

SOME DEVELOPMENTS ON PERFORMANCE-BASED SEISMIC DESIGN OF MASONRY STRUCTURES

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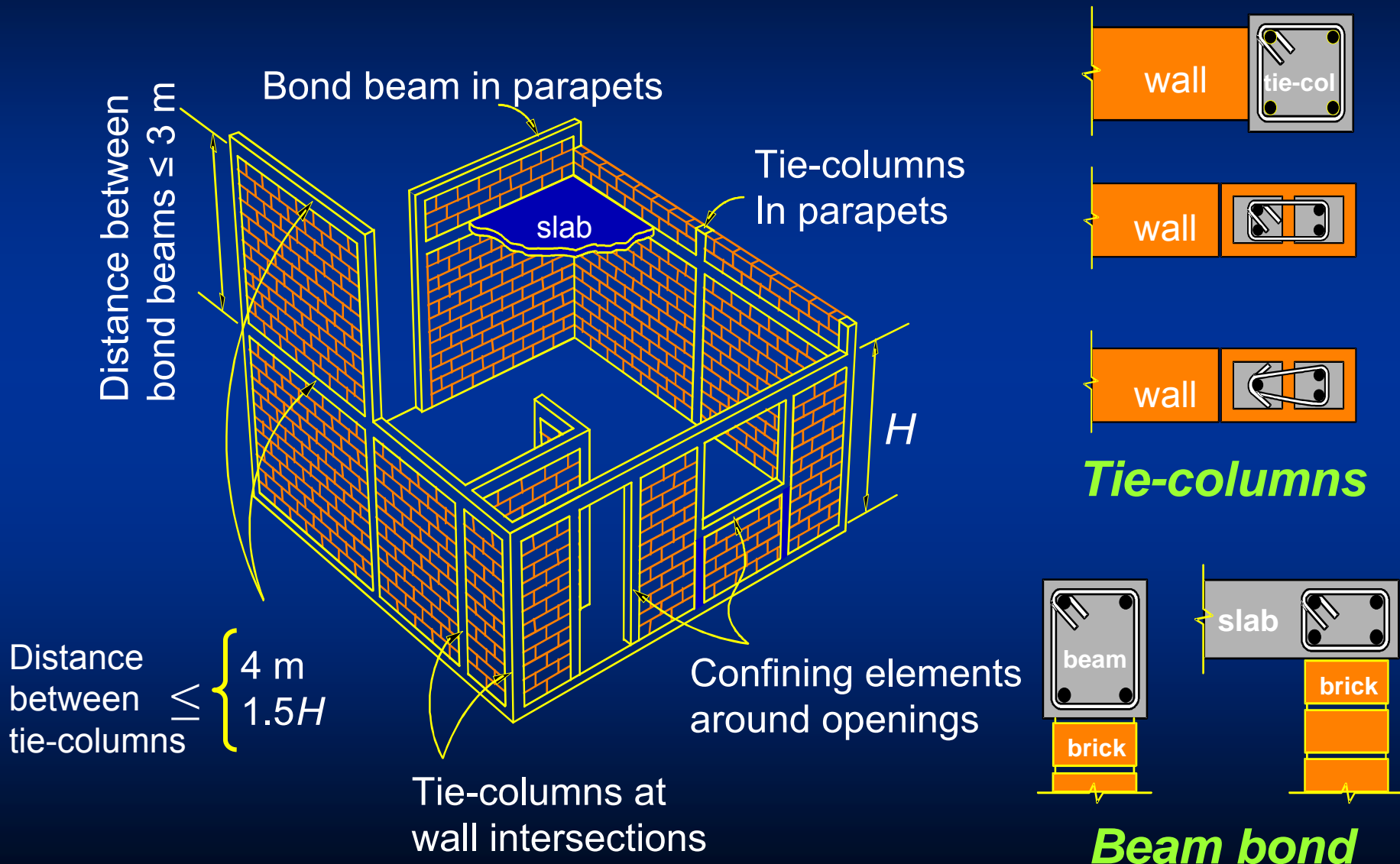
Masonry construction in Mexico 1

- Because of the large housing deficit in Mexico (4.3 M houses), over 70% of the construction industry is focused on housing development and rehabilitation
- Over 50% of housing projects are built with masonry
- Historically, one-third of the total losses infringed by earthquakes has concentrated in housing

