

# Analysis of Fastening Loads in Road Transport

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## Authors' contributions

This work was carried out in collaboration between both authors. Author MK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PG managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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## ABSTRACT

**Introduction:** The topic of the article is "Analysis of cargo securing in road transport". It consists of an analytical part and a research part, the assumption of which is to conduct a survey among people who have passed a number of requirements allowing to obtain the title of a professional driver. The subject of the work is the analysis of the most important issues related to cargo securing and securing means used in road transport of cargo, which are supported by the relevant legal acts [1,2].

**Aims:** The aim of the research was to analyze the securing of loads in road transport and to check the knowledge of drivers of heavy goods vehicles professionally transporting loads by road on a given topic. The respondents are both drivers employed in nearby transport companies (Zakład Rolniczo-Przemysłowego "Farmutil HS", PHUS Eksport-Import Transpil Spedition Waldemar Bocheński, PUH "Gólcz i Sons" Mieczysław Gólcz, Martrans, AGA-Guderski Transport & Logistyka) and drivers, who are members of transport groups on Facebook The research lasted 3 months and covered the period from January 7, 2020 to April 7, 2020.

**Research Object:** The subject of research is a number of issues related to loads on the means of transport, i.e. legal regulations, fastening accessories, methods of fastening. Drivers answering according to their knowledge reveal a practical perspective on securing and transporting loads. The three-month survey period resulted in 230 forms returned. The majority of respondents are

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men in the number of 214 people (93%). Only 16 women took part in the survey, which constitutes 7% of all respondents. The difference between the representatives of both sexes is great, which suggests that the profession of a driver is performed to a greater extent by men. Education can be a factor indicating the level of knowledge of the respondent. More than half of the respondents declared their education as secondary - 135 people (59%), then 48 people (21% chose the answer higher, basic - 39 people (17%), primary - 6 people (2%). 2 people (1%) completed their education at lower secondary school. Due to the length of service, the respondents can be divided into 6 groups. The most numerous group of 88 people (38%) are drivers who have been working in the profession for one to four years. Among the respondents there were 60 people (26%) with 5-10 years of work experience, then 43 people (19%) working 11-20 years, 24 people (10%) working less than a year, while 11 people (5%) were employed with transporting loads from 21 to 30 years. Only 4 people (2%) of the respondents can boast over 30 years of professional experience. The total length of the employment periods should indicate the level of knowledge and experience gained. The graph shows that drivers with various years of service took part in the survey, which has a positive impact on the accuracy of the results. In conclusion, the largest group of people was respondents who answered 1-4 years, which means that the road transport department has developed, and this resulted in an increase in the demand for people authorized to drive heavy goods vehicles.

**Methodology:** Before the actual study, a pilot study was performed. It was aimed at acquiring preliminary knowledge about the studied community and testing the correctness of the questionnaire. A questionnaire survey was used to conduct the research. There were 15 single-choice closed questions and 10 open-ended questions in the survey. Some questions included photos. The complete questionnaire was made available through the Facebook social network on transport thematic groups gathering professional drivers and delivered to the transport companies previously discussed.

**Results:** The survey was aimed at extracting the knowledge of professional drivers traveling both in Poland and other European countries about the securing of loads in road transport. The questionnaires included a properly prepared pool of questions and research techniques, which are also important for the accuracy and reliability of the research. The questions were arranged and edited in a clear and legible manner for the respondent, both in electronic and paper form. The tools used are closed-ended questions and open-ended questions with photos. The main part of the study was conducted on 230 respondents. It turned out that drivers do not have sufficient knowledge in the area in which they operate on a daily basis. Some drivers refused to answer the questionnaires, even knowing that their answers would be anonymous or they had no knowledge about it. As the survey shows, more than half of the respondents did not participate in any educational form related to cargo securing. The problem may result from the savings of the people managing the enterprise, as well as the reluctance of drivers to improve their own qualifications. Most of the respondents do not use the aids and measuring instruments available on the market to check the necessary amount of fixing means to ensure the safety of other road users. The tabular or template method of determining the number of lashings eliminates the need to use mathematical formulas, which could be problematic for some professional drivers. These are measures that improve the work and make it easier without the need to perform complex calculations. In the course of the research, difficulties arose in the form of the apparent reluctance of professional drivers to fill out an anonymous questionnaire. Unfortunately, some companies also refused to take part in the survey. It can be assumed that this was caused by the fear of the consequences that could be drawn by the legislator or the fear of the overall result of the study in the case of a specific company.

**Conclusion:** It is required from transport to be effective, and thus profitable and safe, and it is conditioned by the proper securing of the cargo. To sum up, it can be stated that the essence of securing loads in road transport is the appropriate selection of securing means, securing methods and available security systems so that the cargo with a specific weight, shape, plasticity and other own characteristics is immobilized on a properly selected loading surface and prevents its movement. The material collected in the course of the research and the analyzes carried out show that professional drivers have insufficient knowledge in the field of load securing. The problem of poor knowledge of the subject, externalized among drivers, is a significant problem that may lead to dangerous road situations and may generate unnecessary costs in the enterprise. In this situation, its managers should react. An example of a response to such signals may be the

employment of a person providing consultancy services in the field of cargo securing, training or audits in transport companies. Retraining professional drivers or organizing training for those who are just taking their first steps in the profession is crucial. A person who becomes aware of the scale of the risk and shows the visual effects of road accidents with greater diligence and accuracy will secure the load that has been assigned to him and make sure that he drives to the road with a vehicle that does not pose a threat. Lashing loads is a field of transport in which an individual approach should be taken to the load taken for transport. Standard mathematical formulas are helpful for this. But not all charges can be formulated and act schematically. Various loads of different shapes, sizes and other own characteristics are a challenge for people responsible for their safe transport. The driver carrying the load can make sure that it has been properly secured, without the need to use complicated mathematical formulas. It may turn out to be problematic for him, which is why publications have been made to facilitate these issues. Each type of trailer has a different security method. The driver, acquiring the license, is obliged to have knowledge in this topic and the translation of the lack of competence is groundless. On the current labor market, entrepreneurs dynamically develop their fleet following the prospect of a potential customer, which results in the transport of various goods. They are looking for specialized drivers with skills, failure to improve qualifications may result in job loss. Load securing is a field of transport that is constantly expanding its range. Demanding from the people involved to create innovative solutions to emerging problems posed by loads during transport. The guarantee of the search for the most effective methods of fastening and auxiliary devices is the growing transport and the willingness to transport various loads. To conclude the considerations undertaken in this paper, it should be stated that the common goal of people involved in the transport of goods should be to improve the safety of all road users and to comply with applicable road regulations.

*Keywords: Cargo securing; driver; transport safety; cargo; road transport; securing methods; securing means.*

## 1. INTRODUCTION

Road transport is a dynamically developing branch of transport, thanks to the constantly expanding and modernized road networks and "automotive achievements", on which this form of transport is based. Examples include tractor units with low fuel consumption with a comfortable working and living space, as well as semi-trailers tailored to the individual needs of the user. Initially, road transport was non-mechanized and was carried out using human force or animal traction. The rapid development of civilization and the use of inventions such as the wheel, steam-powered machines, as well as primitive internal combustion engines caused that the techniques of moving both people and goods developed over the years. The constantly growing needs for the transport of goods are caused by more and more troublesome and characteristic loads. This has resulted in the need to find appropriate fastening techniques in order to reduce the number of goods delivered to the destination with a defect and to avoid generating unnecessary costs related to it. At the same time, vehicle construction has become a "field of show" for leading manufacturers. Over time, an increasing number of problems began to

be noticed with regard to damage to cargo during loading, unloading, and to a large extent the transport itself, which is caused by improper formation of the loading unit and lack of security or improper fastening. The efficient transport of loads is influenced by many elements, such as: roads and their technical condition, the use of appropriate packaging, the selection of an effective method of fastening, the use of available amenities such as modern systems and security measures often adapted to the individual needs of the user, efficient planning of each stage of transport and most importantly the human factor.

