

*Research Summary*  
*14 March 2019*

*Kieran Haymes*

# Developing Procedures for the Prediction of Floor Response Spectra



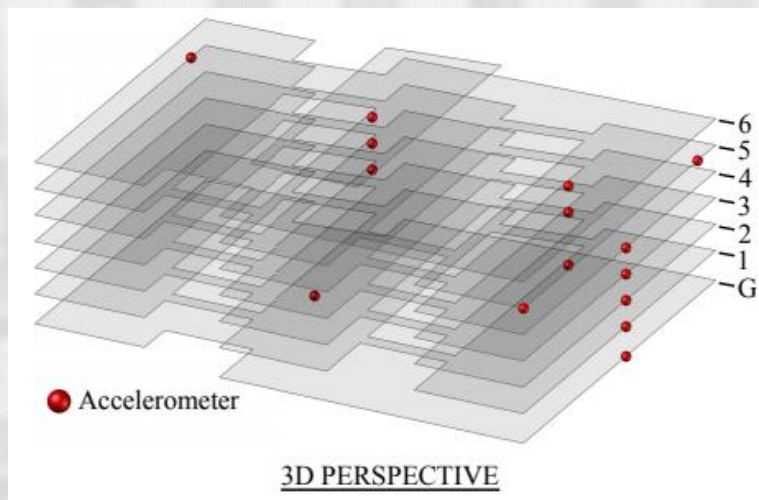
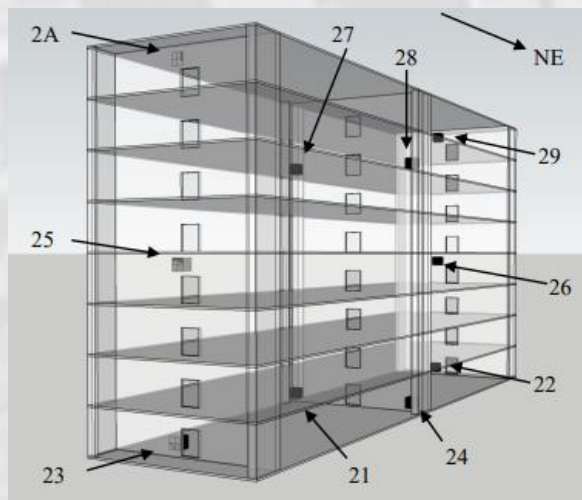
# Instrumented Buildings



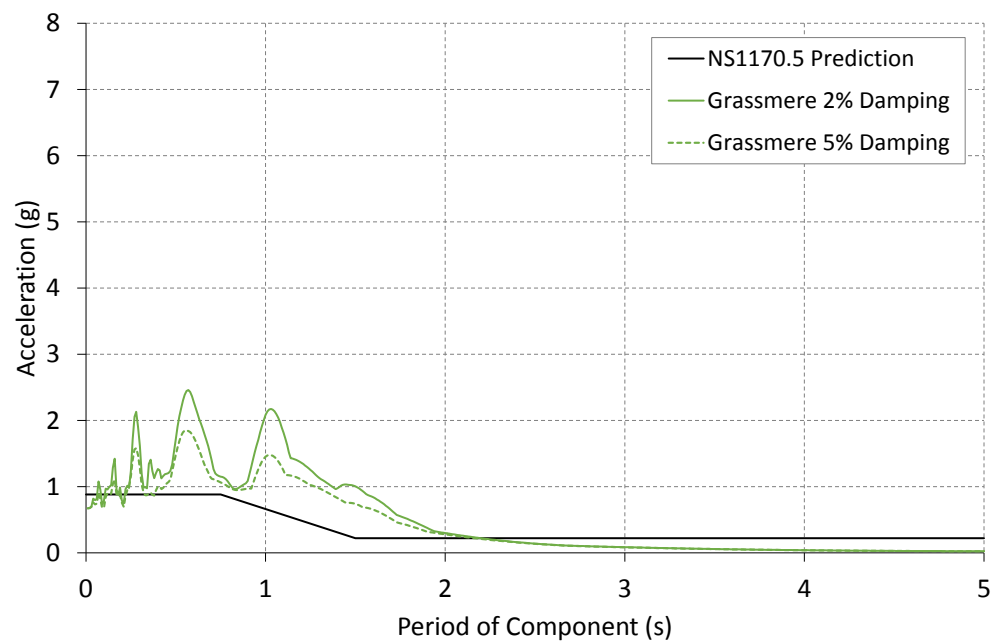
UC Physics Building  
*From McHattie, 2013*



