ABCB

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FINAL REGULATION IMPACT STATEMENT FOR DECISION

(RIS 2007-03)

Proposal to Amend the Earthquake Provisions of the Building Code of Australia

December 2007

This Regulation Impact Statement (RIS) has been prepared in accordance with the requirements of the *Principles and Guidelines for Standard Setting and Regulatory Action by Ministerial Councils and Standards Setting Bodies*, endorsed by the Council of Australian Governments. Its purpose is to inform interested parties regarding a proposal to make new regulations. Comments were invited on the Consultation RIS (2007-1) and have been considered in this Final RIS.

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EXECUTIVE SUMMARY

BACKGROUND

Under Council of Australian Governments (COAG) Principles[1], national standard-setting bodies such as the Australian Building Codes Board (ABCB) are required to develop a Regulation Impact Statement (RIS) for proposals that substantially alter existing regulatory arrangements. This requirement is reaffirmed in the ABCB's Inter-Government Agreement[2] which requires that there must be a rigorously tested rationale for regulation.

A draft RIS is initially undertaken for the purposes of public consultation ('Consultation RIS'). The Consultation RIS may be developed further following its public release, taking into account the outcomes from the community consultation. A Final RIS is then developed for decision-makers. This entire process is undertaken in cooperation with the Office of Best Practice Regulation.

THE PROPOSAL

This RIS analyses the likely impact of a proposal to require certain buildings to be designed to resist more severe earthquakes than is currently the case. Specifically, it is proposed to revise the 'annual probabilities of exceedance' stated in Tables B1.2(b) (Volume One) and 3.11.3(b) (Volume Two) of the Building Code of Australia (BCA), and to adopt the revision of Australian Standard AS 1170.4 (*AS 1170.4 2007*) into the BCA as a means of compliance with the relevant BCA Performance Requirements.

The earthquake provisions of the BCA vary according to regional variations (at-risk areas have a higher 'hazard factor'), and the relative 'importance' of buildings (from 'low degree of hazard' to 'essential for post-disaster recovery'). These arrangements will be preserved.

THE PROBLEM

Historically, damaging earthquakes in Australia have been rare. However, when they do occur, they can cause significant loss of life and injury, damage to buildings and property, and disruption to economic activity (earthquakes account for about 13 per cent of the total costs of natural disasters in Australia[3]). It is prudent to assume that earthquakes will occur again.

There is a clear role for government in setting standards for protection of buildings from earthquake, largely because these are low probability events that most Australians have not experienced. Consumers cannot reasonably be expected to individually assess the issues.

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[1] COAG *Principles and Guidelines for National Standard Setting and Regulatory Action by Ministerial Councils and Standard-Setting Bodies*, 2004

[2] The ABCB IGA can be located at: www.abcb.gov.au

[3] Bureau of Transport Economics: *Economic Costs of Natural Disasters in Australia*, Report 103 (2001)

Recent reports on the management of natural hazards agree that building standards are the first line of defence against earthquakes. A review of the existing Australian Standard (now 14 years old) identified a number of opportunities for reform.

THE OBJECTIVE

The objective of the revised Standard is to provide designers of structures with improved earthquake actions and general detailing requirements for use in the design of structures subject to earthquakes. The Standard has been revised to provide for greater design flexibility, to provide simpler provisions based on current understanding of earthquake actions, and to bring the Standard into line with international practices.

THE OPTIONS

The only feasible options considered in this RIS are to either accept or reject the proposals. Rejection means that the existing arrangements are preserved. Given the nature of the problem and the need for certainty about impacts on public health and safety, and the necessity of meeting community expectations, it is considered that there are no feasible options of no regulation, quasi-regulation or non-regulatory intervention in this area.

THE IMPACTS

Some elements of the proposal are cost-increasing; others are cost-reducing. There will be increased costs to provide increased earthquake resistance for level 4 and level 3 buildings; these are estimated as being around 0.5% of the total cost of this type of building work undertaken, or approximately $29.7 million/year. The relationship of this total to the 'total building task' is more in the order of 0.05%.

It must be remembered that these are not ‘ordinary’ buildings (e.g. houses, apartments, offices, shops and factories), but buildings such as hospitals and emergency services (level 4) that need to survive an earthquake and remain in operation, and schools, churches and theatres (level 3) where people congregate in large numbers. Confidence in the cost estimates can be described as ‘medium to high’.

It should also be noted that the vast majority of residential structures are not required to be specifically designed for earthquakes. The construction systems already in place for wind resistance are generally adequate for earthquake resistance. Moreover, the proposed measures do not significantly alter the building measures required for residential structures.

There will be off-setting cost reductions, arising primarily because engineers can respond to increased loads by using more sophisticated analysis to demonstrate compliance, rather than increase the strength of the building. This option is available under the existing Standard but would be further facilitated and encouraged by the new Standard. The intention is to provide engineers with a hierarchy of compliance testing methods, with the more demanding computations providing more certainty and reducing the amount of over-strength design that is needed to compensate for approximations in the computation.

It is difficult to quantify the benefits that will flow by further encouraging engineers to substitute ‘brain’ for ‘brawn’, but it would be wrong to dismiss them as insignificant.

The proposals will also reduce the cost of future earthquakes. It is not, however, feasible at this time to specifically quantify the savings achievable through the adoption of the proposed measures, as the data and technical capability required to comprehensively assess the incremental benefits of the proposed measures is not currently available. Rather, it is a matter of acting prudently in the presence of considerable uncertainty.

The impact on business compliance costs will be insignificant and may be negative, that is, cost reducing. This is because the procedural requirements of the Standard have been rationalised, updated and made more flexible.

The proposals do not impede competition in any way.

CONSULTATION

Consultation was sought on this proposal over an eight week period from 1 June to 31 July 2007. This involved inclusion in the corresponding BCA Amendment *Public Comment Draft* process, the targeting of specific relevant stakeholders, and use of the Australian Government's Business Consultation website.

Five submissions were received with all parties broadly supportive of the proposal. The submissions covered a range of topics including the effect of the proposal on both earthwall constructions and residential houses, concerns about practitioner training, and a suggestion that the ABCB undertake some additional work on the quantification of the benefits of the proposal. Additional analysis was undertaken in relation to all issues (refer Chapter 6), however none have resulted in any change to the proposed measures. Thus, the findings of this RIS remain unchanged.

IMPLEMENTATION

If approved, the measures will be introduced in BCA2008. This will be available to BCA subscribers by February 2008 for a 1 May 2008 adoption. It is also proposed that the existing reference to the 1993 edition of AS1170 Part 4 will be retained to allow a transition period for industry to become familiar with the new Standard.

RECOMMENDATION

The current regulations have resulted in market failure in the form of insufficient information. Information failure exists in the sense that consumers do not have sufficient information about the risk of earthquake to make informed choices regarding the level of building protection required. Thus, the market can be said to have failed to adequately deal with the risk of earthquake damage and it is therefore the role of government to intervene. The existing BCA-referenced Standard is 14 years old and requires updating to bring it into line with international practices.

It is for these reasons that the revision of AS 1170.4 is recommended for consideration for referencing in BCA2008.

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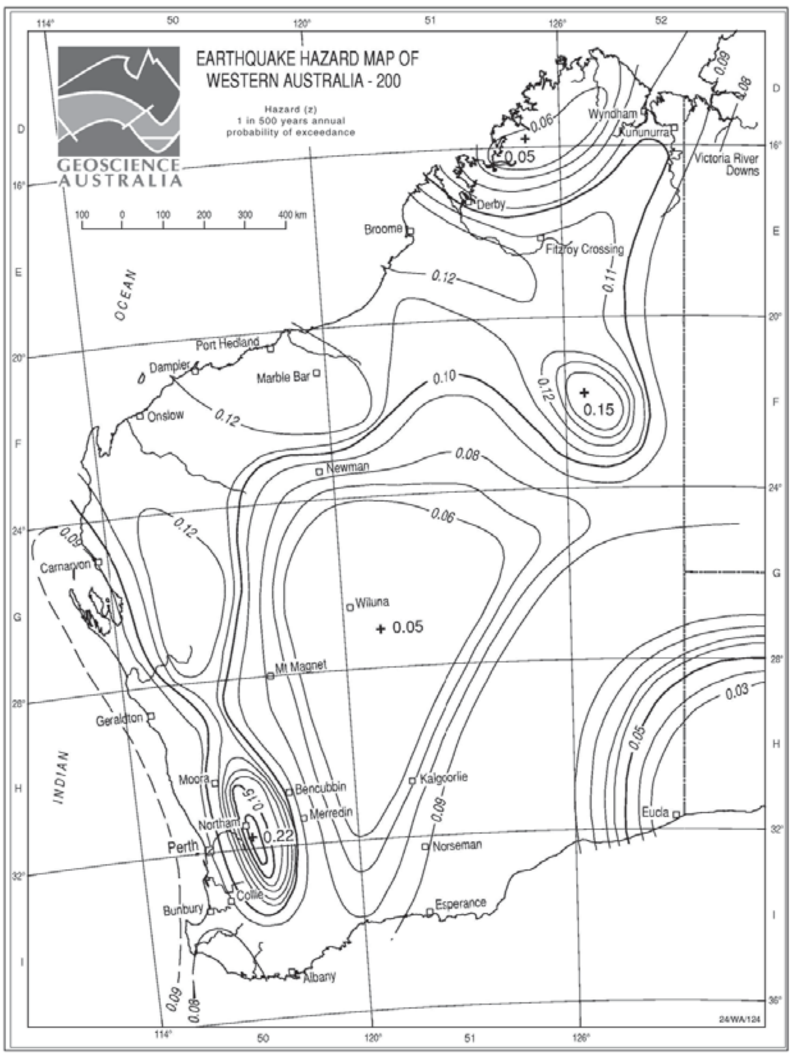
1. NATURE AND EXTENT OF THE PROBLEM

1.1 Earthquake hazards in Australia

Geoscience Australia (GA) has primary responsibility for producing geo-scientific information and knowledge that informs government and community decisions about the exploration of resources, the management of the environment and the safety of critical infrastructure. GA's current understanding of the earthquake risk is summarised in a series of Earthquake Hazard Maps such as that for Western Australia, reproduced below as figure 1.1. Maps for the rest of Australia are provided in Appendix A of this document.

Figure 1.1 2003 Earthquake Hazard Map for Western Australia



Source: Geoscience Australia

These maps summarise the degree of hazard at a particular location as a single number. This is the 'hazard factor' or 'Z factor', which is equivalent to an acceleration co-efficient with an annual probability of exceedance of 1/500, (i.e. a 10% probability of exceedance in 50 years). In lay terms, it is the amount of earthquake induced movement that, on average, would be exceeded only once in 500 years. Several aspects of this assessment should be noted.

First, there is considerable inter-regional variation in the degree of hazard. On the basis of existing knowledge, the most active seismic zone within mainland Australia is the Meckering region, located about 150 kilometres east of Perth. It is an area of roughly 300 by 500 kilometres of inter-plate seismic activity that cuts across south-west WA in a north-west to south-east direction (see figure 1.1). This was the site of a 1968 earthquake that measured 6.9 on the Richter scale and destroyed the small town of Meckering, population 240. It caused ground rupturing over a distance of nearly 40 km. The maximum heave was 2.4 metres and the maximum vertical displacement was 2.0 metres. The Meckering region returns the highest Z factor that GA records for Australian territory (0.22). There are also high Z factors for certain island territories but, otherwise, the Z factor varies from 0.03 for Hobart to 0.13 for Tennant Creek[4]. The Z factors for the major capitals are:

- Hobart – 0.03
- Brisbane – 0.05
- Canberra – 0.08
- Melbourne – 0.08
- Sydney– 0.08
- Perth – 0.09
- Darwin – 0.09
- Adelaide – 0.10

Newcastle experienced Australia's most damaging earthquake in 1989, measuring 5.6 on the Richter scale, and has a Z factor of 0.11.

Second, the Z factor does not indicate that a given location will experience earthquakes of a particular magnitude. All locations are exposed to earthquakes that range from minor tremors to major disasters, with the Z factor indicating the magnitude of the earthquake that, on average, would be exceeded only once in 500 years.

Third, GA acknowledges that key aspects of Australia's earthquake hazard are poorly understood (Leonard 2003: page 1). Leonard's broad assessment of the state of knowledge is that:

[4] These values are reported in table 3.2 of Australian Standard AS1170.4–1993 (*Minimum design loads for structures: earthquake loads*).

- The main difficulty is that the historical record is short relative to the return period of earthquakes, which is the elapsed time between significant earthquakes. This creates uncertainty about the magnitude and frequency of earthquakes. However, uncertainty can be reduced by researching the build-up of stresses and strains in Australia's geology and understanding how they are expressed in seismic activity, that is, rather than simply wait for the accumulation of historical evidence;
- Regarding the source locations of earthquakes, a database of 10,000 recorded earthquakes provides basic information about the distribution of earthquake epicentres. But it needs to be supplemented with more complete geological mapping of faults and enhanced methods for identification of epicentres; and
- It is only the processes of earthquake attenuation that are well understood. 'Attenuation' refers to the moderation of the shock as it physically propagates outwards from its source.

