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FRP Laminates for Post-Earthquake Repair of Columns in 2 Hours

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Major Challenges with Post-Earthquake Repair of Columns

- 1) **Shape & Size**
 - One does not know the shape & size of columns that may get damaged.
 - Ideal repair system will be applicable to all columns
- 2) **Ease of Repair**
 - Trained workers are hard to find in the aftermath of EQ
 - Ideal repair system will require minimum skilled labor



Methods of Repair of Columns with FRP

- 1) **Wet Layup**
 - Repair to smooth surface
 - Wait for repairs to dry
 - Wrap with FRP fabric
 - Requires trained crew to install
- 2) **Laminates**
 - Create a shell around col. with FRP
 - Fill annular space w/grout or resin

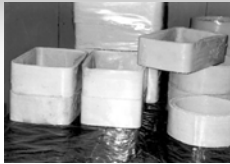



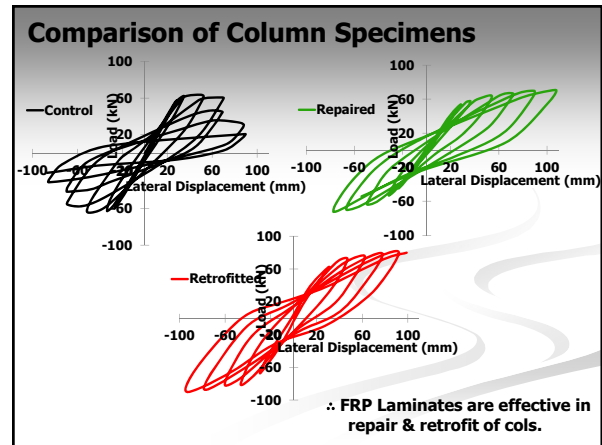
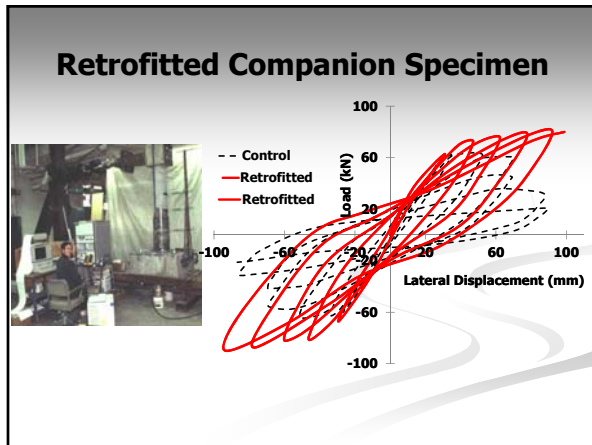
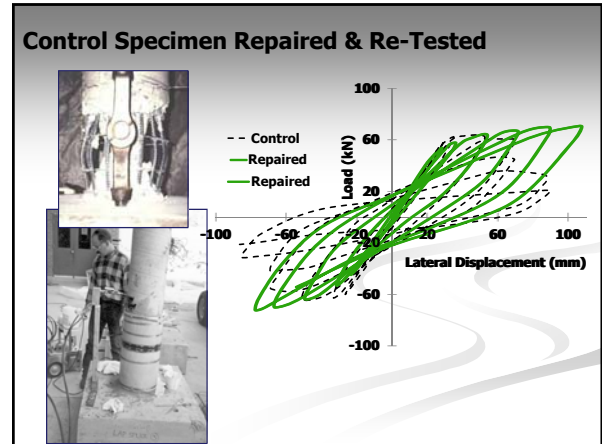
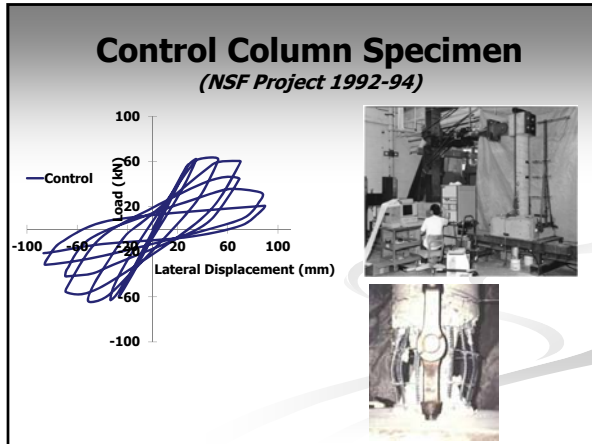
Repair of Columns with Laminates

