The Seismic Assessment of Existing Buildings

Technical Guidelines for Engineering Assessments

July 2017

Initial Seismic Assessment

Part B

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NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

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NEW ZEALAND GEOTECHNICAL SOCIETY INC

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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EQC
EARTHQUAKE COMMISSION

ISBN:978-0-478-43366-1 (Online)
ISBN:978-0-478-43367-8 (Print)

Document Status

Version	Date	Purpose/ Amendment Description
1	July 2017	Initial release

This version of the Guidelines is incorporated by reference in the methodology for identifying earthquake-prone buildings (the EPB methodology).

Document Access

This document may be downloaded from www.building.govt.nz in parts:

1 Part A – Assessment Objectives and Principles

2 Part B – Initial Seismic Assessment

3 Part C – Detailed Seismic Assessment

Document Management and Key Contact

This document is managed jointly by the Ministry of Business, Innovation and Employment, the Earthquake Commission, the New Zealand Society for Earthquake Engineering, the Structural Engineering Society and the New Zealand Geotechnical Society.

Please go to www.building.govt.nz to provide feedback or to request further information about these Guidelines.

Errata and other technical developments will be notified via www.building.govt.nz

Acknowledgements

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Funding for the development of these Guidelines was provided by the Ministry of Business, Innovation and Employment and the Earthquake Commission.

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Appendices

B1. Introduction

B1.1 General

This section describes the Initial Seismic Assessment (ISA), which is the recommended first step in the overall assessment process. It is intended to be a coarse evaluation involving as few resources as reasonably possible.

Figure B.1 summarises the main elements of the ISA. It also highlights that the continuum ranges from a "basic" ISA which involves collecting basic building data, an exterior inspection and completing an Initial Evaluation Procedure (IEP) (explained below) to a "comprehensive" ISA which adds the collection of all readily available building data, an interior inspection, drawing review, and supplementary calculations as required. The use of original drawings will also allow a reasonable review of internal details such as foundations, stairs, column ductility and floor type; and this is recommended if the building's earthquake rating is around the threshold levels of 34*%NBS* and 67*%NBS*.

If important decisions need to be made that rely on a building's seismic status, it is expected that an ISA would be followed by a Detailed Seismic Assessment (DSA). Such decisions could include those relating to pre-purchase due diligence, arranging insurance, or before designing seismic retrofit works. A comprehensive ISA with reference to drawings and interior and exterior inspections and supplemented with calculations (if required) may be used to confirm the status of an earthquake-prone building, provided that the engineer is confident that the result reflects the expected behaviour of the building.

Note:

It is likely that this option would only be viable in cases where the assessment clearly indicates that either the building is earthquake prone or it is not. The situations when a comprehensive ISA would be considered appropriate are covered in the EPB methodology. Refer also to Part A.

The process adopted for a particular assessment will depend to a large extent on its specific objectives and the number of buildings involved. For example, the ISA process for a portfolio of buildings may have a different focus than that for a single building. If multiple buildings are involved, the engineer may need to prioritise, as it will probably be impractical to assess all buildings simultaneously and immediately.

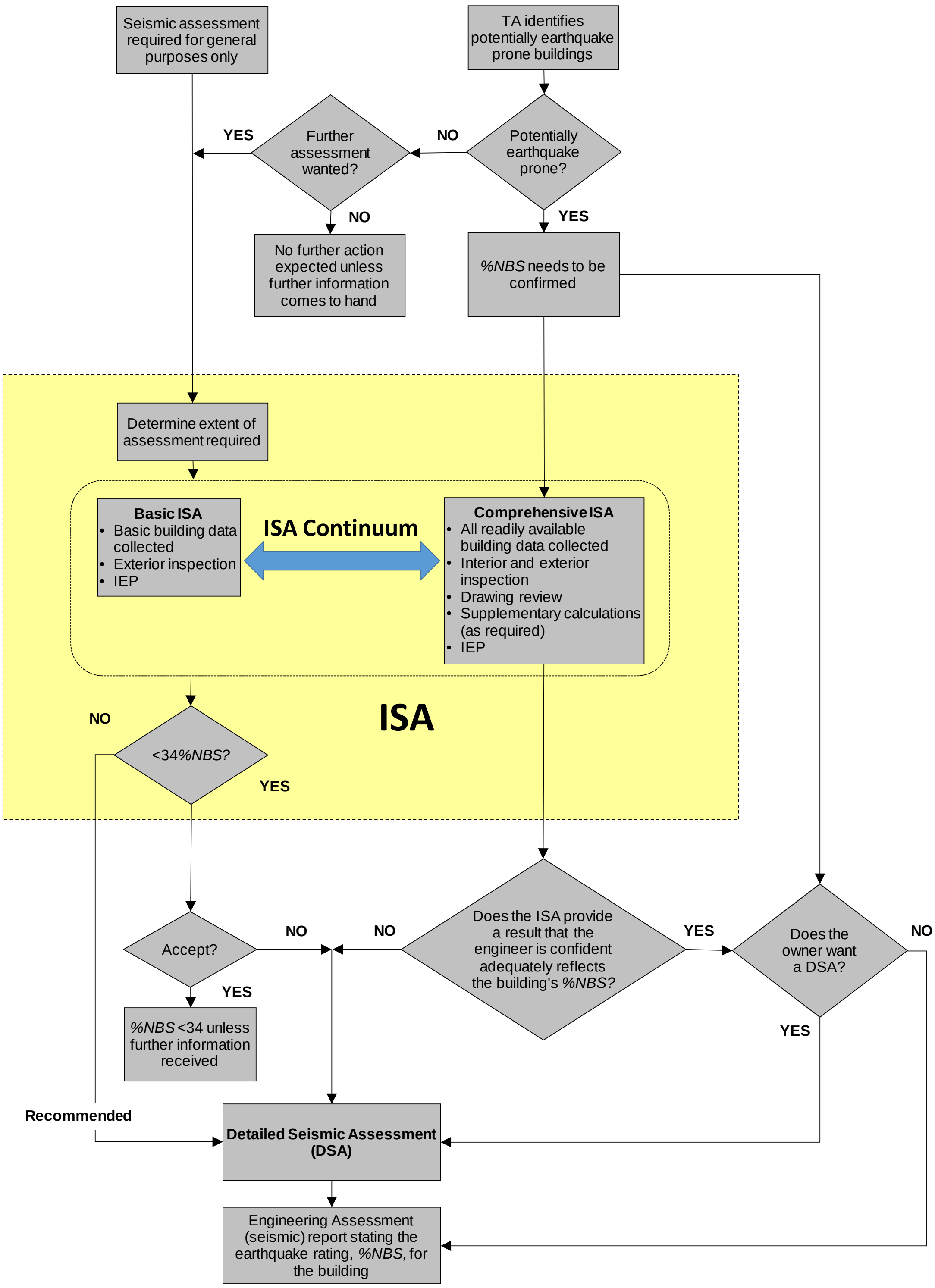

Figure B.1: Diagrammatic representation of the Initial Seismic Assessment process

When undertaking an ISA for post-1976 buildings (those designed and constructed using seismic design codes from 1976 onwards) the engineer will need to approach the assessment from a slightly different perspective. While these buildings are unlikely to be earthquake prone, they can contain 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) shaking. It is also important that buildings that may be earthquake risk but that are not earthquake prone (i.e. that 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 B4.3. Post-1976 buildings can also feature potential CSWs that relate to detailing issues rather than configurational SWs relating to regularity. It is therefore important that ISAs of post-1976 buildings involve both a full interior inspection and a review of available structural documentation.

Note:

In buildings of the post-1976 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.

The main tool provided by these guidelines for carrying out an ISA is the Initial Evaluation Procedure, or IEP. While other procedures can be substituted for the IEP in the ISA, it is important for consistency that the IEP's essence is maintained and the result is reflective of the building as a whole.

Section B3 discusses the IEP process and level of experience required. It also discusses the limitations of this process and how to deal with differing assessment results. Section B4 covers issues specific to building type and era, and Appendix BA details the steps involved in the IEP and includes the required worksheets (Tables IEP-1 to IEP-5).

Note:

The IEP was introduced in these guidelines in 2006 and refined in 2014 (NZSEE Guidelines, 2006 including corrigenda 1, 2, 3 and 4). The version in these guidelines is essentially unchanged from 2014.

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 (pCSWs). Section B2 discusses these further and also lists the potential severe structural weaknesses (pSSWs) that must be noted if identified.

These guidelines recognise that the IEP can be meaningfully enhanced for certain building types such as unreinforced masonry (URM) by considering specific attributes. Appendix BB provides an attribute scoring method for URM buildings which can be used in conjunction with the IEP. However, this method generally requires a greater level of knowledge of a building than is typically expected or intended for an IEP carried out as part of a basic ISA.

Calculations to support judgement decisions on particular aspects of the ISA are encouraged. This would be expected to lead to a more reliable earthquake rating from the ISA without the full cost of a DSA. However, care should be taken to avoid over-assessment in one area at the expense of another without a more holistic assessment of the building. The potential rating for a building as a whole from an ISA must reflect the best judgement of the engineer, taking into account all aspects known to that engineer

The result from the ISA process is reported in terms of a *%NBS* (percentage of new building standard) earthquake rating the same way as the result from a DSA. For the reasons outlined above, the results from an ISA are generally reported as a potential earthquake rating for the building, and all potential SWs are given the status of potential CSWs. More detailed assessment, or consideration of further information, could potentially raise or lower the ISA rating and this should be expected. The exception to this is when an ISA is considered by the engineer to provide sufficient justification to establish the earthquake rating for earthquake prone assessments in accordance with the requirements set out in the EPB methodology. In such cases the SWs remains as potential CSWs but the result of the ISA is reported as the earthquake rating.

The reporting of the results of the ISA should be appropriate for the particular circumstances. These guidelines recommend that ISA reports sent to building owners and/or tenants 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.

Section B5 covers expectations for reporting the ISA and providing an accompanying technical summary, which is required if the ISA is to be submitted as an engineering assessment to a Territorial Authority (TA) for the purposes of determining whether or not a building is earthquake prone. These guidelines also include recommended templates for the covering letter from the engineer to building owners or tenants who have commissioned an ISA (Appendix BC).

B1.2 Regulatory Considerations

Before mid-2017, ISAs and IEPs as outlined in the NZSEE's 2006 guidelines were used extensively by a number of TAs to help them establish which buildings in their cities or districts were potentially earthquake prone. This was typically undertaken as part of TAs' active earthquake-prone building policies established under the Building Act 2004.

On 1 July 2017 significant changes to the Building Act's earthquake-prone building provisions took effect (via the Building (Earthquake-prone Buildings) Amendment Act 2016). As a result TAs no longer have individual earthquake-prone building policies. However, they are still responsible for determining whether or not individual buildings in their district are earthquake prone or potentially earthquake prone.

As well as following the provisions in the Building Act and supporting regulations, TAs must now follow the Earthquake-prone Building (EPB) methodology set by the chief executive of the Ministry of Business, Innovation and Employment. This methodology has similar status to a regulation and references these guidelines.

The EPB methodology contains profiles of potentially earthquake-prone buildings; i.e. categories of buildings with known seismic vulnerabilities and that can be considered potentially earthquake prone. TAs must consider which buildings in their district fall within these profile categories within set time frames and then write to the owners to request an engineering assessment. The methodology contains criteria for when an ISA (or other form of seismic assessment) may be used as a suitable "engineering assessment" to meet the legislative requirements – either for buildings within the profile categories or for those the TA wishes to consider at any other time.

TAs may also continue to use the ISA in addition to the profiling as a more specific screening tool or as an additional engineering input to the profiling process for certain types of buildings.

Note:

The EPB methodology also contains criteria for accepting IEPs and ISAs previously submitted to TAs in relation to their earthquake-prone buildings policies or for other reasons. These criteria take into account factors such as the level of detail of the assessment and the degree of review or moderation that has been applied.

This does not include situations where earthquake-prone building notices were issued before the 2017 changes to the Building Act (i.e. notices issued under the previous section 124 of this Act) based on an ISA and/or IEP. In these cases, it is expected that buildings already identified as earthquake prone and issued with a notice requiring remediation work will have this notice replaced under the new provisions, so long as the building remains within scope of the Building Act. Obligations on owners to undertake remediation work and further engineering assessment to move out of earthquake-prone status will remain.

B1.3 Definitions and Acronyms

Critical structural weakness (CSW)	The lowest scoring structural weakness determined from a DSA. For an ISA all structural weaknesses are considered to be potential critical structural weaknesses.
Detailed Seismic Assessment (DSA)	A quantitative seismic assessment carried out in accordance with Part C of these guidelines
Earthquake-prone Building (EPB)	A legally defined category which describes a building that has been assessed as likely to have its ultimate capacity (which is defined in Regulations) exceeded in moderate earthquake shaking. In the context of these guidelines it is a building with an earthquake rating of less than 34*%NBS* (1/3 new building standard).
Earthquake rating	The rating given to a building as a whole to indicate the seismic standard achieved in regard to human life safety compared with the minimum seismic standard required of a similar new building on the same site. Expressed in terms of percentage of new building standard achieved (*%NBS*).
Earthquake Risk Building (ERB)	A building that falls below the threshold for acceptable seismic risk, as recommended by NZSEE (i.e. ≤67*%NBS* or two thirds new building standard)
(Earthquake) score	The score given to part of a building to indicate the seismic standard achieved in regard to human life safety compared with the minimum seismic standard required of a similar new building on the same site. Expressed in terms of percentage of new building standard achieved (*%NBS*).
IEP	Initial Evaluation Procedure
Importance Level (IL)	Categorisation defined in the loadings standard, AS/NZS 1170.0:2002 used to define the ULS shaking for a new building based on the consequences of failure. A critical aspect in determining new building standard.
Initial Seismic Assessment (ISA)	A seismic assessment carried out in accordance with Part B of these guidelines. An ISA is a recommended first qualitative step in the overall assessment process.
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
Potential critical structural weakness (pCSW)	Any structural weakness identified at the time of an ISA is a pCSW
pSSW	Potential severe structural weakness
Severe structural weakness (SSW)	A defined structural weakness that is potentially associated with catastrophic collapse and for which the capacity may not be reliably assessed based on current knowledge. For an ISA, all severe structural weaknesses are considered to be potential severe structural weaknesses and are only expected to be noted when identified.
SLS	Serviceability limit state as defined in AS/NZS 1170.0:2002 (or NZS 4203:1992) being the point at which the structure can no longer be used as originally intended without repair
SSNS	Secondary structural and non-structural

Structural weakness. (SW)	An aspect of the building structure and/or the foundation soils that scores less than 100*%NBS*. Note that an aspect of the building structure scoring less than 100*%NBS* but greater than or equal to 67*%NBS* is still considered to be a structural weakness even though it is considered to represent an acceptable risk.
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.
Ultimate limit state (ULS)	A limit state defined in the New Zealand loadings standard NZS 1170.5:2004 for the design of new buildings.
Unreinforced masonry (URM)	A member or element comprising masonry units connected together with mortar and containing no steel, timber, cane or other reinforcement

B1.4 Notation, Symbols and Abbreviations

Symbol	Meaning
$\%NBS$	Percentage of new building standard. Refer to Section BA.2.2
A_{p}	Plan area of building above storey of interest
A_{w}	Cross sectional area of all URM walls extending over full height of storey
b	Span of diaphragm perpendicular to direction of loading
D	Depth of diaphragm parallel to direction of loading
e_{d}	Distance between the storey centre of rigidity and the centre of mass for all levels above that storey
H	Height to the level being considered or height of the lower building as appropriate
h_{w}	Height of wall between lines of horizontal lateral restraint
I	Importance factor defined by NZS 4203:1992 used for the design of the building
k_{μ}	Structural ductility scaling factor defined in NZS 1170.5:2004
l_{w}	Length of wall between lines of positive lateral restraint
M	Material factor defined by NZS 4203:1992
$N(T,D)$	Near fault factor defined by NZS 1170.5:2004
R	Return period factor defined by NZS 1170.5:2004 based on the importance level appropriate for the building in accordance with AS/NZS 1170.0:2002
R_0	Risk factor used for the design of the building
S	Structural type factor defined in NZS 4203:1992
S_{p}	Structural performance factor defined in NZS 1170.5:2004
T	Fundamental period of a structure
t	Thickness of wall
Z	Seismic hazard factor defined by NZS 1170.5:2004
Z_{1992}	Zone factor from NZS 4203:1992 (for 1992-2004 buildings only)
Z_{2004}	Seismic hazard factor from NZS 1170.5:2004 (for post August 2011 buildings only)
$(\%NBS)$	Percentage of new building standard achieved. Refer to Section BA.2.2
$(\%NBS)_{\mathrm{b}}$	Baseline Percentage of new building standard. Refer to Section BA.2.2
$(\%NBS)_{\mathrm{nom}}$	Nominal Percentage of new building standard. Refer to Section BA.2.2
μ	Structural ductility factor defined by NZS 1170.5:2004

B2. Structural Weaknesses

B2.1 Potential Critical Structural Weaknesses (CSWs)

A structural weakness is an aspect of the building structure and/or the foundation soils that scores less than 100*%NBS*. Note that this includes aspects that score at least 67*%NBS*, even though these are considered to represent an acceptable risk.