GA considers that, given further research, it can provide better hazard maps than are currently available. In all probability, the combined effect of more research and the simple elapse of time will be to identify earthquake hazards that have yet to be fully expressed as recorded seismic activity.

Despite these uncertainties, Australia is regarded as a region of low to moderate seismic activity relative to other parts of the world. Specifically, this means that engineers can regard earthquakes exceeding 7.0 on the Richter scale as highly unlikely (Lam *et al* 2007: page 36).

1.2 Cost of earthquakes in Australia

Earthquake threats have been examined in a number of recent reports. In a 2001 report, the Bureau of Transport Economics examined the costs of natural disasters in Australia (BTE 2001). In 2002, the Council of Australian Governments published a report dealing with the reform of mitigation, relief and recovery responses to natural disasters (COAG 2002). Additionally, GA has produced a series of reports for the National Risk Assessment Project[5], assessing natural hazards for Perth, Mackay, Newcastle, Cairns, Gladstone and South East Queensland (AGSO 2000).

Broad findings from this work are that:

- Historically, damaging earthquakes have been rare in Australia;
- When damaging earthquakes do occur they can cause significant loss of life and injury, damage to buildings and property and disruption to economic activity. With the increasing urbanisation and reliance on power, water and telecommunications lifelines, Australian communities are becoming increasingly vulnerable to the impact of earthquakes;

[5] Initially called the *Cities Project* and subsequently the *Cities and Critical Infrastructure Project*.

- The total cost of earthquakes is dominated by a few extreme events. In particular, BTE estimates that the Newcastle earthquake of 1989 accounts for 94% of the total cost of earthquakes for the period 1967 to 1999. This was a $4.5 billion cost, from a total of $4.8 billion. The same applies to cyclones and bushfires, where costs were dominated by Cyclone Tracy and the Ash Wednesday bushfires;
- The Newcastle earthquake accounts for all recorded deaths (13) from earthquake;
- Estimates of total cost include damage to infrastructure and other forms of indirect cost, but damage to buildings is the major form of direct cost. The Newcastle earthquake imposed modest to substantial damage on 10,000 buildings;
- From 1967 to 1999, earthquakes accounted for approximately 13% of the total costs of natural disasters in Australia (based on natural disasters with a cost of greater than $10 million); and
- There is a lack of reliable, consistent data on the costs of natural disasters.

Table 1.1 provides basic information about the impact of the most significant earthquake events in the 50 years to 2000.

Table 1.1 Most-damaging Australian earthquakes, 1950-2000

Date	*Location*	*Magnitude*	*Damage costs (2006 prices)*	*Deaths*	*Injuries*
03/01/1954	Adelaide SA	5.4	$120 m	-	3
22/05/1961	Robertson/ Bowral NSW	5.6	$5.6 m	-	-
14/10/1968	Meckering WA	6.9	$46 m	-	21
10/03/1973	Picton NSW	5.5	$3.8 m	-	-
02/06/1979	Cadoux WA	6.2	$13 m	-	5
22/01/1988	Tennant Creek NT (3 events)	6.2, 6.3 & 6.5	$2.0 m	-	-
28/12/1989	Newcastle NSW	5.6	$2,375 m	13	160
06/08/1994	Ellalong NSW	5.4	$46 m	-	5

Sources: AGSO 2000: chapter 8, EMA Disasters Database

1.3 Market responses

<u>The engineering profession</u>

Lam *et al* (2007) provide a brief account of how structural engineers have responded to evolving understanding of the earthquake hazards in Australia. Regarding the Meckering earthquake of 1968, they say that …*Earthquake events of such magnitude were not thought to be part of the Australian landscape* (Lam *et al* 2007: page 33), and that it totally changed the way that engineers viewed earthquake hazards in Australia. To appreciate the extent to which attitudes were revised, it is important to understand that the Richter scale is a logarithmic scale to base 10. This means that a 1 unit increase in magnitude – say, from 6.0 to 7.0 – indicates a 10-fold increase in the seismic energy released by the earthquake. The Meckering earthquake, at 6.9 on the Richter scale, was a genuine wake-up call.

Standards Australia subsequently appointed the National Committee for Earthquake Engineering, resulting in publication of the first code for the design of earthquake-resistant building, AS2121-1979. There has been one revision since, resulting in the current Standard, AS1170.4-1993. This revision was largely in response to research that GA initiated in the mid-1980s, providing engineers with a better basis for assessing the nature and magnitude of earthquake hazards.

Finally, the Australian Earthquake Engineering Society (AEES) has been active since at least the early 1990s. AEES is a Technical Society of Engineers Australia and aims to promote the practice of earthquake engineering and engineering seismology in Australia. Its members have contributed significantly in a volunteer capacity to the development of the relevant standards. Based on an examination of recent AEES newsletters, the revision of AS1170.4 has been a focus of attention and there is continuing work to improve the understanding of earthquake hazards in Australia, including in collaboration with GA.

<u>Insurance industry</u>

The insurance industry provides products for the insurance of buildings against earthquake damage, and for insurance against the other types of earthquake damage, such as death, injury and loss of building contents. Insurance is obviously an important mechanism for spreading losses across the community but does not directly protect against the damage in the first instance. Based on the public comments[6] of insurance providers and the Insurance Council of Australia (ICA), we understand that:

- There is a degree of non-insurance and under-insurance, which means that parts of the community are exposed to the risk of large uncompensated losses; and
- The pricing of earthquake insurance, relative to earthquake-related payouts, suggests that insurance companies consider that the risks are somewhat higher than suggested by the historical record of earthquakes in Australia.

We also understand that insurance companies regard their risk assessments as key commercial assets and do not share that information.

<u>Building owners and occupiers</u>

In principle, building owners and occupiers determine their exposure to earthquake hazards by (a) ensuring that buildings are capable of resisting earthquakes of a certain magnitude, (b) insuring their buildings against losses occasioned by larger earthquakes, and (c) accepting the residual risks. Residual risks exist because owners and occupiers may under-insure, because so little is known about some risks that they cannot be insured against, and because insurance companies can fail.

[6] We refer to the content of periodic disaster conferences and a recent ICA conference on non-insurance (*Non insurance - understanding the causes and effects*, Sydney, 3 May 2007).

Most building owners and occupiers would need to take professional advice to understand the risks and costs of risk mitigation, and to determine the optimal strategy e.g. using the services of structural engineers and insurance brokers. Determining a building's vulnerability to earthquake damage requires a specialised assessment that takes account of, not only the size of potential earthquakes, but also soil conditions, building height, building materials and construction methods, and design considerations relating to the 'regularity' of the building.

1.4 Government responses

The market response may be judged inadequate in a number of respects.

Information, research and analysis relating to earthquake hazards

Information, research and analysis have the essential qualities of public goods. Specifically, they are non-rival goods, which is to say that their use by one member of the community does not diminish the amount of the good that is available to other members of the community. It may be efficient for governments to pay for the production of such goods and arrange for their distribution at the marginal cost of dissemination. The latter is generally close to zero which may mean that such information should be free.

GA has the primary responsibility for providing these public goods, which is apparent from the 'hazard mapping' activities that are described in section 1.1.

Setting standards for earthquake protection

In the absence of government intervention, the amount of earthquake protection is decided by building owners and occupiers, but subject to (a) advice from the engineering profession, (b) standards of professional conduct preventing engineers from being involved in the design and construction of unsafe buildings, and (c) the pricing of resultant risks by insurance providers. The potential weaknesses in this decision-making arrangement are as follows:

- It is unsafe to assume that building owners and occupiers will generally acquire the information they need to make a sound decision, or even to know that they should consult an expert;
- Many decisions would be made by owners and builders while risks of injury or death are unknowingly borne by tenants and their employees;
- Professional self-regulation would not be fully transparent and may tend towards the lowest common denominator, particularly during long periods of seismic tranquillity; and
- Some decisions are of a public policy kind, that is, where the community would regard the government as accountable, not the engineering profession. For example:
  - Some buildings need to not only survive an earthquake but also remain functional. Hospitals are obvious examples. Their destruction has the potential to greatly compound the danger to the public in the wake of an earthquake.
  - The destruction of 'buildings of assembly', such as schools and theatres, present a similar threat of enhanced danger to the public, simply on account of the number of occupants.

A further consideration is that the building industry would not welcome a piecemeal solution, preferring instead a comprehensive, national approach to building solutions.

Importantly, this does not mean that all buildings are provided with the same degree of earthquake resistance, regardless of regional variations in the earthquake hazards and in the significance of the building. The BCA provides for varying degrees of earthquake protection, depending on the severity of regional hazards and the importance of the building. Chapter 3 explains the BCA approach in more detail.

We note that COAG's 2002 report on disaster mitigation and management concludes that *… The building and construction industry has a role in promoting natural hazard awareness in the industry and a culture of compliance with building codes and standards* (COAG 2002: page 17). The report accepts that there will be both structural and non-structural damage from earthquakes but says that building standards *… provide the minimum criteria considered to be prudent for the protection of life by minimizing the likelihood of collapse of the structures* (COAG 2002: page 158).

<u>Setting of standards for demonstrating compliance</u>
Having set minimum standards, the further issue is how to demonstrate compliance with those standards. This is more clearly a matter for the engineering profession to address through its professional associations. However, there can be excessive reliance on volunteers and a role for governments to prompt periodic review, to bear some of the expense of those reviews, and to be appropriately represented at these deliberations, especially where the alternative is that compliance procedures become outdated and lag behind good practice.

1.5 Need for periodic review

The earthquake provisions of the BCA[7] are broadly consistent with the philosophy of government intervention that is outlined above. But there is a need for periodic review, recently endorsed by the Australian Government. In its response to the recommendations of the Regulation Taskforce (DPMC 2006: page 88), the Australian Government agreed that … *At least every 5 years, all regulation (not subject to sunset provisions) should, following a screening process, be reviewed, with the scope of the review tailored to the nature of the regulation and its perceived performance.*

[7] Specifically, the BCA sets design parameters for earthquake resistance and references AS1170.4–1993 (*Minimum design loads for structures: earthquake loads*) to provide design guidance and a compliance procedure. It sets out data and procedures for determining minimum earthquake loads on structures and components and also minimum detailing requirements for structures in order for buildings to resist the loads or 'actions' generated by earthquakes. Chapter 3 of this RIS provides a detailed account.

Review of AS 1170.4

The earthquake Standard (AS1170.4-1993) is now 14 years old. There have been complaints about several aspects of the Standard, suggesting that the existing provisions may no longer meet the needs of the community. The review of AS1170.4-1993 undertaken by Standards Australia committee BD-006 identified reform opportunities such as the following:

- international harmonisation of terms, notation, hazard maps and sub soil descriptions;
- simplified provisions that take advantage of improved understanding of earthquake actions, the response of different types of structures, and the potential for damage;
- removal of provisions regarding specific materials, for placement in appropriate material Standards;
- inclusion of the best available international and local information;
- clarification of the roles of the BCA and the Standard; and
- better integration of the Standard with the BCA.

Review of the 'annual probability of exceedance' table

The proposed new values for the revised annual probability of exceedance for earthquake were determined from research undertaken by the ABCB in 2006, including international comparison and benchmarking in comparable socio-economic communities. The research considered the values used in countries such as USA, Canada and New Zealand and was undertaken at the request of the ABCB's Building Codes Committee.

The review found that when benchmarked against comparable communities, the current values are too low for building importance level 3 and level 4 and too high for level 1. It also noted that it is illogical for three different importance levels to have the same value of 1:500 (i.e. one 'event' in 500 years). A progressive, stepped approach to the values would more accurately reflect the appropriate risk to the safety of people in different buildings. The more important the building, the safer the building should be. The review recommended a logical, progressive set of values from a lower value for level 1 to a higher value for level 4.

The new values are intrinsically linked to the revision of AS1170.4 as the development of the Standard has been in tandem with the new exceedence values. Therefore, there is no option to reference AS11704-2007 in the BCA, without also updating the Annual Probabilities of Exceedence table.

2. OBJECTIVES OF GOVERNMENT INTERVENTION

The State and Territory Governments are primarily responsible for the protection of life, property and the environment from natural disasters. The Australian Government assists the States and Territories by enhancing their response capabilities and providing extra resources as required, including for both mitigation and relief of natural disasters.

Emergency Management Australia (EMA) is the agency (within the Attorney-General's portfolio) that advises and supports the Australian Government, States and Territories, and the broader management community. EMA has signaled a renewed focus on disaster mitigation. *The key focus for the future … is the mitigation of disaster impact, the promotion of community safety, and an investment in community resilience* (EMA 2006: page 2).

Mitigation involves a range of measures. For example, the Natural Disaster Mitigation Program provides funds for education, information and infrastructure measures that contribute to safer and more resilient communities that are better able to withstand the effects of natural disasters. Regarding the mitigation of earthquakes, EMA has listed the two key Commonwealth activities as:

- research, analysis, policies and programs on geo-hazards, with responsibility assigned to Geoscience Australia; and
- development of earthquake resistant building design, with responsibility assigned to the ABCB (EMA 1999).

