REVISED VERSION OF C5

INFORMATION FOR ENGINEERS

March 2019

FREQUENTLY ASKED QUESTIONS

What is the revised (Yellow) version of C5?

The revised (yellow) version of C5 released in November 2018 represents the latest information available to engineers on precast concrete flooring and other aspects of existing concrete buildings. It gives a better assessment of the expected seismic behaviour of a building than the July 2017 Version 1 of the Engineering Assessment Guidelines (also known as the Red book).

The revised version reflects both what engineers learned from the Statistics House investigation following the Kaikōura earthquake and an update of other technical provisions relating to existing concrete buildings. It's now clear that precast flooring can perform poorly during an earthquake. And when precast floors are damaged in an earthquake, this can be difficult to identify and repair.

The revised version replaces the method by Fenwick, Bull and Gardiner (2010) that's referenced in the existing (Red book) version by extending the types of floors that can be assessed and removing some of this method's conservatism.

When should you use the revised version of C5?

Engineers should use the revised version when carrying out assessments, **with one exception**. The only time you should use the existing Red book version is when you are establishing whether or not a building is earthquake-prone under the Building Act 2004. That's because the July 2017 version is the only one formally recognised under this legislation. In this situation, the owner of the building will have a letter from the territorial authority advising that the building is potentially earthquake prone and will need an engineering assessment.

What are the changes in the revised version?

- The revised version has different and enhanced material on precast concrete floor systems.
- There is new information on the material properties of older concrete and reinforcing steel, and on assessing older bar splices and newer bar couplers.
- An improved column shear strength model has been added, along with guidance on more modern beam-column joints.

Will the revised version produce different results from the existing version?

Potentially. It depends on the individual building. Because the revised version takes into account our latest understanding of how concrete buildings with and without precast floors can perform in a major earthquake, a building could be rated lower. However, ratings could be higher for some buildings.

Which structures are most affected by the changes?

- Many previous assessments of buildings with precast floors rated only their primary lateral load resisting systems and didn't specifically rate the floor systems. The overall ratings for buildings previously assessed in this way can be expected to decrease, in some cases significantly.
- If the existing (Red book) version had been used to rate a building's precast concrete floor system, then that building's rating will generally be higher using the revised version. However, floor systems with very short seating widths (typically constructed prior to 1996) will have a lower rating.
- Post-1976 buildings with cold drawn mesh in the toppings of their precast concrete floor systems and in their wall panels are likely to have lower ratings using the revised version. Many of these buildings would only have moderate ratings due to other considerations associated with their precast flooring system.
- Pre-1976 concrete frame structures may have lower ratings using the revised version because of a better estimate of column shear capacity, based on latest research. Many of these buildings will already have a moderate rating due to the lack of ductile detailing generally.
- Concrete buildings of all eras may increase their rating if their primary structural system can be expected to respond in a reasonably ductile (or non-brittle) way. Buildings with these characteristics are likely to have ratings well above the 34%NBS threshold, subject to careful evaluation of any precast floor systems.

How can precast floors be strengthened?

Precast floors are generally less robust than other forms of reinforced concrete construction because they have lower damage thresholds and less reliable behaviour once initial damage occurs, especially in large earthquakes.

Providing supplementary support with steel support brackets is strongly recommended. This gives confidence that the floor units won't fall in strong earthquakes.

What does the revised version mean for precast concrete floors that have been previously retrofitted?

For the past few years, engineers have been aware that supplemental support angles should not be placed hard up beneath hollowcore units. An angle directly beneath can potentially cause a negative moment failure within the unit, typically when the unit has short starter bars.

The revised version provides a method of determining if buildings will be susceptible to this failure mode.

Should precast floors that have been retrofitted be re-assessed using the revised version?

The revised version identifies multiple possible failure modes for precast floors. Each failure mode needs to be checked during an assessment.

Previous assessments and retrofits did not always check all failure modes. For example, if only loss of seating was evaluated, the floor system will need to be assessed for other types of failure.

The seating should be rechecked using the revised version because the assessment method has been modified to reflect latest test results and observations from the Kaikoura Earthquake.

