Towards a rational discussion of earthquake strengthening requirements: a critical analysis of the MBIE proposals

About tailrisk economics

Tailrisk economics is a Wellington economics consultancy. It specialises in the economics of low probability, high impact events including financial crises and natural disasters. Tailrisk economics also provides consulting services on:

- The economics of financial regulation
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The Principal is Ian Harrison (B.C.A. Hons. V.U.W., Master of Public Policy SAIS Johns Hopkins). Ian has worked with the Reserve Bank of New Zealand, the World Bank, the International Monetary Fund and the Bank for International Settlements

Contact:
Ian Harrison – Principal tailrisk economics

Harrisonian52@gmail.com

Ph. 0221753669
04-3848570

or

John Woolf - Senior consultant tailrisk economics

Ph. 021 064 8676

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Executive Summary

In December 2012 the Ministry of Business, Innovation and Employment (the Ministry) released a set of proposals relating to the earthquake strengthening of existing buildings. The most important of these proposals is a nationwide timetable that would accelerate the strengthening or demolition of 'earthquake prone' buildings.

The Ministry's proposals are largely based on the premise that between 15,000 and 25,000 buildings in New Zealand are earthquake prone. This is not true. In fact very few buildings are earthquake prone as defined in New Zealand law, or as most people would understand the term.

In assessing the size of the problem the Ministry did not use the legal definition of an earthquake prone building, which defines earthquake prone as 'likely to collapse in a moderate earthquake'. Instead it used a test devised by a working group of the New Zealand Society of Earthquake Engineers (NZSEE) in 2006. This test applies a much stronger definition of earthquake prone, and captures a much wider set of buildings, than the legal test. Very few of the buildings caught by the NZSEE test are likely to collapse in a moderate earthquake.

In Auckland a moderate earthquake for the purposes of the Act is defined as about a one in fifty year event. This is equivalent to about a 4.5-5 earthquake on the Richter scale - sufficient to break teacups but not to destroy buildings. But in Auckland it is possible that thousands of buildings will be designated as earthquake prone using the NZSEE's test.

The NZSEE test has been used by territorial authorities to designate earthquake prone buildings. It is likely that most of their designations would not survive a legal challenge.

The NZSEE working group's test was not supported by an analysis of its costs and benefits. Recently the Ministry commissioned Martin Jenkins and Associates to do a cost benefit analysis of the NZSEE test and other policy options. This analysis showed that the present value of the direct benefits of the Ministry's preferred strengthening option was $37 million. The benefits are low because very few lives will be saved by the Ministry's proposals - just 0.25 a year on average.
The present value of the costs of strengthening was $1,717 million. The actual costs of strengthening are likely to be over $4 billion but have been discounted because it is assumed that they will be incurred some time in the future.

The analysis did not capture wider economic and social benefits because the consultants did not think they would be material. However, the Ministry came to an 'on balance' view in favor of an accelerated strengthening option, giving the impression that it believed that these economic and social benefits must be substantial.

Our analysis shows that this is not true. We have assessed the wider social and economic benefits as having a present value of just $5 million. The earthquake strengthening requirements are designed to save lives not buildings; they will not materially improve the post earthquake resilience of our cities.

We also found that the Ministry's preferred option would impose substantial additional economic and social costs on those who will have to strengthen their buildings. Some people could lose their homes and others will see their retirement savings devastated. Communities will also be affected with the loss of low cost buildings that support small businesses and possibly hundreds of heritage buildings could be demolished.

With total benefits of $42 million and costs of around $2.4 billion (present value) the Ministry's proposals are clearly sub-optimal. Proposals with a cost to benefit ratio of greater than one should normally be rejected. What is needed here, are standards that are more precisely targeted to identify buildings with design flaws or which have deteriorated over time.

It is also clear that the proposal to impose a nationwide set of standards is flawed and has not taken appropriate account of the seismicity of different cities. As a result the cost to benefit ratios in cities with the low seismicity are extremely high. We have estimated the Auckland cost benefit ratio to be 1762 to one and Dunedin's to be 888 to one. Under the proposals over a billion dollars will be almost entirely wasted strengthening buildings in these cities. The Martin Jenkins study estimated that the Auckland strengthening would save just one life every 4000 years.

Our overall conclusion is that the Ministry's proposals are not based on a coherent analytical framework and are fundamentally flawed. They will result in substantial economic and social damage with very limited safety benefits.
Our key recommendations are that:

- The Ministry should publicly correct the false impression it has given that there are a large number of buildings that are likely to collapse in just a moderate earthquake.
- The Ministry should go back to the drawing board and develop earthquake-strengthening standards and policies that are based on sound, transparent and disinterested analysis.
- Territorial authorities should withdraw earthquake prone classifications that are not based on the legal definition of earthquake prone.
- If the Government decides to proceed with the proposals to fulfill a societal need to 'do something' after Christchurch then it should fund most of the strengthening work.

Section 1: Introduction and key findings

In December 2012 the Ministry of Business Innovation and Employment (the Ministry) released a set of proposals relating to the earthquake strengthening of existing buildings. The most important of these proposals was that there should be a nationwide timetable that would accelerate the strengthening or demolition of 'earthquake prone' buildings. The proposals were supported by three documents: a consultative paper, a regulatory impact statement and an expert report. These documents are intended to assist interested parties to make informed comments on the proposals.

There are a number of serious problems with the Ministry's proposals and supporting documents.

The Ministry's assessment of the number of earthquake prone buildings is exaggerated

The Ministry's proposals are largely based on the assumption that between 15,000 and 25,000 buildings in New Zealand are earthquake prone. This is not true. In fact very few buildings are earthquake prone as defined in New Zealand law, or as most people would understand the term.

