Seismic of structural elements. in this paper, first

SeismicRehabilitation by Steel Jacketing Method Affected by Different Base SupportConditions Using Pushover Analysis AbstractRehabilitation of vulnerableexisting structures against earthquakes is essential. Structures need to beretrofitted for a variety of reasons, such as change of use, structural elementscorrosion, design code changes, and the lack of match between the computationalresults and construction. One of the most common and economical ways of retrofittingstructures in developing countries such as Iran is the steel jacketing methodwhich increase the stiffness and strength of structural elements. In thispaper, first the seismic vulnerability of a three dimensional four storyresidential building was proved and then the effect of base support conditionson structural retrofitting by steel jacketing method was studied using pushoveranalysis. It was observed that the behavior of the retrofitted structuresdepends on their base support conditions. According to pushover curves the retrofittedstructures with pinned and fixed base support conditions showed similarbehavior in the linear zone and presented a different behavior in terms of stiffnessand ductility in the nonlinear region. Keywords Pushover analysis; Seismic rehabilitation; Steel structuresIntroductionAlcocer and Jirsa (1993)stated that seismic rehabilitation is a suitable way to increase people’ssafety and to protect their investments in vulnerable structures.

To obtainthis goal, various investigations have been carried out by researchers, butmost of them are focused on retrofitting reinforced concrete structures. Sheykh(1994) studied on a method for obtaining the amount of confined steel forrectangular columns. Migliacci et al. (1983) studied on a way toincrease the strength and energy absorption of retrofitted connections

by aclosed steel frame at the corners of the column by pre-stressed straps. A modelwas provided by Corazao and Durrani (1989) to increase the stiffness, strengthand ductility of the beam-to-column connections by confined concrete jacketingsurrounded by steel plates. Hoffschild et al. (1993) studied anothermethod which was using a grouted circular steel jacket to increase thecross-sectional moment capacity. Pushover analysis wasutilized to rehabilitate considered structure by steel jacketing method.

In thepushover analysis the structure is subjected to a specific lateral loadpattern. In this type of analysis, the criterion is the amount of displacementof the structure, so the force increases to a point that the desireddisplacement is provided. Although nonlinear time history analysis is moreaccurate than the pushover analysis and Ali Vatanshenas (2017) study showedthat by time history analysis it is possible to determine the directivityeffect of the earthquake on the structure, pushover analysis was used. Thepushover analysis has various merits such that the pushover analysis providesthe nonlinear responses quickly with low computational complexity and alsothere are no response dispersion in this analysis and no complicatedinterpretation in this type of analysis.

In the pushover analysis by applying apredetermined displacement all structural responses to different displacementsare analyzed within that range. Krawinkler and Seneviratna (1997) mentionedthat with pushover analysis it is possible to estimate the deformation demandsfor the components that do not have a brittle behavior and should absorb energyby plastic deformation, moreover forcing a structure to apply the desiredbehavior by the lateral load pattern is a very unique feature that can

beaccomplished through the pushover analysis. Structural vulnerabilityassessmentThe considered structurein this study should provide the life safety level of performance under theinfluence of the design base earthquake, so that the failure occurs in thestructure due to the earthquake but the extent of the failure should not menacethe life safety of occupants. Skokan and Hart (2000) mentioned that consideringthe seismic demand assessment of low and medium height structures has a higheraccuracy in this paper a three-dimensional four-story steel structure with aconcentrically braced frame system that has residential use is considered. Before starting the rehabilitation by steel jacketing method, structuralvulnerability must be proven.

The main components of the studied structure i. e. the elements that resist the earthquake force in order to achieve the desiredlevel of performance are braces and columns beside the braces in which theaxial compressive and tensile forces were created.

As shown in Fig. 1 ahypothetical lateral static force was applied to the structure to determine thesemain components of the structure. Figure 1.

