



WORKSHOP UNISA-RELUIS
Fisciano 12-13 Febbraio 2007



**MATERIALI ED APPROCCI INNOVATIVI PER IL
PROGETTO IN ZONA SISMICA E LA MITIGAZIONE
DELLA VULNERABILITA' DELLE STRUTTURE**

STRUTTURE CONTROVENTATE



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Università di Salerno



CONTROVENTI CONCENTRICI

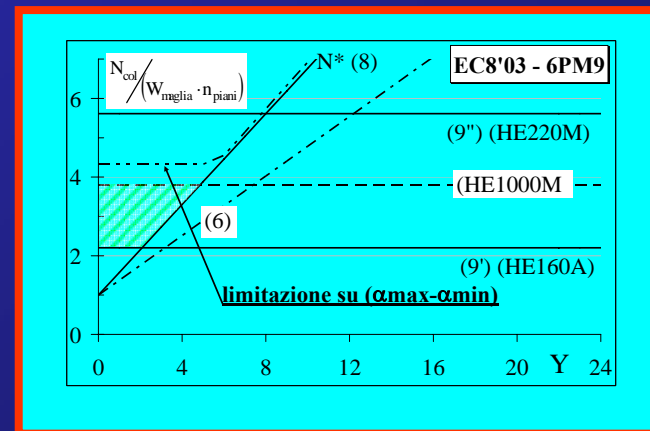
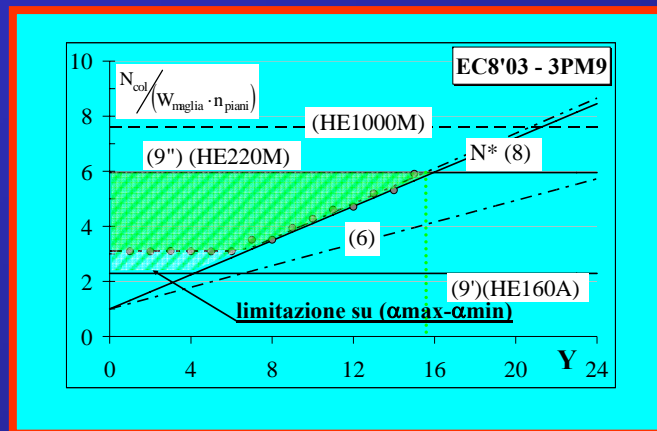


Progettazione sismica di edifici con controventi concentrici

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CONNECTIONS

(full-strength requirement)

$$R_d \geq 1,1 \cdot \gamma_{OV} \cdot R_{fy}$$

where:

γ_{OV} coefficient accounting for randomness of yield strength [from 1 to 1.25]

1,1 coefficient accounting for the influence of strain hardening

BEAMS AND COLUMNS

(the yielding of the first diagonal brace has to develop before beam and column buckling)

$$N_{pl,Rd}(M_{Ed}) \geq N_{Ed,G} + 1,1\gamma_{OV} \cdot \Omega \cdot N_{Ed,E}$$

where:

$$\Omega = \min \Omega_i \quad \Omega_i = \frac{N_{pl,Rd,i}}{N_{Ed,i}}$$

DIAGONAL BRACES OF X-BRACED FRAMES:

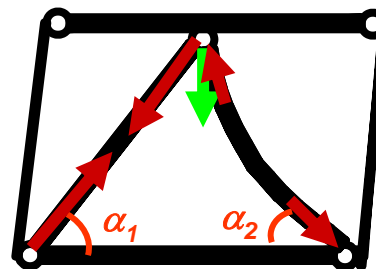
$$1.3 \leq \bar{\lambda} \leq 2.0$$

DIAGONAL BRACES OF V-BRACED FRAMES:

$$\bar{\lambda} \leq 2.0 \quad \text{where:} \quad \bar{\lambda} = \frac{\lambda}{\lambda_y}$$

POST-BUCKLING BEHAVIOUR IN V-BRACED FRAMES:

$$V = (N_{pl,Rd,t} \cdot \text{sen} \alpha_1 - \gamma_{pb} N_{pl,Rd,t} \cdot \text{sen} \alpha_2)$$



$$\gamma_{pb} = 0.3$$



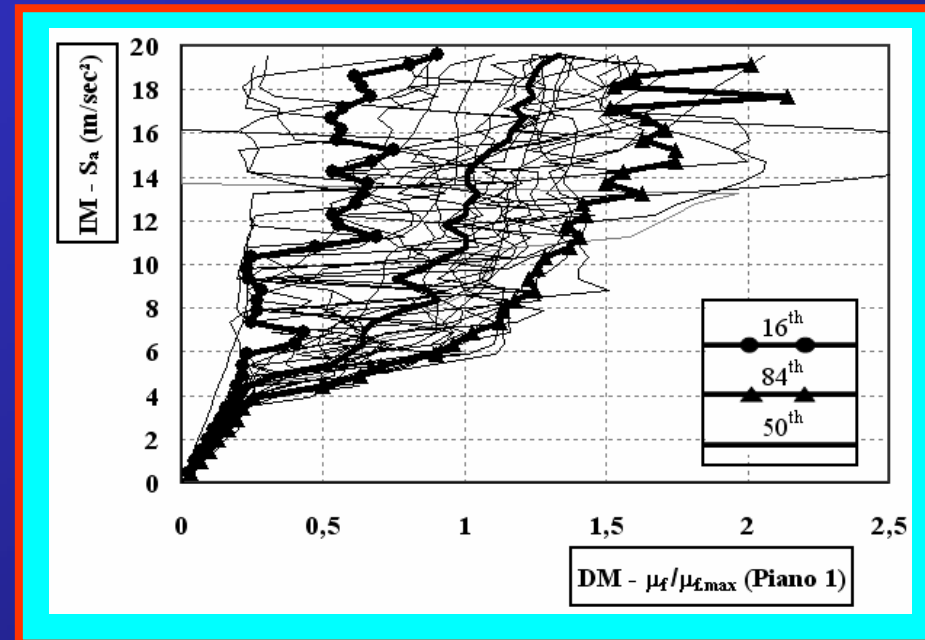
CONTROVENTI CONCENTRICI



Affidabilità Sismica di Controventi Concentrici con Sezioni a Resistenza Ridotta

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EVALUATION OF SEISMIC RELIABILITY



- **CM:** “structural capacity measure”
- **DM:** “structural demand measure”
- **IM:** “seismic intensity measure”