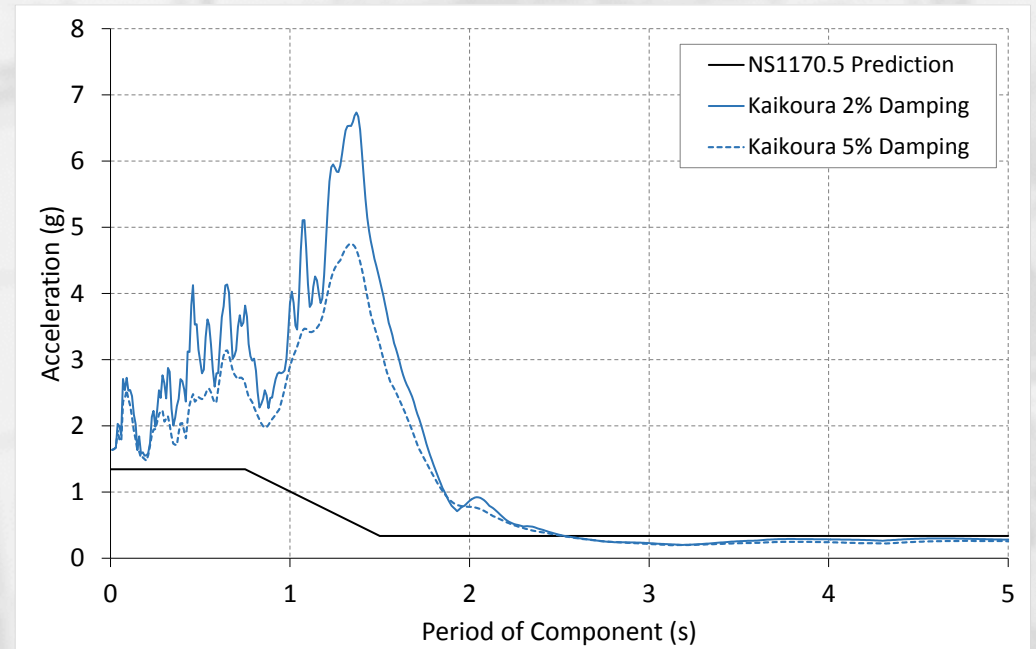
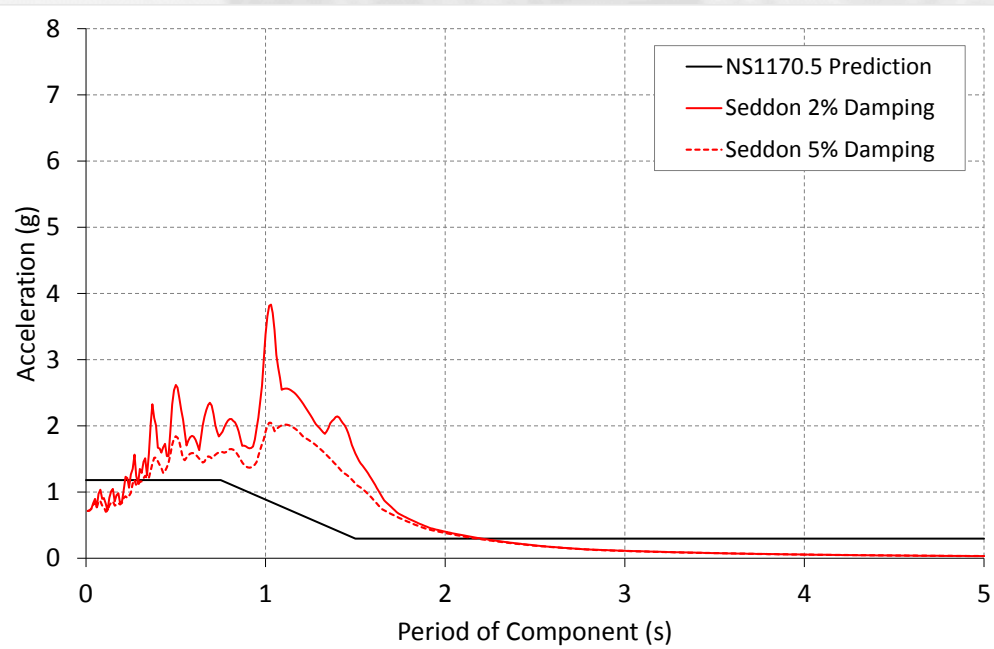
BNZ Wellington Building  
*From Chandramohan, et al., 2017*



