Early-Age Smoothness Variations of Jointed Plain Concrete Pavements

Sunghwan Kim  
Department of Civil, Construction, and Environmental Engineering  
Iowa State University  
192 Town Engineering Building  
Ames, IA 50011-3232  
sunghwan@iastate.edu

Halil Ceylan  
Department of Civil, Construction, and Environmental Engineering  
Iowa State University  
482B Town Engineering Building  
Ames, IA 50011-3232  
hceylan@iastate.edu

Kasthurirangan Gopalakrishnan  
Department of Civil, Construction, and Environmental Engineering  
Iowa State University  
353 Town Engineering Building  
Ames, IA 50011-3232  
rangan@iastate.edu

ABSTRACT

Pavement smoothness is a major measurement related to the serviceability of a road for the traveling user. Many transportation agencies conduct pavement smoothness measurements for quality control and quality assurance purposes to judge the quality of new pavements and monitor the condition of their pavement network. Initial smoothness of pavement especially has been one of the major concerns because poor initial smoothness leads to higher rehabilitation costs, shorter services life, and significant reduction of ride quality (Lee 2005). Previous studies (Khazanovich et al. 1998; Janoff 1988 and 1990; Akhter et al. 2002) also show that initial smoothness can significantly affect the progression of roughness in a pavement. Many agencies have established and implemented smoothness specifications for newly constructed pavements. Using these specifications, the agencies determine the bonuses or penalties to the contractor, thereby encouraging the contractor to construct pavements with smoothness levels higher than a specified value (Chou et al. 2005).

The temperature and moisture variation in a climate could result in changes in the curvature of the portland cement concrete (PCC) slab, known as curling and warping. Previous studies (Hveem 1951; Karamihas et al. 1999 and 2001) shows that curling and warping can influence long-term PCC pavement smoothness measurements. However, Perera et al. (2005) recently observed that there was no noticeable effect of slab curvature changes on initial smoothness in five newly constructed PCC pavements.

The primary objective of this study is to investigate the variations of early-age concrete pavement smoothness at different measurement times and locations in different jointed plain concrete pavements (JPCPs) representing different ranges of construction procedure times. The case studies involve three newly constructed JPCPs: US-151 (Platteville, Wisconsin), US-34 (Burlington, Iowa), US-30.
Each of the JPCPs studied experienced a variety of climate conditions. US-151 (Platteville, Wisconsin) was constructed late in the year (October) and experienced only modest daily diurnal cycles. US-34 (Burlington, Iowa) was constructed early in the paving season (June) and experienced multiple rainfall events during the evaluation period. US-30 (Marshalltown, Iowa) was built towards the middle of the construction season (July) and experienced relatively higher ambient temperatures.

In order to capture the effect of changes in PCC slab curvature conditions due to varying environmental ambient conditions throughout the day, field monitoring activities were performed in a diurnal cycle (morning and afternoon). JPCP shows the unique bending curvature behavior associated with temperature and moisture variations through the depth of PCC slab. In addition, this curvature behavior of early-age JPCP is more complicated because several other environmental factors, such as shrinkage, pavement temperature condition during setting, and creep of the slab, could be also involved. However, in general, the maximum or minimum slab curvature conditions are the timeframe for the maximum (afternoon) and minimum (morning) slab temperature gradient. Variations in pavement temperature during the evaluation periods were monitored using the temperature sensors installed within the test sections.

To accommodate the additional effects of paving procedure times and profile measurement locations, different locations on two test sections corresponding to morning and afternoon construction conditions for each case study were evaluated. This diurnal testing of multiple sections provided a better understanding of the changes in smoothness measurements due to environmental ambient conditions for early-age JPCPs.

The travel lanes in two test sections of each JPCP corresponded to morning and afternoon construction, selected for profile measurements. Several profile patterns, as shown in Figure 1, were used to accommodate the data collection. An inclinometer-based profiler such as a Dipstick or Rolling Profiler was used for surface profile measurements at different times (morning and the afternoon) along the different traces of longitudinal direction in the test sections. All measured longitudinal profiles were in the direction of future traffic.

Since pavement smoothness is related to a lack of roughness, the severity of roughness in pavements has been used to characterize smoothness. Using the Federal Highway Administration’s Pavement Profile Viewing and Analysis (ProVAL) software, the measured longitudinal surface profile data were transformed into smoothness indices, namely the international roughness index (IRI) and ride number (RN).

**Figure 1. Typical longitudinal profile pattern**

Since pavement smoothness is related to a lack of roughness, the severity of roughness in pavements has been used to characterize smoothness. Using the Federal Highway Administration’s Pavement Profile Viewing and Analysis (ProVAL) software, the measured longitudinal surface profile data were transformed into smoothness indices, namely the international roughness index (IRI) and ride number (RN).
The results showed that measurable changes in early-age JPCP smoothness do occur at different measurement times and locations. Within the scope of this study, it can be concluded that the variations in early-age JPCP smoothness can be significant from the standpoint of smoothness specifications. The limited field data from this study showed that morning paving produces smoother JPCP (in terms of measured smoothness indices) than afternoon paving. It is also interestingly noted that the variations of IRI during early-age in afternoon paving produces can more significantly influence the smoothness specification grade of new concrete pavements. Therefore, in situations where nighttime paving may not be feasible, which is the preferred option to maintain minimal temperature gradient change during concrete hardening, it is recommended that paving operations be performed during morning times, where the effects of curling and warping on the PCC slab are considered to be minimal.

**Key words:** early-age—JPCP—pavement analysis and design—smoothness
ACKNOWLEDGMENTS

The authors gratefully acknowledge the Federal Highway Administration (FHWA) for supporting this study. The contents of this paper reflect the views of the authors who are responsible for the facts and accuracy of the data presented within. The contents do not necessarily reflect the official views and policies of the FHWA. This paper does not constitute a standard, specification, or regulation.

REFERENCES


