RAPID EVALUATION OF BUILDING SAFETY: LEARNINGS FROM THE DECEMBER 2007 GISBORNE EARTHQUAKE

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SUMMARY

The 20 December 2007 Gisborne earthquake provided the first opportunity to undertake building safety evaluations in an emergency situation in New Zealand. This process, which features the posting of Red (Unsafe), Yellow (Restricted Use) and Green (Inspected) placards, proved to be a key component of a progressive triage process which enabled the re-opening of the damaged Gisborne CBD area for trading within 30 hours of the earthquake.

Urban Search and Rescue (USAR) Task Force resources were used to assist Gisborne District Council to quickly implement the building safety evaluation process. A significant pool of engineers was mobilised on the day following the earthquake. This proved a key resource in assisting with the swift establishment of the building safety situation, and in implementing direct stabilisation and initial repair measures.

This paper provides a brief overview of the earthquake and its impacts, describes the New Zealand Society for Earthquake Engineering Building Safety Evaluation arrangements, and how they were implemented immediately following the earthquake. The key process learnings and how they are being incorporated into an updated information and training package are also outlined.

1. INTRODUCTION

The City of Gisborne is located on the East Coast of the North Island of New Zealand, and has a population of approximately 42,000 people.

The Gisborne earthquake that occurred at 8.55pm on Thursday 20th December 2007 was of magnitude M_w 6.6 and generated a peak felt intensity of MM8. While the damage was moderate in nature, a significant proportion of the building stock of Gisborne comprises older unreinforced masonry buildings, and the direct property damage has totalled more than NZ$50 million. This includes approximately NZ$29 million of residential sector damage covered by the Earthquake Commission. While no lives were lost and very few serious injuries were recorded, the potential for considerable casualties existed.

A feature of the response to this earthquake was the effective rapid assessment of the safety status of buildings within the Central Business District. While this is a vital function following any damaging earthquake, the rapid re-occupancy of the many largely undamaged retail premises was particularly important given the proximity of this event to Christmas.

A significant update of the NZ Society for Earthquake Engineering's *Post-earthquake Building Safety Evaluation Guidelines* was well advanced by the time of the December 2007 Gisborne earthquake. As well as providing impetus to complete the update, the experiences of applying this rapid evaluation process have highlighted additional specific arrangements that local authorities must have in place prior to an earthquake.

2. OVERVIEW OF THE EARTHQUAKE AND KEY IMPACTS

The magnitude M_w 6.6 earthquake occurred at 8.55pm on Thursday 20th December 2007. The epicentre was 47km southeast of Gisborne (approximately 400km southeast of Auckland), with a focal depth of

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44km. The earthquake was within the Pacific plate subducting beneath the North Island of New Zealand, and was in the region of the Hikurangi trench (Figure 1).

The earthquake was felt widely, especially along the east coast of the North Island, with strong shaking lasting approximately 30 seconds in Gisborne. There were 3,257 felt reports submitted to the GeoNet website (www.geonet.org.nz). The event was felt as quite 'punchy' in Gisborne because the direction of the fault rupture was towards the city. There were a number of aftershocks, with the largest of magnitude 4.6 occurring on December 22nd.

This is a reasonably common type of earthquake to be experienced in the North Island, with the 1921 Hawke's Bay (M6.8), 1942 Wairarapa (M7.0), and 1993 Ormond (M6.3) earthquakes being similar in nature. The 1947 earthquakes (M_W 6.9-7.1) and 1996 earthquake (M_W 5.6) occurred on the interface between the subducting and overriding plates (Figure 2).

The peak ground acceleration recorded was 0.28g. The NZS1170 spectrum was exceeded in a narrow band around 0.45s, with a spectral peak at 0.45 to 0.55s. Gisborne City has now experienced recorded peak ground accelerations exceeding 0.25g three times since 1966 (Francois-Holden et al, in press). The peak ground velocities from the three closest strong motion sites exceeded 200 mm/s (Geonet website), noting that all three sites were class D (Deep or Soft Soil).

The recorded motions on deep soft soils in the Gisborne central business district exceeded current NZS1170.5:2004 design-level (return period factor R=1, nominally 500-year return period) motions for Class D Deep or Soft Soil Sites in a narrow period band around 0.45s. They generally exceeded half code-level (R=0.5, 100-year return period) motions over much of the period band up to 1s, but fell to much lower levels beyond this period band. Serviceability Limit State (R=0.25, return period 25 years) motions were exceeded for all periods up to 1.5s (Francois-Holden et al, in press).

