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Western Bridge Engineers' Seminar

Novel deconstructible columns for ABC in high seismic zones

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General project description

- *"Sustainable highway bridges with novel materials and deconstructible components"* funded by NSF grant IIP-111406
- PI: Dr. M. 'Saiid' Saiidi
- In collaboration with 4 U.S. business partners and 1 international partner
- Periodic updates and further information:

http://wolfweb.unr.edu/homepage/saiidi/NSF-PFI

Overall Objective:

Develop resilient and sustainable bridge columns

"Failure"

"Success"

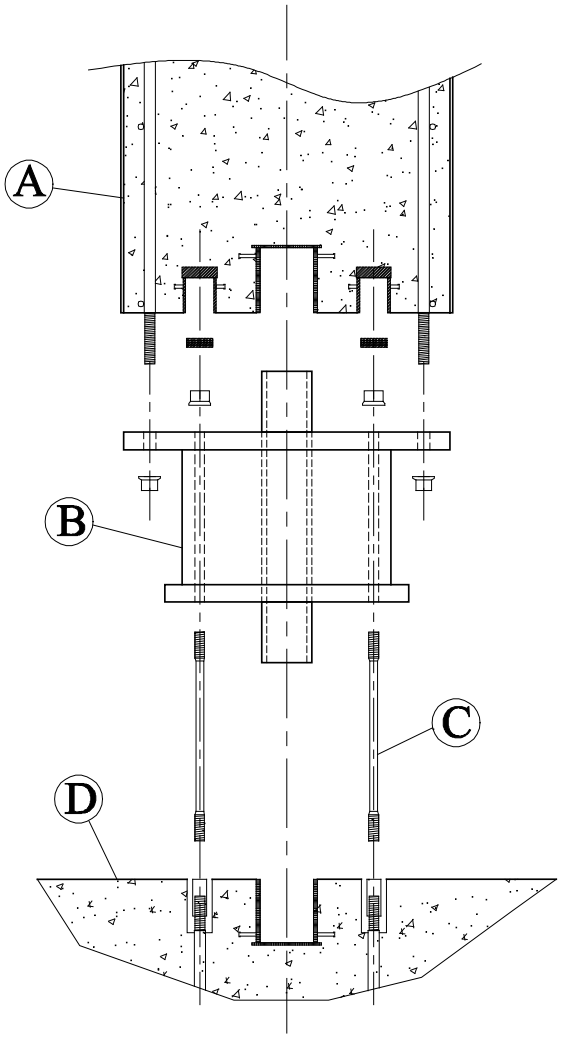
Introduction

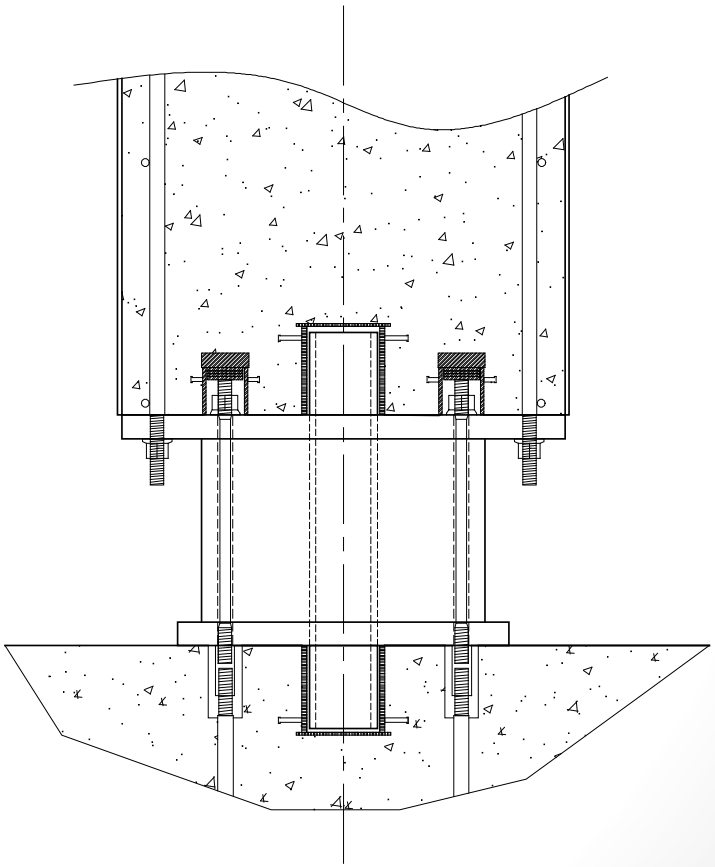
- Where do bridges go after they are decommissioned?

