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Involving engineers in urban search and rescue

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ABSTRACT: Structural Engineers are a key part of an Urban Search and Rescue (USAR) response. They have a critical role to play in providing technical advice for rescue teams. This includes assessing the overall stability of a partially or wholly collapsed structure, monitoring the structural stability and the development of temporary shoring arrangements.

To be fully effective in a rescue situation, engineers must be specifically trained in USAR procedures and techniques, and must have regular involvement with the rescue teams with which they are associated. As part of the process of developing a national USAR capability in New Zealand, considerable thought has been given to establishing appropriate specialist training for engineers and ongoing engagement arrangements with rescue teams.

This paper summarises the key roles that engineers play in conjunction with a USAR rescue team, and outlines the arrangements currently being established with both the national Task Force teams and local rescue teams. Details are provided of the new Level One and Level Two USAR Engineer training courses that are currently being developed.

1 INTRODUCTION

Urban Search and Rescue involves the location, rescue and initial medical stabilisation of victims trapped in confined spaces following a structural collapse. Search for the injured and rescue of those trapped are among the most important and urgent post-earthquake activities. Those conducting USAR activities can themselves become victims, as a high level of risk is associated with these activities.

The background to the development of New Zealand's USAR capability is provided in an accompanying paper (Angus et al, 2003). More information on USAR generally can also be obtained from the website www.usar.govt.nz. The international post-earthquake reconnaissance visits organised by the New Zealand Society for Earthquake Engineering have played a significant part in highlighting the need for New Zealand to have such a capability.

Engineers involved in USAR activities need to be comfortable dealing with high-pressure situations and able to make rapid decisions. A familiarity with disaster environments and the procedures of specialist rescue task forces needs to be developed. This familiarity requires specific prior training and engagement with emergency service agencies.

This paper describes the functions of an engineer in USAR activities, and outlines the contents of engineering training courses currently under development to enable New Zealand engineers to become effective in emergency events that involve USAR. The wider strategy for the development of an engineering capability is outlined, along with mechanisms for the specific involvement of engineers with national USAR Task Forces.

2 ENGINEERS AS A SPECIALIST USAR SKILL CAPABILITY

Engineers are a recognised specific specialist skill grouping in USAR, along with Paramedics and Search Dogs. The organisational structure set up by the New Zealand National USAR Steering Committee features a specialist skills working group, the focus of which is the development of training material for these three groups, along with mechanisms for their involvement during both the preparedness and response phases.

The USAR project is developing both regional capability in terms of local rescue teams and specialist national capability in the form of three Task Forces. The development objectives for the specialist skill groups reflect this approach, and can be summarised as:

- *At regional level*
    - A group of Engineers, Search Dogs & Paramedics familiar with USAR processes (Category 1 – surface search and rescue) and able to assist the initial response
- *At Task Force level*
    - Have at least two Engineers, Search Dogs & Paramedics assigned to each of the Task Forces and capable of operating at Category 2 level (confined space rescue)

The involvement of engineers from disciplines other than structural is also particularly important, as they can play a significant role in different types of collapse situation (for example, geotechnical engineers in landslide situations), and in the operational planning and logistics support areas generally.

The main focus of the Specialist Skills Working Group during 2002/ 03 is the development of a framework for training engineers in USAR response.

3 THE OPERATIONAL ROLE OF ENGINEERS IN USAR

Engineers play a vital role in the events following a building collapse. One of the first jobs of the engineer is likely to be structural triage – the setting of rescue priorities with respect to the risk posed by the partially or wholly collapsed structure. This task is likely to be carried out initially by regionally trained engineers who would be first on the scene with local rescue teams.

The role of a Task Force engineer is to provide *critical* information, and not to make all the critical decisions (Hammond, 1995). Task Force leaders will consider the advice of the engineer along with others and develop their action plan for the rescue operations accordingly. The opinion of the engineer may not always be adhered to, and some aspects of a rescue will take place without the input of engineering advice.

The scope of the principal inputs required from a Task Force engineer can be summarised as:

- Assist in structural triage
    - Prioritise which structures should be searched first in a multiple collapse situation
    - Advise on safe routes for approaching the building.

- Advise on building stability for planning and executing Search and Rescue:
    - Determine safe staging areas
    - Consider the likely void spaces where victims could be within the collapse.

- Provide structural engineering advice
    - Confirm Task Force decisions on shoring, cribbing, breaching and heavy lifting, when needed
    - Specific design of shoring elements as requested.

- Assist in the reduction of hazards
    - Identify hazards
    - Assist with the set-up and monitoring of systems for checking stability and hazard control, in support of the Safety Officer.