For a DSA, the critical structural weakness (CSW) is the lowest scoring structural weakness. However, for an ISA all potential structural weaknesses are considered to be potential CSWs and are defined as either insignificant, significant or severe as follows:

Insignificant The potential CSW is not evident in the building and/or its parts, or it is of such an extent or nature that it is considered very unlikely to lead to loss of life and/or have an impact on neighbouring property and/or impede egress from the building when the building is subjected to severe earthquake shaking.

Significant The potential CSW is evident in the building and/or its parts, and it is of such an effect or nature that it is considered likely to lead to moderate loss of life and/or have a significant impact on neighbouring property and/or impede egress from the building when the building is subjected to severe earthquake shaking. For the potential CSW to be categorised as having a 'significant' consequence under this level of shaking it would need to be likely to result in deformations in the structure and/or its parts such that localised collapse should be considered a possibility.

Severe The potential CSW is evident in the building and/or its parts, and it is of such an extent or nature that it is considered likely to lead to significant loss of life and/or have a severe impact on neighbouring property and/or severely impede egress from the building when the building is subjected to severe earthquake shaking. For the potential CSW to be categorised as having a 'severe consequence' it would need to result in partial or complete collapse of the building and/or its parts.

B2.2 Potential Severe Structural Weaknesses

There are some severe structural weaknesses (SSWs) that experience from previous earthquakes shows are often associated with catastrophic pancake collapse or significant loss of egress. At the ISA level, these are referred to as potential SSWs that could result in significant risk to a significant number of occupants.

Note:

If any potential SSWs have been identified then careful consideration should be given before rating the building above 34*%NBS*.

It is important that the potential existence of these is noted as part of an ISA assessment even if the ISA earthquake rating is greater than the required target level (e.g. 34*%NBS*). Having said that, these potential SSWs are only expected to be noted when identified.

Note:

Potential SSWs should not be confused with the 'severe' performance category for the more general, potential CSWs scored within the IEP and described above.

It is considered reasonable to limit consideration of potential SSWs to buildings of three or more 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 (e.g. timber) floors, with the possible exception of URM buildings, are of the type that would be particularly susceptible to pancake failure.

The potential SSWs 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 SSW would have 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 storeys and the element sizes have 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**
   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 such 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 can be sudden, resulting in pancaking of floor slabs as the slab regions adjacent to the columns fail in shear. This SSW may 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 only needs to be an identifiable issue here for buildings with more than six storeys. It is considered that evacuation of lower height buildings will be relatively easily achieved through other means.

It is acknowledged that these SSWs and/or any mitigating factors that are present may only be recognisable from construction drawings. Therefore, an ISA based on a visual inspection only will not necessarily identify their presence. As stated earlier, the intent of these guidelines is that the items listed above should only be noted if they are observed: i.e. the engineer does not need to confirm that they are not present as part of an ISA.

Both the IEP (Table IEP-5) and the template letter provided in Appendix BC have provision for recording the presence of these SSWs as potential SSWs if they have been observed.

Note:

The SSWs highlighted above vary slightly from those which require specific consideration in a DSA. This is because some of the above (e.g. weak or soft storeys) can be assessed adequately in a DSA, while others listed for special consideration in a DSA may be difficult to identify from an ISA.

B3. Initial Evaluation Procedure (IEP)

B3.1 Background

The IEP is an integral part of the ISA process outlined in these guidelines. It has been designed to accommodate a varying level of knowledge of the structural characteristics of a building and its parts. It also recognises that knowledge of the building may increase with time.

This section provides guidance to engineers on what the IEP process should achieve, the level of experience required, the IEP's limitations, and how to address specific 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 engineer experience and/or judgement.

Note:

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

The expectation is that the IEP will be able to identify, to an acceptable level of confidence and with as few resources as possible, most of those buildings that fall below the earthquake-prone building threshold without catching an unacceptable number of buildings that will be found to pass the test after a DSA. Therefore, an IEP earthquake rating higher than this threshold determined as part of a comprehensive ISA may be sufficient justification under the EPB methodology to confirm the building is not earthquake prone. Of course the IEP cannot take into account aspects of the building that remain unknown to the engineer at the time the IEP is completed. Therefore, it cannot be considered as reliable as a DSA.

Note:

The requirements for an ISA to enable it to be used as justification for raising the earthquake rating for a building identified as potentially earthquake prone using the profiling process are covered in the EPB methodology.

The IEP was developed in 2000 and first presented in June 2006. Since then 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 ratings achieved for the same buildings by different engineers
- 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 that even the engineer does not support
- varying skill level of engineers, many of whom lack the experience to apply the judgements required
- the incorrect view of some engineers that assessments are solely restricted to the issues specifically raised in the IEP and also do not include the secondary structural and critical non-structural components

- further confirmation from the Canterbury earthquake sequence of 2010/11 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.

B3.2 Outline of the IEP Procedure

An outline of the IEP procedure is shown in Figure B.2 (refer to Appendix BA for more details of the expected process, including Tables IEP-1 to IEP-5). It involves making an initial assessment of the standard achieved for an existing building against the minimum life safety standard required for a new building (the percentage of new building standard, or *%NBS*).

As knowledge of a particular building may increase with time, 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 it can be referred to by anyone considering or reviewing the results.

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 adjusted until the engineer believes the result is a fair reflection of the standard achieved by the building.

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

The next steps involve applying the IEP to the building to determine the percentage of new building standard (*%NBS*) for that building.

The *%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.
A *%NBS* of less than 34 (the limit in the legislation is actually one third) fulfils one of the requirements for the building to be assessed as earthquake prone in terms of the Building Act.
A *%NBS* of 34 or greater means that the building should be regarded as being outside the requirements of the earthquake-prone building provisions of the Building Act, although the TA will need to be satisfied that the assessment is valid. It is likely that the IEP will need to be at the more comprehensive end of the continuum, with review of drawings and interior inspections for the TA to be satisfied (refer to Part A and Figure B.1).
A *%NBS* of 67 or greater means that the assessment is indicating that the building should not be a significant earthquake risk, based on NZSEE recommendations.

Note:

It is important to realise that the reliability of the *%NBS* rating determined at the IEP level will depend on the level of information available during the assessment process. A rating determined by a DSA should generally be assumed to be more reliable than one from an ISA. As noted above an IEP prepared as part of a comprehensive ISA may be sufficient to confirm earthquake-prone building status. Refer to the EPB methodology for specific requirements.

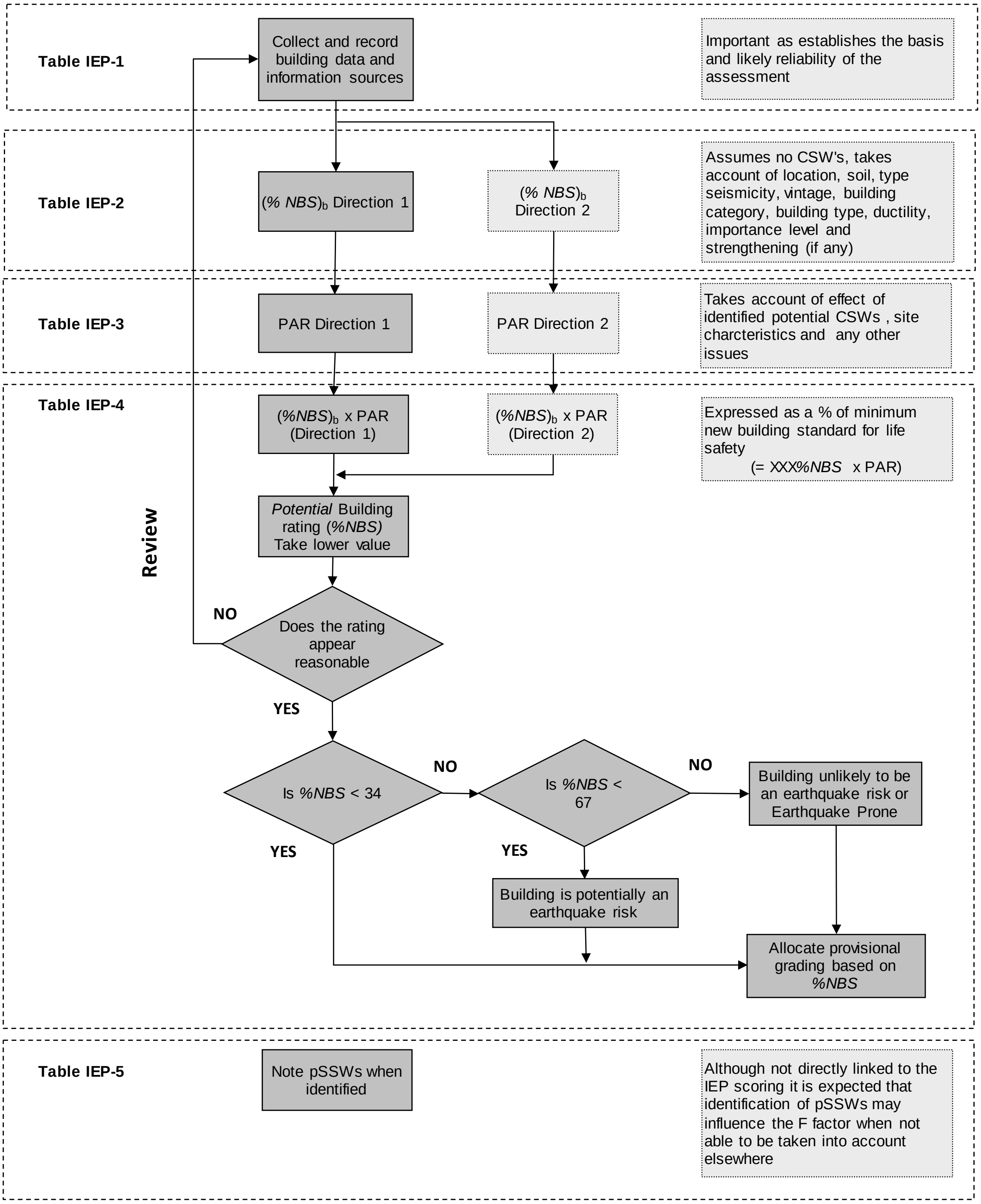

Figure B.2: Initial Evaluation Procedure

For URM buildings, the IEP can be used as presented but it may be difficult to apply in some circumstances. An attribute scoring method (refer to Appendix BB) is suggested as an alternative to Steps 2 and 3 of the IEP for these buildings. However, this method generally requires a greater knowledge of the building than typically expected or intended for an IEP.

B3.3 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 essential that IEPs are 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
- have received specific training in the objectives of, and processes involved in, the IEP.

Note:

The IEP is based on the current standard for earthquake loadings for new buildings in New Zealand, NZS 1170.5:2004, 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 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. However, the lower the experience of the inspectors, the greater the need for adequate briefing and review by experienced engineers before the IEP building rating is finalised.

B3.4 Implied Accuracy and Limitations

The IEP is a largely qualitative, score based assessment. It is based on generic building characteristics and is dependent on knowledge available at the time of the assessment.

Accordingly, *%NBS* ratings determined by an IEP should reflect the accuracy achievable and should 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 ratings are rounded to the nearest 5*%NBS*.

Engineers should also consider carefully before rating a building between 30 and 34*%NBS* or between 65 and 67*%NBS*. The ramifications of these ratings are potentially significant in terms of additional assessment required, perhaps for arguable benefit. Providing specific ratings above 100*%NBS* is also to be discouraged as these may provide an erroneous indication of actual performance. It is recommended that such ratings are simply stated as >100*%NBS*.

The score based nature of the IEP can also lead to very low ratings for some buildings. While these low ratings 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 earthquake-prone building criteria. In such cases the engineer should be careful to advise his/her client of the limitations of the IEP and the recommendation that a DSA should be completed before any significant decisions are made.

In general terms, these guidelines recommend that engineers make sure building owners and other recipients of IEP assessment reports are fully aware of the limitations of the IEP process when discussing the results. These include the following:

- The IEP assumes a building has been designed and built in accordance with the building standard and good practice current at the time. In some instances, a building may include design features ahead of its time, leading to better than predicted performance and therefore warranting a higher rating. 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; e.g. 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. Therefore, it is 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 having a lower *%NBS* rating 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 can be largely a visual assessment of the building exterior for a less than comprehensive ISA.
- The IEP cannot take into account aspects of the building that are unknown to the engineer at the time the IEP is completed. (While this is also the case with a DSA, it is perhaps less likely given the greater level of information required.)
- An IEP is designed to assess the building against the ULS only. It does not assess against the serviceability limit state (SLS) as defined in AS/NZS 1170.0:2002. While this is consistent with the general seismic assessment approach in these guidelines of focusing only on aspects that could impact on life safety, it is important to bring this to the attention of the building owner or end user of the assessment results.
- For buildings designed after 1976, drawings and/or design calculations should be reviewed for an IEP 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 building's age.
- 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 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 rating may not be truly representative of the seismic performance of the building (particularly around 34*%NBS*) and that a DSA is recommended.

- TAs are required to consider any information that might be available for a building. 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 process (that may have included an IEP) that conferred the original status. Therefore, reliance on an IEP for important decisions carries risks.
- The IEP 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.

B3.5 Reconciling Differences in Assessment Results

Due to the qualitative nature of the ISA 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 assessment.

In situations where assessment outcomes are significantly different, engineers should enter into a dialogue to understand the points of difference. These guidelines recommend that any differences in opinion regarding the IEP that cannot be resolved through discussion and sharing of information are resolved by the completion of a DSA. This should either be for the aspect under contention if it is appropriate to consider this in isolation, or for the building as a whole.

All judgements made need to be justified/substantiated if this is requested (e.g. by TAs). Judgements should preferably be recorded on the IEP sheets and included as part of the ISA.

B4. Issues Specific to Building Type and Era

B4.1 General

This section provides guidance on how to address some commonly encountered issues when carrying out IEPs. 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 level of knowledge is consistent with the objectives that underpin the IEP.

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 B4.3 to review drawings for post-1976 buildings and the requirements for engineering assessments for earthquake prone status given in the EPB methodology.

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) rating from the IEP without the full cost of a DSA. However, engineers should be careful to avoid over-assessment in one area at the expense of another. The potential rating for a building as a whole from an IEP must reflect the best judgement of the engineer, taking into account all aspects known to the engineer.

B4.2 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. Therefore, the engineer needs 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.

In the IEP, penalties are applied based on the potential effects on the building 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* rating.

Penalties are generally not applied for hazard sources located <u>outside</u> the site. This includes geohazards such as rockfall from above, rolling boulders, landslide from above and tsunami and hazards resulting from neighbouring buildings (e.g. adjacent URM walls and parapets).

Note:

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 that will potentially attract a penalty, include:

- excessive ground settlement
- liquefaction
- lateral spreading, and
- landslide from below.

However, penalties should only be applied when these characteristics would lead to building damage to 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.

Regarding liquefaction, the Canterbury earthquakes have provided evidence that this on its own is unlikely to lead to a risk to life in light timber buildings or other low rise (less than three storeys) buildings that are well tied together and are therefore likely to maintain their integrity after significant settlement occurs. However, unstrengthened 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 $(\%NBS)_{\mathrm{nom}}$. However, as with any other issue, the engineer is required to make a judgement call regarding any additional impact on the score that may be appropriate, over and above any allowance in the procedure.

Engineers 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. Engineers are also referred to Table BA.4 and to Section C4 of these guidelines for further discussion on geotechnical matters.

B4.3 Post-1976 Buildings

B4.3.1 General

Note the following for buildings designed after 1976:

- From the mid-1970s, 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 than this 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 recommended that the engineer reviews drawings and/or design calculations of post-1976 buildings for an IEP, 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.

- Consideration should also be given to the following:
  - location and clearance to non-structural infill walls (refer to Section B4.7)
  - poorly configured diaphragms (Section B4.7.7)
  - gap and ledge stairs, particularly if these are in a scissor configuration (Section B4.7.8)
  - non-ductile columns (Section B4.3.2)
  - unrestrained/untied columns (Section B4.3.3), and
  - detailing and configuration of shear walls (Section B4.3.4).

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

Also note that post-1976 buildings can feature potential CSWs that relate to detailing issues rather than configurational SWs 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
- 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, and
- detailing no longer considered to provide the level of ductility assumed at the time of design or previous strengthening.

B4.3.2 Non-ductile columns

Investigation into the collapse of the CTV building during the 22 February 2011 Christchurch earthquake highlighted the potential for incorrect interpretation of requirements for secondary columns in buildings designed using NZS 3101:1982. These requirements were clarified in NZS 3101:1995, but there is potential for non-ductile secondary columns in buildings designed during the period broadly from 1982 to 1992.

Such detailing is unlikely to make the building rate less than 34*%NBS*, unless the columns are already highly stressed under gravity loads. However, the presence of non-ductile columns should result in the building being rated less than 67*%NBS*.

B4.3.3 Unrestrained/untied columns

The evidence would suggest that there are a number of multi-storey 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 B4.7.7, 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 rate less than 34*%NBS* but should result in a rating less than 67*%NBS*.

B4.3.4 Concrete shear wall detailing and configuration

The performance of concrete shear wall buildings in the Canterbury 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 nonlinear behaviour. Asymmetric walls (i.e. 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 rated less than 34*%NBS*, but could potentially reduce the rating below 67*%NBS*.

