Evaluation of Business Interruption Losses in the Capital City of New Zealand

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ABSTRACT :

Presented in this study is a probabilistic estimation of the seismic risk in the capital city of the New Zealand. The contribution of three factors to the economic losses is discussed. The first factor is the level of seismicity in the Wellington region. The second factor is the significant growth of exposure in the region. The third factor is the location of major access roads and railroads in the region. Earthquake losses are estimated both for a stochastic event set and for a given scenario. The results presented are computed using the Risk Management Solutions recently upgraded earthquake model for the New Zealand. The upgraded model is a probabilistic model that takes into account the uncertainty corresponding to the seismic hazard and the one corresponding to the vulnerability of the building inventory in that region. The hazard component of the model is upgraded using the latest seismic hazard maps released by the New Zealand Institute of Geological and Nuclear Sciences. The vulnerability component of the model is upgraded by implementing a performance-based earthquake engineering methodology. It is found that the business interruption losses in Wellington during a major event have the potential of becoming catastrophic, primarily because of the contribution of the lack of redundancy of the transportation network in that region.

KEYWORDS: Seismic Risk, Loss Estimation, Business Interruption, Lifelines, New Zealand Earthquake

1. INTRODUCTION

The possibility of escalating levels of business interruption losses in the capital city of New Zealand, Wellington, has become a major concern for the insurance industry. From a risk management perspective, three major factors contribute to the economic losses associated with loss of functionality. The first factor is the fact that Wellington is geographically located in an area with high seismicity. Faults in this area are capable of producing strong ground motions with magnitudes as high as the magnitude 8.2 Wairarapa earthquake occurred in January-23, 1855. The second factor is the significant growth of built environment in Wellington region over the past decades. According to the New Zealand 2006 Census, population in Wellington region is around half a million which is almost 10 times the population at the time of Wairarapa earthquake. During the past twenty years the commercial and industrial sectors have experienced a major growth in the capital city. The third factor that contributes to the losses is how the transportation infrastructure is laid out in the region. Major portions of the Wellington transportation network are built very close to the active faults in the region. Therefore, during a major earthquake event, it is highly likely that these access roads are disrupted which can lead to a significant delay in the transportation activities after the earthquake and consequently can increase the business interruption losses.

In this study the contribution of each of the above factors to the economic losses in the Wellington region is taken into account. In particular, the contribution of the losses from the damage in the transportation network is estimated. Losses are estimated for a series of events in the region and for a repeat of the 1855 Wairarapa earthquake. The results presented are computed using the Risk Management Solutions earthquake model for the New Zealand which is upgraded in 2007. The upgraded model is a probabilistic model that takes into account the uncertainty corresponding to the seismic hazard and the one corresponding to the vulnerability of the building inventory in that region. Both components of the model have been significantly upgraded using the state of the art methodologies. Losses estimated for the Wellington region shows that as a result of the lack of redundancy in the transportation network in the capital city of the New Zealand, insured exposure can experience an increase of 100% in the level of losses.

2. NEW ZEALAND SEISMICITY

New Zealand is consisted of two islands: the north island and the south island. Figure 1 shows the geographic distribution of the faults taken into account for the New Zealand earthquake model. As can be seen in figure 1a, on the left, there is a concentration of the faults in the south of north island where Wellington is located. Figure 1b shows the seismic faults that can impact the Wellington region. One of the faults shown in figure 1b is the WellingtonS fault which passes through the central business district of the capital city.

