



CRACK SURVEY

Rotorua Museum of Art and History, Oruawhata Drive, Rotorua

- Geotechnical Investigation & Design
- Structural and Civil Design
- Earthquake Engineering and Assessments
- Traffic and Safety Assessments
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**Crack Survey Report of 1906 Built Section
December 2016**

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1.0 INTRODUCTION

1.1 Project Details

Client's Name Rotorua Lakes Council
Site Address Oruawhata Drive, Government Gardens
Rotorua

1.2 Background

This report is for the as built factual information gathering Stage 1A of a Detailed Seismic Assessment (DSA) as well as for further monitoring.

In 1985 Kerslake and Partners prepared a report of the Rotorua Museums' foundations, and recommended the Rotorua Lakes Council inspect the condition of the concrete substructure at regular intervals. Kerslake and Partners is an engineering consultancy based in Wellington. In 1996 and 2000, the foundations of the old section (1906 built) of the Rotorua Museum were inspected for cracks and corrosion of the concrete. The general plan of the building and elevations are shown in Appendix D.

This report presents the findings of the investigation of new and existing cracks in the basement ceiling, walls and columns in November 2016, in the 1906 built section only. The findings will be compared with previous foundation investigation reports for spatial and temporal variations.

1.2.1 November 14th 2016 Post-Earthquake Developments

After the 14th November 2016 earthquake near Waiiau, concern was raised of the structural integrity of the Rotorua Museum. The crack survey was completed after this event on the 21st November 2016 to 6th December 2016. Museum staff noticed cracks appeared or widen in the foyer area walls (Ground floor of Central Section).

1.3 Scope

This report is undertaken to:

- Document all visible cracks in the 1906 built basement section of the building only
- Record data in a usable format for ongoing monitoring and seismic analysis
- Compare previous crack survey data to current

This report does not include the following:

- Geotechnical Investigation or below ground level findings
- Dimensional check of asBUILT model. asBUILT provides 3D laser scanning services for use in construction projects, and are based in Auckland.
- Monitoring recommendations. This is included in the 2017 As Built Factual Information Report by GDC.

The findings of this report will enable GDC to make decisions on the structures' integrity, critical areas for loads, a detailed seismic analysis and options for remedial work.

1.4 Adopted Methodology

A visual survey of the cracks has been carried out by GDC staff between the 21st November 2016 to 6th December 2016. Cracks smaller than 0.4mm were not included in the survey due to low importance and difficulty in recording. Visible cracks in the basement ceiling/slab, walls, columns and arches were documented on a previous crack map by Jay Menzies and partners in 2000. A similar naming convention of cracks has been followed to this report. The December 2016 crack map can be found in Appendix A.

Size varies along the length of the crack, so to minimise these inaccuracies, the crack was measured in the same spot as previously indicated on the Jay Menzies report basement map. A crack gauge, which is accurate to 0.1 to 0.5mm was used. A high tensile 0.7mm diameter wire was used to measure the depth of cracks, however couldn't fit into smaller cracks, hence the depth of those is unknown. The depth of a crack varies significantly, so the largest depth on the crack was recorded. Photos of the crack with the corresponding number were taken for reference of position.

2.0 SUMMARY

The 2000 Jay Menzies foundation investigation reports findings were that there was 'no significant increase in crack width, length, differential movement or new 'crack generation', compared to the 1996 Kerslake and Partners foundation investigation report. Independently comparing the two reports showed no difference in data between them.

140 new and existing cracks, including 67 major (greater than 2mm width or settlement) cracks have been observed in 2016. 17 out of the 37 documented existing cracks in 1996 have increased in size over 20 years. In 1996, 26 major cracks were recorded, which is an increase of 41 major cracks.

Considering the scope of the 1996 and 2000 Jay Menzies foundation reports, it is obvious that these reports were not as thorough as this 2016 report. This may have resulted in some cracks not being recorded. It is also likely that movement of the building due to lateral loads has caused extra cracks to appear in the 20 years since the initial foundation report.

Critical areas where many major cracks exist are the north-east corner of the north section, along and across the display walkway, the wall between the central section and intermediate-south section, the north-east and south-east corners of the intermediate-south section.

Cracks have been distinguished by load type (gravity load or lateral load) as a spreadsheet in Appendix A for further analysis.

Considering a crack survey was not completed in the last few years before the earthquake, only after, it is difficult to draw conclusions on movement due to the recent earthquake in November. However, staff at the museum have noticed cracks appear or widen, in plaster, in the foyer area of the ground floor after the earthquake.

3.0 LIMITATIONS

This report has been prepared for Rotorua Lakes Council as our Client in accordance with the agreed scope of services. The reliance by other parties on this document shall without our prior agreement in writing be at such parties' sole risk.

