

Analysing the global response of RC buildings for earthquakes with arbitrary orientations

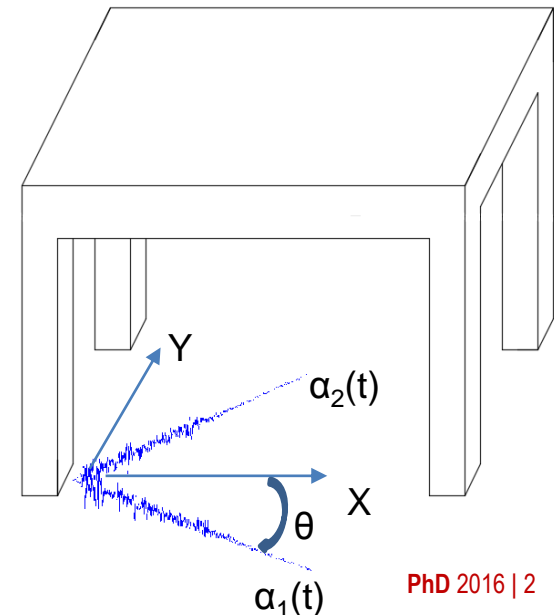
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Structural analysis of 3D buildings: EC8 provisions

- Simultaneous application of two components of ground motion:
 - Along the structural axes, but..
 - ..**underestimate** structural demand.
 - Angle θ that leads to the highest demand, but..
 - ..how to calculate?
 - ..**different for each element** and changes with
 - Structure and number of storeys
 - Ground motion
 - Intensity
 - Behaviour factor..



Structural analysis of existing 3D buildings: proposal

- Conceptually:

Assessment of the behaviour of existing buildings

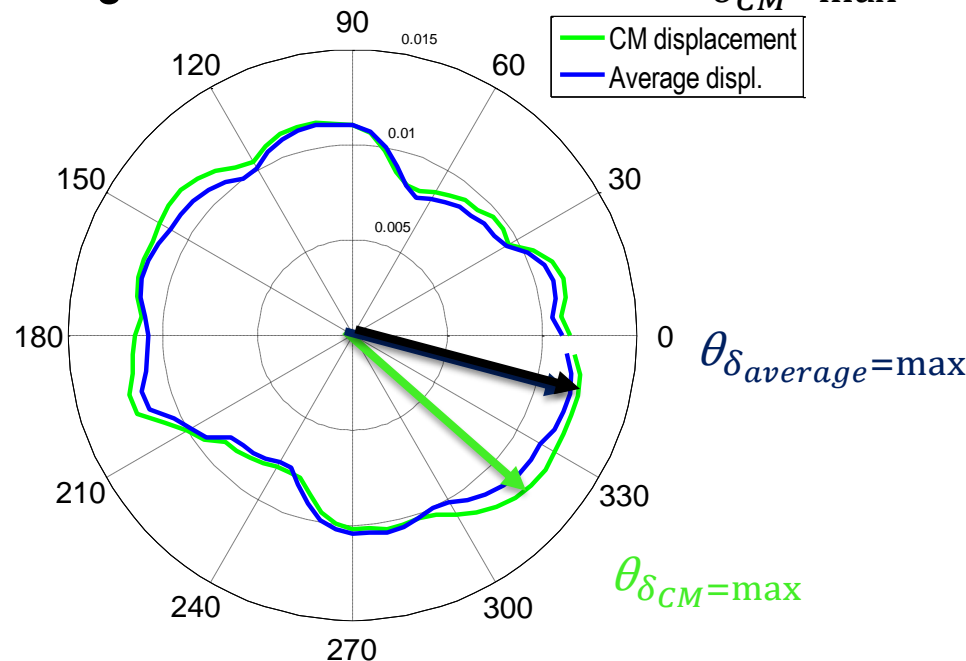
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Design of new buildings

- For the purpose of **assessment** and taking into account the **angle of incidence** of the seismic action:
 - Definition of one demand parameter able to describe **average global response** for all angles of incidence
 - Determine the **critical angle** for this parameter
 - Examine the demand at the **element level** for the critical angle

