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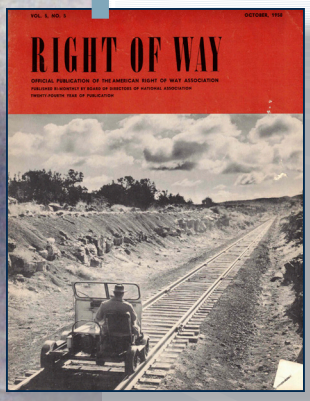
MODERN HIGHWAY DESIGN

BY JOHN L. HAYDEN

The following piece is an edited republication of an article from the October 1958 issue of Right of Way Magazine. We hope you enjoy reading about where we've been, appreciate how far we've come and be inspired by where we'll go next.

Like the submerged portion of an iceberg, the location, study and design phases of a modern highway are the most important factors of the visible end product. But being invisible, these factors are understandably not appreciated by the property owner who may be first made aware of a proposed project by a survey party driving stakes in his backyard.

A broader understanding by the public of the background of modern highway design and of the efforts made by engineering agencies on the public's behalf would greatly ease the shock inflicted on those people who are directly affected by new highway locations and upon the taxpayers. These groups can be — and usually are — extremely articulate; they deserve — and indeed demand — satisfactory answers.



In modern highway design, the engineer considers the social and economic significance of what he is doing. These factors may indeed outweigh the advantages of a purely technical solution to a given problem. Despite some current impressions among the laity, an engineer does not arbitrarily decree that, for example, a 300-foot-wide swath be taken for a highway from Point A to Point B. On the contrary, the arrival of the first bulldozer signifies not only the beginning of actual construction but also the end of the labors of scores, or even hundreds, of engineers.

The initiation of these highways is usually a joint effort by local, state and federal agencies who are increasingly relying upon the private consulting engineer to assist them in highway design. As in any science, the first principles of the design are: 1) the meticulous assimilation of facts 2) the unbiased and careful interpretation of these facts by competent personnel.

There are those who insist that highway engineering is in fact not a science but an art, sometimes defined as "Your guess is as good as mine." Nevertheless, these first principles must apply in any event.

First Data Needed is Traffic Survey

What is the factual data that is needed for the design of a modern highway? The first requirement is a traffic survey. A traffic survey is the foundation of all highway planning and establishes the need and type of highway that will best serve a particular area. An increase in highway accidents or repeated traffic congestion at particular locations are the usual indicators that will signify the need of traffic surveys.

These surveys are conducted in several ways, the most common being automatic counters, personal interview stations on existing roads and solicitations of information by postcard from automobile owners in the area concerned. Indispensable data relative to the origin and destination of vehicles and of their volume and types is obtained from such surveys.

Since this is the first contact that is made with the general public, it is essential that good public relations be promptly established. No one who has to meet his foursome on the first tee in 15 minutes will take kindly to a delay for a traffic survey, or indeed, for any other reason.

Traffic Analysis

Until quite recently, the analysis of traffic data was a long and difficult process requiring many manhours of a traffic engineer's time. However, there are encouraging indications that some of the drudgery of this phase of work can be handled using electronic computers.

This data, generally projected 20 years into the future, leads to the establishment of traffic desire lines. These desire lines show graphically on a map how many vehicles might wish to go directly, for example, from your hometown to the new shopping center, or to the next town, or to bypass the next town to go to the beach.

Location Study

Once the need for a new highway has been established and the general area of its location indicated by means of desire lines, the next phase of work for the engineer is to establish precisely the most desirable location, the number of traffic lanes and the points of egress. This is where the trouble begins, but this is also perhaps the most stimulating and certainly the most important phase of modern highway design.

All the engineer's resources must be brought to bear at this particular stage and not the least of these is the ability to engender the goodwill and spirit of cooperation from local citizen and industrial groups. The assistance of local interests is indispensable to the successful performance of the engineer's location studies.

Aerial Photography

To develop the presentation of his or her study, the engineer, as first step, employs the services of a fellow engineer who has specialized in the field of aerial photography.

This engineer is commissioned to prepare the basic maps that will be used throughout the study. These maps cover an area usually about 2 miles wide over the entire length of the major desire line. The actual flight pattern for the aerial photographs is determined by using smaller scale maps published by the federal government.

From the photographs, plans are then drawn which show the topography and all physical features such as buildings, existing roads, utility lines, railroads, waterways, fences and walls. It is even possible, although it is a very recent development, for an experienced geologist to determine general subsurface information from these aerial photographs.

But impressive as are the advances in the interpretation of aerial photographs, even more startling technical breakthroughs in aerial photogrammetry are continually being made. For example, under current practices, up to 60% of the time and cost of the photogrammetry is consumed by setting up prerequisite ground controls. Under a new system recently announced by the Bureau of Public Roads, much of this tedious and expensive ground survey may be eliminated by airborne radar, synchronized with cameras and a refined altimeter.

However carefully or expeditiously made, these photos must still be reduced to contoured maps before they can help the engineer. Until now, this step required infinite pains by highly skilled

technicians, but new plotting systems will permit profile plotting speed to be increased as much as 100 times over the speed that can be maintained by mere humans.

