Engineering and Resilience

Dr Ron McDowall FIPENZ has written a discussion paper as a starting point for the development of a Practice Note on resilience, a subject not considered an "engineering practice" in the traditional sense. Due to the complexity of the subject, the Engineering Practice Advisory Committee is asking for Member feedback on the following abridged version of Dr McDowall's paper.

PRELUDE

Ordinarily, Practice Notes are short, rule-based guides providing engineers with knowledge of an engineering practice. It was initially thought that a Practice Note on resilience, while necessary, would be relatively straightforward to draft. However, resilience is a complex, wide-ranging facet of engineering, and it soon became apparent that any Practice Note on the topic would veer from the norm. For that reason, your ideas on what form such a Practice Note should take are encouraged. In developing this paper I have relied on several authors, in particular Charlie Edwards and his excellent 2009 paper, "Resilient Nations".

RESILIENCE

Along with infrastructure and lifestyle (including pandemics, terrorism and environmental degradation), three disruptive forces threaten New Zealand: extreme weather events (climate change), earthquakes and tsunami, and volcanism. Together they comprise what Edwards calls "our brittle society", one that relies on infrastructure that, as technology advances, is becoming progressively more outmoded and archaic, and increasingly lacking in capacity to support our complicated lives.

> Our everyday lives and the national infrastructure which they rely on operate in a fragile union, vulnerable to even the smallest disturbances in the network.
> (Edwards, "Resilient Nations")

Consequently, we need to rethink the concept of resilience in a way that resists the temptation to treat it only in terms of the ability of an individual or society to "bounce back". Instead, greater focus on learning and adaptation is required, and this is the lesson of complexity.

In the last 12 months the Government has realised it needs to draw away from formal institutions and organisations and focus instead on private enterprise, individuals and communities.

> The topic of resilience has taken on renewed importance in recent months with Canterbury being hit by two major earthquakes in five months. The city's infrastructure was damaged in the first earthquake, but most services were quickly restored. The second earthquake caused far greater damage to essential infrastructure, and is a significant test of New Zealand's infrastructure resilience.

The concept of resilience is wider than natural disasters, and covers the capacity of public, private and civic sectors to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions, including climate change, and grow over time. Of particular importance is the resilience of lifeline utilities, disruptions to which can have serious consequences for businesses and communities. (*National Infrastructure Plan 2011*)

The New Zealand Government has indicated some adaptation to the new complexity and risks by passing new legislation and designing more effective civil protection structures and activity (leading to the establishment of the lifelines code, which covers water, sewage, telecoms, electrical and gas systems).

Amanda Ripley in her book *The Unthinkable* cites several reasons for the new line the Government is taking: our environment is changing, natural disasters are becoming more frequent and intense; society is complex and individual choices are more influential on communities than they were in the past; in major disasters we expect emergency services to arrive instantaneously (placing responsibility on all of us to ensure we are prepared for and resilient in an emergency); and local body and national politicians continue to believe in the "myth" of civil defence.

As *individuals* we have never been safer, wealthier (in spite of the current recession) or healthier. We have never had so many tools to help us live our lives. However, as a *society* our complicated lives, individual fears and increasingly high expectations have led some of us to believe we are more at risk than ever.

RETHINKING RESILIENCE

> Resilience is an important feature of modern day societies. Recent experience in New Zealand illustrates the diverse nature of risk and its ability to affect our everyday lives however (and wherever) we choose to lead them. Governments have in the past tended to understand and describe resilience in a narrow, mechanistic way. David Omand reflected this thinking in a journal article in 2005 describing resilience as the "capacity to absorb shocks and to bounce back into functioning shape, or at the least, sufficient resilience to prevent stress fractures or even system collapse". More recently Kenny MacAskill echoed this sentiment when he launched Scottish Resilience, suggesting

that the reorganisation was to "take all practicable steps to ... respond and cope with major shocks [so] we can bounce back quickly". ("Resilient Nations")

The ability to bounce back instinctively feels too narrow, too short term and too reactive when considering the scope of resilience. Resilience cannot solely be about how citizens and society respond to risks; disaster preparedness appears missing from this argument. For others, resilience is "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Dr Brian Walker, Commonwealth Scientific and Industrial Research Organisation). Others believe that "resilience of social-ecological systems is determined by their ability to absorb disturbance, their ability for self-organisation and the capacity to learn and adapt" (Neil Adger, Tyndall Centre for Climate Change Research).

Despite being theoretical these definitions provide a useful starting point in thinking about resilience in today's network society. How we behave depends on who we are – rarely do we simply "bounce back" from an event. Instinctively we change our behaviour, act differently and learn from the experience. This is why Neil Adger's description is so important – as humans we have the capacity to learn and adapt. Humans change their habits continuously, especially after emergencies. Sectors of society – like the business community – constantly reorganise themselves, especially after a major shock like the credit crunch. The same is true for wider society: we adapt our lifestyles, change our habits and learn from people around us. Therefore, we need to find a new definition of resilience that suits our complex lives and reflects our collective response to risk.