### 1.1 Load Securing

The concept of cargo is understood as material goods that are the object of paid transport, which takes place in the supply chain. The goods are called the cargo from the moment they are posted by the sender until the recipient collects the cargo [3].

The International Road Transport Union (IRU) has created a document called "International Guidelines for the Safe Lashing of Loads in Road Transport". The publication issued in 2015

provides an extensive overview of basic information on cargo securing in road transport. It contains practical aspects that are valuable to anyone who is part of the transport chain. The content therein is based on the European standard EN 12195-1: 2010 [4].

Those interested are available a study made available by the European Commission "Lashing loads in road transport - Guidelines for good European practice" issued in 2008. The European Commission issued another brochure 6 years later, entitled: "Guidelines for European best practices in cargo securing for road transport". The purpose and scope of these publications is similar to the guidelines mentioned in the paragraph above.

This topic was also taken up in an article appearing in the journal "Logistyka" Olszewski Zbigniew, Krawiec Piotr and Waluś Konrad entitled "Lashing loads and road transport safety". The authors realize in their work that there are many factors that affect the safety of cargo transportation. They pay particular attention to the poor condition of means of transport, worn out securing devices, often without labels, and the inability to properly select a vehicle for the transported load [5].

It is worth mentioning the article in the magazine "Buses" entitled: "Selected examples of cargo damage in car transport" by Agnieszka Deja, Zbigniew Matuszczak and Małgorzata Stempień. It includes a detailed description and photos of damage to loads transported by a small transport company located in Poland. Subsequently, the causes of damage are explained and solutions, techniques and activities are proposed to prevent the recurrence of such situations [6].

Noteworthy is the text written by Józef Stokłosa, Grzegorz Koszałka and Leszek Gil entitled: "Analysis of forces in elements securing loads on motor vehicles". In the discussed work, the authors use the Ansys version 13 software to perform a strength analysis of the load securing elements. The simulations were to check whether the selection of securing measures in accordance with the thematic publications will effectively secure the transported load during sudden road situations, such as sudden braking on a bend or on an uneven surface. The object of the research was a metal box with a mass of 10 tons, secured with four lashings, i.e. anchoring method [7].

An interesting foreign publication available in English is "Safety in the supply chain in relations to packing of containers", published in Geneva in 2011 by the International Labor Organization (ILO). It is an organization cooperating with the United Nations. The publication is a report from a global forum for discussing a specific type of problem. In this case, security in the supply chain in relation to container loading.

The German police research reports from previous years on cargo securing, where roadside checks were targeted at nine selected points throughout Germany, showed that the cargo in 90% of the inspected vehicles was not secured to the satisfaction of the inspection authority. Additionally, 50-60% of vehicles could not continue driving without re-securing the load properly. In practice, this caused downtime and monetary losses for enterprises. Lack of security and failure to use legally formulated methods of securing loads disrupt the proper process of the flow of goods in the supply chain and poses a threat to people who are part of this chain [8].

The essence of securing loads is immobilization, i.e. preventing the load from moving while the vehicle is moving on the road. The friction that occurs between the two surfaces is insufficient to prevent displacement, legally defined fixing methods are used for this.

The most frequently used methods of securing loads include: locking, blocking and securing with lashings. The securing means should be selected according to the type of transported load and the means of transport. The dimensions, shape and weight of the load should also be taken into account. However, the essence of the matter here is the required force, which is necessary to immobilize the load, and the securing technique used. Fastening means include: fastening belts, chain, steel ropes. There are also auxiliary fastening means: a spreader bar, blocking beams, wedges, air bags, hedgehogs, anti-slip mats, nets, sheets [2,4,9-13].

Load securing is used to balance the forces induced by the load during road transport. The selection of fastening means must be supported by calculations. To be correct, you need to know the forces acting on the load while driving. The movement of the means of transport results in the inertia forces acting on the load as shown in Fig. 1. The above-mentioned forces are [11]:

- Longitudinal forces - occur during acceleration and braking (Ox axis direction),
- Shear forces - arise in a curvilinear motion (Ox axis direction),
- Vertical forces - arise when driving on uneven surfaces (direction of the Oz axis).

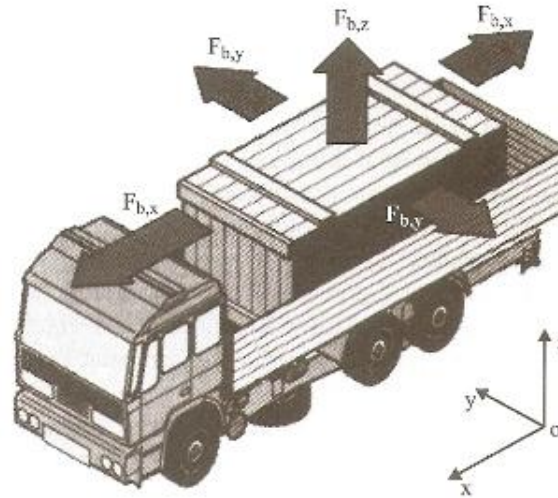


Fig. 1. List of inertia forces acting on the load while driving [11]

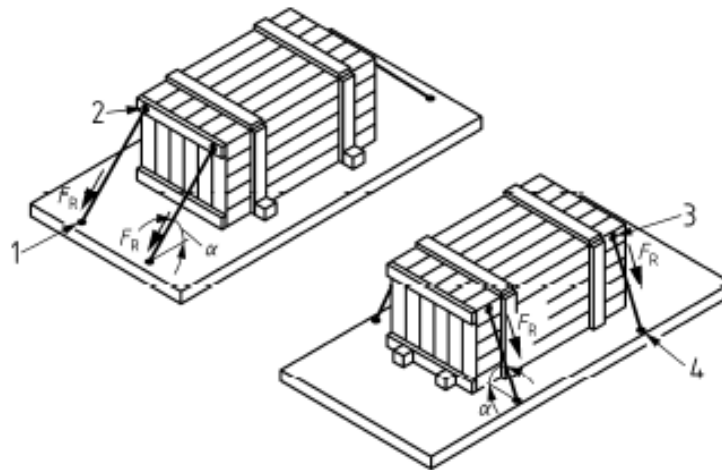


Fig. 2. Method of securing the load directly with lashings 1. Lashing point, 2. Lashing point, 3. Lashing point, 4. Lashing point [14]

### 1.2 Lashings in the Longitudinal or Transverse Direction

In this method, the load is attached directly to the means of transport using four lashings (Fig. 2). In the presented two types of fastening, there are two identical restraining forces FR [11].

The following equations express the balance of forces in the longitudinal and transverse directions when two pairs of lashings are symmetrically placed [14]:

$$2F_{Rx,y} + F_{FM} + F_{FR} = F_{x,y} \quad (1)$$

$$2 \cos \alpha \times F_R + \mu \times f_{\mu}(m \times c_z \times g + 2 \sin \alpha \times F_R) = m \times c_{x,y} \times g \quad (2)$$

$$2 \cos \alpha \times F_R + \mu \times f_{\mu}(m \times c_z \times g + 2 \sin \alpha \times F_R) = m \times c_{x,y} \times g \quad (3)$$

Where,

$F_R$  - restraining force of the lashing,  
 $F_{FM}$  - friction force as a result of vertical force  $F_z$ ,

$F_{FR}$  - friction force as a result of the restraint force  $F_R$ ,  
 $F_x$  - longitudinal force due to load,  
 $F_y$  - shear force due to load,  
 $c_{x,y,z}$  - acceleration factors,  
 $m$  - load weight,  
 $g$  - acceleration due to gravity,  
 $\mu$  - coefficient of friction,  
 $\alpha$  - vertical clamping angle,  
 $f_\mu$  - conversion rate.

