

Final Meeting

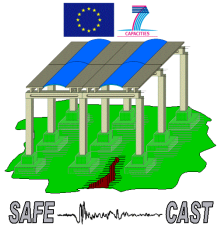
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Rome
 21st-22nd March
 2012

Cyclic Test

- Summary Results*

Cyclic loading	
“Yield” strength	58 kN
Maximum strength	70 kN
“Yield” displacement (d_y)	≈ 90 mm
Ultimate displacement	190 mm
Total energy dissipated by the connection	≈ 20 kNm
Total energy dissipated by the assemblage	≈ 26 kNm



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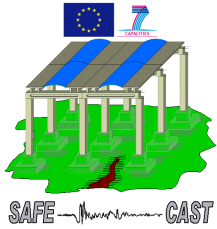
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Cyclic Test

- *Damage Observation*

Spalling of concrete cover
Crushing of concrete





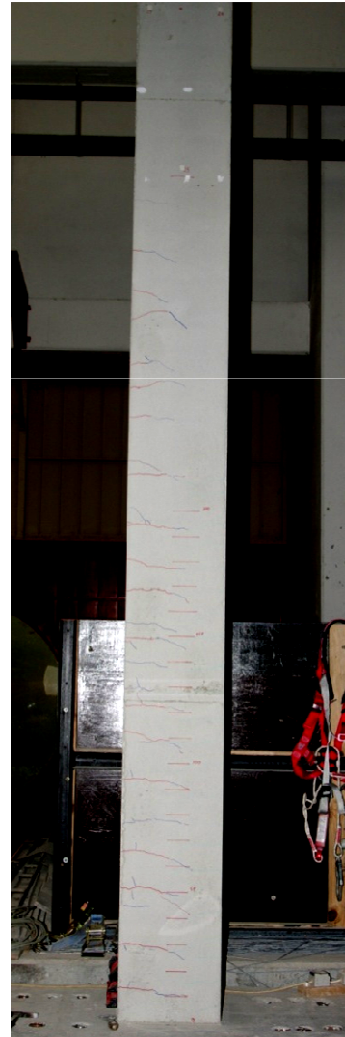
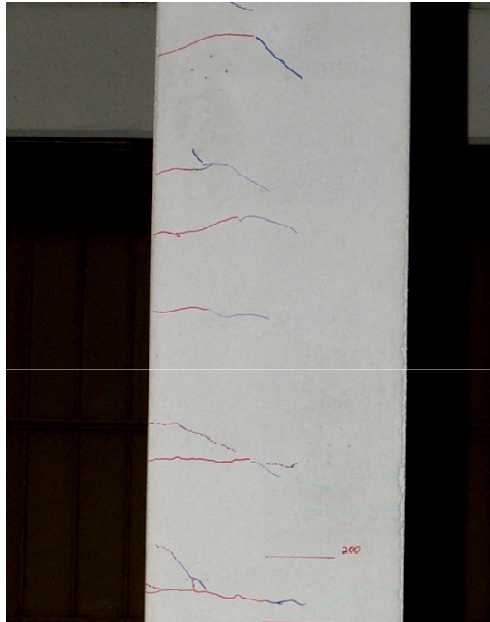
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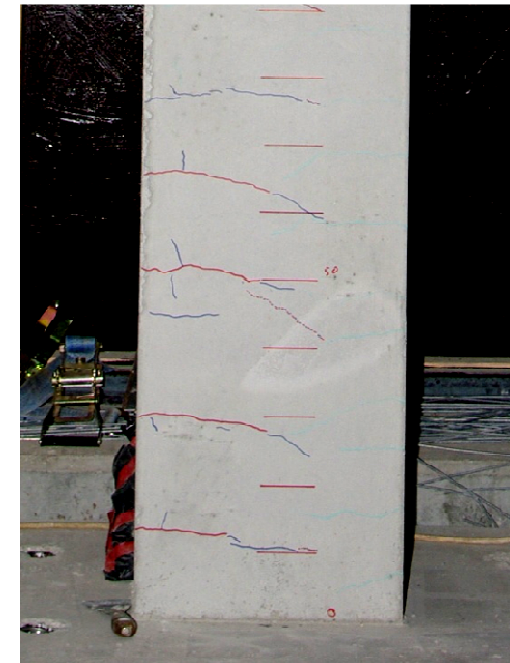
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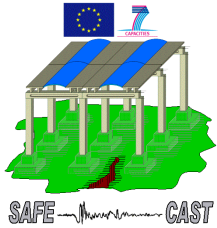
Cyclic Test

- *Damage Observation*



**Cracking of concrete
(1mm cracks)**





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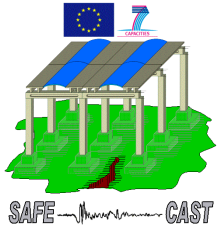
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Cyclic Test

- *Key results*

- Even with a large displacement input collapse of the assemblage was not reached;
- There is some initial beam-column joint moment-rotation stiffness that reduces along the test;
- Damage was concentrated mainly in the beam-column connection;
- Moderate damage was also observed along the height of the column (flexural cracks along the lower 2m);
- Energy dissipation was mainly carried out by the beam-column joint mechanism;
- Spalling and crushing of concrete on the corbels and beams at the joint reduces the moment resisting capacity of the connection.



