PERFORMANCE OF STEEL BRIDGE PIERS UNDER BI-DIRECTIONAL LATERAL LOAD REVERSALS

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At present, seismic design of structures in the world assume independent action of a uni-directional lateral seismic load combined with constant or varying axial loads. This lacks an important feature of coupled inelastic response in two lateral directions because an actual earthquake load has two simultaneous horizontal components, which cause bi-directional flexure in the columns. The behaviour of structures under such bi-directional earthquake loads combined with the dead load is complex hence needs more comprehensive investigations. In this context, as the first stage of this research project, an experimental investigation of earthquake resisting characteristics of square-shaped steel columns representing highway bridge piers was carried out considering several idealized bi-directional cyclic loading patterns namely linear, circular, oval, radial, square, and octagonal types. The linear type includes three cases where loading direction inclined 0, 22.5 and 45 degrees to an axis of the section. As a result, eight identical specimens were fabricated and tested under above loading patterns. In all the specimens, axial load was kept constant at 20 percent of the yield load of the section. The load path was taken as the primary test variable. Specimen under linear 0 degree case (i.e., uni-directional loading) served to be the benchmark specimen.

In each specimen, the incremental lateral load-lateral displacement hysteretic curves in two orthogonal directions were recorded. It is understood that the direction of resultant loading and displacement vectors do not coincide in the nonlinear loading paths because of the different effective flexural rigidities in different directions. Therefore, the resultant lateral load-lateral displacement at each load increment was considered for making conclusions as it gives more meaningful information than what is given in each direction. It was apparent from the results that the resultant strengths under different linear loading patterns were almost the same, but under the other loading types they differ considerably from each other. The strength predictions of all nonlinear bi-directional loading patterns were significantly lower than that of the uni-directional case, in particular the circular type showed the lowest strength. However, under the circular type loading the deformation performance evaluated in terms of a ductility index was found to be higher than that under the uni-directional type. In addition, the cumulative energy absorption capacity, which is one of the important measures of seismic resisting characteristics, was also investigated. The cumulative energy up to the fourth cycle was computed for each loading case and compared with that of the uni-directional case. The energy absorptions of specimens under circular, square, radial, and octagonal loading types were around 2 to 3 times the uni-directional type. In conclusion, it has been revealed that for a highly reliable seismic design of steel bridge piers, the effects due to the multi-directional loading paths should be incorporated into the conventional design methods which are presently based on uni-directional approaches.