

# Rockfill Dams – From Simulation to Failure

Numerical investigation of the dynamic response of rock-fill dams under varying-intensity earthquake excitations

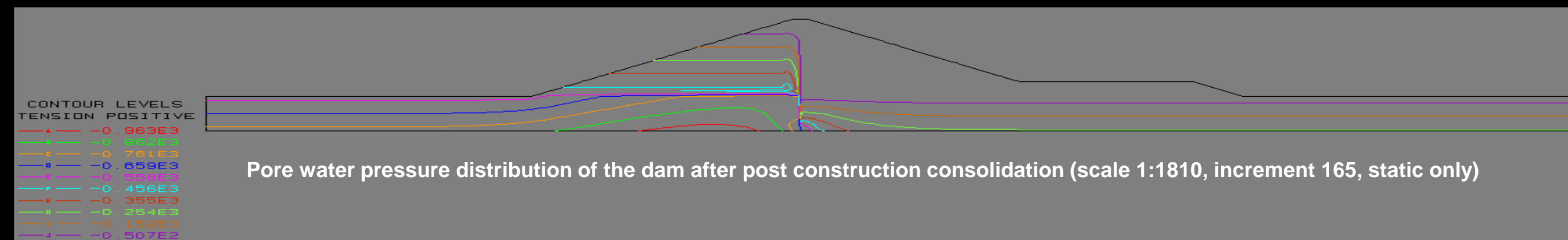
SIU KEI TAM supervised by Dr Bo Han

## YELE DAM

This thesis will investigate the dynamic responses of the well documented Yele Dam using the Imperial College Finite Element Program (ICFEP). This will be achieved by:

- Conducting static analysis to simulate the geological history, construction and impounding of the dam.
- Conducting dynamic analysis under varying intensities of earthquake excitations to deduce the most critical intensity and the potential failure mechanisms that may occur.

