Job No: G8591
Client: Trinity Residents' Association

Trinity Tower
35 Lynedoch Street
Glasgow G3 6AA

Verification of Collapse Risk
February 2022

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Date: 22 February 2022

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Client: **Trinity Residents' Association**
Title: **Trinity House Tower, 35 Lynedoch Street, Glasgow G3 6AA**

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Status: Issue No 1	**Dated:** 22 January 2021
Report by:	**Checked by:**
[redacted]	

1.0 EXECUTIVE SUMMARY

1.1 The Tower structure is currently stable and has a very low risk of full collapse on to the surrounding areas

1.2 Whilst the tower has suffered significant damage during its life, its structural integrity has not been compromised to the extent of becoming unstable. It has remained in an overall structurally stable state, with all recently gathered evidence showing that it is at very low risk of overall collapse and should remain so in the short term.

1.3 The tower is damaged to an extent that it is vulnerable to significant events; however, this does not mean it is inherently unstable. All reasonably realistic and predictable significant events have been assessed and appropriate measures are in place after being carefully studied and designed over the past two years.

1.4 The events occurring during the last week of January 2022, initiating a precautionary safety cordon by Glasgow City Council (GCC), were considered as 'significant' until such time as they could be fully investigated and analysed.

1.5 The events occurring during the last week of January 2022 have been investigated thoroughly and have been found to have posed no additional risk to the tower's stability at the time and therefore remained at very low risk of overall collapse.

1.6 The proposed structural works commencing just before the installation of the GCC safety cordon are designed to reinstate the towers original overall structural integrity to a level where it can be relied upon in the long term.

2.0 INTRODUCTION AND PURPOSE OF REPORT

2.1 Reports Purpose

This report sets out the detailed risk verification assessment carried out considering Trinity Towers risk of overall collapse in the light of the events initiating GCC's installation of an evacuation safety zone around the building

2.2 Background to this report

In 2019, Will Rudd Davidson (Glasgow) ltd were instructed to survey, assess, and analyse Trinity Tower's structure to advise on long standing damage it had suffered during its life, together with the major repairs carried out in the past few decades. There was a concern that the towers ongoing structural condition was deteriorating and that the repairs carried out historically had been ineffective.

Will Rudd Davidson surveyed the building internally and externally and have now been monitoring the tower since November 2019 using tell-tales, digital tilt sensors and crack propagation tags.

2.3 Summary description of the building

The Tower structure is part of the building addressed 31, 33, and 35 Lynedoch Street and 92 and 96 Woodlands Terrace Lane, former Trinity College. It is formally listed category A (LB32171).

Externally, the Tower structure is formed of massive, coursed, smooth faced ashlar elevations with large pilasters and tall arch window features together with cantilevered stone balconies and a 'lantern' turret storey. Architecturally the verticality of the tower is expressed with alternating pilasters of stone known as 'lesenes'. All walls are of sandstone 'sandwich' construction. (Faced ashlar outer leaf, lime rubble 'heart', and random rubble sandstone inner leaf.

Wall thicknesses vary from approximately 800mm at the pilasters and 700 mm between them, and 975mm at the corner piers. The inner face of the wall tapers inwards significantly at level 6 leading to the small 'lantern' and balcony structure at the top level no 7.

The Tower bears on to a residential property (Flat No 14) at level 1, which in turn bears on to a double vaulted arch entrance hall with large entrance apertures on the east and west wall lines.

From previous studies of records and published information, the foundations are assumed to bear on to boulder clay (known generally to be the shallow structural soil in this vicinity) directly below the Tower.

3.0 RELEVANT DOCUMENTATION AND STANDARDS AND TERMINOLOGY

3.1 The description of crack severity is taken from BRE Digest 251, summarised as follows:

- Negligible — Less than 0.1mm (commonly referred to as 'hairline')
- Very slight — 0.1mm to 1.0mm
- Slight — 1.0mm to 5.0mm
- Moderate — 5.0mm to 15.0mm
- Severe — Above 15.0mm to 25mm
- Very severe — Above 25mm

3.2 Reference to timeframes is made on a broad conjectured basis. For guidance, the following definitions are made:

- Urgent — Minimum delay. Immediate.
- Very short term — 1 year
- Short term — 2 to 5 years
- Medium term — 5 to 10 years
- Long term — 10 to 20 years

3.4 Orientation

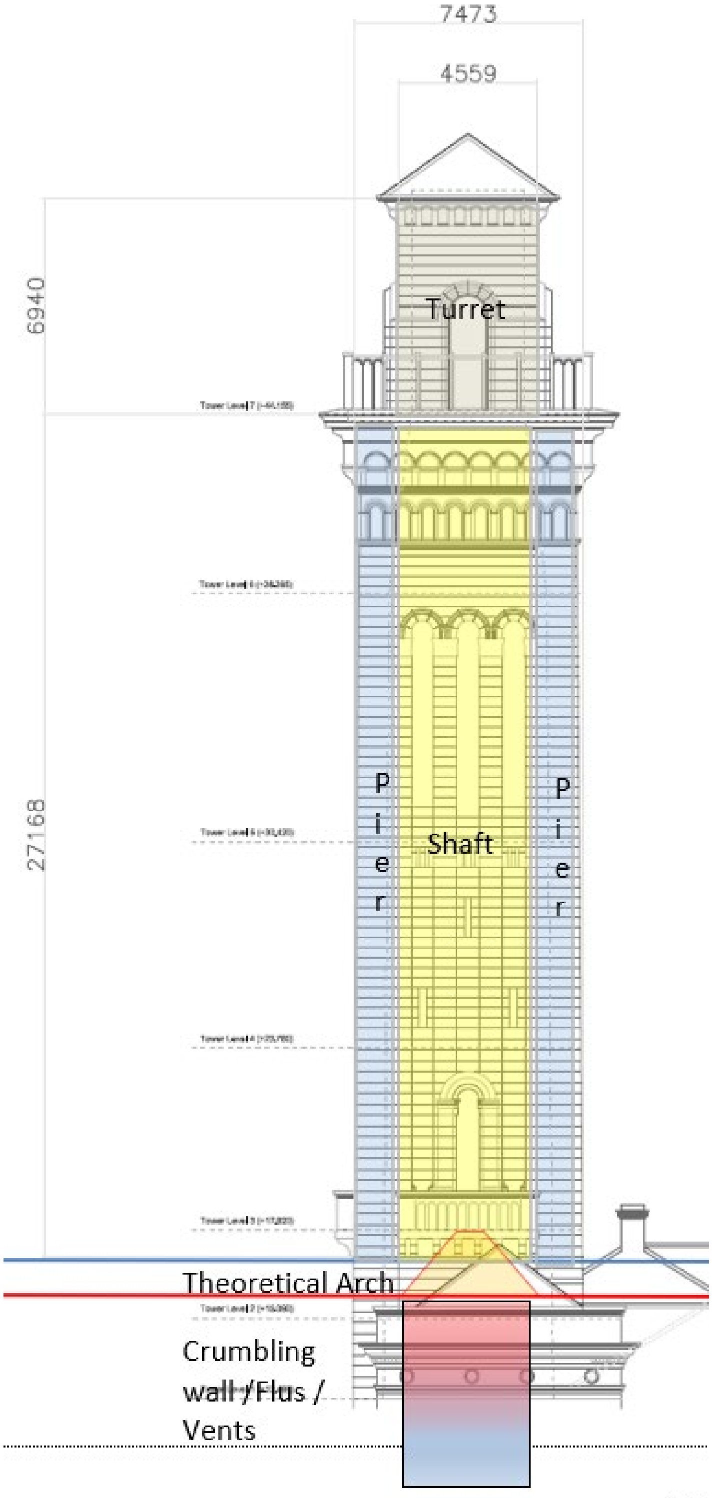

Figure 1: Tower Marking Elevation

4.0 Risk Assessment

4.1 Methodology

This risk assessment covers the overall structural integrity of the tower in the context of 'risk of comprehensive collapse on to the surrounding areas.' This risk assessment does not cover local isolated structural fabric issues unless they onerously impact the 'risk of comprehensive collapse on to the surrounding areas.' Such local isolated structural fabric issues have been assessed separately and are not relevant to this report.