# NZS1170.5 Predictions – BNZ CentrePort Building



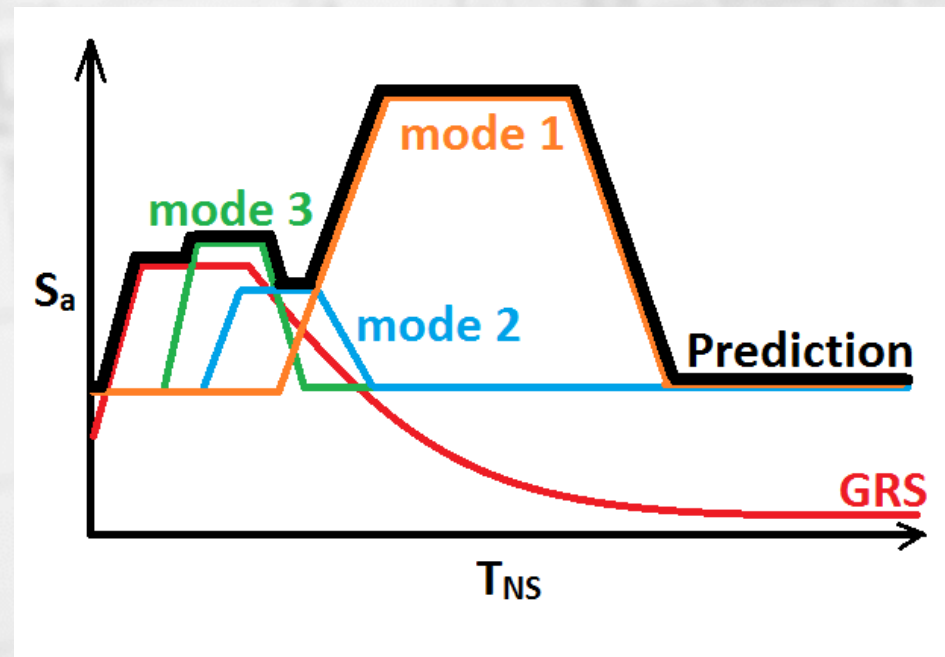
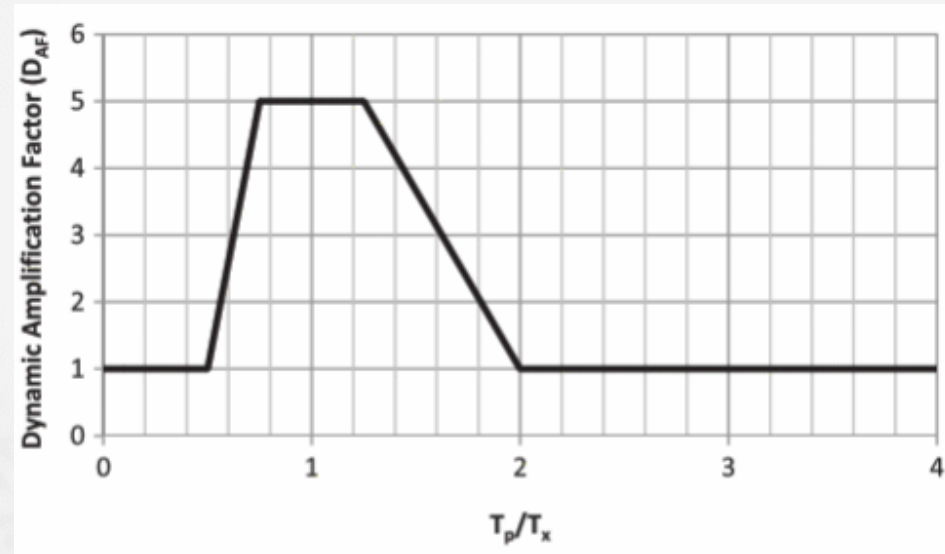
Spectra generated using acceleration response history at floor 5



