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Classification of Damages of Palletized Loads in Road Transport and Its Impact on Environmental Protection

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Abstract: Cargo damage in extreme situations may threaten the safety of people participating in the further stages of the transport task in the distribution chain. Regardless of this, the damage also affects the unplanned extension of the delivery time or even prevents its further execution. The final and inevitable consequence is unplanned additional costs that will be charged to the shipper preparing the cargo for shipment. Additional costs will be incurred, direct (materials for repackaging and load securing, fuel, tolls, insurance) and indirect costs (carbon footprint of the materials produced and the fuel used by vehicles, increased traffic congestion, and the safety of road users). Their consequence will be an unnecessary increase in the pollution of the natural human environment. The article presents the classification of damage to palletised loads. The correctness of the proposed classification was to be achieved by analysing the results of surveys and broadly understood consultations with business entities dealing with the damage to palletised loads daily. The small number of completed questionnaires indicates the need to develop a new, less detailed questionnaire and a possible simplification of the proposed classification of damage to palletised loads. Based on the numerous discussions and meetings held during the consultations regarding the quantity and quality of cargo damage, it can be concluded that this is a very complex, sensitive topic. Literature review studies can confirm it, including industry studies and published statistical data. It is practically difficult to determine the size of damage to palletised loads in road transport. The proposed classification of damage to palletised loads allows for the definition of dangers, difficulties and, consequently, direct and indirect costs of transport, which can be remedied, and certainly significantly reduced. Minimising damaged and destroyed loads result in both a reduction of the direct costs of damaged products and a secondary reduction in the consumption of natural resources of the environment necessary to re-manufacture damaged or destroyed products. It also contributes to reducing the carbon footprint, an important issue, especially nowadays.

Keywords: cargo, cargo damage, classification of damage, carbon footprint, environmental protection

1. Introduction

Safe loads are those that, without damaging the contents and without any final changes affecting the dimensions of individual pallet loading units (unit) can meet the requirements for overload in five directions under the European Union Directive 47/2014 (Directive 2014/47/EU). However, in practice, this is often very difficult to achieve. Factors influencing the occurrence of damage to loads are design features of packaging (size, weight, shape) and distribution conditions (distance, transport relationship, transhipment, method of storage) (Woźniak et al. 2016). The author has discussed damage to palletised loads in road transport (Tkaczyk et al. 2022). Their destructive effect on business and the entire natural environment can be stopped by properly prepared tertiary packaging and auxiliary tools used during transport to secure loads.

Therefore, the article aims to present the classification of damage to palletised loads, to verify it, allowing for the development of ways to reduce them, the so-called good practices for securing palletised loads and its impact on environmental protection. The need to identify and classify damage arose as a result of research work in the area of optimising the costs of securing cargo and minimising damage to cargo during transport (Tkaczyk et al. 2021).

2. Legal Regulations

The transport services market expects the implementation of transport services with a guarantee of safety and timely deliveries. Despite the many problems that carriers currently face (constant legislative changes, fuel prices, lack of drivers, etc.), they are obliged to deliver cargo intact and within the time limits specified in the concluded contracts.

Carriers do not influence how the loads accepted for transport are packed and secured by the consignor (sender). In order to improve the safety of the pallet load units accepted for transport (abbreviated as JŁP), carriers may only apply additional security measures, using available security measures such as belts, corners or wedges. Packaging cargo and their physical securing and fastening on trucks is not the carriers' obligation (according to the current legal regulations). This obligation rests with the senders (senders).

Polish legislation has no clear regulations defining the responsibility for properly preparing cargo for transport. An overview of the legal regulations defining the scope of liability for damage to palletised loads is included in Fig. 1 (Tkaczyk & Różyk 2021). The correct solution seems to be to make senders and carriers aware of the importance of properly packaging the load unit and its securing and fastening on the means of transport. Achieving this is possible by classifying damage to loads and developing methods to reduce this damage.

3. Damage Classification of Palletised Loads

In practice, we encounter many defects occurring while transporting palletised loads by road. Issues related to damage to loads in road transport are widely discussed in the literature (due to the scope of the described issue, the focus was on the review of the domestic literature). Among others, the article by Olejnik & Woźniak 2014 presents the requirements contained in Polish regulations for the transport of various loads by motor vehicles and discusses the differences resulting from specific requirements for the transport of, e.g. things, food and animals. The clarity, comprehensibility and precision of these provisions were assessed. However, the focus here is on the equipment requirements and the loading, transporting and unloading methods, especially for live animals.

The publication of Deja et al. 2017 shows examples of damaged cargo transported by a small transport company from the vicinity of Szczecin, the causes of cargo damage and possible measures for their removal are described. Furthermore, a detailed description of the damage to these palletised loads and an illustration of the damage are included in the article Tkaczyk & Szpotański 2022, prepared for publication.