The risk assessment has been carried out using the evidence gathered since November 2019 via observation, measurement, and digital monitoring. The context of the information obtained from the many historic structural reports and archive research is important to build confidence regarding possible trends and learning from historic events. As such the risk matrix charts the buildings history from the present day back to its birth in 1858

The risk matrix covers the normal risk description and likelihood of occurrence. It also includes a vulnerability assessment. This relates to what are classed as 'significant events.' (See section 4.2d)

The impact of 'comprehensive collapse on to the surrounding areas' is a common factor and is classed as 'very high'.

4.1 Risk Matrix

The risk matrix covers the normal risk description and likelihood of occurrence. It also includes a vulnerability assessment. This relates to what are classed as 'significant events', for example, the proposed demolition and renewal of the crumbling south wall at level 2.

4.2 Risk Sources impacting the likelihood of comprehensive collapse

a. Structural integrity

Trinity Tower has suffered significant structural damage originating from as far back as the early 20th century. It has culminated in vertical fractures rising through the middle third of the building. (Please refer to WRD Structural Survey Report 28 November 2019). At that time there was incomplete measurement surveys indicating a progressive movement. As such WRD set up a network of tell tales and crack propagation tags, together with digital 'tilt monitors' at the top of the tower which could measure very small changes in angle, all to finally verify or disprove the indicated progressive movement.

The vertical fractures predate the first known available report prepared by Page and Park Architects, which recorded the damage in 1990. Therefore, the current damaged structural form of the tower has existed for at least 30 years, likely much longer. The vertical fractures are tied together at each floor level by retro fitted ring beams at each floor level which enhance the tying effect of the floors. Throughout this time the tower has successfully endured very severe weather conditions without significant event.

The network of tell tales and crack propagation tags were installed in November 2019. The tilt monitors (digital recording of the tower's verticality on all four wall planes) were installed in June 2020. Since then, there has been no detected tilt in the tower, and no measured change in the crack width or length except for the south shaft wall at level 2, which has been proven to be a local issue, not onerously impacting the overall stability of the tower. Despite the localised movement detected here, the tower has remained static.

From the evidence gathered from measurement it is concluded that the risk of overall collapse through loss of structural integrity is very low.

b. South shaft wall at level 2

In November 2019, we recorded fresh stone bulging in the south shaft wall and fresh cracking on the southeast corner pier at level 2 of the tower. These cracks were recorded as recent as they were found to be different compared with the most recent structural report photographs by David Narrow Associates in 2018. It was concluded that the south shaft wall was failing and the weight it was originally carrying was being transferred gradually to the southwest and southwest corner piers via the formation of a natural stone arch. (Please refer to WRD Structural Survey Report 28 November 2019).

Calculations of the maximum stresses in the southeast and southwest corner piers were carried out and found to be very low in comparison to normal recognised limits for coursed ashlar sandstone structures. These stresses peak when there is a north westerly wind (relatively rare occurrence). A full failure of the south shaft wall at level 2 was modelled in the calculations, which resulted in the maximum pier compressive stresses applied being less than maximum permissible stresses.

It was therefore concluded that whilst the south wall has bulged and lost an estimated 75% of its vertical load carrying capacity, this situation was not onerously affecting the overall tower stability. Not withstanding this it was recommended that the wall was shored to prevent further bulging and load transfer to the corner piers. The factor of safety against crushing of a weak sandstone was found to be 67 (6700%).

	Static Undamaged Tower	
	Compressive Stress at level 2	
Shaft Wall =	0.603	N/mm2
Pier =	0.388	N/mm2
	Static Damaged South Shaft Wall	
Wall effectiveness x-x	25%	Partial Arch formed
	Compressive Stress at level 2	
Shaft Wall =	0.15	N/mm2
Pier =	0.953	N/mm2
	Dynamic Undamaged (NE wind load only)	
Comp Str Pier @ y-y	0.006	N/mm2
	Dynamic Damaged South Wall (NE wind load only)	
Comp Str Pier @ y-y	0.389	N/mm2
	Total Undamaged	
Pier Comp Stress @ y-y =	0.394	N/mm2
	Utilisation	26%
	Total Damaged South Wall	
Pier Comp Stress @ y-y =	1.342	N/mm2
	Utilisation	89%
Minimum crushing strength of sandstone	90	N/mm2
	Factor of safety =	67
Empirical Premiss Stress for sandstone walls =	1.5	N/mm2

Table 1: Extract Summary Calculation Output

The slenderness of the corner piers was assessed assuming a worst possible case, where they were completely unbonded from their returns and shaft wall neighbours. In this highly conservative scenario, the slenderness ratio at level 2 was found to be 4. With fully bonded return walls making up the towers corner piers, which is closer to reality, the slenderness would tend towards 0. In context, this is very small compared with the historic and modern-day limit set at 28. Therefore, slenderness of the structural wall elements between the fractures are considered to have no impact.

From the evidence provided by the calculations we have concluded the risk of overall collapse due to over stressing at level 2 is very low.

c. Weather Conditions

The stresses introduced in the tower by high winds were calculated and found to be less than permitted levels even if the south wall was removed. (See 4.2b above)

The tilt monitors have been measuring storm events since June 2020 and the towers oscillations have been recorded during several storm conditions over this period. Each 'trace' shows a consistent oscillation between flexing and recovery, measuring only a few millimetres.

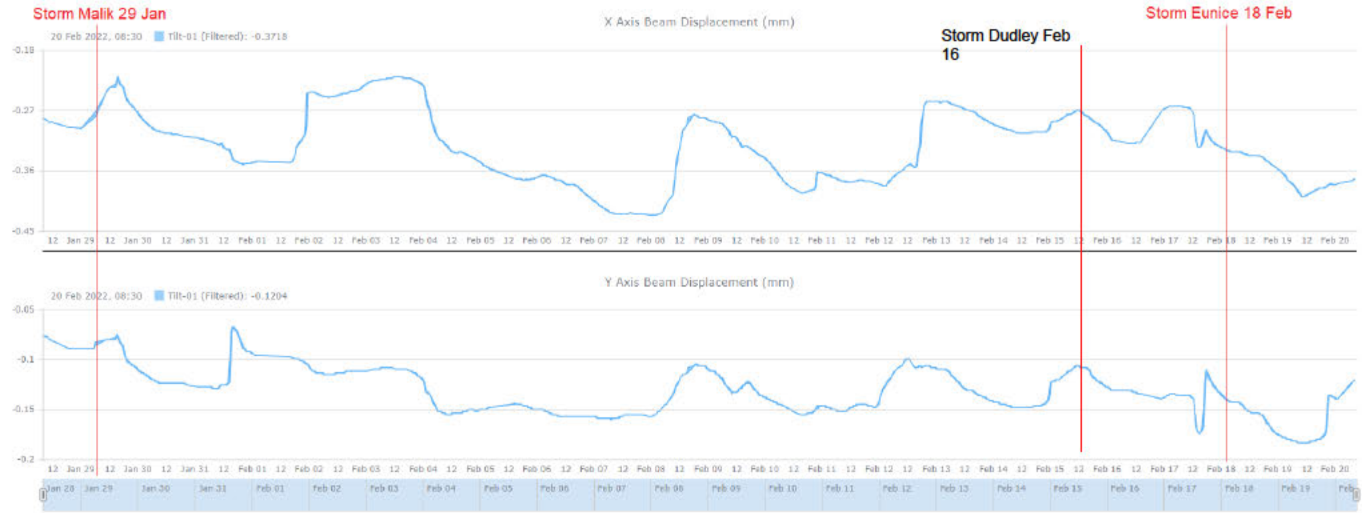

Figure 2: Extract Tilt Monitor Trace

During storm Malic we experienced alarms sounding from our tilt monitors, showing a sharp rise in tilt after which the sensors went offline. Our engineers had to assume the worst in that there was a possible unnatural movement in the tower (significant event) and therefore immediately raised the issue with the contractor, project team, and client group. We immediately initiated 'eyes on protocols.' Once we had ascertained it was safe to enter the tower all monitors were checked and reset, all tell-tales and crack propagation tags were measured and checked, together with a full reinspection of the building to ascertain if there had been any fresh damage caused. All results returned negative by the 2nd of February, and we concluded the storm had not caused any damage to the buildings overall structural stability and that the risk of collapse was very low. It can be seen for the trace above that the tower experienced a catalogue of wind gusts between the recent storms. The tower is very exposed on the brow of a small escarpment making high wind gusts more frequent than normal conditions. However, the traces during this period are no different from those measured in past previous high winds, with all of them showing elastic oscillations with no evolving trends.