The costs of the proposals far outweigh the benefits

The core policy proposal, to accelerate the strengthening or demolition of those buildings that have been (incorrectly) identified as earthquake prone, is a bad policy response to the Christchurch earthquake. Its costs will be at least 50 times greater than its benefits. In areas with low seismicity the cost/benefit ratios are much higher. It Auckland it could be over 1700 to one.

The analysis of earthquake risk could be improved

While there is much that is useful in the Ministry's documents, there are also a number of misleading statements and important omissions. These documents are not always a reliable resource to inform public debate over the issue of how safe we want our buildings to be.

Addressing the deficiencies in the documents

The purpose of this paper is to address the deficiencies in the consultative document and the Regulatory Impact Statement.

We discuss the definition of an earthquake prone building, why few buildings are in fact, and in law, earthquake prone, and that Territorial Local Authorities have not been using the correct legal test when identifying earthquake prone buildings.

Next, we present the results of a full cost benefit analysis of the Ministry's proposals. The Ministry commissioned a cost benefit analysis that captured the direct costs of strengthening buildings and the benefits that accrue from reductions in fatalities and injuries and in lower direct property damage.

This analysis showed that the benefits of the Ministry's proposals were $37 million compared to costs of $1,717 million. However, the analysis did not capture wider economic and social benefits. Because the Ministry came to an 'on balance' view in favor of an accelerated strengthening option, the strong implication is that these economic and social benefits are very substantial.

Our analysis shows that this is not true. We have assessed the wider social and economic benefits as falling in in range of $3-10 million with a mid-point estimate of $5 million. We also found that implementation of the Ministry's preferred option would impose additional economic and social costs, particularly with respect to heritage buildings, that would far outweigh those benefits.

We also did a 'sense' test on the Ministry's implied assumptions concerning wider post-quake benefits and found that the benefits would have to be extraordinarily high to justify the Ministry's policy decisions. As an example we calculated that a single latté would have to be worth $100,000 to generate sufficient post-earthquake benefits from the bar and restaurant sector to justify strengthening to the 34 percent standard.

The evidence is clear. Widespread earthquake strengthening is bad policy. With total benefits of around $42 million and costs of about $2.4 billion it is almost entirely a waste of money. It will save very few lives but it will have a serious impact on the homes and savings of the affected owners and could have a devastating effect on the retention of heritage buildings.

In the third and fourth sections we address some of the misconceptions created in the Ministry's documents and address some key issues and information that were absent from the reports. The discussion covers:

- A comparison of the effectiveness of earthquake strengthening and other ways to save lives
- An assessment of the regional costs and benefits of the proposals
- Whether earthquakes are 'special' from a safety perspective
- A discussion of who should pay for earthquake strengthening if the proposals were to proceed
- Why the Ministry's own expert report shows that unreinforced masonry buildings are not as risky, relative to modern buildings, as the Ministry depicts.

Our recommendations

We conclude with a set of recommendations.

The key ones are that:

- The Ministry should publicly correct the false impression it has given that there are a large number of buildings that are likely to collapse in just a moderate earthquake.
- The Ministry should go back to the drawing board and develop earthquake-strengthening policies that are equitable and which are based on sound analysis and the considered views of the New Zealand public.
- Those territorial authorities should withdraw earthquake prone classifications that are not based on the legal definition of earthquake prone.
- If the Government decides to proceed with the proposals to fulfill a societal need to 'do something' after Christchurch then it should fund most of the strengthening work.

‘Earthquake prone’ buildings Oamaru

Section 2: Are there 15000 to 25000 earthquake prone buildings in New Zealand?

The Ministry's assessment is wrong

The Ministry's preliminary assessment, that there are between 15,000 and 25,000 earthquake prone buildings in New Zealand that likely to collapse in just a moderate earthquake, should certainly be a source of concern and should, with some urgency, motivate a policy response.

Fortunately the Ministry is wrong. In fact very few buildings are likely to be earthquake prone, as defined in New Zealand law or as reasonable people would understand the term 'likely to fail in a moderate earthquake'.

What does earthquake prone building mean?

Obviously the term 'earthquake-prone' does not, by itself, mean very much. All buildings in New Zealand are earthquake prone in the sense that they are all subject to earthquakes, and nearly all will fail if the earthquake is big enough. Earthquake prone only has meaning where it defines a class of buildings that fail a specified performance test against a defined earthquake event.

The Building Act 2004 provides such a definition. Section 122 reads as follows:

> *(1) A building is **earthquake prone** for the purposes of this Act if, having regard to its condition and to the ground on which it is built, and because of its construction, the building—*
>
> *(a) will have its ultimate capacity exceeded in a moderate earthquake (as defined in the regulations); and*
>
> *(b) would be likely to collapse causing—*
>
> *(i) injury or death to persons in the building or to persons on any other property; or*
>
> *(ii) damage to any other property.*

The Building Regulations (Earthquake Prone Buildings) 2005 defines a moderate earthquake as follows:

> *For the purposes of section 122 (meaning of earthquake-prone building) of the Act, **moderate earthquake** means, in relation to a building, an earthquake that would generate shaking at the site of the building that is of the same duration as, but that is one-third as strong as, the earthquake shaking (determined by normal measures of acceleration, velocity, and displacement) that would be used to design a new building at that site.*

A moderate earthquake, therefore, is defined in relation to the 'large' earthquake that is used to design a new building. The large earthquake is broadly defined as a one in 500 year event and is measured using a technical term which expresses the force exerted by the earthquake on a building. The magnitude of the force will depend on the seismicity of the area. In Wellington a one in 500 year earthquake is defined as having a peak ground acceleration (PGA) of 0.4 m/s^2. The PGA figure for Auckland is 0.13. The moderate earthquakes are defined as having a PGA of one third of these figures and are one in fifty year events. In more commonly understood terms the Wellington and Auckland 'moderate' earthquake can be roughly equated to earthquakes measuring 6 and 5 on the Modified Mercalli Intensity (MMI) scale[1], or around 5.5-6 and 4.5-5 respectively, on the Richter scale. Earthquakes of these magnitudes are not destructive events. An MMI 6 event is associated with light building damage. A MMI 5 earthquake might break a few teacups.

