Report from the NZIS Working Party

Review of Survey Practices in Relation to the Canterbury Rebuild

Version 2 - September 2014

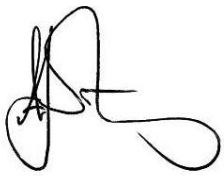
Introduction

The Christchurch earthquakes in 2010 and 2011 tested New Zealand, those living in Canterbury and many in the construction sector. Following such a significant event all hands have focused on responding to the immediate needs of the situation but there must eventually be time put aside to reflect and review procedures that have come into use. In 2013 the New Zealand Institute of Surveyors (NZIS) became aware of significant concerns regarding the measurement of earthquake damaged buildings in Canterbury. After consultation with various stakeholders, the NZIS decided that it could play a valuable role, as the professional body for surveyors, in a review of the measurement practices that have evolved in Canterbury. Our aim is to ensure that the measurement systems employed are actually good practice and sustainable.

An NZIS Working Party (WP) was formed under the leadership of Emeritus Professor of Surveying, formerly at the University of Otago, John Hannah and included Scott Williams (NZIS Canterbury Branch Chair), Warren Haynes (former NZIS Canterbury Branch Chair) and Richard Hemi (Professional Practice Fellow at the National School of Surveying, University of Otago). The WP members are all Registered Professional Surveyors and brought a strong mix of academic and professional practice experience to the group. They were required to complete a review of the Ministry of Business, Innovation & Employment (MBIE) Guidelines relating to the measurement of floor levels of earthquake damaged buildings and to investigate the measurement methodology and practices that have been applied in Christchurch and to make recommendations for improvement.

The WP members have given their time and expertise freely, as have the many experts and individuals that they interviewed in order to understand the issues involved. NZIS extends its appreciation to the WP members and all those who have taken the time to contribute to this excellent report. The WP have provided valuable recommendations and guidance for anyone leading or undertaking this type of work to follow. The NZIS Board supports the recommendations and commends this report to all those involved in the assessment and repair of earthquake damaged buildings.

On Behalf of NZIS



Andrew Stirling

NZIS Board Chairman

Executive Summary

This report, which outlines the Working Party's findings, also describes best practice procedures for levelling. The important elements of the report are summarised as follows.

1. Many residential dwellings were damaged in the earthquake sequence. While by no means the only relevant measurement metric, floor dislevelment is used by engineers as a primary indicator of building performance. The criteria against which the floor assessment is made have been published by the Ministry of Building, Innovation and Employment. A decision to repair or rebuild typically involves an assessment against these criteria.

2. Some dwellings have had multiple, independent floor level assessments with the resulting documentation passed on to engineers, homeowners and/or insurance companies, amongst others. These assessment surveys have been carried out by a wide variety of people all with varying levels of measurement knowledge and skill. Unfortunately, the documentation from some such assessments has been insufficient to determine: (a) whether or not they are fit-for-purpose, and/or (b) whether those doing the task have had the appropriate skills, knowledge and techniques to be able to guarantee the quality of their work.

3. There is evidence of at least some poor or incorrect assessments due typically to (a) an apparent failure to consider a wider suite of assessment criteria and, (b) incorrect and/or inadequate floor levels being obtained. For this latter reason the WP is strongly of the view that irrespective of the equipment used in the assessment of a building, the process used for floor levelling and the records kept should reflect what the surveying profession would regard as normal, good survey practice. To this end the WP has developed a template that it believes should be used by all those who undertake floor level assessment surveys. This template should lead to much improved levelling data and accountability.

4. Due to the widespread uses to which levelling data may be put, and the many techniques available, no one specific measurement method can be recommended. In cases of doubt, only a competent person or someone operating under the direction of a competent person should make such decisions.

5. The WP is satisfied that hydrostatic levelling devices in general, and the ZipLevel Pro-2000 in particular, when used by trained users and in strict accordance with recognised procedures of best practice, can be an appropriate floor levelling tool for a range of assessment purposes. However, the WP believes that some measure of formal training should be expected of all users of Zip Levels. It is suggested that the NZIS either initiate such a training course or partner with others in delivering such a course.

