THE FIRST SLIPFORM PAVERS

By Thomas Berry

Until machines capable of consolidating it during placement were developed, concrete and asphalt concrete pavement had to be placed between forms until it had cured and hardened, and machines that rode atop the forms spread and finished the material. The evolution of formless asphalt concrete paving is fairly straightforward; Barber-Greene and Adnun developed the first formless, free-traveling asphalt pavers in the mid-1930s, and aside from subsequent improvements on the technology, that was pretty much that. But, just as laying concrete pavement required more machinery than did asphalt concrete, the transition to slipform paving was more involved.

Form-Riding Equipment

Forms for concrete paving were usually set a standard of twelve feet apart, although narrower widths were used in special circumstances. Later in the history of the technology, 24 feet came into wide use, and many form-riding machines could be adjusted to variable widths. The concrete was usually produced and placed by a dry batch paver, and the machines that spread, consolidated and finished it were collectively dubbed a "paving train" (figure 1). A typical paving train included a spreader, transverse finisher and longitudinal finisher (or float). From the late 1940s until the end of the technology's widespread use, one machine could variously combine the spreading, finishing and float functions. Additional machines for trimming and fine-grading the subgrade, inserting expansion joints, texturing, and applying curing compounds were also used.

The paving train was typically supported by a formgrader, which resembled a half-track tractor with a digging rotor designed to grade a slot in the roadbed for placing the paving forms; the vehicles and equipment needed to transport and handle the forms; a form tamper to position them securely; and an air compressor and form pin driver to anchor them. The process was highly labor-intensive. And, of course, there were the forms themselves; a single contractor could amass thousands of feet of them in various sizes. As one might imagine, the costs of labor, equipment and supplies for such

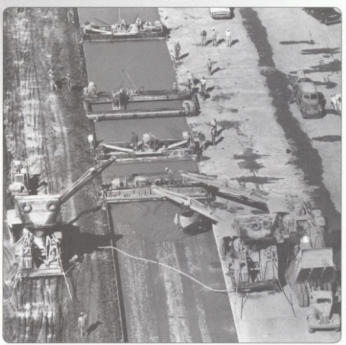

Figure 1: On forms or slipforming, the only limit on a well-organized paving outfit's production was the supply of concrete. Three 34E dry batch pavers keep the concrete coming to this form-riding train working at Grand Forks Air Force Base in North Dakota in the 1950s. *Photograph courtesy of Western Contracting Corporation*

an operation could be considerable, and were a major instigator for the development of slipform paving.

Slipforming Principles

Instead of using fixed forms to contain the concrete, slipform paving uses free-traveling equipment that pulls the forms along with it as it spreads, shapes and consolidates the concrete. In order for the concrete to retain its shape after the forms have moved away, slipforming requires a lower-slump concrete that uses less water and usually has higher compression and flexural strengths than does the concrete used in form paving. It produces a smoother surface than form paving and its greater efficiency allows for much higher productivity; the technique is used for such applications as highway and runway pavement, canal lining and vertical structures.

Modern slipform paving involves three basic machines. A placer/spreader receives concrete from trucks or windrows and distributes it across the roadbed. The paver itself (not to be confused with a dry-batch paver) strikes the concrete off with a screed, consolidates it with vibrators and tampers powered by an onboard diesel generator, and rough-finishes it with a pan shaped to the finished profile of the road (sometimes augmented by a sheet of burlap or artificial turf for microtexturing). A texturing and curing machine produces the final surface with tines and applies curing compound. Along with hand floating, an additional finisher that smoothed the surface with a tube is also often used, and instead of mechanically forming the joints, large saws cut the joints in the hardened concrete.

The equipment straddles the roadbed, with the placer/spreader and paver (except for the earliest prototypes in this article) traveling on crawlers, and the other equipment was typically on rubber tires. As early as 1968, slipform equipment was capable of paving up to four lanes simultaneously; but a machine built by Guntert & Zimmerman for Griffith Company worked to sixty feet on the Los Angeles River flood channel project in 1959.

Except for some early machines, the paver was guided by string lines along the roadbed. Otherwise, it was supremely important that the subgrade be finished perfectly because it gave the paver its grade control. As slipform and stringline guidance technology evolved in the late 1950s and 1960s, tractor-drawn or self-propelled trimmers also used the line for grade control. It became possible to set up a basic machine for either spreading and trimming subgrade material or placing and spreading concrete; and some slipform machines, such as the Gomaco Commander, could be converted from slab to curb and gutter paving.