Task Force engineers need to be well prepared to make difficult decisions in an environment that is very different from the orderly design office. The environment during a USAR event is likely to be chaotic, with many uncertainties relating to the safety status of buildings and many traumatised people.

The engineer also needs to be aware of the roles of the other members of the Task Force. Most of the Task Force personnel come from rescue backgrounds and are used to making rapid, high-pressure decisions as part of their normal occupation, and will take a significant risk in order to save a life. Therefore a conflict in focus can arise between engineers and rescue workers – rescuers save victims, whereas engineers focus on rescue safety.

It is emphasised to Task Force technicians that each person is responsible for their own safety when exposed to a variety of hazards (chemical, biological and structural etc.). Task Force technicians need to be carefully instructed on hazard recognition and mitigation. Engineers therefore have an important role in the training and preparation of USAR team members. Structural hazards include the range of typical collapse modes for different types of structures, along with the fundamentals of structural instability (what can a damaged structure do once it has come to rest; what will trigger further collapses; consideration of approaching and working on and in damaged structures) and the estimation of component masses, to list some aspects. Engineers are there to support the USAR teams. To this end, the engineers are responsible for establishing sound skills for communicating engineering objectives, between the Task Force engineers and all other teams members. The third author, who was part of the NZSEE reconnaissance team to the Northridge earthquake in 1994, has been closely involved in the training of the members of the USAR units that have been established in Palmerston North and in Christchurch.

4 PROPOSED USAR TRAINING FOR NEW ZEALAND ENGINEERS

Work on creating a framework for training engineers to be able to effectively participate in a USAR event was initiated by research undertaken at the University of Canterbury by the second author (McGuigan, 2002). The framework supports the development of a regional and national capability of engineers to deal with minor and major building collapse incidents. The training is intended to help participants go beyond their normal office-based experiences and gain familiarity with the demanding nature of rescue operations.

The contents of the USAR Engineer courses also draw on teaching methods employed in the United States, where a Structural Specialist course has been run since 1992. Some New Zealand engineers will have had prior exposure to this USAR training for engineers from the lecture series run in New Zealand in 1995 by David Hammond, a prominent figure in the development of USAR training material in the USA.

There are two components of training engineers in USAR – (i) *familiarity with how emergency services operate,* and (ii) *specialist engineering skills for collapse situations*.

A progressive training system is being developed for engineers to become familiar in dealing with situations involving USAR, with the key features summarised as follows:

Level 1 USAR Engineer

- *Outcome* – a regional resource assisting (or part of) local volunteer rescue teams
- *Focus* - operating on the outer perimeter of building or site
- *Status* – IPENZ–endorsed CPD course with 12 hours credit
- *Targets* – Graduate engineers and above

Level 2 USAR Engineer

- *Outcome* – capable of operating with USAR Task Force teams
- *Focus* - operating within a structural collapse site (overall structure & element stability)
- *Status* – IPENZ–endorsed CPD course with 12 hours credit plus Orange Card endorsed with engineering capability
- *Targets* – Registered (Chartered Professional) engineers who have completed USAR Level 1 Engineer and obtained their Orange Card

The relationship of these courses with the USAR category training system (as presented in an accompanying paper (Angus et al, 2003)) is shown in Table 1. The basic entry level USAR qualification is obtained from a 2-day NZQA unit standard training course *Cat 1A USAR Awareness*. Holders of this unit standard are issued a pocket-based Orange Ticket. For those wishing to become more actively involved, a *USAR Responder* Orange Card results from the completion of 3 additional courses totalling 5 days (including the First Aid certificate which ideally all engineers should have as a matter of course). The Orange Card features a photograph of the holder, and so provides an appropriate form of identification that addresses the often-raised question of how engineers and other supporting technical resources will obtain access through perimeter cordons around major emergency sites.

The content of this Level One *USAR Engineer* course is shown in Table 2. This course is to be taught over a 24 hour period (an evening and the following day) at regional centres in New Zealand. This course is currently under development, with the aim of being available for delivery during the second half of 2003.

The Level Two USAR Engineer course builds on material taught during Level One training and intends to give the participating engineer more knowledge to deal with collapsed structures and an understanding of how people perform in a real emergency. It is intended that the advanced USAR engineering course be delivered over the same 24 hour basis as for the Level One course, but taught from the Task Force bases. The course content is shown in Table 3. Detailed development of the course material is planned for later in 2003, leading to delivery in 2004.

