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A study on rehabilitation methods for deformed pavements

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Abstract

Pavement rehabilitation is defined as a structural or functional enhancement of a pavement which produces a substantial extension in service life, by substantially improving pavement condition and ride quality. Pavement maintenance activities, on the other hand, are those treatments that preserve pavement pavement condition, safety, and ride quality, and therefore aid a pavement in achieving its design life. The current article discusses the rehabilitation methods for deformed pavements.

Keywords: Pavement, Rehabilitation, Concrete

1. Introduction

Individual rehabilitation treatments are often categorized as belonging to one of the “4 R’s” – restoration, resurfacing, recycling, or reconstruction. There are some problems with trying to fit each rehabilitation treatment into one of these four major categories. For example, some treatments may be done as part of a restoration effort or as part of a resurfacing effort. The 4 R’s are good descriptors of the type of rehabilitation effort most appropriate at a given point in a pavement’s life, but are less useful as a classification scheme for rehabilitation treatments than as.

Recycling is the process of removing pavement materials for reuse in resurfacing or reconstructing a pavement (or constructing some other pavement). For asphalt pavements, this process may range from in-place recyling of the surface layer, to recycling material from all pavement layers through a hot mix plant. For concrete pavements, recycling involves removal and crushing for reuse as aggregate, either in the reconstruction of the pavement or for surface, base, or subbase layers in other pavement construction. Recycling of asphalt-overlaid concrete pavement may be either surface recycling or removal and recycling of both asphalt and concrete. In this case, the asphalt and concrete layers are removed and recycled separately. Reconstruction is the removal and replacement of all asphalt and concrete layers, and often the base and subbase layers, in combination with remediation of the subgrade and drainage, and possible geometric changes. Due to its high cost, reconstruction is rarely done solely on the basis of pavement condition. Other circumstances, such as obsolete geometrics, capacity improvement needs, and/or alignment changes, are often involved in the decision to reconstruct a pavement.

Asphalt concrete pavement is also sometimes referred to as asphalt pavement or flexible pavement. Asphalt pavement on untreated or treated base has a hot-mixed asphalt concrete surface, usually over a base layer which may be either untreated or treated granular material, and possibly a subbase layer (usually untreated). Full-depth asphalt concrete pavements are those in which all layers contain an asphaltic binder. The asphalt concrete layers (which may be of different gradations and asphalt cement contents) are constructed directly on the prepared subgrade.

Jointed reinforced concrete pavement (JRCP) has transverse joints typically spaced more than 20 ft apart. The reinforcement (welded wire fabric or deformed steel bars) comprises about 0.15 to 0.25 percent of the cross-sectional area of the slab. Due to its longer joint spacing, jointed reinforced concrete pavement is expected to develop midslab cracks. The purpose of the steel reinforcement is to keep these cracks tight. Transverse joints are typically doweled in jointed reinforced concrete pavement. Continuously reinforced concrete pavement (CRCP) does not have transverse joints, other than the transverse construction joints placed at the end of each day’s paving and at abutting pavement ends and bridges. Continuously reinforced concrete pavements have a considerably higher steel content than jointed reinforced concrete pavements – typically 0.6 to 0.8 percent of the cross-sectional area. The purposes of the longitudinal steel are to control the spacing of cracks resulting from drying shrinkage and temperature changes and to keep these cracks tight. Transverse reinforcing steel is often used to support the longitudinal steel during construction and to control any random longitudinal cracks which may develop. All three types of concrete pavements are usually constructed on a layer of untreated or treated granular material, commonly referred to as the base layer. In some cases, a lower-quality gravel is used to separate the base from the subgrade. This layer is commonly referred to as the subbase.

1.1 Traffic Analysis

The current traffic volumes and axle loadings and anticipated traffic growth rates should be determined. With this information, traffic volumes and axle loadings may be forecasted for the design traffic lane (usually the outer lane in one direction) over whatever design periods are later selected for the rehabilitation strategy alternatives considered. For the purposes of pavement rehabilitation strategy selection, the current and projected future traffic should be characterized in terms of whatever traffic input is used in the resurfacing and reconstruction design procedures used by the agency.

In the 1993 AASHTO methodology, which is used by many State DOTs, the mixture of anticipated axle loads is expressed in terms of an equivalent number of 18-kip single-axle loads (ESALs). The Asphalt Institute procedures for asphalt pavement design3 and overlay design4 also use ESALs as the traffic input. The Portland Cement Association procedures for concrete pavement design5 and concrete overlay design6 use the axle load data directly.

