ADAPTING THE LOAD-BEARING STRUCTURE OF A GONDOLA CAR FOR TRANSPORTING HIGH-TEMPERATURE CARGOES (p. 6–13)

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This paper determines the load on the load-bearing structure of a universal gondola car during the transportation of cargo with a temperature of 700 °C in it. It has been established that the maximum equivalent stresses, in this case, significantly exceed permissible ones. The maximum temperature of the cargo, at which the strength indicators of the carrying structure of the gondola do not exceed the permissible values, is 94 °C. At the same time, the temperature of the cargo transported in the cars by rail can be much higher. In this regard, to use gondola cars for the transportation of cargoes with high temperatures, it is possible to arrange them in heat-resistant containers of open type – flatcars. Therefore, in this study, a structure of the flatcar with convex walls has been proposed. Such configuration of the sidewalls makes it possible to increase the usable volume of the container by 8 % compared to the prototype. As a flatcar material, a composite with heat-resistant properties is used. To justify the proposed solution, the strength of a flatcar was calculated. It has been established that the maximum equivalent stresses in the carrying structure of the flatcar are about 300 MPa and do not exceed permissible ones.

To determine the main indicators of the dynamics of the gondola car loaded with flats, its dynamic load was mathematically modeled. The calculation results showed that the accelerations in the center of the mass of the load-bearing structure of a gondola car are about 1.5 m/s². The vertical dynamics coefficient is 0.22. The estimated dynamics indicators are within the permissible values.

The study reported here could contribute to improving the efficiency of the use of gondola cars and to further advancements in the design of innovative vehicles.

Keywords: transport mechanics, load-bearing structure, body load, temperature impact, heat-resistant flatcar.

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DOI: 10.15587/1729-4061.2022.254218 STRENGTH ANALYSIS OF PRESTRESSED VERTICAL CYLINDRICAL STEEL OIL TANKS UNDER OPERATIONAL AND DYNAMIC LOADS (p. 14–21)

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This paper reports a study into the effect of the winding type on the stressed-strained state of the wall of a steel cylindrical tank filled with oil to the predefined level. The shapes of free oscillations of oil in the tank and the effect of the winding type on the natural
frequencies of the structure were analyzed. Stress in the tank wall was estimated on the basis of finite-element simulation of the deformation of a three-dimensional structural model under the influence of distributed oil pressure on the inner surface of the wall and stresses on the outer surface of the wall. The stresses were induced by the winding of various types, taking into consideration the level of oil loading, the winding step of the winding, and the mechanical characteristics of the thread.

The stressed-strained state of a cylindrical tank with winding was investigated at its full filling with oil, half-filling with oil, and without oil. Three winding options were simulated: single, double, and triple intervals. Two types of winding were considered: made from high-strength steel wire and made from composite thread. It was established that when winding the tank wall with steel wire at a triple interval, the stress in the structure does not exceed 34.2% of the yield strength. At the same time, the height of oil loading does not significantly affect its strength. Applying a composite thread leads to an increase in the stress of up to 47.2% of the yield strength but makes it possible to reduce the mass of the tank with winding. When winding with a composite thread at a triple interval, the mass of the structure increases by only 3.6%. The results reported here make it possible to effectively use pre-stress in order to improve the strength and dynamic characteristics of the studied structures, taking into consideration their windings made of different materials.

Keywords: steel tank, pre-stress, tank oscillations, operational loads, winding step.

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Determining Features of the Deformed State of Reinforced Concrete Beams of Road Bridges When Strengthening the Span Structures (p. 22–28)

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The technology of repairing reinforced concrete bridges typically involves closing traffic on one half of the structure and
performing work on it when it is possible to move vehicles on the second part of this structure. The main process of interest to practitioners in terms of hardening concrete, which occurs in the beams of a span structure during the passage of a temporary moving load, is deformation. By the time the cement of freshly laid concrete of the overhead reinforcement slab is hardened, it is necessary to perform the necessary conditions for this (temperature, humidity, immobility over time, etc.). Before concrete acquires strength, movements arising in the span structure cause the destruction of cement stone at the formation stage. It is necessary to investigate the presence of deformations, as well as their impact on the impossibility of forming a homogeneous structure of concrete and its adhesion to reinforcing elements that combine the existing slab with the new one.

