Concrete Pavement Progress

Volume 41, Number 3 **Joints and Jointing Practices** March 30, 2005

This month ...

ACPA provides the latest technical information about joints and jointing practices.

Next month...

ACPA will provide technical tips and cover best practices to achieve smooth concrete pavement ...

The Relationship Between Sawed Joints and Dowel Bars

A common practice during construction involves sawing joints at the proper location relative to dowel bars. Although this is a common practice, there are also occasional mistakes, e.g. misplaced saw cuts. This article provides tips on sawing joints appropriately, as well as fixing mistakes.

Sawing with Tolerance

Correctly placed joints increase a pavement's performance and life-cycle. The tolerance for sawing transverse joints (i.e., the allowable translation of the saw cut from the center of the dowel) depends on the specified dowel bar length, which is typically 18 inches. A joint that is sawed up to three inches either way from the center of an 18-inch dowel will not impact pavement performance, because six inches of dowel embedment is all that is necessary to develop effective load transfer under highway loadings.

Here are a few tips to ensure that the saw cut is centered near the middle of the dowel bars:

- Firmly stake the dowel baskets (if used) and correctly mark the dowel location along the edge of the pavement for either baskets or dowel bar insertion placement methods.
- Be sure the marks are accurate and easy for the sawing crew to locate.

Below are other factors to consider:

- When staking dowel baskets, be sure to anchor firmly to the base material with high and low anchor points. High anchors prevent tipping, while low anchors prevent shoving of the basket.
- The type anchors used and the frequency of use are dependent on the base type used. Anchor styles vary from simple pins driven into granular material to ramset anchors for stabilized bases. If the anchors are not matched to the base material, the basket may shove during paving, causing misaligned dowels.

Dowel bars have a significant impact on the long-term performance of a concrete pavement. Other than pavement thickness, dowel bars are the most important structural feature of pavement design.

Dowel bars facilitate load transfer at the joints and minimize faulting, corner cracking, and the potential of transverse cracking. Since the mid-1980's, when state agencies began using dowel bars regularly in their designs, the number of roadways in the United States with the classic 'thump' ride (from faulting) has diminished drastically.

Repairing Misplaced Saw Cuts
When a saw cut must be repaired because it's misplaced, there are several points to keep in mind. Fixing an incorrectly sawed joint depends on how far the saw cut is from the correct location.

If the saw cut is several feet away from the correct location, the best option is to retrofit dowel bars along the saw cut (joint). This will establish load transfer in the joint.

If the saw cut is over the dowels, but do not provide six inches of embedment, there are two ways to address it. The first option is to perform full-depth repairs at the incorrect saw cut location. Although expensive, this is a proven technique, particularly if only a few joints are affected.

The second option is to immobilize the joint through stitching and then saw cut and retrofit dowels at a different location. However, the pavement will likely have cracked at the saw cut because of restrained drying shrinkage and movement attributable to thermal cycling. Sawing a new joint and retrofitting dowels does not guarantee that the pavement will then crack at the desired location.

One of the most problematic locations for poorly located saw cuts is on curves. The saw cut always should be perpendicular to the dowel bars, and the dowel bars should be parallel to the roadway's centerline. On curved sections, this means the saw cut location always must be indexed to the dowel bar locations rather than a measurement, because the inside and outside radii are different. Paint marks or colored nail heads are simple but effective ways to identify the center of dowel baskets for correct sawing. To avoid affecting joint spacing, don't just establish the first cut and then set the others by measuring. Be sure to check the alignment markers at each joint.

