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Review on Study of Rigid Pavement

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ABSTRACT- In a developing like a India, the construction and improvement of high quality roads plays an important role. In this research paper, chi-square hypothesis is performed to study different parameters for designing rigid pavement. The hypothesis performed includes Relationsheep between time and deflection This report outlines the design, instrumentation and construction of a portland cement concrete pavement capable of evaluating nondestructive testing (NDT) equipment such as the Dynaflect and the Falling Weight Deflectometer. To test these devices, several variables that affect their output (i.e., deflection) will be recorded. The variables that will be supervise at the test facility are subsurface moisture content, slab temperature gradient, voids, warping, and load transfer across a joint This report summarizes the investigations undertaken by the University of California Pavement Research Center between 1998 and 2005 to assess Caltrans strategies for the construction of rigid pavements, specifically jointed plain concrete pavement. The overall aim behind these studies is reviewed and the studies undertaken to meet these objectives, namely desktop studies and laboratory and full-scale experiment are discussed. The reports and recommendations from each study are listed, as well as some details on how the recommendations have been implemented.

KEY WORDS- rigid pavement design, rigid pavement construction, instrumentation, Dynaflect, Falling Weight Deflectometer Concrete pavement, Long-life pavement rehabilitation strategy, joint plain concrete (JPCP)

1. INTRODUCTION

Caltrans operates a state highway network of more than 78,000 lane-kilometers (49,000 lane miles), 32 percent of which is rigid pavement (Portland cement concrete), mostly on truck routes in urban areas with heavy traffic volumes. In 1995, at the time that this study was being considered, 48 percent of the rehabilitation projects These pavements were mostly constructed between 1959 and 1974, and were designed for 20 year lives based on traffic volumes and loads estimated at that time. Consequently, rigid pavements in California are mostly jointed plain concrete on cement-treated bases, have no load transfer devices at the joints (dowels), and usually have asphalt concrete shoulders. Slab lengths vary, and are typically between about 3.6 and 5.8 m (12 and 19 ft). Slab thicknesses are nearly always 200 or 225 mm (8 or 9 in). Typical rehabilitation strategies for the network include slab replacement, diamond grinding, and asphalt

2. STUDY OBJECTIVES

The overall objective of the study was to assess Caltrans long-life pavement rehabilitation strategies for rigid pavements, which aim to add at least 30 years of service life, require minimal maintenance (although zero maintenance is not a stated objective), and allow approximately six lane-kilometers to be rehabilitated or reconstructed within a construction window of 67 hours. Using this as a framework, the research objectives and outcomes listed in were identified for the study. Specifically excluded from the study's objectives were:

- An evaluation of the LLPRS objectives and constraints;
- Development of alternative strategies, unless related to structural load transfer or slab geometry technology;
- A desktop study covering design analysis, computer modeling, and estimation of critical stresses and strains within the pavement structure under typical environmental conditions and traffic loading, for comparison with failure criteria;
- Laboratory testing of the strength, fatigue properties, and durability of concrete materials that could be considered for use in LLPRS pavements;

3. DESKTOP STUDIES

Studies were undertaken to determine the boundaries of existing technology and approaches to testing, design, and construction within the context of the Caltrans long-life rigid pavement strategies (LLPRS). Issues addressed included the limitations of existing design procedures and the load equivalency concept, paving train productivity, concrete fast-tracking, concrete opening strength, and distress in concrete pavements, specifically longitudinal cracking. Practices and performance over the last fifty years were reviewed to obtain a better understanding of factors that need to be considered in pavement designs with thirty years of service life as well as the implications of incorporating criteria from the existing structures, such as lane delineation, specific joint spacings, and slab thicknesses. Extensive use was made of past and concurrent Caltrans and other Caltrans-sponsored research. In addition to the stated objectives, this research produced many observations of field construction practices that were noted by Caltrans, the concrete paving industry, and the University during initial projects and test section construction between 1996 and2000. These enhanced practical knowledge for handling the new materials and for lane paving operations as opposed to slab replacements.

