RETROFIT OF REINFORCED CONCRETE COLUMNS WITH PARTIAL OR NO INTERNAL STEEL REINFORCEMENT USING NEAR SURFACE MOUNTED FIBER REINFORCED POLYMERS

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Introduction

In this study, the retrofitting of a reinforced concrete column that **lost part of its internal steel reinforcement** due to adverse environmental conditions is numerically assessed using **NSM FRP rods**.

Fig.1 Example of a column's steel deterioration.

Methodology

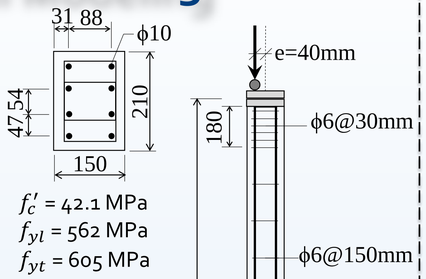
A 3D nonlinear analysis of a **slender column** was performed on ANSYS and validated based on the **experimental work** of Gajdosova and Bilcik (2013). A short **parametric study** is performed to evaluate the influence of **different NSM FRP and steel reinforcement configurations.**

Numerical Modeling

Concrete modeled using Mander (1988) theory. Tri-linear steel reinforcement response.

One fourth of the column modeled.

Concrete: 8-node translational DOF with cracking and crushing. Steel: truss element.



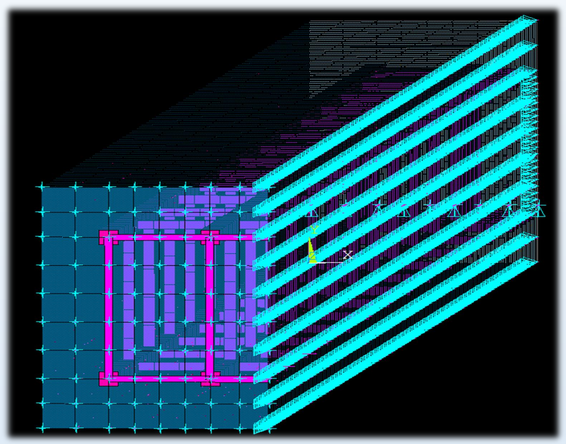


Fig.2 3D model with boundary conditions and column information.

Validation

Based on Axial Force - Moment relationship. Failure by **crushing at mid-height** of the column, with a calculated to experimental difference of: 8.9% in axial force and 0.23% in moment.

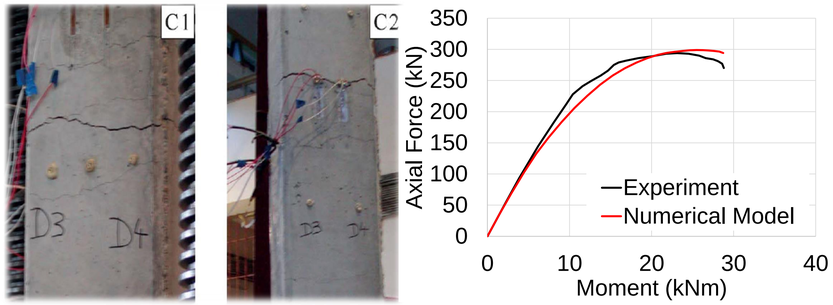


Fig.3 Experimental failure (Gajdosova and Bilcik, 2013) and axial-moment response.

Parametric Study

10 models (6 in this poster) with partial removal of internal steel reinforcement retrofitted with NSM CFRP rods. **Same FRP area as lost steel area**, resulting in a diameter of 14.2 mm. Groove size of two times the rod diameter. The **bonding between Epoxy-Concrete** was also included in the nonlinear 3D model.

Results

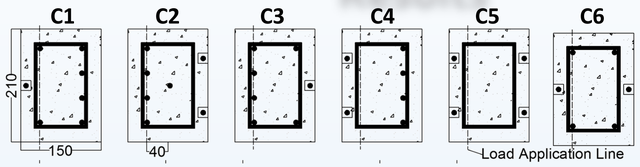


Fig.4 Parametric study sections.

- **Loss of compression steel (C1 and C4)**

Retrofitted columns are about **2% weaker**. Crushing occurred at mid-depth of both columns. However, **tangential slip occurred** on the CFRP rods of column C4. Rod's stress at failure is about 10% of rupture (2800 MPa).

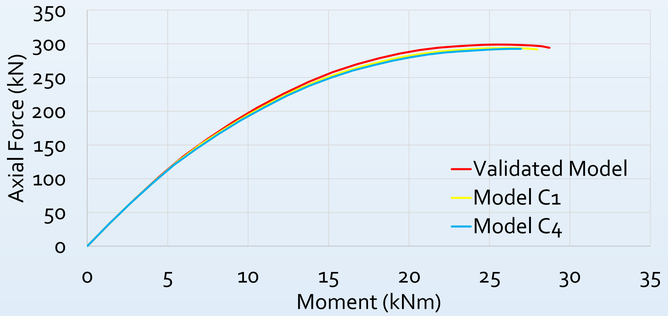


Fig.5 C1 and C4 calculated response.

Results (cont.)

- **Loss of tension steel (C2 and C3)**

The overall response is **10% stronger**. Failure remains crushing at mid-depth. Column C2 present normal debonding values **very close** to debonding stage at failure. Rod's stress is about 15% of rupture.

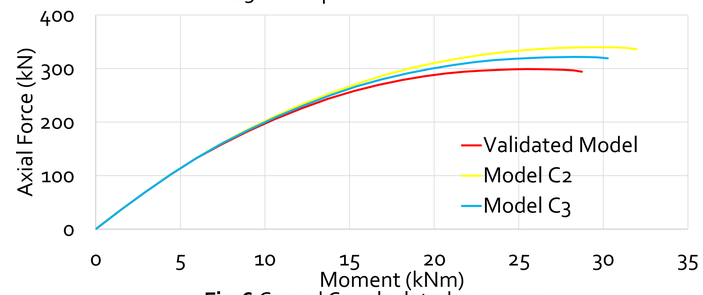


Fig.6 C2 and C3 calculated response.

- **Higher load eccentricity (C8 and C10) – e=60mm**

Model C10 fails due to **complete debonding** of the CFRP rods. Column C8 fails of rods normal debonding followed by crushing of concrete at mid-depth.

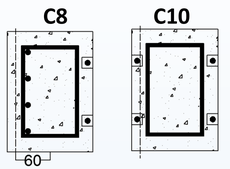
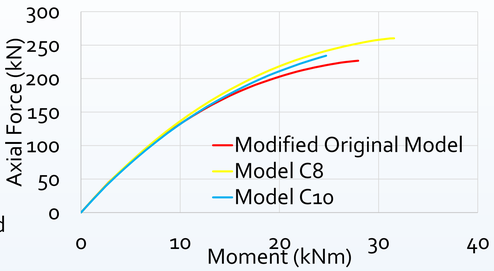


Fig.7 C8 and C10 sections and calculated response.



Conclusion

- All retroffiting techniques presented in this poster provides a column axial-moment **capacity similar or greater** than the original, un-retroffited column.
- The substitution of tension steel reinforcement by NSM CFRP bars provides, in general, **higher axial-moment column capacity**. On the other hand, a **smaller improvement** is provided by compression CFRP rods are reduced.
- **Debonding of the CFRP rods needs to be considered** as it plays an important role in the failure modes of the columns.
- Debonding is more likely to occur when **two CFRP rods** are used in a face with no internal steel reinforcement.

This poster received the Best Poster Award at the 2016 Fall ACI Convention in Philadelphia in , PA.