Resume of AASHO Report on Road User Benefit Analyses

D.W. LOUTZENHEISER, W.P. WALKER and F.H. GREEN, U.S. Bureau of Public Roads

● AS EARLY as 1945, several state highway departments were using some type of formal approach in appraising the economic feasibility of proposed construction projects. Also, the same general methods were being used to determine the relative merits of two or more alternate locations or designs. It became apparent that some effort should be made to coordinate the work of these various agencies, and to establish some sort of a specific guide which would promote the use of this type of analysis in all highway departments, and encourage standardization of the procedures. Such a report, Road User Benefit Analyses for Highway Improvements, was published by AASHO in 1952.

Any economic analysis of a proposed highway improvement must include an appraisal of the expected benefits to be derived from the project, as compared to the estimated cost of the improvement. There are several means by which this comparison may be expressed. In the AASHO report, a benefit cost ratio is prescribed. This ratio represents the amount of savings to highway users for each dollar invested in the highway facility.

The basic formula calls for the computation of highway costs and road user costs, from which road user benefits can be determined.

Highway costs include both construction and maintenance. Costs for the improved facility are based upon the estimated annual amortized cost, plus annual maintenance, while for the existing highway only the annual maintenance is included. The resulting highway cost is, therefore, the increased annual cost due to the proposed improvement of the facility.

Road user costs, on an annual basis, include the actual cost of vehicle operation, plus factors indicating the value of time spent in travel, and for the less tangible advantages or disadvantages of traveling on roads with greater or less degrees of traffic service characteristics.

In the formula, road user benefits are the savings to be derived from the improvement, indicated by the difference between the road user costs on the existing and the improved facility. Other factors, including increased safety and community benefits, might also logically be included in this item if sufficient information were available for estimating the amounts.

The formula indicates a simple division, in which the estimated annual road user benefits are divided by the increased annual highway costs, to obtain a benefit cost ratio.

This method, which includes a systematic summation of estimated costs and a logical means for comparing the cost items, provides a sound approach for making a routine economic analysis of a proposed construction project. It also provides a procedure for comparing two or more alternate locations or designs for the same project, by comparing each alternate to the basic (existing) condition, using the same total traffic for purposes of comparison.

CALCULATION OF ROAD USER COSTS

The estimated costs to the road users are computed by establishing the unit costs per mile, which are multiplied by the average annual traffic volume for the analysis period and the total length of the analysis section.

Unit operating costs are affected by many factors, some of which are interrelated. For example, increased speed of operation results in increased fuel consumption and tire wear, but decreased cost of time. In the report, it was necessary to combine some of these factors, and the unit operating cost data are presented according to a selected group of specific variables. These include:

1. Type of highway design, type and condition of surface;
2. Type of traffic operation (free, normal or restricted);
3. Speed;
4. Gradients;
5. Curvature; and
6. Type of vehicle.

These variables were selected to provide a practical means of presenting unit operating costs in tabular form. They establish the amounts of the several individual items of cost, which normally are not needed as separate items in the analyses, since they are combined into a total unit cost in the tables. These specific items of expense include fuel, oil, tires, maintenance, depreciation, time, and an intangible item for "comfort and convenience." The cost tables are presented in detailed form, in order that prices may be kept current and local price situations accounted for. In the discussion of operating costs which follows, only the total costs are considered.

In presenting the unit cost data, a separate table is used for each major type of highway design and highway surface. One table lists costs for 4-lane divided highways, paved and in good condition. The second table lists paved 2-lane highways and another loose aggregate surfaces. Corrections are indicated in the text for surfaces in poor condition.

Each cost table is subdivided into three sections, one for each type of traffic operation, that is for free, normal, and restricted operation. The determination of the type of operation is based upon a comparison of the predicted traffic volumes and the practical capacity of the highway, according to information included in the text of the report.

Within the framework of each section of the tables, operating speeds form a major subdivision. Speeds are grouped in increments of 4 mph, and costs for specific estimated speeds can be interpolated.

Finally, under each classification for speed of operation, various gradients are listed in increments of 2 percent.

At this point, the analyst is able to read directly from the table an estimated unit operating cost of a passenger vehicle operating on a tangent section of a rural highway. A correction for horizontal curvature is then made by reference to a chart included in the report.

In addition to the itemized cost tables, cost charts are also presented. Total unit operating costs, in cents per vehicle-mile, for each situation or variable included in the tables, may be read from the appropriate chart.

The cost tables and charts are for passenger vehicles only. However, the method is set up to utilize similar separate and detailed unit cost tables for trucks, when sufficient information is available for their preparation. As an interim approximation, in order to account for the increased operating costs for commercial vehicles, a table is included which indicates the equivalent number of passenger cars to be substituted for each type of commercial vehicle.