The earthquake generated only limited permanent ground deformation, with some areas of local liquefaction observed along with isolated landslides.

The earthquake was highly directional, being almost exactly parallel to the main street of Gisborne. This meant that unrestrained parapets and walls perpendicular to the main street experienced the greatest out-of-plane accelerations (Figure 3). A common form of damage was therefore from masonry falling from a two storey building onto (and in many cases through) the sheet metal roofing of an adjacent single storey building (Figure 4). Most of the damage in the CBD was directly attributable to damaged or failing parapets.

In contrast, unrestrained parapets along and above the main street showed little sign of displacement, even those with appreciable signs of ageing and deterioration. This characteristic of the earthquake was therefore very fortunate for pedestrians in the main street at the end of late night shopping just prior to Christmas.

Other typical unreinforced masonry damage was experienced, including loss of gable ends. Various levels of earthquake strengthening had been applied to a number of buildings in Gisborne over the years. In most cases this strengthening did effectively restrain URM walls and parapets, but this would not necessarily have been the case if the shaking had approached full code levels.

Damage to newer structures was also observed. There were useful learnings in relation to transfer diaphragms and the detailing of K braced systems, and reminders for designers and constructors in relation to the anchoring of fixings in precast panels.

There was relatively minor damage and disruption to lifeline utility services. A brief power outage was experienced, and some breakage of asbestos cement water and sewer mains, with minor damage to one water reservoir. Road access was unaffected, apart from one bridge whose approaches were washed out following the fracture of a water main crossing the bridge.

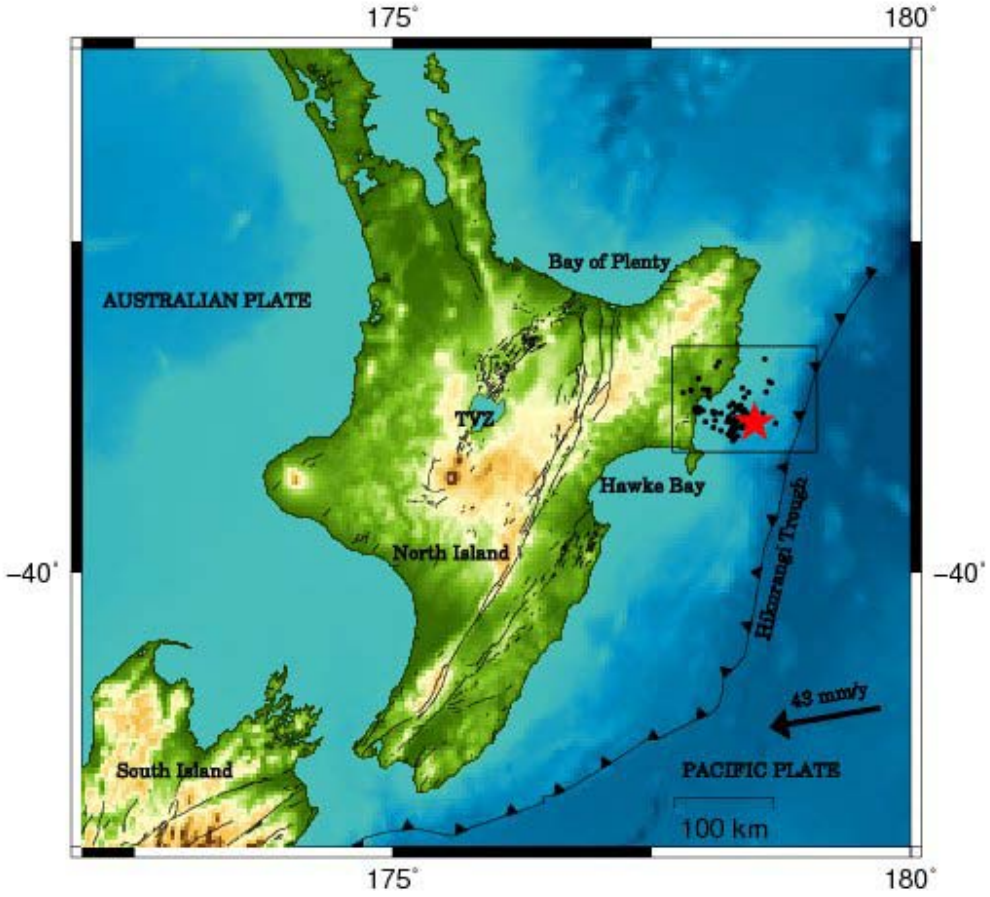

Figure 1: December 2007 Gisborne epicentre (red star) and its aftershocks (black circles). Triangles represent the Hikurangi trench. The box delimits the detailed area in Figure 2 (Francois-Holden et al, in press).

