Existing Research Topic 19

Innovative Multi-Hazard Resistant Bridge Columns for Accelerated Bridge Construction

2018 Ultra-high performance concrete-filled steel tubular columns

<https://www.sciencedirect.com/topics/engineering/concrete-filled-steel-tube>

2014 Axial behavior of FRP-wrapped circular Ultra-High Performance Concrete specimens

<https://www.researchgate.net/publication/270810030_Axial_behavior_of_FRP-wrapped_circular_Ultra-High_Performance_Concrete_specimens>

Ultra-High Performance Concrete (UHPC) is an innovative new material that, in comparison to conventional concretes, has high compressive strength and excellent ductility properties achieved through the addition of randomly dispersed short fibers to the concrete mix. This study presents the results of an experimental investigation on the behavior of axially loaded UHPC short circular columns wrapped with Carbon-FRP (CFRP), Glass-FRP (GFRP), and Aramid-FRP (AFRP) sheets. Six plain and 36 different types of FRP-wrapped UHPC columns with a diameter of 100 mm and a length of 200 mm were tested under monotonic axial compression. To predict the ultimate strength of the FRP-wrapped UHPC columns, a simple confinement model is presented and compared with four selected confinement models from the literature that have been developed for low and normal strength concrete columns. The results show that the FRP sheets can significantly enhance the ultimate strength and strain capacity of the UHPC columns. The average greatest increase in the ultimate strength and strain for the CFRP- and GFRP-wrapped UHPC columns was 48% and 128%, respectively, compared to that of their unconfined counterparts. All the selected confinement models overestimated the ultimate strength of the FRP-wrapped UHPC columns.

2011 Behaviour of Ultra High-Performance Concrete Confined by Fiber-Reinforced Polymers

<https://www.researchgate.net/publication/270844472_Behaviour_of_Ultra_High-Performance_Concrete_Confined_by_Fiber-Reinforced_Polymers>

Over a decade of studies have demonstrated the benefits of ultra high performance concrete (UHPC) in terms of damage tolerance, energy absorption, crack distribution, and deformation capacity. However, little information is available on the confinement behavior of UHPC, especially when confined with fiber-reinforced polymers (FRP). Sixteen UHPC-filled FRP tubes with different fiber type and tube thickness were tested under monotonic uniaxial compression. All specimens failed by rupture of the tube at or near the midheight. Similar to conventional concrete, test results showed significant enhancements in the ultimate strength and strain of UHPC-up to 98% and 195%, respectively, compared with its unconfined counterpart. The experimental results were compared with a number of available confinement models. Although one of the models provided a reasonable fit for the stress-strain response in most cases, all models generally underestimated the effectiveness of FRP confinement at higher confinement ratios. The study demonstrated the need for confinement models that could accurately predict the behavior of FRP-confined UHPC in terms of the stress-strain relationship and the respective ultimate strengths and strains.

RiP Database: <https://rip.trb.org/Results?txtKeywords=steel%20tube%20column&txtTitle=&txtSerial=&ddlSubject=&txtReportNum=&recordStatus=&projectStatus=&ddlTrisfile=&txtIndex=&states=&specificTerms=&txtAgency=&sourceagency=&txtAuthor=&ddlResultType=&chkFulltextOnly=&subjectLogic=or&dateStart=&dateEnd=&rangeType=emptyrange&sortBy=publisheddate&sortOrder=DESC&rpp=25#/View/1320622>

Alaska DOT 2020: External Pocket and Socket Connections for the Seismic Design of Alaska Bridges

