APPLICATION OF DRIVER BEHAVIOR AND VEHICLE PERFORMANCE STUDIES

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SYNOPSIS

Studies of driver behavior and vehicle performance have been in progress for the last three years During this time partial analyses have been completed and the results have been applied in the solution of a wide variety of problems regarding vehicular movement Widening and other improvement programs, design standards and prospective legislative regulations all have had the benefit of results and procedures developed in the analyses thus far completed As the work continues and more nearly complete data become available, the scope of their application will be broadened. With an intimate knowledge of the basic laws of traffic behavior nearly any problem of traffic movement can be solved.

Design for the future must be based on driving practice At present, it is found, vehicles generally fall far short of their potential or desirable performance when in the hands of our average drivers

Numerous indications now point to substantial changes in future highway policies Attention after the cessation of our defense effort will be directed to the more costly jobs of providing effective means of travel into, through and around our cities In the design of such projects the idiosyncrasies of the individual drivers must be carefully evaluated, and their effects incorporated into the finished facility.

Effective use of highways demands collaboration between the highway, police and motor vehicle officials These officials, now cooperating in the solution of our defense traffic problems, will find that their collaboration in the post-war period is even more essential than during the emergency

The papers in the Symposium on Driving Practice report the results of a number of phases of comprehensive studies of driver behavior and vehicle performance sponsored and largely conducted by the Public Roads Administration. Intensive field studies, undertaken in cooperation with a number of State highway, motor vehicle and police departments, occupied roughly two years, 1939 and 1940. Analysis, begun concurrently with the field work, has received more concentrated attention during the past year, with major attention being devoted to the interpretation of the results. Much remains to be analyzed and interpreted in our own office and a number of States are still carrying on independent analyses of similar data obtained from our cooperative efforts. The findings reported at this meeting represent the results of the more obvious approaches to the problem, and those for which the need has been the most immediate. As the analysis continues and as its scope is broadened, a more nearly complete and much more refined picture will result.

Effort has been made in the analysis procedure initially to obtain those figures and relations that find most immediate application in design problems and in construction programs. The justification of this course is found in the many uses of the methods developed and of the results obtained from these studies in assisting in the solution of highway planning problems.

Typical applications that have been made by, or have come to the attention of, the Public Roads Administration reveal the breadth and utility of the results that have already been obtained and reported. Other applications have been made of information abstracted from partially complete analyses in response to specific requests.

One of the simplest and most direct of these applications was the analysis of transverse positioning on bridges to assist in the establishment of standards for bridge widths on the strategic network. Transverse placement data give promise of providing some of the most valuable results of these studies.

Figures obtained and procedures developed in the analysis of the passing practice and highway capacity studies have seen a wide usage. A number of States now regularly tabulate and interpret the data obtained at automatic traffic counters, and other traffic-count stations, to provide the basis of priority for widening beyond two lanes, or in developing long-range improvement programs. In general they follow the procedures developed from these studies, and frequently employ relations presented in highway planning survey memoranda or at previous meetings of this Board. Notable among these States are Ohio, Minnesota, Utah, Oklahoma and Michigan.

Basic relations between vehicle speeds and spacings with varying volumes of commercial traffic, and under various alinement conditions have been used in estimating the likelihood of congestion in tunnels and on bridges. This use has assumed added importance during the defense effort These same relations were invaluable in determining standards of surface widths used in the report "Toll Roads and Free Roads."

The more fundamental figures developed in the grade ability studies have frequently been employed in answering questions regarding highway design and traffic regulation. A grade-ability regulation proposed by one State was shown to be wholly impractical and impossible of enforcement, and accordingly was dropped from further consideration. Traffic regulations proposed for certain national parks were critically reviewed and their effects evaluated by reference to these basic figures. More recently these same figures were used in determining the most economical gradient for trucks hauling large quantities of ore.

Most of these uses have been straightforward applications of the more obvious relations developed in the studies Generally they apply to localized problems, the solutions of which were easily reached from the results of a single phase, without the necessity of correlating the findings of two or more phases.

But such applications represent a very limited appreciation of the scope and possibilities of the data developed in this work Wider use of the results undoubtedly will follow a wider dissemination of the material and the completion of further analysis. The more use that is made of figures of this kind by any analyst, the more it becomes apparent that proper correlation of the basic values of the several phases will provide the answer to nearly any question regarding vehicular movement.