MEAN ANNUAL FREQUENCY OF EXCEEDING A SPECIFIED DEMAND VALUE (usually the drift hazard curve):

$$H_{DM}(dm) = \int P[DM \geq dm | IM = x] \cdot dH_{IM}(x)$$

MEAN ANNUAL FREQUENCY THAT STRUCTURAL DEMAND EXCEEDS STRUCTURAL CAPACITY (LIMIT STATE PROBABILITY)

$$P_{f.LS} = \int P[CM \leq dm] \cdot dH_{DM}(dm)$$

BRIEFLY:

$$P_{f.LS} = \iint F_{CM}(dm) f_{DM|IM}(dm|im) \left| \frac{dH_{IM}(im)}{dim} \right| \cdot dim \cdot ddm$$

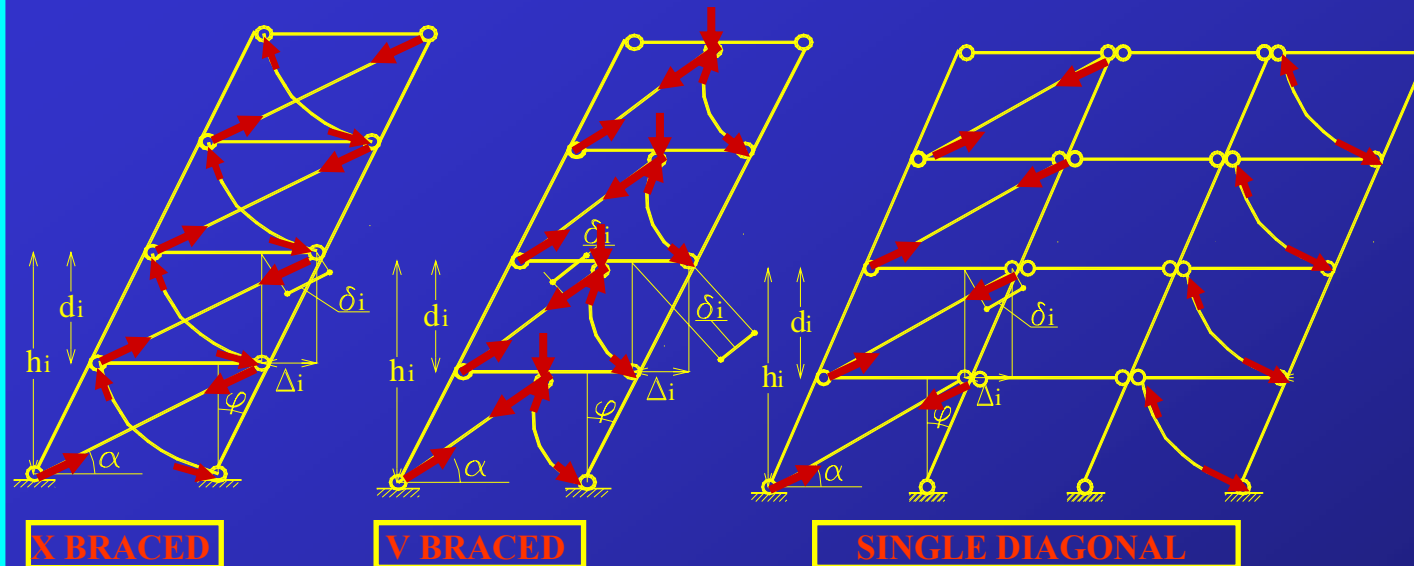
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PSCA

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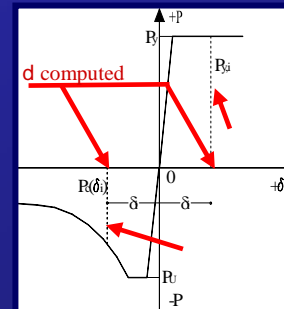
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PROPOSED DESIGN APPROACH



Column continuity



The brace axial displacement corresponding to yielding of i -th storey is:

$$\delta_{pi} = \frac{P_{yi} \cdot L_i}{E \cdot A_i} = \frac{f_y \cdot L_i}{E}$$

For the i -th storey the base rotation corresponding to brace yielding is given by:

$$\delta_i = \phi_i \cdot d_i \cdot \cos \alpha_i = \delta_{pi} \Rightarrow \phi_i = \frac{\delta_{pi}}{d_i \cdot \cos \alpha_i}$$

The value of ϕ leading to yielding of all the diagonal braces is: $\phi_m = \max_{i=1}^n (\phi_i)$

The corresponding vector of deformations of storey braces is: $\delta = \phi_m \cdot d \cdot \mathbf{I} \cos \alpha$



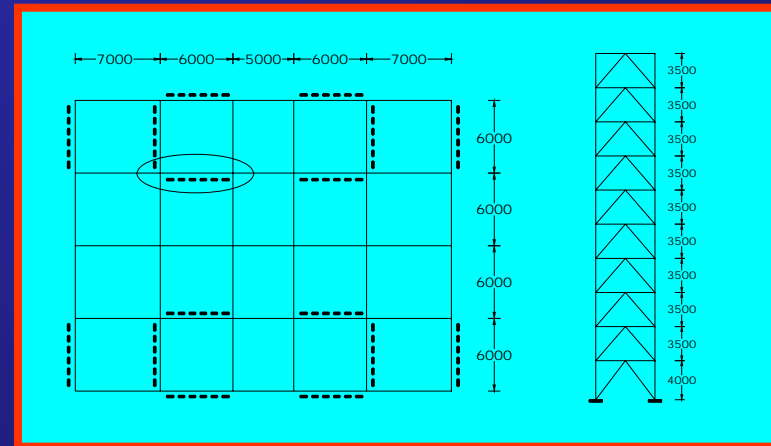
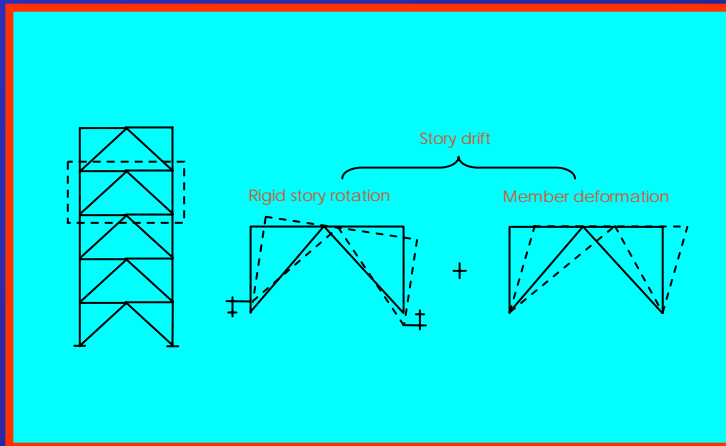
CONTROVENTI CONCENTRICI



