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NOTE: The airphotos used in this paper were photographed for the Commodity Stabilization Service, U. S. Department of Agriculture.

Contractors' Acceptance of Measurements Made by Photogrammetric Methods*

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ABSTRACT: 1. Statements made at prior meeting in Atlanta recently, relative to acceptance by Highway Engineers and Contractors.

2. Adoption by engineers dependent on their conclusions of the comparable accuracy with prevailing methods.

3. Comparatively recent practice of furnishing contractors with plans containing limited information, thus requiring the contractor to do his own quantity take-offs and bidding lump-sum or on a mileage basis. Such a contractor would be equipped to handle the proposed methods of photogrammetry.

4. The highway departments and manufacturers should provide the advance education of the contracting industry prior to letting construction contracts under these new methods.

THE science of photogrammetry and electronic computing on highway work has not been applied to any projects in the area in which our company normally

operates. Some use has been made of aerial photographs in the preliminary stages of highway location work in some of the states. But the preparation of the plans

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and estimation of quantities have been made by the time-honored methods with which everyone is familiar. Consequently, I do not have any experience in doing construction work where these new methods have been used.

At the "Conference on Increasing Highway Engineering Productivity" held at the Georgia Institute of Technology in Atlanta last July, I was asked by a friend in the Bureau of Public Roads how long I thought it would take for the contractors to accept for payment purposes on construction projects, measurements made by photogrammetric methods and computations by electronic methods. My reply was that they would accept it in far less time than it would take the highway engineers to accept the methods and put them in use.

I repeat this statement because I am sure that before adopting the new methods the engineers will be thoroughly convinced that these new methods will give results as accurate, or within a very close percentage as accurate results, as the old established methods. Traditionally, engineers try to make highway engineering an exact science and hence measure everything to the exact dimension. This effort begins with the measurement of the length of the project, profile, and cross-section, and ends with the computation of the cross-sections to the nearest tenth of a cubic yard. He practices this exactness in all of his paper work, even though he is aware that the field work is only approximately accurate. He depends upon the experience and conscientiousness of his field crew and inspectors on the job, for the accurate quantities derived by his calculations. A loose tape and sloping level rod in the hands of a careless rodman and chainman can set at naught his most careful office calculations. Nor is it practical to take a reading on all the breaks in a cross-section. But we know that these errors tend to "cancel out."

The limited knowledge I have on the use of photogrammetry and electronic computing in preparing plans and quantities makes me believe that the errors will tend to "cancel out" as in the present methods of taking field measurements. As I said earlier, I feel that if the engineers are satisfied to adopt these methods, the contractor can safely accept them.

With the increasing complexity of highway design, especially on the Interstate,

Primary and Urban Systems, it behooves the contractor to have employees who are engineers capable of interpreting and checking the accuracy of the plans as prepared by the highway engineers. Most contracting firms bidding on certain classes of Federal construction projects have had to have engineering employees in order to prepare bids. The contractor is furnished a set of plans and specifications showing the location layout, contours, finished grades and elevations; from these data he has to make the quantity takeoffs. Some states have furnished us with a plan, profile, grade line, and typical cross section; we have bid on a cost-per-mile basis. When only this information is furnished we have to go into the field and make our own estimate of the quantities involved. This practice has been mostly on projects in the secondary road systems, but recently one or two states have used this method in letting projects on the primary highway system. In some cases the engineers also furnish a mass diagram, the total quantity of cut, fill, and borrow; the contractor then has to determine the most economical construction procedure and provide his own borrow and material pits. I am, therefore, fairly certain that most of the larger contractors are presently staffed with personnel capable of handling this phase of the work.

I assume that the method of photogrammetry and electronic computing will be applied only to the larger projects. I think this would be true during the period the highway departments were adopting and becoming accustomed to using this new method. Hence the smaller projects would still furnish work for the smaller contractors who might not be able to furnish the engineering talent needed to handle the new method. They would also be available for subcontract work on the larger projects.

It is also becoming more and more the practice to leave much of the field engineering on construction for the contractor to do. This makes necessary the contractor having capable engineering personnel in his organization.

Contracting is essentially a gambling venture. The contractor must try to evaluate the vagaries of the weather, the delays over which he has no control, the unforeseen conditions not shown on plans or not made clear in the specifications, an increase in price of labor and materials,

and last but not least, what one of my contemporaries called "Madki." When presenting the Resident Engineer an itemized bill for some extra work ordered by the engineer, the engineer objected to the percentage added to the itemized cost. This was 20%, The Resident Engineer told him he thought 10% was ample. The contractor replied that 10% would only cover the "Madki." "What in the hell is 'Madki?'" asked the engineer. "Mental anguish, don't know, and indifference on the part of the engineer" was the reply. So the new type of plans and measurements are just one more factor that the contractor must evaluate and take into account.

It will undoubtedly be sometime after a highway department decides to adopt the method before it will be put into actual use. It may decide to equip and staff its own organization so that it can do the work in its entirety. Or the decision may be to contract this work to engineering companies already doing this kind of work. In either case the delay in getting the first plans ready for bidding will be quite lengthy. In my opinion the delay in the first instance would be at least a year. It could possibly be that long or longer if attempt is made to do the work by contract, due to prior commitments on the part of the engineering firms.

Under these conditions, the highway departments would have ample time to promote the "education" of the construction contractors in the use of the new methods. This could be done in several ways. A panel discussion could be set up at some highway letting at which the engineers could make talks to the contractors on the various phases of the work. Most states have a contractors' association and they could invite the engineers, and the photogrammetric and electronic

instrument manufacturing company representatives to discuss the matter at their yearly conventions. No doubt highway construction specifications will have to be rewritten around these new methods. This should be done and put in the hands of the construction contractors far enough in advance of letting the first projects to give the contractors time to clear up anything they did not understand or were uncertain about. I feel that it is a matter of educating the contractors as well as the engineers. Once the engineer is sold on the accuracy of the method for meeting his requirements, then the contractors should have no hesitancy in following suit. But since their profit and livelihood depend on an understanding of the method, it behooves the highway engineer to make clear how it works and how the construction contractor will be expected to operate under it.

I think the instrument manufacturers and engineering firms sponsoring these new methods could very well direct some of their educational and advertising effort in the direction of the highway construction contractors. They could point out the benefits and advantages to the contractors as a result of the adoption of these new methods. If the new method materially reduced the time now consumed by the Highway Departments in getting out the final estimates, this quicker action would be a strong point in talking to the contractors. I think I can safely say for the majority of the highway construction contractors that once they understand the operational limitations as well as the advantages and accuracies of the proposed methods, they will have no hesitancy in accepting them and cooperating with the engineers in carrying out the construction work under the plans and specifications prepared by and for their use.

DISCUSSION*

MR. GOODALE: (Caracas, Venezuela) I'm particularly interested in photographic interpretation. Could you, Mr. McLerran, give me the names of text books recently published on photographic interpretation?

MR. MCLERRAN: Probably the best source

of information are recent papers published by the Highway Research Board. There is a text book, not illustrated, put out by the Civil Engineering Department of Purdue University. I believe the title is "A Manual on the Airphoto Interpretation of Soils and Rocks for Engineering Purposes." Others

* This section is incomplete. Omissions were made necessary by the wording of some questions or answers and some questions and answers being confusing, obscure or incorrectly stated—
EDITOR.