

# MATES

## MICHIGAN DEPARTMENT OF TRANSPORTATION

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### BRIDGE DECKS - PART I

When you take the road off the ground, and put it in the air, a whole new set of problems arise in terms of building and maintaining it. Bridge construction and maintenance problems fall into two general categories, the deck and its supporting structures. Since the supporting structures are rather massive and stable, it is the relatively light, thin decks that pose most of our general maintenance problems. Maintaining them is an ever increasing task, compounded annually by growing traffic volumes, increasing truck loadings, aging of the systems, deicing chemicals and fluctuating monetary constraints. Our State trunk-line system (routes designated M, US, or I) includes approximately 4,400 bridges, of which 1,450 are over 30 years old. Of these 1,450 structures, approximately 460 are in the 50 to 60-year category with 180 of them older than 60 years. Our most recent statistics indicate that close to 40 percent of our bridges are classified as either structurally deficient or functionally obsolete. Functional obsolescence may consist of such things as narrower widths, shorter sight distances, steep vertical curves, etc.

Although not posing an immediate danger to the motoring public, the structurally deficient bridges cannot carry the full legal loads. These bridges also pose serious problems for the Department when considering options for their maintenance, rehabilitation, or replacement. The investigations, evaluations, and analysis procedures that lead to the final decision to maintain, rehabilitate, or replace are beyond the scope of this article. This two-part presentation will focus attention on the evaluation procedures and rehabilitation options associated with the bridge deck only.

#### Concrete Deck Deterioration

The deterioration of concrete in bridge decks occurs mainly as a result of active corrosion of the reinforcing steel caused by intrusion of chloride ions from deicing salts, and the freeze-thaw degradation of the coarse aggregates and concrete mortar. Cracks caused by shrinkage, poor curing, moisture and temperature changes, and loads provide numerous open pathways for water and deicing salts to invade the concrete slab. Further, the porous micro-structure of the concrete mortar and the aggregate pore structure provide additional avenues through which water and chemicals migrate into uncracked concrete initiating the freeze-thaw degradation process. Although today's concrete mix designs and components are much more resistant to the forces of deterioration than the concrete used in years past, we are still faced with solving the problems encountered in the rehabilitation of 30 to 60 year old bridge decks.

#### Bridge Deck Inspection

The Federal Highway Administration (FHWA) requires all bridges to be inspected at least every two years. These inspections are performed by MDOT Maintenance Division bridge engineers. Bridges with critical design features, such as bascule (lift) bridges or bridges with non-redundant girders, are inspected on an annual basis. A non-redundant girder is one that has no 'back-up' member to carry its load should it fail. Bridges in serious need of rehabilitation or replacement, but not yet programmed, are inspected on a more frequent basis.

During their inspection the bridge maintenance engineers evaluate and rate about 25 different components or aspects of the total structure. The bridge deck and its associated elements (joints, sidewalks, curbs, railings, etc.) are visually inspected and individually rated. A bridge deck condition rating is generally based on the proportion of patched and delaminated areas, extent of surface cracking, and the extent of cracking and leaching on the underside of the deck.

Overall structure condition ratings are computed based on weighted summations of the individual component ratings. The overall structure condition ratings are ultimately used to generate an initial bridge "Call for Projects" list. The bridge Call for Projects is a prioritized list of statewide bridge rehabilitation and replacement projects prepared by the Maintenance Division. After District review and input, the final bridge Call for Projects list is generated. Maintenance Division bridge engineers then make initial recommendations as to appropriate maintenance or rehabilitation actions for all bridges on the Call for Projects. The list and recommendations are forwarded to the Program Administration and Program Planning Divisions where they are incorporated into the Department's annual program strategy. After approval of the annual program by the Transportation Commission, and verification of appropriate funding, job numbers are issued and Design Division project managers are assigned, and the bridge repair design process begins.

#### Bridge Deck Evaluation

During the preliminary engineering phase of a bridge rehabilitation project involving bridge deck work, the Design squad formally requests the Materials and Technology (M&T) Division to conduct a deck survey. Deck surveys typically include the following:

Delamination Survey - A delamination is a horizontal physical separation of the concrete, usually located just above the top steel reinforcing layer (See MATES, February 1988, Issue No. 16). Delamination surveys locate areas of the deck where evidence of concrete delamination may or may not be visible. Visible delaminations, or spalls, are easily located and mapped. Delaminations or hollow areas where the overlying concrete is still in place are located and mapped by dragging chains across the deck or tapping the deck with a rod or hammer. Automated delamination detection methods using an electronic delamination detection device have been used in the past; however, survey reliability and set-up and down time were major drawbacks of this method, and it is not being used now.

Chloride Sampling - Taking chloride analysis samples involves collecting small samples of pulverized concrete from the bottom of a drill hole at two levels in the deck. An electronic instrument called a pachometer is used to determine the depth and location of the steel reinforcement. The first sample is taken at a level approximating the top bar of the top mat of steel reinforcement. The second sample is taken at the level approximating the bottom bar of the top mat of reinforcement. The total number of chloride samples taken on a particular bridge deck depends upon its surface area.

Coring - Cores are taken to determine the 'soundness'

and strength of the existing deck concrete. Cores for compression testing are generally taken from 'good' areas of the deck. A good area is an area free of delaminations, spalls, and excessive cracking.