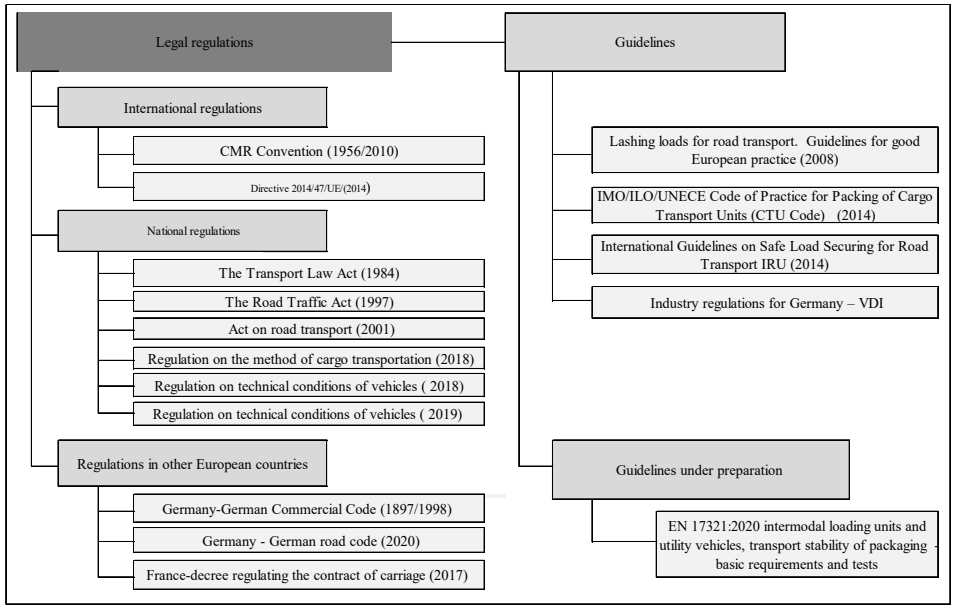


Fig. 1. Review of legal regulations defining the scope of liability for damage to palletised loads (Tkaczyk & Różyk 2021)

Due to the lack of a systematic approach to cargo damage, it was necessary to develop a classification of damage to palletised cargo, which often occurs during transport in long, multi-tier supply chains. The proposed classification of cargo damage was developed based on the author's many years of experience and the real problems observed in domestic and international transport of various palletised loads. Fig. 2 presents a proposal to classify damage to palletised loads during road transport.

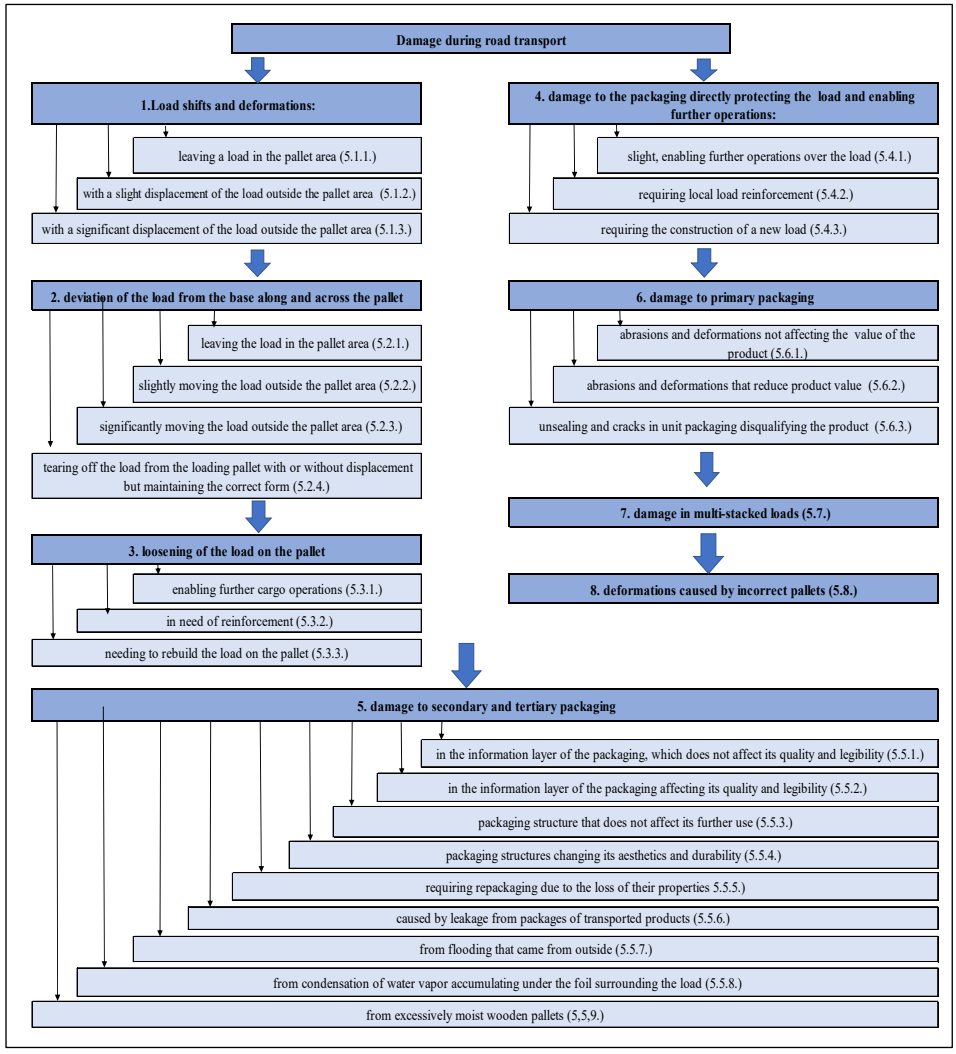
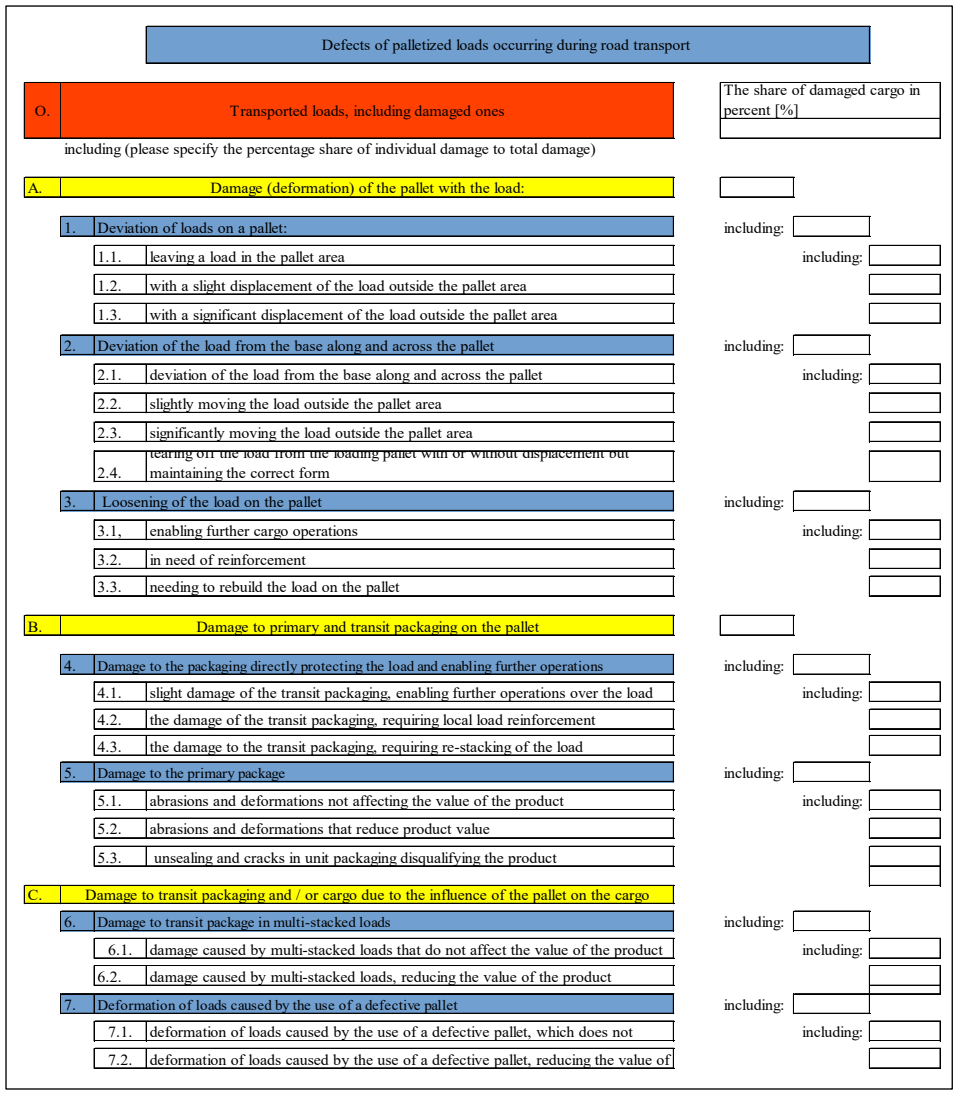