Findings and opinions in this report are based on data obtained from the investigations and site observations as detailed in this report at the time of inspection only (21st November to 6th December 2016).

This report does not include the analysis of the cracks in respect to how they have been distributed within the building.

4.0 INVESTIGATION FINDINGS

4.1 Crack Survey

All cracks in the 1906 built basement (central section) only have been observed and documented, including width, length, location, settlement and spalling at the time of inspections. Areas found with noticeable and major cracks are listed below. The north-eastern bath area has multiple significant (greater than 3mm wide) cracks in the ceiling, some with settlement greater than 2mm. Under the cinema, where additional columns and beams have been constructed recently, a large opening has been left for services by the east wall, resulting in minor cracking in the new concrete beam. The fountain has two deep cracks greater than 3mm through it. A major 6 to 8mm crack over the opening between the central and intermediate-south sections has been discovered that is likely to not have been observed and recorded before. A significant 5mm crack was observed in the north-east corner of the intermediate-south section wall. Multiple cracks that are greater than 3mm in the south-east corner of the intermediate-south section. It should be noted that most holes drilled for services have developed cracks propagating away from them. The nature of this concrete is that it is a lightweight pumice concrete, with no large aggregate pieces. This means cracks that are larger than 3mm are likely to have little or no friction and resistance to movement usually resisted by large aggregate particles.

More than half of the original columns have sulphide corrosion at the base of the column greater than 50mm in depth. This sulphide corrosion leads to a brittle and spalling concrete, which is also seen in many areas on the ceiling. In some places this has been covered recently to prevent further corrosion by spray-on concrete.

Some larger cracks have also recently been grouted, however some cracks have widened after grouting. Unfortunately, the date of the spray-on concrete or grouting is not known.

Spatial and temporal variations between the 1996 Kerslake and Partners foundation report and the 2000 Jay Menzies report have been found to be non-existent. The width and settlement values for 37 major (2mm or greater width or settlement) cracks that have been documented in 1996 are all exactly the same in the 2000 report, including spot height reduced levels of positions in the basement. Comparing the extent of the cracks on maps from either report indicates no variation in crack length, position or new minor cracks. For this reason, the crack survey data collected this year (2016) will be compared to the 1996 data. This effectively increases the time between crack surveys to 20 years. No other basement crack data has been found.

An excel spreadsheet of the crack data has been compiled, taking into account the 1996, 2000 and 2016 crack data. The 2016 crack survey is much more extensive than the previous reports, including recording 140 new and existing cracks, photos, the direction of settlement between slabs, cracks observed in walls, columns and arches and the depth of most cracks greater than 1mm wide. Comparing 37 cracks from the 1996 and 2016 data, 9 cracks have increased in size by more than 1mm, 12 cracks show no change, 8 cracks had been covered by spray-on concrete and had reappeared, but

observed to be decreased in size, and 8 were not able to be measured as they had been covered over. Some major cracks have been grouted, and most are reappearing.

Size does vary along the length of the crack, so to minimise these inaccuracies, the crack was measured in the same spot as previously indicated on the Jay Menzies report basement map. A crack gauge, which is accurate to 0.1 to 0.5mm was used. A high tensile 0.7mm diameter wire was used to measure the depth of cracks, however couldn't fit into smaller cracks, hence the depth of those is unknown. The depth of a crack varies significantly, so the largest depth on the crack was recorded.

From the 2016 data, one quarter of cracks showed settlement, of which 35% was in the south side down direction, with other directions evenly distributed. In 1996, 26 major cracks were recorded, and in 2016, 67 major cracks were recorded. Some of this difference could be due to the different extent of each year's survey, new cracks forming, and that wall and other cracks were not recorded in the two earlier reports. One out of five plastic strain gauges were broken in the south-eastern corner of the intermediate-south section by the offices, however it is unknown when they were placed.

The cracks were also separated by area and type of crack. Areas were divided into; north wing, intermediate-north wing, central section and intermediate-south wing. The type of crack was determined by its position. If a crack is observed in the midspan of the arch, roughly halfway between columns, it is labelled as 'between columns' in the spreadsheet. These cracks are typically due to excessive deflection from gravity and live loads, and occur at the position where the flexural stress is largest. The other type is due to lateral loads or subsidence. These cracks are typically positioned on or close to columns and walls, and labelled 'in proximity to columns and walls'. Approximately 65% of the cracks documented were described as being in proximity to columns and walls. The excel spreadsheet in Appendix A shows the size and distribution of major cracks in each area. Over half of the major cracks are described as in proximity to columns or walls.

4.2 Post-Earthquake Developments

The crack survey was completed after the 14th November 2016 on the 21st November to 6th December 2016. There is no recent information to compare this crack survey to for monitoring of recent crack developments. However, asBUILT the company completed a 3D scan of the building approximately 8 weeks prior to the earthquake and a week after, so it would be of use to compare that data to find areas of concern.