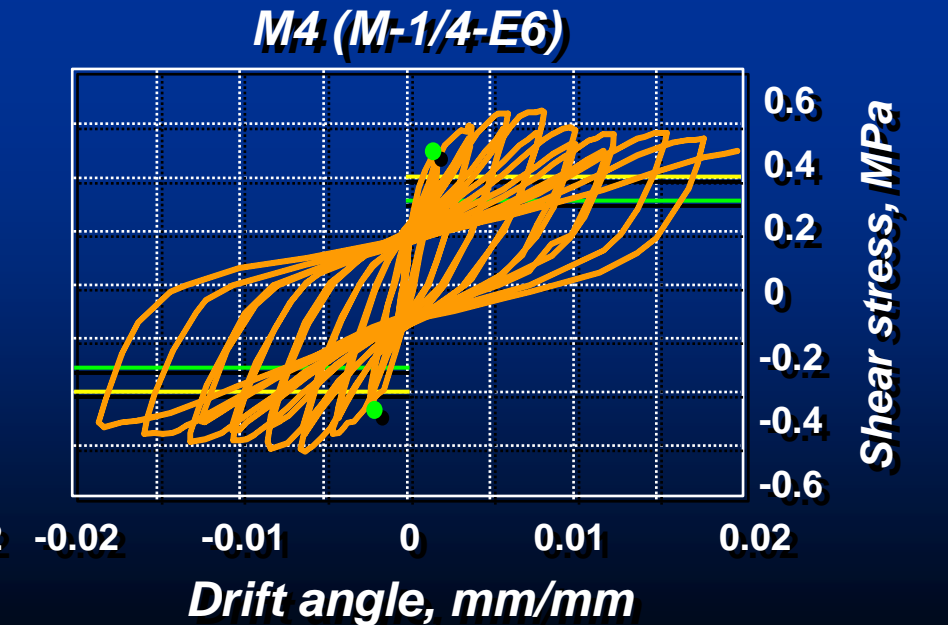
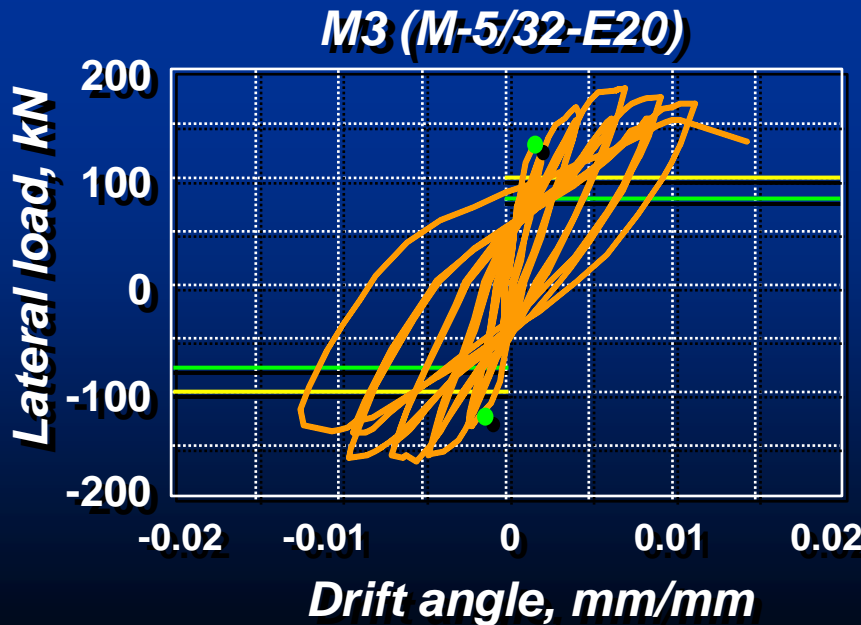
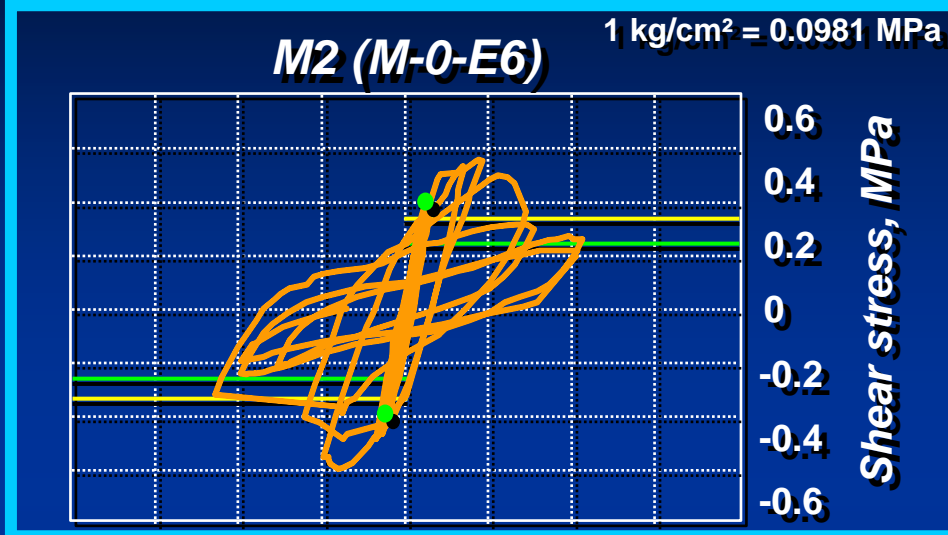
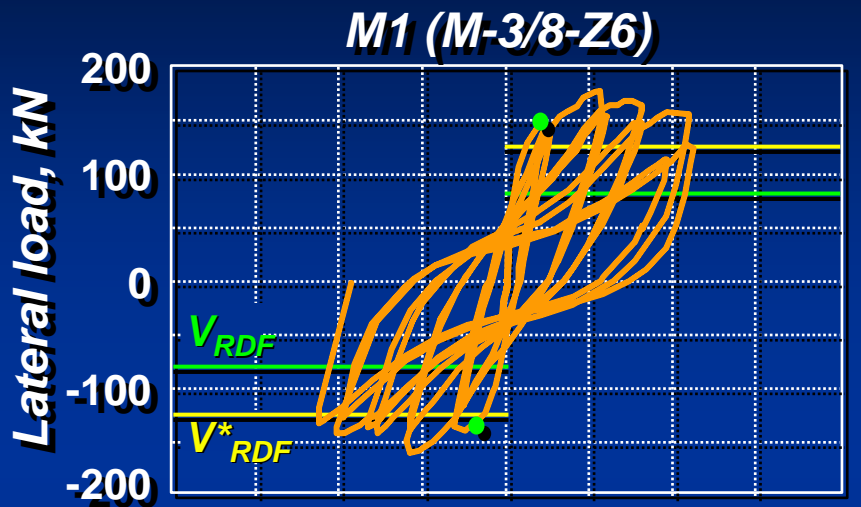
Masonry construction in Mexico 2

- Confined masonry, confined with tie-columns and bond-beams, is the prevalent masonry system in the country (and in Latin America)
 - *Excellent performance when properly confined: amount and detailing*
- Improvements in design practice, based on sound principles and models, will have a significant **economical impact** because housing prototypes are largely replicated
- All savings of families are invested in their houses; therefore, a house is the **most cherished family asset**