B4.4 Timber Framed Buildings

The Christchurch earthquake sequence of 2010/11 confirmed what has been long known that timber framed residential and small commercial buildings generally perform extremely well in earthquakes and that, even when significantly distorted due to ground movements, the risk of a significant life safety hazard as a result is low.

Buildings of this type have been shown to have significant inherent capacity and resilience (beyond the ULS as might be determined by consideration of NZS 3604:2011 requirements) which means that they should rarely be found to be less than 34*%NBS* 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 600 mm above the ground. These buildings are rarely completely reliant on their roof diaphragms unless the spacing of parallel walls is large.

Whether or not these building are potentially earthquake risk, i.e. less than 67%, will depend on issues such as:

- site characteristics
- age (i.e. is the building likely to have been engineered? Correct application of non-specific design requirements such as NZS 3604:2011 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 to perform in earthquakes well above what their ULS 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 less than 34*%NB*S unless the following are evident, and then judgement will be necessary to determine the likely effect:

- missing load paths (e.g. open frontages, particularly at ground floor level of multi-storey buildings)
- obvious poor connections between elements (e.g. 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 a particularly hazardous nature (e.g. 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:

- The structural performance factor, 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 600 mm.
- No penalty should typically be applied for site characteristics; e.g. liquefaction (refer also to Section B4.2).
- Ductility, μ, is equal to 2 and 3 for pre and post 1978 buildings respectively.

The judgement factor, or 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.

B4.5 Single Storey Steel 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 should rarely be found to be less than 34*%NBS*. 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.

B4.6 Tilt-up Industrial and Commercial 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.

If complete load paths can be seen (including the roof diaphragm), with no obvious problems with the connections (e.g. missing or obviously undersized bolts, poor welds to weld plates), such buildings are unlikely to be less than 34*%NBS*.

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 (e.g. 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.

B4.7 Other Building Elements

The behaviour of secondary structural and non-structural (SSNS) elements, where the failure of these could present a significant life safety hazard or damage to neighbouring property, must be considered in the overall assessment of the building.

The rationale for what elements are expected to lead to a significant life safety hazard and therefore need to be included in a seismic assessment is provided in Part A.

Parts of buildings that should be included in an assessment include, but are not limited to:

- URM parapets and walls (Section B4.7.1), and chimneys (Section B4.7.2)
- masonry veneers above a public thoroughfare, neighbouring buildings or egress routes (Section B4.7.3)
- masonry infill panels (Section B4.7.4)
- heavy non-loadbearing partition walls (Section B4.7.5)
- precast panels located over egress routes, public areas or neighbouring buildings (Section B4.7.6)
- diaphragms (Section B4.7.7)
- stairs (Section B4.7.8)
- support frames for cladding systems including curtain walls (Section B4.7.9), and
- heavy and large items of building services plant, tanks, etc. (Section B4.7.10).

Note:

These elements also fall within the scope of “parts” under the Building Act for the purposes of determining whether or not a building is earthquake prone (refer to Part A).

The behaviour of general building services is not intended to limit the earthquake rating of a building.

B4.7.1 Unreinforced masonry parapets and walls

The presence of URM walls (irrespective of whether or not these are bearing walls) or cantilevering parapets should be sufficient grounds to rate a building as less than 34*%NBS*, at least until the stability of the wall or the effectiveness of the restraint of the masonry can be confirmed.

Appendix BB contains specific provisions for URM buildings – the attribute scoring method – which is intended for use in conjunction with the IEP. However, as noted earlier, this method generally requires a greater level of knowledge of a building than is typically expected or intended for an IEP.

B4.7.2 Chimneys

Experience indicates that chimneys can be vulnerable in earthquake shaking and can score less than 34*%NBS*; 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. The following approach is recommended for assessing chimneys and determining their effect on the building rating.

If a building has a chimney that is not restrained by the roof structure or other fixing at the roofline, the building should be assigned an earthquake rating of less than 34*%NBS* and the F Factor in Table IEP-3 set accordingly.

A building with a chimney should also be assigned an earthquake rating of less than 34*%NBS* (and the Factor F in Table IEP-3 set accordingly) if the chimney meets **ALL** of the following criteria:

- it is constructed of URM 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, and 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 $ZR \leq 0.2$

  where Z and R are as defined in NZS 1170.5:2004, **AND**
- if either or both of the following apply:
  - 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, **and/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.

If the engineer determines a building with a chimney is less than 34*%NBS*, he or she should record in the IEP the particular issues (from the options listed above) that led to this rating.

B4.7.3 Masonry veneers

If a masonry veneer above an egress route or public space became separated from the supporting structure, this would likely create a significant life safety hazard.

Heavy veneers in these locations consisting of stone or brick and that are thicker than the standard 110 mm units require specific investigation.

Veneers that have ties (from any code era) are considered to rate ≥34*%NBS*. Accordingly, if the presence of ties to veneers above egress routes and public thoroughfares is indicated from scanning, then a rating ≥34*%NBS* can generally be taken. For buildings of three or more storeys, the engineer will need to verify the condition and effectiveness of the veneer ties by intrusive investigation. This can be undertaken as part of an ISA or recommended for inclusion within a subsequent DSA.

A building with masonry veneer should not be rated ≥67*%NBS* without first verifying the condition and effectiveness of ties by intrusive investigation.

B4.7.4 Masonry infill panels

Infill masonry panels are typically used to form boundary walls within concrete and encased steel frames.

Prior to the early 1970s, infill masonry walls typically comprised unreinforced brick and concrete masonry blocks, mortared up against the framing elements with no seismic separation.

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 10 mm to 20 mm 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 secondary 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 score less than 34*%NBS* 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. Their impact on the regularity of the structure (horizontal and vertical) should be carefully considered. In many cases it may be difficult to determine the effect, and a DSA is recommended.

As noted in the previous section, the potential for masonry infill panels to fail out of plane when there are gaps between the panel and the perimeter framing (particularly adjacent to egressways, public spaces and thoroughfares) should be assessed and appropriate scoring and recommendations made.

B4.7.5 Heavy non-loadbearing partition walls

Heavy non-loadbearing partition walls typically comprise:

- unreinforced clay brick masonry
- hollow clay brick masonry (which can be filled or unfilled, reinforced or unreinforced), or
- concrete block masonry (which can be solid or hollow, unfilled, partially filled or fully filled, and either reinforced or unreinforced).

Common issues that affect the seismic behaviour of heavy non-loadbearing partition walls include:

- insufficient or absent restraint at the tops of the walls to prevent out-of-plane movement, and
- insufficient gaps between ends of walls and the main structure to allow for inter-storey drift.

Heavy non-loadbearing partition walls will generally be < 34*%NBS* without a detailed investigation and supporting calculations.

B4.7.6 Precast panels

Issues relating to precast panels include:

- whether they are primary structure or secondary structure
- their size
- the effect they may have on the building structure regularity (horizontal and/or vertical) if they are not adequately separated from the expected structural deformations of the structure, and/or
- the hazard they may present if they were to fall from the building. For this situation the focus will be on panels located over egress routes, public areas or neighbouring buildings.
- the detailing of the connections to the structure, and
- the condition of the fixings.

When precast panels have clearance to the building structure or are obviously built into the structural system, they may be assumed to score ≥34*%NBS*.

In order to score above 67*%NBS*, panels should be clearly recognisable as either primary or secondary structure. If it is determined that they are primary structure, the connections to the structure would be expected to be robust reflecting the actions that would need to be transferred. If secondary structure, then separations to reflect the need to accommodate the flexibility of the structure and, at the same time, provide restraint to the panels under face loading would be expected. Slotted holes should be inspected to ensure that bolts are appropriately positioned in the slots and that the connection is free to slide.

Note:

When it is apparent that precast panels do not have separation from the primary lateral structure, their effect on the primary structure (e.g. consideration of plan irregularity) should be considered. From an ISA point of view this has the same effect as assuming the panels are part of the primary structure.

B4.7.7 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 (e.g. 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 behaviour of the lateral load resisting elements.

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

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

The potential behaviour of precast floor diaphragms (and in particular hollowcore floors) has received much attention over the last decade and evidence of diaphragms under stress was seen after the 2010/2011 Christchurch earthquake sequence and in Wellington buildings following the 2016 Kaikoura earthquake. 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 rated less than 34*%NBS*.

The engineer 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’s rating is <34*%NBS*.

B4.7.8 Stairs

Stairs required for egress or above occupied areas should be considered as part of an IEP and where appropriate noted as pSSWs.

The experience of the 2010/2011 Canterbury earthquake sequence showed that some types of 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 100 mm, and with or without a definite gap. Monolithic concrete stairs in multi-storey reinforced concrete or steel frame buildings could be similarly vulnerable.

Such details, on their own, are very unlikely to make a building rate <34*%NBS* unless the stair flights are precariously supported, but their presence should result in a rating less than 67*%NBS*.

The ability of the connections of steel stair framing to withstand the inter-storey drifts needs consideration. Generally this would be very unlikely to make a building rate less than 34*%NBS.*

Where concrete stair flights are cast integrally with the floors of a building, they may influence the response of the primary structure in an earthquake, and in turn be susceptible to failure. This needs to be considered as a potential structural weakness (refer to Table BA.4).

B4.7.9 Lightweight cladding systems including curtain walls

The failure of individual panes of glass or individual lightweight cladding panels is not typically considered to be of sufficient severity to meet the criteria associated with a significant life safety hazard or damage to adjacent buildings, as defined in these guidelines. What would meet these criteria are the failure of:

- a glazing or cladding support system where large sections could fall, or
- large glass panels adjacent to egress routes.

The more likely cause for system failure of these elements (i.e. that would lead to them falling from the building) is failure of the connections to the structure due to undersizing and inadequate allowance for building movements. At the time an ISA is completed the connections are not generally available to view. It is considered that the connections are unlikely to score <34*%NBS* but that a score greater than 67*%NBS* should not be assumed unless the connections have been viewed and confirmed as reasonable.

Therefore it is considered reasonable to assume that these elements are unlikely to make the building rate <34*%NBS* but should result in a rating less than 67*%NBS* unless the connections are able to be assessed.

B4.7.10 Building services plant, tanks, etc.

In-ceiling building services and lightweight services in general are not intended to influence a building’s rating. The exceptions include heavy items such as large tanks and large items of plant which if they were to lose support could fall and create a significant life safety hazard.

If heavy items are precariously supported or have no restraint, and their failure could lead to a significant life safety hazard, they should be scored less than 34*%NBS*. If restraints have been provided it is considered reasonable to assume that the score is greater than 34*%NBS*. Robust connections and/or supports would need to be present before scoring these items over 67*%NBS*.

Tanks with hazardous contents will require special consideration.

B5. Reporting

B5.1 Covering Letter

The way the results of an ISA are reported is extremely important to make sure these are appropriately interpreted and their reliability is correctly conveyed.

Recipients of an ISA 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 any misinterpretation by building owners and/or tenants of an ISA result it is recommended that the ISA (typically expected to be in the form of an IEP) is accompanied by a covering letter. This letter should describe the:

- building
- scope of the assessment and information available for this
- rationale for the various decisions made
- limitations of the process, and
- implications of the result.

Refer to Appendix BC for a template covering letter showing how these aspects might be addressed.

When the results of a TA-initiated ISA are being reported, building owners must be advised of the limitations of the process. If the building has been found to be not earthquake prone and the IEP report is provided, it should be made clear that the primary objective was to determine the earthquake-prone status and not necessarily the rating for the building.

B5.2 Technical Summary

A stand-alone technical summary should also be provided as part of reporting an ISA. This should follow the template that can be found in Part A to achieve consistency in the reporting of assessment outputs and to allow comparisons between assessments of multiple buildings.

Note:

Providing a technical summary in a consistent form is considered an important part of an ISA and is a requirement of an engineering assessment completed in accordance with the EPB methodology to identify earthquake-prone buildings. This summary is considered to be essential for TAs managing the requirements of the earthquake-prone building legislation, and potentially very useful for owners of multiple buildings, and for future engineers looking at the same building.

The same template should be used to record the results of a DSA.

References

AS/NZS 1170.0:2002. *Structural design actions – Part 0: General principles*, Standards Australia/Standards New Zealand.

EPB methodology. The methodology to identify earthquake-prone buildings, Ministry of Business, Innovation and Employment, July 2017

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Appendix BA: Initial Evaluation Procedure – IEP

This appendix summarises the eight steps involved in the IEP and includes the necessary worksheets (Tables IEP-1 to IEP-5). It also includes information tables and figures required for this assessment.

Section BA.2 provides further guidance and commentary to support the IEP process.

Note:

Working spreadsheet versions of Tables IEP-1 to IEP-5 are available from the EQ-assess website at www.EQ-Assess.org.nz.

BA.1 Summary of Step-by-Step Procedures

Step 1 Collect general information

Use Table IEP-1.

1.1 Add photos of the building exterior for all visible exterior faces, showing features.

1.2 Draw a rough sketch of the building plan that can be ascertained from the exterior of the building, noting relevant features.

1.3 List any particular features that would be relevant to the seismic performance of the building.

Note if the building has been strengthened in the past and the level of strengthening targeted at that time.

Record the characteristics of any adjacent buildings if the separation is not sufficient to prevent pounding.

1.4 Note any information sources used to complete the assessment.

Note:

As noted in Section B3.2, Steps 2 and 3 may not be appropriate for URM buildings. Appendix BB provides an attribute scoring method that can be used for these buildings.

Step 2 Determine baseline percentage of new building standard $(\%\boldsymbol{NBS})_{\mathbf{b}}$

Use Table IEP-2. **An assessment is required for each orthogonal direction.**

2.1 Determine $(\%NBS)_{\mathrm{nom}}$ = A x B x C x D as shown (making any adjustments to account for reaching minimum lateral coefficients in either the design or current Standards), unless the building is post-2004; in which case set this equal to 100% and go to Step 2.7.

2.2 a) Refer to NZS 1170.5:2004 for near fault factor.

b) Calculate near fault scaling factor.

2.3 a) Refer to NZS 1170.5:2004 for hazard factor.

b) Calculate hazard scaling factor (Factor F).

2.4 a) Refer to original design for design importance level if date of design is post-1984; otherwise set to 1.0. For buildings designed prior to 1976 and known to have been designed as a public building I may be taken as 1.25.

b) Refer to original design for design risk factor or set to 1.0.

c) Determine current return period factor from Table BA.1.

d) Calculate return period scaling factor (Factor G).

2.5 a) Assess available ductility for building (refer to Table BA.2 for maximum allowable).

b) Obtain ductility scaling factor (Factor H) from Table BA.3. Set to 1.0 for post 1976 buildings.

2.6 a) Obtain structural performance factor from Figure BA.2, or from the appropriate materials Standard, whichever requires the greater value.

b) Calculate structural performance scaling factor (Factor I).

2.7 $(\%NBS)_{\mathrm{b}}$ = $(\%NBS)_{\mathrm{nom}}$ x E x F x G x H x I as shown.

Step 3 Determine performance achievement ratio (PAR)

Use Table IEP-3. An assessment is required for each orthogonal direction.

3.1 to 3.5
Assess effect on structure of each potential CSW.
(Choose from the factors given – do not interpolate. Note that a 'severe' categorisation for the general factors considered in the IEP should not be confused with a potential SSW determined in Step 8 and as described in Section B2.)

3.6 Note that the effect of any known potential CSWs not listed is intended to be via Factor F.

Refer to Section BA.2.3 and B4 for further guidance as required.

3.7 PAR = A x B x C x D x E x F as shown.

Step 4 Determine the percentage of new building standard, *%NBS*

Use Table IEP-4.

4.1 Compare product of PAR x $(\%NBS)_{\mathrm{b}}$ for each direction.

4.2 *%NBS* = the lowest value of PAR x $(\%NBS)_{\mathrm{b}}$.

4.3 Review and adjust as necessary.

Step 5 Is the earthquake rating less than 34*%NBS*?

Use Table IEP-4. Assess on basis of *%NBS* in Step 4.

Step 6 Is the building potentially earthquake risk?

Use Table IEP-4. Assess on basis of *%NBS* in Step 4.

6.1 If *%NBS* $\geq$ 67 then it is not considered to be a significant earthquake risk.

6.2 If *%NBS* < 67 then a DSA is recommended before confirming the building as earthquake risk.

Step 7 Provide provisional grading based on IEP

Use Table IEP-4. Assess on basis of *%NBS* in Step 4.

7.1 Grade building based on *%NBS* earthquake rating using the relative risk table provided in Part A. Use the lowest result from consideration of both orthogonal directions.

Step 8 Note any identified potential SSWs that could result in significant risk to a significant number of occupants

Use Table IEP-5.

8.1 If the number of storeys is less than or equal to three it is assumed that the number of occupants is not significant and no further consideration of this issue is required for the ISA.

8.2 If the floors and/or the roof are not of heavy (concrete) construction it is assumed that the risk is not significant and no further consideration of this issue is required for the ISA.

If the number of storeys is greater than three and the floors and/or roof are of heavy construction then the presence of the listed potential SSWs should be noted. Note that the potential stair issue is only activated in the list if the number of storeys is greater than or equal to six.

