COST C26

Urban habitat constructions under catastrophic events

1st Workshop

Prague, 30th-31st March, 2007

WG2 – earthquake resistance

Shear panels for seismic upgrading of new and existing structures

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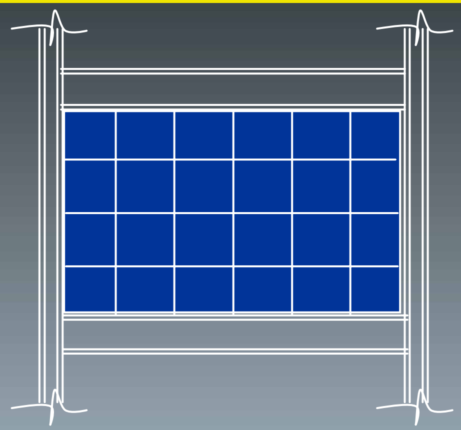
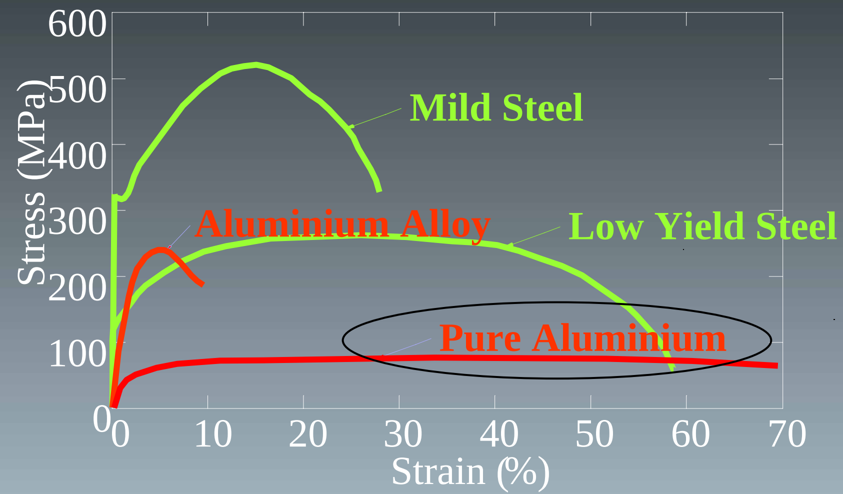
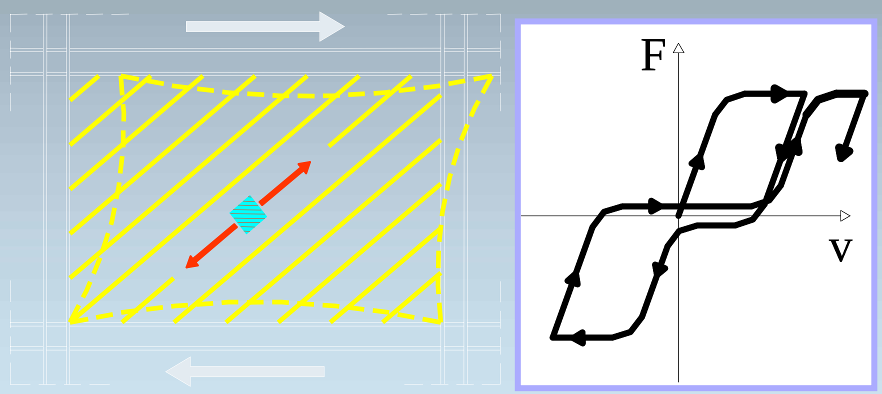
METAL SHEAR PANELS

Stiffened shear plate

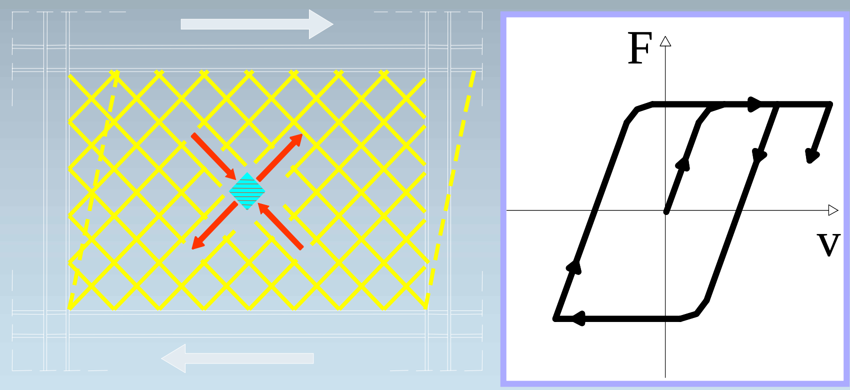


Adopted metals



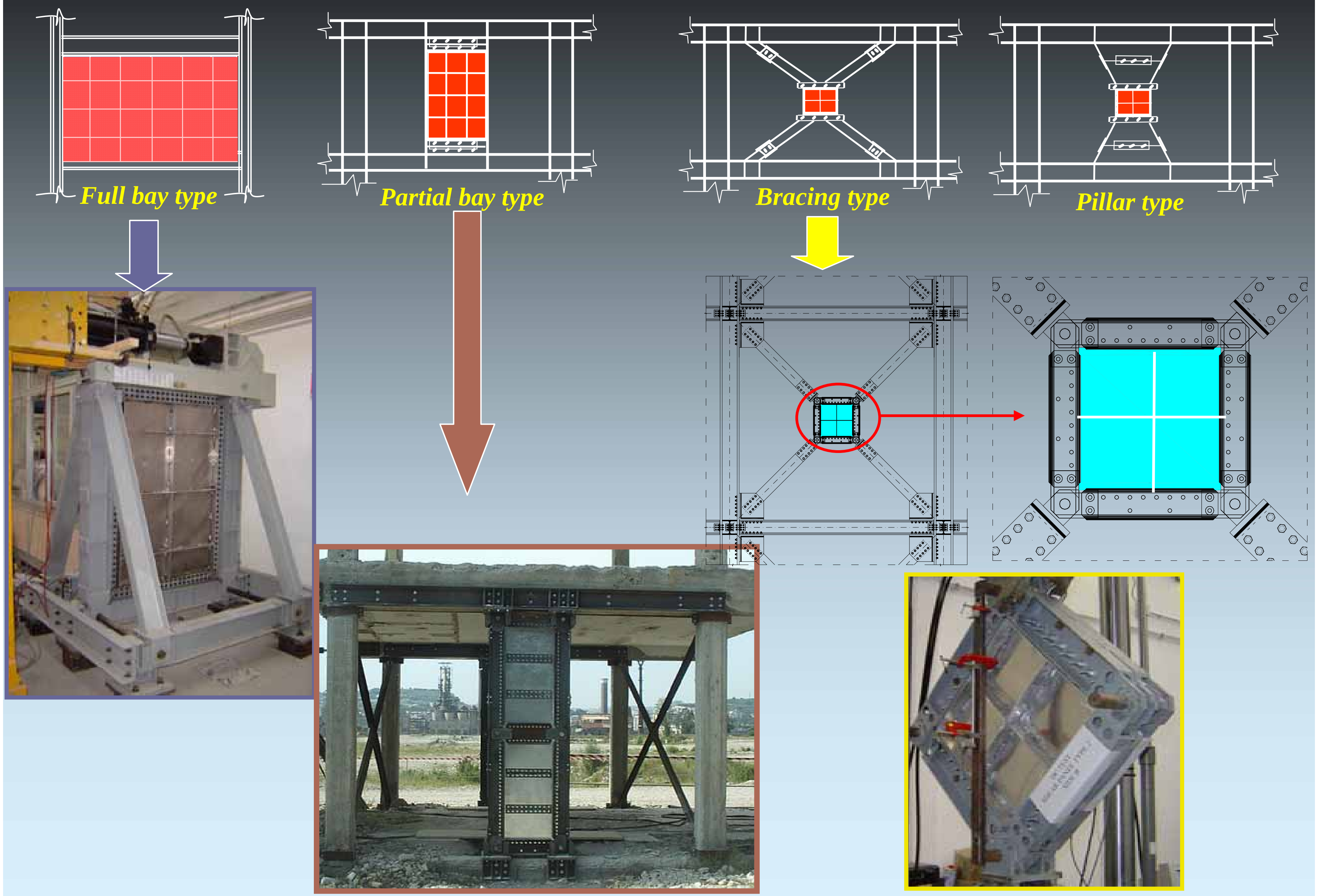


Tension field mechanism
(elastic buckling)

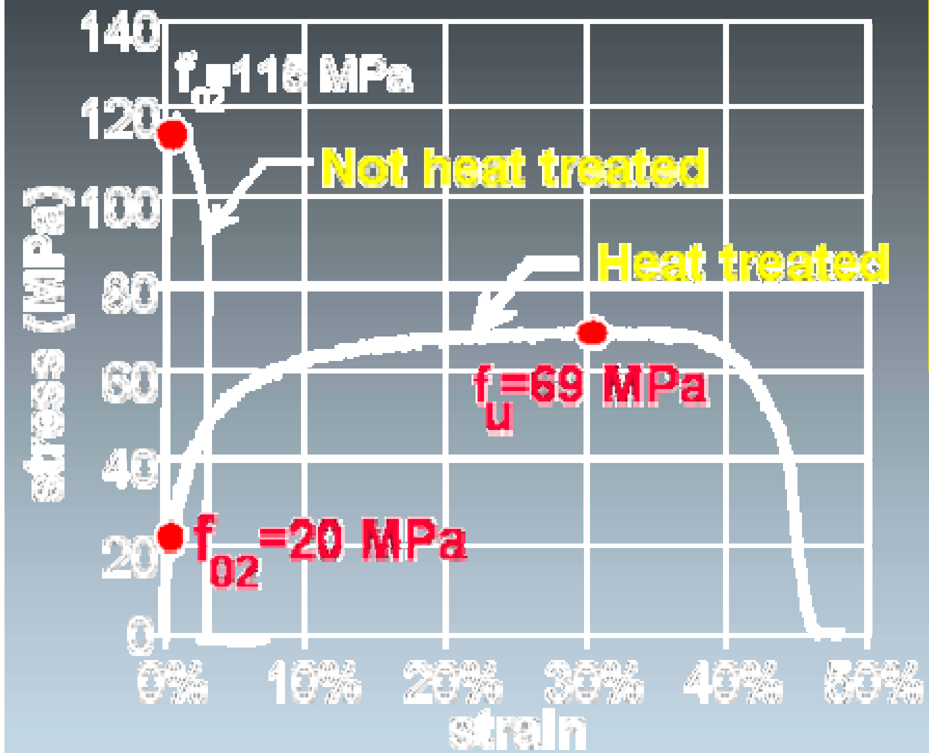


Pure shear mechanism
(no-buckling)

SHEAR PANELS ARRANGEMENTS AND RELATED TESTING ACTIVITIES



ALUMINIUM ALLOY USED FOR SHEAR PANELS

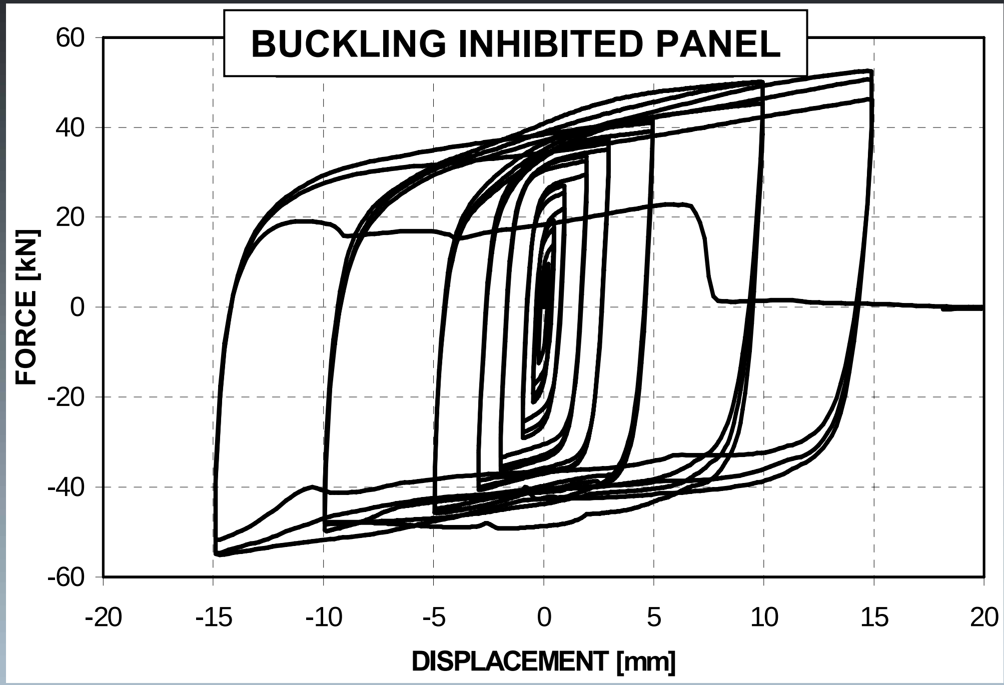


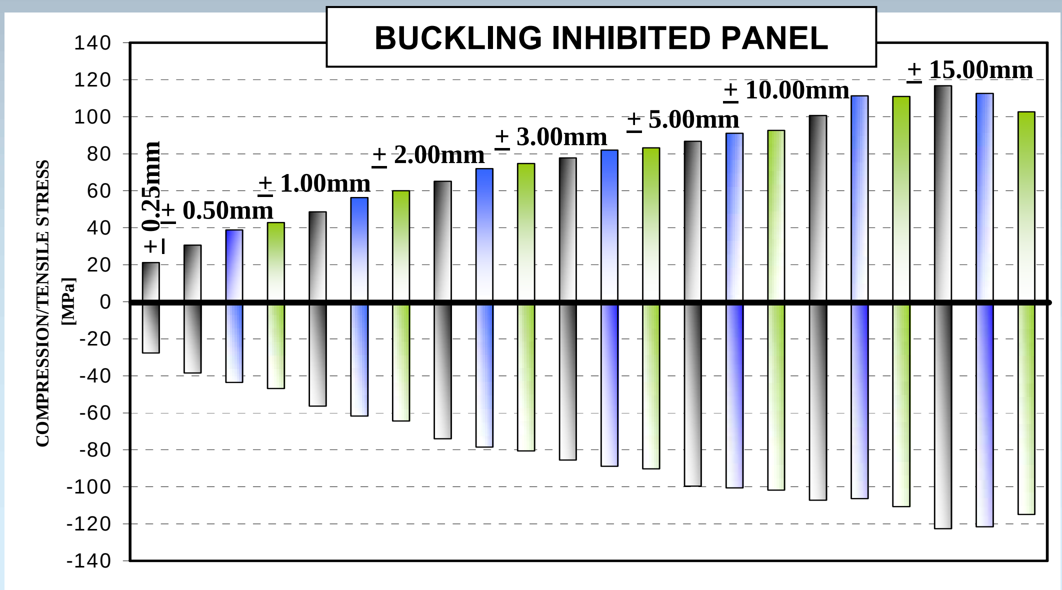
Cycles of heat treatment of the aluminium alloy

