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EFFECT OF ROAD SURFACE QUALITY ON THE OPERATING AND MAINTENANCE COSTS OF MOTOR VEHICLES

SUMMARY

When investigating the economical effects inherent to construction and modernization of roads, it is indispensable to know the running costs of the various vehicles using the road. It was realized long ago that the running costs of vehicles being used on better roads are less. Research has, however, not yet arrived at estimating the costs pertinent to the various road surfaces, for the simple reason that it sought the solution of the problem by means of mechanical investigation. The intricate correlation between road and vehicle, however, doesn't allow to evaluate the said costs by way of mechanical methods.

On realizing the complicated nature of the problem, the authors came upon the idea of investigating the relationship between the operating and maintenance cost and the road surface quality on the basis of the costs actually incurred. The expenses in question were investigated for buses and trucks used on road of different types and surfacings.

These investigations have been extended to about 400 vehicles operated by 20 motor transport undertakings. Included into the investigation were only vehicles that complied with the test requirements.

Thus, operating and maintenance costs were determined in the following breakdown: maintenance materials; maintenance wages plus public charges on wages; foreign repair costs; tyre costs; fuel costs; lubricant costs.

The data obtained were plotted against road surface quality in Fig. 1 to 8. From these diagrams the trend of the various cost items on the different roads, as well as that of the total costs listed above can be perceived. The knowledge as regards these costs is indispensable for the economic evaluation of road investments.

1. INTRODUCTION

The economic gain to be derived from modernization of roads or construction of new roads respectively is a widely discussed matter. This question is mostly raised in connection with modernizations as, in general, traffic can be maintained on the old road as well. It rarely occurs that an old road gets in a condition paralysing traffic altogether.

It is a matter of common knowledge that on an up-to-date road traffic is faster, lifetime of the vehicles longer, maintenance costs, risk of accidents are less and so on. Nevertheless, it could not be numerically demonstrated so far when and how the capital invested in modernization is reimbursed.

From the point of view of people's economy the favourable effect of road modernization can be felt in many ways: operating costs of motor vehicle transport diminish, speed of goods transportation increases, traffic becomes more culturated, etc.

Investigations performed hitherto have been greatly hampered by the fact that the numerical trend of one of the most substantial factors, i. e. that of the operating costs of motor vehicles was unknown. Many attempts have been made at the deter-

mination of the same, but all these failed for administrative and economical reasons.

Within the scope of the investigations discussed in the paper a new path for solving the problem has been resorted to. Instead of recording the data of vehicles selected and operated under permanent control, this being a very cumbersome and lengthy procedure, the method applied has been to evaluate the actual data obtained in the near past. Several hundred motor vehicles running for years, but at least for one year on the same route being in the same condition all along were selected. Such vehicles were to be found, first of all, among buses. Some four hundred IKARUS 30, 31, 601, 602, 620, 630, AMG 408 buses and CSEPEL D 350 trucks were selected.

The vehicles were operated by some twenty undertakings. The latter were chosen on the principle that they possibly be of the same technical level and of satisfactory testimonial discipline.

First of all, fleets being run on the plains were considered, since the effect of inclines was to be excluded.

In cooperation with the traffic departments of the undertakings, vehicles were selected the route of which during 1961, the year of investigation, remained unchanged. Out of these vehicles only those were taken into consideration which were running on level roads and possibly on those of the same surface quality. Vehicles at which the previous conditions prevailed, but the route thereof had been modernized in the test year, were excluded from the investigation.

The next step consisted in investigating the cost items. First, the costs depending on the road surface quality, thus variable costs from the point of investigation were separated from the invariable costs, i. e. from those being independent of the road surface quality.

This discrimination is necessary in order to determine the variable costs in the function of road surface quality. The various kinds of costs were investigated according to this classification. This investigation yields a picture as regards the composition of the costs incurred, the structure of prime costs, the material and labour requirements of transport, and relative to the vehicle, reflecting its operation conditions. Naturally, according to the costs being composed of one or more kinds of costs, they can be considered as

simple (elementary) costs or
combined (complex) costs.

