INVESTIGATION OF THE USE OF STUDDED WINTER AND UNIVERSAL TIRES IN VEHICLES OF M1 AND N1 CATEGORIES IN ŠIAULIAI

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Annotation

Tires are one of the most important elements of vehicles in terms of traffic safety. This is even more evident in unfavourable weather conditions on winter roads. The wrong choice of tires quite often becomes the cause of a traffic accident. It is very important to pay attention to the correct use of tires for drivers of trucks and cars. The vehicle is in contact with the road surface only on the four surfaces of the human palm size. Road traffic safety depends on various traffic elements: driver education, road quality and technical condition of cars. Tires are one of the components of a car. This paper examines the types of tires suitable for use in winter, the tire tread patterns, in order to determine the types of winter tires used, the prevalence of studded winter tires is studied. The aim is to determine the reasons why some European countries prohibit the use of studded winter tires.

Key words: *winter tires, studded winter tires, traffic safety, road surface.*

Introduction

Car tires are one of the components of the car, the proper use of which can improve road safety. However, activities in various areas of traffic safety are necessary: educating road users, improving the quality of roads and ensuring good technical condition of cars. After analysing the development of tires, we notice that there were no very significant structural changes. The only difference is the production technology itself and the properties of the materials used. The aim was to improve the operational characteristics of the tires by evaluating the adhesion coefficient, driving speed and noise. Not only the characteristics of the tires have improved, but also the technical progress of the car. In order to ensure safety, cars are equipped with various systems that help the driver in emergency situations: anti-lock brake system, traction control system, electronic stability system. None of the mentioned systems will be able to function properly when cars are operated with improperly selected tires. The interaction of car tires with the road surface has an impact on traffic safety, which encourages the improvement of both car tires and road performance parameters of cars.

Vehicle tires are of special importance because they are an elastic support that gives the car engine traction and braking power, allows the car to change direction, and prevents the car from sliding under the influence of centrifugal forces. In adverse weather conditions, i.e. with a large amount of water on the road surface, the insufficient depth of the tire tread significantly reduces the adhesion of car tires to the road surface. A wedge of water or wet snow intervenes between the car tire and the road surface. This phenomenon is called aquaplaning. Therefore, the purpose of determining the minimum tread depth is to prevent accidents that occur in conditions that reduce road grip. The depth and type of tread pattern must be such as to guarantee sufficient grip on the road even in the worst conditions. During the winter period in the European Union, in those countries where the use of winter tires is mandatory or recommended, the minimum tread depth requirement for winter tires ranges from 1.6 mm to 5 mm. [20].

It is very important that cars are operated with tires that have grip properties that match the weather conditions, i.e. during the winter period, winter or universal tires would be used. In order to find out what tires are used by drivers of cars operating in Šiauliai, a study was conducted evaluating the use of different types of tires during the winter period.

The aim of the research:

1. Research the types of tires for M1 and N1 category vehicles exploitation in winter.

Research tasks:

1. Find out why winter tires are banned in some countries;
2. Determine how widely winter studded tires are used;
3. Investigate whether cars with studded winter tires are properly marked;
4. To determine the prevalence of the use of universal tires on winter roads.

Methodology of investigation

According to the road traffic rules of the Republic of Lithuania, vehicles with winter or universal tires must be used in Lithuania from November 10 to March 31. Some drivers choose winter and winter studded tires. Studded winter tires can be exploitation in Lithuania for a limited time, i.e. from November 1 to April 9 [16]. The task of the research was to investigate which tires cars are used on winter roads. Several parking lots of Šiauliai city shopping centers where cars are not left for a longer period of time were chosen to implement the task. This assumes that the analyzed cars are in continuous operation. The check of the condition and types of car tires was carried out at the shopping centers “Saulės miestas”, "Bruklinas", "Tilžė" and "Maxima" stores located on Rudės st. 14, "IKI-TURGUS" store, located at Vilniaus str. 220, store "IKI-DAINAI" located on Gardino str. 2, "LIDL" stores, located at Pramonės st. 1A and Tilžės str. 217. The map of tire types inspection locations is shown in Figure 1.

