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INFLUENCE OF VEHICLE CENTER OF GRAVITY CHANGE ON DYNAMIC CHARACTERISTICS

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Abstract: *The position of the vehicle's center of gravity is one of the most important vehicle parameters, which have a significant role in the dynamic characteristics of the vehicle (roll, pitch, yaw) and the vehicle load transfer. When the vehicle chassis moves, the weight of the vehicle is redistributed, which affects grip and stability. The aim of this work is to prove experimentally the influence of the change in the height of the center of gravity on the vehicle by adjusting the suspension system. Changes in the angles of the vehicle in the longitudinal and transverse planes were observed, such as roll, pitch and yaw of the vehicle.*

The experiment was performed on a vehicle that have a mechanically adjusting suspension system, by moving the spring support point, which changes the vehicle chassis and the height of the center of gravity. The test was performed using the VDA (Verband der deutschen Automobilindustrie) test, which is official as ISO 3888-2, and the data on angle changes were measured using a gyroscopic and GPS sensor. The test results show that a vehicle with a lower center of gravity position has better dynamic characteristics in the form of less roll, pitch and yaw of the vehicle, which leads to the conclusion that the stability of the vehicle is increased.

INTRODUCTION

A Vehicle is a complex system consisting of components arranged within its body with different function, impact and movement. However, for many elementary analyzes that are applied, all components move together. For example, when braking, the vehicle slows down and can be presented as a object with mass at its center of gravity. Knowing the coordinates of the vehicle's center of gravity is one of the necessary conditions for conducting detailed analyzes of a large number of traction and dynamic characteristics of the vehicle. The position of the vehicle's center of gravity is one of the most important parameters of the vehicle, which have a significant role in the dynamic characteristics of the vehicle, its roll, pitch, yaw and the load transmitted to the wheels . The dynamic behavior of a road vehicle is a very important aspect of active vehicle safety. Each vehicle, along with its driver and prevailing environment, represents a unique closed-loop system. The task of assessing dynamic behavior is therefore very difficult, because the significant driver-vehicle-environment interaction is complex in itself. A complete and accurate description of the behavior of a road vehicle must necessarily include information obtained from several different tests. During the test which is used in this paper, significant movement parameters are measured and then comparative criteria for assessing vehicle dynamics are derived.

MATERIALS AND METODS

- ***Calculating the position of the center of gravity***

Calculating the position of the center of gravity of a motor vehicle is very delicate because it requires knowledge of the position of the center of gravity of each part of the vehicle. Therefore, experimental procedures are very often used.

Determination of longitudinal coordinates of the center of gravity

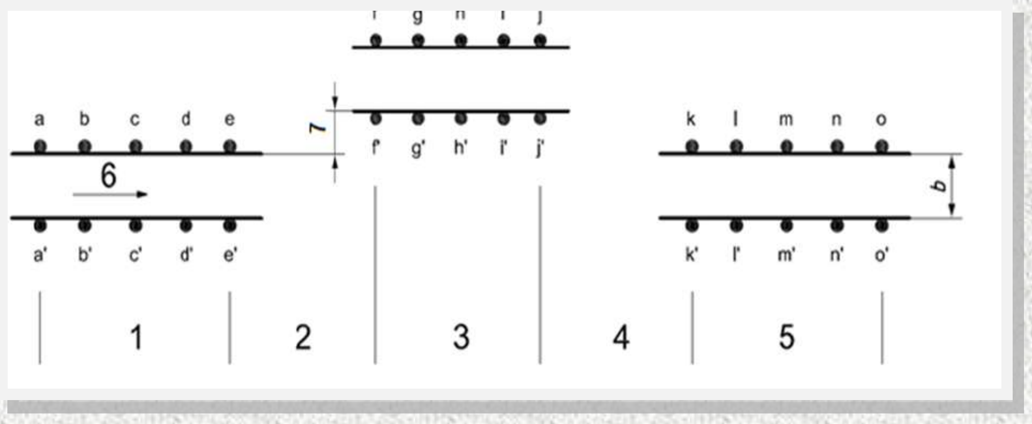
Determining the position of the height of the center

- ***Suspension system with mechanical vehicle height adjustment***

The height adjustment of the vehicle can be achieved mechanically by using a thread located on the elements of the suspension system. The height of the front of the vehicle is adjusted using a threaded spindle located on the damping element under the spring. The height of the rear of the vehicle using an additional element located above the spring, and also has a thread for height adjustment (Figure 22).

- ***Moose test (VDA test)***

The VDA test (Verband der deutschen Automobilindustrie) defines the criteria for the lane change test to ensure that the results are reproducible, visible and also understandable to consumers. The test is designed to provide a criterion for proving vehicle stability in the areas of maneuverability, vehicle control and rolling tendency.