Table IEP-1: Initial Evaluation Procedure – Step 1

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 1**

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedure set out in the "The Seismic Assessment of Existing Buildings" Technical Guidelines for Engineering Assessments, July 2017. This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-1 Initial Evaluation Procedure Step 1

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

NOTE: THERE ARE MORE PHOTOS ON PAGE 1a ATTACHED

1.2 Sketches (plans etc, show items of interest)

NOTE: THERE ARE MORE SKETCHES ON PAGE 1a ATTACHED

1.3 List relevant features (Note: only 10 lines of text will print in this box. If further text required use Page 1a)

1.4 Note information sources Tick as appropriate

Visual Inspection of Exterior	☐	Specifications	☐
Visual Inspection of Interior	☐	Geotechnical Reports	☐
Drawings (note type)	☐	Other (list)	☐

Table IEP-1a: Carry-over page, if required

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 1a**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-1a Additional Photos and Sketches

Add any additional photographs, notes or sketches required below:

Note: print this page separately

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedure set out "The Seismic Assessment of Existing Buildings" Technical Guidelines for Engineering Assessments, July 2017. This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

Table IEP-2: Initial Evaluation Procedure – Step 2

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 2**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-2 Initial Evaluation Procedure Step 2

Step 2 - Determination of *(%NBS)*$_b$

(Baseline *(%NBS)* for particular building - refer Section B5)

2.1 Determine nominal *(%NBS)* = *(%NBS)*$_{nom}$

	Longitudinal	Transverse
a) Building Strengthening Data		
Tick if building is known to have been strengthened in this direction	☐	☐
If strengthened, enter percentage of code the building has been strengthened to	N/A	N/A
b) Year of Design/Strengthening, Building Type and Seismic Zone		
Pre 1935	◉	◉
1935-1965	○	○
1965-1976	○	○
1976-1984	○	○
1984-1992	○	○
1992-2004	○	○
2004-2011	○	○
Post Aug 2011	○	○
Building Type:	▼	▼
Seismic Zone:	**Not applicable**	**Not applicable**
c) Soil Type		
From NZS1170.5:2004, Cl 3.1.3 :	▼	▼
From NZS4203:1992, Cl 4.6.2.2 : (for 1992 to 2004 and only if known)	**Not applicable**	**Not applicable**
d) Estimate Period, *T*		
h_n =	25	25 m
A_c =	1.00	1.00 m^2
Moment Resisting Concrete Frames: $T = \max\{0.09h_n^{0.75}, 0.4\}$	◉	◉
Moment Resisting Steel Frames: $T = \max\{0.14h_n^{0.75}, 0.4\}$	○	○
Eccentrically Braced Steel Frames: $T = \max\{0.08h_n^{0.75}, 0.4\}$	○	○
All Other Frame Structures: $T = \max\{0.06h_n^{0.75}, 0.4\}$	○	○
Concrete Shear Walls $T = \max\{0.09h_n^{0.75}/A_c^{0.5}, 0.4\}$	○	○
Masonry Shear Walls: $T \le 0.4$sec	○	○
User Defined (input Period):	○	○
T:	1.01	1.01

Comment:

Note: 1.00 wi... entered...

Where h_n = height in metres from the base of the structure to the uppermost seismic weight or mass.

			Longitudinal	Transverse
e) Factor A:	Strengthening factor determined using result from (a) above (set to 1.0 if not strengthened)	**Factor A:**	1.00	1.00
f) Factor B:	Determined from NZSEE Guidelines Figure 3A.1 using results (a) to (e) above	**Factor B:**	0.03	0.03
g) Factor C:	For reinforced concrete buildings designed between 1976-84 Factor C = 1.2, otherwise take as 1.0.	**Factor C:**	1.00	1.00
h) Factor D:	For buildings designed prior to 1935 Factor D = 0.8 except for Wellington and Napier (1931-1935) where Factor D may be taken as 1.0, otherwise take as 1.0.	**Factor D:**	1.00	1.00
***(%NBS)*$_{nom}$ = AxBxCxD**		***(%NBS)*$_{nom}$**	3%	3%

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Table IEP-2: Initial Evaluation Procedure – Step 2 continued

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 3**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-2 Initial Evaluation Procedure Step 2 continued

2.2 Near Fault Scaling Factor, Factor E

If $T \leq 1.5$sec, Factor E = 1

			Longitudinal	Transverse
a) Near Fault Factor, *N(T,D)* (from NZS1170.5:2004, Cl 3.1.6)		N(T,D):	1	1
b) Factor E	= 1/N(T,D)	**Factor E:**	1.00	1.00

2.3 Hazard Scaling Factor, Factor F

a) Hazard Factor, *Z,* for site

Location: Akaroa — Refer right for user-defined locations

Z =	0.3	(from NZS1170.5:2004, Table 3.3)
Z_{1992} =	0.6	(NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))
Z_{2004} =	0.22	(from NZS1170.5:2004, Table 3.3)

b) Factor F

For pre 1992 = $1/Z$

For 1992-2011 = Z_{1992}/Z

For post 2011 = Z_{2004}/Z

	Longitudinal	Transverse
Factor F:	3.33	3.33

2.4 Return Period Scaling Factor, Factor G

a) Design Importance Level, I

(Set to 1 if not known. For buildings designed prior to 1965 and known to be designed as a public building set to 1.25. For buildings designed 1965-1976 and known to be designed as a public building set to 1.33 for Zone A or 1.2 for Zone B. For 1976-1984 set I value.)

b) Design Risk Factor, R_o

(set to 1.0 if other than 1976-2004, or not known)

c) Return Period Factor, R

(from NZS1170.0:2004 Building Importance Level) *Choose Importance Level* (● 1 ○ 2 ○ 3 ○ 4) / (● 1 ○ 2 ○ 3 ○ 4)

d) Factor G = IR_o/R

	Longitudinal	Transverse
I =	1	1
R_o =	1	1
R =	0.5	0.5
Factor G:	2.00	2.00

2.5 Ductility Scaling Factor, Factor H

a) Available Displacement Ductility Within Existing Structure

Comment:

	Longitudinal	Transverse
μ =	2.00	2.00

b) Factor H

		Longitudinal k_μ	Transverse k_μ
For pre 1976 (maximum of 2)	=	2.00	2.00
For 1976 onwards	=	1	1
Factor H:		2.00	2.00

(where k_μ is NZS1170.5:2004 Inelastic Spectrum Scaling Factor, from accompanying Table 3.3)

2.6 Structural Performance Scaling Factor, Factor I

a) Structural Performance Factor, S_p

(from accompanying Figure 3.4)

Tick if light timber-framed construction in this direction ☐ ☐

b) Structural Performance Scaling Factor = $1/S_p$

	Longitudinal	Transverse
S_p =	0.70	0.70
Factor I:	1.43	1.43

Note Factor B values for 1992 to 2004 have been multiplied by 0.67 to account for Sp in this period

2.7 Baseline *%NBS* for Building, *(%NBS)*$_b$
(equals $(\%NBS)_{nom}$ x E x F x G x H x I)

Longitudinal	Transverse
55%	55%

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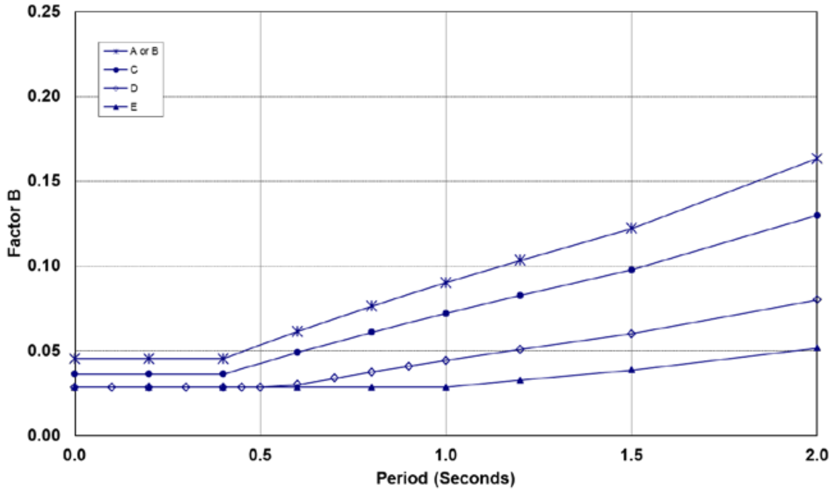


Figure BA.1(a): Factor B Pre-1965, All Zones

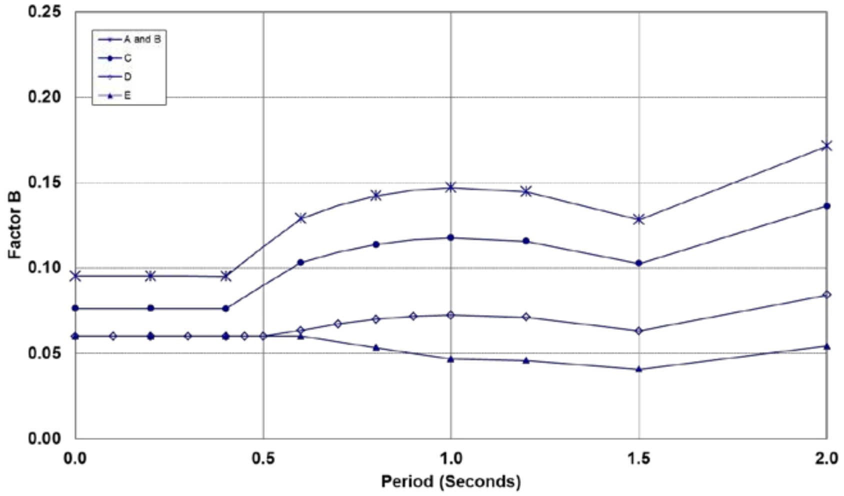


Figure BA.1(b): Factor B 1965-76, Zone A

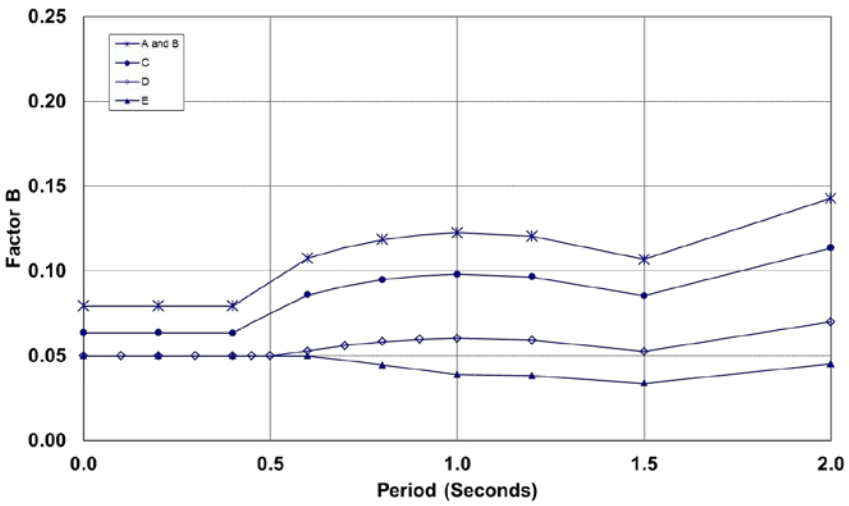


Figure BA.1(c): Factor B 1965-76, Zone B

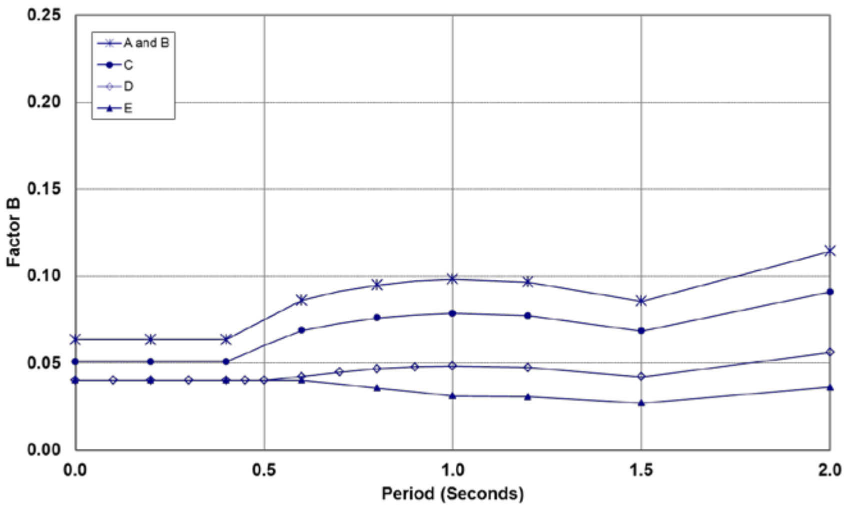


Figure BA.1(d): Factor B 1965-76, Zone C

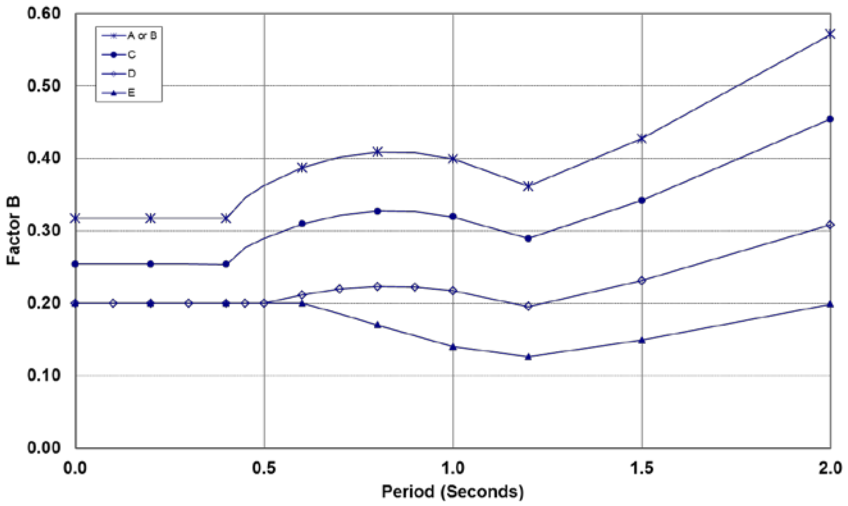


Figure BA.1(e): Factor B 1976-92, Zone A

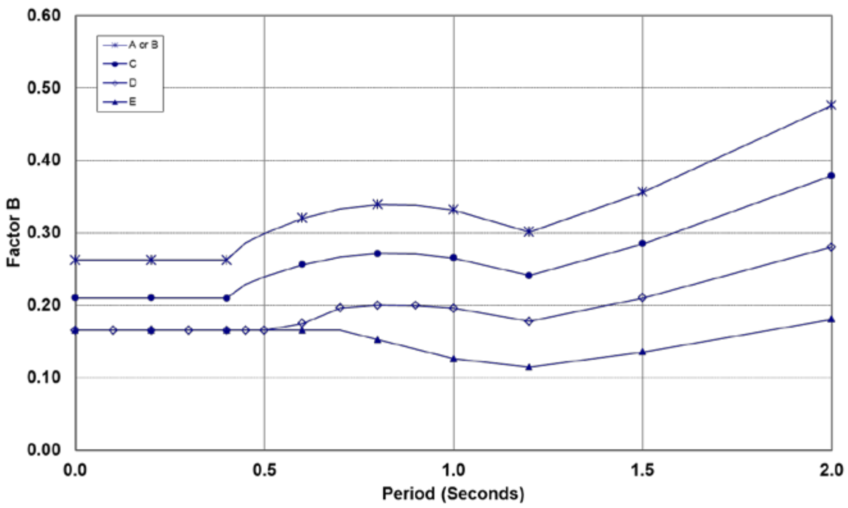


Figure BA.1(f): Factor B 1976-92, Zone B

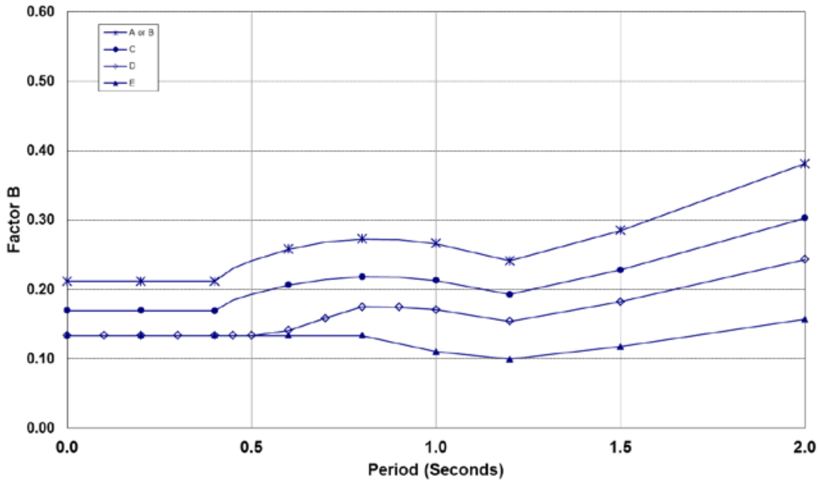


Figure BA.1(g): Factor B 1976-92, Zone C

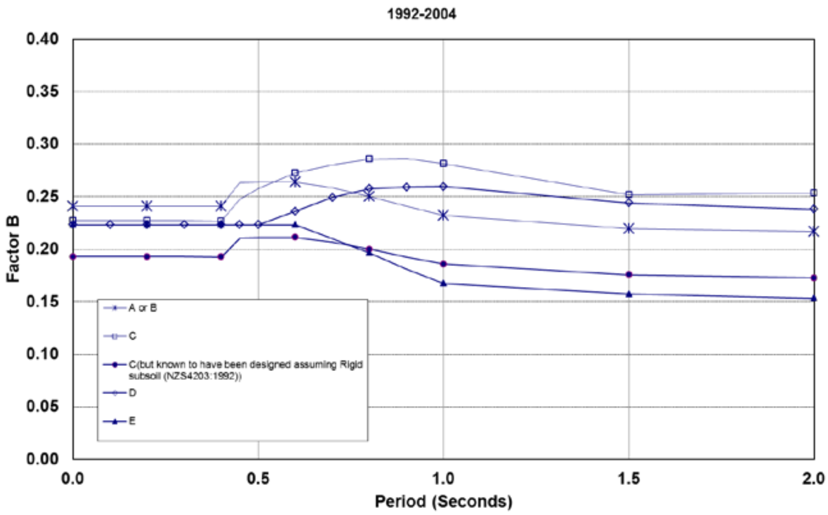


Figure BA.1(h): Factor B 1992-2004

Figure BA.1: Factor B for different building design vintages

Table BA.1: Current return period factor, *R*

Importance level	Comments	*R*
1	Structures presenting a low degree of hazard to life and other property	0.5
2, or if otherwise unknown	Normal structures and structures not in other importance levels	1.0
3	Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds	1.3
4	Structures with special post-disaster functions	1.8
5	Special structures (outside the scope of this Standard — acceptable probability of failure to be determined by special study)	

