EVALUATION OF BRAKING DECELERATION DURING EMERGENCY BRAKING OF AGRICULTURAL TRACTORS
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ОЦЕНКА НА СПИРАЧНОТО ЗАКЪСНЕНИЕ ПРИ АВАРИЙНО СПИРАНЕ НА ЗЕМЕДЕЛСКИ ТРАКТОРИ

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ABSTRACT
The use of tractors for transporting agricultural produce is a widespread practice in Bulgaria and imposes high requirements for traffic safety. Assessing the braking performance of these vehicles is essential for effective risk management and accident prevention. This study provides a database of experimentally obtained data on the braking deceleration of Zetor Crystal HD 170 and Belarus 952.3 tractors under various braking conditions, gathered using modern equipment under real road conditions. The results offer valuable insights for expert analyses in accident investigations involving these vehicles and contribute to developing strategies for enhancing road safety.

РЕЗЮМЕ
Използването на трактори за транспортиране на селскостопанска продукция е широко разпространена практика в България и налага високи изисквания за безопасност на движението. Оценката на спирачните свойства на тези превозни средства е от ключово значение за управлението на риска и предотвратяването на пътнотранспортни произшествия. В настоящата работа е представена база от експериментално получени данни за спирачното закъснение на трактори Zetor Crystal HD 170 и Belarus 952.3 при различни условия на спиране, получени чрез съвременна апаратура в реални пътни условия. Получените резултати предоставят ценна информация за бъдещи експертни анализи при разследване на инциденти с тези транспортни средства и допринасят за предприемането на мерки за подобряване на пътната безопасност.

INTRODUCTION
Effective emergency braking of agricultural tractors is essential for ensuring safety both for the tractor driver and surrounding road users. Braking deceleration, as a primary indicator of braking system performance, is crucial for enabling rapid stopping in critical situations. A comparative analysis of tractor deceleration across different wheel drives and driving speeds is presented by *Gurevicius et al. (2017)*. Additionally, *Aykan et al. (2023)* conducted notable studies on the braking performance of tractor-trailer combinations under various operating conditions.

In Bulgaria, road safety is at a very low level compared to other European Union countries (*European Commission, 2024*), despite the „Vision Zero" road safety framework adopted in our country, as well as in other countries (*Lopoo et al., 2024*). Improving road safety is a particularly relevant issue for our country. Many responsible institutions view road safety primarily as a set of legal regulations governing traffic, vehicle standards, and driver requirements. However, to effectively enhance road safety, this approach must evolve to encompass a broader perspective considering road safety as a complex interplay of scientific, social, and economic factors that support safe, efficient traffic flow and protect human life. One essential component of this multifaceted approach is the expert investigation of road accidents, which includes analysing causes, understanding the mechanisms of incidents, and exploring preventive measures.

A fundamental aspect of expert assessment in any traffic accident is determining the vehicle stopping distance. Accurate identification of this distance is essential for evaluating whether the accident was preventable. Calculating the stopping distance requires several input factors, among which braking deceleration during emergency braking is one of the most critical.

In Bulgaria, tractors are commonly used to transport agricultural produce and fertilizers across municipal and republican road networks. A substantial portion of agricultural transport involves moving plant and livestock products or securing inputs for production. Due to the seasonal nature of agricultural work, this transport requires a significant number of vehicles. Cargo specificity often dictates the selection of specialized trailers, and to accommodate cargo varying bulk densities, additional superstructures may be installed on trailers, which alters the trailer mass depending on the type of cargo. Factors such as cargo type, trailer configuration, and road conditions impact the braking deceleration of tractors.

While technical literature provides information on emergency braking deceleration for passenger vehicles, data specific to agricultural tractors is limited and often pertains to different conditions and applications (*Pradhan et al., 2024; Ahokas et al., 2003; Canli et al., 2023*). Some studies, such as those by *Janulevičius et al. (2002),* offer theoretical insights into braking efficiency for tractor-transport aggregates. However, under real road conditions, the complex interaction of factors can limit the applicability of these findings for forensic accident analyses.

The absence of data on agricultural tractors' braking deceleration under Bulgarian road conditions is a notable research gap. This lack of information complicates the preparation of auto-technical reports for accidents involving tractors. Therefore, this study aims to fill this gap by investigating the braking deceleration of tractors during emergency braking under real road conditions in Bulgaria, providing essential data to enhance traffic safety analysis and accident investigation accuracy.

