Comparison of the Impacts of Cyclone Tracy and the Newcastle Earthquake on the Australian Building and Insurance Industries

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Abstract:

Cyclone Tracy and the Newcastle Earthquake were two of the largest natural disasters to impact Australia during the past 40 years. Each was an unexpected event, they resulted in similar overall damage costs, and they both had significant impacts on the building and insurance industries. However, although extensive recommendations for changes in building practice were made in the reports on both events, Cyclone Tracy caused far greater changes in building practice than did the Newcastle Earthquake. Cyclone Tracy also had a much bigger impact on the insurance industry. Another significant difference was that building costs almost doubled in Darwin following Cyclone Tracy but hardly changed in Newcastle following the Newcastle Earthquake. In respect of building practice it is suggested that the greater influence of the Commonwealth Government in Darwin at the time of Tracy was a major factor in driving the resulting Australia wide changes in building practice. In respect of the insurance industry the lessons learned from Cyclone Tracy lessened the impact of the Newcastle earthquake, although the latter was the catalyst for a major change in the way catastrophe insurance risk is assessed in Australia. The differences in post-event building costs are attributed to differences in the supply and demand for building services following the events. The analysis of comparative costs also revealed major anomalies in the current published data on the costs of both events and revised estimates of these are presented.

1 The Events

1.1 Cyclone Tracy

Cyclone Tracy was a small intense tropical cyclone which crossed the coast directly over Darwin in the early hours of Christmas Day 1974. Although the central pressure of approximately 950 hPa was not exceptionally low, the maximum 3 second gust wind speeds at a height of 10 m in flat open terrain – Terrain Category 2 in terms of the Australian Wind Code - were estimated to have been of the order of 70 m/s and were probably the most severe experienced by any major Australian community during the past 100 years. Although small with an eye diameter of about 8 km, its slow forward speed of less than 10 km/h meant that the destructive winds were experienced for several hours, and it was large enough for the whole of Darwin to be exposed to destructive winds.

At the time the population of Darwin was about 48,000 living in about 8500 houses and about 3000 flats. About 60% of the houses and 80% of the flats were privately owned, and the remainder government owned. The reason for the high percentages of government owned dwellings was that at that time the Northern Territory was governed almost entirely by the Commonwealth Government from Darwin, with a large number of public servants stationed in Darwin. Housing was provided on a rental basis by the Government for the majority of them, along with a relatively high number of Housing Commission dwellings provided for rent to other low income families. Although the proportion of commercial and industrial buildings owned by the government may have been higher than normal in southern cities it would still have been small in comparison to the proportion of such buildings which were privately owned.

After the cyclone 50-60% of the houses were classified as having being destroyed, and only 6% were classified as intact apart from minor damage to wall cladding or windows. Most of the rest were regarded as uninhabitable without major repairs. The intensity of the destruction was more similar to that associated with tornadoes than with tropical cyclones. The resulting evacuation of most of the population was the largest such operation ever conducted in Australia. Damage to larger apartment, commercial and industrial buildings was not as great as that to small buildings such as houses, but was still significant. In addition to the damage to buildings the overhead electrical distribution system in Darwin was almost totally destroyed and significant damage occurred to telecommunication, water and sewerage systems.

Around 70 people are recorded as having been killed, 650 injured, 41,000 made homeless, and over 35,000 evacuated as a consequence of the damage.

The level of damage, combined with the large evacuation of citizens, meant that local building resources in terms of labour, materials and professional services were completely overwhelmed in regard to the repair and reconstruction. Most of these resources had to be obtained from southern Australia. The logistics associated with getting these resources to such an isolated place as Darwin resulted in a large inflation in the cost of these resources, with the overall building costs for the reconstruction being approximately double what they had been prior to Cyclone Tracy. This had a big impact on both the insured losses and the total losses.

Recording of total costs of disasters in Australia is extremely poor. A search on Google for "Cyclone Tracy" and "Cost" headlines its first item as 'Darwin: Cyclone Tracy. Total Cost. $837000000.00' and directs the inquirer to the Emergency Management Australia Disasters Basis as the source. This source indicates that this rather precise figure of $837 million is both the insured cost and the total cost, but gives no indication of whether these are original dollars or current dollars (although the sources are claimed to be a Coroner's Report and two media reports in 2005 so it might be inferred that they are in 2005 dollars). An RMS report published around the same time indicates the insured loss was '$837 million AUD today'. Wikipedia in its article on Cyclone Tracy states that the total cost in original values was $837 million. The Insurance Council of Australia (ICA) in its list of Australian disasters published in 2000 gives the original insured loss in round figures as $200 million which was estimated to be the equivalent of $837 million in year 2000 values! It is almost certain that this ICA estimate in 2000 is the source of all the other reported estimates and consequently they are all misleading.