Deadheading a Longitudinal Joint

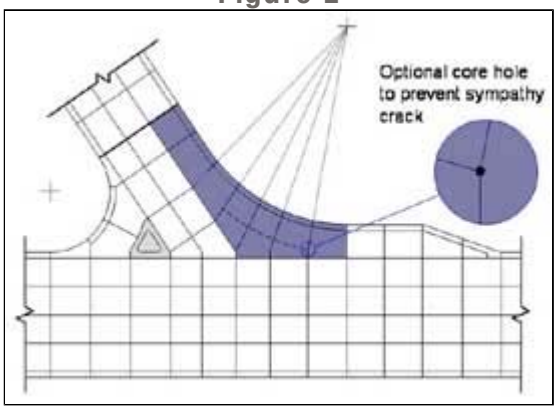
Deadheading a longitudinal joint involves placing the joint between two transverse joints. It is typically necessary only for a relatively short distance, e.g. wide turning lanes, ramps, and merge areas.

The function of a pavement joint is to accommodate shrinkage, movement, and at later ages in the concrete's life, expansion and contraction of the concrete slabs. Typically, joints do not stop or start in the middle of the pavement -- they are usually brought to the edge. If a joint stops before it reaches the edge, it will continue on its own as a crack.

To prevent the longitudinal joint from continuing into the adjacent slab(s), there are two options:

1. Consider placing a small-diameter core hole (typically 2 inches [50 mm]) at the junction of the longitudinal and transverse joints. (See Figure 1.) To fill the core hole, fill the bottom and middle of the hole with foam or some other compressible material to the same level where the backer rod is in the joint.

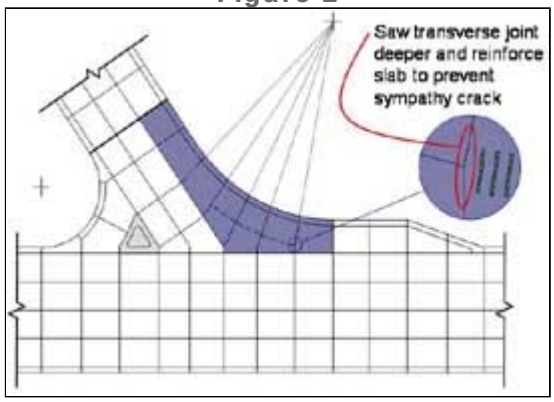
Figure 1



Then, top it off with the joint sealant material when sealing the joints. Similar to selecting the backer rod material, be sure that the foam or other material in the core hole is compatible with the sealant. Note that the foam could melt if hot-pour asphalt-based joint sealant is used.

2. Another option is to saw the transverse joint deeper where the longitudinal joint deadheads into it. Do this in combination with some reinforcing bars in the slab. (See Figure 2.) Place three to five #4 bars (use more bars or larger diameter bars for thicker pavements) along the location where the slab may potentially crack.

Figure 2



One other point to consider is the use of dowel bars in the area of the deadheaded longitudinal joint. Leave out dowel bars in the area of the longitudinal joint, to minimize the chance of the longitudinal joint continuing into the adjacent slab. This will have to be done with the second option if you are sawing close to mid-depth in the slab.

For more information, see ACPA publication *Intersection Joint Layout* (ACPA catalog number IS006P) and *Concrete Intersections - A Guide for Design and Construction* (ACPA catalog number TB019P). To order these publications, visit www.pavement.com; call toll-free 1-800-868-6733.

Making Concrete Durable - Part 2

Story contributed by Jim Shilstone, Sr.
Chairman, The Shilstone Companies, Inc.

Editor's Note: *This is the second of a four-part editorial on mix designs. It addresses aggregate gradation, another key factor in durable concrete pavements. Part 3 will provide information about air entrainment. Part 4 will cover developing mix designs for durability*

It is important to produce a concrete mixture for durability, not just one with strength at the lowest price. The contractor or materials supplier is responsible for selecting materials and proportions to meet the design criteria. However, a major question about the "design" is the key to the problem of durability.

