

"DESIGN AND CONSTRUCTION COORDINATED WITH ELECTRONIC COMPUTATION"

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During the summer months while attending the University, worked for the Department of Highways and continued employment after graduation from the University. Employment has been continuous in all phases of location, design, and construction.

The subject of this paper may be somewhat misleading in that it is my purpose to not only discuss with you the coordination of design and construction work with Electronic Computations but also to point out the possibilities and practicabilities of using photogrammetry in both design and construction and also some of the advantages that accrue from using photogrammetry in conjunction with Electronic Computations for both design and construction. No attempt will be made to delve into the technical aspects of either Photogrammetry or Electronic Computations.

During the past few years, papers have been presented to you at this Conference covering the detail explanation of both the Photogrammetry and Electronic Computations. Basically, the purpose of both of these fields is to speed up engineering work and furnish more accurate information. Aerial Engineering and Photogrammetry is being used by Engineers in a large number of the Highway Departments and, in particular, for preliminary engineering studies.

Your Kentucky Department of Highways has been and is continuing to use Photogrammetry for preliminary engineering studies, but in addition, has been and is using these facilities for detail design. There are many advantages to be gained; however, there has been in some engineers mind doubt as to the accuracy that could be obtained using Photogrammetric principles. There has never been in our mind any doubt as to the accuracy that can be obtained by the use of Photogrammetry when good Judgment is used. Basically, to obtain an elevation from a Kelsh Plotter, the operator must be able to see the ground as photographed where the elevation is to be determined. It follows, therefore, that if the operator cannot see the ground, an accurate observation cannot be

obtained. In such cases, information should be obtained by conventional field methods. We have seen instances where detail design was based on information obtained from Photogrammetry that was totally unsatisfactory.

We have been well aware of the limitations and have made no attempt with Department policies to overstep the bounds of good engineering practices. We firmly believe that cross-sections taken by photogrammetric methods are as accurate and in many cases more accurate than those taken by field methods. To obtain its accuracy, however, certain precautions must be taken. First, the centerline survey must be staked within third order control; second, accurate elevations must be obtained for picture control; third, an accurate field profile must be obtained along the centerline. Having this information, the operator of the Kelsh Plotter can adjust the entire cross-section up or down to coincide with the centerline elevation obtained from the field profile.

The Kentucky Department of Highways' thinking concerning the accuracy of cross-sections from Photogrammetric methods has been brought out by a test project undertaken by the California Department of Highways. If you are interested, it can be found in the Highway Research Board Bulletin 228. Briefly, and without going into any detail concerning the method of comparison used by the California Department of Highways, their conclusions were as follows:

1. The most important factor in the accuracy of earthwork quantities is the vertical accuracy of the survey measurements.
2. Photogrammetric surveys are subject to relatively small systematic errors. Such errors have a serious effect on the accuracy of earthwork quantities.
3. Use of photogrammetric surveys for pay quantities is questionable unless they are checked by statistical comparison with an accurate field profile.
4. The greatest saving in manpower in obtaining earthwork quantities which can be achieved under current practice is development of a method of utilizing photogrammetric quantities for payment.
5. The most important fact developed by this study is that adjusted quantities from all of the photogrammetric surveys were within limits generally considered tolerable for pay quantities. They were more accurate than quantities obtained by a field survey made by commonly accepted methods.
6. The method of adjusting photogrammetric quantities by use of a centerline profile appears to have considerable potential value as a means of obtaining pay quantities with a minimum expenditure of manpower.

On the basis of this information and experience which the Kentucky Department of Highways has, and substantiated by the test project made by the California Highway Department, there is no doubt in our minds as to the feasibility of obtaining accurate cross-sections and terrain data by Photogrammetric methods. So far, I have dealt primarily with cross-sections as they appear to be the most controversial phase of Aerial Engineering. Other information such as topography has been generally accepted for many years.

I would like to depart briefly from Aerial Engineering and discuss in general the Electronic Computing facilities which the Department also has available. The Department is equipped with International Business Machine Equipment including one of the latest models for electronic computations. This equipment is used for many things other than engineering services; however, it is available for engineering purposes and the engineers working with the electronic computing program have time allotted for engineering purposes. Generally speaking, a electronic computer is a machine which makes mathematical computations very rapidly. I am told that the equipment which we have will make additions, subtractions, multiplications, and divisions at a rate of approximately 50,000 per minute. Much work has gone into the Engineering Programs and the Department has developed programs for earth work computations, superelevation, grade line, interchange geometry, and many, many, more programs which are used day in and day out by the highway engineer.

Certainly, the available facilities are not being used by the Kentucky Department of Highway Engineers to the fullest advantage. It is expected that the use of the Electronic Computer will increase as time goes on and of course, more time will have to be obtained for use of the Computer. We are looking forward to the time when its use will be so great that additional facilities will have to be provided. The age old law of supply and demand will apply since until such time as it can be definitely shown that a need for additional facilities exists, there is little reason to insist on an individual computer for engineering purposes.

It is my belief that many of the Highway Engineers feel that the computer is primarily for use by Central Office Personnel or that the computer is too far from the local offices of the Department in the far reaches of the State. This definitely is a misconception in that we are more than anxious that the computer be used to the best advantage to improve efficiency in all phases of highway engineering as well as to relieve the highway engineer of some of the drudgery he has become accustomed to over the years. It is not my intention to lead you to believe that you can come to the Central Office and sit down to the Electronic Computer and start solving your problems. The Computer is a very complicated instrument, but personnel are available in the Engineering Division who are thoroughly acquainted with its operations and can process most any problem for you very quickly.

Some months back, on one of my visits through the Area Offices, we were discussing the use of the Computer for the various phases of highway engineering and in particular were discussing the possibility of its use for earth work computations. After some discussions, one of the Design Employees spoke up and said that it appeared to him that we are working toward eliminating the 209 man. Of course, this is not our intention, as our main purpose, as stated before, is to relieve the 209 man of some of the drudgery involved in computing earth-work quantities. This in turn will give him a better opportunity to advance in grade and learn more about other phases of highway work.

The Department has, for one reason or another, set up the Electronic Computing Section for roadway purposes in the Design Division. It is not our intent that it be restricted to Design and, in fact, we are of the opinion that it is of much usefulness, perhaps more, for earth work computation for the Construction Engineer than the Design Engineer. This is particularly true since at the design stage, under current practices, earth work is classified into at least two categories, those being common excavation and solid rock excavation. As you all know, payment for roadway excavation is on an unclassified basis and for that reason the computer program is perhaps a little more adaptable to computing pay quantities for construction purposes than for design purposes. In fact, some of our neighboring states are spending considerable time with the computer program for final pay computations and information obtained from one state indicates it is entirely successful.

The combination of Aerial Engineering and Electronic Computing has proven to be a very satisfactory combination. This does not mean that data obtained from ordinary field methods is not just as adaptable for electronic computations, but there are some advantages in the combination with Aerial Engineering. In particular, due to the ease of furnishing data to the computer, the Department has purchased and expects to place in operation in a reasonable length of time, another electronic device. If used in connection with the Kelsh Plotter, it will automatically place the terrain data on cards which are used by the computer. I am told that this piece of equipment is called a Digitizer. It has not been on the market nearly as long as some of the computers and photogrammetric equipment, but its use has performed satisfactory in other State Highway Departments. It is my firm belief that the highway engineer today is in a position to rapidly and accurately use the new facilities that are available to him to a great advantage. For example, during the winter months is the most advantageous

time for photography for use in design purposes, while the summer months provide a very good opportunity for photography which can be used for final pay quantities. It makes little difference whether the original cross-sections were obtained by photography or conventional field methods. It is not even necessary that final cross-sections be obtained by photography. They can be obtained by conventional field methods and the computer can still be used to an excellent advantage.

When photography is used, certain precautions must be taken, but these are relatively simple when a field party is trained to use the necessary procedure, little additional time is required. Of course, in any program of this kind, some changes must be made in standard practices. For example, in using the computer, the information must be placed on cards which is done by a staff of Key Punch Operators who have no knowledge of what the information is or what it is to be used for, and truthfully other than a large group of numbers means nothing to them; therefore, it is essential that a uniform method of furnishing information to the Key Punch Operators be adopted. This requires some slight changes in the ordinary methods of recording cross-sections in the field. Actually a slight additional amount of time may be required but in the overall picture, considerable time and effort will be saved.

It is hoped that in the not too distant future that definite instructions can be furnished to you in written form of the steps involved using both the facilities of the Aerial Engineering Section and Electronic Computing Section for both design and construction purposes. In the meantime, it is sincerely hoped that the highway engineer will not fail to take advantage of every facility which the Department now has and he need only to contact the Design Division through the proper channels for information concerning these facilities.

At the time Mr. Drake and Mr. Blythe asked me if I had any suggestions in connection with the program for this Conference, I do not believe that either of these gentlemen had any idea that any further discussion of photogrammetry or electronic computations would be included in this Conference and possibly they were asking me for ideas; however, I felt that this was a good opportunity to acquaint not only the Highway Engineer but also other interested people with the facilities and opportunities which the Kentucky Department of Highways now has available.

Probably due to my enthusiasm and extreme interest in both Photogrammetry and Electronic Computations prompted me to undertake this discussion with you. The Department has, what I consider, a very fine group of Engineers and Technicians who are completely devoted to developing and employing both photogrammetry and electronic computations to any problem that is practical to apply such methods. This group of people will be only too glad and will welcome the opportunity to work with you in connection with any of your problems. For example, we know it to be practical and have used the Computer to develop balanced grade lines before the first cross-section has ever been plotted. This, as you realize, practically eliminates the need for computing quantities over and over again to obtain a balance in quantities.

I can realize the hesitancy on the part of some of our Engineers and possibly the fault is not with the individual, but due to the fact that the pressure for quick completion of plans has been rather strenuous during the past several years and as such, the Highway Engineer has hesitated to enter into a new field not knowing the problems with which he may be involved. I am sure though that you will appreciate the time that can be saved if the Designer could know in advance that his grade line would approximately balance before cross-sections were developed. Of course, minor changes can be expected which would be brought about by such things as revisions to meet drainage requirements, clearances in connection with grade separation structures, etc. The Designer could knowing that his grade line would approximately balance, make the

necessary adjustments in order to refine his grade line and then obtain final quantities with the Electronic Computer.

The Construction Engineer can probably save the most man hours from a combination of photogrammetry and electronic computations in the field of pay quantities for Roadway Excavation. There are other advantages, however, that can be quickly worked out for the Construction Engineer which will be considerably time-saving during the actual construction phase. In this instance, I refer to such items as superelevation problems on the higher type projects such as Interstate.

Programs have been completed and are in use from which the Construction Engineer can be furnished with elevations at the edge of pavement at any point which he desires quickly and with very little work required in the furnishing of information to the Electronic Computer Section.

I have touched only briefly on the many points and benefits which we believe should be utilized by the Highway Engineer in both Design and Construction Fields, but there are many more benefits which the Highway Engineer can make use of and which the Engineers working in the field of Photogrammetry and Electronic Computations will be most helpful if given the opportunity to serve you.