New Zealand Society For Earthquake Engineering

Assessment and Improvement of the Structural Performance of Buildings in Earthquakes

Corrigenda 3
(Section 3, Initial Seismic Assessment)

9th September 2014

Recommendations of a NZSEE Project Technical Group
In collaboration with SESOC and NZGS
Supported by MBIE and EQC

This document is the current version of Section 3 of the NZSEE Guidelines, published in 2006, and as amended by corrigenda 1, 2 and 3. The amendments associated with the corrigenda are noted in the margin adjacent to the change.

A full version of the guidelines, including this section, is also available for download.

Any comments on the section will be gratefully received.

Please forward any comments to NZSEE Executive Officer, Win Clark, at exec@nzsee.org.nz

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Definitions

For ease of reference, definitions are given in the relevant Section or Chapter

Notation

For ease of reference, notation is given in the relevant Section or Chapter

Abbreviations

b	span of diaphragm perpendicular to direction of loading.
CBD	Central Business District
CSW	Critical structural weakness. The Structural Weakness that is confirmed by DSA as limiting the *%NBS* score for the building to less than 67*%NBS*.
D	Depth of diaphragm parallel to direction of loading.
EPB	Earthquake prone building – refers to definition in the Building Act 2004 i.e. < 34*%NBS*
ERB	Earthquake risk building – a building assessed as having greater than moderate risk i.e. < 67*%NBS*.
I	Importance Factor defined by NZS4203 used for the design of the building
IEP	Initial Evaluation Procedure.
IL	Importance Level defined by AS/NZS1170.0
ISA	Initial Seismic Assessment
k_{μ}	Structural Ductility Scaling Factor defined in NZS1170.5.
M	Material Factor defined by NZS4203
N(T,D)	Near Fault Factor defined by NZS1170.5
NBS	New Building Standard – i.e. the standard that would apply to a new building at the site. This includes loading to the full requirements of the Standard.
NZS	New Zealand Standard.
NZSEE	New Zealand Society for Earthquake Engineering.
PAR	Performance Achievement Ratio
PIM	Project Information Memorandum – refer Building Act Section 31
pCSW	Potential Critical Structural Weakness. A Structural Weakness identified by an ISA and having the potential to be the CSW.
R	Return Period Factor defined by NZS1170.5 based on the importance level appropriate for the building in accordance with NZS1170.0
R_0	Risk Factor used for the design of the building.
SLS	Serviceability limit state as defined in NZS 1170.5:2004 (or NZS 4203:1992), being the point at which the structure can no longer be used as originally intended without repair.

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S	Structural Type Factor defined in NZS4203
S_p	Structural Performance Factor defined in NZS1170.5.
SW	Structural Weakness. An identifiable characteristic of a building and/or part of a building that would or could adversely affect structural performance in earthquakes such that there would be a noticeable increase in risk to life and/or risk to neighbouring property and/or ability to egress the building.
T(L)A	Territorial (Local) Authority. Use of TA in this document is intended to describe a Council administering the requirements of the Building Act. A Council's role as a building owner is intended to be no different from any other building owner.
ULS	Ultimate Limit State. This is generally as defined in NZS 1170.5:2004 and AS/NZS 1170.0.
URM	Unreinforced masonry.
%NBS	Percentage of New Building Standard achieved
$(\%NBS)_b$	Baseline Percentage of New Building Standard
$(\%NBS)_{nom}$	Nominal Percentage of New Building Standard
μ	Structural Ductility Factor defined by NZS1170.5
Z	Seismic Hazard Factor defined by NZS1170.5
Z_{1992}	Zone Factor from NZS 4203:1992 (for 1992-2004 buildings only).
Z_{2004}	Seismic Hazard Factor from NZS1170.5:2004 (for post August 2011 buildings only).

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Section 3 - Initial Seismic Assessment

3.1 Introduction

The NZSEE recommends a two-stage assessment process. An outline of the overall recommended process is given in Figure 2.1 and discussed in Section 2 (which is yet to be updated). in more detail. The initial seismic assessment (ISA) is intended to be a coarse evaluation involving as few resources as reasonably possible and is the recommended first step in the overall assessment process. It is expected that the ISA will be followed by a detailed seismic assessment (DSA) for those buildings identified in the ISA as likely to be an Earthquake Prone Building (EPB) in terms of the provisions of the New Zealand Building Act 2004 or where important decisions are intended that are reliant on the seismic status of the building. Such decisions might include those relating to pre-purchase due diligence, arranging insurance, confirming the earthquake prone status and prior to the design of seismic retrofit works.

The process that is adopted for the ISA will, to a large extent, depend on the particular objectives of the assessment and the number of buildings that are involved. The ISA process for a portfolio of buildings or for the identification of earthquake prone buildings by a Territorial Authority (TA) may have a different focus from that for a single building. The principal elements of the ISA process are shown in Figure 3.1.

When assigning earthquake prone status is the primary objective it is possible to conduct some screening of buildings where the outcome is reasonably certain without necessarily requiring a formal assessment. 3

When multiple buildings are involved, prioritisation may be necessary as it may be impractical to assess all buildings simultaneously and immediately. Accordingly there will be a need to focus resources on buildings which have the potential for greatest gains. Prioritisation will not be an issue if only a small number of buildings are being considered.

The main tool being promoted in these guidelines for the initial assessment of buildings is the Initial Evaluation Procedure, referred to as the IEP. The IEP is described below and in Appendix 3A, and is essentially the same as the well-known IEP introduced in the 2006 guidelines. It is recognised that for particular types of building the IEP can be meaningfully enhanced by considering other attributes that are specifically targeted to the type of building. Appendix 3B contains specific provisions for unreinforced masonry buildings which are intended to be used in conjunction with the IEP. However, the attribute method may require a greater level of knowledge of a building than is typically expected or intended for an IEP.

A fundamental aspect of the IEP is the identification, and qualitative assessment of the effects of any aspects of the structure and/or its parts that would be expected to reduce the performance of the building in earthquakes and thereby increase the life safety risks to occupants and/or have an adverse effect on neighbouring buildings. These deficiencies in the building are referred to as potential critical structural weaknesses (CSWs).

While other procedures can be substituted for the IEP in the ISA, it is important for consistency that the essence of the IEP is maintained and that the result is reflective of the building as a whole.

Calculations to support judgement decisions on particular aspects of the ISA are encouraged. This would be expected to lead to a more reliable (but still *potential*) score for the ISA without the full cost of a DSA. However, care should be taken to avoid over-assessment in one area at the expense

