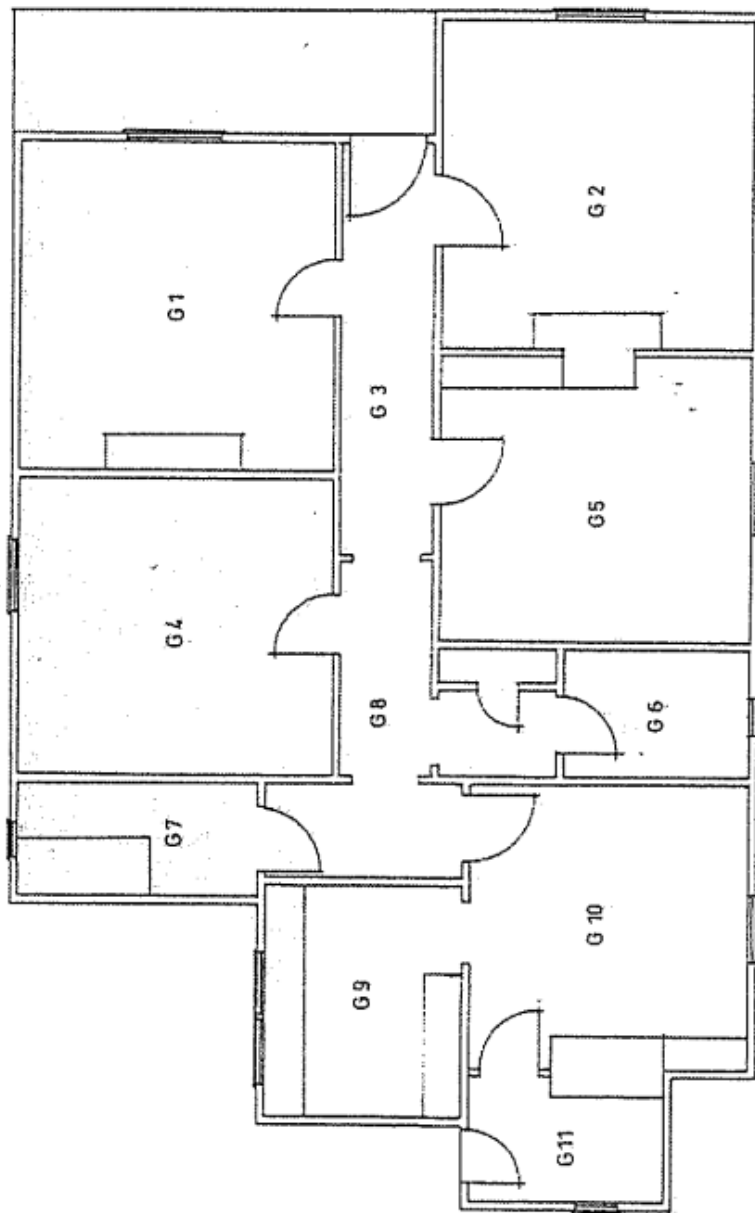
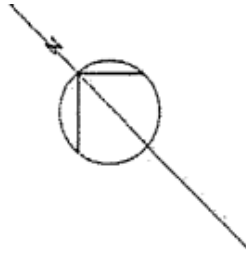
the full compliance with the Building Code unless substantial and heavily invasive strengthening works are carried out.

49. Based on my professional experience in heritage projects, Local Authorities do not necessarily impose the achievement of 100%NBS seismic capacity as a requisite to grant a Building Consent. They usually positively consider strengthening solutions aiming to achieve a seismic capacity equal or above 67%NBS, even if change of use is proposed.
50. I consider concerns on the effective extent of strengthening works required to strengthening St James Church if change of use is to be pursued are premature.

