LESSONS LEARNED
CHRISTCHURCH EXPERT EARTHQUAKE ENGINEERING PANEL

LEGACY DOCUMENT 4

GUIDANCE FOR ENGINEERS ON RESIDENTIAL DAMAGE ASSESSMENT AND REINSTATEMENT

engineering new zealand
te ao rangahau

THE LEGACY PROJECT :: GUIDANCE FOR ENGINEERS

Residential Damage Assessment and Reinstatement

This document forms part of the set of information referred to as the 'Legacy Toolbox Package'. This set of documents was prepared by engineers from the Christchurch Earthquake Expert Engineering Panel and the Engineering Advisory Group. Review and input have also been provided by Engineering New Zealand, GCCRS (now NZCRS) and representatives from the Legal, Insurer and Homeowner Advisory Groups.

TABLE OF CONTENTS

1. OVERVIEW

This document provides guidance to professional engineers undertaking an engineering assessment of residential buildings damaged by natural disasters. While this guidance is intended to be a general reference applicable to any type of building damage, the basis of its development is experience gained through the repair phase following the Canterbury Earthquake Sequence (CES). It is therefore not intended to be exhaustive but to communicate general principles and good engineering practice for engineering assessment of natural disaster damage to residential dwellings and the development of appropriate repair strategies.

This document covers the engagement and briefing of engineers, the context of engineering assessments and professional ethics and impartiality. An overview of insurance policy matter is provided, including key terms and the claims process, along with relevant building regulatory provisions. Other considerations such as understanding the building and its pre-event condition are summarised.

The process of preparing for and undertaking investigations is outlined, including consideration of the input of other specialist inputs such as geotechnical engineers. Guidance is provided on communication and conduct whilst on site, and the health and safety and wellbeing of the engineer. The importance of forensic analysis and the avoidance of assumptions where possible is emphasised.

Engineering New Zealand provides a standardised report framework to provide a consistent approach to the reporting of engineering assessments. This framework has been refined through the work of the Christchurch Earthquake Expert Engineering Panel, and example reports are provided, along with tips on the scope and content of effective reports.

A definition of key terms has been included in Appendix One of this document.

2. ENGAGEMENT AND BRIEFING

Engineering New Zealand has developed briefing letters for engaging engineers to undertake assessment and reinstatement work resulting from natural disaster damage. Whilst this letter will be most useful for homeowners it should be considered as best practice by all industry participants, including insurers and engineers themselves. This initial template letter was prepared in 2018 in response to community concern around the diversity of engineering opinions for the same property. Prior to the preparation of the template letter, there was growing distrust of engineers where homeowners were at times bewildered when the engineering report they had relied on, in their decision-making to pursue their case, was discounted by the other party. This often resulted in multiple engineering reports with often different conclusions for the same property.

In response to the severe weather events in 2023, Engineering New Zealand further developed the template letter to make it applicable to all natural disasters and to provide separate template letters for engaging structural and geotechnical engineers. The use of these templates provides a consistency of briefing and resultant reporting that reduces the variability of damage assessments and repair strategies.

The most recent versions of the Engineering New Zealand letter of engagement should be regarded as best practice and can be found on the Engineering New Zealand website[1].

3. CONTEXT OF ENGINEERING DAMAGE ASSESSMENTS

A key issue following the Canterbury Earthquake Sequence (CES) was reports based on opinion or interpretation. Reports often referred to the engineer's professional opinion rather than providing empirical evidence such as photos or technical evidence of damage. This opinion-based reporting led to significant distrust of engineers as homeowners were not able to clearly review the evidence.

Investigative and forensic engineering involves the assessment of information from a wide variety of technical sources to determine, in insurance terms, "the more likely than not" cause or causes of damage.

By definition, all assessments of natural disaster damage are of an investigative nature. The engineer assesses the available evidence to determine the likely extent of damage caused by the natural disaster event.

Engineering investigations of damage are forensic in nature. They are often subject to a legal process and is therefore under special scrutiny. It is vital that an engineer comprehensively investigates and collects data about the natural disaster event related to the materials, products, structures or components that failed or were damaged. This involves inspections, collecting evidence, measurements, developing models and engineering analysis.

4. PROFESSIONAL ETHICS AND IMPARTIALITY

Professional engineers that are Members of Engineering New Zealand and/or are Chartered Professional Engineers are bound by the Engineering New Zealand Code of Ethical Conduct[2]. As engineering assessments may be referenced for subsequent court proceedings, all assessments should therefore be undertaken in a manner that complies with the Engineering New Zealand Code of Ethics, the High Court Code of Conduct for Expert Witnesses[3], and for Canterbury, the Canterbury Earthquake Insurance Tribunal Code of Conduct for Expert Witnesses[4]. This requirement is also included in the Engineering New Zealand template Letter of Engagement.

Engineering assessment of damage should only be undertaken by suitably qualified and experienced professional engineers, as it involves the application of engineering judgement, which only comes through experience. In practice this means the assessment should be undertaken by either a Chartered Professional Engineer or an intermediate engineer with not less than 5 years of experience in a relevant practice area, working under the direct supervision of a Chartered Professional Engineer. Assigning engineering damage assessment work to graduate or inexperienced engineers is not appropriate.

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[1] Engaging an Engineer | Engineering NZ

[2] Code of Ethical Conduct | Engineering NZ

[3] High Court Rules 2016 (LI 2016/225) (as at 01 May 2023) Schedule 4 Code of conduct for expert witnesses – New Zealand Legislation

[4] Canterbury earthquakes insurance tribunal (justice.govt.nz)

Engineers undertaking damage investigation must work within the bounds of their competence. If the engineer determines that they do not have the specialist knowledge, skill, or experience to address a particular aspect of forensic investigation, they should declare this and seek input from a suitably qualified person for that part of the assessment. A common example of this through the Canterbury Earthquake Sequence was where a structural engineer undertaking the structural assessment of a building sought input from a geotechnical engineer to advise on site characteristics and expected performance.

