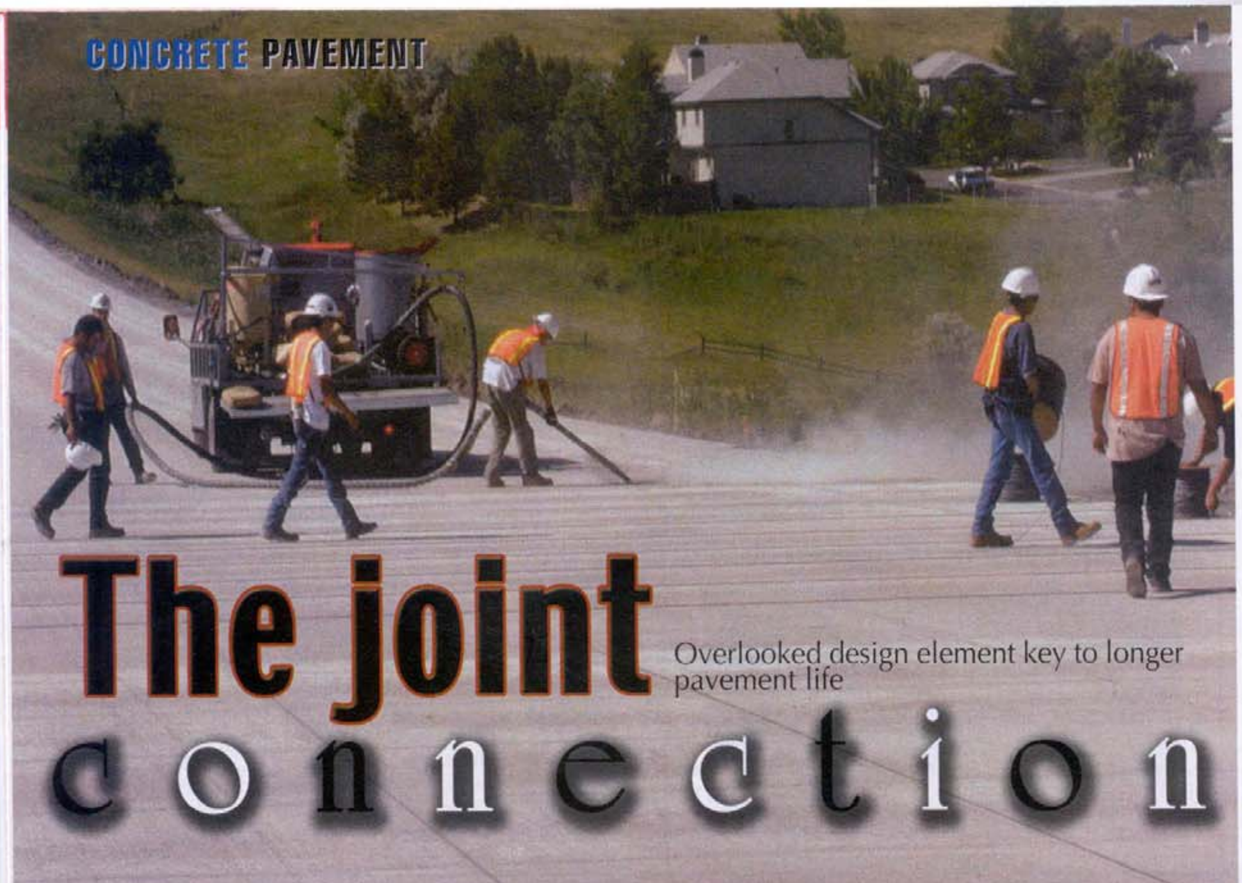

The joint connection

Overlooked design element key to longer pavement life

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To ensure the concrete pavements we are building now will continue to serve the needs of the traveling public well into the future, it is essential to take into account all design and construction aspects that may affect the performance and durability of the pavement.

Joint design is extremely important, but sometimes not given its due importance in an overall pavement design. A proper jointing system for concrete streets ensures that the structural capacity and ride quality of the pavement is maintained at the highest level of performance at the lowest possible cost.

A proper jointing system will control cracking; divide the pavement into practical geometric increments for construction; accommodate slab movements; and provide sufficient load transfer. Concrete pavement joint design has evolved from a tremendous body of theoretical studies, laboratory tests, experimental pavements and performance evaluations of in-service pavements. Understanding project-specific considerations such as traffic and environmental considerations is of paramount importance in design of slab dimensions and jointing details.

The primary purpose of joints in a concrete pavement is to control the location of transverse and longitudinal cracking, which results from stresses caused by normal drying shrinkage, temperature and moisture differentials and applied traffic loadings. If the stresses are not relieved, uncontrolled cracking will occur.

Designers also must consider climatic and environmental conditions; slab thickness; load transfer; shoulder, curb and gutter construction; and traffic. It's important to note that late or improper joint formation may cause cracks to occur at locations other than those intended.

Crack control

Observing slab behavior of unjointed and plain pavements in service has provided excellent perspectives on how joints are used to control cracking. To obtain adequate workability for placing and finishing concrete, more mixing water is used than needed to hydrate the cement.

As the concrete consolidates and hardens, some of the excess water bleeds to the surface and evaporates. Mix water also is consumed in hydration, the chemical reaction of cement hardening. With the loss of mix water, the concrete shrinks, occupying slightly less volume.

