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# Modelling of U-shaped reinforced concrete walls under seismic loading with diagonal direction


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## CONTEXT

- Current design codes provide design rules for the simple rectangular walls and for parallel or perpendicular-to-the-flanges seismic loading direction.
- But for the core walls, the most unfavourable situation is the diagonal loading, where the occuring phenomas are still unclear. Most of the current computational models still overestimate the capacity of such walls.
- So how to design safely yet economically such walls?

Fig.1 L`Aquila, Italy –2009 Earthquake – RC core wall damage (R.1.)


Fig.2 Bhuj, India –Structure with RC core after the 2001 Gujarat Earthquake (R.2.)

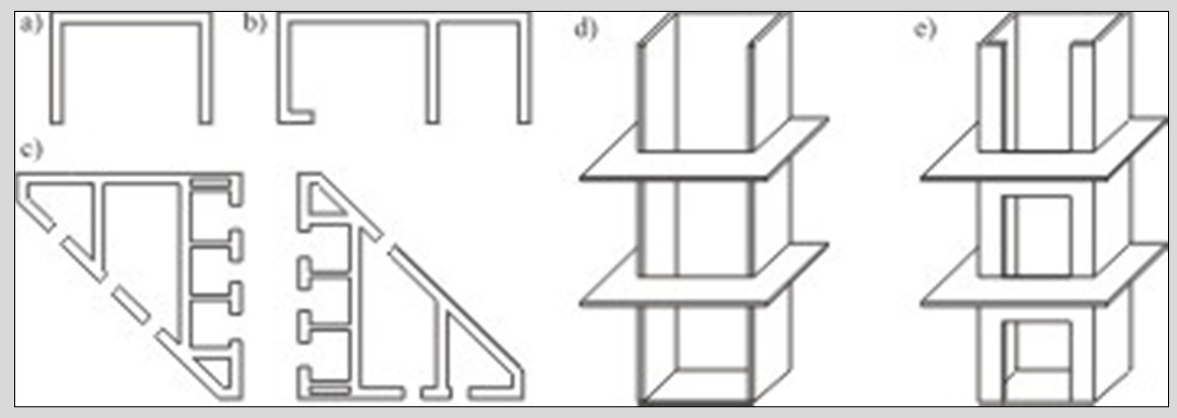


Fig.3 Cross section of core structures(a-c) and examples of an open(d) and partially closed core (e). Cross section (a) U-shaped wall = the most simple type of core wall (R.3.)

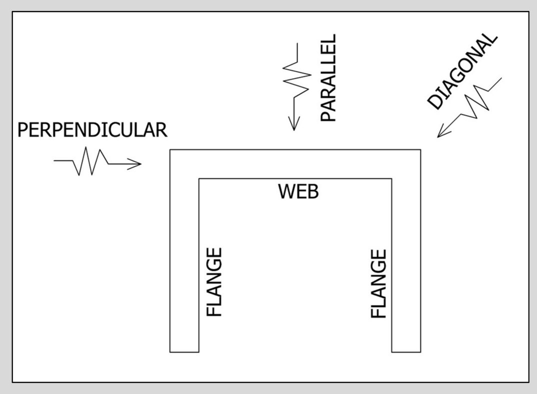


Fig. 4 Plan view for U-shaped wall with possible earthquake loading directions

- Diagonal direction -most unfavourable from the point of view of resisting capacity

## MODELLING APPROACHES

- Lumped plasticity model: the inelastic deformation is concentrated in one plastic hinge in the section of the wall with the largest moment demand ( at the base).
- Stick model: the wall section is modeled by one single element.
- Wide Column Model with inelastic properties (Fig.5)
- Shell Model: walls are modeled using multi-layered shells and discrete or smeared reinforcement.