The fee arrangement for damage assessment and reinstatement work should be clearly agreed and documented prior to the work commencing. It is inappropriate for any fee arrangement to include a component contingent upon a certain outcome, as such arrangements inherently undermine the engineer's obligation to undertake their work independently and objectively.

The engineer must not undertake damage assessment work where they have a conflict of interest. In cases where there could be a perceived conflict of interest, this must be declared at the outset.

Credible engineering assessments are those that are considered and follow a robust and clearly communicated process to reach a well-reasoned conclusion. The outcome of an engineering investigation should be the same, regardless of which party has engaged the engineer undertaking the work. Engineers should be wary of clients who attempt to set the terms of reference to steer the investigation towards a particular outcome.

5. INSURANCE POLICY MATTERS

Insurance Policy

Engineering assessment and reporting following an insured event such as a natural disaster requires the engineer to have a general understanding of insurance as it applies to the context of damage assessment and reinstatement. The insurance policy is triggered most often by the occurrence of physical damage that requires an appropriate repair. Subject to any regulatory requirements, the engineer should apply these criteria to their observations to determine the natural disaster damage and the necessary repairs. However, it is important that the engineer focuses on engineering matters and does not allow themselves to be drawn into the interpretation of insurance policies or advising on the extent of the insurer's obligations. Policy interpretation should be referred for legal advice.

Key Terms

A full list of key terms is included in Appendix One.

Claims Process

Typically, an insurance claim proceeds along the following process:

- An insured event, such as a natural disaster occurs (e.g. earthquake, storm, flood, landslip etc.);
- Homeowner registers a claim with their insurer;
- The insurer sends an assessor to assess the damage and identify a scope of works for the repair;
- The homeowner and insurer agree on the scope of works and the further involvement of the parties, and a choice (the election) is made on who will be responsible to effect the repairs;

- The repairs are completed.

Where the homeowner and insurer are unable to agree on the extent of the damage, the scope of repairs, the adequacy of the repairs, or some other technical concern arises, the process becomes more complex. Typically, this involves:

- The homeowner obtaining an engineering report; and
- The insurer obtaining an engineering report.

If these reports are not consistent with each other, then efforts are usually made to reconcile the engineering differences between the engineers involved. Where the differences cannot be fully reconciled, then the remaining differences and the reasons for those differences are usually clearly identified. Engineering New Zealand provides the following services from a technical panel to assist in the reconciliation:

- Peer reviews of previous reports;
- Engineering facilitations involving the engineers and a panel-appointed facilitator; and
- Binding and non-binding repair recommendations.

Other methods for resolving inconsistencies can include Court-directed expert conferrals.

Any remaining engineering differences are usually addressed in more formal processes that include the parties and their legal counsel. These can include mediations, joint settlement conferences, tribunal and court hearings.

Prior to their engagement, the engineer should identify where the matter is in relation to the claims process and the reports prepared for all the parties. Engineers should also make it clear whether they can commit to completing the repair documentation if requested, ultimately issuing the necessary producer statements.

Previous Judgements

Insurance claims are often complex and previous court/ tribunal judgements may provide valuable insights into the correct approach for the engineer's particular matter to be assessed. Engineering New Zealand has prepared a list of key judgements that have been made concerning natural disaster event insurance claims. These have been included in the Legacy Documents Package.

The engineer should read and familiarise themselves with these judgements.

Engineering New Zealand provides training in Insurance Law for Engineers and recommends that engineers in this field complete some specific training. Contact Engineering New Zealand at learn@engineeringnz.org to find out the current training schedule.

6. LEGISLATION/ REGULATION

Engineers undertaking assessment work are required to have a sound working knowledge of building regulatory framework requirements. This is particularly important where the scope of engagement includes the recommendation of a suitable reinstatement methodology.

Recommended repairs are required to comply with all relevant New Zealand legislation and regulations. It is however important to note that the scope of the repairs will be determined from the insurance policy clauses.

The Building Act doesn't specifically provide for repairs to damage due to natural disaster. The most applicable clauses are briefly outlined below:

Section 17 of the Building Act 2004

The repairs need to comply with the Building Code. Section 17 states:

> *All building work must comply with the building code to the extent required by this Act, whether or not a building consent is required in respect of that building work.*

The extent of the repair that needs to comply with the Building Code needs to be carefully considered. For example, in an operation to repair the dislevelment of a floor, it may be necessary to re-level a foundation by jacking and packing a pile. There are four elements; the subfloor framing, the pile, the base pad of the pile and the connection between the pile and the subfloor framing. The repair will lift the subfloor framing off the pile and install a packer between the pile and the subfloor framing. The pile, base pad of the pile, and the subfloor framing are not being repaired; it is the levelness of the floor that is being repaired and consequently, they will not need to comply with the current Building Code. The new packer will need to comply with the relevant requirements of the Building Code. The operation will release the connection between the pile and the subfloor framing and consequently, when it is reconnected it will need to comply with the Building Code, even where no physical element was present prior to the repair.

