

# Upgrading the shear strength of non-ductile reinforced concrete frame connections using FRP overlay systems

**Mohamad J. Terro**

*Kuwait University, Kuwait*

**Sameer Hamoush**

*North Carolina AandT State University, USA*

**Moetaz El-Hawary**

*Kuwait Institute for Scientific Research, Kuwait*

---

## ABSTRACT

*This investigation presents the use of Fiber Reinforced Polymer (FRP) composite systems in upgrading existing reinforced concrete frames to meet strength and ductility requirements laid out in recent ACI building codes (ACI-318, 2002). Analytical calculations are presented for the shear behavior of frames strengthened with layers of FRP and an experimental study is carried out to verify the mechanical properties of the proposed FRP systems with various fiber architecture designs. Carbon and fiber glass FRP systems have been analysed. Flat layers and corrugated shapes with rectangular and circular configurations are employed in the retrofitting systems in addition to various orientations of the fibers which are taken into consideration. The ductility requirement is ensured by controlling the out of plane flexural rigidity of the FRP systems. The desired out of plane rigidity is obtained by increasing the thickness of the FRP systems or by corrugating the applied FRP overlays. In conclusion, this study has shown that the use of FRP systems is an efficient and viable repair method for upgrading concrete frame connections with shear deficiency.*

**KEYWORDS:** *shear; FRP; connections; strength; ductility*

---