Where legal action appears likely or where there is a dependence upon an accurate and credible presentation of survey information obtained in accordance with best survey practice, the WP is strongly of the view that as measurement specialists, Registered Professional Surveyors (RPSurvs) or Licensed Cadastral Surveyors (LCSs) are the only appropriate professional people to be engaged for such data collection and its presentation.

1. Background

In response to concerns about the assessment of earthquake damaged properties in Christchurch, the New Zealand Institute of Surveyors (NZIS) formed a Working Party (WP) to consider the guidelines relating to the Canterbury rebuild. The WP was specifically tasked to consider:

- Improvements and additions to the existing guidelines
- Methodologies required to apply the guidelines
- Who may sign off on the correctness of the data when the guidelines have been applied

In undertaking this task the WP has sought to act with impartiality taking a constructive and objective view of the rebuild process as it exists. It recognises that the Canterbury Earthquake sequence has placed both the people of Christchurch, and New Zealand's earthquake response processes, under stresses not experienced since 1931. Since the start of the Canterbury rebuild, there have been many lessons and learnings that have brought improvement and change to earthquake response processes. As organisations at all levels seek to respond in the most appropriate way to the needs created by the earthquake sequence, they have recognised that going forward, improvements in practice can be made. Such improvements, when implemented, provide stronger procedural foundations for dealing with future earthquake events. This report should be seen as contributing to this process improvement.

The report will first describe how the WP gathered information and then outline some of the relevant building assessment processes in use. It will then discuss issues around how building assessment data is collected, followed by comments about the knowledge and skills of those undertaking such tasks. The report will conclude with recommendations followed by some brief additional observations.

2. Methodology

In order to form initial thoughts and observations, the WP interviewed a number of people associated with the rebuild process (surveyors, engineers, builders, and rebuild administrators amongst others). It listened to their wide ranging comments and saw examples of what is happening on the ground. Much of the material presented to the WP was relevant to its deliberations.

On the basis of the interviews undertaken, and the specific examples of practice presented, the WP formed a consultation document that outlined its initial observations. The document was distributed for comment both to members of the NZIS and also to other interested parties. The WP is exceedingly grateful to all those who took the time to respond and has noted the comments made. It believes this final document fairly represents not only the consensus views of all those who have interacted with the WP, but also makes best-practice recommendations moving forward.

3. The Building Assessment Process

3.1 The Typical Assessment Process

When assessing the extent of damage to a residential property the WP was told that more than one assessment is likely to take place. Such assessments may be as a result of additional earthquake events or as a dwelling passes from one interested party to another e.g., EQC to insurer to project manager. These assessments may (but not necessarily), include the following: an estimate of the extent of foundation damage, floor dislevelment, block settlement, verticality problems, and lateral spreading. While by no means the only measure, the WP was informed that floor dislevelment is not only fundamental to understanding building performance but will also provide a first indication of what remedial action may be required for the foundations. For this reason it is given a great deal of prominence in the assessment process.

It was clear to the WP that by far the majority of these initial assessment surveys had been carried out by a wide variety of people (for example, building practitioners, earthquake assessors, engineers and, occasionally, surveyors) all with varying levels of measurement skill and knowledge.

The WP understands that following the initial assessment by EQC, cosmetic damage (less than $15,000) typically results in a cash settlement, minor damage (between $15,000 and $100,000) results in repair and anything over $100,000 passes to the insurer. Once with the insurer, the building assessment information gathered is considered, and a residential dwelling is then usually allocated into one of two streams, either a full rebuild (new dwelling) or a repair of the existing structure. Where the decision is obvious to all parties, there appears to be little debate. However, when it is not obvious, or where there is dispute, the issue can become highly contentious. It is typically only at this point that a professional surveyor becomes involved in the process and only if the need for accurate, precise and authoritative measurement data is recognised.