Section 112 of the Building Act 2004

Repaired elements that do not need to be upgraded to meet current Building Code provisions as part of normal repairs. Section 112(1)(b) of the Building Act requires that any alterations to the building ensure that *after the alteration*:

> *(b) the building will,*
>
> (i) *if it complied with the other provisions of the building code immediately before the building work began, continue to comply with those provisions; or*
>
> (ii) *if it did not comply with the other provisions of the building code immediately before the building work began, continue to comply at least to the same extent as it did then comply.*

The MBIE Canterbury Residential guidance[5] points out that section 112 relates to the situation immediately prior to the repair (alteration), not prior to the disaster. It should be noted that the MBIE guidance is not an insurance response but can be used in supporting the scope of repairs as determined by the insurance policy.

Even though the *repaired element* (and the remainder of the building) need only comply with the Building Code as far as it did before the disaster, the *repairs themselves* need to fully comply. For

[5] https://www.building.govt.nz/building-code-compliance/canterbury-rebuild/repairing-and-rebuilding-houses-affected-by-the-canterbury-earthquakes/

example as above, if the bearer/ foundation connections are released to re-level a house, they would need to be reinstalled with a code-compliant connection.

Section 42A provides the same requirements for works not requiring a building consent.

Building Consent/ Exemption from Building Consent

Some work may be exempt from requiring a building consent.[6]

The Building Consent Authority (BCA) in a natural disaster-affected region may also allow some work to be exempt from the building consent process that would otherwise require a building consent. But it is likely that an application for exemption to the BCA will be required in this circumstance.

It is noted that even if the repair works are exempt, all repairs must comply with the Building Code to the extent required by the Act.

Homeowners may require a full consent process to ensure full transparency on their building file for due diligence processes at the time of future property sales.

Earthquake Prone Buildings

Section 122 of the Building Act states that the provisions for earthquake prone buildings do not apply to residential buildings unless the buildings comprise two or more storeys and contain three or more household units.

Where these conditions are met, the Earthquake Prone Building clauses of the Building Act apply and it may be necessary to strengthen buildings to obtain a building consent to complete the repairs.

7. MBIE/ INDUSTRY GUIDANCE

MBIE has provided a series of guidance documents on repairs to residential structures. Industry sectors have also prepared repair guidance. These cover both the Canterbury earthquakes and weather event impacts.

Engineering New Zealand has prepared a list of key documents in a reference library that is included in the Legacy Document Package.

The engineer should read and familiarise themselves with these documents.

8. UNDERSTANDING BUILDING TYPE AND PERFORMANCE

Building standards, construction types, and their associated performance are subject to change over time. Older construction does not perform the same way as modern 'equivalent' construction. An example of this is lath and plaster internal wall lining over rough-sawn timber framing, which responds to earthquake induced actions differently than modern planer gauged light timber framing with plasterboard lining.

[6] Exempt building work guidance | Building Performance

Before undertaking an inspection, the engineer should familiarise themself with the expected building type and the corresponding performance characteristics of that construction type for the event being investigated. They should take time to carefully inspect the house to confirm its construction detailing. A brief look in the roof space is a good way to determine the ceiling type, which is often indicative of the wall lining type. This will also confirm if the framing is rough-sawn, or planer gauged, and possibly what species of timber has been used for the framing; all this information is useful when trying to determine the building age and infer its general construction detailing.

The process outlined above assumes no invasive investigations are to be undertaken. Such investigations may be necessary in some instances.

9. PRE-EXISTING CONDITION

An assessment should be made of the likely pre-existing condition of the building immediately prior to the natural hazard event. Once a view has been formed on the likely pre-existing building condition and alignment, this can be compared with the current condition of the building and an assessment can then be made of what damage may be attributable on the balance of probability to the event.

The standard of construction of houses varies considerably, resulting in a range of observed construction tolerance. To further complicate matters, many houses have had alterations or extensions constructed at various times, often by different tradespeople, leading to different construction tolerances in different areas.

The following forensic considerations are useful to help form a view of original construction tolerance:

- **General fit and finish** can be a good indicator of construction tolerance. The flatness of walls is one example of this. Be aware, however, that older lath and plaster walls are unlikely to be as flat as modern light timber framed walls, regardless of the quality of the original construction.
- **Parallelism of walls** gives a good indication of construction tolerance. Note: Care is needed when taking verticality measurements, as walls that are not flat can give different results depending on where the measurement is taken if a sprit level is used. Reliable wall verticality measurements should be based on the average gradient between the two points at floor and ceiling junctions.
- **Parallelism of floor and ceiling levels**. The ceilings of houses are constructed flat and level, subject to the skill and quality of work of the tradesperson involved. Ceilings are not constructed to replicate construction level tolerances of floors, so a comparison between the two is a good indicator of the original construction tolerance of the house. Measurements for this purpose should be limited to around points adjacent to walls, where the relative distance between the floor and ceiling will not have been significantly affected by time-related factors like ceiling sag deflection due to timber creep (particularly on houses with heavy roof cladding), or floor level variations due to the differential settlement of the subfloor structure. Similar assessments can be made between floors in a multi-level house.
- **Windows and door dimensional variation**. A length measurement of the four sides of a window or door frame gives a good indication of its construction tolerance, regardless of the effects of any racking displacement or differential settlement that may have occurred either before, or due to an earthquake.
- **Levels of built-in joinery** relative to other parts of the house, such as walls and floors, are useful indicators.

It is important to know the alteration history of the house when undertaking any measurements to indicate as-built tolerance. It is not uncommon, for example, for false suspended ceilings to be constructed beneath original ceilings in older houses, in which case the relative alignment of the ceiling and floor is no longer indicative of construction tolerance. In one case a house was assessed where most of the ceilings were not original and in one area two newer suspended ceilings had been built beneath the original at different times. The presence of bulkheads and remodelling of the house made it look more modern, meaning that the new ceilings were not obviously new. In that case, two previous forensic engineering assessments had failed to recognise the alteration history, so the conclusions reached about as-built tolerance were invalid, which impacted the appropriateness of the reinstatement scope of work proposed.