The main components of considered structurewas determined by a hypothetical lateral static forceFor investigating the vulnerabilityof the considered structure following assumptions were considered: the monitorpoint was selected as the center of the mass of the roof, the lateral loadpattern was determined according to the first mode of the structure. The amountof target displacement is obtained by equation (1) based on Fema (2005) where C0is the correction coefficient for the spectral displacement of

one degree offreedom system to the roof displacement of several degrees of freedom, C1is the correction coefficient to apply system’s inelastic displacement, C2is the correction coefficient for the effects of reduction of stiffness andstructural members strength, C3 is the correction coefficient toshow the displacement of the P-? effect, Sa is the spectralacceleration and Te is the effective period obtained by equation (2)based on Fema (2005) Where, Ki and Ke are obtained by thepushover diagram shown in Fig. 2. After analyzing the studied structure, it wasillustrated in Fig. 3 that the structure in both directions of X and Y needs tobe retrofitted. Figure 2. TheKi and Ke parameters in the pushover diagramFigure 3. The structure in both X and Y directionsneeds to be retrofittedThe effect of steeljacketing method on seismic rehabilitationSeismic rehabilitationgoal is balancing the structure’s demand and capacity; therefore, thestructure’s demand should be reduced or its capacity should be increased forrehabilitation.

When rehabilitation is carried out by increasing the structuralcapacity, it is referred to as retrofitting. As shown in Fig. 4 one of the mostcommon methods of retrofitting is the use of steel jacketing in which thevulnerable section is retrofitted by increasing strength and stiffness. Afterretrofitting the vulnerable columns by steel jacketing method no plastic hingewas created in any column even though the hinges created in the braces wentbeyond the life safety performance level. However, in the case ofconcentrically braced frame the strip color shown in Fig.

5 and Fig. 6 is not avalid criterion for the acceptability of the braces and their acceptabledisplacement should be checked based on their acceptance criteria at the lifesafety performance level for all created hinges. It was

observed that allhinges created in braces provided the desired performance level. Figure 4. A retrofitted element by added steel platessurround itThe impact of the steel jacketing method wasconsidered in two modes. The first mode is shown in Fig. 5 when the structureconnection to the foundation is assumed to be completely rigid, and the othercase is shown in Fig. 6 when the structure connection to the foundation isassumed to be pinned.

The created hinges, in the last step of pushover analysisof the retrofitted structures were dependent on the base supporting conditionsand in the retrofitted structure with pinned support conditions, the hingescreated in the first floor had a more critical condition than the second floorwhile the opposite was observed in the structure with rigid support conditions. Figure 5. Hinges created in the structure with rigidsupport after rehabilitation by steel jacketing methodFigure 6. Hinges created in the structure with pinnedsupport after rehabilitation by steel jacketing methodComparison of obtainedpushover diagramsThe total capacity of the structure was indicatedby the base shear-roof displacement diagrams. The results obtained from thepushover diagrams of the non-retrofitted and retrofitted structures by steeljacketing method with rigid and pinned support conditions were comparedaccording to the Fema (2005). As shown in Fig. 7 and Fig.

8 It was observedthat the retrofitted structures by steel jacketing method had higher slope inthe linear region which means that the retrofitted structures by steeljacketing method were stiffer than the non-retrofitted structure and the slopeof the linear region in the case that the retrofitted structure had the rigidsupport conditions was not different with the case that the support conditions werepinned thus they have equal stiffness. In the

obtained diagrams, retrofittedstructures showed more brittle behavior than the base structure and thenon-retrofitted structures showed more ductile behavior because of the greaterdistance between its yield and final displacement. It was observed that along Ydirection which structures had less stiffness than the X direction, theretrofitted structure with pinned support conditions showed better ductility. It was also observed that in nonlinear region the stiffness of the retrofittedstructure with rigid support conditions was more than the structure with pinnedsupport conditions. Figure 7.

pushover diagrams of the base andretrofitted structures by the jacketing method in X direction Figure 8. pushover diagrams of the base andretrofitted structures by the jacketing method in Y directionConclusionIt was observed that in the case that the structurehad pinned support conditions, the hinges created on the first floor were morecritical than the second floor while the opposite was observed in the structurewith the rigid support conditions. After reviewing the pushover diagrams it wasobserved that the retrofitted structures behaved stiffer than the basestructure and there was no significant difference between the stiffness of thetwo retrofitted structures in the linear region but in nonlinear region thestructure retrofitted with the rigid support conditions behaved stiffer thanthe one retrofitted with the pinned support conditions.