This is consistent with the ABCB's mission, which is to address issues relating to health, safety, amenity and sustainability by providing for efficiency in the design, construction and performance of buildings through the BCA and the development of effective regulatory systems.

Broadly speaking, the ABCB has responsibility for:

- developing and managing a nationally uniform approach to technical building requirements, embodied in the BCA;
- developing a simpler and more efficient building regulatory system; and
- enabling the building industry to adopt new and innovative construction technology and practices.

The BCA includes the objective of safeguarding people from injury caused by structural failure of buildings and from loss of amenity caused by structural behaviour of buildings. The provision of reasonable (minimum acceptable) protection against seismic shocks, primarily to save lives and reduce human suffering, can also result in the continuity of basic services and minimisation of disruption to economic activity. There are two sub-objectives within this overall objective:

- Whatever level of protection is provided, it should be at 'least cost' for that level of protection. This is the issue of cost-effectiveness; and
- The benefits of additional protection should be weighed against the additional cost. The appropriate balance is likely to vary from building to building, depending on the nature of the activities conducted in the building, and the consequences of interrupting those activities.

There is a need to periodically review regulations and respond to building and design technologies, growing understanding of earthquake threats, and changing community needs.

This proposal directly addresses these responsibilities.

3. IDENTIFICATION OF FEASIBLE POLICY OPTIONS

This chapter describes the regulatory arrangements that are proposed for BCA2008 (section 3.1), explains the key differences between the existing and proposed arrangements (3.2), and identifies the feasible policy options (3.3).

We refer to the proposal as being governed jointly by BCA2008 and AS1170.4-2007, and existing arrangements as being governed jointly by BCA2007 and AS1170.4–1993.

3.1 Regulatory arrangements proposed for BCA2008

It is proposed that AS1170.4-2007 be referenced by both volumes of BCA2008.

- The Deemed-to-Satisfy (DTS) provisions of Volume One (Section B1.3) will require that Class 2 to 9 buildings must *… resist* [earthquake] *loads determined in accordance with AS1170.4* as a means of compliance with Performance Requirements BP1.1 to BP1.3; and
- Volume Two contains Acceptable Construction Practice provisions in Part 3.10.2 and/or requires that Class 1 and 10 buildings must … *resist* [earthquake] *loads determined in accordance with AS1170.4* as means of compliance with Performance Requirement P2.1. It is anticipated that Part 3.10.2 of Volume Two will be considered for removal from BCA Volume Two. It is expected that the impacts of adopting the new Standard into Volume Two will be minimal: most domestic structures are not required to be specifically designed for earthquakes because the construction system already in place for wind resistance is usually adequate for earthquake resistance.

It is not enough for BCA2008 to simply reference AS1170.4-2007. It has two further tasks. First, BCA2008 defines the structural objectives that designers, using AS1170.4-2007, will be required to demonstrate. This scheme for ‘designing according to importance’ is set out in table 3.1. It is important to note the following:

- Level 4 buildings are the most important and include emergency centres, hospitals and law and order facilities. These need to remain operable after an earthquake that will be exceeded only once in 1,500 years. This is the ‘design event’ for level 4 buildings[8];
- Buildings in levels 3 and 2 will be defined as progressively less important, and designed to meet progressively less demanding ‘design events’. These events are expected to be exceeded more frequently, which means that the survivability of these buildings is reduced relative to level 4 buildings; and

[8] The term ‘design event’ refers to the earthquake event that the building is designed to withstand. It is a larger but less frequent event for more important buildings.

- Specific design for buildings in level 1 is not expected to be required as loadings already imposed by wind actions are likely to exceed earthquake actions.

Table 3.1 BCA-defined importance levels and probability of design event

Importance level	*Building type*	*Annual probability that the design event will be exceeded** *(probability of exceedance in 50 years)*
1	Buildings or structures presenting a low degree of hazard to life and other property[9] in the case of failure.	1:250 (20% in 50 years)
2	Buildings and structures not included in importance levels 1, 3 or 4.	1:500 (10% in 50 years)
3	Buildings and structures that are designed to contain a large number of people.	1:1,000 (5% in 50 years)
4	Buildings and structures that are essential to post-disaster recovery or associated with hazardous facilities.	1:1,500 (3.3% in 50 years)

Note:

* The technical term used in the BCA is 'annual probability of exceedance'.

The second task required here relates to the importance levels assigned by BCA2008 and how they will influence the design procedure that the designer is required to adopt. This is a more complicated arrangement than the assignment of importance levels and design events. Briefly, however, AS1170.4-2007 will require designers to adopt more precise design procedures where there is some combination of the following: a larger design event; softer sub-soil; taller building; more important building[10].

The least important buildings (level 1) and most houses have no specific earthquake design requirements for the reasons noted earlier. However, there is a residual category of houses with more severe seismic hazards, such as Newcastle and the Meckering region (WA), and houses built with non-standard materials to a non-standard layout, for example, a 2-storey earth-wall construction, that require earthquake design consideration.

For all other buildings, and depending on their specific seismic hazards, height and importance, AS1170.4-2007 will require the designers to adopt one of three design procedures[11]. It is easiest to explain the three 'earthquake design categories' (EDCs) in reverse order.

[9] Other property is any building on the same or adjoining allotment, an adjoining allotment, or road.

[10] Note that two factors determine the magnitude of the design event, (a) the degree of exposure to seismic shock, and (b) the importance of the building. This means that the importance level affects the design procedure in two ways: it is not only a direct consideration but also influences the magnitude of the design event that the engineer designs for.

[11] These procedures are, for practical purposes, methods of testing for compliance with the requirements of the BCA.

- EDC III – dynamic analysis: This is the most sophisticated check and is used only rarely. It is reserved for the tallest buildings, for buildings of intermediate height on softer soils, and for the most important buildings that are taller than 12m. The analysis is dynamic in the sense that it examines the forces created as the building oscillates during an earthquake event;
- EDC II – equivalent static analysis: This method assumes the application of a constant static force to the building and is computationally less demanding than EDC III. Equivalence is maintained by magnifying the static force in a manner calculated to mimic the dynamic stresses; and
- EDC I – minimum static check: This is a minimum check to confirm that the structure can resist a horizontal force that relates to the 'seismic weight' of the structure, which is a function of its mass and stiffness. It is not an acceptable method for any structure that is taller than 12 m.

Given this account of how BCA2008 will engage AS1170.4-2007, it remains to describe the Standard's content. Putting aside the definitional material in section 1 of AS1170.4-2007, the remaining 7 sections and appendix can be grouped as follows:

- Sections 2, 3 and 4: These sections show the structural engineer how to determine which design procedure is required, if any. This includes for example, maps showing the variation in earthquake hazards across Australia, methods for determining the class of sub-soil, and the rules for combining this environmental information with building factors (height and importance) to determine the design procedure;
- Sections 5, 6 and 7, plus Appendix A: These contain detailed instructions for each of the design procedures, focusing on the performance of the 'seismic-force-resisting-system' within the structure of the building. With the exception of the general principles and static tests, this material tends to be highly technical; and
- Section 8: This section deals with non-structural elements such as the architectural, mechanical and electrical components of a building. It provides for both simple and more complex methods of analysis.

3.2 How BCA2008 would differ from BCA2007

The proposed and existing arrangements allocate tasks to the BCA and the Standard in the same manner. The BCA says what is required: for example, whether the building should be built to resist an earthquake that is exceeded once in 500 years, or an earthquake that is exceeded once in 1,000 years. The Standard says how compliance with any such requirement can be demonstrated. Within that framework, there are differences in both requirements (in the BCA) and the process for demonstrating compliance (in the Standard).

Table 3.2 lists the changes, which will be implemented by amending tables B1.2b and 3.11.3b, in BCA Volumes One and Two respectively. Note that:

- The effect of BCA2007 is to define only two levels of building importance, since buildings in levels 1, 2 and 3 are all designed to meet an earthquake that is exceeded once in 500 years. Only level 4 buildings have a lower exceedance probability, at once in 800 years on average. BCA2008 will be more discriminating, with each level assigned a different exceedance probability;
- The BCA2008 proposal effectively eliminates earthquake design requirements for buildings in level 1; and
- The BCA2008 proposal also decreases the exceedance probability for levels 3 and 4, increasing the structural requirements for such buildings.

Table 3.2 Differences in the earthquake 'design event'

Importance level	*Building type*	*Annual probability that the design event will be exceeded**	
		BCA2007	BCA2008
1	Buildings or structures presenting a low degree of hazard to life and other property in the case of failure.	1:500	1:250
2	Buildings and structures not included in importance levels 1, 3 or 4.	1:500	1:500
3	Buildings and structures that are designed to contain a large number of people.	1:500	1:1000
4	Buildings and structures that are essential to post-disaster recovery or associated with hazardous facilities.	1:800	1:1500

The effect of these changes is that, for buildings in levels 3 and 4, compliance with BCA2008 will be more demanding and more costly than compliance with BCA2007. Offsetting that, however, changes to the Standard are expected to be cost-reducing: AS1170.4-2007 will allow the Performance Requirements to be achieved and demonstrated more efficiently than AS1170.4-1993. The impact of the proposal on the cost of buildings is the net result of these cost-increasing and cost-reducing elements, as discussed in chapter 4.

The cost-reducing impact of AS1170.4-2007 is itself the result of several changes to the Standard. Some of these are incremental improvements, clarifying the provisions, eliminating ambiguities, aligning notation and terminology with international practice, and deleting appendices that provide out-dated information or references. The Standard is shorter by 16%, down from 61 pages to 51 pages.

The major drivers for the more substantive differences are dot-pointed below (if the explanations are repetitious, it is because some changes have more than one driver and many are inter-related):

- Better integration with the BCA: AS1170.4-2007 is more user-friendly than AS1170.4-1993. A simple change is to consolidate all provisions relating to domestic buildings in Appendix A of AS1170.4-2007, reflecting the BCA's consolidation of domestic provisions in Volume Two[12]. AS1170.4-2007 uses the BCA's terminology for levels of importance (levels 1 to 4) whereas AS1170.4-1993 does not recognise level 1 and labels the rest as 'structure classification types' I, II and III. AS1170.4-1993 provides examples of buildings in the various structure classifications that do not always align with the 'importance levels' given in the *Guide to the BCA*. They have been deleted from AS1170.4-2007;
- New knowledge: Earthquake science is an evolving area, with most work originating in countries that face more severe hazards than Australia. A number of the changes to the Standard are to catch up with developments since 1993. For example, whereas AS1170.4-1993 characterises soil in descriptive terms such as 'stiff clay' or 'coarse sand', the new characterisation is in terms of physical properties such as compressive strength, shear strength or number of blows for a standard penetration[13]. *Geoscience Australia* has provided revised maps of earthquake hazards, and a number of other parameters have also been revised;
- More options and greater flexibility: The Standard has become more performance based. For example, a number of outright material prohibitions and requirements have been deleted. Simplified procedures have been devised and added as new options. Some materials-related provisions have been shifted to relevant materials standards;
- New rules governing the selection of a design procedure: AS1170.4-2007 incorporates significant changes to the rules governing the selection of a design procedure and presents the decision process in a more straightforward manner. Regarding the rule changes, the differences are that:
  - In AS1170.4-2007, the design procedure is determined by the degree of seismic hazard, soil type, and the importance and height of the building. These determine whether a design procedure is required and, if so, which of 3 procedures is engaged.
  - In AS1170.4-1993, the determinants are the degree of seismic hazard, soil type, building importance, whether the design is regular or irregular, and whether the structure is ductile or non-ductile. These determine whether a design procedure is required and, if so, which of 2 procedures is engaged, and

[12]The house designer needs to consult the main text of AS1170.4 only for domestic buildings higher than 8.5 metres.

[13] In relation to soil testing, AS1170.4-1993 also calls up a site investigation standard (AS1276) that no longer exists.

- Tiered approach to design procedure: AS1170.4-2007 also provides a number of short-cuts. These are simpler methods of implementing EDC II and EDC III, replacing computations with various adjustment factors for particular situations. The effect is to present engineers with a hierarchy of compliance testing methods, with the more demanding computations providing more certainty and reducing the amount of over-strength design that is needed to compensate for approximations in the computation. We understand that, when a building fails a simple test, engineers often demonstrate compliance by applying a more sophisticated test, rather than design a more robust building. The intention is to facilitate that process, substituting 'brain' for 'brawn'.

3.3 Feasible policy options

With respect to the proposed changes to the BCA, the only feasible policy options are to either accept or reject the proposed changes. The impacts of the proposed changes are assessed in Chapter 4. We have not considered the option of partial implementation of the Standard as the Standard is an inter-related document that cannot be implemented piecemeal.

Additionally, the following options are not considered to be feasible and therefore do not require detailed assessment.

- Quasi-regulation: The term 'quasi-regulation' refers to forms of rule-making that fall short of 'black letter law' and the associated legal sanctions. In the present case, one option would be for the government to encourage and assist the engineering profession to formulate appropriate standards, but then leave compliance as a voluntary matter or subject to professional sanctions. Possible professional sanctions range from informal sanctions to exclusion from professional bodies.

