ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

5 (449)

SEPTEMBER – OCTOBER 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

Clarivate
Analytics

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

Бас редактор

ЖҰРЫНОВ Мұрат Жұрынұлы, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Қазақстан Республикасы Ұлттық Ғылым академиясының президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан) Н = 4

Редакциялық алқа:

ӘБСАМЕТОВ Мәліс Құдысұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «У.М. Ахмедсафина атындағы гидрогеология және геоэкология институтының» директоры (Алматы, Қазақстан) Н = 2

ЖОЛТАЕВ Герой Жолтайұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, Қ.И. Сатпаев атындағы геология ғылымдары институтының директоры (Алматы, Қазақстан) Н=2

СНОУ Дэниел, Ph.D, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска штаты, АҚШ) Н = 32

ЗЕЛЬТМАН Реймар, Ph.D, табиғи тарих мұражайының Жер туралы ғылымдар бөлімінде петрология және пайдалы қазбалар кен орындары саласындағы зерттеулердің жетекшісі (Лондон, Англия) Н = 37

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция) Н=15

ШЕН Пин, Ph.D, Қытай геологиялық қоғамының тау геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Пекин, Қытай) Н = 25

ФИШЕР Аксель, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 6

КОНТОРОВИЧ Алексей Эмильевич, геология-минералогия ғылымдарының докторы, профессор, РҒА академигі, А.А. Трофимука атындағы мұнай-газ геологиясы және геофизика институты (Новосибирск, Ресей) Н = 19

АБСАДЫКОВ Бахыт Нарикбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, А.Б. Бектұров атындағы химия ғылымдары институты (Алматы, Қазақстан) Н = 5

АГАБЕКОВ Владимир Енокович, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь) Н = 13

КАТАЛИН Стефан, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 20

СЕЙТМҰРАТОВА Элеонора Юсуповна, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, Қ.И. Сатпаев атындағы Геология ғылымдары институты зертханасының меңгерушісі (Алматы, Қазақстан) Н=11

САҒЫНТАЕВ Жанай, Ph.D, қауымдастырылған профессор, Назарбаев университеті (Нұр-Сұлтан, Қазақстан) Н = 11

ФРАТТИНИ Паоло, Ph.D, Бикокк Милан университеті қауымдастырылған профессоры (Милан, Италия) Н = 28

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.
Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*
Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.
Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

© Қазақстан Республикасының Ұлттық ғылым академиясы, 2021

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

Главный редактор

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик НАН РК, президент Национальной академии наук Республики Казахстан, генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан) H = 4

Редакционная коллегия:

АБСАМЕТОВ Малис Кудысович, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан) H = 2

ЖОЛТАЕВ Герой Жолтаевич, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, директор Института геологических наук им. К.И.Сатпаева (Алматы, Казахстан) H=2

СНОУ Дэниел, Ph.D, ассоциированный профессор, директор Лаборатории водных наук университета Небраски (штат Небраска, США) H = 32

ЗЕЛЬТМАН Реймар, Ph.D, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия) H = 37

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция) H=15

ШЕН Пин, Ph.D, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай) H = 25

ФИШЕР Аксель, ассоциированный профессор, Ph.D, технический университет Дрезден (Дрезден, Берлин) H = 6

КОНТОРОВИЧ Алексей Эмильевич, доктор геолого-минералогических наук, профессор, академик РАН, Институт нефтегазовой геологии и геофизики им. А.А. Трофимука СО РАН (Новосибирск, Россия) H = 19

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, член-корреспондент НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан) H = 5

АГАБЕКОВ Владимир Енокович, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь) H = 13

КАТАЛИН Стефан, Ph.D, ассоциированный профессор, Технический университет (Дрезден, Берлин) H = 20

СЕЙТМУРАТОВА Элеонора Юсуповна, доктор геолого-минералогических наук, профессор, член-корреспондент НАН РК, заведующая лаборатории Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) H=11

САГИНТАЕВ Жанай, Ph.D, ассоциированный профессор, Назарбаев университет (Нурсултан, Казахстан) H = 11

ФРАТТИНИ Паоло, Ph.D, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия) H = 28

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

© Национальная академия наук Республики Казахстан, 2021

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

Editor in chief

ZHURINOV Murat Zhurinovich, doctor of chemistry, professor, academician of NAS RK, president of the National Academy of Sciences of the Republic of Kazakhstan, general director of JSC “Institute of fuel, catalysis and electrochemistry named after D.V. Sokolsky» (Almaty, Kazakhstan) H = 4

Editorial board:

ABSAMETOV Malis Kudysovich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, academician of NAS RK, director of the Akhmedsafin Institute of hydrogeology and hydrophysics (Almaty, Kazakhstan) H = 2

ZHOLTAEV Geroy Zholtaevich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, director of the institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=2

SNOW Daniel, Ph.D, associate professor, director of the labotatory of water sciences, Nebraska University (Nebraska, USA) H = 32

Zeltman Reymar, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) H = 37

PANFILOV Mikhail Borisovich, doctor of technical sciences, professor at the Nancy University (Nancy, France) H=15

SHEN Ping, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) H = 25

FISCHER Axel, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) H = 6

KONTOROVICH Aleksey Emilievich, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) H = 19

ABSADYKOV Bakhyt Narikbaevich, doctor of technical sciences, professor, corresponding member of NAS RK, Bekturov Institute of chemical sciences (Almaty, Kazakhstan) H = 5

AGABEKOV Vladimir Enokovich, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) H = 13

KATALIN Stephan, Ph.D, associate professor, Technical university (Dresden, Berlin) H = 20

SEITMURATOVA Eleonora Yusupovna, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=11

SAGINTAYEV Zhanay, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) H = 11

FRATTINI Paolo, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) H = 28

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

© National Academy of Sciences of the Republic of Kazakhstan, 2021

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF
KAZAKHSTAN **SERIES OF GEOLOGY AND TECHNICAL SCIENCES**
ISSN 2224-5278
Volume 5, Number 449 (2021), 161-169 ***https://doi.org/10.32014/2021.2518-170X.110***

UDC 624.132.3, 30.19.29, 52.39.37.