Table 1 USAR Engineering Training Framework

Course Qualification	Duration (IPENZ CPD Value)	Pre-requisites
USAR Category One Awareness (Cat 1A)	2 days (16 hours)	
Level 1 USAR Engineer	Evening and whole day following (12 hours)	USAR Cat 1A
Level 2 USAR Engineer	Evening and whole day following (12 hours)	Level 1 USAR Engineer and Orange Card
USAR *Task Force Familiarisation*[1]	4 days	Level 2 USAR Engineer

[1]*Participation in selected days of the full Cat 2 Technician course or full participation in a 72 hour Task Force exercise*

Table 2 Level 1 Engineering Course Outline

Module	Key Elements
Module 1.1 ***Introductory*** ***The USAR Training & Response Framework***	USAR organisational structures USAR Training Framework Response processes for engineers CIMS introduction/ refresher; Health & Safety context
Module 1.2 ***Role of the Engineer*** ***Rescue Team Culture***	Role of the engineer at a USAR operation Understanding rescue team culture
Module 1.3 ***Site Technical Processes***	Building Triage Assessing the safety and stability of damaged buildings Hazard Assessment and Building Marking
Module 1.4 ***Understanding Damaged and Collapsed Buildings***	Engineering issues in collapsed buildings Introduction to the design of shoring and bracing
Module 1.5 ***Scenario: Role Playing/ Process Familiarity***	Single site collapse Earthquake (multi-site)
Module 1.6 ***Course Conclusion***	Recap on key points; Discussion Professional Indemnity & Personal Insurances Preview of Level 2 course

Table 3 USAR Level 2 Engineering Course Outline

Module	Key Elements
Module 2.1 ***Introductory*** ***Task Force Reality***	Course introduction What does it mean to be part of a Task Force? Response and training expectations
Module 2.2 ***Human Response Issues***	The reality of how people perform in real emergencies
Module 2.3 ***Site Technical Processes***	The design of shoring & bracing Hazard assessment/ reporting
Module 2.4 ***Understanding Collapsed Buildings***	Shoring & cribbing Breaching & cutting
Module 2.5 ***Hazard Mitigation*** ***Safety Equipment***	Advanced building monitoring techniques Hazard monitoring and gas analysis Use of search cameras and Trapped Person Locator Heavy (specialist) equipment
Module 2.6 ***Course Conclusion***	Recap on key points, next steps Discussion and course closure

Task Force Engineers also need to attend part of a three week Category Two Technician course for four days. This includes participation in a three-day rescue simulation exercise. It is envisaged that at least six New Zealand engineers will be trained to this level and will become the specialist engineers who will deploy with the Task Force during an actual event. A review of a recent USAR Technician course is presented in a recent paper by the second author (McGuigan et al, 2002). Engineers attending this technician course gain first-hand exposure of the multi-agency nature of the Task Force and develop working relationships with the technicians that do the search and rescue work.

An engineer who participates in Task Force activities needs to have achieved 'Registered (Chartered Professional) Engineer' status, and will need to possess a number of personal attributes so that they are suitable for actual events. This includes a reasonable level of fitness due to the demanding nature of the exercise and the potential long hours that can be worked. The engineer will need to be adaptable and able to fit in to the structured nature of the Task Force operation. A good understanding of practical construction methods and some experience in construction and demolition related work would also be expected.

Ongoing training and refresher courses will need to be held on an annual basis for trained engineers at all levels. These should be run at the same time as refresher courses for those involved from the emergency services, helping maintain working relationships. Those involved in rescue operations however also need to be aware that engineers cannot be available at all times and, that by training a pool of engineers there should be an adequate number that can be obtained when the need arises.

Recent feedback from Australian USAR Task Force leaders and engineers suggests that some of the modules of these courses are of interest to them. Although Australia has also been developing a USAR capability since the mid-1990's, they have not taken a systematic approach to involving engineers with their Task Forces. This is in part due to the direct availability of state-employed engineers in some states who are expected to assist with emergency events.

5 MECHANISMS FOR INVOLVEMENT WITH TASK FORCES

There are many professional considerations associated with the operational involvement of engineers in USAR training and actual deployments. These include:

- Scope of involvement in training and deployment situations (ie. the nature of engineering inputs sought)
- Training obligations for the engineer
- Mobilisation mechanisms –response expectations
- Professional indemnity and public liability
- Health and safety responsibilities
- Remuneration

A draft agreement between professional engineers and the USAR Task Forces has been prepared and is currently under legal review. The preferred concept is for invited individual engineers to be attached to the Task Forces by way of a standing secondment from their practice to the NZ Fire Service. This is seen as a way of creating a defined and renewable relationship between nominated individuals and the Task Forces which doesn't attract undue liability to either the individual or their practice. An honorarium which contributes towards the annual training and engagement time commitments is to be offered with this appointment.