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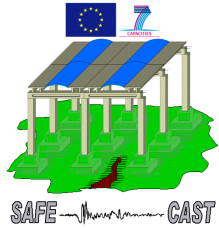
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☐ 2D real scale static tests on beam-column subassemblies

Conclusions

Even with a large displacement input collapse of the assemblage was not achieved either for monotonic and cycling loading.

1. There is some initial beam-column joint moment-rotation stiffness that reduces along the test.
2. Damage were concentrated mainly in the beam column connection.
3. Moderate damage was also observed along the height of the column (lower 2m flexural cracks)
4. Energy dissipation was mainly absorbed by a beam-column joint mechanism
5. Spalling and crushing of concrete on pile corbels and beams at the joint reduces the moment resisting capacity of the joint



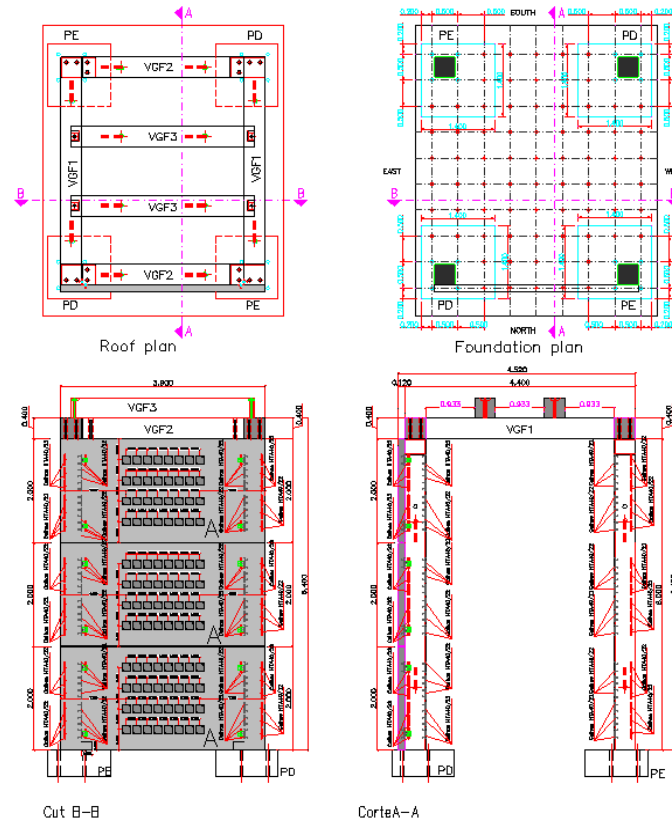
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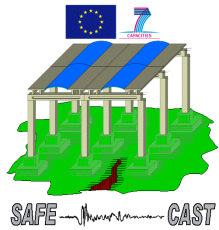
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3D large scale dynamic tests on precast cladding panel to column connections

Two Configurations tested



Configuration 1 – Three panels A placed on the North side of the model



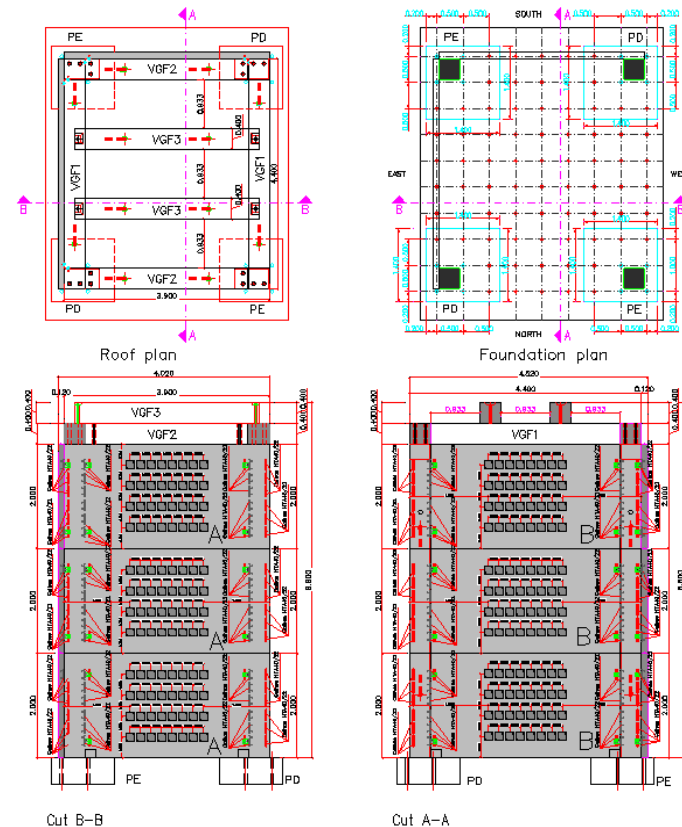
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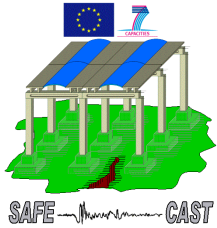
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❑ 3D large scale dynamic tests on precast cladding panel to column connections