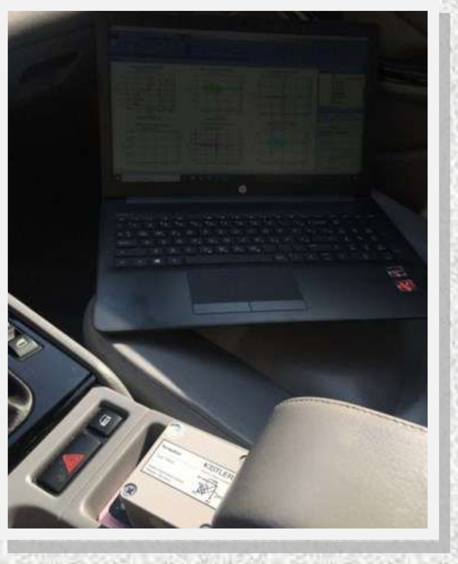
- ***Equipment used in testing***

Kistler tans

Racelogic GPS VBSS05

QuantumX

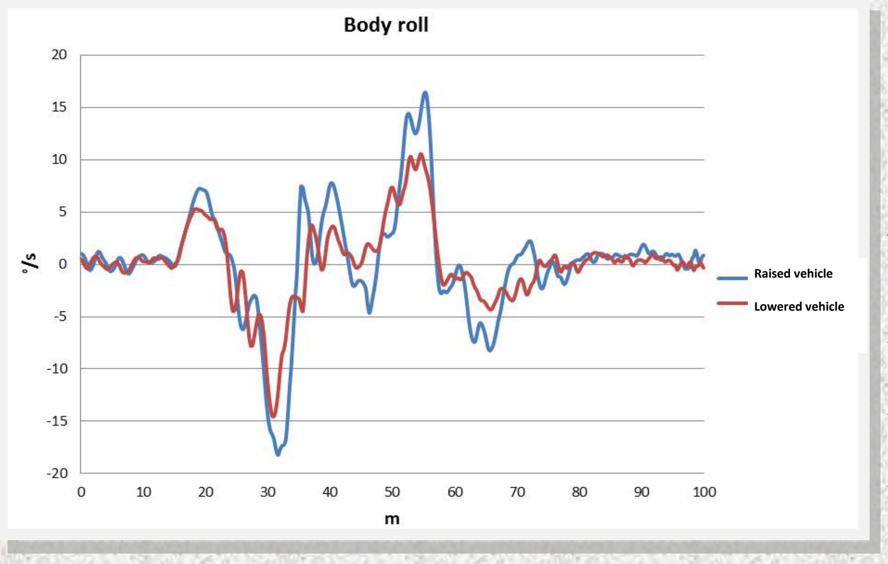
Catman Easy



On 23.08.2020. year at the location Batajnički drum - Zemun (Belgrade), a test of the dynamic characteristics of the vehicle was performed. Based on the calculation and measurement of the vehicle center of gravity position, the navigation sensor is placed approximately in the vehicle center of gravity position so that the results are accurate.

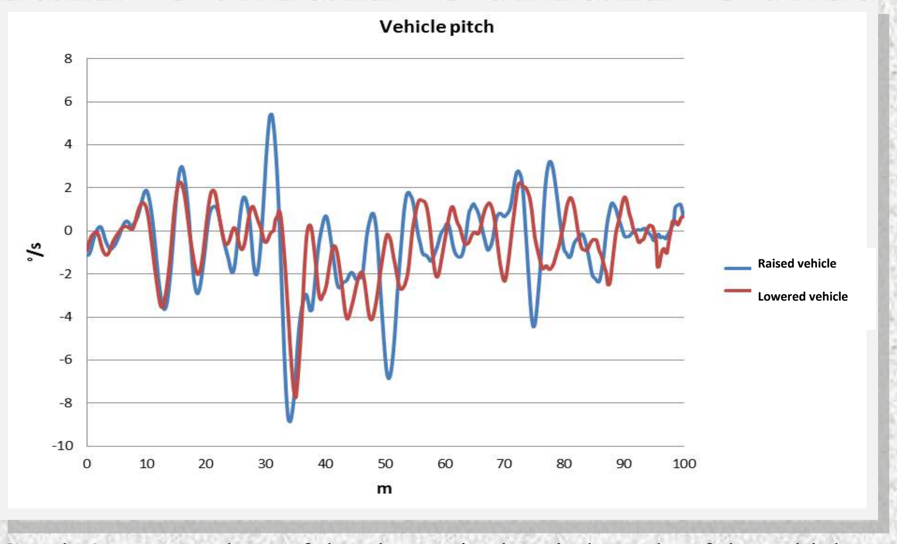
By gradually passing the marked polygons, connecting the speed with each passage, it was installed that the safe speed for binding the test is 65 km / h. The test was performed with the driver and front passenger. After several times the vehicle passed through the polygon, the suspension system was adjusted and the position of the center of gravity was lowered. Based on the measurement of the height of the center of gravity, and the table shown, we notice that by adjusting

By using the mentioned measuring equipment and passing through the polygon, we come to the test results. In order to obtain the most relevant results, the test was repeated six times for a vehicle with a higher and lower center of gravity, after which the results were compared. The following graphs show the obtained values of angles for Roll, Pitch and Yaw of vehicles from three selected vehicle passages.



