Assessment of ground motion selection and scaling methods for response history analyses of mid-rise symmetric-plan buildings

J. Reyes¹, N. Kwong², J. Acosta¹

¹Universidad de los Andes, Colombia.
²The Cooper Union for the Advancement of Science.

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Which target spectrum should be used?

![Graph showing target spectra](image)

- **UHS**
- **CMS**

- $S_a$
- $T_{min}$, $T_1$, $T_{max}$, $T$

**CONCLUSIONS**
Which target spectrum should be used?

![Graph showing Sa vs T with UHS and sGCMS curves]

- UHS
- sGCMS

Legend:
- $T_{min}$
- $T_{max}$
Which target spectrum should be used?

$S_a$ vs. $T$

- UHS
- Composite CS

$T_{min}$

$T_{max}$
Objective

Evaluate proposed target spectra available in the literature for the selection and scaling of seismic records.
Methodology

Phase 1: Building site

• Case Study: Santa Clara, California.
  Latitude: 37.35N°
  Longitude: 121.96W°
• $V_{s30}=300$ m/s
Phase 2: Selected buildings

Realistic buildings

- $\beta = 1.00$
  - $T_x: 0.85\ s$
  - $T_y: 1.03\ s$

- $\beta = 1.13$
  - $T_x: 1.05\ s$
  - $T_y: 1.53\ s$

- $\beta = 1.1$
  - $T_x: 1.49\ s$
  - $T_y: 2.51\ s$

- $\beta = 1.43$
  - $T_x: 0.64\ s$
  - $T_y: 0.54\ s$

- $\beta = 1.3$
  - $T_x: 1.83\ s$
  - $T_y: 1.70\ s$

- $\beta = 1.35$
  - $T_x: 0.524\ s$
  - $T_y: 0.628\ s$

- $\beta = 1.2$
  - $T_x: 1.23\ s$
  - $T_y: 1.23\ s$

- $\beta = 1.26$
  - $T_x: 1.93\ s$
  - $T_y: 1.59\ s$
Shear buildings
Phase 3: Seismic Hazard Analysis (PSHA)

Seismic sources definition → Magnitude recurrence distribution $n$ for each source → Ground motion prediction equations → Hazard curves for given structural periods
Phase 4: One-component ground motions

\[ SF_{optimal} = \left( \prod_{j=1}^{N_P} \frac{A_{sGCMS}(T_j)}{A_0(T_j)} \right)^{1/N_P} \]

\[ SSD = \sum_{j=1}^{N_P} \left\{ \ln [A_P(T_j)] - \ln [A_{sGCMS}(T_j)] \right\}^2 \]
Phase 5: Two-component ground motions

Target Spectrum in X-Direction

Target Spectrum in Y-Direction

T_{1x}  

T_{1y}
Direction X

\[ SF_{SSD_{xy}} = \left( \prod_{j=1}^{N_p} \frac{A_{T,x}(T_j) \times A_{T,y}(T_j)}{A_{0,x}(T_j) \times A_{0,y}(T_j)} \right)^{1/(2N_p)} \]

Direction Y

\[ SSD_{xy} = \sum_{i=1}^{2} \sum_{j=1}^{N_p} (\ln [A_{P,i}(T_j)] - \ln [A_{T,i}(T_j)])^2 \]
Phase 6: Identify possible outliers

Modal analysis

Pushover analysis first 3 modes

Idealizing pushover curves

Run UMRHA (Chopra, 2007)

\[ u_r \approx \sum_{n=1}^{N} \Gamma_n \phi_{rn} D_n(t) \]

\[ \frac{F_n}{L_n} \rightarrow D_n \]

\[ T_n \rightarrow \zeta_n \]

\[ \Gamma_n \phi_{rn} D_n(t) \]
$u_r \cong \sum_{n=1}^{N} \Gamma_n \phi_{rn} D_n(t)$
Phase 7: Run nonlinear RHA
Results for one component GMs

Realistic structures

![Graph showing MSDRx and MSDRy for different components (CMS, sGCMS, CS, UHS). The graph includes percentiles and arithmetic means, with a red circle highlighting a specific area.](image)
INTRODUCTION

RESULTS 2D

OBJECTIVE

METHODOLOGY

RESULTS 1D

CONCLUSIONS

Idealized structures

- MSDRx (%)
- MSDRy (%)

- Percentile 25/75
- Arithmetic Mean

- R03, R06, R09, R12, R15
- R18, R21, R24, R27, R30

- mCMS, sGCMS, CS, UHS
Results for two component GMs

Realistic structures
Idealized structures

- INTRODUCTION
- OBJECTIVE
- METHODOLOGY
- CONCLUSIONS

Results 2D

MSDRx (%) vs. MSDRy (%) for L03, L06, L09, L12, L15.
Conclusions

- The CMS method leads to the smallest median and interquartile range of story drift estimates.
- The sGCMS and the composite methods lead to conservative estimates of story drifts in comparison with the CMS method, but they are, in general, smaller than those from the UHS method.
- The proposed method for identifying outliers shows excellent correlation with nonlinear RHAs.