The estimated cost of stops is also considered as an item of operating cost. A chart is included in the report by which the cost of each stop, according to the approach speed and the length of delay, may be read directly. The estimated number of stops per year is computed by considering the expected traffic situation at each intersection along the route. Vehicles approaching or crossing the highway under study are also included. On many rural projects, the cost of stops is not of sufficient importance to be included in the analyses.

Accident costs form a logical part of road user costs, if adequate cost data are available. If there is a significant difference in the accident potential between the existing situation and one or more alternates, or between various alternates, this item is sometimes approximated and included in the totals.

For analysis of a particular project the different sections of highways carrying traffic affected by the improvement under consideration are set up as analysis sections on which the road user costs before and after are calculated separately. Sections limits are established by major factors involved, such as points of traffic change, type of highway, number of lanes, and differences in the basic design elements. Summation of the road user costs for all sections provides the project totals.

Total road user costs are computed by using the total unit operating costs, the estimated average annual volume for the analysis period (frequently 20 years) and the length of each analysis section. It is important that the total traffic is assigned to each alternate and to the basic condition, even in situations where such an assignment of traffic to the existing facility may be somewhat unrealistic.

CALCULATION OF HIGHWAY COSTS

Highway costs are computed on an annual basis. They include the amortized annual cost of construction and annual maintenance charges.

The estimated cost of construction is amortized over a period of years which to some degree represents the expected useful life of the various elements. Right-of-way costs are therefore amortized over a longer period than the cost of less durable portions of the highway. Typically, the total estimated cost of the new work is divided into three parts — right-of-way, grading and structures, and pavement and base. A logical amortization period is assigned to each of the totals and an appropriate rate of interest is selected. Then, from an amortization table included in the report, a total annual cost may be computed.

No value is assigned for the worth of the existing facility. Annual maintenance costs are estimated.

The estimated increase in the annual highway cost is the difference between the amortized construction cost of the new facility plus maintenance less the cost of maintenance on the existing highway.

USE OF ROAD USER BENEFIT RATIO

Cost benefit ratios are used to appraise the soundness of a proposed highway investment or to aid in the selection of an alternate location or design.

In using a ratio to appraise a proposed project, a ratio of less than unity indicates a poor investment; that is, the benefits which are expected to be derived by the highway users are less than the funds to be invested in the highway. However, because of the general deficiency of highway construction funds, any proposed project normally considered for construction is likely to show a ratio of considerably more than unity. High-priority projects usually have ratios of from 3 or 4 to 10 or more.

In using the cost benefit ratio procedure for the selection of an alternate location or design, each alternate is normally compared to the basic, or existing, condition with the same total volume of traffic used in all cases. The preferred alternate, as indicated by this analysis, is the one for which the cost benefit ratio is the highest. Where several major alternates are under study, usually a second analysis should be made, using the "preferred" alternate as the base, to determine if an added increment of investment might yield a proportionately larger increase in road user savings on another alternate.

LIMITATIONS IN USE OF PROCEDURE

The procedures which are outlined in the report are intended to provide only one indication, although a very important indication, of the soundness of an investment or of the advantages of one location and design alternate over another. Other important factors, many of them intangible and difficult to include in a prescribed formula, can never be ignored.

In many situations, several routes, or section of routes, must be included in the over-all analysis of a proposed project. Since identical total traffic volumes must be assigned to these routes for each alternate proposal, predicted increases in future traffic volumes may present a distorted pattern, in which the traffic assignments may be completely unrealistic, or which may be impossible to predict.

Since arbitrary assignment of values for certain factors must be made in any analysis, there is a constant temptation for the analyst to select values which will favor a preselected project or alternate. Accordingly, complete objectivity may be difficult to achieve.

LIMITATIONS OF THE 1952 REPORT

The information contained in the 1952 report has several recognized limitations.

The cost information, except for the data on the cost of stops, was developed for operations on rural highways. Its use on urban facilities requires adjustments for the various factors for which there is a limited amount of available data.

The unit operating costs were obtained only for passenger cars. The use of passenger car equivalents for various types of commercial vehicles represents an effort to recognize this factor in the analysis, but greater refinement is needed.

Cost information for freeway operation is not completely adequate. It is especially deficient in the operation at interchanges.

Factors affecting the cost of operation are not fully representative of the operational characteristics of modern vehicles.

Unit prices which were used to establish operating costs are in need of adjustment.

PROPOSED ADJUSTMENTS IN NEW ISSUE OF REPORT

Specific changes to reflect the increases in certain unit prices since 1952 are being proposed for a current republication of the report. These changes include the following: (a) gasoline, (b) oil, (c) depreciation, (d) maintenance and repairs, and (e) time.