Force-based vs. displacement based design of braced steel frames

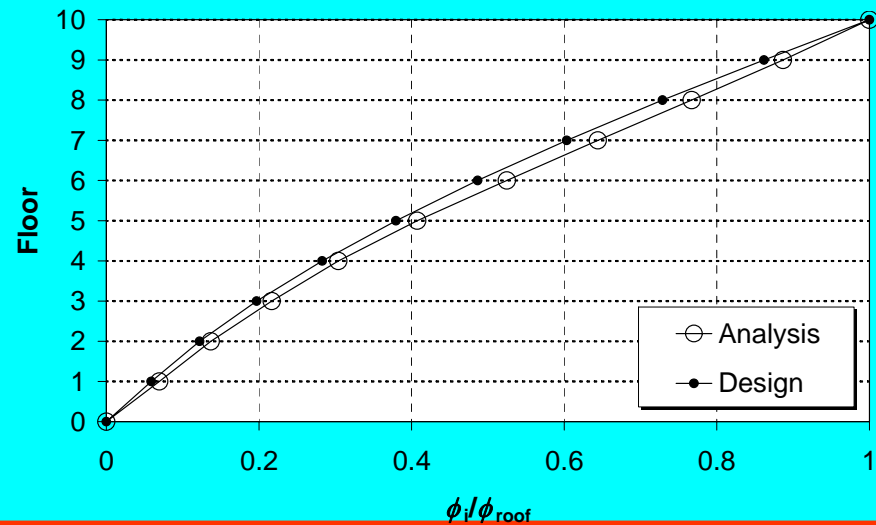
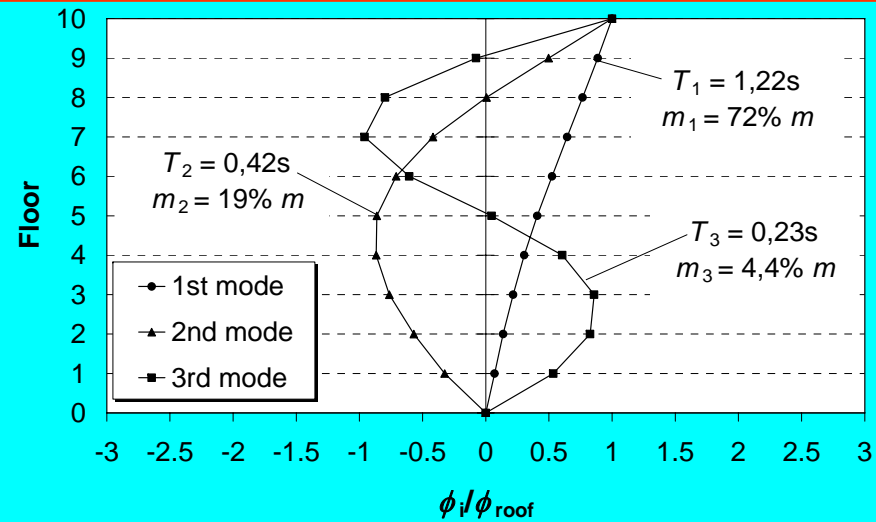
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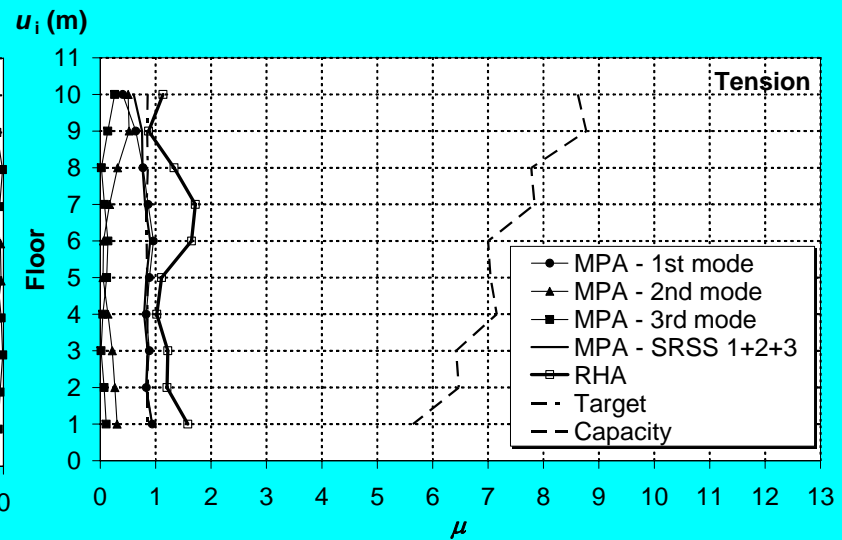
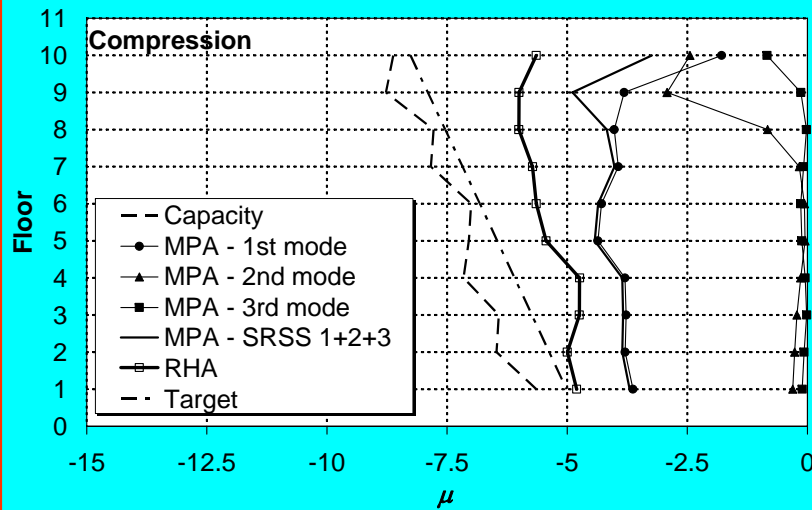
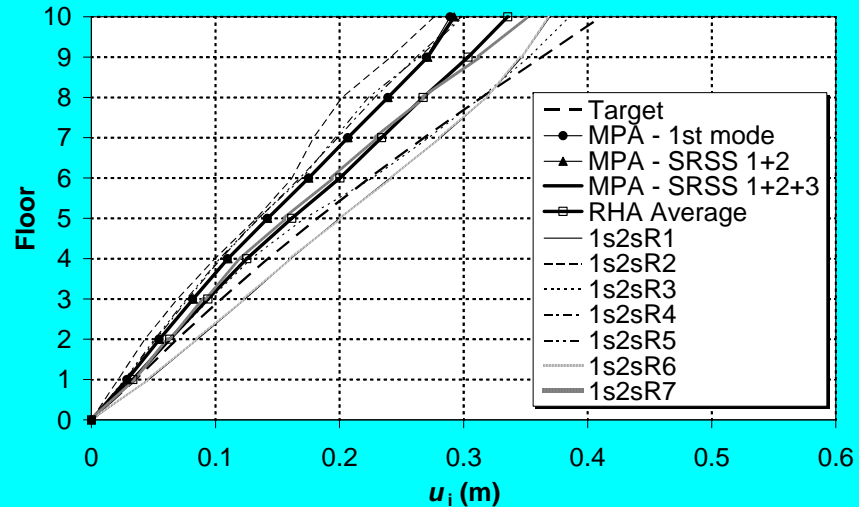