One of the most intriguing aspects of this research is the marked difference between the potential abilities and the actual practices, both of vehicles and of drivers. Perhaps the most striking example is the fact that the performances of trucks selected at random and observed without the drivers' knowledge was, on the average, but 70 percent of the potential ability as determined in the controlled tests of similar vehicles. Caused in part, no doubt, by faulty maintenance, but in larger part by lack of skill or alertness on the part of the driver, this 30-percent reduction in performance level represents an almost confiscatory tax on the assets of any administrator attempting to provide for reasonable highway performance on a limited budget.

The break-down of the passing practice data reveals similar below-par performance of the machine or driver, or perhaps both. Here it is seen that valuable time and space are lost in passing maneuvers when the rates of acceleration of

vehicles in use do not even approximate their potentialities. Drivers who, on the average, exhibit in the laboratory reasonable powers of perception and reaction, seem to suffer startling depreciation of these senses when exposed to highway traffic. Again the highway engineer's budget is eaten into in order to provide extra sight distance to overcome this lack of ability or interest on the part of the road user. So long as these conditions exist—and their correction, even if possible, will be long extended—they must be recognized and their effects carefully evaluated in the solution of our highway problems.

Differences between actual practice and potential ability are not all on the debit side of the ledger, however. Fortunately, for many reasons, very few drivers of passenger cars wish to take full advantage of the speed potentials of their vehicles, although recent experience leads us to revise some of our previously-held ideas regarding the ability of the motor vehicle and its accessory equipment to sustain top-speed performance for indefinite periods This very general desire to travel at speeds well below that permitted by the road and vehicle places a substantial item on the credit side of the ledger, if the highway designer takes advantage of it.

In the design of any highway the various elements must be carefully integrated in a balanced plan. It is generally accepted that the design must provide for the safe travel of the highest speed drivers, excluding the reckless minority, who will be expected to use the facility. Whether the road be heavily traveled or only infrequently used, once the design speed is adopted, factors of vertical and horizontal alinement and superelevation must be properly correlated to provide a surface over which an individual vehicle may move with safety A uniform speed should be possible on tangent and curve, and there must always be a sufficient sight distance to permit the driver to stop within the capacity of his vehicle's brakes, allowing necessary factors for below-par performance of vehicle and driver. All these apply to individual vehicles, regardless of what other traffic may be using the highway.

Passing sight distances, however, in this balanced design need not be, and for proper economy of public funds, cannot be based on the potentials of the faster few. Instead they must be based on the actual practices of all drivers. In short, passing sight distance is a function of traffic, of the relation between the speeds and spacings of all vehicles on the road, and not of the individual vehicles for which the other elements must be designed. Only by analysis of the anticipated traffic, of the frequency of use of the road and of the distribution of actually-desired speeds, can the most effective policy of providing passing sight distance be evolved. Only the traffic itself can determine what proportion of any route must permit passing, and what optimum minimum passing sight distances must be employed. It is perhaps in this particular application that the results of the passing practice analyses, correlated with those of widespread speed distribution studies, can be most effectively used. Compared to the answer to these questions, the physical measurements of time and space involved in passing maneuvers assume secondary importance.

A properly designed highway must, through its anticipated life, effectively meet the demands of traffic. There is thus required an accurate forecast of what driving practice and vehicle performance may be expected some given number of years beyond the date of construction. Such forecasts for a given route, were sufficient historical trend data available, would not be difficult. But long-term trends of speeds and performances are not now generally available, nor, because of the expense of such studies, is it likely that they will be available in the future

except on the most important routes Ability to forecast future performance, therefore, requires an ability to work in a three-dimensional field. Not only must trends be projected into the future; these same trends must be translated laterally to permit the prediction of the present and future experience on routes for which direct information is unavailable.

Based on careful analyses of speed-distribution data collected in these studies, and on past experience with respect to vehicle performance, certain speculation regarding the methods of forecasting future driving practices is warranted.

Traffic is composed of commercial and passenger vehicles The performance of commercial vehicles has steadily improved, but with it has come increased loading to offset to a large degree the benefit of the added power. Present trends in regulation make it appear that in the future added power will be more than offset by increased loads. Since the performance of commercial vehicles, particularly on grades, is closely related to their potential abilities, trends in speed may reasonably be estimated from trends in vehicle design and in regulatory practices.

