BS EN 12195-1:2010

BSI Standards Publication

Load restraining on road vehicles — Safety

Part 1: Calculation of securing forces

National foreword

This British Standard is the UK implementation of EN 12195-1:2010. It supersedes BS EN 12195-1:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MHE/16, Load restraint assemblies.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 12195-1:2010) has been prepared by Technical Committee CEN/TC 168 "Chains, ropes, webbing, slings and accessories – Safety", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2011, and conflicting national standards shall be withdrawn at the latest by May 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12195-1:2003.

The main changes compared to the previous edition of EN 12195-1 are:

a) title changed;

b) k-factor deleted;

c) tilting factor altered;

d) safety factors f_S = 1,1 and f_S = 1,25 and conversion factor f_μ = 0,75 for friction introduced;

e) Annex B on friction factors μ made normative and friction factors revised;

f) test methods for the determination of the friction μ and verification of securing arrangements included;

g) static and dynamic friction factors deleted and friction factors μ in accordance with Annex B introduced.

EN 12195, *Load restraint assemblies on road vehicles — Safety*, consists of the following parts:

— *Load restraining on road vehicles — Safety — Part 1: Calculation of securing forces*

— *Load restraint assemblies on road vehicles — Safety — Part 2: Web lashing made from man-made fibres*

— *Load restraint assemblies on road vehicles — Safety — Part 3: Lashing chains*

— *Load restraint assemblies on road vehicles — Safety — Part 4: Lashing steel wire ropes*

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Introduction

This part of EN 12195 has been prepared to provide a means of conforming with the essential safety requirements to calculate securing forces for load restraint assemblies to be used in the Common European Market and thus enabling unrestricted transport of cargo.

This part of EN 12195 contributes to the harmonization of the calculation of load securing on road vehicles by giving the different procedures and equations of load securing.

Blocking and lashing procedures and appropriate combinations are described for load securing. The equations used are based on relevant scientific and, in particular, on mechanical laws and practical experience. For this purpose, a suitable vehicle with appropriate assemblies for blocking, bracing and securing should be used to ensure safe load transportation. Transportation safety should be guaranteed by the dimensioning of load securing according to this European Standard. The extent to which the hazards acting on the load during transport and resulting from the forces of load are addressed is given in the scope of this European Standard. In addition, load restraint assemblies for securing of loads on vehicles with respect to their securing and load bearing ability, which are not covered by this European Standard, should conform to the other parts of this standard and to EN ISO 12100-2.

1 Scope

This European Standard is applicable to the design of securing methods (blocking, lashing, and combinations) for securing of loads for surface transport by road vehicles or parts of them (lorries, trailers, containers and swap bodies), including their transport on vessels or by rail and/or combinations thereof. Hump shunting with acceleration over 1 g during railway transport is excluded, as it is not foreseen in combined transport. (Web lashings see EN 12195-2, lashing chains see EN 12195-3, lashing steel wire ropes see EN 12195-4).

This European Standard does not apply for vehicles with a total weight equal to or lower than 3 500 kg.

NOTE Lighter vehicles can have driving characteristics, which give higher values of acceleration on the road.

For dimensioning of load securing a distinction is made between stable loads and loads liable to tilting.

Furthermore, the acceleration coefficients for surface transport are specified.

For over top lashing the force loss in the tension force of the lashing at the outer edges between load and lashing is taken into account. The securing forces to be chosen for calculation in this EN 12195-1 are static forces produced by blocking or tensioning of lashings and dynamic forces, which act on the lashing as a reaction of the load movements.

Examples for the application of calculations are given in Annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12195-2:2000, *Load restraint assemblies on road vehicles — Safety — Part 2: Web lashing made from man-made fibres*

EN 12195-3:2001, *Load restraint assemblies on road vehicles — Safety — Part 3: Lashing chains*

EN 12195-4:2003, *Load restraint assemblies on road vehicles — Safety — Part 4: Lashing steel wire ropes*

EN 12642:2006, *Securing of cargo on road vehicles — Body structure of commercial vehicles — Minimum requirements*

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system (ISO 7500-1:2004)*

3 Terms, definitions, symbols, units and abbreviations

For the purposes of this document, the following terms, definitions, symbols, units and abbreviations apply.

3.1 General terms and definitions

3.1.1
lashing
securing method where bendable devices are used in the securing of the load on a load carrier

3.1.2
lashing device
flexible device used in the securing of the load on a load carrier

3.1.3
tensioning device
mechanical device inducing and maintaining a securing force in a load restraint assembly

EXAMPLES Ratchets, winches, overcentre buckles.

3.1.4
tension force indicator
device which indicates the force applied to the lashing device by means of the tension devices and movement of the load or elastic deformation of the vehicle body, acting on the lashing devices

3.1.5
attachment point
rigid part of the load to place the load restraint assembly and lashing devices

3.1.6
lashing point
securing device on a load carrier to which a lashing device may be directly attached

NOTE A lashing point can be e.g. an oval link, a hook, a D-ring, a lashing rail.

3.1.7
standard tension force
S_{TF}
residual force after physical release of the handle of the tensioning device

[EN 12195-3:2001]

3.1.8
frictional lashing method
lashing procedure (e.g. top over) where the friction force is enhanced by adding a vertical force component to the weight of the load

3.1.9
direct lashing method
lashing procedure where the lashing devices are fixed directly to the solid parts of the load or to attachment points, that are intended for this purpose, and to the load carrier

3.1.10
blocking
securing method where the load lies against fixed structures or fixtures on the load carrier, may be in the form of headboards, sideboards, sidewalls, stanchions, wedges, supporting beams, bracing or other devices

3.1.11
securing
locking, blocking, lashing or combination of blocking and lashing to secure a load to all directions on the load carrier to prevent sliding and tilting

3.1.12
bracing
method of blocking mostly wooden structure, fixed to the load carrier to keep a load in one or more directions at its place

3.1.13
unstable load
load which unsecured will tilt when exposed to the given accelerations

3.1.14
load carrier
road vehicle or part of it

3.1.15
locking
securing method where the load is secured by mechanical devices e.g. twist-locks on a load carrier

3.2 Terms and definition of calculation parameters

3.2.1
mass of the load
m
mass which is to be secured

3.2.2
acceleration of the load
a
maximum acceleration of the load during a specific type of transportation

3.2.3
acceleration coefficient
c
coefficient which when multiplied by the acceleration due to gravity g gives the acceleration $a = c \times g$ of the load during a specific type of transportation

3.2.4
longitudinal force actuated by the load
F_x
inertia force, actuated by the load as a result of the load carrier movements in its longitudinal axis (x-axis) ($F_x = m\, c_x\, g$)

3.2.5
transverse force actuated by the load
F_y
inertia force, actuated by the load as a result of the load carrier movements in its transverse axis (y-axis) ($F_y = m\, c_y\, g$)

3.2.6
vertical force actuated by the load
F_z
sum of forces that arise from the weight of the load and the inertia force actuated by the load ($F_z = m\, c_z\, g$) due to the load carrier movements during the transport in the vertical axis (z-axis) of a load carrier

3.2.7
friction factor
μ
friction coefficient between the load and the adjoining surface

3.2.8
internal friction factor
μ_i
friction coefficient between rows of unstable loads, forming a load unit

3.2.9
friction force
F_F
force acting due to the friction between load and adjoining surfaces against the movement of the load

3.2.10
blocking force
F_B
force acting on a blocking device in a specified direction

3.2.11
blocking capacity
BC
maximum force that a blocking device is designed to carry in a specified direction

3.2.12
number
n
number of lashing devices or lashing lines

3.2.13
tension force of a lashing device
F_T
force in the lashing device created by tensioning of a tensioning device

3.2.14
restraining force of a lashing device
F_R
force carried by a lashing device to prevent movements of a load in relation to a load carrier during transport

3.2.15
lashing capacity
LC
maximum allowed force that a lashing device is designed to sustain in use

3.2.16
vertical lashing angle
α
angle between lashing device and the horizontal plane

3.2.17
longitudinal lashing angle
β_x
angle between lashing device and longitudinal axis (x-axis) of a load carrier in the plane of the loading area

3.2.18
transverse lashing angle
β_y
angle between lashing device and transverse axis (y-axis) of a load carrier in the plane of the loading area

3.2.19
safety factor
f_S
factor to cover uncertainties of distribution of tension forces for frictional lashing

3.2.20
conversion factor
f_μ
ratio of the dynamic friction factor and friction factor in accordance with Annex B

3.2.21
lashing line
working leg of one or more lashing devices

3.3 Symbols, units and terms

Table 1 — Symbols, units and terms

Symbol	Unit	Term
B	m	Total width of the load section
BC	N	Blocking capacity
F	N	Force
F_B	N	Blocking force
F_R	N	Restraining force of a lashing device
F_T	N	Tension force of a lashing device
F_x	N	Longitudinal force actuated by the load
F_y	N	Transverse force actuated by the load
F_z	N	Vertical force actuated by the load
F_F	N	Friction force
F_{FM}	N	Friction force as result of the vertical force F_z
F_{FR}	N	Friction force as result of the restraining force F_R
F_{FT}	N	Friction force as result of the tension force F_T
F_{LP}	N	Maximum force to which a lashing point is designed
H	m	Total height of the load section
LC	daN	Lashing capacity
S_{TF}	daN	Standard tension force
a	m/s²	Acceleration
b	m	Lever arm of the standing moment
c	—	Acceleration coefficient
c_x	—	Longitudinal acceleration coefficient
c_y	—	Transverse acceleration coefficient
c_z	—	Vertical acceleration coefficient
d	m	Lever arm of the tilting moment
f_S	—	Safety factor for frictional lashing
f_μ	—	Conversion factor
g	m/s²	Gravitational acceleration
h	m	Lever arm of the lashing moment
i	—	Index for lashing lines
ℓ	m	Length of the load
m	kg	Mass of the load
n	—	Number of lashing devices
N	—	Number of rows

Table 1 *(continued)*

Symbol	Unit	Term
p	m	Horizontal distance from the outer edge of the load to the point where the lashing device acts on the load
q	—	Number of lashing lines
r	m	Horizontal distance from the outer edge of the load to the tipping point
s	m	Vertical distance from the platform to the point where the lashing device acts on the load
t	m	Vertical distance from the platform to the tipping point
w	m	Width of the load
α	°	Vertical lashing angle
β_x	°	Longitudinal lashing angle
β_y	°	Transverse lashing angle
φ	°	Test angle
μ	—	Friction factor
μ_i	—	Internal friction factor

4 Acceleration coefficients

4.1 General

The acceleration coefficients given in the Tables 2, 3 and 4 are specified according to 3.2.2 and 3.2.3 as maximum values for a load on a load carrier for the specific type of transportation.