Consider the National Institute of Standards and Technology (NIST) October 1995 workshop, which included a discussion of "Cement and Concrete Standards of the Future." Engineering and materials leaders representing the American Society for Testing and Materials (ASTM), American Concrete Institute (ACI), NIST, and the Canadian and Mexican standards organizations attended. Following are excerpts of Report No. NISTIR 5933:

- "Design and Construction Standards…Concrete durability and how it affects the long-term serviceability of a structure is not adequately covered in current codes and standards."
- "Concrete Materials Standards…Materials science research will be needed to establish performance criteria, including modeling of material performance, development of databases on materials properties, and the development of knowledge-based systems."

For many years, public agencies and contractors have sought a means to use performance requirements and leave the means and methods to the contractor. There are two historical examples where that approach was applied. During the 1933-34 construction of the Oakland Bay Bridge over San Francisco Bay, The California Department of Transportation (Caltrans) developed a "mixture design" based on the grading of the combined aggregate. Aggregate producers were advised that if the aggregate complied with an agency specification but did not fit the combined grading, their product could not be used.

The second approach originated with the 1940 "Joint Committee on Standard Specifications for Concrete and Reinforced Concrete" in their "Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete." The joint committee consisted of six engineering and concrete technical organizations. Their specification provided:

- "Proportioning-The increased strength and improvement in concrete technology make it possible to produce concrete having a strength sufficient for ordinary design purposes with a water content too high for many types of exposure. The committee is of the opinion that a classification of grading of concrete based on the character of exposure will be more generally useful than if based on common requirements of minimum strength. Special emphasis is also placed on those factors that affect workability and production of dense homogeneous concrete.
- "Alternate Specifications-Two types of specifications covering the proportioning of concrete are presented: One, in which the contractor is required to produce concrete of a specified quality (exposure and strength considered) with considerable freedom of procedure within certain limits, and the other, in which the engineer specifies the proportions required, including a minimum cement content. Where the strength is specified, the test procedure is given together with the basis for enforcement of the strength requirement."

The 1996 issue of TRB Circular 457 defined the terms "performance-related" and "performance-based" as being predicated upon "engineering characteristics." Constructability and durability are not based upon engineering factors. Following considerable discussion, a new definition was included in the 1999 re-issued document:

- "Performance-based: Specifications and/or methods that will contribute to producing the desired levels of engineering, construction, serviceability, and/or other properties required for both economic considerations and long-term service of the constructed project."

Although the semantics may appear subtle at first glance, the precise wording of this definition is important.

During the first three years of work at Lewis Institute more than 80 years ago, about 50,000 tests were conducted. Duff Abrams, an early concrete researcher, wrote: ". . . A large number of investigations have been under way at the Structural Materials Research Laboratory, Lewis Institute, Chicago, which throw considerable new light on the subject of proportioning concrete. These studies have covered an investigation of the inter-relation of the following factors:

1. The consistency (quantity of mixing water).
2. The size and grading of aggregates.
3. The mix (proportion of cement).

"Any comprehensive study of proportioning concrete must take into account all of these factors." The sequence is also important … and of paramount importance is not starting with a given amount of cement to be "safe." That safety factor will only add water and increase the cost of the mix.

About the Author - Representing three generations of service to the transportation industry, Jim Shilstone, Sr., is Chairman of the Shilstone Companies, Dallas, TX. For more than 60 years, Shilstone has conducted extensive research on concrete mixture development and analysis. The research results led to standard changes for several institutions, including the American Society for Testing and Materials; the American Concrete Institute; and the U.S. Air Force.

Shilstone was recently recognized by the American Concrete Pavement Association, which awarded him its distinguished Honorary Life Membership, an award reserved exclusively for those who have rendered outstanding service to the concrete pavement industry and to the Association. Contact the author at The Shilstone Companies, 9400 N. Central Expy., #105, Dallas, TX, 75231. Phone: 214-361-9681. Fax: 214-361-7925.