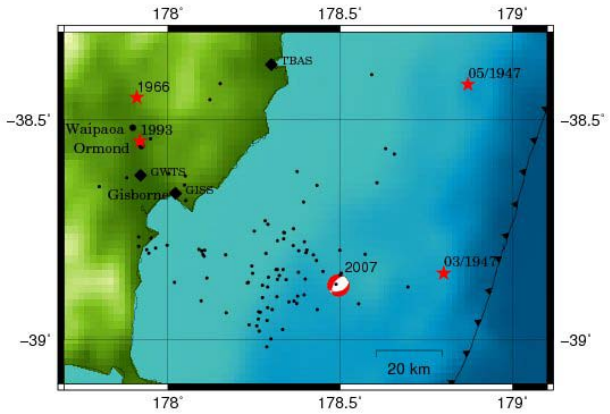

Figure 2: December 2007 Gisborne epicentre location and focal mechanism (red) and its aftershocks (black circles). Triangles represent the Hikurangi trench. Diamonds represent strong motion instrument locations mentioned in the strong motion instrument studies. Red stars represent locations for the 1947 earthquake

sequence, the 1966 Gisborne earthquake and the 1993 Ormond earthquake (Francois-Holden et al, in press).

Figure 3: Indication of common mode of parapet failure parallel to the main street (noting unaffected roof below)

Figure 4: Damage to single-storey building from failure of upper level wall and parapet from neighbouring building at right (Photo from Gisborne Herald)

3. THE NZ BUILDING SAFETY EVALUATION PROCESS: BACKGROUND AND STATUS

The United States building safety evaluation process developed by the Applied Technology Council (ATC 20) had been adapted by NZSEE during the 1990s. Copies of a guideline document outlining how the process should be implemented was issued to all territorial authorities in 1998 (NZSEE, 1998). The NZ adaptation featured four placards – at that time an additional Orange placard was considered useful in facilitating a more rapid occupancy of moderately damaged structures.

Only a limited number of territorial authority Building Control departments had however used the NZSEE guidelines to prepare themselves by the time a review was undertaken by NZSEE in 2004. At this stage, NZSEE took the decision to prepare a more comprehensive training package, in addition to updating the Guideline document to reflect the new Civil Defence Emergency Management Act and Building Act. Initial pilot training sessions had highlighted the challenges in achieving consistency in making assessments across the four placard categories, and along with the importance of international consistency, led to the decision to revert to the international three placard system.

The revised Guidelines were developed by NZSEE to a draft stage by the end of 2006. Discussions were commenced in 2007 with the Department of Building and Housing, with a view to the department assuming a national ownership role for the Guidelines and training material to enable a more systematic introduction and resourcing. Under this arrangement NZSEE would continue their involvement in order to provide technical input and appropriate international linkages.

4. OVERVIEW OF THE RESPONSE

The local Emergency Service Co-ordinating Committee comprising Civil Defence, Fire Service and Police representatives co-ordinated the initial stages of the response. A state of local emergency was declared at 1am on Friday 21st. The Fire Service worked through the night marking buildings that they viewed as dangerous. By 8.30am the Gisborne District Council Building Control Officials had identified the most seriously damaged buildings within the CBD.

The three national USAR Task Forces were placed on standby immediately following information being received about the earthquake. USAR Task Force 1 deployed from its base of Palmerston North soon after midnight, and the 29 member team arrived in Gisborne at 7.30am on Friday 21 December. This team included the author, who is one of the two Level 2 USAR Engineers contracted to this Task Force.

The decision to implement the draft updated NZSEE Building Safety placarding system was made by the Controller and Gisborne District Council by 9.00am. The focus was on the Central Business District, as this was the worst affected area, and the Civil Defence Controller had directed that this area was to be re-opened as soon as possible once the unsafe structures could be identified and isolated. The implementation process is outlined in more detail in the following section.

