National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

DIGEST 23 - DECEMBER 1970

Running Costs of Motor Vehicles as Affected by Road Design and Traffic

An NCHRP staff digest of the essential findings from the final reports on NCHRP Project 2-5A, "Running Cost of Motor Vehicles as Affected by Highway Design and Traffic," and Project 2-7, "Road User Costs in Urban Areas," by Paul J. Claffey, Transportation and Traffic Consultant, Potsdam, N. Y.

THE PROBLEM AND ITS SOLUTION

The running costs of passenger cars and trucks and the manner in which these costs are affected by road design and traffic conditions in both urban and rural areas were the subject of a comprehensive research investigation completed during the period from 1964 to 1969. The research consisted principally of field experimental measurements conducted in six states on road sections selected for their particular design and/or traffic flow patterns. Additional data were obtained by questionnaire-type inquiries to agencies having information on road user costs and by reference to the results of motor vehicle running cost studies carried out by others.

Motor vehicle running costs that were studied consisted of all those items of automobile and truck expense incurred as a result of vehicle operation. They were the costs for fuel consumption, tire wear, oil consumption, and the portions of maintenance, depreciation, and accident costs that are related to vehicle use. In this research, there were seven highway features studied that affect motor vehicle costs: Profile, alignment, surface, intersections at grade, access-exit points, road and shoulder widths, and length.

Information on the effect of road design and traffic conditions on running costs was secured by direct experiment, analyses of user cost records, personal and written inquiries to those likely to have particular information in the area of user costs, and reviews of motor vehicle cost data developed in studies conducted by others. Direct experiments consisted of field measurements of elements of running cost for actual road and traffic conditions.

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Fuel consumption measurements were recorded for each of several representative types of vehicles operating on each of several road test sections. Fuel consumption was measured for each vehicle with the vehicle stationary and the engine idling. Fuel measurements were made for five different passenger car models, five types of trucks (including a diesel-fueled truck), and a bus. The passenger car test vehicles represented the full range of cars from the small foreign import to the large Chrysler New Yorker. The trucks ranged from a pickup truck to a 2-S2 tractor semi-trailer truck combination. All fuel consumption measurements were made with the electronic fuelmeter, a precise fuelmeter specifically developed for the operating cost studies.

Tire wear measurements were made for a passenger car and for a two-axle six-tire truck. The test vehicles were operated on selected test roads at each of several running speeds and for certain speed change patterns. Tire wear was established by noting the loss in tire weight occurring during a test operation. Tire wear values per unit of travel were developed at each of several speeds for operation on each of several surface types and degrees of curvature. Four roadway surface types were used: good concrete, good asphalt, typical asphalt, and dry well-packed gravel.

FINDINGS

Development of the Fuelmeter and Use of Radioisotopes for Tire Wear Measurement. - An entirely new fuelmeter specifically designed for motor vehicle fuel consumption research was successfully developed and tested, first as a prototype model and later as a production model. Also included in the research were the development and testing of a technique for using a radioisotope to measure tire wear. Radioisotopes were found to be unsatisfactory for this purpose because of changes that occur in tire surface material as wear progresses.

Fuel Consumption and Tire Wear Measurement. - Fuel consumption and tire wear were measured for a wide variety of vehicle types, road designs, traffic volumes, and operating speeds (speed changes). Families of curves of fuel consumption and tire wear developed from test measurements for 11 individual test vehicles for various road and traffic conditions are given in the agency's report. The tables and graphs of findings show average fuel consumption and tire wear values for composite or representative vehicles in each of four categories: (1) passenger cars, (2) pickup trucks, (3) two-axle six-tire trucks, and (4) tractor semi-trailer truck combinations.

Maintenance Costs. - The average total maintenance cost for those vehicle parts affected by travel (engine, transmission, wheels, steering, and suspension, for example) is 1.15 cents per mile for passenger cars and 1.42 cents per mile for pickup trucks. In addition, it costs 0.12 cents per stop cycle for passenger car stops from 25-mph running speeds.

Oil Consumption Rates. - In this study, it was determined that on dust-free roads with free-flowing traffic oil consumption is 0.70, 0.60, and 2.50 quarts per 1,000 miles for the composite passenger car, the pickup truck, and the two-axle six-tire truck, respectively. Oil consumed by motor vehicles as a result of burning, evaporation, and/or leakage is also presented in the agency's report.

Depreciation. - Depreciation as a motor vehicle running cost was investigated. The principal finding is that as highways improve vehicles travel farther and faster, resulting in greater lifetime mileage and lower depreciation cost per mile. It was not practicable, however, to develop numerical relationships between particular types of highway improvements and the corresponding effects on unit depreciation cost.

Accident Costs. - An analytical study of motor vehicle accident cost as a user operating cost based on accident data was carried out. Passenger car accident cost per million miles of travel of all vehicles (cars, trucks, and buses) is $1,673 on rural non-freeway routes, $4,287 on urban non-freeway routes, $734 on rural freeways and $1,430 on urban freeways (1958 dollars).