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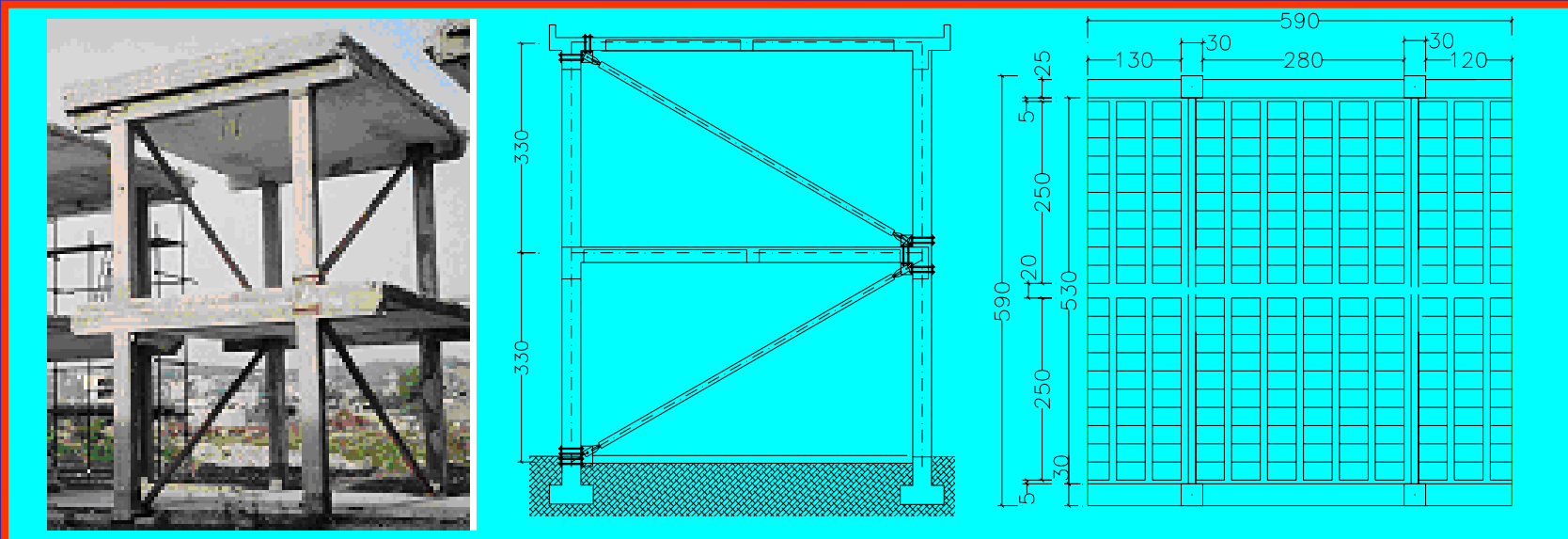
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Steel-buckling restrained braces for seismic upgrading of RC buildings

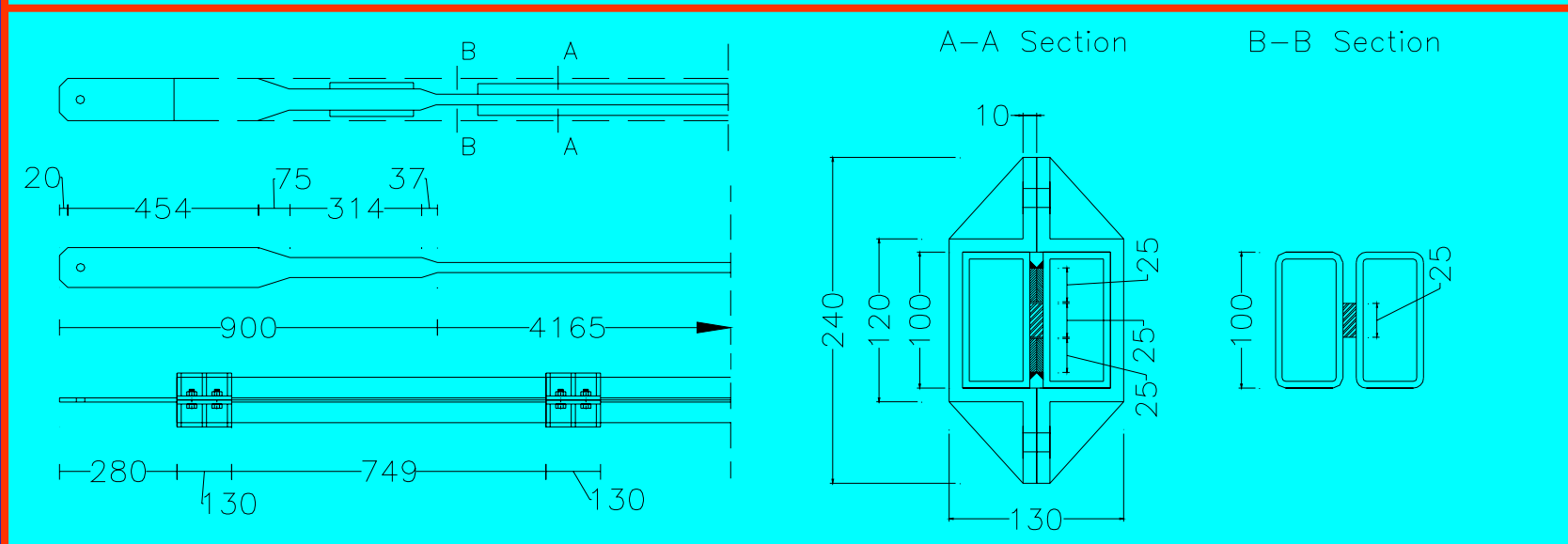
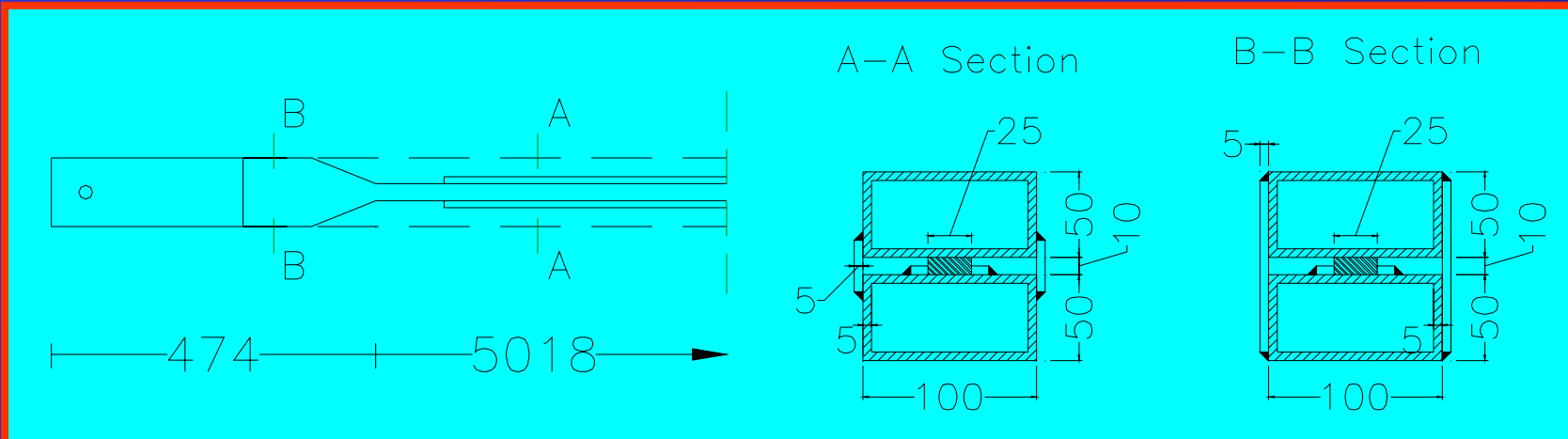
M. D'Aniello, G. Della Corte & F.M. Mazzolani

