Validation of Ground Motion Simulations for Seismic Slope Stability

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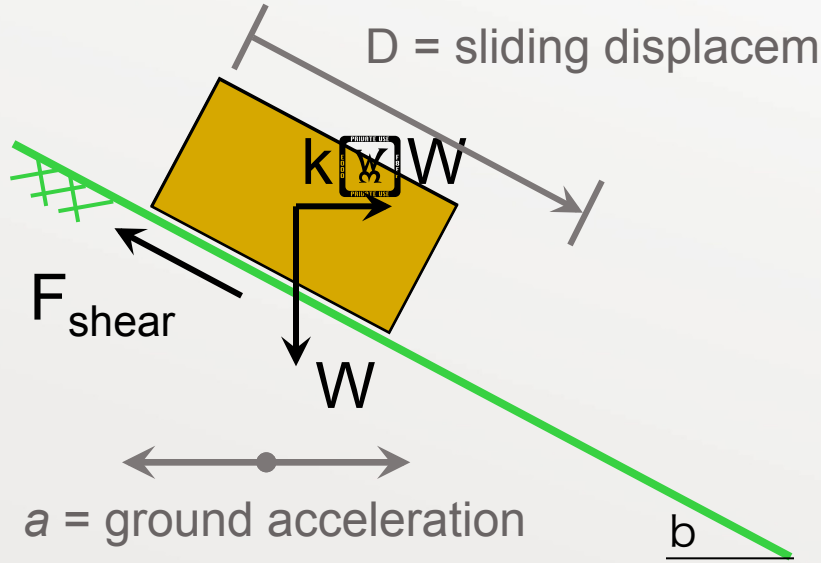
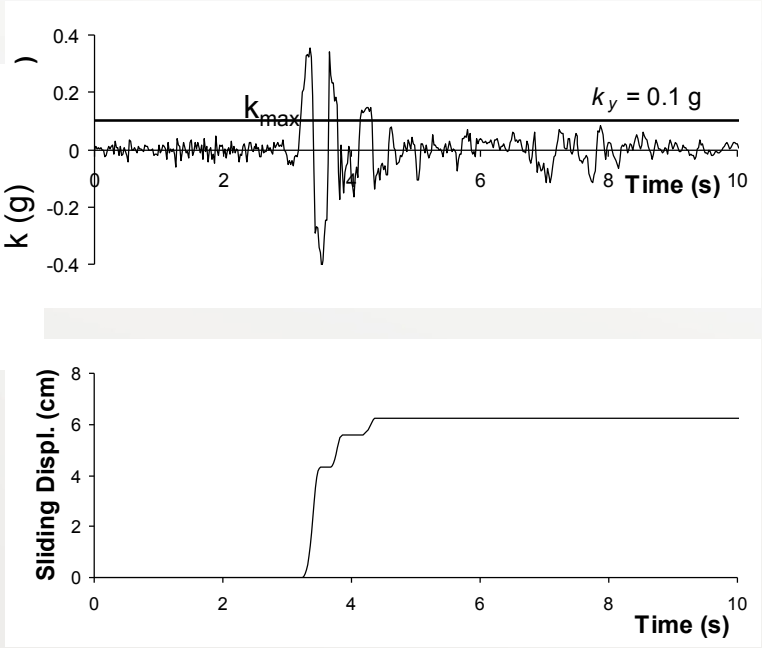
Sliding Block Model



If k exceeds k_y:

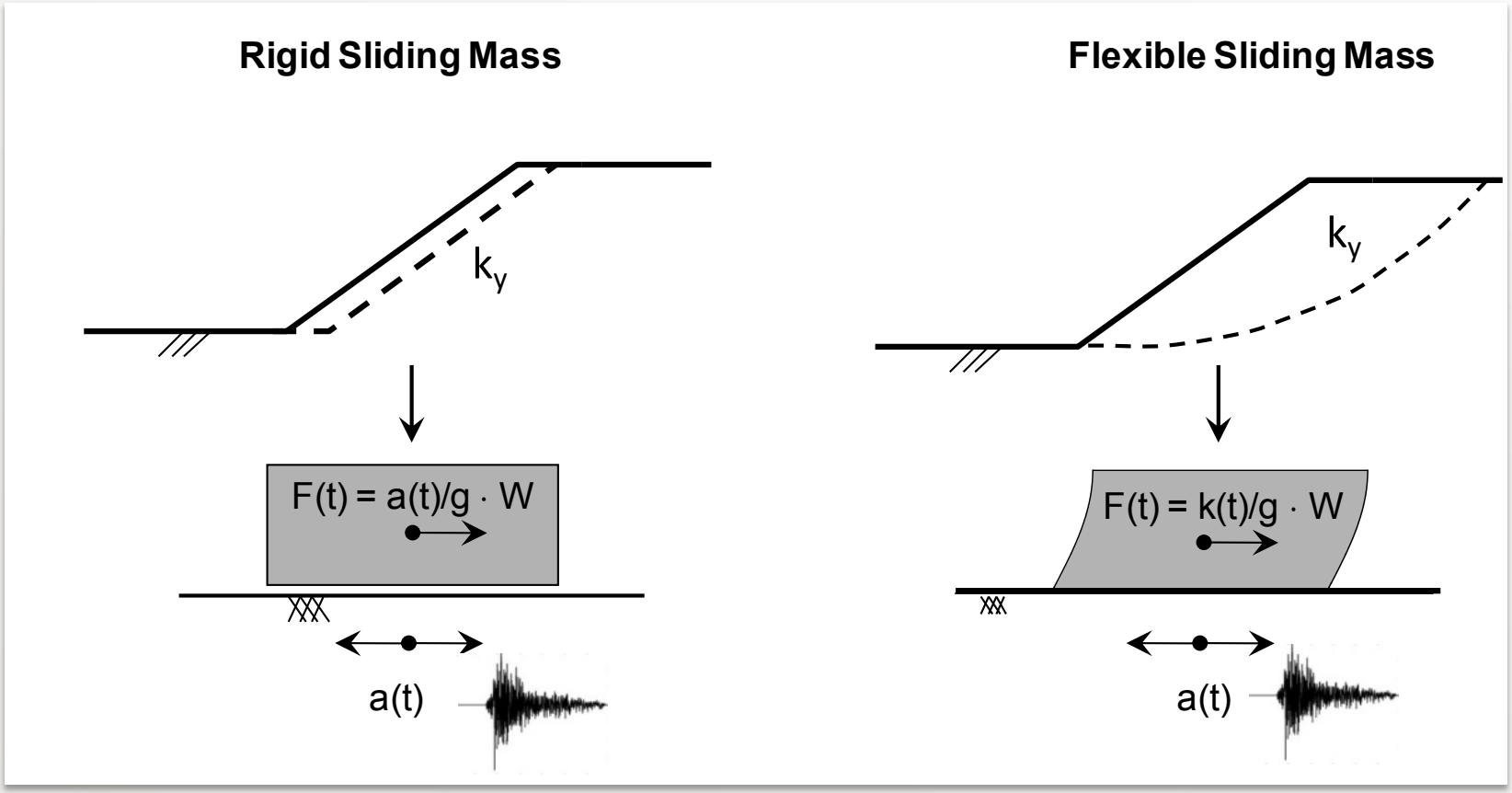


k = seismic coefficient
k_y = yield seismic coefficient
or yield acceleration

Analysis used for natural slopes, cut/fill slopes, dams, landfills