Turgumbayev J.J.[1*], Turgunbayev M.S.[2]

[1]Kyrgyz State Technical University named after Razzakov, Bishkek, Kyrgyzstan;
[2]Talas State University, Talas, Kyrgyz Republic.
E-mail: jenishtur@gmail.com

PREDICTION OF THE CUTTING RESISTANCE FORCE OF THE SOIL CONTAINING STONY FRACTIONS

Abstract. Soils containing stony inclusions can be represented as a soil-stone mixture with a different content of stony inclusions. This mechanical mixture is mainly a source of generating random loads and premature fatigue destruction of the metal structure of the earthmoving machine during its operation, increasing the cost of soil development. In order to predict the strength of the cutting resistance has been developed of the soil containing a spherical rocky inclusion, an analytical model based on the theory of the ultimate equilibrium of the bulk medium, dimensional analysis of dependence parameters and similarity principles. The principle of dividing the surface of a rocky inclusion is applied into elementary ball retaining belts, to which components of passive ground pressure are applied. Stress zones are conditionally distinguished on the surface of the cutting tool (homogeneous zone), and around the rocky inclusion (rocky zone). In the absence of a rocky inclusion, the resistance force of a homogeneous ground to cutting is calculated. The value of the resistance force of the soil is influenced by the strength parameters and the geometry of the cutting of the soil, the size of the rocky inclusion and the quantitative content of stones in the soil.

The types of soil destruction with rocky inclusion are determined depending on the coordinate of the action of the cutting element. The correctness of the developed model is evaluated in comparison with experimental data. A computational analysis is carried out of the dynamics of the cutting resistance force arising from the heterogeneity and structural randomness of soils containing rocky inclusions. With an increase in the content of stones in the soil, the values of the angle of friction of the soil against the working body and the specific cohesion of the soil increase, which ultimately cause an increase in the strength of resistance of soils containing stony inclusions to cutting.

It should be noted that the geometric shape of stony inclusions in the soil array varies randomly, and the above technique allows us to develop a model for predicting the strength of resistance to cutting of soil containing various stony inclusions, for example ellipsoid shape.

Key words: Soils containing stony fractions, stony fractions, cutting resistance force, analytical model, theory of the limiting equilibrium of a loose medium, dimensional analysis, structural state, heterogeneity, structural randomness.

Introduction. There is a tendency in the world to automate the process of digging soil with earthmoving machines [1] - [2]. The effective implementation of the plan for the development of heterogeneous soils by earthmoving machines mainly depends on taking into account the ground conditions and power constraints on the working equipment [3]. It is known that soils contain stony fractions in different amounts, their geometric shape and size, and the depth of their occurrence in the soil mass change randomly. Soils containing stony fractions can be represented as a soil-stone mixture with a different content of stony fractions by mass.

The metal structure of the working equipment of earthmoving machines undergoes random loading processes during operation. The structure of these random processes depends mainly on the presence of solid large rock fragments in the ground – stony fractions. The area of stony soils in the Kyrgyz Republic only in the zone of agriculture is about 3809 thousand hectares, including: slightly stony – 1477 thousand hectares; medium stony – 1495 thousand hectares; strongly stony -10.4 thousand hectares [4].

Methods for determining the parameters of both homogeneous soil and soil with rocky inclusions have been developed to predict the strength of soil resistance, modeling the trajectories of the excavator's working equipment in automatic mode [5] - [7]. The soil containing stony fractions is a type of uneven loose sedimentary material consisting mainly of stone, fine-grained soil, water and pores, which is located between the homogeneous soil and the fractured rock mass of the Quaternary period. The strength and deformation characteristics of the stony fractions are directly affected by its structural state: the number, location, shape, cementation of block stones and porosity. On the basis of three-dimensional modeling, a mesostructural model of a stony fractions was developed and used to model shear strain curves [8]. In [9] the deformation characteristics of the shear zone and the movement of block stones in stony fractions are studied experimentally.

Analytical [10] - [13] and numerical models [14] - [19] have been developed to predict the strength of soil resistance to cutting. In the work [11], the cutting resistance force is determined without taking into account the effects of the angle, cutting width, and features of the normal and tangent components of the passive ground pressure of a homogeneous and rocky zone. The volume of the soil is determined based on the pre-set values of the shear angles of the central and lateral parts of the fracture slot.

Based on the Poisson distribution of random events (components of the drag force) in the half-space of the bulk material Z. Korzen [12] established a mathematical regression dimensionless model of the resistance of inhomogeneous rocks to cutting with a curved cutting tool. To establish the coefficients of the mathematical model, active orthogonal experiments were carried out involving the cutting geometry, humidity, velocity, and average size of mineral rock particles. The regression model does not take into account the cohesive and frictional properties, which are the main factors that affect the strength of the resistance of the soil containing stony fractions to cutting.

The aim of the study is to develop an analytical model for predicting the cutting resistance of soil containing stony fractions.

