What's New in Concrete Paving?

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INTRODUCTION

The concrete being placed in pavements today is much the same as it was 10 and 20 years ago. Cement, aggregate, water and entrained air are basic materials and no major changes have taken place. The design procedures and construction methods, however, have undergone amazing changes in just the past few years and the end is not in sight. Engineers, equipment manufacturers and contractors are continually seeking ways to improve pavement performance, rideability and safety and to reduce construction costs.

An ARBA Bulletin* published in 1965 described many of the "recent developments" of that day. This paper is intended to bring that information up to date and to point out recent changes which represent forward steps in paving technology.

DESIGN

The thickness design of concrete pavements has become more sophisticated and exacting. Influence charts, computer programs, and other analytical design procedures have provided engineers with new tools to evaluate the effects of subgrade support, traffic, and concrete strength.

The airlines, aircraft manufacturers, and consulting engineers are using the new PCA computer program for design of airfield pavements. The computer has simplified design for the new 747, DC10, L1011, C5A and SST's—all involving many more wheels and landing gears than previous generations of aircraft.

Several state highway departments have adopted the new Portland Cement Association highway design procedure or modified versions of it. This new method is based on stresses at slab edges due to leads at transverse joints rather than at corners as has been the practice for many years. It also recognizes the added support provided by stabilized subbases. The design procedure allows a designer to avoid the illogical

* ARBA Technical Bulletin No. 256, "Recent Developments in Portland Cement Concrete Pavement Design and Construction."
practice of using a standard 8-, 9- or 10-in. cross-section irrespective of traffic or soils conditions.

Several states and counties currently build 6- or 7-in. concrete pavements for light-traffic roads. Counties in Iowa have built over 2,000 miles of these thinner concrete pavements on their state secondary system. A recent survey of these pavements with the PCA roadmeter showed that their present serviceability indices range from 3.26 for pavements built in 1955 to 4.15 for those built in 1969. The average was 3.91 for the total 2,000-plus miles.

Skewed randomized transferse joints which were just coming into use in 1965 are now standard in several states and parts of Europe and Canada. They have greatly improved riding qualities—Fig. 1.

Fig. 1. A bird’s-eye view of the skewed randomized joint pattern now used in several states. Joints are skewed 2 ft. in 12 ft. and spacings are 13, 19, 18, and 12 ft.

Continuously reinforced concrete pavement (CRCP) was built experimentally in several states prior to 1950 and, by the end of 1959, 100 two-lane miles of CRCP had been built. Since then more than 7,000 two-lane miles of CRCP has been constructed in 30 states. The higher first cost of CRCP is justified on some major highways by its potentially longer service life and lower maintenance cost.

STABILIZED SUBBASES

All state highway departments have been using granular subbases under concrete highways since about World War II. In the 1960’s,
after the AASHO Road Test, nearly all states began to consider the many advantages to be gained from a change to stabilized subbases. Cement-treated subbases have been enthusiastically endorsed by paving contractors who find that the strong working platform they provide allows increased production, minimizes problems associated with weather, and—most importantly—ensures construction of smoother-riding pavements with longer service lives.

SUBGRADE PREPARATIONS

The most exciting new developments in paving have been in equipment. Subgrading operations have been revolutionized in the past few years—Fig. 2. Electronically controlled full-width equipment is now being used to fine grade subgrades, to spread and trim subbases, either granular or cement-treated, and in some cases to mix the cement-treated material. Both alignment and grade are controlled by electronic sensors operating from pre-set nylon lines or from skids on the grade or on adjacent pavement. These new machines have reduced construction costs and overruns in subbase and pavements, have increased production, and have greatly improved pavement rideability.

Fig. 2. Electronically controlled fine-grading machines can now trim subgrades and spread and trim subbases. The same preset stringline can be used for both operations and slip-form paving if necessary.

