Before 1930 all of Warren County's bridge and culvert repair work was done by contract. Dissatisfaction over some of the bids for repairs during that year caused the board of commissioners to organize a county bridge repair department with the county engineer in charge. Some equipment was bought, men were hired, and work was started about the middle of the year.

This department was to make all bridge and culvert repairs that would not exceed $500 in cost. The character of the work included the reflooring and painting of some of our longer steel bridges, the widening of the older stone and concrete culverts and bridges to a standard width of 24-foot clear roadway, the replacing of bridge floors, wings, and abutments, the constructing of some of the large concrete headwalls of the cantilever type, and the building of temporary bridges in cases of emergency. For the year 1930, repairs were made in this manner to the amount of $9,400.

In 1931, the first year the writer had charge of this department, 20 repairs were made at a total cost of $5,478, or an average of $274 per job. In 1932, a total of 19 repairs were made, costing $4,910, or an average of $258 per job. These figures include all costs of labor, materials, repairs, and supplies of every kind except costs of gasoline and oil and depreciation of equipment.

The present personnel of the repair crew consists of a working foreman and from three to five workmen, one of whom is also the truck driver. These men are picked with an idea as to what will be required of them. One is a carpenter, another a truck driver, another excels in the homely art of being an excellent dirt handler. All workmen on the bridge crew are employed directly by the engineer.

The equipment consists of a 1 1/2-ton truck, a half-sack-batch concrete mixer, a 3-inch diaphragm power pump, a tank wagon and tanks, a sectional tool and cement shed, and all the tools necessary for this class of work.

The highway superintendent, a member of the board of commissioners, or the engineer, reports to the board of commissioners the need of any repair. The board, if it is favorable and if the estimated cost of the proposed repair is over $200 and under $500, orders plans to be drawn by the engineer and submitted for their approval. Upon approval, the engineer is ordered to proceed with the work. Repairs estimated to cost less than $200 are made directly by order from the highway superintendent or by informal consent of the board of commissioners.
It must be understood that to keep within a limit of $500 no single job can be very extensive. So it has always been our plan to make as many repairs in one locality as possible. Thus we cut down the cost of moving, and if jobs are less than a mile apart, we work on both at the same time. The work is first laid out by the engineer, who sets all line and grade stakes and supplies the foreman with the necessary plans. The work, in the absence of the engineer, is in charge of a working foreman who is supposed to do a reasonable day's work besides overseeing the job. He has charge of from three to five men, according to the size of the job and the time to complete it. A daily report is made out by the foreman and given to the engineer at the end of each day's work. This report is a form blank with spaces for names and classes of work outlined. The foreman notes the number of hours each man works and on what particular part of the work. The foreman also notes on this report the amount of work, in detail, completed that day. In this manner, it is easy to compare costs, and if any particular part of the work is running too high, to investigate. Daily contact is made with the work, either by the foreman's reporting at the end of the day or by the engineer's making personal inspection.

Selection of a competent foreman is essential if a county bridge repair department is to be successful. He must not only be able to handle the men and the work to best advantage, but also be able to read blue prints and be far-sighted enough to plan his work for more than one day at a time.

**TYPICAL EXAMPLES**

The engineer has considerable responsibility, also. Decision, good engineering, and good judgment are necessary. A bridge or culvert that four years ago might have been condemned with a wave of the hand is now being examined carefully to see if it can not be made to last another year or, with a reasonable amount of expense, be restored to first-class condition. In 1931 we had a case that will illustrate my point. A culvert on one of the township roads was partly washed out and the township trustee petitioned the board of commissioners to make the repair. The board turned the job over to the bridge repair department. The culvert was 10 feet in span, about 7 feet high, and had a roadway 15 feet wide in the clear. The abutments were 6-inch vertical I-beams filled in between with concrete. The I-beam floor stringers, carrying a concrete floor, were riveted to the vertical I-beams in the abutments. One abutment had settled so much out of line that the concrete had cracked and loosened. The other abutment, if it could be called that, had only about a 10-inch footing.

When we dug out our footings for the extension of this
abutment, we cut in under from each end of the old abutment to a distance of about 4 feet and ran a new footing under the old part. A few days later, after this footing could carry the weight, we dug out in front of the middle part of the old abutment and ran in the balance of the new footing. Of course, we braced the wall and supported the floor while this and the building of the complete new abutment was being done. Not an extraordinary piece of work, but it saved a fairly good percentage of cost of the entire work and it will last indefinitely. And aside from a part of the floor being somewhat more rough than the outside edges, the traveler does not know that the entire culvert is not in first-class condition.