$$A_{ix} = p_{ix} S_{ai} D_{AF}$$

- $A_{ix}$  – Acceleration contribution of mode  $i$  on floor  $x$
- $p_{ix}$  – Modal participation of floor  $x$  in mode  $i$   
(participation factor  $\times$  mode shape)
- $S_{ai}$  – Ground spectral acceleration of mode  $i$
- $D_{AF}$  – Dynamic amplification factor

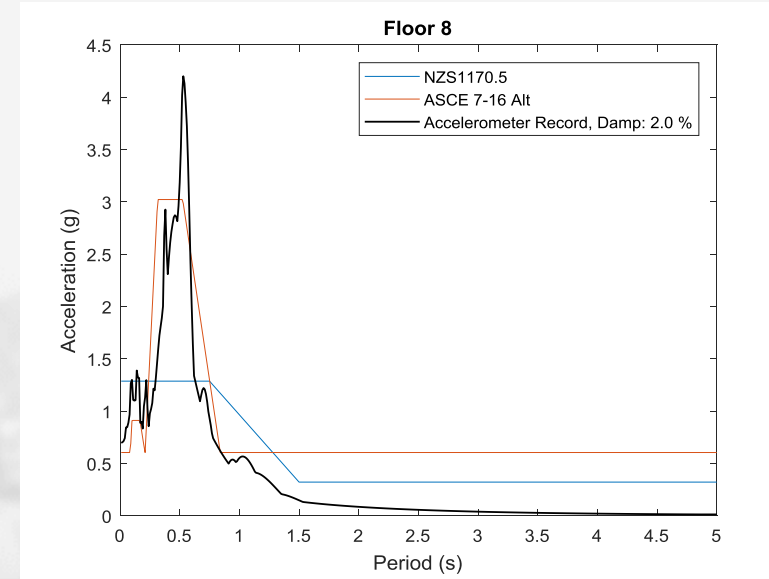
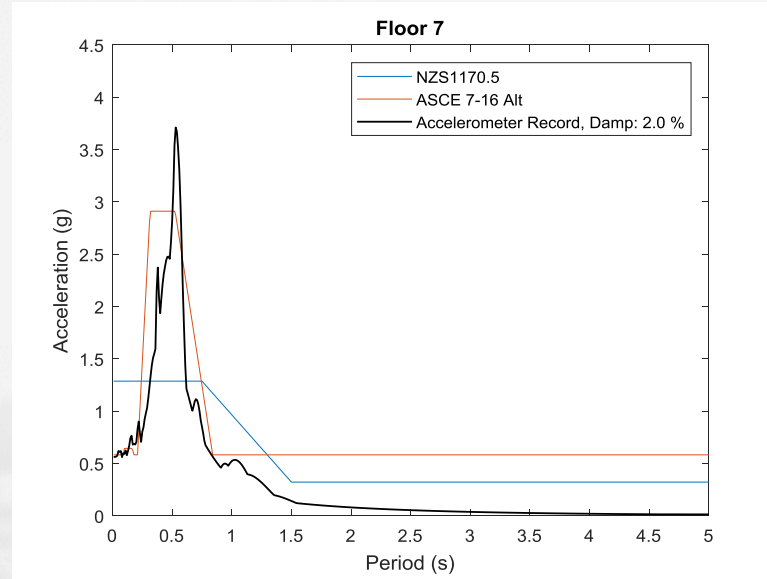
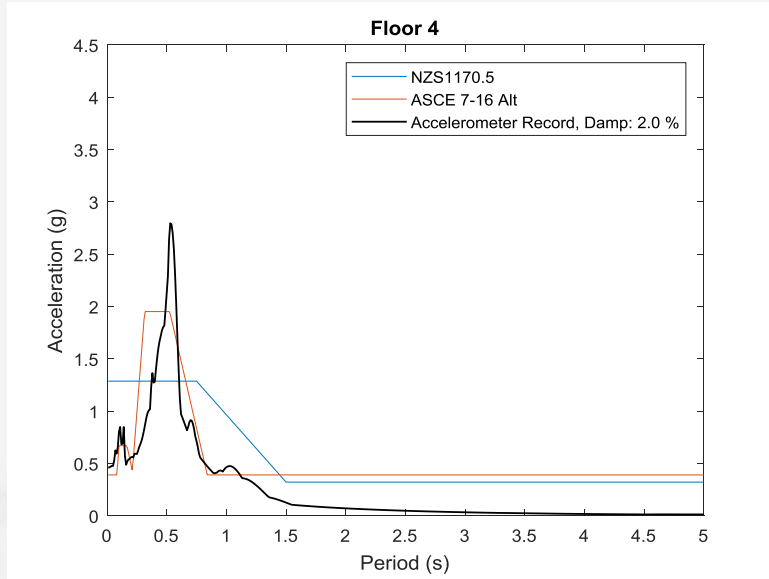
$$S_a = \max \left\{ \begin{array}{l} \text{Modal contributions } A_{ix} \\ \text{Ground response spectrum} \end{array} \right.$$



