Alternative ABC Connections Utilizing UHPC

QUARTERLY REPORT

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A. DESCRIPTION OF RESEARCH PROJECT

The most common form of ABC is the use of prefabricated bridge elements. These parts can be produced in a controlled environment off site and assembled in place at the bridge site to make a complete bridge [1]. One of the most challengeable issues in prefabricated construction is concern about the durability, behavior and structural integrity of the joints between elements.

The FHWA manual entitled *Connection Details for Prefabricated Bridge Elements and Systems* includes much information for various prefabricated element connections [2]. On-going research projects in several research institutions are looking into durable prefabricated connections with good behavior [3-4]. Moreover, in seismic areas, connections between elements of bridge must resist the maximum force demand and cyclic effects. The bridge should be designed for a large seismic event, and detailed to exhibit ductile plastic hinging in the column next to the cap beam (and footing) [3].

There are several methods for connecting precast cap beam to column. In most cases, these connections are designed to transfer lateral seismic forces from the superstructure to the column. Some of these methods include:

- Bar couplers,
- Grouted ducts,
- Pocket connections,
- Member socket connections,
- Hybrid connections,
- Integral connections, and
- Mechanical connections.

This project proposes a new connection system between cap beam and column for seismic areas using Ultra-High Performance Concrete (UHPC).
A.1. PROBLEM STATEMENT

In seismic regions, columns should be designed to form plastic hinges and dissipate seismic forces. The high demand region on a typical column is at the ends where the column connects to the footings and pier caps [5].

The main purpose of the project is to develop a new UHPC connection between cap beam and column for Accelerated Bridge Construction (ABC), with desired plastic hinge location and behavior. This project concentrates on developing suitable details for joining cap beam to column and includes numerical analysis and experimental test to validity the results.

A.1.a. BRIEF DESCRIPTION OF THE PROPOSED CONNECTION DETAIL

A UHPC connection part was utilized to connect cap beam to column. The connection consists of two parts, first part includes cap beam and top layer of UHPC and normal strength concrete. The second part is the column which would be connected to the first part using another layer of UHPC in the field. The advantage of utilizing UHPC for connecting these two parts is shorter development length compared to normal strength concrete [6]. Using the top layer of UHPC forces the plastic hinge to develop in the column and desired location.

![Concept of the connection using UHPC.](image)

A.1.b. SYSTEM ADVANTAGES

Some of the advantages of the proposed connection detail include:

- Defined plastic hinge location and size,
- Large tolerances,
- Developing the reinforcement over short length,
- Minimal volume of concrete to be casted in the field,
- Eliminating the potential interferences with reinforcement in the cap beam, and
- Potentially eliminating or reducing the need for having shear or confining reinforcement.

A.2. **RESEARCH APPROACH AND METHODS**

This project is a feasibility study to explore the possibility of simplifying seismic connection details through the development of alternate details utilizing UHPC. The scope of the project includes envisioning connection detail, investigating its performance through numerical studies and conducting a limited number of experiment tests.

A.3. **DESCRIPTION OF TASKS TO BE COMPLETED IN RESEARCH PROJECT**

Following are description of tasks and their current status.

**Task 1 - Literature review**

Through various resources within published papers and reports, research team is familiar with connection types between cap beam and column. Nevertheless, a literature search is underway to understand ongoing projects in ABC.

**Task 2 – Test setup details**

Considered test setup has two parts, first part includes cap beam, a layer of UHPC and plastic hinge part. Support and plastic hinge part is made by regular concrete. The second part is column with regular concrete. These two parts will attach with UHPC. The column size considered 20x20 inch with 16 #6 bars. The length of connection with UHPC is 20 in. The configuration of test setup has been shown in Fig. 2.

![Fig. 2. Concept of the connection using UHPC.](image-url)
Task 3 – Numerical Modelling

To predict the behavior of the connection, the specimen has been analyzed with Finite Element Method (FEM). Results show the location of the plastic hinge, cracking locations and moment-deflection curve. Following figures show the cracking formations and moment displacement curve of the specimen under lateral loading.

![Crack forming in the column.](image)

**Fig. 3. Crack forming in the column.**

![Moment-deflection curve.](image)

**Fig. 4. Moment-deflection of the specimen.**

Task 4 – Experimental Study

Beside numerical studies, an experimental test has been conducted to understand the real behavior of the connection. Construction sequence for the specimen are as follow:
1. Formwork construction (Fig. 5),
2. Casting regular concrete (both column and support) (Fig. 6)
3. Casting UHPC (top layer) (Fig. 7)
4. Casting regular concrete (Plastic hinge part) (Fig. 8)
5. Connecting the two parts with UHPC (Fig. 9-11)

Fig. 5. Formwork construction.

Fig. 6. Casting regular concrete for the support.
Fig. 7. Moment-deflection of the specimen.

Fig. 8. Overall view of the first part.
Fig. 9. Joining column to the first part.

Fig. 10. Casting UHPC for joining two parts.
A.4. EXPECTED RESULTS AND SPECIFIC DELIVERABLES
Results of this preliminary investigation will be in the form of the development of a seismic connection detail that shows merit in field application and significantly simplifies the construction processes. There will be a need to carry out additional investigation before project recommendations are utilized in the field.

A.5. OTHER COMMENTS, CHALLENGES, MODIFICATIONS, AND MORE
There is a plan to discuss the details of the project with state bridge engineers in seismic areas to ensure that the project is moving in right direction for developing the detail suitable for seismic areas. Once the detail is finalized, the project plans carry out an experiment to test on the proposed connection.
References:


