*California Location Practice**

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MODERN freeways with their wide rights-of-way, complex interchanges, and high standards of alignment and grade, require an entirely different location technique than the conventional highways of ten or fifteen years ago. Fortunately, developments in the fields of photogrammetry and control surveys have kept pace with these constantly increasing requirements and have provided products which the highway engineer can use to solve his location problems.

It is only natural that engineers in different parts of the country in approaching the problem of locating these new type superhighways with the aid of new tools—photogrammetric products—should arrive at the end results by a wide variety of methods. Possibly the time has come to examine and compare the various methods which are being used to solve location problems with the aid of photogrammetry. Such a comparison would be of assistance to highway engineers who are just starting to use photogrammetry and might also have a strong influence in directing research work in photogrammetry and electronic computations during the next few years.

Location practice in some sections of the country has followed the trend started by engineers for several of the large turnpikes a number of years ago in obtaining a strip of topographic mapping a mile in width at a scale of 1 inch = 200 feet with 5-foot contours. The maps were used to study various alternate lines and select the best location. The final line was not calculated in the office but was staked in the field by scaling ties from planimetric features to the graphic projection on the map. The locator made such adjustments as were found necessary in the field and proceeded with profiles and cross sections in the conventional field survey manner.

Further refinements of this method are being used in several of the States. They generally consist of a follow-up photographic flight at low altitude after the proposed centerline has been staked in the field. From this low altitude photography a planimetric map at 1 inch = 50 feet is prepared and photogrammetric cross sections for use in detailed design work are developed in the stereoplotter.

California location practice, as contrasted to this method has stressed a maximum use of aerial photography and a minimum use of topographic mapping in the early stages. Aerial photographs are used in the planning and reconnaissance stages of practically every project. Frequently several different scales of photography, ranging from as large as 1 inch = 200 feet to as small as 1 inch = 2,000 feet, are required for a single project.

When quantitative information which cannot be obtained from the photographs is required, the first source is existing topographic maps. In locations where they are available the seven and a half minute series U. S. Geological Survey quadrangle maps will usually suffice. Where a larger scale is needed or where quadrangle maps are not available, reconnaissance-type photogrammetric mapping generally at a scale of 1 inch = 400 feet with 20-foot contours is obtained. Such mapping is the exception rather than the rule. Several of the highway districts in California have made all their planning and reconnaissance studies by the use of aerial photography supplemented by existing maps. Most of the other districts have required reconnaissance-type mapping on less than 15 per cent of their projects.

As aerial photographs can be obtained in a matter of a few weeks as compared to several months for photogrammetric mapping, this practice saves valuable time in

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the early stages of a project. It should be stressed that the location, as determined by aerial photographs supplemented by small-scale topographic mapping were required, is approximate only and is subject to refinement during the design stage.

After the approximate location of the highway has been determined, the next step in California practice is to obtain large-scale, small contour interval photogrammetric maps for determination of the final line and detailed design of the facility. Such mapping is generally at a scale of 1 inch = 50 feet with 2-foot contours or with photogrammetric spot elevation at 100-foot intervals in level terrain where contours would not provide sufficient accuracy. A scale of 1 inch = 100 feet with 5-foot contours is occasionally used for design work in mountainous terrain. The mapping is generally from 1,000 to 1,400 feet in width with additional width at interchange sites, thus allowing the designer considerable latitude in determining the final line. He can make this determination with the large-scale detailed mapping at hand and does not have to rely on small-scale mapping for his information. Furthermore, he is not influenced by a line previously staked on the ground to which he feels he must adhere if possible.

The first step in design mapping is a control survey run through the mapping area. This survey is occasionally made by State forces, but generally by the mapping contractor. As its only purpose is to control the topographic mapping and to establish monuments at intervals of from 1,000 to 2,000 feet, the survey can be made by either triangulation or traverse, depending on the terrain, and it can follow the course of least resistance through the area. The survey is generally made to second-order accuracy and is based upon the California Coordinate System. In order to have uniformity between adjacent projects, the coordinate system is generally unmodified for either grid or elevation factors. Corrections for converting grid distances to ground distances are made the same way a temperature correction would be applied, by adding or cutting a few hundredths in each tape length.