If either site-specific or general truck axle frequency distribution data are available, equivalent slab thicknesses and Structural Numbers can be computed for any design terminal serviceability and total truck axle volume, by the following procedure.

1. Use the total truck axle volume and truck axle frequency distribution information to determine the number of axles of each type (single, tandem, tridem) in each axle load group.
2. For the selected design terminal serviceability, compute the rigid and flexible load equivalency factors corresponding to the midrange of each axle load group considered.
3. Multiply the number of axles in each load group by the rigid and flexible load equivalency factors calculated for that load group, and sum the rigid and flexible ESALs calculated in each load group to determine the total rigid and flexible ESALs.
4. Solve for the concrete slab thickness and the flexible pavement Structural Number that both yield 1:1 ratios between the total ESALs computed in Step 3 and the ESALs computed from the basic AASHTO design equations for an 18-kip single axle. The rigid and flexible ESALs thus obtained are equivalent.

1.2 Distress Survey

Rehabilitation of a pavement is most likely to be successful – that is, provide satisfactory performance and cost-effectiveness – if it is selected on the basis of knowledge of the types of distresses occurring in the pavement and the causes for those distresses, and it effectively repairs those distresses. A good understanding of the types of distress which may occur in different types of pavements, and the causes for those distresses, is therefore essential to the success of pavement rehabilitation.

For network-level management purposes, distress surveys are sometimes conducted over a sample of the full project length, e.g., 10 percent. For project-level purposes, however, sampling of a greater portion of the project length is necessary to accurately quantify the distress present. In some cases it may be advisable to sample the full project length, i.e., 100 percent. Automated devices are also available for use in conducting distress surveys. These devices operate at highway speeds without disrupting traffic, and thus are particularly well suited to hightraffic-volume situations. Information on the capabilities of some automated distress survey devices is summarized in NCHRP Synthesis 203, Current Practices in Determining Pavement Condition.

1.3 Nondestructive Deflection Testing

While some agencies may not be equipped for nondestructive deflection testing, such testing is always highly desirable, especially when the distress survey indicates that the pavement requires a structural improvement. A Falling Weight Deflectometer (FWD) or other device capable of applying loads comparable in magnitude to truck wheel loads is recommended for this purpose. Nondestructive deflection testing devices are classified according to loading method: static (e.g., Benkelman Beam), vibratory (e.g., Dynaflect, Road Rater), or impulse, commonly called falling weight deflectometers or FWDs (e.g., Dynatest, KUAB). An example of a Dynatest FWD is shown in Figure 8, and an example of a KUAB FWD is shown in Figure