By early afternoon, 23 Red (Unsafe) placards had been issued, along with 11 Yellow (Restricted Entry) placards. Retailers in the affected streets were able to access their premises to assess damage and clean up (but not to trade) at 3pm on Friday 21 December.

Virtually all of the CBD streets were open for the start of trading on the following morning, and all retail premises apart from those Red and Yellow placarded were able to open and trade.

The USAR Task Force had completed a range of assistance tasks, including assessing approximately 80 residential buildings with typically minor levels of damage. The team departed Gisborne at midday on Saturday 22 December.

It is important to note that the implementation of a building safety evaluation process is not seen as the prime focus of a USAR Task Force and its engineers. The focus of Task Force engineers is to advise the Task Force Technicians conducting rescue activities, with a focus on:

- Determining the potential for further collapse
- Monitoring of building movements
- Identifying hazards
- Determining suitable points of entry

The NZ and Australian training courses for USAR Engineers do however include sections on building safety evaluation processes, as it is important that USAR engineers have a good level of knowledge of these arrangements. One of the many learnings from this event is that the NZSEE Building Safety Evaluation process guidelines (which include placards ready for printing) and induction materials should be included in a datastick within the USAR Task Force Engineers cache.

Gisborne District Council have faced many issues in the months following the December 2007 around the levels of earthquake strength that structural repairs should be undertaken to, having due regard to the Council's Earthquake Prone Buildings Policy in place. The interaction with the insurance industry on the levels of strengthening levels that their policies would cover created additional complexity. By the end of August 2008, nine commercial premises in Gisborne City were still dangerous buildings requiring major structural repairs, and remained unoccupied. Two other upper floor tenancies also required structural work before they could be re-occupied.

5. IMPLEMENTATION OF THE RAPID BUILDING SAFETY EVALUATION PROCEDURES

The Gisborne District Council building control officials had undertaken a quick assessment of the CBD area from daybreak, and the locations of sections of the CBD with the greatest damage had been marked on a hardcopy aerial photograph.

Once the decision was made to implement a structured building safety assessment process, the affected CBD area was sectorised into four precincts. This decision was predominantly because only four professional engineers were available at the commencement of the process, and teams comprising one engineer, one local building control official and two senior Task Force Technicians were established. The broad range of skills within these teams contributed to rapid decision-making.

The concept of multi-disciplinary teams undertaking safety assessments and the opportunity for revisitation of these assessments by other engineers within the wider group of assessing engineers reduced aspects of the pressure (and hence direct accountability) on individual engineers for the assessment decisions.

Despite the lack of systematic induction at the commencement of the process, and that none of the local engineers had undertaken any form of prior training, a good level of consistency of assessments between the engineers and the teams was achieved.

The placards used following the Gisborne earthquake were taken straight from the December 2006 Draft Guidelines prepared by NZSEE (unpublished).

Using Task Force Technicians subsequently to inspect roofs and parapets of one and two-storey buildings provided valuable additional information that could not be seen from the street. In a couple of cases this input changed the initial assessment from Yellow to Red. The Task Force Technicians were also subsequently able to identify quick tasks to undertake to remove safety hazards. This mainly involved the removal of damaged parapets and loose brickwork on roofs, and shoring wall corners that had been detached.

The outcomes of the initial phase of placarding were conveyed to the Controller and Police via a 'walkthrough' of the CBD main streets with the engineers early in the afternoon of Friday 21st. In order to come to a view about the extent to which the areas cordons around the CBD could be narrowed or removed, it was important to communicate the nature of the damage and assessments made using visual and spoken means. This would not have been as easily achieved if a larger area had been affected.

Dangerous Building Notices were issued under section 124 of the Building Act to remaining Red and Yellow placarded premises by the end of Saturday when the declaration of the state of emergency was lifted, with summary notices posted on virtually all affected buildings by the end of the Saturday.

6. THE RESPONSE OF ENGINEERS

Like most NZ local authorities, the Gisborne District Council does not have structural engineering personnel in-house. Initially only three East Coast-based engineers were available to assist Gisborne District Council from the commencement of the Friday. Other engineers including the author and representatives from consulting practices, GNS Science, BRANZ and the Department of Building and Housing arrived progressively during that day, resulting in a total pool of approximately fifteen engineers by the beginning of Saturday. These engineers were deployed for various re-inspections and new inspections that were undertaken on Saturday.

