UHPC CONNECTION FOR SDCL STEEL BRIDGE SYSTEM

Quarterly Progress Report
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1. Background and Problem Statement

SDCL steel bridge system has been investigated thoroughly for non-seismic and seismic areas [1-3]. SDCL bridge system provides a solution for ABC application of steel bridges. The current detail uses a cast-in-place concrete diaphragm over the middle pier to connect the steel girder and make them continuous (Figure 1). Application of an SDCL steel bridge system has many advantages including eliminating field splices, eliminating expansion joints, reduced negative moment over the pier, and minimized traffic interruption. Further, encasing the ends of the girder in concrete protects the girder ends and results in enhanced service life and lower inspection and maintenance costs if compared to conventional continuous steel bridge systems.

The current system has shortcomings that can be addressed by taking advantage of new advanced materials such as UHPC. By using the current SDCL detail, although the resulting closure time for the facility carried by structure is reduced if compared to the conventional methods of steel construction, but it might exceed the weekend closure time limits that is usually available for high traffic roadways. The reason is that normal strength concrete usually reaches its minimum required strength in more than a couple of days. Another issue with the current SDCL detail is the tight tolerances for steel fabrication. As the steel girders are placed on adjacent spans in this system the end detail of the girders (steel blocks) should be touching to prevent concrete diaphragm from crushing.

UHPC has been recently widely considered for ABC applications due to its superior mechanical properties, durability and also high early strength as compared to normal concrete. However, this material is more expensive than conventional concrete so it should be utilized strategically. In this research, the use of UHPC as diaphragm material is proposed that results in decreasing construction time for the facility carried, increasing the tolerances and simplifying the cast-in-place detail of the concrete diaphragm.

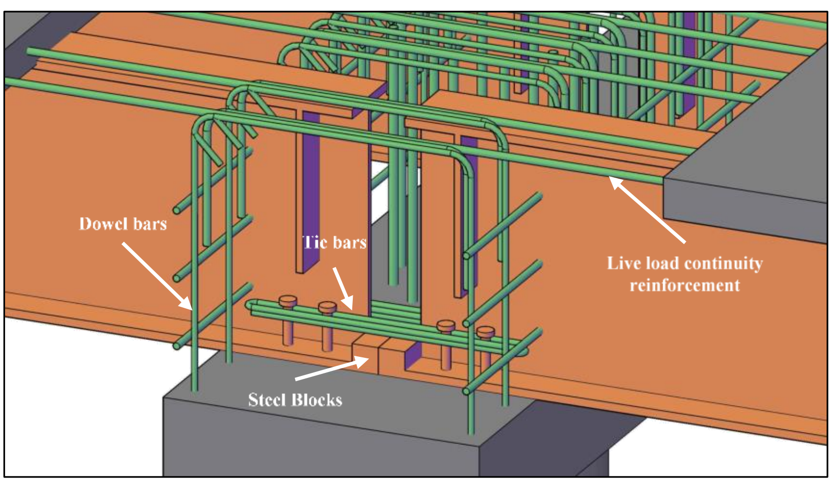

Figure 1 Current SDCL connection detail using normal concrete diaphragm.

2. Research objectives and Approach

The main objectives of this project are:

1- Developing finite element models capable of modeling the new proposed system;

2- Studying the effect of connection parameters and details when the diaphragm is made of UHPC, therefore there are opportunities to simplify the end girder details;
3- Developing tentative design guidelines for UHPC connection; and
4- Developing a research plan and road map to experimentally evaluate the proposed connection.

3. Description of Research Project Tasks

The following is a description of tasks carried out to date.

Task 1 – Conducting a literature review on the current practice of SDCL steel bridge system and UHPC

In this task, a comprehensive literature review will be conducted including the current construction of steel bridges and SDCL bridge system, especially for ABC applications. Also, the developments in the material technologies and UHPC will be reviewed to accurately model the UHPC material properties in the numerical study.

Progress: This task is completed.

Task 2– Validating the numerical models

In this task, a set of models will be developed to match the experiments performed for the development of SDCL system. This assumptions in the models will be used later for other tasks.

Progress: A set of models have been developed in the finite element analysis software ANSYS. The models are intended to capture the behavior observed in the experiments. The material models were first used in replicating small scale material tests such as cylinder and three-point bending tests. Out of various options available in ANSYS. The gradient enhanced damage-plasticity microplane model was chosen for the concrete material. The parameters for the same material model was also calibrated for UHPC. A set of large-scale models were developed from non-seismic and seismic tests which were performed on previous SDCL connection. However, as UHPC was not used in these connections, a second set of large-scale models were developed using data from other UHPC related research to validate the material parameters developed from the small-scale tests. The assumptions and parameters developed in this section will be used for the next section of the research and developing the connection detail.

Task 3 – Performing a parametric study

In this task, based on the developed validated models, UHPC will be modeled and a parametric study will be performed to understand the behavior of the connection in various loading conditions.

Progress: A study is underway to see the effect of some of the connection parameters including: the width of the UHPC diaphragm, the distance between the girders, the embedment of the girders inside UHPC, and presence of the endplate at the end of the girder. These parameters have been studied under gravity type loadings for non-seismic application. In the next step, the connection will be modeled for seismic loadings (upward loading and moment reversal) and other parameters may be added to the study.

Task 4 – Developing design recommendations and experimental research plan

In this task, based on the findings of the numerical study tentative design guidelines will be developed and proof of concept experiments will be designed.

> *Progress: The result of the parametric studies for the non-seismic loading types have resulted in the preliminary design recommendations. The final recommendations will be published for non-seismic and seismic details.*

Task 5 – Final Report

In this Task, Full assessment of the findings from Task 1 throughout Task 4 will be conducted and a report will be published including design recommendations and experimental research plan for proof of concept.

> *Progress: Not started.*

4. Expected Deliverables

The main deliverable from this project will be a final report which will include design recommendations for the proposed SDCL connection using UHPC and experimental program for proof testing. A short video will be prepared describing research work and findings.

5. Schedule

Research task	2020											
	J	F	M	A	M	J	J	A	S	O	N	D
Task 1 – Conducting literature review on current practice of SDCL steel bridge system and UHPC	■	■	■									
	■	■	■									
Task 2– Validating the numerical models			■	■	■							
			■	■	■							
Task 3– Performing parametric study						■	■	■				
						■	■					
Task 4– Developing design recommendations and experimental research plan								■	■	■	■	■
								■	■			
Task 5 – Final Report										■	■	■

Proposed
Completed

Item	% Completed
Percentage of Completion of this project to Date	70%

6. References

[1] Mahboub Farimani, Mohammadreza. *Resistance mechanism of simple-made-continuous connections in steel girder bridges.* PhD thesis, University of Nebraska-Lincoln, 2006.

[2] Javidi Niroumand, Saeed. *Resistance mechanism of simple-made-continuous connections in skew and non-skew steel girder bridges using conventional and accelerated types of construction.* PhD thesis, University of Nebraska-Lincoln, 2009.

[3] Sadeghnejad, Amir, Ramin Taghinezhadbilondy, and Atorod Azizinamini. "Seismic performance of a new connection detail in an SDCL steel bridge system." *Journal of Bridge Engineering* 24.10 (2019): 04019094.