Museum staff noticed cracks appear and widen in the foyer area on the ground floor. GDC staff also noticed one crack in the foyer widen by approximately 1mm during the three weeks of investigation at the museum. This crack is shown in Appendix C.

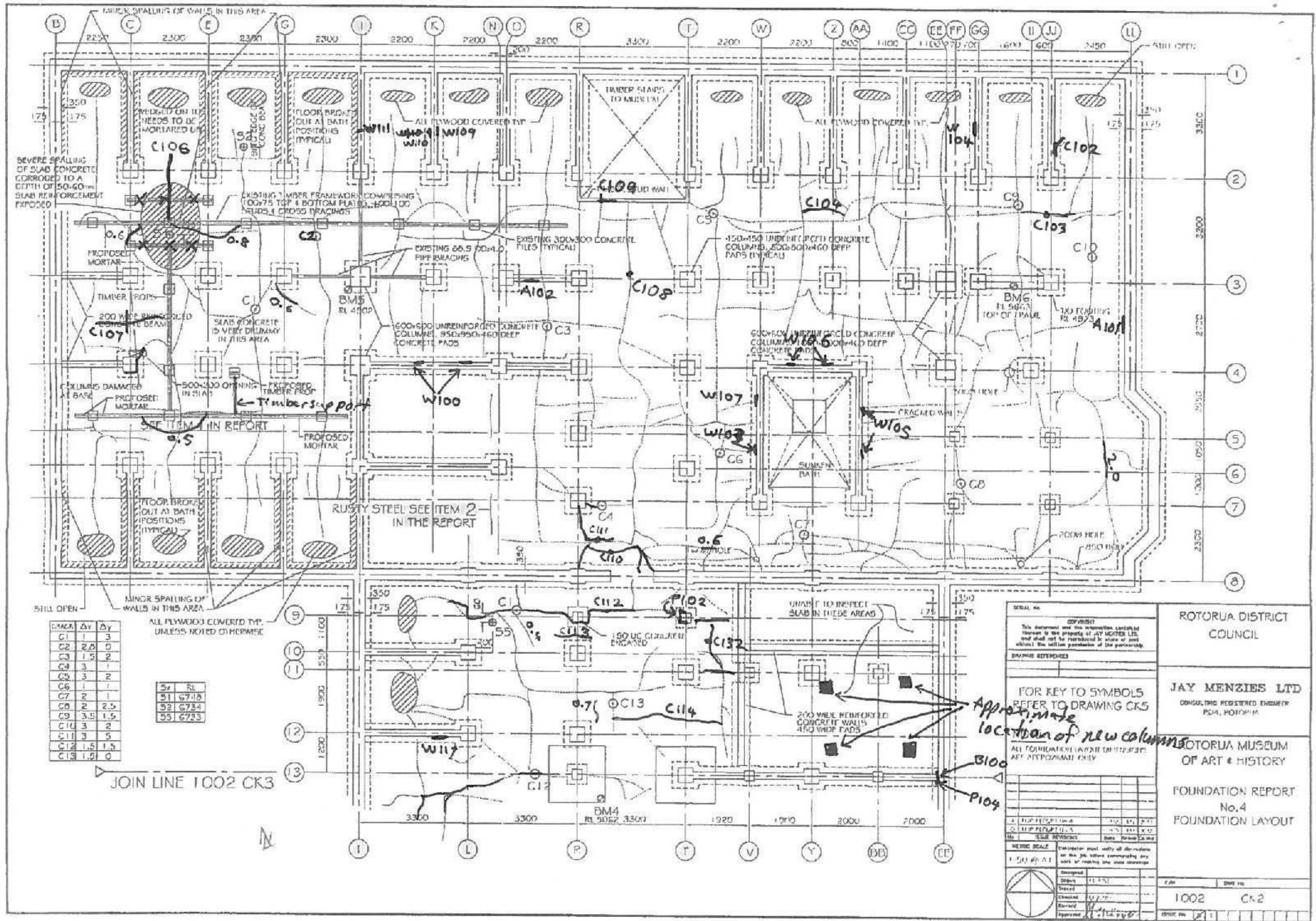
5 REFERENCES

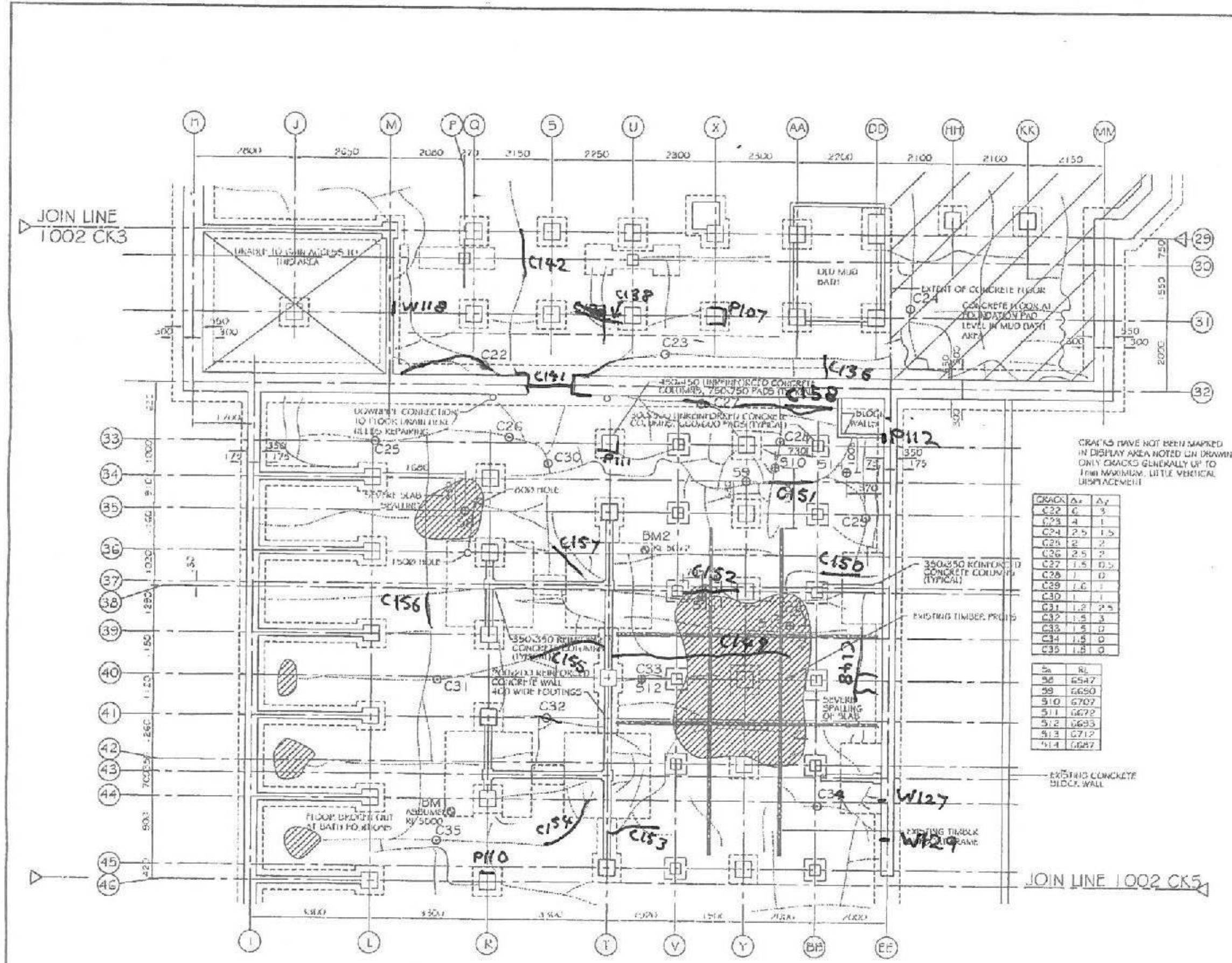
Jay Menzies (2000), *Foundation Inspection Report No. 4, Rotorua Museum of Art and History*. Retrieved from Rotorua District Council.

asBUILT (2016), *Visible Architecture and Structure Model, Rotorua Museum*. Retrieved from G:\Rotorua\Clients\J000949 - Rotorua Lakes Council - Museum\basement crack assessment 25.11.2016\asBUILT plans.pdf

6 APPEDNDICIES

Appendix A: Map of cracks in 1906 built Basement at 6th December 2016





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DRAWING REFERENCES

FOR KEY TO SYMBOLS REFER TO DRAWING CK5

NOTE
ALL FOUNDATION LAYOUT DIMENSIONS ARE APPROXIMATE ONLY

NO	DESCRIPTION	DATE	BY	CHECKED
1	FOR SUPPORT B14	10/11/16	AM	CK4
2	PLAN FROM SET NO 2	10/11/16	AM	CK4
3	ISSUE REVISIONS			

SCALE: 1:50 (E.A.)

