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ЕКОНОМІКА ТА УПРАВЛІННЯ

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MODEL OF FEES CALCULATION FOR ACCESS TO TRACK INFRASTRUCTURE FACILITIES

Purpose. The purpose of the article is to develop a one- and two-element model of the fees calculation for the use of track infrastructure of Ukrainian railway transport. **Methodology.** On the basis of this one can consider that when planning the planned preventive track repair works and the amount of depreciation charges the guiding criterion is not the amount of progress it is the operating life of the track infrastructure facilities. The cost of PPTRW is determined on the basis of the following: the classification track repairs; typical technological processes for track repairs; technology based time standards for PPTRW; costs for the work of people, performing the PPTRW, their hourly wage rates according to the Order 98-Ts; the operating cost of machinery; regulated list; norms of expenditures and costs of materials and products (they have the largest share of the costs for repairs); railway rates; average distances for transportation of materials used during repair; standards of general production expenses and the administrative costs. **Findings.** The models offered in article allow executing the objective account of expenses in travelling facilities for the purpose of calculation of the proved size of indemnification and necessary size of profit, the sufficient enterprises for effective activity of a travelling infrastructure. **Originality.** The methodological bases of determination the fees (payments) for the use of track infrastructure on one- and two-element base taking into account the experience of railways in the EC countries and the current transport legislation were grounded. **Practical value.** The article proposes the one- and two-element models of calculating the fees (payments) for the TIF use, accounting the applicable requirements of European transport legislation, which provides the expense compensation and income formation, sufficient for economic incentives of the efficient operation of the TIE of Ukrainian railway transport.

*Keywords***:** enterprises; track infrastructure facilities; fees; service life

Introduction

The main problem of determination the fees for the use of the track infrastructure facilities of railway transport is that the people do not always understand the need to pay to the railways for the economic benefits they generate. Therefore, it is the railroads that are interested in evaluating and offering the benefits providing the public with compensation. The sources of fees will be different in each case but they can be grouped into several categories.

Determination of the fee level for the use of the track infrastructure of railways should be implemented in accordance with the experience of the railways of the EU-27. The Directive 91/440/EU, 95/19/EU Directive, Directive 2001/14/EU [1] are the governing Directives.

The so-called two-element rate structure with fixed and variable constituents is introduced in seven European countries. The first constituent is determined by the relationship between the planned needs of the operator and fixed costs for track infrastructure enterprises. The variable constituent is determined on the fact of use of the network resources and is determined by mileage of cargo ton-km [13].

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One-element structure is calculated on the basis of mileage (train-km) and gross freight turnover, i.e. the fee is directly proportional to the actual use of the operational activity intensity.

It is in the one-element structure the most of marginal costs are determined on the basis of statistical data, which much simplifies the method of determining their level. However, a significant drawback of the one-element structure is a low level of justification of conditionally fixed costs [12, 13].

If it is necessary to form and maintain the internal competition, the presence of more than one operator is an appropriate use of the two-element fee. In cases there is no need to form a competition the one-element fee is reasonable (high-speed lines, one operator – the track infrastructure user).

In this case the track infrastructure enterprises of Ukraine have to charge a fee on the basis of projected costs and desired profits. But today there is not the calculation model of fee for the use of track infrastructure facilities.

Purpose

According to the above mentioned and the Paragraph 1 and 5 of the Article 4 of the Section II «Fees for the use of track infrastructure» of the Directive 2001/14/EU from February 26, 2001 [1] the purpose of the article is to develop a one- and two-element model of the fees calculation for the use of track infrastructure of Ukrainian railway transport.

Methodology

The one-element model of the fee calculation is based on the level providing the compensation for expenses and generation of the profits sufficient for economic incentive of efficient operation of the track infrastructure enterprises.