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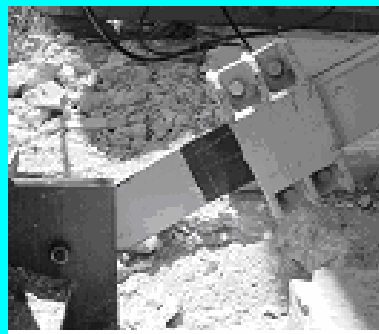
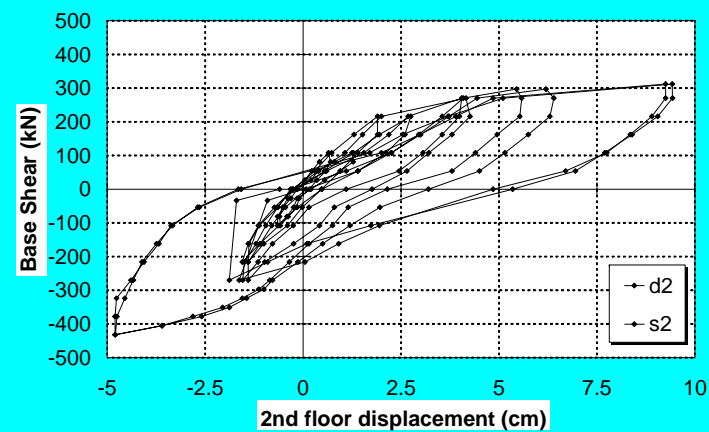
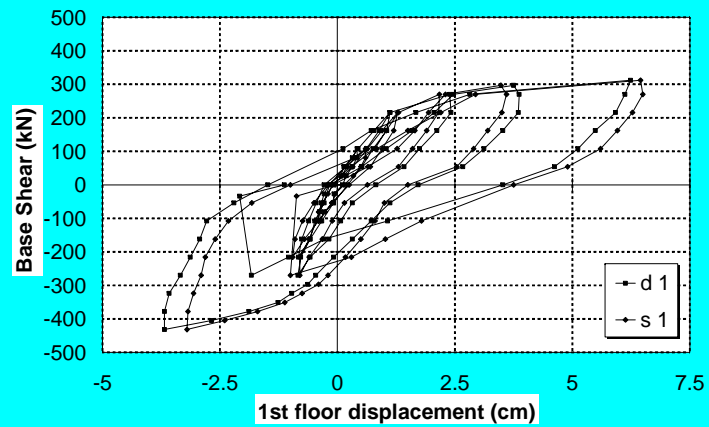


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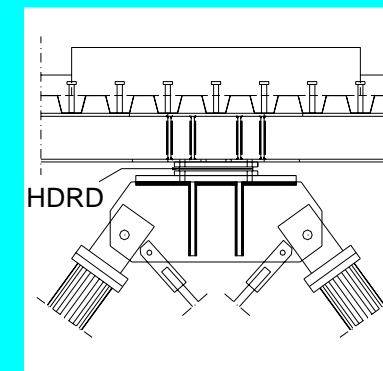
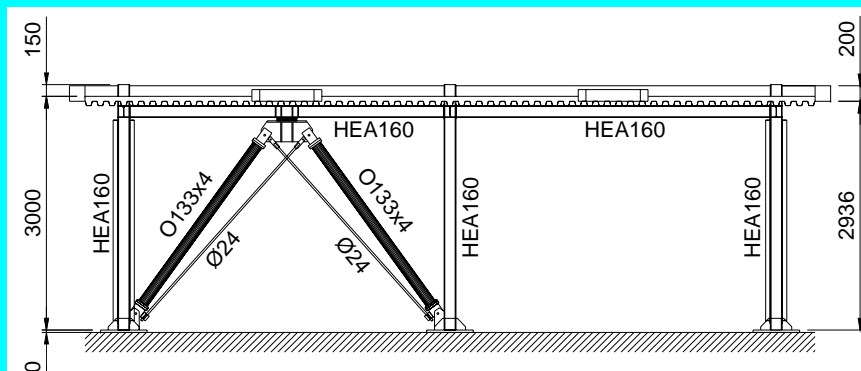


Criteria semplificati di progetto per strutture miste dotate di controventi dissipativi in gomma ad alto smorzamento

