

Addressing the Challenges of Assessing Low-rise Buildings

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ABSTRACT

The seismic assessment of low-rise buildings is an important area of seismic assessment in New Zealand given the prevalence of these types of structures, especially outside the main centres. The Joint Committee for the Seismic Assessment of Existing Buildings (Joint Committee) convened by Ministry of Business Innovation and Employment (MBIE) with members from the technical societies and Toka Tū Ake EQC (EQC) has identified that in many instances seismic assessments of low-rise buildings typically constructed with steel portal frames, reinforced masonry, tilt-slab walls or timber framing with lightweight flexible diaphragms are resulting in unrealistically low ratings (<34%NBS). This is often due to a lack of readily identifiable and reliable load paths making assessment using the current guidelines more difficult. However, anecdotal evidence from past earthquakes suggests these types of structures will generally perform well despite their apparent lack of a defined load path. To address this issue MBIE has commissioned Stage 1 and 2 of a project to investigate the issue in more detail and recommend next steps for providing engineers with updated guidelines/procedures to allow more appropriate ratings to be assessed for this building typology. This paper will summarise the findings of stage 1 and what the recommendations are for future stages.

1 INTRODUCTION

In 2022, MBIE along with Toka Tu Ake EQC and the technical societies formed a committee to provide guidance on the maintenance and updating of the New Zealand seismic assessment guidelines. The committee is made up of members from MBIE, EQC, the New Zealand Society for Earthquake Engineering (NZSEE), the Structural Engineering Society (SESOC) and the New Zealand Geotechnical Society (NZGS).

During 2022, the Joint Committee undertook a high-level review to capture lessons from the use of the Guidelines since their release in July 2017 to inform the management and maintenance of the Guidelines. The review involved one online workshop with 19 territorial authority representatives and three half-day

workshops in Wellington, Auckland and Christchurch that were attended by 40 engineers. One of the findings of the review was concerns around many low-rise buildings being given ratings that don't reflect their general overall resilience. The associated recommendation was to establish a technical workstream to reflect on the ratings that are being recorded for low rise buildings (other than unreinforced masonry), and consider whether adjustments should be made to certain provisions within the Guidelines (Kestrel Report, 2023).

The buildings highlighted by the report for consideration are typically constructed with steel portal frames, reinforced masonry, tilt-slab walls or timber framing with lightweight flexible diaphragms, and typically do not fall into any of the profile categories within the Earthquake Prone Buildings Methodology. If they are being identified as earthquake prone it is typically via the "Identify at any time" route.

Assessments on these types of buildings are resulting in unrealistically low ratings (<34%NBS), often due to a lack of readily identifiable and reliable load paths making assessment using the current guidelines more difficult. However, anecdotal evidence from past earthquakes suggests these types of structures will generally perform well despite their apparent lack of a defined load path. Research undertaken for Ministry of Education over the past decade has clearly demonstrated the good performance of one and two storey timber-framed classroom blocks despite the presence of windows interrupting the load path in timber framed walls (Carradine et al 2016; Brunson et al 2023).

Following the completion of the above referenced report, the Joint Committee endorsed the findings of the report and recommended a workstream be established to investigate the issue further. In the early part of 2023, a proposal was prepared to seek funding from MBIE for an initial stage of work to investigate the issue via a workshop with practising engineers and other industry participants.

In mid-2023 the proposal was funded and the workshop was held in November 2023. The focus of this paper is reporting on the outcomes of this workshop and potential next steps for the project, noting that funding beyond the current stages is yet to be confirmed.

2 WORKSHOP FOCUS

On 21st November 2023 a workshop was held to explore the issues identified by the Kestrel Report and the Joint Committee in relation to low-rise buildings. Workshop attendees were made up from a cross section of practising engineers and industry representatives from MBIE, EQC and Engineering New Zealand.

The focus of the workshop was existing buildings and not compliance of new buildings. It was not the intention of the workshop for any outcomes of the workshop to excuse poor design of new structures. A critical part of the design of new structures is getting the load path right.

The workshop was split into two parts. Part 1 of the workshop focussed on various building typologies and comment was sought from attendees on their views in relation to each of the typologies presented. All typologies generally focussed on one to two storey construction with various different structural systems and materials. The typologies started with the most lightweight construction types progressing to structures with elements of heavier type construction on to structures consisting of predominantly heavy construction.

Typology 1 considered buildings consisting of all lightweight construction consisting of either timber framing or light gauge metal framing. Refer figure 1 for a typical example of this typology.



Figure 1: Example of typology 1 building

Typology 2 considered buildings consisting of generally lightweight construction but with an element of heavier construction such as a reinforced concrete blockwall down one side. Refer figure 2 for an example of this building typology.



Figure 2: Example of typology 2 building

Typology 3 considered buildings of heavier wall construction with lightweight roofs such as warehouse buildings or reinforced block “toilet block” type buildings with a timber truss roof and limited or no roof diaphragm. Refer figures 3 and 4 for examples of this building typology.



Figure 3: Example of typology 3 building



Figure 4: Second example of typology 3 building

The focus of the workshop was only the typologies mentioned above. Therefore, buildings containing any unreinforced masonry or of predominantly multi-storey heavy construction were not considered during the workshop and are not considered to be within the scope of this project.

