Structural Monitoring Policy: What Australia Could Learn From The Philippines

A. Pascale[1]

1. Chief Technology Officer, Seismology Research Centre, VIC 3121, Australia
   Email: adam.pascale@src.com.au

Abstract

Very few countries require buildings and other structures to be monitored for response to earthquake. Australia has no such requirements, nor authorities making strong recommendations, presenting an opportunity for AEES.

In the Philippines, an optional recommendation for structural monitoring that has been in place for over 20 years is now a mandatory requirement, driven by the expectation of a large earthquake occurring near Manila. This presents a great opportunity to learn about ground motion attenuation across major cities and about how buildings perform compared to their design.

This paper looks at the how the Philippines Department of Public Works and Highways Guidelines and Implementing Rules for Earthquake Recording Instrumentation for Buildings has evolved since originally published in the National Structural Code in 1992. Do the current guidelines reflect the changes in technology in building design, construction and monitoring equipment in the last 24 years? Has the implementation methodology been specified to optimise the value from having hundreds (possibly thousands) of high quality monitoring points throughout major cities? Should a greater variety of buildings be instrumented than the current rules specify?

The function of the structural monitoring is two-fold: to provide a seismic alarm to building occupants to indicate whether or not the level of shaking they just experienced warrants evacuation, and also to provide data to seismologists and structural engineers to learn more about how earthquakes affect cities and their structures. Some changes are suggested to the guidelines to maximise the benefits from this monitoring policy.

Keywords: building, structural, monitoring, policy, instrumentation

POLICY HISTORY

In 1992, the National Structural Code of the Philippines (NSCP) first introduced the requirement for seismic monitoring of structures for engineering design purposes. The 1992 Northridge and 1995 Kobe earthquakes demonstrated that factors other than strength design capacity needed to be considered, so the monitoring requirement was revised in 2001 and reiterated in 2010. The NSCP 2010 stated that buildings above 50 metres should have three seismic monitoring points installed, but at this time the requirement for instrumentation was not mandatory.

Recently the Director of PHIVOLCS (the national earthquake authority) officially issued a warning that an earthquake of up to magnitude 7.2 is overdue for the West Valley Fault, which would be potentially devastating for Manila and surrounding populated areas. In 2015, the Department of Public Works and Highways (DPWH) issued a directive to all building officials that the seismic monitoring requirement would no longer have exemptions, and released a document titled "Guidelines and Implementing Rules on Earthquake Recording Instrumentation for Buildings".

CURRENT POLICY

The requirement to install earthquake recording instrumentation applies to *existing* and newly constructed buildings located in Seismic Zone 4 (the entire Philippines except for Palawan and Tawi-Tawi, located in Zone 2). Building owners must satisfy these requirements before an annually renewed Certificate of Occupancy will be issued, and a plan to instrument a structure must be demonstrated before a new building permit is issued.

The DPWH Guidelines outline which buildings should be monitored due to their size, importance and classification, which is a reasonable approach that will cover a good selection of building types for response.

TYPE/HEIGHT OF BUILDING	LOCATION OF INSTRUMENT
GOVERNMENT BUILDINGS	
A. Hospitals, schools and other buildings above fifty (50) meters in height	At least 3 accelerographs located at: 1. Ground Floor / Lowest Basement; 2. Middle Floor; and 3. Floor Below Roof
B. Hospitals with fifty (50) bed capacity or more and schools with twenty (20) classrooms or more but not less than three (3) storeys	One accelerograph installed at: Ground Floor / Lowest Basement
C. Provincial/City/Municipal Halls and Buildings	One accelerograph installed at: Ground Floor / Lowest Basement
PRIVATE BUILDINGS	
A. Buildings above fifty (50) meters in height	At least 3 accelerographs located at: 1. Ground Floor / Lowest Basement; 2. Middle Floor; and 3. Floor Below Roof
B. Hospitals with fifty (50) bed capacity or more and schools with twenty (20) classrooms or more but not less than 3 storeys	One accelerograph installed at: Ground Floor / Lowest Basement
C. Commercial buildings with occupancy of at least 1,000 persons or gross floor area of at least 10,000 square meters.	One accelerograph installed at: Ground Floor / Lowest Basement
D. Industrial buildings with occupancy of at least 1,000 persons and gross floor area of at least 10,000 square meters	One accelerograph installed at: Ground Floor / Lowest Basement

A POLICY FOR AUSTRALIA

It took a statement from the head of the Philippine national earthquake agency to spur structural monitoring activities into action. The recommendation had been in place for years prior, but it was just that – a recommendation. As such, building owners accepted that it was a good idea, and some proactive owners installed equipment years ago. The fact that the recommendation became mandatory has made it easier to for owners to accept that the cost of such a program was their responsibility.

Whilst some may speculate that the government should bear the responsibility of earthquake monitoring, this is not earthquake monitoring – it is structural monitoring. The government already has an earthquake monitoring network that meets its needs.

There exists expertise within AEES to provide guidelines and recommendations for structural monitoring in Australia. It is widely recognised that there are many locations in Australia where a magnitude 6+ event is possible near major populated areas. A similar earthquake warning from Geoscience Australia may then spur our own regulatory authorities to make a monitoring program compulsory.

THE IMPORTANCE OF MONITORING LOW RISE BUILDINGS

The DPWH requirement to monitor three points in buildings is solid policy, but the policy infers that it is more important that we learn about the performance of tall buildings rather than the performance of structures below a height of 50m above the ground. On the contrary, buildings below 50m are more likely to have natural periods that will resonate with the frequencies generated by large nearby earthquakes. As such, they are more likely to be damaged from earthquakes, and are more likely to produce useful data for performance, safety, and design verification assessments.