The group of simple costs covers such expenditures as cannot be further specified, like the costs of energy, wages, duties etc.

The complex costs can be distributed, being composed of several elementary items. This is, however, encountered by practical difficulties (i. e. incidental costs which can be subdivided into costs of material, labour etc.). The overhead costs of traffic, operation and administration making out a considerable part of the transportation costs, fall under this heading.

When grouping the costs, the breakdown of each cost into possibly elementary items was aimed at. In determining the complex costs, the principle of including only the costs reacting uniformly to the examined changes was observed.

According to the said principle it seemed practicable to divide the costs into the following groups:

1. Costs directly related to speed changes of the vehicle.
2. Costs related to road surface quality.
3. Relatively invariable costs, more or less independent of both of the former.

The costs incurred with the operation of the selected vehicles were grouped according to being accountable directly or indirectly. In this sense, the costs being directly accountable can, except for amortization, be regarded as dependent on the road condition (road surface quality), while the indirect costs as those independent of the latter, the so-called relatively invariable costs. It should be noted, however, that the indirect costs also vary with the road condition, but this variation, owing to their complexity, is slight and difficult to establish. The costs dependent on road conditions were assembled on the basis of records for the period of January 1 to December 31, 1961, i. e. for one year, under the following headings:

- Maintenance material.
- Maintenance wages.
- Public charges on wages.
- Foreign repair costs.
- Tyre costs.
- Fuel costs.
- Lubricant costs.

(Amortization)

It can be seen from the above that out of the direct costs only direct transport wages were not evaluated.

Beyond this, naturally, the annual mileage necessary for obtaining specific values had to be established as well. First of all, it should be noted that in assembling the costs listed above not a simple summation of the accounted actual amounts was made use of, but the book-keeping data were technically and economically checked, analysed and, if necessary, corrected. This means that the costs assembled in monthly breakdown, if any of them seemed on any account too high or too low, were treated separately, the reasons of discrepancy investigated and if they were due to some reason independent of the road (accident, negligence, improper operation or repair, etc.) the respective items were corrected, or if correction had had caused any uncertainty in the costs, the vehicle concerned was ruled out of evaluation. On this basis the costs of about 400 vehicles were evaluated in the grouping referred to above.

For the vehicles involved in the investigation the surface conditions of the road to which the costs were related had to be established, too. Each route was travelled over by car.

The number of roads pertaining to the 400 vehicles being also high, the number of road measurements had to be restricted and the latter were confined to such roads where the characteristic value of the road surface could not be satisfactorily established by visual inspection and, also, where the vehicle ran on a perfectly uniform road pavement and — regarding the test results — an accurate value had been aimed at. For mixed roads the surface values were calculated by taking weighted arithmetical means, so that each value was weighted by the respective length of route.

The records were tackled and evaluated as presented in the following chapters.

2. DETERMINATION OF MAINTENANCE AND OPERATING COSTS FOR EACH KIND OF COSTS

The annual costs were computed by summing up the costs of each vehicle for the various kinds of costs.

Calculation of costs per month:

$$K_m = \sum_{1}^{31} K_d$$

where K_d = daily expenses, 1 to 31 = number of days of the month.

Calculation of costs per year:

$$K_a = \sum_{1}^{12} K_m$$

where K_a = annual sum of cost factors in Ft;

K_m = monthly sum of cost factors in Ft;

1 to 12 = number of months of the year.

The specific costs were calculated by dividing the annual total sum by the mileage

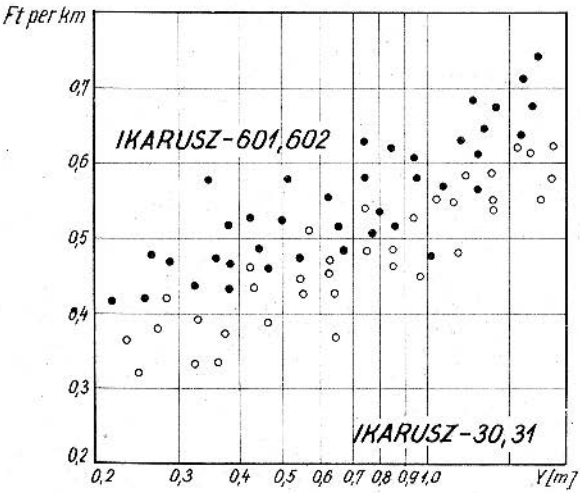

Fig. 1. Fuel costs for different road surface qualities

$$K_{as} = \frac{\sum_{1}^{12} K_m}{\sum_{1}^{12} K}$$

where K_{as} = annual total sum of specific costs per each kind;

K = vehicle mileage per month.