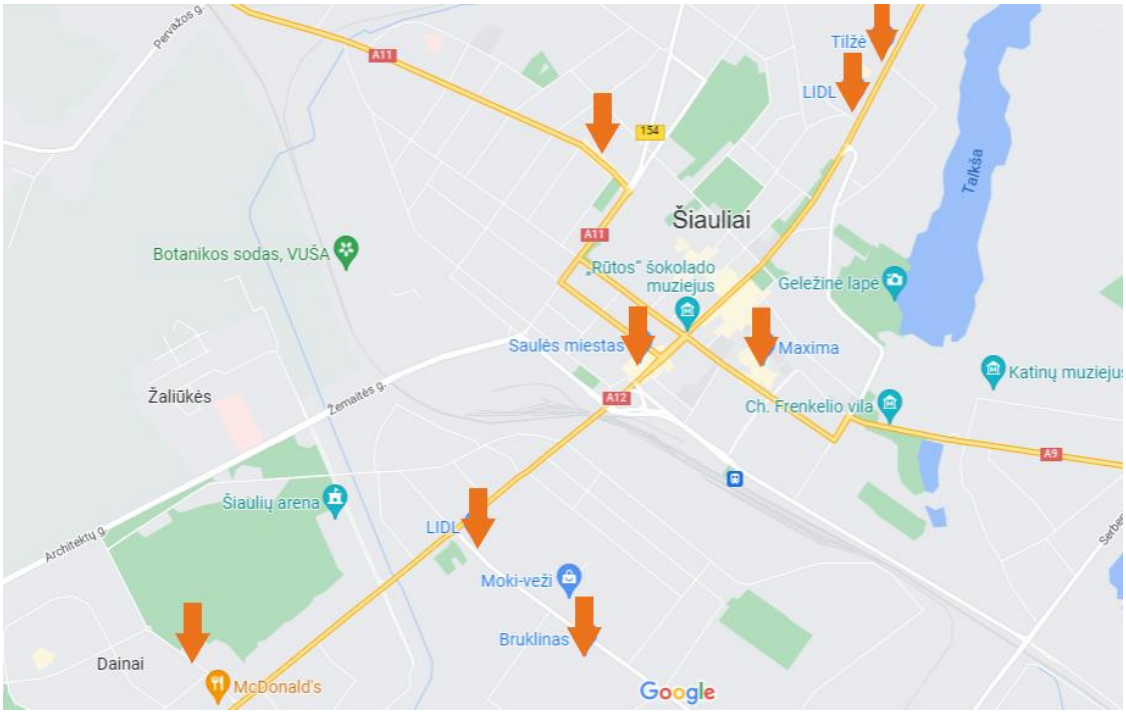

Fig. 1. Inspection places for tire types in Šiauliai

During the investigation, car tires were checked and their type was determined based on the tread pattern and markings. Tire manufacturers insert various markings on the sides of the tires (Figure 2), some of which can be used to determine the type of tire.

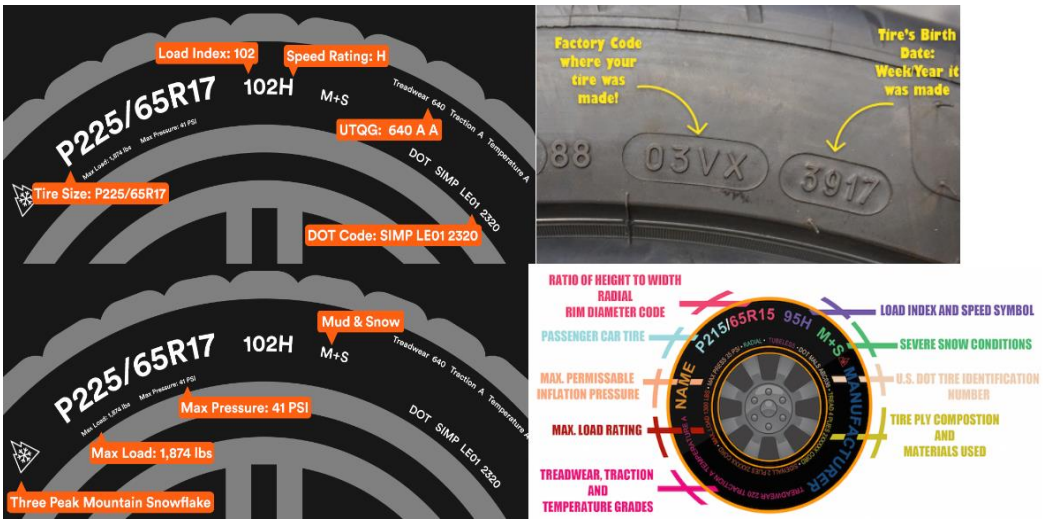

Fig. 2. Tire marking [21; 22]

P: It's a passenger car tire or light truck tire. 225 is the tread width. It simply tells us how wide your contact patch or tread width is in millimetres. 65: This number tells us how tall the tire

