A Photogrammetric Approach to Highway Route Location and Reconnaissance

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● AS HAS BEEN the case in many western states, Montana's roadways grew up along easily traversable routes which usually meant river valleys. As a result, most major highways are located within the confines of rugged terrain, along rivers and through the higher-valued farming lands. Major population concentrations are also located along these routes as well as most major industry. Due to these factors and many others, the most important of which are economic barriers, great care must be taken by the highway engineer in selecting a location for a new highway. Very thorough and fairly detailed studies must be made, and, due to the greatly increased pace in highway programming and construction, these studies must be accomplished in the shortest period of time.

Available data in the form of PMA and Forest Service photography at scales of 1:20,000 and 1:63,000, U.S. Geological Survey quadrangle maps, and planimetric maps made by photographic projection were used previously as guides to highway reconnaissance. These data are invaluable if utilized correctly. However, they are very limited in scope since no accurate comparisons of alternate routes can be made. In very rugged terrain, where a minor horizontal or vertical projection might result in a double construction cost, these data are not accurate enough and do not provide an acceptable base for comparing alternate routes.

The general problem, keeping in mind the aforementioned factors, would be to utilize all available information, and, in addition, make the most economic use of various additional photogrammetric processes and equipment, which will result in a speedy, accurate and economical method of highway reconnaissance and location, as well as provide an accurate base by which alternate routes may be compared.

If utilized properly, U.S. Geological photography and mapping and planimetric maps, together with traffic data and a good understanding of the objectives of a highway with respect to land use, topography, economy and development typical to the respective locality, a reliable and economical method of making reconnaissance of broad areas for route possibilities is established. Necessarily, other problems, such as recency of photography and mapping and possible future changes in types of development, are taken into consideration. However, it has been found that, due to various circumstances, typical only to Montana, these other problems are very minor in all but a few instances.

By thoroughly reviewing the foregoing factors and information relative to many route possibilities, it is entirely possible to delete all but a few alternates and, in many instances, only one location is evident.

Once several route alternatives have been chosen, the inevitable assignment of the highway engineer to compare and choose the best route arises. Along with this assignment, the questions arise as to the method to be used, the economic aspects of the method chosen, the rapidity of the method and the accuracy. The first three of these considerations may be grouped and discussed as one item, since they tend to be contingent upon each other. The method utilized should assure the utmost in economy, and, due to the rapidly accelerated highway program, should be very speedy. As has been found throughout the highway engineering profession, the fastest, most economic methods of ascertaining data required in comparing route alternates is encompassed in photogrammetry. The methods of utilizing photogrammetry in highway reconnaissance and location differ widely throughout the country. However, the following two methods are generally used:

1. Strip Photography, at a scale such as 1:12,000, is acquired of the alternate routes. By measuring parallax, using a parallax bar or other measuring device, fairly accurate differences in elevation may be computed and utilized in planning gradients

and profile. In this manner the routes may be compared as to physical features as well as approximate over-all costs. After a route has been chosen, the final route may be set by topographic maps made photogrammetrically or by field survey

2. Strip photography at an appropriate scale is acquired of the alternate routes. Topographic maps are prepared from this photography for use in route location, laying grades, computing earthwork quantities for comparisons and arriving at a final location.

TABLE 1

Item	Photogrammetric Method	Field Survey Method
Length	4.06 mi	4.07 mi
Excavation	1,148,667 cu yd	1,144,505 cu yd
Embankment	997,194 cu yd	1,028,505 cu yd
Time of completion	36 man days	189 man days
Vertical accuracy	± 5 ft	*
Maximum gradient	+1.8 percent	+1 86 percent

* Use as basis of comparison unless tabulated.

There are both advantages and disadvantages to both the above methods. The first method may be speedy and very economical. However, when applied in some of the very rugged terrain typical to more than one-half of Montana, it was found that in many cases where the alternates to be compared were located very close together, the method was not accurate enough. In one case in particular, a horizontal shift of 100 ft entailed approximately three-quarter million cubic yards of additional rock excavation in one cut alone.

In the second method it was found that the required accuracy was attainable; but it cost too much and the time consumed was considerably more than could be allowed in many instances.

