SUGGESTIONS ON SPECIFYING CONCRETE PAVEMENTS:

PARTNERING WITH YOUR CONCRETE SUPPLIER VOLUME II

The first volume of Suggestions on Specifying Concrete Pavements focused on items related to concrete mixes that occasionally contribute to confusion or miscommunication between the design documents and contractors or material suppliers during the bidding process. Volume II will look at nine topics related to placement of concrete after batching.

Delivery Methods – Transit Mixers

Fixed Form or Slipform Placement

Curing Concrete

Dowels and Tie Bars

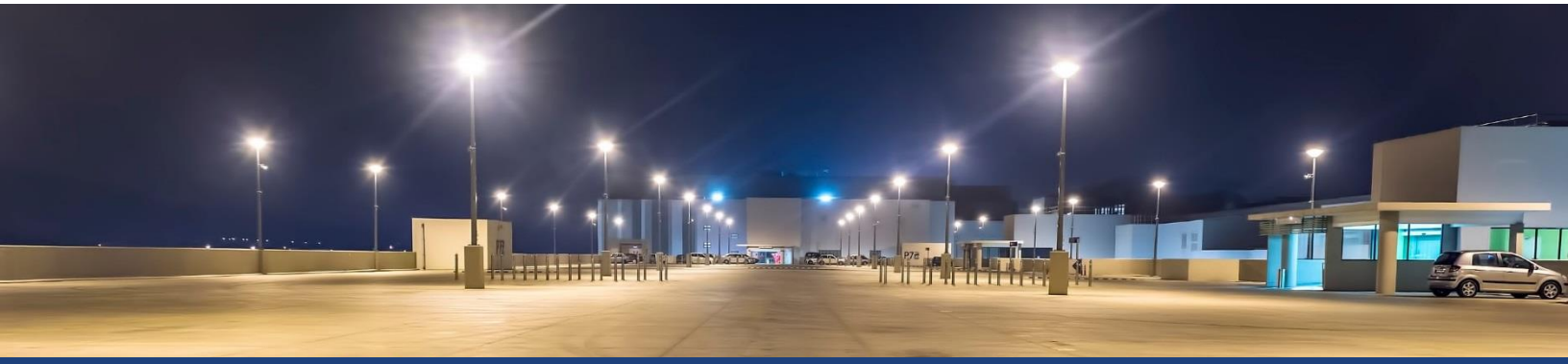
Reinforcing for Crack Control

Dump Trucks and RCC

Finishing Concrete

Joints and Joint Layout

Sealing or Filling Joints

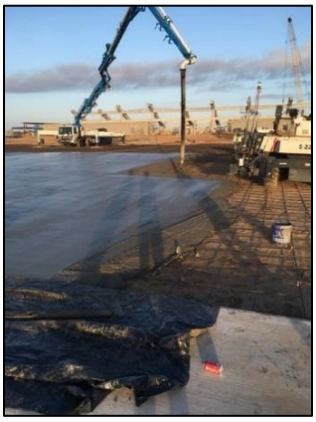


Les White, PE
Paving Solutions Engineer
Leslie.white@cemex.com

DELIVERY METHODS – TRANSIT MIXERS

Transit mixers, like the one shown in the picture to the left, typically have drum capacities ranging from 8 – 11 cubic yards, with the maximum load size delivered to a project site often limited to 9 cubic yards, due to weight restrictions placed by governing Departments of Transportation. Time from batching to discharge is typically limited to 90 minutes which, when combined with relatively small load sizes, 9 cubic yards as compared to a project requiring several hundred cubic yards of material, means careful consideration must be given to scheduling and resource availability for a successful concrete pavement placement.

Another consideration when planning a concrete pour is the limited reach of a mixer. Even with chute extensions shown in the picture to the right, the maximum reach is approximately 18 feet from the truck tires to the point of discharge. A mixer's reach can be further reduced as they must be positioned away from unsafe site conditions, such as the top of a slope or retaining wall. One-foot horizontal offset for every foot of height is not uncommon for mixer locations relative to the top edges of slopes or the tops of retaining walls.