MATERIALS AND METHODS

Braking is the movement of vehicles at a speed that decreases to a certain value or to a complete stop. If the braking is performed with the maximum possible braking deceleration, it is generally called emergency braking.

To study the dynamic properties of vehicles, various equipment can be used: sensors installed in tires (*Higuchi et al., 2023; Ise et al., 2017*); measuring the effective braking distance or using an accelerometer (*Uzunov et al., 2022*); fifth wheel *(Ivanov et al., 2022*), etc. These methods have various limitations. Today, to study the dynamic properties, GPS equipment is widely used, which has a number of advantages related to versatility, precision and ease of operation (*Phan et al., 2023; Pandey et al., 2023; Famiglietti et al., 2020*).

To study the braking deceleration of tractors during emergency braking, specialized global positioning systems (GPS) equipment for precise measurements VB20SL from the company RaceLogic Ltd – England *(https://www.racelogic.co.uk/index.php/en/*) was used. The main module of the equipment is a satellite receiver that uses data from GPS (Fig. 1).

Fig. 1 - Satellite receiver VB20SL

According to the technical specification, some of the main parameters that can be registered by the system are: speed - from 0.1 to 1609 km/h, dispersion 0.1 km/h; distance - accuracy 0.05%, dispersion 0.001m; acceleration - up to 20 g, accuracy 0.5%, dispersion 0.01 g. The VBOX Tools software is used to visualize and process the recorded data. The data is presented in different windows: main window, showing the acceleration as a function of the distance travelled or time; window presenting a table with the recorded data; window showing the vehicle's trajectory.

The experiment was conducted in 2023 at the Dimera Neykov EOOD agricultural farm in the city of Glodjevo, Bulgaria. The weather conditions were: temperature 13.5 °C, wind speed 2 km/h and humidity 83%. The study was conducted with Zetor Crystal HD 170 tractors and Belarus 952.3 tractor (Fig. 2 and 3).

The Belarus 952.3 tractor is equipped with Rosava 13.6R20 (380/70R20) front tires. The rear ones are Seha 16.9-38 (420/85R38). For the purpose of the experiment, an RSD-4 trailer equipped with Barum 245/70R17.5 tires was attached to the Belarus 952.3 tractor. The Zetor Crystal HD 170 tractor was equipped with Mitas 480/65R28 front tires and Mitas 600/65R38 rear tires. A Remel-RS-14 trailer equipped with Alliance 400/60-15.5 tires was attached to the Zetor Crystal HD 170 tractor.

(a) (b)

Fig. 2 – Object of study: a) Tractor Zetor Crystal HD 170; б) road surface and tire skid marks

(a) (b)

Fig. 3 – Object of study: a) Tractor Belarus 952.3; б) road surface and tire skid marks

The main technical data of the tractor Zetor Crystal HD 170 are shown in Table 1.

Table 1

Technical data of the tractor Zetor Crystal HD 170 and Belarus 952.3

Technical data	Zetor Crystal HD 170	Belarus 952.3
Rated engine power, kW	120	70
Rated engine speed, rpm	2100	1800
Weight of the tractor, kg	5760	4800
Wheelbase, mm	2840	2450
Front tires	480/65R28	380/70R20
Rear tires	600/65R38	420/85R38
Permitted maximum load of front axle (kg)	4200-6000	2360-2500
Permitted maximum load of rear axle (kg)	6500-7000	3104-4500
Recommandations front tires pressure, kPa	150-190	120-150
Recommendations rear tires pressure, kPa	140-160	110-120

In the process of emergency braking, 4 main phases of change in braking deceleration are distinguished: phase 1 – decelerated movement of the vehicle without activated braking system. It begins when the accelerator pedal is released. Braking deceleration occurs due to various resistances (from movement, air, etc.); phase 2: braking deceleration increases when the brake pedal is pressed to a maximum value for the specific conditions; phase 3: during this phase the brake pedal is pressed. Braking deceleration is relatively constant; phase 4: during this phase the brake pedal is still pressed. The braking deceleration of the vehicle decreases almost linearly, and immediately before reaching the zero value a peak with positive acceleration is observed, which is due to the longitudinal oscillations of the vehicle. In this study, the results obtained are for phase 2, which is characterized by a relatively constant deceleration for the specific real road conditions.