Fuel Corrections for Environmental Factors. - Corrections for the effect of air temperature and elevation above sea level on motor vehicle fuel consumption are presented in the agency's report.

Graphs of Fuel Consumption Rates and Tire Cost. - Several simplified graphs, each showing rates of vehicle fuel consumption (or tire cost) as affected by various combinations of gradients, curves, road surfaces, and speed changes, are provided for convenience in the use of study results. Graphs of fuel consumption rates are given for passenger cars, pickup trucks, two-axle six-tire trucks, and tractor semi-trailer truck combinations. Similarly, graphs of tire cost are given for passenger cars and pickup trucks.

APPLICATIONS

The results of this research are presented in a series of graphs to facilitate their use. Their application can best be demonstrated by the following typical example that points out the utility of the graphs. Given a section of two-lane paved rural highway on a 4° curve, graded at 4%, with free-flowing traffic having average speeds of 30 mph, 0.5 stops per mile, and three 10-mph slowdown cycles per mile, find the average fuel consumption rate (gpm) for upgrade operation for the composite vehicles presented in Figures 1 and 2. Inspection of Figures 1 and 2 indicates that the fuel consumption for the passenger car would be 0.1 gal per mile, and for the tractor semi-trailer truck 0.8 gal per mile.

Throughout the agency's report, graphs of findings (similar to Figures 1 and 2) are presented for convenience in applying the research results to alternate possibilities of highway location and design. Each graph is designed to provide fuel and tire wear cost for various combinations of road design elements and speed change conditions for a given running speed. Also included are families of curves of fuel consumption and tire wear for the eleven test vehicles used in the study.

In addition, the findings of this study can be used by the American Association of State Highway Officials Committee on Planning and Design Policies to supplement, update, or revise their 1960 Informational Report on "Road User Benefit Analysis for Highway Improvements."