N° PHASE	TEMPERATURE [°C]	EXPOSURE TIME [hours]	BRINNELL INDEX [MPa]
iniziale	ambiente	/	69
1	150	4	68
2	230	4	67
3	280	4	44
4	330	4	35

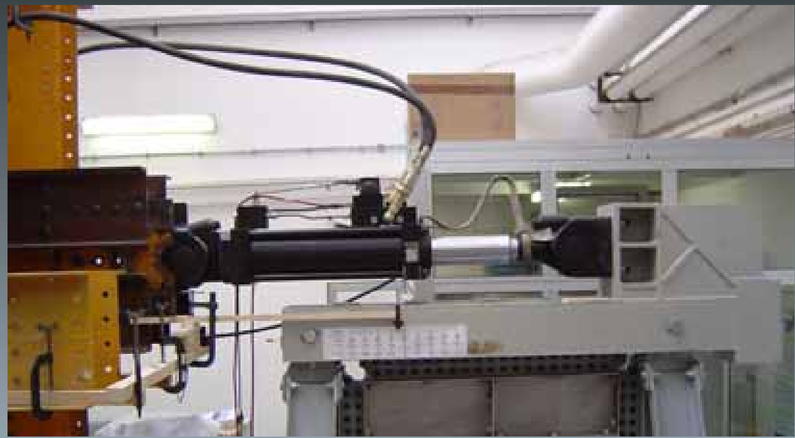
Material	$f_{0.2}$ [N/mm^2]	f_u [N/mm^2]	ε_u %	E [N/mm^2]	$E/f_{0.2}$ [N/mm^2]	$\alpha = f_u/f_{0.2}$
LYS steel	86	254	50	210000	2442	2.95
Nominal Pure Aluminium **(EN-AW 1099A)**	15-20	40-50	40-50	70000	3500-4666	2-3.3
Nominal Pure Aluminium **(EN-AW 1050A)**	30-70	70-100	20-40	70000	1000/2333	2.33-3.33
Employed Pure Aluminium **(EN-AW 1050A)**	80	100	5	70000	875	1.25
Heat Treated Pure Aluminium **(EN-AW 1050A)**	21.3	80	45	70000	3286	3.76

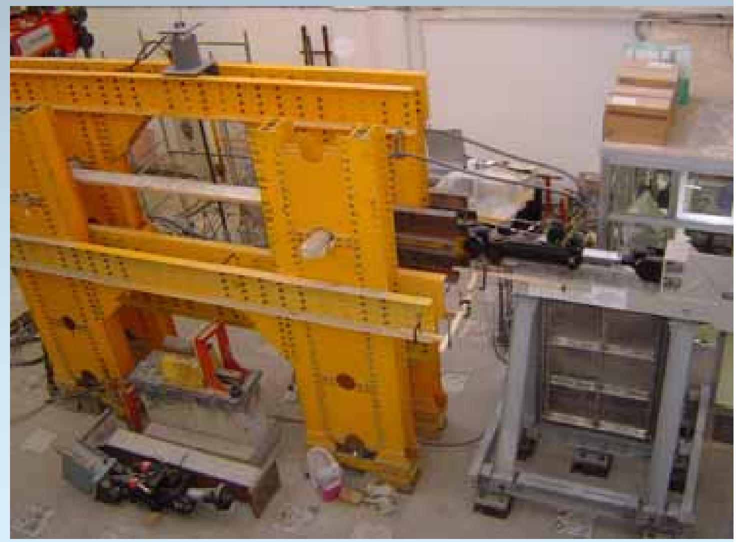
ALUMINIUM ALLOY USED FOR SHEAR PANELS-Cyclic behaviour



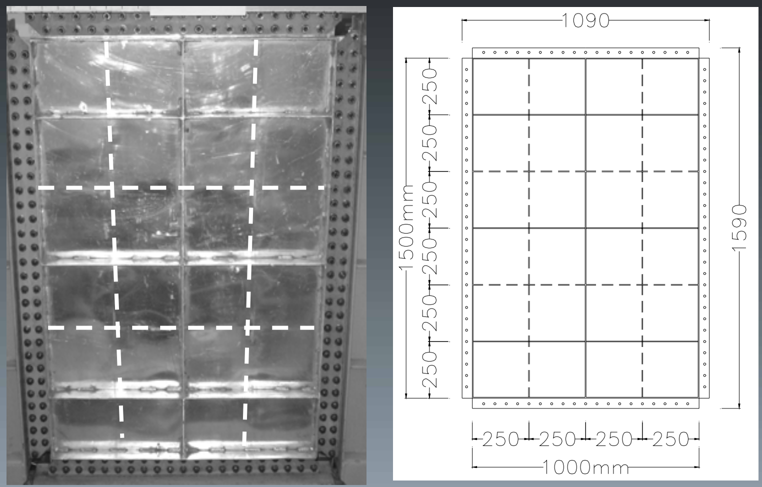


EXPERIMENTAL CAMPAIGN ON FULL BAY TYPE PURE ALUMINIUM SHEAR PANELS



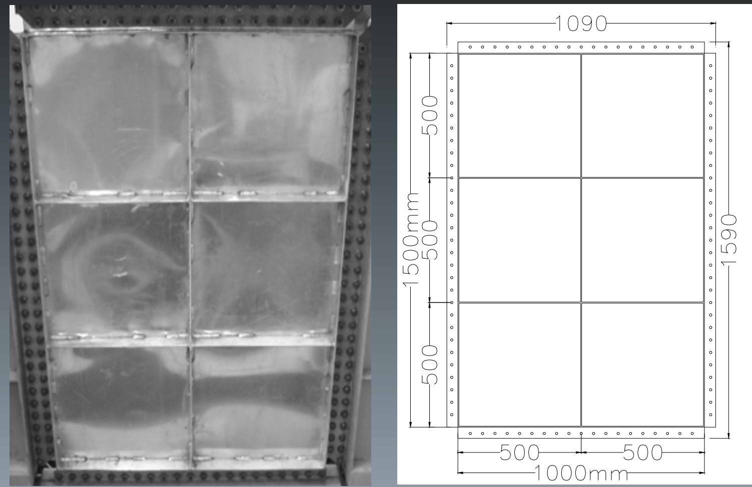


TESTED CONFIGURATIONS OF FULL BAY SHEAR PANELS



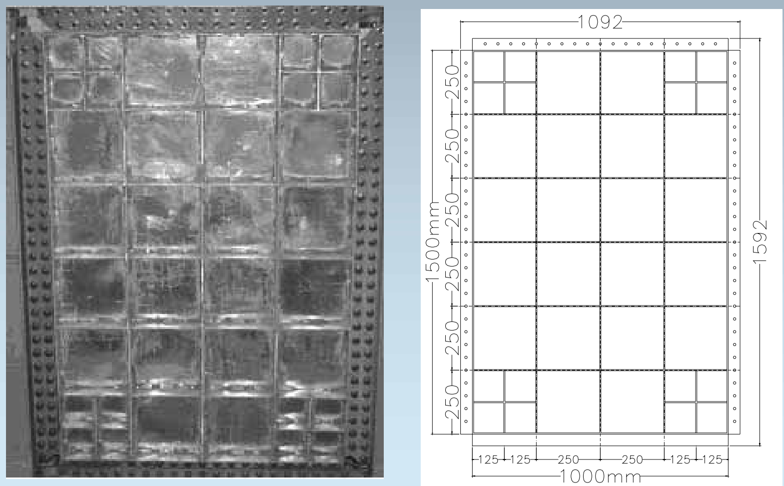
<u>Panel type F</u>

b/t=50



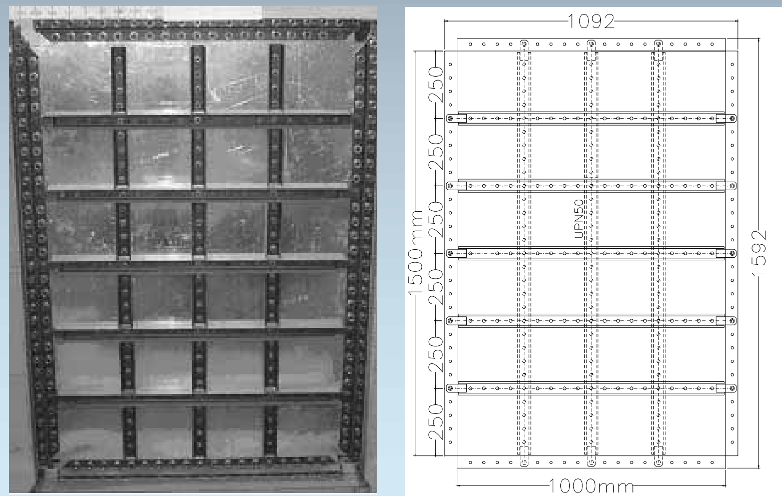
<u>Panel type B</u>

b/t=100



<u>Panel type G</u>

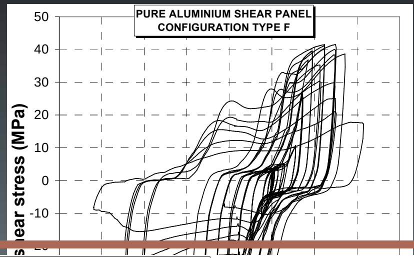
b/t=50 (=25 in the corners)

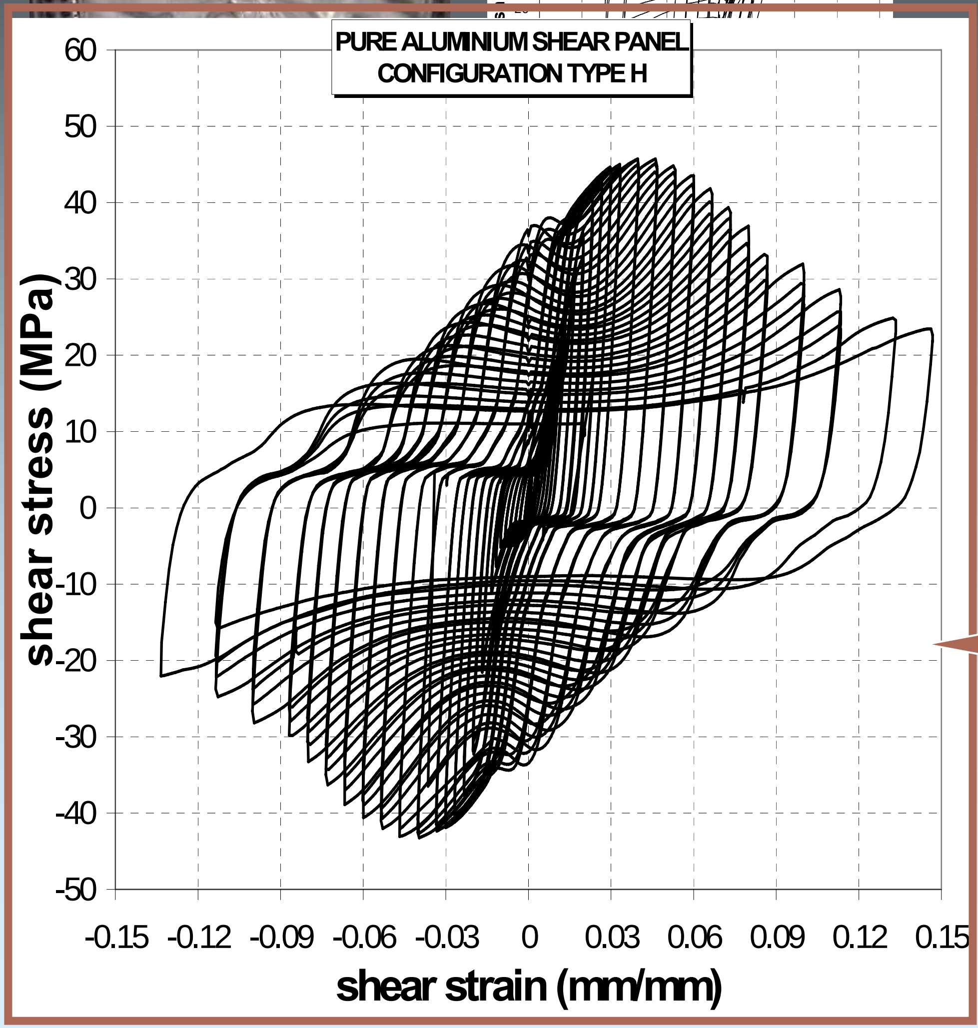


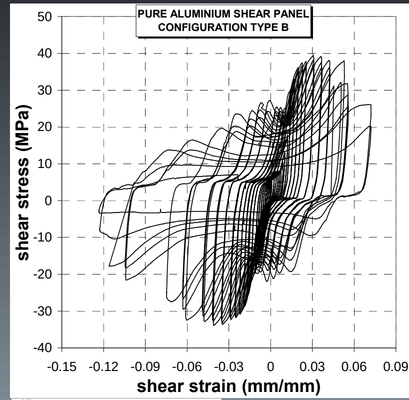
<u>Panel type H</u>

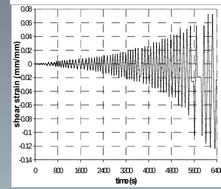
b/t=50 (ribs: UPN50)