Demolition of a bridge in OR, 2009

Debris typically ends up in dumps

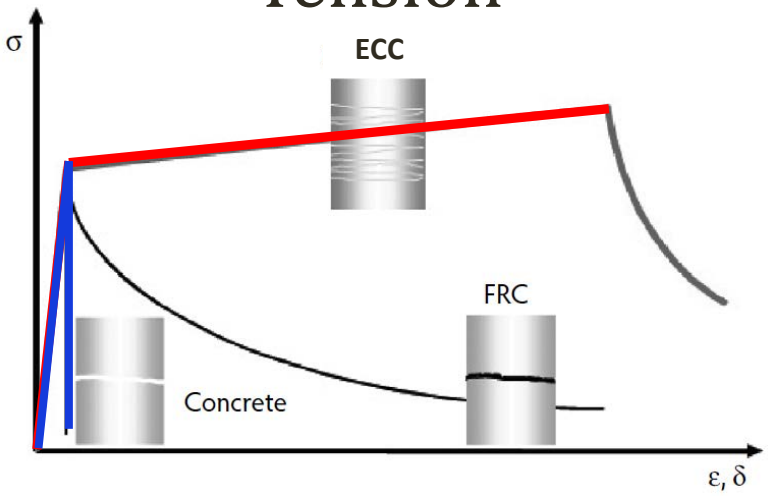
DfD concept for ABC columns

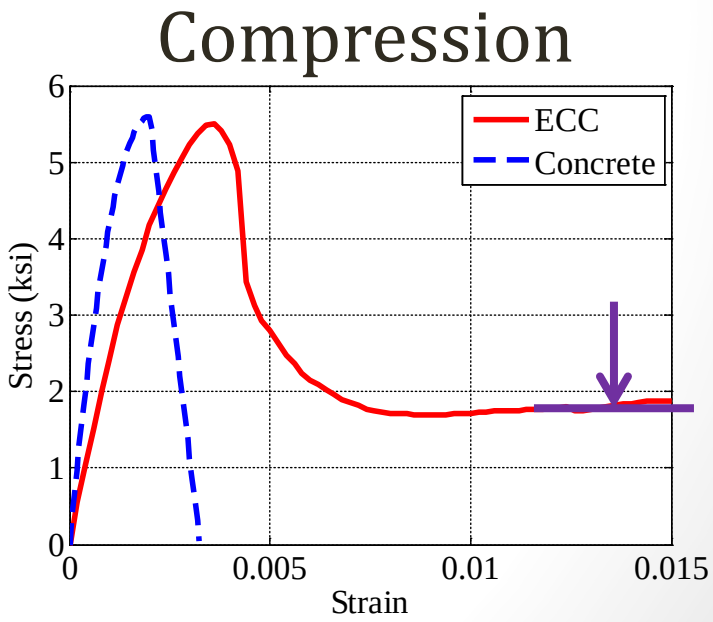




Novel materials: ECC

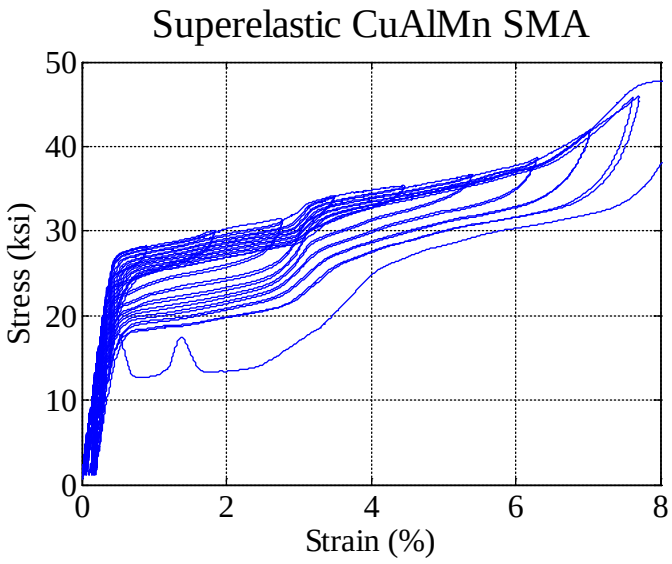
- Engineered Cementitious Composite: superior tensile ductility and decrease on the extent of apparent damage. Replaces concrete.