Clara Caponi

9 October 2023

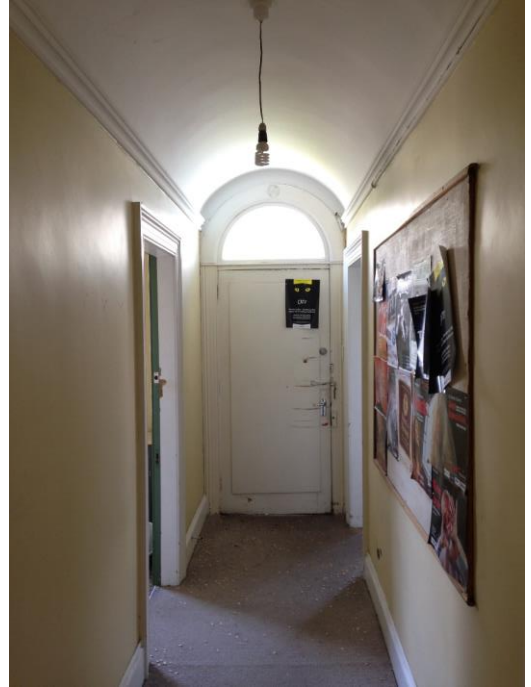
APPENDIX A BLUE COTTAGE GROUND FLOOR PLAN⁹

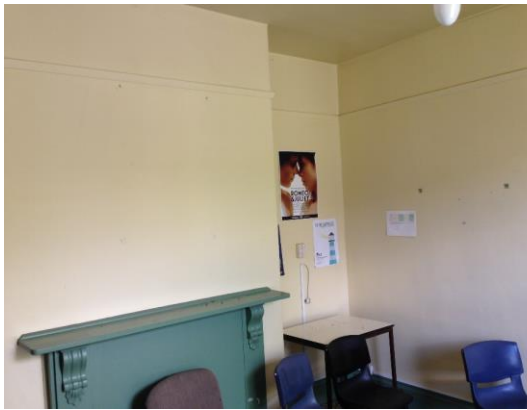
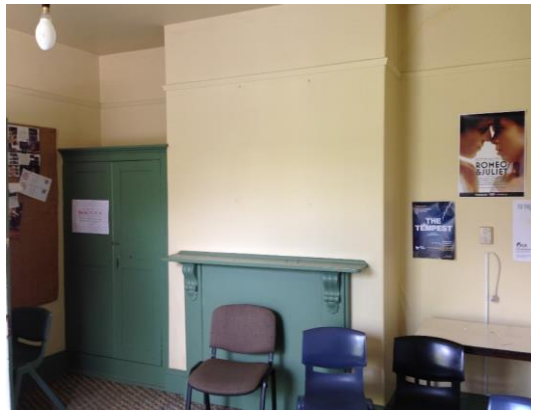
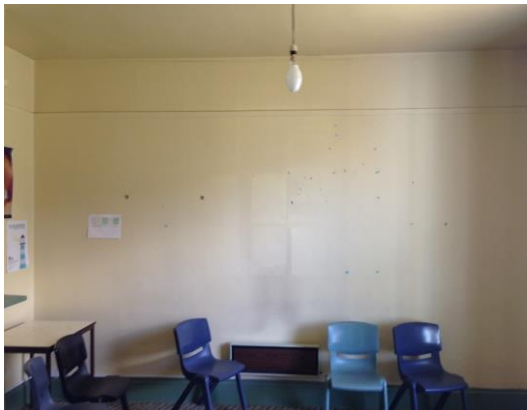
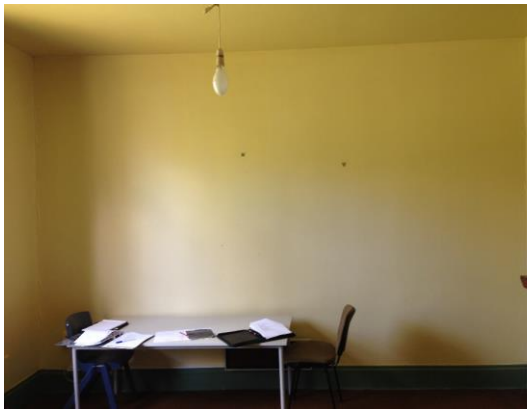


⁹ From the document: "The Caretaker's Cottage, Cramner Centre, Christchurch – A Conservation Plan", Dave Pearson Architects Limited, January 2003.

