Accidental Torsion with Industrial Buildings – over-conservative Rules in EC8

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We look at structural design of a steel structure subjected to earthquakes – strictly from a designers point of view

- Note on Levels of Engineering Effort
- Provisions in EC8-1
- How seismic design is done – and a fictitious torque problem
- Proposal for an amendment in EC8-1

Definition: „Torsion“ is around a vertical axis of a building structure
Levels of Engineering Effort

- For a nuclear power plant you are doing as much as needed – and you are being payed for it (Olkiluoto 3, courtesy of Hodapp, D- 77855 Achern, Germany)

- This contribution is on five-hours-seismic design of simple steel structures, such as warehouses or plant construction
Provisions in EC8-1

- Clause 3.2.2.4 (1) eq. 3.12 on displacements
  \[ d_g = 0.025 \cdot a_g \cdot S \cdot T_C \cdot T_D \]

- Clause 4.3.2 (1)P eq. 4.3 on centroid dislocation
  \[ e_{a,i} = \pm 0.05 \cdot L_i \]

- Clause 4.3.3.2.4 (1) eq. 4.12 on simplified design
  \[ \delta = 1 + 0.6 \cdot \frac{x}{L_e} \]
  For a typical steel storage building with bracing in opposite walls:
  \[ \delta = 1 + 0.6 \cdot \frac{0.5 \cdot L_e}{L_e} = 1.3 \]

- Aim of this paper is to get rid of these 30 %
Example Structure

- Courtesy of Dieffenbacher, D-75031 Eppingen, Germany, taken from Knoedel/Hrabowski/Ummenhofer Eurosteel 2014.
- More examples with exemplary seismic design are given in the paper.
How seismic design is done

- Simple way (lateral force method):
  get effective horizontal acceleration
  \[ S_{d,\text{hor},\text{max}} = a_g \cdot S \cdot \frac{2.5}{q} \]
  Plateau value might be reduced in case of favourable eigenfrequencies

- Get your base shear (total horizontal seismic force (=reaction))
  \[ F_b = S_{d,\text{hor}} \cdot m \]
  load your structure horizontally with loads proportional to the masses

- You have accounted for
  distributed snow on the roof;
  eccentric hanging crane loads assigned to one bracing

- Thus, you did translatory design for the two major axes

- Is there a possible way of having bigger bracing forces due to torsional effects?
Fictitious torsional problem

- You designed already for the big vector of the left bracing
- Taking off the snow from the right hand side of the roof, does not increase the forces in the left bracing
- Torque also activates the bracings in the gable walls again, your left bracing will not receive bigger forces
If accidental dislocation of the masses cannot be excluded, then ...

Eq. 4.3 is also applicable for the lateral force method.
<<< centroid dislocation >>>

Thank you for your kind attention
looking forward to a lively discussion