ASCP *Concrete Pavements Conference* 2011

Presenters

Jamshid **Armaghani**, Florida Concrete Products Association, USA
Neeraj **Buch**, Michigan State University, USA
James **Grove**, Federal Highway Administration, USA
Jake **Hiller**, Michigan Technological University, USA
John **Hodgkinson**, Senior Consultant, Tasman Associates Pty Ltd
Erwin **Kohler**, Dynatest Consulting, Chile
Bryan **Perrie**, Cement & Concrete Institute, South Africa
Luc **Rens**, FEBELCEM, Belgium
Mark **Snyder**, American Concrete Pavement Association, USA (and President ISCP)
Julie **Vandenbossche**, University of Pittsburgh, USA
Leif **Wathne**, American Concrete Pavement Association, USA
Dan **Zollinger**, Texas A&M University, USA

Paper Synopses

PAVEMENT DESIGN

***Design features of CRCP in Belgium**, Luc Rens*

Continuously reinforced concrete pavements (CRCP) have been built in Belgium for more than 50 years. In 1950, the first Belgian experience with CRCP was achieved in Leuze-en-Hainaut. The technique was based on the American know-how of these days.

In March 1968, in view of further developments, a Belgian expert team went on a study tour to the U.S. where they met all the relevant authorities related to CRCP. The details of the technique were compared and studied, followed by a number of experimental worksites. Based upon that experience, it was decided to use continuously reinforced concrete for the development of the motorway network in Belgium. This was a very bold decision in these days since it concerned the largest works ever in Belgium. In the 1970's, over 18 million m² of CRCP were built in Belgium.

This paper presents the history of the CRCP design features in Belgium, in particular the pavement structure, concrete thickness and steel reinforcement percentage. The design parameters have always been the result of a searching for a better behaviour of the pavement, in particular with regard to punch-outs and corrosion, which are linked to the crack pattern, characterized by crack distances and crack widths.

Other particular applications and developments include :

- Thin CRCP
- CRCP for roundabouts
- CRCP for tramways
- Double layered CRCP with recycled aggregates in the bottom layer and fine exposed aggregate finishing for the top layer
- Trial sections with combined steel bar-steel fibre reinforcement.

A well-designed and –built CRCP stands for a long-life pavement with low maintenance needs, resulting in a durable and sustainable solution.

Research, development and implementation of ultra thin concrete pavements in South Africa*, Bryan Perrie*

Over the last ten years a large amount of research has gone into the development of ultra thin concrete pavements in South Africa. Two different technologies have emerged namely ultra thin continuously reinforced concrete pavements (UTCRCP) and ultra thin reinforced concrete pavements (UTRCP). Both pavements are approximately 50 mm in thickness but while the UTCRCP uses high strength, heavily reinforced, fibre reinforced concrete and is suited to heavily trafficked applications, the UTRCP uses light reinforcement and conventional concrete for lightly trafficked pavements.

Both technologies have been subjected to Heavy Vehicle Simulator (HVS) testing and significant field trials under real traffic. Both technologies have now been used in actual pavements in South Africa both on major freeways and urban streets. This paper will cover the research, development and particularly the challenges with implementation of both technologies of ultra thin concrete pavements.

Design of CRC Pavement Using an Enhanced Subbase Erosion Model*, Dan Zollinger*

This paper will address how the MEPDG punch-out model can be modified to more mechanistically reflect the erodibility potential of different subbase materials. This modification corrects the present trend in the current MEPDG punch-out prediction increasing with an increase in k value.

Sensitivity of Built-in Curl on the Predicted Fatigue Cracking Performance in Jointed Plain Concrete Pavements*, Jake Hiller*

Waiting on synopsis

PAVEMENT MATERIALS

Exploring the use of Self-Sustained Smart Sensing Systems for Concrete Pavement Applications*, Neeraj Buch*

The control of construction quality of highway pavements still remains a major problem in practice. A myriad of factors highly influence the early age behaviour of concrete with consequences on the long-term performance of jointed plain concrete pavement and continuously reinforced concrete pavement systems. These parameters include: the generated heat from hydration of the cement; the climatic conditions such as air temperature, relative humidity and wind speed; the concrete temperature and sub base temperature during placement; the concrete coefficient of thermal expansion; the concrete shrinkage as a result of the drying process; the temperature gradients; and the creep/relaxation phenomena.