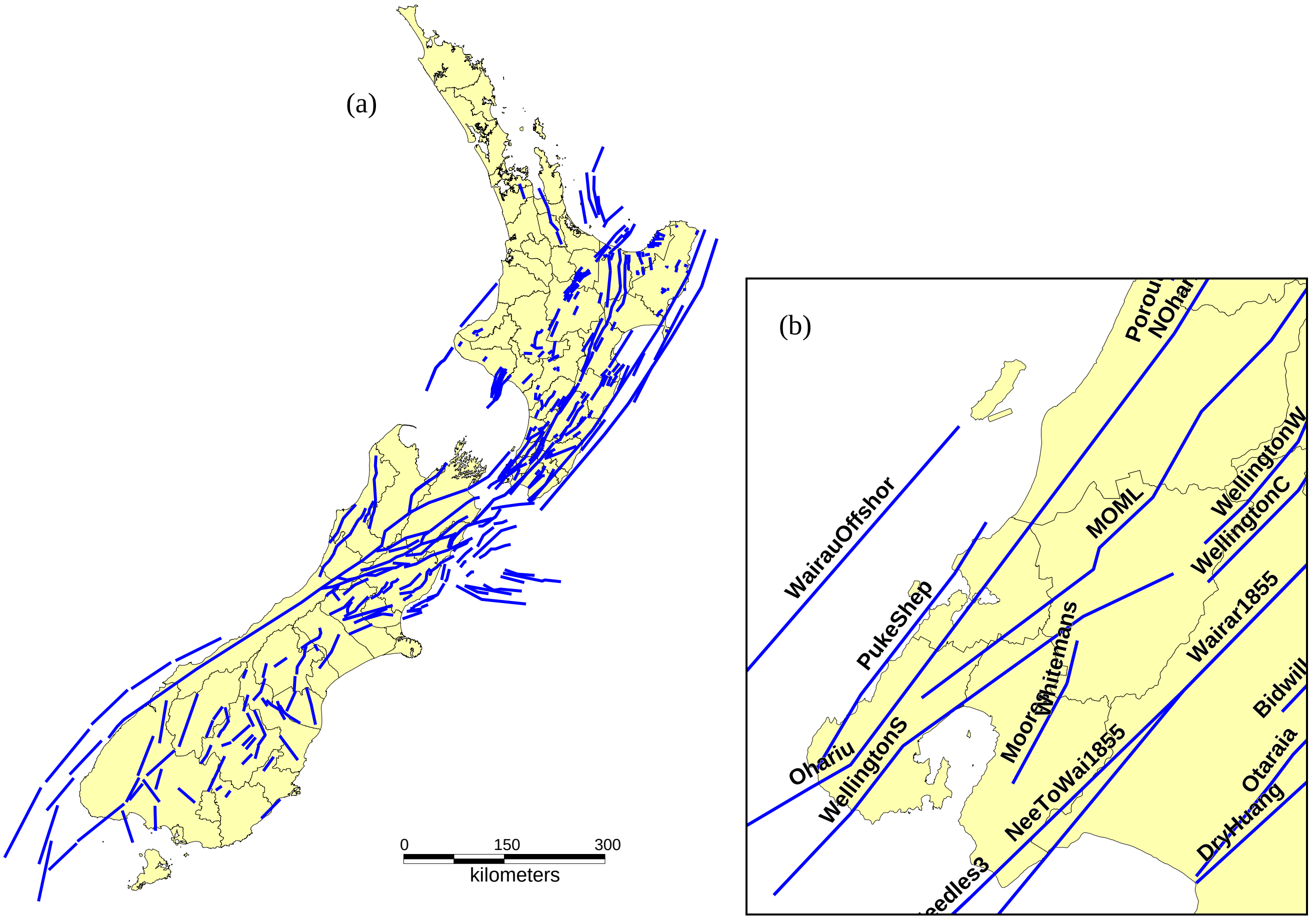

Figure 1 (a) Geographic distribution of faults taken into account for the RMS New Zealand earthquake model released in 2007, (b) Faults that can impact the Wellington region

3. EXPOSURE GROWTH IN WELLINGTON

Majority of the building inventory in the country is located in the north island. The largest city of New Zealand, Auckland, is located in the north of the north island and the capital city is located in the south region of the south island. Figure 2 shows the growth of exposure in the central business district of Wellington for various construction materials normalized to exposure value predicted for the properties built prior to 1940. As can be seen in the figures there has been a major exposure growth in the region during the past 30 years. In particular,