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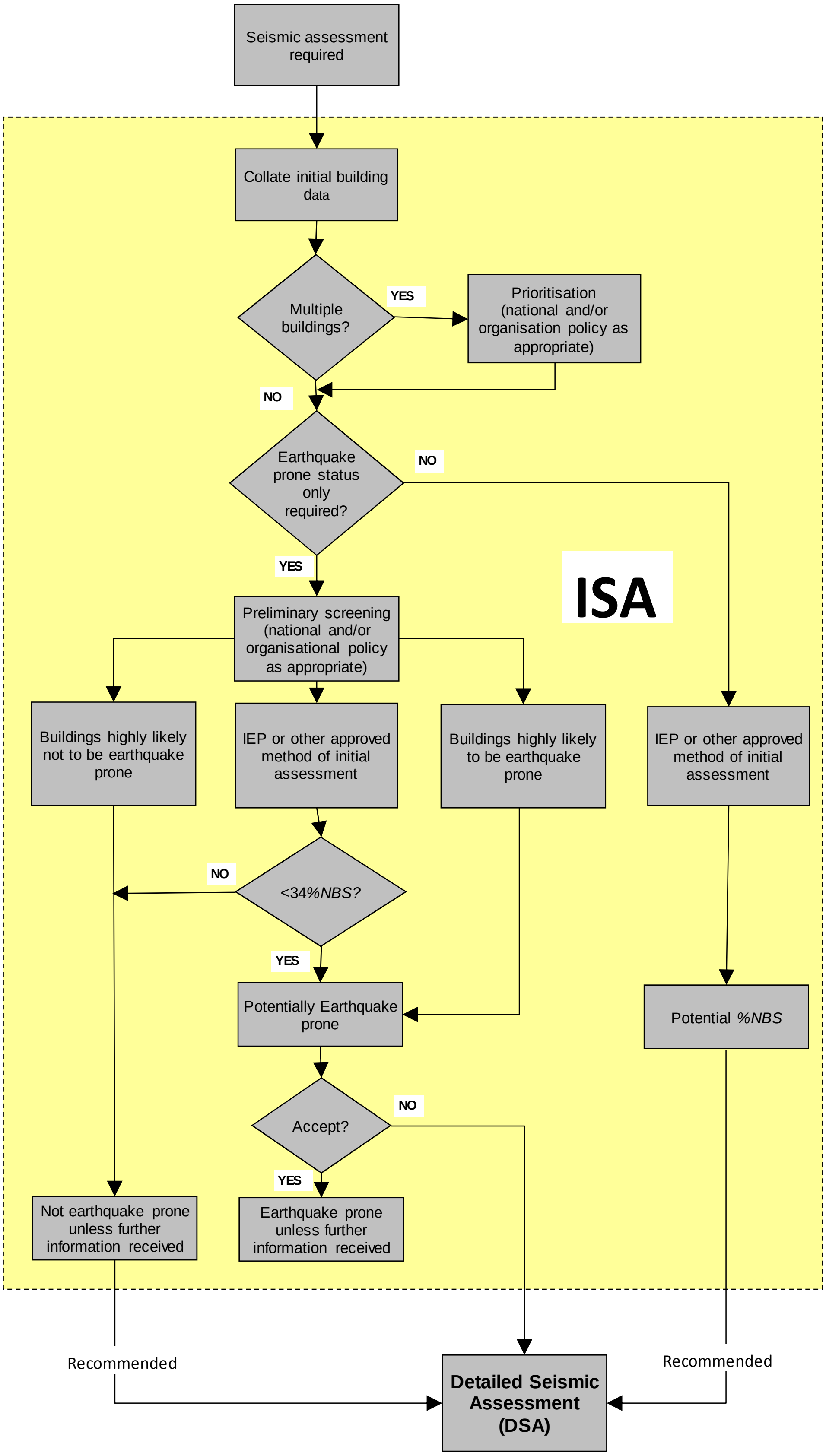

Figure 3.1: Diagrammatic Representation of Initial Seismic Assessment Process

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of another. The potential score for a building as a whole from an ISA must reflect the best judgement of the assessor, taking into account all aspects known to the assessor.

The result from the ISA process is reported in terms of a *%NBS* (percentage of new building standard) rating or score in a similar fashion to the result from a DSA, but must be considered an initial or interim result for the reasons outlined above. It therefore reports a *potential* status for the building. Further, more detailed assessment, or consideration of further information, could potentially raise or lower the interim score(s) and this should be expected.

An ISA can be carried out with varying levels of knowledge. For example an ISA can be completed solely on the basis of an exterior inspection, or could extend to a detailed review of drawings. The use of drawings will allow a reasonable review of internal details such as stairs, column ductility and floor type and is recommended if the building is rating around the earthquake risk level of 67*%NBS*.

The reporting of the results of the ISA should be appropriate for the particular circumstances. It is recommended that when ISA reports are sent out to building owners and/or tenants they include explanatory information such as a description of the building structure, the results of the ISA, the level of knowledge available and the limitations of the process. Refer also to section 3.5.

3.2 Preliminary Screening and Prioritisation

3.2.1 General

When evaluating the earthquake prone status of a building is the primary objective (eg for a TA responding to legislative requirements) preliminary screening, as outlined below can be carried out to avoid the need for a formal assessment where the outcome may already be known with some certainty.

TAs, building portfolio owners and Corporates (as tenants) faced with determining the potential seismic status of large numbers of buildings will not necessarily be able to deal with all buildings simultaneously, and therefore prioritisation may be required.

It is also recognised that the focus of owners and tenants of buildings may be different from TAs which will be primarily interested in compliance with EPB legislation (national policy objectives) On the other hand owners or tenants are also likely to be interested in issues that could affect the ongoing viability of their businesses (national plus organisational objectives).

These guidelines are primarily focused on life safety but, for completeness, the discussion below also includes comment on these other aspects where they are likely to be relevant.

Prioritisation will only be required when multiple buildings are involved.

Both screening and prioritisation as described can be carried out as a desk top exercise.

3.2.2 Preliminary Screening for Earthquake Prone Status

There are some building types/categories where experience has shown that the *potential* earthquake prone status can be predicted with some certainty without entering into a formal assessment process.

These are:

- Unreinforced masonry (URM) buildings where no previous strengthening has been carried out – *Potentially earthquake prone*.

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- Timber framed, Importance Level (IL) 1, 2 and 3 buildings without heavy roofs and located on flat sites where the height of the ground floor above the ground is less than 600mm – *Potentially not earthquake prone*.

- Post 1976, IL 1, IL 2 and IL 3 buildings– *Potentially not earthquake prone*.

Screening of buildings within these categories and assigning the appropriate earthquake prone status is considered reasonable, provided it is recognised that the categorisation is *potential*.

The assignment of earthquake prone status from a screening process does not preclude the possibility that a potential CSW is present that will ultimately lead to a lower classification or that the building may not be earthquake prone. However, the likelihood is considered to be low.

3.2.3 Prioritisation

Prior to undertaking formal initial seismic assessments for all buildings in a community that are required to be considered under earthquake prone building legislation, or within a portfolio, it may be appropriate to carry out an initial desktop exercise to prioritise buildings for assessment. This will enable priority to be given to buildings that are generically likely to present a higher risk to life, or are likely to be of high importance to the community in the aftermath of a large earthquake (eg. hospitals, fire-stations).

Prioritisation could proceed in the following steps.

3 **Step 1:** Compile a list of all buildings noting the following criteria:

- Age or date of design/construction
- Current Importance Level in accordance with AS/NZS1170.0
- Construction type; eg unreinforced masonry, timber framed or other.
- Any previous strengthening, and, if known, to what standard.
- Location; eg in CBD or on important transport route.

Step 2: For each building, assign a rating factor to each of the criteria as shown in Table 3.1

Step 3: For each building multiply the rating factors together.

Step 4: Rank the buildings based on the product of the rating factor, with the lowest product indicating the highest priority for an IEP.

For example, consider the following buildings in Wellington.

Building 1: A small URM bearing wall retail building located in the suburbs built in 1935 and strengthened to two thirds of Chapter 8 NZS1900:1965.
Rating factor product = (Min (1+1, 0.67x2) x 3 x 1 x 1 x 3) = 12

Building 2: A concrete framed office building in the CBD built in 1977.
Rating factor product = 3 x 3 x 3 x 1 x 2 = 54

Building 3: A concrete framed hospital building constructed in 1965.
Rating factor product = 2 x 1 x 3 x 1 x 1 = 6

Building 4: A 2 storey timber framed house on a flat site used for residential purposes, constructed prior to 1935.
Rating factor product = 1 x 3 x 4 x 1 x 3 = 36

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Table 3.1: Prioritisation Rating Factor

Criteria	Rating Factor			
	1	2	3	4
Age (when built or strengthening code)	Pre 1965	1965 - 1975	1976 - 1992	Post 1992
Importance Level	IL 4	IL 3	IL 2	IL 1
Construction Type	URM Bearing Wall	Timber Framed on side of hill	Other	Light Timber Framed on Flat Site
Seismic Hazard Factor[1]	≥0.4	0.31 – 0.39	0.14 - 0.3	≤0.13
Location[2]	On critical transportation route	In CBD	Other	
Previous Strengthening	Add 1 to rating factor for age or multiply Rating factor for age by % strengthening, whichever gives the lowest value			

Notes:
1. Importance Levels are as defined in AS/NZS1170.0
2. Seismic hazard factor differentiation may be relevant for consideration of a property portfolio across New Zealand.
3. Rating factor = 4 if unlikely to have any effect on neighbouring property or streets, ie. location unimportant.

The resulting priority for IEP, from highest to lowest, would therefore be buildings 3, 1, 4 and 2.