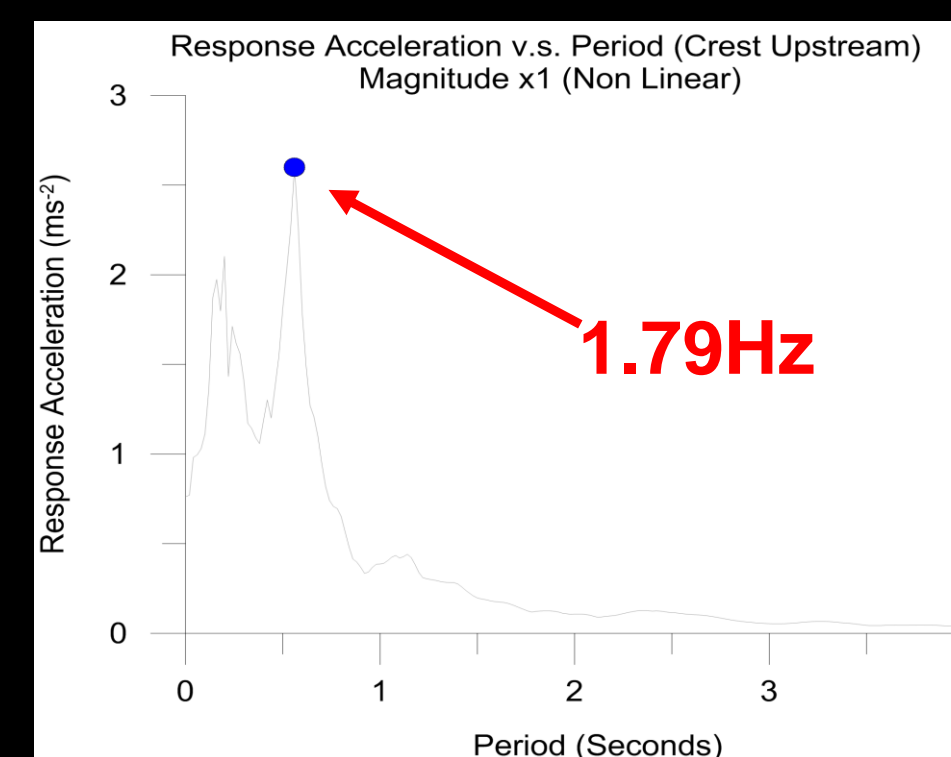
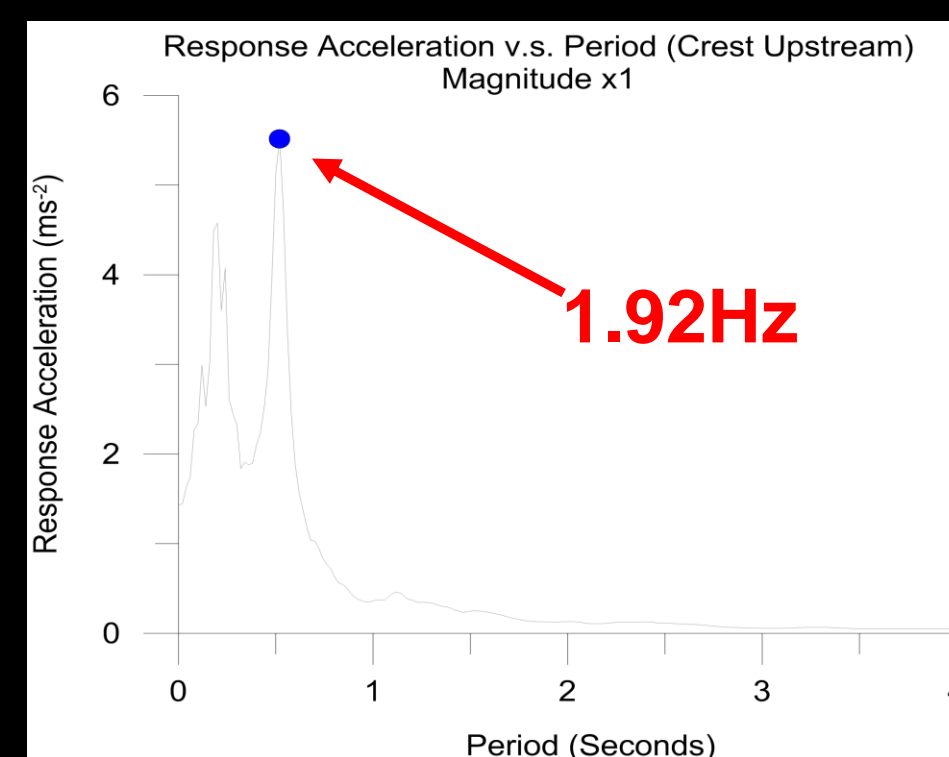
## FINITE ELEMENT SIMULATION



## LINEAR OR NON-LINEAR?

The ICFEP is able to implement a number of models to simulate the behaviour of soil. Ultimately, the Cyclic Non-linear Hyperbolic model coupled with Mohr-Coulomb failure criterion was implemented for the following reason:

- Realistic simulation of the non-linear soil behaviour at large strains.
- Acceptable computational times.



From the response spectra:

- The non-linear behaviour of soils shift the predominant frequencies lower by filtering high frequency content from the input motion (Huang et al, 2001).

