SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2017

ODOT Research Unit
555 13th St NE
Salem, Or 97301-6867

Phone (503) 986-2700
Fax (503) 986-2844

I. PROBLEM NUMBER AND TITLE

17-023_ST Performance of High-Strength Steel Reinforcement in Shear Friction Applications

II. RESEARCH PROBLEM STATEMENT

High strength steel (HSS) reinforcing bars with nominal yield strengths greater than 60 ksi are commercially available and can provide economic and constructability benefits when used in shear friction interfaces in bridge structures. However, concerns arise due to lack of laboratory test results from members containing HSS reinforcement. Because of this, the current LRFD specifications limit the yield stress of the interface reinforcement to 60 ksi for the shear friction resistance calculations.

To date, only a limited number of tests (Harries et al. 2012, Zeno 2009) have been performed to characterize the shear friction resistance in members containing HSS reinforcement. Results from these tests indicate that using the full yield strength of the HSS reinforcing steel could overestimate the shear interface capacity of the specimens.

Completed in 2015, the Oregon Department of Transportation and Region X University Transportation Center (PacTrans) supported a focused research project to investigate the effects of HSS reinforcement on concrete shear interface behavior. The tests were performed at Oregon State University. Test results indicate that as long as the reinforcing bars yield, a stress higher than 60 ksi may be used to estimate the shear friction resistance. However, based on a group of other test specimens from the same project, it was found that when the reinforcing bars did not yield the results are in agreement with the findings in Harries et al. (2012). The reinforcement bar size and spacing between the bars may have played a role in this difference between the two sets of specimens.

To clarify the influence of bar size and bar spacing and to gain a better understanding of the effects of reinforcement bar strength on the performance of shear friction interfaces, further research is proposed. The proposed program will include test variables not considered in the previous phase of research, such as interface roughness, other high strength steel concrete strength, reinforcement grades with various stress-strain characteristics, reinforcing bar size, and reinforcing bar spacing.

III. RESEARCH OBJECTIVES

The objective of this research is to evaluate and define the performance of A706 Grade 80, ASTM A615 Grade 100, and ASTM A1035 (120 ksi) reinforcing steel performance in shear friction applications. Understanding the performance is crucial for evaluating and assessing the applicability of the current design equations for RC structures using HSS reinforcement. If successful, the research will provide necessary data for supporting a recent working agenda item (WAI) presented to the AASHTO-T10 committee by Oregon DOT.

IV. WORK TASKS, COST ESTIMATE, AND DURATION

Task 1: Literature review. A literature review will be performed throughout the duration of the project to assess and summarize work currently being done by other researchers and State Highway Agencies (SHAs) on HSS; if available, the team will identify current design methodologies for using HSS in shear interface applications.

Task 2: Develop stress-strain characteristics for HSS grades. Currently there are several HSS grades available on the market, including: ASTM A615 Grade 100; ASTM A706 Grade 80; and ASTM 1035 Grade 100 and 120—each ASTM 1035 grade has three types: CS, CM, and CL. In this task the researchers will acquire sufficient samples of each grade and perform monotonic tension testing to develop characteristic stress-strain plots for each HSS. These test results will be used to identify steel reinforcements with various characteristics that will be included in the testing program.

Task 3: Develop experimental design. Based on the initial literature review findings and the test results from Task 2, the team will develop an experimental program to reliably assess the performance of shear interfaces using HSS reinforcement meeting three (3) grades. The team's current thinking is to test three (3) specimens from each set of parameters that affect the shear capacity of interfaces containing HSS steel reinforcement, including: influence of reinforcement grade, concrete strength, interface preparation, reinforcement spacing, and reinforcement size. The

researchers will confirm the final experimental plan with the DOT partners during Task 3 and prior to testing.

Task 4: Perform experimental testing program. The experimental design developed in Task 3 will be carried out to develop analytical equations for the design and for estimating the performance of shear interfaces containing HSS reinforcement. Push-off test specimens will be constructed and tested following test setups described developed in testing completed in 2015. The team's current thinking is that 35 to 40 specimens will be tested. This will generate the significant data on interface shear performance so that design equations can be reliably developed.

Task 5: Produce final report and disseminate findings. The research team will document all aspects of the research program and report findings in a manner such that ODOT and other agencies can easily implement these findings. Recommendations to ODOT (and other agencies) on using HSS reinforcement will be made.

Anticipated Budget and Schedule: The research team is requesting $415k from ODOT over a 2-year period (~$205k in year 1; ~$210k in year 2).

V. IMPLEMENTATION

If it is determined that HSS reinforcement meets minimum performance requirements, the product of this research will include analytical equations and procedures that will allow engineers to rationally design shear friction applications using HSS reinforcement. If it is determined that HSS reinforcement does not substantially impact the current design equations, researchers will provide clear reasoning why the HSS reinforcement yield strength cannot be used in design. If it is determined that HSS reinforcement can only be used under certain conditions (e.g., with certain size of reinforcement), the researchers will clearly identify these restrictions. The results, after validation by ODOT bridge engineers, will be added to the ODOT Bridge Design and Drafting Manual and potentially to AASHTO documents. The final report will provide the information and guidance on the use of HSS reinforcement in design.

VI. POTENTIAL BENEFITS

HSS reinforcement in reinforced concrete elements has the potential to provide several benefits: less congestion of the reinforcement cages can result in improved constructability (easier bar and concrete placement), reduced shipping costs, reduced construction costs, improved structural performance, and reduced environmental impact. If research shows that HSS can be used in all members on a construction project, the chances of mistakenly placing Grade 60 reinforcement in members requiring Grade 80 reinforcement can be eliminated. This research will provide ODOT and other DOTs with test data as well as analytical models to reliably and safely use HSS reinforcement in shear applications.

VII. REFERENCES

Trejo, D. and Kim, Y.H. (2011). Development of Precast Bridge Deck Overhang System, Research Report 0-6100-3, July 2011, FHWA/TX-10/0-6100-R3, 74 pages.

Shahrooz, B.M. (2011), Design of Concrete Structures Using High-Strength Steel Reinforcement, NCHRP Report 679, American Association of State Highway and Transportation Officials

Harries, K. A., Zeno, G., and Shahrooz, B. (2012). "Toward an Improved Understanding of Shear-Friction Behavior." ACI Structural Journal, 109(6), 835-844.

Zeno, G. A. (2009). "Use of High-Strength Steel Reinforcement in Shear Friction Applications." Master's Thesis, University of Pittsburgh.

VIII. SUBMITTED BY

Stage 1 Submitter	***Stage 2 Submitter***	***ODOT champion***
Andre Barbosa and David Trejo *andre.barbosa@oregonstate.edu* *david.trejo@oregonstate.edu*	Andre Barbosa and David Trejo *andre.barbosa@oregonstate.edu* *david.trejo@oregonstate.edu*	Tanarat Potisuk *Tanarat.POTISUK@odot.state.or.us*