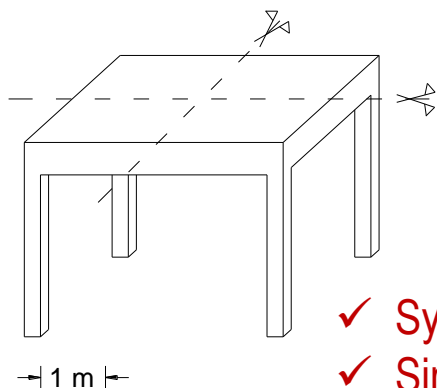
Structural analysis of existing 3D buildings: proposal

- Definition of one demand parameter able to describe **average global response** for all angles of incidence
 - Proposed parameter: displacement of the centre of mass, δ_{CM}
 - Global response: average displacement of all columns, δ_{ave}
 - Hypothesis: Both response quantities attain their maximum value for the same angle of seismic incidence, $\theta_{\delta_{CM}=\max} = \theta_{\delta_{ave}=\max}$

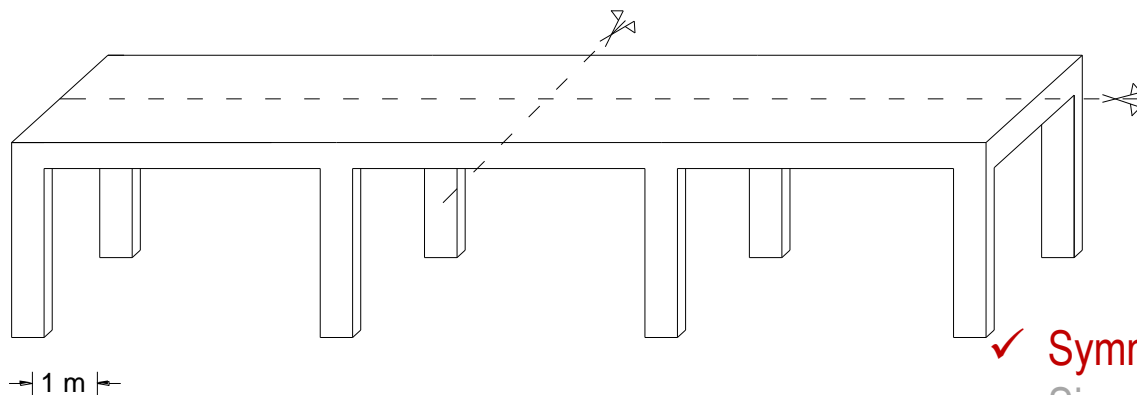




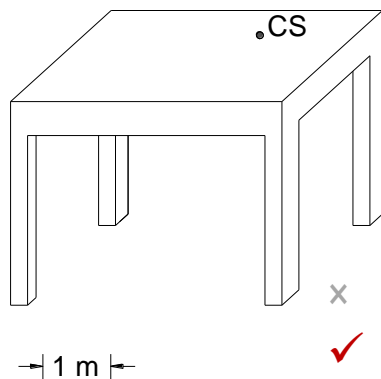
Analysed Structures



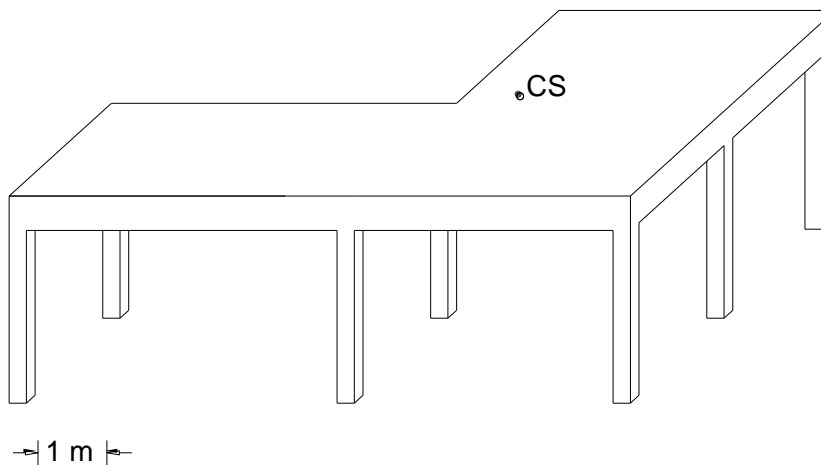
- ✓ Symmetry
- ✓ Simplicity
- ✓ Regularity