Fig. 2. Classification of damage occurring during the transport of palletised loads (own study)

4. Verification of Damage Classification

Verification of the proposed classification of damage to palletised loads was to be carried out through the analysis of the results of the questionnaire developed by the author (Fig. 3) and widely understood consultations with economic entities dealing with the phenomenon of damage to palletised loads daily.



Defects of palletized loads occurring during road transport			
O.	Transported loads, including damaged ones	The share of damaged cargo in percent [%]	
	including (please specify the percentage share of individual damage to total damage)		
A.	Damage (deformation) of the pallet with the load:		
1.	Deviation of loads on a pallet:	including:	
1.1.	leaving a load in the pallet area	including:	
1.2.	with a slight displacement of the load outside the pallet area		
1.3.	with a significant displacement of the load outside the pallet area		
2.	Deviation of the load from the base along and across the pallet	including:	
2.1.	deviation of the load from the base along and across the pallet	including:	
2.2.	slightly moving the load outside the pallet area		
2.3.	significantly moving the load outside the pallet area		
2.4.	tearing off the load from the loading pallet with or without displacement but maintaining the correct form		
3.	Loosening of the load on the pallet	including:	
3.1,	enabling further cargo operations	including:	
3.2.	in need of reinforcement		
3.3.	needing to rebuild the load on the pallet		
B.	Damage to primary and transit packaging on the pallet		
4.	Damage to the packaging directly protecting the load and enabling further operations	including:	
4.1.	slight damage of the transit packaging, enabling further operations over the load	including:	
4.2.	the damage of the transit packaging, requiring local load reinforcement		
4.3.	the damage to the transit packaging, requiring re-stacking of the load		
5.	Damage to the primary package	including:	
5.1.	abrasions and deformations not affecting the value of the product	including:	
5.2.	abrasions and deformations that reduce product value		
5.3.	unsealing and cracks in unit packaging disqualifying the product		
C.	Damage to transit packaging and / or cargo due to the influence of the pallet on the cargo		
6.	Damage to transit package in multi-stacked loads	including:	
6.1.	damage caused by multi-stacked loads that do not affect the value of the product	including:	
6.2.	damage caused by multi-stacked loads, reducing the value of the product		
7.	Deformation of loads caused by the use of a defective pallet	including:	
7.1.	deformation of loads caused by the use of a defective pallet, which does not	including:	
7.2.	deformation of loads caused by the use of a defective pallet, reducing the value of		

Fig. 3. Palletized cargo damage survey (own study)