sidewall is. The 65 means the sidewall height is equal to 65 % of the tire's width. If the width is 225 mm, the sidewall measures 146.25 mm tall. R: The R indicates that the tire is radial, which you will find on most tires these days. However, there may be a D here, which simply indicates that this is a rarely used bias tire. 17: The last number tells us the diameter of the wheel. In this case, the wheel is 17 inches. The next largest number on our tire's sidewall is the load index. This essentially tells us how much weight the tire can support. In the example photo, that number is 102H. The load index is another standardized number of two or three digits. From the diagrams it is possible to determine how much a specific number corresponds to kilograms. In this case, 102 equals 850 kg for each tire. The capital H behind the load index is the tire's maximum allowable speed rating. It basically tells you how fast the tire can safely travel, and it's important to think of this as the top speed. Tire speed ratings are also standardized, so whatever letter appears on tire will correspond with the speed ratings listed. Yes, most of the list is in alphabetical order aside from S, H, and V. That's because those speed ratings were introduced in the 1960s before listing the remainder of the speed ratings would be done in alphabetical order. In this case, H means that with such tires the car's speed is limited to 210 km/h. M+S simply means the tire can handle light mud and snow. In example, mud and snow are spelled out, but the symbol may appear as an alternative and is typical to find on an universal tire to let us know it can handle those conditions. The snowflake is present to let us know that we're working with an all-weather or winter tire that can handle moderate to severe winter conditions. It's found on the Three Peak Mountain, and is a standardized rating to ensure the tires can be used safely in wintry conditions.

The tire test was carried out by inspecting the tires of cars parked in parking lots. After evaluating the symbols (Figure 3) on the tires and the structure of the tread pattern, the type of tire is determined.

Fig. 3. Marking of universal tires [23]

In order to be considered winter tires, they must have symbols of a snowflake or an iceberg with a snowflake on the side (Figure 4).

Fig. 4. Marking of winter tires [24]

The study of the types of tires used in the city of Šiauliai in M1 and N1 vehicle categories was conducted in the winter period of December 2022 and January 2023.

Theoretical analysis of the characteristics of the types of tires used on winter roads.

A tire is one of the car's elements, on which traffic safety, fuel consumption, and passenger comfort depend. The adhesion coefficient is the main parameter for predicting the car's behaviour during braking and other emergency situations and for designing active safety systems. The contact properties of the road surface and tires determine the driver's behaviour in an emergency situation and the consequences [8]. The adhesion coefficient is defined as the ratio of the longitudinal force of wheel traction acting on the road surface and the normal load pressing on the wheel.

The adhesion of a tire to the road surface is one of the main indicators of its efficiency, which affects traffic safety. By improving tire designs, materials that allow improving the main indicators of tire adhesion to the road surface (adhesion and sliding friction coefficients), new tread patterns, special tread rubber compounds have been created. Which significantly improve tire grip on wet and slippery road surfaces, tire elasticity at low ambient temperatures (-8 °C and below) [8].

One of the main indicators of tire adhesion to the road surface is tread slippage. The values of the adhesion coefficient depend on the longitudinal slip. On a dry road, with a wheel slip of about 14 %, the grip is the highest and its value reaches $\mu_k = 0,99$. On a wet road, the μk value decreases by about 20 %, on a snow-covered road - by about 60 % ($\mu_k \approx 0,40$) and on an ice-covered road - by about 82 % ($\mu_k \approx 0,18$). As tire slippage increases, the efficiency of its tread grip with the road surface decreases. When the slip reaches the critical limit, that is 100 %, the longitudinal contact force acting on the area of contact of the tire with the road will become equal to the frictional force between the tread and the road surface. This happens when braking the car with locked wheels or when moving with spinning wheels. In this case, the adhesion coefficient is immediately reduced by 20...35 %. The values of the coefficient of adhesion and the coefficient of sliding friction are equal: $\mu_k = \mu_l$ [10]. Under this condition, the car practically becomes out of control (emergency situation).

The European Commission classifies vehicles as part of emission standards and other vehicle regulations. Passenger cars receive an “M” categorization, while commercial vehicles receive an “N” categorization. Two directives of the European Parliament and of the Council serve as sources for these definitions and classifications: 2002/24/EC of 18 March 2002 and 2007/46/EC of 5 September 2007. In addition, the EU legislation on driving licenses (Directive 2006/126/EC of 20 December 2006) provides for a splitting of some categories of vehicles [14].

Category M – Motor vehicles having at least four wheels and for the carriage of passengers. Category M1 – Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver’s seat, and having a maximum mass (“technically permissible maximum laden mass”) not exceeding 3,5 tons. Category N – Power-driven vehicles having at least four wheels and for the carriage of goods. Category N1 – Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver’s seat, and having a maximum mass (“technically permissible maximum laden mass”) not exceeding 3,5 tons. [15].

Tires are the only part of the car that is in direct contact with the road, therefore, they must be suitable and of good quality. They provide adequate grip with the road surface, thanks to which the car is easy to control, accelerate or brake when necessary. Tires can be of different types (Figure 5), intended for different seasons, with different tread depth and pattern.

