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INVESTIGATION OF THE RELATONSHIP BETWEEN RENEWAL COSTS OF MOTOR VEHICLES AND ROAD SURFACE QUALITY

SUMMARY

Amortization of the vehicles constitutes a considerable part of road transport costs. From the financial point of view, amortization can be divided into two parts: a) *amortization of the capital invested and* b) *amortization of renewal costs.*

In principle, both groups can be split further. Thus, renewal costs have been divided into vehicle renewal and major units (assemblies) renewal costs.

The present investigation deals with the relationship between the vehicle renewal costs and the unevennes of the road surface. To determine the wear of motor vehicles dependent on road surface quality, preliminary technical research, i. e. investigations into the stress and wear of the various parts are needed. On the basis of these it can be stated that the stresses and the frequency of their changes assert themselves in the wear-and-tear of the components, and hence in that of the whole vehicle as well. Owing to the varying stresses due to the unevenness of the road surface and to the many complicated parts of the vehicle, mechanical inquiry into the wear of the entire vehicle is not feasible

Therefore, wear-and-tear characteristics due to the unevenness of the road surface has been investigated in terms of the renewal costs actually incurred. For this purpose the relationship between the specific values of vehicle renewal costs of some bus models as well as of the CSEPEL D 350 truck and the unevenness of the road surface have been determined, and regression equations of the costs and road surface values have been established and the relations of the variables plotted (Fig. 2).

The relations obtained verify unequivocally that amortization must not be considered as a constant factor independent of the road condition, since this would disfigure evaluation, rendering it almost useless.

1. INTRODUCTION

In performing their functions, road transport undertakings make use of various means. Transport costs represent such monetary part of the transport value as incorporates the expenses spent on the employed means of transport (means of production) and on labour.

These costs may be grouped according to different aspects, whether serving prime cost calculation purposes or any other economic analysis. The grouping accepted for the present investigations is the following:

— Operating costs.
— Maintenance costs (vehicle maintenance).
— Amortization.
— Total of overhead costs of traffic, operation and administration.

From the point of the investigation, this grouping is practical since it allows to range those cost items in different groups that vary with road surface quality changes or remain independent of the latter, respectively.

Out of the cost items listed above, the analysis of maintenance and operating costs will not be dealt with in detail.

The aim of the present investigation is to analyse amortization in detail, and to study the behaviour of vehicle renewal costs as a part of amortization. This is, however, connected with the actual wear-and-tear of the vehicle. Therefore, in the following the correlation between the stresses imposed on the vehicle and the costs will be briefly dealt with.

2. CORRELATION BETWEEN STRESSES AND RENEWAL COSTS OF MOTOR VEHICLES

As is well known, the surface quality of paved roads varies according to the pavement, but even within the same pavement as well. The various unevennesses of the road surface cause different dynamical stresses on the vehicle. Characteristic to the fatigue of motor vehicle parts are the value and the number of stresses.

This means that a small loading (force or stress) may cause breakings if applied frequently. The parts of motor vehicles are, almost without exception, subject to such repeated loadings. Strictly speaking, „static load" possibly occurs with motor vehicles in stationary condition, under dead weight only. Complex stresses on the motor vehicle assemblies produce combined (multi-axial) stresses in the parts. These stresses cannot be reproduced by fatigue machines. The values of stresses and the frequency of their changes are manifested in the wear-and-tear of parts as well. When the loading of the vehicle doesn't exceed the permissible load, the overstress arising from the effect of road surface, expresses itself in proportionally shorter lifetime.

Vehicle wear-and-tear of the road surface cannot be directly determined on the basis of stresses, because the actual stresses acting on the individual parts of a vehicle assembled of very many parts, are very difficult to establish, and performing tests producing reliable results, would be an extraordinarily costly and tiresome procedure, owing to their great number. Therefore, the wear-and-tear of the vehicle due to the unevennesses of the road surface will be investigated on the basis of the formation of renewal costs actually incurred.

It should be noted that hitherto, when evaluating road surfaces from the point of economy, amortization has been incorrectly reckoned with as an expenditure independent of road surface quality.

3. CONNECTION BETWEEN AMORTIZATION AND RENEWAL COSTS

From financial aspect, depreciation consists of two parts: *a)* amortization of the capital invested and *b)* amortization of renewal costs which are paid in monthly by the undertaking to the appointed banking institution (at present to the Investment Bank) in compliance with its annual budget.

Amortization as a production cost constitutes an item of the prime costs. When investigating amortization, it should generally be examined whether amortization ensures the simple reproduction of fixed assets of production on the one hand and whether it complies with the actual wear-and-tear of the fixed assets on the other.