CYCLIC BEHAVIOUR OF TESTED PANELS

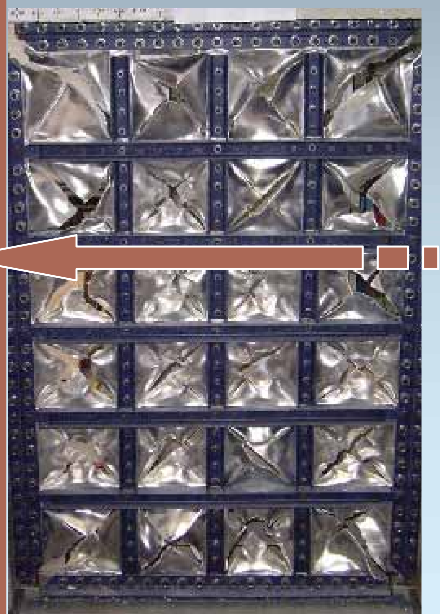


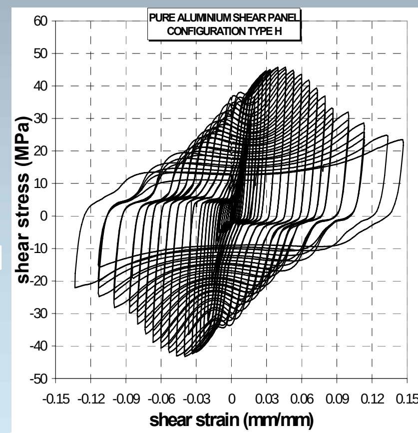


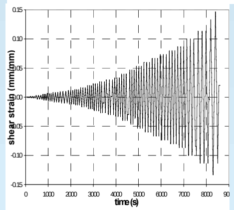




Panel type B



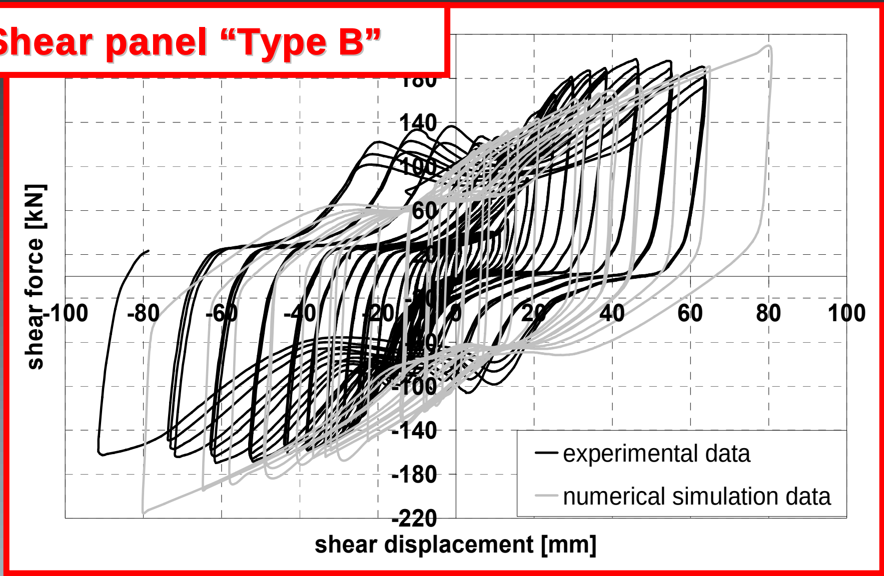


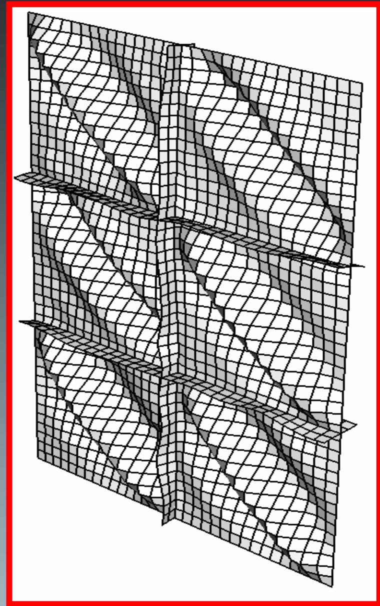


Panel type H

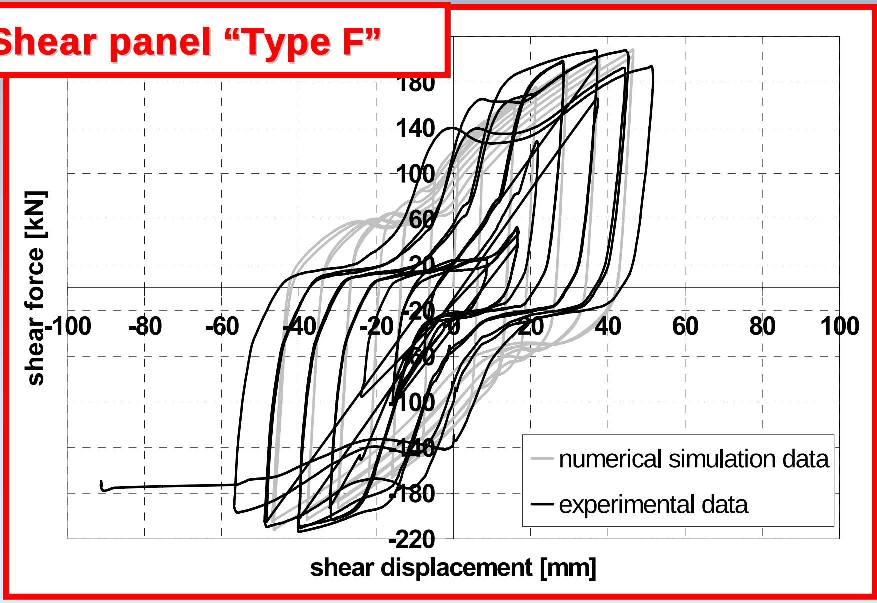
NUMERICAL SIMULATION OF EXPERIMENTAL TESTS ON ALUMINIUM PANELS

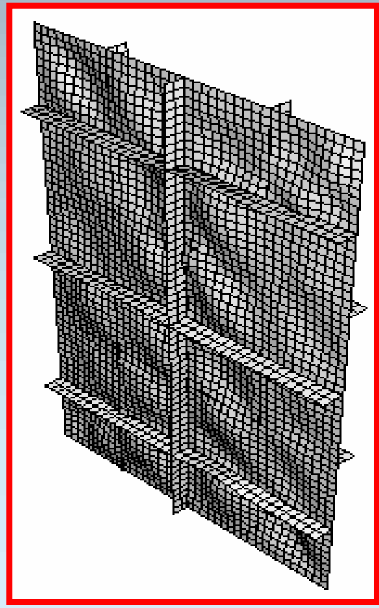
Shear panel “Type B”



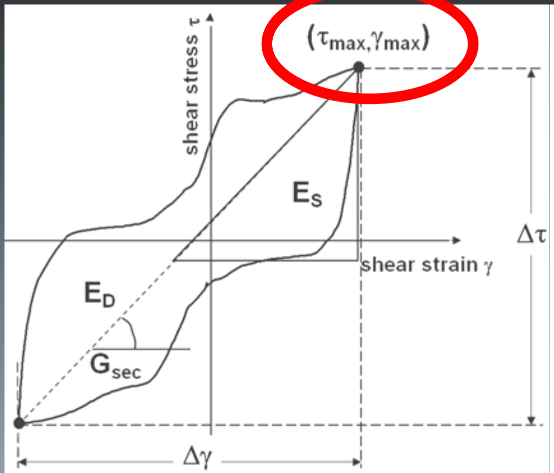


Shear panel “Type F”





ANALYTICAL INTERPRETATION OF EXPERIMENTAL TESTS



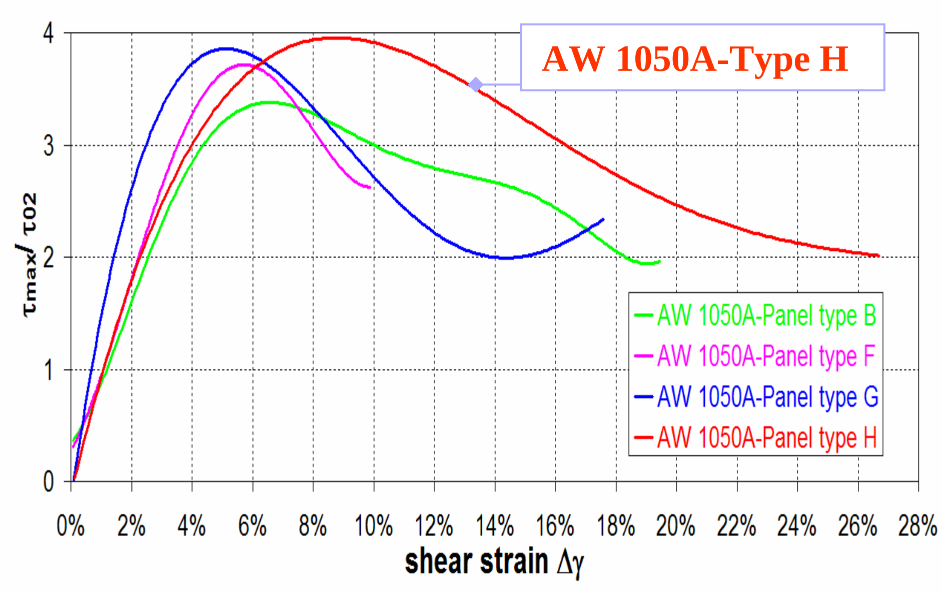
$$E_S = \frac{1}{8}\Delta\tau \cdot \Delta\gamma$$

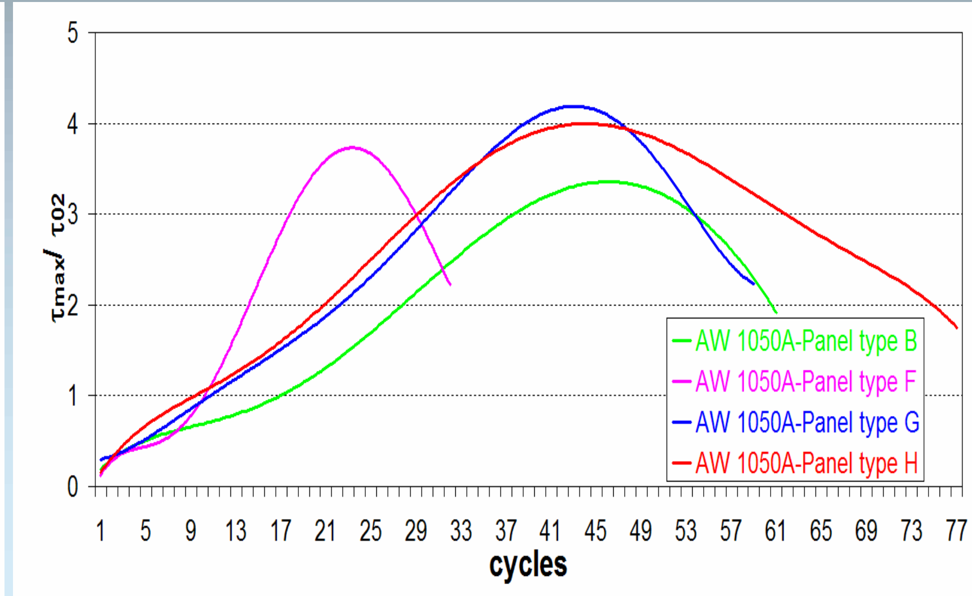
$$\zeta_{eq} = \frac{1}{4\pi}\frac{E_D}{E_S}$$

$$G_{\sec} = \frac{\Delta\tau}{\Delta\gamma}$$

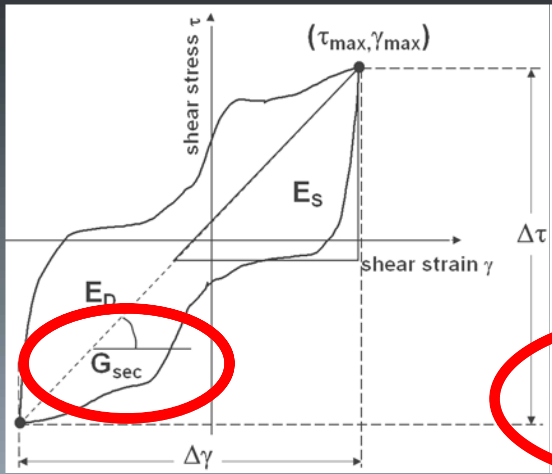
HARDENING RATIO

$$\tau_{max}/\tau_{02}$$





ANALYTICAL INTERPRETATION OF EXPERIMENTAL TESTS



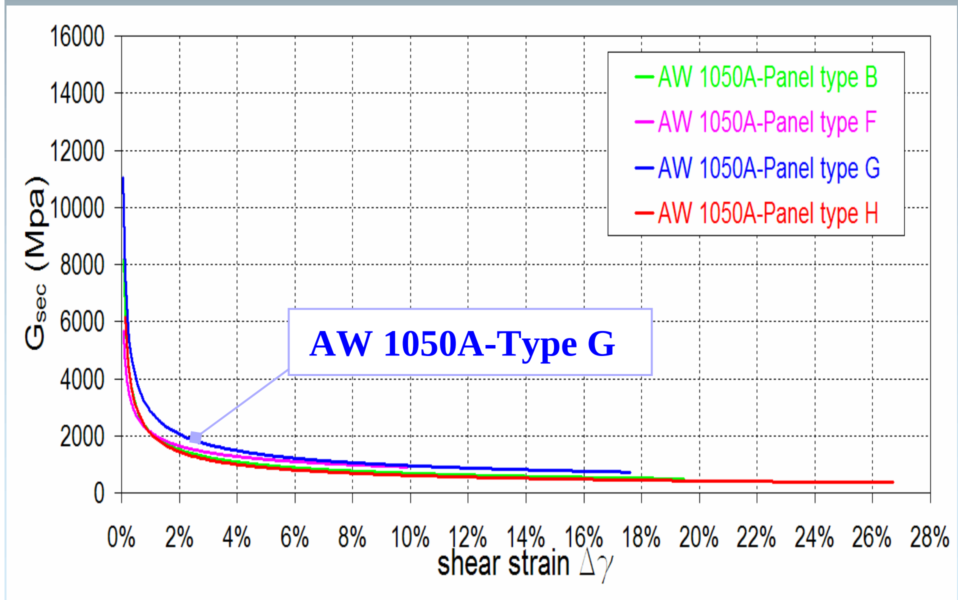
$$E_S = \frac{1}{8}\Delta\tau \cdot \Delta\gamma$$