Can the revised version be used to design retrofit schemes?

The revised version helps you determine a rating rather than directly addressing retrofit design. However, doing the assessment will help you identify likely failure modes for the floors. You can then develop a retrofit plan that protects against these failure modes.

Further research on retrofits for precast floors is currently underway at the Universities of Auckland and Canterbury, in conjunction with BRANZ and in close collaboration with industry.

What ethical obligations do engineers need to be mindful of in relation to seismic assessments?

Under the Code of Ethical Conduct, engineers have an obligation to report significant adverse consequences for people's health and safety. You need to consider how this applies to any given situation and discuss this with your client. You could also seek advice from Engineering New Zealand.

SCENARIOS

This table illustrates actions an engineer could take in different hypothetical situations.

	Situation	Regulatory considerations	What should the engineer do?
1	An engineer undertakes a new assessment for commercial purposes using the revised version. The building sits outside the three profile categories defined in the EPB methodology1 The assessment results in a rating below 34%NBS.	• The TA may or may not take action if they become aware of this assessment result. A TA is able to identify a building as potentially EQ prone at "any time".2	• Encourage the owner to strengthen the building, particularly if the precast floor system is the lowest-scoring element of the building. • Bearing in mind your obligations to the public as well as your client, consider whether you should be recommending in writing that the owner share the assessment result with tenants and possibly the TA.

[1] Profile Categories:

A. URM buildings
B. Pre-1976 buildings of 3 or more storeys
C. One and two storey buildings pre-1935

[2] Reasons that may cause a territorial authority to suspect a building may be earthquake prone include:

- If a territorial authority receives an assessment or other material or
- If a territorial authority becomes aware of issues

2	An engineer undertakes a new assessment for earthquake-prone building purposes using the existing Red book version. The building's rating is below the 34%NBS threshold. But the engineer can see that its rating would be higher than 34%NBS if assessed using the revised version.	• The Red book remains the way to determine whether a building is above or below the 34%NBS threshold. However, we expect that the revised version will be incorporated into the Engineering Assessment Guidelines at some point in the future.	• Recommend to the owner that the assessment be undertaken using both the Red book and the revised version, to better understand these implications. • When submitting the assessment, discuss these implications with the TA.
3	The owner of a building within Profile Category B or C requests a seismic assessment. This assessment is not in response to a letter from a TA.	• The building owner is likely to be approached by the TA once they identify potentially earthquake prone buildings in their city or district using the Profile Categories.	• The engineer should discuss the implications with the owner. In general, the engineer should undertake the assessment using the Red book but also consider what impact the revised version would have.
4	An engineer has reason to work on a building that they have previously undertaken a Detailed Seismic Assessment on. That building was assigned an earthquake rating higher than 67%NBS. But the engineer expects that an assessment using the revised version would reduce the rating to lower than 67%NBS.		• Contact the client and advise that assessment methods have been updated and why this is relevant to their building. Offer to update the assessment and indicate the costs involved. This communication should be in writing.
5	An engineer has reason to work on a building that they have previously undertaken a Detailed Seismic Assessment of that resulted in a rating higher than 34%NBS. The engineer expects that using the revised version would reduce the rating to less than 34%NBS.	• In the future, if the revised version is incorporated into the Engineering Assessment Guidelines, the building may be identified as potentially earthquake prone.	• Take the same actions as for scenario 4. • Also advise that the building could be identified as a potential EPB in the future.
6	An engineer has prepared a draft seismic assessment using the existing Red book version. The assessment is for commercial purposes. The engineer now needs to revise and complete the		• Advise the owner, being clear about any additional costs. • Remind the owner that any draft assessment is

	assessment using the revised version, which may require re-analysis and result in a different rating.		incomplete and should not be used.
7	An engineer has previously undertaken a Detailed Seismic Assessment of a building that led to the TA determining it was earthquake-prone. But the engineer expects an assessment using the revised version will give a rating higher than 34%NBS.	The owner and engineer should discuss the situation with the TA to understand the implications.	Advise the owner of this possibility, encouraging them to continue with their plan to strengthen the building, particularly if the building would still have a rating upon re-assessment lower than 67%NBS.