RELIABILITY ANALYSIS OF DAMAGE ACCUMULATION IN BRIDGE STRUCTURES SUBJECTED TO MULTIPLE EARTHQUAKES IN AUSTRALIA

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Although Australia is not located in a high seismic region, the damage accumulation caused by multiple earthquake impacts could still have a significant impact on the service life of bridges. In this study, a reliability-based assessment framework is presented to quantify the damage accumulation of the bridges caused by multiple earthquakes and progressive deterioration throughout their service life.

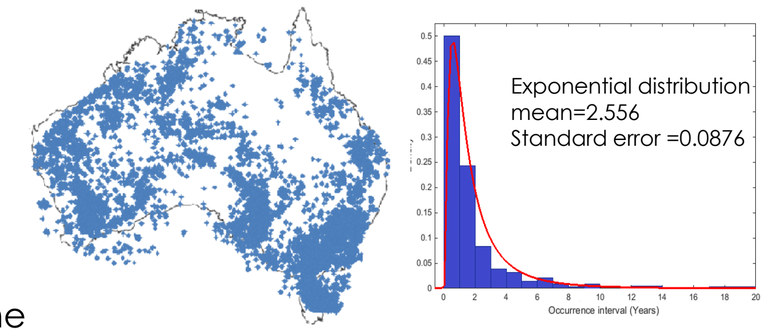
Earthquake is one of the major natural disasters which causes damage to infrastructure even loss of human lives. Although Australia is not located in a high seismic region, the impact of multiple earthquakes over time can cause severe damages to the bridges as a result of damage accumulation exceeding the threshold limit of the structural capacity of the bridges. Damage can be due to

- Multiple earthquake impacts and
- Progressive deterioration

In this study, we proposed a reliability based analysis framework to predict the damage accumulation of bridges due to multiple earthquakes in combination with progressive deterioration. The framework takes into account the probabilistic nature of the earthquakes in Australia (e.g. occurrence interval and magnitude) through statistically analysing the earthquake data occurred in Australia from 1900 to 2016 (Geoscience Australia, 2016).

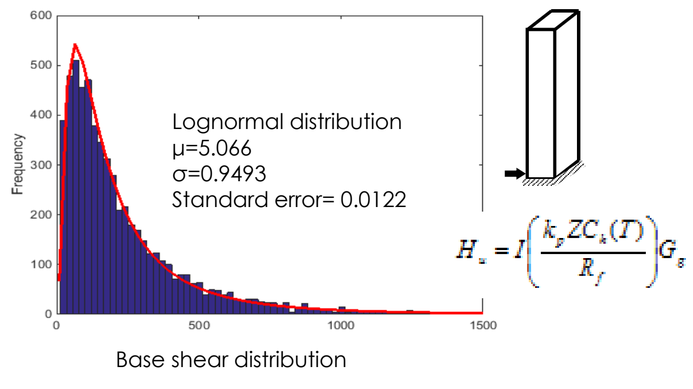
STATISTICAL ANALYSIS OF GEOSCIENCE AUSTRALIA DATA

A total of 24,747 earthquakes occurred in Australia during the period from 1900 to 2016 (Geoscience Australia, 2016)were statistically analysed with the aim of understanding the distribution of earthquake occurrence interval.



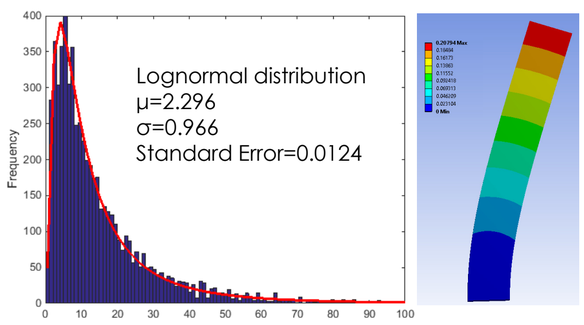
DAMAGE DISTRIBUTION OF THE BRIDGE

A typical reinforced concrete girder bridge (*i.e.* Tenthill Creek Bridge, 82.15m long and 8.6m wide)in Gatton, Queensland, Australia was selected as a case study.
The base shear force (H_U) acting on this bridge was calculated according to AS 5100 (2004) and AS 1170.4 (2007).