The methodology of the experimental study of the braking deceleration includes conducting a series of emergency stops on a horizontal dry road with asphalt pavement, such as the pavement on municipal and republican roads in Bulgaria. The speed at the beginning of the stops is within 20 - 30 km/h. The series of tests for both tractors were conducted in four different scenarios: stopping the tractor without a trailer attached; stopping with an empty trailer with the braking system on; stopping with an empty trailer with the braking system off; stopping with a full trailer with the braking system on; stopping with a full trailer with the braking system off. The mass of the load for the Belarus tractor is 3000 kg, and for the Zetor - 3600 kg.

The results of the study were processed with SPSS Statistics 19 (Statistical Package for the Social Sciences) - a software package used for interactive statistical analysis. This tool is implemented through descriptive menus, so as to satisfy the practical needs for statistical analysis of data collected with the presented equipment and used in science, police and court in expert analysis of road traffic accidents.

RESULTS

An actual record of the acceleration change in a Belarus 952.3 tractor during braking without an attached trailer is illustrated in Figure 4. The red ellipse highlights the region corresponding to the measurement of the average braking deceleration for each test.

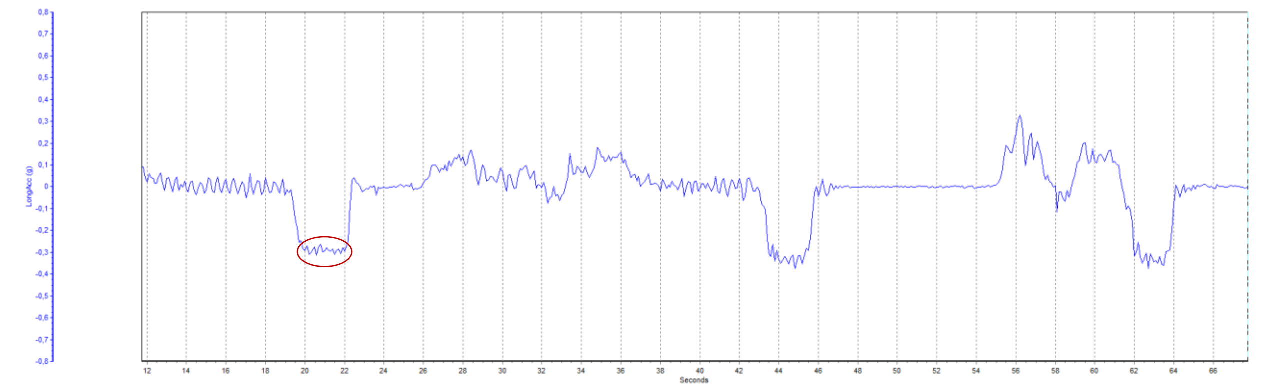

Fig. 4 – The variation in acceleration during a Belarus 952.3 emergency braking

From the part of the experiments presented in the figure, it can be seen that the negative accelerations reach values of 0.38 g or 3.73 m/s^2.

Fig. 5 presents a real recording of the change in acceleration of a Zetor Crystal HD 170 tractor when braking without a trailer attached.

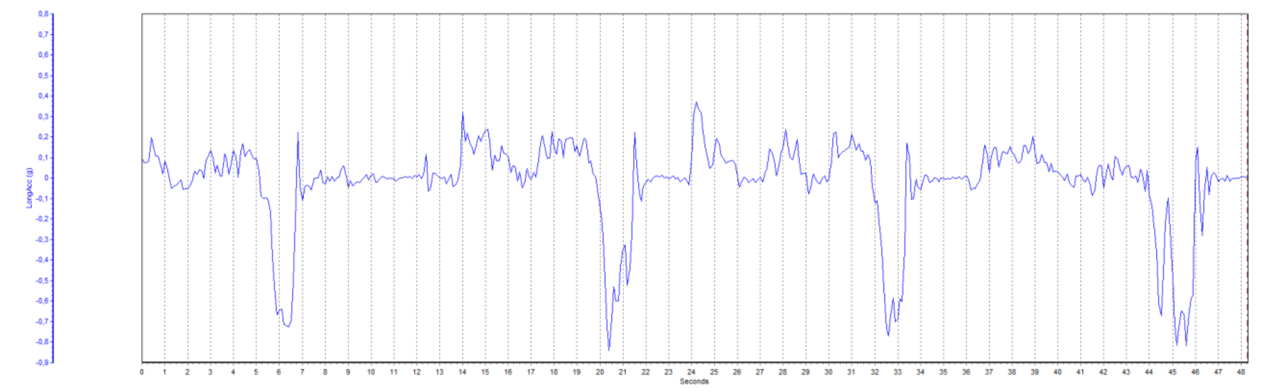

Fig. 5 – The variation in acceleration during a Zetor Crystal HD 170 emergency braking