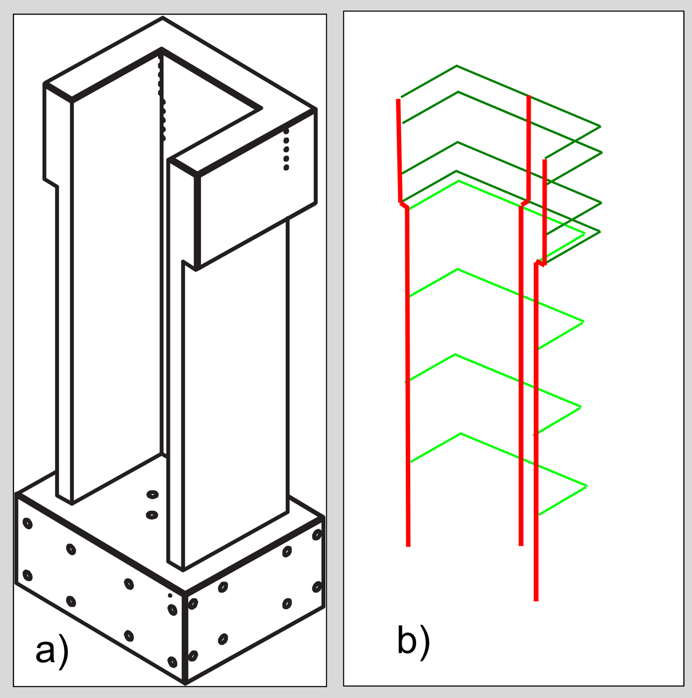


Fig.5

a) U-shaped wall –test specimen

b) Wide Column Model of the wall (R.4)

## SHELL MODEL

### SHELL ELEMENT

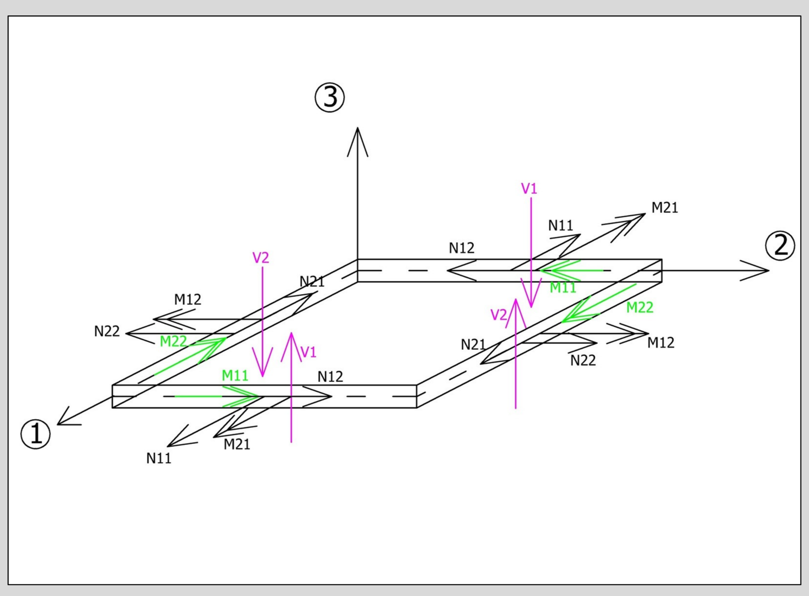


Fig. 6 Shell element internal forces in local coordinates. Shell with transverse shear – COQ4 element from the library of CAST3M software

