Dangerous Building Incident Ref: IR/22/00017 - Section 29 of the Building (Scotland) Act 2003

Address: 35 Lynedoch Street, Glasgow – 'Trinity Tower'

A review and commentary of the document titled 'Verification of Collapse Risk' prepared by Will Rudd Davidson Ltd

Introduction

On behalf of the Trinity Residents Association (TRA), Will Rudd Davidson Ltd (WRD) submitted a report titled "Verification of Collapse Risk" (the VCR) report to Glasgow City Council (GCC or the Council) on 23rd February 2022. This Report, which was in addition to the "Recent new structural movement: Precis situational assessment" letter/report of the 30th Jan 22. It was prepared after the Design Team meeting of 10th February 2022 with GCC and provided an updated assessment on the overall risk of collapse of the Trinity Tower. In doing so, WRD provided an opinion on the requirement to retain the safety exclusion zone initiated by the Council.

GCC provided initial feedback on the VCR by email to WRD on 28th Feb 22. This response advised that GCC had reviewed the technical reports prepared by Will Rudd Davidson along with the most recent Verification of Collapse Risk report. This email confirmed that the significant structural defects observed in the west Trinity Tower on 29th January, together with the benefit of further on-site inspections, lead GCC to the reaffirm our assessment that the structure is unsafe had not changed

The initial feedback provided by GCC went on to further advise that:

- It was not clear why the medium risk of progressive collapse in the WRD letter/report of the 30th Jan 22 had changed compared to the opinion of a lower risk mentioned in email and the later VCR report of the 22nd February
- GCC noted that what was ultimately relevant from either of these opinions was that the risk of collapse of a 50m high tower remained, with the associated catastrophic consequences. That risk was currently mitigated by the extent of the safety exclusion zone and if we were just considering that risk analysis alone, we would not reduce the cordon
- The in-progress extensive shoring of the failed south wall was required to prevent a collapse of the wall that could lead to a much more extensive collapse in the tower
- In addition to that internal timber shoring, and as was discussed at our meeting on the 10th February, we remain of the opinion that there should also be a temporary external bracing system installed to enhance the temporary stability of the tower. It has been documented that as a result of the failure of the main south supporting wall loads have redistributed causing over stressing of the masonry, notably at the south east and west corners. From our site inspections there is clear evidence of that over stressing at these locations. The mechanism associated with the redistribution of load is described as arching action within the south wall above the level of the failed section. To achieve arching there needs to exist a complementary horizontal thrust. There is clear evidence of straining (cracking) on site that supports the arching theory. Installation of a temporary external bracing system, whether a girdle or otherwise, would resist the identified arch thrust and prevent the tower walls from spreading further to prevent possible collapse of these areas prior to the completion of permanent repair and strengthening works
- As was discussed at the meeting of the 10th Feb there required to be external bracing installed to prevent further spreading of these areas enhance the temporary stability of the tower. We would further note that this was discussed at a site meeting on the 11th Feb 22
- Without the installation of an agreed external bracing system in conjunction with the internal timber shoring, there would be insufficient mitigation to reduce the safety exclusion zone

- To have a complete picture of the defects in the tower, there is a need to have additional information on the current condition of the areas of concealed structure within the flats. These works are still ongoing, and information gathered from that exercise still require to be factored in.

The above matters were discussed at the Design Team meeting held on 01st March 22. The Council agreed to consider providing a more detailed response to confirm where appropriate what areas of the report are agreed, highlight areas where GCC disagrees with comments/conclusions or recommendations and confirms where further clarification is required. Itemised clauses that are referenced relate directly to the VCR document. Text from the VCR document is not repeated here, and the document should be referenced for context.

Report Comments

1.1 – 1.2 Executive Summary.

It is important to stress that we disagree with the content of the Executive Summary. The WRD report states that the structure is currently stable and has a very low risk of full collapse on to the surrounding areas. It goes on to say that whilst the tower has suffered significant damage during its life, the structural integrity has not been compromised to the extent of becoming unstable. WRD go on to advise that the tower 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.

For the avoidance of doubt, GCC disagrees with this opinion. It is our view that:

- The Trinity Tower has suffered significant structural damage.
- It is in a vulnerable condition.
- The structural integrity of the tower has been compromised; and
- The building is in a dangerous condition.

Until proposed permanent major repair and strengthening works are completed it is necessary to install adequate temporary bracing to ensure public safety.