While the WP recognises that many of these initial assessment surveys will have been done on a fit-for-purpose basis and probably been adequate for the particular need, it was, nevertheless, disturbing to the WP to be presented with evidence of poor or incorrect assessments due, typically, to one of two sources:

(a) An apparent failure to fully assess and record a building across a full range of assessment criteria listed, and

(b) Incorrect and/or inadequate levels being obtained in the course of foundation/floor assessments.

Incorrect floor assessments, where they have occurred, appear to have been due to:

- Varying procedures and inadequate training in the use of Zip Levels.
- Inadequate coverage (density) of measured floor levels to appropriately assess the extent of foundation damage.
- Inadequate or non-existent information about the spatial position of where the level data was collected.
- A failure to account for different floor coverings with their associated height differentials. Obstructions in rooms (e.g., furniture) have resulted in some level surveys not reaching the corners of rooms.
- Lack of structural and/or building knowledge, or guidance to identify the important locations as to where to take levels (e.g., beside load bearing walls, on the perimeter foundations, etc.).

- Levelling methodologies that have failed to include independent checks on the reliability of the results.

- Inadequate recording and reporting standards, and plan/diagram preparation techniques that unnecessarily leave the measurement data open to interpretation, assumption and doubt as to accuracy.

A good number of examples were available to the WP where there was no record of who collected the data, with what equipment, on what date, for what purpose, and what, if any QA/QC procedures had been used. From the examples presented to the WP, there appear to have been many cases where measurement data collection had been repeated a number of times over, all by different (but unknown) parties – each party wishing to have its own dataset. These multiple surveys were typically independent of each other. Unfortunately, and with the time available, the WP was unable to determine definitively how widespread the problem of poor or incorrect measurement data might be on building assessments. However, the WP was informed that in excess of 1000 Zip Levels (an atmospheric pressure levelling device and one of the primary floor level measurement devices used) have been sold in the Canterbury area alone, most over the last two years. If not maintained within their two-year maintenance cycle they can give erroneous results. The analogy presented to the WP was that of bicycle tyre deflating over a period of time, thus becoming less efficient and, eventually, of limited use.

Similarly, Zip Levels require regular recharging if they are to produce reliable results. In addition, even if fully serviced, Zip Levels can easily produce erroneous results if used by operators who are untrained in the operational and QA procedures appropriate to such levels, and in the more generic good survey practice procedures appropriate to levelling operations.

Given the wide use of such levels and the general lack of knowledge of good survey practice procedures, it seemed clear to the WP that problematic assessments were certainly not an occasional problem and that if appropriate processes had been followed, such problems need not have arisen at all. It is for this reason that perhaps the most substantive recommendation of this report will deal with process and measurement quality issues.

3.2 Wider Assessment Issues

The WP was informed that the insurance companies were well aware of their obligations to repair/restore a building to “as new” status – or to whatever other status might be required by the policy wording. It was clear that there could be significant differences in opinion as to what this meant for a specific building, particularly in trying to assess not only the original status of the building, but also what deterioration might have occurred prior to the earthquake sequence. Indeed, very few dwellings have post-construction as built data that can serve as a baseline against which to measure the full extent (or otherwise) of earthquake damage. While the WP acknowledges both the uncertainties inherent in assessing pre-earthquake condition, and the need for direction from the engineering profession as to measurements to be made, it was clear to the WP that a full suite of measurements required to make a comprehensive and complete post-earthquake assessment should at least consider all of the following:

- Floor dislevelment
- Lateral stretching
- Foundation settlement
- Block settlement
- Building verticality

It seems clear, for example, that while floor levels are a primary measurement metric, some blocks of land with structures built on them may have been subject to lateral stretching and/or relatively uniform block subsidence thus exacerbating future flood risk to the structure. It seemed to the WP that care needed to be taken to ensure either, that such issues were not overlooked, or that limitations are stated in the assessment that identify the issues that have/have not been investigated – these being consistent with the roles and responsibilities of the insurer and/or EQC in having the assessment carried out.