Conversely, knowing the timing of an alteration can be helpful to give a snapshot of likely building alignment at a point in time. For example, built-in benches installed shortly prior to an earthquake give a good indication of the levelness of the underlying floor at that time.

The effect of pre-existing differential settlement can be significant in some older houses. Two common mechanisms of differential settlement are time-related consolidation of fine-grained soils and settlement due to the long-term decay of organic material present in some soils. If the time-related differential settlement is a likely issue, it is good practice to seek the input of an experienced geotechnical engineer. Site soil investigation is sometimes appropriate, even if limited to a shallow investigation of the top 2 to 3 metres.

10. INVESTIGATIONS

Preparation for Inspection

The engineer's preparations prior to the inspection could include:

- Review of previous inspection reports so that the engineer can consider the evidence referred to in their reasoning;
- Review of the Territorial Authority property file to better understand the construction, previous history and any known hazards;
- For the recording of measurements including levels, preparation of base plans of the structure, so that the position of any levels, measurements or observations can be more accurately located; and
- Identification of where and how upper floors are supported so that levels can be taken on both floors at/ above points of support to provide a more meaningful comparison of floor levels between floors.

Non-intrusive Structural Investigation

The engineer's first investigation is likely to be a non-intrusive inspection. The template letter provides detailed requirements for a non-intrusive structural survey. This will likely include:

- A level survey of floors, ceilings, joinery items and other key elements;
- Observation and measurement of visible cracking or separations;
- Consideration of what might have occurred below the surface;
- Measurement of verticality of elements;
- Measurement of levelness of elements; and

- Photographs.

The engineer's equipment will likely need to include:

- Camera;
- Tape measure;
- Crack width gauge;
- Laser level or Zip Level;
- Post-it notes; and
- Digital spirit level.

A Zip level is a high-precision altimeter that requires operator training and a specific procedure to be followed that includes initial calibration and regular checks back to the datum point during the survey. They are susceptible to changes in air pressure and temperature and such devices should be serviced as required to ensure proper function of the machine.

Post-it notes can be temporarily stuck to walls to mark the height of the laser line as a change point. The laser can then be moved to a new position and realigned to the previous height. It is best to remove the post-it notes at the end of the survey. On one occasion the inspector returned to a property some months after the first inspection and found the post-it notes still in place.

Measurements should be made on either side of any change in floor coverings so that the thickness of floor coverings can be allowed for in the reduction of the surveyed levels. Levels provided in the engineer's report should exclude the effect of floor coverings and should represent the substrate of the concrete slab or floorboards.

All equipment should be regularly checked for accuracy and re-calibrated as necessary.

Sounding of concrete floors with a stick or hammer to identify potential voids without recommending follow-up intrusive investigations can provide misleading results. Changes in constructed slab thickness and variations in the angle or speed of the tapping can also be misconstrued as voids.

Intrusive Structural Investigation

Following a non-intrusive inspection, it may be warranted to complete an intrusive investigation. Note the onus is on the insured to prove damage rather than the insurer to identify damage. This responsibility limits the opportunity for the insured to otherwise require the insurer to complete extensive intrusive investigations looking for damage at no cost to themselves.

Irrespective of who is the engineer's client, the engineer has an obligation to “take reasonable steps to safeguard the health and safety of people.” If the engineer considers it is likely there is hidden damage and/or there is a vulnerable structural weakness that may have been further weakened, then the engineer should recommend intrusive investigations.

Geotechnical Investigations

Geotechnical investigations can include:

- Desk-top assessments of existing adjacent geotechnical investigations (these can be found on the New Zealand Geotechnical Database);
- Pits to determine the depth of the existing foundations;

- Shallow Standard Penetrometer Tests (Scalas), Shear Vanes Tests, Hand Augered Boreholes;
- Deep geotechnical investigations, typically involving CPTs;
- Bank Stability Assessments; and
- Susceptibility to expansion/ contraction with groundwater.

The geotechnical investigations should principally be scoped to identify changes/ damage arising from the natural disaster event. At times it may be necessary to identify and consider other geotechnical mechanisms, other than the natural disaster event, that may have contributed to the observable damage. Where possible, the need for geotechnical input should be identified at an early stage of the assessment cycle to avoid repeated site visit or delays.

Other investigations

The engineer should acquaint themself with the available investigations from other professionals and request these reports where appropriate. These may include:

- Subfloor photographic surveys using a piloted four-wheeled vehicle;
- Roof photographic surveys using an aerial drone;
- Building Surveyor reports on the materials used and weather tightness aspects of a building; and
- Ground penetrating radar surveys that might identify potential voids under slabs or reinforcement in slabs. Good operators will usually identify anomalies and recommend that some intrusive investigation is completed to confirm voids. Without follow-up intrusive investigations, these surveys can provide misleading results, particularly where there is subfloor polystyrene.:
- Drainage reports
- Reports on damage to areas outside the dwelling itself
- The widespread, or restricted, general area of damage from the insured event

Engineering New Zealand provides training for forensic engineering inspections and recommends that engineers in this field complete some specific training. Contact Engineering New Zealand at learn@engineeringnz.org to find out the current training schedule.

Other available information

The engineer should review other available information, including from sources such as:

- Previous damage assessments and scopes of work;
- Previous engineering reports;
- Previous repair records;
- Council Property File;
- Council Natural Hazard Property Specific Information including flood management, coastal inundation etc.;
- Old aerial photographs that could show pre-subdivision landforms;
- The New Zealand Geotechnical Database; and

- Listed Land Use Register for hazardous activities and industries.