In order to calculate the LC lashing capacity, the following equation [14] is used:

$$LC \geq F_R \quad (4)$$

It should be borne in mind that the fastening lashing should be tensioned in accordance with the  $S_{HF}$  parameter.  $S_{HF}$ , or nominal manual force, has a standard value of 50 daN. However, it cannot exceed 50% of the value of the LC fastening capacity [14].

### 1.3 Control of Cargo Securing

The Road Traffic Act of June 20, 1997 (as amended) contains guidelines regarding road traffic control and the powers of the controlling authorities in Poland. This applies to article 129 and 129a, which lists the activities to which the Police and the Road Transport Inspection are authorized in relation to road traffic control [15].

These powers also include the control of cargo securing on the means of transport. The indicated authority inspects the technical condition of the vehicle. This also applies to the equipment as well as the condition and level of wear and tear of fastening elements, or also of fastening points. In addition, the load and method of fastening, its mass, dimensions and odor are examined. The axle load of the vehicle traveling on the road is checked, as the values may exceed the permissible values when the load weight exceeds the vehicle load capacity specified by the manufacturer in the technical documentation. Inspection authorities have the right to prohibit the continuation of the drive of a vehicle whose technical condition, load, weight or axle load have a negative impact on the technical condition of roads, road safety or have an inappropriate impact on environmental protection aspects. It is permissible for the inspection units to use the control and measurement equipment to determine the tension force of the lashing strap. The control aimed at checking the securing

of the cargo should be carried out in accordance with Article 13 of Directive 2014/47/EU of the European Parliament and of the Council of 3 April 2014 on technical roadside inspection regarding the roadworthiness of commercial vehicles circulating within the Union [10,14].

The following measuring devices are used to test the correctness of securing loads in road transport: DoMess1,2,3,4 and also a circular template [2,11,13].

## 1.4 Cargo Securing Study for Road Transport

### 1.4.1 Purpose and scope of research

In transport companies, cargo is often damaged due to poor securing of cargo. It is also for this reason that companies incur costs. The research was motivated by an attempt to eliminate these costs by answering the question of whether drivers can properly secure the cargo. The results turn out to be surprising.

The aim of the research was to analyze cargo securing in road transport and to check the knowledge of drivers of heavy goods vehicles professionally transporting cargo by road on a given topic. The respondents are both drivers employed in nearby transport companies (Zakład Rolniczo-Przemysłowego "Farmutil HS", PHUS Eksport-Import Transpil Spedition Waldemar Bocheński, PUH "Gólcz and Sons" Mieczysław Gólcz, Martrans, AGA-Guderski Transport & Logistics). Drivers of the analyzed transport companies and, additionally, drivers who are members of transport groups on Facebook. The research lasted 3 months and covered the period from January 7, 2020 to April 7, 2020.

### 1.4.2 Research object

The subject of research is a number of issues related to loads on the means of transport, i.e. legal regulations, fastening accessories, methods of fastening. Drivers answering according to their knowledge reveal a practical perspective on securing and transporting loads. The three-month survey period resulted in 230 forms returned. The majority of respondents are men in the number of 214 people (93%). Only 16 women took part in the survey, which constitutes 7% of all respondents. The difference between the representatives of both sexes is great, which suggests that the profession of a driver is performed to a greater extent by men.

Education can be a factor indicating the level of knowledge of the respondent. More than half of the respondents declared their education as secondary - 135 people (59%), then 48 people (21%) chose the answer higher, basic - 39 people (17%), primary - 6 people (2%). 2 people (1%) completed their education at lower secondary school. These data are presented in the chart (Fig. 3).

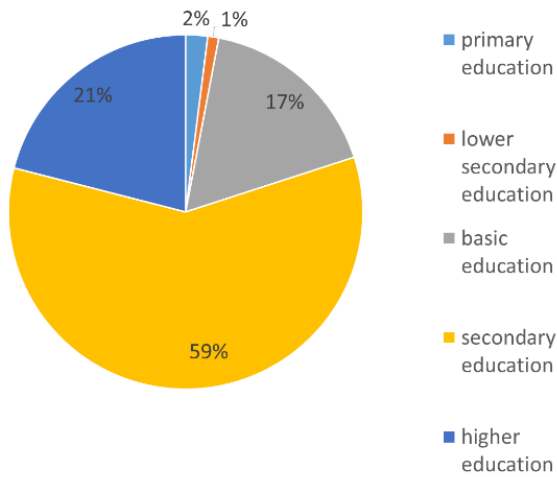


Fig. 3. Education of the respondents

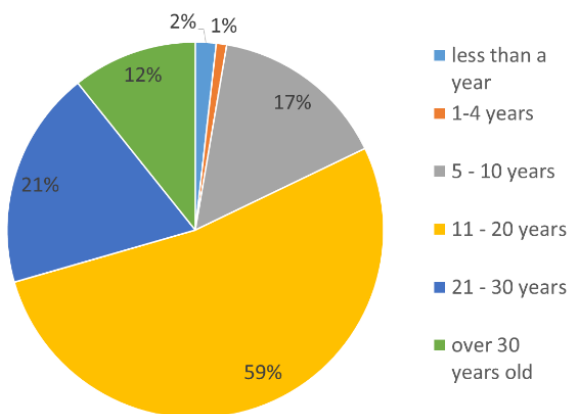


Fig. 4. Work experience of the respondents

Due to the length of service, the respondents can be divided into 6 groups. The most numerous group of 88 people (38%) are drivers who have been working in the profession for one to four years. Among the respondents there were 60 people (26%) with 5-10 years of work experience, then 43 people (19%) working 11-20 years, 24 people (10%) working less than a year, while 11 people (5%) were employed with transporting loads from 21 to 30 years. Only 4

people (2%) of the respondents can boast over 30 years of professional experience. The total length of the employment periods should indicate the level of knowledge and experience gained. The graph shows that drivers with various years of service took part in the survey, which has a positive impact on the accuracy of the results. In conclusion, the largest group of people was respondents who answered 1-4 years, which means that the road transport department has developed, and this resulted in an increase in the demand for people authorized to drive heavy goods vehicles. The above data is presented in the chart (Fig. 4).

## 2. RESEARCH METHODOLOGY

Before the actual study, a pilot study was performed. It was aimed at acquiring preliminary knowledge about the studied community and testing the correctness of the questionnaire. A questionnaire survey was used to conduct the research. There were 15 single-choice closed questions and 10 open-ended questions in the survey. Some questions included photos. The complete questionnaire was made available through the Facebook social network on transport thematic groups gathering professional drivers and delivered to the transport companies previously discussed.

## 3. RESULTS AND DISCUSSION

The research results are presented in the form of pie charts, which make it easy to read the information. They include the answers of 230 respondents professionally related to the topic discussed in the article. After each question, there is an analysis of the collected results.

### Question 1. Is cargo securing important for you in road transport?

Transport operations unite a number of issues, one of which is lashing, which aims to immobilize the load. This question was aimed at examining the individual approach of the person who has direct contact with the load during transport in everyday work. 211 people (92%) saw the importance of fastening and how important a part of road transport is securing the transported goods, 16 people (7%) answered no, while 3 people (1%) did not have an opinion. It becomes reasonable to create a group of 16 people and organize training.

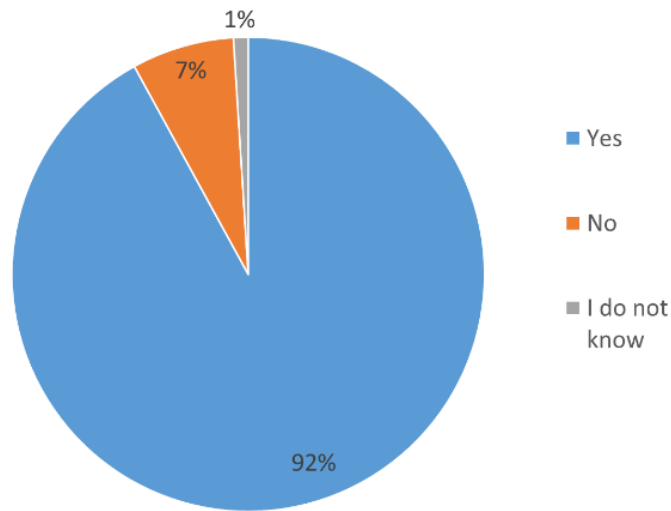


Fig. 5. The answer chart for question 1

**Question 2. Does the securing of loads affect the safety of all road users?**

In this question, it was very desirable to indicate the correct answer, as the correct securing of the load significantly reduces the effects of road collisions involving heavy goods vehicles and the extent of damage and destruction. The number of drivers who are conscious participants of road traffic is 216 (94%). They see the negatives and positives of the proper immobilization of goods placed in the cargo space and they see the safety aspects that are associated with it. 4%, i.e. 10 people answered in the negative, while 4 people (2%) did not have an opinion on this subject. As in the previous question, it makes sense to organize training for these people.