The First Slipform Pavers

The Wood Canal Paver

In the late 1930s, southern California contractor Clyde W. Wood, whose other ventures have been discussed in Issues 75 and 93, developed the world's first known machines for precisely trimming and paving canal slopes and inverts, or floors (figure 2). By using a traveling mold to form the curbs on the brim of the canal, the paver was the earliest known machine to use slipform technology. It rode on rails on the canal berm, and the rails controlled its elevation and steering. Leonard R. Zimmerman, Wood's equipment manager and master mechanic, designed and built the first of these machines.

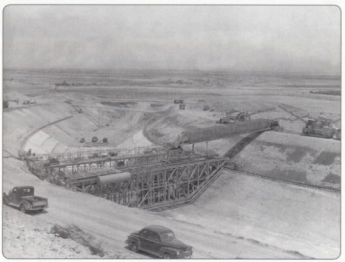

Figure 2: The world's first slipform paver was similar in design to this Guntert & Zimmerman canal paver, working on California's Delta-Mendota Canal in 1947. *Photograph courtesy of Guntert & Zimmerman, Inc.*

The Iowa Highway Commission Machine

In 1946, James W. Johnson, Bert Myers and other engineers of the Iowa Highway Commission's Materials and Testing Laboratory conceived the idea of a machine that allowed one man to place single lanes of concrete pavement without forms. The working premise was that, if it were correctly consolidated, concrete of the proper slump and consistency would hold its shape if the forms were removed before it had set.

The initial lab version, built in 1947, was 18 inches wide, and the following year the first prototype placed a three-foot sidewalk at the Laboratory. In 1949, a full-sized machine (figure 3) placed the first slipformed road pavement, a nine foot wide, six inch thick slab on a county road. Combining the functions of spreading and transverse and longitudinal finishing, it traveled on rubber tires and was capable of placing a ten-foot-wide slab at ten feet per minute. After the first lane had been paved, it was turned and the second lane was laid next to the first. However, it could not place concrete directly abutting the existing slab; a four-inch gap was left between the slabs, and asphalt concrete was used to fill the gap.

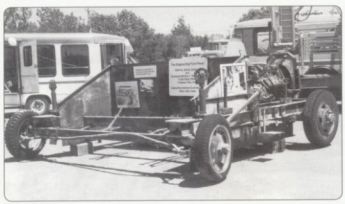

Figure 3: Although it looks nothing like today's slipform pavers, this was the first such machine for road applications. The Iowa Highway Commission's "Johnson paver" is being exhibited by Andrews Concrete of Clear Lake, Iowa, at an unknown venue. *Archival photo reprinted from* Surface Transportation *magazine (3rd Quarter 2006), © 2006, American Concrete Pavement Association, Skokie, Illinois*

A couple of aspects of this machine's story are unresolved. An article in the 1950 issue of *Roads & Streets* stated that it was self-propelled, and in a paper presented in September 1996, Ronald M. Guntert Jr. maintained this assertion; however, an article published in September 2006 by the American Concrete Pavement Association states that a transit mixer charged the paver, then towed it to place the concrete, and Figure 3 shows it with a tow bar and no visible means of propulsion. The *Roads & Streets* article also states that Blaw-Knox acquired the rights to the design by spring of 1950; no further development by Blaw-Knox is known, but the Guntert paper states that Quad City Construction Company, whose machine will be discussed shortly, acquired rights to the Iowa Highway Commission design.

After initial testing, it was determined that the machine had the potential to pave up to 22 feet wide or more in a single pass, and that it could be modified to allow placement of reinforcing materials. The article cited above predicted that "this futuristic paver hints of things to come in concrete Roadbuilding, especially in the secondary road field."

At least three other towed slipform pavers are known to have been built in 1952, apparently for use in the state of Illinois. They were designed to be pulled by truck-mounted winches. One placed an eleven-foot slab and required one truck for power; but the other two, designed to place a wider slab, required the pull of two winches to keep them on line.

The Regenhardt machine

The earliest known modern, self-propelled slipform paver for highway applications was developed in the winter of 1953 by Regenhardt Construction Company of Cape Girardeau, Missouri. Frankie Merritt, the firm's master mechanic; his assistant, Leonard Church; and Tom Regenhardt were its primary designers.

Less known than the other early slipform pavers, the Regenhardt paver (figure 4) travelled on eight-foot crawlers, and used forms thirty feet long. Two transverse box screeds spread the concrete; the first carried a six to twelve inch roll of concrete and struck it off to near final elevation, and the second screed finished it to final elevation. The screeds were eight feet apart, and the transverse vibrator consisted of two 2x10 foot boards mounted vertically midway between the screeds.