This study has established deformations induced by a temporary load from 1.61 to 5.83 mm, which have a negative impact on the process of solidification of concrete in the reinforcement slab for a span structure during the repair of a motorway bridge. The three-dimensional models were calculated by simulating a bridge of the M-04 highway. The results underline the conclusions that the technology of repair work does not take into consideration the possibility of forming a homogeneous structure of concrete and its adhesion to reinforcing elements that combine the existing slab with the new one.

The study results established that operations on concreting an additional overhead reinforcement slab in the presence of vibro-tactual effects exerted by the temporary load on the span structure cannot be performed because of the destruction of concrete at the hardening stage.

Given the above issue, several ways to address it have been devised and analyzed; the best of them is recommended.

**Keywords:** repair of bridges, concrete road beams, reinforcement slab, deformation, concrete structure.

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**INFLUENCE OF THE DEFORMED STATE OF A ROAD BRIDGE ON OPERATIONAL SAFETY (p. 29–34)**

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The article deals with the issues of vehicle traffic safety on artificial constructions. Ensuring safety in the field of rail transport is an essential element in the activities of all subjects of the market of railway services, including passenger carriers. To fully study the issues of the deformed state of beam superstructures, it is necessary to conduct static and dynamic tests. Before the start of the tests, it is mandatory to check the technical condition of the artificial structure:

1) visual inspection, special checks with verification of necessary parameters;
2) carrying out control linear measurements;
3) selective determination of concrete strength by non-destructive methods.

First, the static tests is conducted to determine the total deformations of each beam of the superstructure at the control point with maximum deformations of ½ L. Then dynamic tests with determination of periods of natural oscillations and deformations (stresses). Processing of the results of surveys and tests of the overpass with an assessment of the possibility of passing design loads on the road bridge, after which a dynamic passport of the transport structure is compiled. The study of the stressed state of vehicles gives a clear idea of the causes of deformations in the structural elements when analyzing the work of the span of the automobile bridge in conditions of increasing axial loads and traffic flow speeds. Deformation processes lead to defects, structural failures and accidents on the vehicle, which leads to premature wear, material damage and environmental damage. Periodic measurements of deformations (stresses) of the superstructure over several years will make it possible to predict changes in its condition over time and determine the remaining resource in terms of load-bearing capacity and load capacity. As a result of experimental studies, it was proved that the presented technique, developed in the classical version for detecting structural defects between a single-layer coating and a base of various types, can also work effectively in the case of non-destructive testing of multilayer structures.

Keywords: safety, road bridge, stress condition, technical inspection, static and dynamic tests.

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INVESTIGATING THE INFLUENCE OF THE DIAMETER OF A FIBERGLASS PIPE ON THE DEFORMED STATE OF RAILROAD TRANSPORTATION STRUCTURE “EMBANKMENT-PIPE” (p. 35–43)

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This paper has analyzed the use of fiberglass pipes in the body of the railroad embankment by a method of pushing them through the subgrade. A flat rod model has been improved for assessing the deformed state of the transport structure “embankment-fiberglass pipe” by a method of forces when replacing the cross-section of the pipe with a polygonal one.

The analytical model accounts for the interaction between the pipe and soil of the railroad embankment. To this end, radial and tangential elastic ligaments are introduced into the estimation scheme, which make it possible to simulate elastic soil pressure, as well as friction forces that occur when the soil comes into contact with the pipe.

The deformed state of the transport structure “embankment-fiberglass pipe” was calculated by the method of forces and by a finite-element method under the action of load from the railroad rolling stock, taking into consideration the different cross-sections of the pipe.

It has been established that with an increase in the diameter of the fiberglass pipe, the value of deformations of the subgrade and fiberglass pipe increases. With a pipe diameter of 1.0 m, the deformation value in the vaulted pipe is 2.12 mm, and with a pipe diameter of 3.6 m – 4.16 mm. At the same time, the value of deformations of the subgrade under the sleeper is 3.2 mm and 6.0 mm, respectively.