The liability implications for engineers responding as part of local rescue teams or as individuals are still being worked through. Both the previous Civil Defence Act and the new Civil Defence and Emergency Management Act provide cover for responders working under the direction of the Controller in a declared emergency. A local structural collapse situation (eg. single building) would however not result in a declared civil defence emergency, and the level of protection afforded to an engineer providing operational advice is unclear. This applies to engineers operating as either individuals (eg. outside working hours) or on behalf of consulting practices. A working party involving ACENZ representatives is being set up to address this question.

In any operational situation it is important to note that while the principal role of an engineer is to provide specific safety advice, the overall responsibility for Health and Safety must stay with the rescue team leader.

6 ASSOCIATED ACTIVITIES AND INITIATIVES

A number of initiatives have been undertaken over the past twelve months to increase USAR awareness for practising engineers. This included NZSEE holding several seminars on *'Involving Engineers in Emergency Response Processes'* at various centres in New Zealand. These were well attended and informed engineers on emergency response procedures, USAR procedures, building safety evaluations and Priority Response Agreements (NZSEE, 2002).

In July 2002 a major rescue exercise was held in Wellington – Operation Phoenix – intended to simulate the effects a major earthquake would have on Wellington. The Palmerston North-based USAR Task Force including engineers were deployed, and public demonstrations of rescue techniques and equipment were held.

Another initiative for promoting the greater involvement of the engineering profession in emergency management was undertaken at the most recent ACENZ conference. A session entitled *'Emergency Management in New Zealand - Implications for Consulting Engineers'* was held. The thrust of this session was conveying to the owners and managers of professional engineering practices the need to encourage their engineers to become involved in specialist training, and to support them in this objective.

One of the principal observations to emerge from this work is that professional engineers need to become more familiar with and involved in emergency management right across the 4Rs of *reduction*, *readiness*, *response* and *recovery*. The Ministry of Civil Defence and Emergency Management and the NZ Fire Service are currently developing a new project to link the various existing building safety initiatives across the 4Rs. This project is aimed at putting *reduction* activities such as fire safety improvement and the strengthening of earthquake risk buildings in the same overall context as the *response* aspects such as structural collapse rescue and building safety placarding and the *recovery* element of building consent processing by territorial authorities and building certifiers. This project will provide a more appropriate context for engineers and other building professionals to become involved in emergency management.

7 CONCLUDING OBSERVATIONS

Professional engineers are required to fulfil an important role in rescue operations, assisting with critical decisions relating to the safety of operations and determining suitable methods to ensure temporary stability of collapsed structures. Engineers need to be specifically trained so that they can be effective in demanding and dangerous situations that are quite different from their normal working environment.

A two-level USAR training system for New Zealand engineers is being developed with the objective of providing a specialist engineering response capability at both regional and national levels. The training includes specific courses for engineers and courses involving participation with members of the emergency services.

During USAR training, engineers will gain first hand exposure of the nature of rescue operations and the personnel involved. Ongoing training will need to be undertaken to ensure skill levels are maintained. The USAR engineering courses are expected to be ready for delivery later this year and will form a valuable continuing professional development module for practising engineers, providing an opportunity for engineers to develop leadership skills and promote community awareness of the engineering profession.

In conclusion, it must be emphasised that no amount of training can prepare people for the overall effects of a disaster scene, but appropriately focused training goes a long way towards giving an engineer a better idea of what to expect.

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REFERENCES:

Angus, L. B., Dance, R. J. & Brunsdon, D. R. 2003. Developing an Urban Search and Rescue Capability for New Zealand: Two Years of Achievements, *Proc. of the Pacific Conference on Earthquake Engineering, Christchurch, February 13-15, 2003.*

Hammond, D. 1995. “Engineering” the Collapse: Making the Structure Safe, *Fire Engineering Journal*, Vol 148 (11) 49-63.

McGuigan, D. M. 2002. Urban Search and Rescue and the Role of the Engineer. *Masters of Engineering Project Report*. University of Canterbury, Christchurch.

McGuigan, D. M., Deam, B. L., & Bull, D. K. 2002. Urban Search and Rescue and the Role of the Engineer, *Proc. of the NZSEE Annual Conference, Napier, March 15-17, 2002*.

New Zealand Society for Earthquake Engineering. 2002. The Response of Professional Engineers to a Major Earthquake: Priority Response Agreements and a National Register of Engineers, www.nzsee.org.nz