From Fig. 5 it can be seen that in some of the tests for the tractor Zetor Crystal HD 170 the negative acceleration reaches a value of 0.85 g or 8.34 m/s^2 which are more than twice as large as those of the Belarus 952.3 tractor.

The results for the main statistical characteristics of the braking deceleration for the Belarus 952.3 tractor for different braking conditions are summarized in Table 2.

The mean values of the braking deceleration of the Belarus 952.3 tractor for different braking scenarios vary from 3.10 to 1.84 m/s^2. The smallest value obtained is 1.62 m/s^2, respectively, when braking with a full trailer with the brake system turned off.

Table 2

Statistical characteristics of the experimental results for Belarus 952.3 tractor

Belarus Statistics	No trailer	Empty trailer with brakes	Empty trailer without brakes	Full trailer with brakes	Full trailer without brakes
Number Valid	10	10	10	10	10
Mean	3.1009	2.7115	2.2229	2.1180	1.8413
Standard Error of Mean	0.03698	0.04837	0.02190	0.05173	0.04110
Median	3.0951	2.7027	2.2318	2.0846	1.8541
Mode	2.84	2.48	2.12	1.95	1.89
Standard Deviation	0.11694	0.15297	0.06924	0.16359	0.12998
Variance	0.014	0.023	0.005	0.027	0.017
Skewness	-1.060	-0.091	-0.113	0.367	-0.397
Standard Error of Skewness	0.687	0.687	0.687	0.687	0.687
Minimum	2.84	2.48	2.12	1.92	1.62
Maximum	3.23	2.91	2.32	2.34	2.00

The largest value obtained is 3.23 m/s^2, respectively, when braking the tractor without a trailer attached. The Table 3 summarizes the results of the study conducted on the interval estimates of the braking decelerations of the Belarus 952.3 tractor for the various braking scenarios.

Table 3

Interval estimates of the mean braking deceleration of the Belarus 952.3 tractor

Descriptives			Statistic	Std. Error
No trailer	Mean		3.1009	0.03698
	95% Confidence Interval for Mean	Lower Bound	3.0173	
		Upper Bound	3.1846	
Empty trailer with brakes	Mean		2.7115	0.04837
	95% Confidence Interval for Mean	Lower Bound	2.6021	
		Upper Bound	2.8209	
Empty trailer without brakes	Mean		2.2229	0.02190
	95% Confidence Interval for Mean	Lower Bound	2.1734	
		Upper Bound	2.2725	
Full trailer with brakes	Mean		2.1180	0.05173
	95% Confidence Interval for Mean	Lower Bound	2.0010	
		Upper Bound	2.2350	
Full trailer without brakes	Mean		1.8413	0.04110
	95% Confidence Interval for Mean	Lower Bound	1.7484	
		Upper Bound	1.9343	

From interval estimates of the mean braking decelerations for the different braking conditions it can be assumed that in 95% of cases their values would fall between the specified limits. The results for the main statistical characteristics of the braking deceleration for the Zetor Crystal HD 170 tractor for the different braking scenarios are summarized in Table 4.

Table 4

Statistical characteristics of the experimental results for Zetor Crystal HD 170 tractor

Zetor Crystal HD 170 Statistics	No trailer	Empty trailer with brakes	Empty trailer without brakes	Full trailer with brakes	Full trailer without brakes
Number Valid	10	10	10	10	10
Mean	6.7100	5.9664	5.0070	4.3527	3.6523
Standard Error of Mean	0.04029	0.05467	0.04103	0.02425	0.02516
Median	6.7248	6.0086	5.0276	4.3605	3.6738
Mode	6.46	5.66	4.83	4.26	3.54
Standard Deviation	0.12740	0.17290	0.12975	0.07670	0.07957
Variance	0.016	0.030	0.017	0.006	0.006
Skewness	-0.534	-0.589	-0.075	-0.026	-0.024
Standard Error of Skewness	0.687	0.687	0.687	0.687	0.687
Minimum	6.46	5.66	4.83	4.26	3.54
Maximum	6.88	6.17	5.20	4.45	3.79

For this tractor, the mean values of the braking deceleration for the different braking scenarios vary from 6.71 to 3.65 m/s^2. The smallest value obtained is 3.54 m/s^2, respectively, when braking with a full trailer with the brake system turned off. The largest value obtained is 6.88 m/s^2, respectively, when braking the tractor without a trailer attached.

