A Contractor Looks at Slip-Form Paving

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This paper covers the contractor's experience with early bidding and construction, agency acceptance, and job quality. It discusses efficiency, production capabilities, captial equipment and labor involved. It reviews the competitive position of slip-form paving.

•AS CONTRACTORS, we must acknowledge a debt of gratitude to a few hardy engineers, construction men, and equipment designers in Iowa and Illinois for the early pioneering and development work in connection with slip-form concrete paving during the late 1940's and early 1950's. A great deal of credit must be given to personnel in the Iowa State Highway Department for permitting its use and assisting in the development of slip-form paving methods on some of their 6- and 7-in. unreinforced concrete secondary roads during those years. It was during this same period that the Quad-City Equipment Company of Rock Island, Ill., made the initial developments and improvements on their first slip-form paving machines which ultimately became the first commercial machines on the market available to contractors. In 1958, the Rex Chain Belt Company of Milwaukee took over the rights and interests of the Quad-City Equipment Company and began producing slip-form pavers under their own name. Since that time many improvements have been made and at least three other equipment manufacturers have entered the field; today contractors have a choice of several types of slip-form pavers in a competitive market.

The Colorado Department of Highways and some of its far-sighted and progressive engineers were quick to recognize the potential advantages and economies of the slip-form method of concrete paving on the basis of their observation and inspection of the early operations in Iowa. In 1955, they modified their specifications to permit the use of the slip-form method on all concrete paving projects, and since that time the choice of paving methods has been left entirely with the contractor. As a result, since 1956 almost every concrete paving job of any consequence has been constructed using the slip-form method. This highway department led the way nationally and was very cooperative with the contractors in developing and improving the slip-form method of concrete paving on their primary and Interstate highway systems. Results showed that most of the slip-form concrete paving projects built between 1956 and 1958 were equal to or better in quality and riding surface than those constructed by conventional methods with forms and a complete train of paving equipment. In addition, the economies of this new method were becoming apparent; definite savings in cost varied from $0.20 to $0.40/sq yd as reflected by comparative bid prices.

There were times when the number of visiting engineers, equipment manufacturers, highway officals, and contractors from other states almost outnumbered our own paving crews on these early paving projects. Colorado had set the pattern for use of slip-form paving methods on all primary and Interstate concrete paving projects, which was soon followed by many neighboring states, initially Wyoming and New Mexico, during the later 1950's. This new method of paving had by then been proven and was being accepted in several states, and the ultimate end for most conventional types of formed concrete paving operations could be forecast with reasonable assurance within 10 yr or by 1969.

As is true with any new method of work involving new types of equipment, the bidding by contractors on early slip-form paving projects was on the conservative side and did

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not reflect the greater savings which are now being obtained by highway departments and contracting agencies all over the country. As contractors, we had to learn how to utilize and work with new equipment and procedures, train and develop new crews, and overcome some of the usual inertia and resistance to change within our own organizations. This also applied to some of the inspection and engineering personnel within the various state highway departments and other engineering or contracting agencies for whom we were working.

Many of the early slip-form concrete paving jobs had their full share of problems and headaches. Furthermore, in a few instances, some jobs were constructed in part with marginal or even substandard finishes and riding qualities. An inspection of the first slip-form paving job performed by any contractor would show that he had more than his share of problems during the first mile or two, and that following this initial apprenticeship period, each succeeding mile showed definite and continued improvement. This same observation can still be made for a contractor's first slip-form job today, except that with the improved equipment and a larger backlog of experienced engineering and construction personnel, the problems are fewer and the results are usually better. In general, most of the state highway departments and other contracting agencies were quite tolerant and cooperative with the contractor's organizations on their first jobs. We were all learning and developing together as an engineering and construction team. The equipment manufacturers also deserve much credit for their valuable assistance and efforts during these early periods. An analysis of the tough competitive bid prices, the high quality of work, the excellent riding surfaces, and the savings in cost, which are now being obtained throughout the areas where slip-form paving methods are being used by experienced contractors, is ample proof that the early trials and tribulations, plus a very commendable cooperative effort between the contractors and the state highway departments, were well worth while.