It was at that time that the local increase in cracking in the finishes covering the south wall at level 2 were exposed. Our calculations had already proved that this was not likely to onerously impact the towers overall structural integrity. (See 4.2b above)

From the evidence provided by the calculations and monitoring histories, we have concluded the risk of overall collapse due to high winds is very low.

d. Significant events

The tower is damaged to an extent that it is vulnerable to significant events; however, this does not mean it is inherently unstable. It means that significant interventions require careful design and implementation as is the case for most Victorian buildings. In this case, it is important to consider any necessary proactive measures are implemented to cater for events out with our control. All reasonably realistic and predictable significant events have been assessed and appropriate measures are in place after being carefully studied and assessed over the past two years.

Wind induced over stressing:	Proven by calculation and monitoring to be a very low risk
Loss / demolition of the south wall at level 2:	Proven by calculation and monitoring to be a very low risk
Unnatural movement in the tower:	Proven by monitoring to be a very low risk

e. General Structural fabric condition

The general condition of significant areas of the buildings structural is very poor by virtue of the fact that long standing historic repairs have been carried out to a very poor standard and have been largely ineffective. Most notable are failed 'indent' repairs (defective stone is cut back and a natural stone veneer is tied and bonded to the cut-out area to match the existing faces), some of which have fallen from the building and if still in place will not be likely to contribute significantly to the structural strength of the walls. The one historic repair which appears to have been effective is the retrofitted ring beams installed at each floor level, which bind the tower's vertically fractured segments together.

We have examined in detail all the visible structural damage to the towers structural fabric and have concluded through calculation and monitoring and historic observation, that the towers stability is not compromised to the extent that there is a risk of wholesale collapse. The tower structure has a high degree of redundancy (spare strength capacity) enabling it to remain stable during several decades since the damage occurred. That said, we have strongly recommended that the tower is repaired as a matter of urgency to reduce its vulnerability and enable comprehensive fabric repairs to be made safely. These works were commenced in January 2022 and halted when the safety cordon was installed by GCC.

The tower has one major structural repair to be done, to reinstate load paths in the failed south wall at level 2 (See 4.2b above). Whilst this activity can be safely carried out at any time, it has been programmed to occur at the end of the project once the stent is completed. The strategy adopted here was to install a steel framed 'Stent' to reinstate the towers 'box rigidity', tie the inner and outer walls together from the inside, and reduce the slenderness of the vertically fractured segments of the towers structural form. This has been updated since the discovery of the increased bulging in this area, which had cast doubt over the integrity of the balcony directly above it. The shoring of the bulge in the wall has been extended to reach up to support the balcony from falling out. It may have to be removed completely to make working below a suitably safe environment.

The risks associated with deteriorating stonework in the building (e.g. freeze thaw chipping, delamination of failed indents, spalling mortar crack repairs and the bulged south wall) are greatest in the context of falling debris, not overall collapse. The falling debris risk is most onerous at the balcony above the bulged south wall, and stones falling out of this wall itself. Debris fall risks have been mitigated by the installation of scaffolding and crash decks around and within the building. There is sufficient redundancy within the buildings structure to conclude such local issues currently will not onerously impact the overall stability of the building.

From the above we have concluded that the risk of overall collapse as a result of deteriorating stonework is currently very low.

f. Risk of unseen structural issues below the level 2 in concealed areas

The evidence from opening up works have established that the tower structures damage is restricted to the middle third of its height, with the evidence of damage quickly diminishing beyond these areas. Historic records and physical inspection show structural repair works to the walls directly below the tower during previous refurbishments and confirm the damage significantly decrease with distance away from level 2 and level 6 of the tower.

There is therefore no reason to adjust our assessment of the towers risk of overall collapse in this respect, which remains at 'very low'

g. Cumulative risk

All the risk sources discussed above present a very low risk of overall collapse. None of these risks sources currently amplifies the risk of another; therefore, the cumulative risk of overall collapse is very low.

4.3 Risk Mitigations

a. Current Situation

In the short term the risk of over all collapse is very low. Again, in the short term, there are no necessary risk mitigations currently needed to protect this status.

Looking from the present day into the long term, we feel it is essential to improve the towers vulnerability class from high to very low. This is to enable the future progressive building fabric repairs to be carried out with confidence that the structure is of very low vulnerability.

b. Stent installation

The goal of the proposed repair works commenced in January 2022 was to reduce the vulnerability (see 4.3a) of the towers structure to 'low' by installing the following structural enhancements.

- reinstate the towers 'box rigidity',
- tie the inner and outer walls together from the inside.
- reduce the slenderness of the vertically fractured segments of the towers structural form.
- Improve / stiffen the wall panels directly above the bulged south wall to increase safety when inserting the temporary needle supports before renewing the wall.
- Enable external repairs to be carried out unhindered by exoskeletal bracing.

All the above is achieved by a rectangular braced tube structure inserted internally in the tower, analogies to a surgical stent, to create a rigid frame to which the inner and outer leaf of the tower walls can be tied back to. It will have the added benefit of reducing the risk of overall collapse from very low to negligible.