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[1] The Modified Mercalli Scale is a measure of felt intensity and captures perceptions of the force of the earthquake as well as observed damage.

The earthquake prone building definition has two operative words. A building has to be ***likely*** to ***collapse*** in a moderate earthquake. 'Likely' in this context should take its ordinary meaning. It certainly means more likely to happen that not - that is, a probability of more than 50 percent. It is more like a 65 to 85 percent probability with a midpoint of, say, 75 percent.

Collapse also takes its ordinary meaning – that is the building fails completely. It does not just mean the building is just damaged, even quite severely.

We know from the Christchurch and other New Zealand experiences that even unreinforced masonry buildings (which are almost all designated as earthquake prone) will generally stand up to some reasonably severe shaking. Very few collapsed in the first Christchurch earthquake, which was much more severe than the Christchurch measure of a 'moderate' earthquake. If the earthquake prone designations were correct then we would have expected at least 75 percent to have collapsed. And if those buildings were resilient in Christchurch the same designs will be even more robust against the lesser quake standards in areas of low seismicity, and in particular in Auckland.

The evidence for Wellington is also clear. Most of the designated earthquake prone buildings have already survived the 1942 Wairarapa earthquake that subjected them to a greater shock than a 'moderate' Wellington earthquake.

It is likely, therefore, that there are only a small number of earthquake prone buildings in New Zealand, mostly where there is some basic flaw in the design, or where there has been some deterioration in a building over its life that has affected its strength.

Why do the Ministry and local authorities believe there are so many earthquake prone buildings?

If is obvious that there cannot be many earthquake prone buildings the question arises as to why the Ministry, and apparently many local authorities, have come to a different view.

It appears that the main reason is that they have been guided by a paper produced by a working group of the New Zealand Society of Earthquake Engineers (NZSEE) in June 2006. This report was intended to operationalize the Earthquake Prone Building requirements under the 2004 Act and the 2005 Regulations.

In the report the working group applied a more demanding test of building resilience than permitted under the legislation. It substantially ignored the requirements of the Act and substituted its own specification of resilience.

In developing its guidelines the working group made the following significant changes to the definitions of key terms in the Act.

Likely to collapse was defined as follows:
" *(b) "likely to collapse causing injury or death to persons in the building" means that collapse and therefore loss of life could well occur as a result of the effects of earthquake shaking on the building."*

Substituting could "well occur" for "likely" represents a substantial reduction in the probability that a collapse event could occur. An event that has probability of occurrence of, say, 5 percent could be described as something that could "well occur" but not something that is likely. The switch has the effect of strengthening the standard.

The 'collapse' test was removed all together and replaced with a tougher test that is embedded in a set of complicated formulas. A member of the working group, Rob Jury(2006), explained the logic for this change as follows:

"*The point of collapse under earthquake is difficult, if not impossible to predict. It is for this reason that engineers typically design buildings for the ultimate limit state (ULS). The ULS is a somewhat arbitrary state based on a combination of loads and a level of stress/deformation that from experience has been found to produce buildings that should have reasonable (acceptable) earthquake performance. At the ULS most buildings should be a long way from collapse. The NZSEE document does not address, in specific terms, assessment likelihood of collapse."*

Clearly the change to a ULS measure is a tougher test than the legal one. The standard moves from likely to collapse to 'a long way' from collapse. This represents a change from a 75 percent probability to, say, a 1 or 2 percent probability.

While it is reasonable to translate the collapse requirement into the more technically precise ULS measure this does not mean that the calibration of the standard had to be strengthened. A ULS calibration could have been selected that could have been more faithful to the intention in the law.

The effect of these changes was to increase the required minimum of around 16 percent of the new building code under the 1991 Act to 34 percent.

The working Group explained their removal of the collapse criterion by saying that their view was that its reference in the Act did not relate to expected performance in a moderate earthquake but rather to an 'overall expectation'.

It is difficult to see how this interpretation can be sustained. Going back to the passage of the Building Act there is nothing in the Select Committee Report or in Hansard that even suggests that Parliament wanted to give the words in the Act something other than their plain meaning.

The upshot is that the NZSEE has effectively created its own earthquake prone building standard that was much stronger than required by law and the Ministry has given it a form of official status by providing an accompanying letter that stated: "*the NZSEE recommendations provide authoritative and timely information to assist TAs, owners and their engineers to make assessments of the structural performance of existing buildings, and to determine whether or not they are earthquake-prone.*"

Territorial local authorities then seem to have followed the NZSEE and Ministry guidance without independently testing its legal status.

We believe that the NZSEE's interpretation of what constitutes an earthquake prone building is wrong. The meaning of the Act is reasonably clear and obviously requires a resilience test that is weaker than the NZSEE's and the Ministry's interpretation.