- ✓ Symmetry
- × Simplicity
- × Regularity



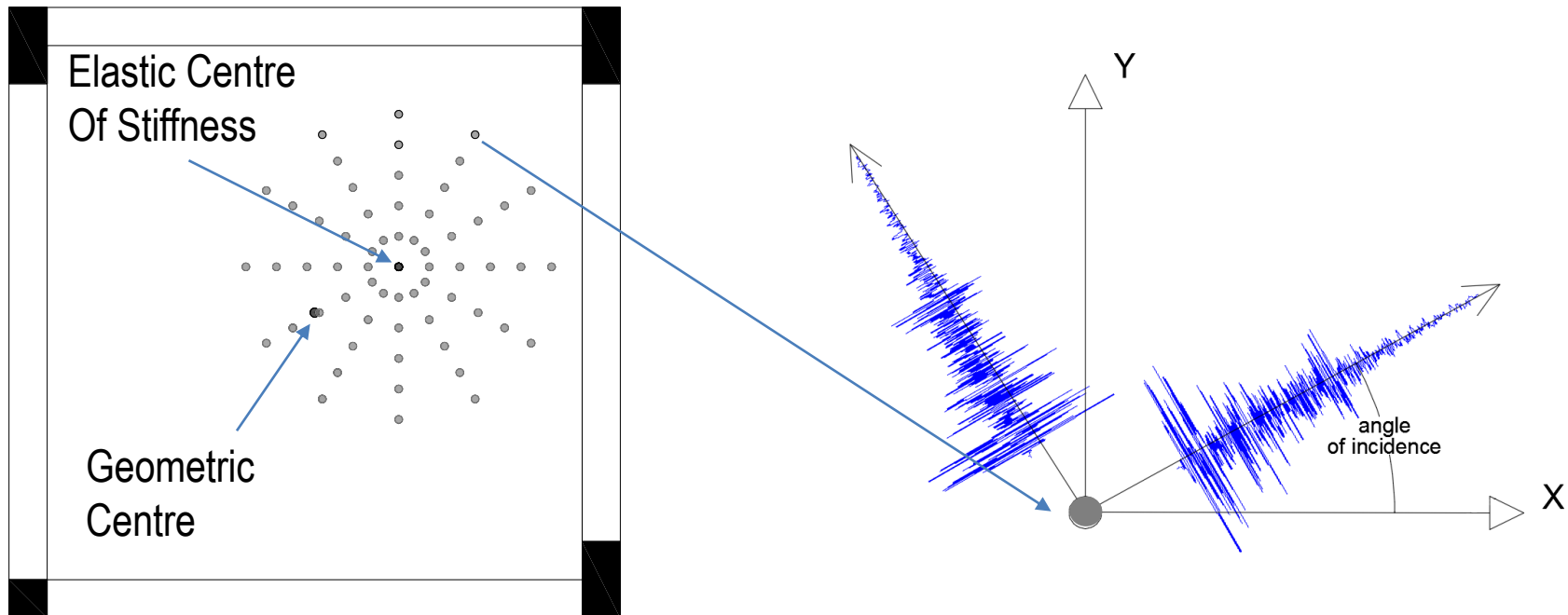
- × Symmetry
- ✓ Simplicity
- ✓ Regularity