A second major source of early volume reduction is caused by the pavement's temperature change. The heat of hydration and temperature of the concrete normally peak a short time after the final set. After peaking, the temperature of the concrete declines, and as the temperature drops, the concrete pavement contracts.

The initial cracks will occur from about 40 to 150 ft apart, depending on the concrete properties, variations in subgrade friction and climatic conditions. Evaluating the combined effect of restrained temperature curling and moisture warping is complicated because of their opposing nature. Repetitive traffic loads compound the problem, but in any case the curling and warping, combined with traffic loads, will cause additional transverse cracks between the initial contraction cracks. Also, a longitudinal crack will form along the approximate centerline of pavements with two lanes of traffic.

Load handling

For jointed pavements to perform adequately, traffic loadings must be transferred effectively from one side of the joint to the other. Adequate load transfer, as this is called, results in lower deflections. The net effect is less faulting and spalling. Load transfer is generated by aggregate interlock or the use of dowel bars.

Aggregate interlock refers to the interlocking action between aggregate particles along the irregular crack faces that form below a saw cut. This form of load transfer has been found to be adequate on roads with short joint spacings and low truck volumes.

Dowel bars, which are cylindrical, smooth bars (usually epoxy-coated steel), when placed across transverse joints will provide mechanical interaction without restricting horizontal joint movements. They also keep slabs in horizontal and vertical alignment and reduce deflections and stresses occurring under various traffic loads. This, in turn, prevents or reduces faulting and pumping. This form of load transfer is well suited for roadways with longer joint spacings and for those that carry a large number of trucks. Dowel bars should be considered necessary when slabs are longer than 20 ft, when truck traffic exceeds 80 to 120 per day per lane or when the cumulative design traffic exceeds 4 million equivalent single axle loads per lane.

What's your type?

There are four general types of joints for concrete streets:

• Transverse contraction joints: Constructed transversely to the street's centerline and spaced to control transverse slab cracking. These are placed primarily to control natural cracking. Their spacing, saw cut depth and timing of joint formation are all critical to performance;

• Transverse construction joints: Installed at the end of a day-long paving operation or other placement interruption. Planned joints are butt-type joints and to perform properly require dowel bars extending through the joint;

• Longitudinal joints: Placed parallel to the pavement centerline to control cracking and delineate traffic lanes. Longitudinal joints on arterial streets also should be spaced to provide traffic and parking lane delineation. On most streets the pavement is laterally restrained by the backfill behind the curbs, so there is no need to tie longitudinal joints with deformed tiebars. But when lateral movement is not restrained, tiebars must be placed at mid-depth of the slab to prevent the joint from opening as a result of slab contraction; and

• Isolation joints: Placed to allow movement of the pavement without damaging adjacent pavements, intersecting streets, drainage structures or other fixed objects.

Isolation joints isolate the pavement from a structure, another paved area, or an in-pavement fixture. Proper use of these joints reduces compressive stresses that develop between the pavement and a structure or between two pavement sections.

Expansion joints are generally full-depth, full-width transverse joints placed at regular intervals of 50 to 500 ft, with contraction joints in between. This is an old practice that was used to relieve compressive forces, but unfortunately one that caused transverse joints to open wide near the expansion joint. These open joints were prone to spalling, pumping and faulting. Proper design, construction and maintenance of contraction joints has virtually eliminated the need for expansion joints, except under special circumstances.

Proper tips

In any application, it is essential to understand all the factors that can influence or can be influenced by pavement joints. Here are some general tips and guidelines to keep in mind when designing a joint layout:

1. Do not exceed maximum transverse joint spacing for streets, usually the lesser amount of either 24 times the slab thickness or 15 ft;

2. Longitudinal joint spacing should not exceed 12.5 ft;

3. Slabs should be kept as square as possible, with a maximum length-to-width ratio of 1.25;

4. Transverse contraction joints must be continuous through the curb and gutter and must have a depth equal to $\frac{1}{4}$ to $\frac{1}{3}$ the pavement thickness, depending on sub-base type;

5. In isolation joints, the filler must be full-depth and extend through the curb;

6. If there is no curb, longitudinal joints should be tied with deformed tiebars;

7. Offsets at radius points should be at least 1.5 ft wide, and within this region all joints should intersect the edge of pavement at 90°. Joint intersection angles less than 60° also should be avoided;

8. Minor adjustments in joint location to meet inlets and manholes will improve pavement performance; and

9. When the pavement area has drainage structures, joints should be placed to meet the structures, if possible.

Although these are general guidelines and tips that apply to proper joint design and construction, there are many other factors and variables that must be considered. ACPA has a number of technical publications that address joint design in various applications. They include:

"Design and Construction of Joints for Concrete Highways" (TB010P);

"Design and Construction of Joints for Concrete Streets" (IS061.01P);

"Intersection Joint Layout" (IS006P);

"Joint and Crack Sealing and Repair for Concrete Pavements" (TB012P);

"Proper Use of Isolation and Expansion Joints in Concrete Pavements" (IS400P); and

"Concrete Pavements with Undoweled Joints for Light Traffic Facilities" (IS405P).

Pricing, ordering information and additional details about these publications may be found on ACPA's website at www.pavement.com, or by calling 800/868-6733. Fax requests to 847/966-9666.

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