2.1 Report Purpose

The stated purpose is noted and GCC's position on these matters is in the commentary which follows

2.2 Background

We note the background and would add that this is extensively covered elsewhere, particularly in WRD Reports dating 28th Nov 2019 and (letter of) 30th Jan 2022. These Reports set out in detail the many significant structure defects in the Trinity Tower structure and the major permanent works necessary to repair and strengthen the structure. The observations on the visible condition of the tower such as locations of defects and cracking are acknowledged and understood. WRD has prepared and specified works necessary to repair and strengthen the structure and the JCJ Group is contracted to execute the work.

The background to Building Standards & Public Safety involvement arises from the morning of the 29th Jan 2022 when the contractor carrying out work on Trinity Tower, JCJ, contacted Building Standards to report that the building was in a dangerous condition. They were evacuating the Trinity building and suggested there may be a wider public safety concern due to risk of collapse of the Tower. Building Standards responded and after inspecting the building that morning it was agreed that it was unsafe and could also significantly impact the surrounding area.

2.3 SUMMARY DESCRIPTION OF THE BUILDING

We have no comments on this section

3.1 to 3.4 RELEVANT DOCUMENTATION AND STANDARDS AND TERMINOLOGY

Your references are noted. We would add that cracks and their severity are dependent on the nature and location. Similarly, the guidance on timescales has to be taken in the context of a building which is 165 years old. Our commentary on the condition and stability of the building encompassing such considerations is given elsewhere.

4.0 Risk Assessment.

4.1 Methodology/Risk Matrix

We do not consider the basis for the risk assessment is consistent with the evidence in previous WRD Reports and the evidence apparent on site following various inspections.

We would assert that the failed south wall of the tower and other significant defects in the structure cannot be described as "isolated local structural fabric issues". It is our consideration that when viewed and taken in context of the Tower's defects, a significant event did indeed occur with the failure of the south wall. You will recall that the design team brought this to the attention of GCC, having uncovered it in the days leading up to the 29th Jan.

Our position is that the normally defined parameters in a risk analysis do not apply, by reason that it is not possible to adequately, accurately and safely define the likelihood or probability of uncontrolled and unpredictable collapse. Our comments are therefore based on the impact to public safety. On this basis, the consequence must be considered to be unacceptable. A risk analysis is qualitative and therefore subjective. The inclusion of vulnerability [taken to mean lack of robustness] as a separate assessment, cannot therefore be justified.

It is agreed that the Tower structure is 'vulnerable'. Per our feedback to-date, we believe that this can only be addressed in the short term through the installation of temporary bracing and in the long term by the proposed strengthening works. A lack of robustness is not a separate issue or a secondary issue, consideration of robustness is intrinsic to any structural assessment. If the tower were not considered to be in a vulnerable condition, then it could be argued there would be no need to undertake such a major repair and strengthening works. Clearly that isn't the case. When considering such matters in terms of timescales we recognise the building is around 165yrs old. The building is in a dangerous condition and the challenge is to mitigate that danger by introducing an effective temporary bracing and shoring construction to reduce the extent of the current safety exclusion zone prior to full repairs of the building.

4.2 Risk Sources [note; this is taken to mean hazard or danger]

a) Structural Integrity

GCC cannot agree that the failed south wall is just a local issue that does not affect the structural integrity. To categorise the failure of the south wall of the tower in that way appears to trivialise the nature of defect. As noted, Trinity Tower has suffered significant structural damage which is evident on site and is reported by WRD. The structure has clearly been significantly damaged by intolerable movement. There is a major construction contract in progress that is intended to repair and strengthen the Trinity Tower to re-instate its' structural integrity. The damage evident in the structure is causing the structure to be in a dangerous condition.

b) South wall at level 2

Calculations are presented as evidence that the risk of collapse is very low. The calculations are based on conjecture and assumptions, should not be taken to represent fact and therefore, in our opinion, they cannot be relied upon as being definitive.

The estimated load distribution presented is questionable as we have discussed. The wall construction and its' mechanical characteristics can only be estimated at best, particularly in relation to the random rubble wall and the core infill. Given the above, accurate modelling is not possible.

As noted in the WRD reports the Tower walls are not a homogenous construction, therefore calculating accurate load sharing characteristics of the different elements is, in our opinion, not possible [see also 4.2e reference to stone indents].

There are so many unknowns to be considered and that fact [covered in previous WRD Reports] means that any inference of accuracy or fact assigned to calculations is implausible. The evidence viewed on site [recorded in previous WRD Reports] indicates that the south wall of the tower between levels 1 and 3 has failed and the adjacent return walls, particularly the west wall, are overstressed, This, in our opinion, inconsistent with the calculation. Therefore, we believe that the conclusions reached via the calculations (That there is a very low risk) are flawed.

c) Weather conditions

It is concluded here that the Trinity Tower is not adversely affected by high wind events and that the risk of collapse due to high winds is very low. To justify the low-risk categorisations reference is made to the calculations that had *already proved* that the tower was not adversely affected by high winds.