It was determined that the maximum deformations of the subgrade, which occur above the pipe, with a pipe diameter of 3.6 m, are 4.46 mm. At the same time, the maximum vertical deformations of a fiberglass pipe arise in the pipe vault and, with a pipe diameter of 3.6 m, are 4.16 mm. It has been established that the maximum horizontal deformations of the subgrade occur at points of horizontal diameter of the fiberglass pipe while the minimal horizontal deformations of the subgrade occur at points lying on the vertical diameter of the pipe.

Keywords: subgrade, fiberglass pipe, railroad track, horizontal and vertical deformations, equivalent load.

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In this study, computational analysis has been carried out using computational fluid dynamics (CFD). These calculations have been made to investigate the rheological behavior of the mixed-phase flow in horizontal pipelines. In order to study the shear stress in a vertical pipe, a new numerical model for oil-water dispersion in three dimensions has been developed. CFD software has been used to study the wall shear stress function and water droplet pressure. Using Reynolds numbers and the Navier-Stokes equations with k–\epsilon turbulence model, the simulations were performed. The results from a recent study on experimental methodology were simulated. In this study, the diameter of the tube is 40 mm and the length is 3.5 m and modeled and analyzed using Ansys software. Thus, the geometry has been imported and converged accordingly. The primary data of the simulation have been verified with experimental results successfully. Oil droplet widths have previously been thought to be dependent on the flow Reynolds number, which was confirmed in this case study. Droplet diameter Dd was measured at 6 mm while the mixture moved at a speed of 1.9 m/s. It was found that the largest shear stress value was found at the top of the pipe, where the oil fraction (cut-off) was 0.3, in the simulation results for varied velocities (1.6, 2.5, 2.9 m/s) and oil fraction (cut-off) values. The results of the simulation analysis of the two-phase flow of crude oil for the horizontal pipe are wall shear stresses with different velocities for crude oil in the two-phase flow. As well as pressure drop at different velocities for the same fluids.

**Keywords:** Iraqi crude oil, CFD, FEM, wall shear stress, pressure drop.

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ESTIMATING THE INITIAL STAGE IN THE PROCESS OF RADIAL-REVERSE EXTRUSION USING A TRIANGULAR KINEMATIC MODULE (p. 51–60)

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Those parts of solid or hollow blanks whose shape is complex should be produced by means of combined radial-longitudinal extrusion. However, the use of combined extrusion processes with several degrees of flow freedom requires a preliminary assessment of shape formation, which is true, taking into consideration the peculiarities of evolution of strain sites at different stages of deformation. When deforming high blanks, the presence of an intermediate rigid zone can be observed, separating two autonomous strain sites. When constructing an estimation scheme of the initial stage of the process of combined radial-backward extrusion of hollow parts with a flange, the presence of an intermediate rigid zone is taken into consideration. The need to improve the devised estimation scheme is caused by significant deviations in the projected growths of a part from its experimentally derived dimensions. As an alternative to the axial rectangular kinematic module of the lower deformation site, the use of an axial triangular module has been proposed, whose effectiveness is demonstrated in simulating the process of radial-longitudinal extrusion with expansion. The rationality of the proposed replacement was revealed, both for forecasting the forced mode of the deformation process and for the gradual part’s shape formation. This has made it possible to reduce the projected estimates to 10% in terms of the increase in the size of a part based on a comparative analysis with experimentally derived data. It is recommended to use the devised scheme for modeling the initial stage of the process for relatively high blanks at \( H_0/h_0 \geq 4 \ldots 6 \). The limitation is the degeneration of the intermediate rigid zone. This will contribute to compiling recommendations for expanding the possibilities of using combined radial-backward extrusion of hollow parts with a flange during production.