SECTOR: 11 JUNE 2016

DESIGNED BY: AM

DRAWN BY: AM

CHECKED BY: CK4

DATE: 10/11/16

APPROVED BY: Jay Menzies 25/1/17

ROTORUA DISTRICT COUNCIL

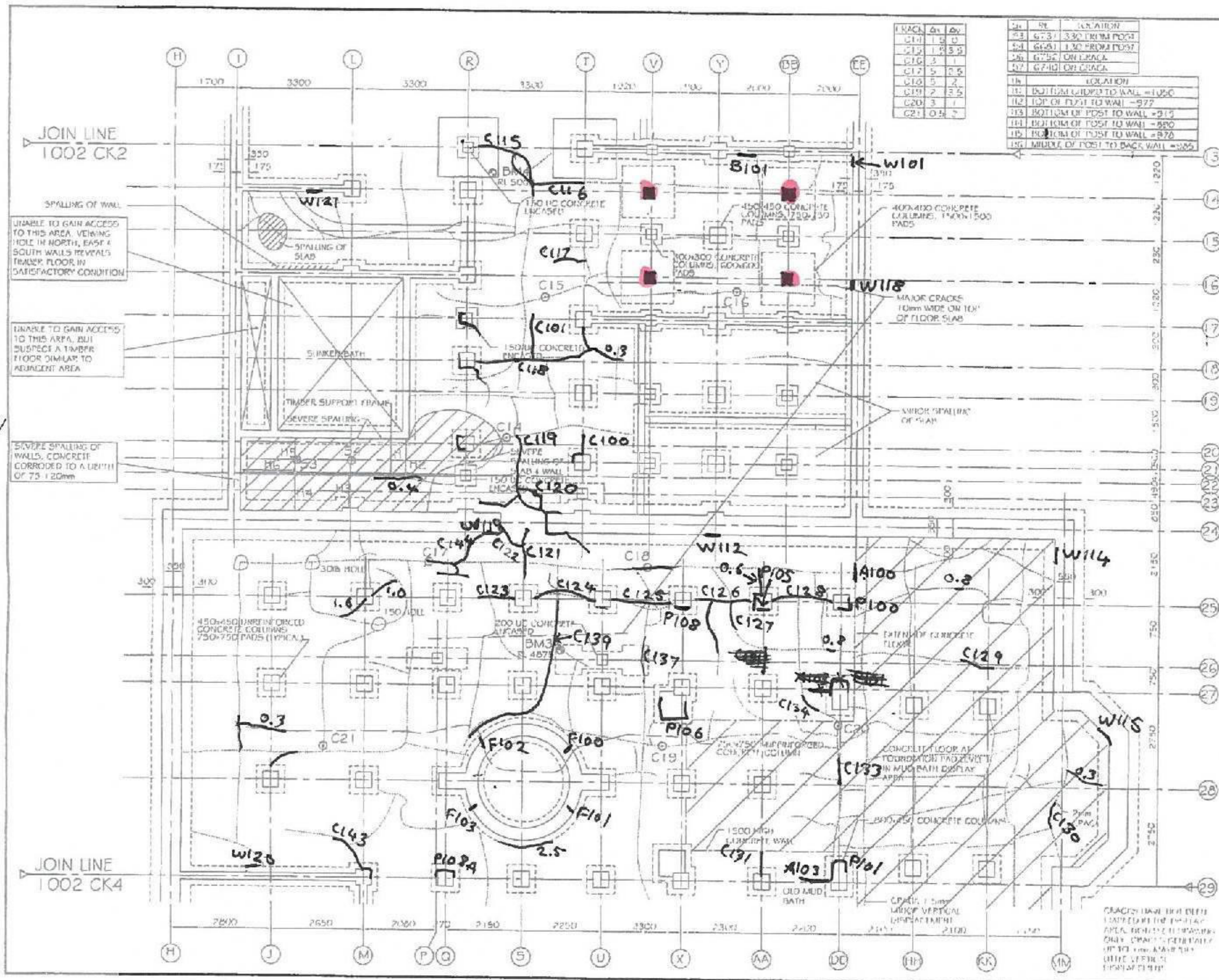
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HEM, ROTORUA

ROTORUA MUSEUM OF ART & HISTORY

FOUNDATION REPORT No.4
FOUNDATION LAYOUT

1002 CK-1





CRACK	Δx	Δy
C10	1.5	0
C15	1.5	3.3
C16	3	1
C17	5	0.5
C18	5	2
C19	2	3.5
C20	3	1
C21	0.5	2

SL	RE	LOCATION
53	6731	3.30 FROM POST
54	6751	1.30 FROM POST
55	6752	ON CRACK
57	6740	ON CRACK

SL	LOCATION
11	BOTTOM EDGE TO WALL = 1050
12	TOP OF POST TO WALL = 977
13	BOTTOM OF POST TO WALL = 915
14	BOTTOM OF POST TO WALL = 890
15	BOTTOM OF POST TO WALL = 870
16	MIDDLE OF POST TO BACK WALL = 855

GENERAL

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DRAWING REFERENCES

FOR KEY TO SYMBOLS REFER TO DRAWING CK5

NOTE

ALL FOUNDATION LAYOUTS SHOWN ARE APPROXIMATE ONLY

SCALE

1:50 @ A1

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ROTORUA MUSEUM OF ART & HISTORY

FOUNDATION REPORT
No. 4
FOUNDATION LAYOUT

CRACKS HAVE BEEN DEPTH LIMITED BY THE 10% SLAB AREA. HOWEVER, EXTENSIVE ONLY CRACKS ARE PRESENT ONLY TO 10% AREA. ALL OTHER CRACKS ARE VERTICAL CRACKS.