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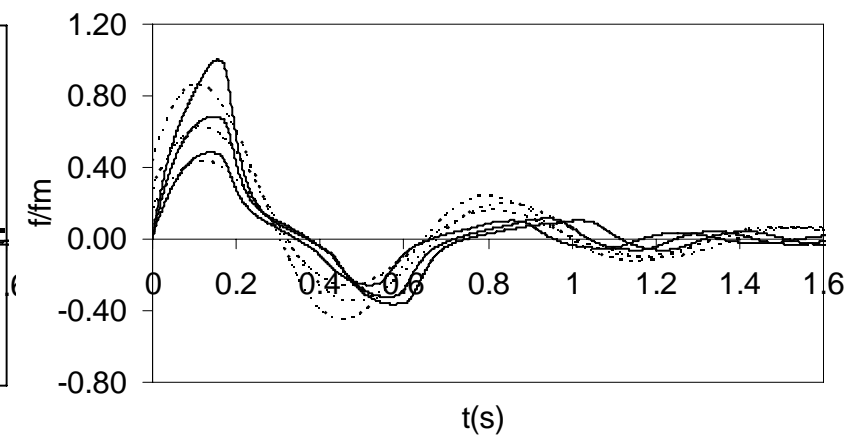
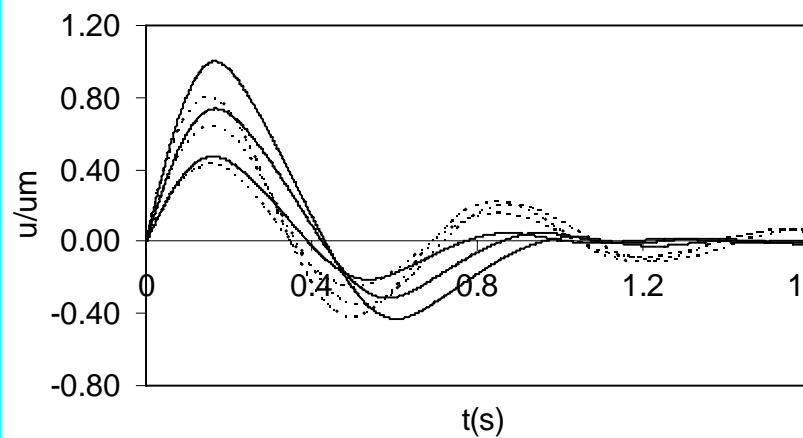
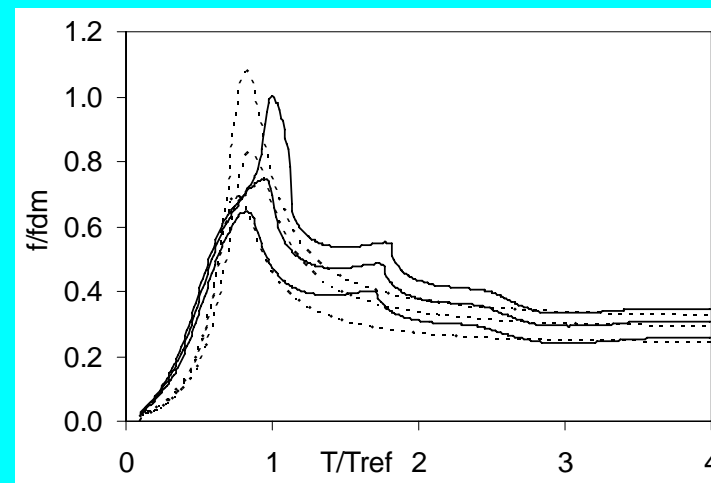
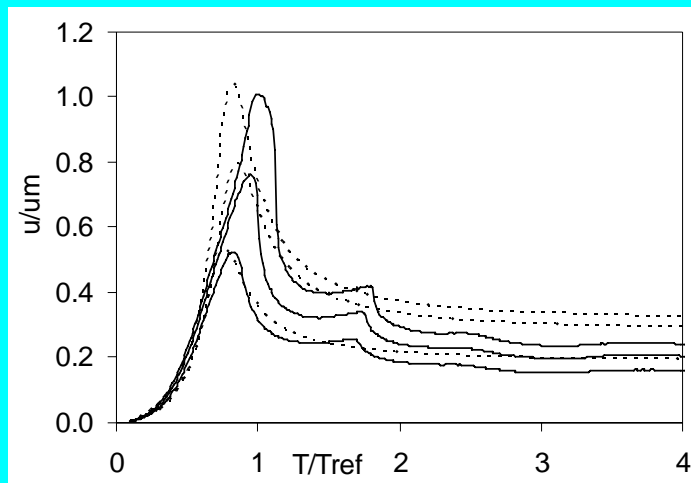
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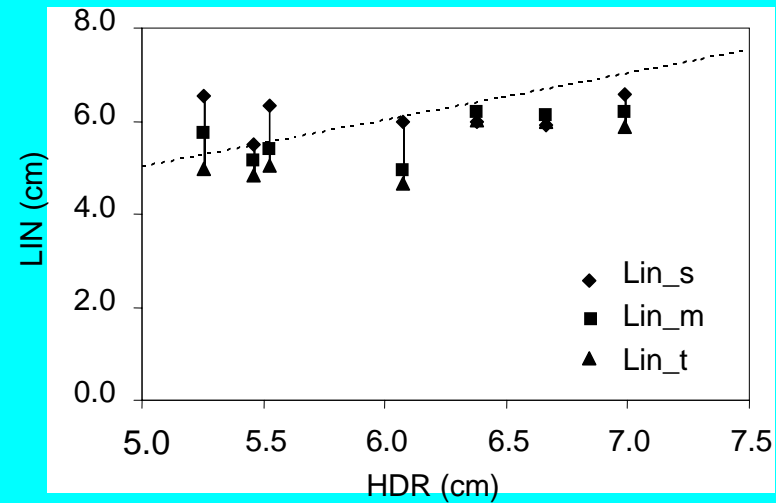