Lining Up Joints While Adding Lanes

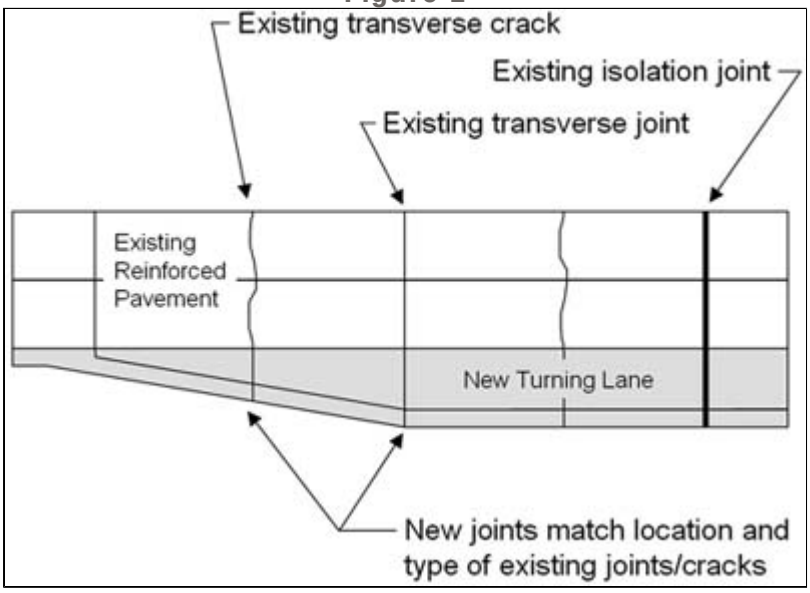
Adding lanes next to existing pavements is common when designing and constructing intersection improvements. Adding lanes increases capacity and separates turning movements from the traffic stream.

For these improvements, it is essential to place transverse contraction joints (typical sawed joints, either doweled or undoweled, depending on the thickness) that match any existing joints or cracks in the adjacent pavement.

Without a contraction joint, movement of the old concrete pavement may cause a sympathy crack in the new lanes.

An alternative to avoid sympathy cracking is to place an isolation joint with a separating medium (for example, fiberboards 1/2 to 1 inch thick) between the edge of the existing pavement and the new lane.

Figure 1



For additional information, see ACPA publication TB019P, *Concrete Intersections - A Guide for Design and Construction*. To order, visit www.pavement.com; call toll-free 1-800-868-6733.

ACPA Addresses Joint Skewing

Joint skewing is said to be a performance-enhancing technique, which has existed in concrete pavement design for years. Skewing joints may seem a good idea to the pavement designer, but it adds risk to the pavement construction process, especially during the sawing operation. Simply stated, it presents a chance for error.

Based on ACPA's 1999 survey of state Departments of Transportation (DOT's) concrete pavement practices, only 12 out of the 50 state DOT's have skewed-joint details in their standard plans and specifications. Many have abandoned the technique, and skewed joints are even rarer today. The Federal Highway Administration's Technical Advisory T5040.30, "Concrete Pavement Joints," states there is no benefit to skewing joints on pavements designed with dowels for load transfer. Typically, dowel bars impact performance more favorably.

Skewing is also not advisable for intersections of local roadways, as well as tapers for auxiliary lanes.

The only beneficial application for skewing joints is in undoweled pavements, particularly on local roadways. The advisory essentially recommends skewed joints should only be considered on low-volume truck routes that do not have load transfer devices.

ACPA's current publication on jointing, *Design and Construction of Joints for Concrete Highways* (TB010P) also states that skewing is effective only for undoweled joints on low-volume routes. The publication cites past studies sponsored by FHWA, among them, "Rigid Pavement Performance and Rehabilitation" (1990), as well as "Common Characteristics of Good & Poorly Performing PCC Pavements" (1998), both of which have concluded that some slight benefit is seen when skewing joints on undoweled pavements.

A Look Back

San Antonio Boasts Historical Concrete Street

Donald H. Taubert, Capitol Cement, San Antonio, reports on an historical concrete street in his city.