Having this widely experienced resource pool rapidly mobilised was a key element in the aggressive building triaging that took place on the Friday and Saturday. The willingness of engineers to give of their time over a couple of days (including travelling from Hamilton, Auckland and Wellington) to assist the affected community on a voluntary basis was a very positive feature of this response. In addition to making a contribution to the affected community, this was a valuable learning experience for the individuals and their organisations.

It was interesting to observe that none of the responding engineers requested the formalisation of their involvement with Gisborne District Council in terms of any conditions of engagement during the initial two days.

Gisborne District Council were advised that once the declaration was lifted (ie. just less than two days after the earthquake), they would need to specifically engage engineers for any further or ongoing inspection work. This was part of a broader message that Council needed to give to the building owners as the *response* phase transitioned into *recovery* – namely that while Council undertook the initial rapid evaluations as part of establishing impacts and public safety issues, owners were responsible for directly engaging engineers for detailed building assessments and repair specifications.

Given that Gisborne District Council did not have any structural engineers on their staff, they were also advised that they should appoint an engineer as their technical adviser in order to provide continuity of advice, and with a view to the policy issues that were emerging with regard to earthquake prone buildings.

Other engineers arrived in subsequent days and weeks to assist insurance companies with structural assessments.

7. KEY LEARNINGS FROM THE RAPID BUILDING SAFETY EVALUATION PROCESS

It is important to acknowledge the flexible approach by Gisborne District Council in running with the draft NZSEE placards, given that the overall draft NZSEE package did not at the time of the event have any formal national status. In the interests of time, the Council also didn't require formal indication of 'council authorisation' to be added to the placards.

The Building Safety Evaluation process was implemented under the direction of the Controller. The Controller participated in the initial briefing of the field inspection teams, and hence for liability purposes, the engineers were clearly working under the direction of the Controller. The placards were

issued at the direction of the Controller (ie. under the Civil Defence Emergency Management Act). The placards were subsequently 'converted' to Dangerous Building Notices that were issued under the Building Act.

The enhanced practical understanding of both of these aspects, particularly the latter as it relates to closing out the process and transitioning back to business as usual, has provided much needed clarity in finalising the updated guidelines and training material.

Operational issues at the more detailed level that need to be in place prior to an earthquake are:

- A summary information sheet of the building safety evaluation process including objectives, key features of each of the 'traffic light' designations, arrangements, etc needs to be available for officials, the media and building occupants.
- An induction process for the field teams must be run through before they are deployed. While this has been prepared as part of the NZSEE training package, the keenness of the teams in the urgency of the moment to get out into the field in Gisborne meant that no induction or process briefing was given.
- In addition to a pre-deployment briefing process, a laminated summary card (incl. FAQs) is required for inspecting personnel in the field.
- A standard log sheet to record the names and contact details of official inspectors is required, and agreed way of signing off on each posted placard.
- An efficient means of conveying the specific building assessments and placard assignments back to the Council Emergency Operations Centre for rapid and systematic recording is required. This must link back with the database and mapping system being used to display the information. The current Guidelines do include forms for recording purposes, and these need to be used to maintain consistency of process and information. In an ideal situation a support resource would be allocated to the team for logging purposes.
- The use of digital photos of placards posted on buildings is recommended as part of the field recording process. This has the advantage of overcoming the typical lack of visible street numbering on retail tenancies.
- The representation of the placarded buildings onto an aerial photo by the GDC GIS team provides an essential visual summary of the situation for everyone involved in the response. Displaying this on the Council website also proved a useful public communications tool, noting the need to provide a comprehensive legend or key to the colours and lines drawn.

Other key learnings that have informed the remaining work to complete the post-earthquake building safety evaluation package included:

- The issuing of the placards was primarily aimed at building occupants (tenants) to give a visual indication of status, whereas the Dangerous Building Notices are a form of legal designation that is primarily aimed at the building owners (as well as having direct implications for tenants).
- How the cordoning process can be managed in this situation, and in particular how the broad initial area cordons can be reduced progressively to building-specific barricades by Building Safety Evaluation Teams working with Police and the Controller.
- Having engineers available to allow controlled access to Red placarded buildings for short periods of time was very helpful to occupants, particularly for the early removal of food from food premises and for access to the likes of chemist shops. The Red placards were explained as meaning '*You may be able to work around and even within a Red placarded building for short periods of time, provided it is under the direct supervision of a structural engineer at all times.*'
- There is a need to emphasise to building owners that receive Green placards that they still require a detailed engineering assessment and report back to Council, ideally within three months.

