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AN ASSESSMENT OF AUSTRALIAN PREPAREDNESS FOR TALL BUILDING USAGE IN A NEW RISK REGIME

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Abstract

An assessment of the current state of readiness of Australia to combat terrorist attacks on large occupancy buildings has been assessed in terms of the criteria considered to be key safety issues by the international working group established by the Institution of Structural Engineers in the light of the attacks of September 11th, 2001 in the USA. Nineteen structures in the Eastern states of Australia were assessed in terms of these vital criteria as an indication of the preparedness of the nation to deal with any terrorist assault in that country. The survey was carried out before the October bombings in Bali, and has shown that Australia was generally poorly prepared to deal with terrorism. The events in Bali have changed Australian perceptions, and some evidence is reported to show that the level of preparedness in Australia has increased significantly since that time.

Keywords: Risk Management, progressive collapse, Australia

1. Introduction

In the wake of the collapse of the World trade Center buildings committees were set up in the USA and in the UK to establish what lessons could be learned from the terrorist attacks, in terms of the future use and security of buildings of large occupancy. The UK established the International working group convened by the Institution of Structural Engineers (IWGSTB) and was particularly concerned with the future use of tall buildings and other large occupancy structures The WGSTB addressed the issues for the future use of such structures. There was considerable interchange of information between the US and the UK. Several major safety issues were identified in the report issued in September 2002, and these issues were taken as the substance of a survey of facility managers for structures of large occupancy in two eastern states of Australia. The issues assessed were:

(i) Vulnerability to progressive collapse

(ii) Fire protection

(iii) Security of means of escape

(iv) Training for escape

(v) Security of building services

(vi) Protection against unauthorised entry

(vii) Overall level of security

Inspections were carried out at each of the facilities, and interviews were conducted in most cases with Building facilities managers. Because of the sensitive nature of the information, no identification of individual facilities is made in this paper. The survey covered government buildings, hotels, clubs and commercial buildings both inside major cities and in rural areas. Some of these facilities have already been identified publicly as being potentially prominent targets.

After the survey was conducted, the bombings at night clubs in Bali occurred and the Australian perspective of risk changed dramatically. An attempt has been made here to give an early indication of how this experience might have affected the result obtained in the survey. The IWGSTB list of key

safety issues was used as the template for the investigations. The list was produced as a result of an intense investigation of the experience particularly from the collapse of the world trade center towers. These issues are considered in detail below.

2. The parameters investigated

Nineteen buildings were investigated. The parameters considered in the IWGSTB report to be key safety issues were given particular attention. These are considered below.

2.1 Vulnerability to progressive collapse

Progressive collapse, or disproportionate response, is caused when the failure of one element of a structure caused a consequent overloading of an alternative load path that in turn causes a failure. Such failures then progress through the structure until such time as a load path is capable of withstanding the extra loading imposed. Probably the earliest major experience of such an occurrence was that occurring at the Ronan Point building in the UK as reported by Jeary et al (1984). Experiments conducted at that time concluded that the mechanisms do not change, even when strengthening occurs, but that the threshold for the occurrence of a progressive collapse can be raised. An assessment of a building in terms of its' vulnerability to progressive collapse includes an assessment of the materials used, the structural form, the design, and the available leverage of primary failures.

The first three of these considerations interact, since the choice of materials has an influence on the available choices for the structural form. The lighter weight of a steel frame (compared with a concrete frame) tends to mean that the primary failure may occur at a lower threshold, but that the available mass to create a secondary failure is less. Coupled with this consideration is the fact that the use of a lightweight frame tends to require a lightweight flooring system. Such a flooring system by itself would reduce the propensity to progressive collapse but the connections between such a floor and a wall may be of critical importance. In general terms the connections throughout a structure are the key to the likelihood of a progressive collapse. In the case of Ronan Point, the structural system consisted of precast concrete panels that were connected together with a mortar joint. The World Trade Center towers were of a framed tube design in which the truss floor connections to the outer curtain wall and to the core of the building was of crucial importance to the occurrence of the trigger for the progressive collapse.