With the above calculations the fuel costs, tyre costs and lubricant costs were established and are shown diagrammatically in terms of road surface quality in the Figs. 1, 2 and 3.

On the abscissae the road roughness values, on the ordinates the specific costs of the vehicle are plotted.

The dots in the diagrams refer to the costs of IKARUSZ 601, 602 buses and the small circles to those of IKARUSZ 30, 31 buses.

Models 601, 602 and 30, 31 were drawn together because as to operation they may be regarded as equivalent.

3. DETERMINATION OF THE TOTAL AMOUNT OF MAINTENANCE COSTS

Maintenance cost factors were evaluated for material, wages and public charges on wages as a total, too.

As to this evaluation it should be emphasized that the trends of the different kinds of costs are not independent of each other. It may occur that the wages increase

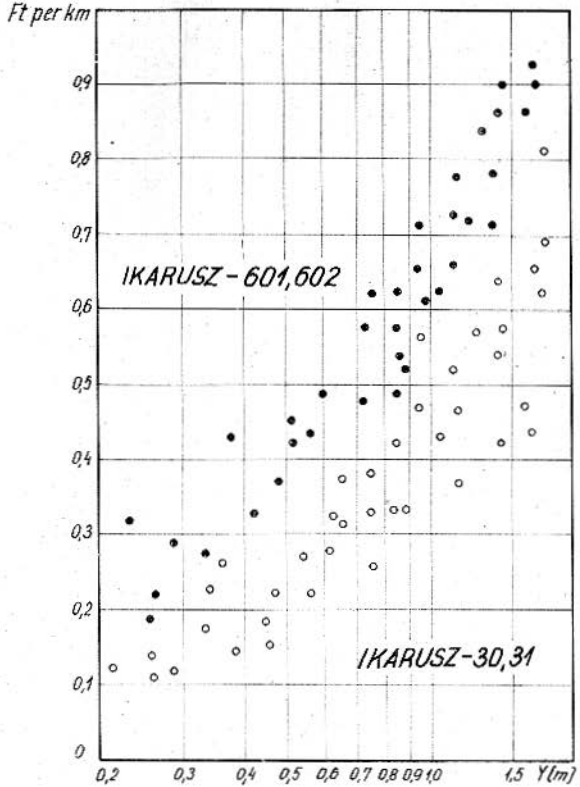

Fig. 2. Tyre costs for different road surface qualities

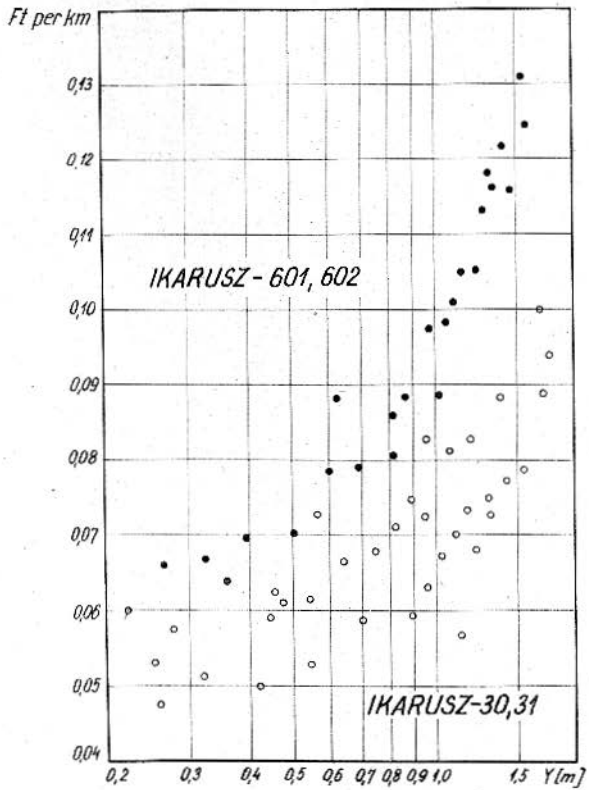

Fig. 3. Lubricant costs for different road surface qualities

with the decrease of material costs for the reason that the undertaking has a restricted cooperation with other companies and made provision for such parts itself which otherwise should have been purchased. Also, other similar relations may be present between the cost factors investigated. For instance, the effect of economy measures may bring savings in material costs and, on the other hand, result in arising of plus bonuses (i. e. more wages). That is the reason why the maintenance costs summed up give a more realistic picture regarding the road conditions when taken separately. Another reason is