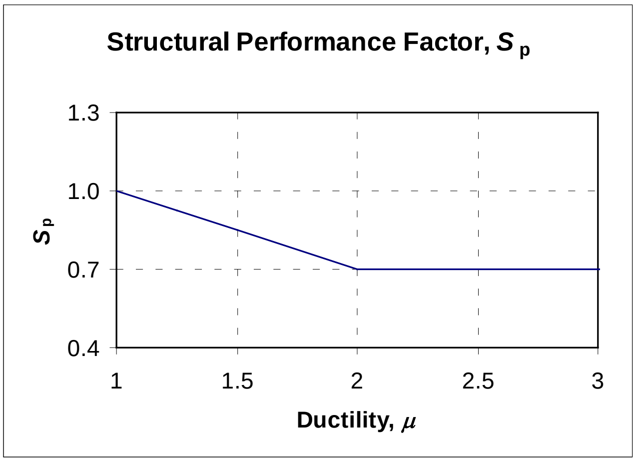
Table BA.2: Maximum ductility factors to be used in the IEP

Structure type	Maximum ductility factor			
	Pre-1935	1935-65	1965-76	>1976
Unstrengthened URM buildings	1.5	1.5	N/A	N/A
All other buildings	2	2	2	6

Table BA.3: Ductility scaling factor, Factor H

`	Structural ductility factor, μ							
	1.0		1.25		1.50		2	
Soil Type	A,B,C & D	E	A,B,C & D	E	A,B,C & D	E	A,B,C & D	E
Period, *T*								
≤ 0.40s	1	1	1.14	1.25	1.29	1.50	1.57	1.70
0.50s	1	1	1.18	1.25	1.36	1.50	1.71	1.75
0.60s	1	1	1.21	1.25	1.43	1.50	1.86	1.80
0.70s	1	1	1.25	1.25	1.50	1.50	2.00	1.85
0.80s	1	1	1.25	1.25	1.50	1.50	2.00	1.90
≥1.00s	1	1	1.25	1.25	1.50	1.50	2.00	2.00

Note:
For buildings designed post-1976, Factor H shall be taken as 1.0.



Where S_p is the structural performance factor from NZS 1170.5:2004, Clause 4.4.2 for light framed timber structures S_p = 0.5

Figure BA.2: Structural performance factor, S_p

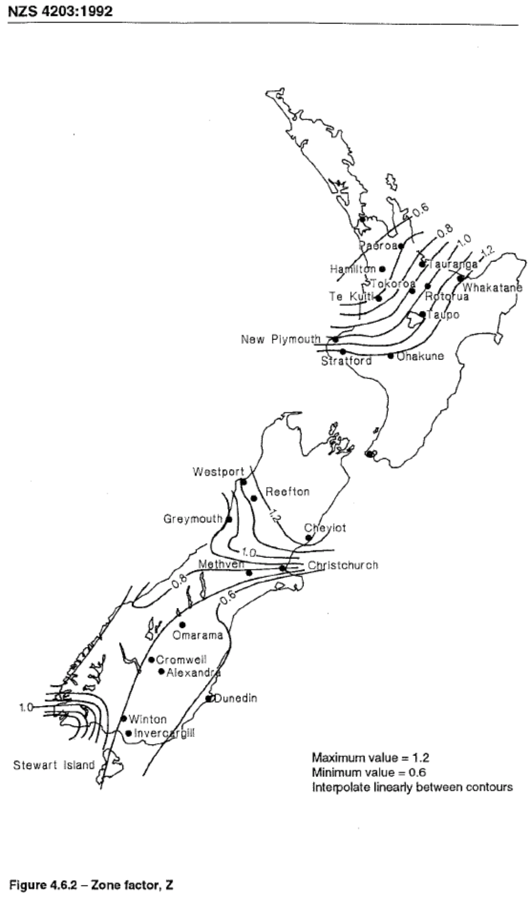


Figure BA.3(a): NZS 4203:1984, NZS 4203:1976 and NZSS 1900:1965 Chapter 8

Figure BA.3(b): NZS 4203:1992

Figure BA.3: Extracts from previous Standards showing seismic zoning schemes

Table IEP-3: Initial Evaluation Procedure – Step 3

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 4**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-3 Initial Evaluation Procedure Step 3

Step 3 - Assessment of Performance Achievement Ratio (PAR)
(Refer Appendix B - Section B3.2)

a) Longitudinal Direction

potential CSWs	**Effect on Structural Performance** (Choose a value - Do not interpolate)			**Factors**
3.1 Plan Irregularity				
Effect on Structural Performance	○ *Severe*	○ *Significant*	◉ *Insignificant*	**Factor A** 1.0
Comment				
3.2 Vertical Irregularity				
Effect on Structural Performance	○ *Severe*	○ *Significant*	◉ *Insignificant*	**Factor B** 1.0
Comment				
3.3 Short Columns				
Effect on Structural Performance	○ *Severe*	○ *Significant*	◉ *Insignificant*	**Factor C** 1.0
Comment				

3.4 Pounding Potential
(Estimate D1 and D2 and set D = the lower of the two, or 1.0 if no potential for pounding, or consequences are considered to be minimal)

a) Factor D1: - Pounding Effect

> *Note:*
> ***Values given assume the building has a frame structure. For stiff buildings (eg shear walls), the effect of pounding may be reduced by taking the coefficient to the right of the value applicable to frame buildings.***

Factor D1 For Longitudinal Direction: 1.0

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 1	◉ 1	○ 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8
Comment			

b) Factor D2: - Height Difference Effect

Factor D2 For Longitudinal Direction: 1.0

Table for Selection of Factor D2	Severe	Significant	Insignificant
	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	○ 0.4	○ 0.7	◉ 1
Height Difference 2 to 4 Storeys	○ 0.7	○ 0.9	○ 1
Height Difference < 2 Storeys	○ 1	○ 1	○ 1
Comment			

Factor D 1.0

3.5 Site Characteristics - *Stability, landslide threat, liquefaction etc as it affects the structural performance from a life-safety perspective*

Effect on Structural Performance	◉ *Severe*	○ *Significant*	○ *Insignificant*	**Factor E** 0.5
Comment				

3.6 Other Factors - *for allowance of all other relevant characterstics of the building*

For ≤ 3 storeys - Maximum value 2.5
otherwise - Maximum value 1.5.
No minimum.

Factor F 1.0

Record rationale for choice of Factor F:

Comment

3.7 Performance Achievement Ratio (PAR)
(equals **A x B x C x D x E x F**)

	PAR
Longitudinal	**0.50**

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Table IEP-3: Initial Evaluation Procedure – Step 3 continued

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 5**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-3 Initial Evaluation Procedure Step 3

Step 3 - Assessment of Performance Achievement Ratio (PAR)
(Refer Appendix B - Section B3.2)

b) Transverse Direction

Factors

potential CSWs **Effect on Structural Performance**
(Choose a value - Do not interpolate)

3.1 Plan Irregularity
Effect on Structural Performance ○ *Severe* ◉ *Significant* ○ *Insignificant* **Factor A** 0.7
Comment

3.2 Vertical Irregularity
Effect on Structural Performance ○ *Severe* ◉ *Significant* ○ *Insignificant* **Factor B** 0.7
Comment

3.3 Short Columns
Effect on Structural Performance ○ *Severe* ◉ *Significant* ○ *Insignificant* **Factor C** 0.7
Comment

3.4 Pounding Potential
(Estimate D1 and D2 and set D = the lower of the two, or 1.0 if no potential for pounding, or consequences are considered to be minimal)

a) Factor D1: - Pounding Effect

Note:
Values given assume the building has a frame structure. For stiff buildings (eg shear walls), the effect of pounding may be reduced by taking the coefficient to the right of the value applicable to frame buildings.

Factor D1 For Transverse Direction: 0.7

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 1	○ 1	○ 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	◉ 0.7	○ 0.8

Comment

b) Factor D2: - Height Difference Effect

Factor D2 For Transverse Direction: 0.4

Table for Selection of Factor D2	Severe	Significant	Insignificant
	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	◉ 0.4	○ 0.7	○ 1
Height Difference 2 to 4 Storeys	○ 0.7	○ 0.9	○ 1
Height Difference < 2 Storeys	○ 1	○ 1	○ 1

Comment

Factor D 0.4

3.5 Site Characteristics - *Stability, landslide threat, liquefaction etc as it affects the structural performance from a life-safety perspective*

Effect on Structural Performance ○ *Severe* ○ *Significant* ◉ *Insignificant* **Factor E** 1.0
Comment

3.6 Other Factors - *for allowance of all other relevant characterstics of the building* **For ≤ 3 storeys - Maximum value 2.5 otherwise - Maximum value 1.5. No minimum.** **Factor F** 1.00
Record rationale for choice of Factor F:
Comment

PAR

3.7 Performance Achievement Ratio (PAR)
(equals **A x B x C x D x E x F**) **Transverse** **0.14**

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedure set out in "The Seismic Assessment of Existing Buildings" Technical Guidelines for Engineering Assessments, July 2017. This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

Table IEP-4: Initial Evaluation Procedure – Steps 4, 5, 6 and 7

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 6**

Street Number & Name:		Job No.:	
AKA:		By:	
Name of building:		Date:	
City:		Revision No.:	

Table IEP-4 Initial Evaluation Procedure Steps 4, 5, 6 and 7

Step 4 - Percentage of New Building Standard *(%NBS)*

		Longitudinal	Transverse
4.1	**Assessed Baseline *%NBS (%NBS)*$_b$** (from Table IEP - 1)	55%	55%
4.2	**Performance Achievement Ratio (PAR)** (from Table IEP - 2)	0.50	0.14
4.3	**PAR x Baseline *(%NBS)*$_b$**	25%	15%
4.4	**Percentage New Building Standard *(%NBS)* - Seismic Rating** (Use lower of two values from Step 4.3)		15%

Step 5 - Is *%NBS* < 34? YES

Step 6 - Potentially Earthquake Risk (is *%NBS* < 67)? YES

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade E

Additional Comments (items of note affecting IEP based seismic rating)

Relationship between Grade and *%NBS* :

Grade:	A+	A	B	C	D	E
%NBS:	> 100	100 to 80	79 to 67	66 to 34	< 34 to 20	< 20

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedure set out in "The Seismic Assessment of Existing Buildings" Technical Guidelines for Engineering Assessments, July 2017. This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

Table IEP-5: Initial Evaluation Procedure – Step 8

Initial Evaluation Procedure (IEP) Assessment - Completed for {Client/TA} **Page 7**

Street Number & Name:		**Job No.:**	
AKA:		**By:**	
Name of building:		**Date:**	
City:		**Revision No.:**	

Table IEP-5 Initial Evaluation Procedure Step 8

Step 8 - Identification of potential Severe Structural Weaknesses (SSWs) that could result in significant risk to a significant number of occupants

8.1	**Number of storeys above ground level**	6
8.2	**Presence of heavy concrete floors and/or concrete roof? (Y/N)**	Y

Potential Severe Structural Weaknesses (SSWs):

Note: Options that are greyed out are not applicable and need not be considered.

Occupancy not considered to be significant - no further consideration required

Risk not considered to be significant - no further consideration required

The following potential Severe Structural Weaknesses (SSWs) have been identified in the building that could result in significant risk to a significant number of occupants:

1. None identified ☐

2. Weak or soft storey (except top storey) ☐

3. Brittle columns and/or beam-column joints the deformations of which are not constrained by other structural elements ☐

4. Flat slab buildings with lateral capacity reliant on low ductility slab-to-column connections ☐

5. No identifiable connection between primary structure and diaphragms ☐

6. Ledge and gap stairs ☐

IEP Assessment Confirmed by ______ **Signature**

______ **Name**

______ **CPEng. No**

WARNING!! *This initial evaluation has been carried out solely as an initial seismic assessment of the building following the procedure set out in "The Seismic Assessment of Existing Buildings" Technical Guidelines for Engineering Assessments, July 2017. This spreadsheet must be read in conjunction with the limitations set out in the accompanying report, and should not be relied on by any party for any other purpose. Detailed inspections and engineering calculations, or engineering judgements based on them, have not been undertaken, and these may lead to a different result or seismic grade.*

BA.2 Guidance and Commentary

BA.2.1 Step 1 – Collect general information (Table IEP-1)

The first step in the IEP should be to collect relevant information necessary to carry out the assessment and to record this as the basis of the assessment. It is a fundamental premise of the IEP that limited definitive information is likely to be available and the assessment will necessarily be made on the basis of a visual inspection of only the exterior of the building.

Photographs of the building should be taken as part of the IEP and should form part of the permanent record. Likewise, a record of the features observed and the extent of information that was available at the time of the assessment will be important considerations if the assessment is questioned in the future. Table IEP-1 provides a means of recording this information.

BA.2.2 Step 2 – Determine baseline percentage of new building standard $(\%NBS)_b$ (Table IEP-2)

Introduction

One of the first questions typically asked regarding existing buildings is how their overall expected seismic resistance compares to a building designed to the standard required for new buildings as specified in NZS 1170.5:2004. The comparison available through the IEP provides a simple and convenient measure of relative performance in earthquakes; provided that the limitations of the IEP are recognised (refer to Section B3.4).

It must be emphasised that the percentage figure derived, $(\%NBS)_b$, is a first step in any evaluation. It gives only an indication of the likely situation. It does not take full account of the particular characteristics of a building, which may be beneficial (as in the case when extra walls are added for architectural reasons but are nevertheless significant structural elements). It also does not take into account the effect of potential CSWs that can greatly reduce the overall seismic resistance predicted by the $(\%NBS)_b$ calculation.

Approach

There are a number of variables that feed into the calculation of a baseline percentage current code ratio $(\%NBS)_b$. These include:

- the natural period of vibration of the building
- its location in relation to seismic hazard
- the site subsoil characteristics
- the vintage or code to which the building was designed or strengthened. If the building has been strengthened, the level of strengthening is required.
- the available ductility in the building, and
- the design and current importance level designation of the building.

Different codes have had different requirements for design over the years. In broad terms these amount to:

- pre-1935: no seismic design (except for buildings in Wellington)
- pre-1965: typically design for 0.1 g lateral force
- 1965-1976: design to NZSS 1900:1965, Chapter 8
- 1976-1992: design to NZS 4203:1976, with some changes to risk and importance factors and for reinforced concrete structures in 1984
- 1992-2004: design to NZS 4203:1992
- post-2004: design to NZS 1170.5:2004.

Note:

Each orthogonal direction should be assessed separately unless it is clear from the start which governs.

Definitions

$(\%NBS)_{\mathrm{nom}} \Rightarrow$ The assessed nominal performance compared to NZS 1170.5:2004, assuming ductility of 1.0, hazard factor of 1.0, near fault factor of 1.0, return period factor of 1.0, and structural performance factor of 1.0 (refer to Table IEP-1).

$(\%NBS)_{\mathrm{b}} \Rightarrow$ The baseline $(\%NBS)$ modifies $(\%NBS)_{\mathrm{nom}}$ to account for assessed ductility, location (hazard factor and near fault factor from NZS 1170.5:2004) and occupancy category (i.e. return period factor) but assuming a good structure complying with the relevant code provisions at the time it was built.

The resulting value of $(\%NBS)_{\mathrm{b}}$ may be regarded as a measure of the seismic capacity of a well designed and constructed regular building of its type and vintage on the site in question. It is a "yardstick" against which to measure the effect of critical structural weaknesses that may exist in a particular building of the same type.