The gravel used on repair work is a "concrete mix" washed gravel from commercial pits. The gravel content grades from 1 1/4-inch down to 1/4-inch in size. The sand content runs from 45 per cent to 50 per cent of the total volume. We find that a high percentage of builder's sand in the total sand content faces better and more easily. At rare intervals we can find gravel in a pit or stream bed that is well graded and clean enough to be used in concrete work. Great care is taken, however, in selecting such material. Quality of materials are never sacrificed for a slight decrease in cost.

The mix, using a "concrete mix" gravel for aggregate, range from 5 sacks of cement to the cubic yard for heavier portions of the work, to 6 sacks of cement to the cubic yard for the smaller sections. During 1932 we paid foremen 60 cents per hour, carpenters 35 cents per hour, and all other labor 30 cents per hour. The cement was contracted by the year for $1.85 per barrel from stock. Gravel cost 30 cents per cubic yard from local pits and 90 cents per cubic yard from commercial plants. Lumber was bought from stock at $40 per thousand. Reinforcing steel cost 2 1/4 cents per pound base.

In repair work of such varied classes as would naturally come under a bridge repair department of this type, there are so many small items, incidental to the work, that increase the total cost that it is not quite a fair proposition to figure the total cost of the repair strictly on a concrete yardage basis. We have done this, however, to show relative costs. The most expensive job we did in 1932 ran $12.60 per cubic yard, there being over 40 cubic yards of concrete in the work. This included all labor and material costs, but does not include gasoline and oil charged against the truck.

On another repair job involving 15 cubic yards of concrete, the cost was $12.18 per yard. This consisted in widening a small 4 x 5-foot culvert from a 16-foot to a 24-foot clear roadway. The widening was on both ends of the old culvert and of unequal distances. Handrails and wings were added. On account of the small sections, the cost of placing steel and
building forms ran rather high, being $2.05 per cubic yard. The cost of placing concrete on this job, approximately 83 cents per cubic yard, ran fairly low for the type of mixer used.

The highest cost placing concrete was $1.42 per cubic yard on a 12½-hour run, using 6 men and placing a total of 17.5 cubic yards. By using one less man on this run, and we now believe that as much work could have been accomplished with 5 men, the cost of placing could have been cut 21 cents per yard. Other things occurring in this day's work helped keep the cost of placing above the average. Costs given above have been for reinforced concrete culverts of the closed bottom and slab types.

The type of the mixer used has much to do with the costs of placing concrete. Our mixer is a small, half-sack-batch type mounted on rubber-tired wheels. Its light weight makes it very convenient to move from place to place, but its advantages stop there. It is slow in mixing if the drum is loaded to capacity. And every batch has to be loaded by shovel measure—something never allowed in contract work, and not altogether satisfactory in gang work. This manner of loading makes it necessary to handle both cement and gravel twice, and complete mixing does not start until the entire charge is in the drum. We believe that a light mixer of one-sack-batch type with skip attached would cut the cost of mixing at least 30 cents per yard on the average job.

Headwalls are constructed of the cantilever type, and are built as far as possible in accordance with standard plans furnished by the county engineer. Costs of such headwalls range from $1.00 to $2.00 less per cubic yard than similar costs for box culverts.

Dry excavation ranged in cost from 40 cents to 76 cents per cubic yard, all excavated materials being moved by hand labor and most of the material being handled twice. Wet excavation ranged as high as $1.00 per yard, with two handlings, the extra handling accounting for the higher cost.

The lumber, mainly ship-lap and 2 x 4-inch studding, was judiciously used. The ship-lap was used on 5 or 6 different jobs before it became useless and the studding was used on almost twice as many jobs. All form lumber was thoroughly oiled before using and cleaned and oiled before each subsequent using. This, we believe, had much to do with the longer usefulness of the lumber. The oil used was waste crank case oil from the county highway garage. Sheet piling was usually oak boards discarded from old bridge floors, or green native stuff, about 1½ inches thick, from a local sawmill. The cost was $1.25 per hundred.

The concrete mix gravel was always deposited on a 2-inch oak platform along the side of the grade as near as possible to the repair job. Cement was stored at the job in a 6x6x5-foot shed. This shed is of the sectional, takedown type of six parts
including a platform floor, four sides, and a roof section. The sides are dowelled and fastened by plates to the floor and at the corners to each other. The roof is grooved and hooked to the sides. A shed of this type can be taken down or put up in a few minutes' time and is capable of holding over 90 sacks of cement. In two years' time we have not lost, from weather conditions, a single sack of cement stored in this shed. The cost of this shed for labor and materials was $32.50.