Accelerated bridge construction (ABC) has gained momentum over the last several years due to the promise of rapid, robust construction. For Alaska, where the construction season is shorter than all other states, this is especially important. Numerous ABC connection options have been proposed in the literature as summarized by NCHRP 12-88 (Marsh et al., 2011). However, for the purpose of this research proposal, the most relevant connections are termed ‘Socket’ and ‘Pocket’ connections. Both will be described in more detail later. Recent research funded by AKDOT&PF at NCSU has resulted in the development of a rapidly constructible steel bridge system which uses grout and shear studs to connect bridge pile/columns to the cap-beam. The technique was shown to be tolerant of large construction errors, and robust for the seismic demands expected throughout Alaska. The design detail is now the recommended practice for Alaska DOT for construction of these bridge systems, which are employed for temporary (or semi-permanent) structures. A technique similar to that which was developed for steel bridge systems could be employed for reinforced concrete or reinforced concrete filled steel tube (RCFST) systems, the latter of which is the dominant form of construction for permanent bridges in Alaska. By adapting the grouted shear stud (GSS) connection to RCFST substructures, the benefits of rapid, robust construction could be extended to this class of bridges. RCFST or concrete columns would be placed in the usual manner in the field. A prefabricated assembly which consists of the cap beam and external socket would then be placed over the columns with the remaining gap filled with grout in the field. The proposed system would allow for significant construction tolerance, while also being robust against seismic forces. The design of the column to cap joint may also be simplified due to the lower strain levels that would exist in the joint as a consequence of elastic reinforcing steel which connects the column to the cap.

2018 (active) Envisioning Connection detail for Connecting Concrete Filled Tube (CFT) columns to cap beam for High Speed Rail Application <https://abc-utc.fiu.edu/envisioning-connection-detail-for-connecting-concrete-filled-tube-cft-columns-to-cap-beam-for-high-speed-rail-application/>

American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specification, through AASHTO SCOBS T-14 committee (Steel Bridges) have recently developed design provisions for use of Concrete Filled Tube (CFT) columns for bridge elements, such as columns in substructure. In the case of High Speed Rail (HSR), about 60 to 70% of the HSR infrastructure consists of elevated bridge structures. In one recent case in California, a segment of the High-Speed Rail (HSR) consists of elevated bridge structures with spans of about 110 to 150 ft. with columns, ranging in height from very short to as tall as 100 ft. Use of pre-fabricated sub-structure elements could significantly reduce cost and expedite the HSR project delivery. U.S. DOT has identified the use of HSR as a strategic area for addressing mobility challenges. Development of an efficient substructure system for HSR is therefore urgent and will result in significant savings. The recent adaptation of CFT columns by AASHTO LRFD Bridge Design Specification is a first step. Development of efficient substructure system for HSR using CFT columns, demands development of cap beam system and their connection to CFT columns. This project is a joint investigation with University of Washington. The FIU project will concentrate on development of a connection capable of connecting cap beam system to CFT column, while University of Washington will concentrate on developing a pile cap system that could be utilized in conjunction with CFT columns. Together, these two projects, combined with existing information about CFT columns, will provide an economical substructure alternative system for HSR that will be presented to HSR authority for additional development and implementation.

TRID/TRIS Database:

2014 Behavior of Hollow-Core FRP-Concrete-Steel Columns Subjected to Cyclic Axial Compression

<https://transportation.mst.edu/media/research/transportation/documents/R357%20Final%20Report.pdf#140815105338>

This report presents the results of an experimental study that was conducted to investigate the effects of key parameters on the compressive behavior of fiber reinforced polymer (FRP)-concrete-steel double-skin tubular columns (FSDT). Hybrid FSDT columns have been introduced as a new form of hybrid columns. They consist of an outer tube made of FRP and inner tube made of steel, with sandwiched concrete between them. This report investigated the effect of fiber angle and the ratio of steel tube diameter to its thickness (Di/ts) on the compressive behavior of FSDT columns. Ten FSDT cylinders with different (Di/ts) in addition to three concrete filled-fiber tuber (CFFT) cylinders were manufactured and tested under axial cyclic compression. The results of the experimental study indicate that the overall behavior of FSDT and CFFT is similar and the main difference is in the capacity load. The cylinders with high D/t ratio achieve lower capacity than the normal capacity due to the local buckling of the steel tubes. Using the saturated fiber tube increases the axial ductility but does not give high confinement. These results are presented together with a discussion on the influence of the studied parameters on the compressive behavior of FSDTs.