Combinations of longitudinal and transverse accelerations occurring during transport are covered by the values of the tables.

In case of combination of different modes of transport the maximum relevant acceleration coefficient, as appropriate, has to be taken into account.

Superposition of the weight of the load with high frequency stresses and occasional occurring shock loadings of short duration are absorbed by the elongation of the lashing devices and the shock absorber system of the lorries and trailers. This occurs without any significant increase of stress, so that this can be ignored for the purpose of this European Standard which gives a practical and not a scientific view.

Even for cargo with no risk of sliding or tilting, measures (e.g. blocking or lashing) shall be taken to avoid them to be significantly displaced due to vibrations.

4.2 Load on load carriers during road transport

The acceleration coefficients for load carriers during road transport shall be as given in Table 2.

Table 2 — Acceleration coefficients c_x, c_y and c_z during road transport

Securing in	Acceleration coefficients				
	c_x, longitudinally		c_y, transversely		c_z, vertically down
	forward	rearward	sliding only	tilting	
longitudinal direction	0,8	0,5	—	—	1,0
transverse direction	—	—	0,5	0,5/0,6 [a]	1,0

[a] See 5.1.

4.3 Load on load carriers during rail transport

The acceleration coefficients for load carriers during rail transport shall be as given in Table 3.

Table 3 — Acceleration coefficients c_x, c_y and c_z during rail transport

Securing in	Acceleration coefficients				
	c_x, longitudinally		c_y, transversely	c_z, minimum vertically down	
	sliding	tilting		sliding	tilting
longitudinal direction	1,0	0,6	—	1,0	1,0
transverse direction	—	—	0,5	0,7	1,0

4.4 Load on load carriers during sea transport

The acceleration coefficients for load carriers during sea transport shall be as given in Table 4.

Table 4 — Acceleration coefficients c_x, c_y and c_z during sea transport

Sea area	Securing in	Acceleration coefficients		
		c_x, longitudinally	c_y, transversely	c_z, minimum vertically down
A	longitudinal direction	0,3	—	0,5
	transverse direction	—	0,5	1,0
B	longitudinal direction	0,3	—	0,3
	transverse direction	—	0,7	1,0
C	longitudinal direction	0,4	—	0,2
	transverse direction	—	0,8	1,0

NOTE See IMO/ILO/UNECE, Guidelines for packing of cargo transport units (CTUs).

A Baltic Sea bordered in west by Jylland and in north by a line between Lysekil and Skagen.

B West of Sea area A bordered in north by a line between Kristiansand and Montrose, in west by UK and in south by a line between Brest and Land's End as well as the Mediterranean Sea.

C Unrestricted.

5 Methods of calculation

5.1 General

The general requirements for a safe transport are:

— the sum of forces in any direction equals zero;

— the sum of moments in any plane equals zero.

Load securing devices and aids, as e.g. wedges, web lashing devices according to EN 12195-2, lashing chains according to EN 12195-3 and lashing steel wire ropes according to EN 12195-4 have to sustain the forces and moments, longitudinally, transversely and vertically, the restraint device and the cargo unit are supposed to sustain.

Generally, load securing consists of balancing the forces of a load by locking, blocking and/or lashing. Locking, a completely positive connection, is mainly used in the transport of containers and is not usually combined with lashing devices. Blocking results in a positive connection in the blocked direction only and therefore is often combined with lashing devices. This is taken into consideration in 5.3, 5.4 and 5.5.

All calculation equations given in this European Standard are based on symmetrical (longitudinal and transverse) lashing methods. If the lashings are made unsymmetrical, this shall be taken into account when calculations are performed; this is not dealt with in this European Standard.

The two basic lashing methods are:

— frictional lashing (see 3.1.8);

— direct lashing (see 3.1.9).

For the design of the direct lashing method a conversion factor f_μ = 0,75 will be used in combination with μ and is included in all appropriate equations.

The frictional lashing method is described in 5.4, the direct lashing method in 5.5.

For load of which the effectiveness of the load securing arrangements cannot be determined by means of calculations in this European Standard (e.g. for some non rigid goods), the calculations can be replaced by suitable tests (see Clause 7) reflecting basic design parameters (see 4.2 to 4.4).

For unstable goods in combination with frictional lashing, the increased force in the lashing device due to tilting of the goods should not exceed half of the LC. The number of lashing devices to be used should be the largest of the following two calculations:

— c_y = 0,5 calculated with $F_T = S_{TF}$;

— c_y = 0,6 calculated with F_T = 0,5 LC.

In the case of the direct lashing method the calculation should be used based on:

— c_y = 0,6 calculated with $F_R = LC$.

5.2 Stability of unsecured load

The stability of a load should be determined both in longitudinal direction (x-axis) and in transverse direction (y-axis).

Using the designations of Figure 1, the stability condition for a load is specified as follows:

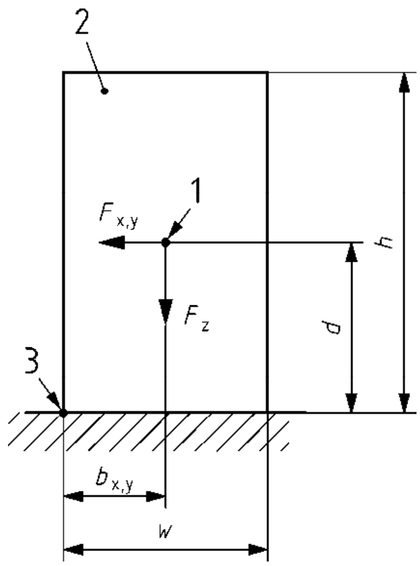
$$F_z \times b_{x,y} > F_{x,y} \times d \tag{1}$$

$$b_{x,y} > \frac{F_{x,y}}{F_z} d \tag{2}$$

$$b_{x,y} > \frac{c_{x,y}}{c_z} d \tag{3}$$

The quantities c_x, c_y and c_z are the acceleration coefficients in accordance with Clause 4 (for road transport c_y to be taken as 0,5).

If the condition of Equation (1) is met, a load is stable. An unstable load will have a high centre of gravity in relation to the dimensions of the bottom surface. In the case of an unstable load the risk of tilting over has to be taken into account.



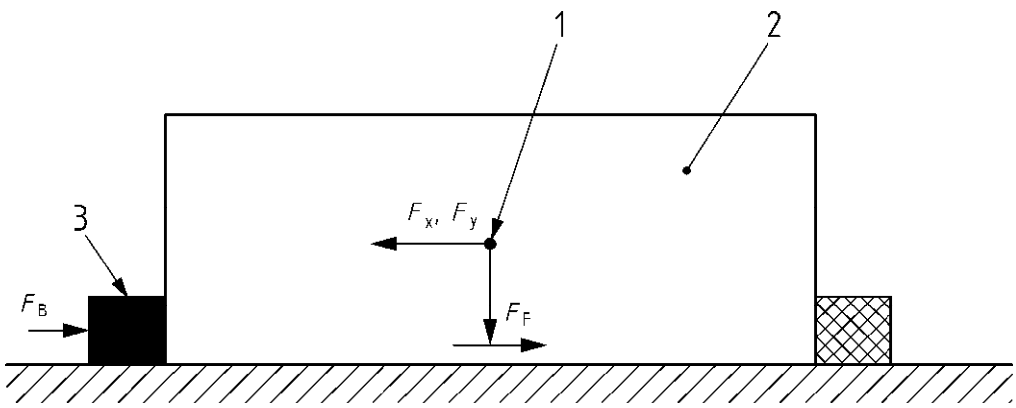
Key

1 centre of gravity
2 load
3 tilting edge

Figure 1 — Stability of an unlashed load

5.3 Blocking

For the design of blocking the friction factor μ is to be used.



Key

1 centre of gravity
2 load
3 blocking device

Figure 2 — Load securing by blocking

The balance of forces in longitudinal or transverse direction is as follows:

$$F_B + F_F = F_{x,y} \tag{4}$$

$$F_B + \mu \times m \times c_z \times g = m \times c_{x,y} \times g \tag{5}$$

$$F_B = (c_{x,y} - \mu \times c_z)\, m \times g \tag{6}$$

The condition for calculating the blocking capacity BC is as follows (see also Figure 2):

$$BC \geq F_B \tag{7}$$

5.4 Frictional lashing

5.4.1 General

Frictional lashing, as shown in Figure 3, consists of tensioning the lashing devices to the tension force F_T so as to increase the friction force at the contact surface of the load to avoid any sliding of the load.

The tensioning devices of the lashing devices, if more than one, should be arranged alternatively on the opposing sides of the load.

Because of practical reasons, e.g. setting behaviour of the load, retightening after short travelling is recommended. Indicated by the surface of the load, corner protectors should be used.