**Question 3. Have you participated in training / classes related to cargo securing?**

Analyzing the answers of the respondents, in this question, it can be concluded that more than half of the drivers (145 respondents, 63%) have not been trained in the topic of cargo securing. A minority, because 85 people (37%) took part in the trainings. It follows from the content of Annex II of Directive 2000/56 / EC on driving licenses concerning the minimum requirements for the driving test that the test is required to check the general knowledge of the applicant for the C + E license. In the theoretical and practical part, it should more precisely check the factors related to both the loading of the vehicle and the distribution and securing of the load.

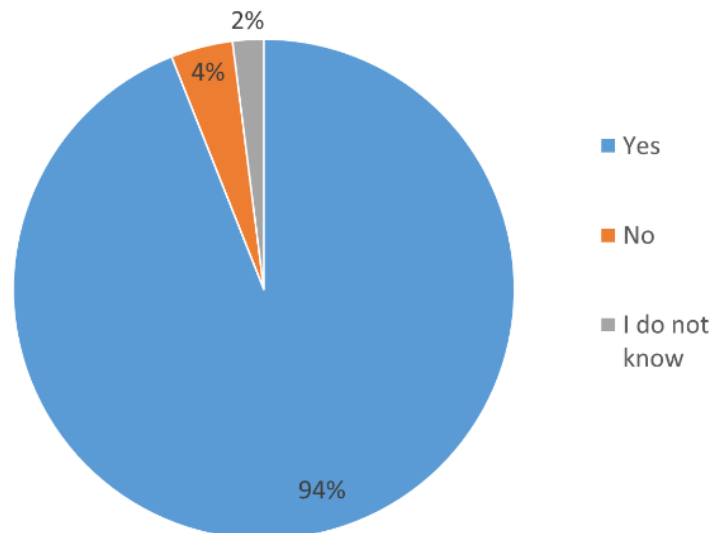
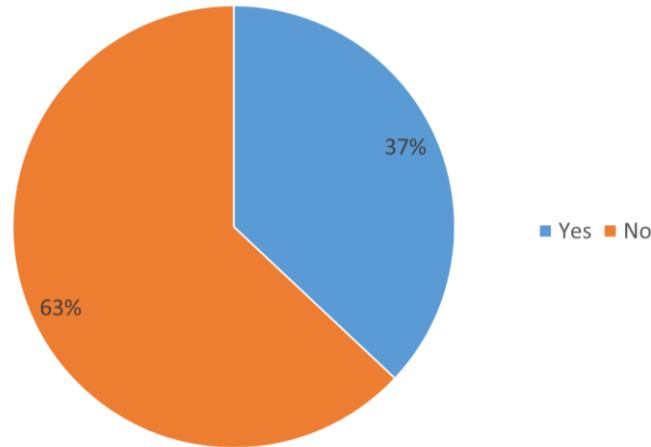


Fig. 6. Chart of answers for question 2





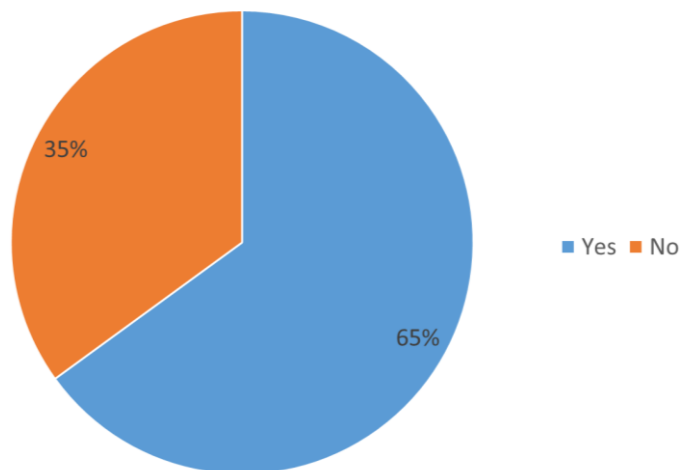
**Fig. 7. Chart of answers for question 3**

**Question 4. Would you be interested in participating in training or classes referred to in question no. 3?**

The number of people who showed willingness to participate in the training was 149 people (65%). Meanwhile, 81 respondents (35%) are not interested in participating in educational activities. Here you should answer the question of what it is caused by - whether you have already completed training in the past, or whether you are convinced that you have sufficient knowledge in the field of cargo securing. It is helpful to link the answers given in this question with the results of question number 3. From the presented results, partial data were drawn, presented as follows. Out of 149 professional drivers, 68%, ie 96 people, did not participate in the training on load

securing and this is the reason for expressing interest in taking part in educational forms. On the other hand, as many as 45 people (32% out of 149), despite participating in trainings, would be eager to participate in such classes again in order to refresh and consolidate their knowledge. This is illustrated in Fig. 9.

Chart 10 concerns the answers given by 81 people participating in the survey who do not want to participate in training. More than half (55%, 49 people) did not participate in any educational form in the field of cargo securing, and yet they are not interested in it. However, 40 people, which constitutes 45% of the answers, are not interested in the trainings because they have already participated in them, as declared in question 3.



**Fig. 8. Chart of answers for question 4**

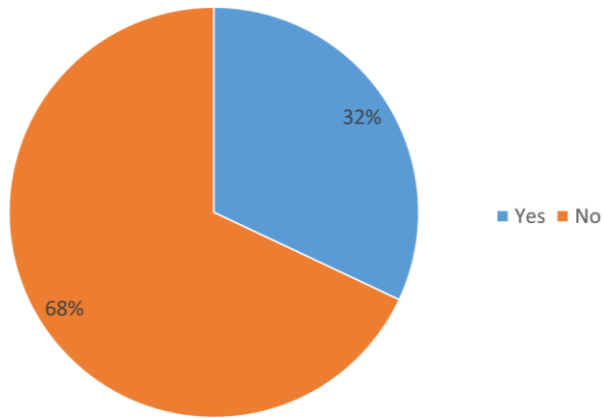


Fig. 9. Partial chart for the answer "Yes" to question 4

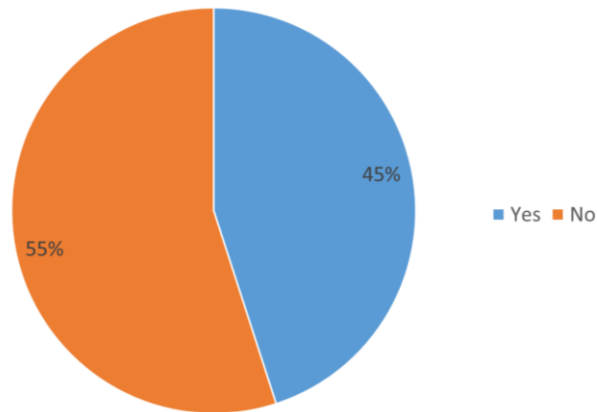


Fig. 10. Sub-chart for the answer "No" to question 3

**Question 5. Are there legal regulations specifying the methods of securing loads?**

The question was to check whether people directly related to the transport of cargo are aware that the methods of securing cargo are

legally regulated. This is important because these are documents from which drivers can learn and use in their work. Only 70% of drivers in the number of 161 are aware of the validity of regulations and normative provisions in this area.