Fig. 5. Types of tires suitable for use on winter roads [25]

Snow or winter tires are specially designed for cold weather; they perform poorly in summer conditions. Universal tires are a compromise that works satisfactorily in all conditions. However, it does not excel in any particular type of weather. Not very good in winter or summer. Universal tires rubber more durable rubber compound that hardens in cold weather. Winter tires rubber less durable rubber compound that remains flexible in the cold. Universal tires are designed for both dry weather and snow. They have medium sized tread blocks with more edges than summer tires. Some hair-thin cuts, or snipes, cross the tread to add extra grip. In cold weather, they will harden, reducing their traction and grip. Snow or winter tires use rubber compounds that are specifically designed for extra grip in low temperatures, and have a tread designed to bite into snow. They are ideal in areas that experience winter storms and blizzards. Snipes cross the treads, creating extra edges for added grip. The tread, as a result, is less stable.

Studdable winter tires. The differences between studded and studless winter tires go beyond tiny metal studs. Studless snow tires offer great traction for most winter conditions without the metal spikes. Wide, deep grooves in the tread help keep you in control. Studded winter tires have spikes or studs that break through packed snow and ice for added traction. Studs are lightweight, small metal spikes (studs) that are staggered and inserted across the tread of a winter tire. These studs protrude slightly from the rubber tread surface. Winter tire studs have a large diameter cylindrical end that roots down into the tire tread, and a small tungsten carbide pin that extends from the “active” end of the stud.

From tire manufacturers' comparative tests, we can see the differences in acceleration and braking between universal and winter tires. In the snow, winter tires have an unexpected advantage. On snow, the winter tires accelerate from 0 to 95 km/h in 19.1 seconds, and the universal ones in 22.9 seconds. When stopped in the snow, the car with winter tires stopped from 95 km/h in 117 meters, and with universal tires in 128 meters. In wet conditions, the snow tires accelerate from 0 to 95 mn/h in 12.7 seconds, while the universal tire took 15.4 seconds. When stopping in wet conditions at 95 km/h, the snow tires stopped in 55 m, while the universal tires stopped at 66 m. In dry conditions, the snow tires accelerate from 0 to 95 km/h in 8.9 seconds, while the universal tires do so in 8.7 seconds. The snow tires stop in 47 m from 95 km/h, while the universal tires stop in 40 m. [23]

Summer tires have a dedicated rubber compound that delivers excellent grip and handling on both dry and wet roads in warmer conditions. They also have reduced rolling resistance and therefore provide greater fuel efficiency and generate less road noise. The tread pattern on a summer tire is more streamlined than a winter tire, with fewer grooves for water clearance, maximizing the contact patch with the road. Consequently, the vehicle has superior traction and braking during dry summer months. However, these same characteristics – the unique rubber compound and simple tread design – make summer tires unsuitable for winter driving conditions. When the temperature drops below 7 degrees Celsius, the compound becomes hard and brittle, and the tread design can’t adequately handle snow or ice.

Winter tires provide outstanding grip on road surfaces covered with snow and ice, as well as wet roads in cold conditions. The tread compound of a winter tire contains more natural rubber, so it doesn’t harden when the temperature drops below 7 degrees Celsius. Instead, it stays flexible and limber in cold climates to reduce the stopping distance when braking. The tread design has deeper blocks that will dig into snow and ice to provide more grip. The winter tire also has a lot of sipes, which are excellent for clearing water and slush from the path of the car and mitigating the risk of hydroplaning [18].

Comparison of studded and non-studded winter tires. When choosing winter tires, the following questions should be taken into account: How much is driven in winter? What roads are used? What are the driving skills in winter conditions? Is it possible to use public transport? Is the car equipped with special safety accessories (stability and traction control, ABS brakes)? Whichever option you choose, remember that driving requires skill. Predictable and calm driving style, correct speed and relaxed graphics improve driving safety and comfort. Snowy or icy roads.

If you drive more on icy roads than snowy roads in winter, studded tires are a better choice. Studded winter tires are particularly useful if the place of residence is near the coast, where the roads are often icy in winter. Studded winter tires are a good choice for snowy roads. Wet ice and packed snow. If studded winter tires are used, extra care should be taken at intersections, etc., where there may be wet ice or hard snow. Studded tires are superior to non-studded winter tires on wet ice and hard snow. If quiet tires on bare roads are a priority, studless winter tires are the right choice. Non-studded winter tires can be installed in autumn earlier than studded ones. By installing studless winter tires, you won't have to worry about the rapidly changing road conditions in the fall. Studded winter tires are also a good choice when temperature changes can be surprisingly quick. Studded winter tires that have landed unevenly on bumpy spring roads are no match for good summer tires. Therefore, we do not recommend

using studless winter tires as all-purpose tires. Summer tires are the safest and most economical choice for summer driving [26].