The calculations in the standard are based on theoretical principles. Operational factors can positively or negatively impact the required number of lashing devices, e.g.:

— retensioning not feasible;

— self-tensioning effect;

— influence of the corner frictions.

To compensate for uncertainties of the distribution of lashing forces and for acceleration during braking a safety factor f_S is to be used.

f_S = 1,1 in all horizontal directions, except for road transport in forward direction, where f_S = 1,25.

The tension force of any tensioning device has to meet the following conditions:

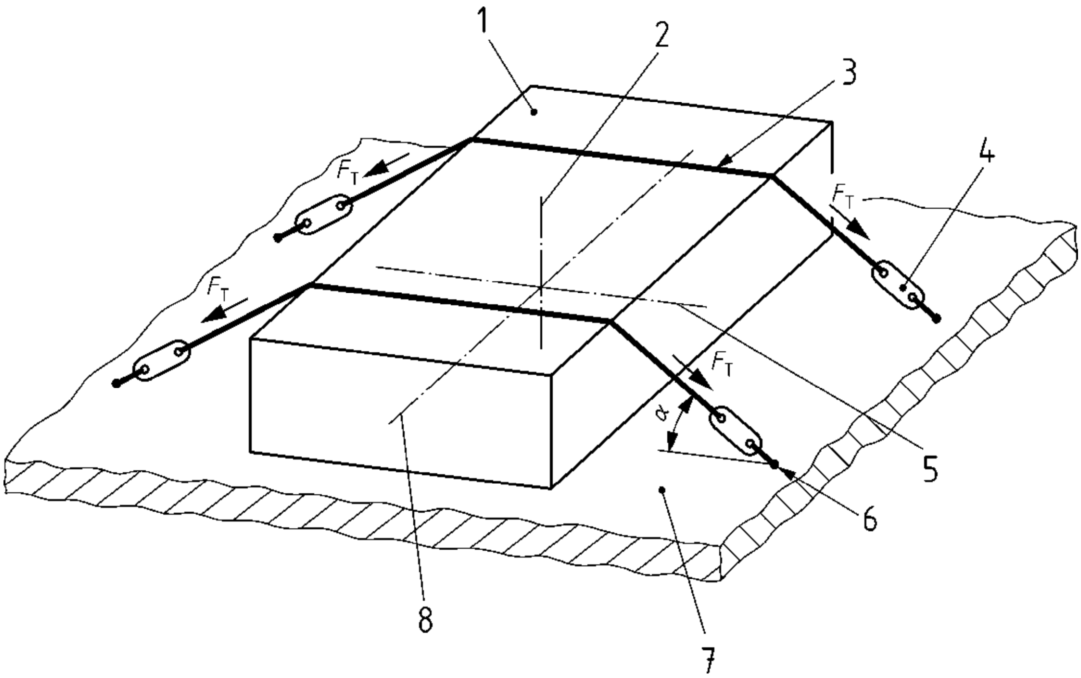
$$0{,}1\ LC \leq F_T \leq 0{,}5\ LC \tag{8}$$

For the calculation F_T has to be taken as S_{TF} if no other values are shown by tension force indicators.

NOTE In practice LC and S_{TF} are given in decanewtons, but all other forces in newtons. For reasons of comparison however the same unit is used.

5.4.2 Avoiding sliding

For the design of frictional lashing the friction factor μ is used, see Annex B.



Key

1 load
2 vertical axis
3 lashing device
4 tensioning device
5 transverse axis
6 lashing point
7 horizontal plane
8 longitudinal axis

Figure 3 — Frictional lashing of a load

The equation for the calculation of the tension force is:

$$F_T \geq \frac{(c_{x,y} - \mu \times c_z)\, m \times g}{2n \times \mu \times \sin \alpha} f_S \quad (9)$$

if the tension force of a lashing device is questioned.

If the number of lashing devices is questioned:

$$n \geq \frac{(c_{x,y} - \mu \times c_z)\, m \times g}{2\mu \times \sin \alpha \times F_T} f_s \quad (10)$$

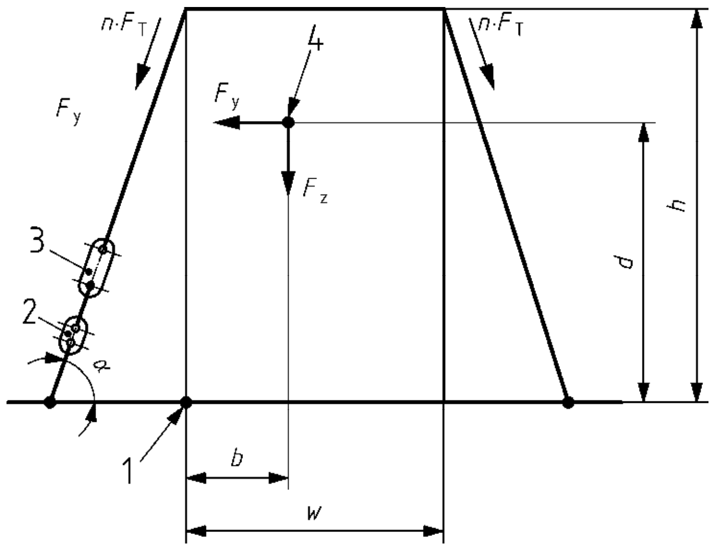
For "frictional lashing" combined with "blocking", Equations (7) and (9) are combined to give:

$$BC + 2n \times \mu \times \sin \alpha \times F_T \,/\, f_s > (c_{x,y} - \mu \times c_z)\, m \times g \quad (11)$$

5.4.3 Avoiding tilting

5.4.3.1 Frictional lashing to avoid tilting

This example is similar to the one in 5.4.2. A rigid block with height h and width w is attached to the carrier surface by n lashing devices.



Key

1 tilting edge
2 tension force indicator
3 tensioning device
4 centre of gravity

Figure 4 — Frictional lashing of a load to avoid tilting in transverse direction

For tilting in transverse direction Equation (12) applies.

$$n \times F_{\mathrm{T}} \geq \frac{m \times g\ (c_{\mathrm{y}} \times d - c_{\mathrm{z}} \times b)}{w \times \sin \alpha} \times f_{\mathrm{s}} \tag{12}$$

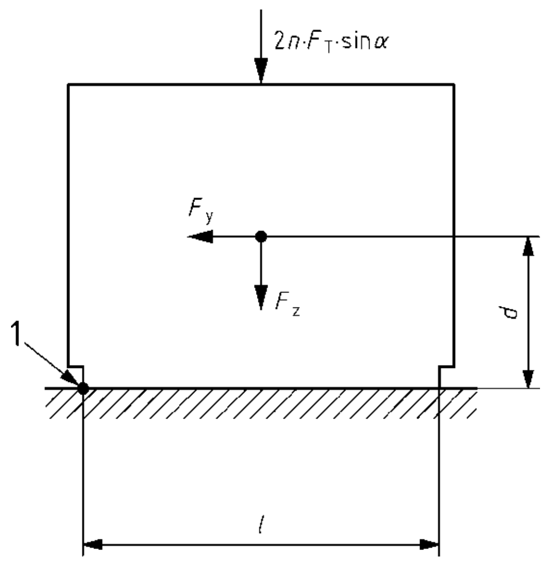
In the case of a symmetrical mass centre of the block, $b = \frac{w}{2}$, $d = \frac{h}{2}$ and Equation (12) becomes:

$$F_{\mathrm{T}} \geq \frac{m \times g}{2n \times \sin \alpha} \left(c_{\mathrm{y}} \frac{h}{w} - c_{\mathrm{z}} \right) \times f_{\mathrm{s}} \tag{13}$$

$$n \geq \frac{m \times g}{2 \times F_{\mathrm{T}} \times \sin \alpha} \left(c_{\mathrm{y}} \frac{h}{w} - c_{\mathrm{z}} \right) \times f_{\mathrm{s}} \tag{14}$$

For tilting in longitudinal direction with symmetrically located lashing devices between tilting points (see Figure 5) Equation (15) applies.

$$2n \times F_{\mathrm{T}} \times \sin \alpha\ \frac{l}{2} \geq m \times g \left(c_{\mathrm{x}}\ d - c_{\mathrm{z}}\ b \right) \times f_{\mathrm{s}} \tag{15}$$



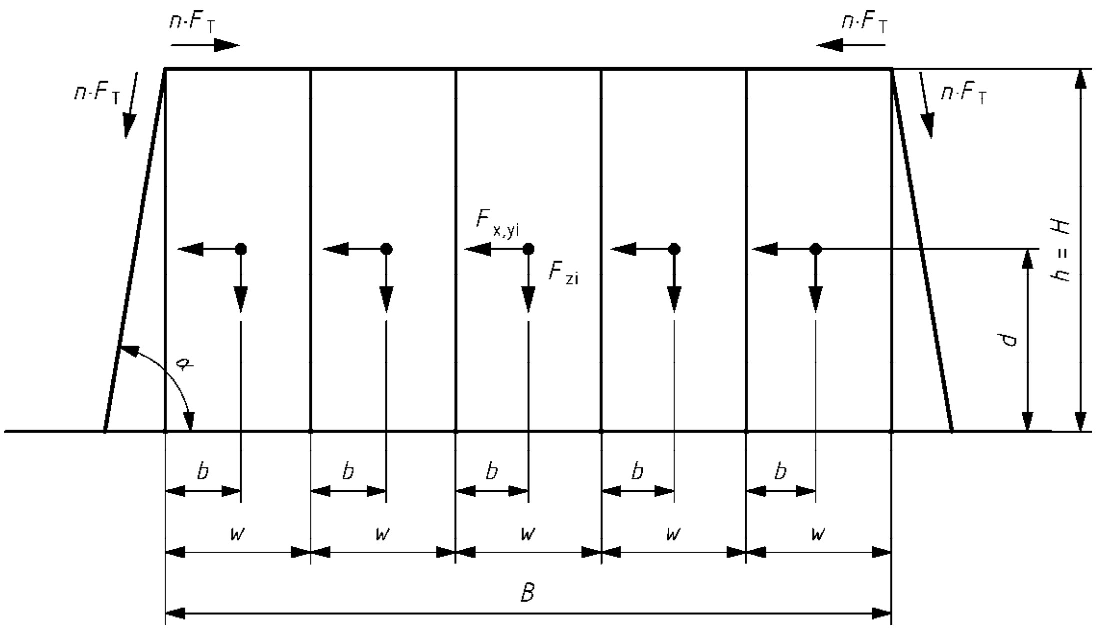
Key
1 tilting edge

Figure 5 — Frictional lashing of a load to avoid tilting in longitudinal direction

5.4.3.2 Rows of unstable rigid loads

Unstable loads with vertical contact areas can be calculated if they form a load unit. The inner friction between the rows may only be taken into account if it can be assured by suitable measures (such as e.g. self secured load units, pressure resistant packaging).