### MATERIAL MODELS

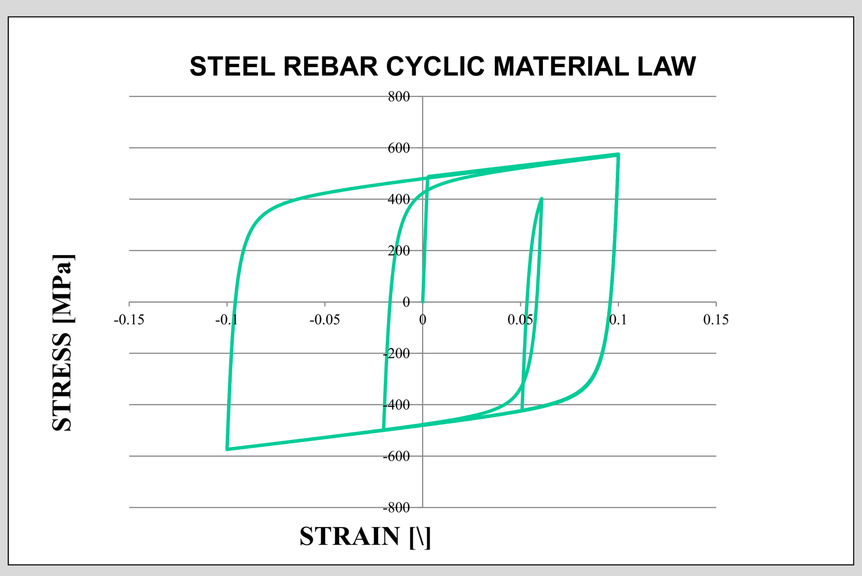


Fig.7 STEEL REINFORCEMENT
Modified Menegotto-Pinto
(uniaxial law taking into account the buckling of the reinforcement bars and the Bauschinger effect)

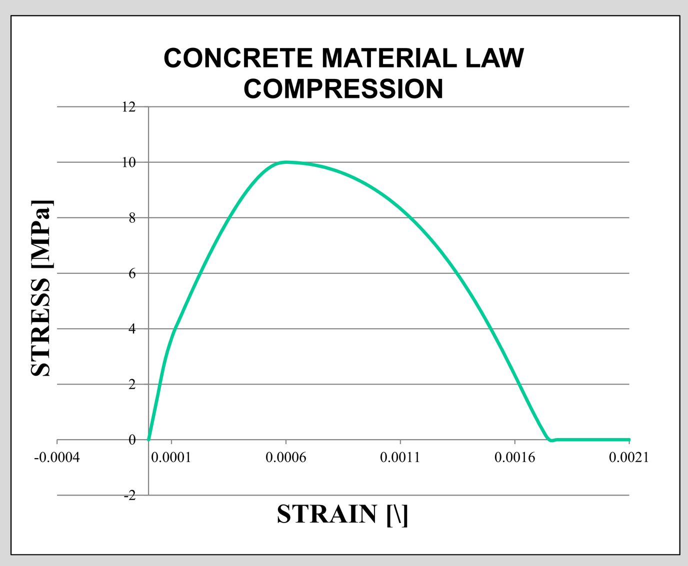


Fig.8 CONCRETE
Ottosen Material Model

### MULTI-LAYERED SHELL

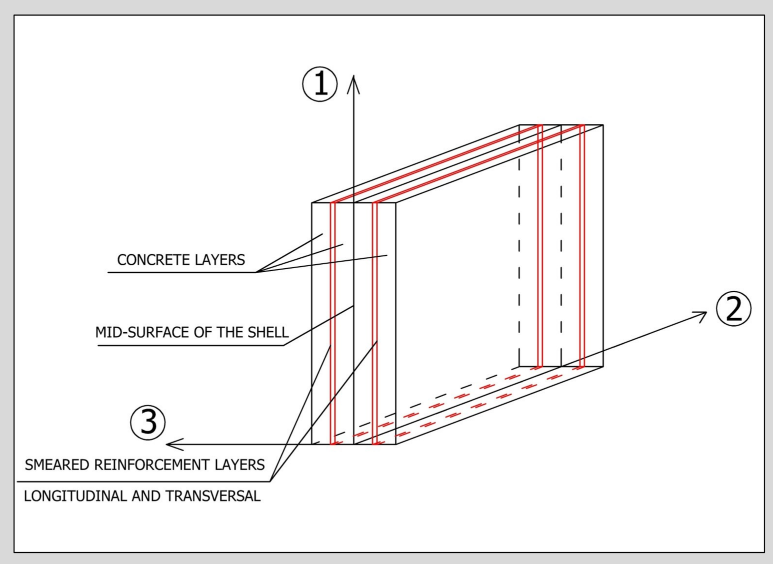


Fig. 9 The shell has 3 concrete layers and 4 reinforcement layers (2 for longitudinal and 2 for transversal bars- the transversal and longitudinal are overlapped)

## OBJECTIVES

- Understanding and modelling the shear transfer mechanism between the web and the flanges of the wall
- Understanding the behaviour of the wall under different loading directions
- Having a model which estimates corectly the force and displacement capacity of the wall

**REFERENCES:**


R.1&3,4. By the courtesy of K. Beyer

R.2. http ://www.iitk.ac.in/nicee/EQ_Reports/Bhuj/build_rc1.htm