Thus, the amount of fees for the use of track infrastructure on the one-element basis can be calculated by the formula (1):

$$Fees_{t.i.} = \frac{C_{TIE}^{reduced} + P_{TIE}}{\sum PL_{gross}(L_{TIF}^{reduced})} \qquad (1)$$

where $C_{TIE}^{reduced}$ – are the reduced annual costs of track infrastructure enterprises (TIE) of the structure of track infrastructure facilities (TIF) on the railroad section; P_{TIE} – profits of the track infrastructure enterprises; $\sum PL_{gross}(L_{TIF}^{reduced})$ – the planned volume of operation activity on the railroad section, 1 000 ton-km gross (1 km of the reduced TIF structure of the main track length).

Recently, the EU-27 devotes much attention to the effective operation of the railroad infrastructure.

April 4, 2008 the European Transport Commission organized a workshop. It was attended by participants from ministries, regulatory bodies, railway infrastructure managers and railway enterprises from different countries of the EU. The workshop dealt with the issue of charging fees for the use of railway infrastructure.

In November 2012 the Directive 2012/34/EU was adopted, which is the most advanced basis for the development of the fee charging methods for the track infrastructure use [12].

In particular, the Paragraph 67 of the Directive stresses that in order to establish a fair level of fee (payment) for the use of track infrastructure; the manager should charge the fee on the basis of clear understanding of the factors affecting the operating costs of the infrastructure [1].

Taking into account the above mentioned and the influence factors of the TIE costs identified in this work, the two-element model of determining the fees for the TIF use were proposed. This model takes into account the fixed (I) and variable (II) components (2):

$$Fees_{t.i.} = \frac{C_{TIE}^{reduced} + P_{TIE}}{\sum PL_{gross}(L_{TIF}^{reduced})} k_1\ k_2\ k_3\ k_4\ k_5 . \qquad (2)$$

where k_1 – is the coefficient taking into account the level of railway section capacity (according to the Paragraph 4, 9 of the Article 7 of the Directive 2001/14/EU [1]); k_2 – is the increase coefficient of the gross train weight, as compared to the design coefficient (3 300 tons); k_3 – is the coefficient taking into account the increase in statistical loading of the reduced car, ton/car (63 ton); k_4 – is the coefficient of the operating speed increase; k_5 – is the coefficient taking into account the cost increase of 1 ton of the cargo that is transported by the railway section over the average index of the cost parameter of 1 ton of the cargo «on the road».

The total volume of annual costs of the track infrastructure enterprises on the j rail section under the influence of operational factors caused by the operation of the transportation activity subjects (3):

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$$C_{TIEj} = C_{TIFj}^{ann} + C_{r.j.}^{s.r.} + C_{clampj}^{s.r.} + C_{b.m.j.}^{change} + C_{slj}^{s.r.} + \Delta C_{wfj}^{c.m.} + C_{mechj} \quad (3)$$

C_{TIFj}^{ann} – average annual costs for the PPTRW and current maintenance of track infrastructure facilities of the j section; $C_{r.j.}^{s.r.}$ – is the costs for solitary replacement of rails; $C_{clampj}^{s.r.}$ – is the solitary replacement of clamps; $C_{slj}^{s.r.}$ – is the costs for the need of solitary replacement of sleepers; $C_{b.m.j.}^{change}$ – is the costs for ballast materials; $\Delta C_{wfj}^{c.m.}$ – is the coefficient of the relative change of the workforce value, needed for current maintenance of the track; C_{mechj} – is the costs for machinery.

To ensure the reliable operation of the track infrastructure facilities a complex of the planned preventive track repair works and the approximate interrepair scheme are assigned [8].

According to statistics of Ukrzaliznytsia [2] the average traffic volume per 1 km of operational track length is 21.6 mln ton-km gross. Thus, for the entire standard operating period of the track (25 years) the traffic volume of will amount 540 ton-km gross, which is much less than the specified standard coefficient. On the basis of this one can consider that when planning the planned preventive track repair works and the amount of depreciation charges the guiding criterion is not the amount of progress it is the operating life of the track infrastructure facilities.

The cost of planned preventive track repair works (PPTRW) is determined on the basis of the following: the classification track repairs; typical technological processes for track repairs [10]; technology based time standards for PPTRW [3, 9]; costs for the work of people, performing the PPTRW, their hourly wage rates according to the Order 98-Ts; the operating cost of machinery; regulated list; norms of expenditures and costs of materials and products (they have the largest share of the costs for repairs); railway rates [5]; average distances for transportation of materials used during repair; standards of general production expenses and the administrative costs.

