Estimating Axial Force Demand in Columns of Seismic-Resistant Steel Structures

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Axial Force Demands in Columns

• Current Design Approach
  ▪ Obtained by considering simultaneous yielding at all the stories

• Issue
  ▪ Over conservative for tall structures
    - Results in uneconomical sections

• Past studies
  ▪ Considering SRSS combination of the forces
  ▪ Study on simultaneously yielding stories
  ▪ Yet, no method has been proposed to quantify the number of simultaneously yielding stories ($N_{SYS}$) in buildings
Methodology

• Procedure for estimating $N_{SYS}$ due to full-sine velocity pulse excitation
  – Use concepts of wave propagation theory (Relationship between ground excitation and story forces)

• Procedure extended for earthquake excitation
  – Identify the main pulse and idealize with full-sine pulse

• Procedure for estimating axial force demand by using the estimated $N_{SYS}$
Structure Considered

- Forty story shear-type BRB frame
- $k_{col}/k_{br}=0.25$
- $R=8$
- Elastic-ideal-plastic (kinematic strain hardening with $r=1\%$)
- Viscous damping of 2%
Ground Excitation Considered

Category A

Category B

Category C
Results for $N_{SYS}$ (Condensed)
Results for $N_{SYS}$ (Condensed)

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<th>EQ</th>
<th>$MN_{SYS,Incident}$</th>
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<th>Maximum $N_{SYS}$</th>
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Estimation of Axial Force Demand

• Vertical force transferred from:
  • $N_{SYS}$ yielded stories + SRSS of the remaining stories considering their yield capacity

• Consider three cases
  • $AFD = \text{maximum} \left( P_{Incident, j}, P_{Top, j}, \text{and} \ P_{Base, j} \right)$
Calculation of Axial Force Demand
Comparing $P_{\text{Estimated}}$ and $P_{\text{Actual}}$ (Condensed)

Average $P_{\text{Estimated}}/P_{\text{Actual}}$ for all the EQs was 1.12
Strain Hardening at different stories
(Condensed)

1994 Nortridge, Newhall-W.Pico Canyon Rd. (WP046)
Conclusion

• Estimation procedure for finding $N_{SYS}$ was found to work well for the BRB frames considered.
• Axial force demand estimated by considering forces transferred from SYS and SRSS of remaining stories yielded good estimates of the actual values.
• SYS stories do not reach the ultimate capacity at the same time.
Related Papers


Thank You!