Investigation of composite columns under seismic loading

Investigation of Composite Columns under Seismic Loading

Etude des colonnes mixtes sous charge sismique

Untersuchung von Verbundstützen unter Erdbebenlasten

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1. PREFACE

An experimental investigation on the behaviour of a concrete-filled steel tube (composite column), as shown in Fig.1, has been performed to evaluate the applicability of a composite column for bridge construction in a highly seismic area. The results demonstrated that the load bearing capacity and deformability of the composite column were considerably improved in comparison with those of existing steel columns. In addition, their behaviour will form a suitable basis for the development of a rational design method for a pier.

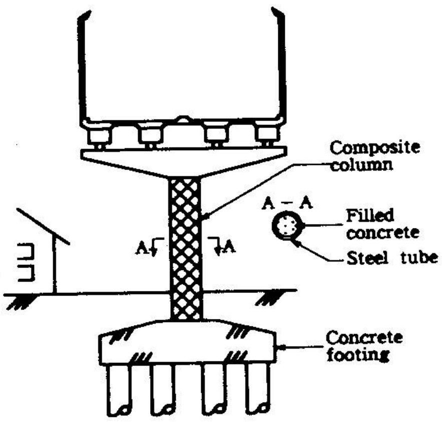

Fig.1 Bridge with composite column

2. AIMS OF RESEARCH

Steel columns and/or reinforced concrete columns have been used in bridge construction. However existing columns, have problems with both a load bearing capacity and construction cost. These problems may possibly be solved by filling a steel tube with concrete. As the steel tube can provide effective lateral confining pressures to the contained concrete, the composite column has improved buckling resistance and substantially increased flexural strength and deformability. This allows a possible reduction in the column section providing the same earthquake resistance as other types of columns with larger diameter. However, there is not enough existing test data to formulate a design method for composite columns applicable to a bridge pier in a seismic area. Accordingly, the following experimental approach was employed to validate the suitability of composite columns with regards to flexural strength and ductility.

3. SCOPE OF TEST

The experiment evaluated the effects of various parameters on the flexural strength, ductility and buckling resistance. The parameters of specimens considered were diameter-thickness ratio (D/t) of a steel tube (D/t=90, 110, 150), steel strength ($fsy=240^{N/mm^2}, 330^{N/mm^2}$) and the use of vertical stiffeners welded inside the steel tube. Eight model specimens of 0.5m diameter and 4.0m length, shown in Fig.2, were tested. These specimens were initially loaded with a thrust equivalent to a dead load of a superstructure, and then alternate shear forces simulating earthquake motion was imposed on them. The view of the loading rig is shown in Photo 1.

4. TEST RESULTS AND DESIGN APPLICATION

(1) The flexural strength of composite columns with diameter to thickness ratio (D/t) of 90 to 110 obtained from the test exceeded the calculated full plastic moment by 10%, and the deformability and energy absorption of the columns also showed good ductile behaviour as required for a bridge pier. The flexural strength of the composite column may be evaluated from the full plastic moment.

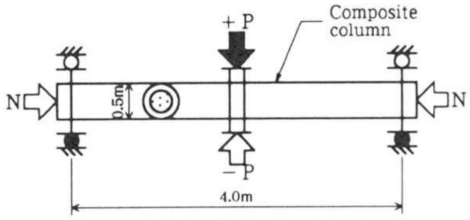

Fig. 2 Test specimen

(2) However, the experimental flexural strength of the column with D/t ratio of 150 was slightly lower than the calculated strength, and the deformability and energy absorption also deteriorated to a small extent. Presumably the limit of D/t ratio may be in the range of 110 to 150.

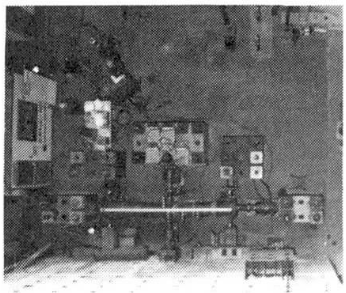

Photo 1 Loading rig

(3) The specimens with a high tension steel have not improved local buckling load, although the flexural strength obtained from the test was larger than the calculated strength by 10%. However, sufficient deformability and a stable hysteretic loop was obtained.

(4) The columns with vertical stiffeners showed substantially improved local buckling resistance, flexural strength and ductility. An increase in D/t ratio is followed by larger effects. It would appear worthwhile to apply the effects due to vertical stiffeners to the column design.
The hysteretic loop of a composite column is illustrated in Fig. 3.

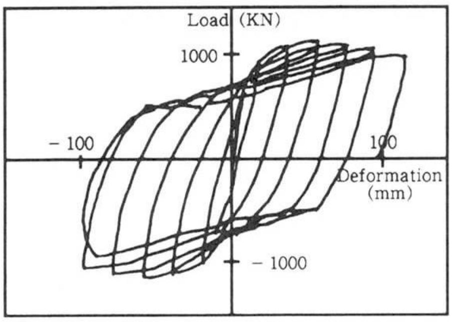

Fig. 3 Hysteretic loop

5. CONCLUDING REMARKS AND FUTURE DEVELOPMENT

(1) The research clearly pointed out the earthquake resistance of a composite column in load bearing capacity and deformability.

(2) The above test results gave a suitable basis for the structural design of composite columns subject to extreme shear forces induced by a severe earthquake.

(3) The current research programme includes the investigation on the behaviour of joints between beam and column and column and footing, as shown in Fig. 4 . The aim of the test is to establish a suitable configuration of joints utilising the characteristics of a composite column. The test result may contribute to development of rational design provisions for a bridge substructure which includes a composite column.

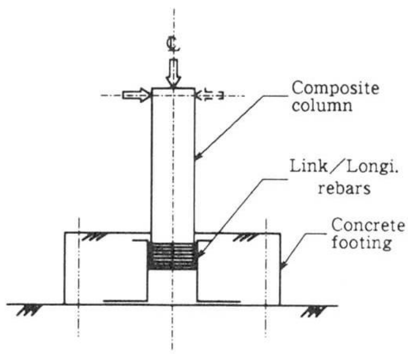

Fig. 4 Structural configuration of joint between column and footing