"San Antonio has a concrete street that was placed before the war. When I tell them that this street was placed in the fashion that the European concrete streets and highways are being placed today, it amazes them," Taubert wrote.

"What goes around, comes around. The street, Belknap Place, was placed on a lean concrete first course; the second, a higher strength-wearing surface. The top course was stamped to look like a brick street. I assume this was before any jointing knowledge was very widely known, therefore some cracking is noted. We don't know of any construction specifications or any testing done. There is a brass or bronze inlay near one of the intersections that is imprinted: Texas Granitoid Construction Co."

Taubert continued, “By the way, people sometimes ask, ‘What war are you speaking of?' I tell them, it wasn't the Gulf War, the Vietnam War, the Korean War, not even World War II! It was placed in 1914, before World War I.

“The city of San Antonio has plans to commemorate it in 2014, on the roadway's centennial."

Top 10 Solutions to Joint Sealant Installation Problems

Joint and crack sealants will minimize the infiltration of water and incompressibles into the joint or crack, typically from eight to 25 years before needing replacement. The performance of the sealant depends primarily on the sealant material (hot-pour, silicone, or preformed neoprene), but it is also affected by the installation procedure(s), traffic, climate, etc.

One early distress that might be seen in a joint sealant is where the sealant is not bonded with or touching the sidewalls of the joint. This can result in the sealant being picked up or pulled out when traffic, particularly high-speed traffic such as aircraft or highway vehicles, crosses the joint.

The following lists some common causes of this sealant problem and possible solutions:

- **Cause:** Opened to traffic too soon after application.
  Solution: Delay opening.
- **Cause:** High ambient temperature.
  Solution: Seal in cooler temperatures.
- **Cause:** Excessive sealant application.
  Solution: Apply flush with surface or with specified recess.
- **Cause:** Sealant too soft for climate.
  Solution: Use stiffer sealant.
- **Cause:** Sealant tacky.
  Solution: Use a de-tackifier or blotter to reduce initial tack.
- **Cause:** Overheated or underheated sealant.
  Solution: Install at correct temperature, verify temperature gauges on melter.
- **Cause:** Sealant contaminated with solvent or heat transfer oil from tank leak.
  Solution: Discard affected sealant; repair or replace defective parts and re-seal.
- **Cause:** Joint faces contaminated with old, incompatible sealant or lubricant/adhesive (may also cause bleeding).
  Solution: Re-clean joint (i.e. sandblast) to remove old sealant or residue.
- **Cause:** Preformed sealant installed too high in joint.
  Solution: Use required recess.
- **Cause:** Preformed sealant not sized correctly for slab size, joint opening, and/or temperature variation.
  Solution: Use correct compression sealant size.

For more information on sealants, refer to *Joint and Crack Sealing and Repair for Concrete Pavement* (ACPA catalog number TB012P). To order, visit www.pavement.com; call toll-free 1-800-868-6733.

A Re-Introduction to Slag Cement - Part 2

By Jan R. Prusinski, P.E.
Executive Director, Slag Cement Association

Editor's Note: *This installment of a two-part article on slag cement covers characteristics, placing and paving tips, and specifications.*

Concrete from slag cement features several benefits, including improved concrete workability; enhanced finishability; lower permeability; and improved resistance to aggressive chemicals. It also features increased compressive and flexural strengths and can be lighter in color.

Resistance to ASR

Alkali-silica reaction (ASR) occurs when the alkalis in portland cement react with certain reactive aggregates to form an expansive gel that causes the concrete to crack, swell and prematurely deteriorate. Slag cement can mitigate ASR by reacting with the alkalis in portland cement and making them unavailable for reaction. It also lowers the permeability of the concrete, reducing the water available for reaction and, in some cases, lowering the total alkali content of the cement paste.

