American Concrete Institute®
Advancing concrete knowledge

Post-Earthquake Repairs, Part 2

ACI Spring 2012 Convention
March 18 – 21, Dallas, TX

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Seismic Repair of Reinforced Concrete Columns through Transverse Prestressing

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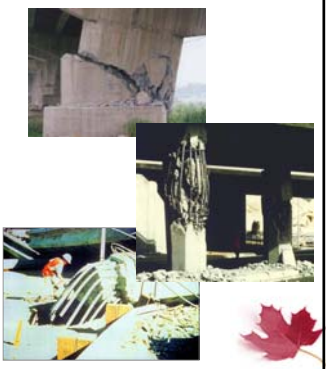
Potential Failure Modes in Columns

- Shear
- Compression Crushing
- Splice Failure



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Repair and Retrofit through External Prestressing

RETRO·BELT

- RetroBelt is a system of external prestressing concrete columns in transverse direction.
- Lateral force exerted by RetroBelt controls diagonal tension cracks while providing shear reinforcement, improving shear capacity.
- Lateral pressure exerted by RetroBelt, both active and passive, confines concrete and improves bond in splice regions, enhancing column ductility.

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External Prestressing

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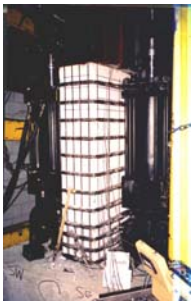
External Prestressing



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Corrosion Protection

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Field Application

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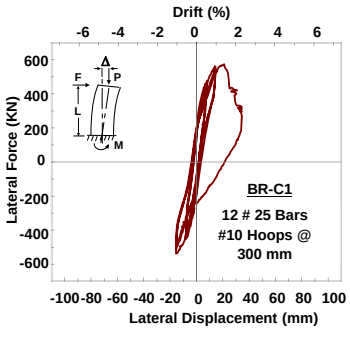
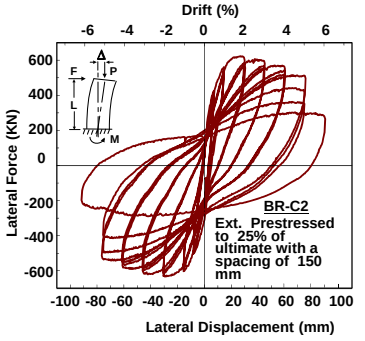
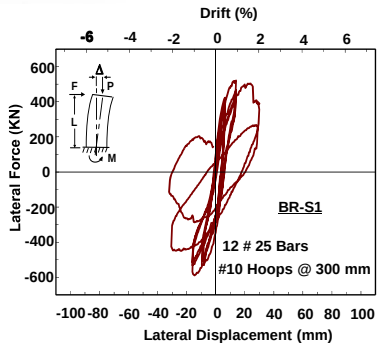
Shear Deficient Circular Column



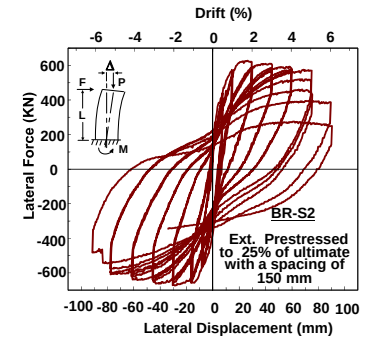
Shear Deficient Circular Column with RetroBelt

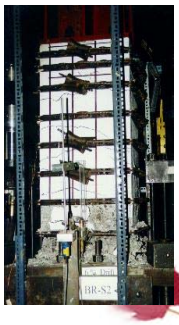


Shear Deficient Square Column

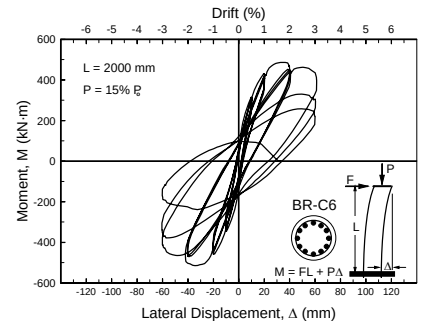


Shear Deficient Square Column with RetroBelt

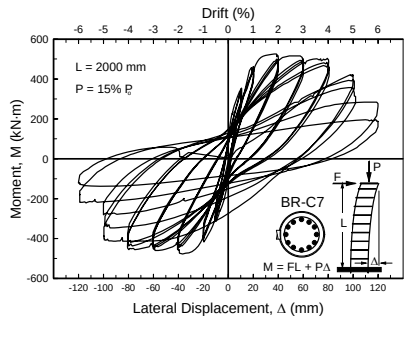




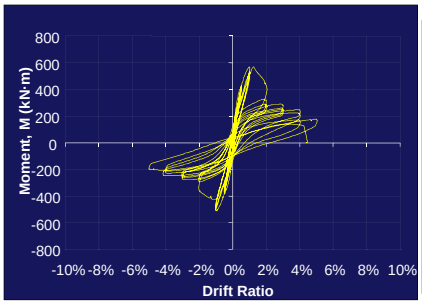
Confinement Deficient – Flexure Dominant Column



Confinement Deficient – Flexure Dominant Column with RetroBelt



Splice Deficient Column



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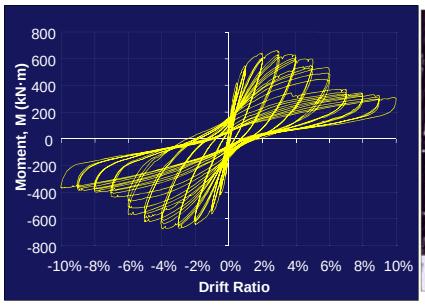
Splice Deficient Column with RetroBelt



