Introduction of PCC Pavement Sections and Associated Research in KHC Test Road

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ABSTRACT

Korea Highway Corporation(KHC) began the ambitious KHC Test Road construction project from 1997. It is 7.7km long two-lane highway next to the mainline of Jungbu Inland Expressway. The KHC Test Road construction was completed at the December 2002. It is composed of twenty-five PCC test pavement sections. Section design parameters are (1) concrete slab thickness, (2) base type, (3) base thickness (12, 15, and 18cm), and (4) pavement type. Twenty-five PCC test pavement sections contain 1241 sensors to evaluate the behavior of pavement system under traffic load and environmental change. The behavior of pavement systems will be identified by the observation of sensor measurement and pavement distress survey from test pavement sections. The Test Road research outcome will validate the Korean Pavement Design Guide which is develop by on-going funded research from the Ministry of Construction and Transportation

1. Introduction

The purpose of the Test Road is to develop pavement design guide with the consideration of actual traffic load and environmental changes. Until 2000, every test roads were constructed in the United States. The first one was the AASHO Test Road located on Ottawa Illinois (Figure 1a), completed on 1959. The AASHTO pavement design guides were developed by the research results from AASHO Test Road. During the 1990s, three more test roads were constructed in the US. They are MnRoad in Minnosota (Figure 1b), SHRP Test Road in Ohio, SmartRoad in Virginia. The research outcomes from those test roads were used to develop state level pavement design guides and AASHTO 2002 guide.

Since 1969 (the construction of first highway route in Korea), we have imported pavement design process from foreign countries, including the US, Europe and Japan. We have tried to gather good aspects from various pavement design guides. Hence, our pavement design guide became a mixture of different design processes. As a consequence, our pavement design results could contain conflicts from various different backgrounds. In order to overcome conflicts, Korea Highway Corporation(KHC) decided to establish its own pavement design guide. The first step was to plan theCorporation(KHC) decided to establish its own pavement design guide. The first

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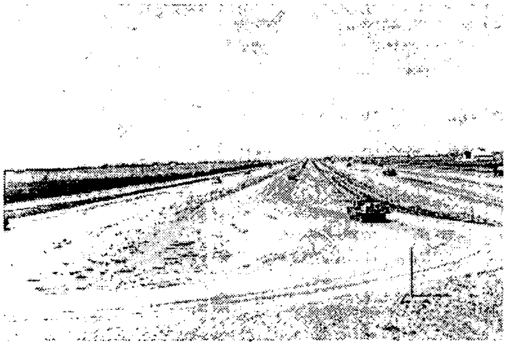

Figure 1a AASHO Test Road

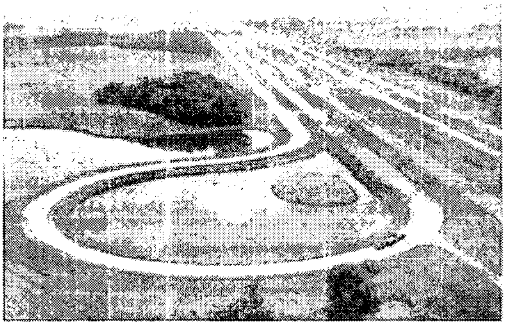

Figure 1b MnRoad

step was to plan the KHC Test Road, including test pavement section design, sensor installation plan and sensor verification. The construction began from 1998 at Jungbu Inland Expressway south bound between Yeoju and Choongju and completed at December 2002. The KHC Test Road is 7.7 km two-lane expressway and it is 4.9m away from the mainline expressway(Figure 2). The KHC Test Road contains twenty-five Portland Cement Concrete(PCC) and fifteen Asphlat Concrete(AC) test pavement sections(Figure 3). It also contains three test bridges and two geotechnical structures. However, we are going to focus only on PCC test pavement sections in this paper.