In a detailed report by the Commonwealth Government's Bureau of Transport Economics (BTE) on the economic costs of disasters in Australia published in 2001, an attempt was made to estimate the total costs of Cyclone Tracy including the costs of deaths and injuries. This came up with an original loss of about $380 million. In 1976 Major General Stretton, the Director-General of the then Natural Disasters Organisation at the time of Cyclone Tracy, indicated that the total cost had been estimated to be of the order of a billion dollars. The original insured loss was of the order of $200 million but the actual cost of the reconstruction of the insured buildings and replacement of contents was much greater than this due to a combination of a large increase in building costs, underinsurance and the large proportion of total losses, with the difference being largely borne by owners. The government outlaid about $200 million to rebuild government homes and in emergency assistance grants, and there would have been considerable other costs related to the initial emergency response, the restoration of infrastructure, and the cost of fatalities and injuries. This suggests the estimate by BTE is probably too low, but that the estimate by Major General Stretton too high. Between $500 million and $600 million would seem to be a more likely estimate of the total cost in original values.

Since 1974 building costs nationally appear to have risen about 8 times but in Darwin they have probably only risen about 5 times since the period of reconstruction because of the inflated building costs during this period. This would suggest that in today's values the total cost of Cyclone Tracy was of the order of $2.5 billion to $3 billion.

1.2 Newcastle Earthquake

The Newcastle Earthquake was a relatively moderate earthquake in terms of its magnitude of M5.6, which was estimated to have originated at a depth of about 12 km on the outer edge of Newcastle on 28 December 1989. Estimated intensities of ground shaking varied from MM6 to MM8 in the Newcastle region, with the most intense shaking being associated with soft soil areas in the inner city area. Ground shaking between MM5 and MM6 was estimated to have been experienced as far afield as Sydney.

The population of the Newcastle region primarily affected by the earthquake at the time of the earthquake was of the order of 300,000 who lived in approximately 100,000 dwellings. Most of these would have experienced ground shaking in the MM6 range, with only a small proportion of them experiencing the most intense MM8 ground shaking. However because the MM8 area coincided with the CBD area a much higher proportion of commercial buildings were exposed to the most intense shaking.

Reports of the number of buildings damaged by the earthquake vary, but are generally between 40,000 including 25,000 homes (EMA Database) and 50,000 including 40,000 homes (NSW State Emergency and Newcastle City Council web sites). Of these about 300 buildings were regarded as total losses with the great majority experiencing minor damage only. The most spectacular damage was generally to larger older buildings constructed on unreinforced masonry, but there were some notable failures of relatively modern buildings including the Workers Club and an apartment building. In general modern brick veneer homes and unreinforced masonry 3-4 story walk up apartment buildings performed well.

Reports of the number of people affected vary between 200,000 and 300,000, of whom 13 died, 9 in the Workers Club, 160 had injuries requiring hospital treatment, and about 1000 were made homeless.

The level of damage was such that it did not create a large number of heavily damaged buildings and homeless residents relative to the size of Newcastle. It is quite probable that the local building resources could have handled the repair and reconstruction. However it happened at a time when there was a recession in the building industry in Sydney with the result that builders from Sydney flocked to Newcastle in the hope of picking up work. As a result competition for repair and reconstruction work was keen and if there was a local increase in building costs for this work as a result of the earthquake it was very small. Most of any increase would have been due to improvements which were often required for older buildings which had been significantly damaged and whose construction did not meet the current building standards.

Reports of the total cost of the disaster are even sketchier than those for Cyclone Tracy, although a reported total insured loss of $862 million in original dollars appears to be more accurate than the rounded estimate of Cyclone Tracy total insured losses. An estimate of $4 billion is commonly reported for the total cost but the source of this has not been found and the author suspects this was an exaggerated estimate that appeared in the media and was subsequently adopted by all for want of any other estimate. There appears to be no rational justification for such a large value. The costs to the NSW government were estimated at about $76 million in one report. The same report indicates that most of the Newcastle City Council building damage was covered by insurance. A reinsurance market report indicates that about half of the insurance losses were expected to be from government losses – presumably due to the fact that the New South Wales Government had catastrophe insurance cover, which at that time was relatively unique among governments. It is therefore likely that most of the losses were covered by insurance, suggesting that the total loss may not have greatly exceeded a billion dollars, and was unlikely to have exceeded 1.5 billion dollars.