The validity of the calculations has been discussed above and the same reasoning would apply here.

Tilt monitors are installed in the Tower to measure and record movement and that would be useful to check trends and magnitude of movement. It is noted, however, that there does seems to be a real concern that the Tower may be susceptible to damage in a high wind event given that it is recorded that the monitor is fitted with an alarm system and that alarm was triggered on 29th January 2022 during high winds. It is also noted that it was necessary to ascertain if it was safe to enter the Tower and check if any fresh damage had been caused after the storm on w/e 29th January 2022. Additionally, our understanding is that the contractor checks such matters as part of their daily safe working practice.

Given the observed defects and the uncertainty regarding the structural response to high winds we consider the conclusion that the risk is very low must be questioned.

d) Significant events.

Wind event – refer back to 4.2e above

South wall collapse – refer back to 4.2a

The Tower is damaged to an extent that makes it vulnerable to a 'significant event' – we are agreed, it is in a dangerous condition.

It is important to consider necessary proactive measures to cater for uncontrolled events – again we are agreed. For the reasons we have outlined why it is necessary to install adequate temporary bracing to ensure public safety until the proposed permanent repair and strengthening works are completed.

Movement- we would consider this to be a consequence of an event rather than being an event.

e) General structural fabric condition.

The structural defects in the Tower are visible and evident on site and are catalogued at length in previous Reports by WRD. The fabric of the structure is in a very poor condition particularly below Tower level 6 becoming progressively worse down Tower level 1 [the habitable spaces below are currently being inspected].

There are numerous cracks and many significant fractures in the masonry traversing over several levels in the tower and passing through the thickness of the walls. All four walls of the tower are affected. There is widespread degradation of the stonework. Significant damage in the random rubble walls construction in the inside face of the Tower is also very evident. In addition, damage is also evident in the outer ashlar walls as highlighted elsewhere. Previous inappropriately specified and poorly executed repairs have been ineffective and have possibly had an adverse effect [as noted by WRD], for example, the repairs to the ashlar stonework will not have contributed to the structural strength of the walls [this is relevant also to 4.2b].

The obvious significant structural defects in and general degradation of the structure fabric clearly affects the robustness of the structure and its' ability to continue to be considered as being 'safe'. It is also stated that *"...the Tower structure has a high degree of redundancy.."* but that has not been proved. We would also have to draw attention to the fact this is contradicted in the letter/report of the 30th Jan 22 where it was stated that *"Critically, as with all tower structures of this nature, small areas of weakness present a high degree of risk due to the scarcity of natural redundancy in the structural mass, which exists in abundance in normal masonry building structures of this age. This critical characteristic has been continually missed in earlier engineering assessments".* GCC agree with this statement. This contradiction has not been explained.

Redundancy and robustness can be designed into a structure. This concept was not prevalent when Trinity Tower was built, and the Tower features are dominated by Architectural style and function. The Tower has necessary penetrations in the lower east and west walls causing the load to transfer from above onto these walls. Other penetrations such as the arched fenestration on the west elevation also cause transfer of load, particularly to the north and south west corners. At lower levels the tower is effectively supported only by the two walls [with short returns] to the north and south. In our opinion this means that the relative load share increases in these walls by some considerable margin [around 60%]. This reduction in number and dimension of the supporting walls [structure] clearly reduces the structure's redundancy, in simplistic terms from four walls to two walls. Given that the south tower wall is in a state of collapse causing load redistribution to occur the latter is more significant when considering robustness and redundancy.

In terms of the mass wall construction, it is clear to GCC that there is evidence of overstressing. There are significant structural fractures in all 4 sides of the tower, which are particularly evident below level 5. These are of particular concern in the south tower wall that is in a state of collapse, and the adjacent the west wall. The significant structural fractures in the structure are evident both internally and externally. Although there is great mass in the walls the inner random rubble walling is weak, and the rubble core infill is very weak and possibly not contributing as an effective load bearing medium. As has been noted, previous attempted repairs to the ashlar have not been successful and that has weakened the construction. By nature masonry is a brittle material and has a low tolerance to differential movement and straining. Failure in masonry can occur suddenly and unexpectedly. Given the many significant structural defects evident, the uncertainties regarding the

wall construction, the obvious load redistribution and the obvious overstressing it is therefore difficult to understand and agree with the assertion made that tower structure has a "*high degree of redundancy".*

It is also difficult to understand and agree with the assertion made that *"there is sufficient redundancy within the buildings structure to conclude that such local issues (*meaning the poor condition of the structural fabric, the significant structural fractures and the collapsing south wall*) currently will not onerously impact the overall stability of the building".* Notwithstanding the commentary above, the contradiction highlighted is undermines the reliability of the conclusion that the risk is very low.