D: damage index for the seismic performance of the slope

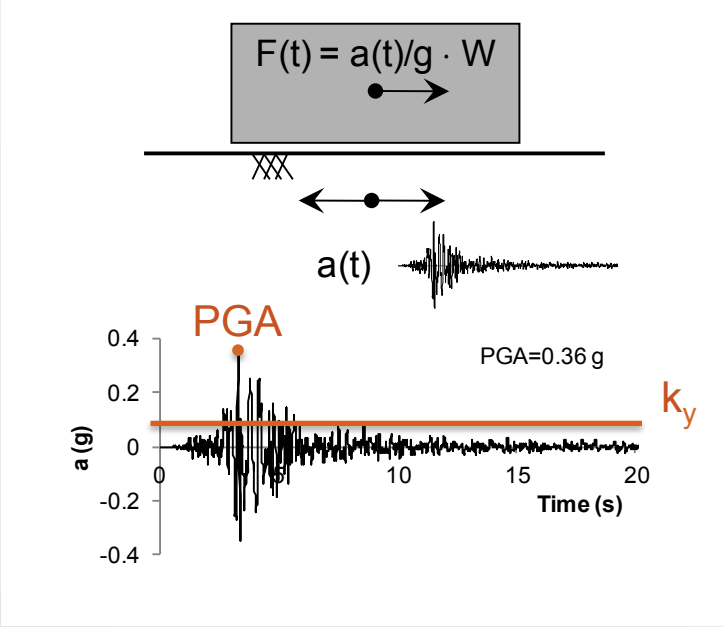
Rigid vs. Flexible Sliding Masses



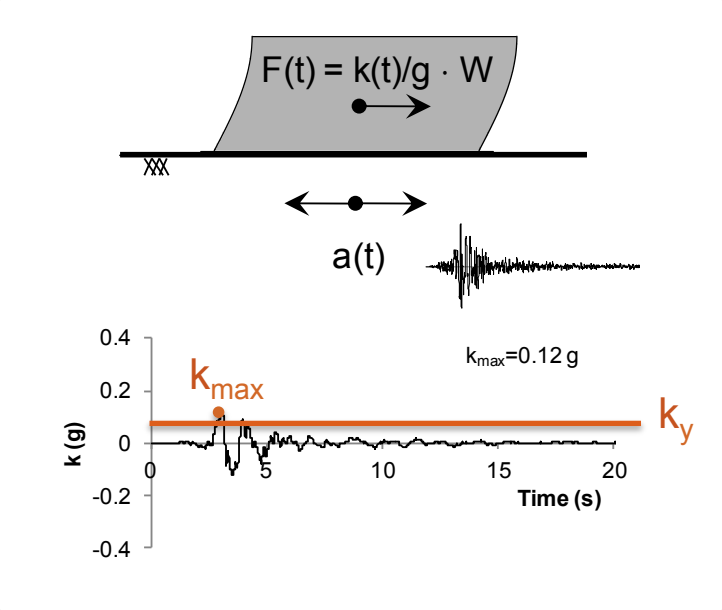
Flexible Sliding:

Calculate dynamic response (k-time history) followed by displacement response

Rigid Sliding

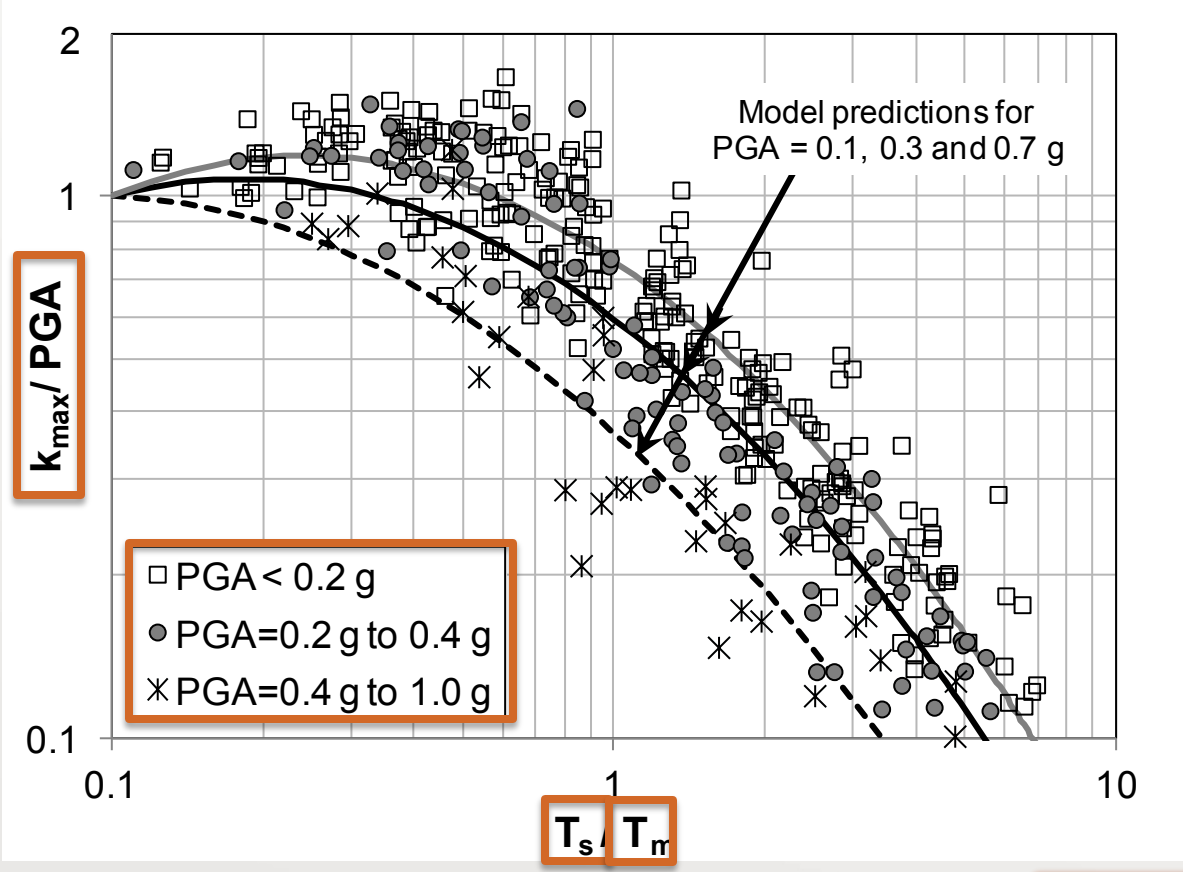


Flexible Sliding



Time series are used as input into dynamic and sliding response analyses

GM and Site Parameters Affecting k_{max}



Natural period of sliding mass

Mean period of motion

Rathje and Antonakos (2011)

Empirical Displacement Models

Rigid Sliding

e.g., Saygili and Rathje (2008) / Rathje and Saygili (2009)

Scalar Model (PGA, M)

$$\ln D = a_1 + a_2\left(\frac{k_y}{PGA}\right) + a_3\left(\frac{k_y}{PGA}\right)^2 + a_4\left(\frac{k_y}{PGA}\right)^3 + a_5\left(\frac{k_y}{PGA}\right)^4 + a_6 \ln(PGA) + a_7 (M-6)$$

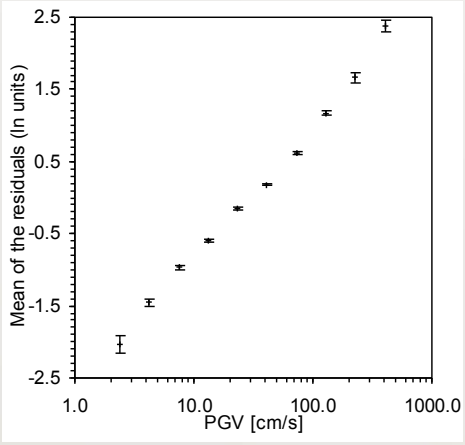
Vector Model (PGA, PGV)

$$\ln D = a_1 + a_2\left(\frac{k_y}{PGA}\right) + a_3\left(\frac{k_y}{PGA}\right)^2 + a_4\left(\frac{k_y}{PGA}\right)^3 + a_5\left(\frac{k_y}{PGA}\right)^4 + a_6 \ln(PGA) + a_7 \ln(PGV)$$

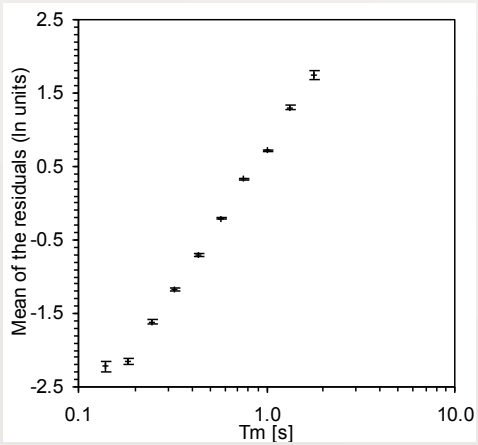
GM Parameters Affecting Displ.

- PGA indicates if k_y is exceeded
- Given PGA, other parameters significantly affect displacement (Saygili and Rathje 2008)

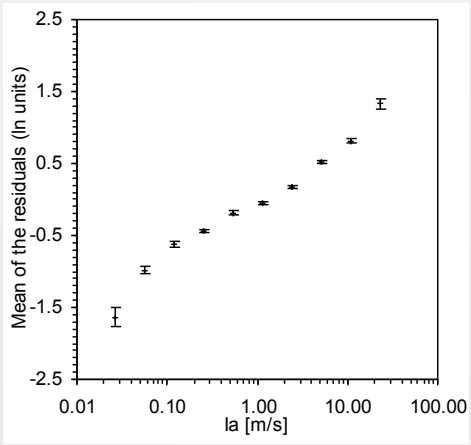
Residual ($lnD_{obs} - lnD_{pred}$)