Since 1989 building costs nationally appear to have roughly doubled and there was very little local inflation of building costs in Newcastle after the earthquake. This would suggest that in today's values the total cost of Newcastle earthquake was of the order of $2 billion to $3 billion.

2 Impact on Building Design and Construction

2.1 Cyclone Tracy

The intensity of the damage to houses in Darwin from Cyclone Tracy shocked the nation as nothing like it had been experienced on such a scale before in Australia – or anywhere else in the developed world from tropical cyclone winds. The Commonwealth Department of Housing and Construction was particularly shocked. Most of the houses in Darwin at the time, including those privately owned, had been built by the Department. The most recent suburbs were dominated by houses built by them which they believed incorporated the lessons learned from the damage to houses in Townsville from Cyclone Althea three years earlier. Far from these houses performing better, the destruction of them was almost total (partly it should be added because these suburbs also experienced the most severe winds). The Department's response was to authorise a detailed investigation of the damage by external experts, which the author was privileged to lead.

The outcome was a 3 volume report comprising a 97 page volume containing the main report, and 2 larger volumes of appendices containing 10 detailed reports by various investigators of aspects of the cyclone and resulting damage which provided much of the background to the main report. The report, which provided the technical foundation for the reconstruction of Darwin, was completed in 8 weeks and tabled in Parliament in March 1975 less than 3 months after the cyclone.

The investigation observed that buildings structurally engineered to resist wind loads in accordance with the existing design codes had performed relatively well despite estimated wind speeds being well in excess of the design working stress wind speeds then in use. The magnitude of the disaster was largely due to the failure of housing. Cyclone Althea had exposed weaknesses in the tie-down of roofs and in the fixing of roof cladding. The newer houses constructed by the Department had roofs which were very well tied down and the cladding fixings had been tested to pressures which were probably not exceeded in Cyclone Tracy. However, apart from these aspects, they were not structurally engineered to the codes, it being assumed that these were the critical weaknesses. The winds in Cyclone Tracy were much greater than in Althea and they exposed other weaknesses. There had also been a change in the nature of roof cladding, the consequences of which had not been appreciated.

Instead of roofs lifting off the houses failed in racking. Instead of failing at the static ultimate pressure the cladding fastening systems failed at much lower pressures due to a loss of strength arising from fatigue loading of the fasteners under the fluctuating wind loads, a mode of failure which did not occur with the ductile steel roofing used at the time of Althea, but is a characteristic form of failure for the thinner high strength steel roofing which had been introduced a couple of years before Cyclone Tracy. The investigation also highlighted the importance of internal pressures caused by failure of the windward wall envelope, especially windows, which was much more common in Cyclone Tracy than in Cyclone Althea because of the higher wind speeds.

There were a considerable number of recommendations made in the report of the investigation, including detailed design criteria to be used in the reconstruction, but the principal recommendations can be summarised as follows:

- Houses in tropical cyclone areas should be fully structurally engineered to resist wind loads, including both horizontal and vertical components of the wind pressures;
- In tropical cyclone areas all buildings should be designed for full internal pressures assuming a dominant wall opening unless the walls including doors and windows are protected from debris impact or designed to resist it;
- Roof cladding and its fixing systems should be designed to resist the cyclic nature of wind loads including fatigue effects;
- A limit state approach should be adopted to design for wind; (At that time working stress design, which was shown in Cyclone Tracy to be deficient in respect of uplift design, was still the normal method of design.)
- Consideration should be given to the provision of in-residence shelters in houses not at risk from storm surge, and the provision of public shelters for persons living in areas at risk from storm surge;
- Research on GIS modelling of tropical cyclone winds based on recorded information on tropical cyclones, which was then its infancy, should be encouraged to obtain a better understanding wind speed risk for design purposes;
- Incentives should be provided for upgrading the wind strength of existing buildings in cyclone prone areas;
- The insurance industry should adopt a pro-active approach in encouraging the adoption of an engineering approach to the design of housing in cyclone prone areas, and upgrading of existing buildings, through the provision of risk rated premiums;
- Research should be encouraged on wind loads on housing and the structural behaviour of houses under wind loads to underpin the engineering design of houses to resist extreme winds.