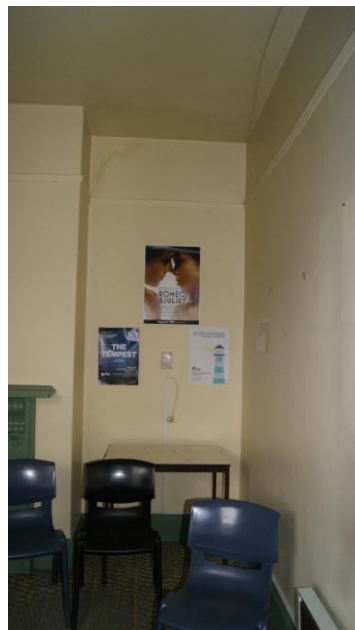
APPENDIX B BLUE COTTAGE PHOTOGRAPHIC DOCUMENTATION

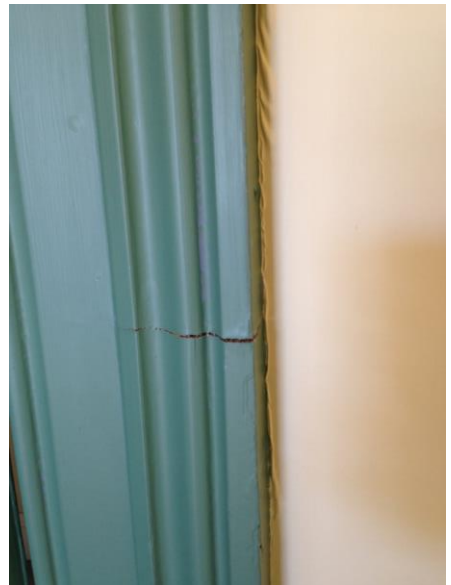
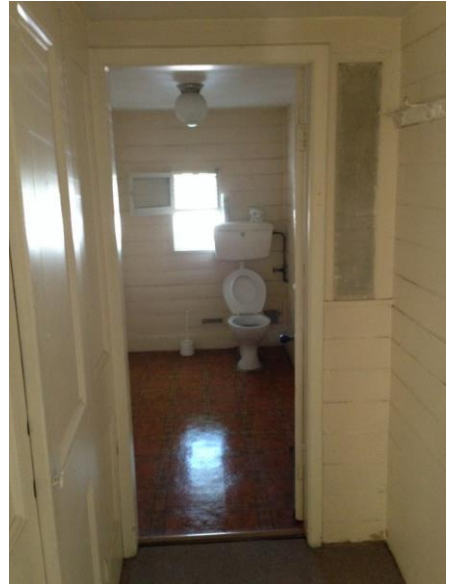
from the Site Inspection performed by Mr Gavin Stanley and Ms Jacqueline Sarah Hilda Gillies on the 9th of November 2015