The experience of the TIF operation has shown that with the increase of load intensity and the speed of train traffic the costs for the workforce to perform the repairs, and therefore the need for mechanization of PPTRW and the current maintenance also increase.

The costs of machinery are calculated by the formula (4):

$$C_{mech} = \left(\sum_{j=1}^{n} \frac{E_{m_{change}}}{L_{change}} + \frac{E_{vehicles}}{L_{change}}\right) \times k_{pass}\, k_{gpe}\, 12\, V_{month}^{T.I.F.} \quad (4)$$

where $E_{m_{change}}$ – are the costs for the change of machines and the use of machinery of the certain type, grn./change; L_{change} – is the performance for the change of machinery of the certain type, km/change; $E_{vehicles}$ – are the operating costs of vehicles (rail trolley, locomotive, car, other equipment providing the movement of workforce, track machines and mechanisms), grn/h; n – is the number of machinery of different types, used for the works of the current maintenance of track infrastructure facilities; k_{pass} – is the coefficient taking into account the loss of time for passing of trains; k_{gpe} – is the coefficient taking into account the volume of the general production expenses; $V_{month}^{T.I.F.}$ – is the monthly fund of works for current maintenance of the track infrastructure, one km of the main track (reduced km).

The above mentioned cost coefficients for the PPTRW and current maintenance based on the concept of the service life of the track infrastructure facilities are characterized by dispersion of the realization time during the lifetime of the object.

For the purpose of the objective cost calculation and further calculation of fees (payments) for the TIF use on the basis of cost level, one should consider in economic calculations the time factor.

The total cost of the PPTRW for the entire service life of the track infrastructure facility taking into account the time difference of its realization is determined as (5):

$$\sum P_j^r = \sum_{t=1}^{SL} P_j^r\, \alpha_t \quad (5)$$

where α_t – is the discount coefficient that brings the costs to the beginning of the service life period of the track infrastructure facility, it is determined by the formula:

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$$\alpha_t = (1+r)^{-t} \qquad (6)$$

where r – is the real (without inflation) rate of return (discount rate).

Considering the above mentioned and the annual costs of current maintenance, let us write the formula for calculating the service life cost of infrastructure track facilities of the j railway section (7):

$$C^{SL}_{T.I.F.j} = P^{m(c)}_j + \sum_{t=1}^{SL} P^r_j \ \alpha_{tPPTRW} + \\ + \sum_{t=1}^{SL} P^{c.m.}_j \ \alpha_{tc.m.} - P_l \ \alpha_{tSL} \qquad (7)$$

where t – is a number of the year of measures implementation for PPTRW or current maintenance; $P^{m(c)}_j$ – is the cost of modernization (construction) of the track infrastructure facility of the j railway section; P^r_j – is the total costs of planned preventive track repair works for the entire life cycle of the track infrastructure object on the j railway section with rails r – type, grn/km, including the cost evaluation of such repairs for the sections with certain types of profiles and track category; α_{tPPTRW} – is the discounting coefficient that reduces the costs for PPTRW to the beginning of the service life for the track infrastructure facility; $P^{c.m.}_j$ – is the annual cost of current maintenance works of the track infrastructure facility of the j railway section; $\alpha_{tc.m.}$ – is the discounting coefficient that reduces the costs for current maintenance to the beginning of the service life for the track infrastructure facility; t – is an ordinal number of the year for implementation of the certain measure; P_l – the loss adjustment expense of the track infrastructure facilities that reached the service life limit is determined proportionally to the re-performance in ton-km gross; α_{tSL} – is the discounting coefficient that reduces the loss adjustment expenses to the beginning of the service life.

Thus, the average annual costs of the PPTRW and the current maintenance of track infrastructure facilities of the j section on the basis of the service life cost is equal to (8):

$$C^r_{TIFj} = \frac{C^{SL}_{TIFj}}{SL_p} \qquad (8)$$

where SL_p – is a specified service life period of the track infrastructure facility, years.