IWGSTB (2002) noted that leverage occurs when the initial trigger event allows the release of energy that can be leveraged throughout the structure. The most familiar occurrence of this type is when potential energy is converted to kinetic energy as a part of a structure falls onto another. Other types of leverage from the conversion of energy from one form to another are also possible.

A building is considered to be "robust" when such a leverage of energy is less likely to occur because of the general form of the structure. Robustness is more likely to be a consequence of such considerations of design as the continuous formation of joints through the use of poured concrete and the use of solid floors. Clearly, height is of primary importance to the introduction of potential energy in a structure.

Whilst fire protection has an important bearing on the ability of a structure to avoid a progressive collapse, especially in the case of steel frame construction, it is more normally a consideration only after the primary impact in which the structural materials are gradually weakened. This is considered separately.

The structural form may mitigate against progressive collapse in other ways as well, and the use of concrete shear walls is helpful in this regard. The weight penalty does mean that such a form is not used for the tallest of structures.

Australian design practice incorporates structural concepts from many parts of the world. As a result the structural stock of the country has a wide diversity, and includes steel frame, concrete frame and concrete shear wall type structures. The major cities of Australia include building that compare with the tallest in the world, although rural areas tend not to have buildings that are more than ten storeys tall.

However, most communities have large occupancy structures in the form of shopping malls.

2.2 Fire protection

Australia is one of the driest countries on the planet, and as a result is particularly sensitive to the risk of fire. Bush fires are common, and as a result the community is generally aware of the dangers, because of a high level of publicity generated by the fire services. Legislation in Australia about fire protection of structures provides a stringent framework for good design practice. Current Codes of practice require an assessment of a building in terms of its' performance. However, the privatisation of inspection has recently called into question whether these standards are being uniformly applied. Whilst "deemed to satisfy" solutions are available, alternative fire engineered solutions are routinely accepted, and are largely based on the use of commercially available fire design suites of programs. Whilst such programs give a good general indication of the suitability of solutions there would appear to be an over-confidence in their ability to model fire behavior precisely. As a result, the Australian building stock is a mixture, in which different materials and different designs are used. The requirements of the Building Code of Australia (1996), means that the performance of building elements must be fire rated in terms that use an assessment from a major testing institution (such as the Commonwealth Scientific and Industrial Research Organisation), the evidence of an expert (who may use a commercially available suite in the assessment) or conventional practice.

Currently used standard fire curves do not accurately reflect the types of fire load that may be imposed in a terrorist attack, nor, for that matter, do they represent the type of characteristic that represents an "ordinary" fire accurately. The currently used curves have been established more as a means of comparing the performance of materials under uniform conditions. The establishment of probabilistic models of likely fire magnitudes would move the fire engineering profession forward considerably.

2.3 Security of means of escape

The stock of buildings in Australia was built in a time when a different philosophy applied. This is epitomised by the phrase in the BCA that requires that occupants must be able to "leave a building with dignity". Such a concept clearly does not envisage life and death situations, in which occupants may sacrifice dignity in an effort to salvage life. The BCA therefore addresses the issues of escape in terms ofan assumption that even an emergency evacuation is conducted under relatively well controlled circumstances. The underlying philosophy is that the integrity of a structure will be maintained, and as a result egress routes are specified in terms of dimensions and capacity with little emphasis placed on alternative escape routes and their separation.

2.4 Training for escape management

It is a requirement of Australian Occupational Health and safety legislation that training for egress should occur as part of a structured risk management plan. Indeed, it is also a requirement that a risk management plan for "all conceivable risks" be available for all workplaces.