$$H_u = I\left(\frac{k_p Z C_h(T)}{R_f}\right) G_s$$

$$Percentage\ of\ damage = \left(\frac{\Delta_D}{\Delta_C}\right).100\%$$

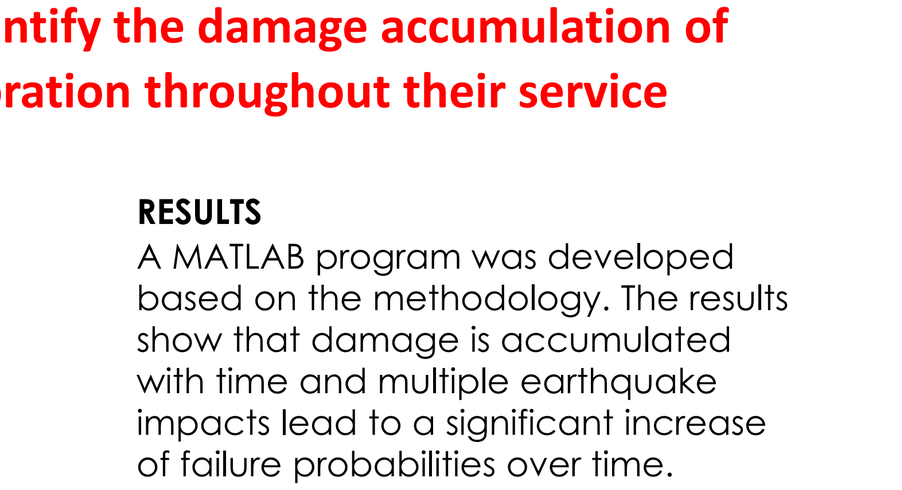


AS 3600 [31] specified deflection limit for a cantilever beam (Δ_C) = H/125

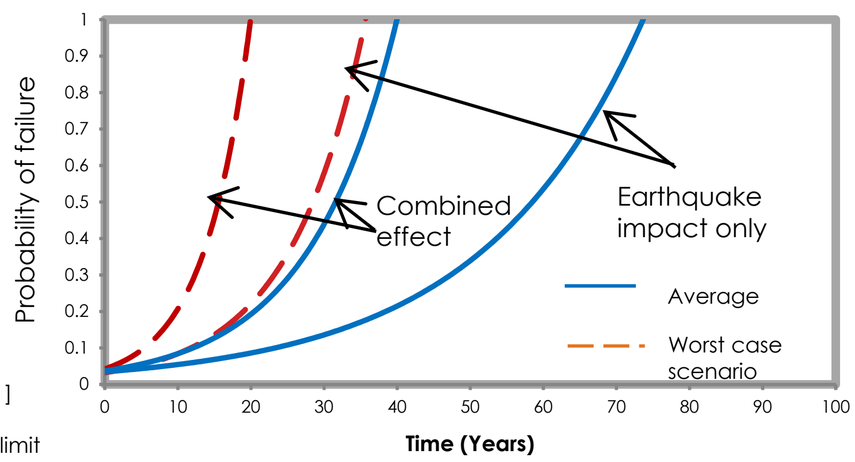
Deflection demand (Δ_D) due to base shear force calculated from FEM

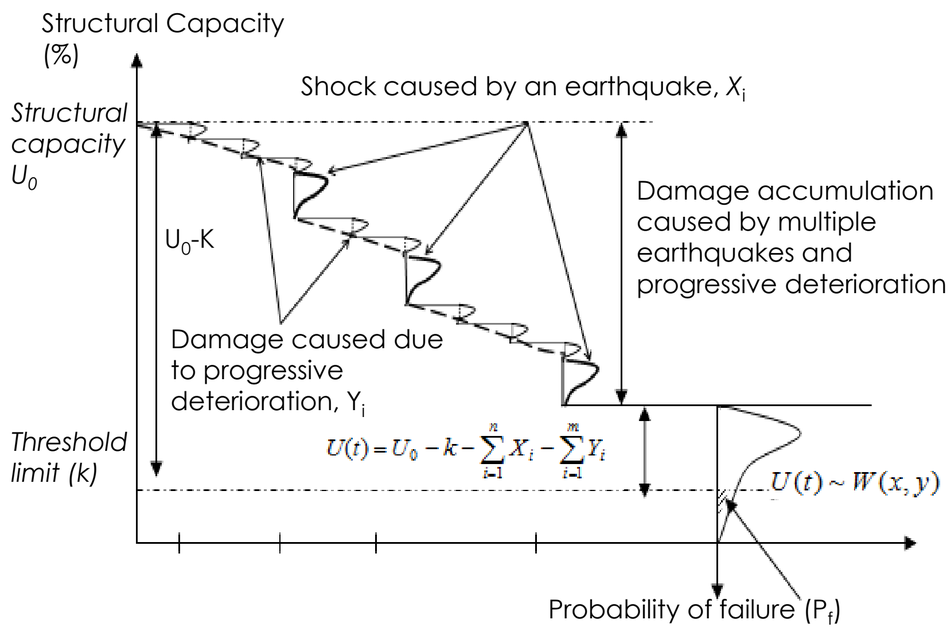
RESULTS

A MATLAB program was developed based on the methodology. The results show that damage is accumulated with time and multiple earthquake impacts lead to a significant increase of failure probabilities over time. Further it shows that, under seismic conditions in Australia, the service life of bridges could reduce from100 years (design life) to 72 years only due to the impact of multiple earthquakes, and the life span could significantly reduce to 36 years in the worst case scenario.



The comparison of probability of failure of multiple earthquake impact and the combined effect of earthquake impact and the progressive deterioration shows that in the worst case scenario, the service life of a bridge could reduce to 20 years.





Where U_0 is the initial structural capacity, X_i is the size of the shock caused by the *i*-th earthquake, Y_i is the *i*-th small damage size occurring at Δt fixed time intervals, *k* is damage threshold and U(t) is the remaining structural capacity at time t.

REFERENCES

Geoscience Autralia.(2016)http://www.ga.gov.au/earthquakes/searchQuake.do

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