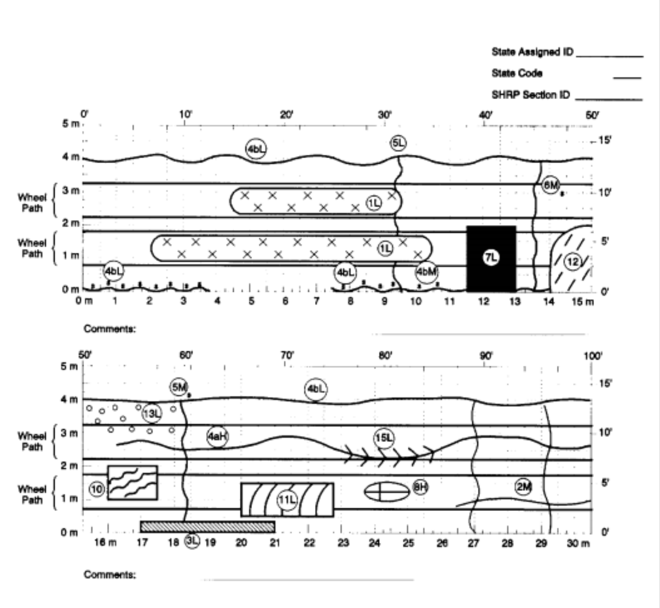

Fig 1: Example distress survey map for asphalt pavement

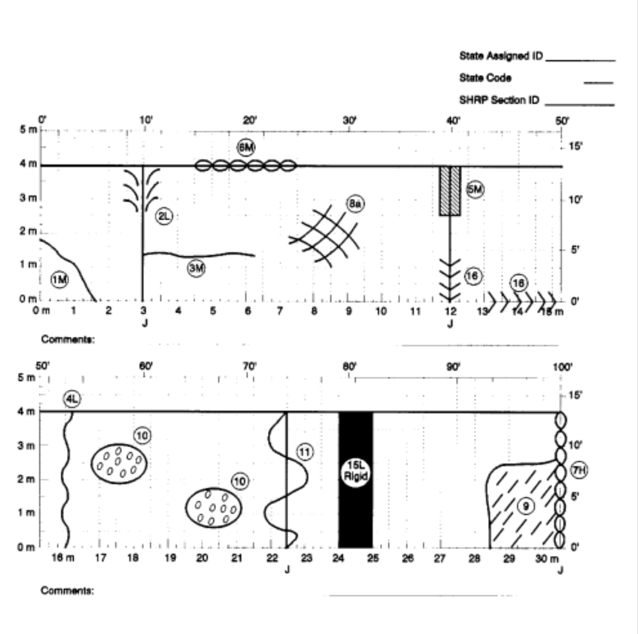

Fig 2: Example distress survey map for jointed concrete pavement

1.4 Purposes of Deflection Testing

Deflection testing is conducted on asphalt pavements for the purposes of back calculating the stiffnesses of the subgrade and pavement layers, assessing the remaining life of the pavement, and/or determining the overlay thickness required to satisfy a structural deficiency. Asphalt highway pavements should be tested in the outer wheel path of the outer traffic lane, which is just one to two feet from the lane edge, for the purpose of attempting to assess the extent of fatigue damage. The assumption of infinite horizontal layers is thus violated, but this is generally ignored. Deflection testing on concrete pavements is conducted at slab interiors, to back calculate the stiffnesses of the subgrade and pavement layers; at transverse and longitudinal joints and cracks, to measure deflection load transfer and differential deflection, and at slab corners, to detect voids under the slabs.

On concrete highway pavements, slab interiors are usually tested at the middle of the outer lane, for the purpose of backcalculating the dynamic modulus of subgrade reaction (k value) and concrete elastic modulus. A concrete slab of highway lane width (typically 12 ft) is narrower than that required to comply with the infinite horizontal layer assumption, so adjustments for the finite slab size are required when analyzing the deflection data. Interior deflections are not measured on concrete slabs with the goal of directly assessing the fatigue damage, so testing at the midwidth of the slab is no different than testing in the outer wheelpath, and may be preferable from the standpoint of keeping the load plate as far away as possible from the lane/shoulder edge.

Testing in the outer wheel path may be more convenient, however, if interior tests and joint load transfer tests are to be combined in one pass down the traffic lane. Deflection load transfer is measured for use in estimating the distribution of stress between adjacent slabs, which may be used in a mechanistic analysis of the fatigue life of the pavement. Deflection load transfer is also considered to be related to the development of faulting at joints and cracks.

The deflection load transfer at transverse joints may also be used to select a load transfer coefficient (J factor) for use in the 1993 AASHTO method of overlay design. For all of these purposes, however, deflection load transfer measurements need to be adjusted for slab temperature in order to be meaningful. One set of deflection measurements can be used to calculate both differential deflection (loaded side deflection minus unloaded side deflection) and deflection load transfer (ratio of loaded side deflection to unloaded side deflection). Differential deflection is more relevant than the deflection load transfer to the rate of deterioration of joints and cracks, and to the likelihood of reflection cracking in asphalt overlays.

2. Conclusion

The rehabilitation strategy which is ultimately selected may simply be that which was found in the life-cycle cost analysis to be most cost-effective. However, in many cases, an agency will wish to weigh the cost analysis results with other decision factors that cannot be expressed in monetary terms. Here too, relative weights may be assigned to various monetary and nonmonetary factors, according to the relative importance of those factors to the agency.

The conduct of a project has demonstrated clearly that, despite the enormous amount of funding dedicated to pavement rehabilitation, the pavement field’s ability to predict the performance of different rehabilitation techniques – primarily as a function of their time of application, pre-overlay repair, and thickness design – remains very limited. A great deal has been written about how rehabilitation techniques should be constructed and what materials should be used, but relatively little useful research has been done into how long and how well these different rehabilitation techniques perform.

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