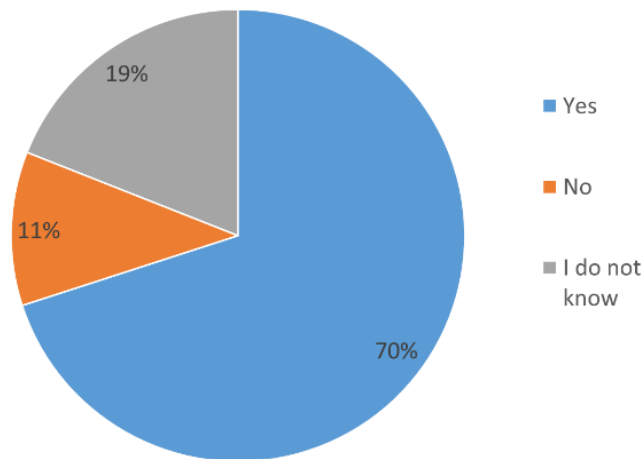


Fig. 11. Chart of answers for question 5

**Question 6. What should be the friction force between the load and the box body?**

75% or 172 people gave the correct answer. The remaining 25% is a worrying number of respondents who do not know the right solution to the basic issue of safe cargo transportation. As many as 58 of the surveyed drivers are not aware of the basic relationship between the coefficient of friction and the friction force, which limits the movement of the load on the loading surface.

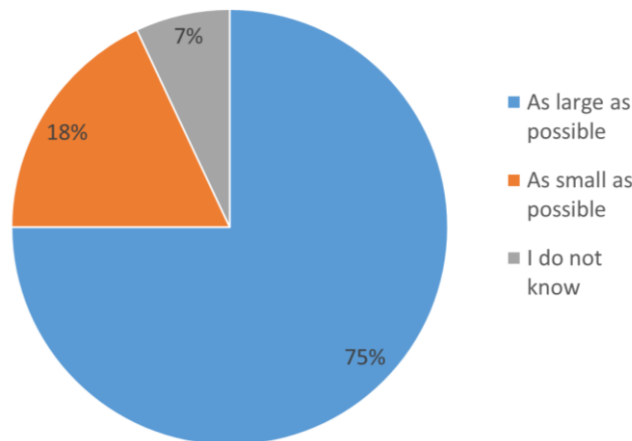
**Question 7. What to do if the lashing strap is dirty with acid or caustic solution?**

The question related to the use of the lashing strap, which is the most frequently used means of securing loads in road transport. A satisfactory majority, as many as 211 people (92%), correctly indicated that the dirty belt should be withdrawn from use. The option "wait until it dries, use it so far" was chosen by 9 people (4%), which is a wrong choice. Contact of the lashing strap with a

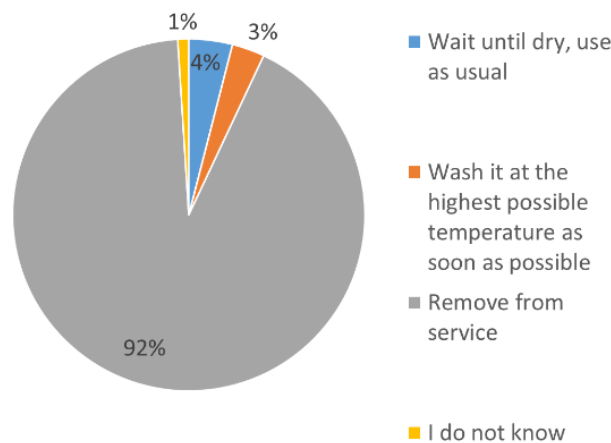
chemical solution may destroy the fibers of the belt and lead to breaking the lashing during transport. The "wash at the highest possible temperature" option was chosen by 7 respondents (3%) who did not realize the risk of deformation or damage to the belt of the transport belt during contact with hot water and / or detergent. 3 drivers (1%) would not know what to do in the given situation.

**Question 8. What is the value of the friction coefficient of the anti-slip mat?**

More than half of the surveyed drivers (134 people, 58%) admitted that they did not know about the key parameter of anti-slip mats. Only 52 people (23%) knew the correct answer to this question, indicating the coefficient of friction  $\mu = 0.6$ . 44 respondents indicated incorrect answers. It should be emphasized that in accordance with the recommendations issued by the European Commission developed by the Group of Experts appointed by the Directorate-General for Mobility and Transport, each time, if possible, taking into



**Fig. 12. Chart of answers for question 6**



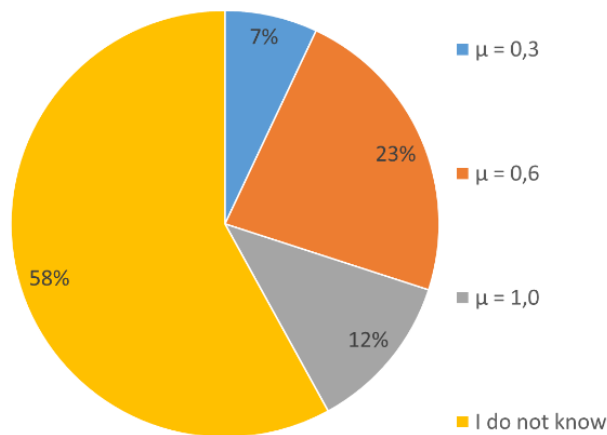
**Fig. 13. Chart of answers for question 7**

account the type of cargo, an anti-slip mat should be used to immobilize the load and reduce the number of lashing straps. Non-slip mats have become popular in cargo transport due to the ease of use and storage in a truck and small dimensions, so the answer to this question should not be a problem for the vast majority of people.

The photo shows incorrect selection of the mounting point. The question was not a problem for people participating in the survey. 89% of 204 drivers noticed in the photo that the fastening means is attached to the vehicle structure (side), which is tantamount to no fastening. There is a high probability that during sudden traffic situations the lashing strap will move against the side, resulting in zero load securing. The remaining 26 respondents did not know the correct solution or gave the wrong answer.

**Question 10. How many lashings would you use to secure long timber?**

According to the annex to the ordinance of the Minister of Infrastructure of January 25, 2018. Regarding the method of cargo transportation, it is recommended to fasten long timber with at least two lashings to each pair of stanchions. Less than half of the respondents, because 42% (97 people) declared their knowledge by choosing the correct answer. The option "Longitudinal lashing machine does not require the use of lashings, but only loading it into a specialized stake trailer" was chosen by 43 people (19%), the option "One lashing with initial stress  $STF = 2000 \text{ daN15}$ " (6%), while the answer "I don't know" was chosen by, as many as 75 surveyed professional drivers (33%).