**Keywords:** combined extrusion, process modeling, energy method, kinematic module, forced mode, shape formation.

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DETERMINING THE INFLUENCE OF GEOMETRIC PARAMETERS OF THE TRACTION-TRANSPORTATION VEHICLE'S FRAME ON ITS TRACTIVE CAPACITY AND ENERGY INDICATORS (p. 61–67)

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This paper reports results of studying the influence of geometrical parameters of the frame in a traction-transportation vehicle on its traction and energy indicators. A method for estimating the influence of geometrical parameters of the frame in a traction-transportation vehicle on its traction and energy indicators has been substantiated, based on the traction calculation of the tractor and taking into consideration the change in the distance from the hinge of the traction-transportation vehicle to the front and rear drive axles. The method makes it possible to determine the normal reactions, tangent thrust forces, and traction power on the wheels of the machine. The method reported here enables defining the optimal geometric parameters for improving the traction-adhesion and fuel-economic indicators of the traction-transportation vehicle. It was theoretically established that the normal reactions on the front wheels of the studied traction-transportation vehicle are 27,800 N and exceed by 1.95 times the normal reactions on the rear wheels of 14,200 N. This is due to the fact that the distance from the hinge to the corresponding axles of the wheels is 1.89 m and 0.97 m. Increasing the distance from the hinge to the axle of the rear wheels to 1.17 m produces a positive effect on improving the tractive performance of the traction-transportation vehicle. There is an increase in the tractive power on rear wheels to 24.39 kW. The experimental study of the traction-transportation vehicle was performed using an all-wheel-drive machine with a hinge-connected frame as an example. The maximum traction power is 121 kW, which is achieved at a speed of 12 km/h, traction efficiency of 0.68, and a thrust force per hook of 30.2 kN. The difference between the results obtained theoretically and experimentally is 8%. Applying the method could make it possible to provide designers and manufacturers with recommendations for the construction and improvement of a traction-transportation vehicle, to improve traction and adhesion properties, and reduce the anthropogenic impact on the soil.

**Keywords:** tractive force, thrust force, normal reaction, geometric parameters, traction-transportation vehicle.

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АДАПТАЦІЯ НЕСУЧОЇ КОНСТРУКЦІЇ НАПІВВАГОНА ДО ПЕРЕВЕЗЕНЬ ВИСОКОТЕМПЕРАТУРНИХ ВАНТАЖІВ (с. 6–13)

О. В. Фомін, А. О. Ловська, М. В. Хара, І. В. Ніколаєнко, А. С. Литвиненко, С. С. Сова

Проведено визначення навантаженості несучої конструкції універсального напіввагона при перевезенні в ньому вантажу з температурою 700 °C. Встановлено, що при цьому максимальні еквівалентні напруження значно перевищують допустимі. Максимальна температура вантажу, при якій показники міцності несучої конструкції напіввагона не перевищують допустимих значень, складає 94 °C. Разом з цим температура наvantажу, що перевозиться у вагонах залізницею, може мати значно більші величини. У зв'язку з цим для можливості використання напіввагонів для перевезення вантажів з високими температурами можливі розміщення їх у термостійких контейнерах відкритого типу – флетах. Тому в рамках дослідження запропоновано конструкцію флета з випуклими стінами. Така конфігурація боковин стін дозволяє підвищити корисний об'єм контейнера на 8 %, що визначається в межах допустимих значень.

Для визначення основних показників динаміки напіввагона, забагатеного флетами, проведено математичне моделювання динамічного впливу. Результати показали, що випадки, коли в центрі має несучі конструкції напіввагона, складають близько 300 МПа і не перевищують допустимі.

Досягнуто нові результати для визначення основних показників динаміки напіввагона, забагатеного флетами, проведено математичне моделювання динамічного впливу. Результати показали, що випадки, коли в центрі має несучі конструкції напіввагона, складають близько 300 МПа і не перевищують допустимі.

Проведені дослідження сприятимуть підвищенню ефективності використання напіввагонів та створенню напрямків щодо створення транспортних засобів.

Ключові слова: транспортна механіка, несуча конструкція, навантаженість кузова, температурний вплив, термостійкий флет.

