Ontario

Small Bars Lead to Large Savings

Problem

Since 1971 the Ontario Ministry of Transportation and Communications (MTC) has allowed commercial vehicles weighing up to 140,000 lbs. on its highway system and has issued single-trip permits to vehicles weighing up to 245,000 lbs. on a regular basis. Faced with growing evidence of extensive spalling on bridge decks caused by deicing chemicals, MTC officials needed to determine if deteriorated decks would be able to support these loads. The surprising results of research undertaken have enabled the MTC to realize significant savings in the cost of new bridge decks.

When Ontario, like many other jurisdictions, introduced deicing chemicals to help increase traffic safety and mobility in cold weather, the adverse effects of the chemicals on bridge decks were unknown. Deck deterioration, and potential decrease in flexural strength, soon became a widespread problem. Despite this development, structural failures of bridge decks were rare. It appeared, therefore, that concrete decks resisted heavy wheel loads in a way other than the flexural mechanism that is the basis for deck design in the *AASHTO Standard Specifications for Highway Bridges*. But how? Research on this question was subsequently conducted by the MTC.

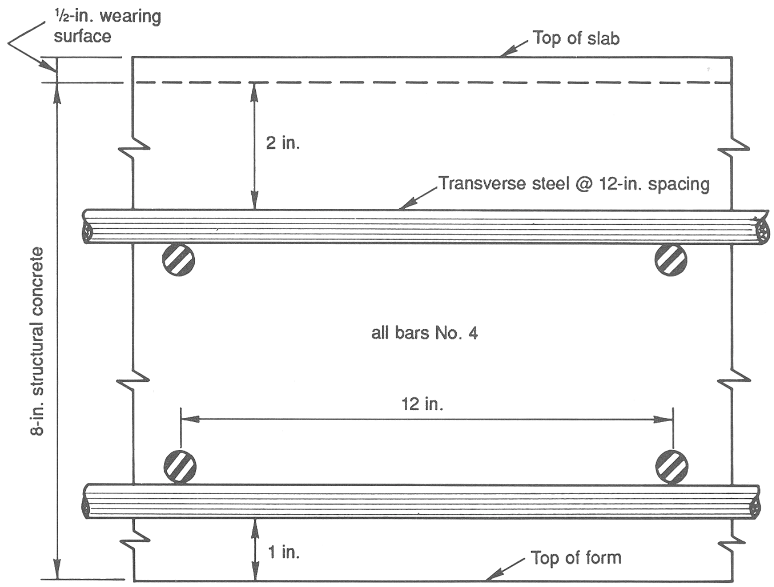
Solution

To better understand the actual behavior of concrete bridge decks, the MTC organized a research program that included laboratory and field tests. Model studies were carried out, most of which were conducted at Queens University, Kingston, Ontario, under contract with the MTC. Some of the test results were surprising. It was found, for example, that the amount of reinforcing steel and the strength of the concrete had only minor influence on the load-carrying capacity of bridge decks. Also, an unreinforced deck could carry as much as 80 percent of the maximum load of its normally reinforced counterpart. The research demonstrated that the decks' load-carrying capacity is controlled by mechanisms other than flexure, such as punching shear and deck arching action.

In the second phase of the research, heavy loads were applied to in-service bridges using a special MTC vehicle. The condition of the bridges ranged from new to condemned. In 300 tests conducted with a simulated wheel load of 100,000 lbs., only two failures occurred, both on the same bridge, which had a severely deteriorated deck.

The test results thus indicated that even deteriorated bridge decks could still regularly carry heavy legal and special-permit loads. Equally important, the results also suggested that bridge decks could be designed with reduced amounts of reinforcing steel, which significantly reduces the overall cost of the structures.

In 1975 the MTC built a test bridge over the Conestogo River. The deck included test panels with steel reinforcement varying from 20 to 100 percent of the normal amount used. Despite 10 years of service under Ontario's heavy traffic loads, there is no evidence of adverse effects due to even the most severe reduction in deck reinforcement.



Deck cross section showing standard isotropic bar placement.

Application

As a result of the research, the first edition (1979) of the *Ontario Highway Bridge Design Code* allowed a minimum of 0.3 percent reinforcement (the reinforcing steel area as a percentage of the effective deck cross section) for isotropically designed bridge decks—more than two-thirds less than the reinforcement normally used.

Since 1982, the state of New York has also been involved in an experimental program in which the isotropic bridge deck design method is being examined. To date, New York has placed eight bridges with isotropic decks in service. Results of field tests and visual inspections are encouraging, and the state intends to use the design for other bridges whenever possible.

In addition, Texas and Florida are studying the isotropic bridge deck design method. Texas is monitoring one test structure and expects to use the method increasingly. The Florida Department of Transportation has initiated a research project through the University of Florida to address other questions related to the isotropic bridge deck design method. The Florida DOT is also planning to begin using isotropic bridge decks on state-funded projects.

Benefits

In a conventional AASHTO bridge deck design, the amount of transverse reinforcement increases with the spacing between girders. Small diameter bars are used only rarely as closely spaced transverse reinforcement. In isotropic bridge deck design, smaller bars are equally spaced at 12-inch centers in both directions in the top and bottom of the slab, leading to a significant cost savings.

The Ontario Ministry of Transportation and Communications estimates that more than $1 million per year in steel reinforcing costs has been saved by using the isotropic deck design method.

The states of New York and Florida estimate that the per square foot savings to be realized by using this method is between $1.25 and $3.00, depending on girder spacing. It has also been estimated that, conservatively, this method would save Florida $7 million annually.

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Suggestions for "Research Pays Off" articles are welcome. Contact Nancy A. Ackerman, Editor, TR News, *Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2972).*