8. UPDATING THE RAPID EVALUATION OF BUILDING SAFETY PACKAGE

Work by the NZSEE Working Party on the updated package during 2005/06 had included the development of drafts of the following elements:

- Information Sheet
- Guideline document
- Training modules
- On the day induction
- Field Guide

The content, target audience and delivery format envisaged for each of these is indicated in Table 1.

Element	Content	Target Audience/ *Format*
1. **Information Sheet**	Fact sheet – an outline of Post Earthquake Building Safety Evaluation	Other agencies eg Emergency Services, CDEM Group Officers, Controllers
2. **Guideline Document**	Update of current 1998 NZSEE Guidelines	Engineers, Building Control Managers and Officials *Electronic copies downloadable plus hard copy to all Territorial Authorities*
3. **Training Modules**	**Introduction**	Brief intro to all interested/ involved parties (especially Bldg Control Managers and CDEM Group Emergency Management Officers) *Powerpoint (1/2 hour session)*
	Module One: Evaluation Process	Engineers Building Control Officials *Powerpoint (2 hour session)*
	Module Two: Management of the Process	Building Control Managers (who need to prepare the arrangements and lead 'on the day') Engineers (who may be involved in a leadership role) *Powerpoint (2 hour session)*
	Module Three: Types of Construction and their Failure Modes	All identified Field Inspectors *Powerpoint (1 hour session)*
	Module Four: Review of Key Structural Principles	Building Control Officials Architects Building Contractors *Powerpoint (1 hour session)*
4. **On the Day Induction**	Process map Briefing on: scope of incident, procedures, priorities, structure, responsibilities PPE / H & S / Field Kits	Field Inspection Teams *1/2 hour session for 'on the day' volunteer resources by Building Control Manager and/or designated induction leaders*
5. **Field Guide**	Field reference document for making post earthquake building safety evaluations	Field Inspection Teams *Laminated reference card* *Pocket Field Operations Guide*

Table 1: Summary of Key Elements of the Rapid Evaluation of Building Safety Package

Work had not progressed beyond those drafts, as the focus during 2007 was on conveying to the Department of Building and Housing the need for the Department to take an overall leadership role in order to give the Building Safety Evaluation process an appropriate national standing and resourcing. While NZSEE wishes to maintain active involvement from a technical perspective, it does not have the resources to provide either the ongoing leadership or deliver the training that is required for TA Building Control to attain and maintain competency in this process. It is considered that the lead responsibility for this should sit with the Department of Building and Housing, as it has the primary responsibilities for building safety and building regulatory matters generally (noting the linkages referred to above).

The experiences from the Gisborne earthquake has highlighted the level of support that territorial authorities require in order to successfully carry out this process. This support principally involves training and standardised materials (ie. pre-event), but also during the emergency in terms of experienced resources. The Department of Building and Housing have subsequently agreed in principle to 'own' the post-earthquake building safety evaluation package, and to work with local authority Building Control personnel to develop their capability.

Given the impetus provided by the Gisborne earthquake and clear indications that the Department of Building and Housing are prepared to provide national leadership and ownership of this package, work has progressed during the second half of 2008. The priority focus has been on producing the updated Guideline document, as this is the core document that describes the process and the specific arrangements that local authorities need to have in place. It is intended that this is circulated to all local authorities in November, after which work will then focus on producing the more detailed field operations guide, subject to funding being provided.

The recommended organisational structure for local authorities to adopt to manage a rapid evaluation of building safety process is shown below in Figure 5. This was developed by the NZSEE Working Party during 2005/ 06, with addition of the key learning from the Gisborne that the CDEM Controller is the overarching director of the process.