Physical characteristics of the dimensional cutting space of soils with stony fractions. The first necessary step is to determine the variables that significantly affect the soil-cutting element system. The relevant characteristics of the soil are those that have a fairly direct relationship to the forces or movements. According to the generally accepted notation, the set of parameters that affect the process of mechanical cutting of soil containing stony fractions can be expressed as follows:

$$P_{cs} = f(\sigma_n, \tau_n, \gamma, C, \varphi, \varphi_0, p, v, g, \alpha, h, b, R_s), \qquad (1)$$

where: σ_n and τ_n – normal components of the passive ground pressure, γ - volume weight, C - adhesion, φ - angle of internal friction, φ_0 - angle of external friction, p - loading, v - cutting speed, g - acceleration of gravity, α - cutting angle, h_s - cutting depth, b_s - cutting width, R_s - radius of the stony fractions.

To satisfy the similarity principles based on the pi-theorem [20] and the ratio of forces to gravity form dimensionless groups of parameters:

$$\frac{P_{cs}}{\gamma L^3} = f\left(\frac{\sigma_n}{\gamma L}, \frac{\tau_n}{\gamma L}, \frac{C}{\gamma L}, \frac{p}{\gamma L}, \frac{v^2}{gL}, \varphi, \varphi_0, \alpha\right). \qquad (2)$$

In (2), each group is dimensionless, does not depend on any particular parameter, and to ensure similarity between the parameters of the prototype of the nature – Pt_{ni} and the model – Pt_{mi}, the scale value – k_{Li} is introduced:

$$Pt_{m_i} = k_{L_i} Pt_{n_i} \qquad (3)$$

In this case, the process of cutting soil with stony fractions is described by the same differential equations of equilibrium, continuity conditions, stress state equations based on the general provisions of the theory of elasticity and the theory of plasticity. The cutting speed, which varies in the range (observed in production conditions), does not significantly affect the value of the sand cutting force [21]. The determination of the cutting resistance of the soil containing the stony fractions is based on the theory of the limiting equilibrium of a loose medium [22]. The design scheme of the soil resistance acting on the cutting element of the earthmoving machine is shown in Fig. 1, where it is possible to conditionally distinguish the stressed zones of homogeneous soil and the zones around the stony inclusion in compliance with the condition of geometric similarity. Surface of the cutting element (bucket tooth) and stony fractions are represented by a set of elementary retaining walls and to follow them accordingly elemental powers of resistance of the soil cutting dP_o homogeneous zones (zone I) and the resistance of the soil around the stony dP_s (zone II, zone III). The destruction of the soil occurs when the maximum stress state is reached on the sliding surfaces. For elementary retaining walls, to determine the force of resistance to cutting, you can apply the forces of ground resistance [22]. The cutting force of the soil containing the stony fractions is balanced by the forces of the resistance of the soil to cutting:

$$P_{cs} = P_{rs}. \qquad (4)$$

The soil containing the stony fractions has a complex stress state. Taking into account the many factors that affect the process of cutting the soil, for practical calculations, an approximate determination of the resistance force of the soil containing the stony fractions is carried out.

The P_{rs} force includes the ground resistance force on the surface of the cutting element P_h and the resistance force on the surface (around) the rock particle P_s, as well as the force of pushing the stone to the surface of the P_g

$$P_{rs} = P_h + P_s + P_g. \qquad (5)$$

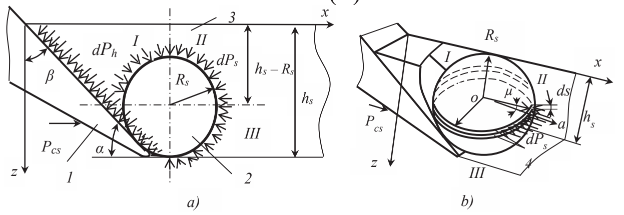

Fig. 1. Calculation scheme for determining the resistance of soil containing spherical stone activation: 1 – cutting element, 2 - stony fraction, 3 – ground, 4 – basic retaining wall (ball belt), β is the angle of inclination of the surface of the cutting element from the vertical, h_s – depth of the stony fraction, ds – height retaining walls, I, II, III – coverage of passive earth pressure.

In the absence of a stony fraction, when $R_s = 0$, forces $P_s = 0$, $P_g = 0$, we have only a homogeneous soil: $P_{rs} = P_h$. The resistance force of a homogeneous ground zone to cutting is defined as [23]:

$$P_h = \sqrt{\left(A - Hh_s/\sin\alpha\right)^2 + \left(A\tan\varphi_0\right)^2}\,\sin\left(\alpha + \varphi_0\right)b_s\eta_{sp_s}, \qquad (6)$$

where $A = a_{\beta_i}\left(0{,}5\gamma h_s^2 + ph_s + Hh_s\right)/\sin\alpha$, H = Cctgφ, $a_{\beta i}$ – the slope coefficient of the retaining walls, η_{sps} - the spatiality coefficient.

Depending on β, the elementary ball belts facing the day surface (zone II) will be located in steep, intermediate and flat areas, and the ball belts that face deep into the ground mass (zone III) are located in the so-called broken areas. The coefficient $a_{\beta i}$ is defined in [22]. The position of the elementary ball belts determines the rotation of R_s by an angle μ_i with a given step, relative to the oa axis (Fig. 1b).

The curved surface of the elementary ball belts is approximated by a straight surface, and the approximation error depends on the size of the split step (Fig. 2). The depth of the detrital-stone particle in the soil mass is determined by the expression

$$h_s = h + k_h R_s, \qquad (7)$$

where k_h is the depth coefficient of the stony fraction, h - cutting depth of homogeneous soil.