ACCEPTANCE AND USAGE

The acceptance or permissive use of the slip-form method for concrete paving on Federal-aid primary and Interstate highways has not been adopted by all of the state highway departments as yet. However, the use of this method has made remarkable progress since Colorado's first Interstate slip-form project in 1956. During these past 8 yr, at least 26 additional states have approved this method as an alternate on some or all of their concrete paving projects. The remaining states are studying the system and some are either seriously considering it or are on the verge of advertising for bids on their first slip-form paving projects during late 1964 or in 1965.

Late in 1962, the Oklahoma Turnpike Authority modified its specifications to permit the use of slip-form concrete paving as an alternate bid for 22 paving contracts on 64 mi of the Southwestern Turnpike (now known as the H. E. Bailey Turnpike) extending from Oklahoma City to Wichita Falls, Texas. All 22 contracts were successfully bid, accepted, and constructed using the slip-form alternate. Due to the excellent paving results achieved in 1963 on the turnpike, the Oklahoma State Highway Department has since opened up its bidding on both primary and Interstate concrete pavements to permit the use of the slip-form method. Needless to say, the slip-form method is now being bid successfully and used by the contractors on practically all of their current concrete paving projects, both plain and reinforced. The Oklahoma Turnpike Authority has stated that the use of the slip-form method on the turnpike "saved them from 35 to 45 cents per square yard on the concrete paving." This permitted them to obtain a very high quality of paving within their engineering construction estimate, which is essential to a project financed through the banks and sale of bonds on the open market. Those contractors and state highway departments and other contracting agencies that have developed a backlog of experience in the slip-form paving field, have demonstrated that this method will reduce the final cost of concrete paving without any reduction in its quality. For public construction agencies, this means that there is a better chance of keeping construction costs within estimates for individual paving projects as well as paving programs. Insofar as the public or taxpayer is concerned, they will benefit by obtaining additional mileage of concrete paving for the same money or the same mileage for less money.

QUALITY OF PRODUCT AND RESULTS

After a contractor has constructed his first slip-form project, he should have solved most of the major problems connected with this system of paving. He should become more proficient with each succeeding job and develop his own trade secrets for handling particular job problems relative to such variables as bases, aggregates, mix designs, unusual climatic conditions, grades, transitions, curves, ramp construction, multiple lane construction, plain or reinforced sections, and many others. The experienced contractor can now meet any current concrete paving specification with the slip-form method if he is given the opportunity.

There are still wide differences in specifications for concrete pavements, and there is much to be done in developing uniform requirements and standards throughout the many individual highway departments and other contracting agencies. The new "Guide Specifications for Highway Construction" as published by AASHO in 1964 is a definite step in the right direction to help standardize specifications and eliminate some of the current inequities and unreasonable requirements in some state specifications. Many joint cooperative committee meetings were held with personnel from the Associated General Contractors of America and the American Road Builders Association to review and discuss most sections of the Guide Specifications before they were published. These joint meetings are continuing, and it is hoped that personnel from the newly organized American Concrete Paving Association will be represented on future joint committees on the specific area of concrete paving, and in particular the slip-form method. As contractors, we believe there is merit in utilizing "end result" specifications to a greater extent. Such specifications were largely responsible for the initial impetus and ultimate success of slip-form paving operations on the primary and Interstate highways in Colorado. This was in line with the department's fundamental policy that construction methods should not be written into the specifications, but rather that an end result should be required. Specifications for the quality of concrete and smoothness tolerance of the finished surface were not changed.