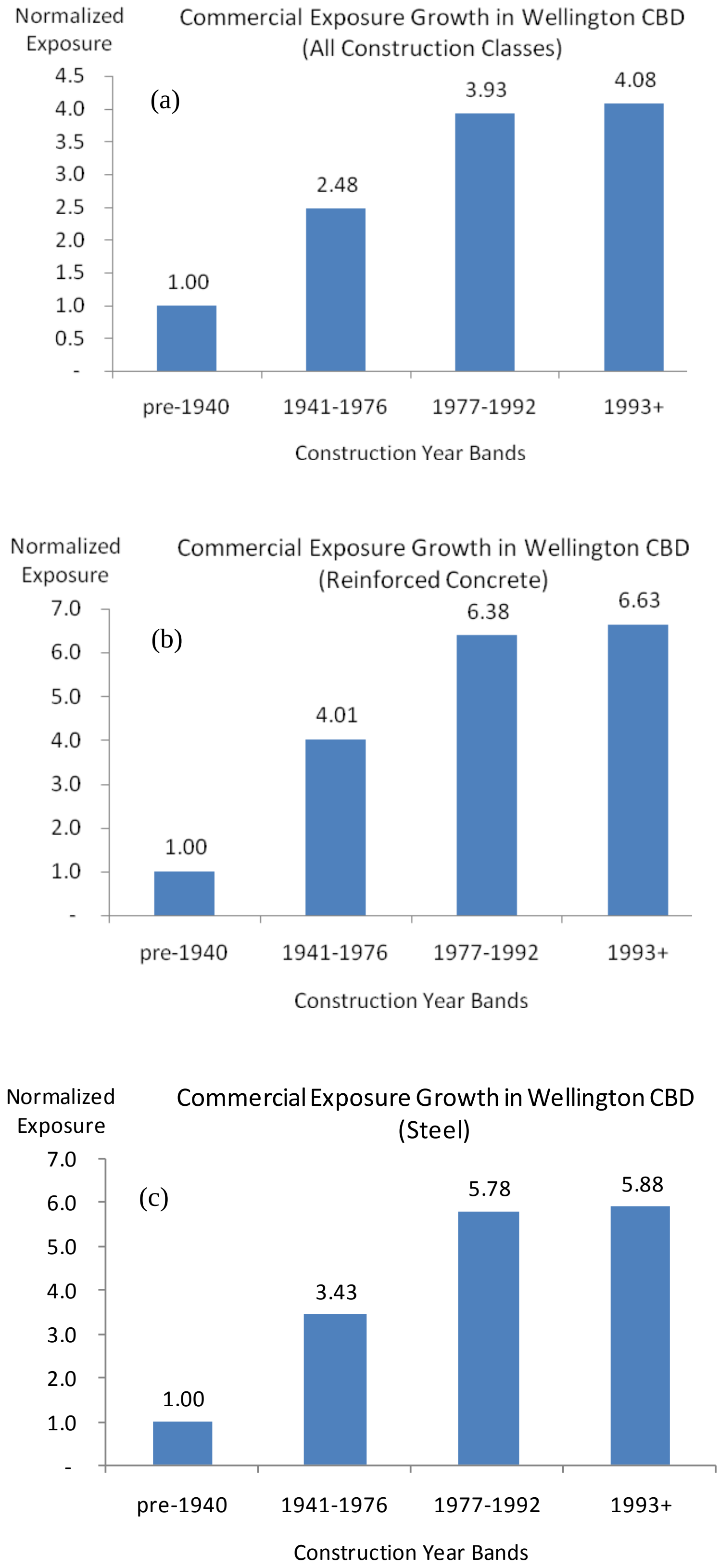

Figure 2 Growth of exposure for various types of construction in the central business district (CBD) of Wellington. (a) All construction classes, (b) Reinforced concrete buildings, (c) Steel buildings

the growth of reinforced concrete and steel construction has been very significant. For example, the exposure value of the steel buildings constructed prior to 1992 is 5.78 times the steel structures existed prior to the 1940, figure 2c. It should be noted that the year bands shown in each of the graphs in figure 2 are the year of constructions considered in the RMS New Zealand earthquake model. These year band are carefully selected on the basis of the changes in the building codes in New Zealand and the input from the Institute of Geological and Nuclear Sciences (IGNS) of New Zealand. More information on the selection methodology of the year of construction can be found in the RMS New Zealand Earthquake model methodology (2007).