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

Whilst it is appropriate for historic records to be reviewed, these need to be viewed in the context of current circumstances and our expressed concerns with the existing condition of the structure. With this in mind, we do not consider they should solely be relied upon.

At the time of writing concealed areas below the Tower are being opened up for inspection, this work is on-going. Logically, until that investigation is complete it is not possible to draw full conclusions but without prejudice to the concerns we have currently expressed on the stability. The presumed 'risk' categorisation does not seem to be justified.

g) Cumulative risk.

For the reason given, the 'Risk Assessment' and 'risk categorisation' does not seem to be justified. In addition, as we indicated in our email communication, even if we agreed with the risk categorisation, we must consider the catastrophic consequences arising from a collapse event. The catastrophic consequences in relation to Tower of this height are currently mitigated by the safety exclusion zone. We therefore conclude that the building is in a dangerous condition.

Proposed permanent major repair and strengthening works are required. Until such works are completed it is necessary to install adequate temporary bracing to ensure public safety. This would permit the safety exclusion zone to be reduced or removed to allow surrounding residents to be returned to their homes and businesses to be re-occupied.

4.3 Risk Mitigations

This is taken to mean measures to reduce the identified danger.

a) Current situation.

Currently the building is in a dangerous condition. To ensure public safety an exclusion zone has been established restricting access to the building and the immediate surrounding area.

In order to mitigate the danger and remove or reduce the safe exclusion zone the contractor JCJ is currently installing extensive temporary internal timber shoring intended to prevent uncontrolled collapse of the south wall of the Tower. To augment the internal bracing and as part of the temporary bracing scheme needed to address the identified significant structural defects, GCC has requested that an external bracing system is installed. The combined internal and external temporary bracing would allow the danger of collapse to be reduced sufficiently to allow the safety exclusion zone to be reduced or removed as we have outlined in response to 4.2g.

b). Stent installation.

The 'Stent', as proposed, is a braced steel framework that is to be fitted within and connected to the inside of the Tower from above Tower level 3 up to below Tower level 5. Installation of the Stent is part of a major permanent repair and strengthening works contract intended to improve robustness and re-instate the structural integrity of the Tower. The purpose and need for the repair and strengthening works is agreed, however, it is notable that in the approved building warrant design, the Stent does not extend down to the most significantly damaged sections of the Tower below level 3.

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

We would refer to comment at 4.2f. At the time of writing the lower sections of the tower are being opened up and inspected. It has been necessary to fully open up the internal finishes to expose the structure for inspection due to the limitations of the borescope survey. Clearly such inspection is an essential action to verify the condition of the structure, particularly in light of the apparent and significant defects that have led to the current repair scheme.

d). GCC suggested girdle structure.

The proposed temporary external bracing is intended to work in conjunction with the temporary internal timber shoring to reduce the danger of collapse of part or all of the structure. The temporary bracing system is intended to remain in place only until the permanent repair and strengthening works can be completed. The temporary bracing system is intended to support and provide restraint to the damaged structure. Installation of the temporary bracing will reduce the identified danger and allow the safe exclusion zone to be reduced or removed. The temporary bracing system is not intended to supplant the proposed permanent Stent.

Existing steel channels are mentioned to "do the same job" [presumably as part of the Stent] but elsewhere it is reported by WRD that "it is likely that they [existing channels] have not been able to fulfil their purpose". Notably, as part of the Stent installation strengthening works, it is required to retrofit a significant number of anchors into the Tower walls through the existing channels intended to tie the channels and walls together and bond the separate inner, core and outer wall elements.

Temporary external bracing will add robustness to the damaged structure and will provide a tie across the fractured walls of the Tower to resist any movement until the permanent works have been completed. The bracing will be installed at a section of the Tower where all 4 walls are significantly damaged, particularly the south and west walls.

There is no expectation that the temporary bracing will remain in place after the permanent phase 1 structural works have been completed so there should be no impediment to carrying out phase 2 external stonework repairs.