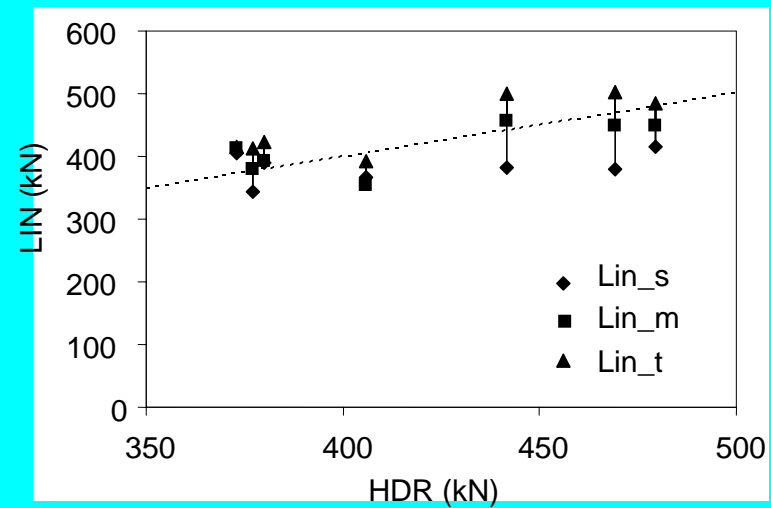
CONTROVENTI DISSIPATIVI



**ANALISI DINAMICA -
CONFRONTO:
MODELLO NON-LINEARE
VS.
MODELLO LINEARE
EQUIVALENTE
SPOSTAMENTI MASSIMI**



**ANALISI DINAMICA -
CONFRONTO:
MODELLO NON-LINEARE
VS.
MODELLO LINEARE
EQUIVALENTE
FORZE MASSIME**





CONTROVENTI DISSIPATIVI



EFFICIENZA DEGLI SMORZATORI NEI CONTROVENTI
(controvento e smorzatore in serie):

$$k_{\text{brace}} = k_D = \frac{EA}{L_D} \quad F_D + \frac{c_D}{k_D} \dot{F}_D = c_D \dot{u}_D$$

RIGIDEZZA EQUIVALENTE: $k_{eq}(\omega) = k_D \frac{(\tau\omega)^2}{1 + (\tau\omega)^2}$

SMORZAMENTO EQUIVALENTE: $c_{eq}(\omega) = c_D \frac{1}{1 + (\tau\omega)^2}$

$$\tau = \frac{c_D}{k_D} \quad \text{Relaxation time constant}$$



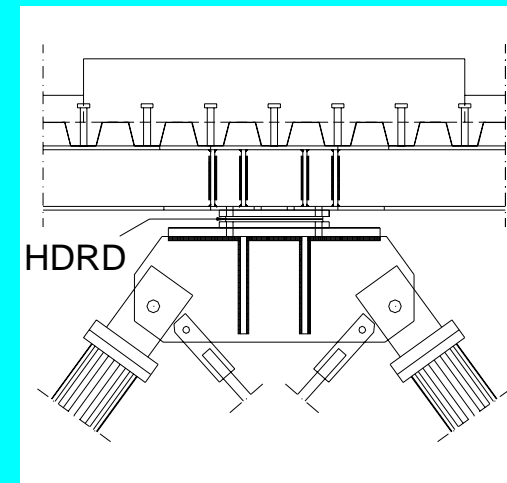
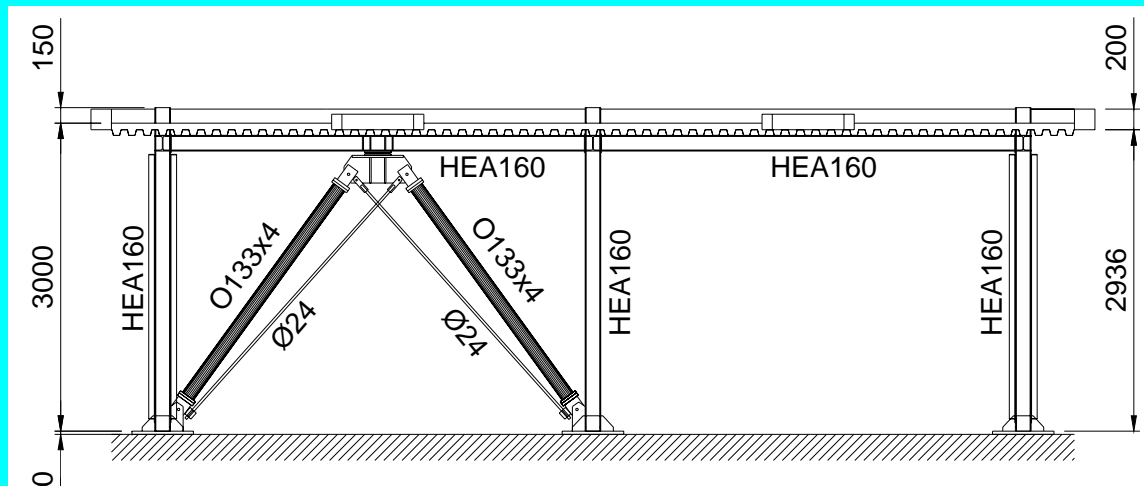
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Seismic analysis of composite frames with viscoelastic dissipative bracings