Depending on the value of k_h, the soil can be destroyed with intensive (k_h = 0...0.25), with extensive removal of stone from the massif (k_h = 0.25...1.75), and with the indentation of the stony fraction into the soil massif (k_h > 1.75) [24]. In our case, k_h = 0, then h_s = h.

Next, we consider the acting forces on the example of one elementary retaining wall (Fig. 2b) with an angle of μ.

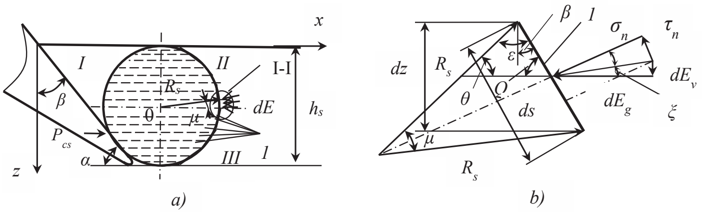

Fig. 2. Scheme for determining the resistance force on the surface of a stony fraction: 1 – elementary retaining wall, dE – elementary resultant ground pressure, dE_v - vertical and dE_g – horizontal components of dE.

The range of variation of the angle of rotation R_s from the oa axis towards the day surface and deep into the soil mass is 0 ... π/2 with a given step - μ. The split step is defined by the expression:

$$\mu = \pi / 2n \ , \qquad (8)$$

where n is the total number of partitions into elementary strips.

The inclined height is a constant value in all elementary walls, and is determined by the expression:

$$ds = 2R_s \sin \mu / 2 \qquad (9)$$

The angle ε is determined by the sine theorem:

$$\varepsilon = \sin^{-1}(R_s \sin \mu / ds) \qquad (10)$$

The point of intersection of the secant plane with the particle surface determines the position of the elementary retaining strip relative to the oa axis (Fig.1b), characterized by the angle θ_i, which is determined by the expression:

$$\theta_i = i\mu \text{, where i = 0,1,2,3…n} \qquad (11)$$

moreover $\theta_0 = 0$.

Determine the angles Q_i and β_i:

$$Q_i = \pi - \theta_i - \varepsilon \text{, where i =0,1,2,3…n} \qquad (12)$$

moreover $Q_0 = \pi/2$.

$$\beta_i = \pi/2 - Q_i \text{, , where i = 0,1,2,3…n} \qquad (13)$$

moreover $\beta_0 = 0$.

In turn, the height of the elementary strips is determined by the expressions:

in the direction of the day surface of the ground

$$z_{u_i} = (h_s - R_s) - ds \cos \beta_i \text{ , i = 0,1,2,3…n} \qquad (14)$$

moreover $z_0 = h_s - R_s$;

to the side deep into the ground mass

$$z_{m_i} = (h_s - R_s) + ds \cos \beta_i \text{, i = 0,1,2,3...n} \qquad (15)$$

moreover $z_0 = h_s - R_s$.

The area of an elementary strip is defined by the following expression:

$$dF_i = dv_{s_i} ds \text{, where i = 0,1,2,3…n} \qquad (16)$$

where dv_{si} is the average length of the generators of the elementary strip.

At the time of the limit equilibrium cutting force is balanced by the passive soil pressure applied on the surface of the cutting element (zone I, Fig. 1,2), and passive pressure acting on the surface of stony fractions, viewed in the direction of cutting (zones II, III, Fig. 1,2). In this regard, the expression for determining dv_s takes into account part of the length of the generators of the elementary strip:

$$dv_{s_i} = \pi(R_i + R_{i+1})/2 \text{, where i = 0,1,2,3…n} \qquad (17)$$

$$R_i = R_s \cos \theta_i \text{, where i = 0,1,2,3…n} \qquad (18)$$

moreover $R_0 = R_s$.

Then: $dF_i = \pi R_s^2 \sin \frac{\mu}{2} (\cos \theta_i + \cos \theta_{i+1})$, where i = 0,1,2,3…n . (19)

The elementary force of the cutting resistance on the surface of the stony fraction is equal to:

$$dP_{s_i} = dE_{g_i} dF_i \qquad (20)$$

In turn, the tangent of the pressure component to the ground cutting path is defined as:

$$dE_{g_i} = dE_i \cos \xi_i \ , \qquad (21)$$

where dE_i is the resultant of the passive ground pressure.

The value of the angle ξ_i is determined by the expressions:

$\xi_i = \pi/2 - Q_i - \varphi_0$, if $(Q + \varphi_0) < \pi/2$ (22)

$\xi_i = Q_i + \varphi_0 - \pi/2$, if $(Q + \varphi_0) > \pi/2$. (23)

The resultant of the ground pressure is determined by the dependence:

$$dE_i = \sqrt{\sigma_{n_i}^2 + \tau_{n_i}^2}\,. \qquad (24)$$

The normal (as hydrostatic) ground pressure on the elementary strips [22] is determined by the formula:

$$\sigma_{n_i} = (\gamma z_i + p + H)a_{\beta i} - H\,, \quad i = 1,2,3...n, \qquad (25)$$

where, z_i is the height of elementary spherical strips on the surface of a stony fraction;
and the tangential ground pressure on the elementary strips [22] is determined by the expression:

$$\tau_{n_i} = \left(\sigma_{n_i} + H\right)\tan\varphi_0\,, \quad i = 1,2,3...n. \qquad (26)$$

The tangential drag force is equal to the sum of the elementary ground cutting resistance forces dP_{si}

$$P_s = \sum_{j=1}^{j=4}\sum_{i=1}^{i=n} P_{s_j} dP_{s_i}\,, \qquad (27)$$

where j = 1 is a steep area, j = 2 is an intermediate area, j = 3 is a flat area, and j = 4 is a polyline area.