11. COMMUNICATION AND CONDUCT DURING THE INSPECTION

Often the engagement will be with the homeowner and/or the engineer will complete the inspection with the homeowner present. Other parties may also be present during the inspection including an advocate or support person for the homeowner, an NZCRS Case Manager, or an agent for the insurer.

Some homeowners may be emotionally affected by the natural disaster event, the claims process, and the timeliness of the process. They should be treated with empathy during the inspection. Their concerns should be recorded and the engineer should discuss these concerns with the engineer's client, or their NZCRS Case Manager, or other appropriate parties. If it appears the engineer's inspection is causing emotional upset, the engineer should offer to cut short their inspection and return another day; if a support person was not present, the engineer's return visit should be when they have a support person available.

It is important for the engineer to communicate openly and clearly with the homeowner and/or their support person to explain:

- The engineer's background and experience;
- Who has engaged the engineer to complete the inspection;
- The engineer's process; and
- The likely time required to complete the engineer's report.

The engineer should encourage the homeowner to point out their areas of concern and identify the potential damage to the property that they are aware of and discuss any differences from before and after the event they have noted. This information should be noted and included in the engineer's report with clear reasoning around the engineering opinion of these matters.

The engineer should encourage the homeowner to raise any questions. These questions should be included in the engineer's report with clear reasoning around the engineering response to these matters.

It is best for the engineer not to discuss their initial conclusions or opinion of matters the homeowner draws to their attention during the inspection. These may be subject to change as the engineer prepares their report and processes and reviews their measurements, assembles other data, and assesses the likelihood of various alternative scenarios that may have caused the anomaly. However, it can be helpful for the engineer to point out visual indicators to the homeowner while on site that they are likely to refer to in their report, e.g. if photographing a horizontal laser plane relative to a pointing line in wall tiles or masonry. This is best done in a factual manner with a comment similar to “I noted the following, you [the homeowner] may want to see this, as it may be part of the information I use when assessing your property.”

Engineers should be wary of body language when discussing issues with homeowners. It is often easy to nod or agree with a homeowner’s statements when on site but these acknowledgements, even if not intended, may cause significant and ongoing harm to the homeowner’s wellbeing.

It is particularly important that any discussions with the homeowner, and the engineer's written report, are in plain English with a clear explanation of any engineering terms or principles.

12. HEALTH AND SAFETY

The engineer must take account of their personal safety and the homeowner's safety during an inspection.

It is unlikely the engineer has been to the property before, and the inspection should be treated as a high-risk activity. The engineer should complete a Safe Work Method Statement [7](SWMS) or similar assessment prior to attending the site. There are also online tools that provide this service, for example, iAuditor, which is a tool that is free for small teams[8].

The site may contain:

- Unsafe structures;
- Unstable land;
- Dangerous animals;
- Upset or aggressive occupants and/or their advocates; and/or
- Asbestos, toxic mould or other health risks.

The engineer's SWMS should identify their strategies to remove, isolate or mitigate these risks. The engineer should also consider whether their activities may be causing harm to the occupant's wellbeing.

If there is any significant risk to the engineer or the occupant, the engineer should cease their inspection and return to complete the inspection when the risk has been mitigated.

Experiences from previous inspections include:

- Dog bites;
- Standing on an unstable deck structure that when viewed from outside the house at a later part of the inspection was considered unsafe;
- Escalating tension between the homeowner and the inspector, resulting in raised voices and intimidatory behaviour. In one instance, both parties were videoing the inspection which raised tensions and when the inspector moved an item to get a better view of an issue, the inspector was accused of causing more damage/ tampering with evidence and the tension escalated. The inspector had previously been in the police and was able to successfully cease the inspection and leave the property using his previous training in de-escalation.
- Homeowners in tears.

13. WELLBEING

The engineer's own wellbeing is important. Working with homeowners, insurers or other engineers who may be visibly upset or angry when the engineer attends a site visit or joint discussion may affect the engineer's mental health. In many cases after the Canterbury Earthquake Sequence (CES), engineers visiting homeowners had also been personally affected by the earthquakes, which could further add to

[7] SWMS Template link

[8] iAuditor by SafetyCulture - Inspection Software & Mobile Inspection App

the challenge of interacting with a homeowner. Since the Canterbury Earthquake Sequence (CES)there has been a greater acknowledgement of the stress that can come from these engagements, and the importance of wellbeing programmes to provide self-care strategies and guidance in working with vulnerable homeowners. Engineering New Zealand now has a wellbeing section on its website[9], providing guidance and tools on coping with stress and maintaining positive mental health.

Contact Engineering New Zealand at learn@engineeringnz.org to find out the current training schedule. Currently, it also provides a one-hour free online module on stress management[10] and a six-hour module on resilience and wellbeing[11] .

14. FORENSIC ANALYSIS

It is important the engineer undertaking forensic assessment has a clear understanding of their terms of reference, and equally important that this is stated in any reporting.

The standard that must be met to draw conclusions is also important. Forensic engineering assessments are most commonly based on a balance of probability (i.e., the test is whether something is more likely than not to have occurred). The applicable standard should be stated in the engineer's report.

Communicating the basis on which the view of pre-existing condition has been reached underpins the credibility of all subsequent forensic engineering work on a property.

Where possible, assumptions should be avoided. Sometimes relevant data is scarce, and it is necessary to make a limited number of reasoned assumptions to move the assessment forward. In such circumstances, all assumptions must be documented with an explanation of their basis. Where validation of assumptions can be made by further investigation, either destructive or non-destructive, this should be documented. It is good practice to provide a commentary on the significance and value of any further investigation, relative to the cost and complexity of undertaking it, and make a recommendation on whether it should proceed.