The main recommendations regarding the design of new buildings were adopted for the reconstruction of Darwin, and were subsequently adopted throughout the tropical cyclone regions of Australia. Some, like the need for houses to be structurally engineered for wind, have been adopted throughout Australia, utilising the outcomes of the extensive research and development related to the design of houses to resist wind loads which followed Cyclone Tracy. The use of limit state design is now standard practice for all structural design in Australia, but moves towards this were already underway at the time of Cyclone Tracy, which probably only hastened its adoption in Australia. After much debate it was decided that if houses were structurally engineered for wind there should not be a need for in-residence shelters. The need for provision of public shelters was recognised and public buildings like schools designated for this purpose, but it is only in recent years that the need for these to be specially designed for extreme events, including debris impact, to ensure public safety has been fully recognised. Incentives have never been provided for upgrading, either by government or the insurance industry. The insurance industry did not play a major role in the subsequent adoption of higher building standards for wind resistance, but as an encouragement to upgrading did fund the production of detailed guidelines for upgrading older Queensland houses – although unfortunately little use has been made of them, even by the insurance industry as an incentive to upgrading.

The widespread adoption of the recommendations arising from Tracy and the outcomes of the subsequent high level of research into the design of buildings, especially low rise buildings, to resist wind loads which followed have resulted in all new buildings in Australia now being structurally designed to meet the wind code requirements, a situation that is relatively rare worldwide.

2.2 Newcastle Earthquake

The Newcastle Earthquake was a big shock to the people of eastern Australia, as although minor earthquakes had been previously experienced in the region, there had been no major events like the earthquake which shook Adelaide in 1954, or the more severe one which shook Meckering and surrounding areas including Perth in 1969, or occasional large ones which occurred in relatively unpopulated areas like the Tennant Creek earthquakes two years earlier in January 1988. It was also a big shock to the engineering profession who were using an earthquake code developed following the Meckering earthquake which rated Newcastle a non-seismic area in terms of building design. Following the earthquake, as a result of this mutual interest, the New South Wales Government commissioned the Institution of Engineers Australia to undertake an investigation of the damage to determine its significance in relation to the current building regulations and existing buildings. The study team was led by Professor Rob Melchers from the Department of Civil Engineering at the University of Newcastle and included the author.

The outcome was a 2 volume report comprising a 99 page volume containing the main report and a smaller volume containing 4 additional detailed appendices. The report was completed in about 8 weeks and presented to the New South Wales Government in March 1990 less than 3 months after the earthquake.

The investigation concluded that the perception that Newcastle was an area of negligible earthquake risk was largely based on the lack of detailed analysis of seismic risk in the region due to the previous history of a lack of significant earthquake damage. Despite buildings not being designed for earthquakes it was observed that in general damage to modern buildings including houses, with one or two significant exceptions, was largely confined to non-structural aspects. In regard to significant structural damage it was observed that this was mostly associated with areas characterised by alluvial soils and with old unreinforced masonry buildings. Where damage did occur in modern buildings the quality of the construction, particularly in relation to masonry, appeared to be an issue, as well as damage to mechanical and electrical equipment. Although infrastructure and buildings having a post-disaster function suffered relatively little structural damage, non-structural damage caused some disruptions of operations, and it appeared that if the earthquake had been more severe, but not greatly so, there could have been a severe disruption of these services. The investigation also revealed some shortcomings in the powers of local authorities to adequately deal with safety assessment of damaged buildings, and heritage buildings in particular, after such an event, and that underinsurance had created some problems.

The principal general recommendations relating to the design and construction of buildings can be summarised as follows:

- All places in Australia should be regarded as earthquake prone with the earthquake code being revised based on a detailed analysis of the seismic risk;
- Specific provision for the amplification effects of soft soils should be made in the earthquake code;
- There should be minimum structural engineering requirements for non-ductile construction in all parts of Australia;
- Special attention should be given to the design of buildings intended for post-disaster functions to ensure they will remain operational after a disaster.
- More attention should be given to the requirements for achieving the necessary quality of construction to achieve the design structural performance;
- Attention should to be given in the design of mechanical and electrical and electrical equipment in buildings to ensure a satisfactory performance in earthquakes;
- There was a need for a much greater level of earthquake engineering related research in Australia, particularly in relation to earthquake risk and to the behaviour of low rise unreinforced masonry construction under earthquakes.