There are many more low rise buildings in existence and being constructed than high rise structures, so learning about how they perform is arguably of higher importance. As previously mentioned, in the Philippines it is the building owners that are expected to fund the monitoring instrumentation, so it is more likely that the owner or body corporate of a larger building may be able to fund the higher cost of more instrumentation. This may have been a factor in the decision to have fewer instruments in low rise buildings.

Locating instruments on the ground floor or lowest basement of a building (as is the policy for low rise buildings with a single monitoring point) will provide input ground motion data. The main purpose of this policy is to gather information about building response to earthquake, and to enable rapid evaluation of potential damage. By only monitoring the ground movement, little will be discovered about the building response during a seismic event. The data can be used as an input into a theoretical model of the building, but this is only measuring the performance of the modeling software, not measuring the performance of the building in the real world.

If a single accelerograph is to be installed in a building, it would be beneficial to have this instrument be located at the top of the building. The input ground motion will be very similar over large areas with similar geological profiles, so top-of-building motion relative to ground motion recorded at a nearby location would give a better measure of structural response than by modeling response from input motion. In most regions there will be a tall building with a basement accelerograph that can serve as the input ground motion reference.

WHAT BUILDINGS SHOULD WE MONITOR IN AUSTRALIA?

The rules around which buildings should be monitored in the Philippines is clear and has some logic, but it doesn't necessarily provide the best data set for learning about the response of different types of buildings. Many buildings will be of similar size, design, construction, and located in similar geological settings. From a rapid response perspective it makes sense for each building to have a seismic alarm system, but monitoring similar buildings in similar areas is not going to add as much to our knowledge of building response as monitoring a variety of building types.

Creating a useful database of seismic structural response should involve monitoring a range of types of buildings (size, shape, construction method, materials, etc) in areas of differing geology and varying distances from possible earthquake source zones. This would reduce the number of buildings that need to be monitored, but provide a richer data set to use for engineering analysis.

Which buildings are selected, and who pays? A random lottery to select buildings of certain types would surely be unpopular with those selected if they were expected to cover the costs alone. One model could be that all owners of certain types of buildings (perhaps the building types required to be monitored by DPWH) contribute a small annual fee to a funding pool that is used to install and operate a selection of building types in a range of areas. A lottery would then be used to selected which buildings in an area are monitored. This makes the lottery result a positive for the building owner.

RESPONSE AFTER AN EVENT

One of the main aims of the monitoring program in the Philippines is to rapidly assess the structural integrity of the building after a significant earthquake.

The DPWH guidelines recommend that the instruments be able to raise a seismic alarm, which could be connected to the building control systems. Unfortunately there is no guidance on what level of shaking should trigger this alarm. Each building will likely have a different design load, but a level of acceleration should be defined where the alarm would sound indicating that it would be prudent to evacuate the building. A default value should be nominated that the local building engineers could modify, but at the moment there is confusion by the owners as to how this facility should be used.

After a significant event there will be dozens, possibly hundreds of buildings requiring rapid assessment. Collecting data manually will be a slow, possibly difficult process due to other emergency actions that may be operating at the same time. The DPWH guidelines state that data is to be collect by the building owner and made available to DPWH for engineering assessment after magnitude 6+ earthquake, but it is unknown how soon a notification could be generated to say that building is safe to re-enter. It is not practical to have residents locked out of their homes for days simply because data from their structural monitoring system cannot be cleared due to collection, transmission or analysis delays. The resources required to care for the displaced or injured population will be significant without adding to the load by needing to care for people waiting for building inspections.

CENTRALISED DATA COLLECTION AND ANALYSIS

The obvious solution is to have building response data readily accessible in a central facility so that structural engineers can rapidly assess buildings. Fortunately the DPWH requirements do specify that instruments must have the capability of data telemetry using modern protocols. It would be relatively simple to establish a central data repository, but it is not known if there is currently a plan for such a resource.

In addition, any central system will need to integrate data from different makes and models of seismic instrumentation, but as no data format or structure has been specified in the guidelines, some effort would be required to ensure a centralised repository will present data to assessors in a uniform, quality controlled manner.

CONCLUSION

The DPWH guidelines and mandatory monitoring requirements are a huge step towards improving earthquake engineering knowledge. Although the policy could be tweaked to collect a wider range of building profiles, the program as it stands will produce a rich data set that will be of great value to seismologists and earthquake engineers for many years to come, and will provide systems that will be of practical use to occupants and building managers in emergency situations.

AEES should take an active role in defining the monitoring requirements for structures in Australia. It is easy to say that we have engineered our buildings to certain standards and that we know how they will behave in an earthquake, but in reality a building has more factors affecting its response than can be modeled. Actually recording the response of various types of structures to a variety of earthquakes is the only way we can verify structural performance. Without real data from real buildings being shaken by real earthquakes, all we have is a theory about structural response. As scientists and engineers we should strive to verify our theories with real data, something that is currently lacking in earthquake engineering in Australia.

REFERENCES:

The Philippine Star (16 May 2015)
http://www.philstar.com/nation/2015/05/16/1455406/phivolcs-chief-explains-timing-feared-7.2-quake

Philippines Department of Public Works and Highways Guidelines and Implementing Rules for Earthquake Recording Instrumentation for Buildings (12 March 2015)
http://www.dpwh.gov.ph/pdf/RulesonEarthquake%20%20_Accelerograph.pdf