4. WELLINGTON TRANSPORTATION INFRASTRUCTURE

Figure 3 presents an aerial view of the city of Wellington. Comparing figure 3 with figure 1, one can see that highways 1 and 2 are right on top of the WellingtonS fault. These two highways are the major access roads to the Wellington CBD. In addition to these two access roads the railroad system also is located along these two highways and on top of the same fault. As a result, in the event of an earthquake in this region, it is highly likely that the transportation system in the area experiences major damage and either of the highways or the railroad system cannot be used, either temporarily or permanently.

Figure 3 Major access roads and railroad in Wellington

5. RMS METHODOLOGY TO MODEL LIFE LINE COMPONENT OF THE BUSINESS INTERRUPTION LOSSES AS A RESULT OF EARTHQUAKES

RMS Business Interruption (BI) methodology is primarily based on the methodology proposed in ATC-13 (1985). Figure 4 provides an overview of how BI losses are being computed in RMS peril models. For a given location BI losses are composed of two major components, time needed to repair the building, and time needed to repair each critical lifeline system. BI losses corresponding to the repair of the building are calculated as a function of the building Mean Damage Ratio (MDR which is the ratio of the building repair cost normalized by the building replacement value. For a given MDR, a BI damage state is selected from seven discrete BI damage states. For each combination of occupancy and BI damage state, a facility restoration curve is specified which provides information on the time needed to restore a certain percentage of the functionality of the facility.

Loss of function of a lifeline system can increase the facility restoration time, even in the case when the facility itself is fully operational. For this reason, the time required to restore critical lifelines is also considered when calculating

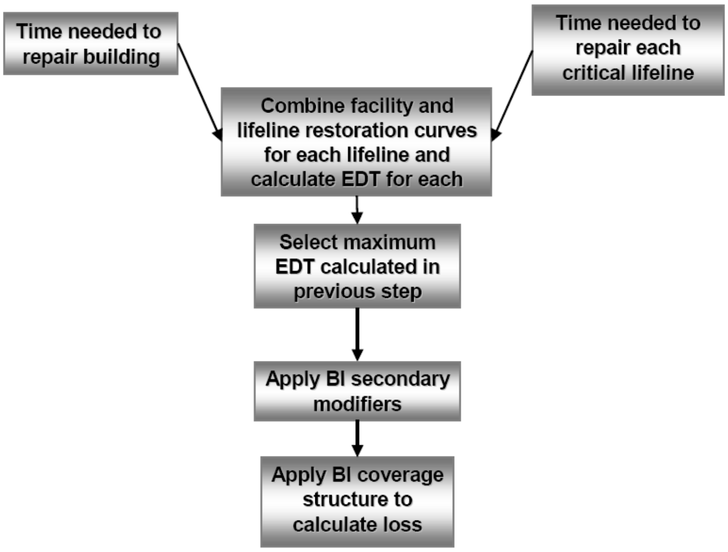

Figure 4 RMS methodology to estimate business interruption losses. (RMS, 2005)