Currently, most monitoring techniques rely only on probabilistic and empirical determinations. For example, guidance from national and state agencies relative to joint sawing operations only state that it should be performed at predetermined locations within the first 24h, while the American Concrete Institute recommends that the joints should be sawed as soon as practical wherein the concrete should have hardened enough. Similarly, only default values for the nonlinear built in temperature gradients are used in the M-E PDG software to predict slab curling, which is a major component of any mechanistic-empirical design procedure. More elaborate techniques, based on mechanistic approaches, have been recently studied. Several computer programs, such as HIPERPAV, have been developed to predict early-age stress development in concrete pavements. But the lack of measured reliable physical parameters still hinders the prediction capabilities of these methods.

As a result, there is a continuing need for low-cost technologies that allow in field real time monitoring and facilitate the application of these techniques. Innovative systems based on advanced application of remote sensing, communication, and information processing technologies are the way forward in the development of enhanced reliable data collection, analysis, and management processes.

Though recently there has been significant research activity in distributed wireless sensors for monitoring industrial process parameters and environmental conditions, all of the commercially viable sensors developed to date would not be practical for embedded effective distributed sensing. The size limitations are usually prohibitive. A maximum size of 5cm3 is required for a sensor module to embed in concrete; this relatively small volume is approximately the size of a large concrete aggregate. Furthermore, high level power consumption of available circuits (> 600 μW) limits the lifetime of the sensors. In contrast, the envisioned future sensing systems would have the following attributes: (1) low cost and ease of installation (embedment) in fresh mix concrete during construction. (2) Low power consumption and autonomous detection capabilities; initial testing on manufactured preliminary prototypes developed at Michigan State University and based on advanced analog technology showed that it is possible to perform variables detection and on-board embedded computations with an average power consumption of less

than 10 μW, thus significantly increasing the operational lifetime of the systems. (3) Long term information storage capabilities; information collected during pavement concrete construction (mixture properties, weather, etc) will be stored for later use. These data can be useful for performance prediction using the M-E PDG software, as well as for pavement management purposes. (4) Robustness to withstand harsh environmental conditions. (5) Possibility of networks deployment; due to the projected low cost, extensive sensor networks could be deployed thus proving the required cover for distributed physical properties measurement.
Successful development of these sensing systems could transform the economics of highway construction inspection and ultimately improve the safety and quality of road systems. The devices would be reliable, practical, economical, and would ultimately assist in the quick determination and short notice adjustment for optimal prediction capabilities. This would ultimately result in high-quality pavement that can be opened quickly to traffic.

Will More Cement in Your Mix Actually Hurt You?*, James Grove*

Peter Taylor has some research that he said I could talk about. One is work that he recently completed looking at the effect of increased cement content in concrete mixes. He finds, as he had suspected, that for a consistent W/C ratio, strength plateaus at about the same cement content, at all ages for a given mix. He also found that for other properties, increased cement in the mix actually makes things worse.

Australian Concrete Highway Pavements – Source Technology 1975-2011*, John Hodgkinson*

Concrete highway pavements, principally in the State of New South Wales (NSW), have been constructed since the mid 1920s. With the exception of one major urban expressway in Sydney constructed in the 1960s, there was very little new construction in the 1950s and 1960s. In what may be termed the modern era and commencing around 1975, some 650km of concrete highway, most of which is dual carriageway construction, have been completed. The inventory is increasing at an approximate annual average of 25km. At the commencement of the modern era the opportunity was taken to assess developments in concrete pavement technology on the international scene over the period 1960 to 1980 during the period of relatively low activity in Australia. International practice has been continually assessed from the 1980s to the present. This paper presents an outline of the various international and local sources of technology which form the basis of contemporary Australian practice in concrete highway pavements.