EFFICIENCY OF OPERATIONS

The contractor as an individual, and the construction industry in general, are recognized as comprising one of the last strongholds of the American free-enterprise system where initiative and ingenuity are prime factors and are rewarded accordingly. Contractors are constantly searching for more efficient methods, procedures, ideas, and equipment to be used in bidding and in the performance of their construction operations. The slip-form method of concrete paving is an outstanding example. One slip-form paver takes the place of from three to four conventional concrete paving machines in a normal paving train which includes such items as spreaders, finishers, float finishers, and belt and burlap drag machines. Furthermore, we are of the opinion that a better quality of concrete is obtained with this new method, as the possibility of overworking and overfinishing the pavement is greatly reduced. In addition, an average of 10,000 to 12,000 lin ft of steel paving forms and the equipment necessary for their continuous rehandling each day are eliminated. This method also results in a substantial savings in skilled and unskilled manpower. The overall savings in labor will average between 20 and 30 men, of which about 30 percent would be skilled.

With a substantial reduction in the amount of equipment and manpower required for a slip-form operation over the conventional paving operation, the job management problems are greatly reduced. The entire operation is simpler and is confined within a shorter working length, and all elements can be controlled and supervised more effectively. The overall efficiency of a slip-form paving operation is far greater than can ever be obtained from a conventional paving operation with all of its equipment and large crews which must be spread out over at least double the working length required for the slip-form method.

PRODUCTION CAPABILITIES

The slip-form method of concrete paving is quite versatile and is readily adaptable to all types of operations and conditions. This is an important factor from a con-

tractor's viewpoint as it gives him more flexibility in his bidding and work programs. This method of paving can be utilized on small as well as large projects with any thickness of paving from as little as 5 in. to as much as 12 in. The slip-form paver can accommodate and place concrete from any type of source such as concrete pavers fed by dry-batch trucks, transit-mixed concrete, or wet batch from ordinary dump trucks or dump-cretes fed by a central mix concrete plant. With its variable travel speed and vibration controls, most slip-form pavers can accommodate a wide range of average concrete productions from as low as 80 cu yd to as high as 400 cu yd/hr. Based on a paving slab 8 in. thick and 24 ft wide, these concrete production figures can be translated into travel or paving speeds of from approximately 130 to 600 lin ft/hr. From these figures it is quite evident that the current mile-a-day target is well within the range of slip-form pavers, and has actually been exceeded in many instances.

The slip-form paving method has further proven its versatility by its ability to handle mesh reinforcement in concrete pavements. The first of such applications was performed by Roberts-Western in two test sections, each ½ mi long, on I-25 south of Denver, Colo., in 1958. On this project, the mesh was fed directly into the front of the slip-form paver by means of a sled type of mesh placer attached to the paver which was designed and manufactured by the contractor. Similar applications have been made in other states. Currently, there are several Interstate projects in Oklahoma and Iowa where mesh is being installed in 9-in. thick concrete pavements by means of two slip-form pavers. The first slip-form paver, or spreader, spreads the bottom 6-in. lift of the slab to permit placing of the wire mesh. The second slip-form paver follows immediately behind and places the top 3 in. and the outside edges of the concrete slab. This has proven to be a very efficient operation. Other types of machines and methods for handling slip-form paving with mesh reinforcement are currently in the development or trial stages.

CAPITAL EQUIPMENT INVESTMENT

Contractors are vitally concerned with the amount of capital investment required for equipment spreads necessary to perform paving operations. The slip-form method shows up very favorably in this respect. For the average paving project, a conventional spread of paving machines, including forms and the related handling equipment, will require an average investment of from $200,000.00 to $250,000.00. Equipment necessary to perform these same placing operations by the slip-form method will require an average investment of under $120,000.00 or less than one-half. Because of the smaller amount of equipment required on the project, the field repair and maintenance problems are also reduced by a corresponding amount. These two factors obviously have a direct bearing in reducing the contractor's cost of operations which in turn is reflected in his bidding. The reduced equipment requirements inherent in the slip-form method of paving should develop a more favorable ratio of earnings to capital investment, which from a business and management point of view, is desirable. There are now several equipment manufacturers in the field who are aggressively trying to obtain a segment of the slip-form method equipment business. This means that contractors now have a choice of several types of equipment in a competitive market. Such a market encourages the development of better equipment, which in turn will benefit the slip-form method and slip-form contractors.