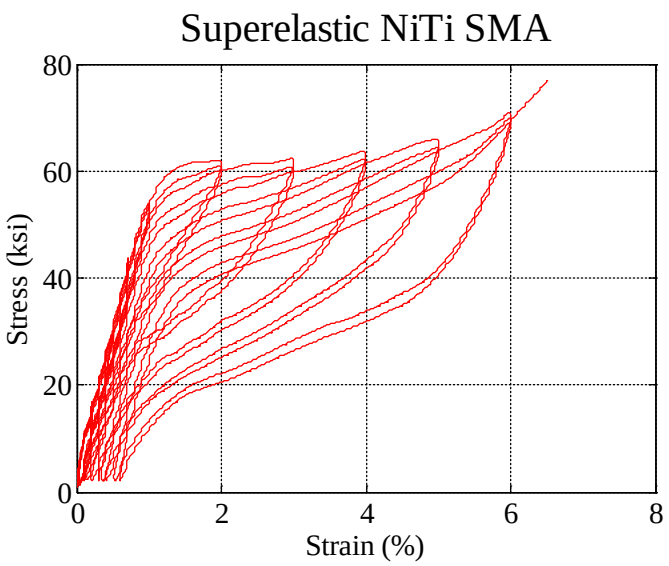


Novel materials: SMAs

- Superelastic Shape Memory Alloys

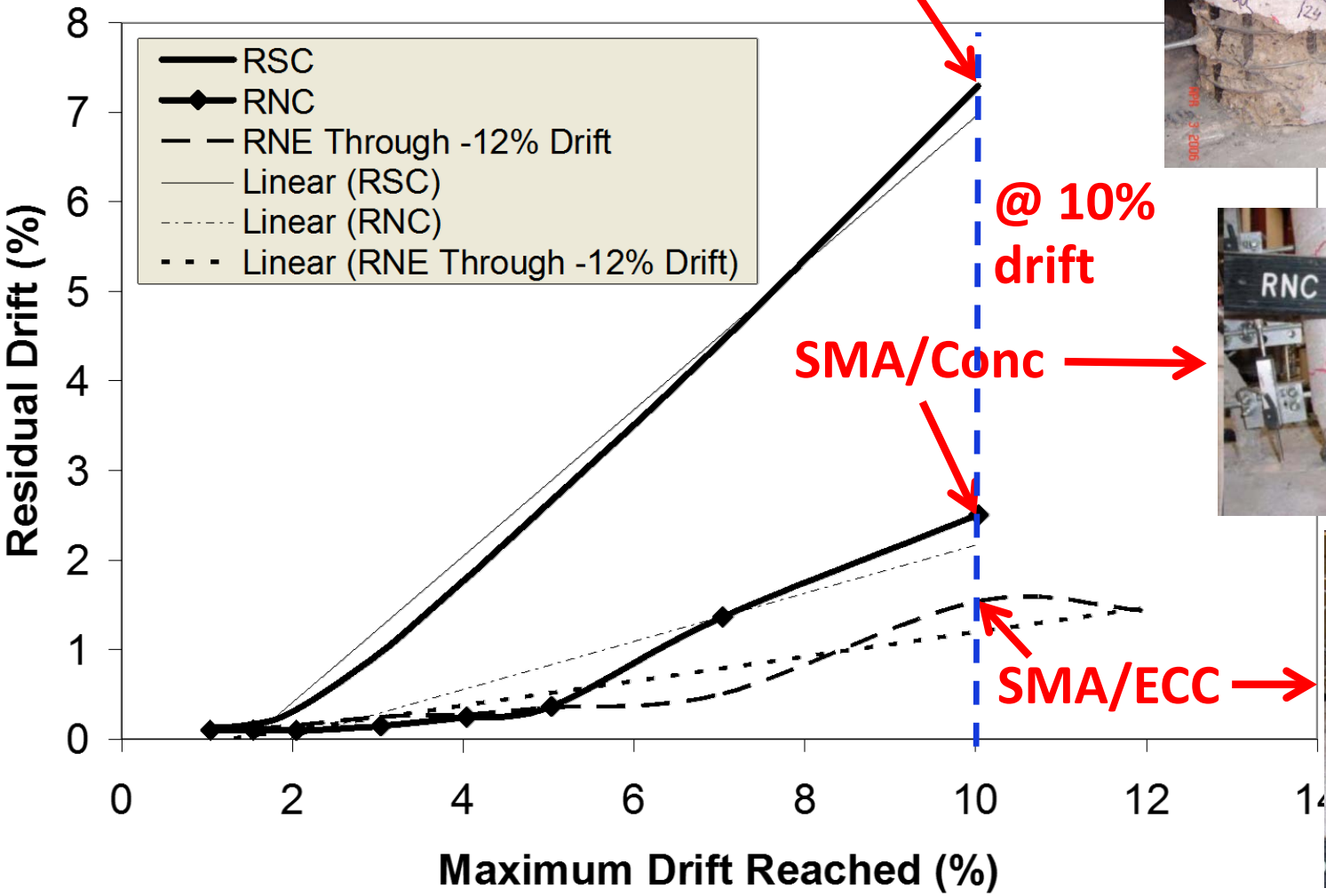


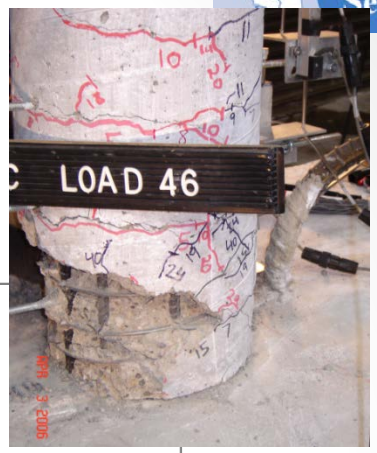
CAM



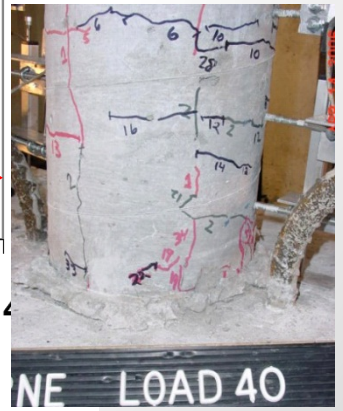
NiTi

NiTi SMA+ECC

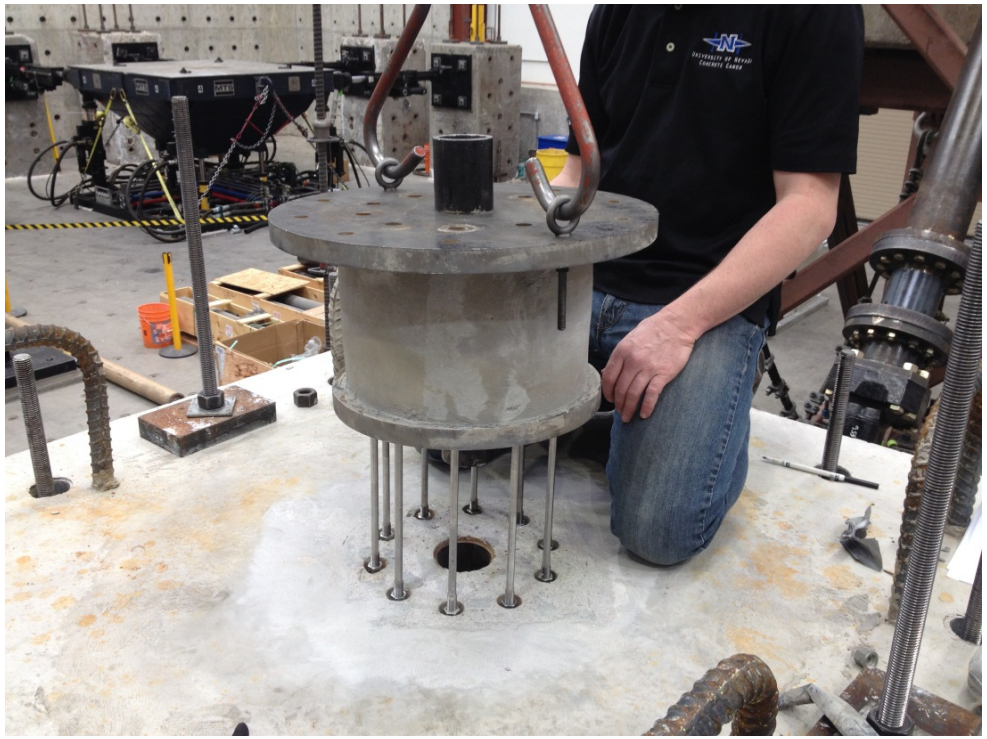

RSC
RNC
RNE Through -12% Drift
Linear (RSC)
Linear (RNC)
Linear (RNE Through -12% Drift)
Residual Drift (%)
Maximum Drift Reached (%)
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
RC
@ 10% drift
SMA/Conc
SMA/ECC

