Slip-Form Today and Tomorrow

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The latest slip-form paving developments and techniques are discussed and illustrated. Among these are the compatibility of slip-form pavers with central-mixed concrete and the most recent technique of using two slip-form pavers to construct concrete pavements having mesh dowel designs. New equipment and recent modifications to current slip-form pavers are also described in order to present the latest results of research and development by all slip-form manufacturers.

Equipment manufacturers, contractors, and highway engineers predict that within a few years slip-form paving will be the standard method of concrete pavement construction. In only 15 years, the slip-form paver has proved itself.

•THE SLIP-FORM TECHNIQUE is no longer experimental. The acceptability and advantages of this method of concrete pavement construction have been proven. The future looks bright. The most significant breakthrough has occurred this year with the use of slip-form in several states where mesh dowel designs are required. Slip-form had not generally been accepted in states employing mesh dowel designs. However, in the past construction season, Oklahoma and Iowa awarded Interstate contracts which permitted the contractor to use slip-form equipment with pavements having a design of mesh and dowels.

The first project was constructed in Oklahoma on I-40 by Brooks and McConnell Construction Co. of Oklahoma City. Two Rex slip-form paving machines were used in tandem to pave 5 mi of dual 24-ft wide, 9-in. thick concrete pavement (Fig. 1). The lead slip-form paver struck off the 6½-in. bottom course of concrete dumped on the grade in front of the machine by a Koehring dual-drum and a tribatch mixer (Fig. 2). The frame of the lead slip-form machine carried the mesh, which was simply pulled off by laborers and dropped into place on the surface of the bottom 6½-in. course (Fig. 3). Offsets, 2 in. thick, were attached to the inside of the sliding forms. This 2-in. reduction in width on each side permitted the second slip-form paver to clear the edges of the bottom course with ease.

The rear machine was a conventional Rex slip-form paver (Fig. 4). A dual-drum paver deposited concrete on top of the mesh in front of the second paver. The 2½-in. top course, plus the filled-out bottom course, was thoroughly vibrated and extruded to a smooth 9-in. thick, full 24-ft wide pavement (Fig. 5).

A similar project was constructed in Iowa on I-80 by the Fred Carlson Construction Co. (Fig. 6). This was the first Interstate slip-form paving in Iowa. Although Iowa pioneered slip-form paving and has more than 1,000 mi of slip-form concrete pavement, this was the first project requiring mesh reinforcement. The only differences between the Oklahoma project and the Iowa project were the following.

1. Iowa's pavement was 10 in. thick.
2. Oklahoma used a sand-asphalt subbase; Iowa used a crushed stone subbase. The Iowa contractor had to stabilize the crawler track path to eliminate tearing up the subbase in front of the tracks of the second slip-form machine.
3. In Oklahoma, the mesh was carried on the frame of the first machine; in Iowa it was stacked along the right-of-way and carried in from the shoulder.

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Figure 1. Two Rex slip-form pavers in use on I-40 in Oklahoma.

Figure 2. Koehring dual-drum and tribatch mixers placing concrete in front of first slip-form paver on I-40.

The Quad City Construction Co., the pioneer of slip-form paving in Iowa, developed its own spreading device coupled with a new Rex slip-form paver and central mix plant to pave its contract on I-80 in eastern Iowa (Fig. 7). A 45-ft section of heavy specially shaped form was fastened to the front corners of the slip-form machine (Fig. 8). A split, reversible screw spreader mounted on crawler tracks and guided by the 45-ft form sections struck off the concrete for the first course. The crawler-mounted screw spreader was self-propelled and could move forward or backward within the 45-ft length of guide forms.

This operation required close coordination between dumping the central-mixed

Figure 3. Mesh carried by front paver.

concrete and operating the screw spreader and slip-form paver. It permitted the contractor to strike off the concrete for a full 24-ft width and kept the distance between the first and second course of concrete to 45 ft or less.

The mesh was laid out on the subbase ahead of the paving operation (Fig. 9). Laborers passed the sheets of mesh over a series of bars on the screw spreader so that the mesh was placed directly on the struck-off first lift of concrete. A total of 21 mi of four-lane divided Interstate pavement was placed in Iowa in 1964 by this method.

Oklahoma to date has had nine projects requiring mesh and dowels built with the slip-form paver. Five contractors have built these nine jobs totaling 37 mi of four-lane Interstate pavement. Of special interest is the progressive reduction in unit cost as contractor experience was gained for this type of construction. This 9-in. pavement, including mesh and contraction joints at 61.5 ft, was first bid in September 1963 at $4.37/sq yd. The last four jobs were all less than $4.00/sq yd, with the lowest at $3.78.