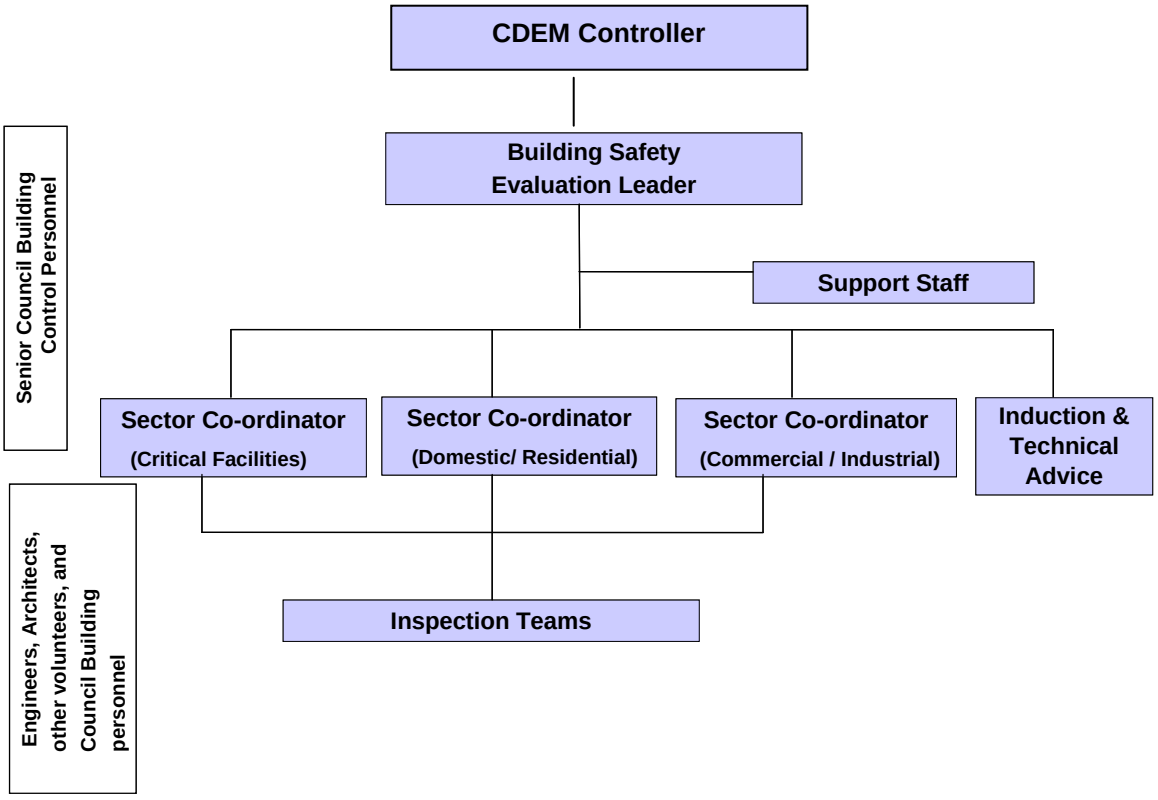

Figure 5: Recommended Organisational Structure

The Green or ‘inspected’ placard wording has been modified to emphasise the brief external nature of the inspection that has led to its posting, and that followup specific or detailed engineering inspection should be arranged by the owner. The currently proposed wording and appearance of all placards as at September 2008 is shown in Figure 6 (further minor modifications anticipated prior to publication).