The machine made its debut on August 3, 1953, laying a nine-inch concrete base course for asphalt pavement on a section of Illinois Route 37 south of Whittington in Franklin County. As was typical in a concrete paving operation, the only limitation on its performance was the supply of concrete, in this case the output of a single 34E dual-batch paver, and the outfit paved up to 1,044 feet of nine-inch slab in one day. It was used on two projects, and met the specifications for smoothness and rideability for primary routes such as Route 37; however, it was unable to keep up with tighter specs that were developed as the Interstate program was launched, and the idea was abandoned.

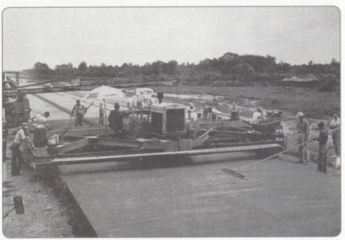

Figure 4: The Regenhardt paver at work. *Photograph courtesy of Bill Regenhardt*

The Quad City machine

A year after the Regenhardt paver was put to work, another contractor-designed slipform paver appeared. Designed by Glenn Perkins and William Dale of Quad City Construction Company from Rock Island, Illinois, the Quad City paver (figure 5) utilized an adjustable screed made of two-foot-high plate steel, a Master vibrating screed that travelled on the forms rather than the paver's frame, and a transverse screed that finished the concrete using an 18-inch-wide rubber belt that moved back and forth across the slab. Like the Regenhardt paver, it was 24 feet wide; its most obvious visual difference from its predecessor was the extremely long 22-foot crawlers, which were chosen so as to overcome minor irregularities in the subgrade.

This paver was first used on a section of US 150 near Coal Valley, Illinois. By the fall of 1954, Perkins and Dale had applied for patents on their paver; fellow contractor Arcole Midwest rented the first machine for another section of US150 near Bloomington, Illinois, and had taken delivery of a second, and more were being

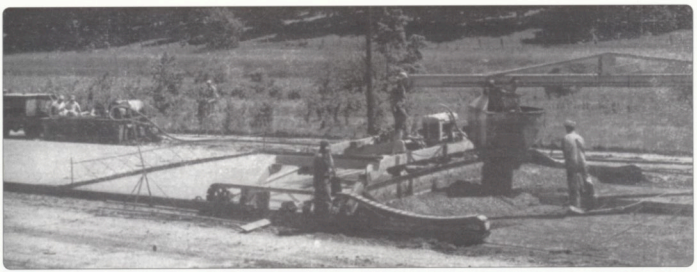

Figure 5: The Quad City paver shows off its lanky 22-foot crawlers. *Image from* Roads & Streets *magazine*

built, making it the first commercially produced slipform paver. By 1956, Chain Belt Company had acquired the rights to the paver and produced it under its famous Rex trade name.

The Guntert & Zimmerman machine

In 1942, Leonard Zimmerman, who had designed the first slipform machine for paving canals, formed a limited partnership with Hickinbotham Brothers Ltd., a steel fabrication and welding firm in Stockton, California, and Ronald M. Guntert Sr., a Hickinbotham employee. The partnership, called Hickinbotham Brothers Construction Division, manufactured Tank Landing Barges, derrick barges, tugboats and other vessels for the Armed Forces at a facility on Banner Island on the Stockton waterfront.

The two men bought out Hickinbotham's share of the partnership shortly after the war and incorporated the firm as Guntert & Zimmerman Construction Division, Inc. A second business unit, Guntert & Zimmerman Sales Division, was incorporated in 1948 to supply materials to the Construction Division. (Zimmerman left both companies in 1950, and his name was retained in recognition of its reputation in the construction, shipbuilding and dredging industries; in 1961, the Sales Division became Guntert Sales Division, and is today's Guntert Steel.)

Guntert & Zimmerman's first construction products were canal trimmers and pavers built under license to Wood. Introduced in 1946 and capable of paving up to 111 feet total width in a single pass, they were used on the Grand Coulee Main Canal in Washington state and the Delta-Mendota Canal (figure 2) in the San Joaquin Valley south of Stockton in 1947, and subsequently on numerous other canal projects in the western United States. Two improvements set the stage for what was to come: Stringline guidance for grade control and steering (by means of a plumb bob that tracked the line) gradually supplanted rails as the means of grade control and steering; and in the early 1950s, crawlers replaced the rail mounting, eliminating the considerable costs of laying and removing track.