Figure 2a PCC Test Pavement Sections

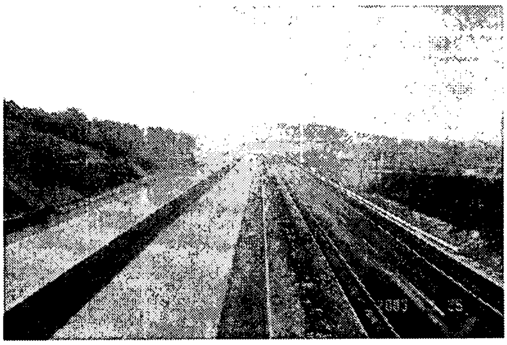

Figure 2b Asphalt Test Pavement Sections

After KHC had made ambitious decision for the Test Road construction, the Ministry of Construction and Transportation(MoCT) granted the project to develop Korean pavement design guide on October 2001. This project covers the development of both PCC and AC pavement design guide with performance improvements issues. New design guide will incorporate mechanistic -empirical based pavement design approach, which is the new trend of modern pavement design guides. The important issues for the PCC pavement design guide will be discussed in the later part of this paper.

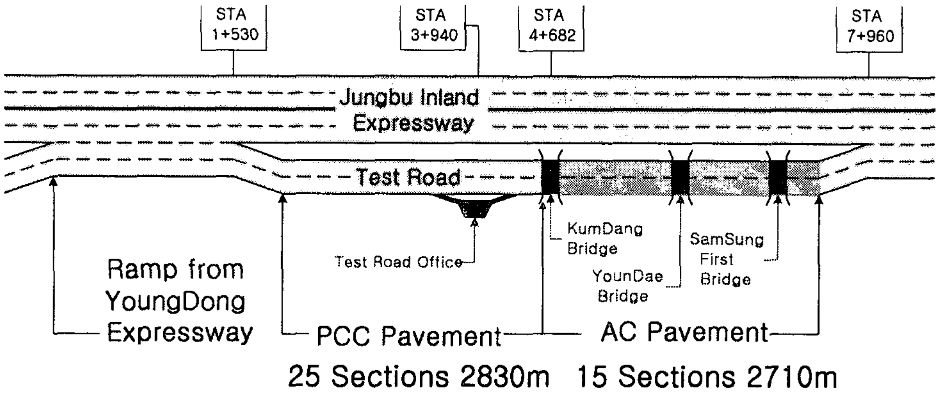

Figure 3. KHC Test Road Plan

2. PCC Test Pavement Sections

Twenty-five Portland Cement Concrete(PCC) test pavement sections are constructed in the Test Road. The test pavement section factorial design was aimed to verify newly developed pavement design guide. We have four major design variables for PCC test sections. They are (1) type of PCC pavement, (2) the thickness of concrete, (3) the thickness of lean concrete base, and (4) type of base material. Each variable definition is written in Figure 4. The section layout is shown in Figure 5.

JCP		Thickness (cm)								
Slab		25			30			35		
Sub-base		12	15	18	12	15	18	12	15	18
Sub-base type	Lean	√	√	√	** √	*, ** √	** √	√	√	√
	Aggregate		√			√			√	
	Black-base		√			√			√	

CRCP	s (%)		
Steel Percentage	0.6	0.7	0.8

* ; permeable base, steel fiber reinforced concrete slab, high strength lean concrete base, undoweled JCP
** ; without frost resistant layer