Note that an assessment of the likely ductility is required but the choice of ductility for post 1976 buildings will have little effect on the IEP score. In formulating the process it has been assumed that what constitutes available ductility has not changed significantly since 1976. If this is not correct the adjustment should be via Factor F in Step 3.2.

PAR $\Rightarrow$ The performance achievement ratio (PAR) may be regarded as the ratio of the performance of the particular building, as inspected, in relation to a well designed and constructed regular building of its type and vintage on the site in question that just meets the requirements of the code of the day. Therefore, such a building would have a PAR of 1.0 (refer to Table IEP-3).

It is expected that all known issues (including for those items that would be considered as parts of the building but nevertheless would present a life safety risk should they fail) will be included in the assessment of PAR.

$\%NBS \Rightarrow$ Percentage of new building standard, $\%NBS$. This adjusts $(\%NBS)_{\mathrm{b}}$ to account for particular characteristics of the building, especially SWs (pCSWs), (refer to Table IEP-4).

Note:

$\%NBS$ = $(\%NBS)_{\mathrm{b}}$ x Performance Achievement Ratio (PAR)

= a relative measure, in percentage terms, of the earthquake performance of the building under consideration with respect to NZS 1170.5:2004, taking into account SWs and other relevant features.

Step 2.1: Determine nominal percentage of new building standard $(\%\boldsymbol{NBS})_{\mathbf{nom}}$

Use the steps (a) to (g) to calculate $(\%NBS)_{\mathrm{nom}}$ using the following equation:

$$(\%NBS)_{\mathrm{nom}} = A^{*}B^{*}C^{*}D \qquad \text{…BA.1}$$

a) Determine code used in design of building:

Note:

If the building is known to have been strengthened, adjust $(\%NBS)_{\mathrm{nom}}$ for an appropriate level of strengthening.

- pre-1935: refer to discussion in (f) below.
- pre-1965 (0.08 g uniform load or 0.06 g applied as a triangular load)
- 1965-1976 (NZSS1900, Chapter 8):
  - Zone A
  - Zone B
  - Zone C
- 1976-1992 (NZS 4203:1976 or NZS 4203:1984)
  - Zone A
  - Zone B
  - Zone C

  For concrete structures designed to NZS 4203:1976 (refer also to (e) below).
- 1992-2004 (NZS 4203:1992), and
- Post-2004 (NZS 1170.5:2004).

b) Determine soil type at the site:

- Use NZS 1170.5:2004 classifications:
  - Class A – Strong rock
  - Class B – Rock
  - Class C – Shallow soil sites
  - Class D – Deep or soft soil sites
  - Class E – Very soft soil sites.

c) Assess period of building:

- Use any recognised method.
- Note that accurate analysis is not warranted in many cases since results are not highly sensitive to changes in period. Refer to Figure BA.1 for an indication of the variation.
- Simplified period calculations given in Table IEP-2 come from the commentary of NZS 1170.5:2004 with an additional limit on A_c.

d) Use the appropriate part of Figure BA.1 to determine Factor B.

e) Concrete buildings designed to NZS 4203 up to 1984 were required to be designed using a structural material factor, M = 1.0. This was amended in NZS 4203:1984 to M = 0.8; hence the adjustment required by Factor C. Take Factor C as 1.0 for buildings outside the date range 1976 to 1984.

f) Prior to 1935, no earthquake provisions were in place in New Zealand except for Wellington and in Napier (post the Hawkes Bay 1931 Earthquake). While it would be possible to discount completely the seismic performance of buildings designed prior to 1935 this is clearly too severe. The approach taken in the IEP is to assume that buildings designed in Wellington prior to 1935 and in Napier in the period 1931 to 1935 will perform at least as well as those designed to NZSS 95:1939 as they are likely to have been subjected to some design for earthquakes. Elsewhere a 20% penalty has been included (Factor D) to reflect that these buildings would not have been required to be designed for earthquakes. It is expected that major deficiencies, if any, will be picked up in the assessment of PAR. For post-1935 buildings take Factor D as 1.0.

Step 2.2: Determine near fault scaling factor (Factor E)

a) Use NZS 1170.5:2004 to determine the $N(T, D)$ value applicable for a new building at the site of the existing one under consideration.

Step 2.3: Determine hazard scaling factor (Factor F)

a) Use NZS 1170.5:2004 to determine the hazard factor, Z, for the site.

b) For 1992-2004 also determine the zone factor, Z, for the site from NZS 4203:1992 (refer to accompanying Figure BA.3(b)).

Step 2.4: Determine return period scaling factor (Factor G)

a) and b) Enter design values for I and R_0, if known. Otherwise enter 1.0. For buildings designed pre-1976 and known to have been designed as public buildings, I may be taken as 1.25.

c) Use NZS 1170.0:2002 (accompanying Table BA.1) to determine the building's current importance level and enter the appropriate return period factor from Table BA.1.

d) Calculate the return period scaling factor.

Step 2.5: Determine ductility scaling factor (Factor H)

a) Assess overall ductility available in the building in question (refer to Table BA.2 for maximum values).

b) Read the ductility scaling factor from Table BA.3.

For 1976 onwards the ductility is effectively included in the appropriate part of Figure BA.2; therefore set this as 1.0.

For buildings designed before 1976 take the value from within the table. This value varies with period and soil type and is effectively k_μ from NZS 1170.5:2004.

Step 2.6: Determine structural performance scaling factor (Factor I)

Use NZS 1170.5:2004 or the appropriate materials Standard (whichever provides the higher value) to determine the structural performance factor (refer to Figure BA.2).

Step 2.7: Determine baseline percentage of new building standard for building $(\%NBS)_\mathbf{b}$

a) Use values from Steps 2.1 to 2.7 to calculate $(\%NBS)_\text{b}$ using the following equation:

$$(\%NBS)_\text{b} = (\%NBS)_\text{nom} =^* E^*F^*G^*H^*I \qquad \text{…BA.2}$$

$$(\%NBS)_\text{b} = (\%NBS)_\text{nom} * \frac{1}{N(T,D)} * \left(\frac{1}{Z} \text{ or } \frac{Z_{1992}}{Z}\right) * \frac{IR_0}{R} * (\mu \text{ or } 1) * \frac{1}{S_\text{p}} \qquad \text{…BA.3}$$

where:

$(\%NBS)_\text{b}$	=	is the baseline percentage capacity of the building assuming regular, complying construction
$(\%NBS)_\text{nom}$	=	the nominal value of $(\%NBS)$ which assumes $N(T,D) = 1.0,\ Z = 1.0$

$R = 1.0,\ \mu = 1.0$, and $S_p = 1.0$

$N(T, D)$	=	the near fault factor from NZS 1170.5:2004
Z	=	the hazard factor from NZS 1170.5:2004
Z_{1992}	=	the zone factor from NZS 4203:1992 (for 1992-2004 buildings only)
R	=	the return period factor from the accompanying Table BA.1
R_0	=	the risk factor used for the design. If it is not known with certainty, R_0=1
I	=	the importance factor used for the design of the building, applicable for 1965-1984 buildings only and only if known with certainty; otherwise take as = 1.0. For buildings designed 1965-1976 as public buildings take $I = 1.25$; otherwise take as $= 1.0$
k_μ	=	the structural ductility scaling factor from accompanying Table BA.3. Note that μ cannot be greater than the values given in Table BA.2.
S_p	=	the structural performance factor applicable to the type of building under consideration (refer to Figure BA.2).

Factor B

The above procedure allows calculation of $(\%NBS)_b$ for a particular type of building providing its location and original design code are known, and an assessment of the available ductility is made.

The values for Factor B shown in Figures BA.1(a) to (h) are based on:

- near fault factor of 1.0
- hazard factor of 1.0
- return period factor of 1.0
- ductility of 1.0
- structural performance factor of 1.0.

The values for Factor B shown are the ratios of the NZS 1170.5:2004 coefficient on the above basis and the coefficient that comes from the Standard used in design (that depends on date of design). Refer to Figure BA.4.

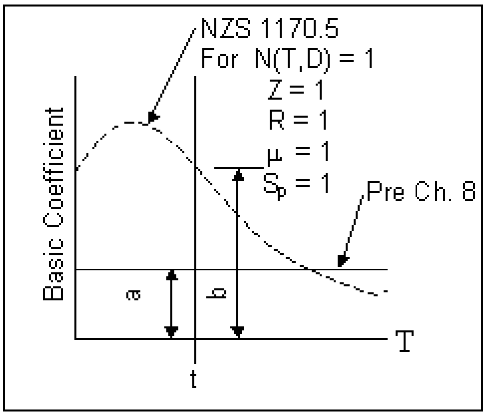


Figure BA.4(a): Pre-NZSS 1900:1965

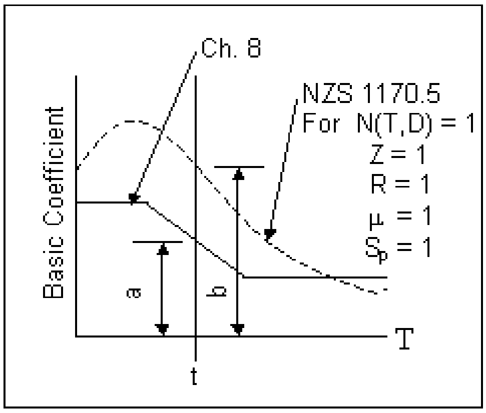


Figure BA.4(b): NZSS 1900: Chapter 8: 1965

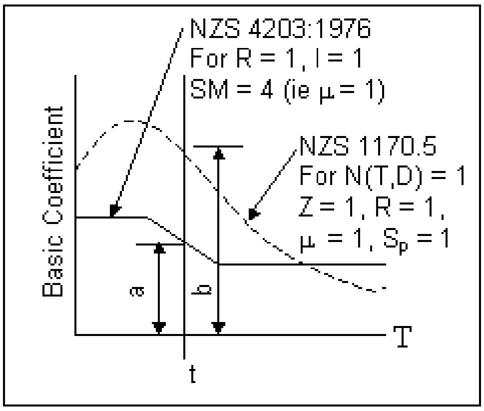


Figure BA.4(c): NZS 4203:1976

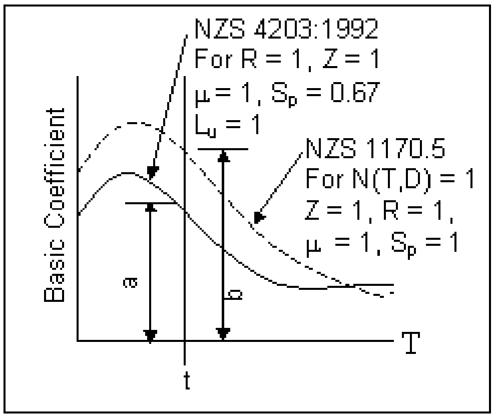


Figure BA.4(d): NZS 4203:1992

Figure BA.4: Concepts behind scaling Factor *B*

For a particular T, $(\%NBS)_{\text{nom}}$ = a/b

a) to adjust for near fault factor multiply by Factor E $= \frac{1}{N(T,D)}$

b) to adjust for hazard factor multiply by Factor F $= \frac{1}{Z}$ for pre 1992, or

$= \frac{Z_{1992}}{Z}$ for 1992-2003

$= \frac{Z_{2004}}{Z}$ for August 2011 onwards. This allows for the change in Z in the Canterbury region following the 2010/2011 Canterbury earthquakes.

c) to adjust for return period factor multiply by Factor G $= \frac{IR_0}{R}$

d) to adjust for ductility multiply by Factor H $= k_{\mu}$ for pre 1976, or

$= 1$ for 1976 onwards

e) to adjust for structural performance multiply by Factor I $= \frac{1}{S_{\text{p}}}$

The values for Factor B are approximate and based on the simplifying assumptions listed below. Engineers can substitute their own code comparisons if they wish.

Assumptions inherent in the assessment of $(\%NBS)_b$

There are a number of assumptions inherent in the assessment of $(\%NBS)_b$. These include the following:

- The building has been designed and built in accordance with the building standard current at the time, and with good practice.
- The building has been designed for the correct subsoil category. (Make pro rata adjustments according to NZS 1170.5:2004 spectra, if this is not the case). Note that the rigid subsoil category in NZS 4203:1992 has been split into two categories in NZS 1170.5:2004. The IEP assumes that buildings on site subsoil type C (NZS 1170.5:2004) designed to NZS 4203:1992 would have been designed assuming intermediate subsoil. The procedure allows an adjustment if it is known that rigid subsoil was originally assumed.
- Buildings designed prior to 1965 have had their assessed capacity increased by a factor of 1.5 to convert from allowable stress to ULS design, and divided by 1.4 to convert from a rectangular shear distribution over the height of the building to a triangular distribution with 10% of the base shear applied at the roof. (The basis for this is the ratio of overturning moments derived by the two methods.)
- Buildings designed to the 1965 code have had their period shifted by a factor of 1.25 to take account of greater flexibility resulting from the allowance for cracking assumed in later Standards.
- Buildings designed to the 1976 code are assumed to use the same elastic spectral values as given in the 1984 code. Therefore, for a μ of 1, the 1976 values are increased by a factor of 4 (i.e. SM = 4).
- Buildings designed to the 1992 code are assumed to have been designed for an S_p of 0.67. If this is not the case adjust accordingly.

BA.2.3 Step 3 - Determine performance achievement ratio (PAR) (Table IEP-3)

Assessment of effects of potential critical structural weaknesses (Steps 3.1 to 3.4)

Note:

Consider each orthogonal direction separately unless it is clear from the start which governs.

A potential critical structural weakness (CSW) is any potential structural weakness (SW) that could potentially influence the building's performance/capacity in severe earthquake shaking. Some examples are shown in Figure BA.5.

Potential CSWs, therefore, are not restricted to the features shown in Table IEP-3. Any potential CSW that is identified but is not specifically included in Table IEP-3 should be accounted for by setting an appropriate value for Factor F.

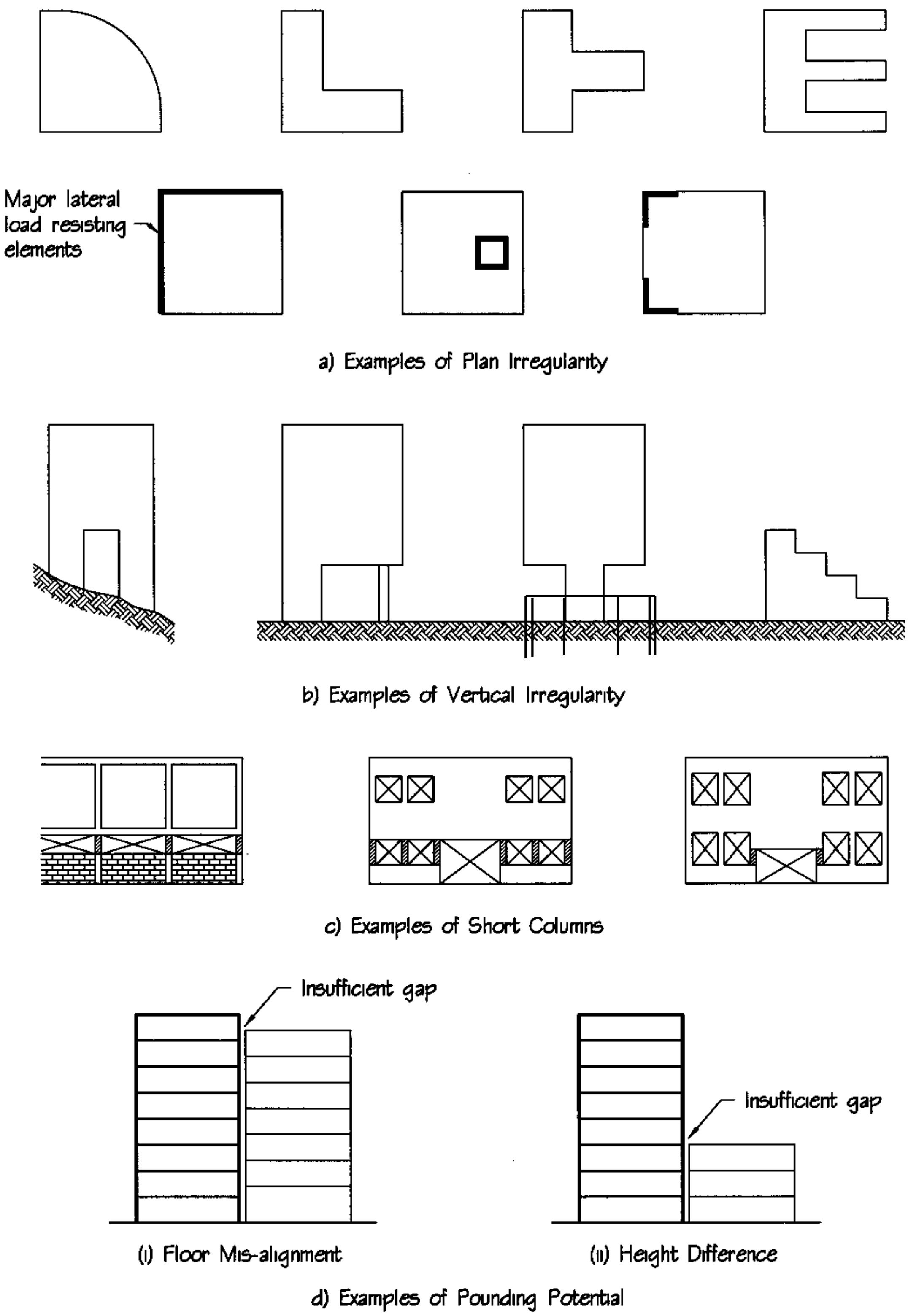


Figure BA.5: Examples of potential critical structural weaknesses

Note:

Figure BA.5 does not describe all potential CSWs that need to be considered.