- 1) **First Generation**
 - Developed in early 1990s
 - Effectiveness was shown in NSF-funded study
 - Requires advance "custom" manufacturing of laminate to size & shape
- 2) **Second Generation (SuperLaminate)**
 - Developed in 2010
 - One size fits columns of any shape & size
 - No advance knowledge of column size & shape req'd
 - Results in much faster repair

First Generation of FRP Laminates

Developed in Early 1990s



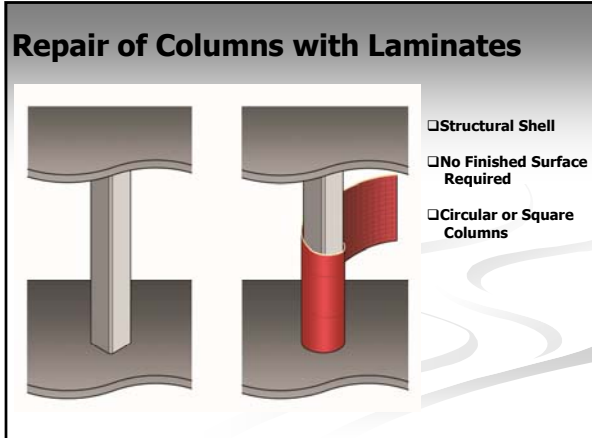
Multi-Layered SuperLaminate™ (Patent Pending)

- Multi-Axial Reinforcement
- Thickness ≈ 0.01 - 0.025 inch
- Tensile Strength ≈ up to 155,000 psi
- Infinite combinations of strength & stiffness can be produced
- ISO 9000 Certified

Comparison of Old & New Laminates

| | | |
|------------------------|-----------------------|----------------------|
| | | |
| | Old Technology | New Laminates |
| Size | Customized to Fit | One Size Fits All |
| Width | 4-6 inches | Up to 5 feet |
| Reinforcing Fibers | Unidirectional | Biaxial |
| Structural Enhancement | Confinement Only | Confinement + Axial |

Moreover, SuperLaminate allow applications that would *not be possible* with the old technology



Methods of Installation

A) Multiple 4-ft wide Bands:

1. Apply epoxy to laminate
2. Wrap around column (min. 2 wraps + 8")
3. Use ratchet straps as temporary support
4. Fill annular space with grout or resin (hydrostatic pressure of filler pushes the two layers together)
5. Repeat steps with next 4-ft wide band & provide overlapping joint with prior band

B) Single Continuous Spiral:

1. Cut laminate into 12-inch wide very long strips
2. Spirally wrap around column while apply epoxy on overlapping portion
3. Use ratchet strap to secure the end
4. Fill annular space

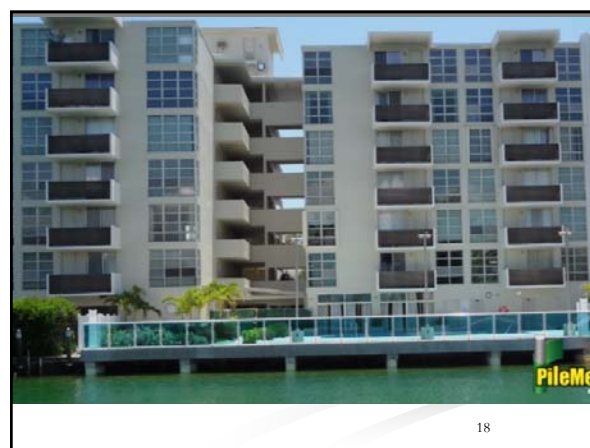
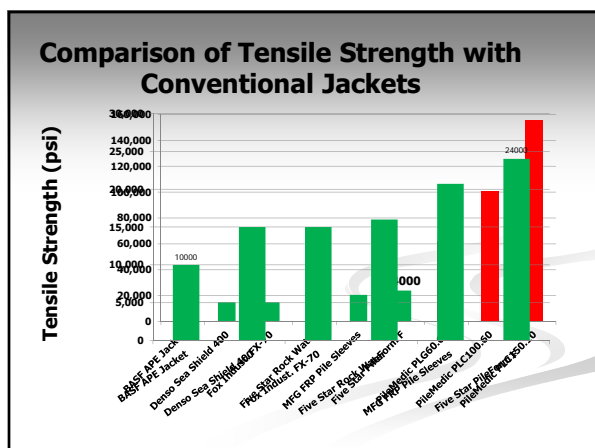
Shape of the Jacket