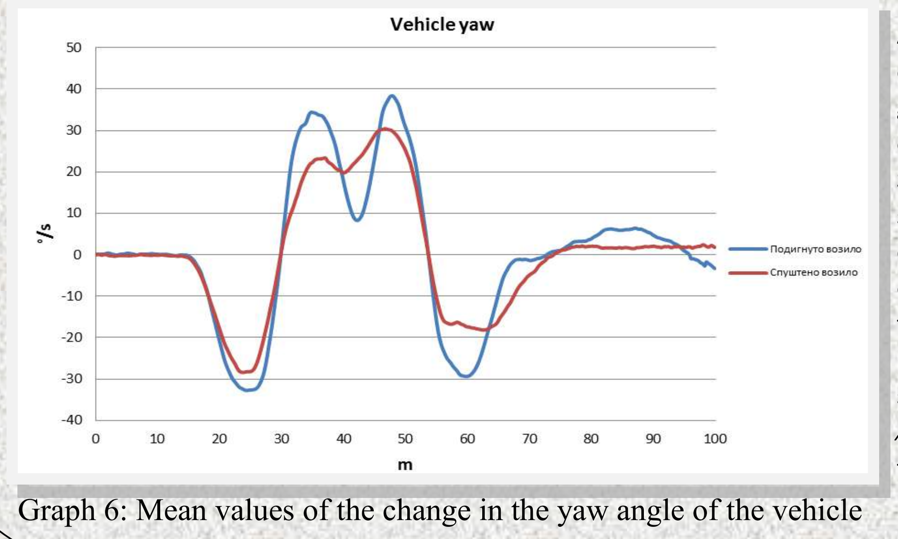
Graph 2: Mean values of the change in the Roll angle of the vehicle

When passing a vehicle through the polygon, the largest change in the value observed on roll of the vehicle, what we can see in Figure 2. By comparing the graphs and observing the maximum values, both for individual passes and for mean values, it can be noticed that the changes in the angle of inclination in time of vehicles with lower center of gravity are smaller compared to vehicles with higher center of gravity by ≈3 °/s. We conclude that a vehicle with a lower center of gravity roll less when performing the test, which results in less redistribution of vehicle weight from one side to the other, and therefore less chance of loss of traction on parts of the track where vehicle wheels become unloaded.



Graph 4: Mean values of the change in the Pitch angle of the vehicle

The change in the angle of the vehicle in the longitudinal plane (Pitch) during the performance of this test was not significantly observed. The values for a vehicle with a lower center of gravity position are higher in some passages than in a vehicle with a higher center of gravity position, and in some passages the situation is opposite. We conclude that when changing direction, the values of angle changes in the longitudinal plane do not change significantly in vehicles with a raised center of gravity position compared to a vehicle with a lower center of gravity position.



Graph 6: Mean values of the change in the yaw angle of the vehicle

According to the obtained results, we can come to the conclusion that when passing a vehicle with a center of gravity in a higher position, there is a greater loss of vehicle control and vehicle yaw, which of course is not desirable. Since the test was prescribed to be performed with vehicle stability control, and for safety reasons, this also contributed to the result. For a vehicle with a raised center of gravity, the difference in yaw angles when passing through the first curve is ≈10%, and then increases when passing through the track. When passing through the second curve the difference between the yaw angles ≈10 ° /s. It can be noticed that through other sections of the track, the difference between the angles yaw is ≈10 ° /s,

RESULTS AND DISCUTION

The first part of the experimental test was to measure the center of gravity of the vehicle. Vehicle measurement and center of gravity determination were performed without a driver. The height of the vehicle's center of gravity was measured in two vehicle states, when the suspension system was set to be raised to the extreme upper position and lowered to the extreme lower position. Based on three measurements and calculations for different vehicle conditions, the following results of the vehicle height position were obtained:

	Suspension system set to the extreme upper position	Suspension system set to the extreme lowered position
h_{T_1}	493,0 mm	437,2 mm
h_{T_2}	486,5 mm	431,7 mm
h_{T_3}	491,4 mm	436,1 mm

CONCLUSION:

Based on the theory and the results of the experiment, we conclude that the height of the vehicle's center of gravity affects its dynamic characteristics and the roll of the vehicle, where the lower the center of gravity the lower the vehicle's roll, which contributes to less mass redistribution and better vehicle stability. This is shown by the results of vehicle yaw during the test, where the results show that the position of the vehicle's center of gravity affects the stability of the vehicle, its handling, which contributes to less vehicle drift, and loss of control over the vehicle while avoiding obstacles, which is simulated by the test. In addition, the height of the center of gravity position also affects the pitch of the vehicle when