Our legal advice is that the NZSEE's and the Ministry's interpretations are wrong and would be unlikely to survive a challenge in court.

Quite part from the legal position the Ministry's interpretation is obviously not consistent with an everyday interpretation of the term 'likely to collapse in a moderate earthquake', and is likely to lead to confusion and unnecessary concern.

‘Earthquake prone’ buildings Whanganui

Section 3: A comprehensive cost benefit analysis of the Ministry's proposals

The Ministry's cost benefit analysis effort

The Ministry commissioned Martin Jenkins and Associates (MJA) to produce a cost benefit analysis of earthquake strengthening options. The analysis captured the costs of strengthening so called earthquake prone buildings, and the expected benefits from lower death and injury rates and from reduced physical damage to buildings due to their higher earthquake resilience. Because the costs and benefits accrue over different time horizons the results are reported as present values. The annual future costs and benefits over 75 years are discounted by an appropriate interest rate.

The major benefit, the reduction in earthquake fatalities, is valued using the same cost of a human life as is used to value improved safety in roading investment decisions. This ensures that the value placed on safety in the analysis is consistent with society's valuation in what is the most important area where infrastructure spending has a safety element.

The results are presented for three strengthening levels, 34, 67 percent and 100 percent of the current code, and for the time allowed to achieve those standards.

The marginal impact of the Ministry's proposals is to increase the present value of benefits by $12 million at a cost of $759 million. The marginal cost to benefit ratio is 63.3 to one.

We have reviewed the MJA cost benefit framework and concluded that it basically sound. There is room for debate about the calibration of some of the key assumptions including the discount rate and the value placed on a human life in this context, but no reasonable alternative calibrations would affect the broad outline of the MJA results.

Table 1: MJA Cost benefit results

Policy	Present value benefits $'m	Present value costs $'m	Cost benefit ratio
34% current time frame	25	958	38.2
34% 15 years	37	1717	46.4
34% 5 years	60	2798	46.6
67% 15 years	89	7692	86.4
67% 5 years	145	12533	86.4
100% 15 years	144	9533	66.2
100% 5 years	237	15532	65.5

The costs far exceed the benefits

The key and obvious conclusion of the MJA analysis is that the costs of the Ministry's proposals far exceed the benefits. The present value of the strengthening costs is $1.717 billion. This is less than the actual costs of around $ 4 billion[2] because most strengthening is assumed to occur towards the end of the 15-year time frame and the costs have been discounted accordingly.

The benefits of the policy are only $37 million. The reasons for this low figure are that strengthening will make very little difference to the cost of post-earthquake repair, and, importantly, will save very few lives. Because the stock of earthquake prone buildings is reasonably resistant to moderate earthquakes, and because very large earthquakes in New Zealand's major urban areas are very rare, the policy would only save, on average, about 0.25 of a life per year. A similar sized investment to make roads safer could save 20 to 30 lives a year.

[2] This figure is likely to be on the low side. There is little information in the MJ report on costs and it is not clear whether the cost estimates made provision for lost rents, remediation work and contingencies.

With a marginal cost benefit ratio of around 63 to one the analysis is telling us that the proposed policy is a bad one and that a more targeted approach, focusing on buildings with design flaws, or where deterioration has materially undermined structural strength, would be optimal.

However, the Ministry does not draw this conclusion. Rather, it says, having listed a set of costs and benefits, that it came to 'an on balance-decision' in favor of its policy position.

The cost benefit results are presented and noted, but it is explained that the estimates do not take account of the follow-on benefits of strengthening such as reduced social costs and impacts, improved post-earthquake functioning of cities and towns, or reduced economic losses.

The inference is that these additional benefits must be very significant to offset the large net direct cost figure. Given this significance it is not clear why the Ministry did not commission a comprehensive cost benefit analysis if it did not accept the MJA assessment that the wider benefits would not be material. It is not good practice, or even acceptable, to base a policy decision on a simple listing of a set of cost and benefit possibilities.

A full cost benefit analysis shows that 'follow on' benefits are not material

Because of the importance of a full cost benefit analysis to an assessment of the policy we have conducted our own analysis. The results are from a simplified model based on an application of the policy to Wellington. The outputs are then uprated to capture a New Zealand wide effect. Because Wellington is likely to accrue higher benefit than cities and towns in less seismically active areas, this approach is likely to overstate the level of benefits. [3]

Our mean estimate of the 'follow-on' social and economic benefits is $5 million dollars. Taking the MJA estimate of the direct benefits of $37 million our estimate of the total benefits is $ 42 million.

[3] We intend to develop a model that would capture the follow-on economic and social costs and benefits for an illustrative provincial town such as Wanganui.

We had to make a number of assumptions in calibrating our model and there is a relatively wide margin in our range of plausible outcomes. The model is at an early stage in its development and some of the figures will move around as the structure and inputs are refined. However, it is very clear that there are no plausible results that would overturn the results of the Ministry's direct cost and benefits model. Even if the true value of the benefits were 10 times our mid–point estimate the overall costs would still be higher than the benefits by a very large margin.

Why are the follow–on economic benefits so low?

There are number of reasons why the economic benefits from reduced business disruption following an earthquake would not be very high.