4. PAVEMENT DISTRESS

The distresses occurring on Caltrans rigid pavements include faulting and transverse, corner, and longitudinal cracking. They are caused by mechanisms that for the most part have been observed and investigated by other researchers in California and in other states, although reliable quantitative models for some mechanisms had not been developed prior to this study. The mechanisms causing longitudinal cracking were also not well understood or documented. Issues relevant to pavement distress mechanisms in LLPRS in California include:

• The most prevalent distress is transverse joint faulting, which occurs throughout the state – with some routes exhibiting the distress over nearly their entire length. Faulting is often severe enough to cause a high level of discomfort to road users. This distress results from poor levels of load transfer across joints and the presence of erodible material in in the layers underlying the joints. Past designs

3.3. Design Methods The effects of various design features and design variables on slab thicknesses required to obtain service lives of thirty years or more were evaluated using three rigid pavement design methods: • Portland Cement Association (PCA) method • The American Concrete Paving Association (ACPA) version of the American Association of State Highway and Transportation Officials (AASHTO) method • Illinois Department of Transportation (IDOT) method Design input variables included expected traffic and axle loads, different levels of base and subgrade support, concrete strength, design features (such as dowels and tied shoulders), design reliability, climate, drainage, and pavement failure modes. Findings relevant to design methods in California include:

5. MATERIAL PROPERTIES

The subgrade soil was a silty clay loam with a compacted bulk density of 2.18 t/m3 (AS1141.4). The maximum dry density of the soil was 1.86 t/m3.Particle size distribution (AS1141.12) showed that 70.7 per cent of aggregate was finer than 0.075 mm. Liquid limit, plastic limit and plasticity indices of the fines were 22.8, 14 and 8.8 per cent, respectively. Subgrade CBR was 14 per cent. The average 28-day concrete compressive and flexural strengths were 7.3MPa and 1.55MPa for the sub base, 50.5MPa and 5.45MPa for the bases and38.5MPa and 4.1MPa for the shoulder, respectively Each aspect of concrete pavement construction was evaluated in terms of paving lane productivity in a preliminary study. In the late 1990s, it had been proposed that the use of Fast-Setting Hydraulic Cement Concrete (FSHCC) was critical to achieving desired construction productivity objectives, and Caltrans was considering requiring the use of FSHCC for lane reconstruction. The following findings are relevant to LLPRS in California: • Time required to achieve opening strength of the concrete is typically not the most important variable controlling productivity, and it only has an influence in the last hours of each construction period (fifty-five-hour weekend or continuous closure). Therefore, the use of FSHCC with four- or eight-hour time to meet opening strength was found not to be the most important variable controlling productivity. It was recommended that high early strength Portland cement mixes be

6. LABORATORY TESTING

Cements under consideration by Caltrans for rigid pavement construction can be classified into four categories: • Portland cements and blends • Calcium aluminate cements and blends • Calcium sulfo aluminate cements • Fly-ash based cements With the exception of Portland cements, most of the materials under consideration have not been extensively used for pavement construction in the United States, and little information about their long term performance and durability under pavement conditions had been documented prior to this study. The calcium sulfoaluminate cements were being used to meet the pre-study specifications for Fast-Setting Hydraulic Cement Concrete (FSHCC). It was thus deemed necessary by Caltrans to characterize the concrete produced from these cements in terms of strength, stiffness, and thermal expansion and shrinkage, as well as long-term resistance to sulfate attack, aggregate-alkali reactions, with a view to their use in long-life rigid pavements in California. The following laboratory investigations were thus undertaken during the

Course of the LLPRS study:

• Resistance to sulfate attack
• Resistance to aggregate-alkali reaction
• Strength
• Stiffness
• Thermal expansion
• Shrinkage
• Flexural fatigue
• Durability of bases

6.1.1 Objectives and Approach

The objective of this phase of the study was to identify the potential durability issues pertinent to concrete pavements in California. Considerable research has been conducted on these topics and thus a literature review was undertaken to identify those issues requiring additional research specific to California. The review focused on sulfate attack, aggregate reactions, corrosion, and freeze-thaw action. Based on the findings of this survey, experimental designs were developed for laboratory investigations to address those issues not adequately covered in the literature, specifically sulfate attack and aggregate reactions. 4.2.3 Findings on Alkali-Aggregate Reactions In the first phase of the study: • Calcium aluminate cement was found to be highly resistant to ASR for both aggregates at both 16 and 32 days. • When using mildly reactive aggregate, both Type I/II and III cements were considered marginal, while the calcium sulfoaluminate cements were considered resistant with an expansion of less than 0.1 percent. • With highly reactive aggregates, these four cements all exceeded the upper expansion limit of 0.2 percent after 16 days and thus failed. in LLPRS.