There are several issues with the management of egress. Firstly, if training is done regularly it should include all people who regularly use the building, and they should see the benefit of such traing. The systems of alarm should be explained and generally intelligible even to casual users of the building. A structured system of alarms indicating different levels of alert (EWIS) is used throughout Australia, although not in all workplaces

2.5 Security of Building services

Access to such services as air conditioning systems by terrorists, represent another major source of risk. Additionally, the handling of mail and the distribution system is another potential source of vulnerability. In each of the surveyed buildings inspections were made of such facilities so as to asses the vulnerability of the building to this alternative form of attack. There are only general requirements in Australia for a concern about such a risk, and these have been introduced only very recently.

2.6 Protection against unauthorised entry

There are two basic forms of unauthorised entry. Those in which a person may feel free to move about a building unhindered, and those in which a forced entry is made. In the former case firearms present a threat (although the possession of firearms is controlled) whilst in the latter, physical protection against the threat of vehicles carrying explosives is the major concern.

2.7 Overall level of security

There are many features available that may make building security better managed. The criteria investigated were the provision and training of personnel, the provision of devices (such as closed circuit television), and the awareness of building users of the risks of attack.

3. The survey

A class of masters level students was asked to choose a building in their local area and to assess that building in terms of the issues discussed in section 2 above.

Table 1 Survey of 19 buildings in the Eastern States of Australia for key safety issues

Building	Height	Risk	Progressive collapse	Fire	Escape	Training	Building Services	Unauth entry	General
Govt. Bldg NSW	11f	Low	7	6	3	7	2	2	3
School Sydney	2f	Low	8	6	2	7	2	0	1
Hotel Queensland	7f	High	8	8	5	7	2	4	2
Govt bldg Sydney	12f	High	8	6	5	7	4	3	4
Club Rural NSW	2f	Low	8	8	7	8	4	3	4
Local Govt. Sydney	6f	Med	4	8	7	9	5	7	7
Hotel Queensland	16f	Low	4	8	8	4	4	2	3
Club Rural NSW	15f	Med	8	8	3	3	2	0	1
Comm Bldg. Sydney	34f	Med	7	8	4	6	8	6	7
Comm Bldg Rural NSW	6f	Med	8	6	4	1	3	0	1
Bank Queensland	10f	Med	4	7	4	3	2	2	2
Comm Bldg Rural NSW	4f	Low	8	8	7	7	2	2	1
Govt Facility NSW	2f	High	9	2	3	0	2	7	3
Comm Bldg Sydney	19f	Med	6	7	4	7	8	6	3
Local Govt. Sydney	3/4f	Med	4	7	7	7	6	9	8
Govt bldg NSW	3/4f	Med	7	7	3	0	2	1	2
Mall Rural NSW	2f	Low	2	7	8	0	2	0	1
Local Govt. Rural NSW	3f	Low	8	1	8	2	2	1	2
Hotel Rural NSW	5f	Low	5	8	8	1	5	1	3
Average		=	6.47	6.63	5.26	4.53	3.53	2.95	3.05

In Table 1 the following nomenclature is used:

Comm - Commercial Building;

Govt. – Government;

NSW - The State of New South Wales;

Unauth – unauthorised;

Linguistic categorisations used are 0-3.33 "poor", 3.34-6.66 "average" and 6.67 and above "good"

Of the surveyed buildings three were from Queensland, six were from the city of Sydney, and ten were from elsewhere in New South Wales. Seven buildings were operated by federal or local government, three were hotels, four were commercial buildings, two were clubs, one was a school, one a bank and there was one other facility.

The results from the survey have been summarised in table 1 above. In each category of assessment the building, the facility managers and the readiness of the personnel have been assessed in terms of their preparedness as a rating on a ten point scale. Whilst this scale is necessarily subjective, it has been assessed in terms of the criteria noted in section 2 above, and there has been a consistent assessment across all of the buildings. In general terms the ratings fall into three categories. Those of good, average and poor, whilst the relative position within those bands has been assessed in terms of the quality of the performance within the assessed parameter.

The final row of the table gives an average assessment across all of the buildings for the assessed category. The results for each category are in broad terms of good, medium or poor for each of the categories being assessed. This allows broad comparisons to be made, and significant conclusions to be drawn from the sample.