- The buildings which are affected by strengthening requirements are mostly old and typically house small, low value businesses. These businesses typically do not have strong downstream linkages that would exacerbate the any initial disruption.
- In the event of an earthquake many of these businesses will have a number of options (such as working from home) to reduce the effects of damage to their physical premises.
- Over-capacity in the many of the affected sectors (i.e. restaurants) means some business will be picked up by competitors who have not been as affected by the earthquake. While there might be a private cost to some small businesses there will be a more limited overall economic cost.
- Strengthening is designed to save lives not buildings. It is likely that many buildings strengthened to the 34 percent standard will have to be demolished or will require extensive repairs after the earthquake. At the very least they will be empty until they have inspected. This could take some time as civil defence authorities are likely to take a very cautious approach to allowing reoccupation after the Christchurch experience.
- Building strengthening won't help when the key problem is damage to critical infrastructure and civil defence restrictions on access due to safety concerns. The key risk to Wellington's post-earthquake business functionality is that the foundations will fail on a few high-rise buildings with large parts of the CBD will being cordoned off until they are demolished.
- Finally, and most importantly, earthquakes that cause widespread damage are rare events, even in Wellington, and the expected benefits are according low.

Our assessment of the present value of the wider economic benefits is $4 million.

The social benefits are also very low

The regulatory impact statement describes the social benefits of earthquake strengthening as reducing:

> *" impacts on sense of community and identity through loss of gathering places, places of employment, schools, hospitals, homes, heritage buildings and places to recreate and create (i.e. sports grounds, performance venues, galleries, museums etc.)*
>
> *costs/impacts associated with the displacement of households."*

Our assessment of these benefits is as follows:

Loss of gathering places

We have interpreted this as the loss of commercial gathering places such as restaurants and as reflecting the value of the business output to consumers (consumer surplus) over and above the value to the business. The present value (PV) of this consumer surplus is low for similar reasons to those set out in the discussion of the wider economic benefits.
PV social benefit: $500,000

Loss of places of employment

This is already captured under economic benefits.

Loss of hospitals and schools

Hospitals and schools will not generally be affected by the requirements and there will be very little social benefit from this sector.
PV social benefit: $100,000

Loss of homes

Only a small number of apartments, primarily in conversions from commercial properties, will be affected by the proposals. In many of those cases the apartments will still be lost in a large earthquake.
PV social benefits: $50,000

Loss of heritage buildings

The standards are not a very effective way to save heritage buildings as they are designed to save lives not physical structures. The Christchurch experience showed that in a severe earthquake a 34 percent standard will not reduce the incidence of damage very much, and that the damaged heritage buildings are likely to be lost when civil defense imperatives outweigh heritage values. In more moderate

earthquakes a 34 percent standard will be more effective in reducing building damage, but this will be of less value in a situation where more time can be taken to save damaged buildings.
PV social benefits: $500,000

Loss of places to 'create and recreate'

The importance of this factor is likely to vary markedly from town to town. With respect to Wellington, to our knowledge, only a few major recreational buildings are affected by the requirement. Two of the more obvious ones are the Opera house and the old stand at the Basin Reserve. Neither are likely to be used post an earthquake, even if strengthened, either because they have been damaged or there is no demand for their services.
PV of social benefits: $100,000

Costs impacts involved with the displacement of households

As noted above few homes are affected by the proposals and the majority of occupants of those that are will still be displaced in a large earthquake.
PV benefit: $50,000.

The wider social and economic benefits are outweighed by the wider social and economic costs

The wider social and economic costs include the following:

Reduction in low cost business accommodation

If owners demolish rather than reinforce their buildings then there will be a reduction in the availability of low cost business accommodation . This will negatively effect startup and marginal businesses. It is very difficult to assess the impact of this factor across New Zealand but even if the loss of producer surplus were just $1 million per year then the present value of this cost would be around $10 million.

Loss of heritage buildings

The proposals present a very significant threat to New Zealand's stock of heritage buildings, particularly in provincial towns, because in many cases it will be more economical to demolish than to strengthen. One way to quantify the social cost of this threat would be to think in terms of how much New Zealanders would be prepared to pay to allay a threat that could see hundreds or even thousands of their

heritage buildings disappear. If that figure were, say, just $5 million a year, then the present value of that benefit would be around $75 million.

Large Impact on individual owners has additional welfare costs

Unlike many policy proposals where the costs are borne widely across the community, the costs of the strengthening proposals will be borne by a relatively small group of owners. In many cases the impact will be devastating. Some owners could lose their homes and be presented with a demolition bill. Many others will suffer a large impact on their retirement savings. Because of these large wealth effects it is appropriate to make an adjustment to the dollar costs of the strengthening to better reflect the welfare costs of the proposals. We think that an adjustment of 33 percent is appropriate. This would increase the present value of costs by around $570 million.

The $100,000 latté

One of the ways we tested the robustness of our conclusions was to make an estimate of the values that key inputs into the 'wider costs' equation would have to take to overturn the result that the overall benefits of strengthening are less than the costs.

In the Wellington context one of the benefits of the policy is that the food and entertainment sector, which is centered in the earthquake prone building dense Courtney Place and Cuba Street precincts, would be more resilient post an earthquake. This would have, applying the distinction used in the Consultative Document, both economic and social benefits. The physical output of the sector would be higher and there would be wider benefits in terms of the value people place on the greater availability of convivial meeting places in stressed times. Thus the hospitality sector can generate a value that is above the market value of the output (this is termed consumer surplus) reflecting the value that people put on these wider attributes.

As a general economic proposition this is a credible story. We tested our model to see just how large this consumer surplus would have to be to generate a sufficiently large expected value. We simplified the question by expressing all of the outputs of the Wellington café, bar and restaurant sector in terms of units expressed in cups of latte's. Thus an actual latte' is equivalent to one latte; a wine is equal to two, a meal six, and so on. We found that the required consumer surplus on per 'latte' basis would have to be as high as $100,000. As much as Wellingtonians are reputed to

love their coffee this figure is beyond the bounds of plausibly by a very wide margin. It tells us that the Ministry's position is not credible.