7. PROJECT DESCRIPTION

An experimental work on rigid pavement performance under dynamic truck loading has been conducted by Queensland University of Technology (QUT) and a major Australian concrete producer, Rinker Australia, at Rinker sand quarry in Oxley Creek, southwest of Brisbane. This location was selected since a weighbridge is available to provide data on truck loads, number and type of axle groups which can be recorded for long term pavement performance monitoring. Furthermore, geotechnical information on subgrade properties including soil classification, soil profile and texture, bulk density, the Atterberg limits, and CBR, which had been derived from surface and depth explorations of the site in 2001, is available in Readymix archive at Milton Branch.

8. HEAVY VEHICLE SIMULATOR TESTING

The Heavy Vehicle Simulator (HVS) testing program was initiated with a pilot study at the UCPRC Richmond Field Station. This included the evaluation of various types of instruments, methods of data recording, and the logistics involved with placing concrete around sensitive instrumentation. After the slab was cast, the HVS was used to evaluate performance of the various instruments as well as the performance of the slab under accelerated trafficking. Using the experience gained in the pilot study, full-scale pavement experiments were constructed with fast-setting hydraulic cement concrete (FSHCC) on SR-14 near Palmdale and subjected to Heavy Vehicle Simulator Testing following comprehensive test plans. The site was provided and prepared by Caltrans' District 7. The construction was completed under the direction of District7, with input and assistance from Caltrans Headquarters units. The first group of sections on the southbound side of SR-14 (South Tangent) included jointed plain concrete on aggregate base on which fatigue tests were performed. The second group on the northbound side (North Tangent) included sections with jointed plain concrete on CTB, on which the following tests were performed: • Two tests on jointed plain concrete slabs without dowels and with asphalt shoulders • Three tests on slabs fitted with dowels and tied concrete shoulders • Three tests on sections with slab widths of 4.3 m (14 ft) [instead of the standard 3.7 m (12 ft)] fitted with dowels and with asphalt shoulders

9. INSTRUMENTATIONS

A total of 120 electrical gauges including 120Ω electrical strain gauges (ESGs), linear displacement transducers (LDTs) and strain gauge based vertical accelerometers have been used to investigate the structural response of the test pavement under either static or dynamic loads. Since recent research (Choubane and Tia 1995, Health and Roesler 1999) showed a strong interrelationship between temperature gradients and damage potential of concrete base, four thermocouples were evenly installed at different depth within the concrete bases. Recording of temperature gradients was started 24 hours after initial set.

10. RESULTS AND DISCUSSION

Differential temperature gradients and loss of moisture content through the depth of the concrete base may affect the pavement response. However, since the variation in ambient temperature during the tests was small (less than 1ºC), pavement curling can be assumed to remain constant in the analysis. Nevertheless, a finite element analysis may help to develop a better understanding on the effects of the aforementioned factors on the dynamic response of concrete pavements. This analysis is currently being done by the Authors of the current paper and the results will be published elsewhere. In Field analysis software was used to develop time history responses of the concrete bases, JPCP and JRCP, under moving truck load for different locations within the test section. Results were then redrawn to appropriate scales using Microsoft Excel for comparison. The dynamic amplification (DA), which is defined as (Dynamic response / Static response)-1) ×100, was then calculated for each individual channel. Whilst DA varies with truck speed, only the maximum and the minimum captured DA are presented and discussed in this paper. Results can be summarized as follows:

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12. CONCLUSION

A fully instrumented rigid pavement test section including JPCP and JRCP was constructed and tested under quasi-static and dynamic truck loading. Information on the test section, instrumentation layout, material properties and truck characteristics were described. Pavement performance under environmental conditions was studied during the first 28 days after casting. Truck loading was subsequently applied at different location of the pavement. Time history responses were recorded for nominal truck speeds between 5 km/h to 55 km/h.

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