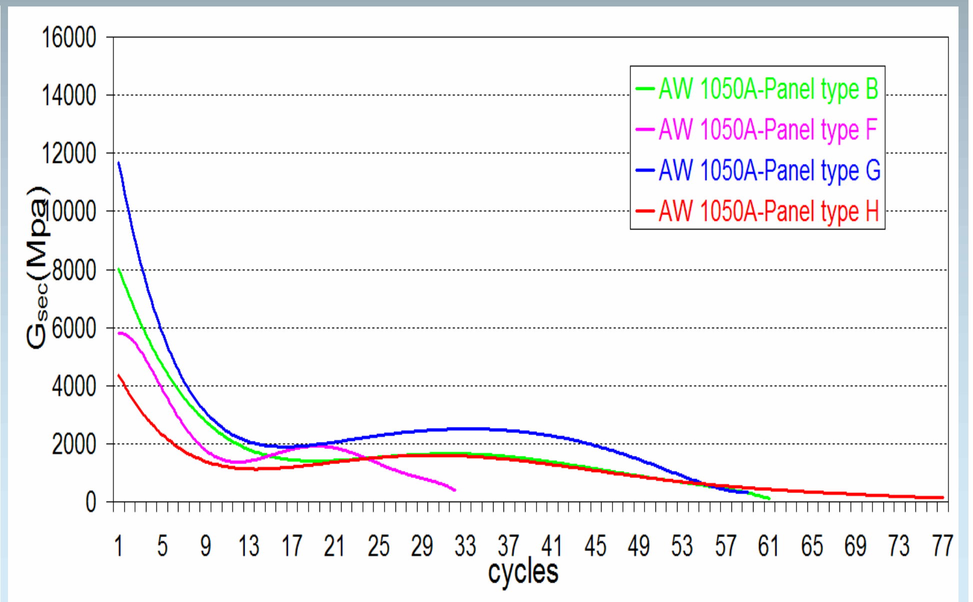
$$\zeta_{eq} = \frac{1}{4\pi}\frac{E_D}{E_S}$$

$$G_{sec} = \frac{\Delta\tau}{\Delta\gamma}$$

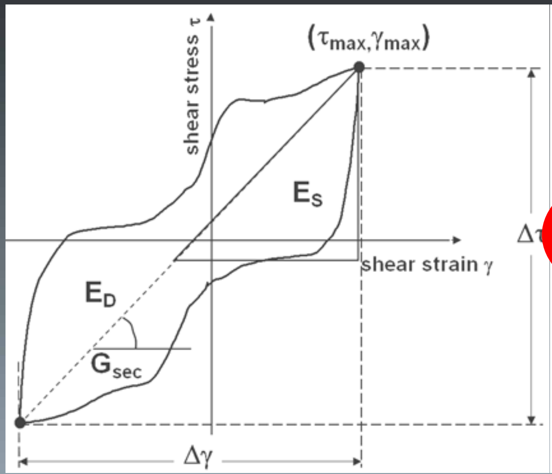
SECANT SHEAR STIFFNESS

G_{sec}





ANALYTICAL INTERPRETATION OF EXPERIMENTAL TESTS



$$E_S = \frac{1}{8} \Delta\tau \cdot \Delta\gamma$$

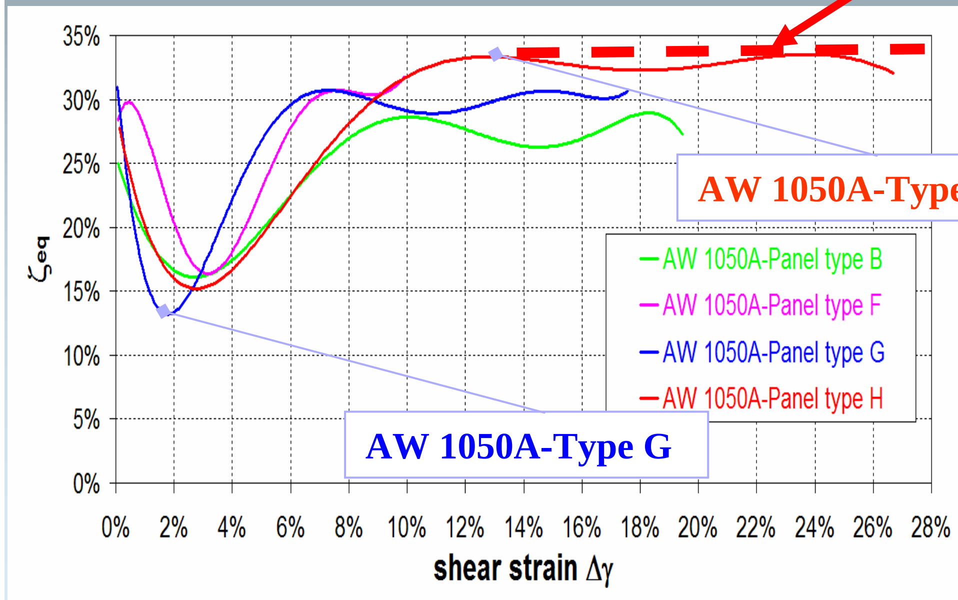
$$\zeta_{eq} = \frac{1}{4\pi} \frac{E_D}{E_S}$$

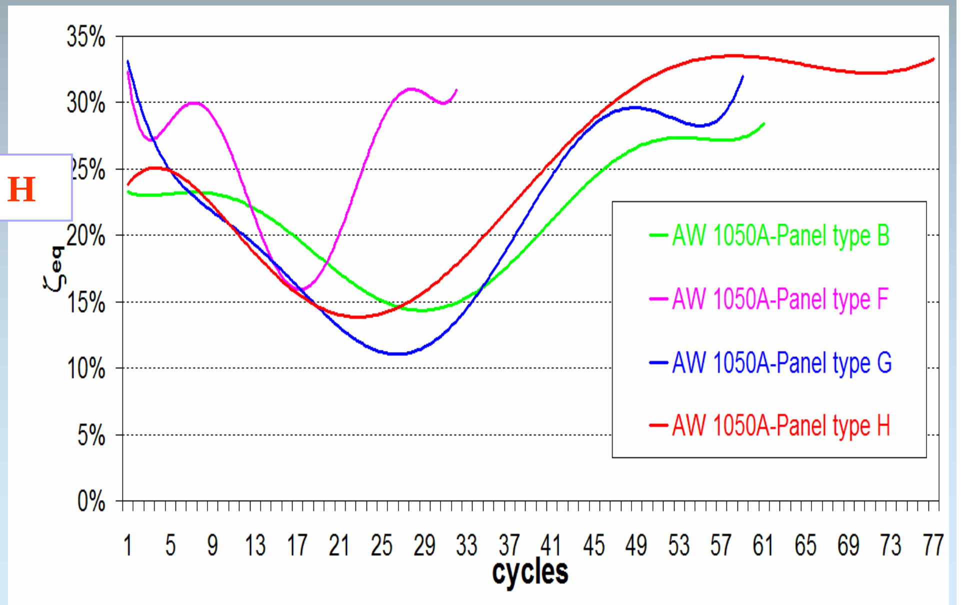
$$G_{sec} = \frac{\Delta\tau}{\Delta\gamma}$$

EQUIVALENT VISCOUS DAMPING FACTOR

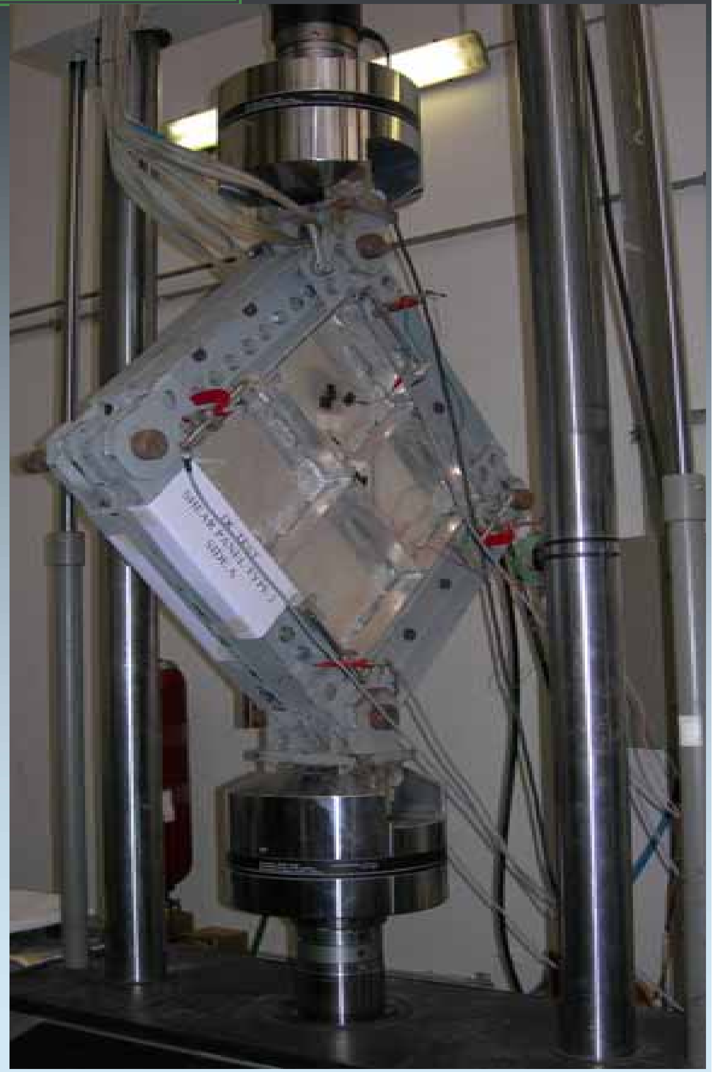
ζ_{eq}

≈35%

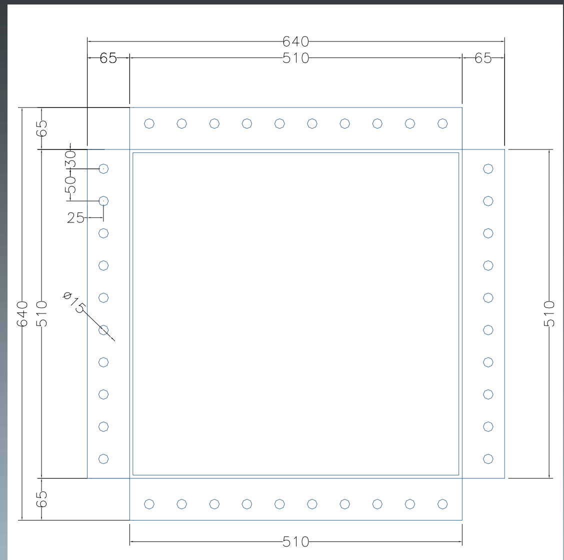




DIAGONAL TESTING SYSTEM FOR BRACING TYPE SHEAR PANELS

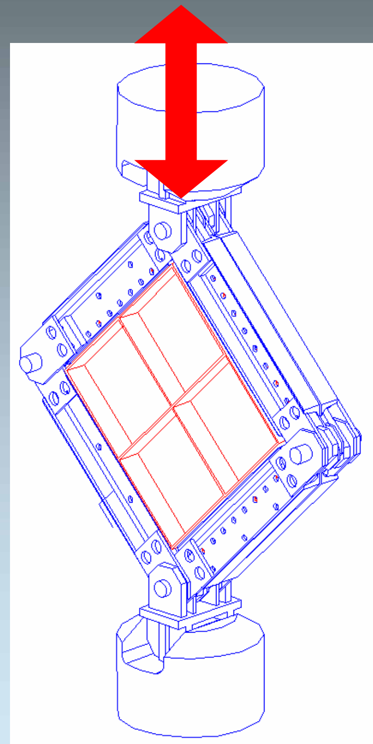


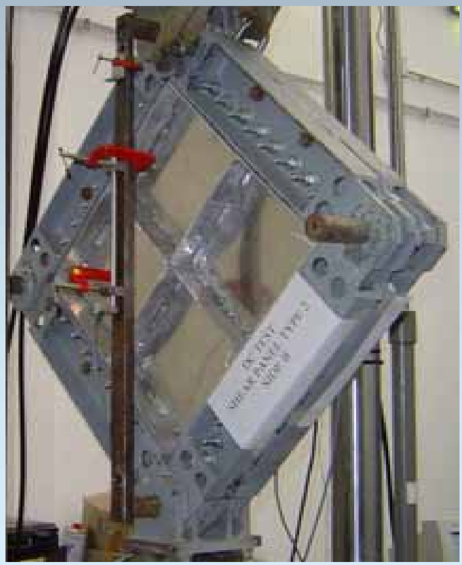
GEOMETRICAL CONFIGURATION OF TESTED SHEAR PANELS

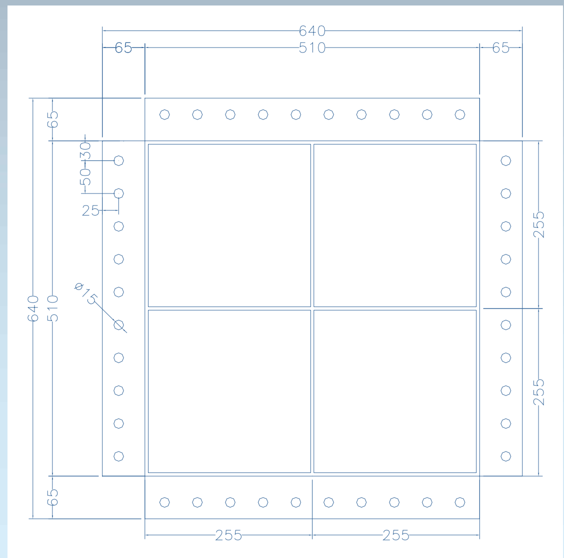


BTPASP configuration 1
(b/t=100)