Now substituting in (27) the expressions (19), (24) we get the formula for the resistance force to cutting the soil on the surface of the stony fraction:

$$P_s = \sum_{j=1}^{j=4}\left[\pi R_s^2 \sin\frac{\mu}{2}\sum_{i=1}^{i=n} dE_i\left(\cos\theta_i + \cos\theta_{i+1}\right)\cos\xi_i\right] \qquad (28)$$

$$P_g = 4\pi R_s^3 \gamma_s f_s / 3, \qquad (29)$$

where γ_s is the volume weight of the stone, and f_s is the coefficient of friction of the stone with the ground.

Thus, on the basis of formulas (5) and (6), taking into account formulas (28) and (29), we obtain a generalized dependence for calculating the cutting resistance force of a soil containing a spherical stony particle under a steady state, with a sharp cutting element:

$$\begin{gathered} P_{rs} = \sqrt{\left(A - Hh_s/\sin\alpha\right)^2 + \left(A\tan\varphi_0\right)^2}\,\sin\left(\alpha + \varphi_0\right)b_s\eta_{sp_s} + \\ + \sum_{j=1}^{j=4}\left[\pi R_s^2 \sin\frac{\mu}{2}\sum_{i=1}^{i=n} dE_i\left(\cos\theta_i + \cos\theta_{i+1}\right)\cos\xi_i\right] + 4\pi R_s^3\gamma_s f_s/3 \end{gathered}\,, \qquad (30)$$

where i = 1,2,3…n, j = 1…4, $A = a_{\beta_i}\left(0{,}5\gamma h_s^2 + ph_s + Hh_s\right)/\sin\alpha$.

The analysis of the dependence (30) shows that the cutting resistance force is influenced by the parameters of the strength and cutting of the soil, the radius of the stony fraction, and the influence of the latter on the cutting resistance force occurs according to a quadratic dependence.

When $(h_s – R_s) < R_s$, the rocky inclusion begins to protrude beyond the day surface of the ground, a “passive part” of the stone appears and the boundary of its appearance is determined by the critical value of μ_{cr}:

$$\begin{cases} \mu_{cr} = a\sin\left[\left(h_s - R_s/R_s\right)\right], when\left(h_s - R_s\right) > 0 \\ \mu_{cr} = a\sin\left[\left(R_s - h_s/R_s\right)\right], when\left(h_s - R_s\right) < 0 \end{cases} \qquad (31)$$

The change in the cutting width when the rocky inclusion protrudes beyond the cutting width is determined by the expression:

$$b_s = \begin{cases} b, when\, b > 2\cot\left(\psi_{ss}\right)\left(R_s/\cos\psi_{ss} - R_s\right) \\ 2\cot\left(\psi_{ss}\right)\left(R_s/\cos\psi_{ss} - R_s\right), when\, b \le 2\cot\left(\psi_{ss}\right)\left(R_s/\cos\psi_{ss} - R_s\right) \end{cases}, \qquad (32)$$

where b is the cutting width of a homogeneous ground, ψ_{ss} – lateral angle of destruction.

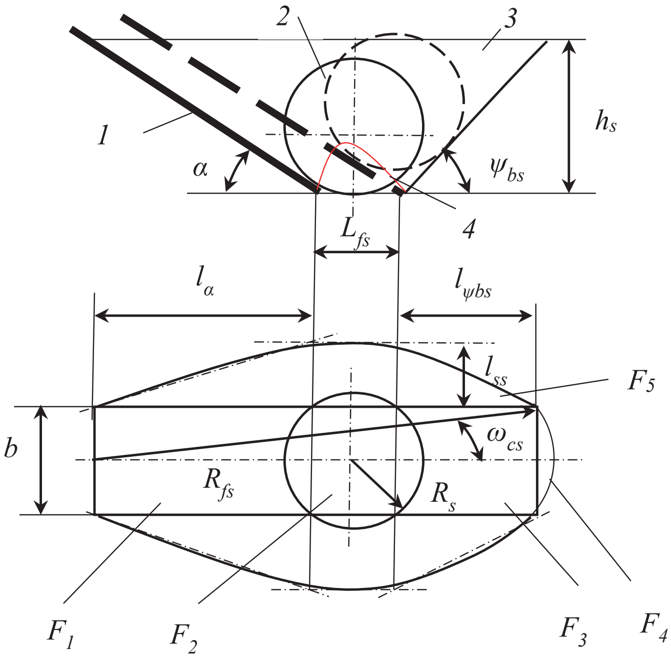

Fig. 3. Scheme for determining the volume of the destroyed soil with a rocky inclusion: 4 - graph of the change in the resistance force of the soil, L_{fs} - cutting length (experimentally determined), F_1, F_2, F_3, F_4, F_5 – the area of the parts of the destruction.

The volume of the soil of the central part and the lateral destruction (Fig.3) calculated by the formulas:

$$V_1 = h_s\left[0.5h_s \cot(\alpha) b_s\right], V_2 = h_s\left(L_{fs} b_s\right), V_3 = h_s\left[0.5h_s \cot(\psi_{bs}) b_s\right], V_4 = h_s\left[0.25R_{fs}^2\left(2\omega_{cs} - \sin 2\omega_{cs}\right)\right],$$

$$\omega_{cs} = a\sin\left(0.5b_s R_{fs}\right), V_5 = h_s\left[\left(0.5R_{fs}\cos\omega_{cs} + L_{fs}\right)\cdot l_{ss}/3\right], R_{fs} = \sqrt{\left\{h_s\left[\left(\cot(\alpha) + \cot(\psi_{bs})\right)\right] + L_{fs}\right\}^2 + \left(0.5b_s\right)^2} \quad (33)$$

The spatiality coefficient is defined by the expression:

$$\eta_{sp_s} = 1 + n_s V_5 \Big/ \left(\sum_{i=1}^{4} V_i\right) \quad (34)$$

where $n_s = 0$, with the free cutting, $n_s = 1$, when polubarinova cutting, $n_s = 2$, at locked cuts.