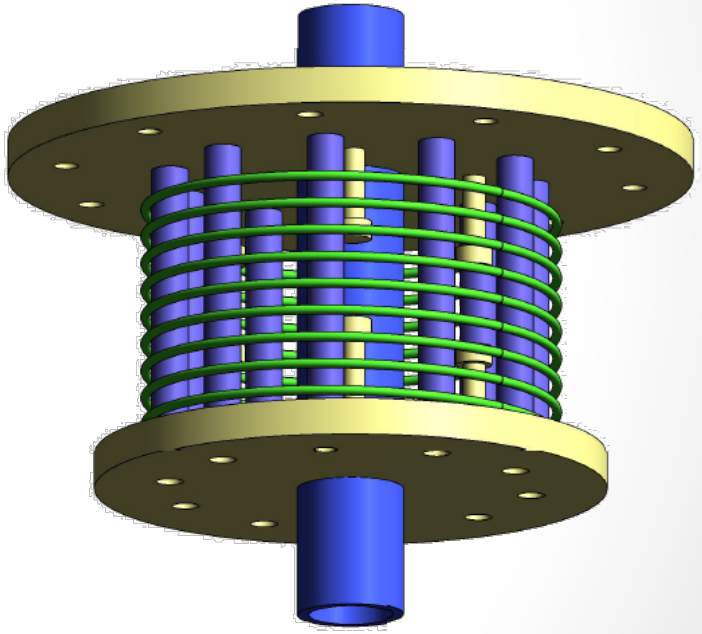

LOAD 46


RNC LOAD 40

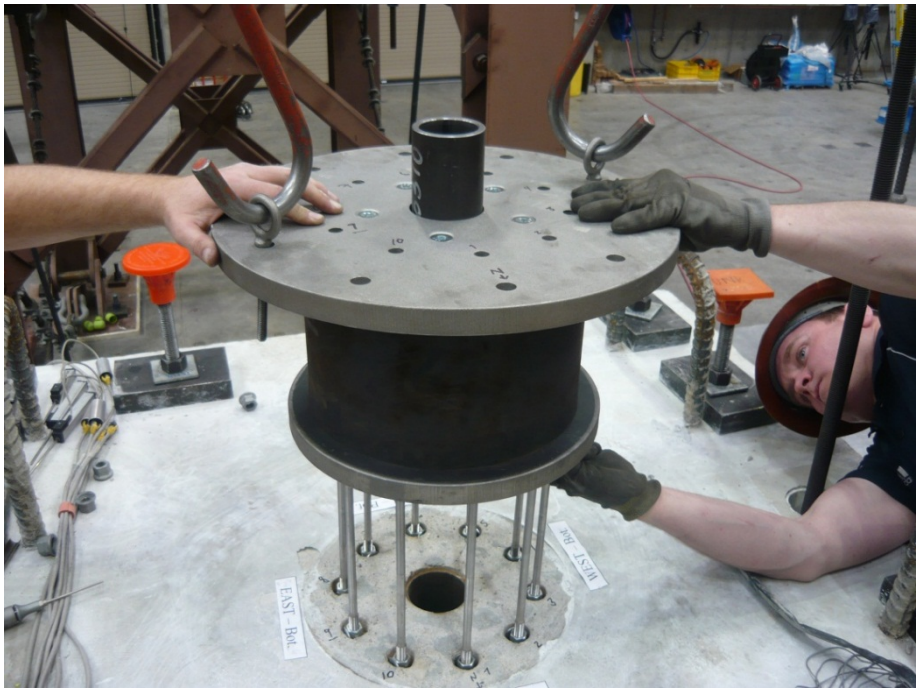

LOAD 40

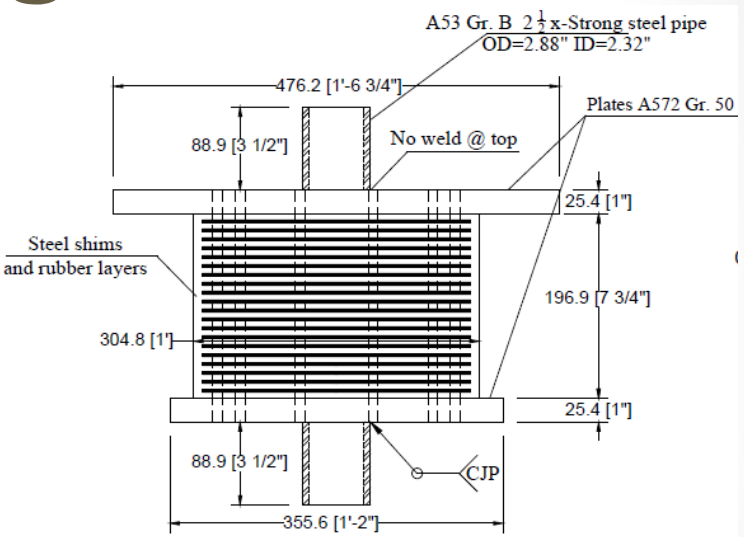
Precast ECC plastic hinge elements



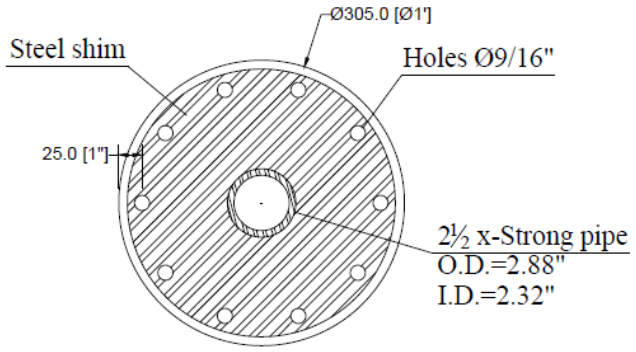


Rubber plastic hinge elements





Rubber element - Elevation



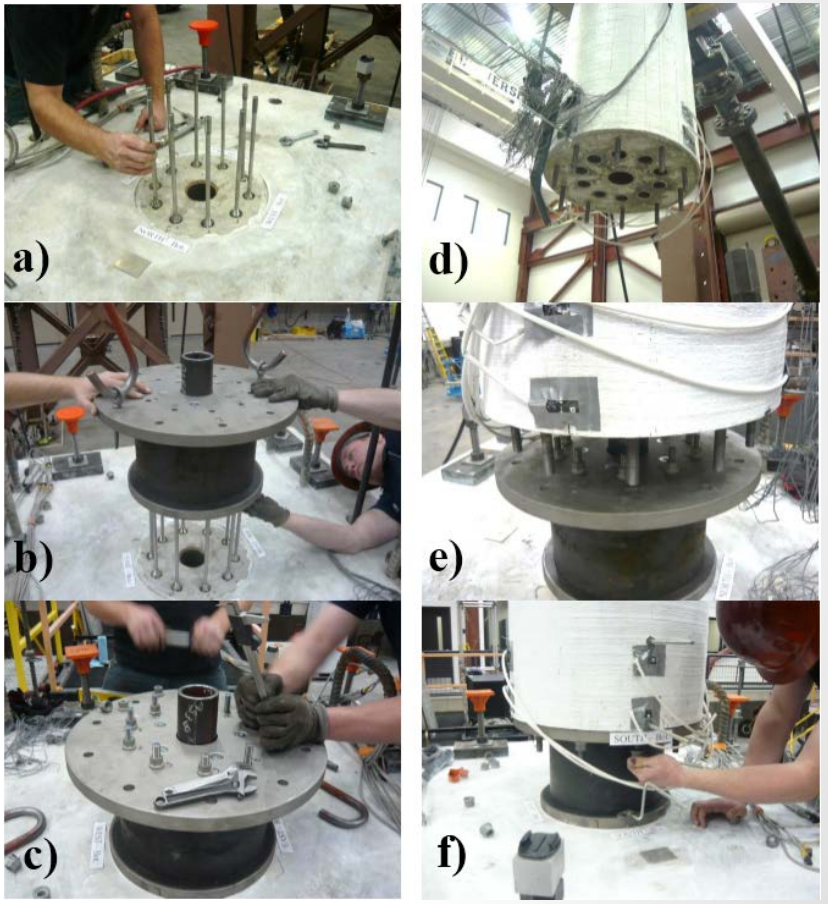
Rubber element - Section

Novel materials: CFRP shells

Tests on ¼ scale single column models