The use of concrete pumps, as shown in the picture to the left, is an effective way to extend the reach for discharge from a transit mixer, adding several feet of access horizontally or vertically. Pumps provide a safe place for a mixer, or sometimes two mixers, to access the pour location. The chosen concrete mix may require adjustment, with regards to aggregate size and slump, to pass through the pump lines.

SUGGESTION: When designing a project with large concrete paving areas, the method of discharging concrete to the pour location can have an impact on the project schedule. Let us help you consider options to make the most of available resources for the concrete pavement on your next project.

DUMP TRUCKS AND ROLLER COMPACTED CONCRETE

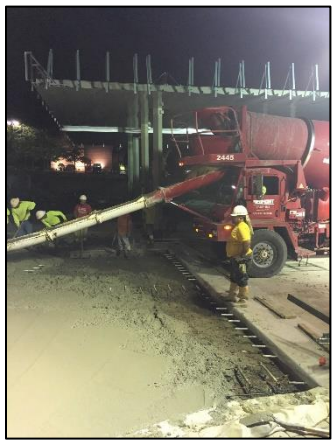
Concrete can also be delivered by Dump Truck. One of the more common concrete materials delivered by dump truck is Roller Compacted Concrete (RCC). This "zero slump" mix gives crews the ability to get on the pavement immediately behind the paver for real time quality control as shown in the picture to the right. The pavers used for RCC placement are like those used for asphalt paving, with high density pavers often preferred because of the higher level of compaction achievable prior to rolling. Once the RCC is placed, rollers are used to get final compaction.

RCC is frequently associated with larger projects that allow for placement of pugmill, such as the one in the picture to the left, on the project site. Material is batched in the pugmill, placed into dump trucks for a short haul to the placement location. Production rates often approach 300 CY/HR. The pugmill and associated stockpiles will require approximately two acres or more and can take a day or more to set up once transported to the site. Considering the area required and costs associated with use of a pugmill on site, projects with paving areas in excess of 250,000 SF – 300,000 SF, depending on pavement thickness, are typically considered the best fit.

To make RCC a suitable option for smaller projects, under the size menitoned above, a central batch ready mix plant, like the one in the picture to the right, can be employed. This method of batching and delivering RCC can achieve production rates of approximately 100 CY/HR without the area requirement and costs associated with placing a plant on site. Like projects using transit mixers, location of the offsite plant is a consideration. Haul times of less than 30 minutes are desired.

SUGGESTION: With the thickness of an RCC pavement being approximately the same as that of conventional concrete, the economy of RCC is generally associated with speed of construction, being comparable to that of asphalt, particularly on larger projects. Let us help you weigh all these factors when you plan paving on your next project.

FIXED FORM OR SLIPFORM PLACEMENT



In fixed-form placements concrete is poured in areas where form boards have been placed in fixed locations around the perimeter of the slab, or pavement. Since concrete mixes are typically in a liquid state coming out of the mixer, these fixed forms contain the mix and provide shape until the concrete has cured enough to stand alone. In the picture to the left form boards have been removed from earlier pours and those cured sections are used as forms for the work taking place. Planning and scheduling operations for fixed-form placements must allow for time to set forms up or strip them from cured concrete.

Slipform paving involves the use of concrete mixes on the lower end of the slump range, typically 0-3 inches. The forms are an integral part of the paver as shown in the picture to the right of a Roller Compacted Concrete placement. Concrete delivery for slip-form paving can be done with dump trucks, as in the RCC example to the right, or in mixers.

When mixers are used to deliver material for slip-form paving, the concrete is often discharged on the ground in front of the paver directly or by means of a conveyor similar to the picture to the left.

SUGGESTION: When considering concrete paving, placement options fit projects differently. Slipform paving is typically associated with large projects, such as roads and highways, where there is available space for paving equipment. Fixed-form paving, like the pictures above from a convenience store, is commonly used for any paving application. We are available to help in determining the placement option most suited for your paving application.

FINISHING CONCRETE

Finishing concrete involves working on visible surfaces, such as floor slabs, pavements, sidewalks, or other similar applications. Depending on the application, finishing can consist of several steps or just a few. Typically, interior floors require more steps than an exterior pavement, due to more stringent flatness and level requirements for the floors. For this discussion, we are talking, primarily, about exterior pavements, like parking lots, where concrete is delivered in a mixer. Finishing of a parking lot can be narrowed to three steps; screeding, bull floating, and brooming.