Commentary was sought from the group on each example building presented, with the attending engineers being asked to primarily comment on whether the presented example should be considered $<34\%NBS$ or not and what level of assessment they considered necessary to determine that a building was $>34\%NBS$. Generally, the typology 1 and 2 examples were viewed as not warranting an overall rating of less than $34\%NBS$ by the workshop organisers.

Part 2 of the workshop focussed on what improvements to the current seismic assessment guidelines could be made to assist engineers with assessing buildings of the typologies discussed in part 1.

3 WORKSHOP OUTCOMES

The workshop generated broad discussion across the agenda items. The general themes that arose during the discussion are outlined below.

3.1 Part 1 Outcomes

For typology 1 there was broad agreement among participants that the building examples presented could generally be considered to be $>34\%NBS$ without any form of assessment due to their construction type - ie a deemed to comply approach could apply to these buildings. It was agreed that a set of criteria (eg building size, flat ground) that had to be met would be required for such as approach to be appropriate.

For both typology 2 and 3 there was general agreement that a deemed to comply approach was not appropriate for these types of construction given the presence of heavier weight elements of construction. However, it was recognised by many that the guidelines currently provide limited guidance on structures with hybrid construction types such as precast panel warehouses with lightweight roof diaphragms and that some guidance on assessment of these types of buildings considering the system as a whole would enable engineers to arrive at more holistic ratings.

It was also recognised by the group that for buildings in the typology 2 category that a limited (targeted) detailed seismic assessment may be appropriate which focuses on the heavy element and beyond this reliance on an ISA may be appropriate to reach the conclusion that a building is $>34\%NBS$.

During the Part 1 discussion several other issues were identified:

- The guidelines provide little to no guidance on what would normally be considered secondary load paths such as corrugated metal roofing and cladding. In many low-rise buildings these secondary load paths will be sufficient to get a score of at least 34%NBS.
- The guidelines do not have any guidance for reinforced concrete block leading to issues such as inconsistent application of probable strengths when using the design standards for reinforced concrete block.
- Potentially incorrect application of parts loadings to single storey buildings for out-of-plane loading of walls

It was also noted by attendees that the types of structures being considered are common in New Zealand and a lot of engineers are involved with assessments on these types of buildings indicating the importance of the discussion.

3.2 Part 2 Outcomes

Part 2 of the workshop covered several areas for potential improvement of the guidelines. The key areas that fall within the scope of this project are noted below:

- There was general agreement that a low-rise building specific guideline would be useful and could address such things as:
 - Use of judgement when using secondary load paths. This was seen as a key area needing further guidance.
 - System assessment of low-rise structures
 - Clarification of how parts should be applied for out-of-plane loading on single storey walls, if at all.
 - Assessment approach for generally lightweight buildings with a single heavy element.
 - Assessment approach for typology 1 buildings that could be deemed to meet 34%NBS provided certain criteria are met.
 - Potential for further guidance in relation to low-occupancy structures and how this could be accounted for in the overall process (but not necessarily within the seismic rating).
 - Guidance on the appropriate application of parts to single storey out-of-plane walls.
- Given the prevalence of precast panel warehouse construction, consideration be given to undertaking a test on an existing building similar to the Ministry of Education testing of school classroom blocks.
- Research into the capacity of elements such as cladding which would normally be considered a secondary load path but may provide significant capacity in lightweight buildings.
- Research into the performance of low-rise structures generally in past earthquakes.

4 NEXT STEPS

Stage 2 of the project is currently underway with the preparation of a pathway document outlining the proposed scope of the project and steps required to produce some updated guidelines and get these released first as a draft for comment and then formally issued as part of the seismic assessment guidelines.

While the pathway document is still under development at the time of writing this paper it is expected to recommend a new chapter to the guideline specific to low-rise buildings that pulls together guidance for engineers on how structures of this type can be assessed and where judgement can be applied.

It is also expected to recommend further research into the capacity of light-weight materials, for example, corrugated sheet metal, which in many instances provides the only means of lateral load resistance.

The writing of a new guideline chapter for the assessment of reinforced concrete block is not expected to form part of the scope of this project. However, this issue will be raised for discussion with the Joint Committee for consideration as a separate project.

5 CONCLUSIONS

Feedback from practitioners and territorial authority representatives from the high-level review in 2022 of how the Guidelines have been applied highlighted general concerns about the low ratings being seen for low-rise (non-unreinforced masonry) buildings. These low ratings are clearly not reflecting the inherent capacity of these types of structure given the lack of evidence of failures in past earthquakes, and in many cases leading to unnecessary investment in strengthening. The resulting recommendation to develop a workstream to investigate this further was supported by the 2022 planning meeting of the Joint Committee.

To further investigate this issue MBIE funded stages 1 and 2 of a project to look further into the issue and produce a pathway to address any issues identified during this process.

Stage 1 consisted of a workshop in November 2023 with practising engineers and industry representation, and preparation of a pathway document for stage 2 is underway at time of writing.

The workshop reinforced the observations from the 2022 review, and there was general agreement among participants that for some building typologies the guidelines could be improved, and ratings are very unlikely to be under 34%NBS except in some special circumstances. The outcomes of the workshop provide excellent information for preparation of the pathway document with the aim being to secure funding for future stages.

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