Placing and Paving

With a few exceptions, placing and finishing concrete with slag cement is similar to placing and finishing conventional portland cement concrete. These few exceptions are related to lower heat generation, the smaller particle size of slag cement, and differences with consolidation. The paving contractor should be aware of the characteristics of concrete containing slag cement, similar to being aware of the effects of admixtures, aggregates, and temperature.

Correctly designed concrete mixtures containing slag cement demonstrate improved workability and finishability when compared with 100% portland cement concrete systems. This is due to several factors including increased paste cohesiveness, glassy structure of slag cement, and low initial water absorption. Slag cement mixtures can achieve required strength at lower cementitious levels while maintaining good workability and finishability.

The history of slag cement

The use of slag cement can be traced to the 1700s, when the material was combined with lime to make mortars. The first U.S. production was in 1896.

Up to the 1950s, granulated slag was used in the manufacture of blended portland cements, or as raw feedstock to make cement clinker. However, around the same time slag cement became available in other countries as a separate product.

The first granulation facility in the U.S. to make a separate slag cement product was Sparrows Point, Maryland, in the early 1980s. Recent years have seen the supply and acceptance of slag cement grow dramatically throughout the U.S.

The product is now widely available east of the Rockies, as well as in some West Coast locations.

Concrete from slag cement features increased compressive and flexural strengths and can be lighter in color.

For many of the same reasons, consolidation of slag cement concrete is generally easier than portland cement concrete. When concretes with constant water-cementitious ratios are compared, those containing slag cement generally exhibit higher slumps. Slump control is essential to preventing edge slump during slipform paving.

Time of Set

Concrete containing slag cement in excess of 25% replacement dosage generally has noticeably slower set times than ordinary portland cement concrete. Time of set is related to the percentage of slag cement used in the mix, the temperature of the concrete, and the ambient temperature. At an ambient temperature of 73°F, time of initial set is usually extended by one to three hours. At temperatures above 85°F, the time of set difference becomes insignificant.

Specifications

Slag cement, when used as a separate component in a concrete mixture, is specified through ASTM C989 *Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortar*. When used as a component in blended cement, one of two specifications is used: ASTM C595, *Specification for Blended Hydraulic Cements*, or ASTM C1157, *Standard Performance Specification for Blended Hydraulic Cement*.

For more information slag cement, visit www.slagcement.org or contact Jan R. Prusinski, Executive Director of the Slag Cement Association, at 281-340-8550.

ACPA Members Donate Services for Research on Sound at the Tire/Pavement Interface

Diamond Surface, Inc., and Diamond B, Inc., volunteered to develop and build a grinding machine that will be used for researching whisper grinding surfaces at the Institute for Safe, Quiet, and Durable Highways (SQDH) at Purdue University.

Once built, the grinding machine will be used to prepare concrete samples with different textures for the Tire/Pavement Test Apparatus. The research, which looks to optimize texturing for concrete pavement, is in planning stages and is set to begin soon.

The Federal Highway Administration and ACPA are also contributing to this grinding research project. Results are expected later this year.

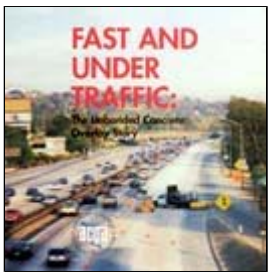
The SQDH is a joint effort by the Schools of Civil and Mechanical Engineering at Purdue University and the test facility and transportation research capabilities of the Pennsylvania Transportation Institute at the Pennsylvania State University.

Photo depicts the SQDH's noise tester. The machine measures noise levels by running a tire over a concrete sample. Up to six different samples can be tested simultaneously.

Look for more information in future issues of **CONCRETE PAVEMENT PROGRESS**.

Product Showcase

ACPA Offers Limited Supply of Traffic Management Video



Don't miss the opportunity to own one of the last copies of a popular video tape on traffic management.