SHEAR CYCLIC TESTS BY DIAGONAL STRESS

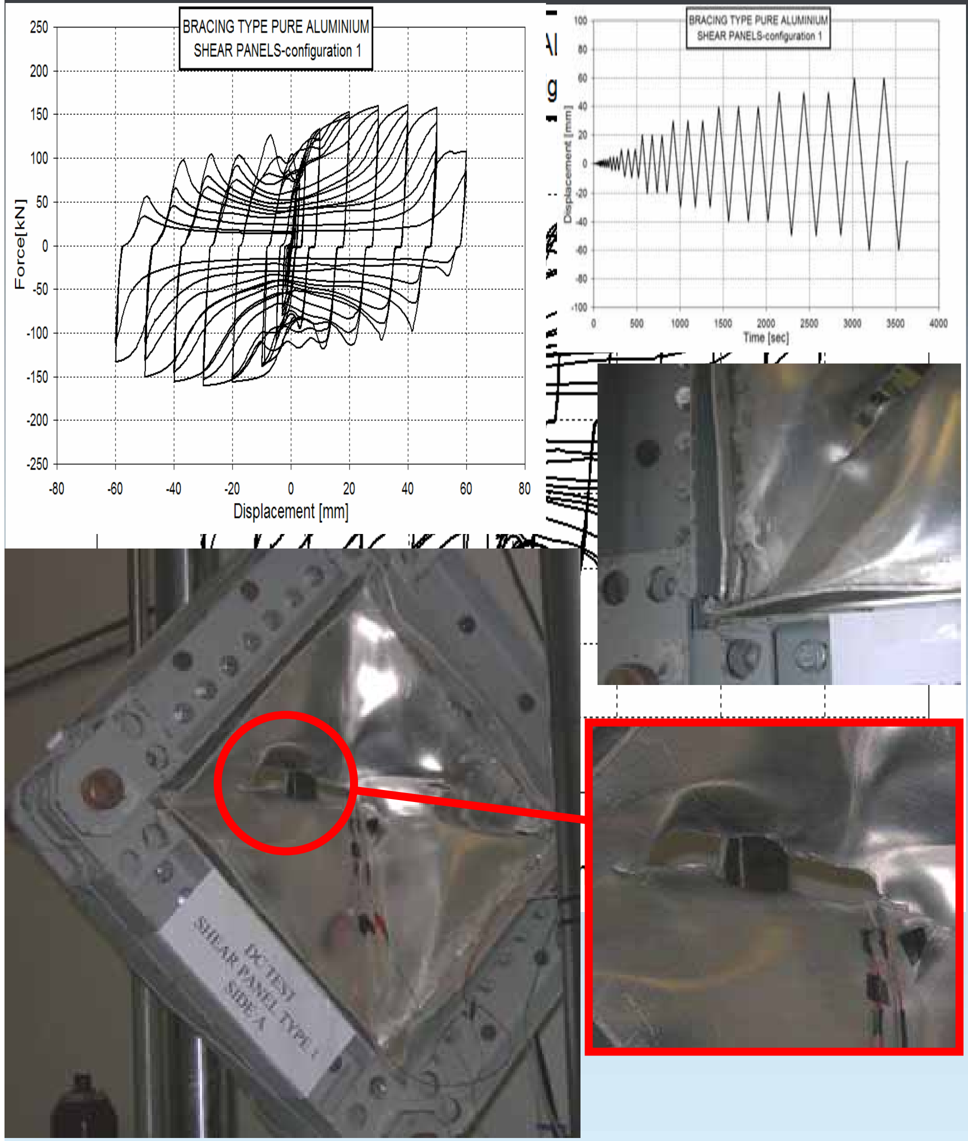


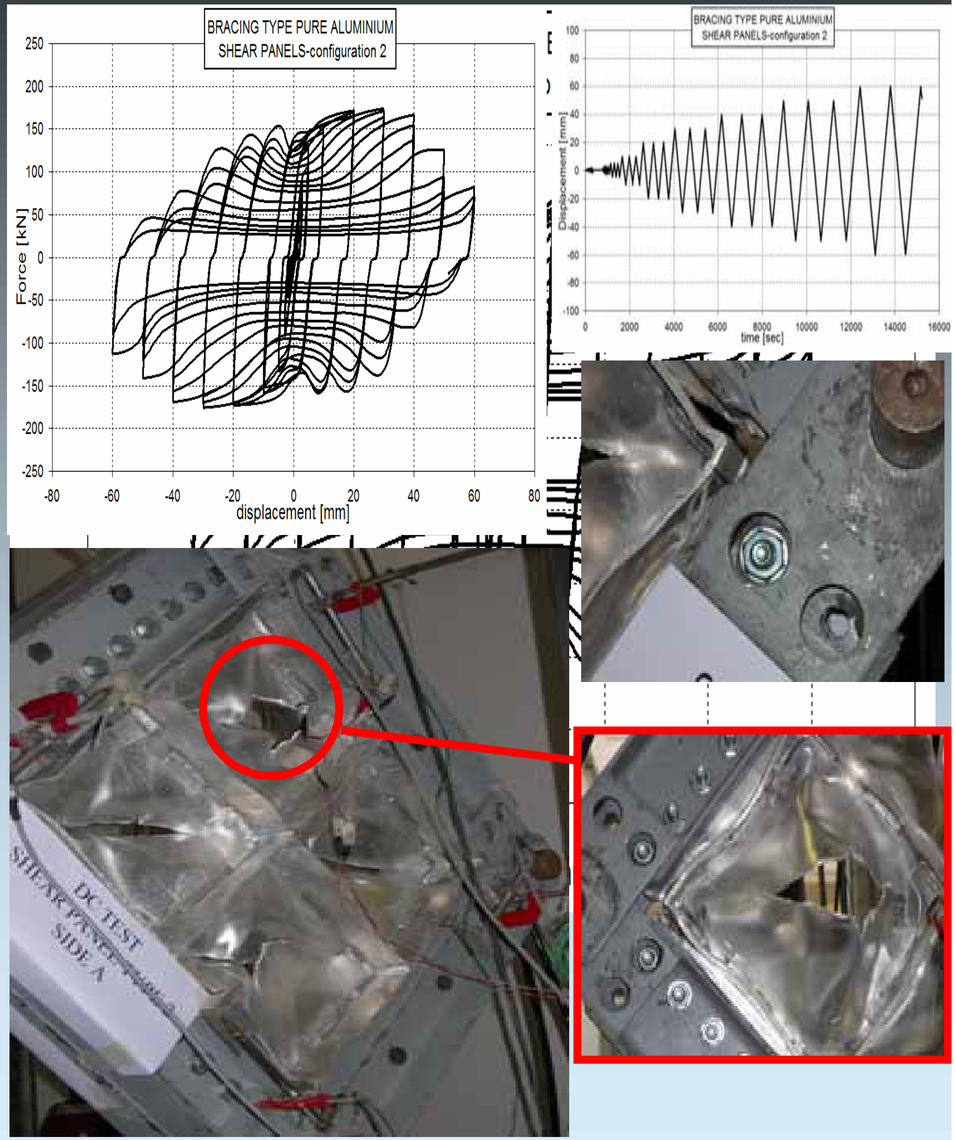




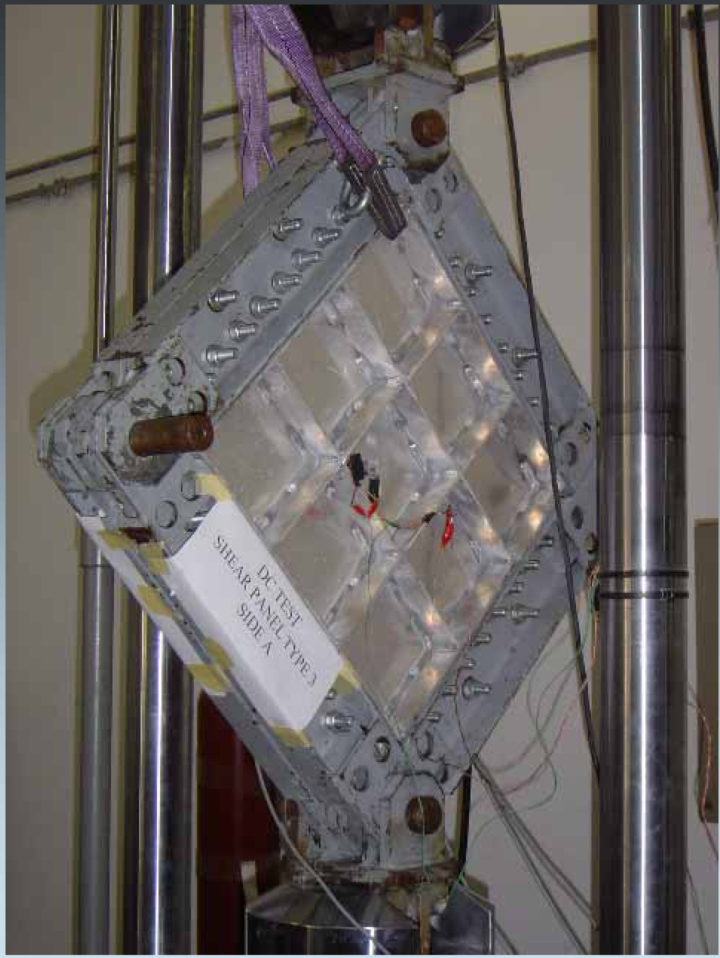
BTPASP configuration 2
(b/t=50)

EXPERIMENTAL RESULTS FOR BRACING TYPE PANELS





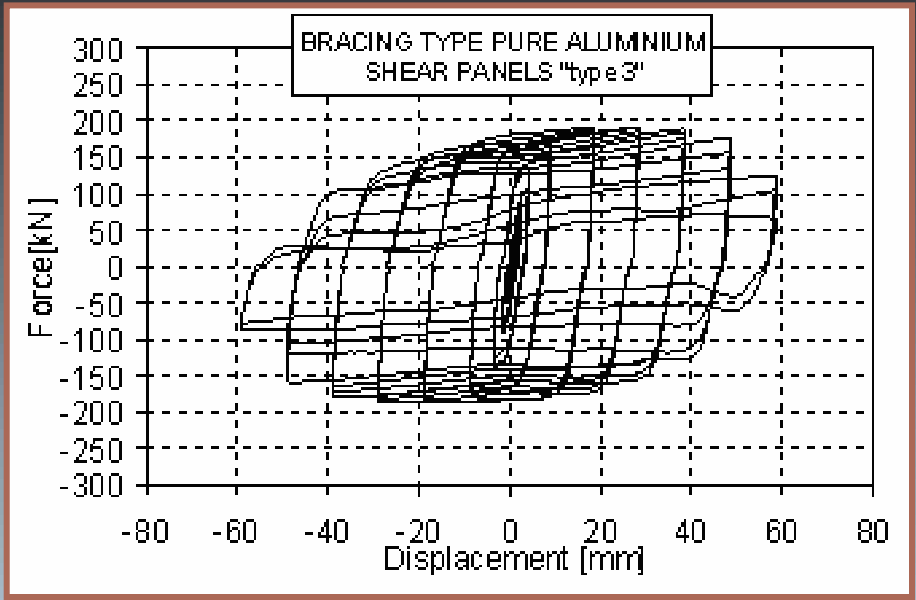
ADDITIONAL TESTED CONFIGURATIONS

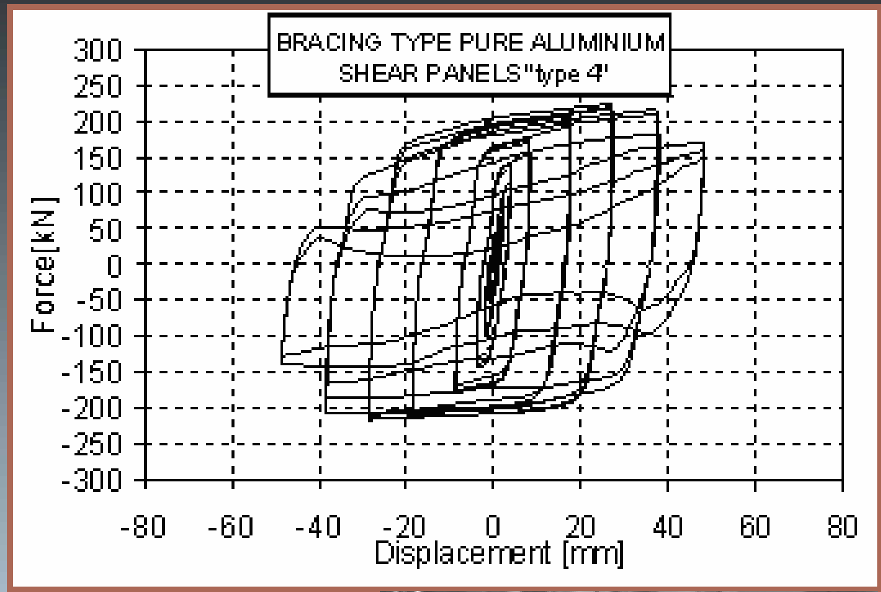


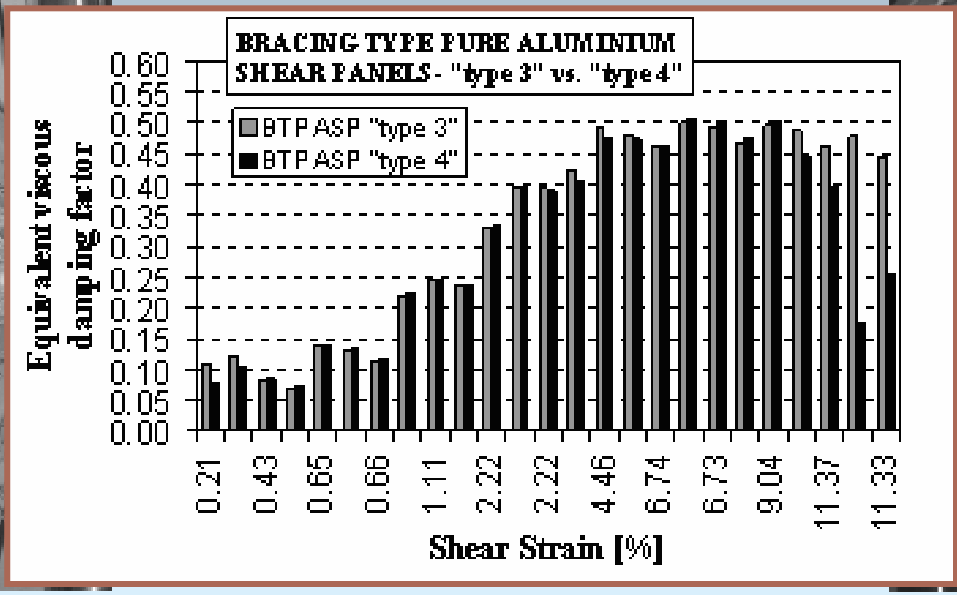
BTPASP configuration 3 (b/t=33)

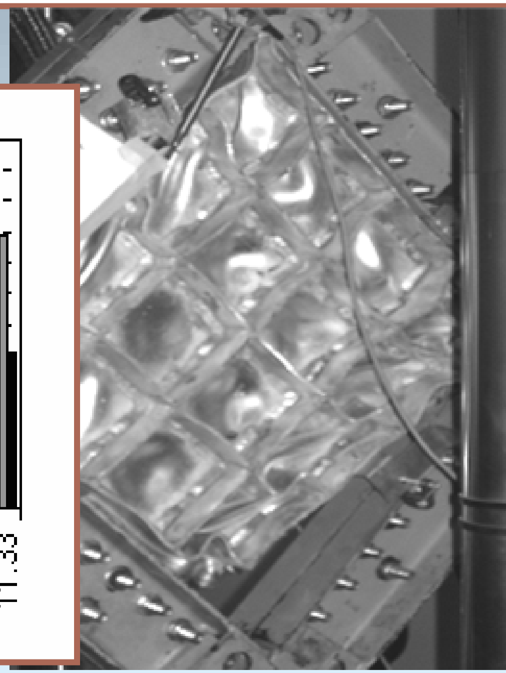
BTPASP configuration 4 (b/t=25)

EXPERIMENTAL RESUTS









SEISMIC PROTECTION OF EXISTING R.C. BUILDINGS BY METAL SHEAR PANELS

ILVA-IDEM (Intelligent DEMolition) RESEARCH PROJECT

Coordinator: prof. F.M.Mazzolani - University of Naples "Federico II"