❑ Two Configurations tested



Configuration 2 – Two sets of three panels (A and B) placed on the South and East sides of the model



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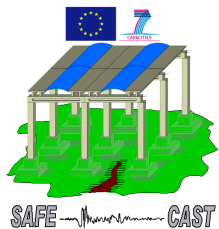
3D large scale dynamic tests on precast cladding panel to column connections

General experimental data

Test	Configuration	Loading	Angles
1	1	Out-of-plane	cold-formed
2	1	Out-of-plane	cold-formed
3	1	Out-of-plane	cold-formed
4	1	In-plane	hot-rolled
5	1	Out-of-plane	hot-rolled
6	2	Bi-directional	hot-rolled



- Cold-formed ST37 ($f_y=235\text{MPa}$) steel angles (8mm thickness)
- Hot-rolled steel equal angles (L120×10)



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□ 3D large scale dynamic tests on precast cladding panel to column connections

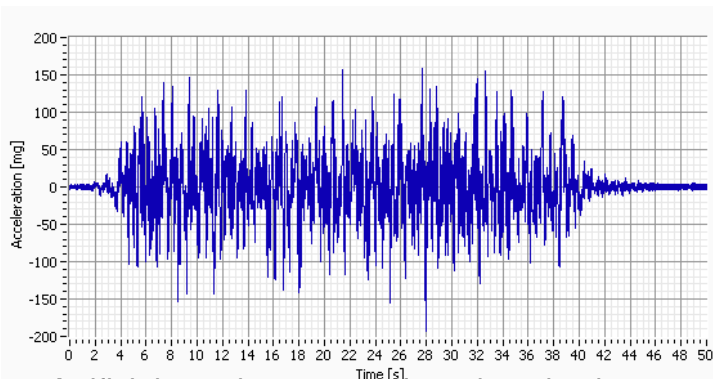
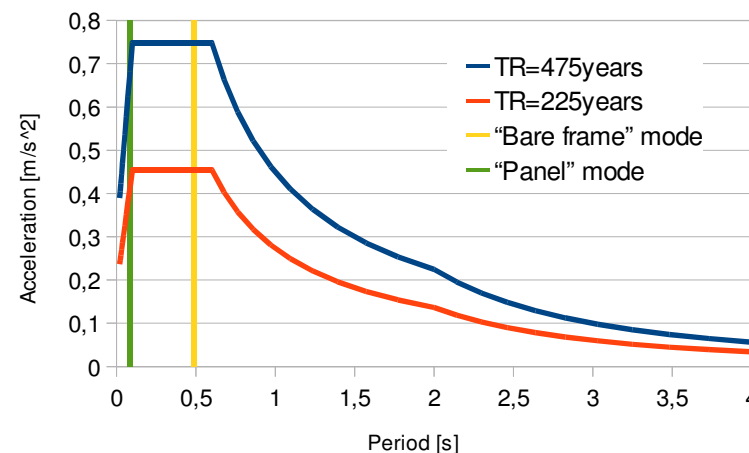
□ Seismic Loading

EC8 pseudo-acceleration response spectrum compatible accelerogram:

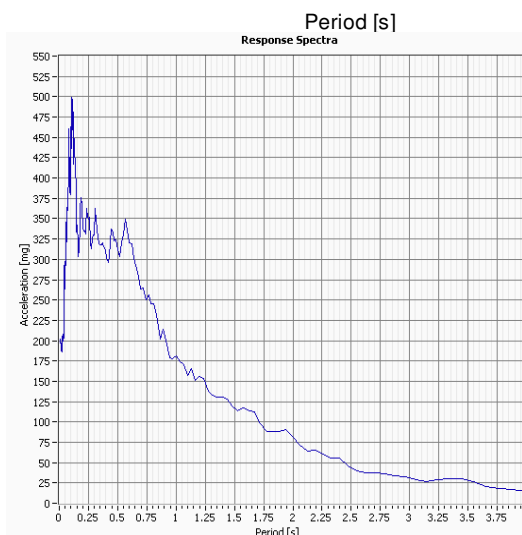
- › Soil type B
- › Horizontal component only
- › Importance class II