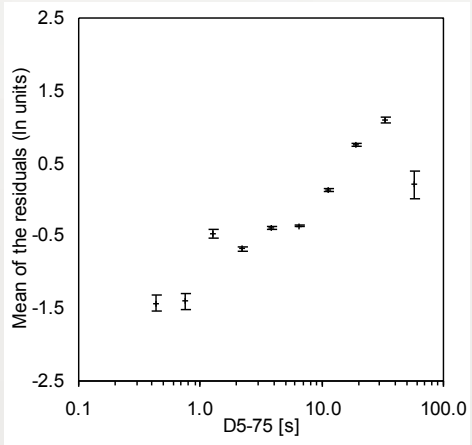
PGV (cm/s)



T_m (s)



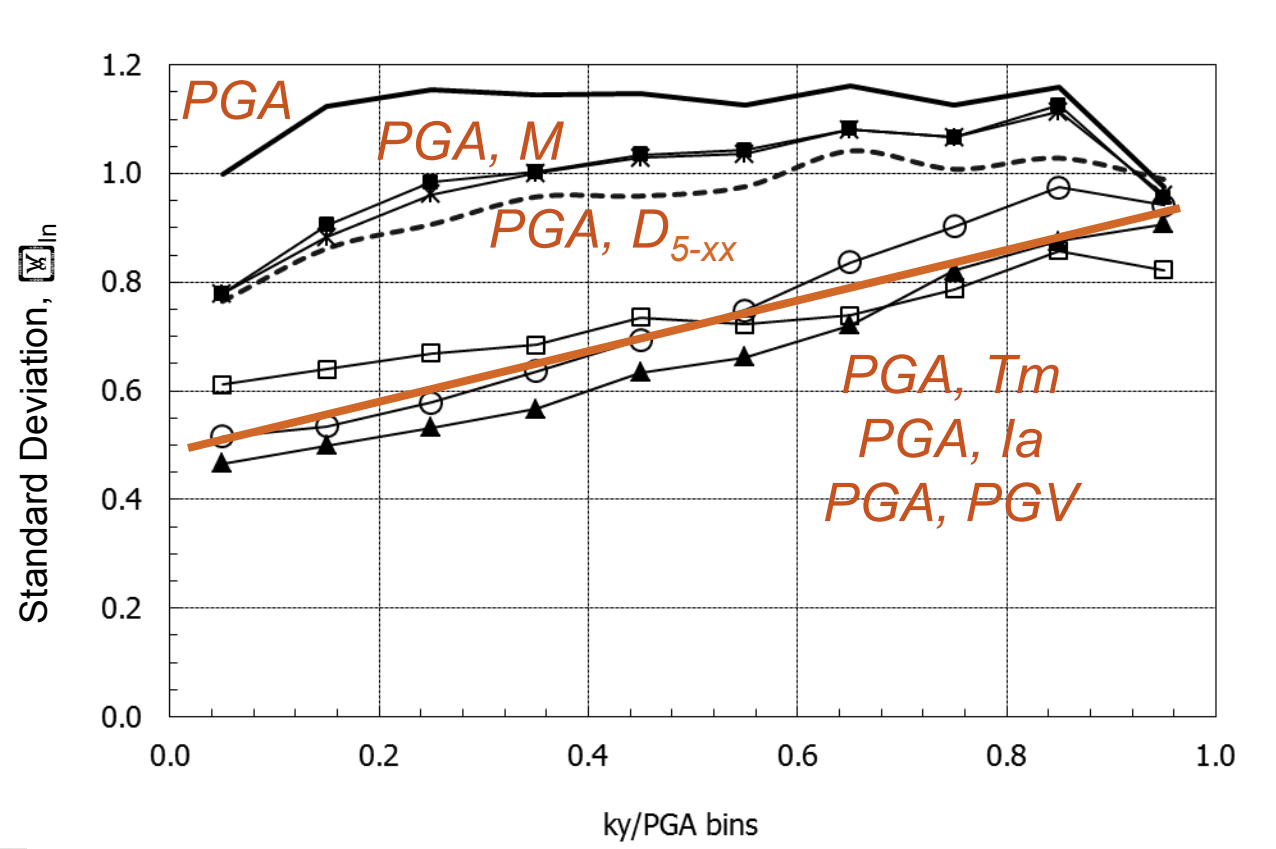
I_a (m/s)



$D_{5\text{-}75}$ (s)

GM Parameters Affecting Displ.