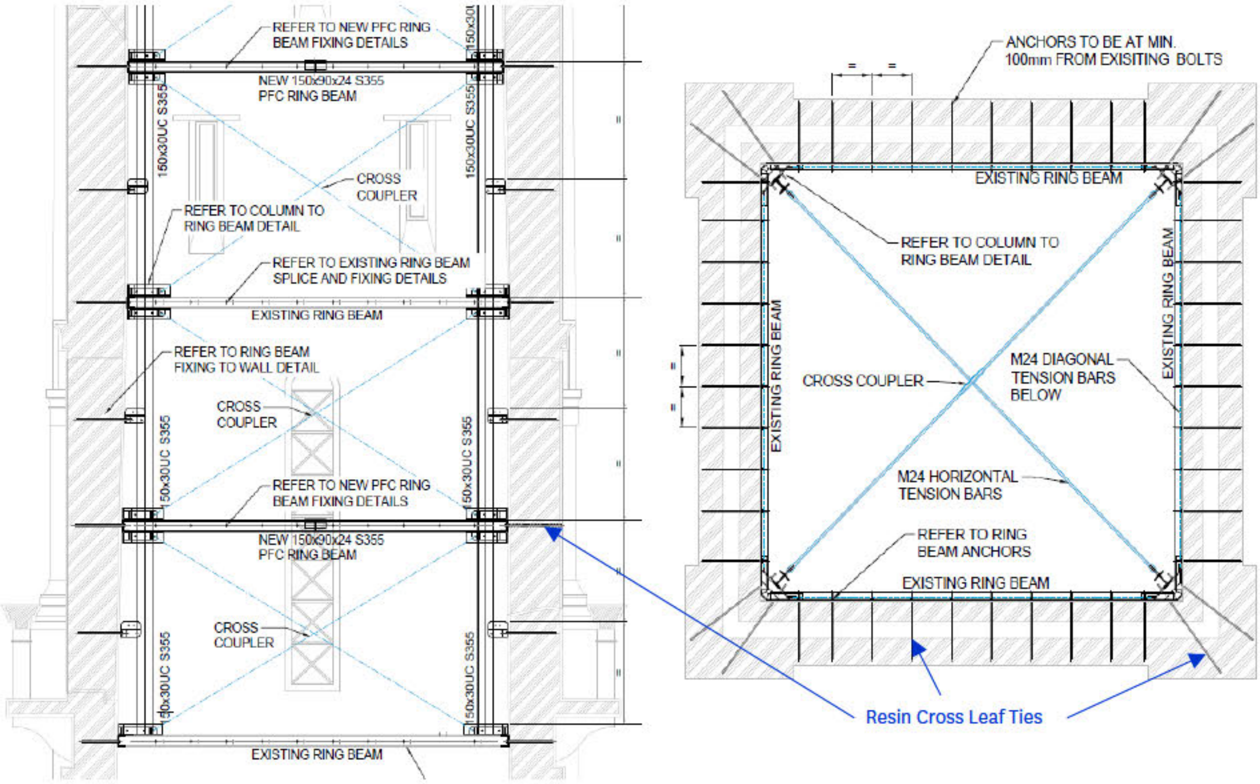

Figure 3: Extract from stent design information

c. Verification of no concealed issues below the tower in the accommodation area

Endoscopic surveys are ongoing at the time of writing in the concealed areas of the tower walls below level 2. This having been requested by GCC, is to provide additional confidence that there are no structural repairs needed in these areas over and above the investigations and assessments which are in place.

d. GCC suggested Girdle Structure

During our discussions with GCC DRS it was suggested that an external girdle frame positioned round level 2 to 3 would be appropriate to protect the buildings overall stability. This option was assessed and compared and contrasted with the existing internal stent proposal, and the following outcomes were confirmed.

- This solution addresses the tying of the inner and outer leaf's at level 2 through external containment. The existing channel ring beams and floor structures do the same job, and the Stent will enhance this by renewing and adding to the density of internal cross ties.
- This solution reduces the vulnerability class of the building to low, as opposed to very low on installation of the stent.
- This solution does not contribute to reinstating the box rigidity of the tower above level 2
- This solution is not necessary for tying the wall leaf's together as the existing channel ring beams and stent will serve the same purpose.
- This solution is not necessary to protect the tower from over stressing or lateral buckling of the walls, as they are not over stressed and not of significant slenderness ratio. (See 4.2 above)
- This solution has no significant impact on the risk of overall collapse of the building, which is currently very low. The stent reduces this risk to negligible.

- This solution creates a large external structure which will be very difficult to install within the scaffolding and subsequently work around when carrying out external repairs. The stent has a free space to be erected internally and will not interfere with the scaffolding or external repairs works.
- This solution is in complete conflict with the building's Grade A listed status and is contrary to all discussions and agreements previously reached with Historic Environment Scotland, GCC Planning Authority and Glasgow City Heritage Trust (GCHT). Securing an exposed structural framework to the existing external historic fabric may breach the terms of grant assistance currently provided by both GCC and GCHT.

Whilst this solution is valid for containing outward moving structures, we are of the opinion that it is not necessary in this instance as the corner structures and shaft walls are not currently moving outwards, and there is no evidence to suggest that they are likely to move outwards in the short term.

Please refer to Appendix A for detailed information.

e. Renewal of the south wall

The renewal of the bulging south wall at level 2 of the tower will reinstate the original load paths for the tower to use when needed. This will dramatically reduce the towers vulnerability which is one of the core objectives of the project.

Risk Matrix													
Ref	Risk event	Likelihood of comprehensive collapse on to the surrounding areas					Supporting evidence	Vulnerability to significant events					Notes
		Negligible	Very low	Low	High	Very High		Negligible	Very low	Low	High	Very High	
1	Future Status on replacement of the crumbled south wall level 2	x					Designed to reinstate the original load distributions		x				
2	Future status on completion of the Proposed Stent	x					Stent is designed to tie the towers walls inner and outer leaf's Stent is designed to reduce the slenderness ratio of the vertical sections of the tower wall by 50% Stent is designed to reinstate original 'box rigidity' Stent is designed to tie / bind the vertical fracture lines created by the historic movement in the tower. Stent is designed create minimum interference with future external works to the tower elevations		x				
3	Installation of the GCC suggested external Girdle frames		x				Will provide the same tying action as the lower sections of Stent design.			x			This system will not provide as comprehensive protection as the stent in terms of reducing vulnerability as it only addresses wall tying at the lower reaches of the tower, and it will be difficult to work round during future external works to eth elevations.

Risk Matrix													
Ref	Risk event	Likelihood of comprehensive collapse on to the surrounding areas					Supporting evidence	Vulnerability to significant events					Notes
		Negligible	Very low	Low	High	Very High		Negligible	Very low	Low	High	Very High	
4	Current Status at 21 Feb 2022						Tilt monitors traces show no movement trends since July 2020						
							Tilt monitor storm event traces all show similar oscillations and recoveries						
							Storm Malik tilt monitor trace is normal						
							Storm Eunice tilt monitor trace is normal						
							Tell-tale readings show no crack changes since January 2020						
			x				Crack propagation tags show no growth since November 2021, except in one isolated area (South Wall level 2 bulge).				x		
							Detailed analysis show that even with a complete failure of the south crumbling south wall, the stresses within the towers corner piers and shaft walls are within acceptable limits under storm conditions.						
							South Wall bulge is proven not to be onerously impacting the overall stability of the tower.						
5	Status 29th January 2022 Detection of two possible 'significant events'. 1.0 Tilt Monitor Alarm and data drop out. 2.0 Discovery of Increase bulge in south wall level 2						Tilt monitors traces show no movement trends since July 2020						
							Storm Malik tilt monitor trace was recovered and found to be normal						Tilt monitor event was proven not to onerously impact the 'Risk of comprehensive collapse on to the surrounding areas'
			x				Tell-tale readings showed no crack changes since January 2020, except in one isolated area (South Wall level 2 bulge).				x		Bulge event was analysed and proven not to onerously impact the 'Risk of comprehensive collapse on to the surrounding areas'
							Crack propagation tags showed no growth since November 2021, except in one isolated area (South Wall level 2 bulge).						

Risk Matrix													
Ref	Risk event	Likelihood of comprehensive collapse on to the surrounding areas					Supporting evidence	Vulnerability to significant events					Notes
		Negligible	Very low	Low	High	Very High		Negligible	Very low	Low	High	Very High	
6	Completion of WRD (Glasgow) 12 month monitoring and analysis period (July 2021)		x				Tilt monitors traces show no movement trends since July 2020 Tilt monitor storm event traces all show similar oscillations and recoveries Tell-tale readings show no crack changes since January 2020 Crack propagation tags show no growth since November 2021, except in one isolated area (South Wall level 2 bulge). Detailed analysis show that even with a complete failure of the south crumbling south wall, the stresses within the towers corner piers and shaft walls are within acceptable limits under storm conditions. South Wall bulge is proven not to be onerously impacting the overall stability of the tower.				x		Close study verified the building is at very low risk of comprehensive collapse on to the surrounding areas. The study recommended that structural enhancements were required in the short term to ensure the building would be able to receive significant essential structural remedial works to the south wall level 2. The building was classed as highly vulnerable to significant events. Remedial works package was developed in close consultation with Historic Environment Scotland, Glasgow Building Preservation Trust, GCC planning authority and GCC DRS.
7	Beginning of WRD (Glasgow) involvement		x?				Fresh cracking occurring in the south east corner pier and the south tower shaft wall at level 2 created a need study the tower in detail to verify or Extensive, very poor historic repairs repair work quality were identified Examination of the main cracking and historical reporting, crack recording and age of the damage (historic alibi), indicated the damage was decades old and not necessarily getting worse.				x		First inspections created initial concern regarding the risk profile of the building, initiating a close study of the building and long-term monitoring to verify the very low risk category allocated by studying the historic structural reports on the building. Extensive, extremely poor and ineffective repairs were identified meriting an increase in vulnerability classification.