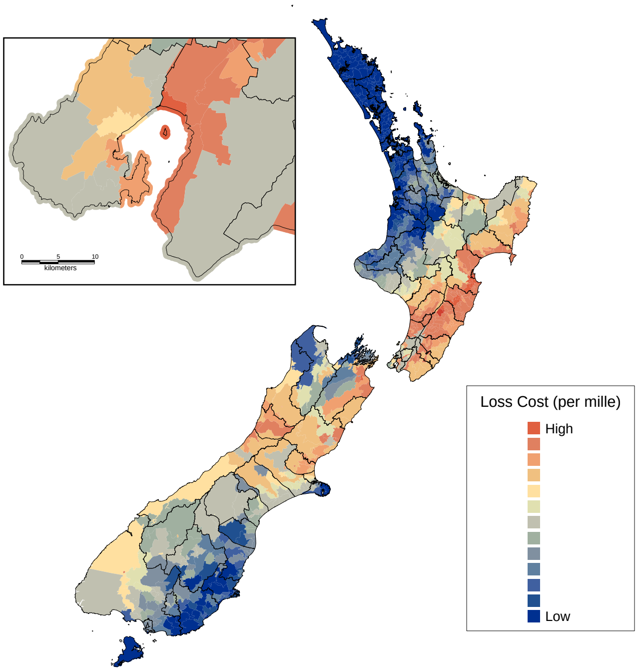

Figure 5 Loss cost map of the New Zealand for commercial exposure

the BI losses. Nine distinct lifelines are considered within the BI model as follows: 1. Water Supply, 2. Waste Pumping Stations, 3. Electrical Power, 4. Natural Gas Compressor Stations, 5. Petroleum Fuels Refineries, 6. Highway Transportation, 7. Railway Transportation, 8. Air Transportation, 9. Sea/Water Transportation. Each of these nine lifelines has several system components that are weighted to determine the vulnerability to damage (RMS, 2005).

RMS applies lifeline importance factors, which are unique for each occupancy type, to determine the effect of lifeline recovery times on the calculated effective downtime at a facility. Both the ATC-13 (1985) and ATC-25 (1991) studies have defined the level of importance of different lifeline systems for the functionality of a variety of occupancy types. RMS has combined and modified these relationships to define the level of importance of different lifelines for different occupancy types. The importance factors are decimal numbers between zero and one (zero means that the particular lifeline system is irrelevant to facility; one means that the occupancy cannot function without it).