Plastic hinge element	SMA inside the plastic hinge element	
	NiTi	CAM
ECC	NE / NE-R	CE / CE-R
Rubber	NR / NR-R	~~CR / CR-R~~

➔ 6 column tests in total



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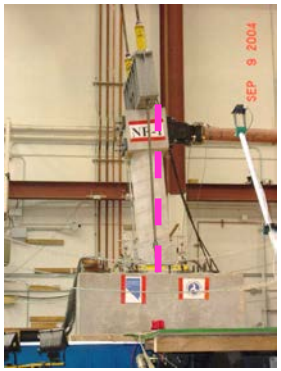
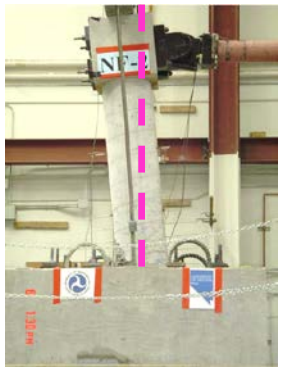
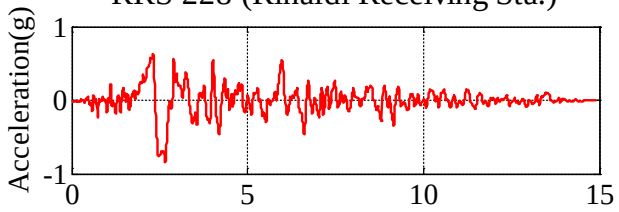
Test setup and procedure

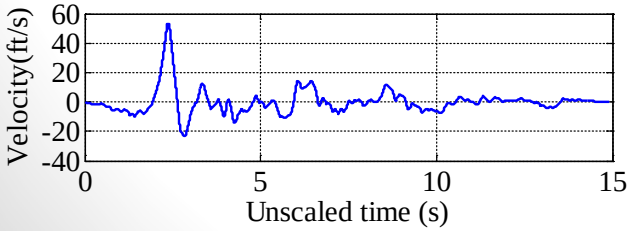
RC columns under NF motions:
Phan et al. '07