In regard to disaster management it was recommended that:

- More attention be given to the establishment of sound procedures for the safety inspection of buildings after major disasters like earthquakes including the powers of the local authorities to enforce compliance and the certification of engineers to undertake the inspections;
- Policies be established on the approach to be taken to the preservation of damaged heritage buildings;
- Policies be established for the control of demolition and rebuilding immediately after a major disaster to ensure they are undertaken in a sound manner.

There were also recommendations specific to the repair and reconstruction of damaged buildings in Newcastle.

The response to these recommendations appears to have been mixed.

At national level the earthquake code was revised based on a new earthquake risk map which essentially recognised that all of Australia is earthquake prone. The new code also specifically recognised the amplification effects of soft soils. However in regions of lower seismic risk it was still possible to build low rise unreinforced masonry buildings up to 3 or 4 stories higher with no particular recognition of the earthquake risk. (This may have been changed in the most recent revision.) The issue of buildings with post-disaster functions has been addressed in the Australian Building Code. The earthquake was also the catalyst for a much greater level of research and development related to earthquake engineering in Australia which has continued to the present day.

At the implementation level the Newcastle City Council appears to have been very rigorous in applying the recommendations relevant to its activities. However it is not clear whether the same level of implementation of code requirements is being applied across Australia, particularly in relation to smaller buildings. Some of the issues relating to post-disaster management have subsequently been addressed at emergency services level, particularly in respect to the response period for which clearly defined roles and lines of control have been established within emergency management plans including those relating to building safety, and in the recovery period where it has become the custom after major events for governments to appoint a person to manage it.

Overall the Newcastle earthquake has had a big impact on the design of buildings generally in the Newcastle region, on the design of larger buildings and facilities throughout Australia, and on earthquake engineering research in Australia, but has probably not yet had a large impact on design of low rise unreinforced masonry which probably remains the most vulnerable form of construction in Australia to earthquake damage.

3 Impact on Insurance

3.1 Cyclone Tracy

Cyclone Tracy had a huge impact on both the local insurance industry and the world wide reinsurance industry because a loss of the magnitude experienced was far in excess of previous estimates of the Probable Maximum Loss (PML) to the insurance industry from a natural catastrophe in Australia. Prior to 1974 the largest insured loss from a natural catastrophe in Australia had been that from Cyclone Althea in Townsville in 1971, which in 1974 values was probably about $35 million. At the beginning of 1974 the Brisbane floods had caused an insured loss of about $70 million which had itself been a shock to the industry – so much so that until very recently insurance companies were loathe to provide insurance for floods! That they were at risk from a loss three times from a cyclone was almost inconceivable in an age when estimation of extreme event losses was large based on taking the previous largest loss and multiplying it by a factor such as 2 or 3 and the Brisbane floods having been considered an extreme event.

Although Cyclone Tracy did not cause any major failures in the Australian insurance industry, it did stretch the industry to its limit, with reinsurance levels being exceeded in some cases and companies having to rely on reserves to pay the total amount of claims. For the reinsurers it raised their perception of cyclone risk in Australia by a large amount resulting in large increases in reinsurance premium rates, compounded by the general practice at that time of reinsurers expecting insurance companies to repay the money received from reinsurers after a disaster through increased premiums over the following few years. It is probably reasonable to assume that of the approximately $200 million of insured losses arising from Cyclone Tracy, at least $150 million of this would have been paid by the reinsurers – which was probably between 25 percent and 30 percent of the total cost of Cyclone Tracy – most of which would have been repaid by Australian property insurance policyholders through increased premiums over the following years.

Following the Brisbane floods the insurance industry decided that some of the hazards they were currently covering appeared to be uninsurable by normal insurance, and set up a committee to investigate the feasibility of a natural disaster insurance scheme. In the committee's report tabled in October 1974 it was concluded that floods, earthquakes and associated natural hazards did not satisfy the criteria for insurability and it was suggested that the Commonwealth Government establish a fund for these hazards, financed by a levy on all fire insurance policies, with the Government acting as a lender of last resort in the event of a shortfall in the fund following a major disaster. Surprisingly tropical cyclones were excluded from this list, indicating that the industry did not perceive a major loss from them at that time - but the omission did not last for long. After Cyclone Tracy tropical cyclones were hastily added to the list.