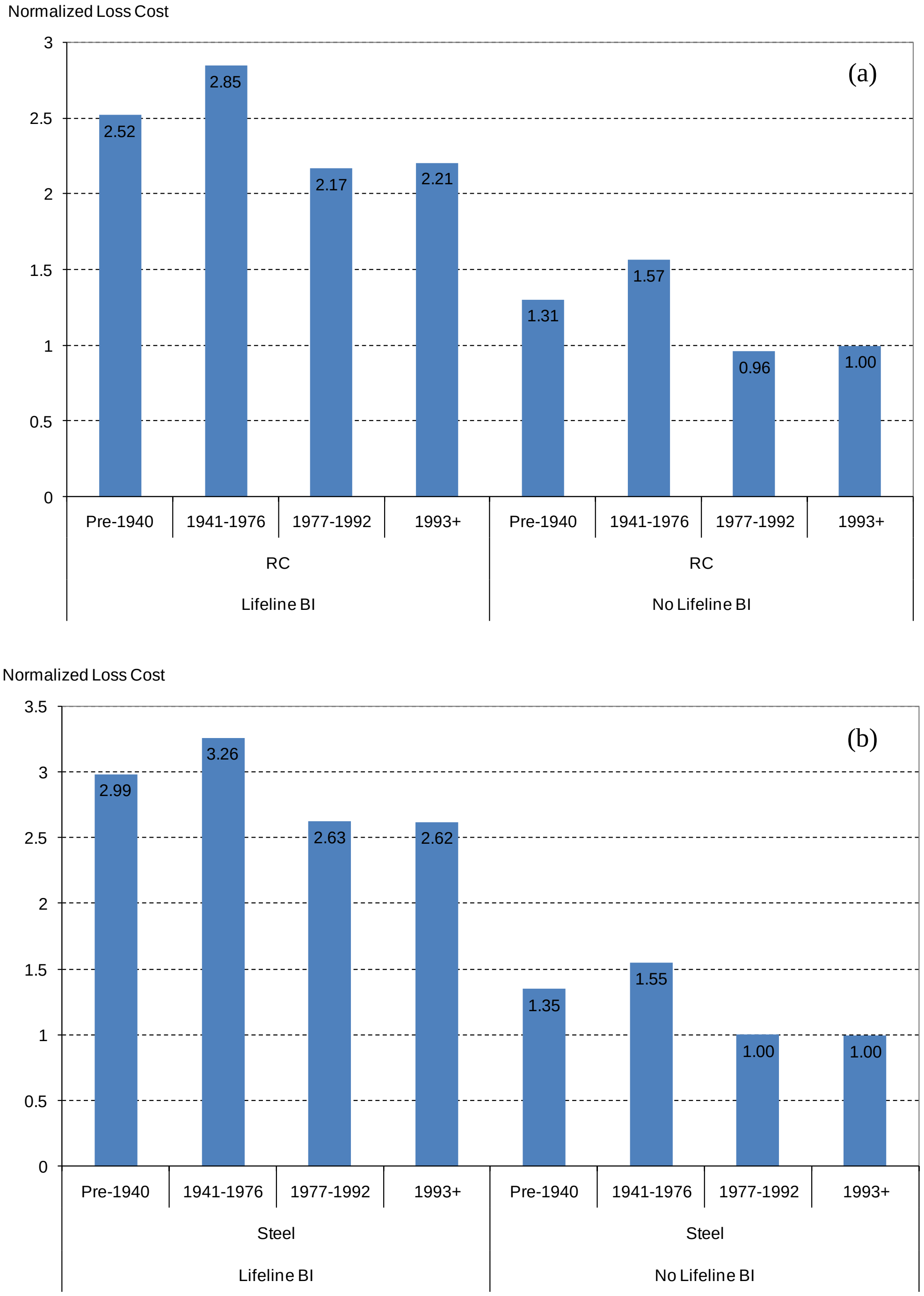

Figure 6 Contribution of the lifeline component of the business interruption losses for (a) Reinforced concrete, and (b) Steel buildings for average annual loss cost in Wellington CBD

6. EARTHQUAKE LOSSES IN NEW ZEALAND

Figure 5 presents a normalized loss cost map of the New Zealand for commercial exposure. On the upper left hand side of the figure, the loss cost for the Wellington region is shown. As can be seen in the figure, compared to other areas in New Zealand, the losses are high. The high losses in the capital city are not only because of the active faults that exist in the region but also high contribution of BI losses and in particular lifeline component of the BI losses. In the next section, we will show the losses in Wellington and the contribution of lifeline damage to the BI losses in that region.