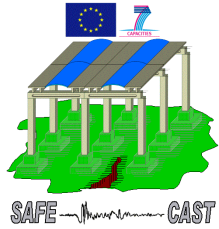
Portuguese 2010 National Annex:

- › Zone 1.1
- › $T_R = 475$ years
- › $a_{gR} = 2.5\text{m/s}^2$, $S=1.35$, $a_g \approx 3.4\text{m/s}^2$



Artificial accelerogram referred to elastic spectrum of EC8 for a soil of type B





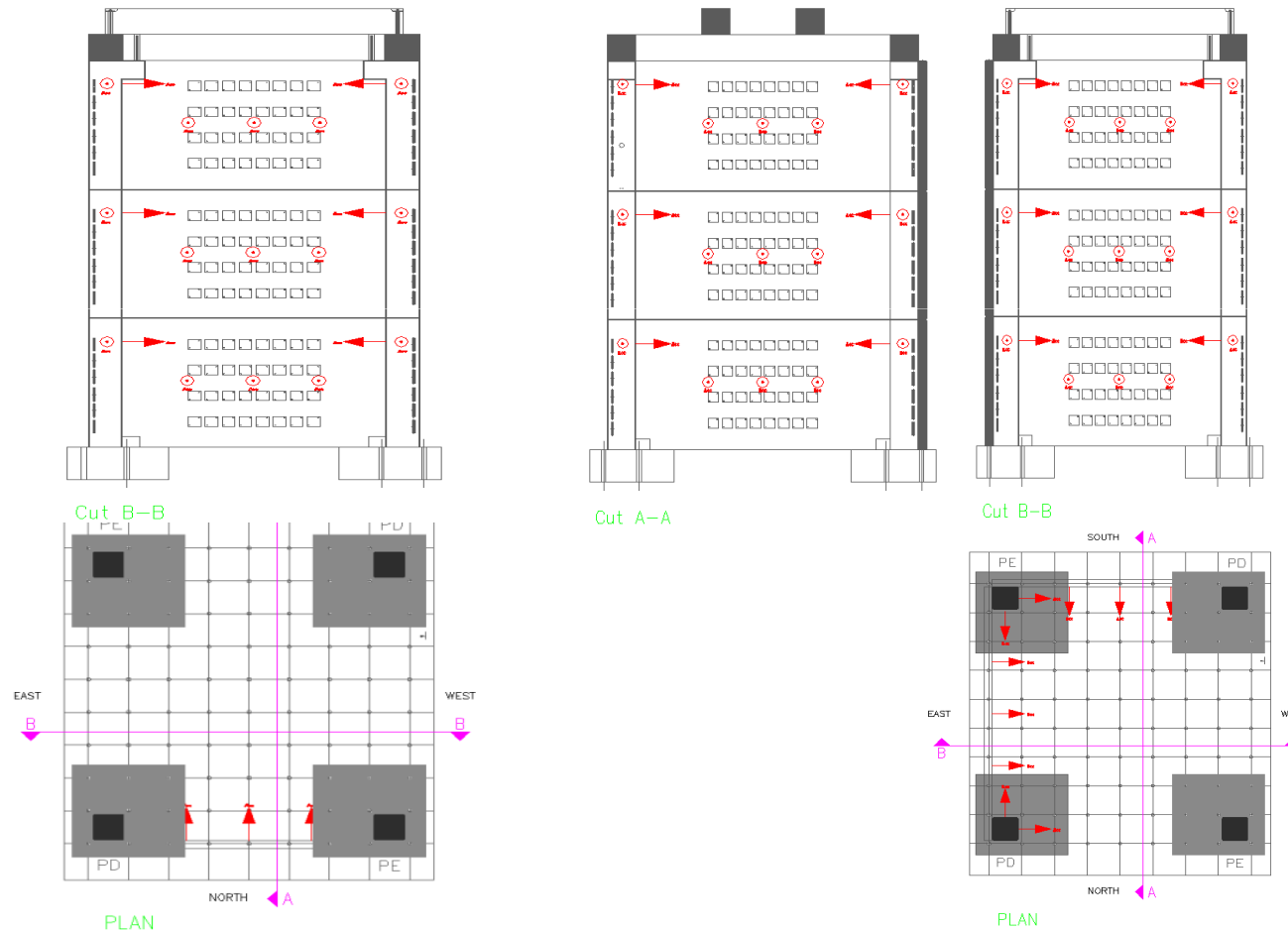
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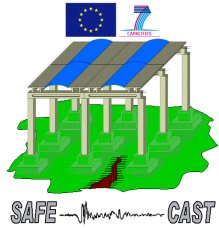
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3D large scale dynamic tests on precast cladding panel to column connections

