HR-238 Strengthening Existing Single Span Steel Beam Concrete Deck Bridges

Key Words: Post-tensioning, Single span steel beam concrete deck bridges, Bridge Strengthening

ABSTRACT

A considerable number of single span, composite concrete deck and steel beam bridges in Iowa, as well as in most states, presently cannot be rated to carry today's design loads. This problem was initially addressed in the research project, HR-214, "Feasibility Study of Strengthening Existing Single Span Steel Beam Concrete Deck Bridges", henceforth referred to as Phase I. The research of Phase I verified that post-tensioning can be used to provide strengthening of the composite bridges in question. This was determined analytically, using a modification of the orthotropic plate theory, and experimentally, through testing of various post-tensioning schemes on a half-scale model bridge.

Because of the importance of the strengthening problems and the wide range of variables, a second research study was undertaken. The second study involved two parts. As the second study was a continuation of the feasibility study (Phase I), the two parts, henceforth, will be referred to as Phases II and III. The primary emphasis of Phase II involved the strengthening of two full-scale prototype bridges. One of the bridges was a prototype of the model bridge tested during Phase I; the other bridge was larger and skewed.

In addition to this field work, Phase II also involved a consider-able amount of laboratory work. A literature search revealed that only minimal data existed on the angle-plus-bar shear connectors. These several specimens utilizing angle-plus-bars, as well as channels, studs and high strength bolts utilized as shear connectors were fabricated and tested. To obtain additional shear connector information, the bridge model of Phase 1 was sawed into four composite concrete slab and steel beam specimens. Two of the resulting specimens were tested with the original shear connection, while the other two specimens had additional shear connectors added before testing. In this way, the effect of the additional shear connectors could be determined.

One of the bridges selected for strengthen-ing was a 45° skewed bridge. Although orthotropic plate theory was shown in Phase I to predict vertical load distribution in bridge decks and to predict approximate distribution of post-tensioning for right -angle bridges, we questioned whether the theory could also be used on skewed bridges. Thus, a small plexiglas model was constructed and used in vertical load distribution tests and post-tensioning force distribution tests for verification of the theory.

Phase III of the investigation involves the inspection of the two strengthened bridges approximately every three months for a period of two years. Both bridges are tested under service loads to determine if

there are any behavioral changes from the initial service load tests.

The overall objective of Phase I of the study was to determine the feasibility of strengthening the type of bridges in question by post-tensioning. As a result of the successful completion of Phase I of the study, Phase II was undertaken with the overall objective of designing and installing post-tension strengthening on two existing bridges. After the bridges were strengthened, they both were tested to determine the effectiveness of the post-tension strengthening systems. Before the field strengthening systems could be designed, additional data were needed on the strength of the angle-plus-bar shear connectors, thus requiring the additional laboratory work in Phase II.

In line with the overall objective of Phase II of this study, the following secondary objectives were established:

- Determine load distribution before and after post tensioning in actual bridges.

- Determine vertical load and post tension force distribution in skewed bridges.

- Determine strength and behavior of angle plus bar shear con-nectors and compare with other shear connectors, such as studs and channels.

- Develop a simple method of adding shear connectors to existing construction and evaluate their strength and effectiveness.

Determine if there are any field problems in employing the post-tensioning scheme developed during Phase I that did not exist in the laboratory. Field experimental results were compared with theoretical predictions obtained from orthotropic plate theory. Laboratory experimental results were compared with theoretical predictions using appropriate theories.