Module n°5
Metal shear panels

SEISMIC PROTECTION OF EXISTING R.C. BUILDINGS BY METAL SHEAR PANELS

Module n°5
Metal shear panels

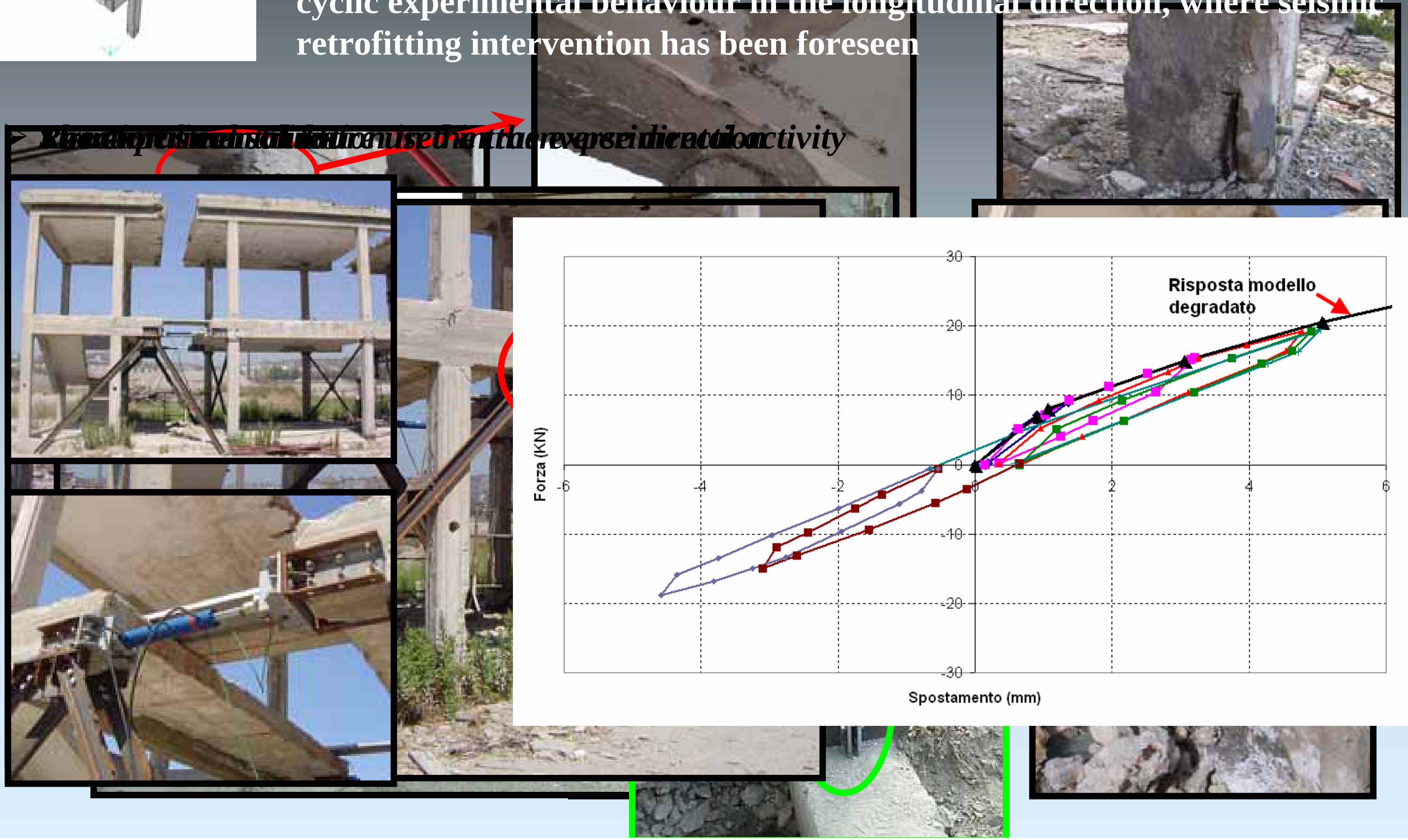
Aluminium panels

Steel panels

THE BUILDING UNDER INVESTIGATION

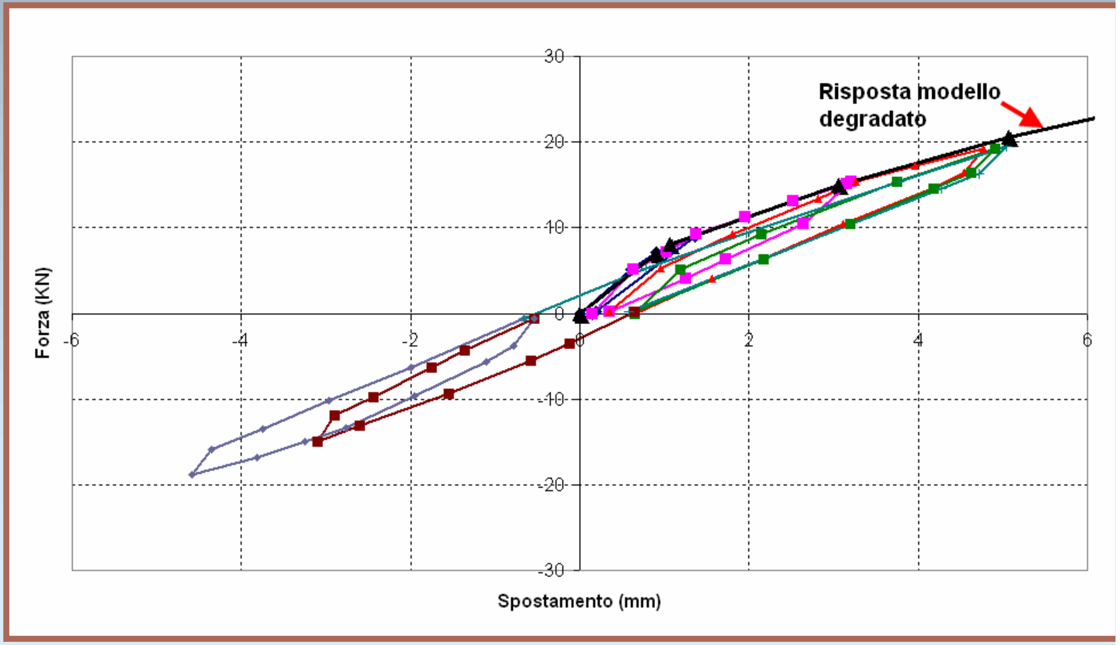
Other than the structural degradation due to both age and environmental conditions, the experimental test on SMA braces in the transversal direction determined a further reduction of the module mechanical features

Such a situation has been considered in the definition of the numerical model of the sub-structure, which has been used in order to calibrate the structural cyclic experimental behaviour in the longitudinal direction, where seismic retrofitting intervention has been foreseen



TEST ON THE BARE RC FRAME

- *The experimental test*



SEISMIC RETROFITTING METHODOLOGY AND DESIGN OF RC STRUCTURES BY MEANS OF METAL SHEAR PANELS

Starting from the knowledge of the contribution which shear panel should provide in terms of both strength and stiffness, its design can be performed by means of the following simplified theoretical relationships:

$$V = \frac{1}{2} f_y t\, bL \sin 2\alpha \qquad K = \frac{E}{4}\frac{b \cdot t}{h_s}$$

Shear panels are realised with two different metallic materials:

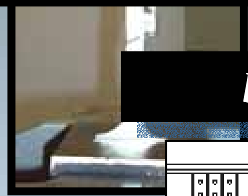
The shear wall ... (600x400mm) co... means of ...

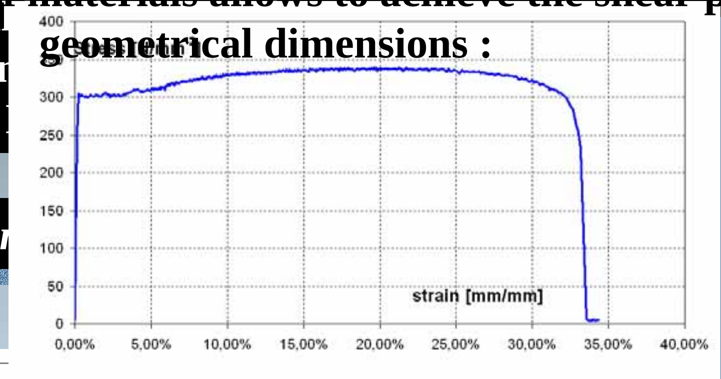
geometrical dimensions :

➢ STEEL

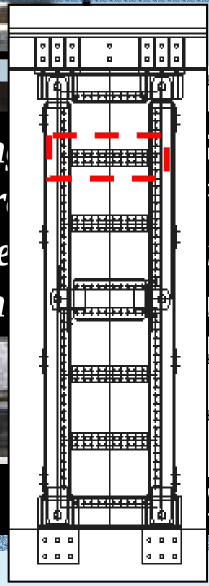
f_y=305 Nmm^{-2} f_u=340 Nmm^{-2}

ε_u>30%

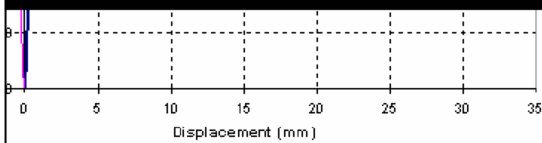


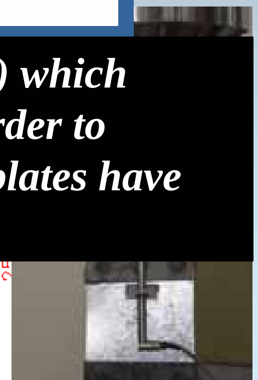


b = 600 ...



Bein... (less than the minimum value (0.8) which guar... full activation of tension field), in order to incre... ratio, two coupled 100 x 4 mm fishplates have been ... both sides of the plate





➢ PURE ALUMINIUM

f_{02}=20 Nmm^{-2} f_u=80 Nmm^{-2}

ε_u>30%

...00 mm d = 2400 mm s= 5 mm

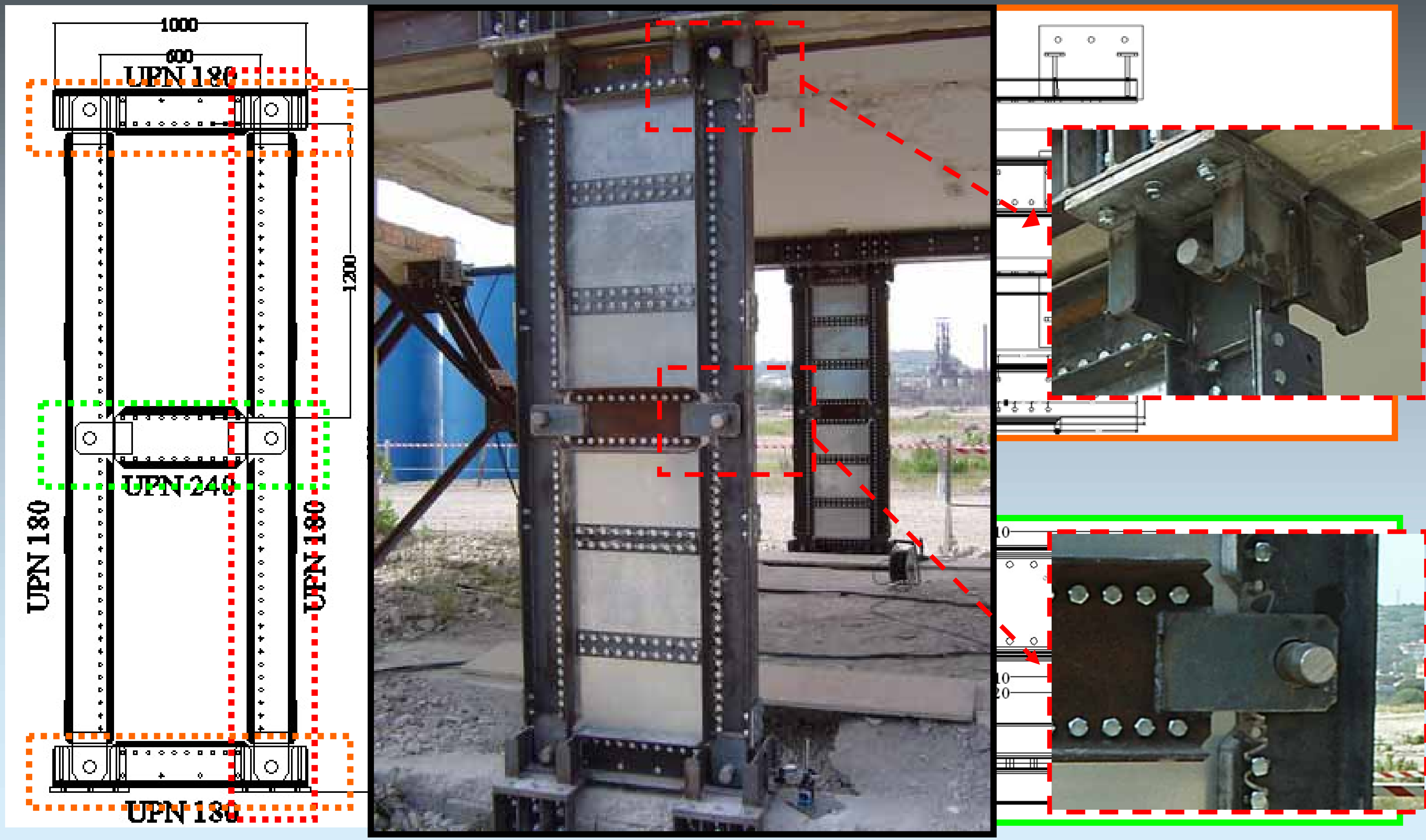
Block tearing failure mechanism

0 0,05 0,1 0,15 0,2 0,25 0,3 0,35 0,4

mm/mm

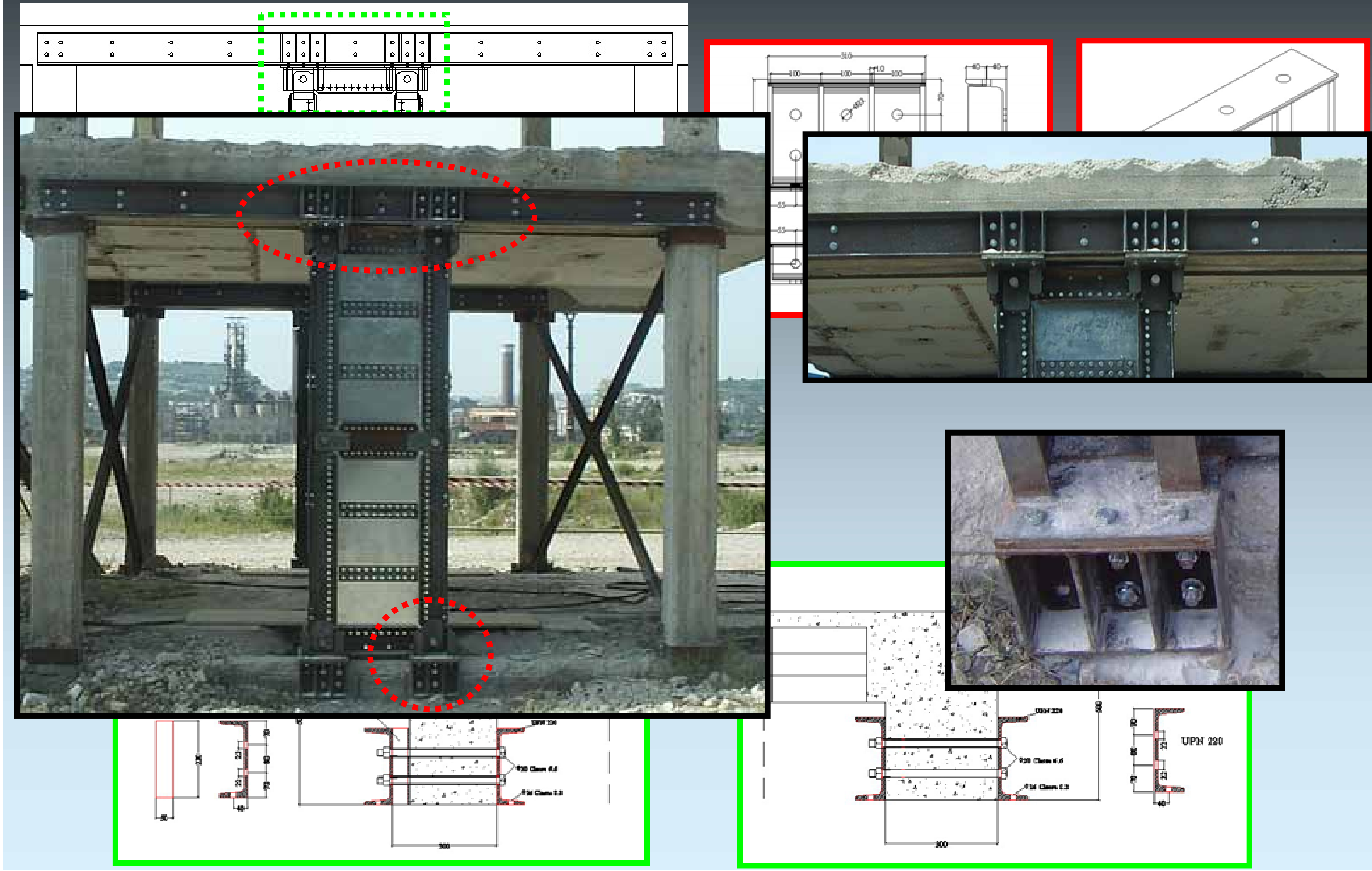
SEISMIC RETROFITTING METHODOLOGY AND DESIGN OF RC STRUCTURES BY MEANS OF METAL SHEAR PANELS

THE EXTERNAL STEEL FRAME



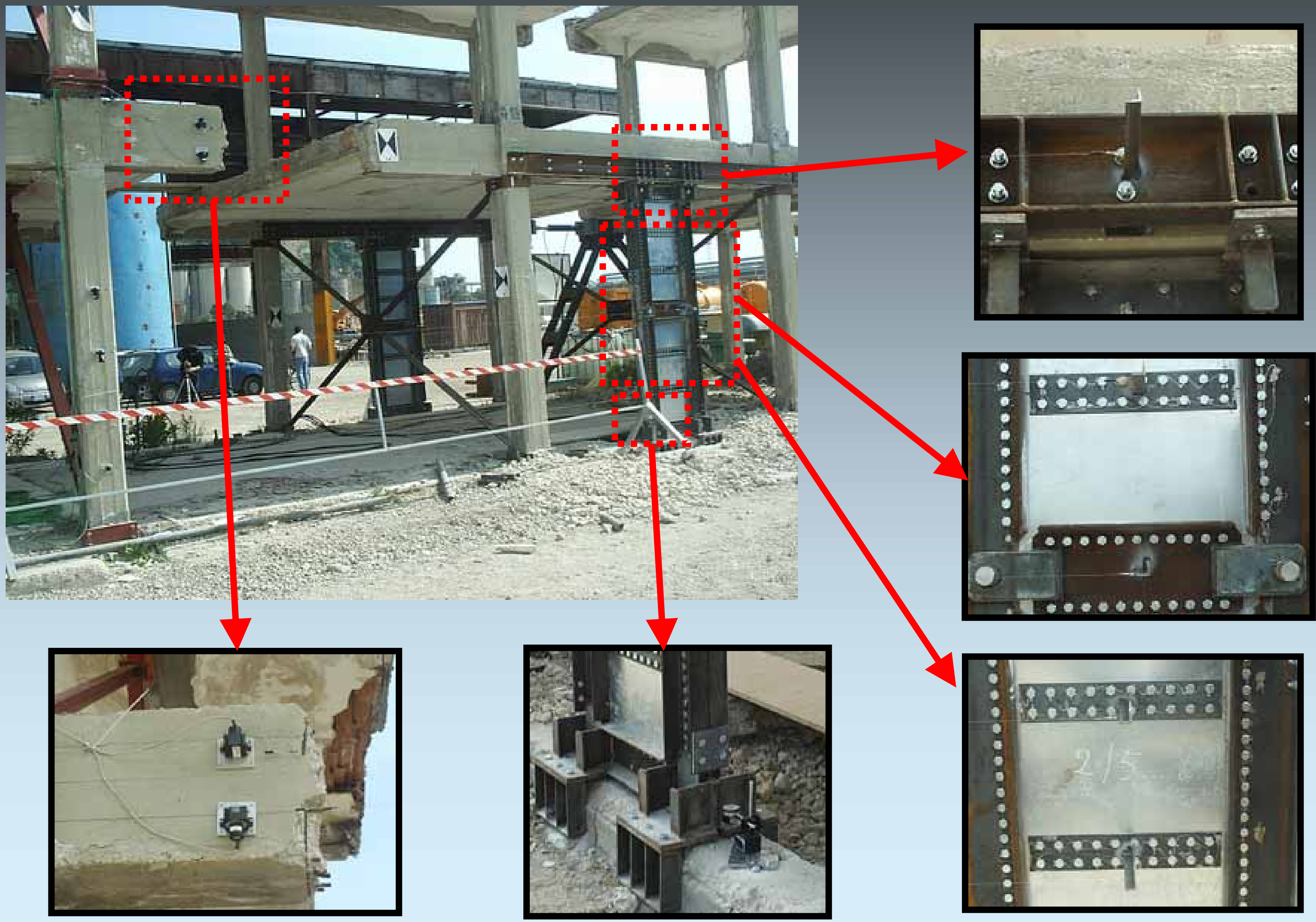
SEISMIC RETROFITTING METHODOLOGY AND DESIGN OF RC STRUCTURES BY MEANS OF METAL SHEAR PANELS

THE STEEL FRAME – RC STRUCTURE CONNECTIONS



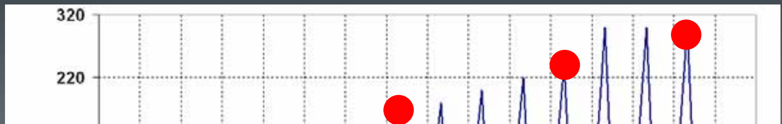
THE EXPERIMENTAL TESTS ON THE MODULE EQUIPPED WITH METAL SHEAR PANELS

MEASUREMENT DEVICES



THE EXPERIMENTAL TESTS ON THE MODULE EQUIPPED WITH METAL SHEAR PANELS

CYCLIC TEST ON THE RC MODULE – STEEL PANELS COMPOSED STRUCTURE



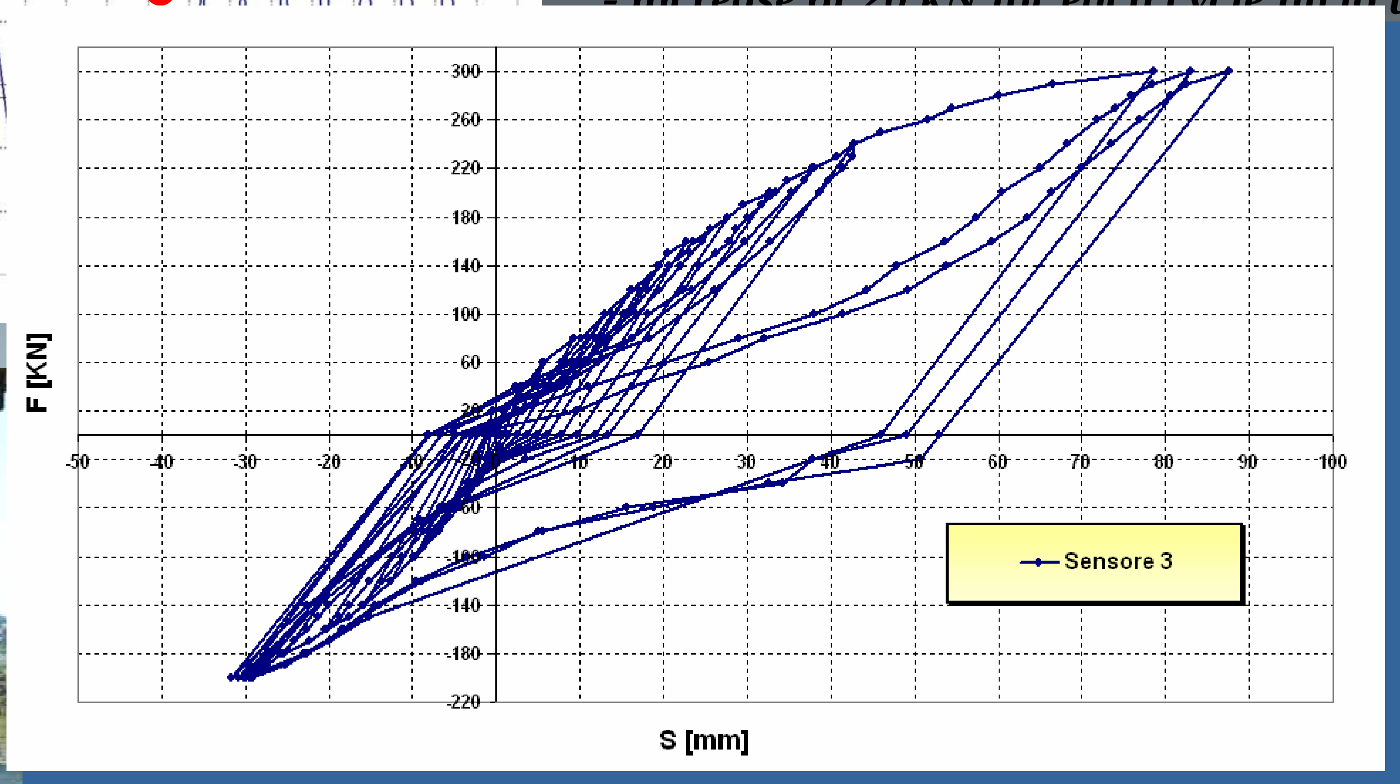
- quasi-static conditions;

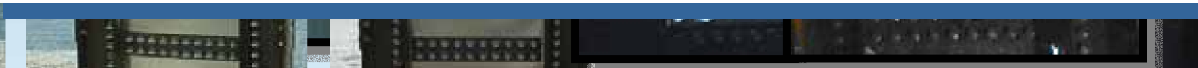
- increase of 20 kN for each cycle up to the last

;

(hence

ed up to





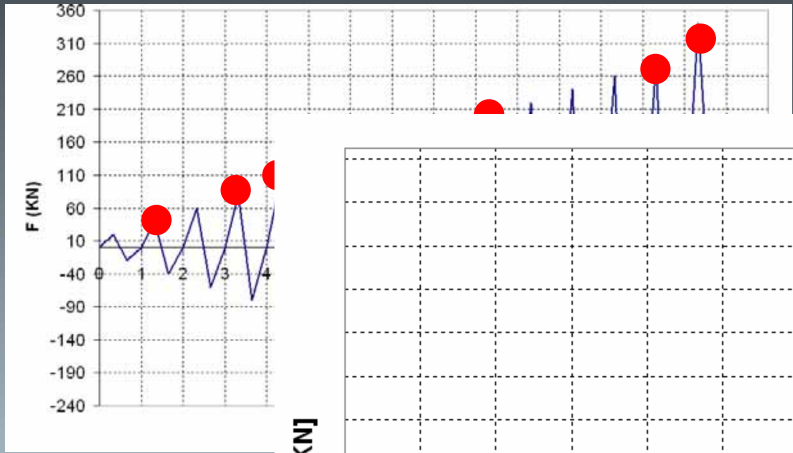
From the cyclic tes *Creation upper su* *Buckling pl panels* *Very pronounced buckling waves which interest all panel fields (folding disappears)* *lates, ent* ***coincident***

with the unloading ***er sub-***

panel which make the system less rigid and delay the activation of the tension field