The results of the previous cost benefit modelling that influenced policy development were wrong

We understand that the Ministry, the NZSEE and some territorials authorities have been influenced in their understanding of the value of earthquake strengthening by some cost benefit modelling [4]that was done around the time the Building Act was drafted. This analysis appeared to show that earthquake strengthening to both 34% and 67% levels showed positive net benefits on a nationwide basis. The Wellington City Council cited a later version of this work (commissioned for the Department of Building and Housing) in its submission to the Royal Commission of Enquiry on the Canterbury earthquakes.

"*There is good evidence of a compelling benefit to cost ratio in strengthening above the current 33% of the New Building Standard in regions like Wellington where seismic risk is high.*"

We have examined the publically available descriptions of the model and concluded that, for a number of reasons, the model was likely to have substantially overstated the benefits from strengthening. For one, it assumed that the on-going economic and social benefits would be a factor of two of the direct life, injury and building damage benefits. There was no supporting evidence for this assumption and, as we have argued above, it is not well founded. We also thought that the model was likely to have materially overstated the direct benefits from strengthening.

The MJA cost benefit analysis confirms our assessment of the direct benefits. Their estimate is only about 10 percent of the Hopkins estimate.

It is now clear that the analytical evidence does not provide support for the Ministry's proposal. It is less obvious, however, whether the improved analysis has yet influenced perceptions of costs and benefits held by territorial authorities and the earthquake engineering community. Many views may still be based on an outdated understandings of social and economic costs and benefits.

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[4] For a good description of the model and its results see Hopkins and Stuart (2003)

Summary of cost benefit results

A summary of the MJA and our cost benefit results for the Ministry's proposals are presented in table 2.

Table 2. Cost benefit analysis summary

Analysis	PV Benefits $'m	PV Costs $'m
Direct costs/benefits (MJA)	37	1717
Wider Economic impacts	4	10
Social impacts	1	650
Total	42	2387

‘Earthquake prone’ buildings Cuba Street Wellington

Section 4: Evidence not considered by the Ministry

In this section we address some issues that were not considered in the Ministry's consultation documents. We discuss the regional differences in the efficiency of earthquake strengthening; the relative effectiveness of earthquake strengthening in saving lives; and the issue of who should pay for the cost of strengthening.

Regional costs and benefits

The Ministry has presented just the aggregate cost and benefit data for New Zealand. This obscures important differences due to varying exposures to large earthquakes in different parts of New Zealand. To show these differences we have calculated city cost benefit ratios using the city data reported in Hopkins and Stuart. While their absolute values for costs and benefits were respectively understated and overstated, their relative cost and benefit figures are probably reasonably robust. We have scaled their results to produce a set of city figures that are consistent with the Ministry analysis. The results, some of which are presented in table one, show that the dollar costs of a dollar of benefits in low seismic zones are extremely high. The ratio is 1762 to one for Auckland and 6209 to one for Whangarei.

Table 3. Ratio of costs to benefits by city

City	PV benefits $'m	PV costs $'m	Cost/benefit ratio
Auckland	0.2	281.3	1762
Dunedin	0.1	73.6	888
Hamilton	0.2	62.1	306
Napier	2.7	82.0	31
Hutt City	3.1	79.1	26
Wanganui	1.2	67.4	54
Wellington	23.1	569.4	25
Whangarei	0.03	19.1	6210

Many more lives could be saved by spending the money elsewhere

Another way of looking at the effectiveness of the earthquake strengthening proposals is to consider their effectiveness at saving lives compared to the other options open to society. Our estimates assume the same, 75-year horizon that MJA used in its cost benefit analysis. Where relevant we take account of time value by allowing money to be invested until is required for life saving expenditures. We also assumed that earthquake strengthening occurs at the beginning of the period so the life saving benefits flow for the whole period. The estimates are preliminary. They are not precise and should be regarded as indicative of relative sizes rather than as point estimates.

Table 4. Lives saved from alternative expenditure options

Expenditure	Lives saved 75 years (normalized)
Health	2000-3000
Road safety	1000-2000
Tsunami mitigation	100-200
Building strengthening	20

The burden of earthquake strengthen should not be wholly borne by building owners

It seems to be taken for granted by the Ministry that the costs of strengthening should be borne by owners. We have argued in this report that there is no case for widespread strengthening and if this perspective is accepted then the issue of burden sharing should generally not arise. If the policy nevertheless proceeds, then there are strong equity and economic arguments that the costs should be shared more widely.

Society should pay if it has very conservative risk preferences

Earthquake prone buildings are not, by any reasonable definition of the term, dangerous and pose much lower risks than society is prepared to accept in other walks of life. If society nevertheless insists on a much higher standard of safety for buildings, and change the rules to give effect to that preference, then it is reasonable that society as a whole should pay for benefits that do not accrue to building owners. Further If the Ministry is correct that the wider social and economic benefits are material then the incidence of costs should follow these benefits.

Burden sharing will improve the quality of decision making

After an event like Christchurch there is an understandable political imperative both at the local and nation level to be seen to be doing 'something' regardless of the economic logic of that something. This is easier to do if the costs fall on a small minority of the population - property owners (who don't naturally attract sympathy if it is thought that they are large investors), and the policy does not have material budgetary implications.

If most of the costs were to fall on government then the proposals would be likely to come under more scrutiny and the quality of the analysis and decision making might improve.