Confined masonry requirements



Hysteresis curves of confined masonry walls





Masonry shear strength

Masonry contribution to shear strength

$$V_{mR} = F_R (0.5 v_m^* A_T + 0.3 P) \leq 1.5 F_R v_m^* A_T$$

Contribution of horizontal reinforcement to shear strength

$$V_{sR} = F_R \eta \rho_h f_{yh} A_T$$

Allowable inelastic lateral drift angle

$$\gamma_{\text{inelastic}} = Q \gamma_{\text{reduced load}}$$

0.006 *infill walls*

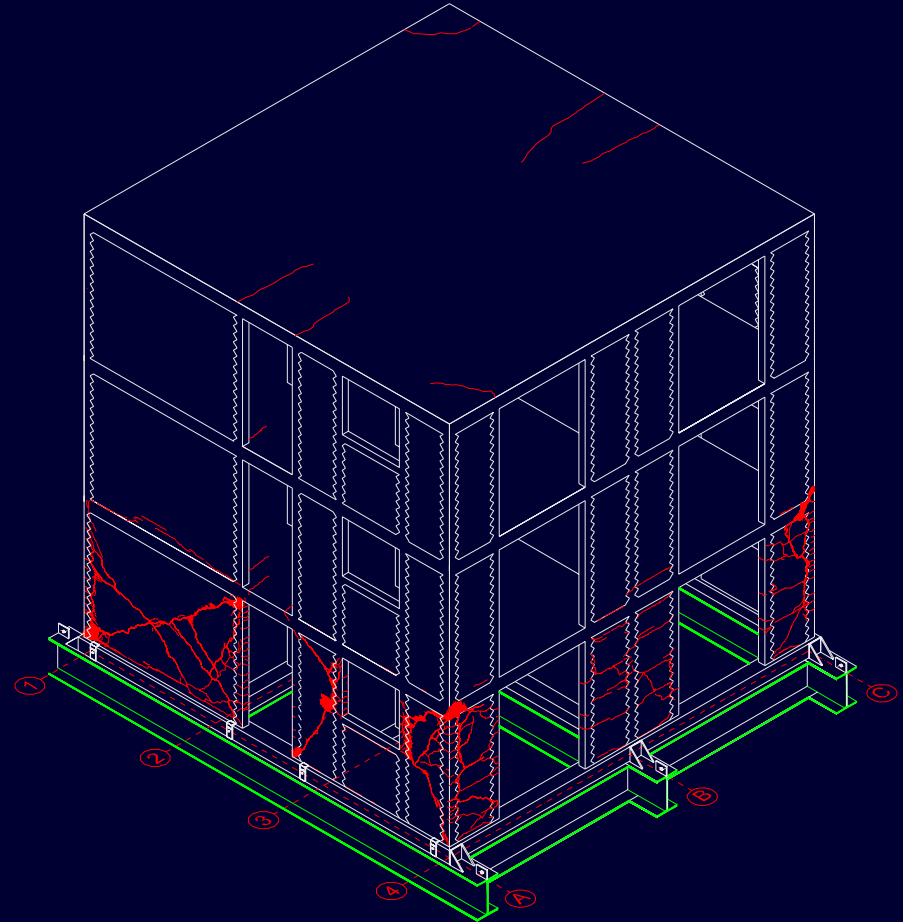
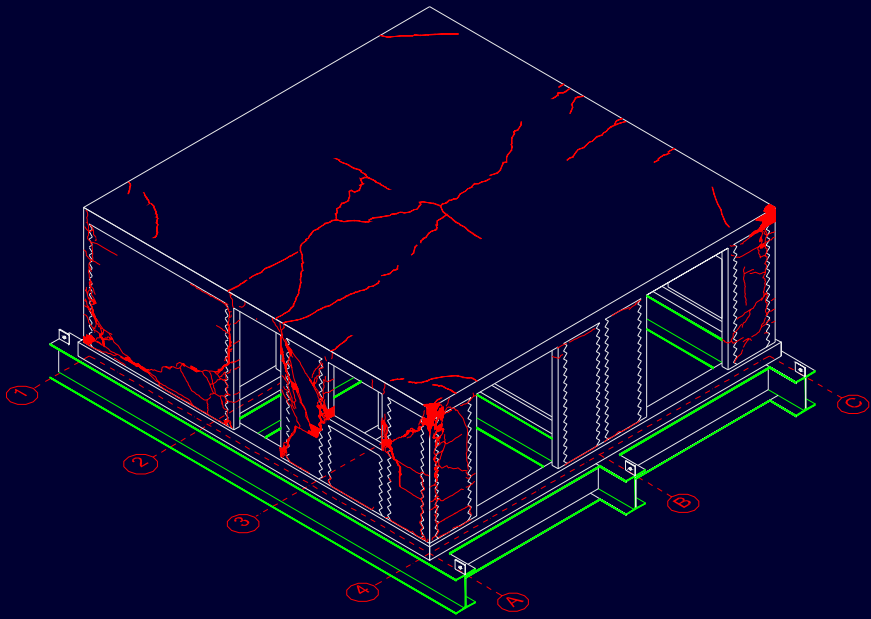
0.0035 *load bearing confined masonry walls, solid units and horizontal reinforcement or wire mesh*

0.0025 *confined masonry walls: solid units or hollow units with horizontal reinforcement or wire mesh*

0.0020 *internally reinforced masonry*

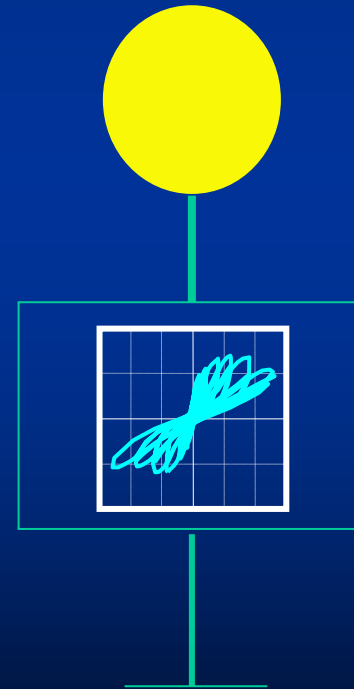
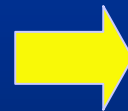
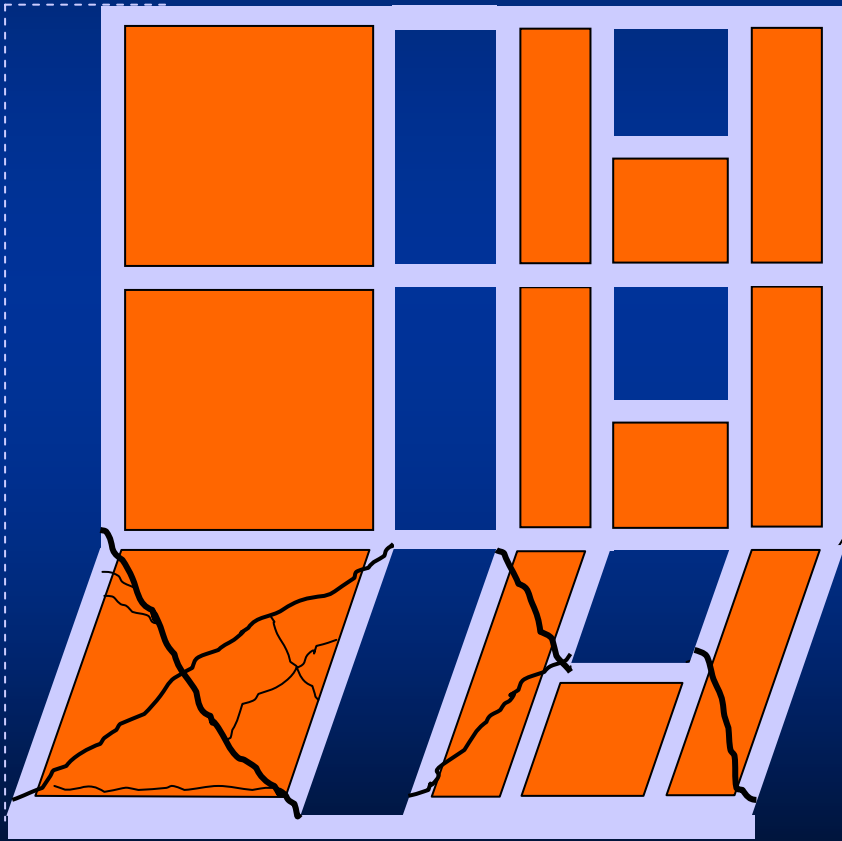
0.0015 *unreinforced, unconfined masonry*

