same location spanned by a single pony truss bridge with concrete walk and slab and steel handrail would have cost 1.07. If a single span plate girder, with the girders entirely encased in concrete, the floor system not encased, had been used, the probable cost of the superstructure would have been represented by 1.40. If the total cost of the rolled beam bridge is taken as unity, then the total cost of the pony truss with its two foundations would be 1.06, and that of the plate girder with its two foundations would be 1.27.

Another cost estimate for a superstructure of 24-foot clear roadway, 30-foot clear span, 20-ton truck loading was made. Using rolled beams, reinforced concrete floor and concrete handrails, none of the beams being encased, we assume cost as unity. These same conditions can be fulfilled by a pony truss with long leaf yellow pine 3-inch creosoted plank, 12-pound treatment, sub-floor, and a one-inch asphalt plank wearing surface for a price of 1.03. The same conditions can be fulfilled by rolled beams, same wood and plank floor, heavy lattice hand rails, for a cost of 1.28. This bridge is located about 125 miles from a creosoting plant, 50 miles from a steel company, and within 20 miles of a gravel supply. These costs are for the year of 1930.

Conclusion

The counties of this state are today building sturdier bridges and more enduring structures than have been built in the past. This paper is not a symposium for the designing engineer who is entrusted with the complicated analysis attendant upon an economical design; if only the surface is scratched and we as a body are brought to a more keen realization of the importance of our function as bridge engineers as well as highway engineers, this paper will have accomplished its aim.

IMPROVEMENT OF CONTRACTING PRACTICE

By W. M. Holland, Executive Secretary, Indiana Highway Constructors, Inc.

Let it be understood that Professor Petty did me no favor when he invited me last evening to "pinch hit" on this subject for Ward P. Christie, now of Ulen & Company, Lebanon, Indiana, and formerly research engineer for the Associated General Contractors of America. While with the A. G. C. of A. the very nature of Mr. Christie's work carried him into close touch with existing practices in the field of contracting and with the development of improvements therein. It should be stated in fairness to him that some of our present practices
originated in his fertile brain, and through his untiring effort were finally adopted by the industry as a whole because of their being eventually recognized as improvements. Obviously then, were he here, he could speak on this subject with greater authority and, perhaps, more convincingly than I. Be that as it may, he is on the west coast and I am here; so I shall endeavor to give you as I see it the high lights of such developments as may be considered appropriate to the assignment.

If you will think for a moment of methods employed in highway construction 10 years ago and compare them with the methods of today, you will quickly realize how numerous the improvements have been and the rapidity with which they were developed. Then, or about that time, on many jobs were still to be found wooden road forms. When the steel form was developed, it was quickly adopted so that today it would be difficult indeed to find a road job under construction on which anything but steel forms were employed. Refinement of the steel form has occurred almost annually until today the latest design of this form shows almost as great a contrast to the original steel form as did the first of this type to the old wooden form.

Many of us can recall the prevalency of the 14-E type of paving mixer which has been chronologically replaced by a 21-E, a 27-E, and, in comparatively few instances, a 32-E, with the 27-E having become in the past few years the standard for paving operations. Those of us who have been identified with the construction industry for any appreciable time can vividly recall when the finishing machine was introduced. It was only a short time until the use of a finishing machine in lieu of hand finish was incorporated in every specification covering road work when the engineer was at all familiar with the results to be obtained through its use.

The development of the subgrade planer is of comparatively recent origin, and while not so generally required as the finishing machine, yet its value to a well done piece of road construction is quite generally recognized, both by the engineer and the contractor.

Developments in the proportioning of aggregate are equally interesting. We have developed from the wheelbarrow method to the batcher method, with batchers of two kinds, that is, measurement by volume and later by weight. Many of the states now require the proportioning of material by weight, having followed closely the development of such equipment by the manufacturer, who in many instances has been a pioneer in the matter of improved methods.

The use of cranes in the handling of materials is today commonplace. Methods of moving dirt have likewise been rapidly improved. The use of steam and gasoline shovels, tractors, 5-yard steel body wagons, and elevating graders,
which equipment is especially adapted to the heavier dirt-

moving jobs, has become relatively commonplace. 