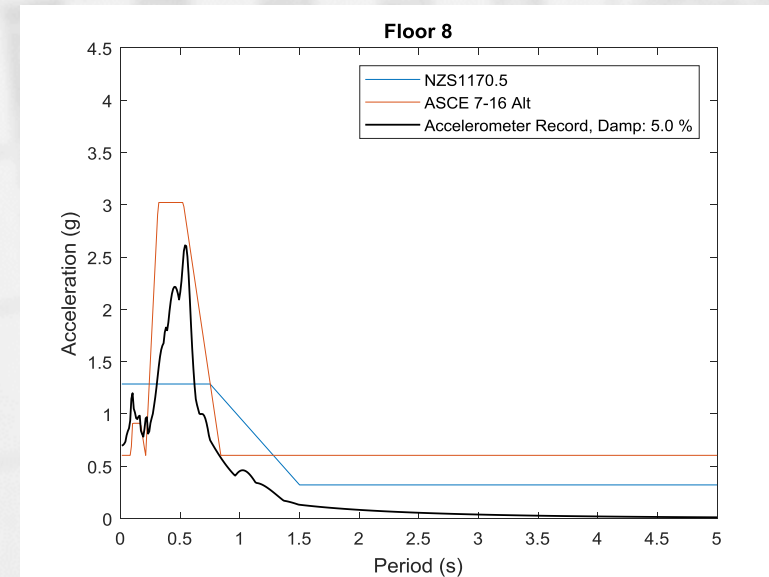
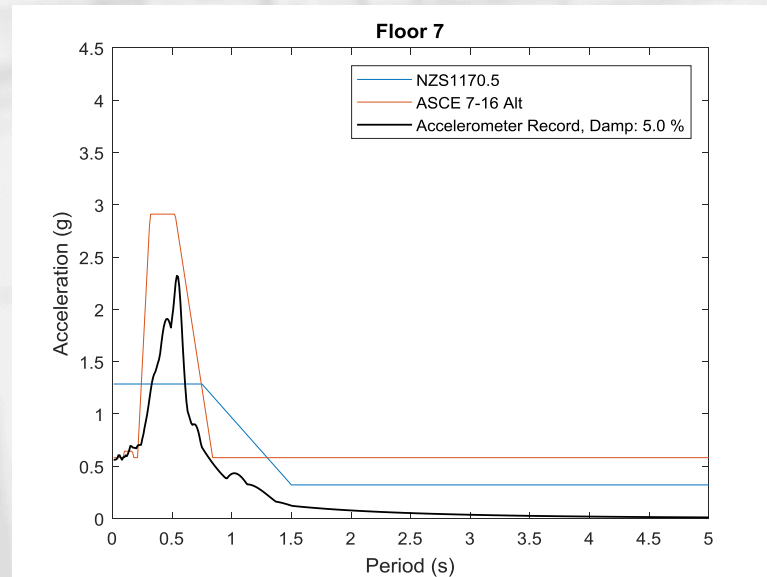
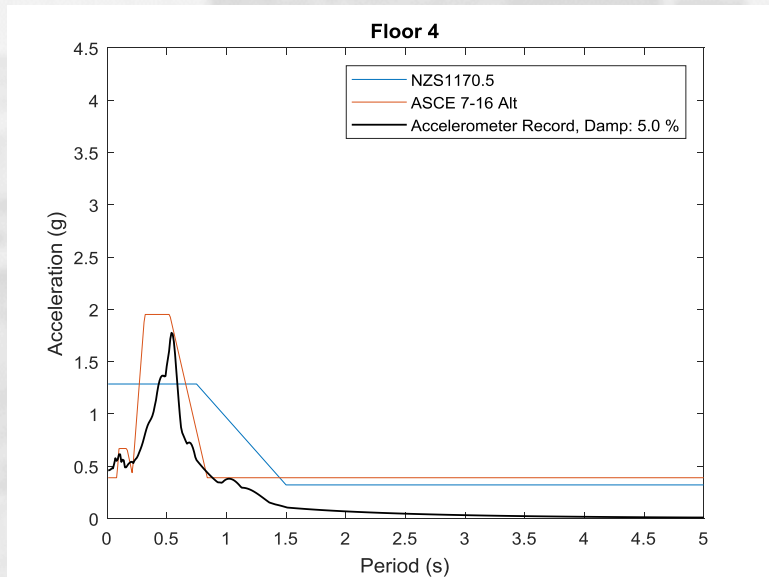