Visual inspection (VI) cores are used for assessing existing concrete conditions, and in determining the extent or boundaries of deterioration. Visual inspection cores are generally taken in 'visually bad' or questionable areas of the deck. A VI core through an existing asphalt patch will allow visual evaluation of the concrete below the patch. A series of VI cores taken around the perimeter of a patched area will help in determining if the concrete is sound or if the delamination has continued to grow. A VI core may be taken in a badly cracked area to determine the extent of deterioration in that area.

**Recommendations** - After full evaluation of the collected field data and the laboratory test results (compressive strengths and chloride analyses) the M&T engineer makes a recommendation to the Design Division as to an appropriate deck rehabilitation action. The recommended action generally would specify rehabilitation by patching or use of an overlay, or would specify full-depth removal and replacement of the deck.

#### Bridge Deck Rehabilitation

The Department has developed only general guidelines governing the decision to do a specific rehabilitation action or the decision to completely replace a bridge deck. Design Division "Informational Memorandum #402-B" summarizes guidelines for bridge deck rehabilitation as recommended by a committee composed of Maintenance, Construction, M&T, and Design Division engineers. The decision as to an appropriate rehabilitation action is primarily a function of the following factors:

- 1) Whether a temporary repair or permanent rehabilitation is desired (e.g., Is the bridge to be replaced in a few years?).
- 2) Is the existing deck sound, i.e., relatively free of cracking and spalling. If much of the concrete proves to be unsound the deck should be replaced.

3) The structure's geographic location. The cost of overlay concrete in remote locations, primarily the upper and northern lower peninsulas, is excessive and complete replacement may be more cost effective in these areas.

4) The amount of chloride determined to be in the deck concrete. Decks containing less than 4 lb/cu yd of total chloride are generally good candidates for rehabilitation by overlay. When the chloride content exceeds 4 lb/cu yd there are no clear guidelines or criteria that can be applied concerning an overlay. The Department places overlays on some of these decks at the present time pending the developments of ongoing research.

5) The proportion of deck area delaminated or spalled. If less than 30 percent of the total area is defective, and analysis indicates chloride levels 4 lb/cu yd or less, then an overlay may be appropriate after proper removal of defective concrete. When 30 to 50 percent or more of the deck concrete is found to be defective then complete replacement is generally the more cost effective option.

Concrete T-Beam bridges present a unique deck rehabilitation problem. These are reinforced concrete bridges with the beams cast along with the deck, thus the deck slab is an integral part of the structural support system and cannot be removed without dismantling or temporarily supporting the entire superstructure. Thus, some special measures are often warranted to salvage the deck on this type of bridge.

The evaluation and analysis of existing bridge deck condition is far from an exact science. Appropriate rehabilitation decisions are based upon the condition of the deck, general guidelines, engineering judgement, and years of experience. Cost effective recommendations aimed at renewing the structural integrity of the deck, improving the structure's overall condition rating, and adding years of service life, are the ultimate goals of this decision process.

Part II of this article, which follows next month, will discuss bridge deck rehabilitation options, and will review developing trends in the rehabilitation techniques and deck condition evaluations.

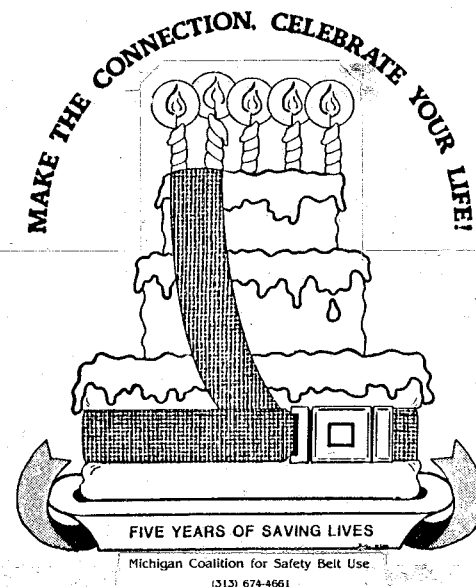
-Glenn Bukoski

## TECHADVISORIES

The brief information items that follow here are intended to aid MDOT technologists by advising or clarifying, for them, current technical developments, changes or other activities that may affect their technical duties or responsibilities.

#### PERSONNEL NOTES

We are pleased to note the promotions of **Ralph Vogler**, who takes over as head of the Testing Laboratory Section, and **Larry Heinig**, new head of the District Support Section. Ralph began his MDOT career with M&T (then the Testing & Research Division) over 34 years ago at the old Testing Laboratory in Ann Arbor. Larry, who started with the Department 28 years ago, came to work in the M&T Division after a brief period in the Construction Division. Both of these veteran Division members have made countless contributions over the years, and we are indeed fortunate to have people of their caliber to fill these two key positions...**Dan Vriebel** returns to M&T, after serving in the Traffic & Safety Division, to become Assistant Bituminous Engineer, Bituminous Technical Services Unit, Testing Laboratory...**Steve Beck** is on loan from the Construction Division, cross-training in M&T, acting in Jens Simonsen's position in the Research Laboratory's Materials Research Unit. Congratulations Larry and Ralph on your promotions, and welcome to Dan and Steve.



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