**Fig. 14. Chart of answers for question 8**

**Question 9. Is the fastening device shown in the photo correctly attached to the vehicle?**



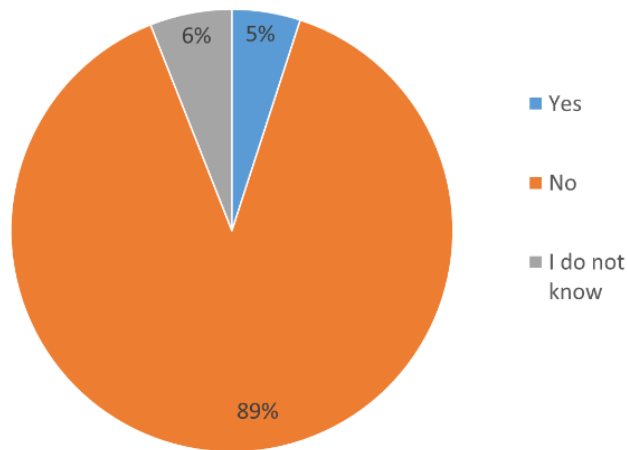


Fig. 15. Chart of answers for question 9

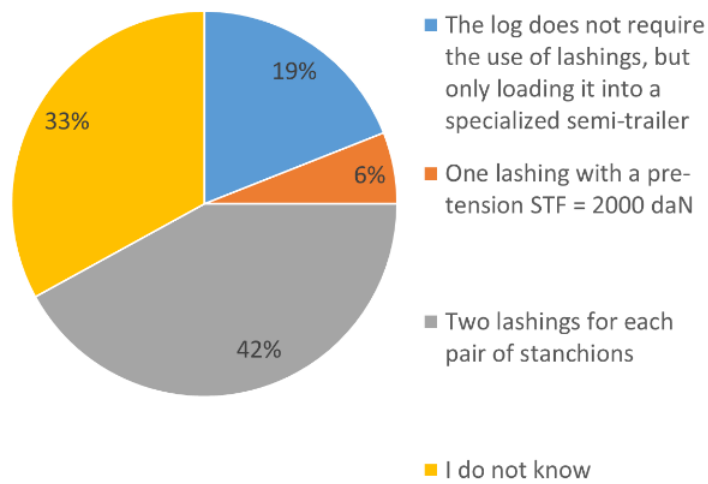


Fig. 16. Chart of answers for question 10

Question 11. What does the parameter LC = 2500 daN on the label of the tether mean?

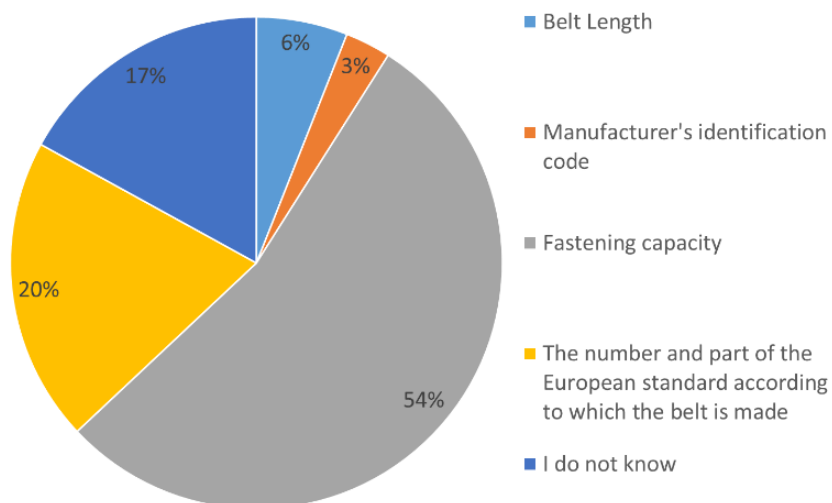
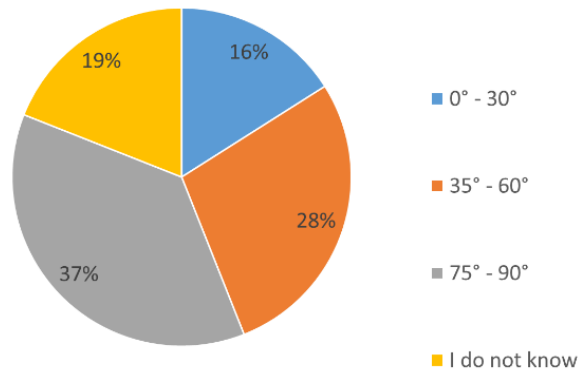
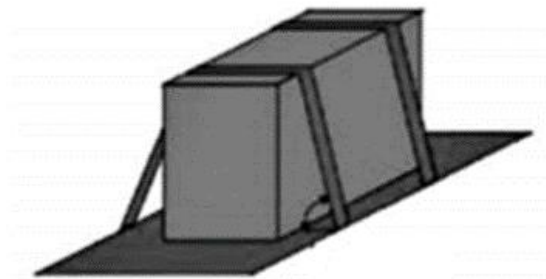


Fig. 17. Chart of answers for question 11

In the opinion of 54% of all respondents (123 persons), the LC parameter means the fastening capacity, which is the correct answer. This term is defined in the EU standard PN-EN 12195-1 and reads as follows: "LC fastening capacity - the maximum allowable direct force that the fastening can maintain during use". The remaining people are not familiar with the definition of the above parameter (107 people - 46% of the respondents). It is likely that they also do not know the other terms and values given on the label of the tether. This leads to a serious conclusion that questions the correctness of the cargo securing performed by this group of drivers, which may have a negative impact on road safety.

**Question 12. By strapping the load from above with the lashings, the angle between the lashings and the cargo space floor is shown in the illustration. What is the most desirable angle value to effectively immobilize the load?**

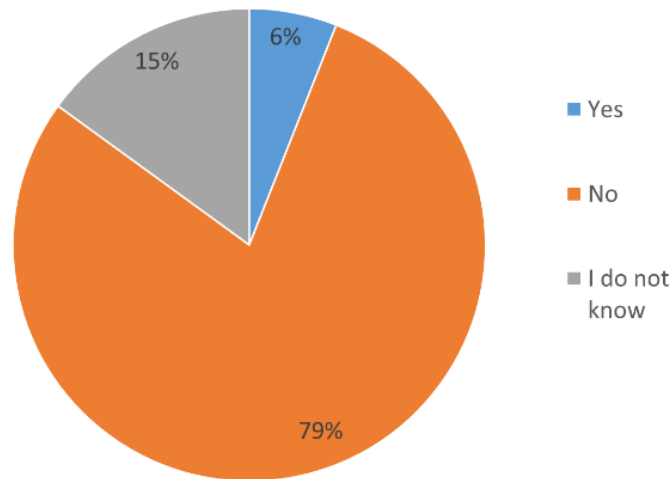


**Fig. 18. Chart of answers for question 12**

The source of the photo contained in question 12 of the research questionnaire is the attachment to the ordinance of the Minister of Infrastructure of January 25, 2018. The question related to one of the cargo securing methods. The correct answer "75°-90°" was indicated by only 37% of the respondents, ie 85 people. Which is a negligible percentage compared to the frequency of using this method. For it to be the most effective, the angle between the lashing and the load space surface must be as large as possible. The range of values 0° - 30° was indicated by 36 people (16%), the answer 35° - 60° was chosen by 64 respondents (28%), while 45 people (19%) chose the answer "I don't know". These people did not demonstrate the ability to analyze the photo and correctly deduce the image value of the angle.

**Question 13. Does the photo show correctly loaded and secured timber arranged crosswise?**





**Fig. 19. Chart of answers for question 13**

The overwhelming number of professional drivers (182 people, 79%) noticed irregularities in loading and securing the cargo shown in the illustration. The latest regulations regarding the transport of wood are included in the Regulation of the Minister of Infrastructure of January 25, 2018 on the method of transporting cargo [9]. In order for the transport process to be legal, it is necessary to load the timber placed transversely between the rigid side walls or in a cage. In this case, the protection should consist

of division of the load in the longitudinal direction into sections using rigid partitions or stanchions, at the same time the method of fastening with at least two top-over lashings is indicated. Additionally, the load must not protrude above the rigid side walls. 15%, i.e. 34 people to whom the questionnaire was addressed, do not have knowledge about the issue raised in this question. The remaining 6% (14 people) did not observe any non-compliance with the applicable standards.

**Question 14. What is wrong with the picture below?**



Open belt tensioner, i.e. the correct answer was indicated by only 87 people (38%). When carrying goods by road and using band lashings as security, the ratchet tensioner must always be blocked. It should also be observed in the illustration that the fastening belt is not secured against loosening, hanging freely and falling off while the vehicle is running. This is an offense under Article 66 (4) of the Road Traffic Act [15]. 23 people pay attention to the obligation to attach long timber with a chain lashing. On the other hand, the legislator uses the term "extraction" without specifying. The photo was

cropped in order to draw more attention of the person participating in the survey to the tensioner of the lashing strap, so it is difficult to determine the presence of the lashing protection and this answer was distinguished by 11% (25 people). According to 12% (40 people) of the respondents, there is no irregularity. The answer I do not know was circled by 42 people (24%). The results presented in the chart are disturbing due to the conclusion that arises about the lack of knowledge of the law and failure to notice gross offenses.