In 1956, A. Teichert & Son, a major highway and heavy contractor based in Sacramento, had a contract to construct a section of the Los Angeles River Flood Channel. They used a Guntert & Zimmerman canal paver, which at one stage of the work was set up to pave the invert only. During this stage of the project, Teichert, in conjunction with Guntert & Zimmerman, conducted a simulation of highway paving at a width of 24 feet for the California Department of Transportation (figure 6). The State allowed Teichert to use the machine on a section of US Highway 99 near Manteca, a few miles south of Stockton; but, since form paving had been specified, Teichert was required to either use the specified forms or repay the State for the bid items pertaining to the forms. After an impasse on this condition, Teichert simply paved over the forms in order to meet the project deadline, a fitting metaphor for slipform's subsequent domination of concrete paving.

Figure 6: Set up for invert paving, A. Teichert & Son's Guntert & Zimmerman canal paver lays a 24-foot slab in the bottom of the Los Angeles River flood channel during highway paving simulations in 1956. *Photograph courtesy of Guntert & Zimmerman, Inc.*

Although slipform paving of highways became widespread while dry batch pavers were being phased out, there was a brief period of time when the technologies overlapped. Slipform pavers seem to have been called finishers at the time, avoiding having two entirely different machines called by the same general term. Conversely, the central mix plant technology that rendered the dry batch pavers obsolete is still used to serve form-riding equipment in certain paving applications today, but the combination of central mix concrete production and slipform paving greatly improved concrete paving productivity while reducing its costs. Indeed, a slipform paving crew enabled a contractor to produce more pavement with a third as many personnel, while eliminating altogether the hard, time-consuming and expensive work of placing and removing forms.

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THE UNLIKELY DISTANT RELATIVES OF THE SLIPFORM PAVER

As explained in the article, the first slipform paver was one of two rail-mounted machines designed to trim and pave canal slopes and inverts. The concept for these machines can be traced, perhaps indirectly, to the Templet Excavator's introduction in 1900. With its variant spelling of "template," the ungainly machine traveled on rails or crawlers and straddled the excavation. A digging frame was shaped to the cross section of the ditch to be excavated and lowered to contact the ground. A single bucket shuttled back and forth along the frame, digging from the ditch slope and invert and dumping clear of the ditch by means of a trip mechanism. The digging frame was lowered with each pass, and when its base reached final grade it was raised clear, the machine advanced three feet, and the process started over again.

Figure 7: This Swiss Army knife of a machine is the Austin Templet Levee Builder, an indirect ancestor of the machines that first used slipform technology. *Image from* Excavation Machinery Methods and Costs, *Allen Boyer McDaniel S. B., 1919*

The Templet Levee Builder (figure 7), introduced circa 1910 by the F. C. Austin Drainage Excavator Company, was a variant of the Templet Excavator. On this version, the frame extended from both sides of the machine. One end was shaped to the excavation, and the other was suspended with its end over the centerline of the levee to be built with the spoil. The bucket, with a capacity of 1-½ to 2 cubic yards, was drawn through the cut, across the machine, and up to the opposite end of the frame, where it was dumped and then drawn back for another pass. The house was 22 feet long by 20 wide, and the machine traveled on flanged wheels atop 200 feet of 12x12 timbers. It required an operator, fireman, two-man track gang, a team of horses to move the timbers, and another man and team to haul fuel and supplies. It could excavate 100 cubic yards an hour in favorable conditions. (F. C. Austin was the leading American manufacturer of construction equipment in the late 1800s, and his story is told in Issue 80. But this machine was unknown to us when the article was written.)

Another distant relative to technology associated with slipforming is worth noting. In the late 1920s, A. W. French & Company offered a crawler-mounted machine called the Utility Grader (figure 8) that incorporated the first known stringline control. It essentially consisted of a bucket loader that traveled on a set of rails that was mounted to a leveling frame. The frame was supported at each corner by a powered jack, and the interchangeable rails could be shaped to any desired contour. The bucket loader excavated material from the roadbed, and a reversible discharge conveyor carried spoil to the side for loading to trucks or windrowing at the roadside. Pointers on the leveling frame traced a roadside stringline to keep the business end of the loader on grade. It was designed for everything from rough earthwork to finegrading to shoulder work, and it is not known if it was continued by Blaw-Knox after they acquired French in 1929. Some thirty years later, Gurries Manufacturing Company and others introduced subgrade trimmers that used similar technology (see Issue 84, page 26).

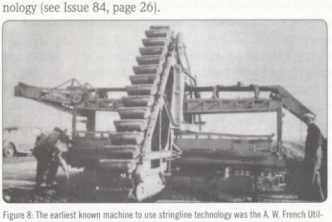

Figure 8: The earliest known machine to use stringline technology was the A. W. French Utility Grader. *A. W. French & Company sales literature*

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