Instrumentation





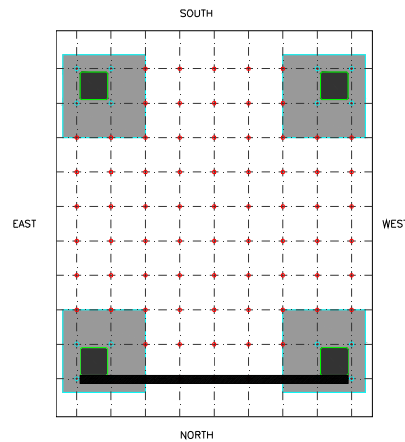
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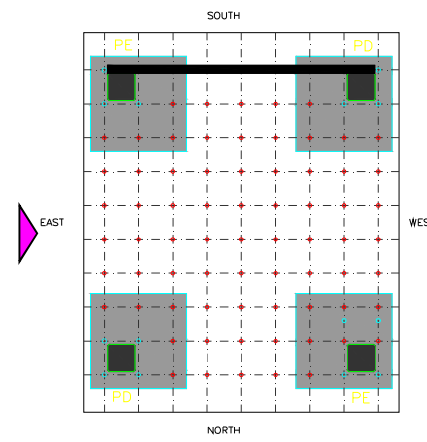
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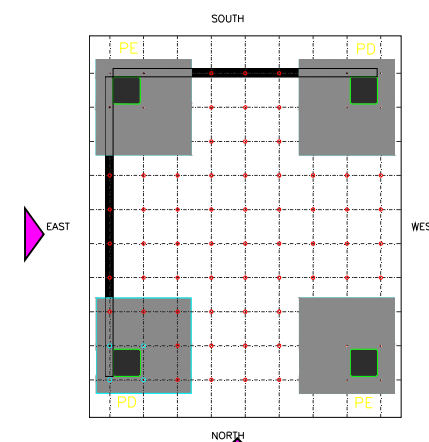
Test setups



OUT OF PLANE

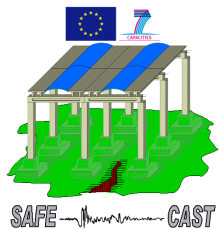


IN PLANE



BIDIRECTIONAL





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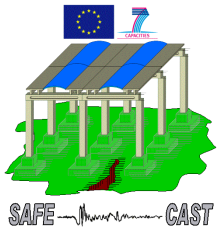
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3D large scale dynamic tests on precast cladding panel to column connections

General experimental data

Test run	EC8	Peak platform acceleration (g)	Frequency (Hz)	Damping %	Max acceleration (g)	Position	Maximum drift %
1st out-of-plane north side	Stg 1-Pink noise	-	2.05	3.4	-	-	-
	Stg 2-Seismic test	0.17	1.94	-	0.49	Column SE P3	0.6
	Stg 3-Seismic test	0.19	1.87	-	0.74	Column SE P3	0.91
	Stg 4-Seismic test	0.27	1.86	-	0.94	Column SE P3	1.05
	Stg 5-Pink noise	-	1.95	3.4	-	-	-
	Stg 6-Seismic test	0.36	1.78	-	1.15	Column SE P3	1.45
	Stg 7-Seismic test	0.43	-	-	6.94	Panel 3 West side	1.76
2nd out-of-plane north side - new position	Stg 1-Pink noise	-	2	3.73	-	-	-
	Stg 2-Seismic test	0.21	1.87	-	0.72	Column SW P3	0.7
	Stg 3-Seismic test	0.21	1.87	-	0.73	Column SW P3	0.71
	Stg 4-Seismic test	0.3	1.6	-	1.21	Column SW P3	1.08
	Stg 5-Pink noise	-	1.9	4.49	-	-	-
3rd out-of-plane north side - fastened	Stg 1-Pink noise	-	2.05	5.07	-	-	-
	Stg 2-Seismic test	0.24	2	-	0.72	Column SW P3	0.75
	Stg 3-Seismic test	0.33	1.82	-	1.05	Column SW P3	0.97
	Stg 4-Seismic test	1.6	-	-	12.2	Panel 3 east side	1.27
1st in-plane south side-signal in transverse direction	Stg 1-Pink noise	-	2.69	4.82	-	-	-
	Stg 2-Seismic test	0.35	-	-	0.72	Column NW P3	0.66
	Stg 3-Seismic test	0.22	-	-	-	-	-
	Stg 4-Seismic test	0.18	-	-	-	-	-
Bidirectional - new steel angles	Stg 1-Pink noise	-	Trasn=2.57; Long=2.59				
	Stg 2-Seismic test	0.07					
	Stg 3-Seismic test	0.1					
	Stg 4-Seismic test	0.14					
	Stg 5-Seismic test	0.22					
	Stg 6-Pink noise	-	Trans=2.39; Long=2.39, 2.78				
	Stg 7-Pink noise	-					
	Stg 8-Pink noise	-					
	Stg 9-Seismic test	0.31					
	Stg 10-Pink noise	-					
	Stg 11-Seismic test	0.43					
	Stg 12-Pink noise	-					
	Stg 13-Seismic test	0.48					
	Stg 14-Pink noise	-	Trans=2.25; Long=2.25				