DATE: 1002 CK3



Appendix B: Excel spreadsheet of 1996, 2000, and 2016 basement crack data

Photos of cracks and the full spreadsheet including descriptions of the cracks can be found in the GDC data server:

G:\Rotorua\Clients\J000949 - Rotorua Lakes Council - Museum\basement crack assessment 25.11.2016\Photos of cracks

G:\Rotorua\Clients\J000949 - Rotorua Lakes Council - Museum\basement crack assessment 25.11.2016\Report\ Crack spreadsheet 2016.xlsx

1996

Ceiling Crack	Δx	Δy Settlement
C1		1
C2	2.8	0
C3	1.5	2
C4	3	1
C5	3	2
C6		1
C7		2
C8		2
C9	3.5	1.5
C10	3	2
C11	3	5
C12	1.5	1.5
C13	1.5	0
C14	1.5	0
C15	1.5	3.5
C16	3	1
C17	5	2.5
C18	5	2
C19	2	3.5
C20	3	1
C21	0.5	2
C22	6	3
C23	4	1
C24	2.5	1.5
C25	2	2
C26	2.5	2
C27	1.5	0.5
C28	1	0
C29	1.6	1
C30	1	1
C31	1.2	2.5
C32	1.5	3
C33	1.5	0
C34	1.5	0
C35	1.5	0
C36	2.5	0
C37	2.8	0

26 major cracks in 1996

2000

Ceiling Crack	Δx Crack Size	Δy Settlement
C1	1	3
C2	2.8	0
C3	1.5	2
C4	3	1
C5	3	2
C6	1	1
C7	2	1
C8	2	2.5
C9	3.5	1.5
C10	3	2
C11	3	5
C12	1.5	1.5
C13	1.5	0
C14	1.5	0
C15	1.5	3.5
C16	3	1
C17	5	2.5
C18	5	2
C19	2	3.5
C20	3	1
C21	0.5	2
C22	6	3
C23	4	1
C24	2.5	1.5
C25	2	2
C26	2.5	2
C27	1.5	0.5
C28	1	0
C29	1.2	2.5
C30	1	1
C31	1.2	2.5
C32	1.5	3
C33	1.5	0
C34	1.5	0
C35	1.5	0
C36	2.5	0
C37	2.8	0