# ASCE 7-16 and NZS1170.5 Predictions – UC Physics Building

2% NS damping



5% NS damping



$$\frac{F_p}{W_p} = \text{PGA} \times \left[ \frac{\left( \frac{\text{PFA}}{\text{PGA}} \right)}{R_{\mu\text{bldg}}} \right] \times \left[ \frac{\left( \frac{\text{PCA}}{\text{PFA}} \right)}{R_{\text{pocomp}}} \right] \times I_p$$

PGA Peak ground acceleration

PFA/PGA Amplification factor from PGA to Peak Floor Acceleration PFA

PCA/PFA Amplification factor from PFA to Peak Component Acceleration PCA, including component ductility

$R_{\mu\text{bldg}}$  Reduction factor for building global ductility

$R_{\text{pocomp}}$  Reduction factor for inherent component overstrength

$I_p$  Importance factor

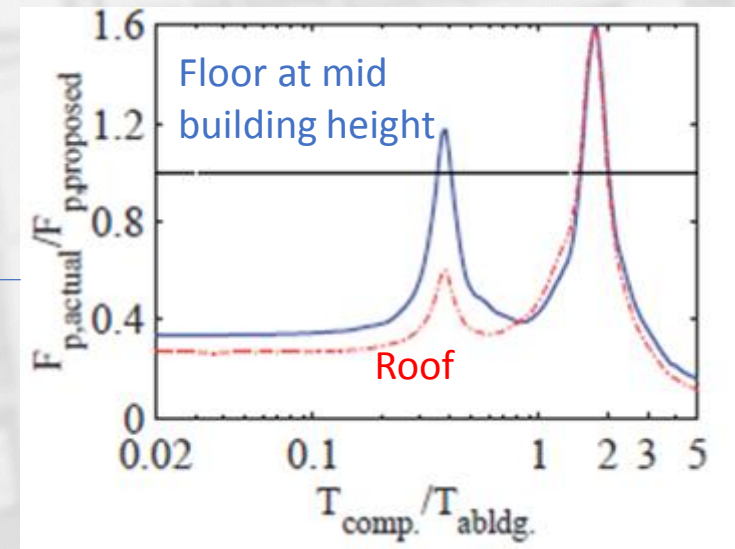
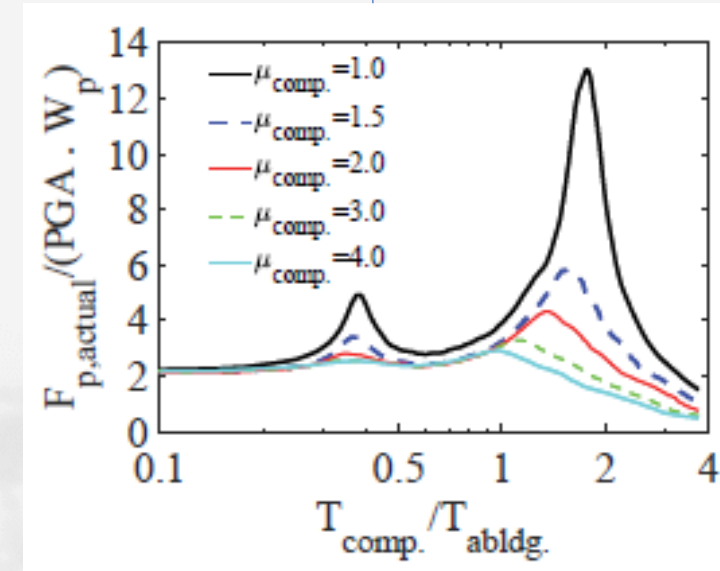
**Table 4-2 PCA/PFA Values**

| Location of Component  | Possibility of Being in Resonance with Building | Component Ductility     |                     | $\left(\frac{PCA}{PFA}\right)^{(2)}$ |
|------------------------|---|-------------------------|---------------------|--------------------------------------|
|                        |   | Category <sup>(1)</sup> | Assumed Ductility   |                                      |
| Ground                 | More Likely                                     | Elastic                 | $\mu_{comp} = 1$    | 2.5                                  |
|                        |   | Low                     | $\mu_{comp} = 1.25$ | 2.0                                  |
|                        |   | Moderate                | $\mu_{comp} = 1.5$  | 1.8                                  |
|                        |   | High                    | $\mu_{comp} \geq 2$ | 1.4                                  |
|                        | Less Likely                                     | Any                     | --                  | 1.0                                  |
| Roof or Elevated Floor | More Likely                                     | Elastic                 | $\mu_{comp} = 1$    | 4.0                                  |
|                        |   | Low                     | $\mu_{comp} = 1.25$ | 2.8                                  |
|                        |   | Moderate                | $\mu_{comp} = 1.5$  | 2.2                                  |
|                        |   | High                    | $\mu_{comp} \geq 2$ | 1.4                                  |
|                        | Less Likely                                     | Any                     | --                  | 1.0                                  |

<sup>(1)</sup> Categories will be assigned to components similar to ASCE/SEI 7-16 Table 13.5-1. Categories need to be determined.

<sup>(2)</sup> Inherent component damping of 5% is assumed as a default.