Passenger cars present a far different picture. Up to perhaps ten or twelve years ago the top speed of a large percentage of the vehicles was relatively low, and it is most likely that many drivers were influenced in their choice of speed by the known top speeds of their vehicles. Today, however, few drivers attempt to attain the potential speed of which their vehicles are capable, and in many cases very probably do not even know what the top speeds are. Few drive over our more modern roads at the speeds the surfaces permit. Their driving performance must, therefore, be largely dependent on their inherent personal characteristics. Thus the accuracy with which we can forecast future driving practice will depend on the degree to which we can relate driving practice to these personal traits, which may be assumed to change slowly if at all, and to which we can predict the types of drivers who will be likely to use the particular facilities we provide.

Exploratory studies designed to provide data concerning the personal characteristics of various classes of drivers have already been undertaken in conjunction with the Institute of Human Relations at Yale University and with the help of a number of States Although these studies are dormant at present, the initial results are encouraging and plans have been consummated to revive the work on a broader scale next year. There is every evidence that the economic and social background of the driver, his age and driving experience, the length and purpose of his trip and many other personal characteristics have a significant influence on his driving practice Only by a detailed review of these personal characteristics can the wide divergence between potential performance and actual practice be explained. But once the reasons for these divergences are established it will be possible to forecast with confidence what driving practices may be expected on any road at any reasonable future time.

The influence of war is felt in all walks of life The field of highway engineering will not escape its impact. It is one of the highway engineer's responsibilities to turn the inevitable dislocations of normal practices to profitable uses.

Recently enacted legislation provides for participation of the Federal Government to the extent of 75 percent of the cost of projects constructed with defense highway funds designated for use on the strategic network. It further provides that unobligated Federal-aid funds, including future appropriations for the duration of the emergency, may be matched by the States on a 25-75 basis, if used on the strategic network, instead of on the time-honored 50-50 basis.

In an effort to forestall a post-war

deflationary period the Interregional Highway Committee, appointed by the President, is now engaged in formulating general policies, from which detailed plans will be drawn to utilize the quantities of labor and material released from defense activities. Significantly these plans recognize that the greatest problems of the immediate future confronting the highway engineer are the provision of more effective means of leading traffic into, through, and around our cities.

More and more States, analyzing the results of the highway planning surveys, are reaching the conclusion that our highway systems are becoming too far extended. With the completion of surfacing of the primary systems the trend has been to assume obligations for more and more lightly-traveled roads. Trends in financing have been away from property taxes toward road-user taxes, with the result that use taxes largely support the State systems The addition of thousands of miles of lightly-traveled roads, that cannot be operated at a profit and must be supported from earnings of the more heavily-traveled routes, means that smaller and still smaller amounts are available for use where the needs are the greatest. It is becoming recognized that this trend must be reversed, and that a larger share of our funds must be apportioned to the solution of the problems of approach to our cities, to make the rural highway systems more available to the millions of potential travelers now stifled by overburdened, under-designed access facilities.

As the need for war transportation grows, highway transportation assumes a constantly increasing importance. Trends toward the liberalization of weight limitations in many sections of the country will undoubtedly be accelerated by these considerations.

The effect of the war production program on future transportation cannot be visualized. Certainly the productive capacity of our expanding aircraft industry will not be abandoned. Its effect on long-distance travel may be of utmost significance. But the airplane does not yet give promise of solving our commuter problems, of moving people from urban centers to nearby recreation areas, or of providing transportation to horse races or football games.

All these trends, when their influences are added one upon the other, presage changes in the direction of our highway construction policies that may be almost revolutionary in character. The significance to the highway engineer lies in the fact that his interest will be focused on metropolitan problems, that he inevitably will be drawn into the field of construction for heavy-volume movements heretofore seldom encountered. It means that he will be designing and constructing facilities that will appear grandiose by comparison with past achievements.

Such construction will demand the utmost in economy. Design must be ample to meet the demands of the anticipated traffic, but over-design cannot be tolerated. Here the matter of operations will take a place of equal importance with matters of design and construction, a fact which leads us directly back to these studies of driving practice. No operations plan can be effectively drawn without a thorough knowledge of the basic factors in the behavior of the drivers.