Final damage state

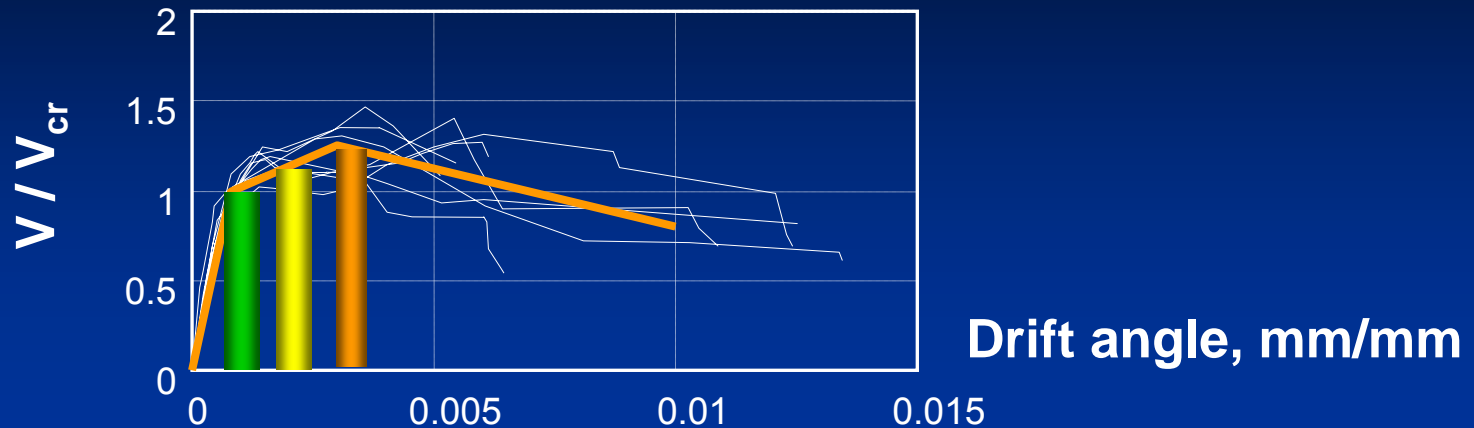


Model proposed

- Shear plastic hinge at ground story
- Basic design parameter is drift angle

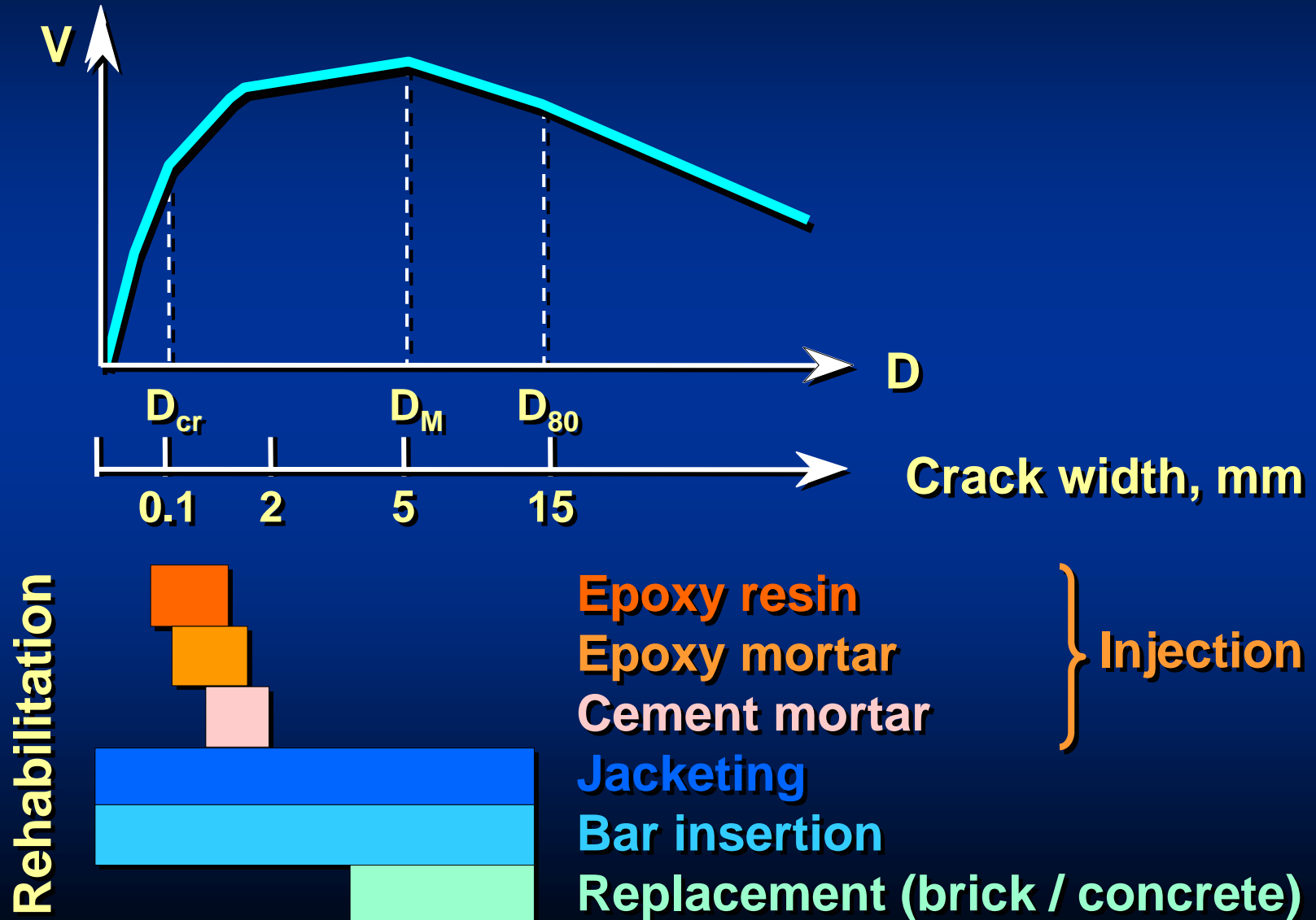


Performance criteria

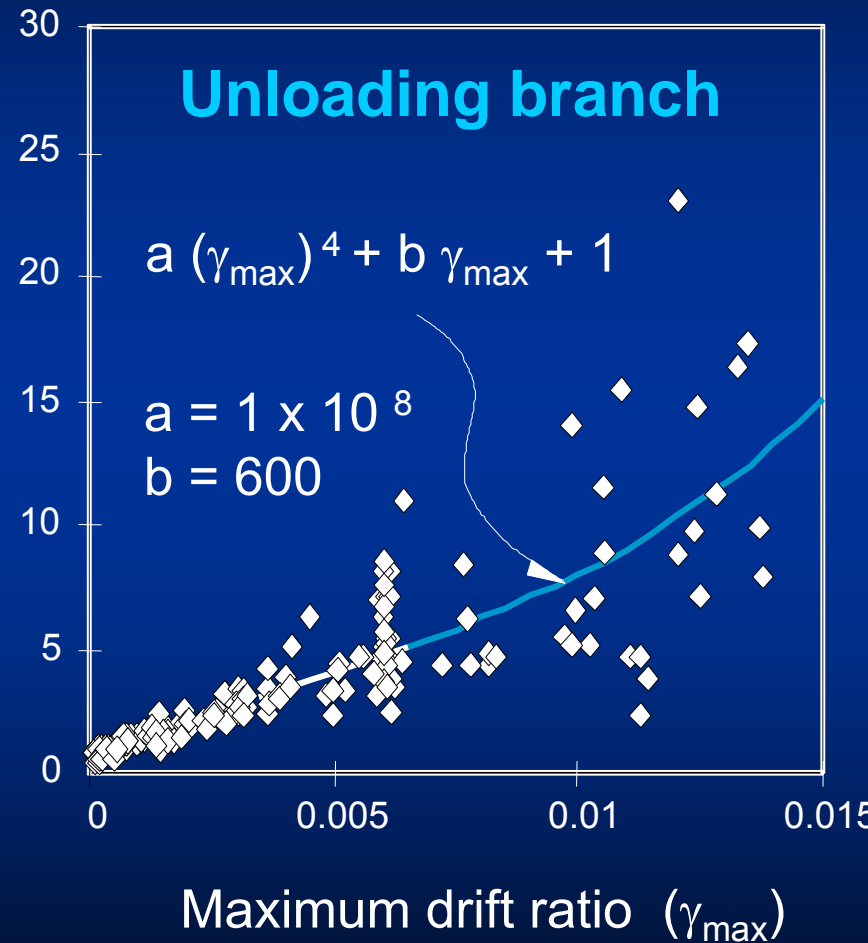
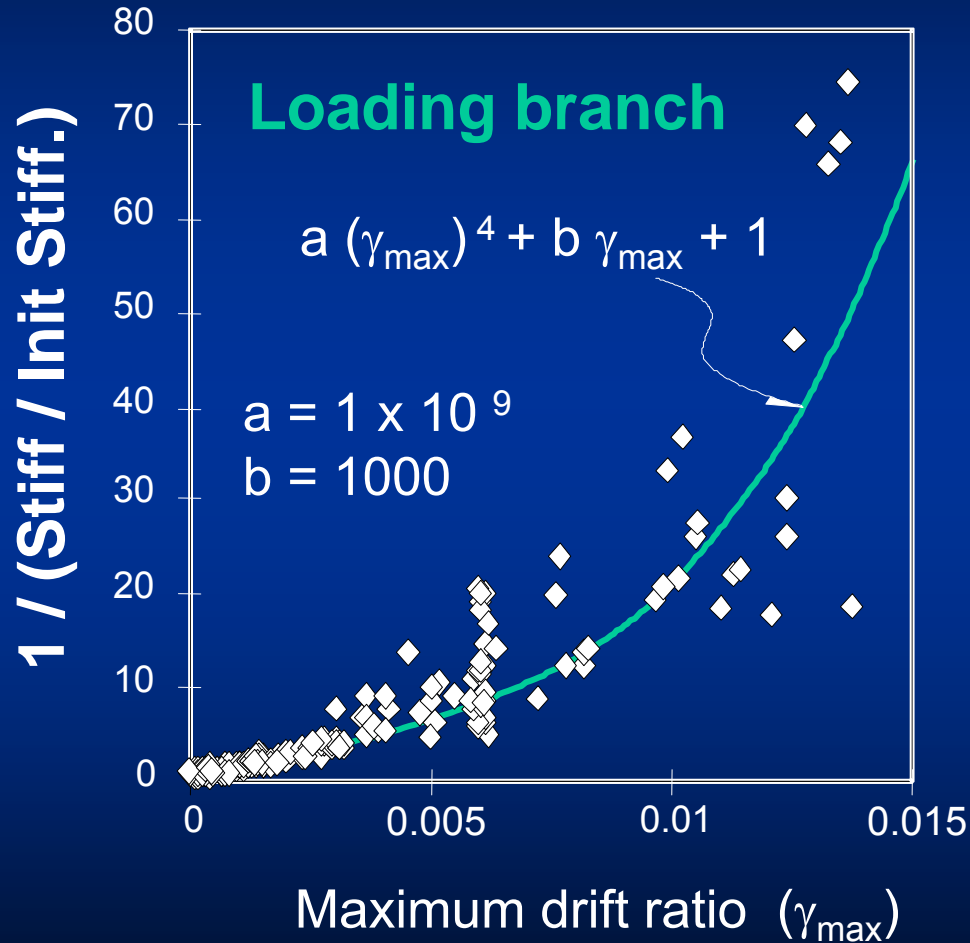


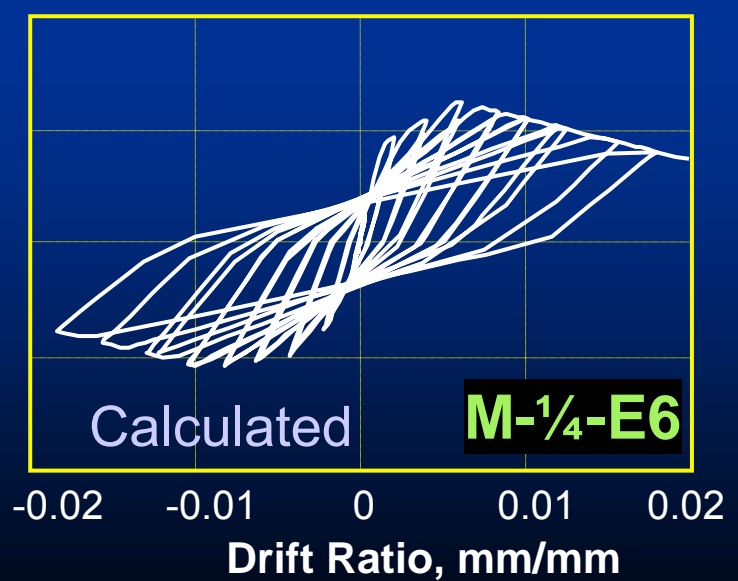
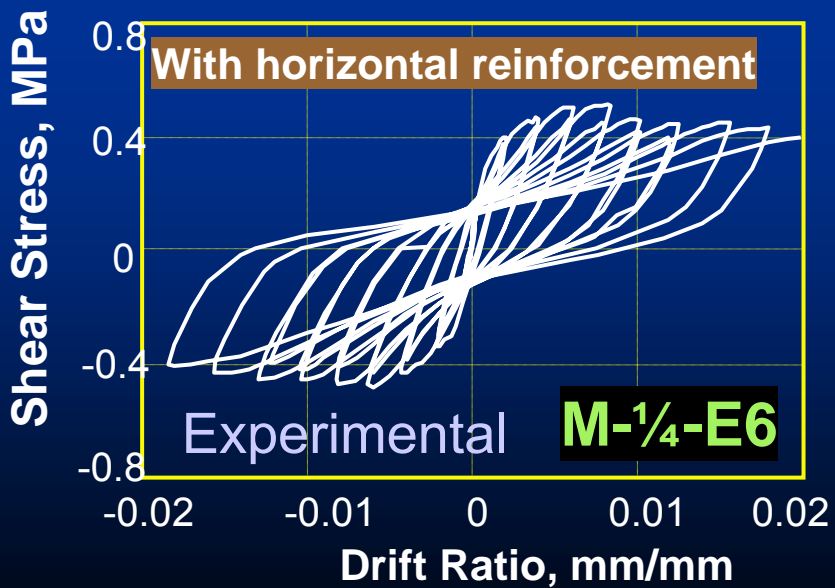
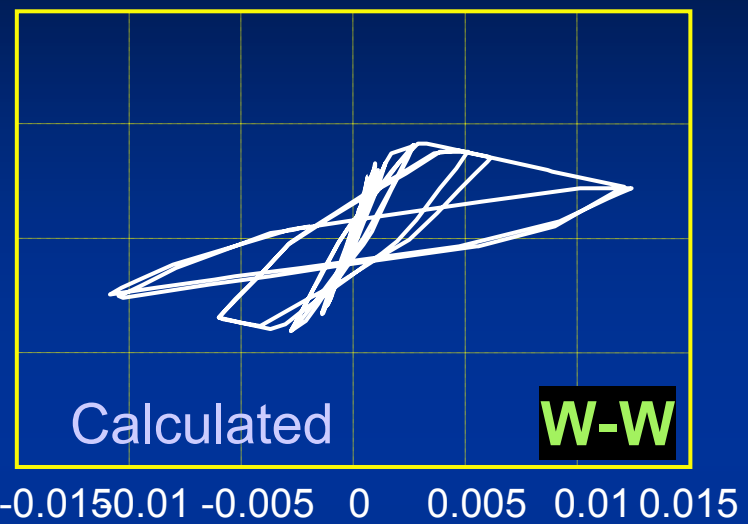
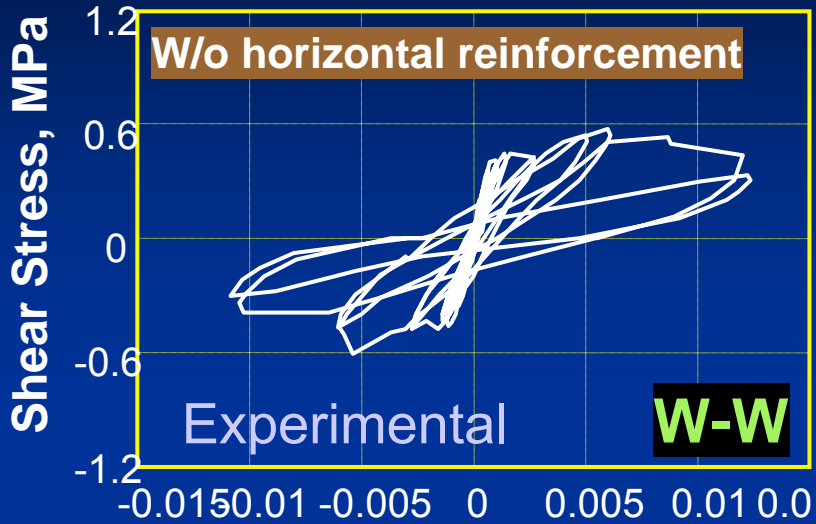
<i>Limit State</i>	<i>Criterion</i>	<i>Residual crack width, mm</i>	<i>Drift angle, %</i>
Serviceability	Onset of masonry inclined cracking (cracking strength)	0,1	0,15
Repairability	Inclined cracking fully formed over masonry wall; hairline cracking into tie-columns; onset of masonry crushing	2	0,25
Safety	Strength of wall; wall cracking penetrates into tie-column ends; yielding of tie-column reinforcement due to shearing; onset of tie-column crushing	5	0,40