EFFECTS OF CONSTRUCTION AND DEMOLITION WASTE LANDFILL ON THE ENVIRONMENT

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Abstract: *In cases of inadequate waste management, there is a tendency for inappropriate disposal of construction and demolition (C&D) waste, especially when its production surpasses the capacities of official disposal sites. By disposing of C&D waste on the edge of the protected natural area during the spring of 2021, a C&D landfill was formed near Reva pond, Belgrade. In this work, the qualitative composition of C&D waste in the field was assessed, including chemical analysis of landfill soil which was investigated by comparing its elemental composition with the control soil by utilizing SEM-EDS analysis. The presence of various C&D waste components, typical (concrete blocks, bricks, armature, glass shards, wood, soil of various origin) and atypical (furniture, industrial-type glass shards, paint bottles and cans), indicated that waste disposal was only partially controlled. Due to the high heterogeneity of the disposed soil, analysis can neither confirm nor exclude the possibility of heavy metal contamination. Herbaceous plants are already naturally colonizing the landfill; also, the aggressively spreading, heavy metal accumulator, honey plant species - the False indigo bush (Amorpha fruticosa), is abundant in the area, and it is expected that it will recultivate the landfill site. To get a full assessment of the landfill's impact on local ecosystems, continuous monitoring is recommended.*

Keywords: *C&D waste; waste disposal; excavated soil; environmental pollution; heavy metals;*

Field photo 1 - Reva C&D waste landfill with visible distinct piles of disposed waste

1. INTRODUCTION

Construction and demolition (C&D) waste is generated in the process of building, and preparation of building sites - commonly including demolition. Each construction project leaves significant amounts of C&D waste in the form of inert waste, non-hazardous (brick, concrete, wood, and other materials) and hazardous (asbestos, materials containing heavy metals, etc.).

Urban development and related construction create various pressures on the environment, including waste generation and changes in land use. The disposal of C&D waste has become a pressing global issue, especially due to the low recycling rates, and its full effect on the environment remains largely unknown [1]. In cases of inadequate local C&D waste management, there is a tendency for inappropriate disposal of C&D waste. Because there is a tendency for C&D waste disposal on uninhabited land in close proximity of the city, forestry and agricultural sectors are especially exposed to pressures from C&D waste generation. [2]

Locality Reva is part of a former distributary of the Danube floodplain, which extends in an east-west direction. The novel C&D landfill is located between the protected natural area "Reva pond" and the protective embankment in the flood zone of Danube (municipality Krnjača, Belgrade) and spans across 7 hectares. The formation of the landfill in early 2021 was marked by many irregularities, and the official cease of all disposal activities happened in June 2021, which also the time when the samples for this study were taken. The ecosystems present at the site included hybrid poplar plantations, hydrophilic deciduous mixed forest, wetland vegetation and ruderal flora along the embankment, with a notable infestation by invasive honey plant False indigo bush (*Amorpha fruticosa*). Reva pond is a part of the internationally recognized Important Bird Area "Usce Save u Dunav" (The confluence of the Sava and the Danube), and also represents a legal hunting ground.

This paper compares the chemical composition of soil found on C&D waste landfill "Reva" with the natural soil sampled in the same area by utilizing SEM-EDS spectral analysis as a comparison method. The overall goal of the study was to gain insight into the properties of the landfill material and the native soil in order to predict the possible future influences on the natural ecosystem.

Field photo 2 - Close-up of leveled C&D waste at the site

Field photo 3 - Vegetation burried by the C&D waste disposal

2. MATERIALS AND METHODS

Field observation was conducted before samples collection, and included the basic visual environmental assessment of the state of the landfill, with focus on the disposed material content and disoisition methods, and vegetation. Soil samples were collected by using standardized soil sampling methods for monitoring pollutants [3,4], slightly modified due to the location's specifics. Forty-seven individual samples from 0-10 cm depth were mixed and quartered to obtain a representative landfill soil sample. The same was done for the control sample obtained from a meadow in a proximity of the landfill, only with a fewer number of individual samples (four), due to the habitat's uniformity.

To compare the morphology of the two samples, scanning electron microscopy (SEM) was applied using JEOL JSM-6390 LV Scanning Electron Microscope at electron beam acceleration voltage of 30 kV. To attain electroconductivity, the samples were coated with gold before analysis in a sputtering chamber (BAL-TEC SCD 005 Sputter Coater, 100 s at 30 mA). Elemental composition was performed using X-Max Energy Dispersive X-ray Spectrometer (EDS) (Oxford Instruments, UK) and AZtecEnergy software (Oxford instruments, UK).

3. RESULTS AND DISCUSSION

3.1. Field observations

The greatest part of the C&D waste was deposited and leveled, rising 4-5 m above the original ground level matching the height of the nearby embankment. On the leveled surface, many aggregations of C&D waste are present in the form of separate piles and include soil, clay, demolished brick and tile, concrete, and glass shards. The presence of discarded furniture, paint and spray cans, glass bottles and other non-C&D waste was also noted, but not prevalent. At the edges of the landfill, waste dumping has knocked over trees, indicating that the site wasn't properly prepared for the waste disposal. At the time of sampling, the herbaceous and predominantly ruderal vegetation has already started to colonize the landfill. Separate unleveled aggregations of soil contained different plant species and communities, meaning that some seeds were brought along with the excavated soil, allowing introduction of plant species not native to the area.