Experimental work was carried out on cutting the soil containing stony fractions on the stand [25] (Table 1).

Table 1 - Initial experience data

Ground	R_s, m	C, Па	γ, n/m³	φ, ⁰	φ_0, ⁰	α, ⁰	h, m	b, m	η_{sps}	k_h
Sandy loam	0.064-0.108	15500	19790	32	25.6	45	0.15	0.15	1.589…1.663	0…0.05

Figure 4 shows a comparative analysis of the cutting resistance force according to different methods and experiments.

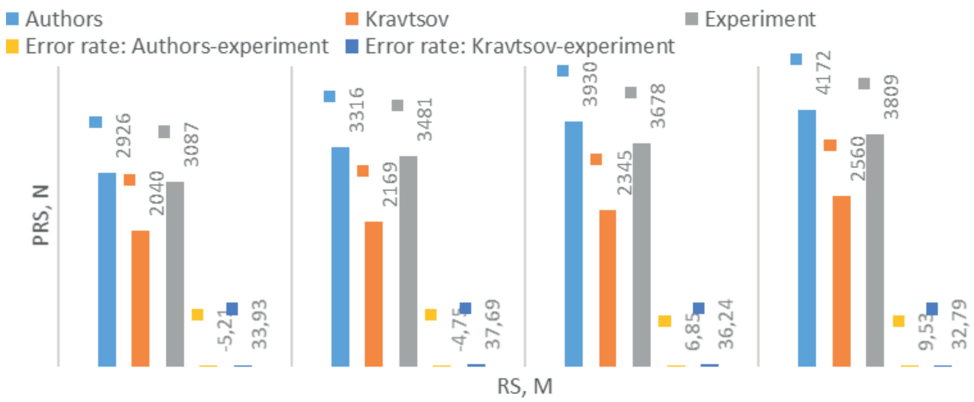

Fig. 4. Comparative analysis of the cutting resistance force according to different methods and experiments

The analysis shows that the discrepancy between the values of the resistance force according to the methods of the authors and E. Kravtsov is in the range of 30.29...40.32% when cutting sandy loam containing stony fractions with an average radius of 0.064...0.108 m. Obviously, this error is caused by the fact that in [11] the cutting resistance force is determined without taking into account the effects of the angle, cutting width, features of the normal and tangent components of the passive ground pressure of a homogeneous and rocky zone. The error in the forces of resistance to cutting soil with stones between the authors ‘ method and the experiment is -5.21...9.53%, and between the method of E. Kravtsov and the results of the experiment – 32.79...37.69%. It should be noted that the discrepancy in the resistance force determined by the E. Kravtsov method increases with the increase in the size of the stone and the cohesive properties of the soil.

According to the data [9], a computational analysis of the dynamics of the cutting resistance force as a function of the number of stony fractions in the ground is carried out (Fig.5).

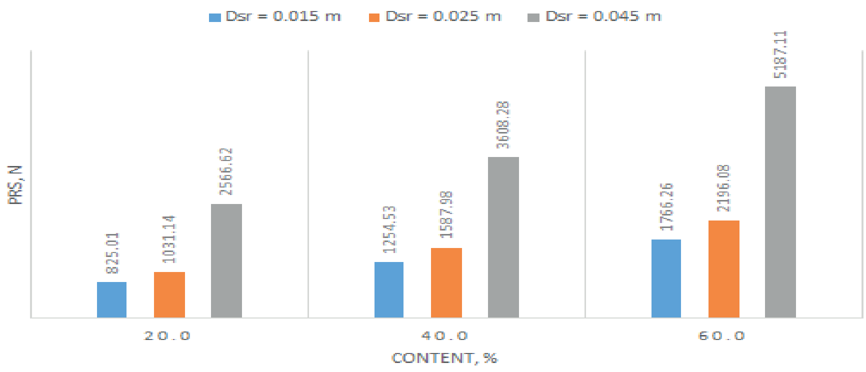

Fig. 5. Computational analysis of the change in the cutting resistance force depending on the content of stones in the ground

The analysis shows that with an increase in the content of stones, the values of the angle of friction of the soil against the metal and the specific cohesion of the soil increase, which ultimately cause an increase in the resistance force of the soil-stone mixture to cutting.

Conclusions the perspective of the methodology application. Soils containing stony fractions can be represented as a mechanical mixture of soil with stony fractions. The heterogeneity and random content of rock particles in the soil have a significant impact on the strength of the soil resistance to cutting. The similarity principles allow the use of passive ground pressure components to develop an analytical model of the cutting resistance force. Its value is influenced by the strength parameters and the cutting geometry of the soil, the radius of the stony fractions and the structural effect. The influence of the radius of the stone on the strength of the resistance to cutting occurs according to the quadratic dependence.

The above methodology allows us to develop methods for predicting the strength of resistance to cutting of soil containing stony fractions of ellipsoid geometric shape.