Rehabilitation criteria

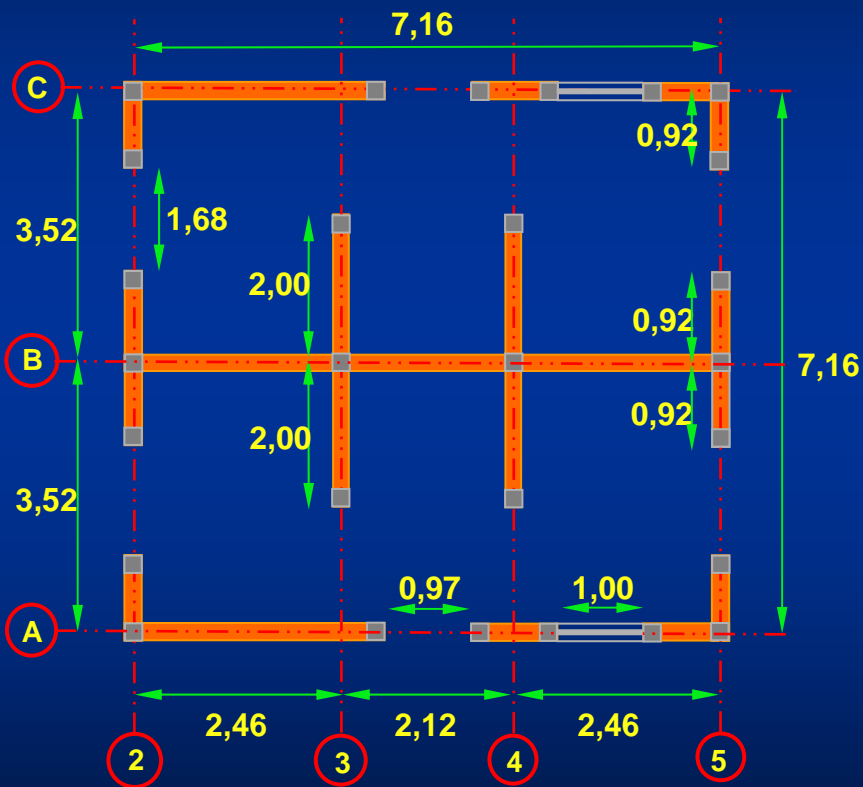


Stiffness law – degrading behavior



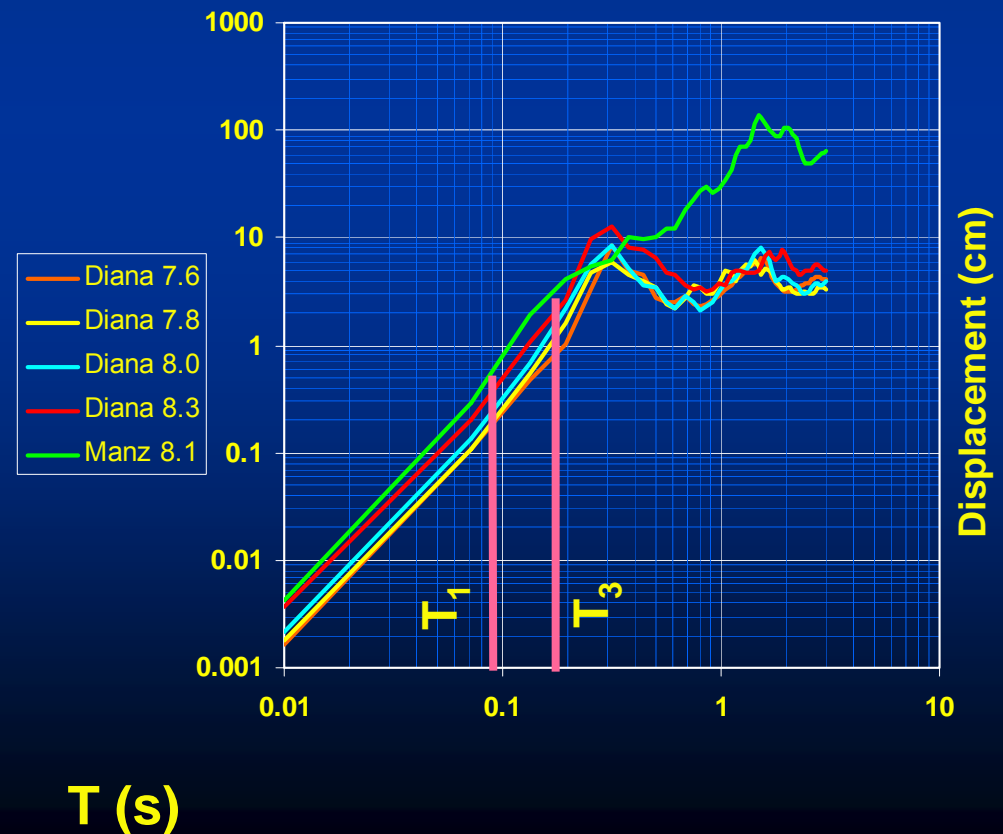