Screeding or "striking off" the concrete involves leveling the surface to grade. Screeds can be as simple as a long straightedge for hand work on smaller placements or as intricate as a 3-D laser guided machine for large placements. Bull Floats are flat tools four to ten feet wide, frequently with long handles, used to smooth the concrete after screeding to minimize high and low spots. Brooming is the last finishing step in this type of application and serves the purpose of adding texture to the surface for improved slip resistance.

Occasionally, paving applications may require additional steps employing other tools. Floats, different from Bull Floats, and trowels are used for surface finishes that are smooth, without the texture of a broom finish. Floating is done to further eliminate remaining high and low spots and produce a plane, level surface and provide additional compaction and consolidation of that surface. Troweling is a final step to produce a surface that is hard and smooth. Troweling is only done after floating. Similar to screeds mentioned above, floats and trowels are available as hand tools or power tools that are walked behind or ridden on.

SUGGESTION: When looking at concrete paving on a commercial project, the finishing capabilities of a contractor may come into the conversation. Access to a laser screed, for example, could have a significant impact on planning and scheduling a large paving project. We are available to help explore a variety of options as you consider the right pavement for your next project.

CURING CONCRETE

According to The Craftsman Workbook for ACI (American Concrete Institute) Certification Concrete Flatwork Technician & Flatwork Finisher "Curing refers to the methods used to keep concrete moist and at the temperature needed to develop the required strength, wear resistance, and durability. The main concern is

preventing moisture loss from the slab surface, especially at early ages." There is typically enough, even extra, water in most common concrete mixes to complete hydration of the cement. However, after placement concrete starts to dry, quicker at the top of a slab than at the bottom, and water is lost, which slows hydration and can reduce strength gain. Listed below are some of the curing methods used to help keep moisture in the concrete and allow for full hydration. Curing times of 3-7 days are not uncommon.

Ponding: Water covers the entire concrete slab surface to a depth of 2-3 inches using soil berms, or dikes, at the slab edges. This method is not suggested for jointed slabs and the dykes must be watertight.

Sprinkling or Fog Spraying: The concrete surface is kept moist using a sprinkler system or something similar. This method is more practical on smaller slabs where there is no danger of runoff damaging the subgrade than it is on larger, commercial applications.

Wet Burlap or Mats: The wet mats, burlap, cotton, or other material cover the entire concrete surface. These are frequently specialty products made for concrete curing.

Reinforced Paper or Plastic Film: Similar to the mats mentioned above, papers (two-layer) and films (minimum 4 mils) are specialty products made for curing concrete.

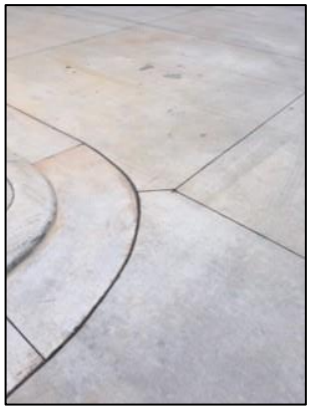
Curing Compounds: When applied to the concrete surface, a film is formed to seal in moisture. There are various types of curing compounds, suited to different applications, available.

SUGGESTION: The curing method chosen on a given project will likely depend on the experience and preference of the contractor perfroming the work as well as the type of slab and application. We are available to help answer questions on curing or any other aspect of concrete paving for your next project.

JOINTS AND JOINT LAYOUT

It has been said that you can divide concrete into two categories. Category one is concrete that has cracked. Category two is concrete that hasn't cracked yet. There are several reasons why concrete cracks after placement including shrinkage from drying, restraint due to friction or bonding with the subbase, changes in temperature or moisture, and first-time loading. While not a method for preventing cracks, jointing is a tool for controlling cracks. Three types of joints used in concrete pavements, Contraction (Control) Joints, Construction Joints, and Isolation Joints, are introduced below.