Burden sharing will reduce the economic costs of the proposal

If the costs are spread to tax payers in general then this will remove the welfare costs that arise when a large wealth shock is imposed on a small part of the population.

We think that the best policy outcome is that the economics of earthquake strengthening are understood and policies are directed to the strengthening of buildings with designed flaws and which are in a weakened condition. However, in

current circumstances it might be politically difficult to admit that the current implementation is both unlawful and too tough, and that it is appropriate to back off from the current interpretation of the standard.

The second best response would be to proceed to enforce just the least economically irrational parts of the proposals (dropping them for regions with low seismicity but proceeding with perhaps just the Wellington area) but to recognize that the burden should principally fall on central and local government.

A starting point would be central government 70 percent, local authorities 20 percent, and owners 10 percent.

‘Earthquake prone’ building Rome

Section 5: Improving our understanding of the costs and benefits of earthquake strengthening

In this section we discuss some of problems that arise because the Ministry does not have a coherent framework for its policy design. Having essentially ignored the results of its costs benefit work it has sometimes had to rely on statements to support its positions, which have the appearance of substance, but which are either meaningless, wrong, or in context misleading. They do not help New Zealanders understand the issues.

The Ministry has also fallen back on the implied support from the Royal Commission and earthquake engineering community who they suggest have come to similar positions to theirs.

We discuss:

- Whether the strength of buildings is 'adequate' or 'acceptable'
- The Royal Commission analysis of the strengthening threshold
- The role of earthquake engineers in determining society's safety standards
- Why earthquake prone buildings are not as risky as the Ministry claims
- Whether earthquakes are special from a societal risk perspective

Current building strengths are broadly adequate and acceptable

Without a clear analytical framework the Ministry has fallen back on general statements to the effect that the status quo is not an adequate or acceptable position. For example in the Consultative document it states:

"*There must be public confidence that the risk posed by buildings in earthquakes is being managed down to an acceptable level. This recognizes that the risk of building collapse, death and injury can be reduced but never eliminated- therefore, the benefits of any reduced risk need to be kept in proportion to the cost of strengthening and building removal".*

There is no guidance here as to what constitutes acceptable other than the implied conclusion that the status quo does not meet those tests. The Ministry has not used the normal test that the acceptable level of risk is where the marginal benefits equal the marginal costs.

Nor has the Ministry taken any guidance from its expert report on what could serve as an objective benchmark for an 'acceptable 'level of risk. The report cites the UK benchmark of 1 death in 10,000 years. Using that figure there is no basis for significant concern in New Zealand. The expert report presents data that shows that the risk of earthquake prone buildings in Wellington is over 1:100,000. This is over 10 times as safe as the acceptable standard. Buildings in areas with low seismicity will be hundreds of times safer.

The risks that we are prepared to accept to have an efficient transport system is a guide to New Zealanders' risk tolerances. Currently the annual death rate on our roads is about one in 12,000. We could decrease this rate sharply if wanted to by the simple expedient of drastically reducing the maximum speed limit to, say, 10kph. We choose not to because the economic cost would be too high.

There is no substantive framework behind the Royal Commission's recommendation on the earthquake prone threshold

The Royal Commission process did not develop an analytical framework to assist its decision on the strengthening threshold. It listed some of the options and their pros and cons but provided no mechanism for choosing between them.

The Royal Commission did not:

- Commission its own expert work on the subject
- Call for submissions on the cost and benefits of strengthening
- Develop its own quantitative framework for measuring costs and benefits

The Commission was aware of the results of the MJA cost benefit analysis. It did not contest the assumptions or results. Rather it suggested that there were other benefits that were not captured by the study. It listed two. One of these was that its recommendation would give 'peace of mind'. The other was a recitation of the facts about Christchurch deaths and a statement that the number of dead in the earthquake came as a surprise. The latter was true, but in a 1:2,500 year event should not in itself be a surprise and it not clear how it supports the Royal Commission's policy recommendation.

On the peace of mind argument, this does have some value, but as 34 percent does not provide complete protection and not much protection against the really big quakes (the Commission's report showed that buildings strengthened to 34 percent failed at the same rate as the un-strengthened buildings) it cannot be represented as a solution to the truly nervous.

With respect to the earthquake prone threshold the Commission simply said that: *"Apart from this one exception* (on parapets and gable ends), *there appears to be no evidence that to protect life safety the shaking level to be resisted for earthquake-prone buildings should be set higher than one-third of the requirement for new buildings."*

The Commission either ignored the evidence in the cost benefit analysis work that a higher threshold would save some lives, or took the view that these benefits were not worth the costs.

The justification for an accelerated imposition of the 34 percent standard was that:

"There is …… considerable merit in completing the work expeditiously as there is obvious benefit in society being better prepared before a destructive earthquake."

There are no supporting arguments elsewhere in the report and no regard appears to have been given to the additional costs of the proposal or of regional differences in seismicity and in benefits and costs.

"Earthquake prone" buildings are not 25 times riskier than buildings built to the current code

In both the consultation document and the RIS the Ministry cites NZSEE figures that purport to show that buildings at 16 and 33 percent of the modern code are, respectively, 25 and 10 times more risky than a modern building. These figures are misleading. They take account of just the likelihood of a building failing but ignore the probability of death and injury once a building does fail. A risk measure should take account of both factors.

The Ministry's expert report (Taig 2012) show that the probability of death given a building failure is much lower in unreinforced masonry buildings than in modern building (about 6 percent compared to more than 25 percent for reinforced concrete high-rise buildings). Thus the risk of death in sound unreinforced masonry buildings is not markedly higher than that in some sound modern high-rise buildings. Figure 22 of the report shows that the risk of a UMR building is only about 40 percent higher than a post 1980s moment resisting high-rise building. With other building types the margins are wider but the relative risks are well short of the claimed 1:25.