2013 Effect of column parameters on cyclic behavior of ultra-high-performance concrete-filled fiber-reinforced polymer tubes

<http://worldcat.org/oclc/13846957>

A novel hybrid column made of fiber-reinforced polymer (FRP) and ultra-high-performance concrete (UHPC) was developed in a previous study by the authors. The steel-free UHPC-filled FRP tube (UHPCFFT) system proved promising as an alternative to conventional reinforced concrete (RC) columns. This study investigates the effect of column cross section, type of FRP tube, and amount of longitudinal steel reinforcement on the cyclic behavior of UHPCFFT columns. Accordingly, six column specimens, including one control RC and five UHPCFFTs with different FRP tubes, steel reinforcement ratios, and diameters, were made and studied under pseudo-static tests. Clear and strong correlations were established between the initial stiffness and strength of UHPCFFT systems and the stiffness index and reinforcement index, respectively. All UHPCFFT columns exhibited significantly lower residual displacement and slightly lower ductility, as compared to Specimen RC.

2012 Cyclic Behavior of Hybrid Columns Made of Ultra High Performance Concrete and Fiber Reinforced Polymers

<https://doi.org/10.1061/(ASCE)CC.1943-5614.0000234>

The unique features of ultra-high-performance concrete (UHPC) in damage tolerance, energy absorption, and deformability were combined with the superior performance of concrete-filled fiber-reinforced polymer (FRP) tubes (CFFTs) to develop a novel hybrid system of FRP tube and UHPC, and the cyclic behavior of this system evaluated. Four specimens were tested. Two were steel-reinforced: one with conventional concrete (RC), and the other (RUHPC) with UHPC within twice the plastic hinge length and conventional concrete for the remainder of the column length. The other two had FRP tubes: one filled with conventional concrete (CFFT), and the other (UHPCFFT) filled with UHPC within twice the plastic hinge length and conventional concrete for the remainder of the column length. Each column was tested as a cantilever under a constant axial load and reverse cyclic lateral loads applied incrementally in displacement control. Each of the tubed specimens without any internal reinforcement achieved the same flexural strength and ductility as its steel-reinforced counterpart. Specimen UHPCFFT showed significantly higher flexural strength and initial stiffness, lower residual drift, and relatively similar energy dissipation as compared with Specimen RC. The proposed hybrid system can be optimized for strength and ductility as a viable alternative to the conventional RC column.

2010 Tube-Based Composite Deck System for Moveable Bridges

<https://trid.trb.org/Results?txtKeywords=fiber-reinforced%20polymer%20(FRP)%20tube%20UHPC&txtTitle=&txtSerial=&ddlSubject=&txtReportNum=&ddlTrisfile=&txtIndex=&specificTerms=&txtAgency=&sourceagency=&txtAuthor=&ddlResultType=&chkFulltextOnly=&recordLanguage=&subjectLogic=or&dateStart=&dateEnd=&rangeType=emptyrange&sortBy=publisheddate&sortOrder=DESC&rpp=25#/View/925901>

Open grid steel decks, commonly used on moveable bridges, have several disadvantages, including poor skid resistance, high maintenance costs and high noise levels, and susceptibility to vibration. It is therefore desirable to find alternative deck systems with solid surface. This research is focused on development of a steel free composite deck made of ultra high performance concrete (UHPC) and fiber reinforced polymer (FRP) tubes. It resembles a hollow core slab but without any metallic reinforcement. FRP tubes take the tension, while the UHPC takes the compression and also serves as the wearing surface. This composite deck is corrosion resistant as both materials used have very good corrosion resistance. A preliminary experimental testing program and analytical evaluation was undertaken to investigate the strength and serviceability of the deck system. Selected results from the ultimate load tests are presented in this paper. The findings indicate that the proposed system is a promising alternative to the open grid steel decks from both strength and serviceability standpoints.

RNS Database:

There are five (5) projects listed for UHPC since 2015, but none reference these types of columns <https://rns.trb.org/search/search.aspx?f1=k%3A%3AKeywords+%28Title%2C+Description%2C+or+Index+Terms%29&ddlType=RNS&orgType=S&status=&date_params=&lower_date=1900&upper_date=2099&sb=&so=a%3A%3AAscending&sc=xx%3A%3AAll+Categories&t1=UHPC>