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EFFECTIVENESS OF FRP COMPOSITES FOR UPGRADING THE DYNAMIC RESPONSE OF A REINFORCED CONCRETE BUILDING

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Summary: Fiber reinforced polymer (FRP) composites providing high strength with lightweight, made of a polymer with reinforcing fibers. The polymer is usually viscous, easily shaped, relatively weak material that can be an epoxy, vinylester or polyester thermosetting plastic. Fibers that support and transfer loads are usually carbon, glass or aramid. Even though FRP composites have been extensively utilized in defense and aerospace industry for a long time, in recent times the use of FRP composites in civil structures have been investigated due to improved fabrication processes of FRP composites with lower energy and cost. Furthermore, the damage observed during recent earthquakes in many existing reinforced concrete buildings built before the introduction of the modern seismic codes, calls for the establishment of reliable retrofitting techniques. Among these techniques, FRP composites with the advantage of high strength to weight ratio and corrosion resistance have found progressively more extensive applications in the retrofitting or repairing of the reinforced concrete structures. In this study, the effectiveness of FRP composites on the seismic performance of a 5 story reinforced concrete building was investigated. The building was designed in accordance with the provisions of ACI 318-63 considering a wind load pressure of 0.63 kPa on vertical surfaces. Due to the fact that the building is almost symmetrical in plan with respect to two orthogonal axes based on the lateral stiffness and mass distribution, a two dimensional planar frame was analyzed as being representative of the building. All columns have a 350 mm x 350 mm cross section with 6 No.20 reinforcement bars throughout the structure. The yield strength of steel reinforcement is Fy = 400 MPa, the unconfined concrete compressive strength is fc'=35 Mpa. To upgrade the seismic performance of the structure, in the current study, glass FRP sheets were applied to increase the flexural capacity of the beams and columns at the regions where the nonlinear behavior observed. These FRP sheets have tensile strength of fr = 3241 MPa, tensile modulus of Ef = 72397 MPa, ultimate tensile strain of εfr = 0.045 and the thickness of tf = 0.589 mm per layer. For modeling the nonlinear properties of the members, lumped plasticity approach with flexural hinges at the ends of the column and beam members was utilized. Firstly, the lateral load and displacement capacity of the buildings with and without FRP application were estimated through nonlinear static (pushover) analysis. From the pushover analysis, capacity curves showing the lateral load carrying capacity and lateral displacement capacity of the structures were obtained. Then, by using nonlinear time history analysis the dynamic response of the structures under natural earthquake accelerations were investigated. The displacement demand of the structures such as roof displacement time history, maximum inter-storey drift, residual displacements were examined, comparatively. The results of the analysis revealed the favorable effect of FRP sheets for upgrading the seismic behavior of the reinforced concrete building.