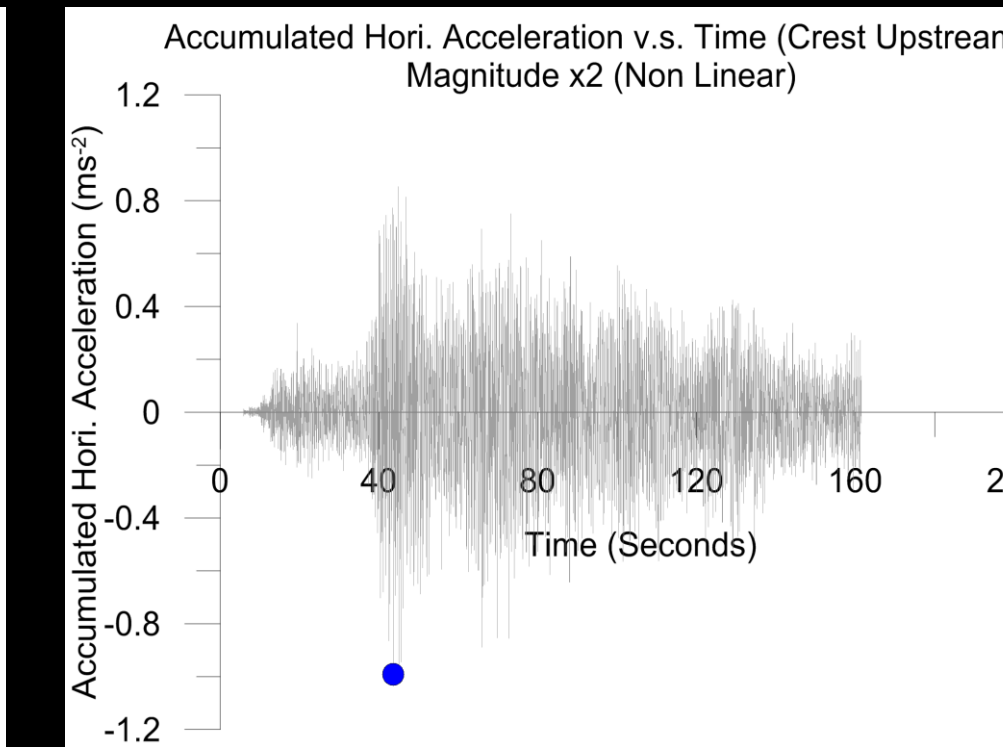
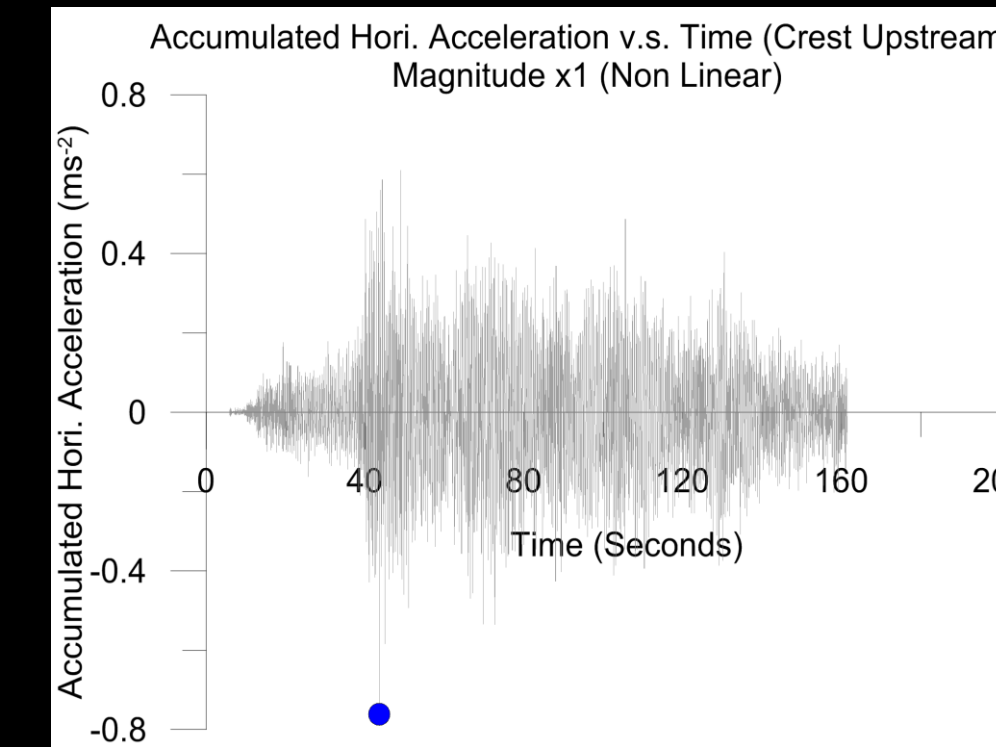
## EARTHQUAKE MOTION – LARGE ENOUGH FOR FAILURE?