APPENDIX C URM TYPICAL FAILURE MECHANISMS

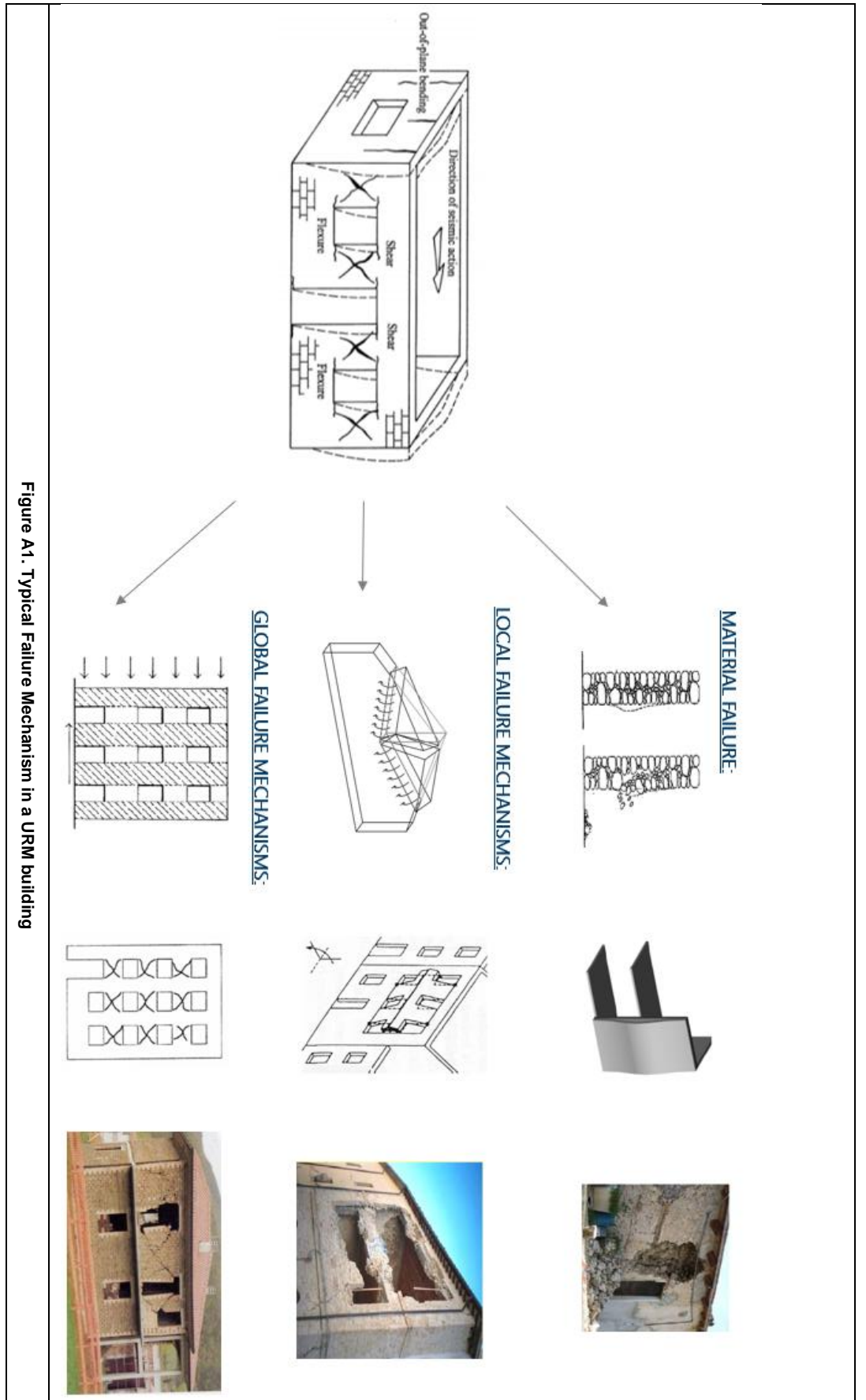


Figure A1. Typical Failure Mechanism in a URM building

Typical Failure Mechanism in URM Buildings

When subjected to earthquake loading, Un-Reinforced Masonry (URM) structures (such as the St. James Church) are generally susceptible to three different failure mechanisms:

- **Material Failure Mechanisms**: When the walls consist of different layers not properly tight together, the vibration and shaking induced by earthquake motions is likely to cause bulging and consequently spalling of the external layer (or internal layer, depending by the specific construction details adopted), severely affecting the stability and capacity of the wall structures.

- **Local Failure Mechanisms**: When subjected to seismic loads, certain portions of the building (usually called “*macro-elements*”) tend to detach from the surrounding fabric and start to develop an independent dynamic response to the earthquake motions. If the earthquake magnitude is sufficiently high, these mechanisms can activate local instabilities and, consequently, lead to partial collapse of the building fabric. The local failure mechanisms are, therefore, mainly related to the out-of-plane capacity of the building portions.