4. The Equipment Used for Building Assessments

The equipment used for any assessment must not only be fit-for-purpose but also be accurate and in complete working order. The purpose for a particular survey will dictate measurement accuracies desired and the measurement method used. If, for example, a full property assessment is being undertaken, then levelling information alone may not provide a complete picture of the situation. In such a case, it is likely that the measurement practitioner will need to be competent in the use of a far greater range of equipment than just a simple spirit level or a Zip Level. On the other hand, if a very quick first assessment of a property is to be undertaken then these may be entirely adequate for the task.

While there was an initial expectation that the WP might provide methodologies for applying the MBIE guidelines, in reality, the many measurement techniques available for such assessments (e.g., spirit levels, dumpy levels, Zip Levels, precise digital levels, total stations, robotic total stations with built in cameras, laser scanners, and panoramic cameras), are so broad as to make this impractical. However, the WP recognised that Zip Levels and optical levels, in particular, are in widespread use by non-measurement specialists. It was apparent to the WP that a number of users of these levels are not trained in good survey practice, may have little idea of the possible shortcomings or error sources in such levels, are not familiar with required calibration and maintenance procedures, and do not undertake fundamental QA/QC procedures. These are all issues typical of people with insufficient training operating outside their areas of knowledge and expertise. Because of its concern over this issue, the duplication of work being undertaken, the questionable quality of some measurement data, lack of accountability, and the apparent lack of quality assurance/quality control, the WP has crafted a generic set of QA procedures for simple levelling work (see Tables 6.1 and 6.2).

Due to the widespread uses to which measurement data may be put, the WP does not recommend a specific measurement method. Any person competent in measurement methods should be able to make an appropriate judgment as to which method and equipment to use. If they are unable to do this, then they should be operating under the professional advice of someone with such competencies.

5. The Skills and Knowledge Necessary for those Collecting Measurement Data

The WP takes a pragmatic view on this issue. Skills shortages (including those found in the surveying profession) have stretched all parties. Some assessments will only require lower levels of measurement data accuracy whilst others will require high quality, verified, high accuracy data. Irrespective of either the accuracy required or of those involved in the data collection process, the WP believes that the following are essential:

- Data must be fit for purpose.
- Measurement documentation is essential.

- Those involved in the collection of measurement data must have the appropriate knowledge and experience.

- Where legal action appears likely and where there is a dependence upon accurate survey information, the WP is strongly of the view that as measurement specialists, Registered Professional Surveyors (RPSurv's) or Licensed Cadastral Surveyors (LCSs) are the only appropriate professional people to be engaged for such data collection. It is expected that in such engagement the surveyor would normally work alongside a structural engineer who would provide a clear brief as to the measurements needed and their required accuracy.

6. Recommendations

1. The WP is strongly of the view that irrespective of the equipment used in the assessment of a building, the processes used for floor levelling and the records kept should be such that they reflect what the surveying profession would regard as normal, good survey practice. In this regard any reporting or associated depiction of survey data at any stage of the assessment should have an accompanying written statement by the surveyor/operator that records clearly the items listed in Table 6.1.

Table 6.1 Essential items to be stated in floor level survey records

1.	Address of property
2.	Date and purpose of survey
3.	Name of the surveyor/operator and employing company
4.	Type of equipment and its serial number
5.	Methodology of position/level determination including the means of independently checking the results. Whether levels have been reduced to a common surface (e.g. concrete floor) and assumptions (if any) related to floor covering thicknesses. Datum information should also be included.
6.	Quality statements that include estimated level (z) and position (x & y) accuracies
7.	Calibration of equipment status and calibration technique
8.	Any limitation of the survey that needs to be part of the record
9.	A statement that the level information presented is a true and correct record of levels obtained including signature of person responsible for the survey

Given the importance of good quality levelling records to the assessment of a dwelling, it is appropriate that the surveyor/operator and employing company have implemented quality control systems that should include, but not be limited, to the tasks identified in Table 6.2.