The operations engineer, whatever his title or designation, deals with units of time and space. Not only must he operate to the best advantage the completed facilities; he must also collaborate in their design to insure that the principles of his field are incorporated into the design exactly as the materials engineer must approve the ingredients that are incorporated into the physical structure. He must be able to forecast the factors of volume, of speed, and of freedom of movement that will be required for the particular facility. Such ability can come only from an intimate knowledge of the desires and

characteristics of the multitude of drivers who will utilize the completed highway.

In his operations job he must also collaborate with officials of other departments. The motor vehicle administrator authorizes drivers and vehicles to use the highway; certain few he deprives of this privilege because of their failure to observe safe practices or for sundry other reasons. The head of the police or enforcement agency likewise controls the drivers, but he exercises more localized and more immediate measures to insure reasonable compliance with traffic laws and design standards.

These three officials have within their authority the opportunity, through joint action, to improve the efficiency of highway operation. By their joint action they determine how effectively our highways are used. The police and motor vehicle officials can profit by the knowledge they can gain from the highway operations engineer regarding the actual practices of various classes of drivers. They can reciprocate by doing all in their power through education and enforcement to narrow the gap between actual and desirable driving practices. The result will be better designed, more efficient highways over which better regulated drivers may move with reduced but improved control

The impact of war has not thrown us off balance. Its lessons are being heeded. Already there are emerging the beginnings of collaboration between these three officials. The Highway Traffic Advisory Committees to the War Department, organized in all States, are composed of these very officials. It is confidently expected that the cooperative approach to the problems of defense traffic movement, and the benefits resulting from their close collaboration will provide the foundation for continued and increasingly effective cooperation after the emergency passes. The period immediately following our successful war effort will be one of great importance to our highway, regulatory and enforcement authorities. They must be prepared for it.

DISCUSSION ON DRIVER BEHAVIOR AND VEHICLE PERFORMANCE

PROF. J. TRUEMAN THOMPSON, *The Johns Hopkins University, Presiding:* It seems to me that one of the needs which has stood out in this symposium, among many, is apparent in the curve which showed the depreciation of hill climbing ability of trucks. It shows the climbing ability of vehicles tested under ideal conditions by well trained truck drivers who were instructed to do certain things. Even so, it is evident that their driving suffers from lack of selectivity of gear ratios and flexibility in gear shifting. Vehicles which are in current use on the highway must suffer an even greater extent which makes one wonder whether the automatic gear shift, which is now becoming so prevalent in the passenger car, might not be applied to commercial vehicles to offset these disadvantages. I should like to ask Mr. Schamehorn if he has anything to say on that subject.

MR. A. J SCHAMEHORN, *General Motors Corporation:* There is not much that I can say about the application of the hydraulic transmission to commercial vehicles at the moment A lot of work is being done, particularly in connection with tanks, and once that problem is solved it should be quite simple.

PROFESSOR THOMPSON. Just from casual observation it is apparent to anyone who stands alongside a highway over which heavy vehicles are moving, that very frequently drivers do not use the gears which are most favorable under the circumstances of the moment, and do not shift when they should. This is possibly due in part to lack of proper instruction

or experience. It seems to me that this problem of making gear shifting automatic is a challenge which the motor vehicle manufacturers must accept, and I believe eventually they will not only perfect automatic gear shifting for passenger cars but for commercial vehicles as well.

I should like also to direct attention to the remarks made by Mr Holmes in the last paper concerning the plans for the study of driver behavior. It is planned to consider things like marital status, age, employment, age of car, etc.

Recently I had occasion to observe that there is, in the educational field, a very great difference of opinion as to which of two major schools of thought the psychology departments should adhere. Hitherto psychologists have largely believed that human action is something almost completely removed from the physiological. Now there is a strong school of thought which believes that almost all human behavior is conditioned and greatly influenced by physical phenomena and physiological conditions. I am wondering if it would be possible in these forthcoming studies to give some thought to the desirability of the physical condition of drivers. Some information can be had from the Commissioners of Motor Vehicles, it does seem to me that an attempt should be made to relate the physiological as well as the psychological condition of the driver in studying influences of various kinds on his behavior.