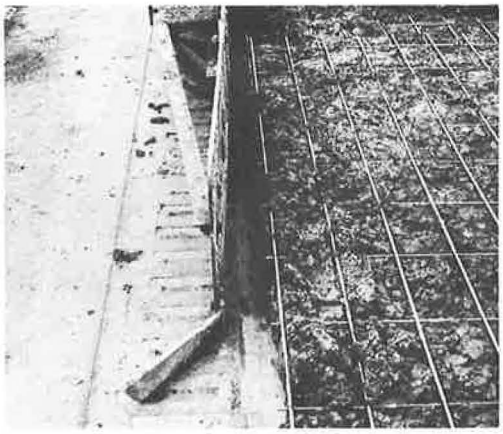

Figure 4. Rex paver placing $2\frac{1}{2}$-in. top course and filling in edges on Oklahoma I-40 jobs.

The versatility of slip-form is becoming more apparent. The Peter Kiewit Sons Co. paved not only the main line but also the ramps on one of its projects in Wyoming this past summer, using a Rex slip-form paver (Fig. 10). A Guntert-Zimmerman slip-form paver was also used in Wyoming to pave ramps on I-25. Roberts and Western Co. successfully placed integral-curb ramps with its Rex machine on an interchange of the Pioneer Expressway near Lawton, Okla.

Texas is having success with slip-form on the state's continuously-reinforced Interstate projects. Texas contractors are building a smoother pavement with slip-form methods than they were able to obtain with formed construction.

The only airfield paving to use slip-form pavers in this country was at Hillgrove Airport in Providence, R.I., in 1958, when the circular parking apron was paved. The apron is 1,300 ft long

Figure 5. Finished slab on twin slip-form project, I-40.

and 300 ft wide, 8 and 10 in. thick. France has had more experience with airfield construction for multiple-lane paving using slip-form paving equipment. Last summer at a completely new airport project near Brest, France, the Rex slip-form paver was used to pave multiple lanes for the main runway, the secondary runway, taxiways, and parking aprons. A Guntert-Zimmerman slip-form paver was used to pave a new taxiway at Orly Airport, Paris. These machines had previously been used successfully on highway pavements in France.

It is no longer an uncommon sight to see a 36-ft wide pavement being slip-formed in one pass without side forms. Contractors using the Guntert-Zimmerman slip-form paver like the cost savings of being able to make one pass rather than two on a 36-ft pavement (Fig. 11). Many of these pavement designs have the two outside lanes 9 in. thick and the inside lane 8 in. thick. The 1-in. difference is built into the cement-treated subbase and subgrade. These 36-ft slip-form pavers are compatible with 34E pavers, central-mixed concrete hauled in conventional dump trucks, and, most recently, truck-mounted mixers carrying $7\frac{1}{2}$ cu yd and capable of discharging in less than 60 sec (Fig. 12). These truck-mounted mixers (ready-mix trucks) are designed to handle low-slump paving concrete.

Figure 6. Paving I-80 in Iowa with two Rex slip-form pavers.

Figure 7. Device developed for paving I-80 project in Iowa.

Figure 8. Special 45-ft length of form to guide crawler-mounted screw spreader.

Figure 9. Placing mesh on first lift of concrete.

The electronic control devices have resulted in grade accuracy and surface smoothness never before attained. At the same time, overruns are kept to a minimum. The same guide wire can be used to trim the subgrade, finish the subbase, and control the pavement elevation.

Some of the excellent riding pavements being built with the slip-form are constructed without the aid of trailing side forms or without hand finishing behind the machine (Fig. 13). One of the main advantages of slip-form paving is that the concrete is confined into its final form at high densities within a comparatively small space and requires only a minimum, if any, manipulation of the surface of the slab behind the slip-form. Any additional working of the surface of the slab behind the slip-form machine only produces a less durable concrete surface.

There are now several new manufacturers entering the slip-form paver market. The trend is toward some form of automatic guide wire control and machines capable of up to 36 ft.

The Koehring-Johnson slip-form paver has been under development for several years. In 1963, an experimental model paved a city street project in Green Bay, Wisc., and a 4½-mi highway project in Oklahoma (Fig. 14). As a result of this experimental work, the machine was redesigned and a production model will soon be available. This production model was tried out on several test slabs at the L. S. Johnson plant in Champaign, Ill., in late 1964 (Fig. 15). The paver has electronic controls for alignment, surface elevation, and cross-slope, all controlled from a single wire.

