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Bridge Strengthening by Post-Tensioning

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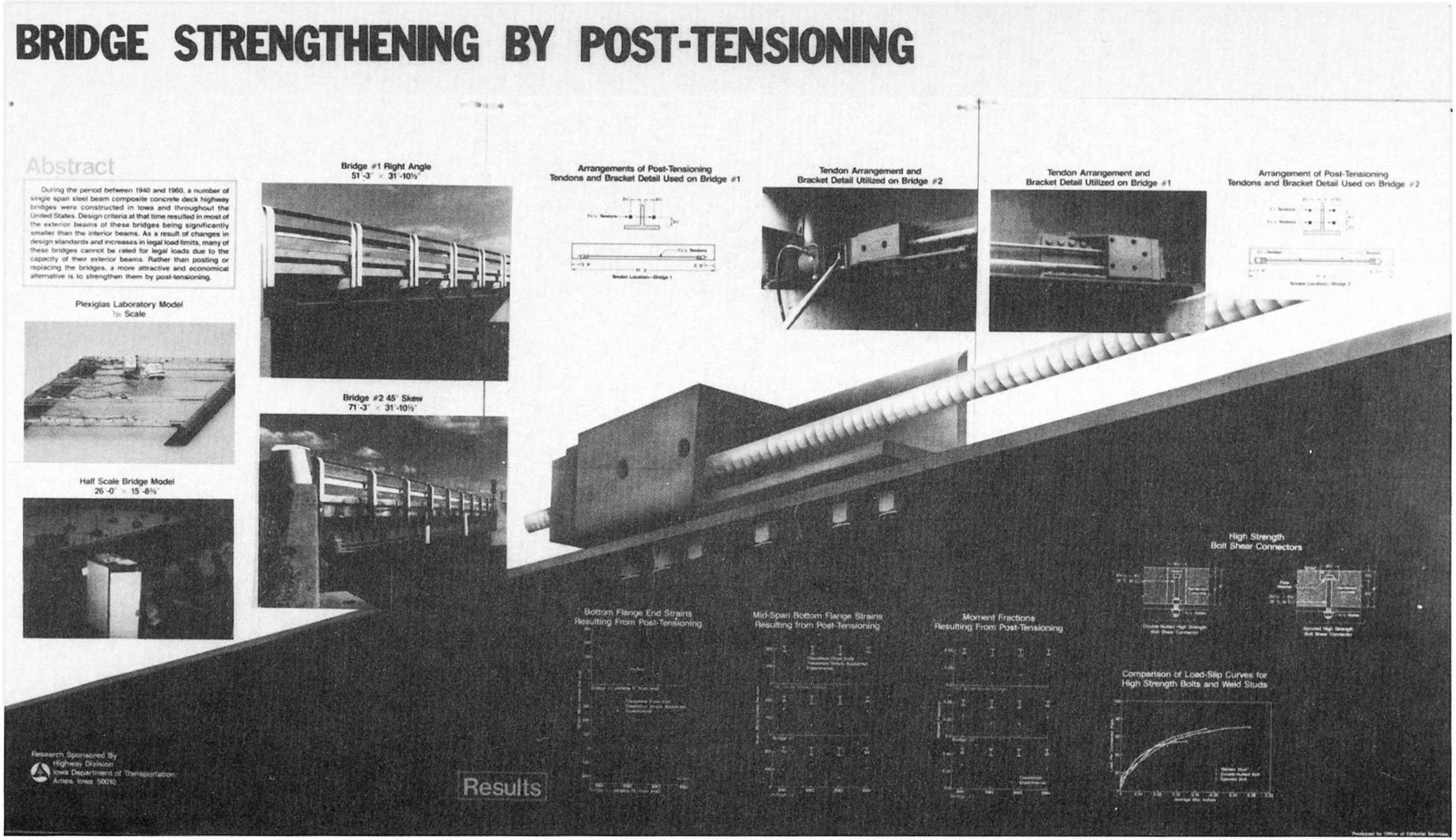
During the period between 1940 and 1960, a number of single span steel beam composite concrete deck highway bridges were constructed in Iowa and throughout the United States. Design criteria at that time resulted in most of the exterior beams of these bridges being significantly smaller than the interior beams. As a result of changes in design standards and increases in legal load limits, many of these bridges cannot be rated for legal loads due to the capacity of their exterior beams. Rather than posting or replacing the bridges, a more attractive and economical alternative is to strengthen them. With research grants from the Iowa Department of Transportation and the Iowa Highway Research Board, a method of strengthening these bridges by post-tensioning has been developed. This study was divided into three phases. Phase I involved the development of bracket designs and the post-tension strengthening and testing of a half-scale model bridge in the laboratory. Phase II - the majority of which was completed during the summer of 1982 - involved the strengthening and testing (before and after strengthening) of two actual bridges. The final phase of the study (Phase III) involves the periodic inspection of the two bridges, their retesting during the summer of 1984, and the development of a practical design methodology for the strengthening technique. The major finding of Phases I and II was that post-tensioning is an economical and viable strengthening method. As may be noted in the graphs, there was considerable end restraint in both bridges (Bridge No. 1 and Bridge No. 2). Thus the post-tensioning was more effective in the laboratory models than on the actual bridges (due to the fact that there was no end-restraint). The end restraint on Bridges No. 1 and 2, however, also reduced the live load stresses. Thus in effect the end restraint effect on live load stresses and post-tensioning stresses compensate each other. Phase III of the study has been completed and the final report is presently being prepared. Both bridges previously strengthened were retested. Very little change was noted in their behavior from that noted during their initial strengthening two years earlier. The retesting made possible the determination of loss of prestress in both bridges; Bridges No. 1 and No. 2 had losses of approximately 5% and 7% respectively. This loss is primarily due to relaxation of the end restraint previously noted. Through the use of orthotropic plate theory and finite element models, a practical design methodology for determining the required post-tensioning forces has been developed for the design engineer and is included in the final report being prepared.


BRIDGE STRENGTHENING BY POST-TENSIONING
Abstract
During the period between 1940 and 1960, a number of single span steel beam composite concrete deck highway bridges were constructed in Iowa and throughout the United States. Design criteria at that time resulted in most of the exterior beams of these bridges being significantly smaller than the interior beams. As a result of changes in design standards and increases in legal load limits, many of these bridges cannot be rated for legal loads due to the capacity of their exterior beams. Rather than posting or replacing the bridges, a more attractive and economical alternative is to strengthen them by post-tensioning.
Plexiglas Laboratory Model
Scale
Half Scale Bridge Model
26'-0" × 15'-8⅜"
Bridge #1 Right Angle
51'-3" × 31'-10½"
Bridge #2 45° Skew
71'-3" × 31'-10½"
Arrangements of Post-Tensioning Tendons and Bracket Detail Used on Bridge #1
Tendon Arrangement and Bracket Detail Utilized on Bridge #2
Tendon Arrangement and Bracket Detail Utilized on Bridge #1
Arrangement of Post-Tensioning Tendons and Bracket Detail Used on Bridge #2
High Strength Bolt Shear Connectors
Bottom Flange End Strains Resulting From Post-Tensioning
Mid-Span Bottom Flange Strains Resulting from Post-Tensioning
Moment Fractions Resulting From Post-Tensioning
Comparison of Load-Slip Curves for High Strength Bolts and Weld Studs
Results
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