After establishing the need to incorporate the non-linear model, a variety of interested parameters are compared under varying intensities, namely 1,2,4 and 8 times the original, established input motion. This is to identify any potential failure mechanisms occurring at the various intensities.

## REFERENCES

Huang, H., Shieh, C. & Chiu, H. (2001) Linear and nonlinear behaviors of soft soil layers using Lotung downhole array in Taiwan. *Terrestrial, Atmospheric and Oceanic Sciences*. 12 (3), 503-524.

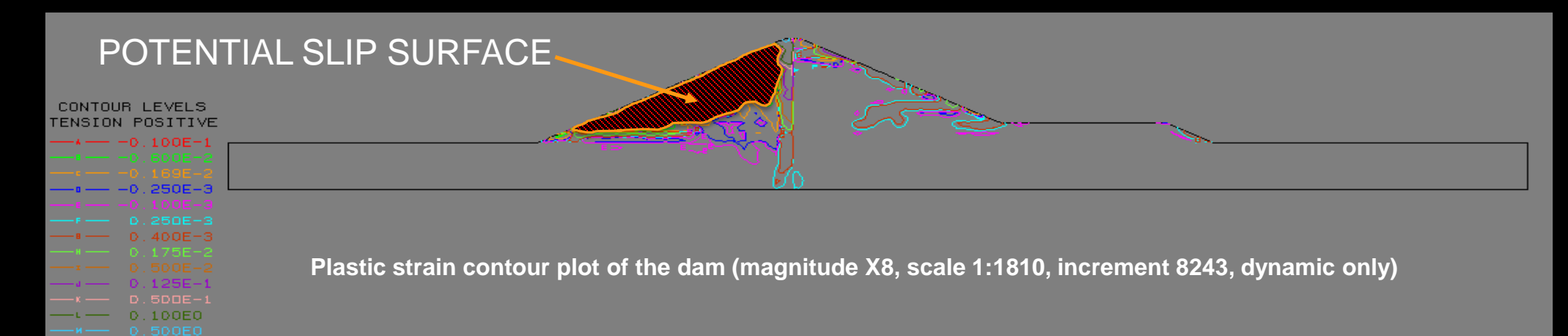
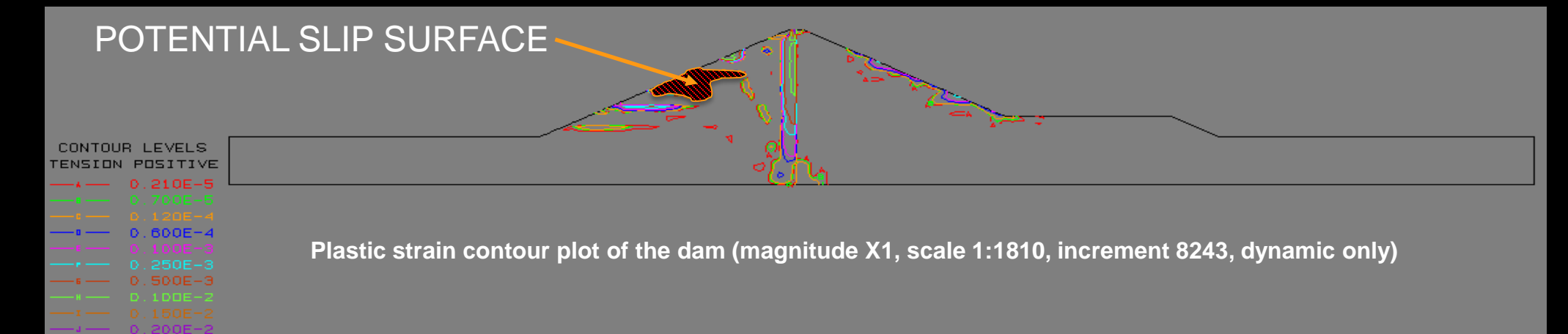
## DYNAMIC RESPONSE - ACCELERATION