If a method could be devised that would utilize the good features of both methods generally outlined above and do away with the bad features, it would be more applicable, subject to governing conditions perhaps typical only to Montana. The desire was to utilize a method or reconnaissance of area and determination of route possibilities, as well as accurately comparing alternate routes and selecting the best one. The following

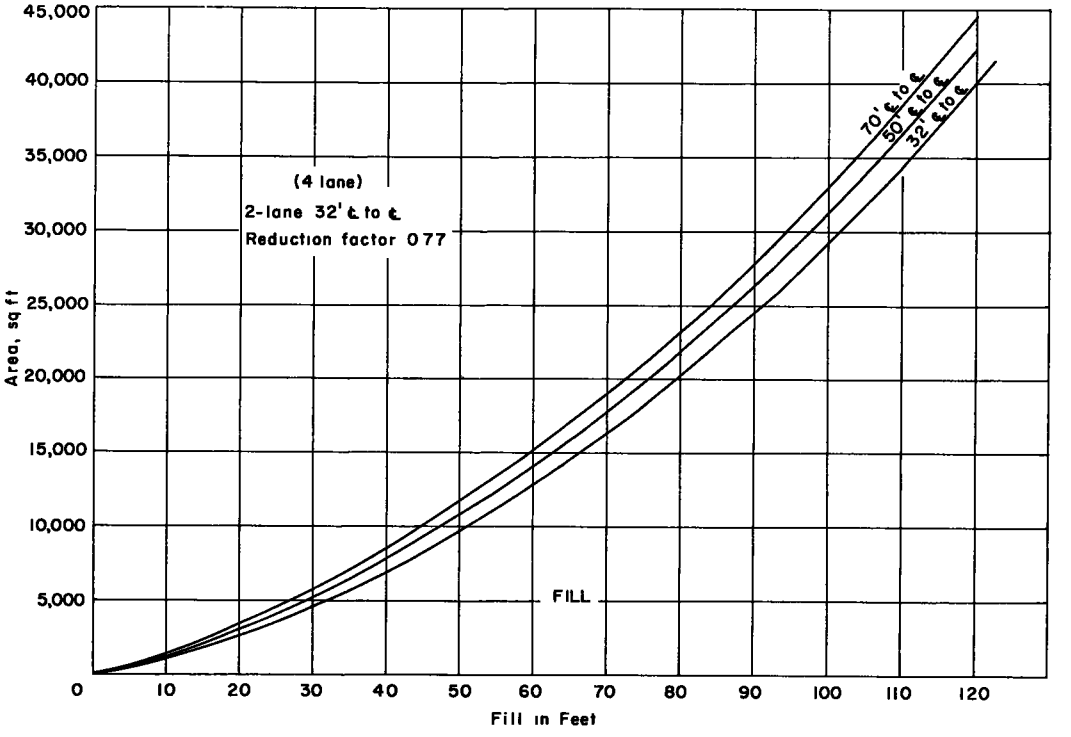

Figure 1.