How much notice the government would have taken of the committee's suggestion if Cyclone Tracy had not occurred will never be known. In the aftermath of Cyclone Tracy, and its severe impact on many insurance companies, the government took little convincing that it was not in the national interest to expect the private insurance industry to bear such risks and thus put the whole insurance industry at risk of insolvency. The Government announced that it had decided in principle to introduce a natural disaster insurance scheme and a working party, which included representatives from the insurance industry, was set up to develop the proposal.

This led to a couple of years of intense activity that involved a wide cross section of stakeholders including State and Commonwealth Government Departments, the insurance and reinsurance industry, hazard researchers in Universities, CSIRO, the Bureau of Meteorology, the Bureau of Mineral Resources (now Geoscience Australia), and the engineering profession. However, despite all the good work and the initial strong commitment of both the Government and the insurance industry it all came to nothing. A major factor was probably that in the 6 years following the announcement of the proposal there were no disasters causing major insurance losses, which allowed time for the insurance industry to get back on its feet, and adjust to the new perception of risk by the reinsurance community, and for the public to adjust to the increases in premiums which had followed the events of 1974.

However in the insurance industry things had changed, including the introduction of a more rational approach to the estimation of PML's by considering the total aggregate of insured values at risk from catastrophic loss in different zones based on concentrations of the population at risk from a single event and multiplying this by an estimated probable maximum percentage loss over the region from a single event. The approach was subsequently adopted worldwide by the reinsurance industry as the CRESTA Zone method of PML estimation.

The catastrophe zone approach combined with the high levels of damage that were now perceived as possible after Cyclone Tracy resulted in the cyclone risk in Queensland being considered the major insured catastrophic risk in Australia with the risk to Brisbane, which was considered to be at risk from a 10 percent loss, dominating the PML values. A major consequence of this was a much higher level of reinsurance at higher premiums being purchased internationally by Australian insurance companies. This had to be funded by increased premiums, and means that one consequence of

Cyclone Tracy is that Australians began paying a much larger amount of money each year for protection from damage from catastrophic events through insurance premiums, most of which went off shore to the international reinsurance industry. This is the primary way individual Australians pay for the cost of disasters. One consequence of Cyclone Tracy is that Australians began paying a more realistic price in relation to the risk – thus averting some of the problems experienced in some other countries such as the United States.

3.2 Newcastle Earthquake

The Newcastle earthquake was also a shock to the Australian insurance industry, although not on the same level as Cyclone Tracy. The industry was aware there was an earthquake risk in Australia as a result of the Adelaide earthquake in 1954, the losses from which were largely covered by insurance, and also of the Meckering earthquake. Prior to 1974 an earthquake in Adelaide had been considered the major natural catastrophe risk to the insurance industry, and extrapolations of this loss had been the primary approach to estimating PML's by national insurance companies. However away from Adelaide and Perth it was generally assumed that the almost universal provision of earthquake insurance was a 'give-away' and it was priced accordingly. The Newcastle earthquake changed this perception in a big way.

It wasn't the Newcastle earthquake itself which was the problem. The insured loss was well covered by the much higher PML's based largely on cyclone exposure that had become normal after Cyclone Tracy. Of the estimated total insured loss of the order of 900 million in original dollars, the international reinsurance market probably paid between $500 million and $600 million – which would probably have been between 40% and 60% of the total cost of the earthquake. The concern was that the earthquake at M5.6 was a relatively small one and significantly larger ones could no doubt occur, and furthermore Newcastle was not far from Sydney with a population many times larger, and if an earthquake could happen so unexpectedly in Newcastle may be one could not only occur in nearby Sydney but also in Melbourne.

The difficulty the insurance industry faced was that the zone method of estimating PML's was not much help when there was no past experience of loss from a major earthquake other than the Newcastle loss. Fortunately it occurred at a time when a new method of estimating PML's based on GIS modelling of catastrophic events losses was becoming established in the US. In the aftermath of the Newcastle Earthquake a group of Australian insurance companies commissioned consultants to model their earthquake insurance risk in Australia's major capital cities, which was soon followed by other such studies, leading the way to this approach becoming the standard method of estimating PML's by Australian insurance companies. It would have eventually happened anyway, but it may not have happened for another decade if the Newcastle earthquake had not occurred.