Figure 4 PCC test pavement section factorial design

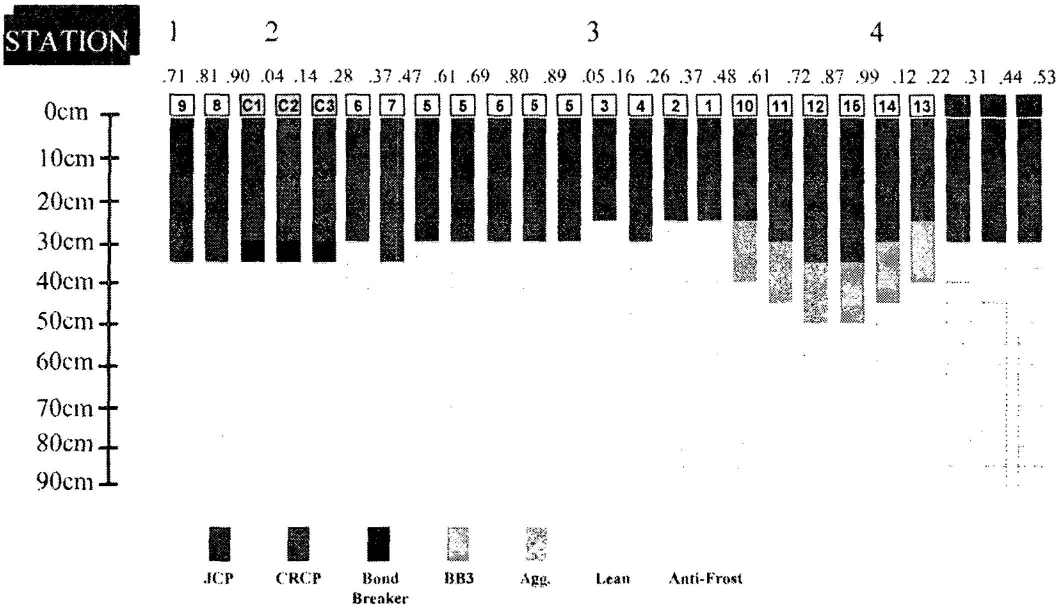

Figure 5. PCC Test Pavement Section Layout

Among twenty-two Jointed Concrete Pavement(JCP) sections, we have seven functionally advanced test pavement sections. They were selected for the development of future pavement technology. We assigned steel fiber reinforced concrete slab, high strength lean concrete base, undoweled JCP, and permeable base. We allocated three sections without frost resistant layer to observe effectiveness. We also varied surface treatments for JCP test sections. We tried longitudinal tining(18 and 26mm spacing), transverse tining(30mm and random spacing), and astrograss drag. They do not make any impact on the structural behavior of PCC pavement.

3. Test Road Sensors

The main purpose of the Test Road is to verify pavement design guide. The mechanistic part of design guide will be verified by the sensor measurement and empirical part will be verified by the pavement distress survey. The mechanistic design part is composed of finite element analysis software that is specially made for pavement analysis. The predicted pavement behavior from software can be directly compared with sensor measurements. The pavement behavior is usually categorized into two parts, such as traffic and environmental load associated behavior. The traffic load associated behavior includes strain, displacement, and vertical pressure. The environmental load associated behavior is temperature distribution, curling, and joint movement. Table 1 shows the number of sensors and measurement purposes. Figure 6 illustrates detailed sensor locations.

Concrete strain gages are located on four positions(center, joint, edge, and corner) of the concrete slab. At least two gages(top and bottom) are installed on each position. In order to observe strain distribution, forty-four mold strain gages are installed on a concrete slab for one

Table 1. Test Sensors

Load types	Sensor types		Measuring purposes	Numbers
Traffic load	Strain gage	Concrete	Slab and lean concrete base strain	636
		Steel	CRCP rebar strain	48
		Mold	Strain distribution	36
		Asphalt	Asphalt treated base strain	132
	Soil pressure gage		Vertical pressure from traffic load	34
	Multi-depth deflectometer		Relative displacement between pavement layers	4
	High speed Weigh-In Motion		Accumulative traffic data	1
Envirn. load	Crack displacement gage		Joint movement	51
			Slab curling	120
	Thermister		Temperature distribution in pavement layers	140
	Frost depth	Thermister	Subgrade temperature	30
		TDR	Relative humidity	30

test section. Three sets of strain gages are installed on three concrete slabs per each test pavement section. This redundancy was determined to prevent sensor loss during the construction and operation periods. Asphalt strain gages are located on asphalt treated base layer. Steel strain gages are installed on steel reinforcement of continuously reinforced concrete pavement section.