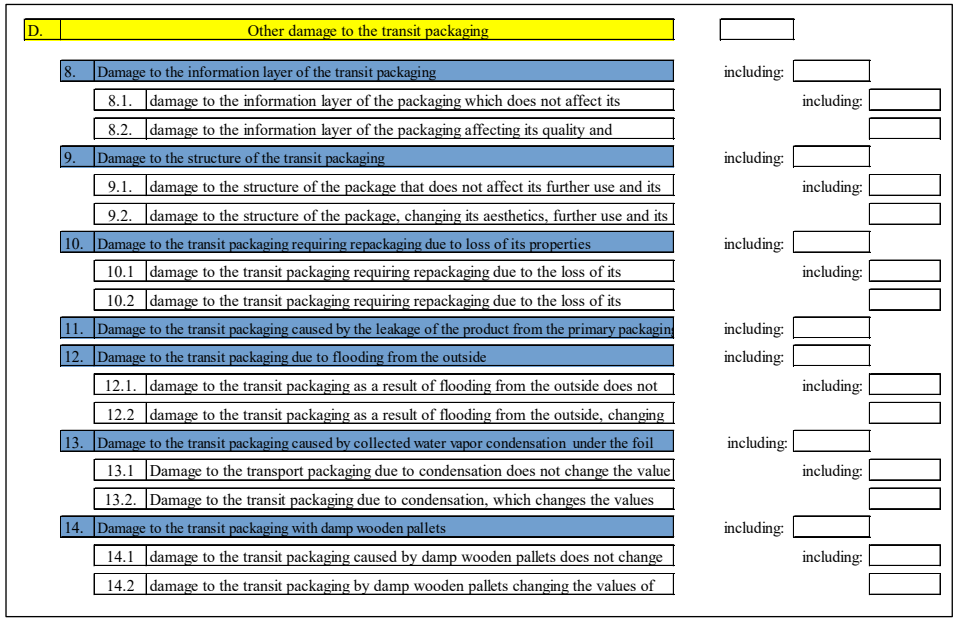


Fig. 3. cont.

The questionnaire "Damage to palletised loads occurring during transport by road" was sent to 5 selected groups potentially related to the problem of damage to loads:

- an association of road carriers (the Association of International Road Carriers (ZMPD) and scientific institutes researching issues related to road transport (Polish Road Transport Institute (PITD),
- selected international road carrier – FEBO Logistics sp. z o.o.,
- producers of stretch film and producers transporting their goods in a palletised form,
- insurance brokers offering OCP and Cargo insurance – PZU, WARTA and STBU Brokerzy Ubezpieczeniowi sp. z o.o.
- state institutions controlling and supervising the transport of road cargo – Chief Inspectorate of Road Transport (GITD) and the Motor Transport Institute (ITS).

ZMPD – brings together about 4 500 carriers – registered business entities involved in international road transport. The carriers associated in the ZMPD include most of the almost 200,000 vehicles that currently make up the Polish fleet of international transport. Road hauliers had the opportunity to familiarise themselves with the questionnaire prepared for this study and its completion via the

ZMPD website, which was active for about two months. The questionnaire, which was usually only partially completed, was sent back via ZMPD by only six carriers.

ITS – conducts, coordinates and popularises research and implementation research in road transport. The main thematic areas of ITS activity 2021-2030:

- safety in transport and road traffic – collecting and analysing accident data to identify sources of threats, behavioural research, with particular emphasis on vulnerable road users, post-accident activities, programming of preventive measures, psychological tests, safety and technical tests of vehicles, testing of control devices and vehicle diagnostics,
- impact on the climate and the environment,
- computerisation of transport,
- economics of road transport.

Despite the Institute's focus on transport safety, due to the protection of personal data and trade secrets, ITS did not disclose any information on damage to cargo.

PITD – specialises in issues related to logistics and transport, such as supply chain security, logistics, road transport, intermodal transport, international transport law or labour law. It has a wide group of experts with extensive experience in the private and public sectors and cooperates with external experts. However, according to the written information, the Institute has no data on damage to the cargo.

FEBO Logistic Sp. z o.o. – an international road haulier specialising in the transport of cargo by semi-trailers equipped with a double floor system, was asked to provide a survey among its drivers and carriers cooperating with it. Only four questionnaires were sent back.

The producer of stretch film ERGIS SA was asked to distribute a survey among its several hundred customers, securing palletised loads with stretch film. Only two manufacturers using stretch film to secure their cargo returned completed questionnaires.

Telephone consultations regarding damage to loads in road transport were carried out with STBU Brokerzy Ubezpieczeniowi Sp. z o.o., one of the largest companies operating in the brokerage market. STBU proposed to review its database in the near future in terms of quantitative and qualitative analysis of claims reported by carriers and producers. To date, however, no data are available. In addition, an e-mail request for information on damage to loads in road transport was sent to the PZU spokesman and the WARTA spokesman – no reply was received.

There was also an attempt to find quantitative and qualitative information on damage to loads transported by road in the Statistical Yearbook of the Central Statistical Office. The necessary data was also not found here.

GITD – established to control compliance with the provisions in force in the field of road transport and non-profit transport of passengers and goods, acts to reduce negative phenomena in road transport based on the Regulation of the Minister of Internal Affairs and Administration of 5 November 2019 on traffic control road. According to § 1.1. The regulation specifies:

1) organisation, detailed conditions and manner of road traffic control,
2) the required behaviour of the controlled road user,
3) detailed conditions for road traffic control by municipal (city) guards, forest guards, Park Guard officers and road management employees,
4) specific conditions for the performance of road traffic control of vehicles referred to in article 1. 73 sec. 3 of the Act of 20 June 1997 – Road Traffic Law, except for vehicles of the Armed Forces of the Republic of Poland,
5) detailed conditions for granting authorisation to perform road traffic control,
6) document templates used in the performance of road traffic control.