Table 6.2 Quality control systems for floor level surveys

• Use of written procedures/work instructions/forms/checklists
• Use of suitable equipment for specified tasks
• Use of trained personnel
• The assessment of plans/diagram as being fit for purpose prior to delivery.
• Internal audit

Explanatory notes to Table 6.1

a) It is important that any survey has traceability so that any party wishing to utilise the results of the survey has a clear understanding of the limitations or otherwise of the survey information and can therefore determine and confirm its suitability for the assessment task under consideration.

b) Floor level surveys may be completed at various stages of the assessment process. The reason for the survey will influence the decisions regarding the accuracies required, equipment to be used, necessary skill set of the equipment surveyor/operator, survey methodology and the presentation of results.

c) The accuracy requirements for level (z) and position (x,y) on resulting plans/diagrams/sketches should be stated at the outset to ensure suitable equipment, survey methodology and surveyor/operator skill sets are suitably matched to the task. Both the level datum and the assumed height of the origin used for the survey should be stated.

d) The type of equipment used should correlate with the expectations of accuracy of survey. It is vital that the surveyor/operator know the accuracies achievable from the equipment being used and record this. Equipment used may include but not be limited to:

- Builder's spirit level
- Zip Level
- Dumpy level
- Laser levels
- Digital Precise level
- Total station

e) All equipment should have an identifying reference number or serial number for traceability purposes. This number should always be recorded.

f) A description of the survey methodology should identify the method of independently checking the reliability and repeatability of the survey results. Statements should include but not be limited to:

- Checks undertaken to the origin/datum point after each room is levelled and recording these check observations in a timeline manner.
- Any analysis made to confirm or otherwise dismiss level anomalies when identified after the initial survey.
- In the case of a Zip Level, moving the base unit, re-zeroing on the origin/datum point and double checking all identified anomalies and approximately 10% of other points previously measured. Where parts of the building have different temperature environments, how these were measured independently by ensuring that the cord and equipment remained wholly within the environment being measured.

g) Floor coverings can, over a period of assessment and reassessment, be altered. Accordingly, it is important to state whether level results have been reduced to the underlying floor surface by deducting floor covering thickness. If an assumption has been made that floor coverings are of a uniform thickness over the whole of the site, then this assumption should also be stated.

h) A statement in respect of positional accuracy (x, y) of recorded heights on any resulting plan is particularly important if calculated gradients between recorded points are to be relied upon. Any independent checks to determine the dimensional reliability of the resulting plan should be identified and a statement made in respect of the estimated positional accuracy.

i) Equipment calibration status provides confidence in the relative accuracy of the readings taken. Checking the height difference between two surfaces capable of being measured by an independent method, e.g., by tape measure or by precise level and recording the acceptance of this independent check provides confidence in the subsequent measurement results. Precision equipment requires a regular program of servicing by accredited agents. All precision equipment should have a current servicing status with a stated date of last service.

j) The person completing the survey or preparing a report that includes a plan of levels should be able to state and sign that the survey data presented is a true and correct record to provide an accountability that the results can be relied upon with confidence by subsequent users subject to any stated limitations.

Explanatory notes to Table 6.2

a) Written procedures, work instruction, forms and quality control checklists are part of an organisation's quality system that provide the necessary assurances that survey work supporting the assessments is correct and fit for purpose. The development of these documents will be specific to an organisation's role in these types of assessments. Techniques for undertaking independent checks should be adapted to the extent necessary to acknowledge the type of equipment used and the skillset of the operator involved. The advice of a Registered Professional Surveyor or Licensed Cadastral Surveyor when establishing these procedures and techniques would be valuable.

b) The procedure for undertaking level surveys and recording results will vary depending on the type of equipment used and the method of plan preparation anticipated.

c) Training records should be maintained by the employing company for all staff undertaking floor level surveys to provide confidence that the level data obtained and the resulting plans have been prepared by personnel who have demonstrated an acceptable competency using the equipment and appropriate level survey techniques.