Risk Matrix															
Ref	Risk event	Likelihood of comprehensive collapse on to the surrounding areas					Supporting evidence	Vulnerability to significant events					Notes		
		Negligible	Very low	Low	High	Very High		Negligible	Very low	Low	High	Very High			
8	Period of 3 historic major renovation and repairs contacts 1970 - 2019		x				Major works were carried out including structural strengthening, therefore the building is likely to have been in much better condition at that time than it is at present.			x					
9	1924 - Removal of spiral stair access and installing current stair well. Possible ceasing of original differential settlement through bearing strata consolidation over 50 - 75 years		x				Steel strapping and remedial strengthening has been installed to the west wall at various locations in an attempt to tie cracks. Likely to have been installed past 1920 / pre 1970 Historic records show the alteration			x			It is thought that the removal of this structural mass, removed essential buttressing to the south wall at levels 1 and 2. The south wall is considered a weak zone due to the presence of a networks of flus and vents within the body of the wall.		
10	1903 - Fire damage and possible manifestation of the buildings original differential settlement	x					Historic records	x					unlikely to have significant structural impact on the tower.		
11	1857 - Original construction	x						x							

5.0 Summary conclusions

5.1 Events during the week of 24 – 29 January

Whilst these events were a concern and merited immediate precautionary safety measures to be put in place, after close examination the tower was found to be at very low risk of overall collapse during that period, as advised on 2nd February 2022

5.2 Assessment of GCC suggested Girdle Structure

This suggested solution is not necessary to protect the towers overall stability, nor is it needed to protect the tower during the renewal of the bulging south shaft wall. The tower is currently at very low risk of overall collapse with no additional measures required.

This solution would decrease the towers vulnerability level to low, however the Stent installation provides a better result in this respect by reducing vulnerability to very low.

5.3 Projected Risk Status and Vulnerability Status

The risk level of overall collapse is predicted to remain at 'very low' until the Stent erection progresses which will reduce this to 'Negligible' on completion. The vulnerability status will reduce alongside this from 'High' to 'very low' on completion.

5.4 General historic risk status

The history of collapse risk is conjectured based on archive information and interpretation of the possible prevailing conditions. Since 1970, the volume of available information increased because there was likely some event that presented the need for more professionals to look at the building. Since then, the evidence available has been photographic and interpretive comparisons (The history of the 15 Structural Engineers reports, 1970 to 2018 has been catalogued in WRD's Structural Inspection report of 19th November 2019). Evidence based study commenced in November 2021 and will continue until the completion of the repairs contract.

The risk of overall collapse of the tower has been judged at very low all the way through the tower's life since the beginning of the 20th century. Since November 2019, this risk evaluation has been evidence based.

7.0 Limitations

7.1 This report has been prepared for the sole benefit of the owners of the property. The report shall not be relied upon or transferred to any other party without the written authorisation of Will Rudd Davidson Ltd.

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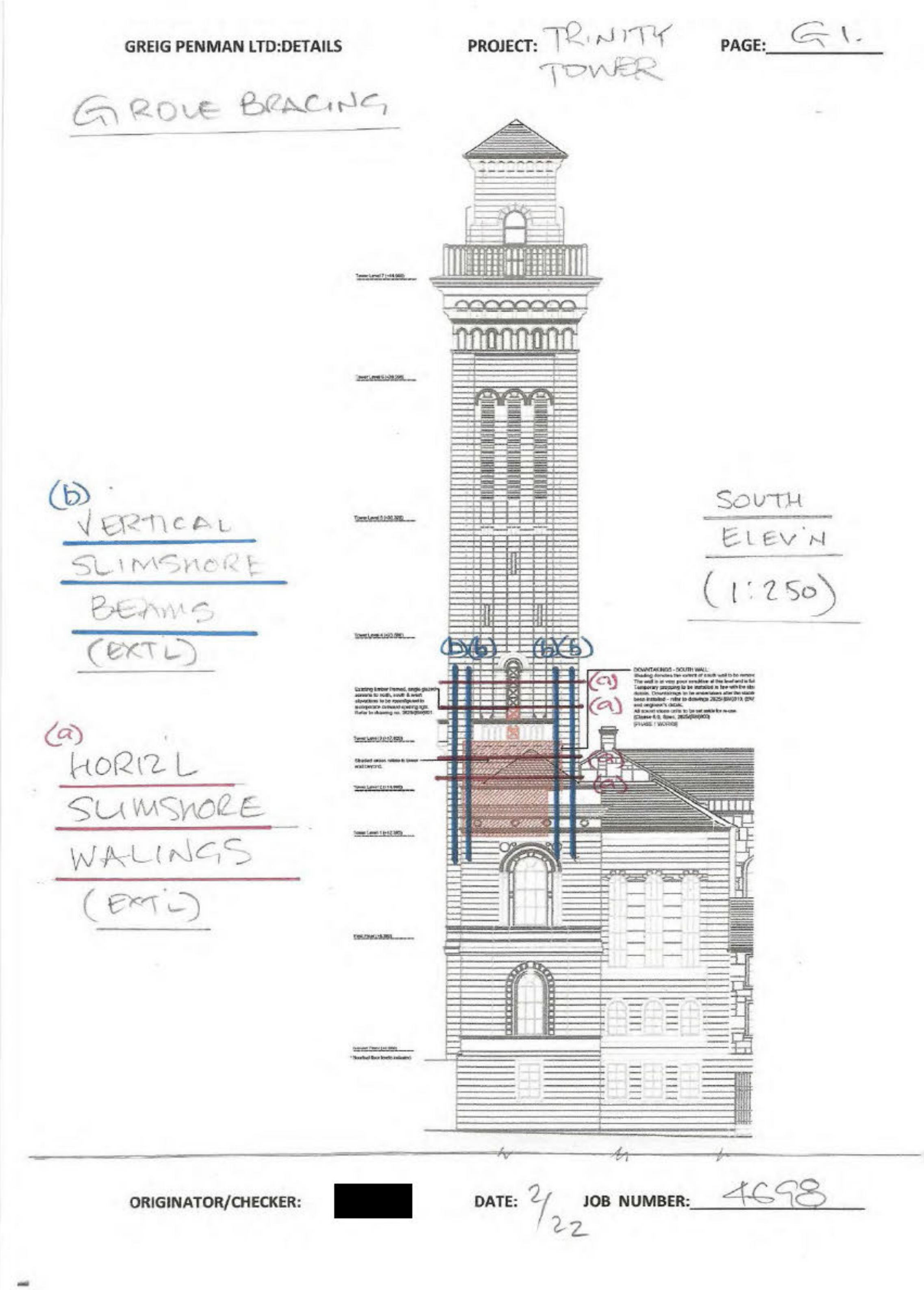
Appendix A: Girdle Structure Technical Design Output Information