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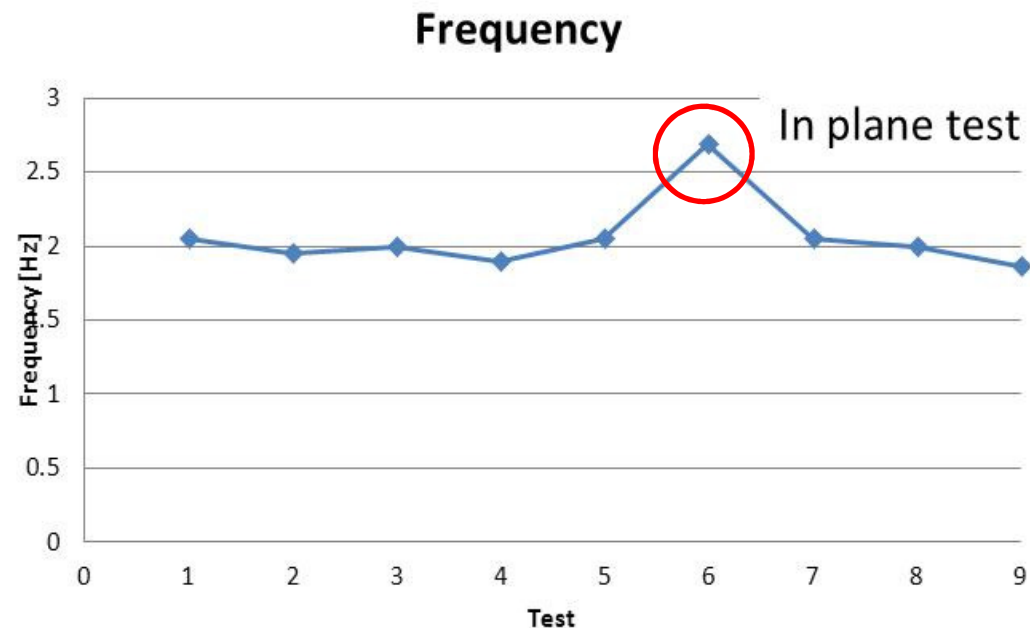
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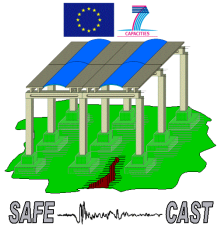
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3D large scale dynamic tests on precast cladding panel to column connections

Key results

- Along the several tests, as the amount of damage increases, the frequency decreases but the stiffness could be improved with the fastening of the connection





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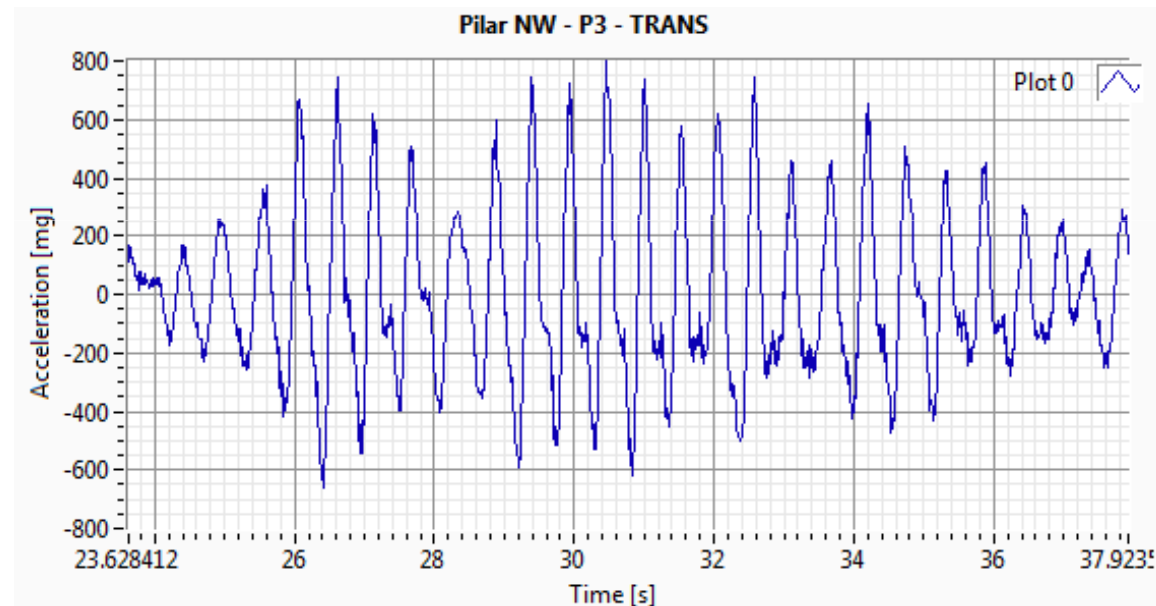
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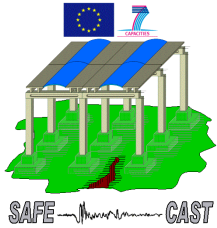
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□ 3D large scale dynamic tests on precast cladding panel to column connections