Such ranking could also form the basis for setting assessment time frames.

If the product of the rating factors for age (including previous strengthening), Importance Level, construction type and previous strengthening is less than or equal to 3 there is a high likelihood that the building will be potentially earthquake prone. If the product of these same rating factors is greater than 30 the building is only likely to be earthquake prone if an obvious CSW has been identified.

3

In addition to the factors considered in section 3.2.1 it is envisaged that building portfolio owners and corporate tenants may also be interested in:

- Potential impacts from neighbouring buildings. eg. falling hazards
- Performance of building services and/or ceilings
- Performance of incoming services and local infrastructure

These aspects can be ranked in discussion with the owner/tenant and included in the ranking scheme as considered appropriate.

The prioritisation process should not be seen as a substitute for using a formal initial seismic assessment procedure, such as an IEP, which is considered to be an important element of the overall ISA process.

3.3 Assessing Post-1976 Buildings

Buildings designed and constructed using seismic design codes from 1976 onwards need to be approached from a slightly different perspective when undertaking an ISA. They are unlikely to be earthquake-prone, but can contain critical structural weaknesses that could lead to a sudden, non-ductile mode of failure at levels of seismic shaking less than current design levels for the Ultimate Limit State (ULS). It is important that buildings that may be *earthquake risk buildings* but are not *earthquake prone* (ie they lie between 34%*NBS* and 67%*NBS*) and that have unacceptable failure modes are identified. How this might be done is discussed further in section 3.4.

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In buildings of this era, the greater use and availability of computer programs for structural analysis and architectural developments has led to the adoption of sometimes quite complex structural configurations and lateral load paths. Whereas for earlier buildings it might have been possible to identify a generic structural form from an exterior inspection, it is often difficult to pick this for post-1976 buildings. This is particularly the case for mixed-use buildings involving the competing structural layouts of accommodation, office and car parking. These structures typically feature offset columns or other transfer structures which cause irregular steps in the load path that may or may not have been taken into account appropriately in the original design.

Post-1976 buildings can also feature potential CSWs that relate to detailing issues rather than configuration CSWs relating to regularity. Examples of these can include:

- Heavily penetrated floor diaphragms (typically reinforced with welded wire mesh) which may lack adequate collector elements back to the lateral load resisting structure.
- Exterior columns without sufficient connection back into the supporting diaphragm.
- Non-structural infill walls with some movement allowance but an insufficient allowance to meet current code requirements
- Egress/access stairs which may not have sufficient displacement capacity for the expected inter-storey drifts, and
- Steel tension braces which may be vulnerable to fracture at threaded ends, where there may be insufficient threaded length to allow the required inelastic drift to develop.
- Detailing no longer considered to provide the level of ductility assumed at the time of design or previous strengthening.

3 It is therefore important that ISAs on post-1976 buildings involve both a full interior inspection and a review of available structural documentation.

Further guidance on using the IEP methodology for post-1976 buildings is given in section 3.4.6.

3.4 Potential severe Critical Structural Weaknesses

There are some severe SWs that experience in previous earthquakes shows are often associated with catastrophic pancake collapse or significant loss of egress. It is important that the potential existence of these is noted as part of an ISA assessment even if the ISA score is greater than the required target level. At the ISA level these are referred to as potential severe CSWs that could result in significant risk to a significant number of occupants.

It is considered reasonable to limit consideration to buildings of greater than or equal to 3 storeys as it is unlikely that buildings with fewer storeys would contain sufficient occupants to be considered a significant risk in this context. Similarly it is unlikely that buildings with lightweight (eg timber) floors (with the possible exception of URM buildings) are of the type that would be particularly susceptible to pancake failure.

The potential severe CSWs considered to be indicative of possible significant loss of resilience and rapid deterioration of performance in severe earthquake shaking are:

1) **A weak or soft storey, except for the top storey.**
This SW has the potential to concentrate inelastic displacements in a single storey. It may be difficult to identify without calculation unless that storey height is much larger than for the other stories and the element size has not been obviously increased to compensate.

2) **Brittle columns and/or brittle beam /column joints the deformations of which are not constrained by other structural elements.**

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Older multi-storey framed buildings with little or no binding reinforcement (beam/column joints), small columns and deep beams are particularly vulnerable to severe earthquake shaking. Once the capacity of the columns has been exceeded failure can be expected to be rapid. When associated with a soft storey the effect can be even greater.

3) **Flat slab buildings with lateral capacity reliant on low ductility slab to column connections.**
Although not common in New Zealand this building type has a poor record in severe earthquakes overseas. The failure is sudden, resulting in pancaking of floor slabs as the slab regions adjacent to the columns fail in shear. This SW will be mitigated by special slab shear reinforcement and, to some extent, by the presence of slab capitals.

4) **No effective connection between primary seismic structural elements and diaphragms.**
Buildings with no obvious interconnection between primary seismic structural members, such as lateral load resisting elements and diaphragms, have little chance of developing the full seismic capacity of the structure in severe earthquakes, especially when the building has irregularities and/or the need to distribute actions between lateral load resisting elements.

5) **Seismically separated stairs with ledge and gap supports.**
This need only be an identifiable issue here for buildings with more than 6 stories. It is considered that evacuation of lower height buildings will be relatively easily achieved through other means.

It is acknowledged that these structural weaknesses may only be recognisable from construction drawings and therefore an ISA based on a visual inspection only will not necessarily identify their presence. 3

Both the Initial Evaluation Procedure (IEP) and the template letter provided in the Appendix to this Section have provision for recording the presence of these potential issues.

3.5 Initial Evaluation Procedure (IEP)

3.5.1 Background

The IEP has been designed to accommodate a varying level of knowledge of the structural characteristics of a building and its parts and also recognises that knowledge of the building may increase with time. It is therefore expected that an IEP may be carried out several times for the same building and that the assessed rating may change as more information becomes available. Therefore the level of information that a particular IEP has been based on is a very important aspect of the assessment and must be recorded so that it can be referred to by anyone considering or reviewing the results.

The expectation is that the IEP will be able to identify, to an acceptable level of confidence and with as few resources as possible, all those buildings that fall below the EPB target without catching an unacceptable number of buildings that will be found to pass the test after a DSA. Accordingly an IEP score higher than the EPB target should be sufficient to confirm that the building is not earthquake prone. Of course the IEP cannot take into account aspects of the building that are unknown to the assessor at the time the IEP is completed and will not be as reliable as a DSA.

The IEP was developed and first presented in this guideline document in June 2006. Since that time thousands of buildings throughout New Zealand have been assessed using this procedure and a number of issues have become apparent. These include:

- The wide range of scores achieved for the same buildings by different assessors

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- Undue reliance being placed on the results of the IEP, notwithstanding the stated preliminary/first-stage nature of this assessment.
- An inappropriate level of accuracy being implied in some assessments.
- Lack of application of judgement in many assessments that is often evidenced by an unreasonably low score.
- Varying skill level of assessors, many of whom lack the experience to apply the judgements required.
- The incorrect view of some assessors that assessments are solely restricted to the issues specifically raised in the IEP and also do not include the building's parts.
- Further confirmation from the Canterbury earthquakes regarding the performance of buildings over a range of earthquake shaking levels, and
- A need to recognise that the importance level classification of a building may have changed since the design was completed.

This section has now been expanded to provide further guidance to assessors and to address these issues with the objective of achieving greater consistency in assessments. However, it should not be assumed that the higher level of guidance given will address all aspects and compensate for a lack of assessor experience and/or judgement.

Section 3.4.6 provides guidance on a number of specific issues that have arisen and includes suggestions on how to allow for these in an IEP assessment.

3 Many buildings have now been assessed using the IEP. The changes made to this section in this latest version are not expected, or intended, to significantly alter the previous scores of buildings, if the judgement of experienced seismic engineers has been exercised.

3.5.2 Level of Experience Required

The IEP is an attribute based, and largely qualitative process which is expected to be undertaken by experienced engineers. It requires considerable knowledge of the earthquake behaviour of buildings, and judgement as to key attributes and their effect on building performance.