It was found that gasoline and oil prices have increased appreciably. Depreciation has increased 50 percent, in the same proportion as the prices of new cars. Maintenance and repair costs also have increased by 50 percent.

The value of time spent in travel was taken to be $1.35 per hr in 1952. It is proposed to increase this amount to $1.55 per hr, in the same ratio as the increase in the cost of living index, approximately 14 percent.

These proposed changes increase the cost of operation approximately 20 percent, in a typical analysis.

Although the proposed changes could be made by the analyst, within the framework of the existing cost tables, it is believed that adjustments in the printed tables will lead to more uniformity in the work. The proposed changes are intended only as an interim arrangement, until a completely revised and expanded report can be prepared. A large amount of research is under way, from which it is hoped much new information will be obtained, not only to introduce new and more accurate operational data and cost information, but to provide a more comprehensive approach to the over-all problem of economic analyses. With more expensive projects and more complex problems facing the highway engineer every year, this new information is urgently needed.

Discussion

Burch. — In the practical adaptation of the warning Mr. Walker gave that the same quantity of traffic should be assigned in each case, suppose we consider a quite usual situation: a community in which an alternate M would be located fairly close in on the one hand, and another alternate N which would be located somewhat further out on the other.

Because of the local generation, you will get more traffic on M than you would on N. There is no way to avoid it. Now, then, would you assign the same quantity of traffic to these two alternate locations?

Walker. — You would have to assign some of it back to the basic or present route. You may have a total volume of 10,000 from point A to point B located on either side of the community. On a bypass there might be 8,000 and 2,000 would continue on the present route. In your case, you might have 9,000 on route M and 1,000 on route N.

Burch. — Then you are assigning different values to these two routes, yet I believe your statement was to be careful that you assigned the same traffic.

Walker. — It is the total corridor traffic that must be the same.

Burch. — Between points A and B plus your generation which occurs on route M which does not occur on route N?

Walker. — That is one of the "limitations" pointed out. The concept doesn't provide for any generation. It assumes that all traffic that wants to go from A to B before a by-pass is built is going to get there, regardless.

Burch. — Are you concerned in comparison only with the through traffic?

Walker. — You may still have a lot of traffic in addition to the assumed 10,000 — there is still a lot of additional local traffic, but you do not include that in the analysis.

Burch. — The traffic to be included could be limited then to through traffic alone?

Walker. — Yes.

Rothrock. — We have problems like that, in which we have more traffic along the route between A and B than the through traffic alone using the corridor, and which would use the M alternate. This route would generate more traffic, and such traffic should be included in the analysis because it is benefited by a reduction in travel distance. The traffic is that which has its origin and/or destination between A and B and is probably benefited by construction of a new route such as M.

Walker. — It would benefit through relief of congestion on the existing route.

Rothrock. — The generated traffic gets on route M somewhere in the middle of the route between points A and B.

Walker. — Would that traffic currently exist? You refer to it as generated, so I assume that this traffic would not exist if the new road were not built. Is that so?

Rothrock. — It is now using the present highway.

Lochner. — Then it is not generated. It is diverted.

Moskowitz. — I think that what is troubling Mr. Burch is the word "assigned" which crept in. Walker didn't mean "assign"; he meant that you compute the cost of the total amount of travel regardless of which alternate you build.

Burch. — I see. It is cost to the the traffic in toto.

Moskowitz. — The cost to all the traffic traveling between your universe of X and Y by routes A, B, C, D, E, F, G, etc. That is what makes it difficult. We may run into 10 or 12 thousand travelers that we have to account for, all in all. It is not just the assigned traffic on a specific route.

Newcomb. — Mr. Walker, may I raise a basic question as to a reasonable approach? As economists we tend to think that the cheaper the productive process the more goods we produced. When we cut the cost of printing, we can produce a lot more newspapers, a lot more books. With the same input, we get a lot more output, because there is less friction and time loss.

With an efficient transportation system you are going to have more traffic at the same total cost. You cannot assume in a growing economy, that you are going to have the same amount of traffic on an inefficient system that you would have on an efficient system. It seems to me you are destroying your concept when you assume that without any changes and with narrow routes and with a lot of intersections, there are going to be just as many people going from A to B, and as happy and as productive when they get there, as there would be if we had an efficient system with improved routes, and with people getting there eager to work.

The two systems are totally different and the products including good transportation are going to be quite different.

Walker. — I think you are agreeing with me rather than asking me to agree with you. I believe that is substantially what I have tried to say. It is a little bit unrealistic to assume that all the traffic that would go from A to B if route N were constructed, would also find its way from A to B if route N were not constructed. However, that is the way the procedure is set up in the "informational report," and I have been saying that that is a limitation — a limitation because it does not recognize the fact of new traffic. That is to say, "generated traffic."