Annex 4 of the Regulation mentioned above contains "Classification of faults in securing the load based on irregularities found" (Fig. 4). Group 20 of the classifications concerns "Lashing methods", including subgroup 20.1. "Closing, locking and direct lashing", 20.2. "Protection by increasing friction", 20.3. "Load securing devices used", 20.4. "Additional equipment (e.g. anti-slip mats, edge protectors, edge slides)". In the classification, it is difficult to find data on the proper securing of cargo on a pallet, at most in subgroup 20.1.2.2.A is classified as "Inadequate securing of cargo", and in subgroup 20.1.2.2.B "Insufficient securing of cargo".

GITD replied and sent a report. In the GITD reports, the data presented concern the "Number of found irregularities in the technical condition of vehicles" and not damage caused by the load itself. Fig. 4. presents the GITD Report received by e-mail with data for 2021 and the first half of 2022. However, it is difficult to find the type and size of damage to loads transported by road in the Report.

Number of irregularities found during roadside checks pursuant to the Ordinance of the Minister of Internal Affairs and Administration of November 5, 1919 on road traffic control.

2021 r.

No	Type of irregularity	Number of found irregularities in the technical condition of vehicles
10.	**Vehicle customization**	12
10.1	**Headboard (if used for the securing of cargo)**	0
10.1.1.	Part-weakening caused by corrosion or deformation	0
10.1.2.	Breakage of parts that may violate the integrity of the cargo compartment	0
10.2	**Side walls (if used for the securing of cargo)**	3
10.2.1.A.	Part-weakening caused by corrosion or deformation, bad condition of hinges or locks	0
10.2.1.B.	Broken parts, missing or not working locks or hinges	0
10.2.2A.	Strength too low (certificate or label, if applicable)	0
10.2.2.B.	Too low height in relation to the transported load	1
10.2.3.A.	Side plates in poor condition	1
10.2.3.B.	Part cracked	1
10.3.	**Rear wall (if used for the securing of cargo)**	1
10.3.1.A	Part-weakening caused by corrosion or deformation, bad condition of hinges or locks	0
10.3.1.B	Broken parts, missing or not working locks or hinges	1
10.3.2.A.	Strength too low (certificate or label, if applicable)	0
10.3.2.B.	Too low height in relation to the transported load	0
10.4.	**Stanchions (if used for the securing of cargo)**	0
10.4.1.A	Part-weakening caused by corrosion or deformation, or poor condition of attachment to vehicle	0
10.4.1.B	Part cracked, attachment to vehicle unstable	0
10.4.2.A.	insufficient strength or inadequate construction	0
10.4.2.B.	too low height in relation to the transported load	0
10.5	**Cargo securing points (if used for cargo securing)**	4
10.5.1.A	poor condition or inadequate construction	0
10.5.1.B	unable to withstand the required clamping forces	0
10.5.2.A.	too small a number	4
10.5.2.B.	too small a number to withstand the required clamping forces	0
10.6.	**Required special structures (if used for the securing of cargo)**	3
10.6.1.A	bad condition, damage	0
10.6.1.B	fracture of parts, unable to transmit clamping forces	0
10.6.2.A.	not suitable for the load being transported	3
10.6.2.B.	missing	0
10.7.	**The floor, if used for the securing of cargo**	1
10.7.1.A	bad condition, damage	0
10.7.1.B	part breakage, load too heavy	0
10.7.2.A.	too little load	0
10.7.2.B.	load too heavy	1

First half of 2022

No	Type of irregularity	Number of found irregularities in the technical condition of vehicles
10.	**Vehicle customization**	90
10.1	**Headboard (if used for the securing of cargo)**	6
10.1.1.	Part-weakening caused by corrosion or deformation	3
10.1.2.	Breakage of parts that may violate the integrity of the cargo compartment	3
10.2	**Side walls (if used for the securing of cargo)**	19
10.2.1.A.	Part-weakening caused by corrosion or deformation, bad condition of hinges or locks	4
10.2.1.B.	Broken parts, missing or not working locks or hinges	3
10.2.2A.	Strength too low (certificate or label, if applicable)	3
10.2.2.B.	Too low height in relation to the transported load	3
10.2.3.A.	Side plates in poor condition	3
10.2.3.B.	Part cracked	3
10.3.	**Rear wall (if used for the securing of cargo)**	13
10.3.1.A	Part-weakening caused by corrosion or deformation, bad condition of hinges or locks	4
10.3.1.B	Broken parts, missing or not working locks or hinges	3
10.3.2.A.	Strength too low (certificate or label, if applicable)	3
10.3.2.B.	Too low height in relation to the transported load	3
10.4.	**Stanchions (if used for the securing of cargo)**	14
10.4.1.A	Part-weakening caused by corrosion or deformation, or poor condition of attachment to vehicle	3
10.4.1.B	Part cracked, attachment to vehicle unstable	3
10.4.2.A.	insufficient strength or inadequate construction	3
10.4.2.B.	too low height in relation to the transported load	5
10.5	**Cargo securing points (if used for cargo securing)**	14
10.5.1.A	poor condition or inadequate construction	3
10.5.1.B	unable to withstand the required clamping forces	3
10.5.2.A.	too small a number	5
10.5.2.B.	too small a number to withstand the required clamping forces	3
10.6.	**Required special structures (if used for the securing of cargo)**	12
10.6.1.A	bad condition, damage	3
10.6.1.B	fracture of parts, unable to transmit clamping forces	3
10.6.2.A.	not suitable for the load being transported	3
10.6.2.B.	missing	3
10.7.	**The floor, if used for the securing of cargo**	12
10.7.1.A	bad condition, damage	3
10.7.1.B	part breakage, load too heavy	3
10.7.2.A.	too little load	3
10.7.2.B.	load too heavy	3