Plotting of Study Lines

When the photogrammetric plans are completed, study lines are plotted. Several things must be kept in mind as these lines are developed, the most essential being basic alignment. A review of the previously developed traffic figures determines the type of highway needed, its design speed and number of lanes required. The speed in turn determines the maximum vertical and horizontal curvature that may be permitted for safe driving conditions.

As noted earlier, these purely technical considerations must be compared with "the human factors"; in short, the effect upon the region in which the study line runs. The most desirable alignment, it need hardly be emphasized, cannot be obtained with only one of these study lines. An engineer must develop several lines so that good comparisons of route selection can be obtained.

Operations Now Put in Motion

Using these preliminary study lines as a starting point, several operations are put in motion. Office engineers now develop plans and profiles to the extent where accurate cost estimates can be made. Traffic engineers assign traffic to the various alternate routes and determine the location and type of interchanges. Structural engineers determine the type and cost of bridges that will be required for each location. Highway, drainage and soils engineers make field reconnaissance to estimate the actual conditions that may be encountered. Skilled real estate investigators are used to obtain estimates of the going cost of property that would be affected. Local and official groups are approached in order to coordinate any local planning that may be underway with the plans of the new highways. Sanitary engineers and electrical engineers investigate public and private utilities that would be affected by each study location.

Flood of Information May be Checked

It may be superfluous to note that this flood of information is usually not unchecked. The most vigorous arguments may be presented, for example, by important industries for location A, while another highly vocal group will demonstrate with equal passion that location B is obviously the logical choice. Both causes must be given careful consideration, but some of the engineer's planning generally must come to a halt until an evaluation can be made. In his evaluation, however, the engineer must keep firmly before him the axiom that you can't please everybody.

Nevertheless, the information does accumulate and as it pours into the engineer's office, it is evaluated with respect to the various study lines. Sometimes the information is of such nature that other alternates will be suggested for investigation.

Usually when all the information is evaluated, two or three of the study lines will show up to be the most promising. When these lines emerge, construction costs, real estate costs and traffic volumes are not determined as accurately as possible for these lines.

Road User's Benefit Ratio

Since the basic purpose of new highways is to transport people and goods safely and efficiently at the least cost to the taxpayer and with the great benefit to the road user, it follows that a mathematical yardstick must be used as one indicator of the comparative merits of each proposed location.

This yardstick is commonly known as the "Road User's Benefit Ratio." This ratio is a function of the traveling costs to you, the use and of the construction costs of the highway. The Road User's Benefit Ratio is one of the key factors in highway location and is frequently definitive.

For example, a large bridge is currently planned to span a river which is heavily industrialized on both banks. This bridge is considerably more expensive than another route which would completely bypass the city involved. Despite the higher cost of the bridge, however, it is favored by the benefit ratio since, centrally located as it is, the bridge would accommodate almost three times as much traffic as would the bypass.

Public Hearing

The engineer has now chosen the location of his or her highway, but even if it is technically perfect, he or she must obtain public approval. One of the provisions of the Federal Aid Highway Act is that a public hearing be held in order to inform the public of the chosen location and to solicit constructive criticism or suggestions from the citizens. It is here that the private citizens come into his or her own and it is here that the engineer explains and defends his or her location. Usually, the extensive preparation by the engineer enables him or her to anticipate that issues that will be raised that hearing; but if the engineer does not have the answers, he or she must be prepared for rough handling. It has been found through experience that the public hearing is a vital, if sometimes awkward, checkpoint before final highway design is started.

Final Decision

The acceptance of a location for a new highway at a public hearing opens the door for the engineer and permits the final design of a modern highway to go forward at full steam. Several items of work are started simultaneously.

A baseline is now staked in the field, which follows as closely as possible the approved alignment. New aerial photos and maps are made to larger scale. Boring programs are instituted to obtain subsurface information at the bridge sites, for foundation design and along the proposed center line to locate peat and ledge. Where large quantities of ledge are expected, seismic investigations may be used.

Property

A most important step that is made at this early stage is the investigation of the ownership of property to be taken. A great deal of effort is being made to speed up this phase of work as much as possible. Here again, the electronic computer is beginning to show its value. For example, the Nebraska Department of Roads has developed a computer program which will furnish the information required in deed description.

Computations

In addition to all the activites already mentioned, there is a multitude of computation which goes into the preparation of interchange designs, bridges and earthwork quantities. Here again, the electric computer is increasingly coming to the engineer's relief, thus freeing him for his true role of creative planning and design.

Plans and Specifications

Finally, all these efforts consummate in a set of construction drawings and specifications together with complete property plans of each parcel of land to be taken. The highway is at last ready to be built. The base of the iceberg has taken form.

The period of gestation for a modern highway may be well over four years from the initial traffic survey to the advertisement for bids. In contrast, actual construction for a typical contract, heralded by that first bulldozer, can usually be completed in less than two years.

Far from being arbitrary in either location or configuration, the highway as finally built is in fact the distillation of the diligent efforts of an army of planners and engineers, all dedicated to the high principles of their mission and to the ultimate criterion — the public benefit. ✪

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