NOTE Special loads, like e.g. rows of barrels, should generally be excluded from this procedure, because the barrel segments can shift into one another.



NOTE For this example N = 5.

Figure 6 — Unstable loads with vertical contact areas

$$n \geq f_s \frac{m \times g \times (c_y \times d - c_z \times b)}{w \times F_T \times (\sin\alpha + 0{,}25 \times (N-1))} \tag{16}$$

In the case of a symmetrical mass centre of the block, $b = \frac{w}{2}$, $d = \frac{h}{2}$ and Equation (16) becomes:

$$m \leq \frac{2 \times n \times F_T \times \left(\sin\alpha + 0{,}25 \times (N-1)\right)}{f_s \times g \times \left(c_y \times \frac{H}{B} \times N - c_z\right)} \tag{17}$$

0,25 is the maximum value of μ to cover the vertical friction between the adjacent rows in close contact. In all cases when cargoes are lashed or blocked it is important that the load items are stored in close contact to each other as much as possible.

5.5 Direct lashing

5.5.1 General

As shown in Figures 7 to 12, direct lashing consists in attaching the load directly to the load carrier. For direct lashing the friction factor shall be multiplied by f_μ = 0,75. Based on pulling tests for the determination of dynamic friction, higher conversion factors than f_μ = 0,75 – but not higher than 1,0 – can be obtained, that may be used.

A lashing method will be deemed to be direct, if the following conditions apply:

— direct connection on the load carrier as well as on the load for slope and diagonal lashing (Figures 7 to 10);

— direct connection on the load carrier only, for both loop and spring lashing (Figures 11 and 12).

Depending on the load direction, restraining forces F_R are usually generated in one pair of the lashing devices used.

For more than two lashing lines working in the same direction due to the static overdetermination special consideration shall be taken.

Among the types of direct lashing methods are:

— slope lashing in longitudinal or transverse direction (Figure 7);

— diagonal lashing (Figures 8 to 10);

— direct lashing against tilting (Figure 9);

— direct lashing against tilting in combination with blocking (Figure 10);

— loop lashing (Figures 11 to 13);

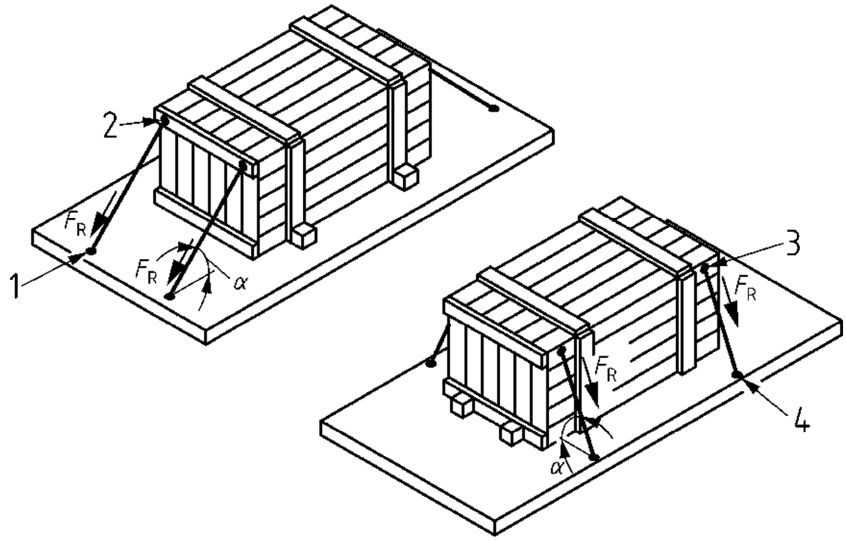
— spring lashing (Figure 14).

These direct lashing methods are dealt with in 5.5.2 to 5.5.4.

F_R has to be less or equal LC unless specified otherwise.

5.5.2 Slope lashing in longitudinal or transverse direction

In slope lashing two identical lashing devices are used in one axial direction (see Figure 7). If the lashing devices are symmetric with the same vertical angle α in both lashing devices two identical restraining forces F_R are generated.



Key

1 lashing point
2 attachment point
3 attachment point
4 lashing point

Figure 7 — Slope lashing of a load in longitudinal or transverse direction

The balance of the forces in longitudinal or transverse direction with two pairs of symmetrically positioned lashing devices is:

$$2F_{\text{Rx,y}} + F_{\text{FM}} + F_{\text{FR}} = F_{\text{x,y}} \tag{18}$$

$$2\cos\alpha \times F_{\text{R}} + \mu \times f_{\mu}(m \times c_{\text{z}} \times g + 2\sin\alpha \times F_{\text{R}}) = m \times c_{\text{x,y}} \times g \tag{19}$$

$$F_{\text{R}} = m \times g \frac{(c_{\text{x,y}} - \mu \times f_{\mu} \times c_{\text{z}})}{2\,(\cos\alpha + \mu \times f_{\mu} \times \sin\alpha)} \tag{20}$$

The requirement for calculating the lashing capacity LC is

$$LC \geq F_{\text{R}} \tag{21}$$

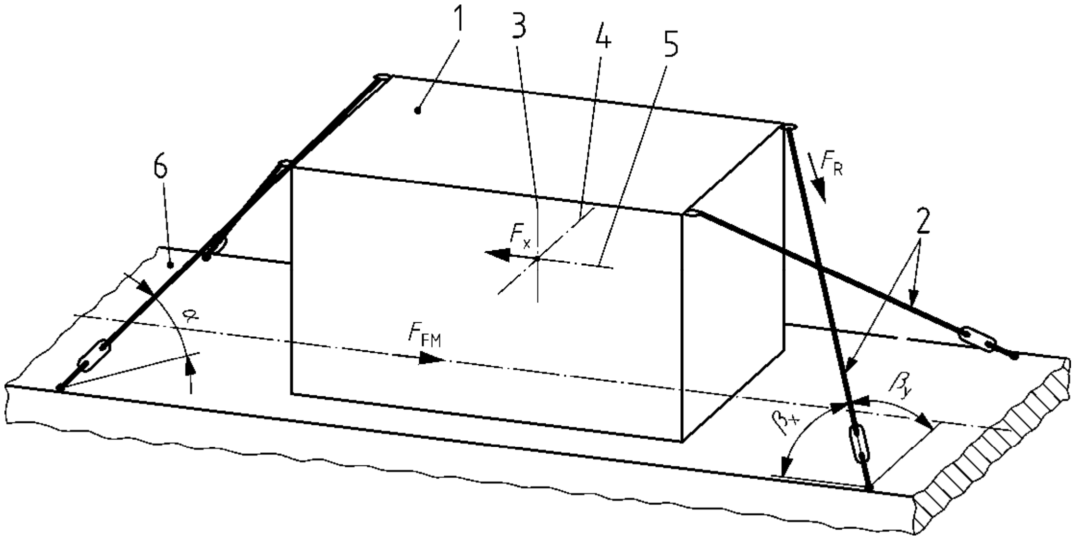
NOTE 1 In practice LC is given in decanewtons, but all other forces in newtons. For reasons of comparison however the same unit is used.

NOTE 2 The lashing device should be tensioned by the standard hand force, but should not exceed 50 % of LC.

5.5.3 Diagonal lashing

5.5.3.1 Principle

The diagonal lashing method is a combination of two sets of lashing devices using two different angles. A longitudinal angle β_x and a transverse angle β_y occur additionally to the vertical angle α under the lashing device (see Figure 8). This allows for the reduction of the number of lashing devices from 8 to 4 for a completely secured load.