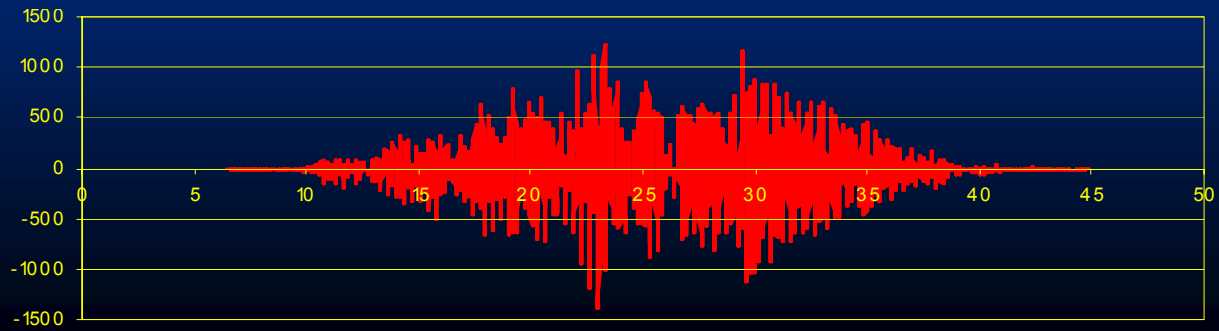
Shaking table tests to assess seismic performance

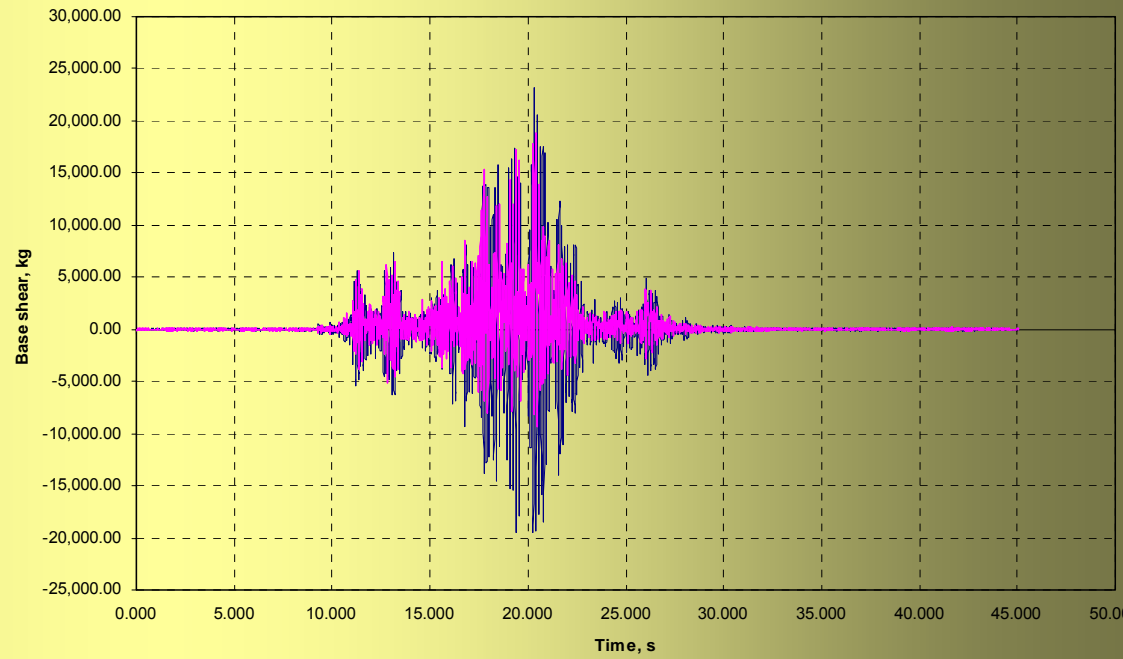
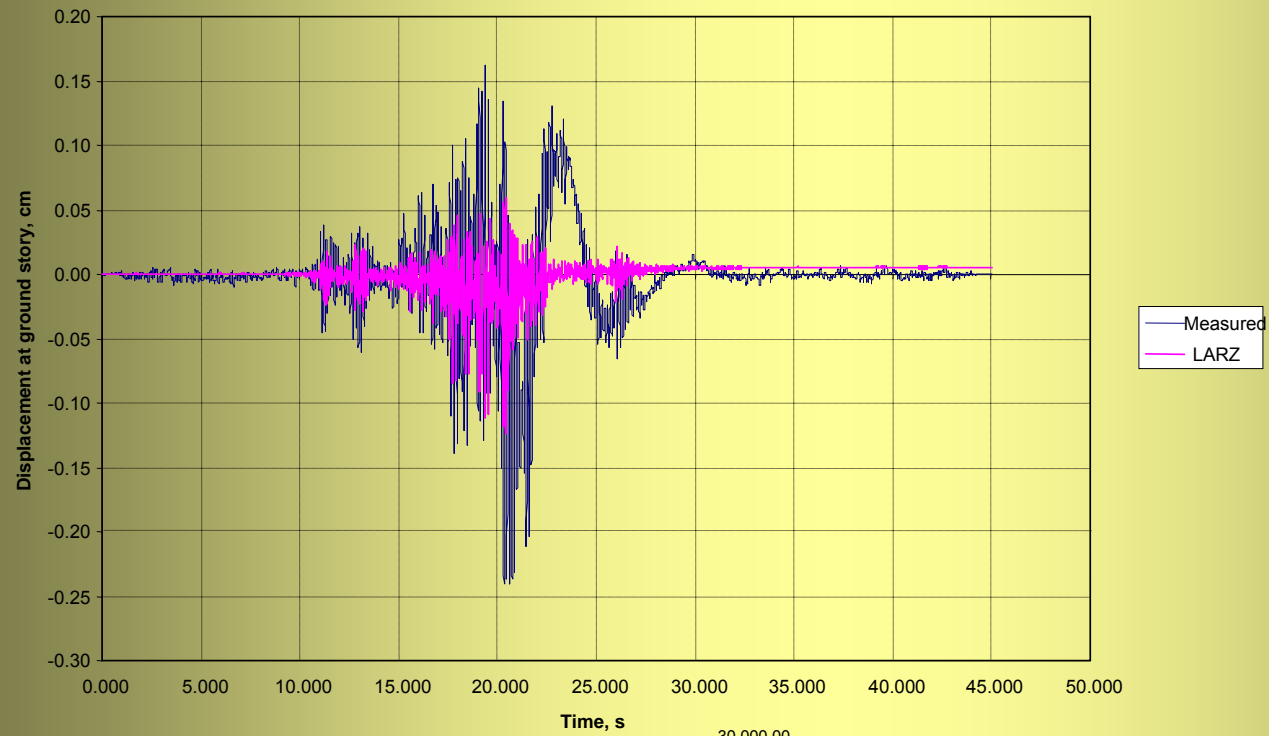


