Analysis of CFST column to precast cap beam connection for bridge

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Abstract - Concrete filled steel tube(CFST)are composite structural element that offers an efficient and economical alternative to conventional reinforced concrete construction and it provides maximum strength and stiffness while permitting rapid construction. In bridges,CFSTs may be used as piers, piles and drilled shaft foundation. At present the use of CFST in bridge construction is limited due to the lack of practical and economical connections.Reecent research has addressed this limitation through the study of column to foundation connection and column to cap beam connections.This paper is intended to provide a summary of the past researches related to CFST column to cap beam connection.

Key Words: cap beam connection, CFST column, ER connection, foundation connection

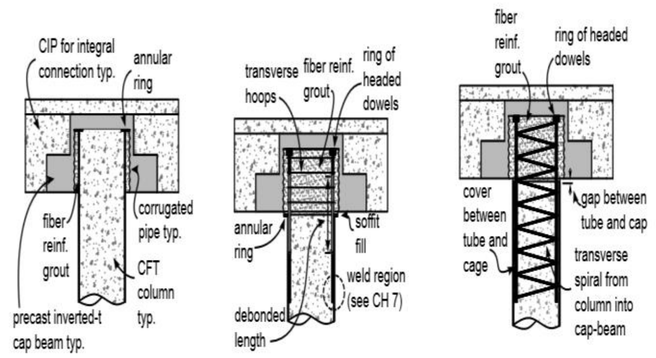
1. INTRODUCTION

Concrete filled steel tubes (CFSTs) are composite structural element that offers an efficient and economical alternative to conventional reinforced concrete construction and it provides maximum strength and stiffness while permitting rapid construction. In bridges, CFSTs may be used as piers, piles, and drilled shaft foundation. The concrete infill increases the compressive strength and stiffness, restrains local buckling of the tube, and enhances ductility and resistance if composite action is achieved. The steel tube serves as formwork and reinforcement for the concrete. It also eliminates the need for flexible reinforcing cages, shoring, and temporary formwork and increase safety and reduces labour. The steel tube is placed at the appropriate location for flexural resistance, there by maximising strength and stiffness while minimizing weight and material requirements. In addition, the steel tube provides optimal confinement and shear strength to the concrete fill. The concrete fill restrains local buckling, and significantly increase compressive strength and stiffness of the tube. In comparison to a RC column of the same geometry, a CFST generally has larger axial, shear and flexural capacity and has larger stiffness. The result of the optimal placement of the steel reduced cracking and increased confinement. In 1980s the CFST was used in buildings to avoid a very large size column. At present the use of CFST in bridge construction is limited due to the lack of practical and economical connections. Recent research has addressed this limitation through the study of column-to-foundation connection and column-to-cap beam connections.

2. LITERATURE REVIEW

Max T. Stephens et al. (2016) carried out a study focused on the analysis of concrete-filled steel tube (CFST) column to precast cap beam connection by both experimentally and analytically with the help of ABACUS 6.12 software. In which three different types of connections studied that is [1] embedded ring (ER), [2] welded dowel (WD) and [3] Reinforced concrete (RC) connection and from the results all the connections undergo large deformations with minimum cap beam damage also additional reinforcement are required for WD and the RC connections as compare with ER connection. These construction methods simplify accelerated bridge construction (ABC) and also from the result the WD connection facilitates sufficient force transfer between longitudinal dowel and the steel tube. The ER connection can fully achieve ABC and provide superior seismic performance and hence prove more advantageous than other connections.

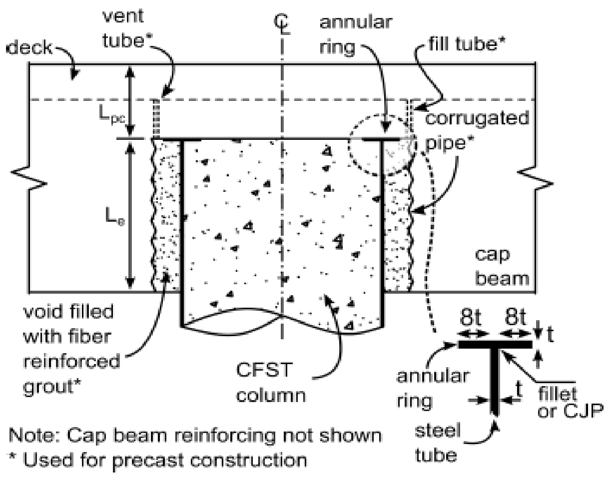
Max T. Stephens et al. (2014) conducted a study that was focused on the seismic design of circular CFT bridge pier connections by both experimental and analytical with the help of ABACUS software. In which two types of connections are studied which including column-to-foundation and column to cap beam connections. Two variations of an embedded CFT column to foundation connection [1] monolithic connection and [2] grouted connection were developed and experimentally evaluated. Results from the experimental analysis indicate that the proposed connection is effective and practical with adequate embedment depth. CFT cap beam connections were proposed including an embedded connection similar to the grouted CFT foundation connection. The embedded connection can achieve strength and ductility requirements within the constraints of the cap beam.