MIXING, HAULING, AND SPREADING

Central mixing plants which were just being recognized for paving ten years ago are now being used on approximately 70 percent
of all highway jobs. Greater sophistication in these plants has resulted in complete automation of batching with interlocking mechanisms to ensure uniform concrete, so necessary for high-speed slip-form paving. Slump (or torque) meters on mixers also permit immediate adjustment of mixing water to provide uniform concrete consistency from batch to batch. Some states require batching plants to have recording equipment to provide a printed record of batch weights for each ingredient in the mix. Such printouts serve as valuable documentation to state highway departments and the BPR.

Spreading equipment for concrete has advanced to keep pace with the change from traveling 34E mixers to central mix. Some states initially specified agitating or bathtub-type trucks for hauling central-mixed concrete. The first spreader developed exclusively for this type of operation was a hopper type spreader which received the concrete from a rear or side dump truck.

As more states permitted central mixing, regular dump trucks also gained acceptance—Fig. 3. With plain pavements and slip-form pavers contractors usually dump on the subgrade or subbase directly ahead of the paver. In some states this practice is limited to projects with stabilized subbases. Where side forms or continuous reinforcement is used, mechanical spreaders are a necessity.

Fig. 3. Dump truck hauling of central-mixed concrete is now standard practice in many states. The use of cement-treated subbase and slip-form pavers make this method possible.

Several equipment manufacturers have produced belt-type spreaders which will take concrete from almost any type of hauling equip-
ment and deposit it uniformly across the slab width. They may run on side forms or straddle reinforcing steel, dowel baskets, or the first lift of two courses slip-form paving—Fig. 4.

![Table](image)

**Fig. 4.** This table from PCA Concrete Report “Description and Cost Comparisons of Modern Concrete Paving Equipment Systems” summarizes the widespread acceptance of slip-form paving and central-mixed concrete in the U.S.

**SLIP-FORM PAVING**

The first slip-form paver was built in Iowa just 21 years ago. Today slip-form equipment is no longer considered new or experimental. Almost all states have some mileage of concrete built with slip-form pavers. Originally they were used for 6-in. plain concrete secondary roads. Today slip-form pavers are also being used to pave jointed reinforced pavements with mesh and dowels, continuously reinforced pavements, airfield pavements up to 20 in. thick and even parking areas and warehouse floors.

Spip-form pavers are capable of placing keyways or keys for tongue-and-groove joints, either with or without tiebars. They have been used to place highway pavements 12, 24, 36 or 48 ft wide. Contractors are currently building curved ramps with slip-form pavers.

New, smaller machines are available for slip-forming feedlots, floors, and city streets with integral curb, if desired. At least one manufacturer has an electronically controlled self-propelled slip-form
paver for placing curb and gutter sections of almost any cross-section in widths up to six feet. Another slip-form paver has been adapted to pave bridge approach slabs right up to the bridge. This eliminates leaving a gap which must be paved later with forms and hand finishing methods.

The first slip-formed reinforced pavements were built using the two-course method and two slip-form pavers. In recent years full-depth pavement has been placed with both mesh and dowels installed by vibratory mesh depressors and dowel installers—Fig. 5. Several states are building continuously reinforced pavements with longitudinal bars only—Fig. 6. These bars are fed through tubes and incorporated in the slip-form paver, which positions them properly in the slab. Another new equipment system passes the longitudinal bars over the spreader and deposits them, with or without transferse bars as required, on top of the full-depth pavement. The bars are positioned and then depressed by vibration to the specified depth in the slab by a tamper attached to the front of the slip-form paver.

Fig. 5. Dowel installers can be used to depress dowels to the proper location in full-depth concrete. This eliminates the need for dowel baskets.

JOINT CONSTRUCTION

There have been no major changes in methods for forming joints in the past few years. In many states longitudinal joints are formed by polyethylene strips fed into grooves cut by a device on the rear of slip-form pavers. These joints usually require no sawing or sealing. Transverse joints are generally sawed. More states are specifying a
stepped or widened groove at the surface in transverse joints to provide a larger sealant reservoir with an adequate shape factor. A number of states are now using premolded neoprene compression seals. These require special installation equipment, but have shown excellent performance and appearance when properly installed.