Therefore, it is critical to the success of the IEP that this level of assessment is carried out, or reviewed by, New Zealand Chartered Professional Engineers (CPEng), or their equivalent, who have:

- Sufficient relevant experience in the design and evaluation of buildings for earthquake effects to exercise the degree of judgement required, and
- Had specific training in the objectives of and processes involved in the initial evaluation procedure.

The IEP is not a tool that can be applied by inexperienced personnel without adequate supervision. Less experienced 'inspectors' can be used to collect data on the buildings, provided that they have an engineering background so that the information collected is appropriate. The lower the experience of the inspectors, the greater the need for adequate briefing and review by experienced engineers before the IEP building score is finalised.

3.5.3 Limitations

The IEP is a qualitative assessment, based on generic building characteristics. There are limitations to what can be achieved using this process, some of which have been discussed above. The NZSEE recommends that assessors make the end users and receivers of the IEP assessment reports

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fully aware of the limitations of the process when discussing the results. Some of the limitations are listed below to assist in this process.

- The IEP assumes that the buildings have been designed and built in accordance with the building standard and good practice current at the time the building was constructed. In some instances, a building may include design features ahead of its time, leading to better than predicted performance and therefore warranting a higher score. Conversely, some unidentified design or construction issues not picked up by the IEP process may result in the building performing not as well as predicted.
- An IEP can be undertaken with variable levels of information; eg exterior only inspection, structural drawings available or not, interior inspection, and so on. The more information available, the more reliable the IEP result is likely to be. It is therefore essential that the information sources available for the assessment are recorded and that the likely effect of including additional information, such as inspection of drawings is reported.
- The IEP is intended to be somewhat conservative, identifying some buildings as earthquake prone, or having a lower *%NBS* score, than might be shown by subsequent detailed investigation to be the case. However, there will be exceptions, particularly when potential CSWs cannot be recognised from what is largely a visual assessment of the exterior of the building.
- The IEP cannot take into account aspects of the building that are unknown to the assessor at the time the IEP is completed. This is also the case with a DSA, but perhaps less likely given the greater level of information required.
- An IEP is designed to assess the building against the ultimate limit state only. It does not assess against the Serviceability Limit State (SLS) as defined in AS/NZS1170. This is consistent with the general NZSEE approach but it is important to bring this to the attention of the building owner or end user of the assessment results. 3
- For buildings designed after 1976, drawings and/or design calculations of should be reviewed for an IEP assessment, unless it is a very preliminary screening. This is because of the increased complexities due to a significant change in construction materials and technology, structural systems, assumed ductility, sophistication of analysis and design procedures post the mid-1970s. Drawings should also be reviewed if the structural system is not clear, or if the building has been strengthened, irrespective of the vintage of the building.
- The IEP is an attribute based procedure where identified potential CSWs are penalised and the penalties are accumulated. For buildings with several potential CSWs, unrealistically low scores/ratings may result, even after the full available adjustment for judgement. In such cases, the end users receiving the rating should be cautioned that the score may not be truly representative of the seismic performance of the building (particularly around the earthquake prone level) and that a DSA is recommended.
- Many TAs take the view that the building is what it is. This means that they reserve the right to react to any additional information and adjust the seismic status of a building at any time, even though they may have carried out the IEP that conferred the original status. Therefore, reliance on an IEP for important decisions carries risks.
- The NZSEE assessment process is only intended to focus on the building under consideration. It does not consider aspects such as the possible detrimental effects of neighbouring buildings (as current legislation assumes that these are the responsibility of the neighbour) or the hazards resulting from items that could be classified as building contents. However, these items may be important considerations for building owners, and tenants and should be brought to their attention if this is appropriate for the level of assessment being undertaken.

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3.5.4 Dealing with Differences in Assessment Results

Due to the qualitative nature of the assessment it should not come as a surprise that, in some circumstances, assessments of the same building by two or more experienced engineers may differ – sometimes significantly. This is to be expected, especially if the level of information available was different for each assessor.

It is expected that experienced engineers will be able to identify the critical issues that are likely to affect seismic performance and that, through discussion, a consensus position will be able to be agreed. For the same reason, an IEP assessment that has been independently reviewed is likely to be more robust than one based solely on the judgement of one engineer.

The NZSEE encourages the different assessors to enter into a dialogue. It recommends that any differences in opinion in the IEP assessments, that cannot be resolved through discussion and sharing of information, are resolved by the completion of a DSA, either for the building as a whole or for the aspect under contention if it is appropriate to consider this in isolation.

All judgements made need to be justified/substantiated, if requested (eg by TAs), and preferably recorded as part of the IEP.

3.5.5 Outline of the Process

An outline of the Initial Evaluation Procedure (IEP) is shown in Figure 3.2.

3 This process involves making an initial assessment of the standard achieved for an existing building against the standard required for a new building (the percentage new building standard, or *%NBS*).

The IEP outlined below is based on the current Standard for earthquake loadings for new buildings in New Zealand, NZS1170.5:2004, as modified by the New Zealand Building Code. It is assumed that the person carrying out the IEP has a good knowledge of the requirements of this Standard.

The first step is to survey the subject building to gather relevant data on its characteristics, sufficient for use in the IEP.

The next step is to apply the IEP to the building and thereby determine, the percentage of new building standard (*%NBS*) for that building.

%NBS is essentially the assessed structural standard achieved in the building (taking into consideration all reasonably available information) compared with requirements for a new building and expressed as a percentage. There are several steps involved in determining *%NBS*, as outlined in the following sections.

A *%NBS* of less than 34 (the limit in the legislation is actually one third) means that the building is assessed as <u>potentially</u> earthquake prone in terms of the Building Act and a more detailed evaluation of it will typically be required.

A *%NBS* of 34 or greater means that the building is regarded as outside the requirements of the earthquake prone building provisions of the Building Act. No further action on this building will be required by law. However, if *%NBS* is less than 67it will still be considered as representing an unacceptable risk and further work on it is recommended.

A *%NBS* of 67 or greater means that the building is not considered to be a significant earthquake risk.

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For a typical multi-storey building, the process is envisaged as requiring limited effort and cost. It would be largely a visual assessment, but supplemented by information from previous assessments, readily available documentation and general knowledge of the building.

The IEP should be repeated if more information comes to hand. It should also be repeated until the assessor believes the result is a fair reflection of the standard achieved by the building.