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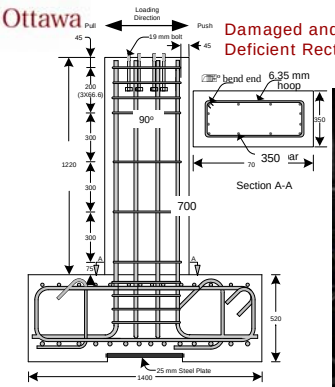
Damaged and Repaired Shear Deficient Rectangular Column



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Damaged Shear-Deficient Rectangular Column

Damage @ 1% Drift
Pulling West

Damage @ 1.5% Drift
Pushing East

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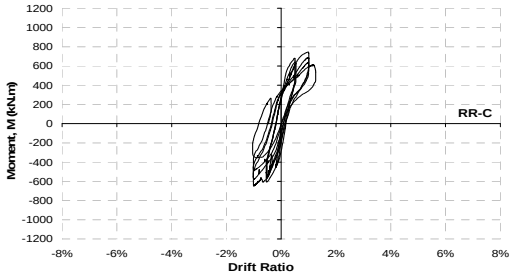
Damaged Shear-Deficient Rectangular Column



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Repairing Shear-Damaged Rectangular Column

Prior to the installation of RetroBelt

After repair
@ 3% Drift

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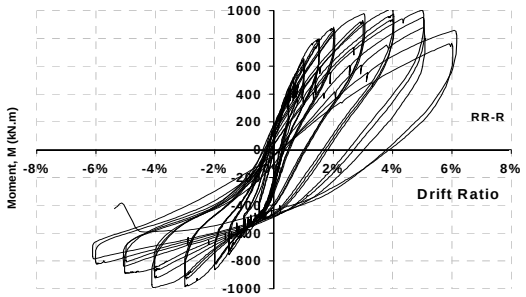
Repaired Shear-Damaged Rectangular Column

After repair
@ 5% Drift

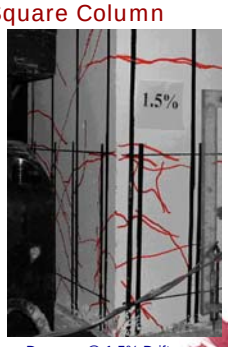
After repair
@ 6% Drift

Repaired Shear-Damaged Rectangular Column



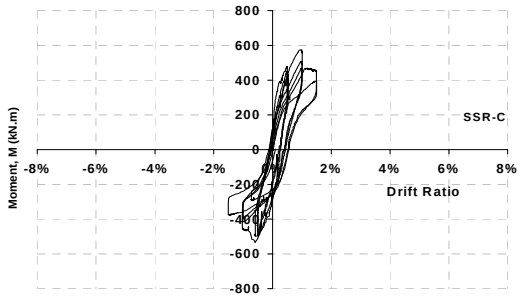
Damaged Shear and Splice Deficient Square Column

Damage @ 1% Drift

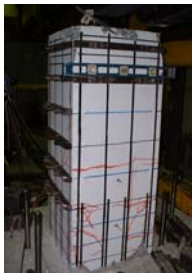


Damage @ 1.5% Drift

Damaged Shear and Splice Deficient Square Column



Repairing Damaged Square Column

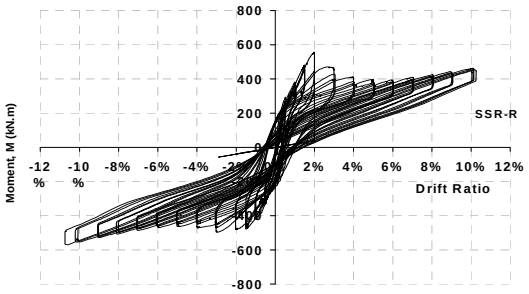


Repaired Square Column

@ 4% Drift

@ 10% Drift

Repaired Shear and Splice Deficient Square Column



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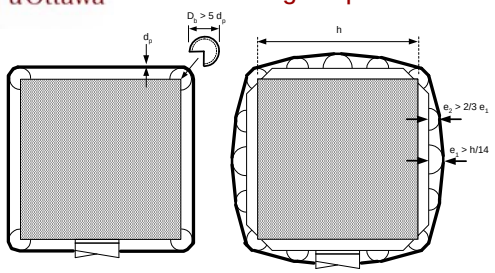
Design Options



Layout for Shear

Layout for Shear and Confinement

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Shear Design

$$V_n = V_c + V_s + V_p$$

Contribution of prestressing to concrete shear capacity:

$$V_{pc} = 2A_{pc} f_{pi} \frac{h}{s_p}$$

Additional shear reinforcement:

$$V_{ps} = 2A_{ps}(f_{py} - f_{pi})\frac{h}{s_p}$$

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Repair and Retrofit for Concrete Confinement

$$\rho_c = 14\frac{f'_c}{f_{yh}}\left[\frac{A_g}{A_c} - 1\right]\frac{1}{\sqrt{k_c}}\frac{P}{\varphi P_0}\delta$$

$$A_{ps} = 2\frac{f'_c}{f_{pe}}\frac{P}{\varphi P_0} h\, s_{ps}\, \delta$$

$f_{pe} = f_{pi} + 0.003\,E_p$

$0.001\,E_p$ for splice clamping

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Conclusions

Thank You…

Questions or Comments?