

I. RESEARCH PROJECT TITLE

Software for AASHTO LRFD Combined Shear and Torsion Computations using Modified Compression Field Theory and 3D-Truss Analogy

II. RESEARCH PROBLEM STATEMENT

The federal highway administration (FHWA) has placed the strict condition of using AASHTO LRFD 2004 specifications for State DOT's to receive federal aid for constructing bridges. This requirement will go into effect in October 2007. It is also very widely known that the new LRFD specifications have implemented drastic changes in their design procedures that State DOT engineers are, for the most part, not familiar with. Accordingly, efforts to develop design tools to address the need of facilitating the learning and usage of such new procedures should be of high priority.

One of the most distinguished changes made in the new LRFD specifications is the use of the modified compression field theory for calculating the shear capacity and the use of 3D truss analogy for computing torsional capacity. Furthermore, combination of the two effects requires invocation of both procedures and implementation of extra equations. Providing KDOT design engineers with a proper design tool on this subject seems to be one of the highest priorities. Acknowledging the insufficiency of developing software, as a black box, that accurately performs the design computations; providing the designer with the actual design equations/calculations as a component in the project documents is equally important.

III. RESEARCH PROPOSED/RESEARCH OBJECTIVES

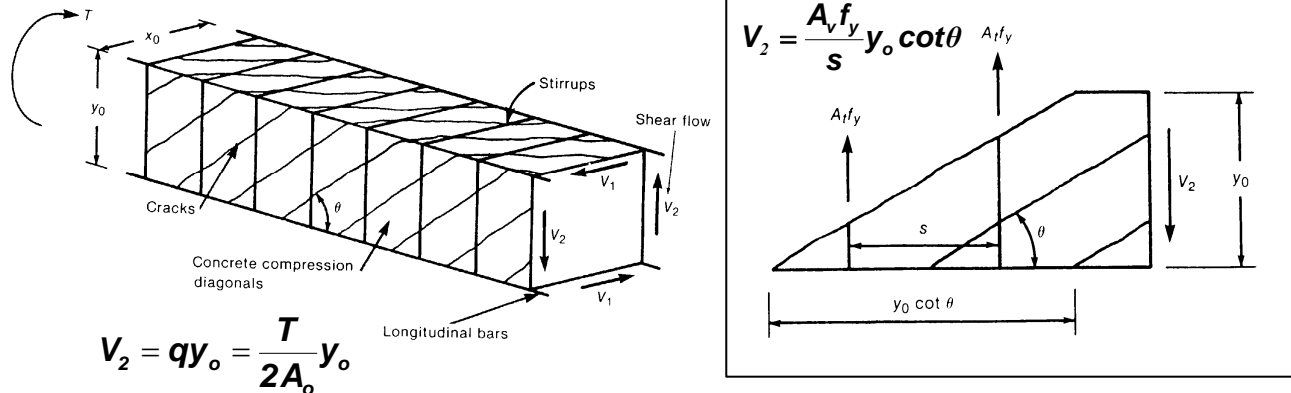
The objective of the proposed research is to develop a design-software for detailed computation/documentation of shear and torsion provisions of the AASHTO LRFD 2004. Complete reference to AASHTO LRFD sections and equation numbers will be provided. The following design modules will be developed:

1. Modified Compression Field Theory for shear design of reinforced and also prestressed members.
2. 3D Truss Analogy for torsion design of reinforced and also prestressed members.
3. Combination of the two for combined shear-torsion design requirements.

To present a flavor of the involved equations in the two design procedure, the torsion equation will be presented below due to pre-proposal space limitations. The cracking torque in reinforced and also prestressed members is a key parameter in torsion design:

$$T_{cr} = 4\sqrt{f'_c} \left(\frac{A_{cp}^2}{P_c} \right) \qquad T_{cr} = 4\sqrt{f'_c} \left(\frac{A_{cp}^2}{P_c} \right) \sqrt{1 + \frac{f_{pc}}{4\sqrt{f'_c}}}$$

Torsion produces a shear force in the side wall that would be in equilibrium with the stirrup forces:



Combining the above two equation, the stirrups for torsion may be directly determined

$$T_n = \frac{2A_o A_t f_y \cot \theta}{s}$$

However, in case of combined shear and torsion, the angles θ and β require a computation process as per the modified compression field theory and the adjusted shear stress and strength is evaluated:

$$v = \sqrt{\left(\frac{V_u - \phi V_p}{\phi b_v d_v}\right)^2 + \left(\frac{T_u p_h}{\phi A_{oh}^2}\right)^2} \quad V_u = \sqrt{V_u^2 + \left(\frac{0.9 p_h T_u}{2A_o}\right)^2}$$

The shear-torsion-bending and axial force interaction needed for computing the longitudinal reinforcement is:

$$\phi (A_s f_y + A_{ps} f_{ps}) \geq \frac{M_u + 0.5N_u}{d_v} + \cot \theta \sqrt{(V_u - 0.5V_s - V_p)^2 + \left(\frac{0.45 p_h T_u}{2A_o}\right)^2}$$

The specific tasks of this proposed project will be developed after the project is approved and in consultation with the KDOT-assigned project monitor.

IV. ESTIMATE OF FUNDING AND RESEARCH PERIOD

Estimated project duration: 15 months (starting May 2007)

Estimated budget: \$ 39,000

V. URGENCY AND PAYOFF POTENTIAL

Implementation of the AASHTO LRFD 2004 is a must and it is inevitable to have a design tool that facilitates furnishing accurate design calculations and documentation for shear and torsion in reinforced and prestressed concrete members using AASHTO LRFD 2004. Accordingly, the research should have a high priority.

VI. IMPLEMENTATION STRATEGY

The software developed under this study will be available for immediate design implementation by the Bureau of Design at KDOT.

VII. PROJECT PERSONNEL

This project will be carried out under the direction of Hayder Rasheed, Principal Investigator and Asad Esmaily, Co-Principal Investigator, in close cooperation with the Bureau of Design. One graduate student in civil engineering will also work on this project. The project is appropriate for a master's thesis.

Hayder Rasheed holds a Ph.D. in Civil/ Structural Engineering from The University of Texas at Austin. His areas of specialty are structural engineering/mechanics, FRP composites and concrete behavior. He is particularly interested in the structural performance of concrete and FRP besides other structural applications. He is a registered Professional Engineer.

Asad Esmaily holds a Ph.D. in Civil/ Earthquake Engineering from University of Southern California. He has more than 11 years of experience in the experimental and analytical studies on reinforced concrete structures, including experimental and analytical work, as well as software development, on bridges in general and bridge piers in particular.

VIII. SUBMISSION INFORMATION

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