□ Key results

- Rankling problem occurs when the connections are not well fastened





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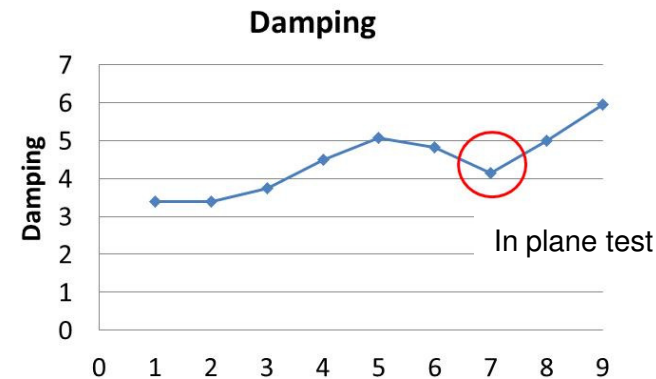
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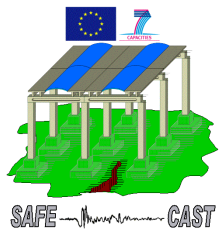
3D large scale dynamic tests on precast cladding panel to column connections

Key results

- Damping Increases during the test run



Test run	Random test	Frequency (Hz)	Damping %
1st out-of-plane north side	Pink noise	2.05	3.4
	Pink noise	1.95	3.4
2nd out-of-plane north side - new position	Pink noise	2	3.73
	Pink noise	1.9	4.49
3rd out-of-plane north side - fastened	Pink noise	2.05	5.07
1st in-plane south side-signal in tranverse direction	Pink noise	2.69	4.82
4th out-of-plane south side - new steel angles	Pink noise	2.05	4.15
	Pink noise	2	5
	Pink noise	1.86	5.95



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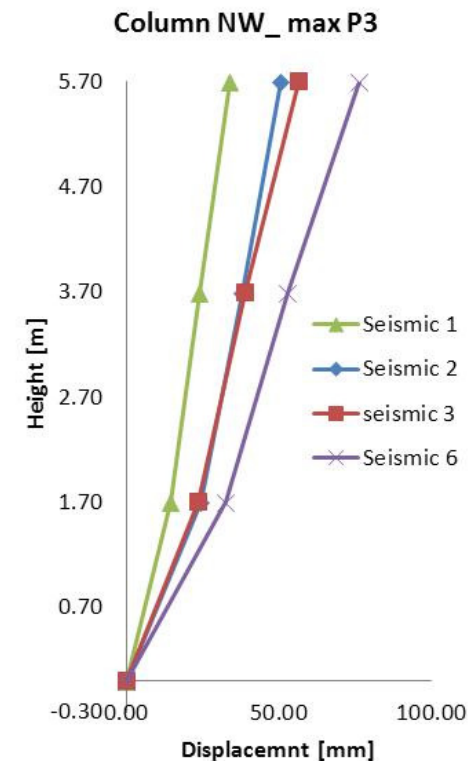
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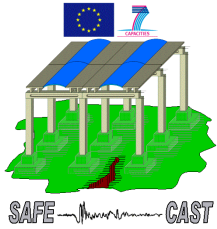
□ Key results

- Model deflected almost exclusively in the first mode shape

Seismic 3			
Time max [sec]	Max P3	Max P2	Max P1
26.37	56.71	56.46	49.14
26.36	38.98	39.20	37.14
31.52	23.54	23.93	25.07
	0.00	0.00	0.00

Seismic 6			
Time max [sec]	Max P3	Max P2	Max P1
26.04	76.38	76.34	76.34
26.03	53.17	53.19	53.19
26.03	32.53	32.69	32.69
	0.00	0.00	0.00