And so it is obvious from this brief outline that the im-

proved practices of today are many and are likewise of great 

benefit. As I see it the construction industry, of which we 

are all a part, including the public official and the taxpayer, 

are responsible for these money-saving improvements. I 

think it safe to say that many of the machinery improvements 

originated with the manufacturer of equipment. As these 

improvements proved to be practical, they were quickly 

adopted by the public official, especially the engineer in charge 

of work and having to do with the drafting of specifications. 

I have purposely mentioned the taxpayer as a part of this in-
dustry responsible for these developments, and I have done so 

because were it not for the money made available for public 

construction work, the manufacturer and other pioneers would 

not have had the incentive to experiment, to spend time, ef-

fort, and money with the view to developing something new. 

It was essential that there be a market for such improvements 

if, as, and when developed; and the taxpayer's dollar that has 

been appropriated for public improvements created an incen-
tive essential to these developments.

Of what benefit have been these improvements, and have 

they benefited the taxpayer, as well as the construction in-
dustry? Obviously they have been of great benefit both, in 

my opinion, to the industry and to the taxpayer. They have 
certainly resulted in a better quality of work, a more uniform 

product, and greater production. In other words, this com-
bination of results means to the taxpayer a better product 
at a less cost, and by reason of prompt completion, less in-
convenience. To the industry it means greater production, 
and by reason of less cost, greater volume of construction 
work, which, of course, inures directly to the benefit of the 
industry.

Prequalification of Bidders

Now for another phase of improvements in contracting 
practices. It is one with which I have had far more to do 
than the development of equipment. I refer to selection of 
bidders for their skill, integrity, and responsibility. The In-
diana General Assembly in 1929 enacted a law which clothes 
the awarding officials with almost unlimited discretionary 
power in the selection of a bidder subsequent to the receipt 
of bids on a given project, and especially sets down certain 
factors that should be weighed in such selection,—experience, 
available equipment, and financial responsibility. It is not 
asking too much of the public official to ask that he so award 
his public construction contracts as to feel fairly confident 
that the work will be properly done and all obligations
promptly met. We have seen this questionnaire adopted by the political subdivisions of Indiana and the Indiana State Highway Commission because of its being required by statute, and we are hopeful that along with its adoption the awarding officials will interpret it as intended and thus award contracts in the best interest of the taxpayer as well as of the construction industry.

Prequalification of bidders on public work is a step ahead of our present statutory requirements, and many states have already come to prequalification by statute, so that it is highly probable the day will come when throughout the country there will be a well-defined policy with regard to this matter of qualifying bidders.

With reference to this same general subject there has been developed at Washington, D. C., within the past three years what is known as the Bureau of Contract Information, Inc., under the auspices of the A. G. C. of A. and at the expense of the surety companies of America. The whole purpose of this Bureau is to develop information concerning the individual bidder so that the surety company in the writing of a contract bond, and the public official in the awarding of a contract, may be fully informed as to the extent of the contractor's responsibility. Much progress has been made in this field, but far greater progress is necessary if we are to attain the ideal involved in the underlying thought.

While addressing you on this subject, and in the presence of so many engineers who are identified with public improvements, I should like to take occasion to mention the relationship between the engineer and the contractor. This is a general observance and yet, in my official capacity as Executive Secretary of Indiana Highway Constructors, Inc., I frequently get the contractor's viewpoint of differences of opinion between the contractor and engineer as they arise and have many times been a party to conferences designed to adjust such differences. I am pretty well convinced that the differences of opinion and the difficulties between contractor and engineer are often the result of lack of understanding of each other's problems—of failure to put oneself in the other fellow's position—the absence of any spirit to give and take as conditions on the job would warrant. I say this is only a general observation, and yet I think if it were kept in mind both by the contractor and the engineer and an attempt were made by each to recognize his own shortcomings and to meet a situation squarely as it develops, there would be created a harmonious atmosphere that would be conducive to better results and better relationships, and certainly to mutual respect.