Moskowitz. — There may be a case for saying that it is valid to assume that all the travel will take place, regardless of whether there is room for it or not. This gives a base to measure against as to how much benefit we are providing traffic in reducing frictions and time by improvements. It is hypothetical. If we do not make the improvement, new travel will not take place, but may we assume for the purpose of considering how much good will be done that it would take place anyway?

Newcomb. — You are understating the case by this assumption.

Moskowitz. — I was afraid I would be accused of overstating the case.

Newcomb. — No, if you make improvements you are going to get new traffic. If you do not improve, then the economy becomes stagnant. You have premised that the economy doesn't become stagnant due to inefficient routes when it does. But with improvement you have enabled the economy to grow, and in the economic analysis have not given yourself credit for enabling it to grow.

Moskowitz. — Well, there is good logic for justification for improvement. California, however, does not use this economic analysis for deciding whether or not to do something. The only thing we use it for is to decide which of several alternate things to do.

Blensly. —May I say that it seems to me, as I reflect on the discussion in Session One, that if we are only considering the relative benefits of all possible alternates we do not have any problem, because we have already decided to improve the existing, or at least do something that we have decided is justified, and in analyzing all of the alternate possibilities we will be enabled to make the best choice, and thus solve our problem.

Walker. — I might say that that is the primary intent of this informational guide. It is to enable you to select the best from several alternates. It is not recommended — although it can be used for that purpose — that it be used for setting priority ratings on highways, in different areas of the state, for example.

Zettel. — I agree with Blensly that in considering all of the alternates, the most unrealistic is that you are going to do nothing. But I think sometimes we tend to underestimate on the cost of our present facilities if they are not improved.

For example, we were faced with the problem of a horseback evaluation of the proposed California freeway system. We compared the costs and benefits deriving from adding this system against the costs and benefits of not having it. I think it was suggested that the cost of the existing facility is nothing. Of course it is quite ridiculous to assume that. Either we would do a great deal of some kind of construction on the existing system, which would be a cost; or the benefits would appear to be so much greater if we did nothing, that we might do nothing with a resulting great economic stagnation.

Walker. — Of course, one alternate would be to improve the existing highway.

Zettel. — Yes, some kind of an interim improvement, rather than the alternate of not improving at all, which would be an unrealistic thing in a growing economy.

Walker. — I am not sure how far afield we are by assuming that traffic which would use an improved system is the same that would use it if it were not improved.

Grant. — Newcomb's question had to do with generated traffic. That is new traffic that might not exist with one alternate, but would with another alternate. This is a "toughy" in these economic studies. The "green book" has a line on this. The problem treated arises in relation to navigation — generated navigation traffic — and the proposed navigation improvement. What they propose, in effect is, "Well, as far as assigning a benefit is concerned, let's split the difference, let's say that the advantages to this new navigation traffic, that would not move without the navigation improvement, and will move with it, are not, of course, the full savings in navigation costs; they are half the savings."

Now some such point of view might be appropriate, with some modifications, in the highway problem, with regard to generated traffic. It is not quite parallel, but it is similar.

Hennes. — Mr. Walker mentioned the increase in vehicle costs as a result of the increase in the gas tax in his remarks. Now, as to decrease in costs as a result of improved facilities, I am a little bit uncomfortable about suggesting the place of the savings, and the operating cost due to the savings in the gas tax portion of the gasoline due to highway improvement.

In the short run, there is no question about its being true that the individual driver does save gas tax resulting from a decrease in use of gas on improved facilities. In the long run, however, the sum total of all these saving is zero, because if we improve the entire road system of the country, we would of course have cut down operating costs, and certainly that part of the savings which is not gas tax charges would be saved. Yet, the total cost of highway work might remain the same (in any event it would unlikely decrease directly with operating costs), and if the cost were paid by gas taxes, we would have to raise the gas tax (on a decreased use in gas) to recover the same amount of money. In the long run, there would be no saving to the vehicle operator, due to the fact that on the gas he did not consume because of highway improvement there is still a bill for that improvement that must be paid eventually.

Walker. — I would agree with you. I think that there are two sides to the argument of how to handle gas taxes in the analysis and I believe you come out at the same place, substantially, by either including the gas tax or excluding it.

We decided that since the earlier "Informational Report" included the tax in the price of the gasoline, it should be included again, but I think our conclusion was that it would not make any substantial difference in the final outcome whether it was included or not.

Hennes. — It would make a difference in the benefit-cost ratio of specific improvements in contradistinction to an over-all economic effect?

Walker. — I believe in comparing alternates, at least, wouldn't it erase itself?