Note:

The 2017 changes to earthquake-prone building legislation confirm that parts of buildings are not able to be excluded from consideration.

The effect of a potential CSW on the structural capacity is assessed on the basis of its severity – i.e. whether this is insignificant, significant or severe – in each case (refer to Section B2 for definitions). The engineer should consider the objectives contained in these definitions and refer to Table BA.4 for more specific guidance on determining the severity for common potential CSWs.

Note:

The 'severe' rating for potential CSWs should not be confused with potential severe structural weaknesses (SSWs).

Table BA.4: Guide to severity of potential critical structural weaknesses

	Effect on structural performance		
potential Critical Structural Weakness	**Severe**	**Significant**	**Insignificant**
Plan irregularity L-shape, T-shape, E-shape	Two or more wings length/width > 3.0, or one wing length/width > 4	One wing length/width > 3.0	All wings length/width ≤ 3.0
Long narrow building where spacing of lateral load resisting elements is …	> 4 times building width	> 2 times building width	≤ 2.0 times building width
Torsion (corner building)	Mass to centre of rigidity offset > 0.5 width	Mass to centre of rigidity offset > 0.3 width	Mass to centre of rigidity offset ≤ 0.3 width or effective torsional resistance available from elements orientated perpendicularly
Ramps, stairs, walls, stiff partitions	Clearly grouped, clearly an influence	Apparent collective influence	No or slight influence
Vertical irregularity Soft storey	Lateral stiffness of any storey < 0.7 of lateral stiffness of any adjoining storeys	Lateral stiffness of any storey < 0.9 of lateral stiffness of the adjoining storeys	Lateral stiffness of any storey ≥ 0.9 of lateral stiffness of the adjoining storeys
Mass variation	Mass of any storey < 0.7 of mass of adjoining storey	Mass of any storey < 0.9 of mass of adjoining storey	Mass of any storey ≥ 0.9 of mass of adjoining storey
Vertical discontinuity	Any element contributing > 0.3 of the stiffness/ strength of the lateral force resisting system discontinues vertically	Any element contributing > 0.1 of the stiffness/ strength of the lateral force resisting system discontinues vertically	Only elements contributing ≤ 0.1 of the stiffness/strength of the lateral force resisting systems discontinue vertically
Short columns Columns < 70% storey height between floors clear of confining infill, beams or spandrels	Either > 80% short columns in any one side Or > 80% short columns in any storey	> 60% short columns in any one side > 60% columns in any one storey	No, or only isolated, short columns, or Columns with width > 1.2 m, or Free column height/column width ≥ 2.5.
Pounding effect Vertical differences between floors ≤ 20% storey height of building under consideration			No penalty
Vertical differences between floors > 20% storey height of building under consideration	0 < separation < 0.005 H	0.005 H < separation < 0.01 H	Separation > 0.01 H
	where H = height to the level of the floor being considered		

	Effect on structural performance		
potential Critical Structural Weakness	**Severe**	**Significant**	**Insignificant**
Height difference effect No adjacent building, or height difference < 2 storeys			No penalty
Height difference 2-4 storeys	0 < separation < 0.005 H	0.005 H < separation < 0.01 H	Separation > 0.01 H
Height difference > 4 storeys	0 < separation < 0.005 H	0.005 H < separation < 0.01 H	Separation > 0.01 H, or Floors aligning and height difference < 2 storeys, **or** At least one building is lightweight construction
	where H = height of the lower building and separation is measured at H		
Site characteristics (refer to TA or regional council hazards maps, where available)	Unstable site. Structure prone to underslip and very susceptible to excessive loss of foundation support.	Signs of past site instability. Underslip may threaten structure and structure not capable of sustaining loss of foundation support.	Geohazards are not a significant threat to life in or immediately outside the building
	Significant liquefaction potential and building very susceptible to excessive settlement	Liquefaction potential and structure not capable of sustaining soil deformation	Liquefaction potential but structure capable of sustaining soil deformations

Compensating provisions (Step 3.6)

Factor F (or the compensating factor) has been introduced in the IEP assessment process. It reflects the engineers' confidence in the final building rating. In general, this factor has been devised to account for:

- any parameter including other CSWs that might not have been accounted for in the evaluation process discussed above, but that the engineer believes should be accounted for
- apparent CSWs that might have been compensated for in design
- hidden strengths and weaknesses
- compensation for over penalty
- higher levels of ductility than might have been assumed in the design of the building
- potential hazards to life (including from parts of buildings), and
- any other parameters.

Note:

Factor F is entirely based on the judgement of the engineer and therefore it is a requirement of the IEP that the factors that have led to the decision for Factor F are appropriately recorded.

In general, 1.0 is considered as the base number for Factor F. The factor should be less than 1.0 to reflect deficiencies not accounted in the process or to highlight that a detailed assessment of the building as a whole or of some specific parts is recommended. Similarly the factor could be more than 1.0 to reflect that the building has higher capacity than evaluated above. The limits on this compensating factor are as follows:

- No limit on factor less than 1.0
- Up to 2.5 for buildings up to three storeys high
- Up to 1.5 for buildings more than three storeys high.

Reasons for adopting a compensating factor higher than 1.0 include, but are not limited to:

- greater than minimum lengths of shear wall
- design for significantly higher gravity loading than current use requires
- need to compensate for otherwise severe effect of combinations of potential CSWs that are not mutually exclusive (e.g. when a single issue results in both a plan and a vertical irregularity – although in such cases it is acceptable to penalise assuming only one potential CSW)
- ductile detailing in pre-1976 buildings
- in timber houses, even older ones, higher ductility could be available
- compensating for inappropriate assignment of penalties (e.g. a soft-storey mechanism is unlikely if reasonable walls are present, in the direction under evaluation)
- presence of details that are known to improve performance (e.g. existence of bond beams in URM buildings)
- frame buildings with strong column-weak beam are unlikely to develop soft-storey mechanism despite having a stiffness discontinuity in the vertical direction
- buildings with long walls are unlikely to develop soft-storey mechanisms
- pounding against walls rather than columns, or wall and frame rather than between frame and frame structure
- pounding between lightweight and stiff heavy buildings is unlikely to be a serious issue
- the known resilience of timber buildings to earthquake shaking, and
- any other known factor.

It may be apparent that potential CSWs have been compensated for in design. This should be established by viewing building design/construction documentation as part of the assessment. Note that even where compensating design has been carried out, a building with discontinuities, such as those nominated as potential CSWs, will likely suffer more damage than a geometrically regular building.

There may be negative factors that are known but have not been included in the IEP. In such cases it is up to the judgement of the engineer to evaluate the potential life-safety risk and adjust the *%NBS* down accordingly. If a reasonable hazard exists due to structural or non-structural items it is recommended to set *%NBS* < 34 with a note that the earthquake rating is due to these items.

Possible negative factors include, but are not limited to, the:

- quality of previous retrofit, if any
- hierarchy of failure, and consequences, and
- hazard arising from parts of buildings such as face loaded infill panels, parapets, chimneys and stairs where this might be known.

These and other issues are discussed in more detail in Section B1, together with guidance on how to make allowance for them in an IEP.

The maximum value of Factor F has been set at 1.5 (no minimum) unless the building has no more than three storeys; in which case the maximum value has been set at 2.5 (also no minimum). The reason for the distinction based on height is that it is felt there is more scope for judgement for low rise structures and as any positive compensating factors are likely to have a more dramatic effect on earthquake performance.

It is expected that the engineer may need to revisit Factor F after a *%NBS* earthquake rating has been determined if this rating appears unreasonable or is not reflective of actual observed building behaviour. Such review is a part of the overall process as indicated in Section B3 and below.

Calculation of performance assessment ratio (PAR) (Step 3.4)

The calculation of PAR is simply the product of the factors identified and shown on Table IEP-3. The focus of the review is on the capacity to resist lateral load.

The earthquake rating for the building shall be taken as the lowest result for the two directions considered.

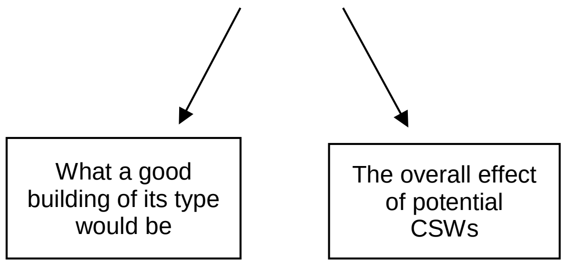
As noted above the engineer should now stand back and reflect on the appropriateness of the *%NBS* that has been determined. If the result is considered unrealistic or inappropriate, the engineer should review all steps including the available information on the building and whether this is sufficient, and also the basis for the Factor F. Several iterations may be required.

If the IEP cannot provide a result that the engineer is satisfied with by virtue of the limits on Factor F, the engineer shall note this in the assessment.

BA.2.4 Step 4 - Determine the percentage of new building standard, *%NBS* (Table IEP-4)

This is a simple calculation:

$$\%NBS = (\%NBS)_{\mathrm{b}}\ x\ PAR$$



BA.2.5 Step 5 – Is the earthquake rating less than 34*%NBS*? (Table IEP-4)

%NBS less than 34	→	Building meets one of the criteria for an earthquake-prone building in terms of the Building Act. Further action is required; e.g. TA consideration, DSA, review of drawings or further inspections.
%NBS greater than or equal to 34[1]	→	If the assessment meets the requirements of the engineering basement in the EPB methodology and is accepted by the TA, the building does not require further action in terms of the Building Act unless further knowledge becomes available that suggests otherwise.

BA.2.6 Step 6 – Is the building an earthquake risk?(Table IEP-4)

%NBS less than 67	→	Building is potentially an earthquake risk. Further action is recommended; e.g. DSA, review of drawings or further inspections.
%NBS greater than or equal to 67	→	Building is unlikely to be an earthquake risk unless further knowledge becomes available that suggests otherwise.

BA.2.7 Step 7 – Provide provisional grading based on IEP (Table IEP-4)

The grading scheme shown in Part A is being promoted by the New Zealand Society for Earthquake Engineering to improve public awareness of earthquake risk and the relative risk between buildings.

It is not a requirement of the Building Act to provide a seismic grade but it is strongly recommended that this is recorded in order to promote this concept.

Seismic grading determined from the results of the IEP should be considered provisional and subject to confirmation by detailed assessment.

The NZSEE grading scheme is only intended to grade the building under consideration. Aspects such as the possible detrimental effects of neighbouring buildings or the hazards resulting from items that could be classified as building contents are not considered but may nevertheless be important considerations for building owners and tenants. These should be brought to their attention if this is appropriate for the level of assessment being undertaken.

[1] The target for an earthquake-prone building is defined in legislation as one third of the requirements for a new building. In these guidelines this target has been rounded up to be less than 34*%NBS*.

BA.2.8 Step 8 – Note identified potential SSWs from list provided (Table IEP-5)

Table IEP-5 has six tick boxes which only need to be considered if the building has more than three storeys and has heavy floors and/or a heavy roof.

The engineer should tick the first box if none of the listed potential SSWs have been identified as being present. Otherwise, he or she should tick as many of the other boxes as appropriate. These represent the five potential SSWs that represent particular weaknesses (vulnerabilities) that it is believed have significant potential to lead to catastrophic collapse and/or loss of egress that would result in a significant risk to occupants. (Refer to Section B2.2 for more details of these.)

The six tick boxes are:

1. None identified. This should not be construed as advice that none are present.
2. A weak or soft storey, except for the top storey.
3. Brittle columns and/or brittle beam/column joints the deformations of which are not constrained by other structural elements.
4. Flat slab buildings with lateral capacity reliant on low ductility slab to column connections.
5. No effective connection between primary seismic structural elements and diaphragms.
6. Seismically separated stairs with ledge and gap supports.

If any potential SSWs (items 2 to 6) have been ticked then careful consideration should be given before rating the building $\geq$34*%NBS*. The Factor F would then be set as considered appropriate, noting that a DSA is recommended to confirm the rating.

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.

The presence of any of these potential SSWs should also be noted in the covering letter (refer to Appendix BC).

Appendix BB: Initial Seismic Assessment of Unreinforced Masonry Buildings using an Attribute Scoring Methodology

BB.1 General

For URM buildings built prior to 1935, Steps 2 to 4 of the ISA can be carried out using the attribute scoring method outlined in this appendix. The *%NBS* is then determined directly from the total attribute score as described below.

The derivation of *%NBS* using the attribute scoring method assumes that all appendages likely to present a significant life safety hazard have been adequately secured or measures taken to remove the risk to life: e.g. provision of appropriately designed canopies or designated “no go” zones adjacent to the building.

If appendages have not been restrained the *%NBS* shall not be taken ≥34*%NBS*.

BB.2 Procedure

The recommended procedure is:

- complete the attribute scoring table, Table BB.1, using the guidance provided in Table BB.2
- then, from the total attribute score determine the *%NBS* from Table BB.3.

Interpolation may be used for intermediate attribute scores. While attributes may differ for each principal direction, it is the intention that the attribute score applies to the building as a whole. Therefore, it will be necessary to choose an attribute score that is representative of the building. This will not necessarily be the lowest score for either direction but can conservatively be taken as such.

Given that local collapse is viewed as having the same implications as total collapse, attributes should correspond to the weakest section of a building where relevant.

Table BB.1: Assessment of attribute score

Item		Attribute ranking				Assessed score	
		0	1	2	3	Long	Trans
1	**Structure continuity**	Excellent	Good	Fair	Poor or none		
2	**Configuration**						
2a	Horizontal regularity	Excellent	Good	Fair	Poor		
2b	Vertical regularity	Excellent	Good	Fair	Poor		
2c	Plan regularity	Excellent	Good	Fair	Poor		
3	**Condition of structure**						
3a	Materials	Sound	Good	Fair	Poor		
3b	Cracking or movement	Not evident	Minor	Moderate	Severe		
4	**Wall (URM) proportions**						
4a	Out-of-plane	Good			Poor		
4b	In-plane	Excellent	Good	Fair	Poor		
5	**Diaphragms**						
5a	Coverage	Excellent	Good	Fair	Poor		
5b	Shape	Excellent	Good	Fair	Poor		
5c	Openings	None			Significant		
6	**Engineered connections between floor/roof diaphragms and walls, and walls and diaphragms** capable of spanning between	Yes			No		
7	**Foundations**	Excellent	Good	Fair	Poor		
8	**Separation from neighbouring buildings**	Adequate			Inadequate		
		Total attribute score:		**For each direction**			
				For building as a whole			

Note:
For definition of grading under each attribute refer to Table BB.2.