- Influence on standard deviation of displacement prediction (σ_{lnD})



GM Parameters Affecting Displ.

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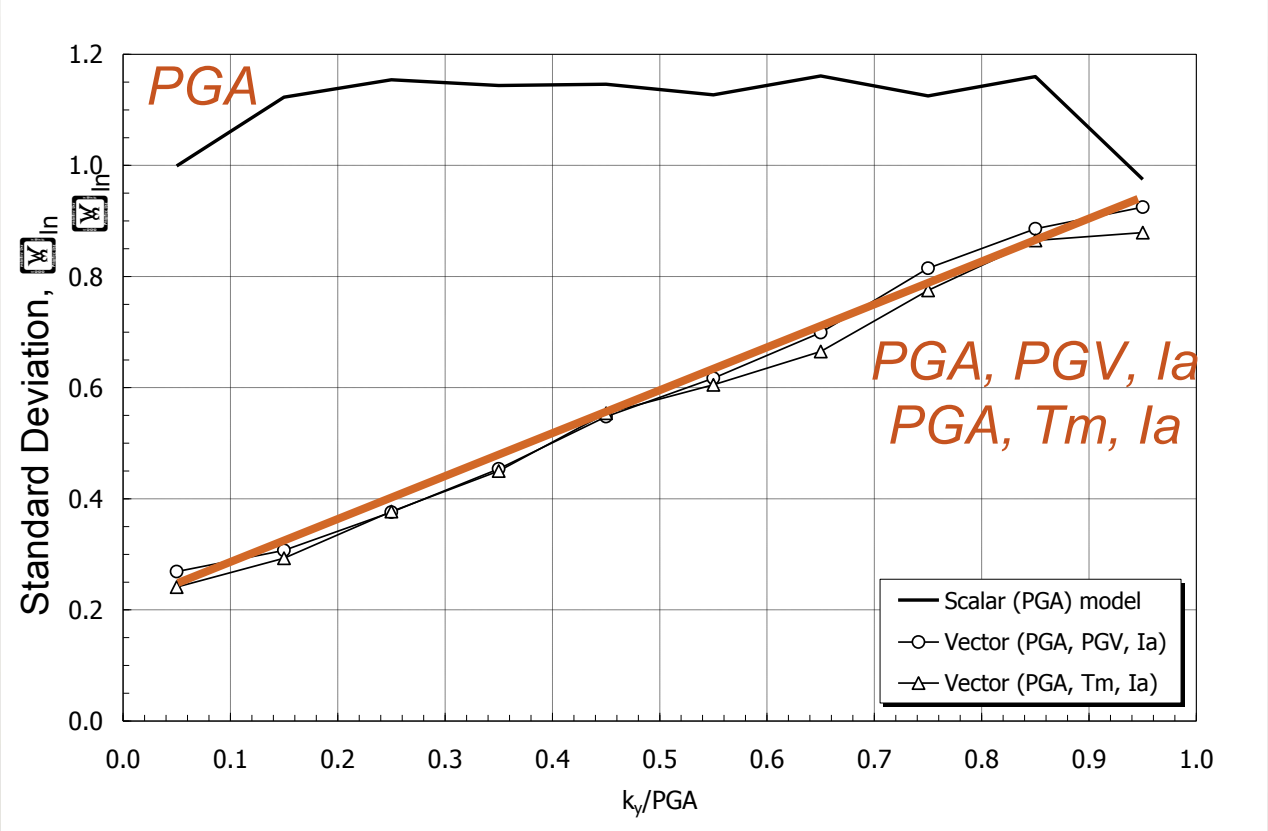

Approaches to Validation

- Motion-specific comparisons
  - Compare responses predicted by recorded motions and corresponding simulated motion
- Comparisons with empirical relationships
  - Compare response predicted by simulated motions with those predicted by empirical relationships
  - Use existing empirical relationships or relationship developed from recorded motions

Validation Approach 1

- Using simulated motion and corresponding recorded motion:
  - Compare ground motion parameters that affect sliding displacement (PGA, PGV, T_m, I_a)
  - Compare dynamic response (k_{max}) of sliding masses with different site periods (T_s)
  - Compare displacements (D) computed for different k_y

Validation Approach 2

- Using simulated motions and empirical displacement models
  - Compare D from the simulated motion and displacement model GIVEN ground motion parameters of simulated motion
  - Use Saygili and Rathje (2008) model, others, model developed from recorded motions
  - Look at residuals across all motions to identify systematic trends