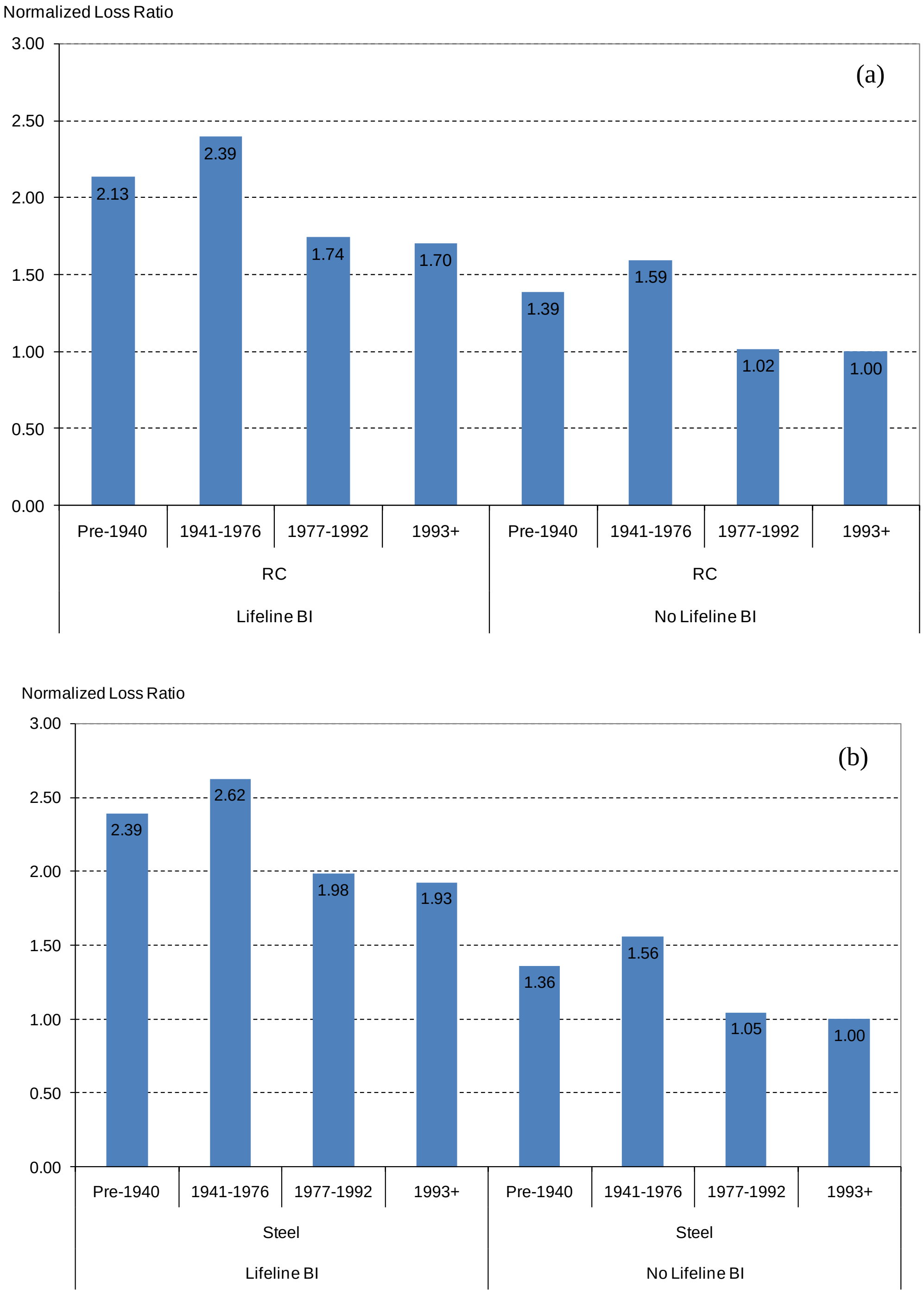

Figure 7 Normalized loss ratios for the repeat of 1855 Wairarapa Earthquake for (a) Reinforced concrete, and (b) Steel buildings

7. EARTHQUAKE LOSSES IN WELLINGTON

Presented in figure 6 are the estimated total, building, content and BI, normalized loss costs for commercial exposures in the postal code of the Wellington region that includes Wellington CBD for two types of construction, reinforced concrete (RC) and steel, and for four year bands. In each of the graphs two cases are shown, one case considers the lifeline component of the business interruption losses and another case does not take into account the lifeline component when estimating the BI losses. As can be seen in the graphs the contribution of lifeline losses in the total loss costs is significant. For example, for reinforced concrete commercial building exposure built after 1992, loss cost increase by a factor of 2.21 when taking into account the lifeline component of the BI losses. This is primarily because of the unique transportation infrastructure in the Wellington region.

Figure 7 presents the normalized total loss ratios for the repeat of magnitude 8.2 Wairarapa earthquake occurred in January-23, 1855 for RC and steel commercial exposure in a Wellington postal code that includes the CBD. Similarly to figure 6, the contribution of lifeline losses to the total losses is significant. For example, for steel commercial buildings built during 1977 to 1992, consideration of lifeline damageability when estimating losses doubles the loss ratio.

8. CONCLUSIONS

Seismic risk in the wellington area, capital city of New Zealand, is investigated. The impacts of three important factors on the seismic risk are discussed. The first factor is the high seismicity of the Wellington region which is primarily because of the existence of active faults that are capable of producing large ground motions similar to what was experienced in the 1855 Wairarapa earthquake. The second factor is the distribution of the transportation network in Wellington region. Major highways and railroad network are located on an active fault in the region and as a result during a major earthquake it is highly likely that the accessibility to the damaged areas becomes very limited. The third factor is the major growth of the building inventory in the capital city of New Zealand as a result of its economic growth. It is found that all these factors lead to considerable losses in the Wellington region. In particular, the impact of the damageability of the ground transportation system on the losses in the central business district is estimated and it is found that lifeline damageability contributes significantly in the total losses for that area.

ACKNOWLEDGEMENTS

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