- **Global Failure Mechanisms**: When the in-plane shear or flexural capacity of the building lateral resistant system is exceeded, significant cracking and damage to piers and spandrels occur severely compromising the capacity of the building to withstand earthquake loading.

APPENDIX D ST JOHN THE BAPTIST CHURCH (324 HEREFORD STREET, CHRISTCHURCH).



**Fig 1. West gable end
- External View - .**

Out-of-Plane (partial) local failure of the gable end masonry wall. In this case, the installation of the external temporary securing works (steel frame strutting) was not sufficient to prevent further damage to the structure during the 22 February 2011.



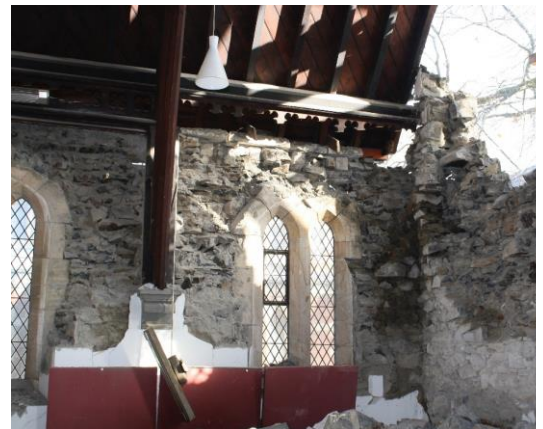
**Fig 2. Church Roof Structure
- Internal View-.**

Minor to negligible damage to the roof timber structure following the 4th of September 2010 and the 22nd of February 2011 earthquakes.



**Fig 3. Church North- West Corner
- Internal View - .**

Out-of-Plane (partial) local failure of the West gable end masonry wall. In the picture it is also possible to observe, the material failure of the stone masonry installed at the building south-west corner.



**Fig 4. Church South-West Corner
- Internal View-.**

Out-of-Plane (partial) local failure of the West gable end masonry wall. In the picture it is also possible to observe, the material failure of the stone masonry installed at the building south-west corner.



**Fig 5. Church Nave (South side)
- Internal View - .**



**Fig 6. Church Nave (South side)
- Internal View - .**

Out-of-Plane local failure of the masonry spandrel above nave window. Material failure of the pier internal layer.

Out-of-Plane local failure of the masonry spandrel above nave window. Material failure of the pier internal layer.

APPENDIX E CANTERBURY EARTHQUAKE SEQUENCE – SEISMIC DEMANDS AND EARTHQUAKE OCCURRENCE

The following graphs¹⁰ from the scientific paper “*Geotechnical Aspects of the 22 February 2011 Christchurch earthquake*” by Cubrinovski, M. et al. (Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 44, No.04, December 2011) illustrate how:

- the seismic demands imposed by the 22 February Earthquake were actually above the 475-year return period design ground motion for Christchurch site class D as specified by the New Zealand Loading Standard NZS1170.5 (see Fig 2(a));
- for structures whose secant period at peak displacement is in the region of 1.5 or 3.5 seconds (as likely would be the case for the St. James Church), the displacement demands imposed by the ground motion were in order of two times the seismic design level (see Fig 2(b)).