Previously it was stressed that the governing factors of performance of the PPTRW complex are the regulatory periods of their execution, but not the performance of the track infrastructure facilities [6]. However, the introduced regulations for the PPTRW were developed excluding the economic principles of operation, repair and replacement of the track infrastructure facilities. Therefore it would be reasonable to propose a mechanism of economic optimization of the regulatory list and the volumes of the PPTRW execution.

It is possible to solve this task using the Bellman equation.

In the modern operating conditions of the track infrastructure facilities, as it was mentioned above, the term of the PPTRW execution comes earlier than the wear of the facility elements. Therefore, the costs for maintenance of these facilities in the normal conditions are sufficiently clear to account and predict for the future. However, the cost increase for the track infrastructure maintenance is influenced by the following factors: motion speed of the rolling stock, load on car and gross weight of the train. These factors result in both the projected wear accumulation of the track infrastructure elements and the solitary breakdown with the need in solitary replacement of the rails, clamps, sleepers and ballast materials. The cost forecast for these types of repair require additional study of operational conditions and methodology design of determining the costs for solitary replacement of rails, clamps, sleepers and ballast materials.

The first structural element of the TIF, which contacts with the factors of operating component is the rail. The operating experience points out the following types of defects: vertical wear, lateral wear, fracture of contact-fatigue nature [7].

Hence, the costs for the solitary replacement of rails can be determined by the formula (9) [6]:

$$C^{s.r.}_r = \sum_{j=1}^{k} L_{rj} \ O_{rj} \ (C_{nrj} - C_{orj}) \qquad (9)$$

where L_{rj} – is the coefficient of relative change (as compared to the normative one) of the solitary removal of the j linear element of the track; O_{rj} – is the number of rails that are replaced in the target year in the order of solitary replacement, replace-

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ment/ km-year; C_{nrj} , C_{orj} – is the cost of the new and the old rails correspondingly, grn./replacement.

Significant costs on the track infrastructure enterprises also make it necessary to provide a solitary replacement of the clamps.

The frequent breakdowns and short service life of the damping and insulating elements attract the attention in the design of clamps that are in service. The clamp construction itself is quite reliable but on the sections with high load intensity and the rolling stock weight taking into account the non-resistant quality of the construction material the solitary breakdowns become quite frequent phenomenon.

One can obtain the determination of cost value for solitary change of the clamps in the previous calculation using the principle of identity of the clamp breakdowns – a solitary breakdown of rails, noted in the paper [11].

Taking into account the average costs for the solitary replacement of rails and the proportionality coefficient the annual costs for solitary replacement of clamps are be determined on the basis of expression (10):

$$C_{clamp}^{s.r.} = \sum_{j=1}^{k} L_{clampj}\ L_{rj}\ O_{rj}\ (C_{nrj} - C_{orj}) \qquad (10)$$

The most important structure element of the track superstructure providing the transfer of loads from rails to the roadbed is a sleeper. Type, material, design, diagram of sleepers provide soft ride and durability of both the rail and the running gear of rolling stock.

Operating experience of the railway track revealed the root cause of ferroconcrete sleeper breakdown on the main tracks of the heavy-traffic lines. It is the destruction due to mechanical damage in the rail seats. The mechanical damage of ferroconcrete sleepers (rail shelling and splitting) is a criterion of their service and the need in replacement.

The investigation of relationship between the magnitude of mechanical wear of sleepers and operational factors was carried out in the paper [11].

The cost value for solitary replacement of sleepers can be determined by the formula (11):

$$C_{sl}^{s.r.} = \sum_{j=1}^{k} L_{slj}\ O_{slj}\ (C_{NSj} - C_{USj}) \qquad (11)$$

where O_{slj} – is the average number of sleepers that are replaced in the order of solitary replacement per year, replacement/km; C_{NSj} – is the cost of the new sleeper, grn./sleeper; C_{USj} – is the cost of the used sleeper; L_{slj} – is the coefficient of relative change (as compared to the normative one) of the solitary removal of sleepers in the railway section j.