From the point of the present analysis, it is the second stage of examination of the amortization that is of interest, in the following wording: to what extent does the amortization of each vehicle cover the actual amortization of the vehicle for different road surfaces. To analyse the question, amortization proper, as a cost item, should be taken as starting point.

Amortization *differs* from other cost items dealt with in the foregoing in that it is always a *computed, and not actually incurred expenditure.* Thus amortization, as a matter of fact, represents not the amount actually incurred by the actual wear-and-tear of the vehicles (in their quality as means of production) as a production cost, but the sum of writing-off specified (by a determined rate) for fixed assets. Motor vehicle amortization related to mileage does not follow the actual wear-and-tear either, since operation conditions resulting from road surface are greatly different for the individual vehicles. Hence it is evident that among the vehicle costs related to the road, amortization cannot figure as a cost independent of the road surface quality, since it would greatly distort the accounts, showing for bad roads less than the actual, i. e. more favourable, and for good ones more unfavourable costs. Therefore, a correct and usable value of the costs dependent on the road will be shown by using the investment and renewal costs, respectively, instead of amortization. It was on this principle that the determination of the renewal cost items dependent on the road surface was attempted.

4. DETERMINATION OF RENEWAL COSTS

Renewal is to be understood as the amelioration of fixed assets to a degree that results in restoring the original or approximately original condition thereof. Renewal costs increase the value of fixed means decreased by amortization. Maximum upper limit of this increment is the sum of amortization written off up to the time of renewal.

Renewal repairs can be classified as to whether they are performed by the undertaking proper or by an outside firm, as

— renewal done in own management, and
— renewal done by an out-door agency.

(Road transport undertakings employ both forms, especially in case of reconditioning major assemblies).

Financing of the renewals is provided by the Amortization Fund administered by the undertaking proper — in co-operation with the Investment Bank — and by investment and renewal deposits corresponding to the Fund, respectively. On having completed the renewals, an increment value of fixed assets stock results, *which can be accounted in two ways*, viz.:

a) directly on the debit side of the fixed assets account (direct method), or

b) indirectly on the debit side of the fixed assets amortization account (indirect method).

In principle, renewal costs incurred may be divided into two parts:
— vehicle renewal costs, and
— major assemblies' renewal costs.

Both of these costs are functions of road surface quality as well. Accordingly, to the knowledge of the relationship between renewal costs and road surface quality, the calculation of both kinds of costs is indispensable. Calculation of the values of renewal costs dependent on the road is a more elaborate task than that of the operating and maintenance costs. While the changes of the latter costs, caused by the road, can be determined from the annual operating and maintenance costs, following up the changes of the renewal costs dependent on the road requires investigation of the operation of the vehicle between its two major overhauls.

This means that for the purposes of investigation, vehicles had to be found whose operating conditions between two major overhauls were known. The selected vehicles ought to have been run in this period on the same road pavement (macadam, asphalt, concrete etc.), the condition of which in the investigated period of time — i. e. going back two or three years — had been unaltered and also at present can be considered as being the same.

To calculate the costs, first of all the mileage of the vehicles in terms of road quality must be known.

Again, a problem presented itself in the determination of vehicle renewal costs. With the motor vehicles investigated, the actual amount of major overhaul costs could not be established, on account of repairs having been made with substitution of parts. Therefore, in the investigation, the average repair costs approaching reality closer have been used, which were obtained from the arithmetical mean values of the renewal costs of a great number of vehicles.

Thus the relationship between the major overhaul costs of the IKARUSZ 30, 31, IKARUSZ 601, 602, Ikarus 620, 630 buses as well as of the CSEPEL D 350 trucks and the road surface quality was determined.

The average value of major overhaul costs for the buses were calculated on the basis of the invoices of the Motor Repair Works No V. and for the CSEPEL D 350 truck on those of the Motor Repair Works No I.

The average values were divided by the mileage of the vehicles run on different roads, between two major overhauls. In this manner the specific values of the renewal costs for the different road surface qualities were obtained

$$K_{smo} = \frac{K_{ar}}{\sum_{i=1}^{i} K_{mmo}}$$

where

K_{smo} = specific value of major overhaul costs (Forints per km);
K_{mmo} = mileage between two major overhauls;
i = number of major overhauls;
K_{ar} = average value of renewal costs.

Values thus calculated for IKARUSZ 30 buses are shown in Table 1.