Contraction Joints are also referred to as control joints because their purpose is to control where concrete cracks. These joints are sawcut into pavements at regular intervals as shown in the picture to the right. Shorter joint spacing, in the range of 1.5 – 2 times (in feet) the pavement thickness with a maximum of 15 feet, has been shown to provide better pavement performance than longer spacing. The table at the left shows recommended joint spacing for various pavement thickness. Construction joints are located where work stops on a project for the day. Placement of these joints is included with planning of other control joints at the intervals previously indicated.



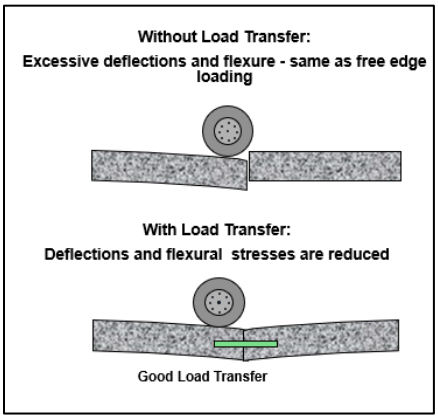
Pavement thickness, in.	Spacing range, ft
4 to 4.5	6-9
5 to 5.5	7.5 -11
6 or greater	9 -15

Isolation joints are placed between the pavement and rigid structures, such as buildings or columns, that will move differently than the pavement. Isolation joints are typically wider than control joints and include a filler material that allows for differential movement between the pavement and the structure. In the picture to the left, with no control joints, a random crack has formed diagonally off the column. The picture to the right shows a situation where random cracking was controlled by the contraction joints placed perpendicular to the faces of the isolated structure.

SUGGESTION: Risk of uncontrolled, random cracking can be reduced with preparation of a jointing plan as part of your concrete pavement design. We are available to help plan a joint layout for any project involving concrete pavement.

DOWELS AND TIE-BARS

Dowels and Tie Bars across concrete joints serve two different purposes. Dowels are intended to aid in load transfer from one slab to another and allow for some movement in the slabs. Tie Bars are intended to hold slabs together and do not encourage movement. ACI 330.2R-17- Guide for the Design and Construction of Concrete Site Paving from Industrial and Trucking Facilities is a good resource for information on Dowels and Tie Bars as well as other aspects related to concrete paving in commercial applications.



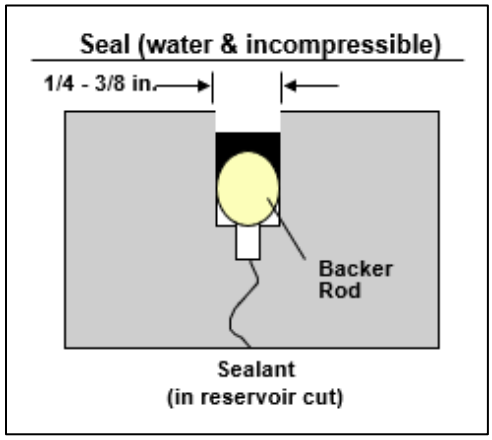
According to the guide, and illustrated in the picture to the left, "Dowels transfer loads between adjacent panels, reduce edge and corner stresses in the concrete and force concrete on both sides of the joint to deflect approximately equally when subjected to a load, helping to prevent pumping, subgrade/subbase material erosion, faulting…., and damage to slab edges as the joint is traversed". Dowels come in various shapes and sizes and are smooth so horizontal movement between the slabs is not restricted. While, dowel bars have traditionally been round or square, flat plate dowels with square or tapered edges are also available.

Round or square dowels range in diameter or thickness from ¾" to 1-1/2" and in length from 10" to 22" and spacing ranges from 12" to 14". Dowels less than 1 1/4" in diameter are typically not recommended for use. Plate dowel sizes are typically specified per manufacturer's recommendations and spaced at 18". Dowels can be placed in control joints, construction joints, or isolation joints. Placement in construction joints is frequently done using sleeves in form boards, as shown in the picture to the right, while installation of dowels in control joints is frequently done using dowel baskets which are placed before the concrete is poured.