The modelling showed that the previous estimates of insured risk from tropical cyclones were in most cases overly conservative, particularly the risk to Brisbane, but that the risk from earthquakes was very much greater, with the PML's arising from the estimated earthquake risk in Sydney and Melbourne dominating the overall risk. One consequence of this is that earthquake risk now dominates the overall catastrophe insurance risk in Australia. In 2006 the author estimated that of the total expenditure by Australians of the order of $750 million on the purchase of catastrophe insurance, $450 million of this was for earthquake cover, most of which went off-shore in the form of reinsurance premiums making Australia one of the largest purchasers of earthquake reinsurance in the world.

An insurance issue raised by the Newcastle Earthquake was the requirement by local authorities that any significant damage be repaired to current code standards, whereas traditional insurance was for replacement as it was. A consequence of the earthquake was a change by insurance companies in their attitude to this problem with replacement to current code becoming the basis of insurance policies.

4 Comparison of Events and Consequences

4.1 Similarities

The Cyclone Tracy and Newcastle Earthquake events, and the consequences of them, had a number of similarities including:

- They were both a big surprise to the building industry and the insurance industry – as well as the general Australian community;
- The probable total cost of each was roughly similar at somewhere between $2 billion and $3 billion in current day terms;
- The major damage investigation reports, the recommendations of which played a major role in the subsequent reconstruction, repair and revision of building codes, were both produced within 3 months of the events – a much shorter time than commonly associated with the production of such reports from much smaller events;
- They both led to significant changes to the assessment of the relevant hazard risk and design codes – ie the wind speed risk and the wind code in relation to cyclone Tracy, and earthquake risk and the earthquake code is respect of the Newcastle earthquake;
- They each led to a big increase in research in Australia related to the mitigation of damage from their respective hazards of wind and earthquake;
- They both led to major changes in perception of catastrophe insurance risk in Australia;
- They both led to major changes in the analysis of catastrophe insurance risk in Australia.

4.2 Differences

There were also some significant differences including:

- Darwin was effectively a city controlled centrally by the Commonwealth Government, whereas Newcastle was a more normal Australian city with a relatively strong local government responsible for some issues like planning and local building control, the New South Wales government in control of some issues including emergency services and building regulations, and the Commonwealth government also having some influence.
- The damage was so great to Darwin that most of the population had to be evacuated and temporary accommodation provided for most of those who stayed or came to assist in the recovery. The damage to Newcastle was small in comparison to the total size of the community with only a tiny proportion of the population being made homeless.

- Cyclone Tracy had a much greater impact on the design of all buildings in cyclone prone areas, and houses in the whole of Australia, in respect of wind resistant design, than the Newcastle Earthquake appears to have had in respect of earthquake resistant design in Australia generally;
- The Newcastle Earthquake raised a number of building damage issues in respect of managing the immediate response that do not appear to have been raised by Cyclone Tracy including the authority of local authorities in respect of assessment of safety of damage buildings and the qualifications of engineers who undertake this task, what to do with damaged heritage buildings, and the overall control of demolition, repair and reconstruction of buildings
- Cyclone Tracy had a much larger impact on the relationship between the insurance industry and government, triggering as it probably did a major investigation aimed at the development of a national disaster insurance scheme in Australia. The Newcastle Earthquake had no similar impact;
- As a result of a larger proportion of the losses being recovered from international reinsurance companies the net loss to Australians from the Newcastle Earthquake was probably significantly less than that from Cyclone Tracy in today's values, despite the total costs being roughly similar;
- In respect of the current assessment of catastrophe insurance risk and pricing of catastrophe insurance in Australia, the Newcastle Earthquake has probably had a much bigger impact than Cyclone Tracy.

5 Comments on Differences

Cyclone Tracy had a much bigger impact on the building industry nationally because of the intensity of the damage which demonstrated serious shortcomings in building construction at the time in relation to wind resistance, particularly in regard to houses. In addition the social impact had a major psychological impact on the whole government which was reflected in a determination by the Australian Government to make Darwin a safer place to live in regard to cyclones. The recommendation that houses should be structurally engineered to resist wind loads was a radical suggestion at the time and its subsequent implementation Australia wide had little precedent elsewhere in the world apart from New Zealand in respect of earthquake resistant design. It may not have happened if the Commonwealth Government had not had such a large vested interest in Darwin.