d) Prior to the release of any plan/diagram or its inclusion in a report, there should be a means by which the plan/diagram is assessed independently by the organisation as being suitable and fit for purpose.

e) Internal audits are not only an ideal mechanism for evaluating the effectiveness of an organisation's quality control processes but they also provide a basis for making improvements to these processes moving forward. The need for targeted internal audits may arise as a consequence of identified trends of inconsistencies and anomalies following independent checking of assessments. Internal audits also have the benefit of adding a sense of credibility to an organisation's ability to consistently obtain and record reliable and fit for purpose measurement data

Insistence on documentation of the type suggested above should bring much greater rigour to measurement processes and lead both to less rework and much improved accountability for poor or incorrect data when it is found.

***Recommendations continued**…*

2. Due to the fact that Zip Levels have widespread use as a tool for post-earthquake floor level assessment, the WP gave particular consideration to this measurement technique. The WP is satisfied that when the instrument is used by trained users and in strict accordance with recognised procedures of best practice it can be an appropriate floor levelling tool for a range of assessment purposes. However, users must maintain the equipment correctly and follow the manufacturer's operating guidelines.

3. While the WP recognises the strategic importance of floor levels in the building assessment process, it stresses that the inclusion of a wider range of possible assessment metrics may be appropriate. A full site assessment, if required, should consider all of the following:

    (i) Floor dislevelment
    (ii) Lateral stretching
    (iii) Foundation settlement
    (iv) Block settlement
    (v) Building verticality

4. The WP is strongly of the view that some measure of formal training should be required of all users of Zip Levels. It was pleased to be told that Southern Response had already taken some initiatives in this direction but would recommend that the NZIS either initiate such a training course or partner with others in delivering such a course. Amongst other things, the content for such a course could substantially be formed around the recommendations made in this document.

5. Where legal action appears likely or where there is a dependence upon an accurate and credible presentation of survey information obtained in accordance with best survey practice, the WP is equally strongly of the view that as measurement specialists, Registered Professional Surveyors (RPSurv's) or Licensed Cadastral Surveyors (LCSs) are the only appropriate professional people to be engaged for such data collection and its presentation.

7. Additional Observations

1. While outside its area of expertise, the WP was not presented with any evidence to suggest that Table 2.3 of the MBIE guidance document set inappropriate standards for dislevelment surveys. The WP was informed that the table is consistent with NZS 3124: 1987, "Specification for concrete construction for minor works" – a document last modified some 27 years ago. The WP was uncertain if, due to its age, that document might not need a review. However, the WP was informed that some assessment practitioners appear to be interpreting the guidelines as a "line in the sand" rather than exercising the flexibility and discretion indicated in the guidelines.

2. One issue that came to the attention of the WP was the lack of pre-quake building assessment (measurement) data and the difficulties this presented when seeking to decide what building deterioration had occurred prior to the earthquake sequence, as opposed to that caused by the earthquakes. The question was further raised as to what would happen with all the current measurement data should a structure be repaired rather than rebuilt. While the WP wondered about some form of long-term repository, it was left with the nagging questions of who might hold this data, for how long, and who might gain the long term benefit from the data? Should the work trigger the need for a building consent, then the local authority would be a logical repository. If no building consent were required, then the WP felt that there was a strong case for the homeowner to have a complete set of data.

8. Concluding Comments

The WP concludes by reiterating its opening words. The Christchurch rebuild has been a difficult and highly charged issue. Many of those deeply involved in the process hold strong views on some of the issues with which the WP has grappled. It has been the wish of the WP to be non-partisan in its deliberations, to be pragmatic and to do its best to provide recommendations that will improve processes going forward. It is realistic to expect that in future years New Zealand will see further earthquake events that cause damage to residential buildings. The WP hopes that this report can be used not only to support process improvement with regard to the Christchurch rebuild, but also to serve as foundation for best practice in the event of future earthquake events.

Note: *Version 2 of this document has removed appendix 1. To access the Zip manufacturers level guide instructions refer to url: http://www.ziplevel.com/index.php?ID=2603*

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