Table 1

Vehicle renewal costs of IKARUSZ 30 buses

No	Mileage [km]	Renewal costs [Ft]	Specific value of renewal costs [Forint /km]	Road surface quality index [Y]
1	127 000	116 121	0.916	1.45
2	134 431	116 121	0.865	1.50
3	220 000	116 121	0.528	0.27
4	158 761	116 121	0.733	0.95
5	129 346	116 121	0.9001	1.40
6	153 435	116 121	0.757	1.20
7	179 389	116 121	0.6462	0.55
8	181 965	116 121	0.6392	0.45
9	158 300	116 121	0.7351	0.95
10	161 000	116 121	0.7215	0.85
11	153 318	116 121	0.758	0.90
12	125 732	116 121	0.928	1.60
13	142 500	116 121	0.824	1.35
14	108 386	116 121	1.065	1.65

The table in question shows the occurring minimum specific value to be 0.528 Forints per km to the costs of an IKARUSZ 30 bus used on asphalt or concrete road of good quality, while the maximum value of 1.065 Ft per km refers to the poor-quality macadam road. When comparing these values it can be stated that the specific renewal costs for the vehicle type investigated, are about twice as high for bad-quality macadam road than for good asphalt or concrete pavement. Using the data of the table, the relationship between the specific vehicle renewal costs of the IKARUSZ 30 bus and the road surface quality were plotted (Fig. 1).

The specific renewal costs of the IKARUSZ 601, 602, IKARUSZ 620, 630 buses and that of the CSEPEL D 350 trucks were calculated in a similar manner.

On the basis of values thus calculated, the relationship between the specific vehicle renewal costs of the types mentioned and the road surface quality were plotted (Fig. 2).

Each line in the diagram represents an individual type of vehicle. It can be perceived that the change of renewal costs is approximately linear with that of the road surface quality.

Accordingly, the regressional correlation between the vehicle renewal costs of the various types and road surface quality, can be expressed with the aid of a linear regression, as seen below. The familiar equation of linear regression is

$$Y_1 = a + bx$$

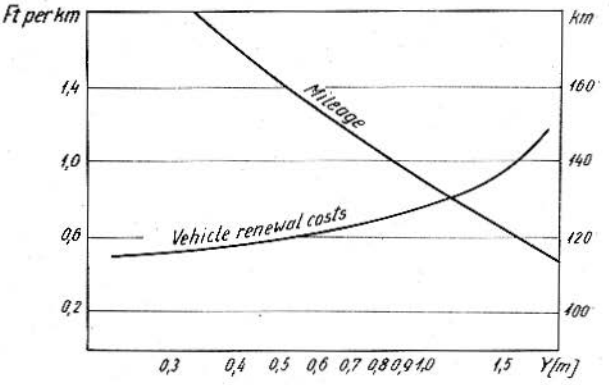

Fig. 1. Relationship between the specific vehicle renewal costs and mileage between two overhauls of IKARUSZ 30 buses and the road surface quality

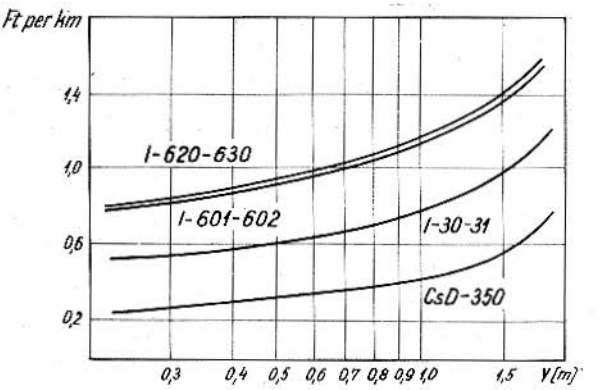

Fig. 2. Relationship between the specific vehicle renewal costs and the road surface quality

The fitting of the straight line to the spread is carried out by the application of the method of least squares, which requires that the sum of squares

$$\Sigma(y - Y)^2$$

be minimum.

On this basis the regression equations of the vehicle renewal cost variations for the types shown in the diagram were derived as follows:

for IKARUSZ buses, Model 30, 31

$$K_{smo} = 0.42 + 0.35 \times Y \text{ Ft per km}$$

for IKARUSZ buses, Model 601, 602

$$K_{smo} = 0.69 + 0.43 \times Y \text{ Ft per km}$$

for IKARUSZ buses, Model 620, 630

$$K_{smo} = 0.72 + 0.44 \times Y \text{ Ft per km}$$

for CSEPEL D 350 trucks

$$K_{smo} = 0.215 + 0.2 \times Y \text{ Ft per km}$$

Notations used in the above equations:

K_{smo} = specific values of major overhaul costs (Ft per km);

Y = index number of road surface quality.

These results can well be made use of in economic calculations.

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