  It is considered that these are major matters of public health and safety, that the government requires the certainty of legal sanctions, and that the public policy content is such that the issues should be resolved and agreed at a national level. Based on the government reports mentioned in chapter 1, there is general agreement on this point; and

- Non-regulatory instruments: The general aim of non-regulatory intervention is to enhance market incentives, for example, by providing building occupants with information about the earthquake resistant qualities that they should expect of a building, providing subsidies for higher levels of earthquake protection, or devising financial penalties where earthquake protection is reduced.

  However, it is not feasible for building occupants to express well-founded preferences for avoiding low-probability/high-impact events of which few people have experience. And it would be administratively cumbersome to institute financial incentives and disincentives. The community can reasonably expect engineers to act professionally and 'do their job', provided governments provide policy direction and institute reasonable arrangements for standardising procedures and facilitating oversight.

4. IMPACT ANALYSIS

The material in this chapter is organised under four headings. We examine the impact on business compliance or 'red tape' costs (section 4.1), the cost of additional building measures that are required to satisfy the new requirements (4.2), the prospect of positive benefits in the form of reduced costs of earthquake damage (4.3), and a statement of reasons for a positive overall assessment of the proposal (4.4).

4.1 Impact on business compliance costs

Any building practitioner who complies with regulation incurs certain compliance costs. COAG requires these costs to be separately identified and assessed in impact statements. One option for this, though currently not mandated for COAG agencies, is the Business Cost Calculator (BCC)[14]. The BCC defines regulatory compliance costs as:

> *… the administrative and paperwork costs incurred by a business in meeting (government) regulatory requirements. They include both the administrative burdens and other compliance costs, such as equipment purchases, and the development and implementation of new information technology and reporting systems.*

For practical purposes, however, the *Business Cost Calculator* defines compliance costs by enumeration. They are:

- Notification: costs of reporting transactions before or after the event;
- Education: maintaining awareness of regulations and regulatory changes;
- Permission: applying for and obtaining permission;
- Purchases: materials and equipment required for compliance;
- Record keeping: keeping statutory documents up-to-date;
- Enforcement: facilitation of audits and inspections;
- Publication and documentation: displays and labels; and
- Procedural: required compliance activities such as fire drills and safety inspections.

Note that the engineering consequences of the regulation – for example, that new buildings are more robust and therefore more costly, or that new buildings are cheaper because the new Standard allows more cost effective measures to be used – are excluded from BCC. These changes alter the competitive or market position of a building that falls in scope of the changes, and are separately considered.

[14] The BCC is administered by the Office of Best Practice Regulation (www.obpr.gov.au)

Regarding the proposal's impact on compliance costs, it is important to note that compliance costs are already incurred under existing arrangements. It is only the incremental costs that are of a concern in the present context. These may arise in two ways:

- Engineers may be required to do more checks or more sophisticated checks, since (a) fewer buildings will escape the design requirements entirely, and (b) the increase in probability factors for levels 3 and 4 will trigger provisions that require more sophisticated testing. These are procedural costs; and
- Existing practitioners need to understand the new requirements, incurring educational costs.

It is difficult to get useful feedback from the engineers who will need to comply with the new requirements, since they are generally unaware of the proposed changes. Nevertheless, we consider that the impact on compliance costs is small and possibly negative – that is, cost reducing. Relevant considerations are that:

- New practitioners will find it easier to understand the requirements and relate them to modern engineering practice. Future educational costs will therefore be lower;
- The various rationalisation initiatives are cost-reducing – that is, putting policy measures in the BCA, relocating provisions for specific materials to the relevant Standard, and reformulating the Standard as a document concerned solely with compliance;
- The provision of more options for compliance checking will offset the cost of additional checks that may be required for some buildings;
- The new Standard is not more technically demanding than the old standard. The most sophisticated checking procedures will be rarely used;
- The Standards committee has revised AS1170.4 with a view to making life easier for the structural engineer, not more onerous; and
- There is nothing in the record of the Australian Standards committee's consultative process indicating that structural engineers are concerned about impacts on compliance costs.

We have not used the BCC software in reaching this assessment. There is no reasonable expectation that the incremental compliance costs are significantly different from zero, in either direction. The cost estimating functions of BCC are therefore of no assistance.

4.2 Impact on construction costs

There will be material impacts on the construction cost of some buildings. We address these impacts in 3 sub-sections. The first two are scene-setting, dealing with uncertainties about the types of building that will be affected and providing a framework for considering the cost impacts. The third subsection reports the cost estimates.

4.2.1 Which buildings are affected by the changes to the BCA?

Increased earthquake resistance will be required only for buildings that the BCA assigns to importance levels 3 or 4. However, a designer may be uncertain about the importance of some buildings and therefore uncertain whether certain buildings will need enhanced earthquake resistance when the new measures are implemented.

BCA2007 says very little about the assignment of buildings to importance levels. The brief descriptions reported in tables 3.1 and 3.2 of this RIS are directly from BCA2007's tables B1.2a and B1.2b. There is, however, more guidance on this in the Guide to the BCA, with many examples of building types for importance levels 3 and 4.

Note: the proposal does not change the importance levels of buildings, only the annual probability of exceedance values for earthquake. As noted, the Guide to the BCA contains substantial advice on determining a building's importance level.

The importance level is a fundamental decision that comes out of the building owner's decisions on size and use of the proposed building. The decision is then relayed to the building designer and structural engineer with the final determination of a building's importance level made by the building certifier/local authority. The Guide to the BCA offers advice but allows for enough flexibility in interpretation to prevent over-compliance being an issue.

4.2.2 Analytical framework and evidence relating to construction costs

Table 4.1 explains our methodology for estimating impacts on construction costs. It starts with an illustrative $1 billion of building work, then asks a series of questions designed to strip away elements of the construction task that are not affected by the measures. The residual is reduced at each stage, eventually providing a basis for estimating the cost impact.

Table 4.1 illustrates a cost impact that is 0.38% of the building task, or $3.8 million in the $1 billion that is identified at the outset. The questions posed at each stage are well defined and seem capable of being answered with some confidence, leading to a plausible estimate of the cost impact. But expert judgment is required, informed by broad profiling of the building task.

Table 4.1 Cost estimation template

QUESTION	*ANSWER*	*ANALYTICAL TASK*
1. What is the total value of the building task under consideration?	$1,000 m	Identify relevant construct task, such as annual expenditure on the construction of medical facilities
2. What proportion involves structural work?	67%	Put aside allowance for refurbishments, refits and other work that is inherently non-structural

4. What proportion of 'work involving structural work' is the cost of 'the structural frame'?	30%	Put aside allowance for the non-structural components like linings, doors, windows, partitions, fittings, finishes and services, and professional fees
5. What proportion of 'the structural frame' is material?	30%	Focus on elements of the 'seismic-force-resisting-system'
6. What increase in materials is required to provide additional earthquake resistance?	25%	Roughly, this equates with the increase in the earthquake design load, which is in the range 20-30% for buildings in levels 3 & 4
Estimate of cost impact		
$ million	$3.8 m	= $1,000 m * 67% * 25% * 30% * 30% * 25%
%	0.38%	= $3.8 m / $1,000 m

Question 1 - profile of building work done, by type of building

Table 4.2 provides a breakdown of building work over the five years to 2006. Based on the discussion in section 4.2.1, it is mainly buildings in the other non-residential category that will need increased earthquake resistance. These account for 14% of the total building task, averaging $8 billion/year over the last several years. About 45% of this work is for the public sector, compared with only 9.5 % for the total building task.

Table 4.2 Building work done, by purpose & sector of ownership

	Average annual work done ($ m, 2001-2006, 2004/05 prices)			*% of total work done*		
	Private	*Public*	*Total*	*Private*	*Public*	*Total*
Residential						
New houses	20,247	304	20,551	35.8%	0.5%	36.3%
New other residential	10,184	290	10,474	18.0%	0.5%	18.5%
Additions & alterations	5,340	189	5,528	9.4%	0.3%	9.8%
Commercial						
Retail & wholesale	3,841	68	3,909	6.8%	0.1%	6.9%
Transport buildings	369	124	493	0.7%	0.2%	0.9%
Offices	3,497	566	4,062	6.2%	1.0%	7.2%
Other commercial	111	55	166	0.2%	0.1%	0.3%
Industrial						
Factories	1,183	23	1,206	2.1%	0.0%	2.1%
Warehouses	1,753	64	1,817	3.1%	0.1%	3.2%
Agricultural & aquacultural	154	10	164	0.3%	0.0%	0.3%
Other industrial	188	8	196	0.3%	0.0%	0.3%
Other non-residential						
Educational	915	1,656	2,572	1.6%	2.9%	4.5%
Religious	143	0	143	0.3%	0.0%	0.3%
Aged care	814	82	896	1.4%	0.1%	1.6%
Health facilities	356	747	1,102	0.6%	1.3%	1.9%
Entertainment & recreation	904	530	1,434	1.6%	0.9%	2.5%
Accommodation	963	21	985	1.7%	0.0%	1.7%
Other non-residential nec	310	614	924	0.5%	1.1%	1.6%
Sub-totals						
Residential	35,771	783	36,553	63.2%	1.4%	64.6%
Commercial	7,818	813	8,631	13.8%	1.4%	15.2%
Industrial	3,278	106	3,383	5.8%	0.2%	6.0%
Other non-residential	4,404	3,651	8,055	7.8%	6.4%	14.2%

TOTAL	**51,272**	**5,352**	**56,623**	**90.5%**	**9.5%**	**100.0%**

Source: ABS Cat 8752.0 Building activity Australia.

'Ordinary' buildings – used for ordinary residential, commercial and industrial purposes – are assumed to be level 2 buildings, with an annual probability of exceedance that will be left unchanged at 1:500.

Question 2 - proportion of work done that involves structural work
About half of the value of building approvals for non-residential work is for new buildings and necessarily involves structural work – see table 4.3. Some proportion of the 'refurbishments & conversions' budget would also involve structural work. Assuming that one third of refurbishments and conversions involve structural work, the proportion of work involving structural work is 67%. This comprises the 50% of work that is new buildings and one third of the 50% of work that is refurbishments and conversions. This is the figure against question 2 in table 4.1 (50% + 33% * 50% = 67%).

Question 3 - proportion of buildings that are designed to resist earthquakes
Not all buildings need to be designed to resist earthquakes, including many level 3 and 4 buildings. We understand that:

- The earthquake hazard increases with the height of building. Buildings of less than 3 storeys will tend to be unaffected by the provisions;
- Many buildings have a highly regular structure, without soft storeys, giving them inherent properties of earthquake resistance;
- Timber and steel framed buildings have inherent properties of earthquake resistance; and
- Wind loads often dominate earthquake loads in the sense that a building that is designed to meet wind loads often exceeds the earthquake load requirements.

Table 4.3 Breakdown of non-residential* approvals, by type of work

Value range	*New building*	*Refurbishments and conversions*	*Total approvals*
$50,000 - 100,000	0.5%	1.6%	2.1%
$0.1m - 0.2m	0.8%	2.1%	3.0%
$0.2m - 0.5m	2.9%	3.6%	6.5%
$0.5m - 1.0m	3.8%	3.0%	6.8%
$1.0m - 5.0m	12.0%	9.0%	21.0%
$5.0m+	31.0%	11.1%	42.1%
TOTAL	**51.0%**	**49.0%**	**100.0%**

Source: ABS Cat 8731 Building approvals Australia (special data request)

Note:
* Includes commercial, industrial & other non-residential

Tables 4.4 and 4.5 provide information that helps inform judgments about some of these factors.

Table 4.4 provides information about the exposure of Australians to earthquake and wind hazards, but with the focus restricted in two ways. First, the table relates to Australians living in the largest 100 urban areas that have populations of at least 10,000-20,000 persons and some prospect that there will be buildings with more than 3 storeys. Second, the table relates to the increase in the design requirements for level 3 buildings. Given that particular focus, table 4.4 says that:

- Under AS1170.4-1993, about 70% of this urban population lives in areas where level 3 buildings would be regarded as exposed to low earthquake hazards. The cities with medium exposure are Adelaide, Geelong, Newcastle and Perth. There are no significant urban areas, and probably no significant buildings, that have high earthquake hazards. Remember that 'low' and 'high' are relative terms and relate to Australia's geological history, which is relatively stable; and
- The effect of AS1170.4-2007 is to shift a substantial proportion of this urban population into the medium category. Notably, Canberra, Sydney and Melbourne are promoted to the medium category, and become roughly equivalent to Newcastle under the existing Standard. Of the capital cities, only Brisbane and Hobart remain in the low category.

Overall, table 4.4 suggests the possibility that earthquake loads become a more significant consideration, relative to wind, in areas where a significant proportion of the population lives.

Table 4.4 Distribution of design loads for level 3 buildings, using share of population* as an indicator

Earthquake design loads**	*Wind loads****		
	low	*medium*	*high*
	AS1170.4-1993		
low	53%	15%	3%
medium	28%	1%	1%
high	0%	0%	0%
	AS1170.4-2007		
low	4%	15%	1%
medium	65%	1%	3%
high	12%	0%	1%

Note:

* Percentage of Australians who live in the largest 100 urban areas, which have populations of at least 10,000-20,000 persons and some prospect of buildings with more than 3 storeys.