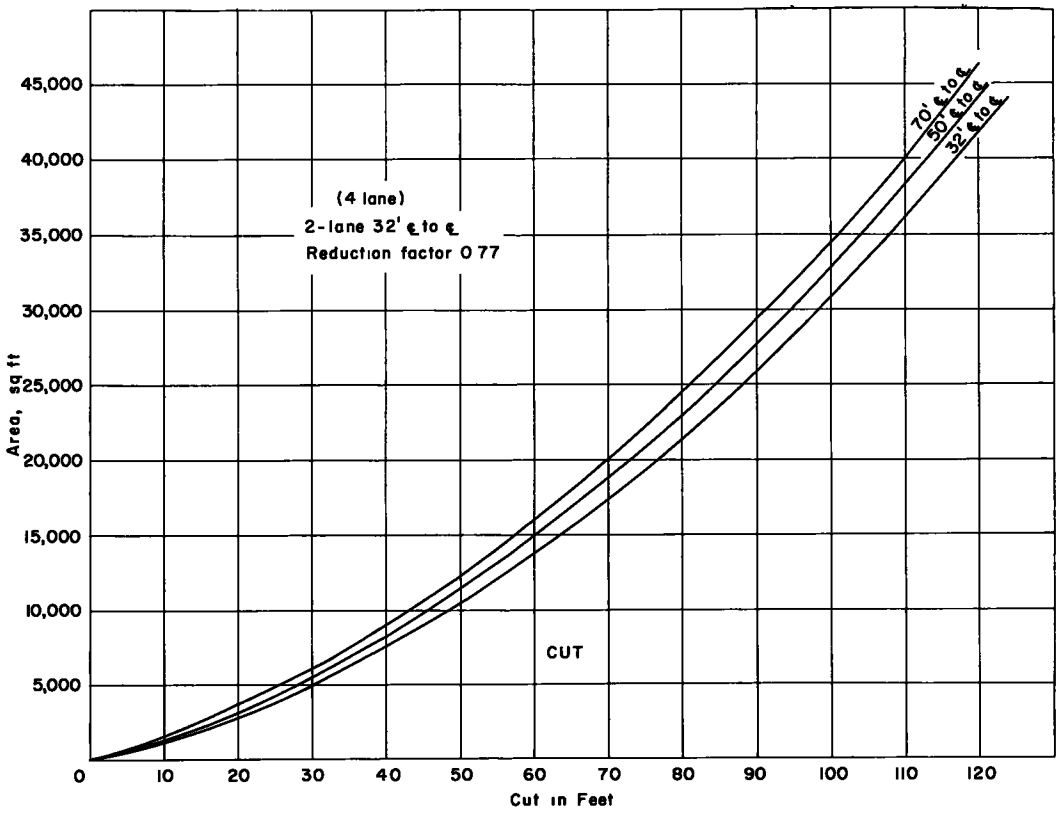

Figure 2.

outline is descriptive of the method now being used in Montana:

Step 1. Reconnaissance of area and determination of route possibilities utilizing:

(a) U. S. Geological Survey and Forest Service Photography at 1:20, 000 to 1:63, 000 scale.

(b) U. S. Geological Survey Quadrangle maps.

(c) Planimetric maps.

Step 2. Photographing route possibilities selected in Step 1 at a scale of 1:12, 000.

Step 3. Compare route possibilities by mirror stereoscope and parallax methods.

Step 4. Compare final alternates by actual cost estimates:

(a) Of entire project where required.

(b) Of problem sections of project where a high degree of accuracy is required (as is the case in most instances). This is accomplished by means of a small economical contact-print type stereoplotter, acquiring ground control from highway construction plans, U. S. Geological Survey maps, and previously mapped areas.

As a case in point, an Interstate Project located in central Montana, is illustrative of this method.

The project is 10. 26 miles in length, lies generally along the Yellowstone River, traverses land from highly productive irrigated types to rugged mountainous terrain and included four major structures.

Seven route possibilities were established from mosaics made of PMA photography at a scale of 1:20, 000. Through judicious use of U. S. Geological Survey quadrangle maps and knowledge of the land use and development, four of these possibilities were

selected as alternates. After photographing at a scale of 1:12,000, reviewing stereoscopically and obtaining gradients by measuring parallax, two of the alternate routes remained equal as far as could be ascertained. Preliminary cost estimates were, for all practical purposes, equal. It would appear that either of these two routes could be chosen, designed and constructed to accomplish the same result. However, some questions remained, and, to answer them, a more accurate and detailed study was required. The crux of the situation lay in a 4-mi section located approximately in the center of the project. Accurate excavation quantities were required, since all excavation was classified as varying from 50 to 100 percent rock. Since the acquisition of cross-sections is too time-consuming a process for these studies, a method was devised utilizing an accurate ground profile and grade line which is considerably faster. The ground profile was plotted utilizing a contact-print type stereoplotter. The accuracy attainable is best illustrated by the comparison, tabulated in Table 1, between the photogrammetric and field methods of the final location. By choosing a centerline cut or fill from the profile and grade line and interpreting cross-sectional area from graphs such as those in Figures 1 and 2, an accurate and speedy means of obtaining earthwork quantities is possible.

As well as being useful in preparing more accurate data for cost comparisons, the contact-print type stereoplotter has been used successfully in preparing design topographical mapping over limited areas. The final location selected by this method resulted in an approximate savings of $230,000.00. This savings was not evident until application of this more accurate method of acquiring data for cost comparisons.