4. Discussion of the results of the survey

The results from the survey show interesting variations and these are commented on below:

4.1 Vulnerability to progressive collapse

There are essentially two groups of building included in the survey. These fall into the robust and vulnerable groups. The structural form generally coincides with robust concrete construction and lightweight steel framed construction. Of major concern in this category was the form of construction of the surveyed shopping mall, which used a lightweight steel construction, with little redundancy. This form of construction is repeated in many locations throughout Australia, and the potential for a progressive collapse appears large.

4.2 Fire Protection

As noted above the Australian BCA requires that great attention is paid to fire protection of structures, and in general terms this fact is borne out by the results of the survey. The general level of protection is good, and the principle of compartmentalising facilities is generally used, and acts to reduce the risks inherent on the outbreak of fire. There are notable exceptions, and this has taken the overall average somewhat lower than might be expected. These exceptions have both occurred in government facilities.

4.3 Escape security

The criteria assessed here included providing pressurised escape routes, and providing maintenance to them. The reasons for this are clear. Smoke ingress into escape routes would be a major prejudice to safe egress, as would the cluttering of the routes. 26% of the surveyed buildings had poorly secured escape means, and over half of these were government run facilities. In mitigation the poor security of the school's escape facilities could be offset by the fact that the school is only a two storey facility, and many unofficial escape routes exist.

4.4 Escape training

In general the results showed that training in escape management was either good or bad, with almost no responses in a middle category. This is somewhat surprising since training of building occupants is a legal requirement in both the states surveyed. The fact that 42% of building owners are not meeting the statutory requirement for such training to be provided points to a very lax attitude in some sectors. The difficulty of providing such training for hotels was noted, but the response appeared to be that if there was not much that could be done then it was better to do nothing.

4.5 Security of the Building Services

In this category the preparedness of building managers was generally poor. The exceptions were two high profile commercial buildings in Sydney. In many cases the poor result was simply a function of the design of the building, with services accessible from areas of public circulation. Additionally mail sorting occurred in public access areas in some cases.

4.6 Unauthorised entry

The finding here was that the general protection against unauthorised entry was poor with government buildings, hotels and schools being particularly vulnerable. This result is a reflection of the general culture of an open society in which a "laid back" attitude is prized. The surprising vulnerability of some higher risk facilities, including a bank, is an indication of some vulnerabilities that exist within Australia. There was one instance in which a local government building had impressive security, with fully trained guards, card access, and a CCTV system that was actively monitored, even though the location was rural New South Wales. In this particular instance the reason for the heightened security was that a previous attack from a disgruntled taxpayer had occurred just two years previously. The response of the building managers had been quick and efficient to this occurrence.

4.7 General level of Security

The general level of security management of the surveyed structures was poor. All of the high risk facilities came into this categorisation. 26% of the sample had virtually no security apparent whatsoever, and only three of the sample (15%) were assessed as "good". 73% of the sample were classified as having "poor" overall security. The size of the sample indicates that the standard error at the 95% confidence level is 16%, and that at this confidence level at least 60% of the stock of Australian buildings is likely to be poorly prepared for terrorist attacks.

5. Subsequent to the survey

After the survey had been applied the bombings in Bali took place and many Australians were killed or injured. Statements in the press indicated that there had been a large change in attitude as a result of this event, and indeed, the preparedness of central government to combat a terrorist attack has been increased considerably. Nevertheless for such measures to be truly effective then the preparedness of the general public, and in particular the managers of building facilities needs to change from those encountered in the survey. It was not possible to complete another survey of the building managers as to whether they had changed procedures since the Bali bombings, however, information obtained from two of the facilities surveyed indicated that no immediate measures had been taken.

Conclusions

The work undertaken has shown that at the time of the survey the general level of preparedness to withstand a terrorist attack, in Australia, was poor. Both high risk and government buildings were categorised as having an overall poor preparedness. 73% of the surveyed buildings were categorised as poorly prepared for terrorist attack.

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