** Earthquake loads are labelled low, medium or high according to the probability weighted earthquake hazard factor (k_pZ), which is a measure of the earthquake load that the building needs to resist. The categories are: low = k_pZ<0.9; high = k_pZ>0.12; medium otherwise.

*** Wind loads are labelled according to wind class: low = A1-A5 (non-cyclonic); medium = B (intermediate cyclonic); high = C-D (cyclonic).

Table 4.5 reports the results of a comprehensive US survey of non-residential buildings. On the assumption that there is a broad family resemblance between the US and Australian building stocks (apart from large differences in the quantity of buildings), it is significant that:

- Only 4% of the floor-space is in buildings with 15 or more storeys;
- 22% of the floor space is in buildings with more than 3 storeys;
- Three types of building have a significant proportion of floor-space above three storeys – office and professional, hospitals and nursing homes, hotels and other non-private residences. (Note: these are US classifications). Of these, we assume that the BCA will be interpreted as assigning office, professional and non-private residential buildings to level 2, with unchanged earthquake design requirements; and
- Assembly buildings account for a quarter of the floor space and about 18% of that space is in buildings with more than 3 storeys. This category is defined to include education, religion, public order and justice (jails, courthouse, fire & police stations), and a range of other public assembly buildings - theatres, casinos, night clubs, gyms, recreational sports, meeting halls and convention centres, libraries, museums, transport terminals, funeral homes and broadcasting studios. While the BCA assigns many of these to level 3, which would have increased earthquake requirements, the US data indicates that 60% of the floor-space is in buildings with 1 or 2 storeys, and therefore not subject to change.

Table 4.5 Breakdown of US non-residential floor-space by number of floors and principal activity of the building

Principal building activity	*Breakdown by number of floors*							Break-down by activity
	1	*2*	*3*	*4-14*	*15-25*	*>25*	*TOTAL*	
Office & professional	19.0%	19.2%	14.0%	31.7%	7.9%	8.2%	100%	17.9%
Retail	55.3%	31.1%	9.7%	3.8%	0.1%	0.0%	100%	16.9%
Service	51.6%	25.5%	13.6%	8.9%	0.3%	0.1%	100%	9.3%
Warehouse	70.1%	22.7%	4.5%	2.7%	0.0%	0.0%	100%	15.6%
Hospital/ nursing hme	15.6%	8.3%	9.9%	58.7%	6.6%	1.0%	100%	3.8%
Assembly	31.9%	29.8%	20.7%	17.3%	0.3%	0.0%	100%	26.2%
Non-private residence	3.6%	23.3%	14.8%	48.6%	7.6%	2.1%	100%	5.7%
Other	46.9%	25.4%	10.8%	13.2%	3.7%	0.0%	100%	4.6%
Total	**39.8%**	**25.2%**	**13.3%**	**17.7%**	**2.4%**	**1.6%**	**100%**	**100%**

Source: US Commercial Building Energy Consumption Survey, 1999

Finally, while table 4.1 makes no explicit allowance for the cost-reducing impacts of changes to AS1170.4, this consideration can be factored into answers to question 3. This refers to the possibility that engineers can respond to increased loads by using more sophisticated analysis to demonstrate compliance, rather than increase the strength of the building.

As discussed in section 3.2, this option is available under AS1170.4-1993 but is further facilitated and encouraged by AS1170.4-2007. While it is difficult to know what those savings may be, it would be imprudent to dismiss them as insignificant.

Questions 4, 5 & 6 - cost of increasing the earthquake resistance of a structure

We refer here to the final three questions posed in table 4.1. Taken together, they ask *…having identified work involving structural work and which needs to be more earthquake resistant, what is the percentage increase in the cost?* We have three pieces of evidence, indicating that the percentage increase is about 2.5%. (This proportion is further diluted in table 4.1 because the increase is expressed relative to the total building task, including structural work that does not need to be strengthened and non-structural work.)

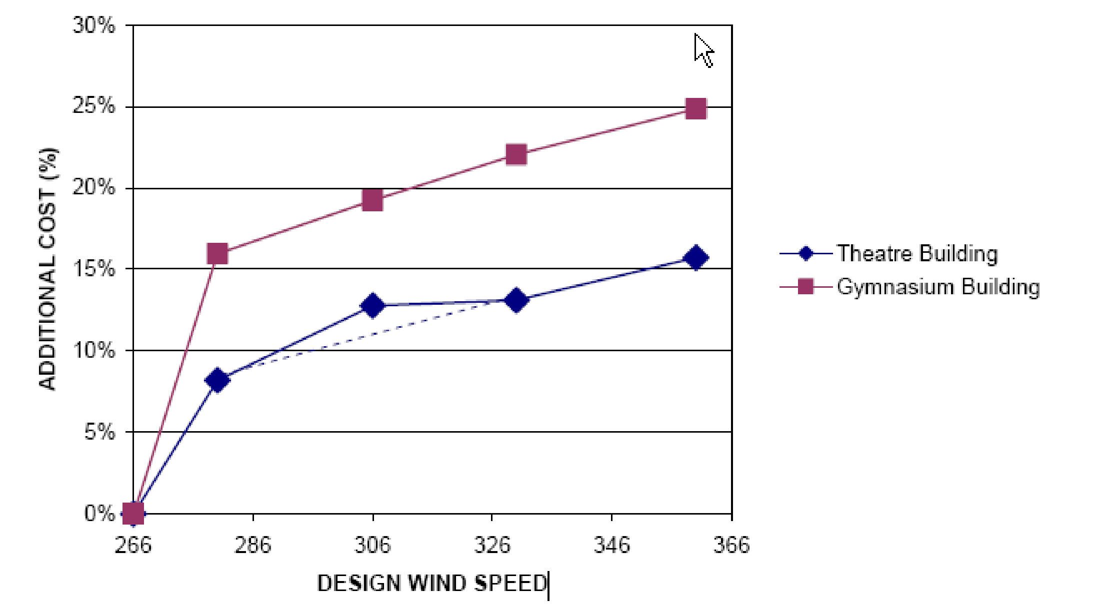
The first is a general calculation used by many structural design engineers and as suggested by Dr Lam Pham, who is the ABCB's representative on the Standards Committee that drafted AS1170.4-2007. Dr Pham suggests that the cost impact can be estimated on the assumptions that (a) materials costs are about 30% of the cost of the structural frame of a building and (b) the structural frame of a building is about 30% of total building cost. This means that the elements that need to be strengthened are 9% of the total building cost (= 30% * 30%). Given that level 3 and 4 buildings would need to be 20% and 30% stronger, respectively, and that strengthening is essentially a matter of adding material, the increase in the cost is, respectively, 20% and 30% of 9%. Therefore, the percentage increases in cost are 1.8% for level 3 buildings (= 20% * 9%) and 2.7% for level 4 buildings (= 30% * 9%).

Second, there is supporting evidence from a Queensland study that examined the additional cost of constructing new buildings to meet guidelines for public cyclone shelters (Mullins Consulting 2006). Two buildings were examined: a classroom theatre building and a gymnasium building. Figure 4.1 presents the results. Note that:

- Additional costs are estimated for a variety of design wind speeds, ranging from 266 km/h to 366 km/h. 266 km/h is the design wind speed for ordinary buildings in class C cyclonic areas;
- There is a large initial cost associated with increasing the design speed from 266 to 286 km/h because it includes costs of the shelter's human requirements (such as generators and emergency lighting), debris screens and weatherproofing. The remaining increases, from 286 to 366 km/h, are costs associated with increasing the strength of the building, for example, by increasing the strength of structural members;
- 366 km/h is 28% faster than 286 km/h but the associated forces are 64% higher, because force increases with the square of the speed. Over this range, therefore, the increase in cost is to resist a force that is 64% greater; and
- The additional measures needed to resist the additional force add 8% to the cost of the building. That is 1.25% for every each 10% increase in strength.

This suggests the cost of level 3 and level 4 buildings will increase by 2.5% and 3.75% respectively, since they would need to be 20% and 30% stronger, respectively.

Figure 4.1 Additional building cost at various design wind speeds

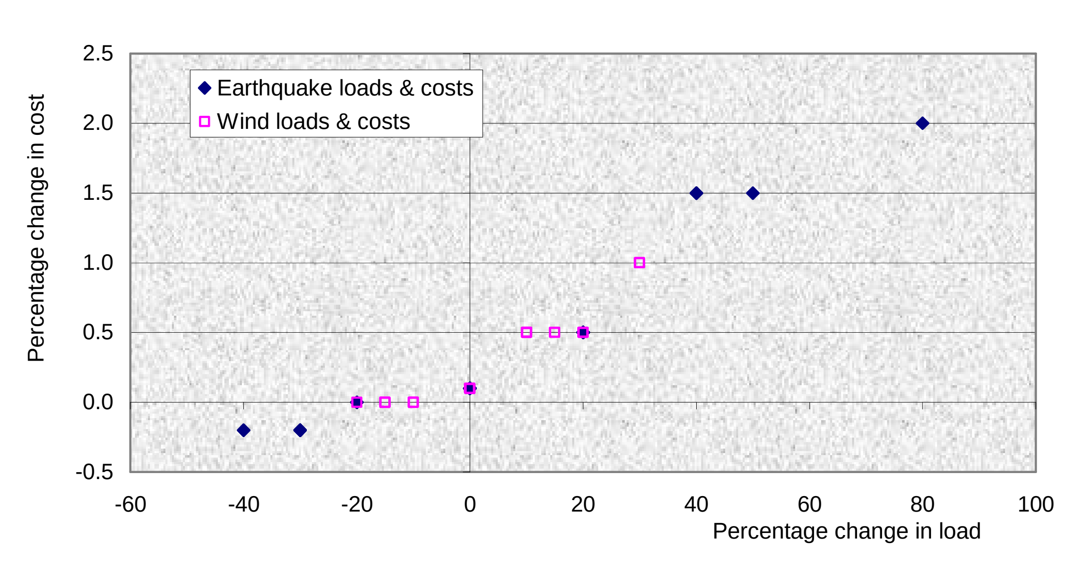


Source: Mullins Consulting 2006: page 8

The third piece of evidence is from a New Zealand study that examined the costs and benefits to changes to earthquake and wind loading design standards (Branz, 2006). Figure 4.2 summarises the results of the various cost studies that were conducted. Importantly, these are based on a sample of buildings that were notionally re-designed for compliance with new standards. Note that the cost/load relationships are similar for wind and earthquakes. For the load increases that are relevant to this study, 20%-30%, the cost increases are in the range 0.5%-1%.

The sample of public buildings - comprising one hospital, two schools, and three social and cultural centres – returned estimates of cost increases of 0.5%, 1.5% and 2%, for load increases of 20%, 40% and 80% respectively.

Figure 4.2 NZ estimates of the relationship between incremental loads and incremental costs



Source: Branz 2006: table 2

Overall, the evidence indicates that the cost increases are in the range 1-3% of the cost of a construction project that involves structural work and needs to be upgraded. The Queensland study comes in somewhat higher at 2-4 %, while the NZ study is somewhat lower, at 1-2%, and the general engineering calculation is intermediate, at 2-3%. A figure of 2.5% is adopted for the purposes of this RIS.

4.2.3 Cost estimates

Table 4.5 presents the cost estimates obtained by implementing the model that is outlined in table 4.1. Table 4.5 is organised as follows:

- The top panel reports ABS estimates of building work done on types of buildings that are likely to be affected by the proposed measures. The estimates have been transcribed from table 4.2. With the exception of ‘other non-residential buildings nec' (nec = not elsewhere classified), the totals are the sum of both public and privately owned buildings;
- The middle panel of table 4.5 reports the workings of the cost estimation model; and
- The final panel presents the results. The key finding is that, for the average annual building task over the 5 years to 2006, the increase in costs is $29.7 million/year. This is 0.5% of the broad categories of building work that seem to fall within the scope of the measures.

The estimate of $29.7 million is an even smaller fraction of the total annual building task: it is 0.05% of the $56.6 billion reported in table 4.2.

The remainder of this subsection comprises notes and explanations regarding the middle panel of table 4.5.