By its' nature and intent, the bracing is will be temporary and will not compromise in any way the buildings' category A listing. It is not therefore clear why this has been mentioned as a possible issue.

e). Renewal of the South wall.

As we have noted previously, the south wall of the tower is in a state of collapse and has been the subject of extensive shoring and bracing. We agree with the need to re-instate the wall as it is

essential that it is reconstructed to a satisfactory standard to re-instate the structural integrity of the building. We cannot therefore agree this is a local failure as has been mentioned in section 4.2a

5.0 Summary conclusions

5.1 Events during the week of 24-29 January.

GCC Building Standards received dangerous building report from JCJ contractors on 29th January 2022. They were evacuating the Trinity building and suggested there may be a wider public safety concern. Following an inspection of the west tower of the building it was observed that there are many significant structural defects, and the lower south wall of the Tower is in a state of collapse. Consequently, the building was declared to be in a dangerous condition. This conclusion was not challenged at that time and in GCC's opinion it was reinforced by the WRD Reports attached to an e-mail dated 02nd February 2022 from where the following is taken:

- *The compound risk of all of the structural issues is high,*
- *The structure has become highly vulnerable,*
- *The exponential nature of the structures deterioration and associated vulnerability has jumped closer to the point of uneconomic and inviable salvageability,*
- *The structures' reaction to the current situation is highly unpredictable,*
- *The impact of a partial collapse of both wall faces is highly unpredictable, ranging from significant debris fall through the building to progressive collapse of the entire structure.*
- *Due to significant recent movement in the structure, the risk of partial collapse is now too high to allow the building to be occupied,*
- *The risk of collapse is now medium; therefore, the tower collapse debris zone should be assessed to evaluate the risk to surrounding properties,*
- *Each wall face should be shored immediately,*

It was clear at that time that temporary bracing works would be required to reduce the danger and the building's owner's representative undertook to instruct JCJ contractors to develop and execute a temporary bracing system.

At the site meeting on 04th February 22 and the meeting of the 10th February 22 at G&S offices, the situation had not changed from the 29th January. On receiving an explanation at the meeting of the 10th Feb of the programme of works and the current bracing and shoring that was being installed, GCC asked clarification from those present if that meant their conclusion was that the exclusion zone could be reduced after that element of work was completed – as opposed to after installation of external bracing which was not being agreed to. This was confirmed. There was no indication from anyone present that the building was not in a dangerous condition.

For the reasons already outlined earlier we are therefore of a different opinion as to the condition of the building.

5.2 Assessment of GCC suggested girdle structure.

We must note again that GCC's position is that we remain of the opinion that there should also be a temporary external bracing system installed to enhance the temporary stability of the tower. The format of this can be a girdle or other suitable proposal. The temporary external bracing around the tower at the section where the most significant structural defects are evident is necessary to augment the temporary internal timber shoring to allow the safe exclusion zone to be reduced. The

extensive timber shoring being installed is necessary to avoid the consequences of possible collapse of that wall, and as we have highlighted earlier, we do not consider the failure of the south wall to be a local issue.

The installation of the Stent is promoted as a better solution, but the Stent structure is curtailed above Tower level 3 and as discussed at the meeting of 10th February, the installation of the Stent will take a considerable period of time to complete.

The possibility of re-designing the Stent so to expedite its installation and extend it below Tower level 3 was discussed at the meeting on 01st March 2022 and GCC have agreed to consider any proposals put forward for that.

5.3 Projected Risk Status and Vulnerability Status.

As we have outlined, GCC consider the building to be in a dangerous condition and temporary external bracing is required to augment and work in conjunction with the temporary internal timber shoring to reduce the danger of collapse of part or all of the structure. Comments on the proposed permanent Stent are recorded in 5.2 above.

5.4 General historic risk status.

Refer to the commentary in 5.1 above. In terms of time history and risk or vulnerability or danger defined in terms of time periods it should be remembered that the building is c165yrs old and any time periods such as short term or medium term we do not consider as relevant. Currently the building is in a dangerous condition. The need for action is also highlighted elsewhere in WRD Reports and repeated below;

- ".over the past 48 hours we have had to re-focus as matters have become significantly more serious than were anticipated…"
- "..the tower structure has been allowed to deteriorate at an ever increasing rate. Every year that passed, increased the problems exponentially."
- "…it was already heading for the steepest section of this exponential curve."

The Tower is in a dangerous condition and the conclusions in relation to there not being a need for the safety exclusion zone do not seem to be justified

Conclusion

In conclusion, the information and commentary in this report supports Glasgow City Council's assertion that the building remains in a dangerous condition.