- × Symmetry
- × Simplicity
- × Regularity

Parametric analysis

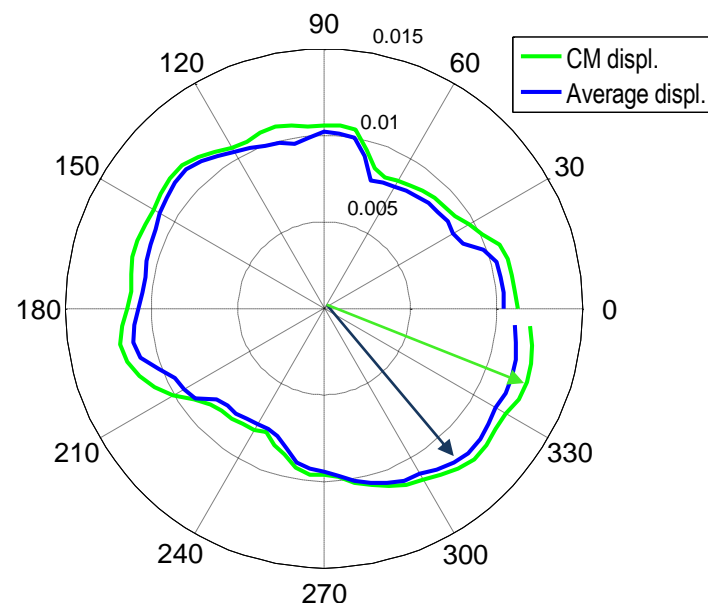
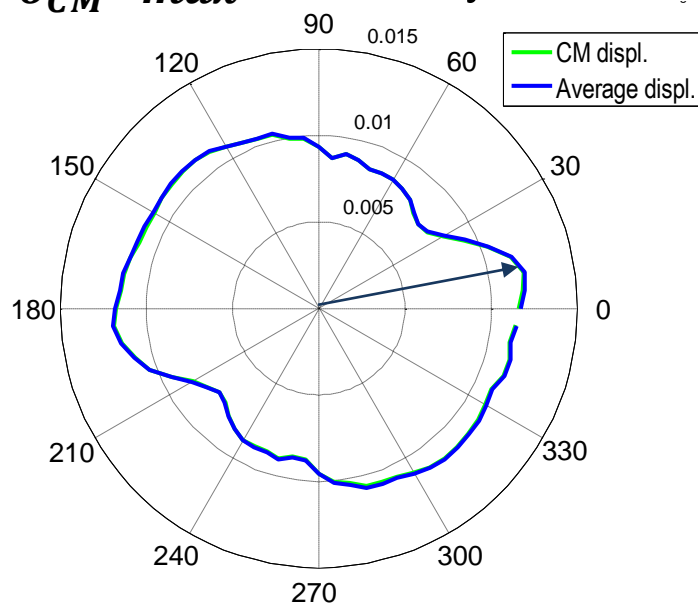
- Different positions of the Centre of Mass with respect to the elastic centre of the structure and
- Different angles of incidence 0° to 360° in steps of 5°
- Two pairs of ground motions