Table 4.5 Cost impact of increasing design load requirements

	ABS building type						
	Educational	*Religious*	*Health facilities*	*Entertainment and recreation*	*Public sector 'other non-residential buildings nec'*	*Warehouses*	
Average annual work done in 5 years to 2006 ($M, 2004/05 prices)	2,572	143	1,102	1,434	614	1,817	
	BCA load category						
	Educational & day-care	*Religious*	*Health facilities*	*Entertainment and recreation*	*Emergency services & detention*	*Buildings with hazardous materials*	*Total*
Importance levels	2 & 3	2 & 3	2, 3 &4	2 & 3	3 & 4	3 & 4	
(Q1) What is the total value of the building task under consideration? ($M)	2,700	143	1,102	1,434	412	91	5,882
(Q2) What proportion involves structural work?	67%	67%	50%	50%	50%	75%	
(Q3) What proportion of this work will require more earthquake resistance?	25%	25%	75%	25%	50%	25%	
(Q4-6)What is the cost of increasing earthquake resistance?	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	
Estimate of cost impact							
$ million	**11.3**	**0.6**	**10.3**	**4.5**	**2.6**	**0.4**	**29.7**
% of building task	**0.4%**	**0.4%**	**0.9%**	**0.3%**	**0.6%**	**0.5%**	**0.5%**

Corresponding BCA load categories
Some of the ABS categories translate directly as types of building that will include some level 3 or level 4 buildings. These are religious buildings, health facilities, and entertainment and recreation. The other categories have been adjusted as follows:

- Educational and day-care: ABS surveys indicate that the value of work done on educational facilities has been running at $2,572 million/ year over the last several years, but excludes work on day-care centres. We add 5% to make a rough adjustment for the additional population of pre-schoolers who assemble in this type of building on a daily basis, taking the tally to $2,700 million/year;
- Emergency services and detention: The ABS assigns these expenditures to a residual category of expenditure on public sector buildings – other non-residential nec. It is what remains after expenditure is assigned to the larger categories of commercial, industrial, agricultural, educational and health buildings. The value of work done on this residual category, for the public sector, has been running at $614 million per year over the last several years. We have conservatively assumed that the bulk of this work (two thirds) is for emergency services and detention facilities; and
- Buildings with hazardous materials: The difficulty is that almost any building may contain hazardous materials, depending on how hazardous materials are defined. We have assumed that the relevant building task is 5% of total expenditure on warehouses. This is not an arbitrary figure. Appendix B of this RIS presents some alternative figuring that plausibly generates a somewhat lower figure.

Proportion of the work that involves structural work
Given the information provided in table 4.3, a reasonable assumption is that 67% of work in the non-residential sector involves structural work. This comprises the 50% that is new building plus one third of the remaining 50% that is refurbishments and conversions. We have adopted this figure for educational and religious buildings, but the lower figure of 50% for health, recreation and emergency service buildings, and the higher figure of 75% for buildings with hazardous materials.

Regarding health facilities, we note that:

- In major cities and regional urban areas there have been a number of examples where regional hospitals have been expanded at the expense of the closure of smaller local hospitals. This suggests a trend to fewer larger hospitals, and associated structural work; and
- That said, it is significant that, in the 8 years from 1997 to 2004, the number of hospital beds in Australia remained constant at about 80,000. This suggests that structural work in the health care sector has been reduced to a minimum. There was a more significant increase in the number of hospitals over this period – from 1,201 to 1,286 (7%) – but most of that increase was in 1998 and relates to the formation of private hospitals, which suggests a change of status as a result of policy changes affecting private hospitals.

We assume that consolidation and rationalisation is similarly reducing the amount of structural work required for emergency service and detention facilities.

With regard to the higher figure of 75% for buildings with hazardous materials; their functional nature suggests that little will be spent on refurbishments.

Proportion of structural work that will require increased earthquake resistance
This parameter is the least well-informed part of the calculation. We set it variously at 25%, 50% and 75%, based on the following considerations:

- <u>25%</u> has been assigned to educational, religious and entertainment buildings, and buildings with hazardous materials. Relevant considerations are the large proportion of buildings with only one storey, a small proportion of buildings with more than 3 storeys, and the proportion of buildings that are level 2 because they accommodate less than 300 people (approximately 600 sqm at 2 sqm/ person);
- <u>50%</u> has been assigned to emergency service and detention facilities because there are no exemptions on account of size; and
- <u>75%</u> has been assigned to health facilities because a significant proportion of such buildings are greater than 3 storeys.

Other buildings
Two types of building have not been addressed in table 4.5, (a) designated emergency shelters and centres, and (b) public utilities for power generation, water and wastewater treatment.

Designated emergency shelters and centres are level 4 buildings and would need to be designed for a 30% increase in the earthquake load. We consider that the costs impacts on these buildings will be trivial, for the following reasons:

- With the exception of cyclone shelters, there seems to be no systematic process of designating emergency shelters in Australia. With respect to cyclone shelters …*A number of authorities have designated public cyclone shelters – for example, Northern Territory since Cyclone Tracy in 1974, and some local governments in Queensland and Western Australia* (Mullins Consulting 2002);
- Cyclone shelters are likely to exceed earthquake requirements. They are buildings of one or two storeys, for which wind loads tend to dominate earthquake loads; and
- It seems reasonable that emergency shelters are designed to meet the emergencies of particular concern to a particular locality, such as cyclones, floods and bushfires. If they fulfil that function, there seems little point in designing them specifically to meet a simultaneous earthquake threat. For practical purposes, there is no correlation between natural hazards.

Public utilities for power generation, water and wastewater treatment are level 3 buildings. However, they are not so much buildings as oversized plant and are not readily classified under the BCA. We assume that such buildings are 'special structures' that are subject to the specific requirements of the utility concerned.

4.3 Impact on the costs associated with earthquake damage

The positive benefit of the proposal is to reduce the amount of physical damage inflicted by future earthquakes, and thereby reduce the associated costs to the community. These costs are of three broad kinds.

- Direct tangible costs are the costs of repairing or replacing buildings and contents that have been damaged or destroyed, but discounted to allow for the fact that the lost assets will not be new and, depending on their age, would have been replaced sooner or later. (Consider that there may be little net cost where an earthquake destroys an old building that is shortly due for demolition and replacement.);
- Indirect tangible costs arise because productive resources are diverted into clean-up, disaster relief and emergency services, and also because normal economic activity is interrupted by the loss of buildings and their contents. Workers are displaced and find it more difficult to 'make a living' during the period of reconstruction; and
- Intangible costs are mainly the costs of deaths and injuries but also include irreplaceable assets. For example, there is a sense in which a heritage building cannot be replaced, no matter how true the replica is to the original.

While the proposed measures will reduce these costs, the ABCB considers that it is not feasible to estimate the amounts of earthquake damage that will be avoided by implementing measures of the kind that are proposed. The main difficulty is that the recorded history of earthquakes in Australia is short relative the return period of earthquakes. The return period of earthquakes is measured in centuries – at least 500 years – whereas there is a recorded history of damaging earthquakes that dates from the 1968 earthquake in the Meckering region of WA. We therefore have a very poor understanding of (a) the average amount of earthquake damage that may be expected over the long term, and (b) the distribution of earthquake damage by size of event.

An additional difficulty in costing these benefits is that the life of buildings is short relative to the return period of earthquakes, which means that the majority of buildings will be demolished without ever being damaged by earthquake. However, there is no sound basis for estimating the residual proportion that will be affected by earthquake, that is, the probability of damage to the buildings that will be affected by the regulation.

4.4 Statement of reasons for a positive overall assessment

It follows from the above discussion that it is not feasible to quantitatively demonstrate that the proposal is beneficial. Rather, it is a matter of acting prudently in the presence of considerable uncertainty. The positive assessment of the proposal is informed by the following considerations:

- Engineers and builders have a professional duty to deal with these issues, which means that they must somehow deal with these uncertainties;
- The issues are such that the community should have a voice, through the agencies of Government;
- COAG has recently endorsed the view that the role of building standards is to *… provide the minimum criteria considered to be prudent for the protection of life by minimising the likelihood of collapse of the structures* (COAG 2002: page 158);
- For ordinary level 2 buildings, which are the majority of buildings, the accepted benchmark is to design for events that, on average, will only be exceeded once in 500 years. The event may destroy the building in the sense that it will need to be demolished and rebuilt, but it will not collapse and kill or seriously injure its occupants. The purpose of the proposed changes is not to alter the benchmark, but to prudently discriminate between levels 2, 3 and 4;
- Currently, level 3 buildings have the same protection as level 2 buildings, despite the fact that people ‘congregate’ in level 3 buildings, as in church or on a dance floor. It is sensible to allow for increased protection because the risks to life and limb are greater. The proposal is that level 3 buildings be designed for events that, on average, will be exceeded once in 1,000 years; and
- Currently, level 4 buildings have more protection than level 2 buildings, but not significantly so. They are designed for events that, on average, will be exceeded once in 800 years: the proposal would extend that to 1,500 years. However, it is not the direct loss of life and limb that matters in this case, but the indirect losses if hospitals and emergency services are disabled. It is prudent to design these buildings to withstand events that cause the collapse of ordinary buildings and which would threaten many lives in the absence of medical and emergency services. From a policy perspective, it is useful to consider the hospital as still designed for a 500 year event but to come through that event in much better shape than a house or a shop. Hospitals should not only not collapse on their occupants but also remain functional for the benefit of all.

It should also be noted that there are benefits other than the particular design events that are the focus of the decision. Not only does a stronger building survive its design event, but less damage is done in all other lesser events. For example, a hospital may be designed to not collapse during a one in 1,500 year event, but will then need fewer repairs after a 500 year or 1,000 year event. Buildings can be damaged to various degrees, both structurally and non-structurally – with the damage variously labelled minor, localised, widespread, extensive or nearly total – but remain repairable and not needing to be demolished. The incidence of all these outcomes is reduced when a particular outcome, such as collapse in a 1,500 year event, is reduced.

5. STATEMENT OF COMPLIANCE WITH NATIONAL COMPETITION POLICY

The National Competition Policy Agreements set out specific requirements with regard to all new legislation adopted by jurisdictions that are party to the agreements. Clause 5(1) of the Competition Principles Agreement sets out the basic principle that must be applied to both existing legislation, under the legislative review process, and to proposed legislation:

> *The guiding principle is that legislation (including Acts, enactments, Ordinances or Regulations) should not restrict competition unless it can be demonstrated that:*
>
> *(a) The benefits of the restriction to the community as a whole outweigh the costs; and*
>
> *(b) The objectives of the regulation can only be achieved by restricting competition.*

Clause 5(5) provides a further obligation that:

> *Each party will require proposals for new legislation that restricts competition to be accompanied by evidence that the restriction is consistent with the principle set out in sub-clause (1).*[15]

The ABCB considers that the proposals do not impede competition in any way. They do not, for example, create special requirements that can be satisfied by some particular class of engineers, builders or suppliers of building materials. In all probability, competition will be enhanced through continued reliance on performance-based regulation and the preservation of flexibility through the timely updating of compliance procedures.

It follows that the proposal complies with Clause 5(1) of the Competition Principles Agreement and there is nothing that triggers the further requirements of Clause 5(5). Therefore, the proposed changes to the BCA are considered to be fully compliant with the National Competition Policy.

[15] *Competition Principles Agreement*, Clause 5. 1995. See: www.ncc.gov.au

6. CONSULTATION

6.1 Consultation processes

6.1.1 ABCB Consultation Processes

The ABCB is committed to regular review of the BCA and to amend and update the BCA to ensure that it meets changing community standards. To facilitate this, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through State and Territory building control administrations, industry and the Building Codes Committee. Further, a National Technical Summit provides an annual forum for industry, government and other stakeholders to have input into the ABCB *Annual Business Plan*. These mechanisms ensure that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

All ABCB regulatory proposals are developed in a consultative framework in accordance with the Inter-Government Agreement. Key stakeholders are identified and approached for inclusion in relevant project specific committees and working groups. Thus, all proposals have widespread industry and government involvement.

The ABCB has also developed a *Consultation Protocol* (refer ABCB website). The Protocol explains the ABCB's philosophy of engaging constructively with the community and industry in key issues affecting buildings and describes the various consultation mechanisms available to ABCB stakeholders.

6.1.2 Standards Australia Consultation Processes

It should also be noted that every new, revised or amended Australian Standard undergoes a Draft for Public Comment period, usually two or three months. All comments from the public are considered in detail by the relevant Committee and, if necessary, further drafting is undertaken.

6.2 Consultation processes for this RIS

6.2.1 Industry consultation for the development of the Consultation RIS

There was no formal consultation for the purposes of developing the Consultation RIS. However, the analysts interviewed a number of practicing engineers in Queensland, South Australia, Western Australia and New South Wales. They also had several consultative sessions with members of the Standards Committee. These discussions were primarily for the purposes of understanding the proposals and gathering information.

6.2.2 Consultation process for this RIS

The Consultation RIS was made available for comment through the following consultative mechanisms:

The RIS was posted on the ABCB website as part of the BCA Amendment Public Comment Draft process, an eight week consultation period held from 1 June to 31 July annually. This process involves consultative opportunities for all ABCB stakeholders including representatives from all the major building and construction-related industry associations and State and Territory Administrations. All members of the ABCB Board and its Building Codes Committee also received a copy of the Consultation RIS.

In addition, the ABCB sought specific comment from a number of organisations directly involved in earthquake protection: Geoscience Australia, Emergency Management Australia, the Insurance Council of Australia (*Risk Engineering Group*) and the Standards Australia committee BD-006 (*General Design Requirements and Loading on Structures*).

Further, the Consultation RIS was made available on the Australian Government's Business Consultation website[16] for a period of six weeks up to 31 July 2007. The purpose of this website is twofold:

- to provide business with a recognised forum to consult with regulators; and
- to provide agencies with an avenue to consult with selected businesses.