The locations of the monuments established by the control survey are carefully planned by the location engineer so they will be readily available for any subsequent survey work on the project, including ties to property corners and staking the final centerline. As the final centerline, as well as the right-of-way lines, will be mathematically computed in the office by the designer, they can be staked in the field at any time by using calculated ties to the control survey monuments. In built-up areas it is unnecessary to stake the centerline until the rights-of-way have been purchased and cleared. If it is necessary to stake a portion of the right-of-way line during negotiations with the property owners, small segments can be staked independently without the necessity of running several miles of centerline.

In the important phase of making the detailed projection and laying out the drainage plan, a designer who is used to working with contour maps can do a faster and more efficient job with them than by using cross sections. The practice advocated in California is to use the contour maps for design and supplement them with a few pictorial cross sections showing both typical and unusual conditions as well as major cross drainage. As these cross sections are not used for earthwork quantities, they can be at a relatively small scale with the vertical scale being exaggerated if necessary. These cross sections, generally averaging ten to fifteen per mile at 1 inch = 20 feet as compared to 110 per mile at 1 inch = 10 feet by the conventional method, are included in the contract plans. The field engineer and the construction contractor are thus furnished sufficient information for estimating and constructing the project. Excavation quantities are calculated by an electronic computer which combines terrain notes picked off the contour maps with roadbed notes tabulated by the designer.

In comparing this method of design with the method of taking photogrammetric cross sections directly from the plotter to the electronic computer, two advantages of the latter are apparent. First, the increased accuracy of the photogrammetric cross sections over the contour maps, and second, the elimination of the labor of taking the cross sections from the maps. These advantages, however, may be more apparent than real and they may be accompanied by serious disadvantages.

As for excavation quantities, a large-scale topographic map with 2-foot contours to National Map Accuracy Standards will provide ample accuracy for all practical purposes in rolling or mountainous terrain. In level terrain the California method of using a map with photogrammetric spot elevations will provide the same accuracy as photogrammetric cross sections. Horizontal or vertical accuracy to fit tight controls is another matter. Such controls might be the location of the edge of a vertical cliff or a costly building or other improvement or the elevation of a railroad track. Controls such as these are relatively infrequent and it is doubtful whether the required accuracy can be supplied by photogrammetric methods. It is also doubtful if the average conventional field survey will supply it. When the experienced designer recognizes such a control, he will call for a check measurement regardless of whether his original information came from photogrammetric data or from conventional field surveys. The added accuracy of photogrammetric cross sections as compared to a topographic map does not appear too important.

The labor involved in taking cross section notes from the contour maps is relatively minor. On an average project, two trainees or technicians can take off terrain notes at the rate of a mile a day or better. It would, of course, be worth-while to save this labor if it could be done without sacrifice of other elements essential to the design. As large-scale contour maps rather than cross sections are considered essential for determination of the final line and fast, efficient design of the project, it would be uneconomical and time-consuming to reset the models in the plotter and take the time of the plotter and operator to produce cross section notes which can be taken from the map by technicians.

Principal advantages of the method used in California are that it saves time in the preliminary stages of project planning and that by obtaining the large-scale mapping before staking the centerline in the field, it provides the designer with the maximum of detailed information for determination of the best possible line. When these various factors are given full consideration, we cannot help but wonder if photogrammetrists and highway engineers are not overselling each other on the advantages of photogrammetric cross sections.

*Obtaining the Optimum Value from Photography and Photogrammetry in Highway Engineering**

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AERIAL photography and photogrammetry have been proved conclusively to be useful tools to the highway engineer in expediting highway projects. In the application of these tools time has been saved, engineering manpower conserved and great economies achieved—all without sacrificing accuracy.

Once the usefulness of a device has been proved and accepted, the next logical step is to determine its optimum value; rather, obtain its optimum value. In accomplishing this with aerial photography and photogrammetry—as in obtaining the optimum value from any device—they must be given the widest possible applica-

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