Key

1 load
2 lashing device
3 vertical axis
4 transverse axis
5 longitudinal axis
6 loading plane

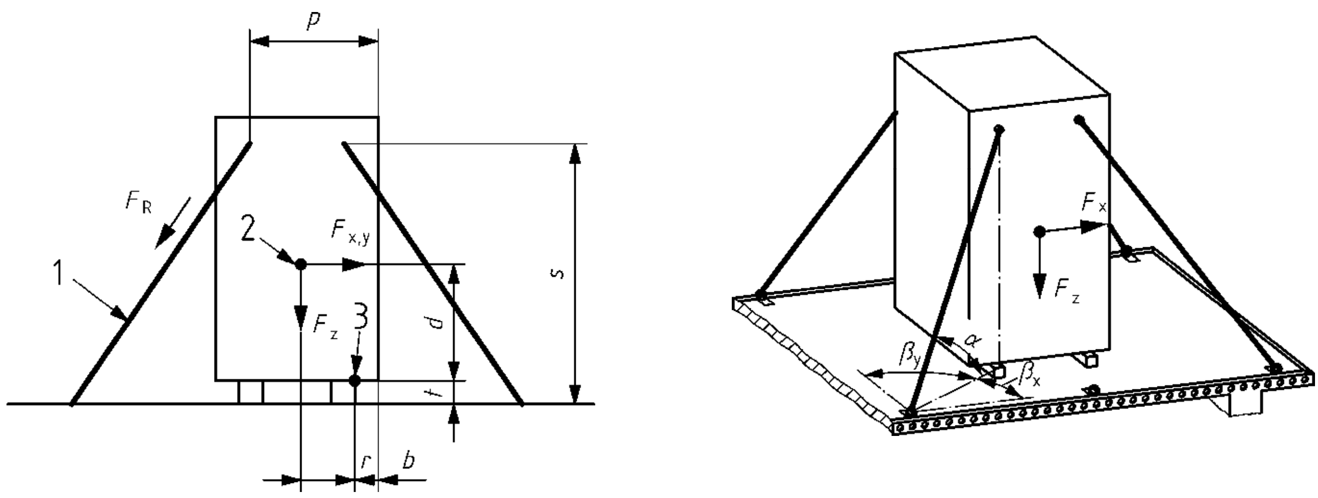
Figure 8 — Diagonal lashing of a load

The equation for calculating the restraining force F_R is:

$$F_R = m \times g \frac{(c_{x,y} - \mu \times f_\mu \times c_z)}{2\,(\cos\alpha \times \cos\beta_{x,y} + \mu \times f_\mu \times \sin\alpha)} \quad (22)$$

NOTE In practice LC is given in decanewtons, but all other forces in newtons. For reasons of comparison however the same unit is used.

5.5.3.2 Diagonal lashing to avoid tilting



a) b)

Key

1 lashing lines preventing tilting in required direction
2 centre of gravity
3 tilting edge

Figure 9 — Diagonal lashing of an unstable load

For the diagonal lashing of an unstable load according to Figure 9 the equilibration of moments at edge 3 is:

$$m \times g \times c_{\mathrm{x,y}} \times d - m \times g \times c_{\mathrm{z}} \times b - F_{\mathrm{R}} \times \left(\sum_{\mathrm{i=1}}^{\mathrm{n}} \left[\cos \alpha_{\mathrm{i}} \times \cos \beta_{\mathrm{x_i,y_i}} \times (s_{\mathrm{i}} - t_{\mathrm{i}}) \right] + \sum_{\mathrm{i=1}}^{\mathrm{n}} \left[\sin \alpha_{\mathrm{i}} \times (p_{\mathrm{i}} - r_{\mathrm{i}}) \right] \right) = 0 \quad (23)$$

The equation for the required restraining force of a lashing device to prevent the load from tilting is:

$$F_{\mathrm{R}} \geq \frac{m \times g \times (c_{\mathrm{x,y}} \times d - c_{\mathrm{z}} \times b)}{\left(\sum_{\mathrm{i=1}}^{\mathrm{n}} \left[\cos \alpha_{\mathrm{i}} \times \cos \beta_{\mathrm{x_i,y_i}} \times (s_{\mathrm{i}} - t_{\mathrm{i}}) \right] + \sum_{\mathrm{i=1}}^{\mathrm{n}} \left[\sin \alpha_{\mathrm{i}} \times (p_{\mathrm{i}} - r_{\mathrm{i}}) \right] \right)} \quad (24)$$

With two symmetrical lashings Equations (23) and (24) will be:

$$m \times g \times c_{\mathrm{x,y}} \times d - m \times g \times c_{\mathrm{z}} \times b - 2 \times F_{\mathrm{R}} \times \left[\cos \alpha \times \cos \beta_{\mathrm{x,y}} \times (s - t) + \sin \alpha \times (p - r) \right] = 0 \quad (25)$$

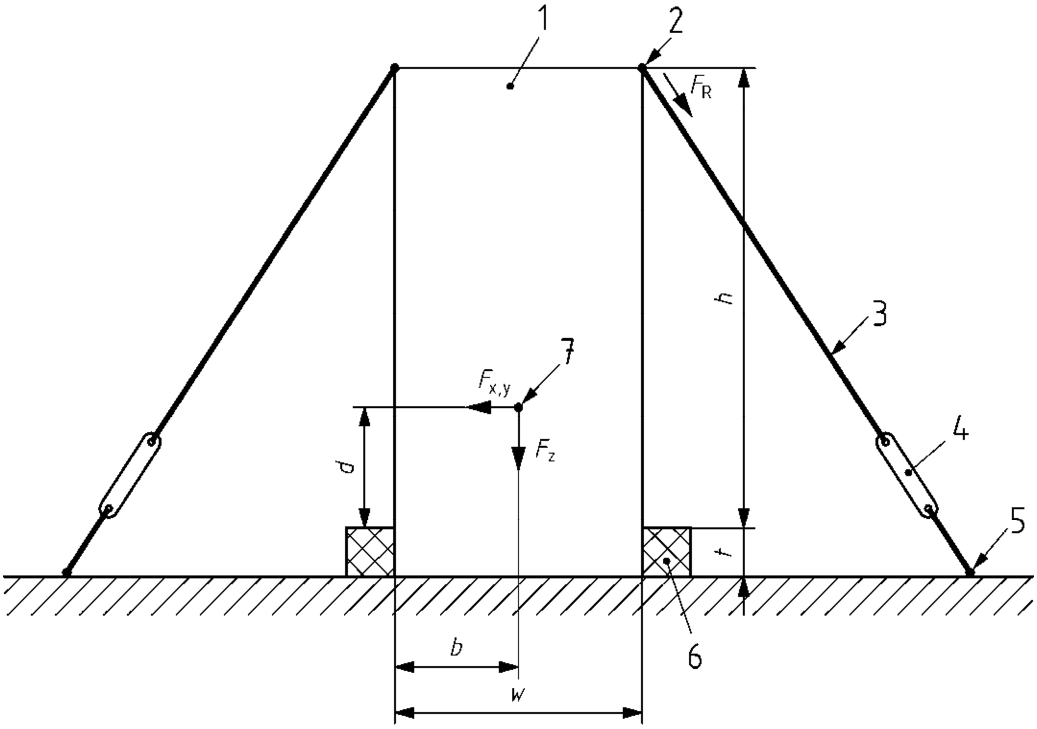
$$F_R \geq m \times g \frac{c_{x,y} \times d - c_z \times b}{2 \times \left[\cos \alpha \times \cos \beta_{x,y} \times (s - t) + \sin \alpha \times (p - r) \right]} \quad (26)$$

The equation for calculating the required lashing capacity *LC* to prevent tilting is c_{y} = 0,6 for road transport (see 4.2).

5.5.3.3 Diagonal lashing to avoid tilting for blocked loads

The diagonal lashing of an unstable blocked load (see Figure 10) is calculated according to Equation (27):

$$m\, g \left[c_{x,y}\, d - c_z \left(b + f_\mu\, \mu\, t \right) \right] \leq 2\, F_{\mathrm{R}} \left[h \cos \alpha \cos \beta_{x,y} + \left(w + f_\mu\, \mu\, t \right) \sin \alpha \right] + \frac{F_{\mathrm{B}} \times t}{2} \quad (27)$$



Key

1 load
2 lashing point
3 lashing device
4 tensioning device
5 lashing point
6 blocking device
7 centre of gravity

Figure 10 — Diagonal lashing of an unstable load combined with blocking

5.5.4 Loop lashing

5.5.4.1 Principle

Loop lashing is a kind of slope lashing. As the load has no attachment points it is secured by a minimum of two pairs of lashing devices.

It is calculated according to the following equation:

$$n\, F_{\mathrm{R}}\,[\cos\alpha + 1 + \mu \times f_{\mu} \cdot \sin\alpha] - mg(c_{\mathrm{y}} - \mu \times f_{\mu} \times c_{\mathrm{z}}) = 0 \qquad (28)$$

Additional securing, e.g. blocking in longitudinal direction, is necessary.

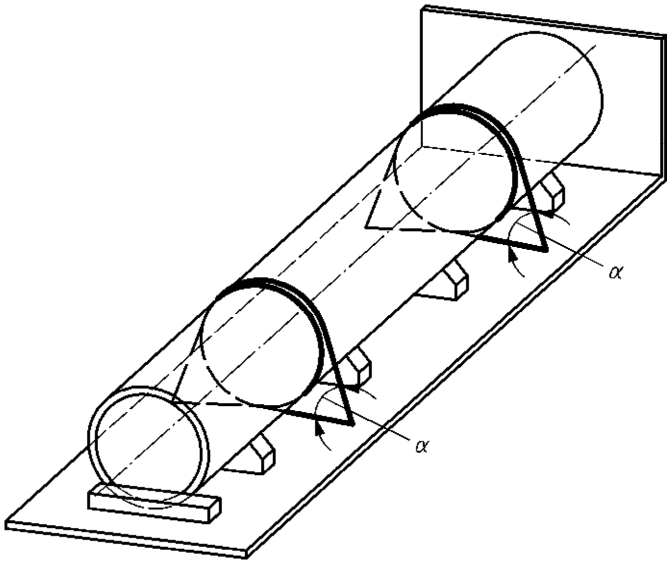
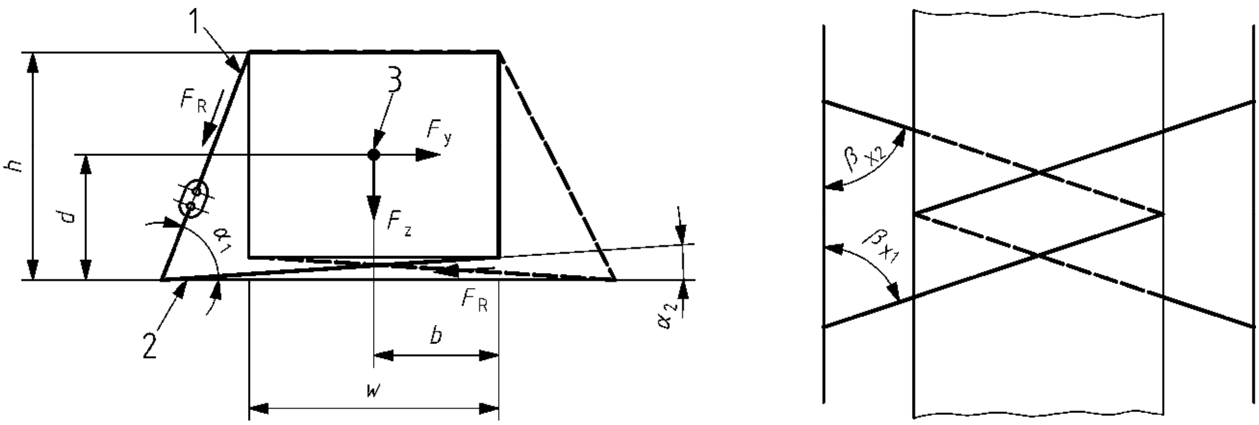