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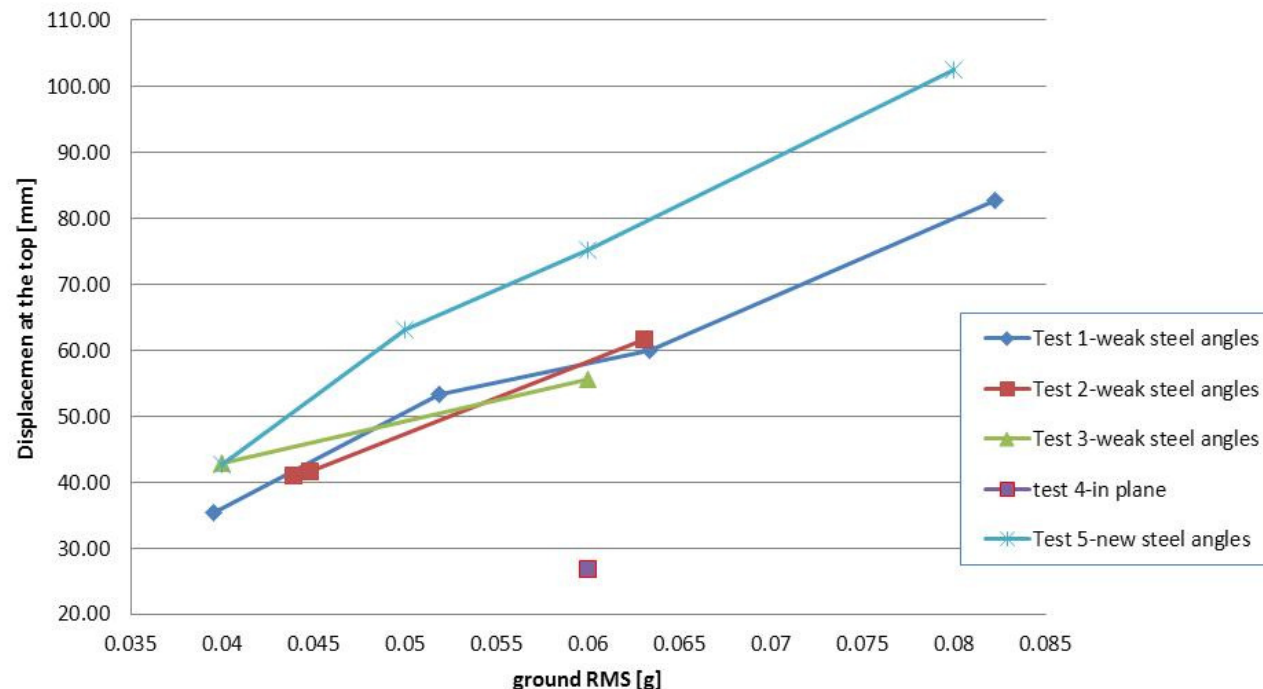
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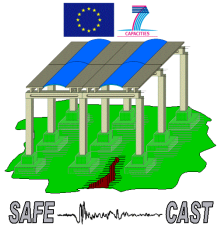
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3D large scale dynamic tests on precast cladding panel to column connections

Key results

- New steel angles do not reduce the displacement so they don't introduce stiffness (?)
- The displacements are higher in the 5th test because the structure has already some damage





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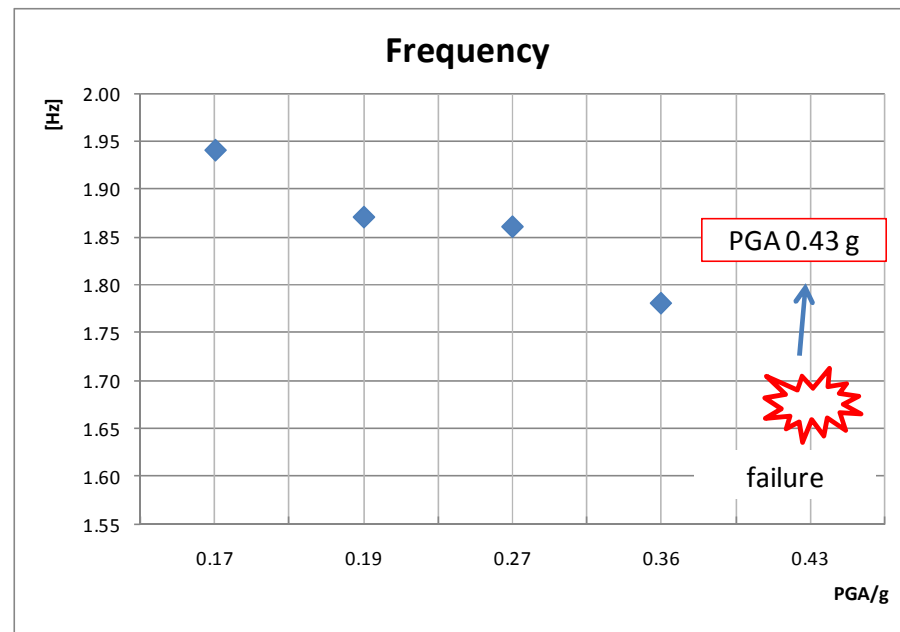
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□ 3D large scale dynamic tests on precast cladding panel to column connections

□ Key results

- Rupture of the connection. First test – out of plane test (example)



	Stage 2	Stage 3	Stage 4	Stage 6
<i>f1</i>	1.95	1.87	1.86	1.78