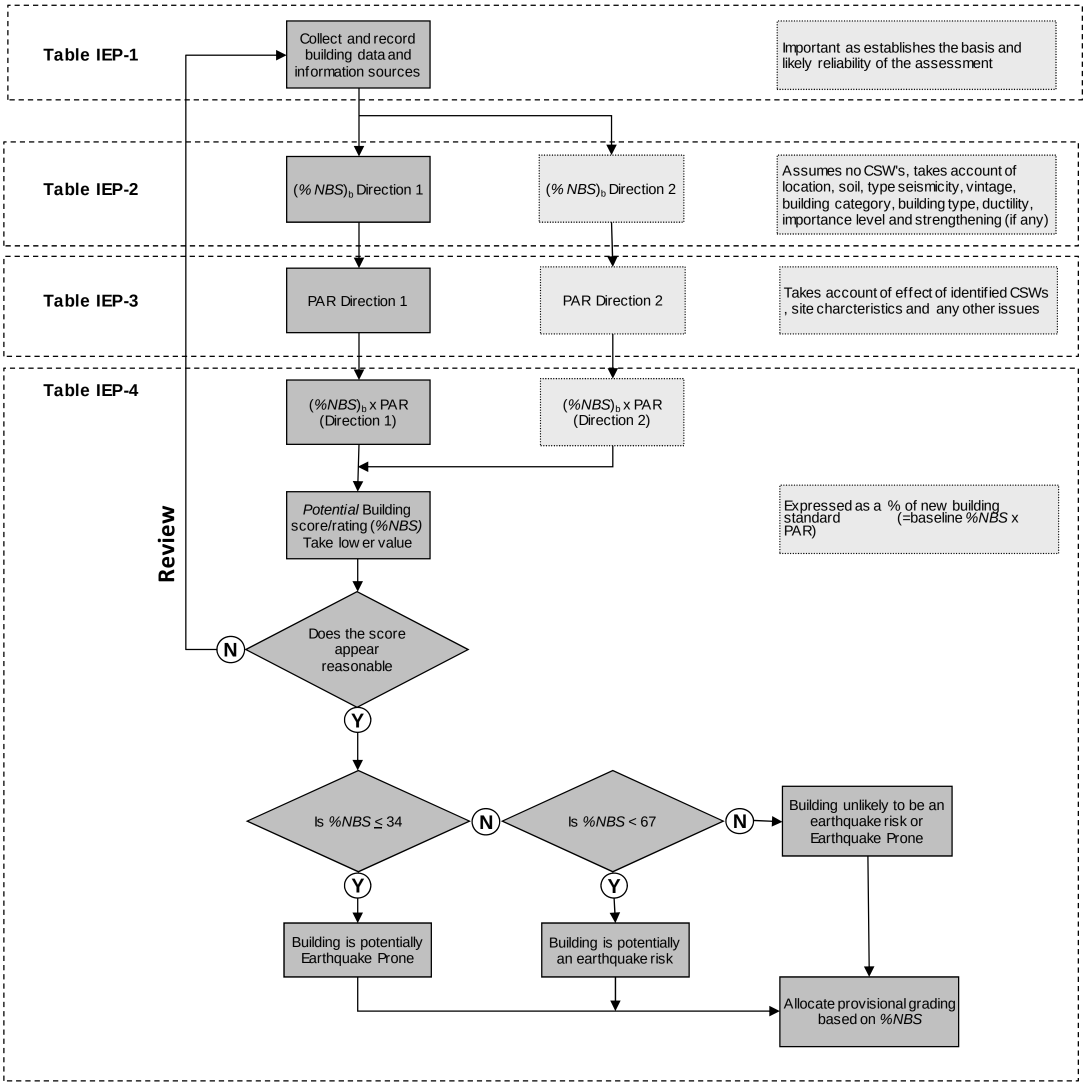

Figure 3.2: Initial Evaluation Procedure

The IEP as presented can be used for unreinforced masonry buildings, however may be difficult to apply in some circumstances. An attribute scoring process (refer Appendix 3B) is suggested as an alternative to the Steps 2 and 3 of the IEP (refer Appendix 3A) but will generally require a greater knowledge of the building than typically expected or intended for an IEP.

3.5.6 Specific Issues

a) General

The purpose of the following is to provide guidance on how to address some commonly encountered issues.

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It is recognised that some of these issues will not be identifiable without access to drawings or an internal inspection of the building. However, this is consistent with the objectives that underpin the IEP assessment, and buildings should not be penalised in the IEP unless there is some evidence that the issue is present. The IEP can be amended at any time if further information comes to hand. Note also the recommendation in section 3.4.3 and also in section 3.4.6(c) to review drawings for post 1976 buildings.

Judgement decisions on particular aspects of the IEP can be supported by calculations. This would be expected to lead to a more reliable (but still *potential*) score for the IEP without the full cost of a DSA. However, care should be taken to avoid over assessment in one area at the expense of another. The potential score for a building as a whole from an IEP must reflect the best judgement of the assessor, taking into account all aspects known to the assessor.

b) Implied accuracy and limitations

The IEP is an initial, largely qualitative, score based assessment dependent on knowledge available at the time of the assessment.

%NBS scores determined by an IEP should, therefore, reflect the accuracy achievable and not be quoted other than as a whole number. Except for the ranges 34 to 37% and 67 to 69% it is further recommended that the scores be rounded to the nearest 5*%NBS*.

Assessors should consider carefully before scoring a building between 30 and 34*%NBS* or between
3 65 and 67*%NBS*. The ramifications of these scores are potentially significant in terms of additional assessment required; perhaps for arguable benefit.

Providing specific scores above 100*%NBS* is also to be discouraged as they may provide an erroneous indication of actual performance. It is recommended that such scores are simply stated as >100*%NBS*.

The score based nature of the IEP can lead to very low scores for some buildings. While these low scores may correctly reflect the number of the potential CSWs present they may not truly reflect the expected performance of the building, particularly when considering against the EPB criteria. In such cases the assessor should be careful to advise his/her client of the limitations of the IEP and of the NZSEE's recommendation that a DSA should be completed before any significant decisions are made.

c) Post 1976 buildings

Note the following for Post 1976 buildings:

- From the mid1970s, perhaps coinciding with the introduction of the modern earthquake design philosophies into Standards and the greater availability and use of computer programs for structural analysis, quite complex structural configurations and lateral load paths were often adopted. Whereas for buildings built earlier it might have been possible to identify a generic structural form from an exterior inspection it is often difficult to pick this for post-1976 buildings.

  For this reason it is highly recommended that drawings and/or design calculations of post-1976 buildings be reviewed for an IEP assessment, unless it is only a preliminary screening or drawings cannot be located. In such cases it might be best to err on the side of caution if it is suspected that there might be issues with the structural system.

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- Consideration of:
  - Location and clearance to non-structural infill walls, refer 3.4.6(g).
  - Poorly configured diaphragms, refer 3.4.6(i).
  - Gap and ledge stairs, particularly if these are in a scissor configuration, refer 3.4.6 (j).
  - Non-ductile columns, refer 3.4.6(k).
  - Unrestrained/untied columns, refer 3.4.6 (l)
  - Detailing and configuration of shear walls, refer 3.4.6(m).

It is not expected that the issues outlined above will result in an earthquake prone designation, although this cannot be completely discounted.

d) Timber framed buildings

The Christchurch earthquakes have confirmed what has been long known that timber framed residential and small commercial buildings generally perform extremely well in earthquakes and, even when significantly distorted due to ground movements, the risk of fatalities as a result is low.

Buildings of this type have been shown to have significant inherent capacity and resilience (beyond the ultimate limit state as might be determined by consideration of NZS3604 requirements) which means that they should rarely be found to be potentially earthquake prone unless they are located on a slope and have substructures that are poorly braced and/or poorly attached to the superstructure. Buildings located on flat sites and poorly attached to their foundations may come off their foundations. However, although this may lead to significant damage, this is unlikely, on its own, to result in fatalities, particularly if the floor is less than 600mm above the ground. These buildings are rarely completely reliant on their diaphragms unless the spacing of parallel walls is large. 3

Whether or not these building are potentially earthquake risk will depend on issues such as:

- Site characteristics
- Age (ie. is the building likely to have been engineered? Correct application of non-specific design requirements such as NZS3604 may be considered as achieving this.)
- Adequacy of connection between subfloor and super structure
- Poorly braced basement structures
- Walls lined with materials of little reliable capacity
- Excessive spacing between walls
- Condition (decayed timber, etc)
- Excessive stud height.
- Roof weight

Larger timber framed buildings such as churches, school and church halls and commercial buildings have also been shown to have inherent capacity and resilience and perform in earthquakes well above what their ultimate limit state capacity as assessed in comparison to new building requirements might suggest. These buildings are typically characterised by larger spans, greater stud heights, greater spacing between walls and fewer connection points between building elements than for the smaller, more cellular buildings discussed above. Nevertheless, these buildings should also rarely be classified as potential EPBs unless the following are evident, and then judgement will be necessary to determine the likely effect:

- Missing load paths (eg open frontages, particularly at ground floor level of multistory buildings)

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- Obvious poor connections between elements (eg between roof trusses and walls)
- Lack of connection between subfloor and super structure and poorly braced basement structures for building on slopes.
- Walls lined with materials of little reliable capacity
- Heavy roofs
- Likely effect on non-structural elements of particular hazardous nature (eg effect of building racking on large areas of glazing or of brick veneers adjacent to egress paths)

At the earthquake risk level the other aspects given above for the smaller buildings will also be relevant.

To reflect these observations the following parameters may be assumed for timber framed buildings in the IEP:

- S_p may be taken as 0.5.
- For most buildings of this type plan irregularity may be assumed to be *insignificant*.
- Unbraced subfloors for buildings on flat ground may be assumed *insignificant* if the height above the ground is less than 600mm.
- No penalty should typically be applied for site characteristics eg. liquefaction. Also refer to section 3.3.6(n).
- 3 Ductility, μ is equal to 2 and 3 for pre and post 1978 buildings respectively.