SUSTAINABILITY

Concrete Pavement Recycling Practices in the USA*, Mark Snyder*

Waiting on synopsis

Application of Pervious Concrete for Florida Roads and Parking Areas*, Jamshid Armaghani*

The presentation will address the uses of pervious concrete in roads and parking areas in Florida with respect to materials and construction methods. Also discussed are the Green aspects of a novel pervious pavement system being developed and tested in Florida. This system incorporates a lightweight foam concrete as a base to enhance permeability and structural support; and surface curing with Lithium Cure to replace conventional and time consuming curing of moisture and plastic-sheet cover.

Sustainability Opportunities With Pavements: Are We Focusing On The Right Stuff?*, Leif Wathne*

In the context of sustainability and sustainable practices, the highway engineer or administrator often tends to focus on elements of either the structural design, the pavement materials, or the construction operation itself. Items such as recycling, use of industrial by-products (fly-ash, slag cement, etc.), resource conservation, CO2 footprint and even embodied energy tends to get a fair amount of attention in this context. Even though these factors are all important, there may be significant sustainability opportunities that are missed by ignoring the benefits presented by considering the operational phase of a pavement's life. Recent research suggests that the long-term cumulative benefits derived from sustainable pavement decisions can be significant, and will typically dwarf any benefit derived during the production and/or construction phase. There are opportunities in the arena of improved vehicle fuel efficiency associated with specifying rigid and smooth pavements, as well as energy savings associated with the use of high-albedo pavements. This paper will focus on these long-term operational benefits and compare and contrast them to the advantages associated with "traditional" sustainable practices. A case will be made that these long-term operational benefits must be properly accounted for when making decisions about sustainable practices in the roadway sector.

***Characterization of Recycled Concrete Aggregates for Reuse in Rigid Pavements**, Jake Hiller*

Waiting on synopsis

PAVEMENT PERFORMANCE

***Quieter Concrete Pavements: Research Results on Tire/Pavement Noise**, Erwin Kohler*

This presentation will address the past and reflect on the future of tire/pavement noise testing using a method developed in the last decade in the United States, called the On-Board Sound Intensity (OBSI). It will describe how the method has been used to evaluate pavements types, the changes in the method that have led to the current status, and a comparison with the European test method (Close Proximity, CPX). The presentation will include results of comparison of tire/pavement noise levels obtained over several years on a large number of asphalt and concrete pavement sections in California, as well as results on tire noise levels on bridge decks. Current attempts to relate tire noise and surface texture will also be presented.

***Premature Deterioration in Concrete Pavements**, Julie Vandenbossche*

Establishing Permanent Curl/Warp Effective Temperature Gradient in Jointed Plain Concrete Pavements

Studies have shown that the slabs do not remain flat in the absence of daily temperature or drying shrinkage gradients. This is because of the influence of the temperature and the drying shrinkage gradient that exists in the slab at zero-stress time. Zero-stress time occurs after the placement of the slab, during curing and following final set time. These gradients, known as the built-in gradients or permanent curling, lock into the slab and either cancel out or enhance the curling due to the transient gradients.

One more factor that is influential in defining the future shape of the slab is the permanent warping. A portion of the drying shrinkage in drier seasons can reverse due to rewetting in seasons with a higher ambient relative humidity, known as reversible drying shrinkage. Permanent warp is due to the irreversible portion of the drying shrinkage that occurs in the slab. Irreversible drying shrinkage progressively increases as the concrete ages and will eventually reach a plateau.

This study focuses on developing a procedure that can be followed to establish realistic values for the combined effects of permanent curling and warping in the concrete slab. This objective is achieved through performing three major tasks. The first task includes identifying the zero-stress time in the slab using the data from four different instrumented pavement structures constructed at different locations in Pennsylvania. A computable index, the degree of hydration at zero-stress time, was established so that can zero-stress time can be identified in any concrete slab with a design similar to those represented by the four instrumented projects. Next a temperature model was developed to predict the temperature within the pavement structure based on the ambient weather conditions and the heat of hydration at the zero-stress time. The results from these two tasks were used to predict the temperature distribution throughout the slab at the time of set for a range of climatic conditions. Long-term static strain data from instrumented pavements along with a humidity prediction model was then used to quantify permanent warping.