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

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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

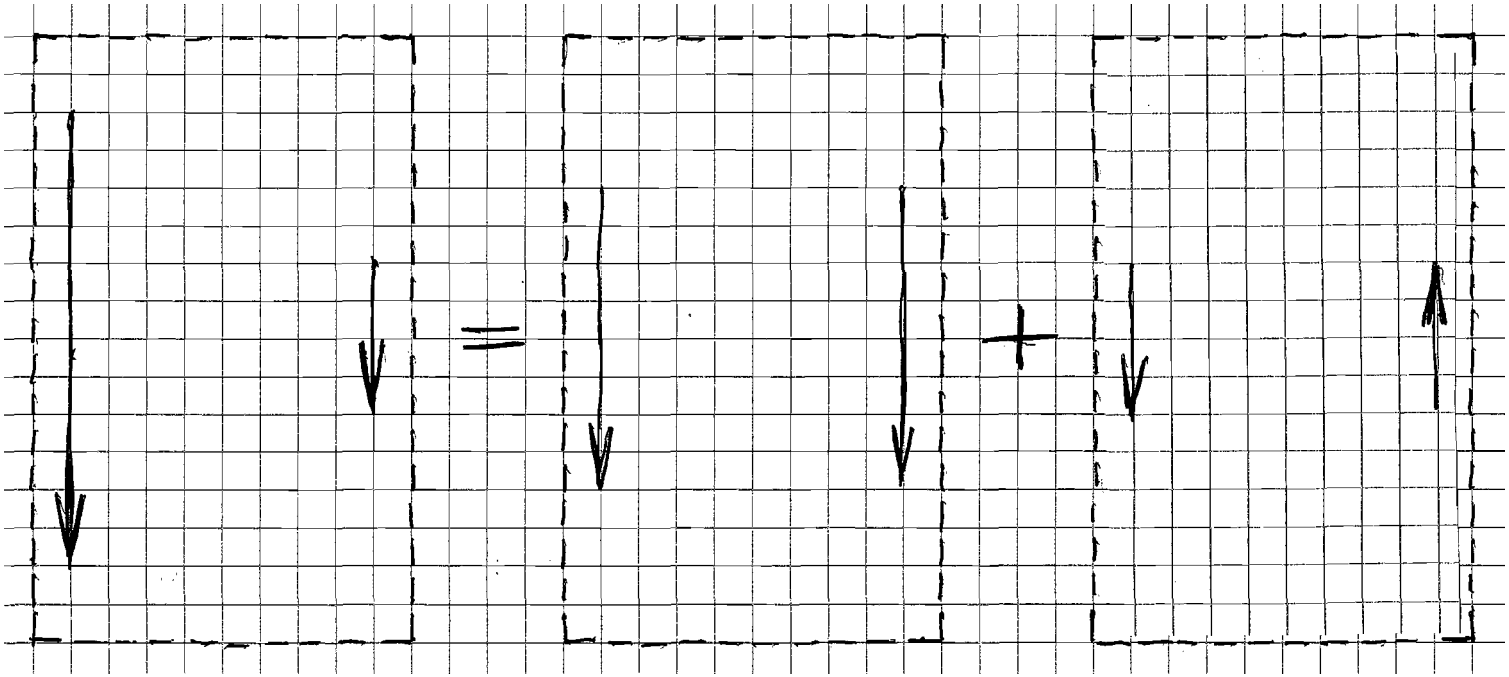
  $$S_{d,hor,max} = a_g \cdot S \cdot \frac{2.5}{q}$$

  Plateau value might be reduced in case of favourable eigenfrequencies
- Get your base shear (total horizontal seismic force (=reaction)

  $$F_b = S_{d,hor} \cdot m$$

  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

Proposal for Amendment of EC8-1

- 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