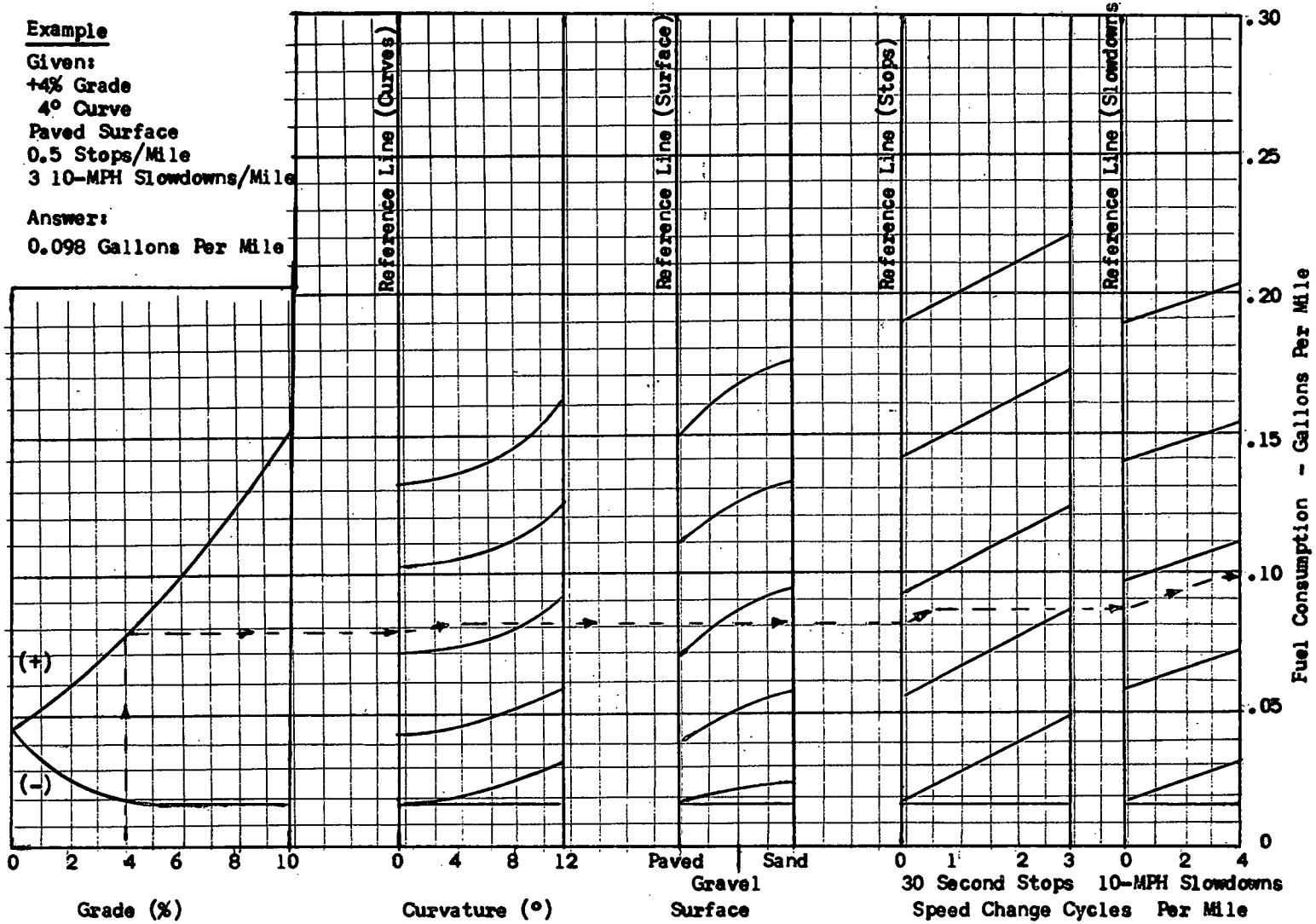

Figure 1 -Automobile Fuel Consumption for Free-Flowing Traffic Volumes - 30-MPH Running Speed.

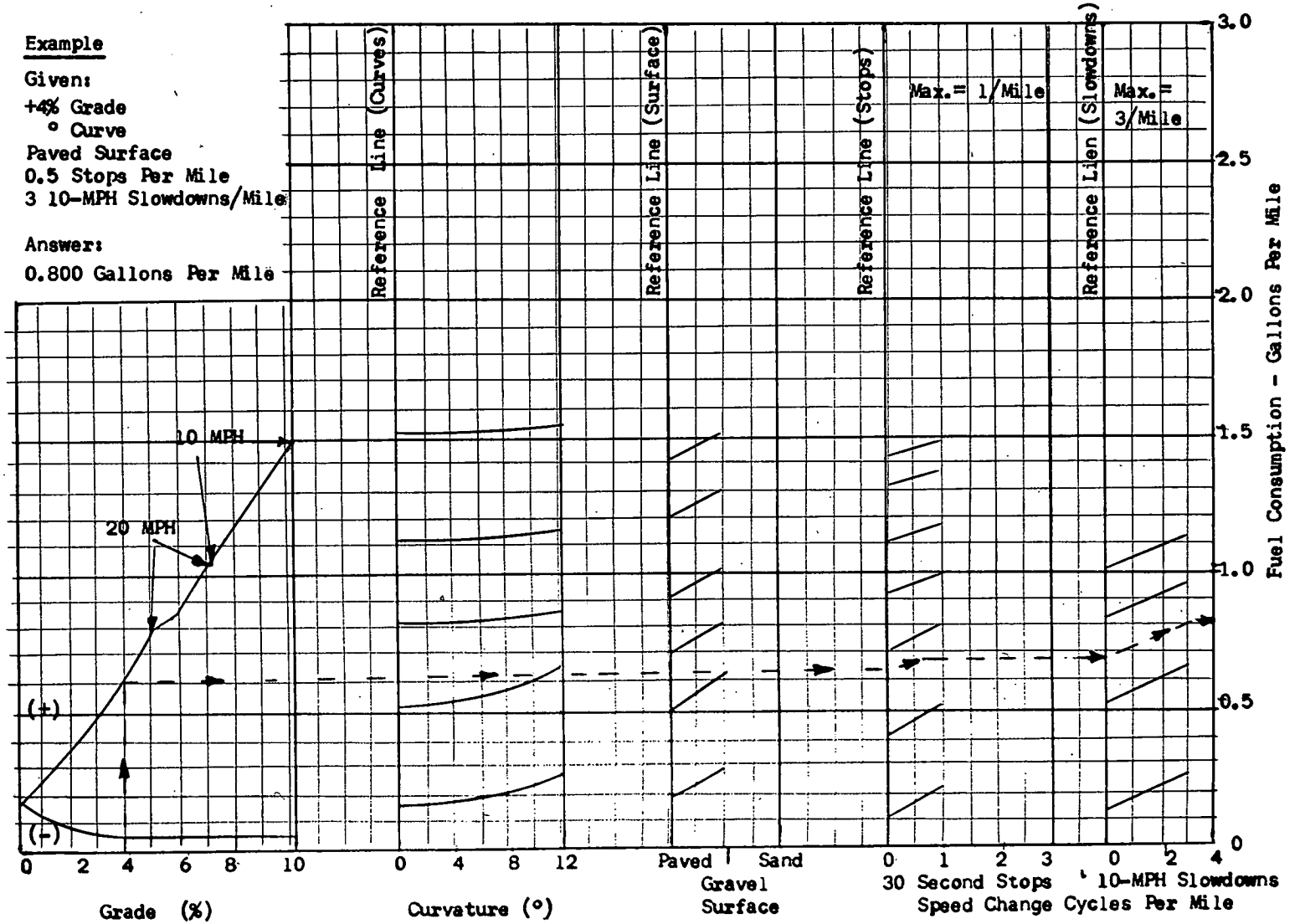

Figure 2 -Tractor Semi-Trailer Fuel Consumption for Free-Flowing Traffic Volumes - 30-MPH Running Speed.

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