Figure 11 — Loop lashing

5.5.4.2 Loop lashing to prevent sliding



a) b)

Key

1 first line of lashing

2 second line of lashing

3 centre of gravity

Figure 12 — Loop lashing to prevent sliding

The balance of forces in transverse direction is:

$$n \times F_\mathrm{R} \times \left(\cos\alpha_1 \times \sin\beta_{x_1} + \cos\alpha_2 \times \sin\beta_{x_2} + f_\mu \times \mu \times \sin\alpha_1 + f_\mu \times \mu \times \sin\alpha_2\right) \geq m \times g \times \left(c_\mathrm{y} - c_z \times f_\mu \times \mu\right) \qquad (29)$$

The equation for required number of pairs of loop lashing devices to prevent sliding is:

$$n \geq \frac{m \times g \times \left(c_\mathrm{y} - c_\mathrm{z} \times f_\mu \times \mu\right)}{F_\mathrm{R} \times \left(\cos\alpha_1 \times \sin\beta_{x_1} + \cos\alpha_2 \times \sin\beta_{\mathrm{x}_2} + f_\mu \times \mu \times \sin\alpha_1 + f_\mu \times \mu \times \sin\alpha_2\right)} \qquad (30)$$

5.5.4.3 Loop lashing to prevent tilting for one or several cargo rows

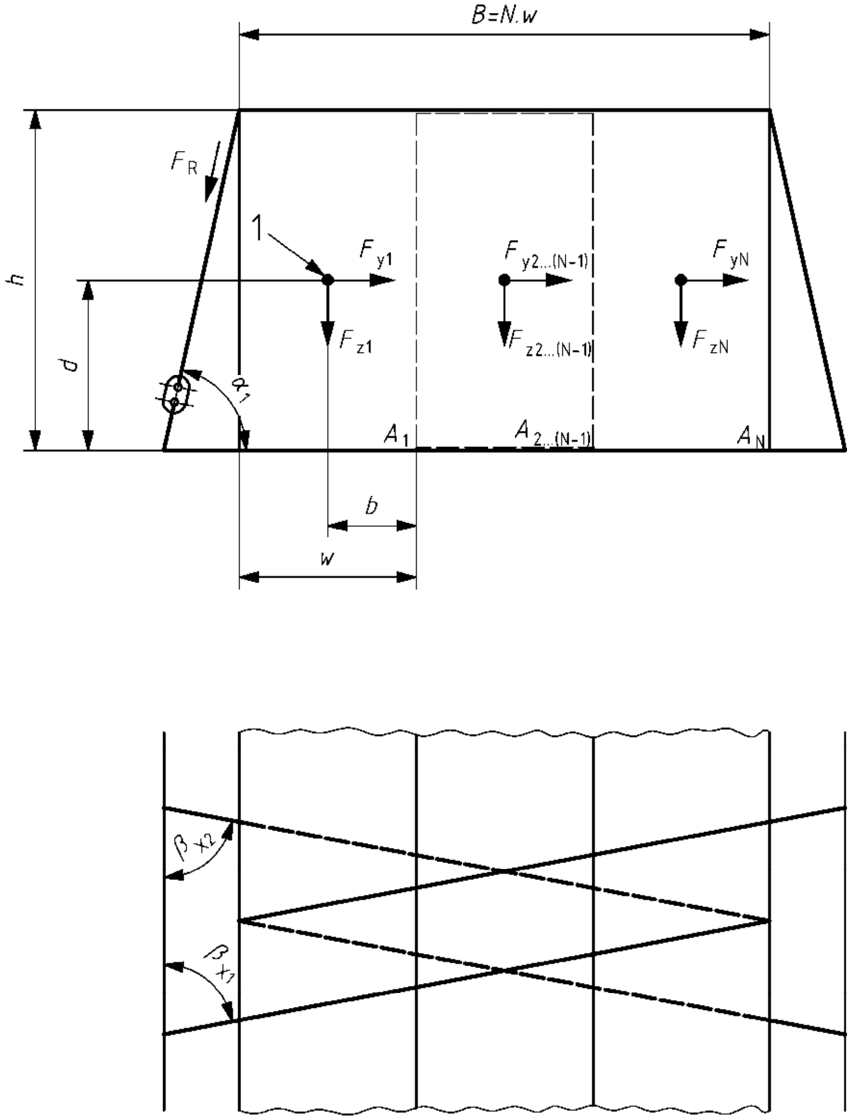


Figure 13 — Loop lashing to prevent tilting for one or several cargo rows

Taking into account an internal friction factor μ_i = 0,25, the equilibrium equation at edges A_i is:

$$\sum_{i=1}^{N} F_{y_i} \times d - \sum_{i=1}^{N} F_{z_i} \times b - n \times F_R \times \sin\alpha_1 \times w - n \times F_R \times \cos\alpha_1 \times \sin\beta_{x_1} \times h - \sum_{i=1}^{N-1} 0{,}25 \times n \times F_R \times w = 0 \quad (31)$$

$$m \times g \times c_y \times d - m \times g \times c_z \times b - n \times F_R \times \sin\alpha_1 \times w - n \times F_R \times \cos\alpha_1 \times \sin\beta_{x_1} \times h - (N-1) \times 0{,}25 \times n \times F_R \times w = 0 \quad (32)$$

The equation for n pairs of loop lashing devices to prevent tilting:

$$n \geq \frac{m \times g \times (c_y \times d - c_z \times b)}{F_R \times (\sin\alpha_1 \times w + \cos\alpha_1 \times \sin\beta_{x_1} \times h + 0{,}25 \times (N-1) \times w)} \quad (33)$$

For n > 2 due to the static overdetermination special consideration shall be taken.

For loop lashing to prevent tilting F_R is to be taken as max. 0,5 LC.

NOTE In practice LC is given in decanewtons, but all other forces in newtons. For reasons of comparison however the same unit is used.

5.5.5 Spring lashing

5.5.5.1 Principle

Spring lashing is a kind of direct lashing. As the load has no attachment points it is secured by a sling which is attached to the edges (see Figure 14).

As spring lashing is possible in transverse direction as well, the equations given have to be adapted accordingly.

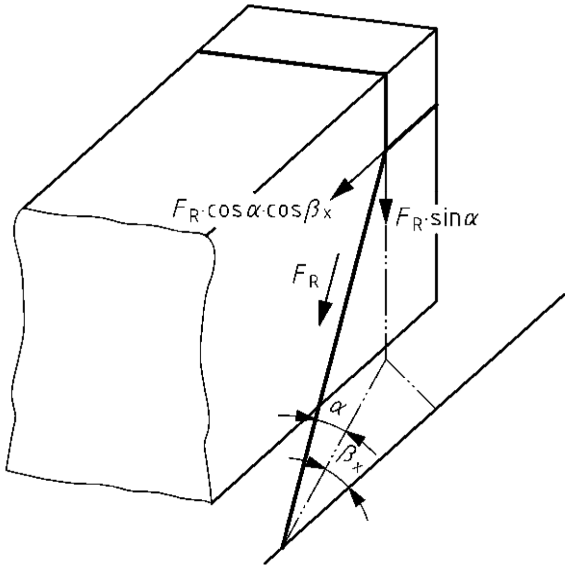


Figure 14 — Spring lashing

5.5.5.2 Spring lashing to prevent sliding

To obtain the required restraining force of a loop lashing device to prevent sliding the equation for the balance of forces is used:

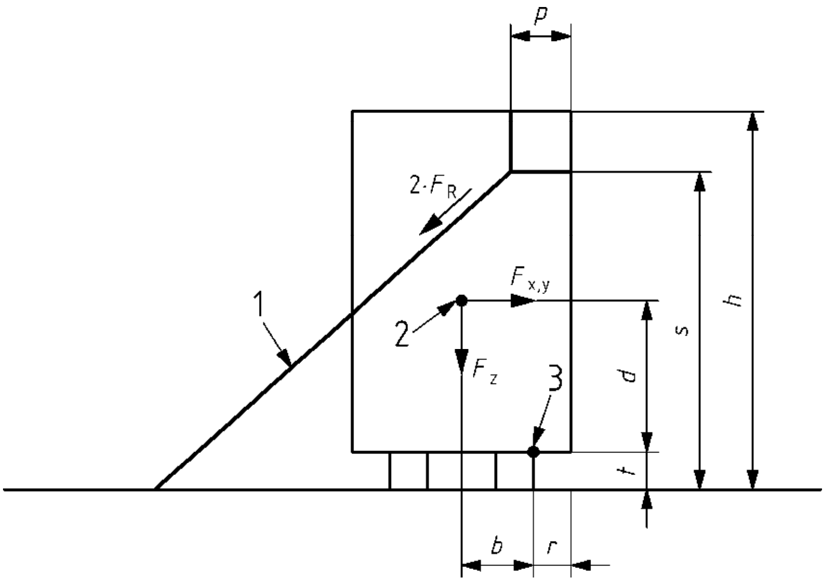
$$F_x - F_z \times f_\mu \times \mu - \sum_{i=1}^{q} f_\mu \times \mu \times F_R \times \sin\alpha_i - \sum_{i=1}^{q} F_R \times \cos\alpha_i \times \cos\beta_{x,y_i} = 0 \quad (34)$$

$$m \times g \times c_x - m \times g \times c_z \times f_\mu \times \mu - F_R \left(\sum_{i=1}^{q} f_\mu \times \mu \times \sin\alpha_i + \sum_{i=1}^{q} \cos\alpha_i \times \cos\beta_{x,y_i} \right) = 0 \quad (35)$$

where

q is the number of spring lashing lines.