The conducted research and the obtained results also establish the influence of the load mass on the braking properties. When braking a Zetor Crystal HD 170 tractor with a trailer with a 3600 kg load, the mean value of the braking deceleration is 27% less than when braking with an empty trailer.

Table 5 presents the results of the study on interval estimates of braking deceleration of the Zetor Crystal HD 170 tractor for different braking scenarios.

Table 5

Interval estimates of average braking decelerations of the Zetor Crystal HD 170 tractor

Descriptives			Statistic	Std. Error
No trailer	Mean		6.7100	0.04029
	95% Confidence Interval for Mean	Lower Bound	6.6189	
		Upper Bound	6.8012	
Empty trailer with brakes	Mean		5.9664	0.05467
	95% Confidence Interval for Mean	Lower Bound	5.8428	
		Upper Bound	6.0901	
Empty trailer without brakes	Mean		5.0070	0.04103
	95% Confidence Interval for Mean	Lower Bound	4.9142	
		Upper Bound	5.0998	
Full trailer with brakes	Mean		4.3527	0.02425
	95% Confidence Interval for Mean	Lower Bound	4.2978	
		Upper Bound	4.4076	
Full trailer without brakes	Mean		3.6523	0.02516
	95% Confidence Interval for Mean	Lower Bound	3.5953	
		Upper Bound	3.7092	

From the results in Table 5, the limits within which 95% of the cases of mean braking decelerations fall for the different scenarios can be determined.

When road accidents occur, the police, the prosecutor's office or the court appoint technical expertise to clarify the circumstances. The main task of the expertise is to provide an answer to the possibility of preventing the accident by the participants. In this regard, one of the most important issues is to determine the vehicles stopping distance. This is the minimum distance that the vehicle travels when stopping, from the moment of perceiving danger to a complete stop. It can be calculated according to the following relationship:

$$VSD = t_d V + t_v V + \frac{V^2}{2b_{dec}} \quad \text{[m]} \tag{1}$$

where: VSD – is the vehicle stopping distance, m; t_d - the driver reaction time, s; t_v – the vehicle reaction time, s; V – the vehicle velocity, m/s; b_{dec} – the braking deceleration, m/s^2.

The driver's reaction time depends on the traffic situation and the probability of an accident. In Bulgarian judicial practice, basic values for this time are used from 0.6 to 1.4 seconds. In special situations (driving at night, alcohol consumption, etc.) the driver's reaction time should be increased.

The reaction time of the vehicle includes the time for activating the braking system and for increasing the braking deceleration. The time for activating the braking system depends on the type of braking system. In Bulgarian case law, it is usually accepted from 0.2 to 0.4 seconds. The time for increasing the braking deceleration depends on the coefficient of friction between the tires and the road and the category of the vehicle. In Bulgarian case law, it is usually accepted from 0.2 to 0.6 seconds.

Using the experimentally obtained mean braking deceleration data under real road conditions, the vehicles stopping distance for both tractors at different speeds was calculated. A value of 0.8 seconds was used for the driver's reaction time, and 0.6 seconds for the vehicle's reaction time.

The results for the vehicles stopping distance during emergency braking of the Belarus 952.3 tractor for the different conditions are presented in Table 5. The results for the Belarus 952.3 tractor show an increase in the stopping distance when braking at a speed of 10 km/h with a full trailer without brakes by 16.5% compared to braking a tractor without a trailer – the boundary conditions of the study.