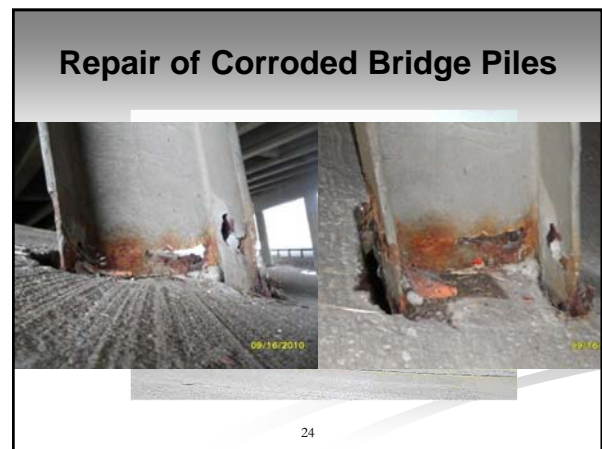
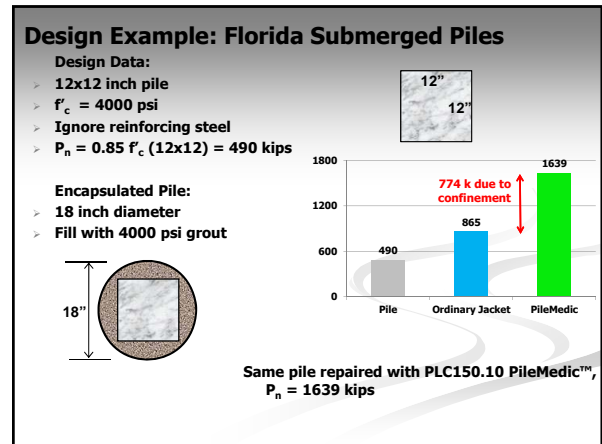
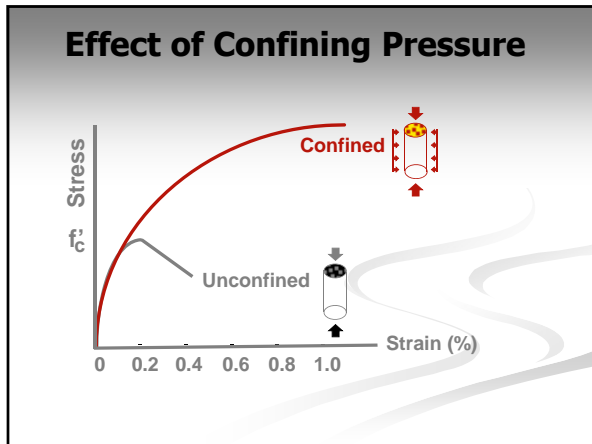
Shell does not have to be cylindrical.

This is a 36" X 36" column with 1.5" PVC pipes used as spacers.

Comparison with Commercially-Available FRP Forms

- > 3-4 times stronger than steel (62-155 ksi)
- > No weak seams along the sides
- > Provides structural confinement
- > Increases axial capacity beyond original strength
- > Grout can be pressurized to fill all voids and cracks
- > No custom manufacturing – one size fits all
- > Annular space adjusted in field to minimize grout vol.





Thank you for your Attention!
Questions?

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