When considering data, remain objective and open-minded; let the evidence lead the engineer to reach conclusion(s). Be aware of potential bias, which could include one or more of the following:

Association bias. This bias can arise out of an engineer's financial or employment relationship with their client or employer.

Expectation bias. This is the subconscious tendency of those who have predetermined a certain outcome to search for data or analysis methods that will support that outcome and ignore contradictory information. Engineers must be careful not to jump to any conclusions about the cause of any suspected damage, based on patterns of common damage they have become familiar with from previous assessments. Every forensic assessment is unique and must be treated as such.

[9] Wellbeing | Engineering NZ

[10] Self-leadership: Stress Management | Engineering NZ

[11] Resilience and Wellbeing (engineeringnz.org)

Maintained condition bias. This is a common expectation bias where the maintained condition of a building affects the inspector's expectation of whether the building has been affected by the natural hazard event. For example, whether a building has or has not been painted in the last twenty years will not affect whether liquefaction has dis-levelled the floor.

Data bias. The specific data collected and how it is analysed can bias findings and conclusions. It is important that sufficient appropriate data is used in the analysis of the observed damage to assess all the potential reasons for it.

Be mindful about applying current building standards and practices to the assessment of older buildings, as building standards and methodologies change over time, so this may not be appropriate.

Be aware of the precision and limitations of the data available. It is easy to make inferences from data that are not valid. For example, following the Canterbury Earthquake Sequence (CES), ground penetrating radar (GPR) has been widely used as a non-destructive investigation tool to indicate if voids are present beneath concrete slab floors, where the dynamic settlement of evenly graded round aggregate hardfill (tailings) is suspected. There is an instance of two GPR reports, where one indicated voids beneath the floor slab and the other indicated no voids. Further investigation determined that different frequency antenna had been used for each investigation, resulting in one set of data lacking the resolution required to draw any reliable conclusion. In that case, a simple engineering first principles calculation of the flexural stresses induced in the unreinforced floor slab, assuming voids of the suggested span were present, demonstrated that the concrete had insufficient tensile strength to support its own weight over that span. The absence of flexural cracking due to the hogging moment and corresponding slumping conclusively ruled out the possibility of voids of the magnitude suggested.

Be prepared to reconsider conclusions if further information comes to light that might lead to a different conclusion. This is why it is important to clearly document the process followed, the information collected, any assumptions made, the basis of conclusions reached, and the basis of analysis used to reach those conclusions. An engineer's willingness to reconsider the outcome of a forensic assessment, in light of new data, is a hallmark of their professionalism.

Conclusions derived from forensic evidence should be based on the consideration of multiple independent indicators. As a minimum, any conclusion should be based on at least two, or preferably more, pieces of independent evidence that all 'tell the same story'. There are likely to be several areas of localised damage within a house which cumulatively form the overall extent of damage caused by an event. When considering the causation of any localised area of damage, it needs to be considered in terms of the overall quantum of damage (i.e., the cause of damage to one element must not be inconsistent with the causation of damage to the house generally).

Everything about the forensic engineering process must be robust, well-considered, and able to withstand subsequent scrutiny from any relevant party. It is reasonable for engineers to refrain from reaching any findings where there is insufficient data. There is no place for unsupported opinion in an objective forensic engineering assessment.

Here is an example of a forensic report **Engineering Forensic Report Example.pdf**.

15. REPORTING

Engineering New Zealand Report Framework

Engineering New Zealand has a report framework that has been developed and refined through the work of the Christchurch Earthquake Expert Engineering Panel.

The framework was originally developed from a review of several reports by different engineers following the Canterbury Earthquake Sequence (CES). The layout and content within the framework have a proven track record of being an efficient and effective basis for documenting forensic engineering assessments.

A key principle in the development of the report framework was to provide a consistent approach to reporting of engineering assessments. The purpose of this was to make it easier to compare reports from two or more engineers that may present different conclusions and recommendations for the same damaged building. Difficulty in making objective comparisons between reports with inconsistent structure was identified as a key obstacle in resolving residential claims following the CES.

This framework is not intended to be a prescriptive 'one size fits all' solution to every engineering assessment. However, the report framework should be considered representative of good practice and modification of it should only be made with due consideration. The most recent versions of the Engineering New Zealand report framework can be found on the Engineering New Zealand website both as a separate document and as Appendices to the template Letters of Engagement.[12]

General Comments on Good Report Writing Practice

The following general comments are intended to be read in conjunction with the Engineering New Zealand report template.

Engineers should be cognisant of the likely audience when report writing. It is common for several different stakeholders to need to read and understand forensic engineering reports (e.g., homeowners, insurers, lawyers, builders, cost estimators). Reports should be written in plain English where possible, to be understood by a layperson homeowner with limited knowledge and include descriptions of engineering principles and methodologies. Where it is necessary to use engineering terminology, a plain English description of the terminology should be provided.

Reports should state the scope of engagement and terms of reference. In particular, the following must be communicated:

- the scope of the assessment;
- the definition of damage; and
- the required standard of repair (if the scope extends to recommending a repair methodology).

Describe the site and building, including key aspects of its construction and the load paths for gravity and lateral loads. A brief history of the house should identify when the house was built, and the timing of extensions or major renovations. Also include summary information from the Council Property File and

[12] Engaging an Engineer | Engineering NZ

other relevant databases, e.g. the New Zealand Geotechnical Database and Geonet. Provide relevant site-specific information on the natural disaster event, e.g. the intensity of ground shaking, depth of floodwater etc. Information from previous technical investigations should be summarised including geotechnical investigations, level surveys, roof and subfloor surveys. The intention of this section should be to provide an overview and to give context to detailed observations included later in the report. Include a view of the pre-existing condition of the house and describe how that view has been reached.