TEXTURING

Until recently most states using slip-form pavers used burlap drags for final surface texture—Fig. 7. Because of inadequate burlap weight and improper timing of the drag operation, the texture depths obtained were sometimes too shallow to provide good skid-resistant surfaces. Increased attention to safety and the danger from hydroplaning has focused attention on the need for adequate surface textures and more rigid specifications and tests are being developed to ensure that they are obtained.

On some airport runways and major high-speed highways, grooves have been cut in the surface of existing pavements to eliminate hydroplaning and skidding—Fig. 8. The grooves have generally been cut longitudinally on highways and transversely on airports. The grooves are cut with diamond saws and are usually about \( \frac{1}{8} \) by \( \frac{1}{8} \) or \( \frac{3}{8} \) by \( \frac{3}{8} \) inch at \( \frac{3}{4} \) or 1 inch spacing.

Equipment manufacturers and contractors have recently developed and tested equipment for brooming either longitudinally or trans-
Fig. 7. This table from “Factors Affecting Skid Resistance and Safety of Concrete Pavements,” HRB’s Special Report 101, compares texture depths obtained by various methods of finish.

<table>
<thead>
<tr>
<th>Method of Finish</th>
<th>Depth, in.</th>
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<tbody>
<tr>
<td>LIGHT BURLAP DRAG</td>
<td>0.017</td>
</tr>
<tr>
<td>HEAVY BURLAP DRAG</td>
<td>0.025</td>
</tr>
<tr>
<td>COCOA MATTING</td>
<td>0.032</td>
</tr>
<tr>
<td>HEAVY BELT</td>
<td>0.020</td>
</tr>
<tr>
<td>WALLPAPER BRUSH</td>
<td>0.026</td>
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<tr>
<td>HEAVY PAVING BROOM</td>
<td>0.037</td>
</tr>
<tr>
<td>WOOD FLOAT</td>
<td>0.014</td>
</tr>
<tr>
<td>WIRE DRAG</td>
<td>0.036</td>
</tr>
<tr>
<td>STIFF WIRE BRUSH</td>
<td>0.075</td>
</tr>
</tbody>
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versely with stiff nylon or wire brooms. Early models have produced excellent textures which have very high skid resistance and minimize hydroplaning tendencies. Equipment is also available to form square grooves in plastic concrete to duplicate sawed grooves at a reduced

Fig. 8. Enlarged photo of a core from a concrete pavement which was grooved with a concrete saw to eliminate hydroplaning possibilities.
cost. One machine combines transverse grooves with longitudinal brooming to obtain excellent texture and maximum surface drainage—Fig. 9. While transverse grooving or brooming may raise the noise level inside automobiles, the improved safety under all driving conditions more than compensates for any increase in noise level.

![Fig. 9. Surface texture created in pavement by longitudinal brooming and transverse grooving. Such a texture minimizes hydroplaning, reduces stopping distance, and provides excellent longitudinal guidance.](image)

**CURING**

Even the curing process has been mechanized further to increase production and reduce costs. Most states now specify white pigmented curing compounds. Older spraying equipment had a spray nozzle which traveled transversely from edge to edge while moving slowly forward. To accommodate faster paving rates, machines are now used which spray the entire slab width and both vertical edges by means of a fixed spray bar as the machine moves forward—Fig. 10.

One manufacturer produces a membrane cure applicator that also carries a supply of continuous polyethylene sheet on a roll. This may be used for curing or for emergency protection in case of sudden rain. The same machine can quickly pick up and reroll the plastic sheet.

**CONCLUSION**

It is obvious that concrete paving techniques are changing—almost daily—Figs. 11, 12. The concrete paving industry is dynamic and
alive. A competitive industry, it must constantly improve, improvise, and modernize to produce a safe, quality product at a reasonable cost. We are confident that it will continue to do so in the years ahead.
Fig. 11. Device for grooving concrete shoulders. Resulting "rumble strip" placed at 50-ft. intervals alerts driver that he is off regular driving lane.

Fig. 12. New concrete highway on multi-lane interstate project in New Jersey. White concrete "Safety Shape" median barrier has been used in narrow median for added safety and improved esthetics.