Studded winter tires provide the best traction on snow or ice near the freezing mark, and lose proportionally more of their traction at lower temperatures than studless or universal tires. The grip of studded winter tires is only marginally superior to studless tires only in increasingly narrow conditions. Since the beginning of the 1990s, with the mandate to use less aggressive (light) studs and the introduction of new studless winter tires, the traction advantage of studded winter tires is primarily evident on clear ice near the freeze-mark condition, where the occurrence is limited. In most tests reviewed for snow and ice at lower temperatures, studded winter tires performed as well or worse than winter studless tires. In conditions where studded winter tires provided better grip than studded winter tires, the gains were generally small. The precise environmental conditions under which studded winter tires provide a traction benefit are relatively rare. The maximum frictional gain (in comparison to non-studded (not studless) tires) is found for new studded winter tires on smooth ice, where they have been shown to provide up to 100 percent gain in certain tests. However, the relative frictional gain of studded winter tires diminishes or becomes negative on roughened ice, as the temperature drops, as the studs wear, or if the comparison is made with studless tires. In one set of braking road tests in Alaska, studded, studless, and universal tires performed nearly equally on snow when averaged across multiple vehicles. On ice, studded winter tires had a 15 percent shorter stopping distance than non-studded winter tires, which in turn was 8 percent shorter than all-purpose tires. In another set of tests in Alaska, studless winter tires offered the best traction performance, especially for braking on both packed snow and ice, in comparison to studded winter tires (which were second) and universal tires (which were last). On bare pavement, studded winter tires tend to have poorer traction performance than other tire types. This is especially true for concrete; for asphalt, there is little difference in stopping distance between studded and non-studded tires. Tractive performance of studded winter tires is sensitive to stud wear. Studded winter tires may lose more of their tractive ability over time (from stud wear) than studless tires. When stud protrusion diminishes to 0.6 mm, the frictional effect from the studs becomes negligible. Tire tread wear (on studded tires) has relatively little frictional effect if stud protrusion is maintained at 1.0-1.1 mm. A Norwegian study concluded that the use of studded winter tires tends to reduce the accident rate by a small amount—from 1 to 10 percent [11].

A Swedish study found that in 64% of fatal crashes on roads covered in ice or snow, loss of control was the main cause. Furthermore, in 82% of loss-of-control crashes, the passenger car over-steered prior to collision. Studded winter tires were found to have a statistically significant effect of 42% in terms of fatal crash reduction on roads covered with ice or snow, compared to non-studded winter tires. The effect on dry or wet roads in the winter was negative, although statistically non-significant. In the additional study, it was found that electronic stability control (ESC) further reduced crashes with injuries by 29%. The benefits on severe and fatal crashes were slightly greater (32%), although the lower 95% confidence limit was lower. Although Studded winter tires were shown to reduce the risk of fatal crash involvement, compared to non-studded winter tires, the proportion of loss-of-control and over-steering among cars with studded winter tires was large (59% and 49%, respectively). This is also supported by the fact that the share of loss-of-control fatal crashes is considerably lower for ESC-equipped cars. This study recommends that non-ESC cars should be fitted with studded winter tires if they are to be driven on roads covered by ice or snow. If the proportion of studded winter tires is to be decreased on Swedish roads to reduce the about of hazardous particulates especially in built up areas, from a road safety point of view it is recommended that this should be done in phase with the implementation of ESC on all passenger cars [12].

Why are studded winter tires banned in some countries?

In some European countries (Figure 6), winter tires are mandatory for M1 and N1 category vehicles during the winter.

Fig. 6. Winter tires are mandatory in European countries [27]

In the countries shown in red on the map, winter tires are mandatory during the winter period. In the countries shown in black on the map, winter tires are mandatory according to the road conditions. In grey countries, winter tires are optional. Different countries have different winter tire requirements. For example, in Lithuania from November 1 until April 1 winter tires with a tread depth of at least 3 mm are mandatory for vehicles weighing less than 3.5 tons. Studded winter tires are allowed from November 1. until April 10 And in the northern neighbor Latvia from December 1. until March 1 M+S type winter tires with a tread depth of at least 4mm are mandatory for all vehicles weighing less than 3.5t. From October 1 until April 30 studded winter tires are allowed for vehicles. In the southern neighbor Poland, winter tires are not mandatory, but strongly recommended in winter conditions. The use of studded winter tires is prohibited. There are more countries in Europe that ban studded winter tires. They are shown in the Figure 7.