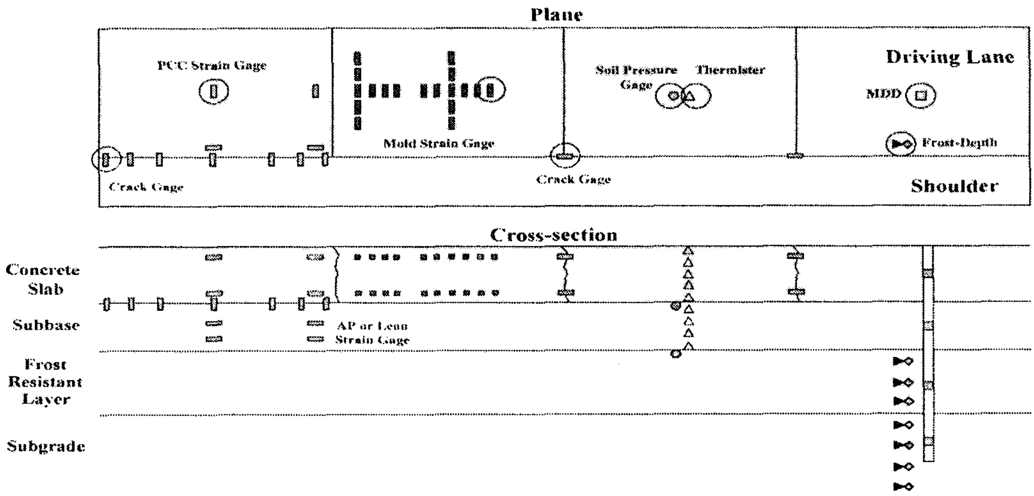

Figure 6. Test Road sensor location

Soil pressure gages are installed on top of lean concrete base and frost-resistant layer to observe vertical pressure distribution from traffic loads. Four multi-depth deflectometers(MDD) were installed to investigate the relative displacement between each pavement layers under traffic loads. Each MDD is composed of four dynamic LVDT sensors. They are located at the middle of concrete slab, lean concrete base, frost-resistant layer, and subgrade.

One set of high speed Weight-In-Motion(WIM) sensor is stalled to accumulate traffic load data. It measures gross weight, axle load, vehicle type, speed, and time of the passed vehicle. It will correlate the total traffic load passed over and the pavement distress. This correlation is the key factor for empirical part of pavement design guide.

Crack displacement gages were installed to observe the behavior of concrete slab under environmental change, such as curling and joint movement. The curling is the vertical deformation of concrete slab due to the internal temperature distribution. The curling makes relative displacement between concrete slab and lean concrete base. These two layers are separated by the thin film interface. Crack gages are installed vertically over the interface. The joint movement is caused by the axial displacement of concrete slab due to daily and seasonal temperature changes. It can be measured by horizontally installed crack gages.

Thermisters measure the temperature distribution within pavement layers. It will verify the temperature prediction model developed by on-going research project. In addition, the frost-depth will be measured by the combination of thermister and Time Domain Reflectometer(TDR: relative water content measuring device). The frostbite occurs if the moisture existed in sub-zero temperature soil. Hence, we have to measure both moisture and temperature simultaneously. This result will prove the effectiveness of frost-resistant layer in pavement systems.

Entire sensor measurements are stored on the Test Road Database system. The environmental load associated data is acquired automatically on the field by data logger and fiber-optic cable networks. Traffic load associated data is obtained manually with vehicle carried data logger systems. The traffic load is applied by the calibrated truck and Falling Weight Deflectometer(FWD: pavement non-destructive testing equipment).

4. Test Road Operation and the Development of the Pavement Design Guide

The Test Road operation will be planned for next twenty years. The traffic will go through the Test Road most of the time except for eight weeks per year. We will close the Test Road four times per year for two week period to conduct the manual data acquisition and the pavement distress survey. The highway traffic will be detoured to mainline that is 4.9m away from the Test Road as shown in Figure 3. During the operation, cored specimens will be extracted from the pavement for laboratory test. It will demonstrate the accumulated pavement damage and strength degradation.

The development of new pavement design guide will be composed of four major parts. The first part is the pavement material and load characterizations to develop pavement design input parameter database containing material properties, traffic load spectrum, and environmental change. The second part is the development of pavement structural analysis model to compute stress, strain and displacement under traffic and environmental loads. The predicted results will be used to determine the adequacy of pavement design and performance prediction. The third part is the development of performance prediction model. This model correlates laboratory test and field performance using accumulated traffic load and pavement distress survey. The last part is the verification of developed pavement design guide. This process will be based on the Test Road database and Long Term Pavement Performance(LTPP) database. The LTPP test section will be scattered in various highway routes in Korea.

5. Conclusions

The Test Road construction was completed at December 2002. Now the KHC is preparing operation for next twenty years. The most important research outcome will be the development of mechanistic-empirical based pavement design guide. The new design guide will optimize pavement design and improve pavement performance significantly. It will reduce pavement construction and maintenance budget significantly. In addition, the Test Road will strengthen the pavement research infrastructure. The Test Road Database will provide valuable research resources to the pavement research community. We believe that this ambitious project will change our pavement infrastructure significantly.

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