3.2. Soil samples analysis

A semi-quantitative chemical of the samples was done by SEM-EDS method. These results are considered an estimation, used to compare the elemental composition of the samples.

Microstructure of soil samples collected at control and disposal site is presented at Figure 1. It is known that soil is built from mineral particles that differ in terms of size, shape, agglomeration and organic matter in different phases of degradation [5]. Figure 1 (a) shows that such a description can be attributed to the control sample whose aggregates vary in size, shape and inner structure indicating natural origin of soil.

A micrograph of soil from the disposal site at Figure 1 (b) is showing a rough surface texture consisting of larger irregularly shaped agglomerates, separated from each other and whose dimensions do not vary significantly. Coarse textured soils have weak waterproof ability which increases water circulation and consequently spread of contaminants [5]. Such a structure is evidently related to the disposed construction waste since C&D waste is a heterogeneous mix of cement and clay-based composite building materials, and further crushing of C&D waste leads to the formation of a rough fractions of primary aggregates such as gravel, stone, crushed brick; fine particles of sizes smaller than 5 mm are generated [6].

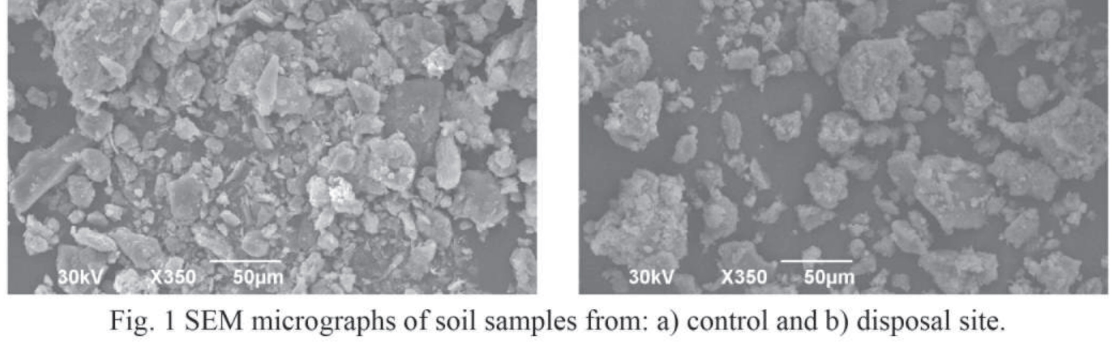

Fig. 1 SEM micrographs of soil samples from: a) control and b) disposal site.

In Table 1, the chemical composition is presented as a sum of elemental content given in weight percentage normalized at 100%. The limit of detection of examined elements was 0.1%.

Quartz (SiO_2) is dominant compound of each mechanical fractions of the naturally occurring soil [8]. In construction waste samples, quartz is attributed to sand particles used for concrete and brick production. Concrete is usually made out of quartz and amorphous carbonates, and quartz and calcite with the addition of clay minerals represent the most common compounds of brick material; however, in the production process that involves high temperatures clay minerals decay and crystal structure is lost leading to the formation of silicon dioxide at the end [6].

Table 1. The chemical composition given as wt.% of samples analyzed in this study

Element	Line Type	C&D-1	Error	C&D-2	Error	Control	Error
C	K series	54.76	0.13	44.17	0.17	38.29	0.34
O	K series	32.47	0.11	38.31	0.13	40.65	0.25
Na	K series	-	-	0.34	0.01	-	-
Mg	K series	0.42	0.01	0.55	0.01	0.88	0.02
Al	K series	2.09	0.01	2.75	0.01	4.32	0.03
Si	K series	4.86	0.02	7.12	0.03	10.38	0.06
K	K series	0.50	0.00	0.57	0.00	0.98	0.01
Ca	K series	2.16	0.01	3.09	0.01	1.67	0.01
Fe	K series	1.17	0.01	1.75	0.01	2.83	0.02
Cu	K series	0.57	0.01	0.47	0.01	-	-
Zn	K series	0.45	0.01	0.39	0.01	-	-
Mo	L series	0.36	0.02	0.33	0.02	-	-
Ba	L series	0.18	0.01	0.16	0.01	-	-
Total:		100.00		100.00		100.00	

Figure 2 and Figure 3 are showing elemental mapping images of soil collected from control and disposal sites, respectively. Elemental mapping of samples microstructures by SEM-EDS method was possible if the element's weight percentage was above 0.1%. In the control soil five elements other than O, C, and Si could be detected (%): $Al<Fe<Ca<K<Mg$ for which the natural distribution in the Earth's crust is significant (8.1%; 5.0%; 3.6%; 2.6%, 2.1%; respectively) [7]. The descending order of elements exactly corresponded to their presence in the Earth's crust.