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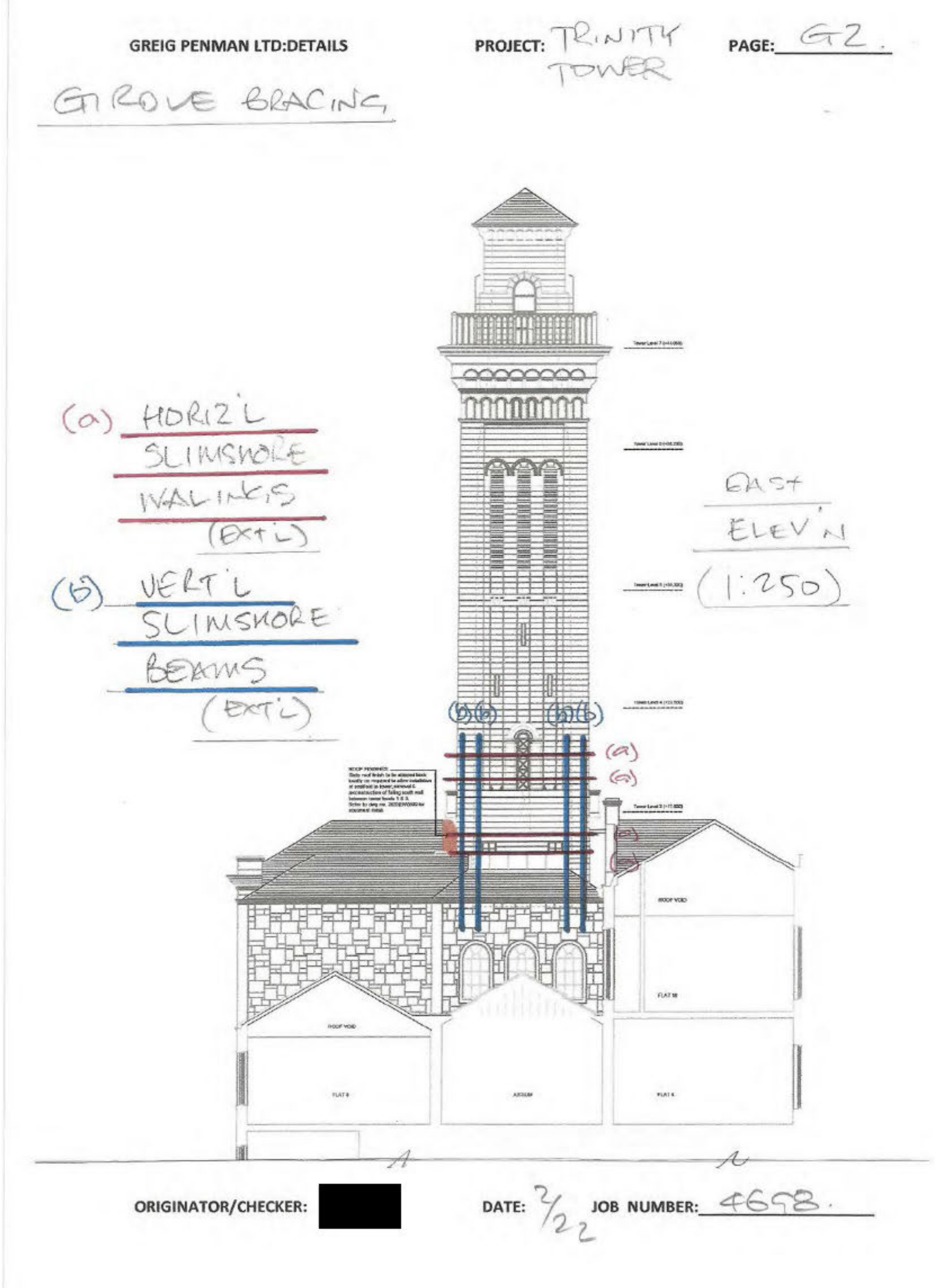
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(b) VERT'L SLIMSHORE BEAMS (EXT'L)
EAST ELEV'N (1:250)
ORIGINATOR/CHECKER:
[redacted]
DATE: 2/22
JOB NUMBER: 4698.

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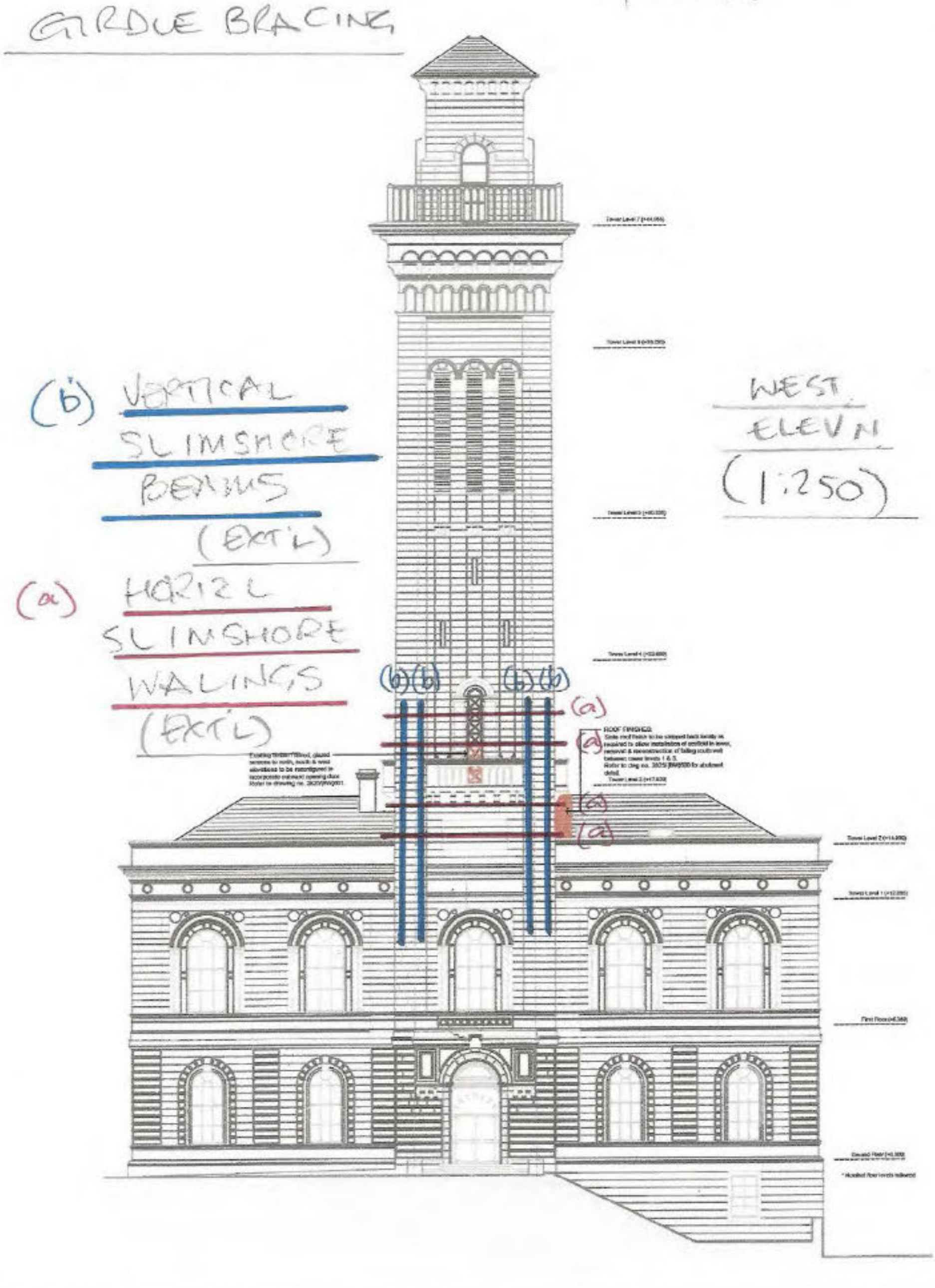
GIRDLE BRACING