that in maintenance the transport undertakings make use of new and reconditioned parts. The reconditioned parts figure among the vehicle maintenance costs as material costs, though they may contain considerable labour costs incurred within the undertaking. This is of importance from the aspect of analysis, because the costs of more than one undertaking were taken into consideration and made use of. But in the level of development in part reconditioning there may be differences between the undertakings. Scatter of cost items in the diagrams can be accounted for partly by this circumstance. Namely, the costs of some undertakings were investigated separately and it was found that the scatter of cost itemsis considerably less when taken separately instead of being treated as a whole.

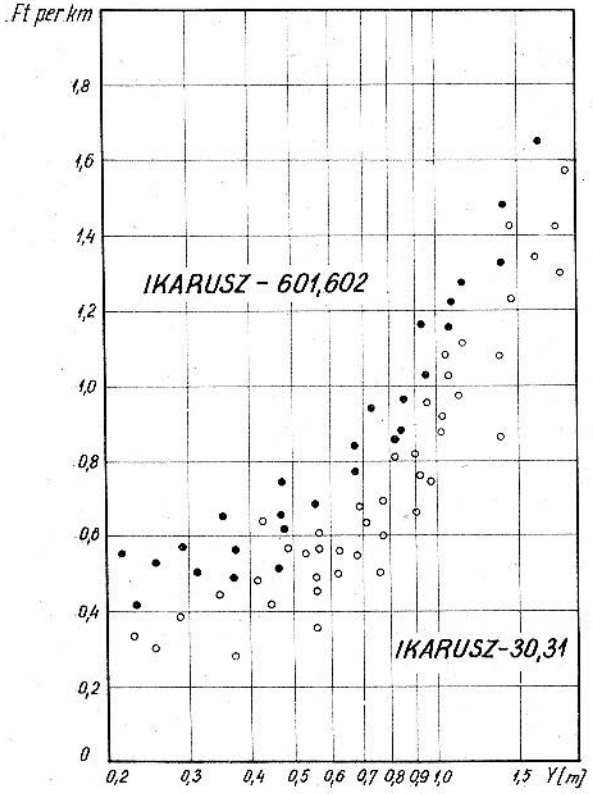

Fig. 4. Maintenance costs for different road surface qualities

3.1 Calculation of summed-up material costs, wages and public charges on wages for the year investigated.

$$K_{am} = \sum_{1}^{12} K_{mma} + \sum_{1}^{12} K_{mwp}$$

where K_{am} = annual sum of maintenance costs (Ft);

K_{mma} = monthly sum of material costs (Ft);

K_{mwp} = monthly sum of wages + public charges (Ft).

3.2 Calculation of specific maintenance costs

$$K_{asm} = \frac{\sum_{1}^{12} K_{mma} + \sum_{1}^{12} K_{mwp}}{\sum_{1}^{12} K}$$

where K_{asm} = annual average of specific maintenance costs (material, wages and public charges on wages) in Forints per km.

The maintenance costs of IKARUSZ 601, 602 and IKARUSZ 30, 31 buses (coaches) drawn together are shown in Fig. 4. The dots refer to types 601, 602 and the small circles to those of 30, 31.