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ВИЯВЛЕННЯ ОСОБЛИВОСТЕЙ ДЕФОРМОВАНОГО СТАНУ ЗАЛІЗОБЕТОННИХ БАЛОК АВТОДОРОЖНЬХ МОСТІВ ПРИ ПІДСИЛЕННІ ПРОГОНОВИХ БУДОВ (с. 22–28)

С. В. Ключник, Д. С. Співак, І. Ф. Горюшкін

Технологія виконання ремонту залізобетонних мостів, зазвичай, передбачає закриття руху на одній половині споруди та виконання робіт на ній, при можливості подальшого руху автомобільного навантаження на другій частині споруди. Основний процес, що вивчається у цих випадках, – це деформації, до моменту закінчення експлуатації мостів з урахуванням деформацій, що виникають в мостах при підсиленні проходження моста по перехрестях.
підсилення потрібно створити необхідні умови для цього (температура, вологость, нерухомість в часі та інше). Коли бетон ще не має міцності, переміщення, що виникають в прогоновій будові, сприяють руйнуванню цементного каменю на стадії формування. Необхідно дослідити наявність деформацій, та їх вплив на неможливість утворення цілісної структури бетону і зчеплення його з арматурними елементами, що об'єднують існуючу плиту з новою.

Дослідженням встановлені деформації від тимчасового навантаження від 1,61 до 5,83 мм, що мають негативний вплив на процес застиття бетону плити підсилення для прогонових будов под час ремонту автодорожнього мосту. Виконується програмне обчис-лення об'ємних моделей на прикладі моста автомобільної дороги M-04. Із наочно отриманих результатів формулюються висновки, що технологія виконання ремонтних робіт не враховує необхідних умов для якісного набору міцності бетону додаткової плити.

В результаті досліджень встановлено, що роботи з бетонування додаткової накладної плити підсилення при наявності вібраційних впливів від тимчасового навантаження на прогонову будову, через руйнування бетону на стадії твердіння, виконувати не можна.

На підставі виникнення вищеописаної проблеми сформовано і проаналізовано декілька варіантів вирішення та запропоновано найкращий із них.

Ключові слова: ремонт мостів, бетонні автодорожні балки, плита підсилення, деформації, структура бетону.

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ВПЛИВ ДЕФОРМОВАНОГО СТАНУ АВТОДОРОЖНЬОГО МОСТУ НА ЕКСПЛУАТАЦІЙНУ БЕЗПЕКУ (с. 29–34)

Ivan Bondar, Mikhail Kvashnin, Dinara Aldekeyeva, Bekzhanova Saule, Aliya Izbairova, Assem Akbayeva

У статті розглядається питання щодо забезпечення безпеки руху транспортних засобів на штучних спорудах. Забезпечення безпеки у сфері залізничного транспорту є найважливішим елементом діяльності всіх суб'єктів ринку залізничних послуг, зокрема пасажирських перевезень.

Для повного вивчення питань деформованого стану балок триванному прогонових будов належного проведення статичних та динамічних випробувань. Перед початком випробувань обов'язково проводяться стійкість стану штучні споруди:

1) вигляд, спеціальні перевірки із перевіркою необхідних параметрів;
2) проведення контрольних лінійних вимірів;
3) вибіркове визначення міцності бетону неруйнівними способами.

Спочатку проводять статичні випробування для визначення сумарних деформацій кожної балки прогону в контрольній точці з максимальними деформаціями \( \frac{L}{3} \). Потім проводять динамічні випробування з визначенням періодів власних коливань і деформацій (напружень). Обробка результатів обстежень та випробувань шляхом визначення можливості проходження розрахункових навантажень на автодорожній міст, після чого складається динамічний паспорт транспортної споруди. Вплив деформації на земляне полотно вимірюється випробуванням передчасного зносу, матеріальних збитків та збитків навколишньому середовищу.

Периодичні вимірювання деформацій (напружень) конструкції надбудови протягом декількох років дозволяють проаналізувати зміну її стану в часі і визначити зализковий ресурс по несучій здатності та вантажопідйомністі. В результаті експериментальних досліджень було доведено, що представлена методика, розроблена в класичному варіанті для виявлення структурних дефектів між одношаровим покриттям та конструкцією, реалізована на розподіленних конструкціях.

Ключові слова: безпека, атмосферний стан, техогляд, статичні та динамічні випробування.
Встановлено, що максимальні горизонтальні деформації земляного полотна виникають в точках горизонтального діаметру склопластикової труби, а мінімальні горизонтальні деформації земляного полотна виникають в точках, що лежать на вертикальному діаметрі труби.

Ключові слова: земляне полотно, склопластикова труба, залізнична колія, горизонтальні та вертикальні деформації, еквівалентне навантаження.