The risks posed by earthquakes in the riskiest areas are lower than other material risks

The RIS makes the following statement about relative risks.

"*Further advice on these issues (risks) was sought from GNS Science and international risk experts as part of the review. A key finding of this work is that individual risk from earthquakes is small when it is averaged over the whole population – other day-to-day activities pose more immediate risks to life safety, for*

example, fatality risk from road accidents (see Figure 1 below). However, it can be significant relative to other hazards at higher risk locations. "

The last part of this passage gives the impression that earthquake risk is still a material source of concern in some locations despite the low overall level of risk. Taken literally the statement is true. The expected death rate from bee stings in Wellington is higher than that from the collapse of unreinforced masonry buildings in earthquakes. But it is substantively misleading because the death rate for all material accident hazards including fire, drowning and motor accidents are all still well above the earthquake death rate in earthquake prone buildings.

Are earthquakes special?

The Consultative Document says that earthquakes are different because of the possibility that they could result in a large number of deaths.
"*While they are rare, earthquakes differ from other risks because of the high death toll and impact that individual earthquakes can wreak on communities. Even though more people die in road accident than earthquakes, most fatal earthquakes involve fewer than four deaths per event. New Zealand's worst single road toll was 15 people killed in a bus accident in Northland in 1963*."

There is at least an implication here that a death is more significant if it occurs en masse in an earthquake rather than in an isolated accident and that this should be factored into the policy decision.

The problem is that the Ministry does not explicitly take this argument anywhere and it is not possible to establish what weight, if any, it placed on the mass casualty possibility in arriving at its policy conclusions. The RIS does refer to a discussion of large-scale events in the expert report but the literature cited in that report does not support any special status for the value of a death in a large-scale accident. Several recent studies found that people value lives equally whether they are lost in small scale or in large-scale events.

However, even if it were the case that New Zealanders would like to place an additional weight on avoiding large-scale death toll events, for the most part taking account of this factor would not support the Ministry's proposals.

The weighting would not apply to small towns and low seismic areas

Death tolls in provincial towns and low seismic areas would not be on a large scale even without any earthquake strengthening so there is no justification for applying a higher weight for the cost benefit analysis for these areas. If 10 people were killed in an earthquake in Wanganui or New Plymouth, this is no more than could be killed in a bad road accident.

Probably wouldn't make a material difference to the death toll in Wellington

If Christchurch is a guide the death toll in unreinforced masonry buildings in a very large earthquake event, Wellington would not be very high. The number of unreinforced masonry buildings was much higher in Christchurch than in Wellington and the pedestrian density in the critical areas was also higher than would be expected in Wellington. While no one died in a reinforced building in Christchurch this may have been a matter of luck because reinforcement to the 34 percent standard did not make a material difference the incidence of building failure.

Tsunamis not buildings pose the greatest risk of large-scale loss of life

After the Indian Ocean tsunami of 2003 a study was conducted of New Zealand's Tsunami risks (Berryman 2005). It showed that the expected loss of life due to tsunamis was of an order of ten times as great as that due to shaking of buildings and that the biggest tsunami loss of life events are much bigger and more prevalent. The biggest 1:2500 year event in Gisborne could take 12,000 lives while thousands could be lost in each of a number of east coast cities including in Napier Wellington and Christchurch.

It would be possible to mitigate some of these risks by building sea walls and by the evacuation and demolition of the most affected areas. If the level of risk aversion applied in the Ministry's proposals were applied consistently it might mean, possibly the abandonment on large parts of Wellingtons low lying Southern suburbs. As that is not proposed it difficult to see what can be motivating the concern with the much less acute risks posed by building shaking.

Safety judgments cannot be made on the basis of the engineering alone

The NZSEE is on the record as wanting a minimum standard for existing buildings of 67 percent of the modern code and as we have seen has been instrumental in having the Building Act interpreted to require upgrading to a 34 percent minimum.

While the earthquake engineering expertise is obviously a critical part of standard setting it is not the whole story. It is also necessary to have a sound economic framework to make an assessment of costs and benefits. There was no such framework in the 2006 Working Group document and the calibration of the standard was simply based on the Working Group's opinion of what is acceptable. That opinion of what is good for New Zealand is no more valid than that of any well informed New Zealander and perhaps less so. Earthquake engineers have a conflict of interest because it is in the profession's economic interest to have a higher standard.

Cuba Street Wellington 2027

Section 6: Recommendations

Our key recommendations are that:

One

The Ministry should publicly correct the false impression it has created that there are a large number of buildings that are likely to collapse in just a moderate earthquake.

Two

The Government should go back to the drawing board and develop earthquake-strengthening standards that are based on a considered analysis of their costs and benefits. The current legal definition of an earthquake prone building is not well crafted and the test set by regulation not firm enough. The NZSEE test is too tough by a wide margin.

Three

An independent and authorative agency such as the Productivity Commission should be commissioned to do the research and analysis that is needed to calibrate the standards.

Four

Standards should be set by a public authority, not by parties with a commercial interest in the outcome.

Five

Territorial authorities should withdraw earthquake prone classifications that are not based on the legal definition of earthquake prone.

Six

The Government should fund most of the strengthening work when it imposes requirements based on a societal need to be seen to be taking some action as a response to Christchurch rather than a reasonable assessment of the risk posed by buildings

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