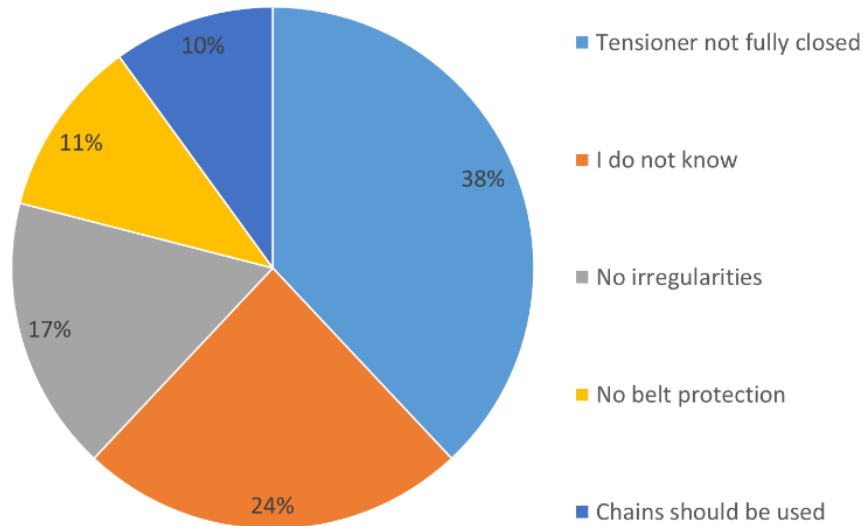
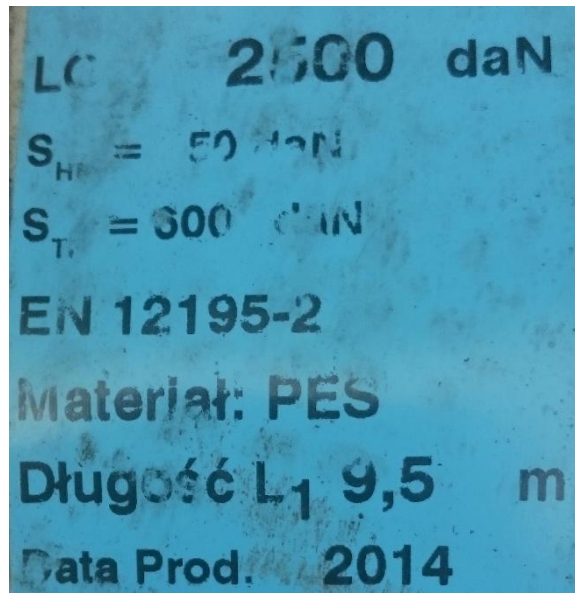


Fig. 20. Answer chart for question 14

Question 15. What does the picture below show? Do you see any abnormality?



The chart shows how the responses of the respondents to question 15 were distributed. Most likely, 18%, that is 42 responding drivers, did not have contact with the lashing straps or did not pay attention to its components. 21 people, which constitutes 9% of all respondents, think that the label looks right. Regardless of the fact that the difficulty in reading information characterizing the belt, used to secure the cargo guarantees that you will receive a ticket during the inspection. It is enough that one of the parameters is illegible and the belt is deemed not to meet the requirements of PN-EN 12195-2. From the responses of 73%, i.e. 167 respondents, it appears that the presented clipping is a label for a tether. The respondents mention that it is illegible. Unfortunately, only 14% (23 people) of



them wrote in an open question that the belt is not suitable for further use, because the identification features must be easy to read by the user or control authorities. The rest are unaware that an illegible label is the criterion for decommissioning the lashing strap.

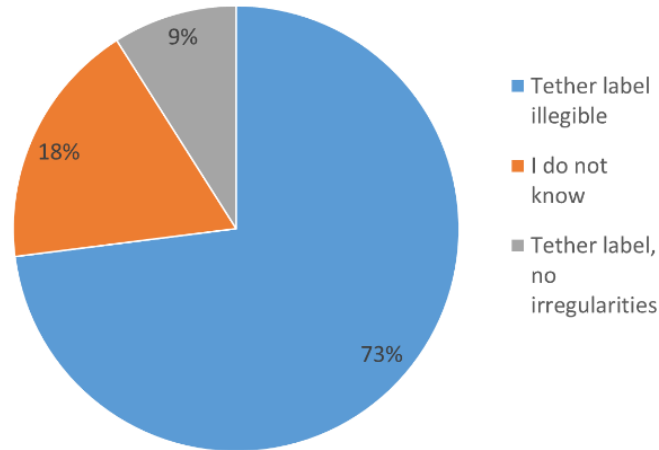


Fig. 21. Chart of answers for question 15

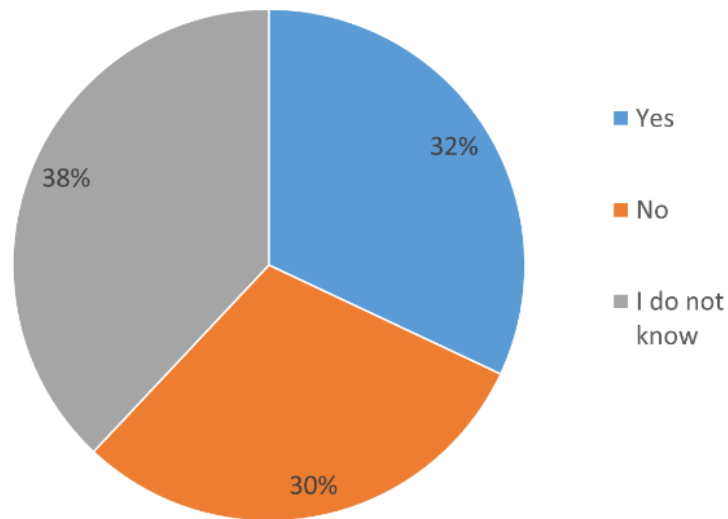
Question 16. What is wrong with the picture below?



This question is the only one in which the total number of respondents gave the same and correct answer. The photo shows the webbing of a transport belt with visible changes in the structure of the weave. This type of damage makes it impossible to meet the parameters described on the label. Due to damaged seams, the belt is considered out of order. It is necessary to replace it with another copy.

Question 17. Are the items shown in the photo below the means used for securing loads?





**Fig. 22. Graph of answers for question 17**

The results of the question about the so-called hedgehogs, distributed almost evenly. The correct answer "yes" was given by 74 drivers (32%), May-87 respondents (38%) answered "I don't know", while "no" was indicated by 69 respondents (30%). The use of hedgehogs is limited due to the destruction of cargo layers or the surface of the load box. They are dedicated to soft loads, e.g. wood, so that it sticks to the material.

**Question 18. What is the apparatus shown in the photo below for?**



The device in the picture is a measuring device called DoMess 3. The study showed that the answer to this question was a big problem. A very low percentage of 32 respondents gave the correct answer "measurement of the initial tension of the lashing strap". The 14 respondents (6%) who believe that it is an ITD control device should also be right. The remaining 6% (13 people) answered the belt retractor, which makes it possible to conclude that they are wrong. 52%, i.e. as many as 119 people to whom the survey was addressed, admitted that they did not know the correct answer to this question.

