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THE STRENGTHENING OF STRUCTURAL MEMBERS (BEAMS, SLABS, COLUMNS, WALLS) USING GLUED CARBON FIBRE-REINFORCED PLASTIC SHEETS

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ABSTRACT: Jordan's high seismic Zones as defined in the new Jordanian Seismic Code demands the use of new methods in order to retrofit and strengthen existing concrete buildings. The strengthening of R/C structural members (beams, slabs, columns, walls) using glued Carbon Fiber-Reinforced Plastic Sheets is a relatively new method of intervention. Upgrading existing reinforced concrete buildings especially in seismic regions is one of the most important and challenging tasks in civil engineering practice. Of great importance is selection of the most appropriate upgrading techniques among several alternatives depending on the type of the existing structure, type of damage or deficiency and desired strengthening level. An efficient upgrading technique is the one, which enhances deficient structural characteristics of existing structures without leading to any unfavorable failure mechanism. Based on recent research and common upgrading practice, this paper describes the new upgrading techniques using CFRP. The techniques presented in this paper can be implemented for upgrading structures subjected to static and dynamic forces due to wind or earthquake excitations. Rational engineering judgment is advisable for analysis and design of such upgrading techniques .

KEYWORDS: UPGRADING; RETROFITTING; REINFORCED CONCRETE; CARBON FIBER –REINFORCED PLASTIC; EARTHQUAKE

INTRODUCTION

The strengthening of R/C structural members (beams, slabs, columns, walls) using glued Carbon Fiber-Reinforced Plastic Sheets is a relatively new method of intervention. The CFRP sheets exhibit the following advantages compared to the steel sheets:

- They are light in weight
- They do not corrode
- They are available in large dimensions
- They have low modulus of elasticity accompanied by large elastic deformations up to failure, which are particularly useful properties for prestressing.

Thanks to the above advantages, CFRP sheets have been used in the development of new techniques for repair and strengthening of R/C structural elements, in which they replace steel sheets. It should be stressed that while these materials can be successfully used to increase strength in bending, shear and compression, they can not affect the stiffness positively. At the same time, in most cases they influence local ductility negatively.

The problem of upgrading existing weak buildings arises strongly and urgently in Jordan and the Middle Eastern Arab Countries, which are vulnerable to severe earthquakes. An example for this threatening problem is the latest earthquake in Izmit-Turkey, which caused thousands of human lives besides billions of dollars as loss in national property. Earthquakes of similar magnitudes and intensities are very likely to occur more often as statically the 1927 earthquake caused the failure of the King Hussain musk miner at at down town Amman, the 100 year occurrence of such major event is becoming closer. Consequently, the need for upgrading and retrofitting major important buildings to survive future earthquakes is a strategic decision to be taken.

Japan have the oldest experience of upgrading and repair where engineers have implemented several techniques after the 1968 Tokachi-Oki earthquake. Also, following the 1985 damaging earthquake in Mexico City, upgrading and repair efforts for damaged reinforced concrete structures were introduced. Also, in U.S.A., engineers employed similar upgrading efforts. The most common techniques used were the addition of concrete or masonry walls, and strengthening by external structural steel elements.

Several structural materials can be used for upgrading and repair of reinforced concrete buildings, most commonly reinforced concrete and structural steel. Reinforced concrete was the first material to be considered for such engineering work where it can be used mainly in two ways: either for jacketing of existing frame columns and beams, or by addition of infilled shear walls in designated openings. The main draw backs in using reinforced concrete for upgrading an old RC building is the amount of construction work required and the disruption caused by the evacuation of occupants. Besides, the additional weight of concrete causes increase in the inertia mass, which affects the dynamic response of the building and requires strengthening for existing foundations. On the other hand the use of CFRP can result in less weight of add material with the availability of prestressing

Upgrading of existing buildings by CFRP becomes more attractive and feasible considering the following advantages: fast construction time, less disruption to occupants, Almost no increase in inertia masses and forces on existing foundations, no interference with building function. Description of the most efficient upgrading conventional and new techniques for existing reinforced concrete buildings, which are the focus of recent research and practice, are presented by showing the application of CFRP and using the epoxy adhesive to bond externally to existing structural elements.

OBJECTIVES OF UPGRADING

Although some upgrading techniques can be used for both static and dynamic forces, there is a fundamental difference between the structural response for each case. This leads to different objectives for upgrading of structures under consideration. Upgrading of old buildings for static loads, which are externally applied quantities, require basically an increase in strength (axial, shear and bending) of the existing columns, beams, and slabs. This is usually done by making the structural elements larger. This was the result of conventional upgrading techniques, on the other hand the use of CFRP will result in no increase in the structural element size which is a required in many of the retrofitting cases.

The seismic loads are function of the interaction between the input ground motion and the structural characteristics. The main objective of any upgrading technique for an old structure against seismic loads is to improve some or all of the earthquake structural response characteristics, such as lateral strength, stiffness, ductility, and energy dissipation. Besides, the upgrading technique should be easy to construct with minimal disturbances. Simultaneously, the failure mode of the upgraded structure should be greatly anticipated avoiding any undesirable abrupt failure mode such as a soft-story mechanism. The use of CRFP in combination with the addition of shear wall either concrete or steel stiffening panels can result in an overall upgrading of the existing structure which satisfies FEMA requirements in high seismic regions.A seismically weak old building may lack one or more of the above resistance characteristics. The lateral strength can be improved separately as in the case of static loads by jacketing the main frame elements by either reinforced concrete or by structural steel members. However, improving stiffness of an old building leads automatically to additional strength. Thus, the displacement response (drift) of the upgraded structure is reduced by shortening its natural period than that of the core structure. This strategy works best if the modified period takes the structure into lower response spectrum regions, such as, when ground conditions have selective dominant periods. The two efficient upgrading techniques, which improve both strength and stiffness, are: RC shear walls and steel bracing.

Alternatively, the objective of upgrading can be improving ductility and energy dissipation especially when higher displacement response is expected during strong ground motions. In this case, some type of energy dissipation devices may be added to the columns of the main lateral resistant existing frame(s). These devices dissipate the input energy and eliminate most of the damage that could have occurred during severe earthquake. These devices can be replaced with little effort, and minimal damage occurs in the main frame(s).

In some particular cases, where several deficient structural characteristics need upgrading, the upgrading technique might be a combination of several schemes, such as CFRP with steel bracing in addition to energy dissipation devices.

CONCLUDING REMARKS

Interest in upgrading of older buildings has become increasingly important in recent years. Intensive engineering design has been expended on improving the structural performance of existing buildings most of it for better resistance to earthquakes. A brief review of state-of-practice and research on the subject of upgrading older RC structures is presented. The subject is too broad where the design and behavior of upgraded systems and their components is very complex. Although recent research have provided some understanding of the behavior of specific upgraded structures, anyone approaching design for upgrading of older buildings is advised to find out how various upgrading techniques performed in recent events.

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