The judgement F Factor should be chosen to reflect the overall expected performance of the building based on the observations set out above. For timber-framed structures of a cellular configuration, F Factor values approaching the upper limit should be used.

e) Light-weight, single storey industrial structures

Single storey industrial structures with profiled steel roofing and wall cladding typically perform well in earthquakes. These buildings typically have steel portals carrying the seismic loads in one direction and steel bracing (roof and wall) in the other.

Such structures are unlikely to be earthquake prone. Although the cladding cannot be relied on in a design sense, it is nevertheless likely to provide reasonable capacity if bracing is missing.

Weaknesses that could potentially affect the capacity of these structures include:

- Missing wall and/or roof bracing
- Lack of lateral flange bracing to portals
- Open walls with little obvious bracing
- Non-capacity designed bracing connections

f) Tilt-up industrial structures

Concrete tilt-up panels inherently provide significant lateral capacity to a building. However, the capacity that can be utilised is very dependent on the connections from the panels to the structure (typically the roof structure) and the capacity of the roof diaphragm.

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If complete load paths can be seen (including the roof diaphragm), with no obvious problems with the connections (eg missing or obviously undersized bolts, poor welds to weld plates), such buildings are unlikely to be earthquake prone.

Non-ductile mesh as the sole means of panel reinforcement could lead to an issue for panels under face loading.

Any identified issues should be subjected to further investigation. The heavy nature of these buildings and possible lack of redundancy means that they are unlikely to perform well when the earthquake shaking is greater than moderate if: any failures occur in connections, the diaphragms have insufficient capacity to transfer loads (eg such as might be necessary when large wall openings are present) or there are reinforcement fractures in the panels.

It is recommended that an inspection of the interior of such buildings be included when completing an IEP.

g) Building parts

The performance of parts, where these are known to be present, must be considered in the overall assessment of the building, particularly where the failure of these could present a hazard to life or damage to neighbouring property.

Parts of buildings that must be included in the assessment include but are not limited to:

- Large glass panels near egress ways.
- Precast panels located over egress routes, public areas or neighbouring buildings that have dubious connections to the main structure e.g connections with little or no allowance for storey drifts. 3
- Brick veneers adjacent to the street, neighbouring buildings or egress routes unless these are known to be tied back to the building
- Parapets
- Face loaded walls
- Heavy items of plant
- Infill partition walls. From the early 1970s infill walls (typically in reinforced blockwork) were separated from the primary structure to prevent the walls from carrying in-plane shear and therefore participating in the lateral load resisting system.

  Prior to 1992 the separation requirements were much less than subsequently required. Gaps of 10mm to 20mm were common and in many instances filled with sealants or fillers that were only partially compressible.

  However, once these gaps have been taken up, the walls will act as shear walls to the limit of their capacity. Problems arise because of the irregular layout of the non-structural wall panels, both in plan and over the height of the structure. The eccentricities that result can be severe. If gaps have been provided it is unlikely that the building will be earthquake prone but the expected performance at higher levels of shaking will be dependent on the wall layouts and the type of primary structure present. The effects will be greater for more flexible primary structures such as moment resisting frames.

  Infill walls not separated from the primary structure should be considered as shear walls of uncertain capacity and scored accordingly. In many cases it may be difficult to determine the effect and a DSA is recommended.

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h) Chimneys

Experience indicates that chimneys can be vulnerable, even at levels of earthquake shaking consistent with EPB considerations, particularly if they are unreinforced or poorly restrained back to the building. Failure of such chimneys has led to fatalities in past earthquakes in New Zealand and this should be reflected in the IEP assessment.

The following approach is recommended for the assessment of chimneys and the effect on the building score:

A building with a chimney should be considered potentially earthquake prone, and the Factor F in Table IEP-3 set accordingly, if either:

- The chimney is not restrained by the roof structure, or other fixing, at the roofline, **OR**
- The chimney meets all of the following criteria:
  - It is constructed of unreinforced masonry or unreinforced concrete, **AND**;
  - The ratio of the height of the chimney (measured vertically from the chimney intersect with the lowest point on the roofline to the top of the chimney structure (excluding any protruding flues or chimney pots)) and its plan dimension in the direction being considered is more than;
    - 1.5 when $ZR \geq 0.3$, or
    - 2 when $0.2 < ZR < 0.3$, or
    - 3 when $ZR \leq 0.2$

    3 where Z and R are as defined in NZS1170.5, **AND**
  - If any one or more of the following applies:
    - There is any possibility that the chimney could topple onto an egress route, entrance way, over a boundary (including over a street frontage), over any public/ private access way or more than 2 m down onto an adjoining part of the building, or
    - The roofing material comprises concrete masonry, clay tiles or other brittle material, unless suitable sheathing (extending horizontally at least the height of the chimney away from the chimney) has been laid within the ceiling space to prevent the roofing material and collapsed chimney from falling through the ceiling.

The particular issues from these options that have made a building with a chimney potentially earthquake prone must be recorded in the IEP.

i) Diaphragms

The role of diaphragms in a building may be complex. All diaphragms act as load collectors distributing lateral load to the lateral load resisting elements. Where the lateral load resisting system changes (eg. at basements or transfer levels) the diaphragms may also act as load distributors between the lateral load resisting elements. In the post elastic range, progressive inelastic deformations in lateral load resisting elements may impose significant internal forces detrimental to both the diaphragms and the performance of the lateral load resisting elements.

In addition to the configuration (plan irregularity) issues noted in Figure 3A.5 and Table 3A.4 there are also issues relating to diaphragm detailing that could affect the seismic performance of the building as a whole. These include:

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- Poor placement of penetrations interrupting potential load/stress paths
- Inadequate load paths (eg no chords which lead to little in-plan moment strength or lack of means to transfer loads into the lateral load resisting system (eg lack of “drag” steel to concrete walls)
- Incomplete or inexistent means of load transfer, eg missing roof bracing elements
- Inadequate capacity in the diaphragm and its connections, and
- Poor connections from non-structural elements to the diaphragms, (eg connections from the tops of brick walls to the diaphragms).

The potential performance of precast floor diaphragms (and in particular hollow core floors) has received much attention over the last decade and evidence of diaphragms under stress was seen after the Christchurch earthquakes. This included:

- Cracking in floor toppings and fracture of floor mesh (a particular issue if mesh is the sole reinforcement in the topping), and
- Separation of the perimeter concrete frames from the diaphragm, e.g after elongation of the concrete beams, fracture of the topping reinforcement or lack of ties to the perimeter columns

Diaphragm capacity issues are unlikely to become an issue until the earthquake shaking becomes severe so are unlikely, on their own, to cause the building to be categorised as potentially earthquake prone.

The assessor will need to use his or her judgement to assess the effect of missing elements and will need to check for the existence of other, less direct or less desirable load paths for transferring loads before determining that the building is potentially earthquake prone. 3

Any of the factors listed above should lead to a potentially earthquake risk categorisation in an IEP.

j) Stairs

The experience of the Christchurch earthquakes has been that some stairs may be vulnerable in earthquakes. The arrangement that was shown to be particularly vulnerable was the “gap and ledge” stair where a heavy stair flight (typically precast concrete) is vertically supported on a corbel, typically with a seating less than 100mm, and with or without a definite gap. Monolithic concrete stairs in multistorey reinforced concrete or steel frame buildings could be similarly vulnerable.

Such details, on their own, are very unlikely to make a building earthquake prone unless the flights are precariously supported, but their presence should result in at least a rating as potentially earthquake risk.

k) Non-ductile columns

Investigation into the collapse of the CTV building during the 22 February 2011 Lyttelton earthquake highlighted the potential for incorrect interpretation of requirements for secondary columns in buildings designed using NZS3101:1982. These requirements were clarified in NZS3101:1992 so there is potential for non-ductile secondary columns in buildings designed during the period roughly from 1982 to 1992.

Such detailing is unlikely to cause the building to be earthquake prone, unless the columns are already highly stressed under gravity loads. However, the presence of non-ductile columns should result in the building being classified as potentially an earthquake risk.