Traffic Management is one of the crucial factors in rehabilitating today's roadways. This video, *Fast and Under Traffic*, focuses on replacing worn pavements with long-lasting concrete pavements, while still maintaining traffic.

To order this video (ACPA catalog number VC523P), visit www.pavement.com or call toll-free 1-800-868-6733.

Concrete Pavement News Digest

ACPA Names Director of Environmental Technology

ACPA named Larry A. Scofield, P.E., as Director of Environmental Technology. Scofield will focus on researching and promoting the environmental benefits of concrete pavements. In this role, he will provide technical service to ACPA members and affiliates, while also supporting the concrete pavement industry's research initiatives. He also will support ACPA's market areas (highways, airports, and local roadways) to address both existing and emerging environmental issues.

"Larry has both the skills and experience to provide great value to public officials, members, and affiliated Chapter/States on emerging environmental topics in this country," said ACPA Jerry Voigt, P.E., President and CEO.

Scofield is one of the nation's foremost authorities in sound at the tire/pavement interface. He is also well-regarded among transportation professionals for his many contributions to the improvement of highway technology.

Prior to joining ACPA, Scofield spent almost 30 years with the Arizona Department of Transportation, including 20 years as the manager/researcher for the Arizona Transportation Research Center. Most recently, he was the pavement management engineer for ADOT.

Scofield holds a Master of Science degree in Civil Engineering from Arizona State University. He will work from his home office in Mesa, Ariz., where he lives with his wife and two children.

Still Time to Register for Whitetopping Conference

The "International Conference on Best Practices for Ultrathin and Thin Whitetopping" will feature three days full of the world's newest technical developments for whitetopping.

ACPA National and Chapter/State Association staff will provide technical information on several topics at the event. They include: UTW evolution; UTW case studies in Colorado; UTW testing; thin concrete overlays of composite pavements in Michigan; repair of UTW; and thin

whitetopping at airports.

The conference is limited to the first 300 registrants. The conference, to be held in Denver on April 13 - 15, is geared toward federal, state, and municipal engineers; consulting engineers; contractors; materials suppliers; and academia.

ACPA, the International Society for Concrete Pavements, the Transportation Research Board, the Federal Highway Administration, and the Colorado DOT are co-sponsoring the conference. For more information, contact Shiraz Tayabji at 410-997-0400.

Society for Concrete Pavement Announces Internation Conference

The International Society for Concrete Pavements (ISCP) released the brochure for the 8th International Conference on Concrete Pavements in Colorado Springs, Colo.

The brochure includes everything you need to know about the conference, from technical topics to be discussed to available recreational activities. The event, co-sponsored by ACPA, will be held August 13 - 18, in Colorado Springs, Colo.

The ISCP is still seeking papers to be presented at the conference, "Innovations for Concrete Pavement: Technology Transfer for the Next Generation." It is focused on federal, state, and municipal engineers; consulting engineers; contractors; materials suppliers; and academia.

For more information, contact Jason Weiss, Purdue University, at iscp8@ecn.purdue.edu.

CEMEX Acquires RMC

CEMEX announced the acquisition of RMC Group recently. With the integration of RMC, CEMEX will have an annual production capacity of 97 million metric tons of cement, according to a CEMEX press release.

It will be the world's biggest ready mix concrete company with a capacity of 77 million tons per year and the fourth largest global aggregates (sand and gravel) company.

Center for Aggregates Slates Annual Symposium

The International Center for Aggregate Research announced the dates for the 13th Annual Symposium. The event will be held on on April 10 - 13, at the Omni Hotel Downtown, Austin, Texas.

The symposium features the latest research findings on field aggregates issues. The event is geared toward DOT employees and consultants involved in research, construction, and design; industry producers, researchers, sales/marketing personnel, and engineers; construction contractors; and university researchers. The symposium also features exhibitors with the latest products and services for the aggregates industry. Click here to register, or visit ICAR's website, www. icar.utexas.edu.

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