Тургумбаев Ж.Ж.[1*], Тургунбаев М.С.[2]

[1]И. Раззаков атындағы Қырғыз мемлекеттік техникалық университеті, Бішкек, Қырғызстан;
[2]Талас мемлекеттік университеті, Талас, Қырғызстан.
E-mail: jenishtur@gmail.com

ТАСТЫ ҚОСЫЛЫСЫ БАР ТОПЫРАҚТЫ КЕСУГЕ ҚАРСЫ ТҰРУ КҮШІН БОЛЖАУ

Аннотация. Тасты қоспалары бар топырақтарды әр түрлі тасты қоспалары бар топырақ-тас қоспасы ретінде қарастыруға болады. Бұл механикалық қоспа құрамы негізінен кездейсоқ жүктемелердің пайда болуы жер қазу машинасының металл конструкциясының мерзімінен бұрын істен шығуынан, оны пайдалану кезінде топырақтың құнын арттыруы болып табылады.

Тасты қосындылары бар топырақты кесуге қарсы тұру мақсатында болжау үшін борпылдақ ортаның шекті тепе-теңдік теориясы, тәуелділік параметрлерін өлшемді талдау негізінде аналитикалық модель жасалды. Кесу элементінің әрекет ету координатына байланысты тасты қосылумен топырақтың бұзылу түрлері анықталды. Тәжірибелік мәліметтермен салыстырғанда әзірленген модельдің дұрыстығы бағаланды. Гетерогенділіктен және тасты қосындылары бар топырақтың құрылымдық апатынан туындайтын кесуге қарсылық күшінің динамикасына есептеу талдауы жүргізілді.

Түйінді сөздер: Тасты қосу, тасты қосу кесуге төзімділік күші, аналитикалық модель, борпылдақ ортаның шекті тепе-теңдік теориясы, өлшемді талдау, құрылымдық күй, гетерогенділік, құрылымдық апат бар топырақ.

Тургумбаев Ж.Ж. [1*], **Тургунбаев М.С.** [2]

[1]Кыргызский государственный технический университет им. И. Раззакова, Бишкек, Кыргызстан;
[2]Таласский государственный университет, Талас, Кыргызстан.
E-mail: jenishtur@gmail.com

ПРОГНОЗИРОВАНИЕ СИЛЫ СОПРОТИВЛЕНИЯ РЕЗАНИЮ ГРУНТА СОДЕРЖАЩЕГО КАМЕНИСТОЕ ВКЛЮЧЕНИЕ

Аннотация. Грунты, содержащие каменистые включения можно представить, как грунтово-каменную смесь с разным содержанием каменистых включений. Указанная механическая смесь главным образом является источником генерации случайных нагружений и преждевременных усталостных разрушений металлоконструкции землеройной машины в процессе ее эксплуатации, повышения себестоимости разработки грунтов.

С целью прогнозирования силы сопротивления резанию грунта, содержащего каменистые включения разработана аналитическая модель на основе теории предельного равновесия сыпучей среды, размерного анализа параметров зависимости. Установлены виды разрушения грунта с каменистым включением в зависимости от координаты действия режущего элемента. Оценена корректность разработанной модели в сопоставлении с экспериментальными данными. Проведен вычислительный анализ динамики силы сопротивления резанию возникающей от неоднородности и структурной случайности грунтов, содержащих каменистые включения.

Ключевые слова: грунт, содержащий каменистое включение, каменистое включение, сила сопротивления резанию, аналитическая модель, теория предельного равновесия сыпучей среды, размерный анализ, структурное состояние, неоднородность, структурная случайность.

Information about the authors:

Turgumbayev Jenishbek Jumadylovich – Doctor of Technical Sciences, Professor, Professor of the Department of Mechanics of the I. Razzakov Kyrgyz State Technical University, Kyrgyz Republic; *jenishtur@gmail.com*, *https://orcid.org.0000-0002-6151-3083*;

Turgunbayev Melisbek Syrgabayevich – Candidate of Technical Sciences, Associate Professor, Associate Professor of the Department of Technologies of Technical Processes of the Talas State University, Kyrgyz Republic; *melis.turgunbaev08@gmail.com,* https://orcid.org/0000-0003-2128-6100.

REFERENCES

1. A. Gurko, O. Sergiyenko, J.I.N. Hipólito, I. Kirichenko, V. Tyrsa and J.D.D.S. Lopez. (2015) Guaranteed control of a robotic excavator during digging process, in Proc. 12th Int. Conf. Informat. Control, Autom. Robot., vol. 2, Jul. 2015, pp. 52–59 (in Eng).
2. Z. Zou, J. Chen and X. Pang. (2019) Task space-based dynamic trajectory planning for digging process of a hydraulic excavator with the integration of soil–bucket interaction, Proc. Inst. Mech. Eng. K, J. Multi-Body Dyn., vol. 233, no. 3, pp. 598–616, Sep. 2019. (in Eng).
3. Turgunbayev M.S. (2020) To the question of the law of distribution of mineral particles of soil. [K voprosu zakona raspredeleniya mineral'nyh chastic grunta] High technologies in the construction complex. Scientific and technical journal. No. 1, 2020. pp. 134-141. www. ttmko.ru. ISSN 2618-9054 (in Russian).
4. Mamytova D.A. (1998) Natural and agricultural zoning and use of land resources of the Kyrgyz Republic [Prirodno-selskohozjajstvennoe rajonirovanie i ispolzovanie zemelnyh resursov Kyrgyzskoj Respubliki]: Author of the dissertation of the Doctor of Agricultural Sciences: Bishkek: NAS KR, 1998. - 35 p. *URL:http://earthpapers.net/preview/35594/*. (in Russian).
5. Yuming Zhao, Jian Wang, Yi Zhang and Chao Juo. (2020) A Novel Method of Soil Parameter Identification and Force Prediction for Automatic Excavation. Digital Object Identifier 10.1109/ACCESS.2020.2965214. (in Eng).