5.5.5.3 Spring lashing to prevent tilting



Key

1 spring lashing lines
2 centre of gravity
3 tilting edge

Figure 15 — Spring lashing to prevent tilting

For a spring lashing according to Figures (14) and (15) with two spring lashing lines the equilibration of moments at edge 4 is:

$$F_x \times d - F_z \times b - 2\left[F_R \times \cos\alpha_i \times \cos\beta_{x,y_i} \times (s_i - t_i)\right] - 2\left[\sin\alpha_i \times (p_i - r_i)\right] = 0 \qquad (36)$$

$$m \times g \times c_x \times d - m \times g \times c_z \times b - F_R \times \left\{2\left[\cos\alpha_i \times \cos\beta_{x,y_i} \times (s_i - t_i)\right] + 2\left[\sin\alpha_i \times (p_i - r_i)\right]\right\} = 0 \qquad (37)$$

6 Parameters

6.1 Friction factor

The friction factor μ has to be assumed according to Annex B.

The values presented in Table B.1 are valid for dry and wet clean surfaces, free from frost or ice and snow. They are based on several independent practical tests for each combination of materials. The values present a medium of measured static friction values multiplied by 0,925 and measured dynamic friction values divided by 0,925. This is the calculation basis for the purpose of this European Standard.

If friction factors μ are determined by tests, it has to be ensured that the used test method is applicable to the tested goods and transport.

When special materials for increased friction like skid-inhibiting mats are applied, a certificate for the friction factor μ is required.

It has to be ensured that the used friction factors are applicable to the actual transport. If the surface contacts are not swept clean, free from frost, ice and snow a friction factor larger than μ = 0,2 (for sea transport μ = 0,3) shall not be used. Special precautions should be taken for oily and greasy surfaces.

6.2 Transmission of force during frictional lashing

During frictional lashing generally there is the difficulty to establish the values of the tension forces. Even if the tension forces are adjusted very carefully prior to the transport, there may be changes during transport. As a general rule, the tension forces during transport should be checked.

A further basis for the determination of the tension forces for frictional lashing is:

— the presence of tension force indicators or other equipment for verifying or adjusting the tension forces;

or

— tensioning devices, which are marked with the standard tension force S_{TF}, are used.

7 Cargo securing testing

For load of which the effectiveness of the load securing arrangements cannot be determined by means of calculations in this European Standard (e.g. for some non rigid goods), the calculations may be replaced by suitable tests reflecting basic design parameters.

The effectiveness of the cargo securing arrangements may be verified by suitable tests reflecting basic design parameters like:

— dynamic driving tests;

or

— static inclination tests

according to the description in Annex D.

It has to be ensured that the used test method is applicable to the tested goods and transport.

Results from practical tests documented according to Annex E may be complemented by calculations.

8 Instruction for use

8.1 General

The instruction for use, that shall be provided for the safe use of web lashing devices, lashing chains, lashing steel wire ropes (according to the respective Clauses 7) for Parts 2 to 4 of EN 12195 is based on their Annexes B. The basic requirements given in B.1 and B.2 of EN 12195-2:2000, EN 12195-3:2001 and EN 12195-4:2003 for determining the number and lashing capacity of the load restraint devices, are fulfilled when the equations are used which take the parameters of this European Standard into account.

When using the equations given in this European Standard, the examples of Annex A may be helpful.

The instruction for use to be provided for the safe use of load restraint assemblies, may however also consist of tables or computer programs, which in turn are based on the equations and parameters given in this European Standard.

8.2 Marking

Where practicable and feasible, a load securing protocol similar to Annex C should be used to verify that the load has been secured in accordance with EN 12195-1. On this protocol, it should be indicated how the load securing method has been set up to carry the loads.

Annex A
(informative)

Examples for the calculation of lashing forces

Example A.1: Frictional lashing for road transport

Trailer: Width: 2,5 m (see Figure A.1)

Load: Mass: m = 2 000 kg

Width: 1,8 m

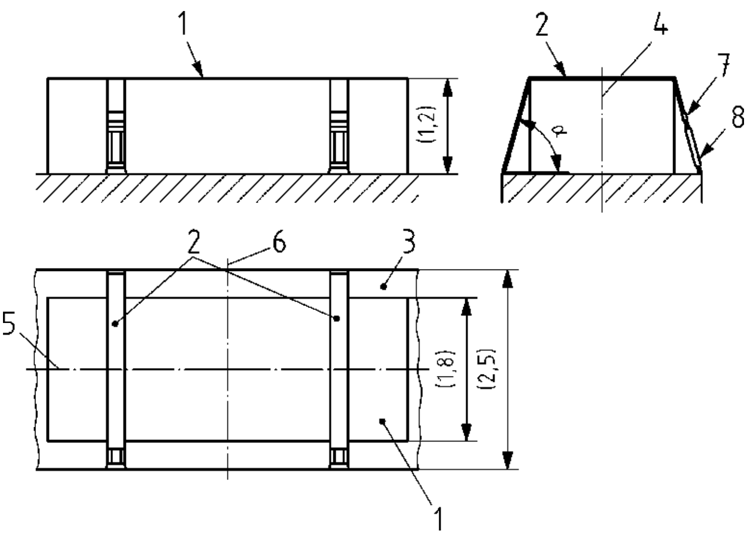
Height: 1,2 m

Length: 4,5 m

Lashing devices: Lashing capacity LC = 2 500 daN, S_{TF} = 520 daN (= 5 200 N)

Several lashing devices of this type, which will be used across the top of the load, are available. Each lashing device is equipped with only one tensioning device in combination with a tension force indicator because only one tensioning device per lashing device is used:

Dimensions in metres



Key

1 load
2 lashing devices
3 loading plane
4 vertical axis
5 longitudinal axis
6 transverse axis
7 lashing force indicator
8 tensioning device

Figure A.1 — Over-top lashing of a stable load (schematic representation with indicated values)

Friction: Load of sawn timber on load area of grooved aluminium, friction factor μ = 0,4 (see Annex B).

Vertical angle: α = 80°

Question 1: What is the number *n* of the necessary lashing devices?

Question 2: Which tension force has to be applied?

Acceleration coefficients according to 4.2, Table 2 for road transport:

Acceleration coefficient in longitudinal direction

c_x **= 0,8**

Acceleration coefficient in vertical direction

c_z **= 1,0**

Calculation according to 5.4.2, Equation (10):

$$n \geq \frac{(c_{x,y} - \mu \times c_z)\, m \times g}{2 \times \mu \times \sin\alpha \times F_T} f_s$$

$$n \geq \frac{(0{,}8 - 0{,}4)\ 2\,000 \times 9{,}81}{2 \times 0{,}4 \times \sin 80° \times 5\,200}\ 1{,}25 = 2{,}4 \Rightarrow 3$$

Answer 1: The number of necessary lashing devices that are to be placed across the top of the load, is *n* = 3.

$$F_T \geq \frac{(c_{x,y} - \mu \times c_z)\, m \times g}{2n \times \mu \times \sin\alpha} f_s$$

$$F_T \geq \frac{(0{,}8 - 0{,}4)\ 2\,000 \times 9{,}81}{2 \times 3 \times 0{,}4 \times \sin 80°}\ 1{,}25 = 4\,150\ \text{N}$$

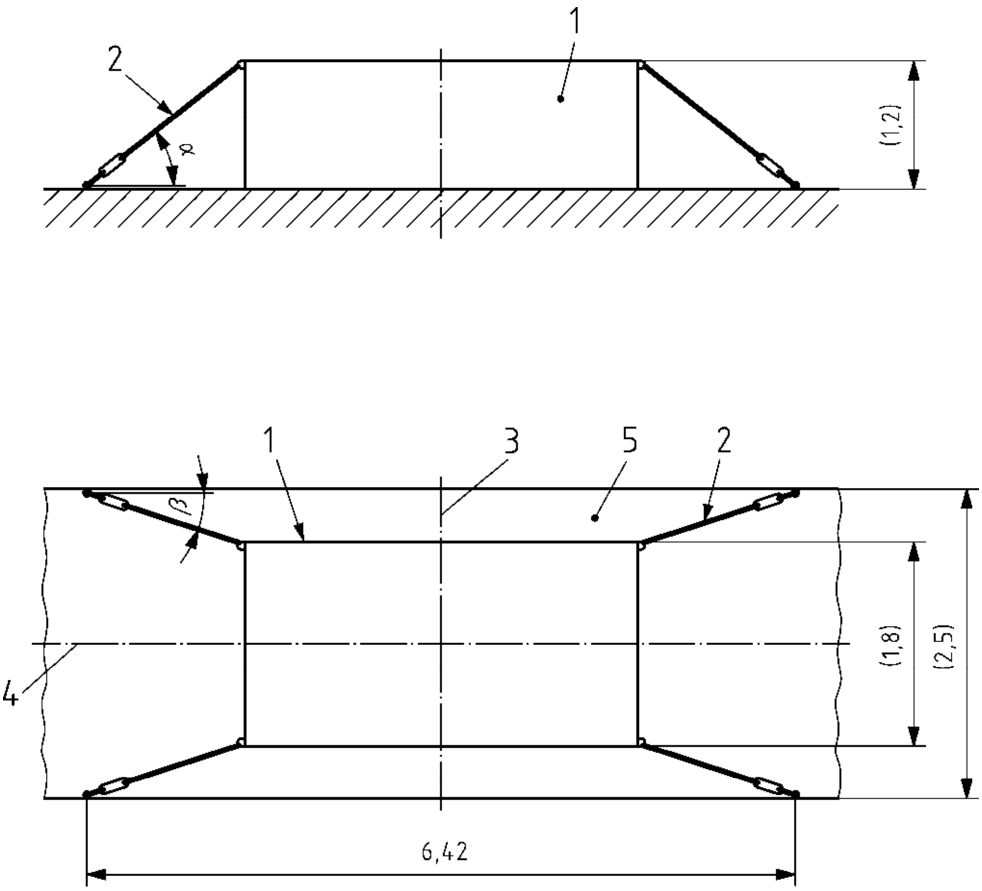
Answer 2: The minimum tension force of 4 150 N has to be applied.