MANPOWER AND LABOR REQUIREMENTS

The reduced manpower requirements of the slip-form method of paving has many advantages beyond that of lowering the contractor's direct costs. For projects located in sparsely populated or isolated areas, it alleviates the problems of manning the job with an adequate number of unskilled and semi-skilled personnel. Most contractors have a nucleus of skilled workmen who will follow them around the country to most of their projects. In highly unionized areas, the smaller working force will normally result in fewer union difficulties and problems for the contractor's management. In

areas of very high labor rates, the reduction in unit labor costs is much more apparent than in the lower labor rate areas. In other words, we can be even more competitive with slip-form methods in the higher labor rate areas.

COMPETITIVE POSITION

As paving contractors, we are vitally interested in our competitive position in order to bid and perform work successfully. Maintaining adequate markets for concrete paving work is also essential if we are to continue in business. The slip-form method of concrete paving helps to achieve both of these objectives because the basic costs and bid prices are lower. In addition, the overall operations are more efficient on almost all types and geometric designs of concrete pavements including the following:

1. Main line pavements usually 22, 24, or 25 ft in width (in some cases, even as wide as 36 ft) and of any thickness from 5 to 12 in.;
2. Most ramps with uniform widths of 14, 16, and 18 ft, including both straight and curved sections (curved sections currently limited to those with a working radius of at least 300 ft);
3. Sections of pavement with certain types of integral curb (some sections, however, still subject to the unrealistic limitations imposed by geometric designers in engineering offices); and
4. Multi-lane construction such as 36 or 48 ft in total width.

As the result of improved paving efficiencies, lower costs, and lower bid prices, the overall market for concrete paving should increase. Also because of improved efficiencies and greater economies, concrete paving should now receive more favorable consideration when alternate types of paving are being selected for particular projects or programs.

CONTRACTOR'S SUPERVISORY PERSONNEL

How do the contractor's supervisory personnel react and make the transition from the conventional to the slip-form method of paving? As far as our company is concerned, the transition was made without any difficulty. In most cases, the slip-form method was accepted with enthusiasm, even by some of our senior foreman and superintendents who had been paving with forms for over 25 yr. After the first experience with slip-form methods, no further selling is needed within a contractor's organization. Other contractors have reported similar results and experiences.

A CHALLENGE

Speaking on behalf of most of the slip-form paving contractors in this country, I can make the following statements with respect to the slip-form method of concrete paving.

1. We can meet and comply with any current concrete paving specifications or requirements as far as end results are concerned.
2. We can produce quality concrete paving more efficiently and economically than by any other current method.
3. We can place concrete paving at any desired rate of speed up to 600 lin ft/hr, to accommodate a wide range of production from current concrete plants.
4. A wire grade control system is not considered essential for obtaining smooth pavements with slip-form pavers if the base courses are constructed and fine-graded to the proper tolerances. Electronic grade control systems should be utilized in the fine-grading and trimming operations of the base course underlying the concrete paving.
5. Universal acceptance and use of the slip-form method of concrete paving will result in more miles of paving for the same dollars and an increasing market for concrete pavements.

A FORECAST AND A HOPE

As contractors, we are predicting that the slip-form method of concrete paving will become the accepted standard for all highway departments and contracting agencies

in the United States by 1970. There will, of course, be some minor exceptions. According to information received from some of the equipment manufacturers, they are already exporting slip-form paving equipment to Europe and South America, where this method is also beginning to attract attention and is being accepted.

As contractors, we are looking forward to the day when we can actually say—"Goodbye Forms."