Trace elements were most likely present in the control sample, but could not be detected here due to limit of detection of examined elements of 0.1% and hence difficulties to separate their characteristic X-ray peaks from the background spectrum. Based on the Al and K elemental mapping, their uniform distribution in the control sample could be observed, while Ca, Mg, and Fe are found in the distinct agglomerates containing their characteristic minerals (Figure 2). Overlapping maps of all detected elements generated one dominant color indicating natural origin of examined soil.

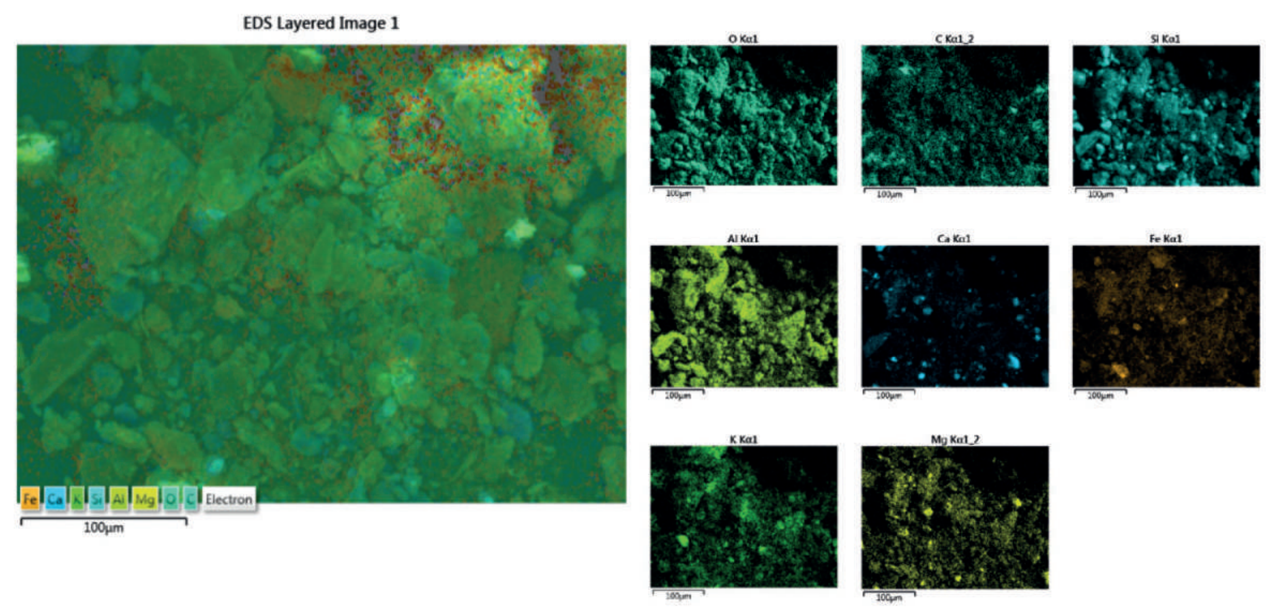

Fig. 2 SEM-EDS elemental mapping images for O, C, Si, Al, Ca, Fe, K, Mg of the control soil sample.

In the sample collected from the disposal site (Table 1, Figure 3), besides major elements Al, Fe, Ca, K, Mg, the traces of Cu, Zn, Mo, Ba were also detected. In the Earth's crust, the sum percentage by weight of all trace elements is 1,5 % [7]. Elements from the C&D-1 sample were aligned in the decreasing order by weight (%): $Ca<Al<Fe<Cu<K<Zn<Mg<Mo<Ba$ (Table 1). This sort of alignment can indicate soil modification. The EDS elemental map (Figure 3) revealed homogeneous dispersion of Mg, Cu, Zn within the sample while Al, Ca, K, Fe, Mo and Ba have shown heterogeneous behavior and were concentrated in individual particles (agglomerates) of the sample. Overall mapping of the sample is showing significant differences in the chemical composition and structure compared to the sample from the control site.