We followed the usual methods of construction on concrete work, approaching closely those given by standard state plans, and we believe our results will compare closely with state work. All exposed walls and handrails are rubbed twice. Last fall I inspected some work that had just been completed. The work looked especially good, true to line and whiter than usual. Afraid the workmen had used too much lime, I spoke of the lighter color and found that instead of using the usual sand from the concrete mix gravel, they had used a white blast sand that was worn out and discarded by a local concern. We are going to watch with some interest to see if this concrete holds its good color.

On repairs over streams that have a continuous flow, we have, after much trouble with wooden troughs and smaller pipe, found that the best way to take care of a moderate water flow is to dam the stream above the bridge, and run the water through a suspended, paved invert, corrugated pipe of not less than 18-inch diameter. Especially is this good for a job where the stream channel is to be concreted to stop the scouring of the stream bed.

On wet jobs a small tool that saves quite a little inconvenience in getting water for mixing is a pitcher pump mounted on a barrel, supplied with two 10-foot sections of discarded gasoline hose. This 20-foot length of hose will pull the water anywhere within its reach.

**SUMMARY OF RESULTS**

At the end of each year a report is made out by the engineer and filed with the board of commissioners. This report gives the number, location, and type of each bridge or culvert repaired. The report also gives a location map of the county showing the location of each repair job. A summary of the work done and recommendations for the coming year are also included. There is also an inventory of tools, equipment, and supplies remaining on hand at the end of the year. A summary of the amounts expended and average costs concludes the report. It is interesting to note that during the year 1931 over 60 per cent of the amount expended went for labor directly on the work (Fig. 1).

There seems to be only one objector to the operation of a bridge repair crew of this type, and that is the contractor
who has been bidding in work of this kind and deriving some source of income from it.

The benefits are many. Better results seems to me one of the most important. Any engineer who has bucked up against a contractor who was trying to finish a job quickly and cheaply knows that the job is going to suffer in some way, especially with the usual type of inspector on county work.

Another benefit is lower cost. By having the county bridge department handle all repair work up to the $500 limit, the work is done by a trained and efficient crew. The cost of advertising bridge lettings is saved and work is done at actual cost, thus saving a contractor's profit, which on small work of this kind would run to a higher percentage than on heavier jobs.

Control of the spending of the county money is another benefit. Men who need the work are picked up as extras and given a day's work now and then to keep them off the township poor relief. Only men of family are hired at any time.

Quickness of operation is an advantage. One morning last December the bridge department was notified that the large Howe Truss wooden bridge over one of our streams had been damaged. A truck during the night had side-swiped the end post and knocked out one member and partly unseated another. Within six hours the repair was completed by the bridge repair crew.

The work of the bridge crew is varied. It covers all the classes of repair work that naturally would come up in maintaining the several hundred bridges and culverts of the county highway system. The crew has even been called upon to do
other work, such as roadside concrete gutters, retaining walls, etc., for the highway department.

The law enacted by the special session of the legislature in 1932, whereby the limit of repair work was reduced from $500 to $200, has been to the detriment of public interest and funds as far as highway repair work is concerned. This law is not, in any sense, working for true economy and the original limit of $500, or even a higher figure, should be allowed for working limits in repairs of this kind.

SOME EXAMPLES OF ROAD AND BRIDGE BUILDING ECONOMY

By J. W. Roadruck, Newton County Surveyor

A few years ago, the necessity for placing this subject on one of our programs would not have been so apparent as it is today. With decreased budgets and delayed tax payments, the need to economize greatly on construction of roads and bridges is growing. Especially do we see the significance of this fact in our purely agricultural counties.

To bring about effectively the desired economies, county highway superintendents, state highway officials, and county surveyors must work together. Materials which in the past have been left to deteriorate must be made available for emergency needs. At the present time, many needed bridges can not be built of new material and in accordance with advanced ideas of modern engineering, but they can be built of usable old material in accordance with common sense practices. As far as durability and use are concerned, many of these bridges will measure up in value to new bridges costing several thousand dollars more.

I have been fortunate in Newton County in getting the co-operation of officials who are in a position to assist me greatly in my economy program, which has been forced upon me by a corn, wheat, and oats taxpaying public. In my case, the old maxim “Necessity is the mother of invention” has been exemplified.

I shall endeavor to give more in detail some of the projects we have actually completed in our road and bridge building program. We needed a bridge over the Wooten Ditch two miles north and one mile east of Morocco. The abutments had fallen in on the old sixty-foot span. This bridge was not designed to carry present-day loads. We had no funds to buy a new structure. After taking an inventory of possible material within reasonable hauling distance, we found that the state highway department had a 100-foot span in their yards