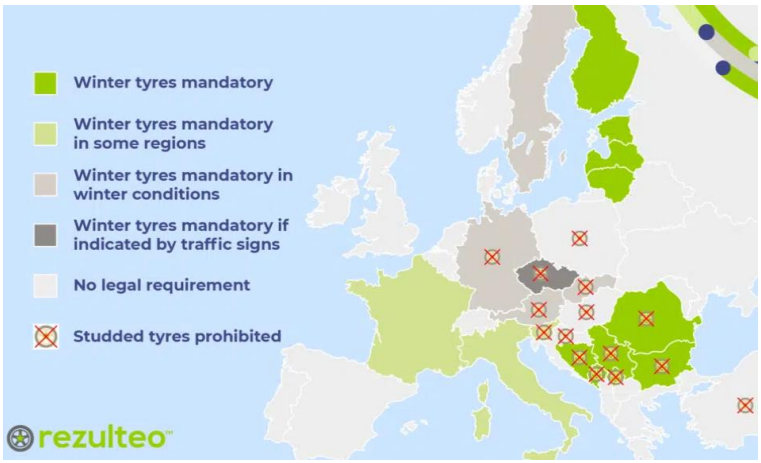

Fig. 7. Studded winter tire rules in Europe [28]

Each European country adopts its own rules for winter tires, studded winter tires and snow chains. In France, as in the UK, winter tires are not mandatory (although strongly recommended for safety in low temperatures). However, countries such as Germany, Austria, Luxembourg, there are strict rules on the use of winter tires. Several aspects of tyre law vary between European countries. Such as not having sufficient tread depth could lead to a fine. Studded winter tires prohibited in such countries as: Netherlands, Germany, Austria, Poland, Czech Republic, Slovakia, Bulgaria, Croatia, Hungary and others. Studded winter tires are banned because they damage the road surface and hollow out deep ruts, which then quickly led to the notorious aquaplaning when it rains. The spikes cause grooves on streets, especially highways, which can cause safety issues such as water pooling, resulting aquaplaning, and other problems for other road users. Spikes slightly but decisively interrupt the interaction between the tread and the road surface, which negatively affects the stopping distance. Studded winter car tires are only useful in black ice and stuck snow. Studs reduce grip on dry or wet winter roads and also draw attention to themselves with significantly higher road noise. Another disadvantage is that spikes on asphalt roads wear the road surface much faster than regular tires.

Studded winter tires can help improve traction for driving on icy roads, but there have long been questions about the harm they cause and whether their benefits outweigh their disadvantages. The tires have small metal studs embedded in their threads, which dig into any ice covering the road, improving your vehicle's traction. If there's no ice on the ground though, the studs dig into the pavement and damage the road. This issue has led some states to ban these tires or allow them only during certain times of the year. According to a new study from researchers at the Chalmers University of Technology in Sweden, the harm studded winter tires cause outweighs the good. The study took a holistic view of the tires' impact on public health throughout their entire lifecycle, from manufacturing to disposal. What the researchers found is that the studded winter tires cost more lives than they save [17]. In Sweden, about 60 percent of drivers use studded winter tires. The researchers, Anna Furberg, Sverker Molander and Rickard Arvidsson, found that the use of studded winter tires in Sweden saves between 60 and 770 life-years. They also found that, across the tires' lifecycles, they cause the loss of 570 to 2,200 life-years [5]. The majority of the negative impacts come from the emissions that studs cause when they damage the road and throw particles up into the atmosphere. That this impact alone causes more loss of life-years than the studded winter tires save. About 67 to 77 percent of

studded winter tires' negative health impacts come from emissions due to road wear. As well as emissions from the production of studded winter tires.

Pavement rutting caused by accelerated wear from studded winter tires can cause thedangerous conditions of tramlining, hydroplaning on accumulated water in the ruts, excessive road spray, and premature damage to pavement markings. The roughening of ice and pavement from studded winter tires provides a safety benefit for all vehicles (with and without studs) by helping to prevent formation of smooth, glare ice. Studded winter tires increase fuel consumption by a small amount (~1.2 percent) over non-studded tires on bare roadways. But the other effects of unevenness, snow, and ice are far more significant than this factor and can increased fuel consumption by 15 percent. Suspended particulate matter from pavement dust created by studded winter tires and noise from studded winter tires are health concerns in heavily traveled urban areas [11].

When driving with studded winter tires, the studs gradually penetrate the asphalt surface and displace small aggregates. This raveling process eventually results in pavement rutting, as shown in Figure 6 [1].

Fig. 6. Studded winter tire wear on the basis by the Washington Department of Transportation [1]

Asphalt pavement rutting can result from deformation of asphalt pavement materials and/or the layers below them under heavy traffic loads or because of raveling from the studded winter tires that are often mounted on passenger vehicles. However, few studies have focused on the reduction or prevention of asphalt pavement rutting related to studded winter tire wear. Rutting from studded winter tire wear could be significant and often becomes an engineering concern. It has been reported that rutting from studded winter tire wear may reach 25 mm within six years, which exceeds the 20 mm rutting depth criterion for rehabilitation/repair specified by most highway agencies [2].