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ВИЗНАЧЕННЯ МЕХАНІЗМУ БАГАТОФАЗНОЇ ТЕЧІЇ В ГОРІЗОНТАЛЬНОМУ ТРУБОПРОВОДІ З ВИКОРИСТАННЯМ ОБЧИСЛЮВАЛЬНОЇ ГІДРОДИНАМІКИ (с. 44–50)

Ashham Mohammed Aned, Saddam Hussein Raheemah, Kareem Idan Fadheel

У даній роботі проведено обчислювальний аналіз з використанням обчислювальної гідродинаміки (ОГД). Розрахунки були виконані для дослідження реологічних характеристик багатофазної течії в горизонтальних трубопроводах. Для вивчення напруги зсуву на вертикальній трубі була розроблена нова тривимірна чисельна модель водонафтової дисперсії. Для дослідження функції напруги зсуву на стінці і тиск крапель води використовувалося програмне забезпечення ОГД. За допомогою числа Рейнольдса та рівняння Нав’є-Стокса з коефіцієнтом турбулентності, що визначає гідродинаміку, було описано діапазон течії для безперервного процесу. Змодельований розвиток недавнього дослідження експериментальної методології. У даному дослідженні діаметр труби становить 40 мм, довжина – 3,5 м, моделювання та аналіз виконані за допомогою програмного забезпечення Ansys. Таким чином, геометрія була імпортувана і змодельована за допомогою інструменту ОГД. Стічна модель була протестована відповідно проведених експериментальних досліджень. Перші данні моделювання були узагальнені підтверджено експериментальними результатами. Вважалося, що ширина нафтових крапель залежить від висоти Рейнольдса течії, що було підтверджено у ньому тематичному дослідженні. Діаметр крапель Dd склав 6 мм за умови руху суміші зі швидкістю 1,9 м/с. Встановлено, що найбільше значення напруги зсуву спостерігається в верхній частині труби, де частина нафти (відсічення) склала 0,3, за результатами моделювання для різних швидкостей (1,6, 2,5, 2,9 м/с) та значень частки нафти (відсічення). Результатами моделювання багатофазної течії сирої нафти для горизонтальної труби є напруги зсуву на стінці і тиск крапель води відносно високих заготовок при різних висотах Рейнольдса течії, що відповідає дійсності, з урахуванням особливостей формування осередків деформації, що відокремлює два автономних осередків деформації. При побудові розрахункової схеми для моделювання початкової стадії процесу комбінованого радіально-зворотного видавлювання порожнистих деталей з фланцем враховано наявність проміжної жорсткої зони. Необхідність моделювання процесів комбінованого видавлювання з декількома ступенями свободи течної турбулентності на колесах машини. Наведений метод дозволяє визначати оптимальні геометричні параметри для підвищення тягово-
зчіпних та паливо-економічних показників тягово-транспортної машини. Теоретично визначено нормальні реакції на передніх колесах досліджуваної тягово-транспортної машини складають 27800 Н та перевищують в 1.95 рази нормальні реакції на задніх колесах 14200 Н. Це відбувається внаслідок того, що відстані від шарніру до відповідних осей коліс дорівнюють 1.89 м та 0.97 м. Збільшення відстані від шарніру до осі задніх коліс до 1.17 м позитивно впливає на підвищення тягових показників тягово-транспортної машини. Відбувається підвищення тягової потужності на задніх колесах до 24.39 кВт. Експериментальні дослідження тягово-транспортної машини виконані на прикладі повнопривідної машини з шарнірно-з’єднаною рамою. Максимальна тягова потужність складає 121 кВт, яка досягається при швидкості 12 км/год, тяговому ККД 0.68 та силі тяги на гаку 30.2 кН. Розбіжність між результатами отриманими теоретично та експериментально складає 8 %. Застосування методу дозволить надати конструкторам та виробникам рекомендації щодо створення та удосконалення тягово-транспортної машини, підвищити тягово-зчіпні властивості та знизити техногенний вплив на ґрунт.

Ключові слова: тягова потужність, сила тяги, нормальна реакція, геометричні параметри, тягово-транспортна машина.