THE EXPERIMENTAL TESTS ON THE MODULE EQUIPPED WITH METAL SHEAR PANELS

CYCLIC TEST ON THE RC MODULE – ALUMINIUM PANELS COMPOSED STRUCTURE



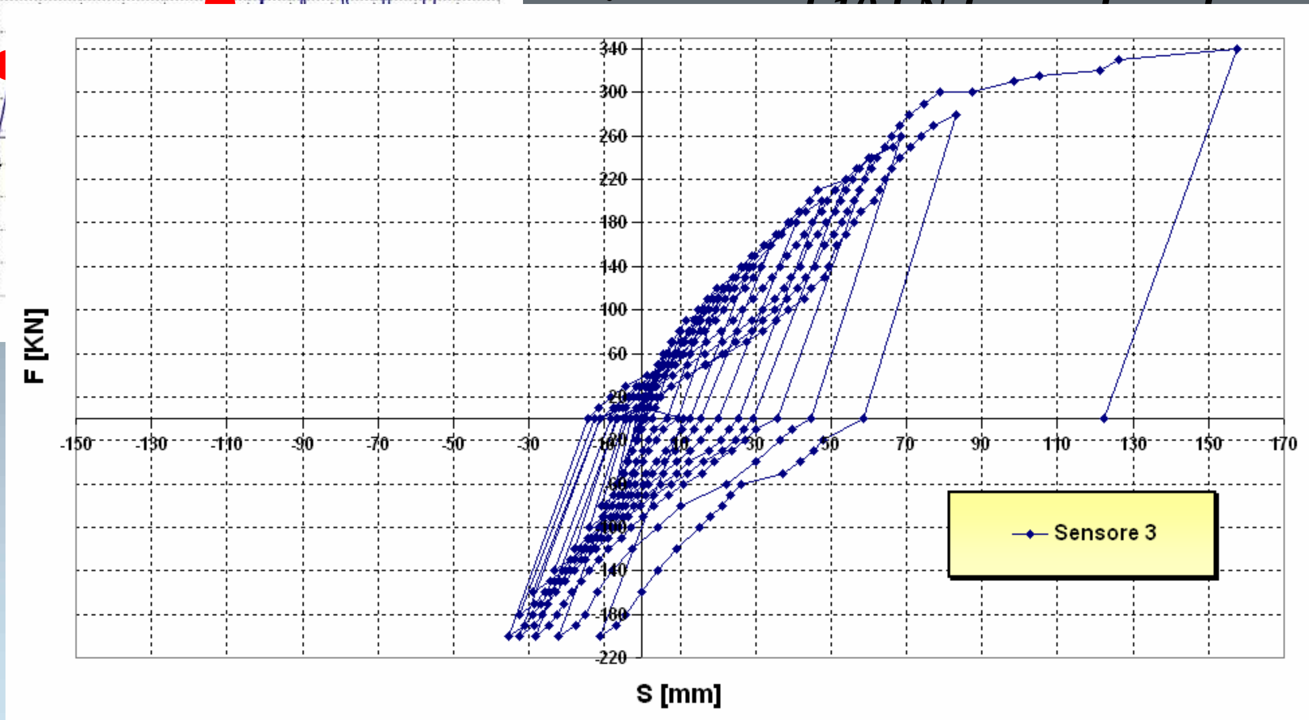
- quasi-static conditions;

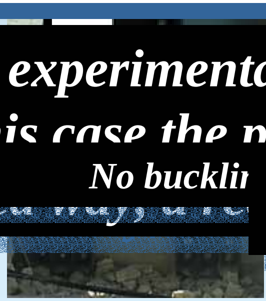
... to the last

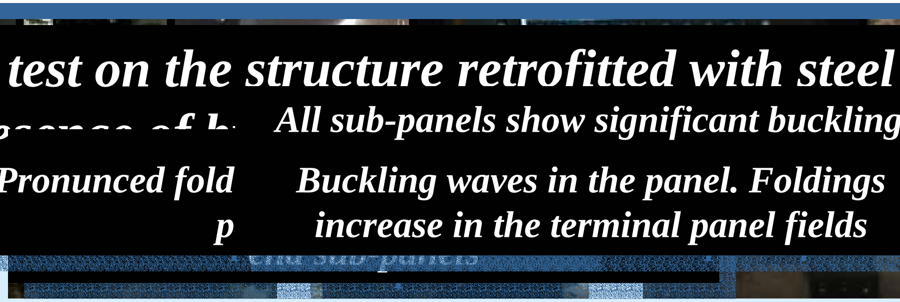
...kN;

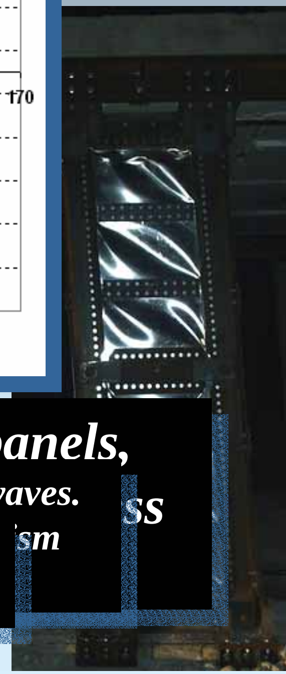
...kN (hence

...ased up to









As in the experimental test on the structure retrofitted with steel panels, also in this case the presence of b... pronun...

No bucklin...

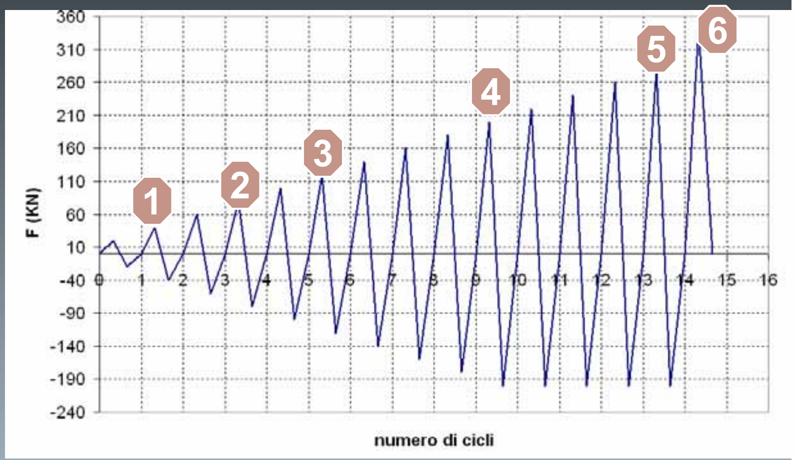
Pronounced fold... p...

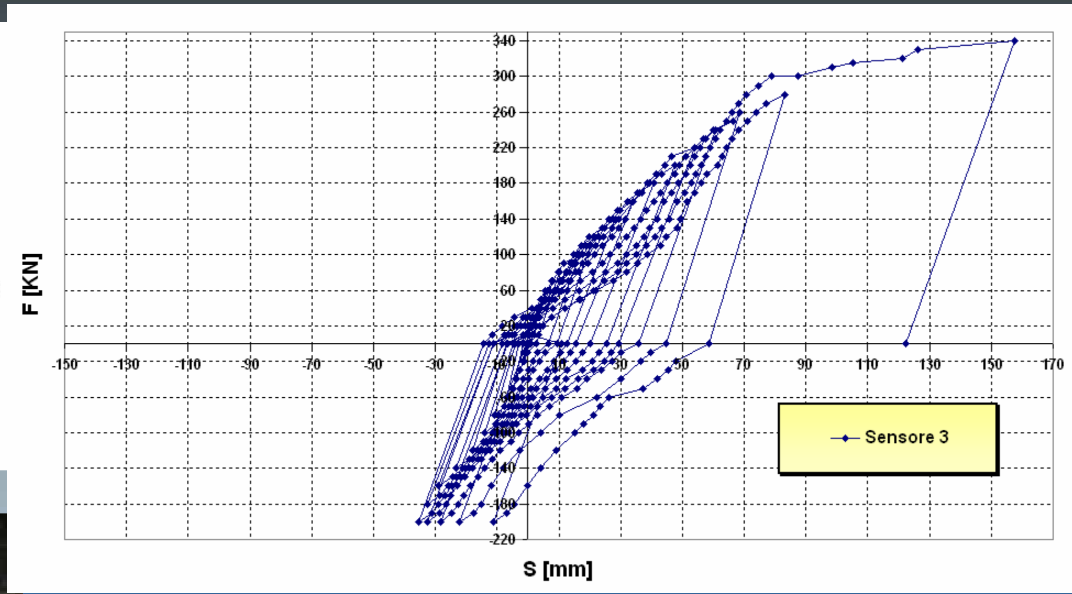
All sub-panels show significant buckling waves.

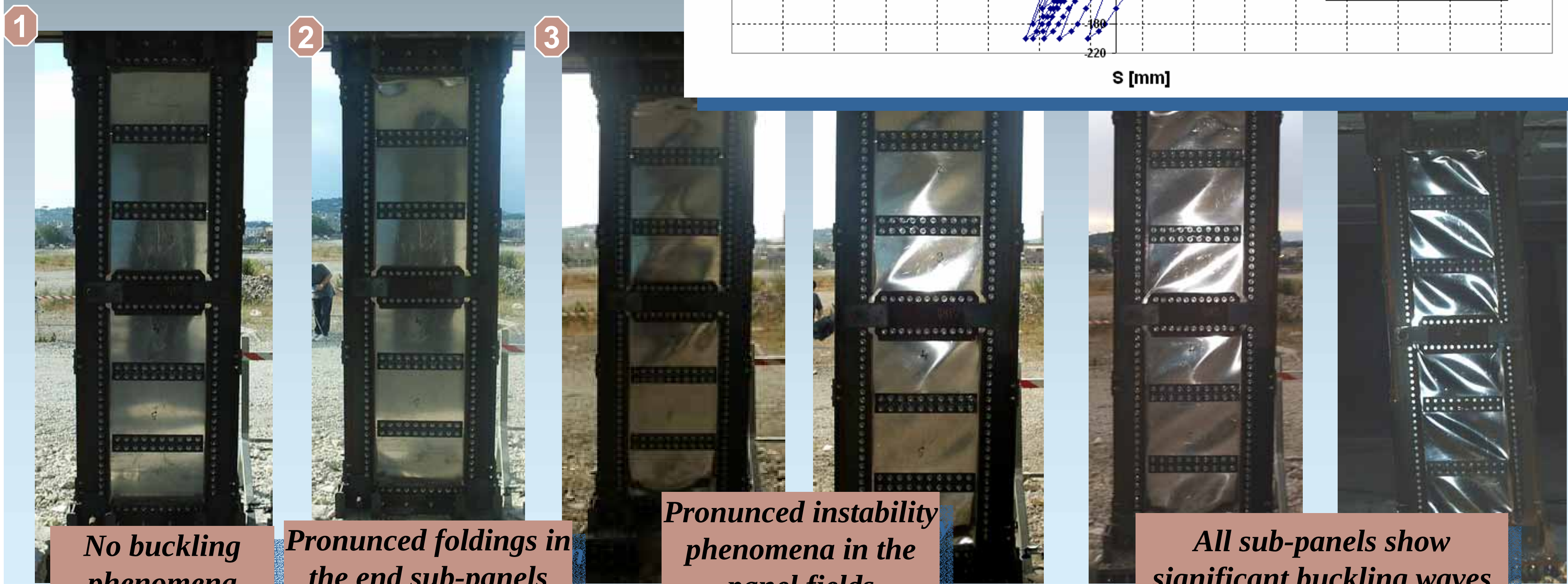
Buckling waves in the panel. Foldings increase in the terminal panel fields

THE EXPERIMENTAL TESTS ON THE MODULE EQUIPPED WITH METAL SHEAR PANELS

CYCLIC TEST ON THE RC MODULE – ALUMINIUM PANELS







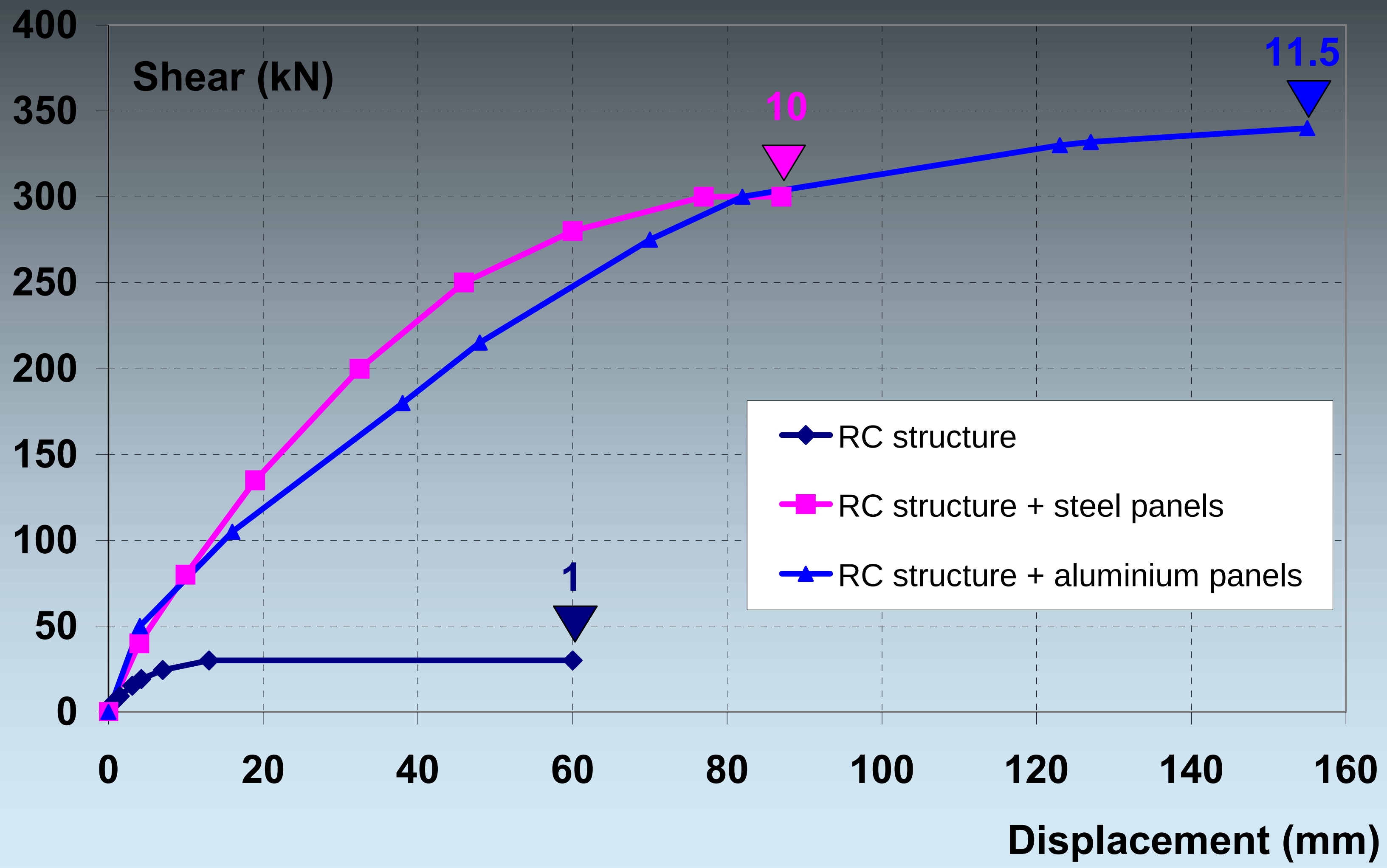
No buckling phenomena

Pronunced foldings in the end sub-panels

Pronunced instability phenomena in the panel fields

All sub-panels show significant buckling waves

COMPARISON BETWEEN EXPERIMENTAL RESULTS



CONCLUSIONS

1. The use of metal shear panels for the seismic protection of new and existing buildings has been investigated;

2. Experimental tests on full bay, bracing type and partial bay type pure aluminium shear panels have been carried out;

3. The obtained results emphasize that shear metals panels actually represent a very attractive strategy to reduce the seismic vulnerability of new (steel) and exiting (RC) framed structures subjected to large earthquakes.