Based on the points above we can compose a simple definition of resilience:

> The capacity of an individual, community or system to adapt in order to sustain an acceptable level of function, structure and identity.

For us as engineers the question is: where should responsibility for resilience lie – at the national level with government and local authorities or with emergency services and voluntary organisations?

The answer is all of the above. At the national level the Government plays a crucial role in shaping and influencing the direction as well as leveraging the human and financial resources of a nation at a time of crisis. At the grassroots level, individuals and communities play a key role – not least because they may be involved in an emergency when their actions during and following crises are essential to their ability to adapt. Individual resilience, based on our instinct for survival, is central to a resilient nation – thus responsibility must lie at the local level too.

In many European countries and in North America, personal responsibility is central to community resilience. In the United States, for example, the Federal Emergency Management
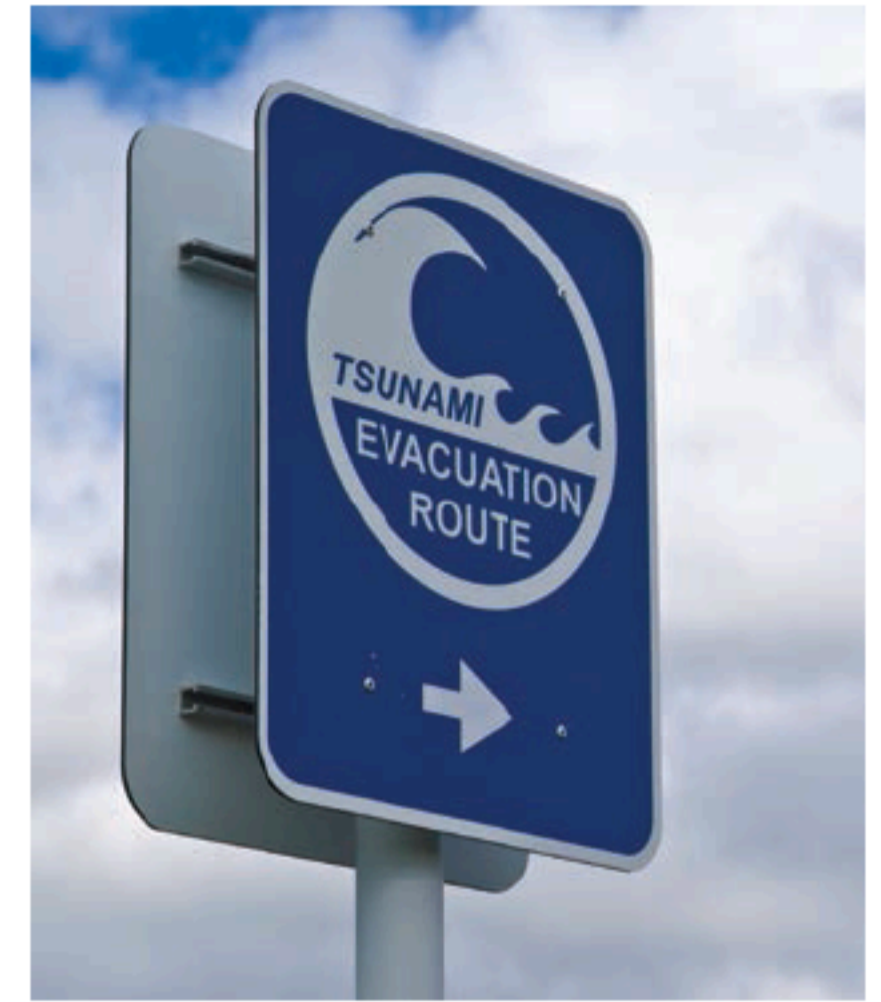
Agency relays this message regularly – individual responsibility is the principal building block of a resilient community. To bring this definition to life consider the following quote:

> Communities lie somewhere between the national and the individual level but their complexity and nebulous structures often provide no obvious "place" to leverage resilience. The community plays two central roles: it acts as a conduit of information and resources from the national and regional level both downwards and upwards by providing feedback and experiences from individuals and neighbourhoods. ("Resilient Nations")

Engaging with local communities presents a number of challenges, not least deciding who to engage with in communities, state institutions and voluntary organisations.

THE PRACTICE NOTE

The Practice Note would normally be aimed at engineers so that they may theoretically consider resilience when designing infrastructure systems. However, this thought piece goes beyond core engineering and into the realm of community and individual responsibility. While our systems may be robust they remain brittle, and that is the gap that a Practice Note could address. Other points to consider:

- Should the Practice Note merely cover the need for robust engineering design or systems design and focus on priorities for engineers engaged in design?
- Should the Practice Note be more broadly philosophical in nature and define system design that is resilient?
- Should the Practice Note simply be based on a description of the social resilience cycle, or should it include more?

Do you have any thoughts on this piece? Please email them to the author at ron.mcdowall@gmail.com