Table BB.2: Definition of attributes and scores

	Attributed score[1]
Attribute Item (1): Structure continuity	
Totally unreinforced masonry	3
Some continuity, e.g. unreinforced masonry with a reinforced concrete band at roof *or* floor level	2
Good continuity, e.g. unreinforced masonry with reinforced bands at *both* roof and floor levels	1
Full continuity (i.e. vertical stability not reliant on URM), e.g. reinforced concrete or steel columns and beams with URM walls/infill or separate means of vertical support provided to floors and roof	0
Attribute Item (2): Configuration	
(a) Plan regularity	
Severe eccentricity, i.e. distance between storey centre of rigidity and the centre of mass for all levels above that storey, $e_d < 0.3\ b$ (b = longest plan dimension of building perpendicular to direction of loading)	3
$e_d < 0.3\ b$	2
$e_d < 0.2\ b$	1
Building symmetrical in both directions	0
(b) Vertical regularity	
Vertical stiffness discontinuities or discontinuities in load paths present	3
All walls continuous to foundations	2
and no soft storeys *and* minimal vertical stiffness changes	1
and no weak storeys *and* no significant mass irregularities	0
where: • *soft storey* is a storey where the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average stiffness of the three storeys above • *weak storey* is a storey where the storey strength is less than 80% of the strength of the storey above • *mass irregularity* exists if the mass varies by more than 50% from one level to another (excluding light roofs which should be considered as a part of the building).	
(c) Diaphragm shape	
Sharp re-entrant corners present where the projection of the *wing* beyond the corner > 0.15 b	3
Regular in plan	0
Attribute Item (3): Condition of structure	
(a) Materials	
Poor, i.e. considerable deterioration, fretting or spalling, etc., or lime or other non-competent mortar or rubble wall construction	3
Fair, i.e. deterioration leading to reduced strength	2
Good, i.e. minor evidence of deterioration of materials	1
Sound	0

<table>
<tr><th colspan="5"></th><th>Attributed score[1]</th></tr>
<tr><td colspan="5">(b) Cracking or movement</td><td></td></tr>
<tr><td colspan="5">Severe, i.e. a considerable number of cracks or substantial movement leading to reduced strength or isolated large cracks</td><td>3</td></tr>
<tr><td colspan="5">Moderate</td><td>2</td></tr>
<tr><td colspan="5">Minor</td><td>1</td></tr>
<tr><td colspan="5">Non-evident</td><td>0</td></tr>
<tr><td colspan="5">Attribute Item (4): Wall (URM) proportions</td><td></td></tr>
<tr><td colspan="5">(a) Out-of-plane performance</td><td></td></tr>
<tr><td colspan="5">Poor:
- for one storey buildings $h_w/t > 14$ and $l_w/t > 7$
- for multi-storey buildings:
top storey $h_w/t > 9$ and $l_w/t > 5$
other storeys $h_w/t > 20$ and $l_w/t > 10$</td><td>3</td></tr>
<tr><td colspan="5">Good (not poor)
Where:
h_w = height of wall between lines of positive lateral restraint, and
l_w = length of wall between lines of positive lateral restraint</td><td>0</td></tr>
<tr><td rowspan="3">(b) In-plane performance[2]</td><td colspan="4">A_p/A_w</td><td></td></tr>
<tr><td colspan="2">One storey building</td><td colspan="2">2 and 3 storey buildings</td><td></td></tr>
<tr><td colspan="2"></td><td>Top storey</td><td>Other storeys</td><td></td></tr>
<tr><td></td><td>Poor</td><td>≥25</td><td>≥20</td><td>≥17</td><td>3</td></tr>
<tr><td></td><td>Fair</td><td>>20</td><td>>15</td><td>>12</td><td>2</td></tr>
<tr><td></td><td>Good</td><td>>15</td><td>>10</td><td>>7</td><td>1</td></tr>
<tr><td></td><td>Excellent</td><td>≤15</td><td>≤10</td><td>≤7</td><td>0</td></tr>
<tr><td colspan="5">where:
A_w = cross sectional area of all URM walls/wall sections extending over full height of storey
A_p = plan area of building above storey of interest.
For buildings of greater than 3 storey take attribute score = 3</td><td></td></tr>
<tr><td colspan="5">Attribute Item (5): Diaphragms (refer to Figure BB.1)</td><td></td></tr>
<tr><td colspan="5">(a) Coverage</td><td></td></tr>
<tr><td colspan="5">No diaphragm</td><td>3</td></tr>
<tr><td colspan="5">Full diaphragm</td><td>0</td></tr>
<tr><td colspan="5">To achieve an attribute ranking of 0 requires a diaphragm to be present at each level, including roof level, covering at least 90% of the building plan area at each level. Interpolation for attribute rankings of 1 and 2 may be made using judgement on the extent of coverage. Note that unless the diaphragm is continuous between walls, its effectiveness may be minimal.</td><td></td></tr>
</table>

						Attributed score[1]
(b)	Shape	**Limiting span to depth ratios for diaphragms of different construction material**				
		Concrete	**Sheet materials**	**T&G timber**	**Steel roof bracing**	
	Poor	> 4	> 4	> 3	> 5	3
	Fair	< 4	< 4	< 3	< 4	2
	Good	≤ 3	≤ 3	≤ 2	≤ 3.5	1
	Excellent	As for good, but in addition the projection of "wings" beyond sharp re-entrant corners $< 0.5\,b$.				0
(c)	Openings					
	Significant openings					3
	No significant openings					0
	Interpolation for attribute rankings of 1 and 2 may be made using judgement.					
	Significant openings are those which exceed the limiting values given below.					

Diaphragm construction material	Limiting values of	
	X/b	Y/D
Concrete	0.6	0.5
Sheet material	0.5	0.4
T&G timber	0.4	0.3

Refer to Figure BB.1 for definition of terms.

	Attributed score[1]
Attribute Item (7): Foundations	
Separate foundations with no interconnection *or* unreinforced piles (unless ramification of pile failure is assessed to be minor).	3
Pads, strips or piles with some interconnection. Concrete piles to be reinforced unless ramification of pile failure is assessed to be minor.	2
Pads, strips or piles with good interconnection in both directions.	1
Concrete raft with sound connections to walls.	0
Attribute Item (8): Separation	
Inadequate – no separation provided or obviously inadequate provisions for separation	3
Adequate – separation provided	0

Note:

1. Individual attribute scores may be interpolated.
2. This is an index describing the extent of brick walls within the building. The numbers given are only loosely related to lateral load capacity.

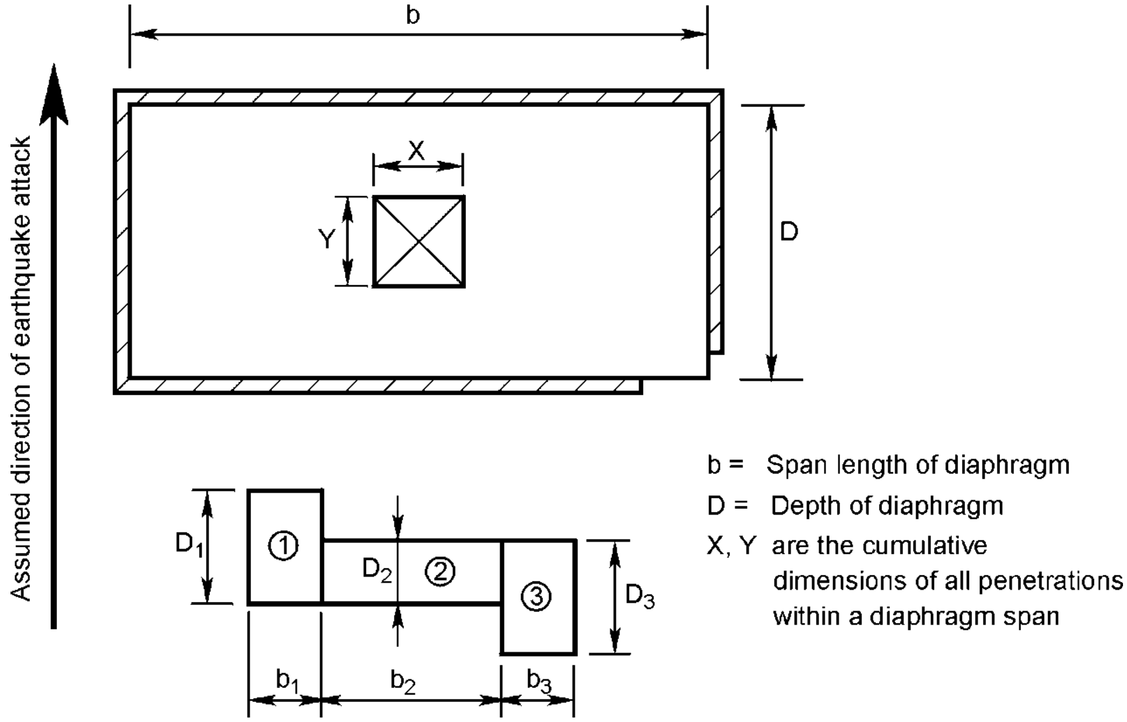


Figure BB.1: Diaphragm parameters

Table BB.3: Assessment of *%NBS* from attribute score

Item	Attribute score	*%NBS*
1	A score of 0 for all attribute scoring items	$67\ x\ 1/Rx\ 0.4/Z^{1}$
2	Less than or equal to 1 for all of attribute scoring items 1 to 6 inclusive, and less than 2 for each of attribute scoring items 7 and 8	$34\ x\ 1/Rx\ 0.4/Z$
3	As for 2 but a score of 0 for attribute scoring item 1	$40\ x\ 1/Rx\ 0.4/Z$
4	5 < total attribute score ≤ 10	$20\ x\ 1/Rx\ 0.4/Z$
5	10 < total attribute score ≤ 15	$15\ x\ 1/Rx\ 0.4/Z$
6	15 < total attribute score ≤ 25	$10\ x\ 1/Rx\ 0.4/Z$
7	Total attribute score > 25	$5\ x\ 1/Rx\ 0.4/Z$

Note:

1. *R* and *Z* are defined in NZS 1170.5:2004.

Appendix BC: Template Covering Letter – Building Owner or Tenant Commissioned IEP

Building Owner
PO Box XYZ
SHAKESVILLE

Date

Dear Sir

Initial Seismic Assessment of Building at XX Tremor Grove

We have now completed an Initial Seismic Assessment (ISA) of the building at XX Tremor Grove, Shakesville using the Initial Evaluation Procedure (IEP) as described in Part B of the guideline document, *The Seismic Assessment of Existing Buildings-Technical Guidelines for Engineering Assessments*, dated [**XXX**]. The assessment was carried out after completing a site visit [*add anything else that formed the basis of the assessment: e.g.* reviewing the original structural drawings *etc.*].

Executive Summary

Provide the final ***potential*** *earthquake rating and building grade. Note the Importance Level (in accordance with NZS 1170.5:2004) that was assumed to apply as this will define the new building standard that the building is rated against. Use the following form: XXX%NBS* (ILY).

Give the potential status of the building in relation to 34%NBS and the earthquake risk (67%NBS) criteria.

Note if any of the potential SSWs in IEP Table IEP-5 have been identified. If they have, also note that these could potentially present an enhanced risk in severe earthquake shaking.

The ISA is considered to provide a relatively quick, high-level and qualitative measure of the building's performance. A more reliable result will be obtained from a Detailed Seismic Assessment (DSA) and is recommended for this building. A DSA could find structural weaknesses not identified from the IEP, or it could find that identified potential CSWs have been addressed in the design of the building.

Introduction

Provide the background and basis of the assessment, i.e. that it has been based on the IEP as defined by the Technical Guidelines for Engineering Assessments referenced above, and if it also meets the requirements of an engineering assessment as prescribed in the EPB methodology

Background to the IEP and its Limitations

The IEP procedure was developed in 2006 by the New Zealand Society for Earthquake Engineering (NZSEE) and updated in 2017 to reflect experience with its application and also as a result of experience from the Canterbury earthquakes of 2010/11. It is a tool to assign a percentage of New Building Standard (*%NBS*) rating and associated grade to a building as part of an Initial Seismic Assessment of existing buildings.

The IEP enables building owners and managers to review their building stock as part of an overall risk management process.

Characteristics and limitations of the IEP include:

- An IEP assessment is primarily concerned with life safety. It does not consider the susceptibility of the building to damage, and therefore to economic losses.
- It tends to be somewhat conservative, identifying some buildings as earthquake prone, or having a lower *%NBS* score, which subsequent detailed investigation may indicate is less than actual performance. However, there will be exceptions, particularly when potential critical structural weaknesses (CSWs) are present that have not been recognised from the level of investigation employed.
- An IEP can be undertaken with variable levels of available information: e.g. exterior only inspection, structural drawings available or not, interior inspection, etc. The more information available, the more representative the IEP result is likely to be. The IEP records the information that has formed the basis of the assessment and consideration of this is important when determining the likely reliability of the result.
- It is an initial, first-stage review. Buildings or specific issues which the IEP process flags as being problematic or as potentially critical structural weaknesses need further detailed investigation and evaluation. A Detailed Seismic Assessment is recommended if the seismic status of a building is critical to any decision making.
- The IEP assumes that buildings have been designed and built in accordance with the building standard and good practice current at the time. In some instances, a building may include design features ahead of its time, leading to better than predicted performance. 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.
- It is a largely qualitative process, and should be undertaken or overseen by an experienced engineer. It involves considerable knowledge of the earthquake behaviour of buildings, and judgement as to key attributes and their effect on building performance. Consequently, it is possible that the *%NBS* derived for a building by independent experienced engineers may differ.
- An IEP may over-penalise some apparently critical features which could have been satisfactorily taken into account in the design.
- An IEP does not take into account the seismic performance of non-structural items such as ceilings, plant, services or general glazing that are not considered to present a significant life safety hazard.

Experience to date is that the IEP is a useful tool to identify potential issues and expected overall performance of a building in an earthquake. However, the process and the associated *%NBS* rating and grade should be considered as only providing an indicative indication of the building's compliance with current code requirements. A detailed investigation and analysis of the building will typically be required to provide a definitive assessment.

Include if appropriate and if comfortable that the rating reflects the building's expected behaviour.

The IEP has been based on a review of drawings and an inspection of both the interior and exterior of the building and can be considered to be a comprehensive assessment at the ISA level. The rating determined is greater than or equal to 34*%NBS* and therefore, if ratified by the TA, the building should not be considered as earthquake prone.

Basis for the Assessment

The information we have used for our IEP assessment includes:

List the information that has been available to carry out the assessment, e.g. structural drawings, whether the site visit included an interior inspection, and basis for the assessment of geotechnical conditions.

Building Description

The building located at [WW Tremor Grove, Shakesville] is a [X] storey structure designed in [YYYY]. It is currently used as [ZZZZZZ].

Provide a brief description of the building including relevant features such as age, structural configuration, lateral seismic resisting system in each direction, relationship to neighbouring buildings and foundation/soil conditions.

IEP Assessment Results

Our IEP assessment of this building indicates the building can achieve XXX%*NBS* (ILY) in the longitudinal direction and YYY%*NBS* (ILY) in the transverse direction. The IEP assessment of this building therefore indicates an overall earthquake rating of ZZZ%*NBS* (ILY), corresponding to a 'Grade X' building as defined by the NZSEE building grading scheme. This is [*above/below*] 34%*NBS* (one of the tests the TA will apply to determine the buildings earthquake-prone building status), but [*above/below*] the threshold for earthquake risk buildings (67%*NBS*) as recommended by the NZSEE.

The key assumptions made during our assessment are shown in Table 1 below. Refer also to the attached IEP assessment and engineering assessment technical summary

Table 1: IEP Assessment Results

Fill in the scoring assumptions from the IEP.

Briefly outline the justification for the scoring decision. Justification is an important aspect of the IEP as it records the judgement decisions of the engineer.

IEP Item	Assumption	Justification
Date of Building Design		
Subsoil Type		

IEP Item	Assumption	Justification
Building Importance Level		
Ductility of Structure		
Plan Irregularity Factor, A		
Vertical Irregularity Factor, B		
Short Columns Factor, C		
Pounding Factor, D		
Site Characteristics		
Factor F		

IEP Grades and Relative Risk

Table 2 taken from the Technical Guidelines referred to earlier provides the basis for a proposed grading system for existing buildings, as one way of interpreting the *%NBS* earthquake rating.

Table 2: Relative Earthquake Risk

Building Grade	Percentage of New Building Standard (*%NBS*)	Approx. Risk Relative to a New Building	Life-safety Risk Description
A+	>100	<1	low risk
A	80 to 100	1 to 2 times	low risk
B	67 to 79	2 to 5 times	low or medium risk
C	34 to 66	5 to 10 times	medium risk
D	20 to 33	10 to 25 times	high risk
E	<20	more than 25 times	very high risk

This building has been classified by the IEP as a Grade [X] building and is therefore considered to be a [YYYYYYYY] life-safety risk.

The NZSEE (which provides authoritative advice to the legislation makers, and should be considered to represent the consensus view of New Zealand structural engineers) classifies a building achieving greater than 67*%NBS* as "low or medium risk", and having "acceptable (improvement may be desirable)" building structural performance.

Seismic Restraint of Non-Structural Items

During an earthquake, the safety of people can be put at risk due to non-structural items falling on them. These items should be adequately seismically restrained, where possible, as specified by NZS 4219:2009 "The Seismic Performance of Engineering Systems in Buildings".

An assessment has not been made of the bracing of the ceilings, in-ceiling ducting, services and plant or contents. We have also not checked whether or not tall or heavy furniture has been seismically restrained. These issues are outside the scope of this initial assessment but could be the subject of another investigation.

If particular potential hazards that could lead to an enhanced risk have been identified during the assessment but they do not influence the %NBS rating (e.g. geohazards outside the site boundaries, tsunami, adjacent URM walls, etc.) they should be noted here using the following wording.

Other Issues

Although their identification is beyond the scope of this assessment and they do not influence the *%NBS* score, the following hazard(s) have been identified as potential issue(s) for this building:

List any hazards.

Conclusion

Our ISA assessment for this building, carried out using the IEP, indicates an overall score of XXX*%NBS* (ILY) which corresponds to a Grade [X] building, as defined by the NZSEE building grading scheme. This is [*above/below*] the threshold for earthquake-prone buildings (34*%NBS*), and [*above/below*] the threshold for earthquake -risk buildings (67*%NBS*) as defined by the NZSEE.

The ISA is considered to provide a relatively quick, high-level and qualitative measure of the building's performance. In order to confirm the seismic performance of this building with more reliability you may wish to request a DSA. A DSA is likely to focus on the following issues:

List the issues identified, including all CSWs (including those identified when establishing the F Factor).

A DSA would also investigate other potential structural weaknesses that may not have been considered in the Initial Seismic Assessment.

If any potential Severe Structural Weaknesses (SSWs) have been noted in Table IEP-5 of the IEP include the following:

While completing this ISA we identified the following potential Severe Structural Weakness(es) in the building:

List any potential Severe Structural Weaknesses noted in Table IEP-5 of the IEP.

If confirmed as structural weaknesses these could have the potential to significantly reduce the resilience of the building and adversely affect its performance in severe earthquakes.

We trust this letter and Initial Seismic Assessment meets your current requirements. We would be pleased to discuss further with you any issues raised in this report.

Please do not hesitate to contact me if you would like clarification of any aspect of this letter.

Experienced, Competent and Appropriately Trained Structural Engineer

CPEng

Encl: IEP Assessment

Engineering Technical Summary