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Foundation connections for circular concrete-filled tubes

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ABSTRACT

Concrete filled steel tubes (CFTs) promote economical and rapid construction. They offer increased strength and stiffness relative to structural steel and reinforced concrete. The steel tube serves as formwork and reinforcement to the concrete fill, thereby reducing the labor requirements. CFT components encourage the optimal behavior of each material (concrete and steel) while providing a symbiotic relationship between the two to mitigate undesirable failure modes. The fill increases the compressive strength and stiffness, delays and restrains local buckling of the tube, and enhances ductility and resistance if composite action is achieved. Both rectangular and circular CFT have been employed, but circular CFT provide better performance, because they provide increased confinement of the concrete and composite action. A missing component for circular CFT construction is reliable and ductile connections. The research described herein that investigated and develops design procedures for simple and economical connections of circular CFT piers or columns to reinforced concrete foundations, pile caps and wide cap beams (bridge construction) is presented and evaluated. The connection requires no dowels or internal reinforcement connecting the tube to the footing or cap beam. Experiments and analytical studies evaluate the inelastic seismic performance and establish design criteria for the connection. The seismic performance of a CFT column and connection assembly is compared to a conventional reinforced concrete column. The research shows that the proposed connection develops the full capacity of the composite column. The assembly provides excellent ductility and inelastic deformation capacity under seismic loading while mitigating damage even at larger drift demands.

1. Introduction

Prior research has demonstrated that concrete filled steel tubes (CFT) are stiff and strong in axial compression, and have substantial bending resistance [1]. The symbiotic relationship between the steel tube and the concrete fill provides superior resistance in tension (steel tube), compression (concrete fill), and to local and global instabilities. The steel tube reinforces the concrete at the outer perimeter, rather than at a lesser diameter as is required for a reinforced concrete (RC) component to meet the cover requirements. This is the optimal location and maximizes the flexural resistance for the size. In addition, longitudinal and transverse reinforcement are not needed inside the steel tube. As a result, a CFT member requires significantly a smaller diameter, and therefore less concrete, to achieve the required stiffness and resistance compared to RC construction.

CFT members can sustain large inelastic deformations because the concrete fill restrains local buckling of the tube, and the tube confines the concrete. The structural integrity of CFT is enhanced with composite action, and therefore the concrete fill should be low shrinkage material. These properties make them ideal bridge piers, foundation caissons and piles as well as columns in multi-story buildings under both gravity and severe loadings, such as earthquake or blast.

CFT members offer construction advantages beyond their structural properties. In comparison to reinforced concrete construction, CFT members have reduced construction requirements, which translated to reduced construction time and labor. The tube acts as formwork as well as the longitudinal and transverse reinforcement, and eliminates the associated labor and materials. Elimination of the reinforcement further enhances constructability with the use of a self-consolidating concrete that can be placed without vibration. In urban building construction, the site accesses and time schedule are constrained, and methods to reduce construction time, labor and materials are advantageous. Rapid bridge construction is beneficial, because most current construction is accomplished in the presence of existing traffic, and this poses safety risks and large social and economic costs.

Rectangular CFT construction is sometimes preferred because it lends itself to use of standard steel-to-steel connections. However, circular CFT construction provides significantly better performance through:

- greater and even confinement of the concrete fill,
- increased composite interaction between the steel tube and the concrete fill, and
- reduced local buckling and improved stability of the steel tube provided by restraint due to the concrete fill [2].

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