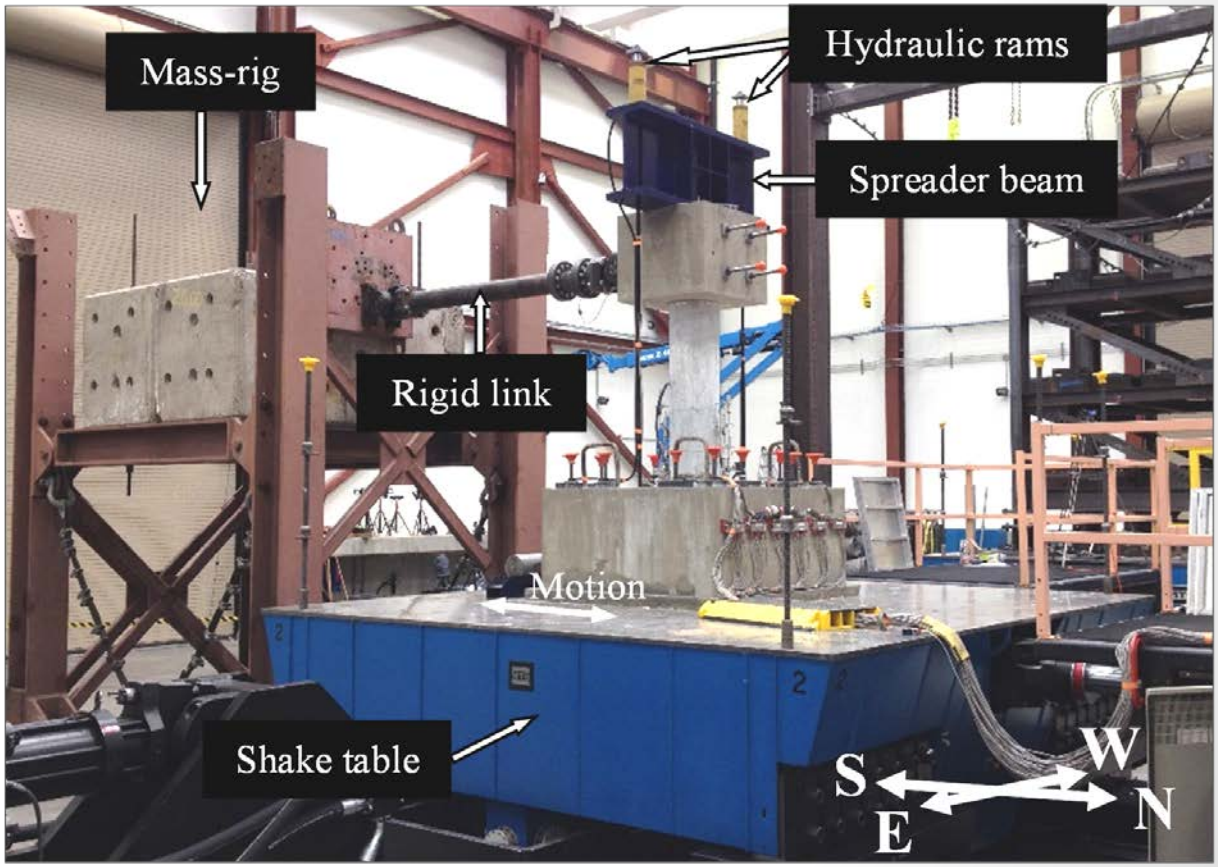




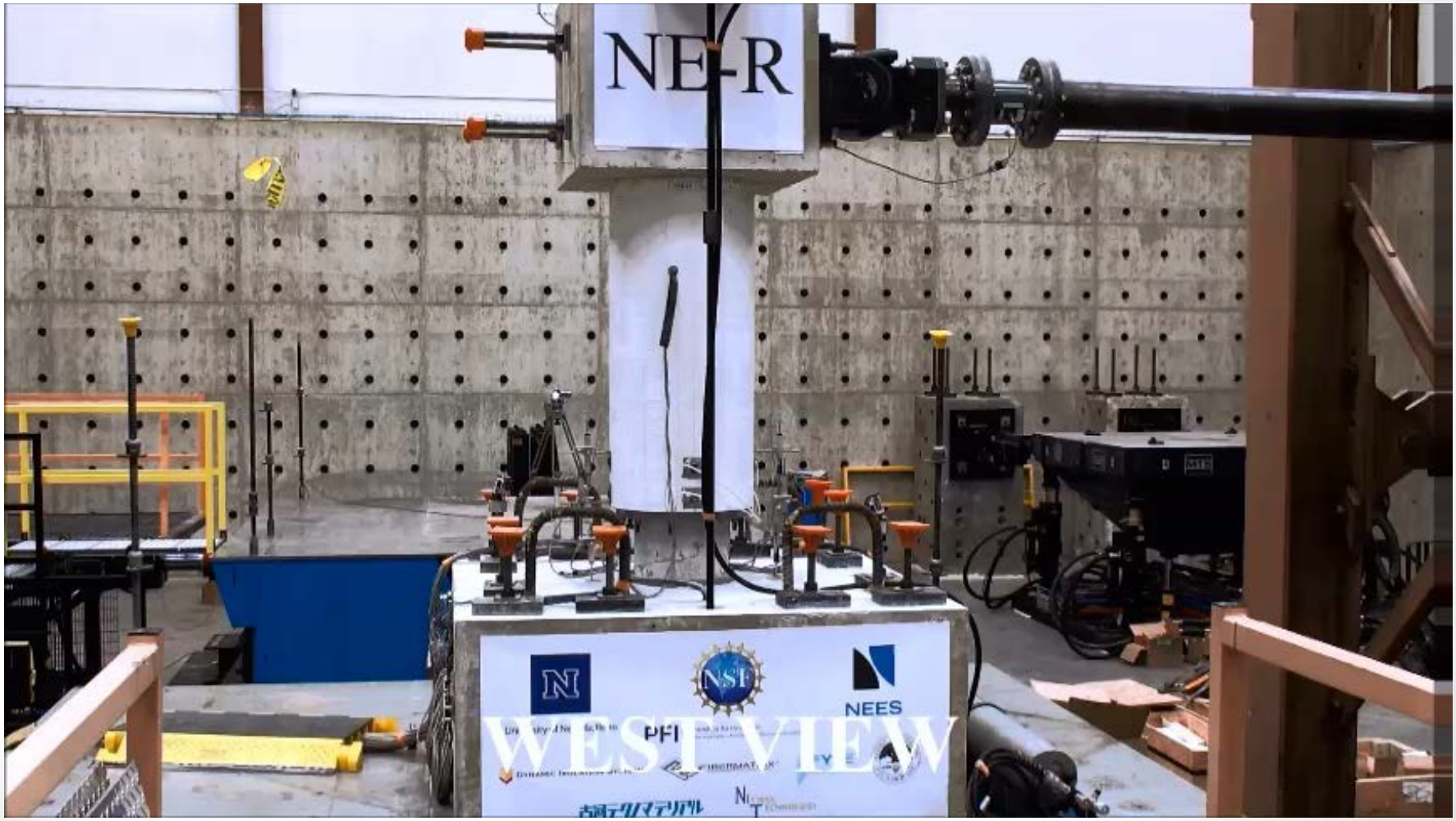
RRS 228 (Rinaldi Receiving Sta.)