6. Uday K.V., Padmakumar G.P., Singh D.N. (2013) Some studies on morphology of the coarse-grained soils. Eng. Geol. 2013, 152, 48–55. [CrossRef] (in Eng).
7. Chang W.J., Phantachang T. (2016) Effects of gravel content on shear resistance of gravelly soils. Eng. Geol. 2016, 207, 78–90. [CrossRef] (in Eng).
8. Xu W.J., Wang S., Zhang H.Y., Zhang Z.L. (2016) Discrete element modeling of a soil-rock mixture used in an embankment dam. Int. J. Rock Mech. Min. Sci. 2016, 86, 141–156. [CrossRef] (in Eng).
9. Zhiqing L., Feng H., Shengwen Q., Ruilin H., Yingxin Zh. and Yawei B.(2020) Deformation Characteristics of the Shear Zone and Movement of Block Stones in Soil–Rock Mixtures Based on Large-Sized Shear Test. Appl. Sci. **2020**, 10(18), 6475; *https://doi.org/10.3390/app10186475* (in Eng.).
10. Chechenkov M.S. (1987) Development of strong soils [Razrabotka prochnyh gruntov] - L.: Stroyizdat, 1987, 231p. (In Russian).
11. Kravtsov E.A. (1988) Intensification of working processes of earthmoving machines [Intensifikacija rabochih processov zemlerojnyh mashin]. Training manual . - M. MADI, 1988, 91 p. (In Russian).
12. Korzen Z. (1985). Studia Geotechnica et Mechanica, Vol. 7, No. 1, 27-54. (in Eng).
13. Mendekeyev R.A., Turgunbaev M.S. (2015) To determine the strength of resistance to the destruction of a rock containing a stony inclusion by the working body of an earthmoving machine [K opredeleniju sily soprotivlenija razrusheniju porody, soderzhashhej kamenistoe vkljuchenie, rabochim organom zemlerojnoj mashiny] // Mechanization of construction. - 2015. № 8. P. 24-26. *http://ms.enjournal.net/article/11870/* (In Russian).
14. Nureddin Bennett, Ashwin Walawalkar, Meike Heck and Christian Schindler. (2016) Integration of digging forces in a multi body-system model of an excavator. Reprints and permissions: sagepub.co.uk/journals Permissions.nav DOI: 10.1177/1464419315592081 pik.sagepub.com. (in Eng).
15. Ovsyanko V., Petrovsky A. (2014) The computer modeling of interaction between share moulboard surface of plough and soil J. Res. Appl. Agric. Eng. 59 100-3. (in Eng).
16. Lysych M.N. (2019) Review of numerical methods for modeling the interaction of soil environments with the tools of soil tillage machines. Journal of Physics: Conference Series 1399 (2019) 044014 IOP Publishing doi:10.1088/1742-6596/1399/4/044014 1. (in Eng).
17. Chen Y., Li B. (2017) Measurement and modelling of soil displacement from sweeps with different cutting widths Biosyst. Eng. 161 1-13. (in Eng).
18. Ucgul M., Saunders C and Fielke J.M. (2018) Comparison of the discrete element and finite element methods to model the interaction of soil and tool cutting edge Biosyst. Eng. 169 199-208. (in Eng).
19. S.F. Azam, P. Rai. (2020) Finite element-based simulation and analysis of dragline bucket in static and dynamic loading condition, Current Sci., vol. 116, no. 4, p. 612, Jan. 2020. (in Eng).
20. Balovnev V.I. (1994) Modeling of processes of interaction with the environment of working bodies of road-building machines: textbook. manual for universities [Modelirovanie processov vzaimodejstvija so sredoj rabochih organov dorozhno-stroitel'nyh mashin] 2 nd ed., pererab. - M.: Mashinostroenie, 1994. 432 p. (In Russian).
21. L.W. Saperstein, R.N. Franklin (1971) An investigation into the forces on bodies dragged through sand // Journal of Terramechanics, Pergamon Press Printed in Great Britain. 1971, Vol. 8, No. 2. P. 29-37. (in Eng).
22. Sokolovsky V.V. (1954) Static bulk media [Ctatika sypuchej sredy]. M.: Gostekhteoreizdat. (In Russian).
23. Turgumbayev J.J., Turgunbayev M.S. (2021) Predicting the resistance force of homogeneous ground to cutting // News of the Natonal Academy of Sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224-5278 Volume 4, Number 448 (2021), 91-98. *https://doi.org/10.32014/2021.2518-170X.86*. (in Eng).
24. Turgunbaev M.S. (2017) On the question of the features of the destruction of the soil containing detrital-stone inclusions by the working body of the earthmoving machine [K voprosu osobennosti razrushenija grunta, soderzhashhego oblomochno-kamennye vkljuchenija rabochim organom zemlerojnoj mashiny]. Online Journal "Naukovedenie", volume 9, No. 3 (2017), Article URL: htpp://naukovedenie.ru/PDF/98TVN317.pdf (In Russian).
25. Turgunbaev M.S., Shamuratov K.T (2010) Stand for studying the process of cutting soil [Stend dlja issledovanija processa rezanija gruntov] Patent for a utility model of the Kyrgyz Republic [Patent na poleznuju model' Kyrgyzskoj Respubliki] No. 113 dated 30.08.2010. (In Russian).

МАЗМҰНЫ-СОДЕРЖАНИЕ-CONTENTS

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:

www:nauka-nanrk.kz

http://www.geolog-technical.kz/index.php/en/

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Редакторы: *М.С. Ахметова, А. Ботанқызы, Д.С. Аленов, Р.Ж. Мрзабаева*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.08.2021.
Формат 60х881/8. Бумага офсетная. Печать – ризограф.
4,6 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19