Torsional Response of Bridges

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Presently, many cities have to face the problems about the space limitation for the transportation systems. One probable solution is to construct the bridges with special configurations. The examples of these bridges are skewed bridges, C-bent column bridges and curved bridges. During an earthquake, the collision between skewed bridge deck and abutments or adjacent spans possibly occurs and it may result in the rotation about the vertical axis of skewed bridge deck. Consequently, this probably causes the torsional moment coupling with other internal force components in the below reinforced concrete piers. The available experimental investigations indicate that the structural capacity of a reinforced concrete pier may significantly deteriorate when it is subjected to combined bending and torsion. Thus, an analytical investigation was conducted in order to study the seismic torsion response of skewed bridge piers. A time history analysis of a 4-span continuous skewed bridge was conducted by employing the finite element method. Several parameters; skewed angle, pounding, cable restrainer system, and locking of steel bearing movement after suffering damage and its location, were taken into account in this analysis. The analytical results showed that pounding between skewed bridge deck and abutments took place and it resulted to the inplane deck rotation and increased the seismic torsion in skewed bridge piers. Moreover, the consideration of the locking of bearing movement after failure could extremely amplify the seismic torsion in skewed bridge piers. The magnitude of torsion depended on the location of locking bearing.

In order to clarify the behavior of reinforced concrete columns under combined cyclic bending and torsion and obtain the information for the formulation of a nonlinear torsional hysteretic model, an experiment investigation was carried out. The column specimens were designed based on the Japanese 1996 Design Specification of Highway Bridges. All columns had a 400x400mm square cross section and a 1350mm effective height. They were tested under different loading conditions; cyclic torsion, cyclic bending and combined cyclic torsion and cyclic bending, with and without a constant axial force. A parameter called the rotation-drift ratio, θ/Δ, was defined to present the level of combined bending and torsion. The experimental results revealed that the flexural capacity and ultimate lateral displacement, defined as the column displacement when the flexural restoring force decrease to 80% of the flexural capacity, of columns tend to deteriorate as the torsion increases. On the other hand, the increase of bending moment results in the deterioration of the torsional capacity and ultimate rotation, defined as the rotation when the torsion reduce to 80% of the torsional capacity. Moreover, the different bending-torsion combinations altered the cracking patterns and failure modes of columns. Damage in column was likely to occur above the plastic hinge region as the increase of degree of torsion. Therefore, the length and location of plastic hinge region have to be evaluated carefully and the interaction between bending and torsion shall be taken into account for the column under the combined action.