Fig. 4. GITD Report with data for 2021 and the first half of 2022 (GITD)

20.	Methods of securing cargo	224
20.1.	Closing, locking and direct fastening with straps	120
20.1.1.	Direct load securing (locking)	6
20.1.1.1.A.	too far from the headboard if it is used for direct load securing	4
20.1.1.1.B.	more than 15 cm and danger of puncture the wall	0
20.1.1.2.A.	too great a lateral distance from the side wall if it is used for the direct securing of cargo	0
20.1.1.2.B.	more than 15 cm and danger of puncture the wall	0
20.1.1.3.A.	too much distance from the rear wall if it is used for direct load securing	2
20.1.1.3.B.	more than 15 cm and danger of puncture the wall	0
20.1.2.	Load securing devices such as lashing rails, blocking beams, slats and wedges at the front, side and rear	108
20.1.2.1.A.	improper attachment to the vehicle	15
20.1.2.1.B.	Too weak fastening to vehicle	7
20.1.2.1.C.	device incapable of transmitting immobilizing forces, loose	0
20.1.2.2.A.	improper securing of cargo	20
20.1.2.2.B.	insufficient securing of the load	61
20.1.2.2.C.	completely ineffective	2
20.1.2.3.A.	the fastening systems are insufficient	0
20.1.2.3.B.	completely unsuitable fastening systems	0
201.2.4.A.	non-optimal method of securing the load	3
20.1.2.4.B.	the chosen method is completely inadequate	0
20.1.3.	direct attachment with nets and covers	2
20.1.3.1.A.	condition of the nets and covers (missing or marking damaged, but equipment in good condition)	1
20.1.3.1.B.	damage to the immobilization devices	0
20.1.3.1.C	load-restraint devices that are severely worn and unfit for use	0
20.1.3.2.A.	insufficient strength of nets and covers	0
20.1.3.2.B.	strength less than 2/3 of the required lashing forces	0
20.1.3.3.A.	insufficient fixing of the nets and covers	0
20.1.3.3.B.	clamping strength less than 2/3 of the required clamping forces	0
20.1.3.4.A	improper selection of nets and covers for securing the load	0
20.1.3.4.B	equipment totally unsuitable	0
20.1.4.	Separating cargo units and filling voids between them or gaps from other elements	1
20.1.4.1.A.	the degree of adequacy of the separation of units and filling of voids	1
20.1.4.1.A.	too large distances between units or distances from fixed elements	0
20.1.5.	Direct attachment (horizontal, cross, diagonal, mixed and bonding)	3
20.1.5.1.A.	too little clamping force	3
20.1.5.1.B.	less than 2/3 of the required force	0
20.2.	Protection by increased friction	7
20.2.1.	Obtaining the required securing forces	7
20.2.1.1.A.	too little clamping force	7
20.2.1.1.B.	less than 2/3 of the required force	0

20.	Methods of securing cargo	263
20.1.	Closing, locking and direct fastening with straps	140
20.1.1.	Direct load securing (locking)	28
20.1.1.1.A.	too far from the headboard if it is used for direct load securing	4
20.1.1.1.B.	more than 15 cm and danger of puncture the wall	4
20.1.1.2.A.	too great a lateral distance from the side wall if it is used for the direct securing of cargo	4
20.1.1.2.B.	more than 15 cm and danger of puncture the wall	4
20.1.1.3.A.	too much distance from the rear wall if it is used for direct load securing	8
20.1.1.3.B.	more than 15 cm and danger of puncture the wall	4
20.1.2.	Load securing devices such as lashing rails, blocking beams, slats and wedges at the front, side and rear	59
20.1.2.1.A.	improper attachment to the vehicle	8
20.1.2.1.B.	Too weak fastening to vehicle	5
20.1.2.1.C.	device incapable of transmitting immobilizing forces, loose	5
20.1.2.2.A.	improper securing of cargo	15
20.1.2.2.B.	insufficient securing of the load	6
20.1.2.2.C.	completely ineffective	4
20.1.2.3.A.	the fastening systems are insufficient	4
20.1.2.3.B.	completely unsuitable fastening systems	4
201.2.4.A.	non-optimal method of securing the load	4
20.1.2.4.B.	the chosen method is completely inadequate	4
20.1.3.	direct attachment with nets and covers	37
20.1.3.1.A.	condition of the nets and covers (missing or marking damaged, but equipment in good condition)	4
20.1.3.1.B.	damage to the immobilization devices	4
20.1.3.1.C	load-restraint devices that are severely worn and unfit for use	4
20.1.3.2.A.	insufficient strength of nets and covers	4
20.1.3.2.B.	strength less than 2/3 of the required lashing forces	4
20.1.3.3.A.	insufficient fixing of the nets and covers	5
20.1.3.3.B.	clamping strength less than 2/3 of the required clamping forces	4
20.1.3.4.A	improper selection of nets and covers for securing the load	4
20.1.3.4.B	equipment totally unsuitable	4
20.1.4.	Separating cargo units and filling voids between them or gaps from other elements	8
20.1.4.1.A.	the degree of adequacy of the separation of units and filling of voids	4
20.1.4.1.A.	too large distances between units or distances from fixed elements	4
20.1.5.	Direct attachment (horizontal, cross, diagonal, mixed and bonding)	8
20.1.5.1.A.	too little clamping force	4
20.1.5.1.B.	less than 2/3 of the required force	4
20.2.	Protection by increased friction	12
20.2.1.	Obtaining the required securing forces	12
20.2.1.1.A.	too little clamping force	9
20.2.1.1.B.	less than 2/3 of the required force	3

Fig. 4. cont.