In addition, rutting has been reported as one of the most important causes of loss of skid resistance in wet weather and of vehicle hydroplaning. It is closely associated with traffic accidents at night and under rainy weather conditions [6]. They found that as the studded winter tire moves over the pavement, its spikes transfer energy to the pavement through the contact points of the studded winter tires. These spikes can scratch the pavement, and punching action can occur between the contact points of the studded winter tires. The punching action leads to rutting and raveling of the pavement, caused by disintegration of the surface layer. One Finnish study showed that a passenger car with four studded winter tires could ravel about 10 kg of pavement material in a decade. [13]. Subsequent studies have shown that with the improvements in the protrusion and weight of studs, this value has decreased to about 2.5 kg. Note, however, that increases in traffic volumes during recent years diminish the net effects of stud improvements.

The effectiveness of electronic active safety systems in a car with different types of tires, including studded ones, on an icy road is different. Significant reduction in effectiveness of electronic active safety systems when tires are studded. Therefore, it is necessary to prepare recommendations on how to improve their management algorithms. To do this, it is also necessary to determine the characteristics of studded winter tires lateral grip on ice [7].

The risk of fatal road accidents in winter between studded and unstudded tires does not differ significantly. However, the accident risk has recently been substantially higher on bald ice for unstudded than for studded winter tires. The magnitude of this risk difference is difficult to determine without specific information on exposure by road surface [9].

Attribute to studded winter tires minor declines in automobile accident rates of 5% for snow- or ice-covered roads, 2% for bare roads and 4% for all road surfaces combined. The results of these studies are consistent with the most recent estimates of the effect on accidents of banning studded winter tires. It is concluded that studded winter tires probably confer a slight safety benefit during wintertime [4].

Tire types research results and their analysis

During the investigation, M1 and N1 class vehicle tires were inspected. The tire type is determined by the tire marking and tread pattern. The study of used tires took place during the winter months of December 2022 and January 2023 in the city of Šiauliai. During the entire investigation, 2987 cars were checked. During the investigation, 146 cars were found running on studded winter tires. Most (2389) cars were exploitation with winter tires. 404 car drivers choose an intermediate option, that is, to equip their cars with universal tires. During the investigation, cars with different types of tires were also found. In 37 cases, both winter and universal tires were found on the same car. In 7 cases, it was found that the car uses winter tires on one axle and studded winter tires on the other axle. Such a combination of tire types on the same car is highly inadvisable from the point of view of traffic safety. Well, 4 violators were also found, using illegal summer tires during the winter. The breakdown of cars according to the types of tires used is presented in Figure 8.

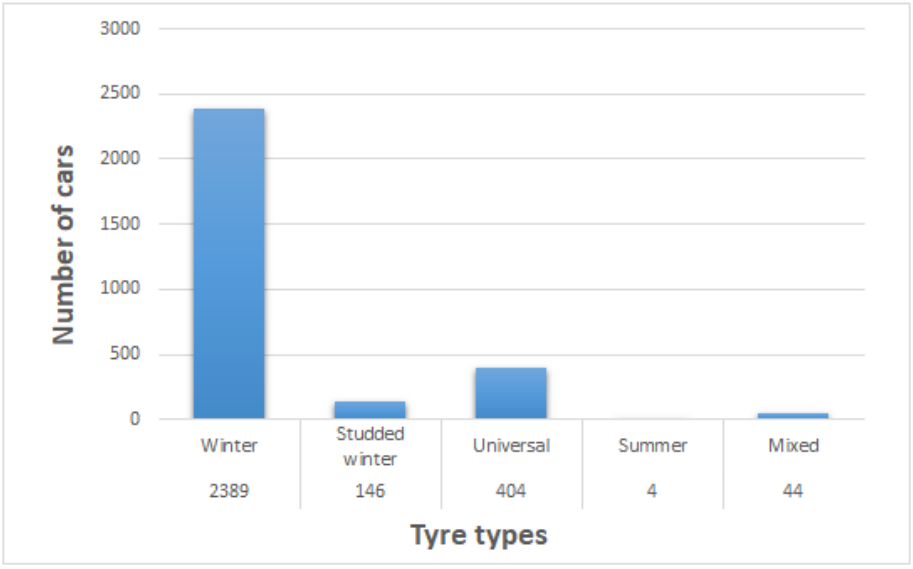

Fig. 8. The results of checking the types of tires of cars in use in Šiauliai

The research revealed that Šiauliai city drivers trust winter tires the most. This is 80 percent of all inspected cars. Not so many studded winter tire users were found, only 4.89%. 13.5% of drivers rely on universal tires, which are not a good choice in terms of traffic safety in harsh winter conditions. Not very many users of unsuitable tires (0.4%) were found.