26 major cracks in 2000

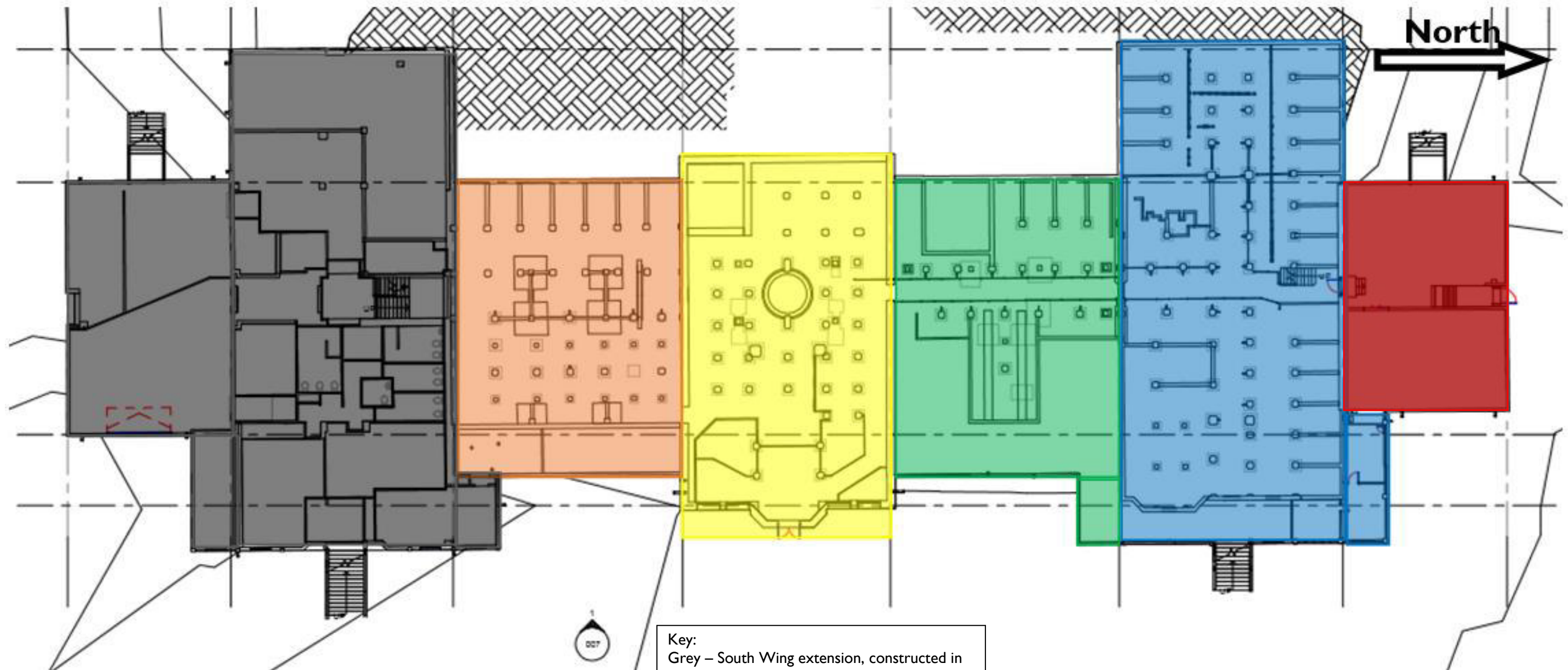
2016

Ceiling Crack	Δx	Δy	Depth
C1	1.6	0	50
C2	1.2	0	
C3	3	0	30
C4	3.5	3	40
C5	2.5	2	30
C6			
C7			
C8	2.8	3	60
C9	5	0	60
C10	2	0	30
C11			
C12	3	0	30
C13	1.8	0	10
C14	2	2	
C15	2.5	3	80
C16			
C17			
C18	3.5	1	30
C19	1	0	
C20	1	0	
C21	0.5	0	
C22	1.4	0	
C23			
C24	3.5	1	
C25	3	1	50
C26	2	0	30
C27	3.5	1	110
C28			
C29	2.5	0	
C30	1.2	1	40
C31			
C32	1.6	1	20
C33	0.8	0	
C34	1.6	0	20
C35			
C36	1.5	0	40
C37	3	0	10
C100	2	0	10
C101	0.9	0	50
C102	1.8	0	
C103	4	5	60
C104	0.5	0	
C105	3.5	2	30
C106	0.8	0	
C107	0.8	0	
C108	3	0	30

Appendix C: Photo of Crack in foyer of Museum, observed 13/12/2016



Appendix D: Plan and Elevation views of Rotorua Museum from asBUILT (2016).