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l) Unrestrained/untied columns

The evidence would suggest that there are a number of multistorey buildings constructed in the 1980s that have perimeter frames where the columns are not adequately tied back into the floor diaphragm. In some cases, as noted in section 3.3.6(i) above, the floor mesh taken over the beam reinforcement provides the sole means of restraint. The lack of column ties is likely to lead to a rapid reduction in capacity of the columns once beam elongation and/or fracture of the slab mesh has occurred.

The lack of column ties back to the floors is unlikely to make the building earthquake prone but should result in a potentially earthquake risk classification.

m) Concrete shear wall detailing and configuration

The performance of concrete shear wall buildings in the Christchurch earthquakes has indicated that current detailing for ductility (spacing and positioning of wall ties) may not be sufficient when the wall is subjected to significant non-linear behaviour. Asymmetric walls (ie C and L shaped walls) were also shown to be problematic when capacity design procedures were not applied. New provisions for wall detailing are being developed: when they are finalised the *%NBS* for existing buildings will need to be compared against these requirements.

This issue is unlikely to cause post-1976 buildings to be earthquake prone, but could potentially reduce the rating below 67*%NBS*.

3

n) Site Characteristics

Identified site characteristics (including geohazards and potentially at risk neighbouring buildings etc) that could have a direct impact on the building and, as a result, could lead to the building presenting an enhanced risk to building occupants, those in the immediate vicinity of the building, or to adjacent property must be recorded on the IEP forms and in the covering letter. The assessor will therefore need to be cognisant of the site's terrain setting and have an awareness of the possible geohazards and other hazards that could impact on the building.

Penalties are applied based on the potential effects in a severe earthquake. Therefore the penalty should not be reduced simply because the hazard is not expected to initiate at levels of shaking implied by the *%NBS* score.

Penalties are generally not applied for hazard sources located outside the site. This includes geohazards such as rock fall from above, rolling boulders, landslide from above and tsunami and hazards resulting from neighbouring buildings (eg adjacent URM walls and parapets). This is consistent with the philosophies underlying the concept of earthquake prone buildings within the Building Act where the focus is on the building and its effect on its neighbours rather than the risk presented by neighbouring property.

Site characteristics that are to be considered, and will potentially attract a penalty include: excessive ground settlement, liquefaction, lateral spreading and landslide from below. Penalties should only be applied, however, when these issues would lead to building damage of an extent that would result in the potential enhanced risks outlined above and when there is some evidence that the particular hazard exists. For example a building should not be penalised solely because it is located on a slope. For such a building to attract a penalty there must be evidence of prior slope instability or knowledge of instability and the potential loss of support of the building must be such that it would be likely to lead to the enhanced risks outlined.

The Canterbury earthquakes have provided evidence, that on its own, liquefaction is unlikely to lead to a risk to life in light-weight timber buildings or other low rise (less that 3 storeys) buildings

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that are well tied together and are therefore likely to maintain their integrity after significant settlement occurs. However, un-strengthened URM buildings are considered to be particularly vulnerable to ground settlement of the extent expected if liquefaction occurs.

Issues relating to ground amplification are assumed to be dealt with when setting the subsoil conditions in the determination of $(\%NBS)_{nom}$. However, as with any other issue, the assessor is required to make a judgment call regarding any additional impact on the score that may be appropriate, over and above any allowance in the procedure.

Assessors are referred to geohazard assessments that have been carried out for TAs and Regional Councils to identify the potential hazards that are likely to be appropriate for the site in question. These are typically in the form of hazard maps. Assessors are also referred to Table 3A.4 and to Section 15 of these Guidelines for further discussion on geotechnical matters.

o) Unreinforced Masonry Walls

The presence of unreinforced masonry frame infills, cantilever walls (irrespective of whether or not these are bearing walls) or cantilevering parapets, should be sufficient grounds to rate the status of the building as potentially earthquake prone, at least until the stability of the wall/infill can be confirmed.

The effect of brick veneers on egress routes, especially for Importance Level 3 and 4 buildings, should be also be considered: at least until the presence or otherwise and the condition of ties back to the main structure can be confirmed.

p) Importance Level 3 and 4 Buildings

The influence of original ultimate limit state design load levels will be reflected in the score determined by the IEP for buildings that are now categorised as either Importance Level 3 or 4.

Even though consideration of serviceability limit states is considered outside the scope of the IEP, the effect of non-structural items such as brick veneers, infill walls and the like on egress routes or the ability to continue to function, should be considered for buildings classified as Importance Level 3 or 4.

3.6 Reporting

The manner in which the results of an ISA are reported is extremely important to ensure that the results are appropriately interpreted and their reliability is correctly conveyed.

Recipients of an ISA carried out by a TA must be warned of its limitations and the need to proceed to a DSA if any decisions reliant on the seismic status of the building are contemplated.

To avoid misinterpretation of an ISA result by building owners and /or building tenants it is recommended that the ISA (which is typically expected to be in the form of an IEP) is accompanied by a covering letter. This letter should describe the building, the scope of the assessment, the information that was available, the rationale for the various decisions made, the limitations of the process and the implications of the result. A template covering letter showing how these aspects might be addressed is provided in Appendix 3C.

When the results of a TA initiated ISA are being reported, building owners must be advised of the limitations of the process employed. Suggested wording is provided in Appendices 3D and 3E respectively for the situation where the building has been found to be potentially earthquake prone and not to be earthquake prone. If the IEP assessment report is to be provided in the event the

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building has been found not to be earthquake prone, it should be made clear that the primary objective has been to determine the earthquake prone status and not necessarily the score for the building.

3 The template letters should be amended, if appropriate, to suit the particular circumstances. However, it is recommended that they retain the key elements noted.

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臺灣木結構工程協會

第二部份

建築物震後結構體功能性評估及復原

PART II

Assessment and Improvement of the Structural Performance of Buildings in Earthquakes

紐西蘭
地震工程協會

建築物震後結構體功能性評估及復原

第 3 節 初步耐震評估

9TH SEPTEMBER 2014

Recommendations of a NZSEE Project Technical Group

In Collaboration with SESOC and NZGS

Supported by MBIE and EQC

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圖目

定義、符號說明及縮寫

定義

為了參考的便利性，相關定義用詞會放在各章節中。

符號說明

為了參考的便利性，相關符號說明會放在各章節中。

縮寫

b　與載重方向垂直的樓板跨度

CBD　中心商業區

CSW　關鍵結構弱點(critical structural weakness)。由DSA所確認之關鍵結構弱點指的是建築物的 %NBS分數限制小於 67 %NSB。

D　與載重方向平行的樓板深度

EPB　地震易損型建築物(earthquake prone building)。參考建築法(Building Act,2004)的定義，即< 34%NBS

ERB　地震風險型建築物(earthquake risk building)。建築物經評估後具有中等以上的風險者，即< 67%NBS

I　進行建築設計時由NZS4203 所定義的重要性因子。

IEP　初步評估程序(Initial Evaluation Procedure)。

IL　AS/NZS1170.0 所定義的重要性程度。

ISA　初步耐震評估(Initial Seismic Assessment)。

k_{μ}　NZS1170.5 定義之結構韌性比例因子。

M　　NZS4203 定義之材料因子。

N(T,D)　　NZS1170.5 定義之近斷層因子。

NBS　　新建築物標準規範，即應用在現場新建建築物的標準規範。包含了現行規範標準內對載重的全部需求。

NZS　　紐西蘭規範。

PAR　　功能性達成比率(Performance Achievement Ratio)。

PIM　　專案資訊備忘錄，參考建築法第 31 節。

pCSW　　潛在關鍵結構弱點。由ISA判定及有潛在成為CSW之結構弱點。

R　　由NZS1170.5 定義且與NZS1170.0 內適合於建築物重要性程度一致的迴歸週期因子。

R_0　　建築物設計所使用的風險因子。

SLS　　NZS 1170.5:2004(或 NZS 4203:1992)所定義的可服務性限制狀態：原意為結構體在未進行任何修理前已不能再使用的狀態。

S　　NZS4203 所定義的結構型式因子。

S_p　　NZS1170.5 所定義的結構功能性因子。

SW　　結構弱點(Structural Weakness)：建築物(或建築物的一部份)在地震時會造成如對生命、對鄰近財產及對建築物出口有明顯增加風險等等對結構物功能性產生不利影響的可確認性特徵。