From the survey of drivers conducted by the "If" insurance campaign in 2020, we see that during the cold season, the majority of Lithuanian drivers - about 65 percent. - chooses winter tires. In terms of popularity, universal (multi-season) tires are in second place, with 25 percent of all-wheel drive cars equipped with them. Only 8 percent cars in Lithuania use studded winter tires more suitable for icy roads. The choice of different winter tires is also affected by increasingly mild winters, when, for example, the need for studded winter tires decreases, and driving with universal tires seems more and more rational to drivers. However, some specialists claim that the driving conditions in Lithuania in warm and cold seasons are too different, so universal tires could be used in winter only when driving is rare and very careful. Latvians choose tires very similarly to Lithuania. And in Estonia, which is the northernmost of the three Baltic states, winter studded tires are preferred - 62 percent of drivers use them. The rest of Estonian drivers choose universal tires for the winter period [19].

During the investigation, it was noticed that a large number of cars with studded winter tires are not marked with the appropriate sign. According to the road traffic rules of the Republic of Lithuania, "A distinctive sign must be affixed to the rear of a car with studded winter tires - a white equilateral triangle with a red rim and a tire stud symbol in the middle. The length of the side of the triangle is 200-300 mm, the width of the rim is 1/10 of the length of the side."[16]. An example of such a sign is given in Figure 9.

Fig. 9. Distinctive sign of a car with studded winter tires [16].

The distinguishing mark of the vehicle operated with studded winter tires must be affixed to the rear of the vehicle. This sign warns other road users about a car ahead with studded winter tires. On extremely slippery road surfaces, such a car can stop much faster.

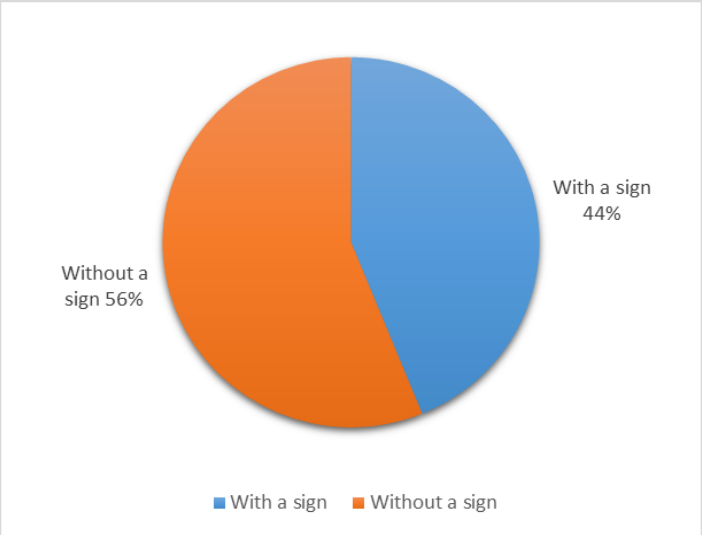

Fig. 10. Distribution of cars with and without a spike sign

As we can see from the conducted research and data representation in Figure 10, more than half (56%) of the cars in operation in the city of Šiauliai are not marked with mandatory signs with the spike symbol. Drivers who drive such unmarked cars violate the road traffic rules of the Republic of Lithuania and do not respect other road users. Compliance with this requirement must be ensured by the police of the Republic of Lithuania.

When researching the types of tires used in the winter period, it was noticed that larger or new cars are usually recorded with winter tires. Cars using universal tires could be classified as city cars. It can be assumed that their owners spend less time driving on country roads, where there may be worse traffic conditions and higher driving speeds. Most cars with studded winter tires were noticeably older. Apparently, their owners hope to use winter studded tires to compensate for the less than good technical preparation of their cars.

Conclusions

The ban on the use of studded winter tires is related to the fact that the studs in the tires damage the road surface. Ruts appear in the road surface due to the impact of spikes. Water accumulates in those ruts in the road surface, which can cause aquaplaning. Another negative effect of studded winter tires is also related to the destruction of the road surface. Disintegrated road surface particles cause ecological consequences for human health. Another negative effect is related to the loud noise caused by studded winter tires.

The study found a low prevalence of less than 4,9 percent studded winter tires. Such a small prevalence of studded winter tires does not have a major detrimental effect on the road surface. Conversely, on extremely slippery road surfaces, cars with studded winter tires make the road surface less slippery for other road users. However, with such a small number of users of studded winter tires, it is not worth banning them completely in Lithuania. When Lithuania's neighbours in the south prohibit studded winter tires, a natural restriction is created for Lithuanian drivers as well.

The road traffic rules of the Republic of Lithuania stipulate that cars with studded winter tires must be marked with a distinctive sign. A sign with a spike symbol must be affixed to the rear of the vehicle. More than half (56 %) of vehicles with studded winter tires are not properly labelled. The police of the Republic of Lithuania should pay more attention to this violation.

A study of tires used showed that most (80 %) drivers choose winter tires for their cars. Only 13.5 % of users use universal tires that are not very suitable for real winter conditions. The good thing is that, as can be seen from the research data, the number of cars operated in the city of Šiauliai with unsuitable tires in winter conditions is very small (0.4 percent).

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