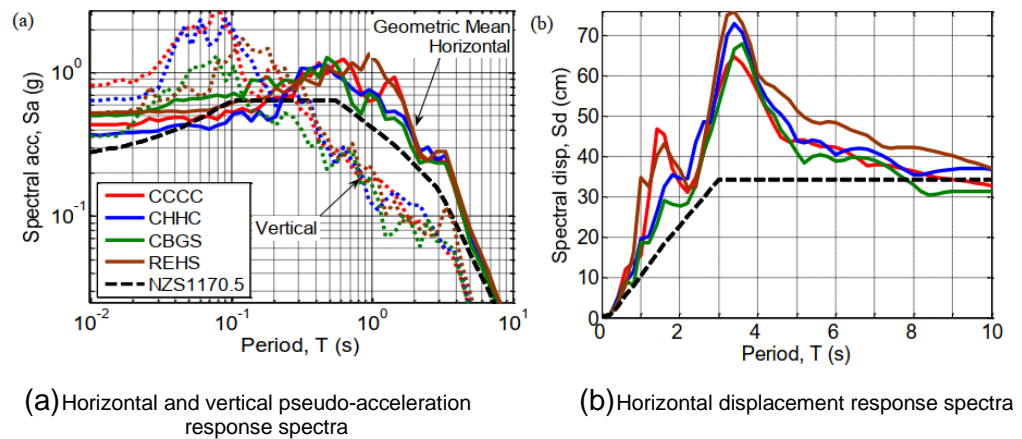


Fig 2. Comparison of response spectra from four strong motion stations located in Christchurch Central Business District (CBD).

The Canterbury earthquake sequence was not only characterised by very severe demands in terms of seismic loading and displacements, but also by a wide spatial distribution of the earthquake epicentre and a significant number of events as illustrated in the following graphs from the scientific paper “*A summary of Strong Ground Motions Observed in the Canterbury, New Zealand earthquake Sequence*”

¹⁰ <https://bulletin.nzsee.org.nz/index.php/bnzsee/issue/view/32>.

by B.A. Bradley. (New Zealand – Japan Workshop on Soil Liquefaction during Recent Large-scale Earthquakes, 2-3 Dec 2013) ¹¹.

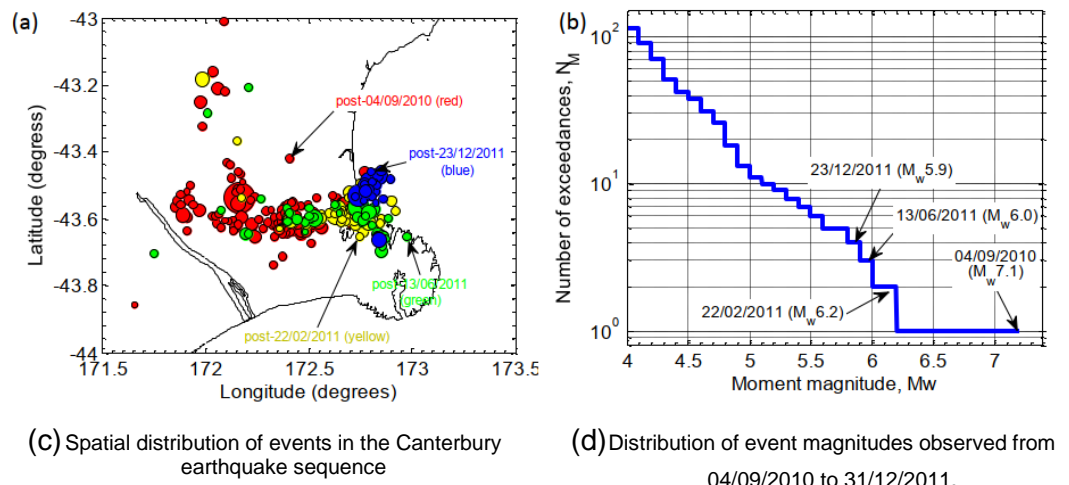


Fig 3. Spatial and magnitudes distribution of the events in the Canterbury earthquake sequence from 04/09/2010 to 31/12/2011.

The data provided in Fig 3(a) and Fig 3(b) demonstrate that St James Church sustained several earthquakes of significant magnitude and from different directivities. Specifically, the building sustained over:

- 70 earthquakes with Moment Magnitude (M_w) equal or greater than 5.00;
- 20 earthquakes with Moment Magnitude (M_w) equal or greater than 5.50;
- 25 earthquakes with Moment Magnitude (M_w) equal or greater than 6.00;

just in the period from the 4th of September 2010 to the 31st of December 2011.

¹¹ <https://ir.canterbury.ac.nz/server/api/core/bitstreams/e8244ec7-3f3b-4886-9d64-4248f182c9c2/content>