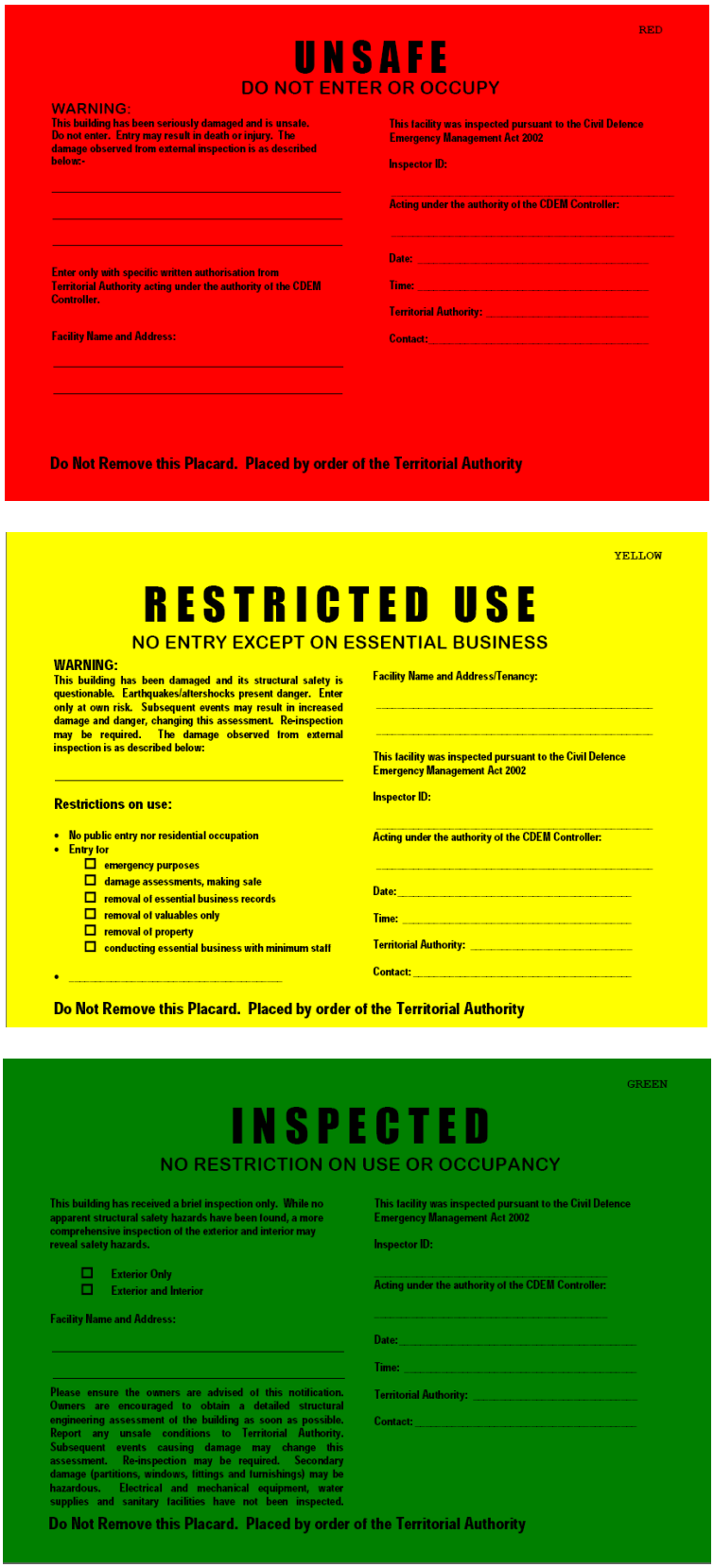

Figure 6: Wording and Appearance of the Updated NZ Placards

9. SUMMARY

A structured post-earthquake building safety evaluation process for evaluating and communicating the status of buildings in the areas of greatest damage was applied effectively for the first time in New Zealand following the Gisborne earthquake. This process was particularly valuable in enabling a rapid reduction in the cordoned area from virtually the whole CBD down to individual building barricades within 30 hours of the event.

The media and community appeared to quickly grasp and accept the rationale of the 'traffic light' placarding system, as evidenced by the clear media coverage and limited questioning from affected retailers and the general public that followed.

The linkages of the Building Safety Evaluation process with other activities are now much better understood, particularly with respect to transitioning back to business-as-usual Building Control processes (ie. the regulatory follow-through in relation to Dangerous Building Notices). These linkages and the associated roles and responsibilities are currently being defined and included in the Building Safety Evaluation documentation.

For this event, Gisborne District Council had assistance from USAR Task Force engineers to implement the rapid evaluation of building safety process. This would not be the expected role of a USAR Task Force in a major earthquake where trapped people are requiring specialist technical rescue. However this event has underscored the importance of USAR engineers knowing how the process operates, and being able to assist if able.

The Department of Building and Housing representatives who assisted with the implementation were able to see first hand (i) the value of this system and (ii) the need to provide support to local authority Building Control Officials. This assistance needs to take the form of both *pre-event* material and training and *post-event* operational assistance.

There are many challenges in implementing these arrangements quickly and effectively, particularly with regard to the geographical scale of the event and possible infrastructure disruption. This moderate event in the provincial city of Gisborne provides a thought-provoking contrast with the issues associated with a stronger earthquake in a larger metropolitan centre.

This event has provided impetus to complete the update of the NZSEE Building Safety Evaluation package. The priority focus has been on producing the updated Guideline document, as this is the core document that describes the process and the specific arrangements that local authorities need to have in place. It is intended that this is circulated as a draft to all local authorities during November, with a view to issuing a final version and commencing training of engineers during 2009.

10. REFERENCES

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