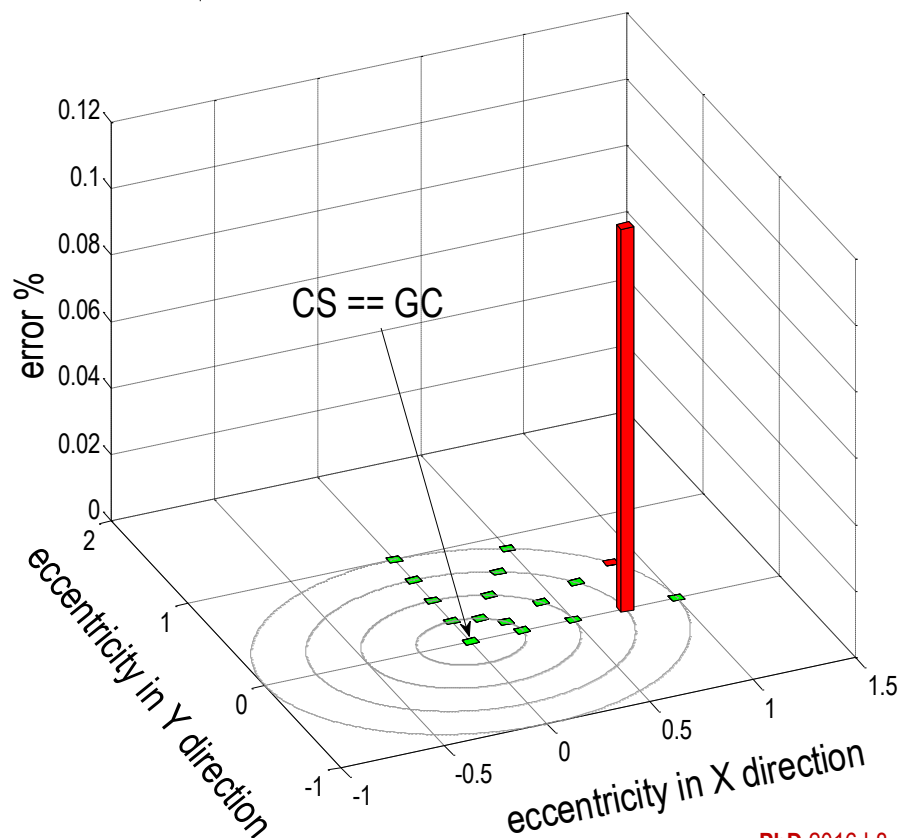
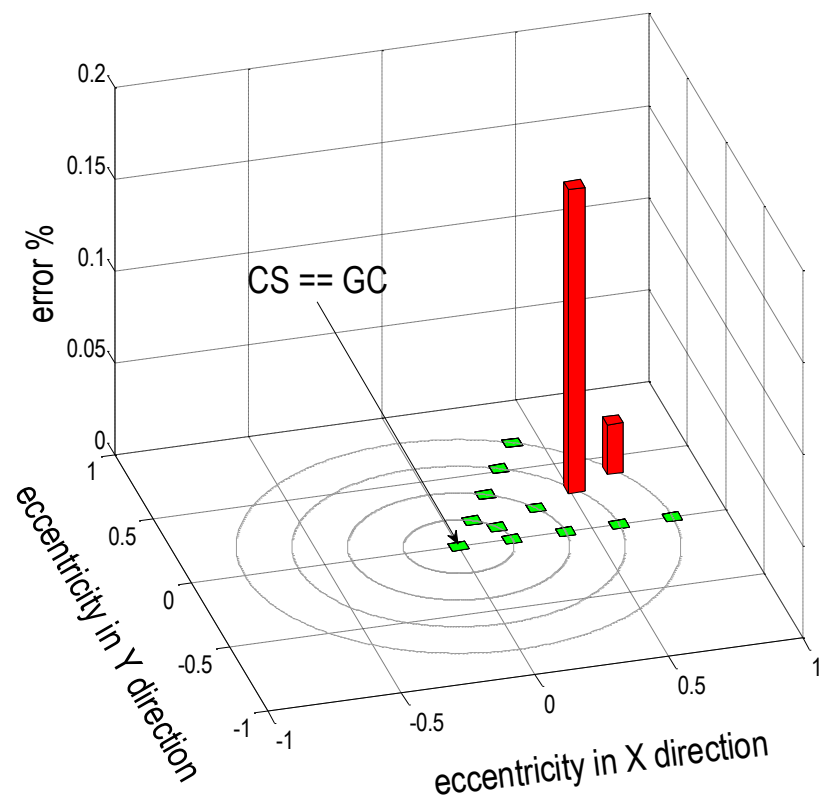
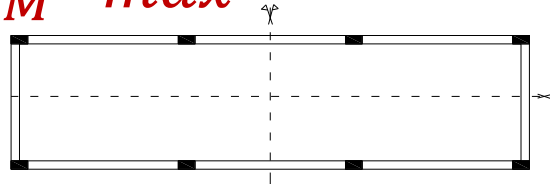
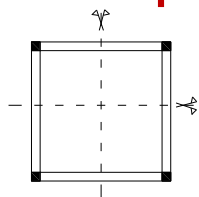
Results

- The pattern of displacements of the centre of mass and of the average displacements of all columns is similar.
- The hypothesis was verified for most of the cases studied for all structures.
- When the angles did not coincide, the **error** between the **maximum average displacement** and the **displacement when $\theta_{\delta_{CM}=max}$** was analysed..