6.3 Consultation received for this RIS, including ABCB response

6.3.1 Summary of Consultation

Five submissions were received on the Consultation RIS: four from State Government Building Administrations (Victoria, Tasmania, Western Australia and New South Wales) and one from Master Builders Australia (MBA).

The Victorian Building Commission and the NSW Department of Planning raised concerns expressed to them about the effect of the proposal on earthwall construction (rammed earth walls and unfired earth bricks), while NSW also noted concerns about practitioner training for the new provisions. The Western Australian Department of Housing and Works raised some issues regarding the effects of the proposal on houses, while the response from the Tasmanian Department of Justice (*Building Standards and Regulation*) was to endorse the proposal. MBA proposed that the adequacy of the RIS could be improved by the ABCB undertaking some additional work on the quantification of the benefits of the proposal.

These matters are dealt with in detail in the sub-sections that follow.

[16] www.consultation.business.gov.au

6.3.3 Earthwall building issue

The Earth Building Association of Australia (EBAA) raised concerns with the Victorian Building Commission and the NSW Department of Planning about the cost effects of the proposal, including the proposed deletion of the BCA Volume Two Part 3.3.5 DTS provisions for earthwall construction. Correspondingly, the States included these concerns in their submissions to the Consultation RIS (note: EBAA did not make a submission to the ABCB based on the Consultation RIS).

EBAA expressed the view to the States that the proposal will make it more difficult and expensive to build earth buildings. They point to significant projects such as Aboriginal Cultural Centres that either may not be constructed, or will be more expensive. The additional costs are reported to arise due to the building requiring design by an engineer and assessment as an *alternative solution*[17] at the building approval stage. This will require the provision of supporting compliance documentation.

In addition, EBAA noted a recommendation from the Victorian Competition and Efficiency Commission (VCEC)'s Housing Report (VCEC 2005), and its subsequent endorsement by the Victorian Government, regarding the retention of current satisfactory practices.

> *5.2 That regulatory impact analysis of a standard referenced in the Building Code of Australia consider (1) whether the standard would preclude retaining practices that have performed satisfactorily in Victoria in the past, and (2) the costs and benefits of that change*

In their comments to the States, EBAA also requested the ABCB consider adopting into the BCA their earth building construction document *Building with Earth Bricks and Rammed Earth in Australia*.

ABCB response:

The views expressed by EBAA are a result of two separate proposals, with only part of their comments relevant to the matter considered by this RIS, that is, the proposal to adopt the 2007 version of AS 1170.4. The other matter covered in the EBAA comments is the separate proposal to remove the reference in the BCA to the outdated 1987 CSIRO Bulletin 5 *Earth Wall Construction*. The assertion that assessment as an *alternative solution* at the building approval stage and the provision of supporting compliance documentation will be required, is relevant to the latter proposal and is therefore outside the scope of this RIS. Note however, that should the EBAA earth building construction document be referenced as a DTS in a future BCA, then the earth building will not need to use the *alternative solution* path for approval.

[17] *An 'alternative solution' means a 'building solution' which complies with the 'Performance Requirements' (of the BCA) other than by reason of satisfying the 'DTS'.*

To that end, the ABCB has been working closely with EBAA to provide guidance on their document to assist them in meeting compliance with the *ABCB Protocol for the Development of BCA Referenced Documents*. Upon compliance being achieved, the EBAA document can be recommended to ABCB decision-makers for referencing in the BCA as a replacement DTS for the outdated CSIRO Bulletin 5.

In respect of the EBAA comment that additional costs will arise due to the building requiring design by an engineer, it should be noted that Bulletin 5, which is currently referenced in the BCA, states that, "In areas where there is a risk of earthquake the method of construction of all forms of masonry including earth-wall must be such as to provide resistance to the lateral forces imposed by earth movement. Design for earthquake resistance is a specialist subject and is outside the scope of this Bulletin."

Therefore, 'current practice' would require, where relevant, consideration of earthquake loads to the current 1993 version of AS 1170.4 for earthwall construction. To the extent that the 2007 version of AS 1170.4 provides benefits for the design process, these benefits will also accrue to earthquake design for earthwall construction.

It is worth noting that the 2007 draft edition of the EBAA document references the following:

1.3 For earthquake design, buildings with a Hazard at the $k_pZ \leq 0.11$ determined in accordance with AS1170.4.2007.

The effect of this provision is that the EBAA document will require earth building in areas with a hazard above 0.11 to be designed to AS1170.4 2007, thereby creating consistency between the EBAA document and the proposal of this RIS to reference AS1170.4 2007 in the BCA.

Further, it should also be noted that should AS 1170.4 – 2007 be referenced in BCA 2008, it will be in tandem with the current BCA requirements. This means that for an initial one year period, earth buildings may be built either to the old or new standard for earthquakes. This is common practice when revised provisions are introduced and allows industry time to adjust to new requirements.

6.3.4 Practitioner training issue

While generally supportive of the proposed amendments, the NSW Department of Planning raised concerns about the low level of understanding of the current requirements by practitioners (building certifiers, designers, builders, contractors), and suggested that further changes would compound this problem. They requested that the ABCB, in conjunction with Standards Australia, prepare and provide appropriate guidance, instruction and education for industry, including how to comply with the proposed provisions.

ABCB response:

Primary responsibility for training on Australian Standards lies with Standards Australia and its commercial partner SAI Global. SAI Global undertook training seminars on the revised Standard in June 2007.

The ABCB is not a Registered Training Provider. Notwithstanding this, a key component of the ABCB work program is to promote awareness and understanding of the BCA and its provisions, within the building and construction community. Each year, the ABCB partners with an industry stakeholder to deliver BCA Information Seminars nationally to increase awareness of regulatory changes in the BCA that directly affect building practitioners and the building industry as a whole.

Should AS1170.4 2008 be referenced in BCA 2008, the changes will be discussed at the Information Seminars in early 2008. This, however, will not address the concerns of the NSW Department of Planning regarding the low level of practitioner understanding of the current requirements. This is a matter for Standards Australia and SAI Global.

6.3.5 Houses issue

In its submission on the Consultation RIS, the Western Australian Department of Housing and Works commended the revised Standard as an improvement on the existing Standard, but was of the view that the RIS does not adequately address a number of possible impacts on housing construction. They also disagreed that the current information failure in relation to earthquake risk will be alleviated by the change.

They raise several issues in relation to housing construction:

- There is a requirement in Appendix A of the revised Standard for external walls to be anchored to resist a load of 0.5 kN per metre run of wall, however there is no DTS detail provided for such an anchorage.
    - Further, if the existing Acceptable Construction Practice (ACP) details for brick cavity masonry wall to roof connection (BCA 3.3.3.3 (b)) are inadequate to resist the 0.5 kN / metre force, then the impact on brick cavity construction needs to be considered.
- They assert that Appendix A applies only to Class 1a/b buildings, not Class 10a buildings (non-habitable buildings/structures). Therefore, Class 10a buildings that are not Importance Level 1 will have to be defined as Importance Level 2 category and as such will be subject to the earthquake provisions of the revised Standard.
- The submission also commented on a number of clauses that have since been removed from the revised Standard and placed in AS 3700 *Masonry Structures*, and are therefore outside the scope of this RIS.

ABCB response:

The Consultation RIS proposed that market failure has occurred in the form of insufficient information about risk, and uses this as the rational for government intervention in the market. This RIS maintains that the revised Standard improves information for designers through inclusion of the best available local and international information, international harmonisation and simplified provisions based on improved understanding of earthquake actions. While consumers may not see the benefit first hand from these improvements, cost benefits should flow from the improved information available to designers and engineers.

On the issue of effects on houses, the Consultation RIS noted that the vast majority of residential structures are not required to be specifically designed for earthquakes. The construction systems already in place for wind resistance are generally adequate for earthquake resistance. Moreover, the proposed measures do not significantly alter the building measures required for residential structures. This RIS maintains that view but offers the following comments on the concerns raised.

Regarding anchoring to resist a 0.5 kN load, this provision only applies to some houses where the earthquake hazard is greater than 0.11 or the geometry is outside Figure A1. In such cases, houses will need to be designed or checked to determine they comply with Clause A2. However, given the small number of houses that would be effected, and the minimal anchorage that would be required to resist a 0.5 kN load, this RIS considers the impact to be minor.

Similar minor impacts relate to the view that the existing ACP's details for wall to roof connection may be inadequate to resist the 0.5 kN / metre force. Removal of the ACP Part 3.10.2 may require adjustment to Parts 3.3.1 and .2 for masonry, to advise when the ACP is acceptable to resist earthquake. Again, given the small number of houses effected, and the minimal anchorage that would be required, this RIS considers the impact to be minor.

Regarding the issue of class application, it is agreed that Appendix A is for housing only. A 10a building (non-habitable) that is an Importance Level 2 building would need to be designed for earthquake to the new Standard. However it is considered that most 10a buildings associated with housing are Importance level 1 buildings. The impact, therefore, is minimal.

The ABCB has discussed these issues with the Western Australian Department of Housing and Works who are satisfied with the ABCB's response.

6.3.6 Quantification of benefits issue

The MBA recommended more work be done to quantify the benefits of the proposal. They noted Section 4.4 of the Consultation RIS which discusses benefits to be achieved through reduced damage etc., and that these are not costed. The MBA suggested that the benefits could be quantified through scenario analysis, attaching probabilities to certain outcomes and developing quantification of the benefits in terms of potential costs avoided through adoption of the proposed changes. This approach would allow for a more straightforward comparison of the costs and benefits.

ABCB response:

The ABCB considers that it is not feasible at this time to specifically quantify the benefits of adopting the proposed measures. The data and technical capability required to comprehensively assess the incremental benefits of the proposed measures is not currently available. This is supported by overseas experience with cost benefit analysis of earthquake protection, which is either not performed, or when it is, may be lacking in rigour. Notwithstanding this, it is proposed that it may be possible to develop the data and technical capability required in the future.

Calculation of Incremental Benefits of Earthquake Protection

The benefits of earthquake protection are the costs that are avoided when earthquakes occur. This is the sum of avoided building repair and reconstruction costs, avoided disruption of economic and community activity, and avoided deaths and injury. The benefits of *improved* earthquake protection are the sum of the incremental increases in the avoided costs. To estimate the benefits of improved earthquake protection, it is necessary to (a) develop a model of earthquake costs, and (b) use the model to calculate the incremental cost-avoiding effect of improved earthquake protection.

Regarding the model of earthquake costs (a), it would be necessary to bring the following elements together:

1. Model of seismic activity – probability distribution of earthquake hazards by region.
2. Model of the building stock – account of the number of buildings, classified by size, structure and region.
3. Projections for the building stock over the period of interest, which is to the end of the life of the buildings that are subject to the proposed measures. (This is important: there are overlapping generations of buildings and it is necessary to focus on the buildings that subject to the measures by following them through to the end of their effective lives, rather than simply truncate all analysis at a particular date.)
4. Model of earthquake impacts on buildings – relating outcomes to the severity of the earthquake, with outcomes ranging from minor repairs to complete structural failure.

5. Building occupancy and emergency response model – providing an account of primary deaths and injuries and of secondary deaths, pain and suffering that depend on the quality of the emergency response, for the range of possible earthquake impacts on buildings.
6. Estimates of repair and reconstruction costs - ranging from minor repairs to collapse of building.
7. Estimates of the money value of deaths and injuries.
8. Estimate of the appropriate rate of discount to be applied to future earthquake costs.

Note that the cost of an earthquake depends partly on the survival of buildings like hospitals and fire stations that are critical to the quality of the emergency response. There may be significant non-linearities, for example, when emergency facilities cope reasonably well up to a point but are then overwhelmed by the scale of a disaster or the loss of critical assets.

Assuming that these elements have been assembled, it would be possible to simulate all of the earthquake events that may happen over the period of interest and calculate the 'expected cost' of earthquakes. This is the sum of the costs of all possible earthquake events, weighted by the probability of each event.

To calculate the cost-reducing effect of improved earthquake protection (b), it would be then necessary to re-run the model with different assumptions for the building stock, for example, a 'with-regulation' stock with improved earthquake protection. These calculations define the demand for earthquake protection, that is, that willingness to pay for reductions in the expected cost of earthquakes. It is usually assumed that the community is willing to pay up to $1 to avoid costs of $1.

Given information about the cost of earthquake protection, it would also be possible to program the simulation model to search for the optimal set of building regulations, spending each additional dollar in a way that delivers the greatest reduction in earthquake costs, and stopping when there are no further opportunities to spend an additional dollar in a way that reduces the cost of earthquakes by at least one dollar. The effect would be to minimise the total cost of earthquakes, which is the sum of the expected cost of earthquakes and the cost of earthquake protection.

This modelling capability does not exist at the present time.

International Use of Cost Benefit Analysis
Internationally, there appears to be no work that meets the requirements outlined above. The following represents an assessment of the current international situation:

United States of America

The US Federal Emergency Management Agency (FEMA) has identified a need for a 'next generation' of performance-based seismic design procedures, and recently published a plan for the development of that capability (FEMA 2006). FEMA defines performance-based design in a manner consistent with the modelling requirements that we listed above. They note the current limitations in ability to accurately predict response, and uncertainty in the level of earthquake hazard (FEMA 2006: page ix).