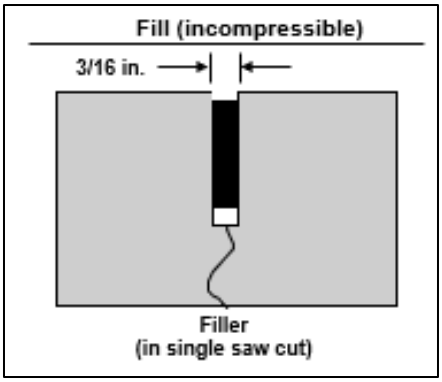
Tie-bars are deformed steel, not smooth, and, as the name implies are intended to restrict horizontal movement of slabs. They are generally placed in longitudinal joints to keep outside panels from shifting laterally. Tie-bars are typically ½" in diameter with lengths ranging from 24" to 30" and spacing ranging from 30" to 36". As with dowels, sizing varies with the slab thickness.

SUGGESTION: The use of dowels or tie-bars may not be necessary for every project. We are available to help you whether dowels and tie-bars would benefit your paving applications and, if so, to help you with sizing, layout, and detailing.

SEALING OR FILLING JOINTS



Sealing and filling joints are different treatments. The picture to the left is an example of a sealed joint. This type of joint treatment helps to prevent intrusion of water into the subgrade and also helps keep incompressible materials out of the pavement section. The Backer Rod helps create the seal keeping water out and reduce leaking of sealant material downward. Installation of sealed joints require two sawcuts and they with are relatively wide, as indicated in the picture.



Different from a sealed joint, a filled joint, shown at the right, is done with a single, narrower sawcut. There is only one material placed in the joint as Backer Rod is not used. While a filled joint will help reduce water intrusion, its seal may not be as tight as with a sealed joint, so the primary function is to help keep incompressible materials, out of the pavement section.

Whether joints are filled or sealed, proper design and installation are critical to obtaining the best performance of your joints and pavement. For most commercial projects, we recommend Filled Joints with the following considerations:

- Single sawcut 3/16 to ¼ inch in width
- Initial cut to 1/3 the slab thickness as required for conventional sawing or to a depth of 1-1/4" for early entry sawing.
- Fill with a hot-poured elastic joint sealer meeting ASTM D6690, Type IV, leaving a recess of approximately 1/8"

SUGGESTION: The decision to fill joints is frequently made on an individual project basis. We are available to help you determine whether your project would benefit from filled joints and provide you with information to get the best possible performance from your concrete pavements.

REINFORCING FOR CRACK CONTROL

While the use of joints is an effective means of controlling cracks in concrete pavements, the smaller panels can mean a relatively large number of joints. There are applications, such as interior floor slabs, where this increased number of joints may not be desired. Welded Wire Fabric or Fibers are two reinforcing methods used for the purpose of controlling cracks that form in concrete slabs.

The use of distributed steel (welded wire fabric, wire mesh, or "chicken wire") has been used with concrete pavement in the US since the early 1900's when widespread use of concrete for pavements began. With the area of steel involved being relatively small, the sole purpose of distributed steel used for crack control is to hold concrete slabs together once cracks form. When placing distributed steel, it is difficult to keep it in the desired location, roughly the middle of the slab section, as the weight of concrete tends to push it to the bottom and, occasionally, out of the slab entirely. Methods to keep the material in the middle of the slab include placing supports, also known as "chairs", throughout the placement area, which is labor intensive and can have an impact of the overall cost of the concrete pavement or other slab.

The use fibers for concrete reinforcement is also not new and has included materials such as straw or animal hair among other things. Today we typically think of steel fibers or synthetic fibers and the various subsets of each type. Steel fibers are designated by type such as Type 1 – cold drawn steel, or Type 2-cut-sheet steel. Synthetic fibers are termed micro or macro and have other characteristics within each size. Fibers are added to concrete as it is being batched, which makes them less labor intensive than distributed steel. The dosing rate and type of fiber used will vary depending on the application. There are many examples of fibers (steel and synthetic) being successfully used to extend joint spacing, and reduce the number of joints, on industrial floors.

SUGGESTION: When considering the use of reinforcement, distributed steel or fibers, in your concrete pavement for crack control or for increased structural capacity, we are available as a resource to help you get the best long-term performance from your concrete pavement, or other slab.