20.3.	**Application of the load securing device**	**33**
20.3.1.A.	improper selection of devices for the immobilization of the load	15
20.3.1.B.	device completely unsuitable	0
20.3.2.A.	missing / damaged marking (e.g. label or hangtag) but the device is in good condition	2
20.3.2.B.	labeling (e.g. label or tag) is missing / damaged and the device shows high wear	2
20.3.3.A.	damage to the load-restraint devices	2
20.3.3.B.	immobilization devices that are severely worn and unfit for use	1
20.3.4.A.	improper use of belt tensioners	2
20.3.4.B.	damaged belt tensioners	0
20.3.5.A.	improper use of the load securing devices (e.g. no corners securing the load)	2
20.3.5.B.	defective use of the load-securing devices (e.g. knots)	1
20.3.6.A.	inadequate fastening of the load-restraint devices	5
20.3.6.B.	less than 2/3 of the required force	1
20.4.	**Additional equipment (e.g. anti-skid mats, edge protectors, edge glides)**	**1**
20.4.	inappropriate equipment was used	1
20.4.	wrong or defective equipment was used	0
20.4.	totally inappropriate equipment was used	0
20.5.	**Transport of loose, light and bulk materials**	**60**
20.5.1.A.	loose material blown away while the vehicle is in motion may disrupt the traffic	37
20.5.1.B.	creates traffic hazards	2
20.5.2.A.	creates traffic hazards	11
20.5.2.B..	inadequate securing of bulk materials	1
20.5.3.A.	no cover for light materials	8
20.5.3.B.	the loss of cargo poses a danger to traffic	1
20.6.	**Transport of tree trunks**	**3**
20.6.1.	the material being transported (trunks) is partially loose	0
20.6.2.A.	the securing forces of the load unit are insufficient	2
20.6.2.B	less than 2/3 of the required force	1

20.3.	**Application of the load securing device**	**63**
20.3.1.A.	improper selection of devices for the immobilization of the load	15
20.3.1.B.	device completely unsuitable	3
20.3.2.A.	missing / damaged marking (e.g. label or hangtag) but the device is in good condition	6
20.3.2.B.	labeling (e.g. label or tag) is missing / damaged and the device shows high wear	4
20.3.3.A.	damage to the load-restraint devices	3
20.3.3.B.	immobilization devices that are severely worn and unfit for use	3
20.3.4.A.	improper use of belt tensioners	5
20.3.4.B.	damaged belt tensioners	3
20.3.5.A.	improper use of the load securing devices (e.g. no corners securing the load)	5
20.3.5.B.	defective use of the load-securing devices (e.g. knots)	3
20.3.6.A.	inadequate fastening of the load-restraint devices	10
20.3.6.B.	less than 2/3 of the required force	3
20.4.	**Additional equipment (e.g. anti-skid mats, edge protectors, edge glides)**	**9**
20.4.	inappropriate equipment was used	3
20.4.	wrong or defective equipment was used	3
20.4.	totally inappropriate equipment was used	3
20.5.	**Transport of loose, light and bulk materials**	**30**
20.5.1.A.	loose material blown away while the vehicle is in motion may disrupt the traffic	9
20.5.1.B.	creates traffic hazards	3
20.5.2.A.	creates traffic hazards	4
20.5.2.B..	inadequate securing of bulk materials	3
20.5.3.A.	no cover for light materials	8
20.5.3.B.	the loss of cargo poses a danger to traffic	3
20.6.	**Transport of tree trunks**	**9**
20.6.1.	the material being transported (trunks) is partially loose	3
20.6.2.A.	the securing forces of the load unit are insufficient	3
20.6.2.B	less than 2/3 of the required force	3

Fig. 4. cont.

5. Summary

As a result of the analysis of the type of damage to the cargo, based on the survey, damage to the cargo can be divided into two groups –the damage that does not change the value of the transported product and damage to the cargo that changes the value of the transported product. Fig. 5 shows the structure of the impact of individual damage (according to the designations proposed in the questionnaire) on the change in the value of transported products.

Damages not changing the value of the transported products are often accepted by final recipients, provided an agreement is reached between the sender and the recipient about the additional costs incurred. Damage reducing the value of the transported products most often results in a complaint and, consequently, discounts or a partial or complete return of the cargo. However, brokers and

agents often do not accept any damage due to the image of the offered product (the so-called commercial appearance). This type of damage generates additional production of goods and packaging and increases the transport of cargo, which in turn leads to an increase in environmental pollution – more waste and a carbon footprint (production and transport). In addition, excessive consumption of packaging materials leads to excessive consumption of raw materials and the formation of unnecessary and difficult to dispose of waste. Therefore, an important activity in this area will be implementing the waste recovery and recycling process (Chamier-Gliszczyński 2010, Chamier-Gliszczyński 2011, Chamier-Gliszczyński 2011a).