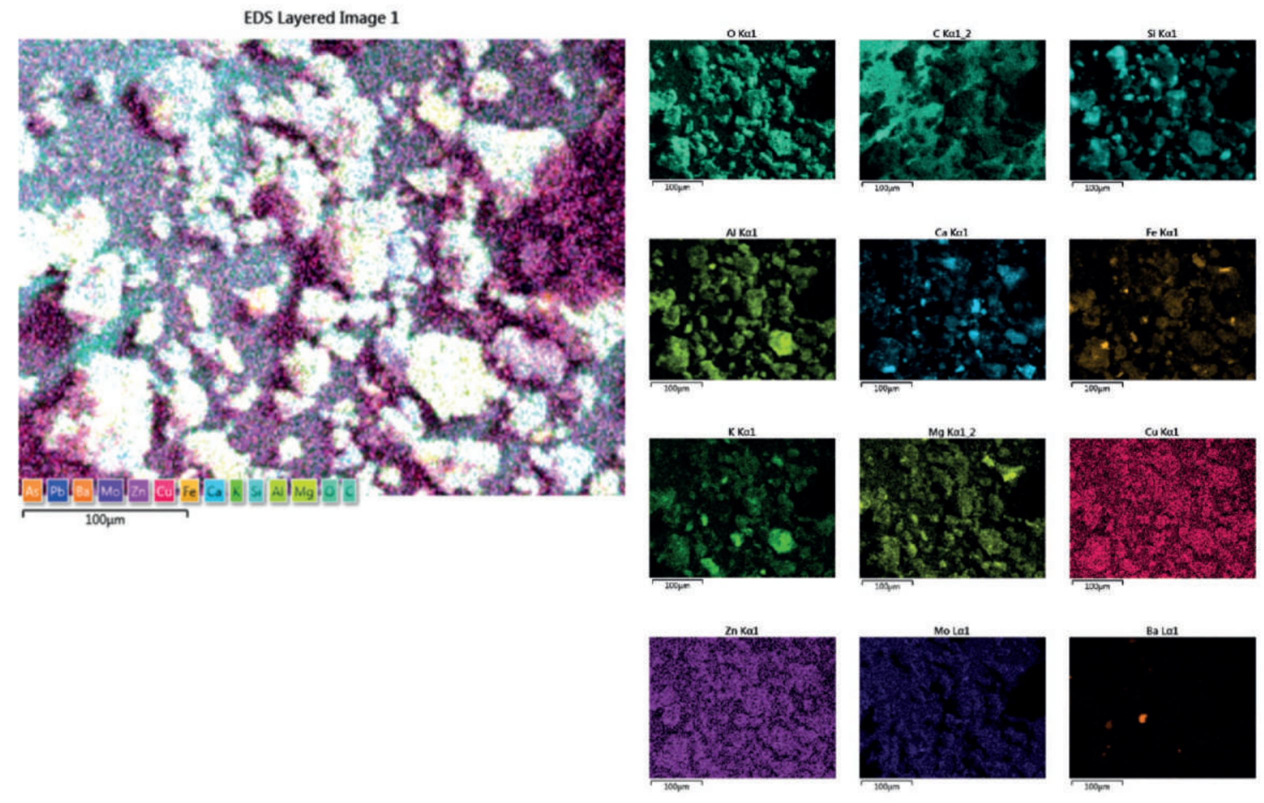

Fig. 3 SEM-EDS elemental mapping images for O, C, Si, Al, Ca, Fe, K, Mg, Cu, Zn, Mo, Ba of disposed soil sample (C&D-1).

4. CONCLUSIONS

No chemical threats arising from the landfill were detected and abnormal presence of heavy metals cannot be confirmed, but cannot be fully excluded either due to the method's limitations. The limitations of the analysis include the highly heterogeneous content of the landfill - many aggregations of excavated soil and other C&D waste at the site were left as separate piles, some highly inaccessible, making the formation of a truly representative sample challenging. Some of the unsampled aggregations could still be contaminated, so multiple analyses should be performed.

SEM-EDS method allowed gaining insight about the main physical and chemical properties of the soil, but to exclude the possibility of contamination, a standard chemical laboratory analysis should be performed, and should also include persistent organic pollutants (POPs), organometallic compounds, asbestos, oil-derived hydrocarbons (C^6-C^{40} fractions), radionuclides, and pathogenic organisms [8]. The return of the original vegetation is questionable due to changed C&D landfill soil quality. In the future, sampling and analyzing of a probable colonizer, *A. fruticosa* and its plant organs be used as a heavy metal incicator accumulator [9]. Also, using the accumulator properties of *A. fruticosa* for phytoremediation is a possibility to explore.

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Abstract Defining energy and exploitation parameters of tractor-machine aggregates during mechanized construction of pits is the subject of this research. The test results of the tractor-machine aggregate show that the lowest driving force engaged for drilling was achieved in the field and was 6.36 kW for the excavated pit with the depth of 885 mm and with a diameter of 520 mm, the number of revolutions of the drill was 93 rpm and drilling was achieved in 27 s. The highest driving force for drilling was engaged in field III, which was 30.8 kW for the excavated pit 780 mm deep with a diameter of 490 mm, the number of revolutions of the drill bit was 111 rpm and drilling was realized in 30 s. The results obtained in these tests show that the consumption of motor power largely depends on the type of soil, the quality of previous soil preparations and the number of revolutions of the tractor

INTRODUCTION

Quality establishment of perennial orchards also implies rational engagement of human labor and means of mechanization. Soil preparation and the process of raising orchards is a complex and complex job that requires a great deal of mechanical work. When raising perennial plants, digging pits as a basic labor operation, involves the most human and machine work. Mechanization of this process is most often achieved with a tractor unit when it consists of a tractor equipped with a connecting machine whose element is in the form of one or more helical drills. In areas of arid climate where irrigation is not present, the establishment of plantings or planting should be realized in autumn in order to achieve the best possible effect of receiving planting material. For these conditions of fruit growing, it is necessary to perform quality basic and additional processing in order to accumulate enough and rationally consume moisture in the soil.