Table 5

Belarus 952.3 Stopping Distance

Braking conditions	No trailer	Empty trailer with brakes	Empty trailer without brakes	Full trailer with brakes	Full trailer without brakes
	Braking Deceleration				
Mean values, m/s^2	**3.10**	**2.71**	**2.22**	**2.12**	**1.84**
Velocity	**Stopping Distance, m**				
10.00 km/h (2.78 m/s)	5.14	5.32	5.63	5.71	5.99
20.00 km/h (5.56 m/s)	12.77	13.49	14.75	15.07	16.18
30.00 km/h (8.33 m/s)	22.85	24.46	27.29	28.03	30.52
40.00 km/h (11.11 m/s)	35.46	38.33	43.35	44.67	49.10
50.00 km/h (13.89 m/s)	50.56	55.04	62.90	64.95	71.87

For a speed of 50 km/h the increase is 42.2%. It is found that the braking deceleration has a more sensitive effect on the length of the vehicles stopping distance at higher speeds. At low speeds, the reaction time has a more sensitive effect on the length of the stopping distance.

Evaluating the influence of the mass of the transported load, it was found that when braking at a speed of 10 km/h and the braking system is on, the vehicles stopping distance increases by 7.3% (with a load of 3000 kg). For a speed of 50 km/h, this increase is 18%.

The results for the vehicles stopping distance during emergency braking of the Zetor Crystal HD 170 tractor for different conditions are presented in Table 6.

Table 6

Zetor Crystal HD 170 Stopping Distance

Braking conditions	No trailer	Empty trailer with brakes	Empty trailer without brakes	Full trailer with brakes	Full trailer without brakes
	Braking Deceleration				
Mean values, m/s^2	**6.71**	**5.97**	**5.01**	**4.35**	**3.65**
Velocity	**Stopping Distance, m**				
10.00 km/h (2.78 m/s)	4.47	4.54	4.66	4.78	4.95
20.00 km/h (5.56 m/s)	10.09	10.37	10.87	11.34	12.02
30.00 km/h (8.33 m/s)	16.83	17.47	18.59	19.64	21.17
40.00 km/h (11.11 m/s)	24.75	25.89	27.87	29.74	32.46
50.00 km/h (13.89 m/s)	33.82	35.60	38.70	41.62	45.88

For this tractor (Table 6), for the limit scenarios of the study, the results show an increase in the vehicles stopping distance when braking at a speed of 10 km/h with a full trailer without brakes by 10.7% compared to braking a tractor without a trailer – the limit conditions of the study. For a speed of 50 km/h, the increase is 35.7%. A significant difference in the length of the braking distance is established for the different scenarios of conducting the study for high speeds. This proves the need to accurately describe the circumstances (mass of the transported load, condition of the braking system, etc.) when each specific accident occurs in order to make the correct choice of braking deceleration and to calculate with high accuracy the stopping distance.

Evaluating the influence of the mass of the transported load for the Zetor Crystal HD 170 tractor, it was found that when braking at a speed of 10 km/h and the braking system is on, the vehicles' stopping distance increases by 5.3% (with a load of 3600 kg). For a speed of 50 km/h this increase is 16.9%.

CONCLUSIONS

As a result of this work, experimental data on the braking deceleration of Zetor Crystal HD 170 and Belarus 952.3 tractors under different braking scenarios in real road conditions were obtained.

The confidence intervals and statistical characteristics of the obtained results for all braking scenarios for both tractors are determined.

The mean values of the braking deceleration of the Belarus 952.3 tractor for the different braking scenarios vary within the limits from 3.10 to 1.84 m/s^2. The largest value obtained is 3.23 m/s^2 when stopping the tractor without an attached trailer.

For the Zetor Crystal HD 170 tractor, the mean values of the braking deceleration for the different braking scenarios vary within the limits from 6.71 to 3.65 m/s^2. The largest value obtained is 6.88 m/s^2 when stopping the tractor without an attached trailer.

The influence of the load mass on the braking properties was assessed. When stopping a Zetor Crystal HD 170 tractor with a trailer carrying 3600 kg of load, the main braking deceleration was 27% less than when stopping with an empty trailer. The vehicles stopping distance for both tractors at different speeds for all braking scenarios was calculated.

The results obtained provide important information for expert analysis in the investigation of tractor accidents and contribute to the implementation of measures to improve road safety.