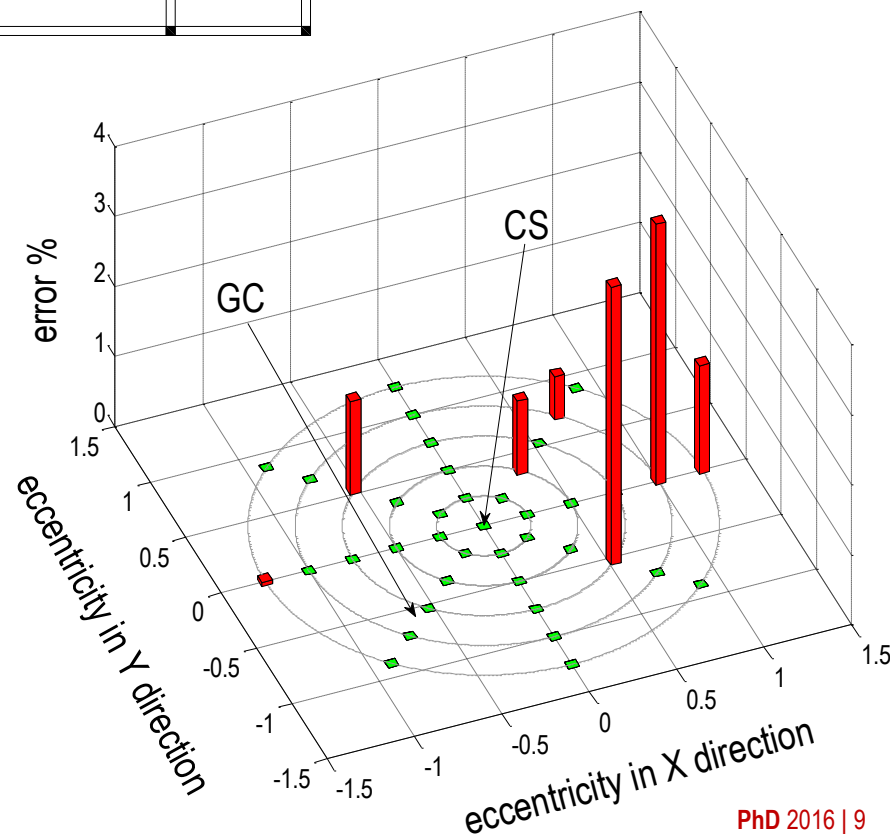
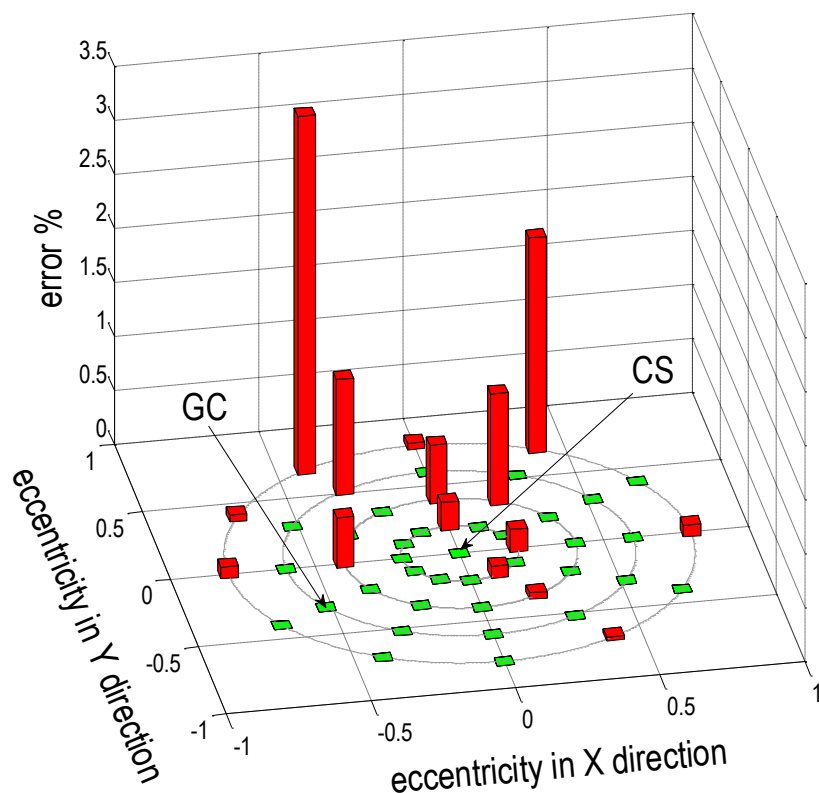
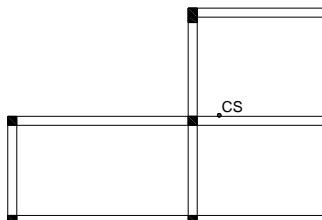
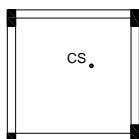


% Error in the max average displacement and the displacement when $\theta_{\delta_{CM}} = \max$





% Error in the max average displacement and the displacement when $\theta_{\delta_{CM}} = \max$





Conclusions

- The proposed **global demand parameter** represents adequately the **average global response** in single storey buildings
- **Small errors** in the relevant displacements when the angles do not coincide
- **Further research** required:
 - More structural configurations
 - Demand at the member level.
 - Preliminary results show that the demand at the member level presents higher discrepancies that cannot be neglected.
 - Definition of criteria/limits up to which this hypothesis is valid at the member level.