The report should identify the source and any collection methodology for all data used in the assessment:

- Background information referenced should be clearly identified. Identifying relevant background information is important because it provides context to the assessment. This is particularly important if more information becomes available following the assessment which might cause the engineer to reconsider their assessment. Understanding the basis of assessments becomes particularly important when comparing engineering forensic reports that have reached different conclusions, or appear to make conflicting recommendations.
- Clearly identify the extent of inspection and investigation undertaken as part of the assessment. Any limitations of the investigation should be included.
- Undertaking forensic assessment sometimes requires assumptions to be made about certain aspects of the building (e.g., assuming a perimeter concrete foundation is unreinforced based on the age of a building and typical construction practice of the time). All assumptions must be documented and the significance of those assumptions to the assessment should be explained. Validation of assumptions often forms an important part of resolving differences in engineering opinion between reports that arrive at different outcomes.

The report should identify the damage observed and consider and report on what the engineer did not observe and why that is relevant. If the damage the engineer should have expected to see, associated with an observed movement, is not present then this could be evidence that the movement pre-dated the natural disaster event.

The report should also identify the various possible causes of the damage including the natural disaster event, construction imprecision, static loads, thermal movement, operational use, previous events, expansive soils etc. The engineer should assess each possible cause and identify on a "more likely than not" basis whether the cause has contributed to the observed damage beyond "de minimis" (ie, in a way that is more than minor or trivial). The engineers should provide a clear rationale for their assessment including the evidence that supports their conclusions. This will necessarily include a commentary on the engineering judgements made. Any contradictory evidence should also be discussed including why it has been discounted or given less weight in the engineer's conclusions.

Reports should include a photographic appendix with descriptive captions for each photograph. Including relevant forensic commentary with photographs is an efficient way to communicate key principles to the reader and assists the author with keeping the body of the report concise.

If the scope of engagement includes making recommendations for reinstatement, a discussion section is needed for each damaged element. This section should describe:

- the reinstatement options considered;
- the merits and shortcomings of each reinstatement option;
- any associated construction methodology challenges, or regulatory challenges;

- how the option being considered meets the required reinstatement standard; and
- limitations of the report, including whether the report can be used for construction purposes, and/or relied on for repair without further involvement of an engineer.

A discussion section should be provided to explain the basis of recommendation for the preferred reinstatement methodology. Note that many insurance policies allow returning the damaged item to its new condition rather than its pre-event condition. In this case, the determination of a repair strategy is a two-step process:

1. Identify if the building has been damaged by the natural disaster event by comparing its current condition to its assessed pre-existing condition; and
2. Identify the repair strategy required to return the damaged items to their new condition, noting that substantial renovations and extensions can at times reset the "new condition" of at least part of the building to when the renovation was completed rather than when the building was originally constructed.

The report should be prepared as a draft and submitted to the engineer's client, and preferably the other parties involved, for comment. Following a review of any comments received, the engineer should issue their report as final.

16. FURTHER WORK

The template Letter of Engagement identifies that the engineer may be involved in further activity beyond the engineer's initial report. This may include attendance at a dispute resolution process, or to prepare reinstatement recommendation reports, to carry out the engineer's reinstatement methodology including issuing appropriate Producer Statements. The engineer should only accept the engagement if they are prepared and able to complete these further tasks if called upon.

The information provided in the engineer's report may be relied on by the parties, including for financial settlements. If at a later stage, the engineer departs from their reinstatement methodology, this may have significant financial consequences for the parties. Similarly, if the engineer declines to attend a dispute resolution process, this may affect a party's case and the party may have otherwise made different case management decisions if they were aware they could not rely on the engineer's attendance.

17. EXPERT WITNESS ROLE

The standard Engineering New Zealand letter requires the engineer to read and comply with the High Court Code of Conduct for Expert Witnesses and/or the Canterbury Earthquake Insurance Tribunal Code of Conduct for Expert Witnesses when engaged as an expert witness.

An expert witness is the only witness in a court of law who is allowed to express an opinion; all other witnesses must limit their evidence to facts. This places a special level of responsibility on an expert witness and their activities are of special importance to the reputation of the New Zealand engineering community.

Engineering New Zealand provides training for the Expert Witness role and recommends that engineers in this field complete some specific training. Contact Engineering New Zealand at learn@engineeringnz.org to find out the current training schedule.

18. CHRISTCHURCH EARTHQUAKE EXPERT ENGINEERING PANEL REPORTS

Over the five years that the Christchurch Earthquake Expert Engineering Panel (the Panel) has been supporting the GCCRS, it has completed over 420 referrals with associated forensic reports. The Panel Legacy Document 'Panel Instruction and Brief' outlines the various services the Panel has provided to support the GCCRS including associated report templates, Letters of Engagement and examples of completed reports.

The report examples have been provided by the GCCRS as examples of reports that stand out positively due to the forensic analysis they provided, with the homeowner and the insurer accepting the findings, whether or not it was in their favour. Also noted was when the homeowner had provided feedback that they had felt 'heard' by the Panel Member both during the site visit and with respect to addressing their questions in the written reports.

Report examples can be found in this folder **GCCRS Report Examples**. The Panel Legacy Document 'Panel Instruction and Brief' provides additional comment for each example from the GCCRS Case Manager.