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REFERENCES

[1] Ahokas, J., & Kosonen, S. (2003). Dynamic behaviour of a tractor-trailer combination during braking. *Biosystems Engineering*, 85 (1), pp. 29-39. DOI 10.1016/S1537-5110(03)00035-7

[2] Aykan, H., Çarman, K., Canlı, E., Ekinci, Ş. (2023). Evaluation of Tractor-Trailer Combination Braking Performance in Different Operating Conditions. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 27(2), 219-225. https://doi.org/10.19113/sdufenbed.1191413

[3] Canli, E., Carman, K., Soylu, S., & Citil, E. (2023). Experimental assessment of a PID control solution for braking safety of transportation by agricultural tractor trailer combinations. *International Journal of Heavy Vehicle Systems*, 30 (2), pp. 211-231. DOI 10.1504/IJHVS.2023.132318

[4] European Commission. Statistical pocketbook 2024. Road fatalities - country rankings. https://transport.ec.europa.eu/facts-funding/studies-data/eu-transport-figures-statistical-pocketbook/statistical-pocketbook-2024_en

[5] Famiglietti, N., Nguyen, B., Fatzinger, E., & Landerville, J. (2020). Bicycle Braking Performance Testing and Analysis. *SAE Technical Papers*, Code 159263. DOI 10.4271/2020-01-0876

[6] GPS equipment for precision measurements VB20SL. https://www.racelogic.co.uk/index.php/en/

[7] Gurevicius, P., Janulevicius, A. (2017). Tractor MFWD braking deceleration research between different wheel drive, *16th International Scientific Conference Engineering for rural development*, Jelgava, 24-26.05.2017, DOI: 10.22616/ERDev2017.16.N173

[8] Higuchi, M., Suzuki, Y., Sasano, T., & Tachiya, H. (2023). Measurement of road friction coefficient using strain on tire sidewall. *Precision Engineering*. Volume 84, Pages 28-36. https://doi.org/10.1016/j.precisioneng.2023.07.001

[9] Ise, T., Higuchi. M., Suzuki Y., & Tachiya, H. (2017). Measurement on friction coefficients of tire grounding surface in arbitrary directions under high-load. *Experimental Mechanics*. Volume 57, November 2017, Issue 9, Pages 1383 – 13931. https://doi.org/10.1007/s11340-017-0309-8

[10] Ivanov, Z., Sitnik, L., Dimitrov, R., Wrobel, R., Mihaylov, V., Skobiej, K., Ivanov, D., & Andrych-Zalewska, M. (2022). Investigation Of Braking Deceleration In Vehicle. *8th International Conference on Energy Efficiency and Agricultural Engineering, EE and AE 2022 – Proceedings*. Code 181234. DOI 10.1109/EEAE53789.2022.9831283

[11] Janulevičius, A., Giedra, K. (2002) The evaluation of braking efficiency of tractor transport aggregate, *Transport*, 17:4, 152-158, DOI:10.1080/16483840.2002.10414033

[12] Lopoo, L.M., Cardon, E., Souders, S., Kroner Dale, M., & Ngo, U. (2024). An evaluation of a Vision Zero traffic-calming intervention, an urban transportation safety policy. *Journal of Urban Affairs*. https://doi.org/10.1080/07352166.2024.2314040

[13] Pandey, P.K., Arora, H., & Kumar, B.A. (2023). Development of Driving Cycles for Electric Buses in Patna, India. *8th International Conference on Models and Technologies for Intelligent Transportation Systems, MT-ITS 2023*, Code 192575. DOI 10.1109/MT-ITS56129.2023.10241532

[14] Phan, C., Meza Buendia, S.A., Nguyen, B.M., Fatzinger, E., & Landerville, J. (2023). Electric Motorcycle Acceleration, Braking, and Regenerative Coast-Down Deceleration Testing and Analysis. *SAE Technical Papers*, Code 187990. DOI 10.4271/2023-01-0631

[15] Pradhan, N.C., Sahoo, P.K., Kushwaha, D.K., Bhalekar, D.G., Mani, I., Kumar, K., Singh, A.K., Kumar, M., Makwana, Y., & Aruna, T.N. (2024). ANN-PID based automatic braking control system for small agricultural tractors. *Journal of Field Robotics*, 41 (8), pp. 2805-2831. DOI 10.1002/rob.22393

[16] Uzunov, H., Dimitrov, K., & Dechkova., S. (2022). Experimental Determination of the Tire-Road Friction Coefficient for a Vehicle with Anti-Lock Braking System. *AIP Conference Proceedings 2557*. Article number 030001-1. https://doi.org/10.1063/5.0103769