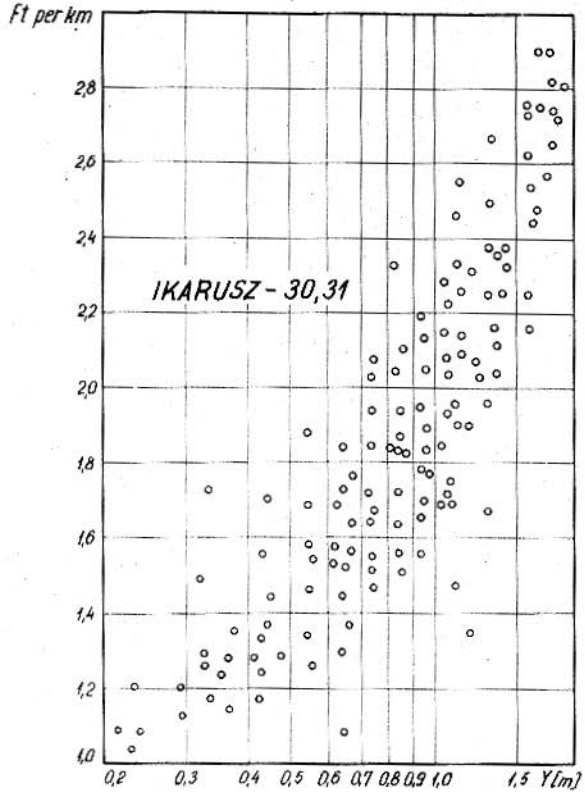

Fig. 5. Variation of direct costs as function of road surface qualities

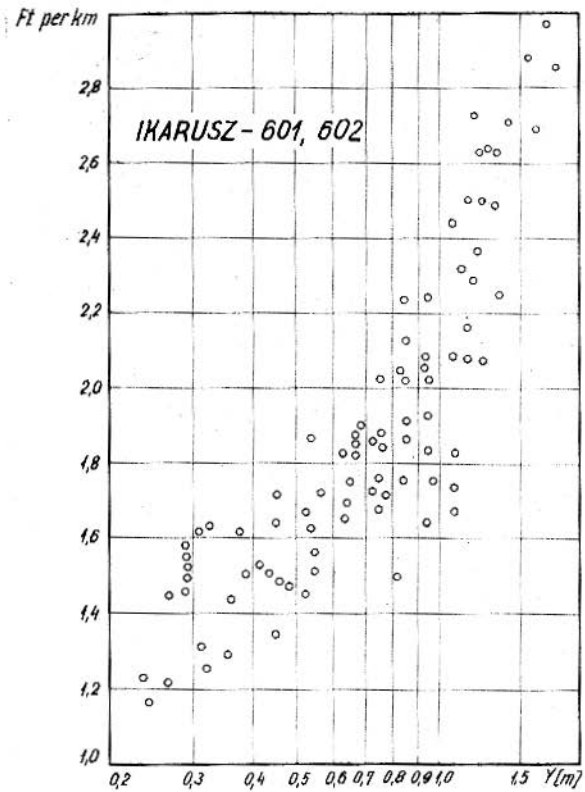

Fig. 6. Variation of direct costs as function of road surface qualities

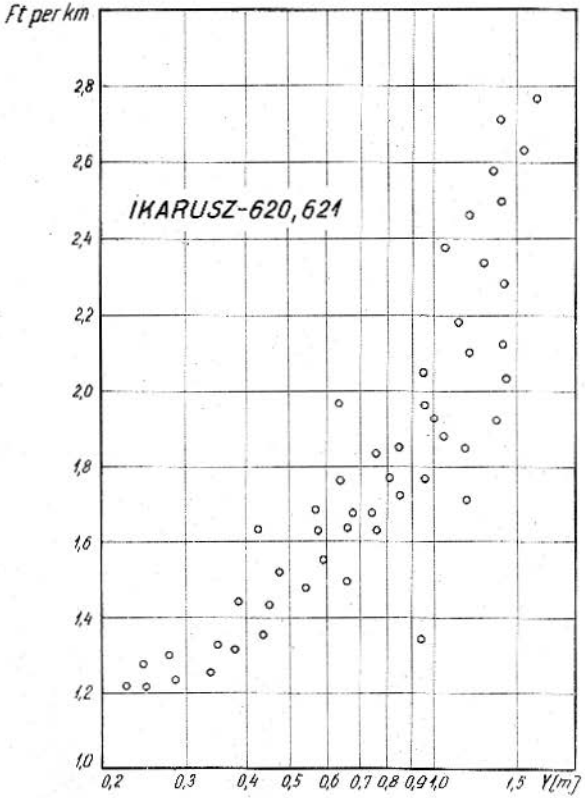

Fig. 7. Variation of direct costs as function of road surface qualities

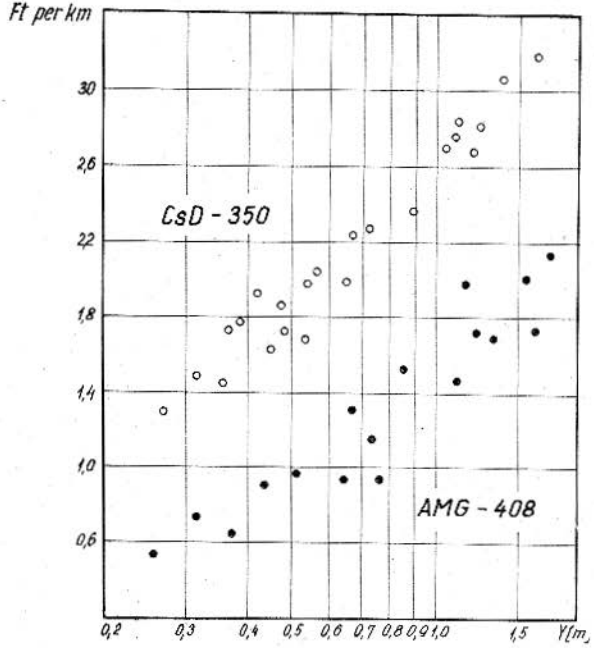

Fig. 8. Direct costs for different road surface qualities

3.3 Calculation of direct (operating and maintenance) *costs.*

Calculation of annual operating and maintenance costs is suggested as follows:

$$K_{aom} = \sum_{1}^{12} K_{mma} + \sum_{1}^{12} K_{mwp} + \sum_{1}^{12} K_{odr} + \sum_{1}^{12} K_t + \sum_{1}^{12} K_f + \sum_{1}^{12} K_l$$

where K_{aom} = annual sum of operating and maintenance costs (Ft);
K_{odr} = monthly sum of out-door repair costs (for repairs not carried out in the undertaking's workshop (Ft);
K_t = monthly sum of tyre costs (Ft);
K_f = monthly sum of fuel costs (Ft);
K_l = monthly sum of lubricant costs (Ft);
K_{mma} and K_{mwp} as above.

Calculation of the specific value of direct costs is suggested by the following formula:

$$K_{asom} = \frac{\sum_{1}^{12} K_{mma} + \sum_{1}^{12} K_{mwp} + \sum_{1}^{12} K_{odr} + \sum_{1}^{12} K_t + \sum_{1}^{12} K_f + \sum_{1}^{12} K_l}{\sum_{1}^{12} K} = \frac{K_{aom}}{\sum_{1}^{12} K}$$

K_{asom} = year's average specific value of operating and maintenance costs for the year investigated (Ft per km).

The diagrams plotted on the basis of the calculations discussed (Fig. 5 to 8) show that both operating and maintenance costs increase with the deterioration of road surfaces. The rate of increase of costs dictates the date of reconstruction and modernization of the road, since the economical use of road section is determined by the invested capital, the maintenance costs incurred during use, as well as the operating costs and the volume of traffic passing on the road.

It is in the knowledge of these factors and the joint weighing thereof, it can be decided as to the order of sequence of road investments and modernizations.

Naturally, besides the investment, maintenance and vehicle operating costs, other existing costs, effects and aspects should be taken into consideration as well.

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