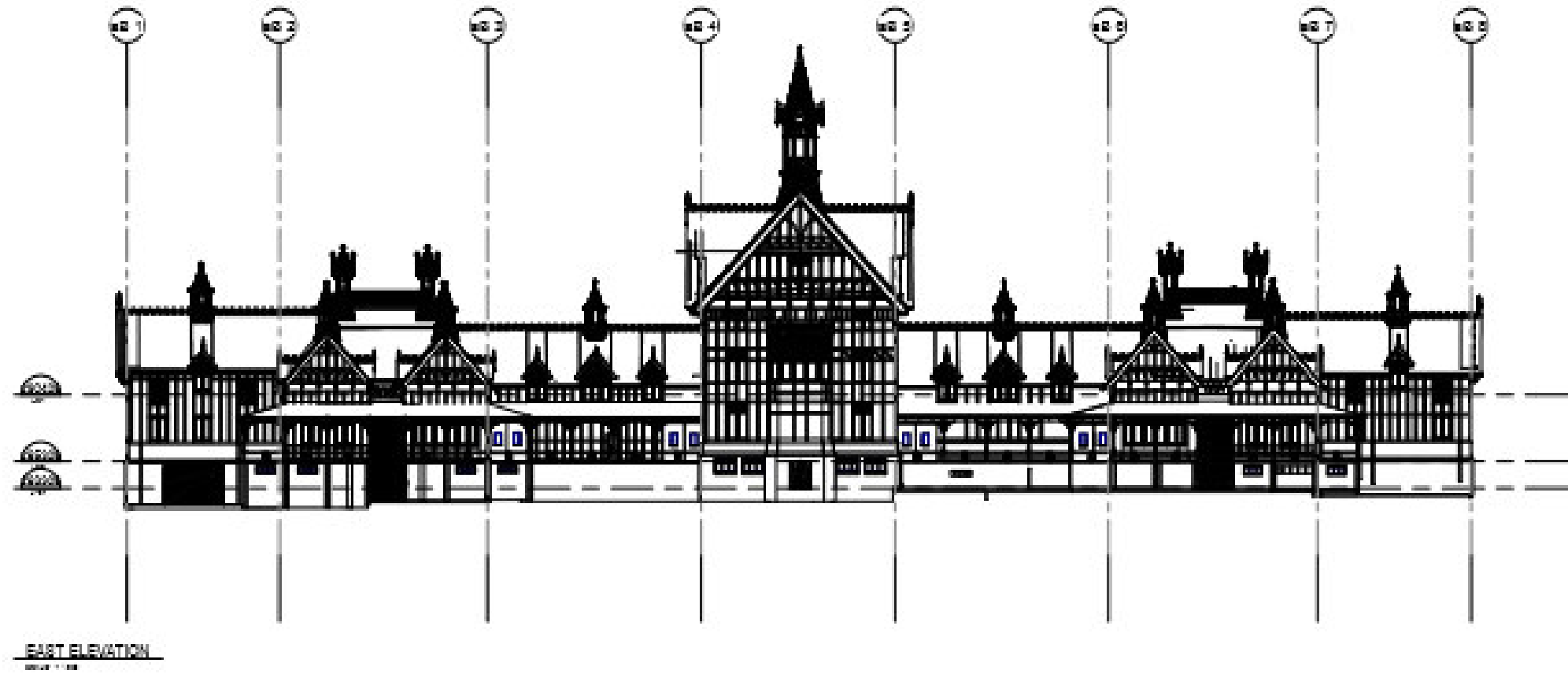


Key:
Grey – South Wing extension, constructed in 2012
Red – North Wing extension, constructed 2008
Orange – Intermediate-South Wing, constructed in 1906, modified in 1967 and 2012
Yellow – Central Wing, constructed 1906, modified 1965
Green – Intermediate-North Wing, constructed 1906, modified 1965
Blue – North Wing, constructed 1906, modified 1978

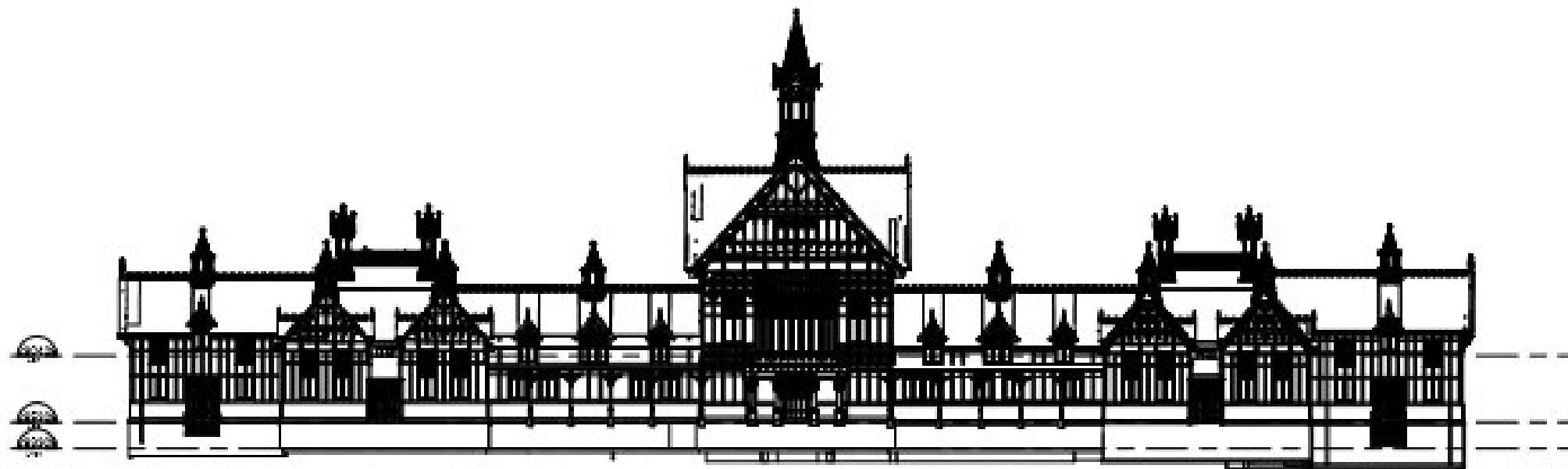
The original 1906 built building excludes the grey and red extensions.



PROJECT	Rotorua Museum	asBUILT
PROJECT TITLE	EXPLODED ISOMETRIC	DATE: 14/05/16 NO: 315.A-002
		FOR MORE INFORMATION CONTACT: TEL: 06 378 7100 WWW.ASBUILT.CO.NZ



EAST ELEVATION
SCALE 1:50



WEST ELEVATION
SCALE 1:50

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1	REVISIONS	DATE	BY																			
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