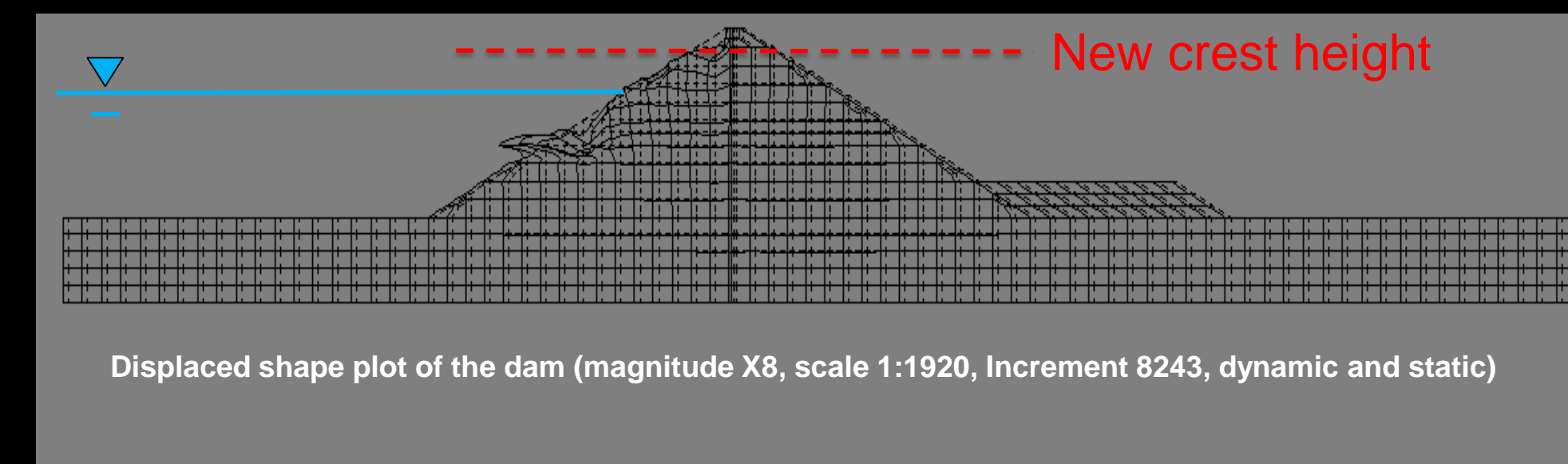
- Maximum peak ground acceleration (PGA) at crest-upstream section of the dam.
- PGA increases with the intensity of the input motion.

## FAILURE BY PLASTIC SLIP SURFACE?

- Plastic shear strain increases with intensity.
- Plastic shear strain increases with height in the dam except for intensity X8 where the maximum plastic shear strain relocated to the middle.
- Larger plastic zones and potential slip surfaces as intensity increases.



## FAILURE BY OVERTOPPING?



- Displacement increases with intensity of seismic motion.
- At 8 times the intensity, the total vertical displacement at the crest is -1.64m which is still within the dam freeboard allowance (6.19m) therefore there is no immediate danger of failure by overtopping.

## CONCLUSION

In conclusion, the ones with the most potential for plastic failure are at four and eight times the original input motion. On the other hand, the intensity that has the most potential for failure by overtopping is at eight times the original input motion where the value of maximum vertical displacement at the crest is nearly twenty times greater than the next closest intensity. It is highly recommended to incorporate a coupled consolidation analysis for future works.

## ACKNOWLEDGEMENTS

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