The ballast section is also the most important element of the track superstructure.

Depending on the operational factors the evaluation of the supporting subgrade was proposed in the methodology [4].

Costs for ballast materials (12):

$$C_{b.m.j}^{change} = \sum_{j=1}^{k} \alpha_{bj}\ N_{calcj}\ N\ K_j\ m_j\ K_{lengthj}\ C_{bj} \qquad (12)$$

where α_{bj} – is the coefficient of relative (as compared to the normative one) ballast consolidation in the railway section j; N_{calcj} – is the calculate norm of the work force losses for the current track maintenance, people/km; N – is the number of work days in the year; K_j – is the share of works of track alignment on all the works of current track maintenance; m_j – cost of ballast material cu.m./people-day; $K_{lengthj}$ – is the coefficient taking into account the track length; C_{bj} – is the price of ballast materials grn./cu.m.

One can find the stress values in rails, sleepers, ballast, which are included in the above mentioned formulas using the theoretical-probabilistic methods for the track calculation considered in the paper [11].

One sets at the value of relative change of work force required for the current maintenance of the track – $\Delta C_{wfj}^{c.m.}$ (13):

$$C_{wfj}^{c.m.} = k_1\ \Delta C_r\ k_2\ \Delta C_{sl}\ k_3\ \Delta C_b \qquad (13)$$

where k_1 – is the share (in fractions of a unit) of the work force necessary for solitary removal of rails during the current maintenance of railway track; k_2 – is the share of the work force necessary for solitary removal of sleepers during the current maintenance of railway track; k_3 – is the share of the work force necessary for the ballast resupply during the current maintenance of railway track.

On the basis of this: $k_1 + k_2 + k_3 = 1$; k_1, k_2, k_3 – is set in accordance to the effective standards – work force losses on current track maintenance.

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Findings

The models offered in article allow executing the objective account of expenses in travelling facilities for the purpose of calculation of the proved size of indemnification and necessary size of profit, the sufficient enterprises for effective activity of a travelling infrastructure.

Originality and practical value

The methodological bases of determination the fees (payments) for the use of track infrastructure on one- and two-element base taking into account the experience of railways in the EC countries and the current transport legislation were grounded.

The article proposes the one- and two-element models of calculating the fees (payments) for the TIF use, accounting the applicable requirements of European transport legislation, which provides the expense compensation and income formation, sufficient for economic incentives of the efficient operation of the TIE of Ukrainian railway transport.

The track infrastructure enterprises have to charge the fees (payments) at their own discretion on the basis of the projected cost level, the desired incomes and the payment requirements, which can ensure the correspondence of incomes of the infrastructure enterprise to its costs for infrastructure maintenance.

The most promising method of calculating the fees for access to the TIF is the budget method. It is based on state forecasting of socio-economic development of the national economics, freight industries and the need in railway transport products.

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МОДЕЛЬ РАСЧЕТА ВЕЛИЧИНЫ СБОРА ЗА ДОСТУП К ОБЪЕКТАМ ПУТЕВОЙ ИНФРАСТРУКТУРЫ

