INDOT Research

# TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

*TRB Subject Code: 32-3 Concrete Curing* *November 2002*
*Publication No.: FHWA/IN/JTRP-2000/25, SPR-2333* *Final Report*

# *Use of Modulus of Rupture, Fatigue Resistance and Maturity in Determining Opening to Traffic Time for Concrete Pavements*

## Introduction

The main objective of this study was to develop maturity-based guidelines for early opening-to-traffic of concrete pavements in the state of Indiana.

The scope of the research included characterization of flexural strength development with time, establishment of relationship between flexural strength and maturity, and determination of earliest opening-to-traffic by correlating opening flexural strength with fatigue of concrete. Flexural strength is widely accepted as the opening to traffic criterion for concrete pavements. Indiana Department of Transportation (INDOT) uses flexural strength of 550 psi (3.79MPa) for opening concrete pavements to traffic

A typical concrete mixture used in pavement construction in Indiana was adopted for this study. The study was conducted using both laboratory and field concrete. The temperature inside the beam specimens was monitored with thermocouples for a prescribed period of time and the data was used to compute maturity. Modulus of Rupture (MOR) was determined for the same samples and a relationship between maturity and corresponding flexural strength was developed using regression analysis. Maturity value corresponding to MOR of 550 psi was used as target maturity for opening to traffic purposes

Fatigue tests were performed at 3, 5, and 7 days. At each age, about 9 beams were tested at three different stress levels (60, 80 and 90% of ultimate MOR at that age). The fatigue curves were developed for this data using regression analysis. The fatigue curves were used to obtain allowable number of repetitions of a given load (stress level) for each age. Combining the allowable number of repetitions with the maturity-MOR relationship allows for determination of the opening to traffic time.

## Findings

The following conclusions can be drawn based on the results from this study:

- There is a strong ($R^2$ = 0.945) correlation between the flexural strength and maturity. Based on the maturity data obtained from the field, pavements can be opened at the maturity of 1995 C-hrs. That value of maturity corresponds to the current INDOT opening to traffic criteria of 550 psi.
- Fatigue tests on 3-days old samples reveal that the pavement can withstand more than 100,000 cycles of load as long as the stress in pavement does not exceed 35% of ultimate MOR in equivalent 6x9x21-in. beam. .
- To further refine opening-to-traffic criteria, the fatigue curves should be developed at various ages (ranging from 12 hours to 7 days) so that safe opening-to-traffic time can be established for variety of mixes and curing conditions.
- Wet burlap curing, like that used in this study, should be adopted in the field in order ensure proper hydration of cement.

- Vebe test was confirmed to be a good tool for assessing the consistency of field-type (stiff) mixes.

## Implementation

The results of this investigation indicate that maturity method can be reliably used to determine the pavement opening to traffic time. However, in order to implement this method a correlation must be developed between the maturity value and the modulus of rupture value for each of the individual mixture designs.

Once this correlation is developed, it can be combined with the MOR-fatigue strength relationship to determine the opening to traffic time. In order to implement this approach the user should calculate the stress induced in the pavement by the type of vehicles expected on the pavement after opening and compare it with the stress level (using fatigue curves) that will provide a required number of fatigue cycles (specified by particular agency). As long as the cumulative stress level generated by various vehicles expected on the pavement during the initial period after opening to traffic is lower than the stress level determined from the fatigue curves the pavement can be safely opened to traffic.

## Contact

*For more information*:

**Prof. Jan Olek**
Principal Investigator
School of Civil Engineering
Purdue University
West Lafayette, IN 47907
Phone: (765) 494-5015
Fax: (765) 496-1364

**Indiana Department of Transportation**
Division of Research
1205 Montgomery Street
P.O. Box 2279
West Lafayette, IN 47906
Phone: (765) 463-1521
Fax: (765) 497-1665

**Purdue University**
Joint Transportation Research Program
School of Civil Engineering
West Lafayette, IN 47907-1284
Phone: (765) 494-9310
Fax: (765) 496-1105