Canada

The Canadian National Institute of Standards and Technology note that more work needs to be done to properly quantify the benefits of earthquake mitigation measures. They are currently working on economic studies of the issue.

Europe Union

The European Committee for Standardisation (CEN) has developed a uniform set of building codes (Eurocodes), including for the design of structures for earthquake resistance (Eurocode 8). An examination of the web-based resource used by CEN's technical committees found no evidence that decisions are informed by cost benefit analysis. The UK Department of Communities and Local Government is responsible for developing the UK building code and publishes Regulatory Impact Assessments for changes to the code. None relate to earthquake measures.

New Zealand

The New Zealand (NZ) Department of Building and Housing (DBH) have published a cost benefit analysis of changes to NZ's earthquake provisions that take effect from September 2007 (Branz 2006). The costs and benefits are estimated as follows:

- The incremental cost of earthquake protection are the nationwide construction cost of the measures, put at NZ$35 million per year.
- The benefits are estimated on the assumption that there is an earthquake matching the 'design earthquake' in Wellington, with avoided costs of $115 million for each year of construction that is subject to the new provisions.

Under these assumptions it is shown that the net present value of the measures depends greatly on when the earthquake occurs. The investment analysis is positive if the earthquake occurs in the first 45 years and negative if it occurs later. Future costs and benefits are discounted at 5% per year.

There are important differences between this calculation and the more comprehensive modelling described above:

- The NZ calculation focuses on the costs that are avoided if the 'design earthquake' occurs, ignoring the costs that are avoided in the event of lesser or greater events.

- Instead of calculating the probability weighted outcome across all regions, it assumes that an earthquake occurs with certainty in a particular place (Wellington) at some time in the next 100 years.
- It compares nationwide costs with benefits to a particular region.
- It does not allow for the positive effects of earthquake protection on the quality of the emergency response.

While it is noteworthy that NZ has made some progress with cost-benefit analysis, we consider that more work needs to be done before useful information can be provided to decision-makers. Risks and probabilities are the essence of the problem and need to be addressed directly.

Future Modelling Capability
Geoscience Australia (GA) have reportedly developed some of the required elements, specifically, items 1, 2, 4 & 6 in our list of modelling capabilities. This means that GA are able to simulate the impact of earthquakes on the existing stock of buildings. Further work over a period of two years would be required to develop the other elements of the required simulation model. This may not, however, include the emergency response component that is needed to assess the earthquake costs that can be avoided by improved earthquake protection for hospitals, fire stations and other buildings that need to remain operational after the earthquake.

Recently, the ABCB has informally consulted with GA on options for exploratory work on a simulation model.

6.4 How the proposed measures have been amended in response to public comment and further analysis

Section 6.3 of this RIS notes the ABCB's response to each issue raised during the consultation period. Additional analysis was undertaken in relation to all issues, however none have resulted in any change to the proposed measures. Thus, the findings of this RIS remain unchanged.

7. CONCLUSIONS AND RECOMMENDATIONS

The proposed regulation achieves the governments' objectives of:

- encouraging the building industry to provide earthquake protection in a cost-effective manner; and
- striking a prudent balance between the costs and benefits of additional protection, depending on the nature of the activities conducted in the building, and the consequences of interrupting those activities.

The proposal is also consistent with the ABCB Board's role in setting minimum technical building requirements, standards and regulatory systems that are nationally consistent between States and Territories and which are cost-effective, performance-based and facilitate modern and efficient building practices.

The objectives of the proposal will be achieved at a relatively modest cost of about $30 million per year, comprised as follows:

Type of building	Cost increase	
	$ million	% of building work done
Educational & day-care	11.3	0.4%
Religious	0.6	0.4%
Health facilities	10.3	0.9%
Entertainment and recreation	4.5	0.3%
Emergency services & detention facilities	2.6	0.6%
Buildings & facilities with hazardous materials	0.4	0.5%
Total	29.7	0.5%

The real cost is an even smaller fraction (0.05%) of the total building task ($56.6 billion/year) over the last several years.

The nature of the earthquake hazard is such that it cannot be known for certain who will benefit from these measures, or when or how. Nor is it is feasible to provide a credible estimate of ‘average annual benefits’. However, in the wake of the more severe types of earthquake than can reasonably be anticipated for a seismically stable region like Australia, the community can be more confident that the worst outcomes will be avoided. These ‘worst outcomes’ involve the destruction of critical post-disaster buildings and the destruction of buildings where large numbers of people congregate.

There is also the prospect that the new regulatory arrangements provide engineers with more scope to devise innovative building solutions and undertake structural analysis that significantly moderates the increase in construction cost.

It is recommended that the revision be considered for BCA2008 reference.

8. IMPLEMENTATION AND REVIEW

If approved, the measures will be introduced in BCA2008. This will be available to BCA subscribers by February 2008 for a 1 May 2008 adoption.

As a matter of policy, proposed changes to the BCA are released in advance of implementation to allow time for familiarisation and education and for industry to modify its practices to accommodate the changes.

It is expected that building control administrations and industry organisations, in association with the ABCB, will conduct information training seminars on the new measures prior to their introduction in to the BCA.

There is no fixed schedule for reviewing provisions of the BCA. However, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. It relies on this process to identify emerging concerns.

Note: It is also proposed that the existing reference to the 1993 edition of AS1170 Part 4 will be retained to allow a transition period for industry to become familiar with the new Standard. It is proposed to withdraw the older edition at BCA2009.

GLOSSARY

ABS	Australian Bureau of Statistics
AEES	Australian Earthquake Engineering Society
AGSO	Australian Geological Survey Organisation
BCA	Building Code of Australia
BCC	Business Cost Calculator
BTE	Bureau of Transport Economics
COAG	Council of Australian Governments
DPMC	Department of Prime Minister & Cabinet
DTS	Deemed to Satisfy
EDC	Earthquake Design Categories
EMA	Emergency Management Australia
GA	Geoscience Australia
ICA	Insurance Council of Australia
nec	not elsewhere classified
RIS	Regulation Impact Statement

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Note: all material prepared or commissioned by the ABCB is available at: http://www.abcb.gov.au

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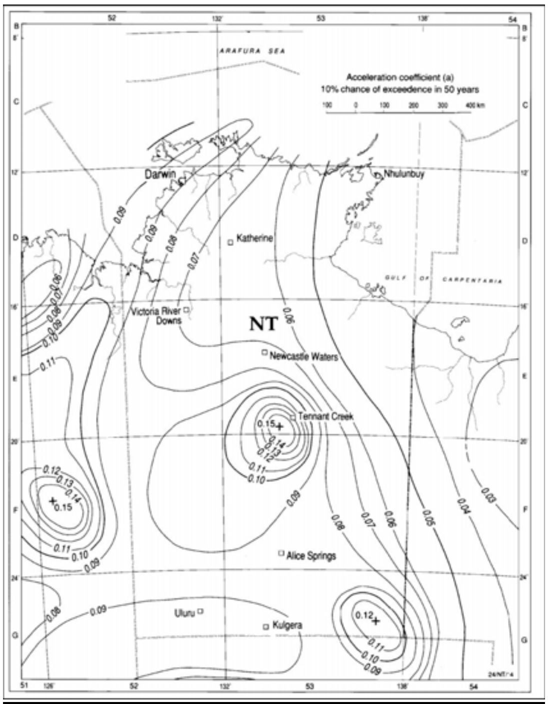
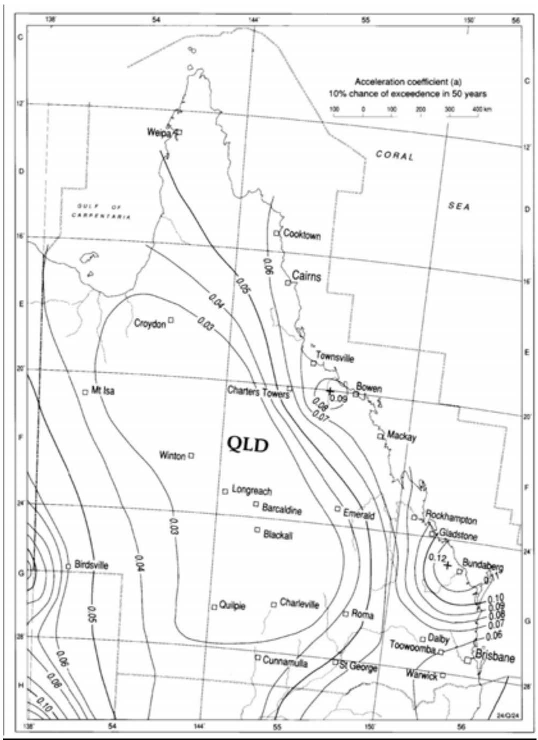
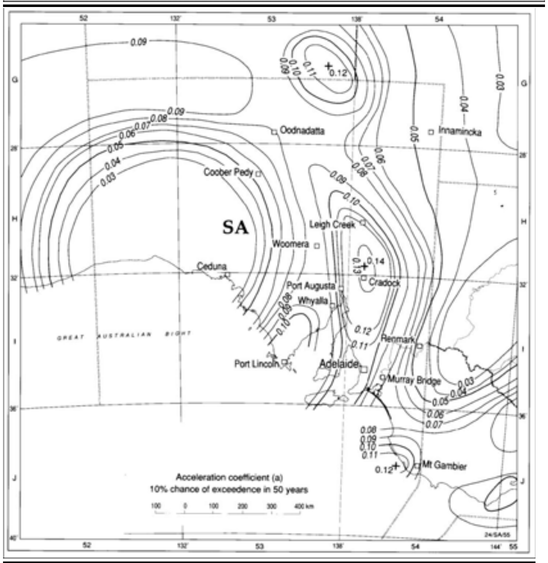
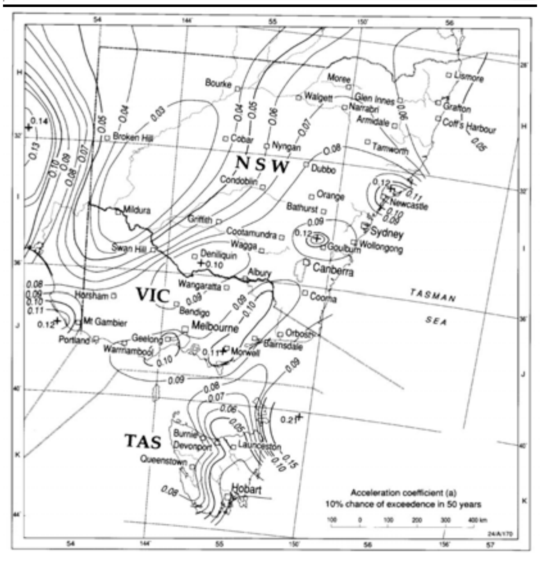
Appendix A Earthquake Hazard Maps

These maps have been copied from the 2005 draft of the revised Standard AS1170.4. The map for Western Australia is reproduced as figure 1.1 in this document.









Appendix B: Buildings containing hazardous materials

Almost any kind of building may contain hazardous materials, depending on how hazardous materials are defined. For guidance, we examined the regulatory categories that are employed in the management of workplace hazards in Australia.

- Major Hazard Facilities (MHFs): These are locations such as oil refineries, chemical plants and large fuel and chemical storage sites where large quantities of hazardous materials are stored, handled or processed;
- Dangerous goods: These are those substances that can be hazardous to people or property or cause accidents with disastrous consequences. Dangerous goods are gases, liquids and solids that are corrosive, toxic, flammable, explosive, oxidising or reactive with water. In locations other than MHFs, they are subject to codes of practice governing their handling and storage; and
- Hazardous substances: These are substances with the potential, through being used at work, to harm the health or safety of persons in the workplace. They are mainly industrial chemicals and can harm people though on-going exposure rather than as a result of a specific accident or disastrous event. They range from toxic to sensitising substances, the latter causing ‘only’ allergic reactions.

We focus on the middle category, dangerous goods. Regarding MHFs, we assume that BCA requirements will be less demanding than the outcomes generated by the risk management and approvals processes that are applied to such structures. And we assume that most hazardous substances are not sufficiently hazardous to trigger the requirements of the BCA.

We assume that there may be 5 million sqm of storage space for dangerous goods, with a replacement value of $3 billion, and generating new construction work of about $45 million/year. This estimate has been derived as follows:

- *NSW Workcover* estimates that there are about 7,000 NSW premises that, under national guidelines, would need to register as holders of dangerous goods. That suggests a figure of 20,000 premises nationwide;
- Assuming that each has 250 square metres of storage for dangerous goods, the total storage space is 5 million sqm. The cost of warehouse construction is about $600/sqm, putting the replacement value at $3 billion; and
- That stock may be growing at 1.5%/year at a cost of $45 million (= 1.5% * $3 billion).

The incremental cost of the measures would then be $1.1 million (= 2.5% * $45 million).

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