Цель. Исследование направлено на разработку одно – или двухэлементной моделей расчёта платы за использование путевой инфраструктуры железнодорожного транспорта Украины. **Методика.** Согласно статистическим данным среднесетевой объем перевозок, который приходится на 1 км эксплуатационной длины пути, – 21,6 млн. ткм брутто. Таким образом, за весь нормативный срок эксплуатации пути (25 лет) объем перевозок составит 540 млн. ткм брутто, что намного меньше установленного нормативного показателя. Исходя из этого, считаем, что при планировании проведения планово-предупредительных ремонтно-путевых работ (ППРПР) и объема амортизационных отчислений руководящим критерием является не объем наработки, а срок эксплуатации объектов путевой инфраструктуры. Стоимость проведения ППРПР определяется, исходя из: 1) классификации ремонтов пути; 2) типовых технологических процессов ремонта пути; 3) технологически обоснованных норм времени на проведение ППРПР; 4) затрат труда рабочих, занятых проведением ППРПР, их часовых тарифных ставок (согласно Приказу 98-Ц); 5) стоимости эксплуатации машин и механизмов; 6) регламентированного перечня, норм расходов и стоимости расходов материалов и изделий (имеют наибольший удельный вес в расходах на ремонты); 7) железнодорожных тарифов; 8) среднесетевых расстояний на перевозку материалов, которые используются на ремонтах; 9) норм общепроизводственных и административных расходов. **Результаты**. Предложенные в статье модели позволяют выполнить объективный учет расходов в путевом хозяйстве с целью расчёта обоснованного размера компенсации и необходимой величины прибыли, достаточных для эффективной деятельности предприятий путевой инфраструктуры. **Научная новизна.** Разработаны методологические основы определения платы за использование путевой инфраструктуры с учётом опыта железных дорог стран ЕС и действующего транспортного законодательства. **Практическая значимость.** В работе предложены одно – и двухэлементную модели расчета платы (сбора) за пользование объектами путевой инфраструктуры (ОПИ) с учетом действующих требований Европейского транспортного законодательства, которые обеспечат компенсацию расходов и получение прибыли, достаточных для экономического стимулирования эффективной деятельности предприятий путевой инфраструктуры железнодорожного транспорта Украины.

Ключевые слова: предприятия; объекты путевой инфраструктуры; жизненный цикл

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МОДЕЛЬ РОЗРАХУНКУ ВЕЛИЧИНИ ЗБОРУ ЗА ДОСТУП ДО ОБ’ЄКТІВ КОЛІЙНОЇ ІНФРАСТРУКТУРИ

Мета. Дослідження спрямоване на розробку одно – або двохелементної моделей розрахунку плати за використання колійної інфраструктури залізничного транспорту України. **Методика.** Згідно статистичних даних середньомережевий обсяг перевезень, що припадає на 1 км експлуатаційної довжини колії, – 21,6 млн. ткм брутто. Таким чином, за весь нормативний термін експлуатації колії (25 років) обсяг перевезень складе 540 млн. ткм брутто, що набагато менше встановленого нормативного показника. Виходячи з вище зазначеного, вважаємо, що при плануванні проведення планово-попереджувальних ремонтно-колійних робіт (ППРКР) та обсягу амортизаційних відрахувань керівним критерієм є не обсяг наробітку, а термін експлуатації об’єктів колійної інфраструктури. Вартість проведення ППРКР визначається, виходячи з: 1) класифікації ремонтів колії; 2) типових технологічних процесів на ремонт колії; 3) технологічно обґрунтованих норм часу на проведення ППРКР; 4) витрат праці робітників, занятих проведенням ППРКР, їх годинних тарифних ставок, (згідно Наказу 98-Ц); 5) вартості експлуатації машин та механізмів; 6)

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регламентованого переліку, норм витрат та вартості витрат матеріалів і виробів (мають найбільшу питому вагу у витратах на ремонти); 7) залізничних тарифів; 8) середньомережевих відстаней на перевезення матеріалів, що використовуються при ремонтах; 9) норм загальновиробничих та адміністративних витрат. **Результати**. Запропоновані в статті моделі дозволяють виконати об'єктивний облік витрат у колійному господарстві з метою розрахунку обґрунтованого розміру компенсації й необхідної величини прибутку, достатніх для ефективної діяльності підприємств колійної інфраструктури. **Наукова новизна.** Розроблено методологічні основи визначення плати за використання колійної інфраструктури, з урахуванням досвіду залізниць країн ЕС і діючого транспортного законодавства. **Практична значимість.** У роботі запропоновано одно – та двохелементну моделі розрахунку плати (збору) за користування об’єктами колійної інфраструктури (ОКІ), з урахуванням діючих вимог Європейського транспортного законодавства, що забезпечує компенсацію витрат та утворення прибутку, достатнього для економічного стимулювання ефективної діяльності підприємств колійної інфраструктури залізничного транспорту України.

Ключові слова: підприємство; об’єкти колійної інфраструктури; життєвий цикл

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