MATERIAL AND METOD

The testing of the tractor drill, a product of the company "Lemind proleter" Leskovac was performed according to the methodology of the Institute of Mechanization, Faculty of Agriculture - Zemun, laboratory-field and exploitation tests, whereby the functionality, properties and quality of work of this machine are determined through all test phases. Field tests were performed on ODPF "Radmilovac" of undulating terrain, at an altitude of about 71 m. The geographical position of the plantations determines the moderate continental climate, and the dominant type of land is the grove. Soil moisture was very low, below 7% since the test was performed during the dry season. The drill was tested in an aggregate with an IMR 65 tractor In laboratory-field tests, measurements of the engine power consumption of the tractor for drilling holes were performed on 3 differently processed terrains and at different speeds of the tractor PTO shaft. To measure the resistance and speed of the drill, the "Torque and speed sensor" DMN 10 was used, which was mounted directly on the tractor shaft and from which a cardan shaft was mounted to drive the drill. The value of the torque expressed in Nm and the number of revolutions in rpm are read directly on the display of the unit of measurement. Registration of the tractor PTO speed of the readings on the "tracometer" of the control panel. Duration The repetition time in the experiments was measured using a stopwatch.

RESULTS AND DISCUSSION

The results obtained in ovine tests are shown in Table 1. The engagement of the engine power largely depends on the type of soil, the quality of pre-cultivation and the number of revolutions of the tractor PTO shaft. In the field, the engine power consumption of the tractor ranged from 6.36 to 11.20 kW. Testing In this field, the tractor engine runs at 1000, 1500 and 1800 rpm. On terrains II and III, the measurement of motor power consumption was performed at 1890 rpm of the PTO shaft. The results presented in Table 1 show that the power consumption of tractors on terrains II ranges from 26.55 to 28.30 kW to III from 29.60 to 30.80 kW. From this it can be seen that to work on drilling holes in insufficient or uncultivated terrain, a tractor with an engine power above 35 kW is needed. Based on the obtained results, it can be stated that for medium and easier arable and well-prepared soils, the IMT-533 or Fe-35 tractor can be used with ease.

Red. broj	Hole drilling time [*s*]	Hole depth [*cm*]	Hole diameter [*cm*]	Speed approx. Tractor lures [*o/min*]	Drill speed [*o/min*]	PTO torque [*Nm*]	Power required to drive the drill [*kW*]
Teren I							
1	85,6	51,0	8,8	716	113	11,20	11,20
2	20	75,8	53,0	540	86	14,76	8,18
3	29	89,9	52,3	360	58	18,99	7,02
4	27	87,6	51,8	360	57	17,20	6,36
Teren II							
1	48	85,6	49,2	715	114	37,32	27,45
2	46	78,5	49,8	718	113	36.10	26,55
3	52	81,5	49,5	652	104		27,37
4	58	76,9	49,3	590	94	48,40	28,30
Teren III							
1	31	78,0	49,3	700	112	42,93	30,80
2	48	82,3	50,4	648	103	40,10	29,60
3	29	75,0	49,4	720	115	49,21	28,55
4	65	89,5	51,2	576	92	48,81	28,85

Table 1. Test results of tractor aggregate In laboratory-field tests

The quality of the excavations pits			Aggregate performance during operation at arranged ruppa 6x6 m					
Congestion		Raised earth above the hole [*cm*]	1 hour of gross work		1 hour of net work		1 hour of clean work	
Depth [*cm*]	From the depths [%]		*Com.*	[*ha*]	*Com.*	[*ha*]	Com.	[*ha*]
16,4	13,7	15,8	69,9	0,25	90,0	0,32	156,0	0,56
37,2	32,7	21,7	35,7	0,13	60,0	0,21	100,0	0,35
21,5	19,7	19,9	55,4	0,20	74,5	0,26	130,0	0,46
12,9	12,9	23,9	43,6	0,15	56,7	0,20	82,1	0,29
16,0	19,7	24,0	40,8	0,14	49,8	0,18	75,8	0,27
11,0	11,1	22,6	56,5	0,20	80,2	0,28	135,1	0,48

Table 2. Quality and chronography of aggregate operation during machine drilling of pits

CONCLUSION

The quality achieved by mechanized drilling of holes satisfies agro-technical requirements and is therefore better in relation to manual work, especially when it comes to holes of greater depths.

In favorable field conditions of compact soils, single-phase construction is recommended, but requires a more experienced and trained tractor driver.The mechanized way of drilling holes for seedlings is economically completely justified and therefore it should be applied in practice wherever there are conditions for that.In addition to the condition of the terrain, the number of revolutions of the drill bit plays a role in the backfilling of the pits, so that with a higher number of revolutions in wetter soil, the walls of the holes become more compact and the erosion is less.

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