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Cyclic performance of retrofitted reinforced concrete beam–column joints using steel prop

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HIGHLIGHTS

- Effective to confine concrete connections and transfer force to RC structure.
- Improvement of strength, energy absorption, rigidity.
- Decreasing horizontal drift up to permissible limit stated in Design codes.
- Usable to strengthen deficient frames with reduced heights and concrete strength.

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ABSTRACT

This paper investigates the cyclic experimental behavior of damaged exterior reinforced concrete beam–column joint specimens retrofitted with the proposed technique using steel elements called steel prop and curb. The technique is usable for local and global strengthening of reinforced concrete frames. Four half-scale RC joints were tested under the cyclic loading; two control specimens with the different beam heights were loaded up to their ultimate strength and this was followed by retrofitting of these damaged specimens as new specimens and tested again under the same loading system. Experimental results showed that the 25% reduction of beam height due to construction mistake caused increasing in deflection of joint beam, decreasing of ductility and also 33% and 26% decreasing in bearing capacity and energy absorption, respectively. The ultimate load was increased up to 80% and the rigidity decreased degradation of retrofitted damaged joints was significantly in the proposed retrofitting system. And also the energy absorption was enhanced and the cracks were minimized due to a new lateral loading in the beam–column joint region in this upgrading method.

1. Introduction

It is required to rehabilitate the existing structures due to many reasons including the retrofitting of damaged structures under the earthquakes or the need for strengthening or retrofitting undamaged structures designed based on the previous building codes, upgrading due to mistakes in the construction process. Having beams with height less than required height is one of design or construction mistakes in RC frames, causing the reduction of bearing capacity, stiffness and increasing vertical deflection of beams followed by increasing lateral deflection of those frames. Therefore these damaged or undamaged frames need to be retrofitted. In recent years, different methods such as braced systems, shear wall, energy dissipation systems and dampers, fiber reinforced polymer, high performance fiber reinforced cementitious composites HPFRCC, have used for retrofitting of deficient RC frames. Each of the preceding methods can be used for upgrading and improving of linear and nonlinear behavior of RC frames such as rigidity, ultimate strength and ductility.

Steel and concrete jacketing were the two adopted methods for local strengthening of deficient beam–column joints in RC frames but the cross sectional area and the self-weight of structures would be increased substantially. Several researches were conducted on retrofitting and repairing of RC beam–column joints with RC jacketing and also steel plates in form of jacket, plain and corrugated tube with grout or epoxy resin [1–5]. A combination of external steel elements was studied for the strengthening of RC joints [6–8]. Externally bonded steel plates and FRP laminates have been extensively investigated by several researchers [9,10]. The technique of retrofitting using externally bonded steel plates has gained widespread popularity, being fast, causing minimal site disruption and producing only small changes in section size. However, it suffered from a number of problems, including undesirable shear

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failures, difficulty in handling heavy steel plates, corrosion of the steel and the need for butt joint systems as a result of limited workable length [11–13]. Yen and Chien retrofitted several internal joints with bonding of steel plates to beams web by the different methods in order to evaluate their cyclic behavior; they have investigated both rehabilitation indexes of strength and ductility [14]. FRP materials, on the other hand, have high strength to weight and stiffness to weight ratios and are chemically quite inert, offering significant potential for lightweight and durable retrofit [15,16]. A major shortcoming of the FRP is its vulnerability against fire and to undesirable brittle failures due to large mismatch in the tensile strength and stiffness with concrete. In the recent decade, different kinds of FRP materials in form of sheet and jacket with various techniques were applied by researchers and that efficiency in shear and flexural retrofitting of beam–column joints under static and cyclic loading were investigated [17–23]. Both of the FRP materials and steel elements were used by several people to upgrade the seismic behavior of deficient RC beam–column joints (possessing of non-ductile detail and designed base on gravity load GLD) [24,25]. Several studies have been undertaken in recent years to investigate the feasibility of using a high performance fiber-reinforced cementitious composite (HPFRCC) in retrofitting of RC beams and joints [26–28].

2. Research significance

Strengthening and retrofitting of exterior or interior deficient RC beam–column joints have been conducted by several researchers by means of different effective methods using traditional and new material and techniques in recent years. Each proposed method has particular advantages such as increasing capacity, stiffness,

Fig. 1. Joints specimens of SC1 and SC2 before loading.

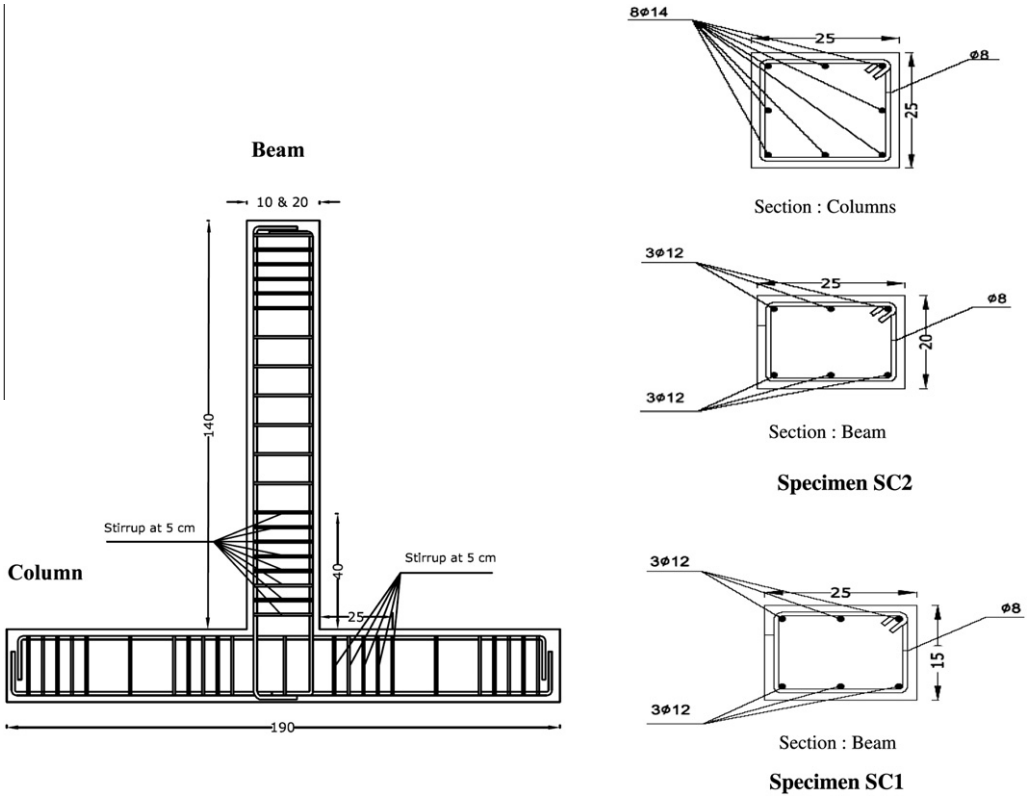

Fig. 2. Sections dimensions and arrangement bars of control specimens of SC1 and SC2 (in cm).