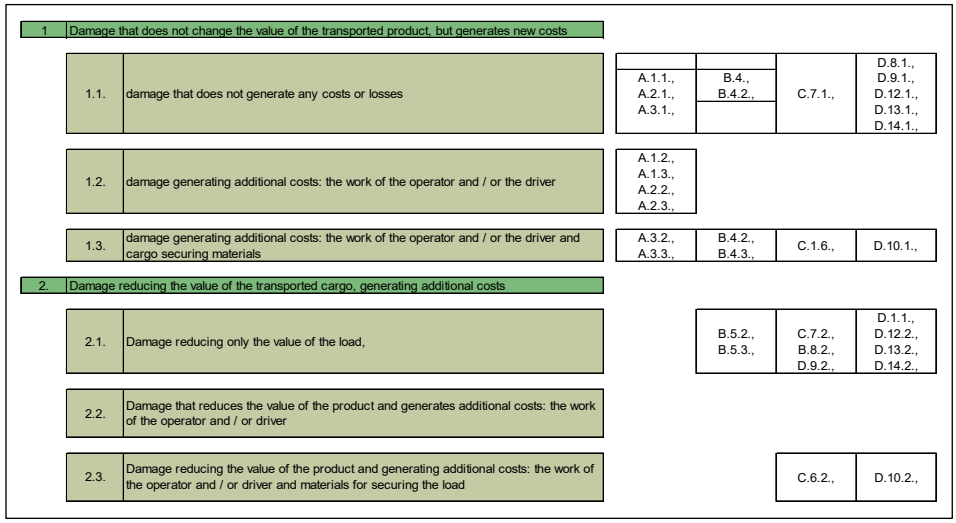


Fig. 5. Split of damage to palletised loads due to the potential reduction in their value (own study)

Allocating too low financial outlays on the cargo packaging leads to its damage, while too high costs result in the safe transport of the cargo but may lead to a significant increase in the price of the product. Therefore, the optimal selection of packaging may allow the manufacturer/supplier to increase the size of transported loads while maintaining the exact costs. Fig. 6 shows the ability to use resources for transported packed loads (Tkaczyk & Szpotański 2021).

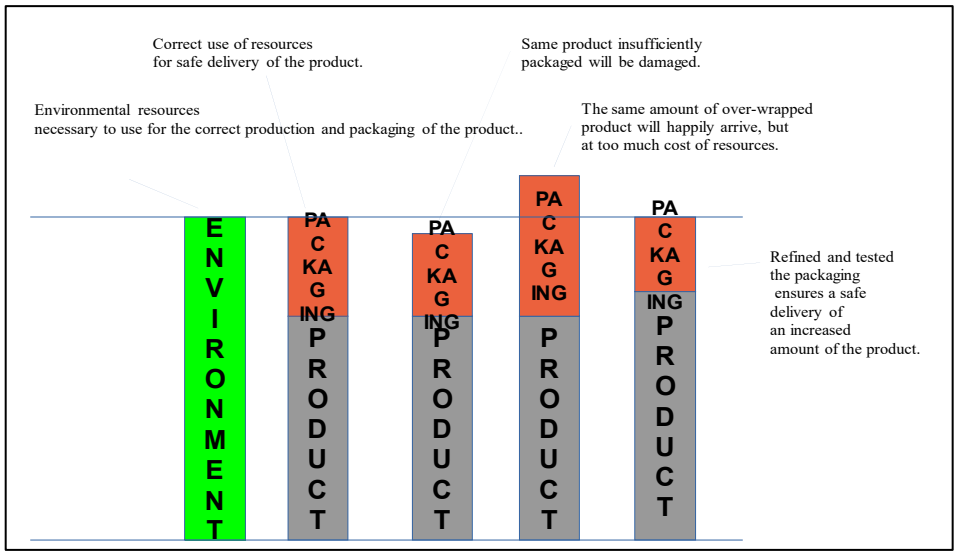


Fig. 6. Ability to use resources to transport packed loads (Tkaczyk & Szpotański 2021)

Increasing packaging efficiency is possible by researching palletised loads' behaviour in laboratory conditions (simulated tests of cargo securing components and packaging methods) (Tkaczyk et al. 2021).

6. Conclusions

The article presents the classification of damage to palletised loads and the impact of the resulting damage on the natural environment. The correctness of the proposed classification was achieved by analysing the results of surveys and broadly understood consultations with business entities dealing with the damage to palletised loads daily. The small number of completed questionnaires indicates the need to develop a new, less detailed questionnaire and a possible simplification of the proposed classification of damage to palletised loads. Based on the numerous discussions and meetings held during the consultations regarding the quantity and quality of cargo damage, it can be concluded that this is a very complex, sensitive topic. Literature review studies can also confirm this, as available industry studies and published statistical data. It is practically difficult to determine the size of damage to palletised loads in road transport.

The presented and classified damage to loads in drastic situations may threaten the safety of people participating in the further stages of the transport task in the distribution chain. Regardless of this, the damage also affects the unplanned extension of the delivery time or even prevents its further execution. The final and inevitable consequence is unplanned additional costs that will be

charged to the shipper preparing the cargo for shipment. Additional costs will be incurred, both direct (materials for repackaging and load securing, fuel, tolls, insurance) and indirect costs (carbon footprint of the materials produced and the fuel used by vehicles, increased traffic congestion, the safety of road users). Their consequence will be an unnecessary increase in the pollution of the natural human environment.

The proposed classification of damage to palletised loads allows for the definition of dangers, difficulties and, consequently, direct and indirect costs of transport, which can be remedied, and certainly significantly reduced. Minimising damaged and destroyed loads result in both a reduction of the direct costs of damaged products and a secondary reduction in the consumption of natural resources of the environment necessary to re-manufacture damaged or destroyed products.

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