APPENDIX ONE :: DEFINITION OF KEY TERMS

House

The insurance policy will define what structures on the property are covered by the policy and what are not. For example, the dwelling, garages, glasshouse, swimming pools, retaining walls, driveways, and so forth. Residential house policies do not provide cover for land.

Some policies refer to the term "house" when defining what structures are covered by the policy. Other policies may refer to the term "building", for example the EQC Act refers to "Residential Building". Whatever term is used, please check the policy to see what structures on the property should be considered in the engineer's assessment and recommendations. In particular, the cover for retaining walls varies between policies and should be checked.

Property

The house and land and other improvements at a specified address

Damage

A structural element is damaged by a natural disaster event if,

- its physical state has been measurably or visibly altered by the natural disaster event in a negative way; and
- that alteration is more than de minimis (meaning trivial or minimal); and
- that alteration affects the original functionality of the structural element.

Pre-existing condition

The condition of the building immediately prior to the event. This is the reference condition against which any damage caused by the event is considered.

Analysis

This is the process of interpreting relevant data to form a well-reasoned view of the cause or contributing factors to damage caused by the event, that cannot be determined by observation alone.

Data

Data is the overall quantum of information upon which forensic assessment is based. Data is generally collected from many sources, which might include:

- review of relevant background documentation
- discussion with the homeowner, insurer, or other relevant persons
  site observations
- site measurements, possibly supplemented by investigations

De minimis

In relation to the law, this is taken from the extended Latin phrase 'de minimis non-curat lex', which translates to 'the law cares not for small things'. De minimis is a legal principle that allows for matters that are small scale or of insufficient importance to be exempted from a rule or requirement. It can be used by the courts as an exclusionary tool to dismiss trivial matters from litigation.

Imminent damage

If further damage is expected to result from a natural disaster event during the 12 months after it. This assumes there will be normal weather conditions during the 12 month period (i.e. no extraordinary conditions) and no remediation or mitigation of the original natural disaster damage.

Natural disaster

Natural disaster means—

- an earthquake, natural landslip, volcanic eruption, hydrothermal activity, or tsunami; or
- natural disaster fire; or
- in the case only of residential land, a storm or flood.

Forensic engineering

Is the application of professional engineering principles, methodologies, and judgement, to identify damage caused to a residential house by an event. Forensic engineering typically consists of the following key phases:

1. Obtaining and reviewing relevant background information, including engaging with the homeowner;
2. Visiting the site to observe the building condition after the event, take relevant photographs and measurements, and possibly carry out other investigation work;
3. Consider and analyse the information gathered;
4. Arrive at well-reasoned forensic engineering conclusion(s); and
5. Write an engineering report summarising the forensic engineering brief, assessment process, outcome, and making recommendations.

Non-intrusive site inspection

This means a site walkover, visual assessment and review of any data reasonably relevant to the property on the New Zealand Geotechnical Database at the time of preparing the report.

Shallow geotechnical investigation

In general, a shallow geotechnical assessment is one that extends to a maximum depth of between 3 and 6m below the ground surface. A shallow geotechnical investigation shall follow the procedure generally outlined in NZS3604:2011. The type and scope of a shallow - must be determined by Chartered Professional Geotechnical Engineer or Professional Engineering Geologist

Further details of the various types and guidance for the appropriate specification of shallow geotechnical investigations are outlined in the MBIE publication “Guidance for repairing and rebuilding houses affected by the Canterbury Earthquakes”.

Deep geotechnical investigation

In general, a deep geotechnical investigation is one that extends to a depth greater than 6m below the ground surface. The type and scope of a deep geotechnical investigation must be determined by a Chartered Professional Geotechnical Engineer or Professional Engineering Geologist. Details of the various types and guidance for the appropriate specification of deep geotechnical investigations are outlined in the MBIE publication "Guidance for repairing and rebuilding houses affected by the Canterbury Earthquakes".

Exacerbation

Where there is pre-existing damage and deterioration in the **land** or where a **house** is already in a dilapidated state, the additional physical effects caused by a natural disaster must make a material difference to the value or usefulness of the house to be damage the Earthquake Commission Act or policy will respond to.

Land Damage

Land damage requires a physical change or loss to the body of the land that has occurred, or is imminent, as the direct result of a natural disaster and which affects the use and amenity of that land.

Land

Land damage covered by Toka Tu Ake EQC includes:

- the land under the **House** and outbuildings (e.g. a shed or garage);
- the land within eight metres of the **House** and outbuildings;
- the land under or supporting the main accessway, up to 60 metres from the House (but not the driveway surfacing);
- bridges and culverts that are within the above areas; and
- retaining walls within 60 metres of the house that are necessary for the support or protection of the home, outbuildings or insured land.

The required standard

Where damage from the natural disaster event has occurred to a structural element, or previous repair work to the damaged structural element is inadequate, the engineer's reinstatement methodology, whether it involves repair or replacement, must meet the following requirements:

a. the reinstatement methodology of a structural element must restore the functionality and durability equivalent to when it was originally constructed, usually to "a condition substantially the same as but not better or more extensive than its condition when new."

b. Where the structural building element also has an aesthetic purpose, the reinstatement methodology will also need to restore the former aesthetic to its condition when originally constructed

c. the reinstatement methodology of a structural element does not have to make the damaged structural element an exact replica of the original

d. most policies require current materials and methods to be used

e. the reinstatement work must meet current building regulatory requirements, including the Building Code to the extent required by the Building Act; including

i. There is no general obligation to upgrade the structure of the House even if it doesn’t comply with current Building Code requirements

ii. The reinstatement work must not make the house less compliant with the Building Code than it was before the damage and reinstatement work

iii. The reinstatement work must not accelerate or worsen a natural hazard on the land or any other property.