While the Newcastle earthquake raised significant questions about the earthquake resistance of much modern construction in Australia, particularly the widespread use of unreinforced masonry which is generally regarded as a 'no no' in earthquake prone areas, the overall relatively good performance of modern buildings incorporating unreinforced masonry meant it was not viewed in the same light as the weaknesses exposed in Darwin. In some ways the Newcastle Earthquake was more like Cyclone Althea in terms of potential hazard severity – not a very good indicator of what might happen if an earthquake occurs which produces ground motions approaching those envisaged for an extreme event. Non-ductile construction performs well in earthquakes up to its failure limit – above which it performs extremely poorly. Because it performed well in the Newcastle Earthquake there is no certainty it will perform as well in an earthquake producing significantly larger ground motions. Hopefully the continuing research on the earthquake performance on non-ductile construction will eventually lead to a resolution of this issue.

At the time of Cyclone Tracy Darwin was effectively a city governed directly by the Commonwealth Government with a highly centralised form of control which was exercised to the full limit following the cyclone. Bureaucrats had decision making power, which they exercised, combined with all the resources of the national government. There was also a clear chain of authority with Major General Stretton in charge during the immediate response period, and then the Department of Housing and Construction together with the government appointed Darwin Reconstruction Commission responsible during the recovery period. Decisions were made centrally, often in Canberra, and acted upon with not a great deal of room for political interference, either internally within government, or externally at the local level. Cyclone Tracy was unique in this respect. At the time of the Newcastle Earthquake there were no clear lines of control with each group in the community, both government and non-government, initially responding as it saw fit. The special issues in relation to damaged buildings were a consequence of this. It is notable that in more recent events like the Sydney Hailstorm and Cyclone Larry the response and recovery were undertaken in a much more orderly manner than that following the Newcastle Earthquake.

There was no pressure on the Commonwealth Government for a national disaster insurance scheme following the Newcastle Earthquake primarily because by that time both the local insurance industry and the international insurance industry had developed sufficient confidence in their understanding and handling of catastrophe insurance risk that they no longer considered Government involvement necessary or desirable in respect of wind and earthquake risk – although they still had a problem in respect of flood risk.

Within the insurance industry there was recognition following the Newcastle Earthquake that it needed to use more sophisticated tools to assess and manage catastrophe insurance risk and the implementation of these changes has revolutionised the management of catastrophe insurance risk in Australia over the 20 years since the earthquake. Initiated in the US before the earthquake these tools have now become a standard part of the catastrophe insurance and reinsurance management worldwide, and their adoption has played a major role in ensuring that in general insurance and reinsurance companies have not been severely affected by the very large insured losses worldwide during the past decade or by the current global financial crisis.

6 Concluding Remarks

Much is made about the dangers of climate change to Australia, but regarding its potential impact on buildings in respect of extreme winds, and on the insurance industry in respect of its capability to meet occasional extreme catastrophic losses, Australia is in a very sound position. The winds for which buildings are currently being designed are very extreme, and will remain so under the most likely scenarios of the climate change being currently presented. The insurance industry in Australia currently assumes a maximum potential insured event loss of the order of $15 billion dollars in determining the amount of reinsurance to buy based on the perceived probable maximum insured loss from an earthquake in the Sydney region– which is of the order of 10 times the insured loss from the Newcastle Earthquake and over 5 times the total loss from Cyclone Tracy in current values. That Australia is in this position can be largely attributed to the consequences of Cyclone Tracy and the Newcastle Earthquake. Of course there has been considerable growth of communities in tropical cyclone prone areas since Cyclone Tracy but much of this has been undertaken using the codes developed after Cyclone Tracy so that even in an extreme event like Cyclone Tracy the intensity of damage is expected to be very much less, and these risks are being monitored regularly using sophisticated tools developed in recent years.

Cyclone Tracy and the Newcastle Earthquake were major catastrophic events in Australian history which had a big impact on our current building codes and catastrophe insurance practice. It is likely that without them Australia would not be as well prepared for a major catastrophe due to extreme winds or earthquakes as it is. A price was paid for this benefit, but the social cost was probably much greater than the financial cost, which pales in comparison with some of the reported financial losses from the current global financial crisis, and in today's values was probably only of the order of 3 to 4 times the annual amount paid by Australians to insure themselves from such events.

7 Sources of Information

This paper is based on a personal distillation of information from many sources. The principal sources of information are listed below.

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