ORIGINATOR/CHECKER: [redacted] **DATE:** 7/22 **JOB NUMBER:** 4698

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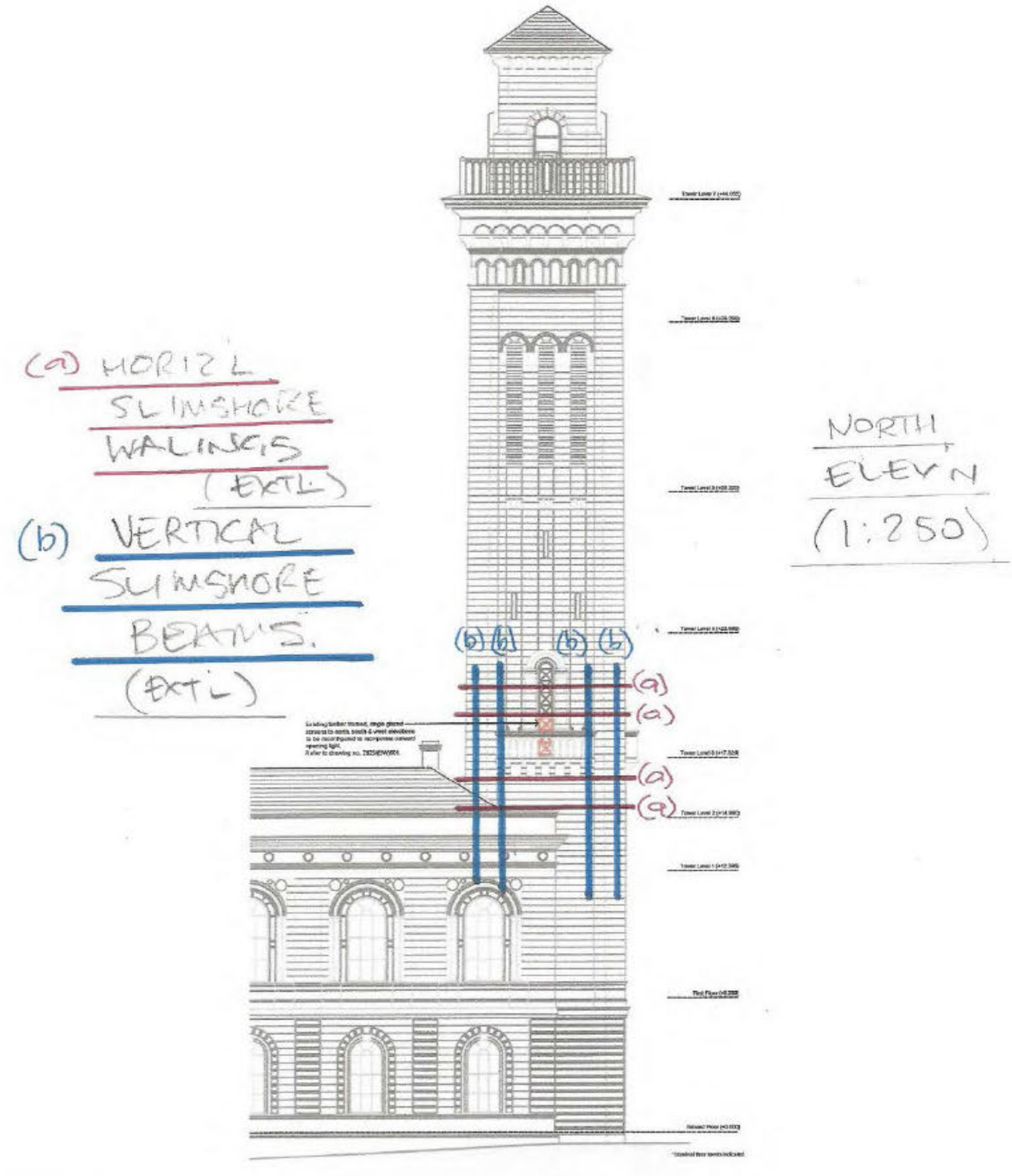
GIRDLE BRACING



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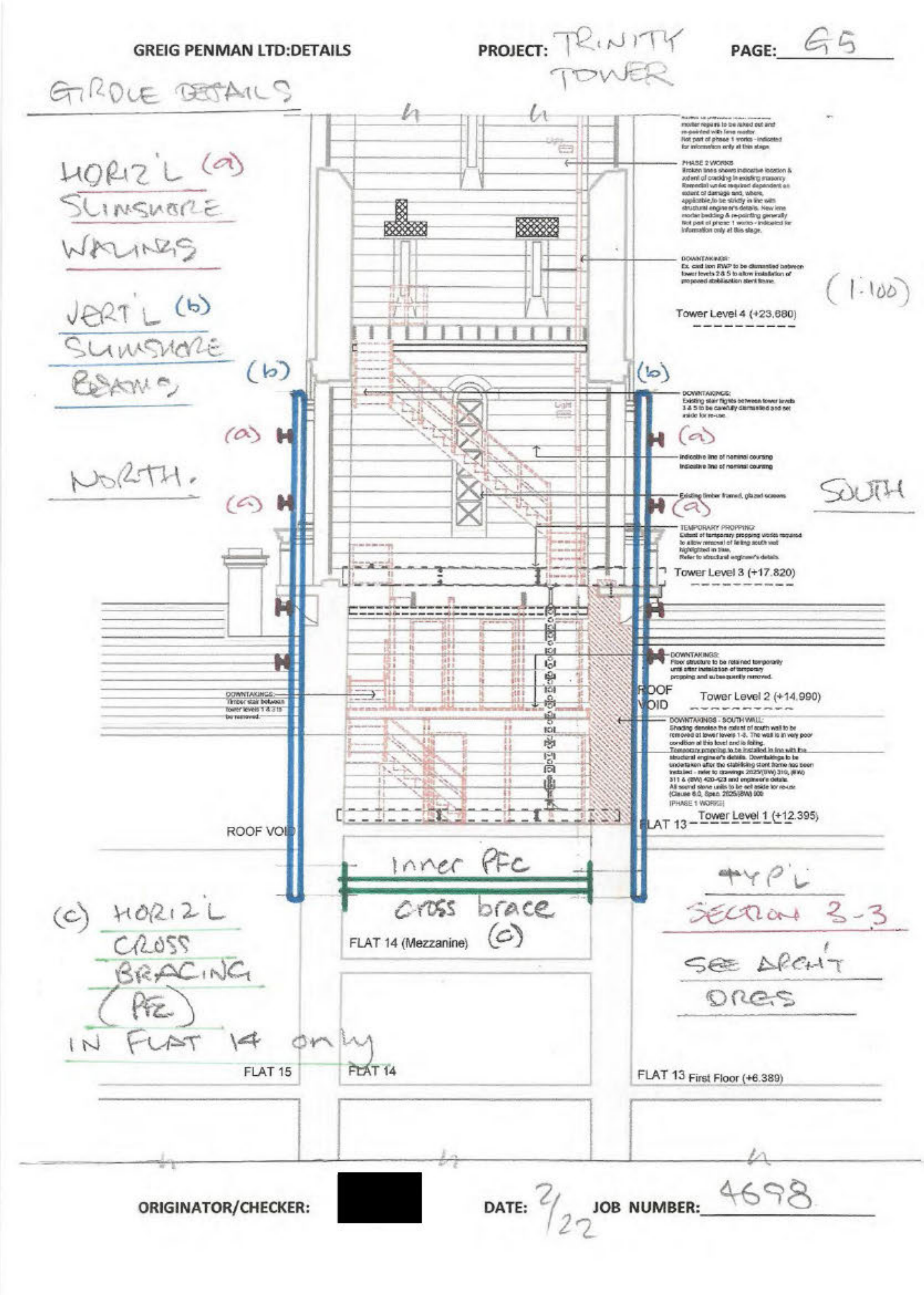
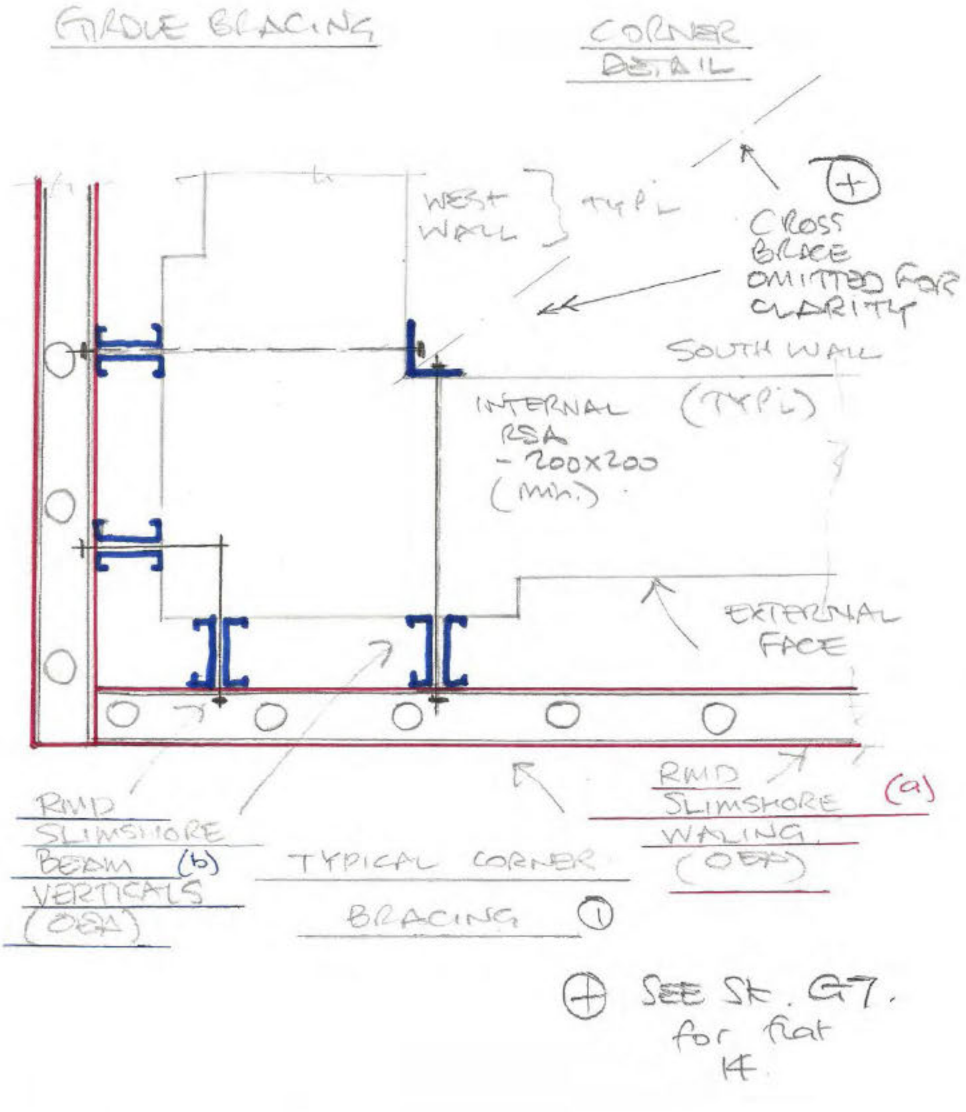
Realise what's possible