The R. A. Hanson Co., having considerable experience with slip-form canal lining and concrete pipe equipment, developed a slip-form paver which operated in California

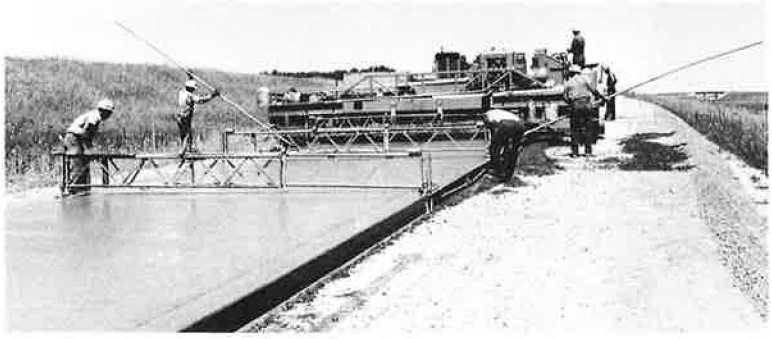

Figure 10. Ramp being paved in Wyoming with Rex machine.

Figure 11. Owl Slip-Form Concrete Co. paving I-10 in southern California with 36-ft Guntert-Zimmerman paver.

Figure 12. Central-mixed concrete hauled in dump trucks feeding 36-ft Guntert-Zimmerman slip-form paver.

Figure 13. Twenty-four-foot Guntert-Zimmerman paver operating in California with pipe drag in lieu of conventional hand finishing.

Figure 14. Koehring-Johnson experimental slip-form operating in Oklahoma in 1963.

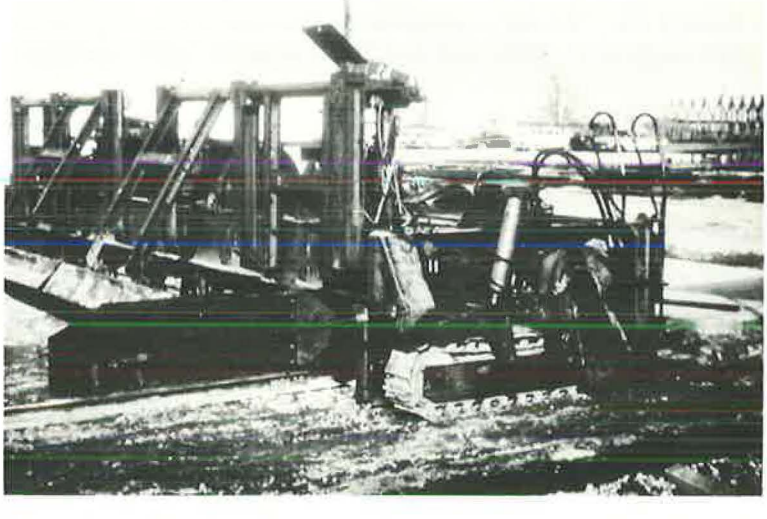

Figure 15. Koehring-Johnson production model on test pavement.

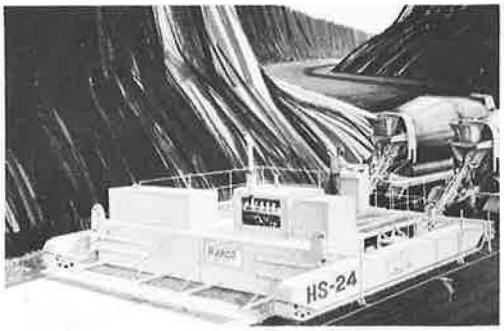

Figure 16. Drawing of HS-24 slip-form paver used in California.

Figure 17. Blaw-Knox slip-form paver operating on ditch invert in southern California.

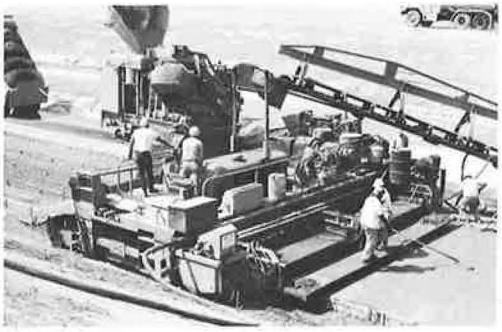

Figure 18. Rear view of Blaw-Knox paver.

this past construction season (Fig. 16). The Hanson paver, known as the HS-24, uses airtrol automatic control for grade and level.

Another slip-form paver, which was introduced for the first time in California this past season, is manufactured by the Blaw-Knox Co. (Figs. 17 and 18). Blaw-Knox has four slip-form pavers in California. These machines have placed both 24- and 36-ft pavements. The machine, according to the manufacturer, can be converted to 12, 24, 36 or 48 ft in about 4 hr. It has a paving speed of up to 20 ft/min and a traveling speed of 60 ft/min.

The slip-form future looks bright indeed. Complete automation is removing the element of human error to produce smoother, more durable concrete pavements at greater economies than ever thought possible.