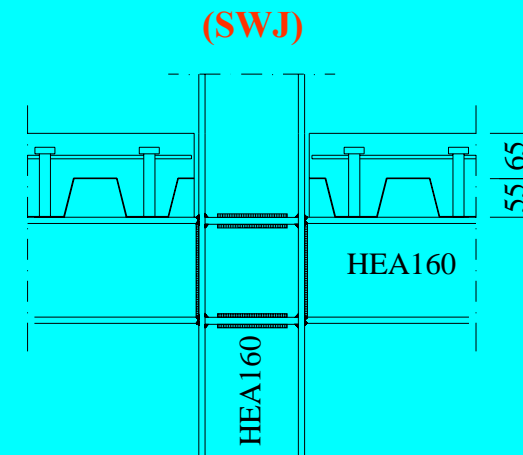
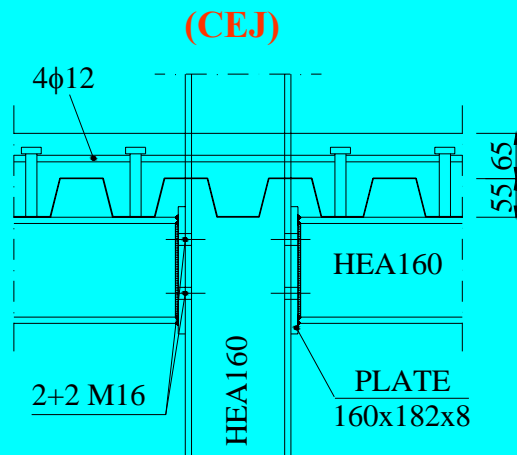
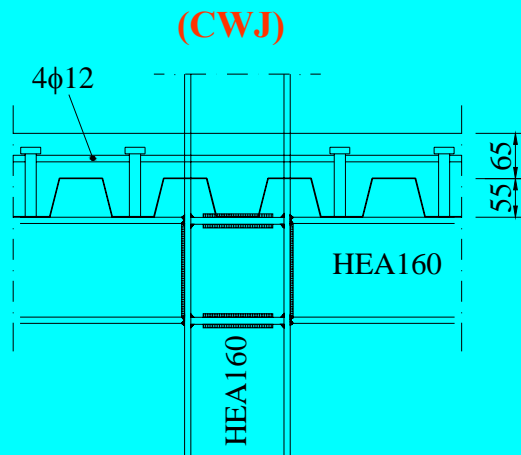
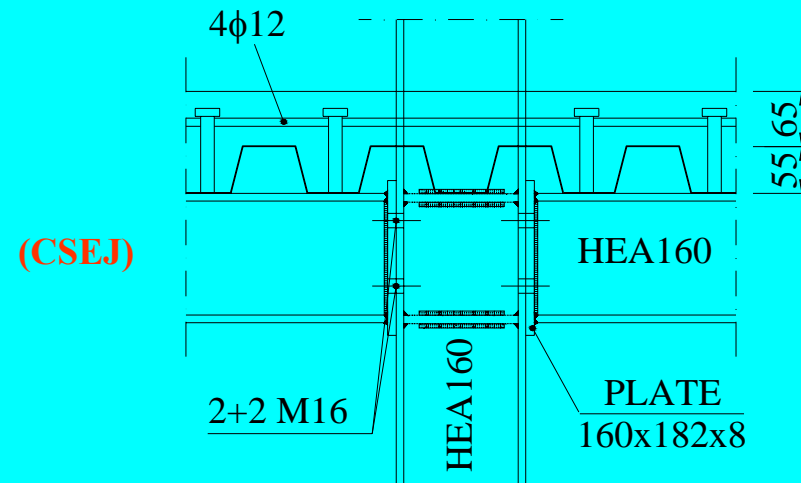
C. Amadio, M. Bella, I. Clemente and L. Macorini

Department of Civil and Environmental Engineering, University of Trieste



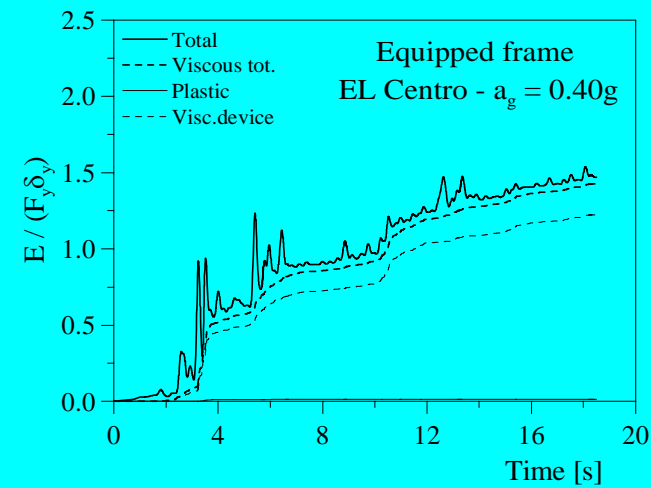
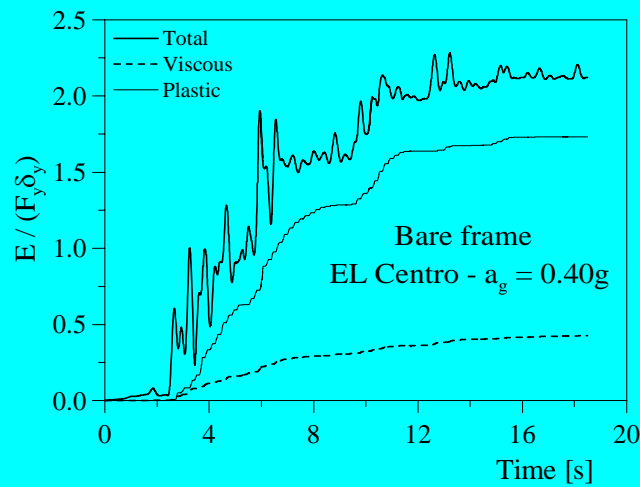
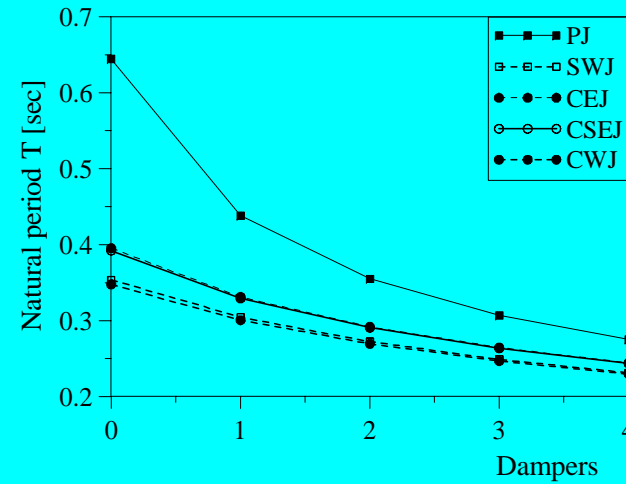
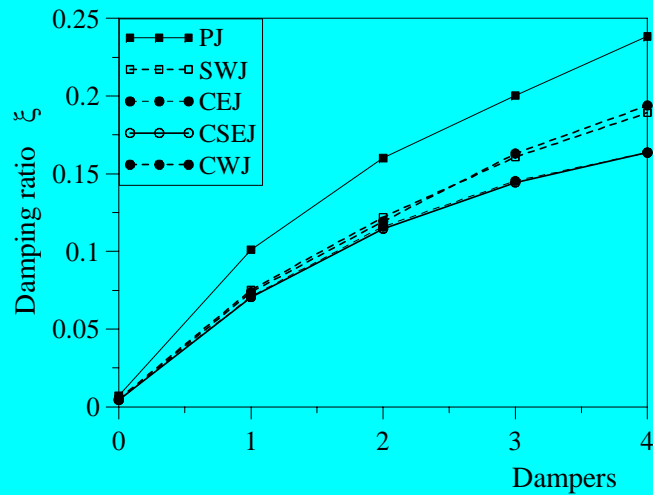


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STRUTTURE CONTROVENTATE



GRAZIE PER L'ATTENZIONE

**PROGETTI DI RICERCA DI INTERESSE
NAZIONALE**

PRIN 2050

**“RECUPERO DI STRUTTURE INNOVATIVE CON
MATERIALI TRADIZIONALI”**

OPEN CALL