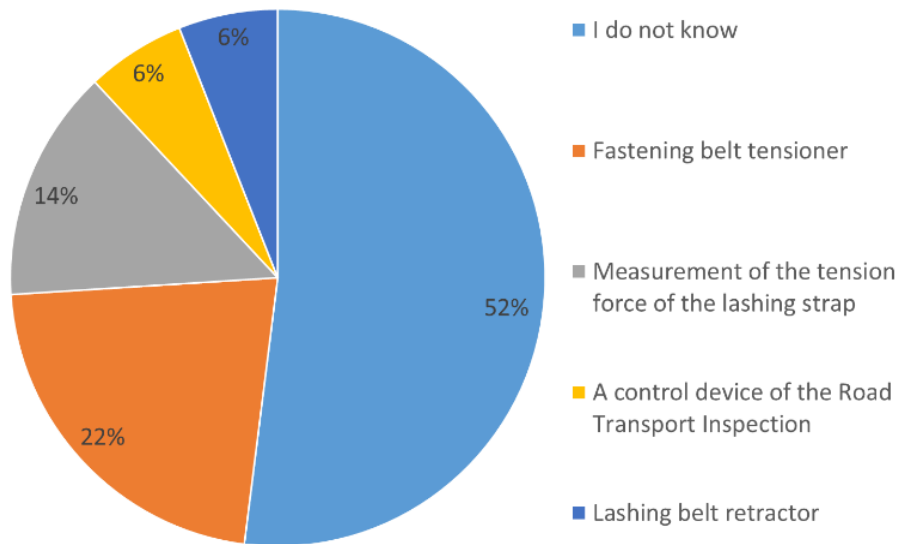


Fig. 23. Chart of answers for question 18

Question 19. What type of cargo are used with the attachments shown in the photo below?

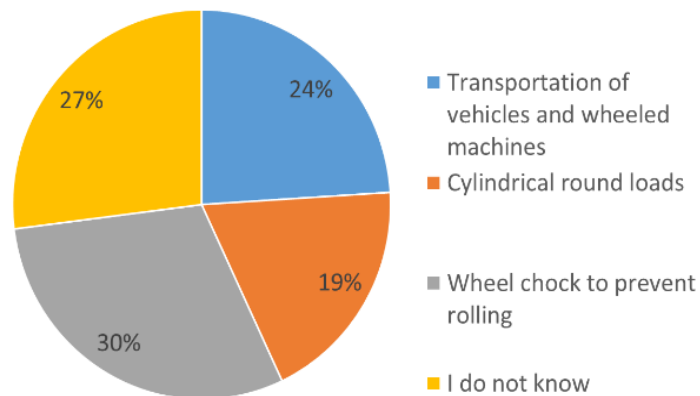


Fig. 24. Chart of answers for question 19

The question concerned the securing of a specific type of cargo. Most of the people (69 respondents, 30%) answering this question did not pay attention to the content of the question and indicated that it was a wedge under the wheels of a semi-trailer that prevents accidental rolling. Load securing wedges are used in the transport of vehicles and wheeled machines (56 respondents) and cylindrical loads, e.g. paper in rolls (44 respondents). 61 people (27%) did not encounter wedges in their work.

**Question 20. Did you use the items shown in the photo below at work as a professional driver?**

As can be seen from the chart above, the overwhelming majority of 213 professional drivers (93%) did not have contact with the devices and calculation aids used to secure the load while practicing their profession. Only 7%,

which is 17 people participating in the survey, confirmed the use of the indicated items in the photo. The question arises why so many respondents do not use the presented aids, which are designed to facilitate their work. Based on the above results, it can be concluded that there is little awareness of the existence of this type of equipment.

The survey was aimed at extracting the knowledge of professional drivers traveling both in Poland and other European countries about the securing of loads in road transport. The questionnaires included a properly prepared pool of questions and research techniques, which are also important for the accuracy and reliability of the research. The questions were arranged and edited in a clear and legible manner for the respondent, both in electronic and paper form. The tools used are closed-ended questions and open-ended questions with photos.

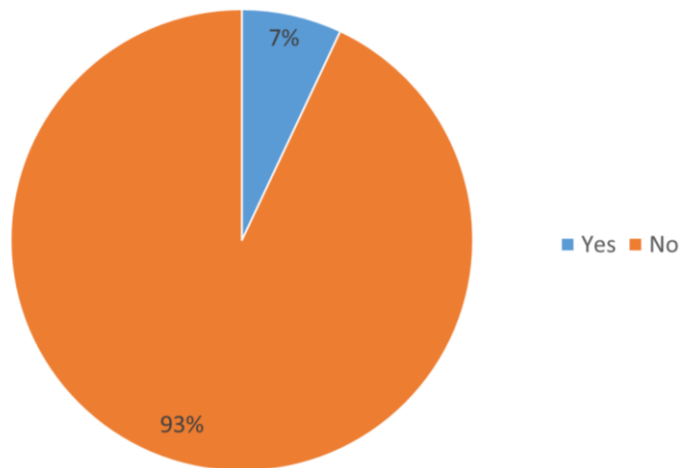


Fig. 25. Graph of answers for question 20

The main part of the study was conducted on 230 respondents. It turned out that drivers do not have sufficient knowledge in the area in which they operate on a daily basis. Some drivers refused to answer the questionnaires, even knowing that their answers would be anonymous or they had no knowledge about it.

As the survey shows, more than half of the respondents did not participate in any educational form related to cargo securing. The problem may result from the savings of the people managing the enterprise, as well as the reluctance of drivers to improve their own qualifications.

Most of the respondents do not use the aids and measuring instruments available on the market to check the necessary amount of fixing means to ensure the safety of other road users. The tabular or template method of determining the number of lashings eliminates the need to use mathematical formulas, which could be problematic for some professional drivers. These are measures that improve the work and make it easier without the need to perform complex calculations.

In the course of the research, difficulties arose in the form of the apparent reluctance of professional drivers to fill out an anonymous questionnaire. Unfortunately, some companies also refused to take part in the survey. It can be assumed that this was caused by the fear of the consequences that could be drawn by the legislator or the fear of the overall result of the study in the case of a specific company.

#### **4. CONCLUSION**

It is required from transport to be effective, and thus profitable and safe, and it is conditioned by the proper securing of the cargo. To sum up, it can be stated that the essence of securing loads in road transport is the appropriate selection of securing means, securing methods and available security systems so that the cargo with a specific weight, shape, plasticity and other own characteristics is immobilized on a properly selected loading surface and prevents its movement.

The material collected in the course of the research and the analyzes carried out show that professional drivers have insufficient knowledge in the field of load securing. The problem of poor knowledge of the subject, externalized among drivers, is a significant problem that may lead to

dangerous road situations and may generate unnecessary costs in the enterprise. In this situation, its managers should react. An example of a response to such signals may be the employment of a person providing consultancy services in the field of cargo securing, training or audits in transport companies. Retraining professional drivers or organizing training for those who are just taking their first steps in the profession is crucial. A person who becomes aware of the scale of the risk and shows the visual effects of road accidents with greater diligence and accuracy will secure the load that has been assigned to him and make sure that he drives to the road with a vehicle that does not pose a threat.

Lashing loads is a field of transport in which an individual approach should be taken to the load taken for transport. Standard mathematical formulas are helpful for this. But not all charges can be formulated and act schematically. Various loads of different shapes, sizes and other own characteristics are a challenge for people responsible for their safe transport. The driver carrying the load can make sure that it has been properly secured, without the need to use complicated mathematical formulas. It may turn out to be problematic for him, which is why publications have been made to facilitate these issues.

Each type of trailer has a different security method. The driver, acquiring the license, is obliged to have knowledge in this topic and the translation of the lack of competence is groundless. On the current labor market, entrepreneurs dynamically develop their fleet following the prospect of a potential customer, which results in the transport of various goods. They are looking for specialized drivers with skills, failure to improve qualifications may result in job loss.

Load securing is a field of transport that is constantly expanding its range. Demanding from the people involved to create innovative solutions to emerging problems posed by loads during transport. The guarantee of the search for the most effective methods of fastening and auxiliary devices is the growing transport and the willingness to transport various loads.

To conclude the considerations undertaken in this paper, it should be stated that the common goal of people involved in the transport of goods should be to improve the safety of all road users and to comply with applicable road regulations.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## CONSENT

As per international standard or university standard, participant's written consent has been collected and preserved by the author(s).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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