(a) Embedded Ring (ER) Connection (b) Welded Dowel (WD) Connection (c) Reinforced Concrete (RC) Connection

Lisa Berg et al. (2016) carried out a study which is focused on the design of CFST column-to-foundation/cap beam connections for moderate and high seismic regions and with the help of experimental result practical design expressions are developed. Seismic design of bridges requires strength, stiffness and stable inelastic cyclic deformation capacity and this can be achieved by using circular concrete filled steel tubes (CFST). Here embedded ring (ER) CFST connection was studied and this connection develops full strength, stiffness and ductility of the CFST bridge pier. The specimens were tested to evaluate the performance of the ER CFST connection in which the Parameters consider are (1) type of connection, (2) material strengths, (3) diameter of the tube (D), (4) diameter- to-thickness (D/t) ratio of tube, (5) embedment depth (Le), (6) the outer diameter (Do) of the annular ring, (7) the punching shear capacity of foundation or pier cap, and (8) the width and thickness of the foundation or cap beam. The columns and cap beams of RC structure are compared with redesigned CFST structure form that CFST structures are more economical than RC structures and also the CFST ER connection implemented without significant changes to the design of the cap beam.

Haiqing Zhu et al. (2017) conducted a study on the Rigidity estimation of embedded CFST column-to-beam connections. In which an embedded CFST column to beam connections subjected to axial and lateral load were studied numerically with the help of a 3D FEA model. The model is verified by using both circular and square CFST column to beam connections. In this study different parameters are consider such as the concrete strength, steel yield stress and embedded length. Also the effective stiffness of the CFST tubes and the flexural stiffness of the CFST column to beam connections are estimated. The proposed FEA model was used to predict the damage states, local deformations, tube yield and tearing. In addition the hysteretic curves show good agreement with the experimental results.



Ashly et al. (2017) carried out a study focused on Numerical finite element analysis using software ANSYS17.0. The Finite Element Analysis (FEA) of ANSYS allows complex analysis of the nonlinear response of concrete filled steel tubular column. In order to evaluate the improvement of the CFST under different loading conditions such as thermal and lateral load in which both loads are calculated by using buckling analysis and from the result it determines the maximum critical load. In structural and thermal analysis, maximum critical load is obtained using eigen and non linear buckling analysis. The overall analysis result suggests that the non linear buckling analyses are more accurate than the eigen buckling analysis.

Raghabendra Yadav et al. (2017) conducted a parametric study on the axial behaviour of Concrete Filled Steel Tube (CFST) columns.The ultimate load carrying capacity of CFST columns depends upon various parameters such as D/t ratio, steel grade, concrete grade, etc. ABAQUS software is used for the finite element modelling of CFST Columns. Results shows that the ultimate load capacity decreases by increase in D/t ratio and it increases by increase in steel grade and concrete grade.

Shilpa sara kurian et al. (2016) carried out a study focused on the behaviour of concrete filled steel tube (CFST) column under axial loading with the help of ANSYS software. Both circular and square columns are considered for the analysis. Both material and geometric nonlinearities are considered for the analysis. CFST columns axial capacity significantly affected with the cross-section of the column, concrete's compressive strength and yield strength of the steel tubes. Form the result it is concluded that the deformation of the column is decreasing 10-15% with increasing grade of concrete. The deformation was influenced by the shape of the CFST. The circular CFST leads to better behavior than square CFST due to better confinement.

Amir Fam et al. (2004) Carried out a study focused an experimental work and analytical modeling for concrete-filled steel tubes (CFSTs) subjected to concentric axial compression and combined axial compression and lateral cyclic loading. In which the bond and end loading conditions did not affect the flexural strength of beam-column members significantly.The axial strengths of the unbonded short columns were slightly increased as compared to those of the bonded ones while the stiffness of the unbonded specimens was slightly reduced.

3. Conclusion

Connections are of three types such as 1) embedded ring connection 2) welded dowel connection 3) reinforced concrete connection. Comparative studies of these connections are carried out by both experimental and analytical method. The embedded connection can achieve strength and ductility requirements within the constraints of the cap beam and it is more economical than other two types this is connection similar to the grouted CFT foundation connection. For the study they include many parameters such as D/t ratio, cap beam and embedment depth, type of steel, grade of concrete but the effect of slenderness ratio was not consider.

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