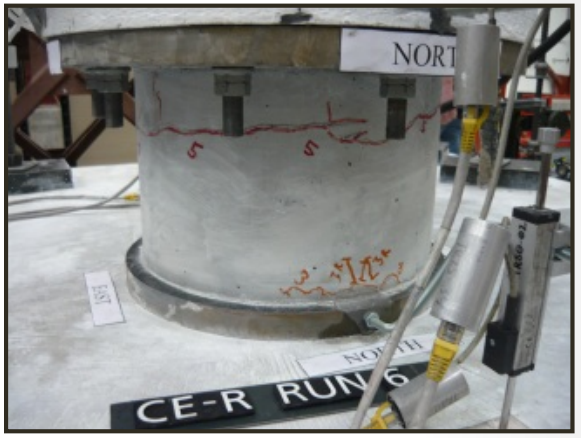


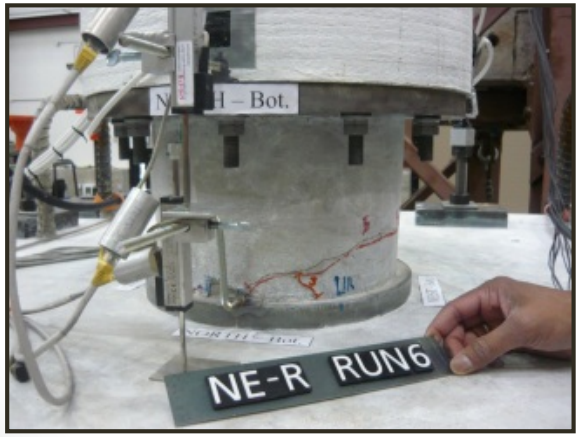


NE-R model: 1.0x Rinaldi =290% x DE



DfD columns: key observations



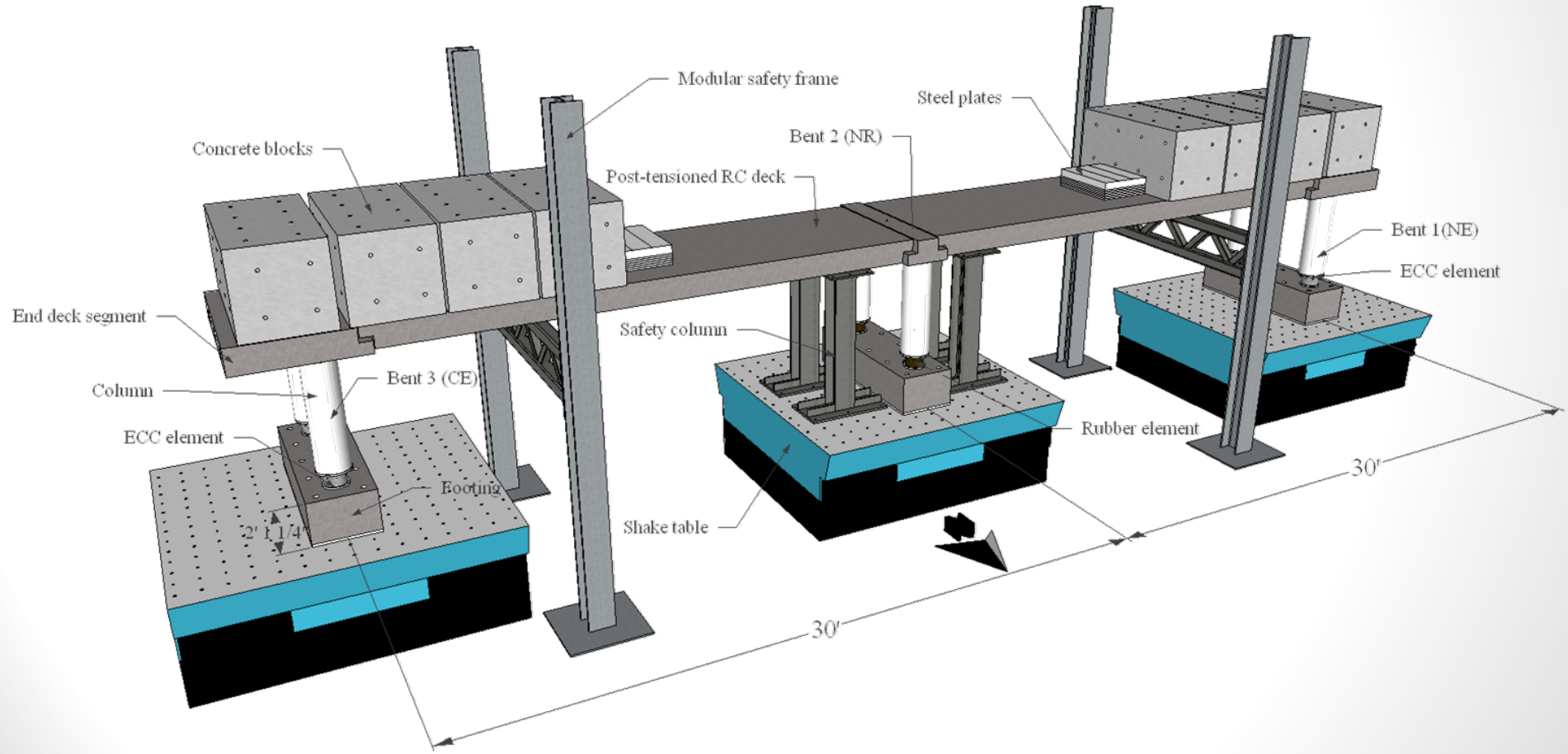


DfD columns: key results

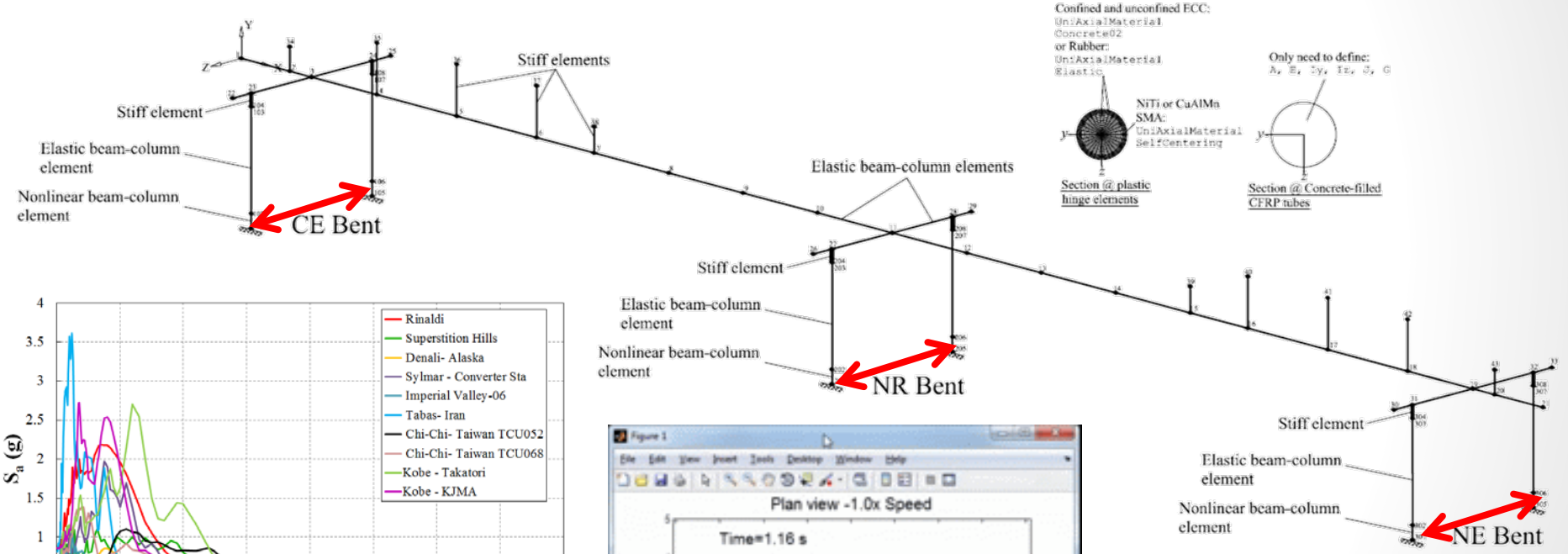
Column model	Run No. [PGA (g)]	Max. Drift	Res. Drift
NE	5 [0.76]	5.7%	0.02%
NE-R	6 [0.83]	6.7%	0.18%
NR	6 [0.95]	6.0%	0.24%
NR-R	7 [1.02]	6.7%	0.29%
CE	5 [0.76]	5.8%	0.22%
CE-R	6 [0.83]	7.0%	0.13%

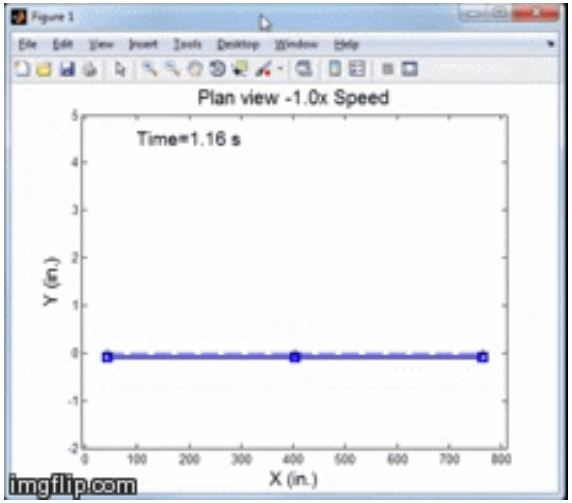
- Easy assembly/disassembly
- High self-centering capabilities

2-span bridge models (bridges 1&2)



Pre-test analytical studies





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Assembly/disassembly time-lapse

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Overview - Shake table test of a reassembled precast modular 2-span bridge model with innovative materials (Bridge #2)

2/6/2015

Run 7 - 1.225 x Rinaldi (PGA=1.2 g)

PI: Dr. M. 'Saiid' Saiidi
Graduate Assistant: Sebastian Varela, PhD student
University of Nevada, Reno

Preliminary results – 2-span bridges

Bridge 1:

			Max. drift			Res. drift		
Run #	**x Rinaldi**	**x DE**	**NE Bent**	**NR Bent**	**CE Bent**	**NE Bent**	**NR Bent**	**CE Bent**
1	0.10	20%	0.86%	0.87%	0.80%	0.03%	0.02%	0.01%
2	0.35	75%	2.44%	2.49%	3.64%	0.11%	0.13%	0.13%
3	0.60	130%	4.01%	4.09%	4.63%	0.15%	0.15%	0.10%