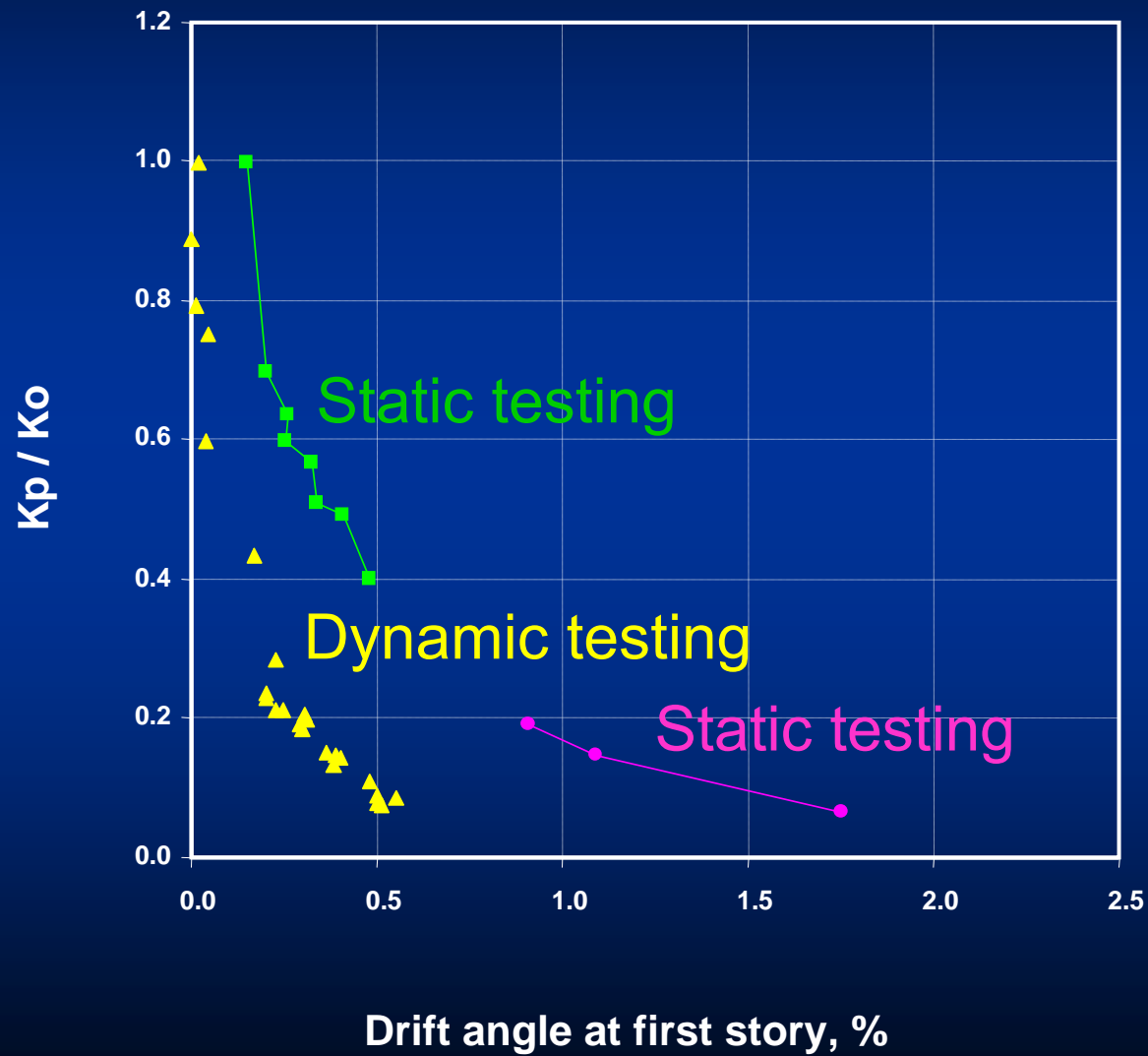
Response spectra of records applied

- A M7.6 earthquake record was used as a Green function to simulate records of higher magnitude (and intensity) and longer duration

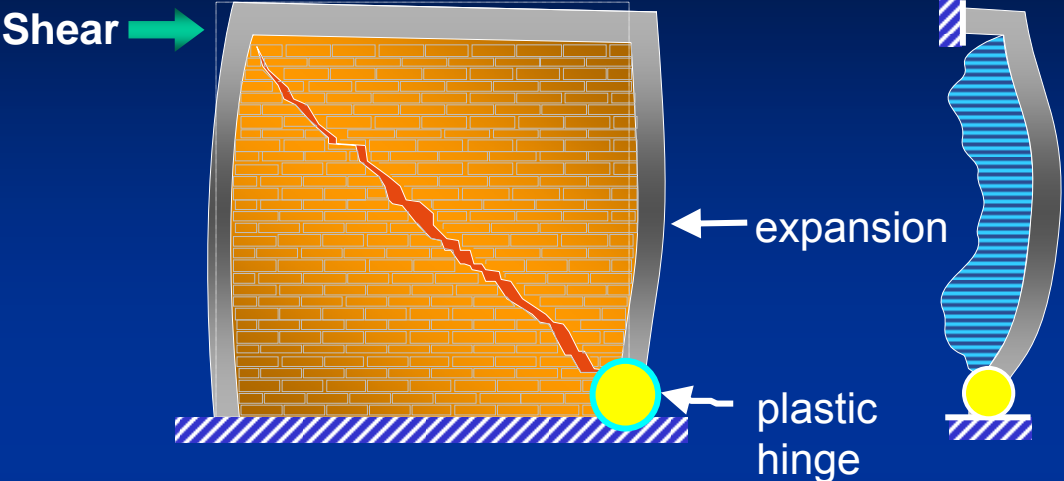




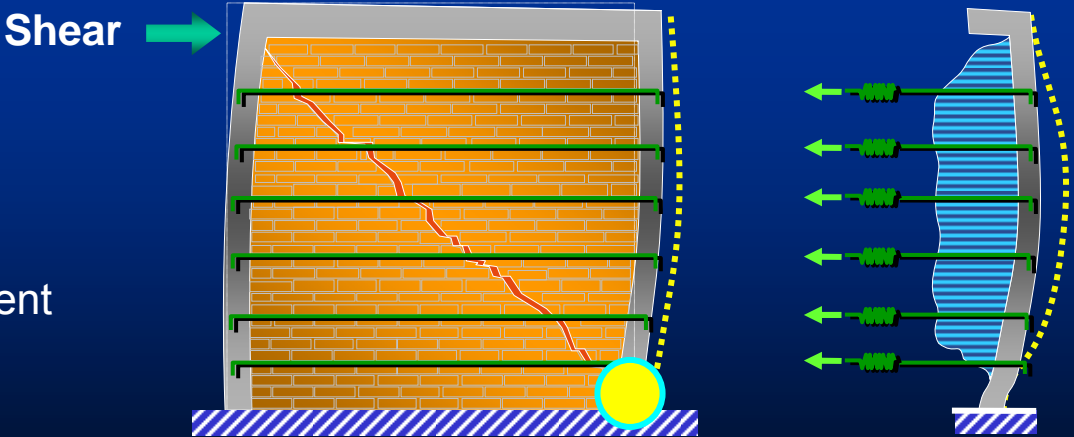




Improvements under development



Wall with horizontal reinforcement



Concluding remarks

- A simplified model to predict the nonlinear response of masonry structures was developed from static cyclic tests
- A performance evaluation series of tests on a shaking table is underway
- Calculated response departs from measured response
- Improvements on nonlinear modeling of complex confined masonry structures are needed
- Simulation needs to capture the effect of confinement and perpendicular walls