T(L)A　　區域性的權力(Territorial(Local) Authority)。這份文件中TA的使用主要是描述委員會如何管理建築法的要求。以委員會角色做為建築物擁有者的方式與其它建築物擁有者並沒有任何的不同。

ULS　　極限限制狀態。這個狀態一般都在NZS 1170.5:2004 及AS/NZS 1170.0 中定義。

URM　　無加強石造物。

%NBS　達到新建築法規要求的百分比

$(\%NBS)_b$　新建築法規要求的基線百分比

$(\%NBS)_{nom}$　新建築法規要求的標稱百分比

μ　NZS1170.5 所定義的結構韌性因子。

Z　NZS1170.5 所定義的地震災害因子。

Z_{1992}　NZS 4203:1992 內的區域因子(只針對 1992-2004 興建的建築物)

Z_{2004}　NZS 1170.5:2004 內的地震災害因子(只針對 2011 八月後興建的建築物)

第 3 節-初步耐震評估

3.1 緒論

紐西蘭地震工程學會(NZSEE) 建議兩階段的耐震評估程序。整個程序的大綱詳見圖 2.1 並在第 2 節中 (目前尚未更新)進行更詳細的討論。耐震初步評估(Iinitial Seismic Assessment, ISA)盡可能用最少的資源進行粗略但合理地評估，以作為總體評估過程中建議的第一步驟。對於那些有可能成為 2004 年紐西蘭建築規範所定義的地震易損性建築物(Earthquake Prone Building, EPB)，或是在地震後可維持信賴狀態的重要建築物來說，耐震初步評估完馬上進行耐震能力詳細評估(Detailed Seismic Assessment, DSA)是被大眾所期待的。這些決定可能包括購屋前的詳盡調查、保險手續及耐震補強工程前的耐震易損性確認。

ISA所採用的評估程序有很大程度上是依照評估的目標及待評估的建築物數量而定。由紐西蘭當地政府(領土當局，Territorial Authority,TA)管理的建築物或是定義的地震易損性建築所使用的ISA程序可能會和單一建築物有不同的著重焦點。ISA程序的主要組成元素詳圖 3.1。

在盡可能的狀況下不需使用正式評估方式而能合理地去篩選建築物的地震易損狀態是一個重要目標。

當有許多建築物需要立即進行評估時，考量其中的優先順序做為評估的依據將是合乎實際的作法。即盡力把資源放在可能有最大利益產出的建築物上。當然，對於少量的建築物來說，優先順序就不再是個考量的議題了。

在這些建築物初步評估的指導方針裡最被推廣的主要工具為初步估價程序(Initial Evaluation Procedure, IEP)。IEP 將會在下面及附錄 3A中描述之，而且和 2006 年指導方針所介紹的眾所皆知之IEP在本質上是相同的。對特定型式的建築物來說，IEP需針對具有其他屬性的此種型態的建築物要有意義性的提高。附錄 3B對於與IEP相關連的未補強石造建物有特別的規定。然而，多屬性的方法是需要對建築物有更高一層的學理而不僅僅是對IEP有典型的期待。

IEP的基本方向是對結構體(或部份)各個方面在地震後因為減少功能性的影響後，對居民及週遭建物的負面影響所進行的識別及定性上的評估。此種建築物的缺陷簡稱為潛在關鍵結構弱點(CSWs)。

當在ISA中有其他程序可取代IEP時，保持IEP的本質及所反應出的整體建築物的結果需要有一致性是很重要的。

對於利用精密計算來支持ISA中特定方面的判斷及決定完全是受到鼓勵的。沒有完全用到DSA的方式就可以得到ISA中更值得信賴(但是仍為潛在的)的分數仍是大眾所期待的。然而，這仍要避免因為犧牲別人而得到了一個區域的過份評估。藉由ISA所得到的整體建築物的潛在分數需完全反應評估者在其他各種領域知識下所進行的專業判斷。

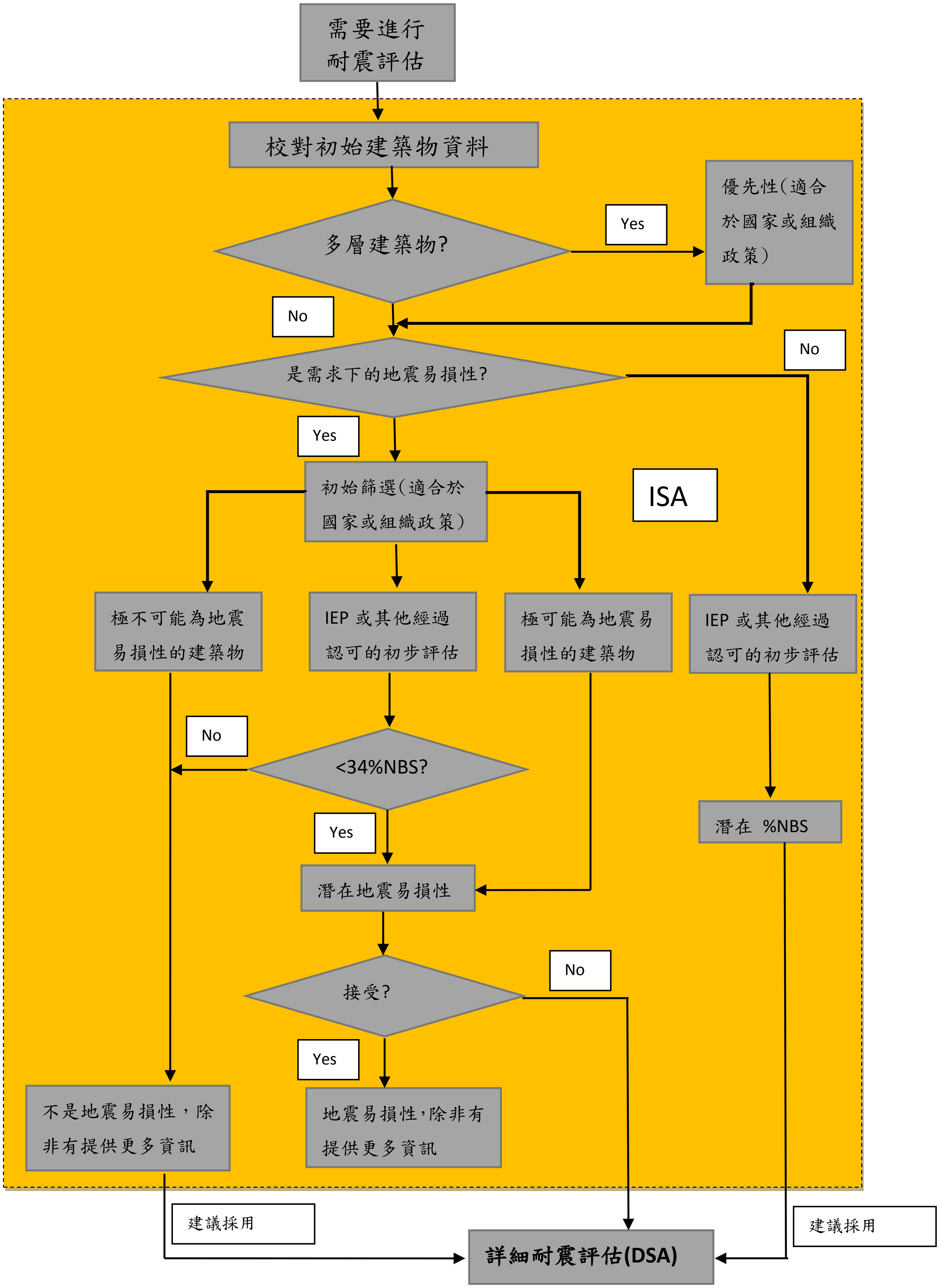

圖 3.1 初步耐震評估流程表