$T_{abldg}$  is from code eqn for  $T_1$

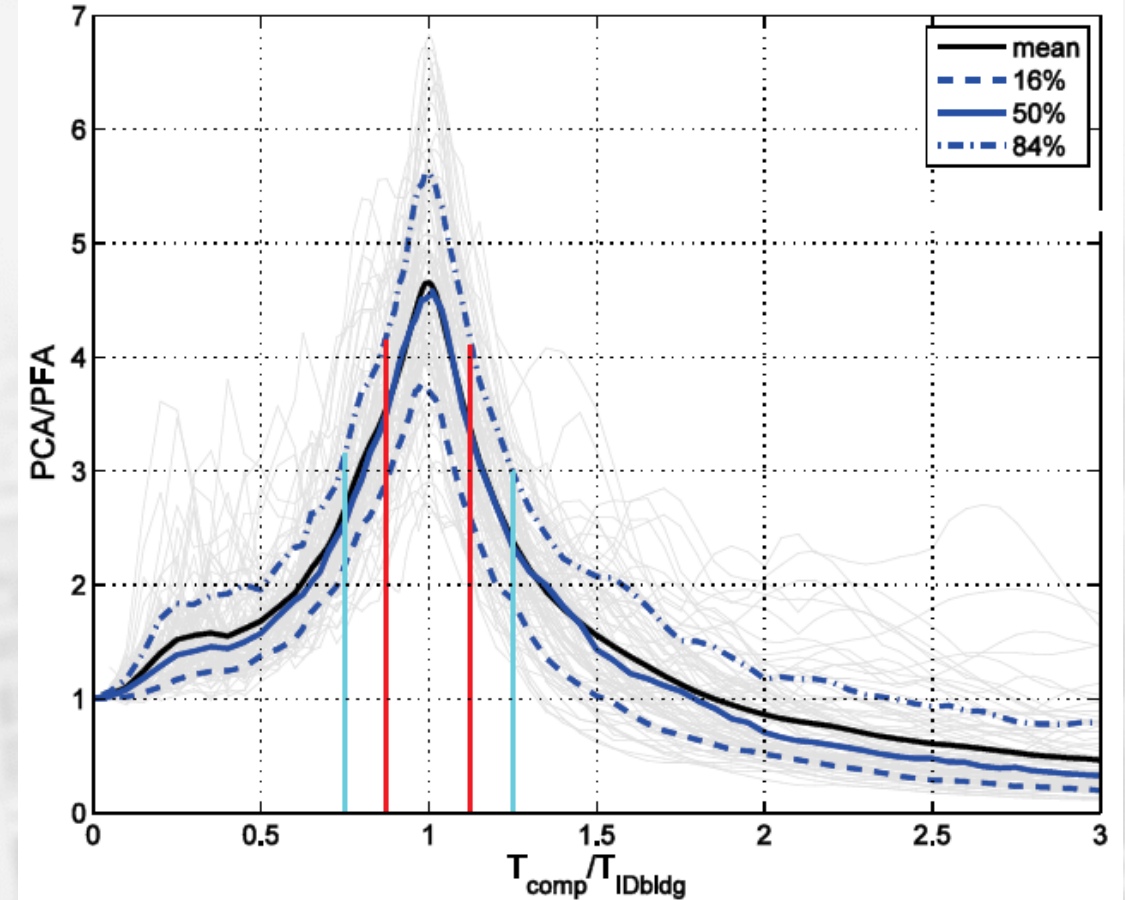


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- Simplified methods for predicting modal properties
  - $T_1$  simplified expression
  - $T_{\text{Higher modes}} / T_1$  standard ratios
  - Standard mode shapes
- Decay curve for DAF shape
  - Compatibility with floor displacement response spectra
- Introducing  $DAF_{\text{max}}$  term to scale DAF by NS damping
  - Capture dynamic amplification of lower damping
- Research into NS Element post-elastic behaviour and damping