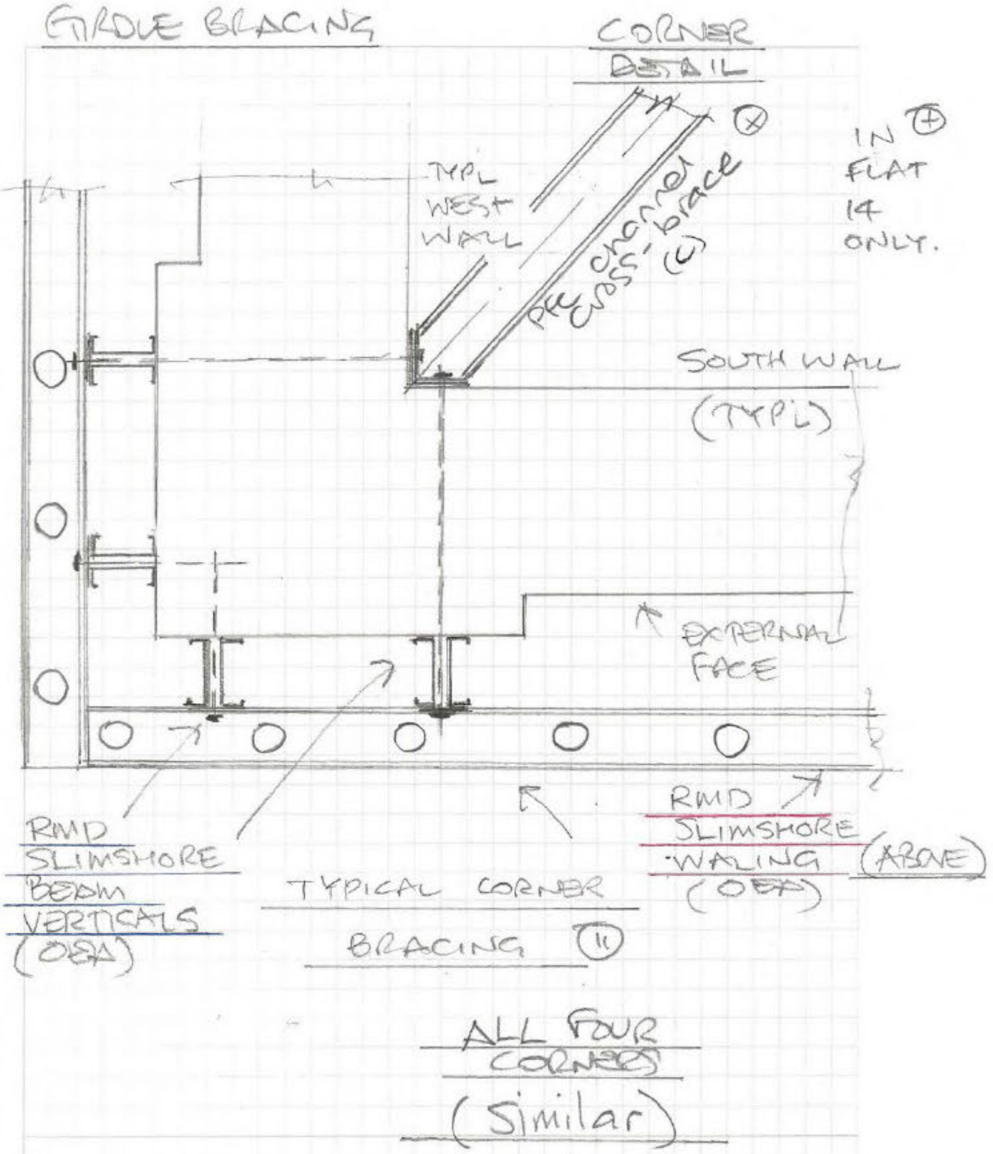

GREIG PENMAN LTD:DETAILS
PROJECT: TRINITY TOWER
PAGE: G5
GIRDLE DETAILS
HORIZ'L (a) SLIMSHORE WALINGS
VERT'L (b) SLIMSHORE BEAMS
NORTH.
SOUTH
(b)
(a)
(1:100)
Tower Level 4 (+23.680)
Tower Level 3 (+17.820)
Tower Level 2 (+14.990)
Tower Level 1 (+12.395)
ROOF VOID
FLAT 13
Inner PFC cross brace (c)
(c) HORIZ'L CROSS BRACING (PFC) IN FLAT 14 only
TYP'L SECTION 3-3
SEE ARCH'T DRGS
FLAT 14 (Mezzanine)
FLAT 15
FLAT 14
FLAT 13 First Floor (+6.389)
ORIGINATOR/CHECKER: [redacted]
DATE: 2/22
JOB NUMBER: 4698

GREIG PENMAN LTD:DETAILS PROJECT: TRINITY TOWER PAGE: G6



ORIGINATOR/CHECKER: [redacted] DATE: 2/22 JOB NUMBER: 4698

GREIG PENMAN LTD:DETAILS **PROJECT:** TRINITY TOWER **PAGE:** G7



ORIGINATOR/CHECKER: [redacted] **DATE:** 2/22 **JOB NUMBER:** 4698