Project - Work Approach:

The first phase will examine the critical problem of controlling cracking in the 82W girders. This complex problem is controlled by effects of concentrated stresses, force transfer from pre-tensioning strand, inelastic behavior of the material in the transfer region of a girder and possible sources of restraint to girder deformation. A solution must include accurate modeling of the behavior verified by experimental measurements.

Analytical modeling will be employed to investigate internal tension stresses developed in the member ends during prestress transfer. The particular key factors that will be considered in accurate modeling of the girder end region include each of the following:

- use of elastic or inelastic analysis methods,
- modeling the inelastic tension softening behavior of the concrete after cracking has occurred,
- modeling the actual stress transfer mechanism between strand and concrete,
- conducting incremental analyses as strands are de-tensioned, and
- verifying that the analytic model is providing acceptable predictions of behavior.

Task 1 – Set Up Advisory Group – precasters and WisDOT engineers.

Task 2 - Initial Analysis:

We propose to initially use elastic analysis with SAP2000 finite element modeling to examine the stress conditions in the end of an 82W girder. A simplified strand-bond model will be employed. Restraint from unreleased strands will not be investigated since the observed cracking patterns are not consistent with that mechanism, but effects of the detensioning sequence will be included. The purpose of the elastic analyses will be to determine if there are obvious conditions of high tensile strain in the girder and where they are located.

If high tensile strains are identified through the elastic analysis, then inelastic analysis methods will be employed to determine the extent and amount of predicted cracking. Analysis will be conducted on a girder size that will also be available from a precaster for instrumentation in Step 3. This process will require careful and accurate modeling of the strand-bond behavior and the tension softening of the concrete after cracking. Incremental detensioning effects will again be examined. The analyses will provide detailed strain predictions as well as extent of cracking.

Task 3 – Experimental Verification:

The accuracy of the analysis methods defined in step 1 will be checked by comparison with experimental test results.

First the literature will be examined and other DOT's and researchers will be contacted to find existing girder test results. The developed analytic methods will be applied to the girders tested in those programs to obtain an initial check on their accuracy.

Secondly, we will work with the precasters in Wisconsin to instrument an actual bridge girder from the ‘W” family before concrete placement. The girder will be gaged to measure internal and external concrete strains near the end as well as strains in the strand. Addtitional gages will be embedded near midspan to provide information relating to creep, shrinkage and deformation of the beam. Monitoring of the strains will be conducted as the strand are detensioned. The output from additional gages at midspan will be available for future long term monitoring. The end strain test results will be compared directly with the predictions produced in step 1 to verify the quality of the modeling procedure or provide clues to improvements needed. The analytic model will be revised if needed.

Task 4 - Girder Simulation:

The verified analytic modelling will then be used to examine possible end cracking in 54W, 72W and 82W girders with at least 3 different strand patterns each (including draped and undraped). The analytical model will be built so that model elements can easily be removed to create a modified model of girders with coped top flanges at the ends per WisDOT specification of a cope size and pattern.

Based on the analysis results and recommendations in the literature, reinforcement design will be suggested and the impact of the reinforcement on changing the girder stresses and possible cracking will be evaluated. This method will be used to develop suggestions for girder detailing and de-tensioning to control cracking.

Task 5 - Develop Standard Detailing Suggestions:

Marked up/redline standard detail drawings will be provided with suggested modifications to girder detailing in section 19 of the WBM Standards.

Task 6 - The analytical computer models used to simulate the girder behavior will be provided on CD to WisDOT for possible in-house future analysis work.

Task 7 – Submit and Modify Final Report:

A final report will be prepared summarizing all of the activities detailed above. The draft report will be forwarded to the WHRP by October 2010 for review with a final version submitted by January 1, 2011.

<u>Anticipated Results:</u>

The expected result of the phase 1 research will be:

1. a description of the causes of 82W end region girder cracking based on verified analytical and experimental studies,
2. analytic inspection results that will suggest whether 54W and 72W girders may be susceptible to end region cracking,
3. detailing or detensioning sequence suggestions that would aid in controlling the extent of end region cracking in 54W, 72W and 82W girders, and
4. suggested standard detail drawings for any suggested modifications to end region reinforcing in 54W, 72W or 82W girders,

5. a final report describing the analysis procedures, verification work, parameter studies on the various girders, development of construction modifications, and the recommended modifications or standard detail drawings.

Future Research:

Additional phased research that may be desirable to better understand the current girder behavior and possible behavior of future spliced girders will be recommended in the final report of the project. This future work might include methods of predicting camber in girders, obtaining long term data from the gages embedded in a bridge girder during this project, and developing designs for post-cast endblocks that could be built onto the current "W" girders to allow future spliced girder construction with post-tensioning.

References:

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5. Davis, H., C. Buckner, C. Ozyildirim, "Serviceability Based Design Method for Vertical Beam End Reinforcement", Proceedings PCI-FHWA National Bridge Conference, Oct 2005
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11. Zia, P., A. Caner, "Cracking in Long-Span Prestressed Concrete AASHTO Girders During Production", Proceedings PCI-FHWA-FIB Intl. Symposium on High Performance Concrete, Oct 2000
12. Baran, E., C. Shield, C. French, T. Wyffels, "Analysis of the Effects of Vertical Pre-Release Cracks on Prestressed Concrete Bridge Girders", PCI Journal, V49, N6, Nov 2004

WORK TIME SCHEDULE

The proposed research will be conducted over a 15-month period according to the schedule below:

YEAR ONE (2009-10)	Oct ‘09	Nov	Dec	Jan ‘10	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Set up Advisory Group												
2. Initial analytical investigation of 82W girder												
3. Experimental verification of analytic method												
4. Analytical simulations of 54W, 72W and 82W girders crack investigations												
5. Recommendations for modifying girder production technique												
6. Final report preparation												

YEAR TWO (2010-11)	Oct	Nov	Dec	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
8. Final report finalization												

Table 3: Summary of Hours

INDIVIDUALS	TASKS							TOTAL HOURS
	1	2	3	4	5	6	7	
Principal Investigator	4	15	20	15	6	15	3	78
Graduate Students/Senior Staff	20	200	160	360	120	120	240	1220
Hourly Students/Junior Staff			50	50				100
Office Staff								0
TOTALS	24	215	230	425	126	135	243	1398