4	0.85	180%	5.60%	5.68%	5.58%	0.26%	0.18%	0.07%

Bridge 2:

			Maximum drifts			Residual drifts		
Run #	**x Rinaldi**	**x DE**	**NE Bent**	**NR Bent**	**CE Bent**	**NE Bent**	**NR Bent**	**CE Bent**
1	0.10	20%	0.72%	0.74%	0.96%	0.02%	0.01%	0.01%
2	0.35	75%	2.49%	2.51%	3.58%	0.04%	0.03%	0.03%
3	0.60	130%	4.33%	4.25%	5.14%	0.09%	0.06%	0.03%
4	0.85	180%	6.06%	5.77%	5.46%	0.21%	0.11%	0.03%
5	0.47	100%	3.44%	3.37%	4.18%	0.21%	0.12%	0.04%
6	1.10	235%	8.38%	7.86%	7.18%	0.32%	0.17%	0.06%
7	1.23	260%	9.95%	8.95%	7.90%	0.26%	0.15%	0.08%

Conclusions

- Innovative concept for resilient DfD-ABC columns was successfully developed and tested dynamically on ¼ scale single column and 2-span bridge models.
- Damage to the plastic hinge elements was limited and could be easily repaired, while broken SMA bars could be replaced.
- Very low residual drifts and loss of capacity: increased functionality after an intense earthquake.
- DfD concept developed facilitates reuse and recycling of column components, thereby reducing energy consumption and CO_2 footprint during material extraction and manufacture.

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Thank you!

Acknowledgments

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- Mr. Greg White – Disc-Lock Inc.
- AVAR-SAS.
- Messrs. Aaron Holmes and Troy Olson – NDOT Materials Lab.
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