Example A.2: Diagonal lashing in longitudinal direction on a load carrier during rail transport

Mass m = 2 000 kg

(as in Example A.1)

Dimensions in metres



Key

1 load
2 lashing devices
3 transverse axis
4 longitudinal axis
5 loading plane

Figure A.2 — Diagonal lashing of a stable load (schematic representation with indicated values)

Friction: Sawn wood against grooved aluminium with a friction factor μ **= 0,4** (see 6.1).

Vertical angle: α = 50°

Longitudinal angle: β_x = 20°

Question: What is the necessary lashing capacity LC of each of the four lashing devices?

Acceleration coefficients according to 4.3, Table 3 for rail transport:

Acceleration coefficient in longitudinal direction

c_x **= 1,0**

Acceleration coefficient in vertical direction

c_z **= 1,0**

Calculation according to 5.5.3, Equation (22):

$$LC \geq \frac{(c_{x,y} - f_\mu \times \mu \times c_z)\, m \times g}{2\,(\cos\alpha \times \cos\beta_{x,y} + f_\mu \times \mu \ \times \sin\alpha)}$$

Longitudinally:

$$LC \geq \frac{(1{,}0 - 0{,}75 \times 0{,}4 \times 1{,}0)\; 2\,000 \times 9{,}81}{2\,(\cos 50° \times \cos 20° + 0{,}75 \times 0{,}4 \times \sin 50°)}$$

$LC \geq 8\,230$ N = 823 daN

Answer: The minimum necessary lashing capacity for each of four lashing devices is LC = 823 daN each.

Example A.3: Units stowed in two layers – upper layer incomplete to prevent sliding sideways and rearwards in curtainsider with sidewalls not designed for load securing – road transport

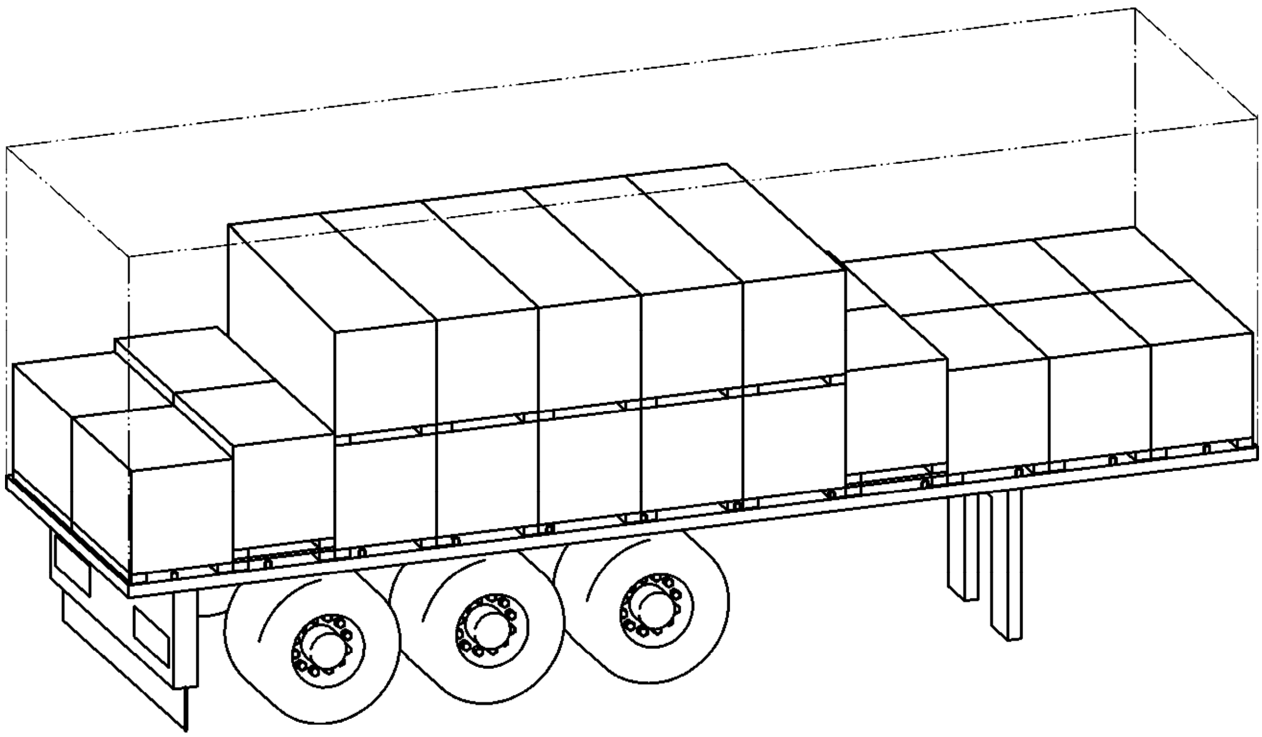


Figure A.3 — 32 units loaded on semi-trailer in two layers

32 units are loaded on semi-trailer in two layers, upper layer incomplete.

Load: 32 box units with unit weight 750 kg.

	Dimensions: height = 1,1 m, width = 1,2 m, length = 1,2 m, centre of gravity in geometrical centre, b = 1,1
Mass:	m = 24 000 kg
Friction:	between units and the platform: μ_1 = 0,4; between layers: μ_2 = 0,3
Securing method:	The bottom layer is blocked forward. The upper layer is blocked forward and rearward. Securing sideways by over top lashing: S_{TF} = 400 daN, LC = 2 000 daN to prevent sliding sideways and rearwards.
Question 1:	**Is the section with units in two layers stable sideways for road transport?**
Question 2:	**How many over top lashing devices are required to prevent sliding sideways and rearwards for road transport in a curtainsider with sidewalls not designed for load securing?**

Transverse stability of double stacked section

According to 5.2, Equation (3) for stable load holds:

$$b_{x,y} > \frac{c_{x,y}}{c_z} \times d$$

Transverse stability of unlashed loads for road transport:

$$\frac{b_y}{d} > \frac{c_y}{c_z}$$

$$\frac{0,6}{1,1} > \frac{0,5}{1,0}$$

$$0,545 > 0,5$$

Answer 1: **Section with units in two layers is stable sideways for road transport.**

Over top lashing to prevent sliding sideways and rearwards

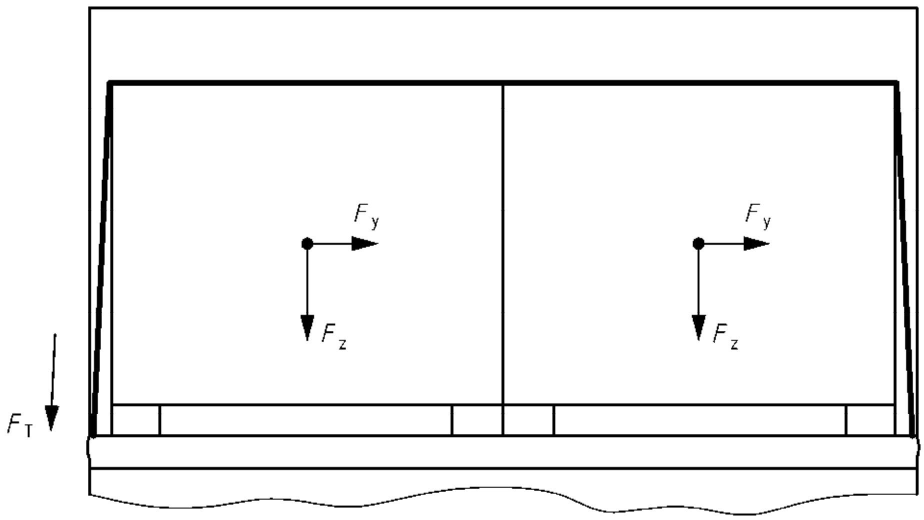


Figure A.4 — Over top lashing to prevent sliding of bottom units sideways and rearwards

Number of over top lashing devices according to 5.4.2, Equation (10):

$$n \geq \frac{\left(c_{x,z} - \mu \times c_z\right) \times m \times g}{2 \times \mu \times \sin \alpha \times F_T} \times f_s$$

for road transport in sideways and rearwards direction

$$n \geq \frac{(0{,}5 - 0{,}4 \times 1{,}0) \times 1\,500 \times 9{,}81}{2 \times 0{,}4 \times \sin 90° \times 4\,000} \times 1{,}1 = 0{,}5$$

One lashing device per section will be sufficient or two lashing devices per three sections when using long supporting edge beams.

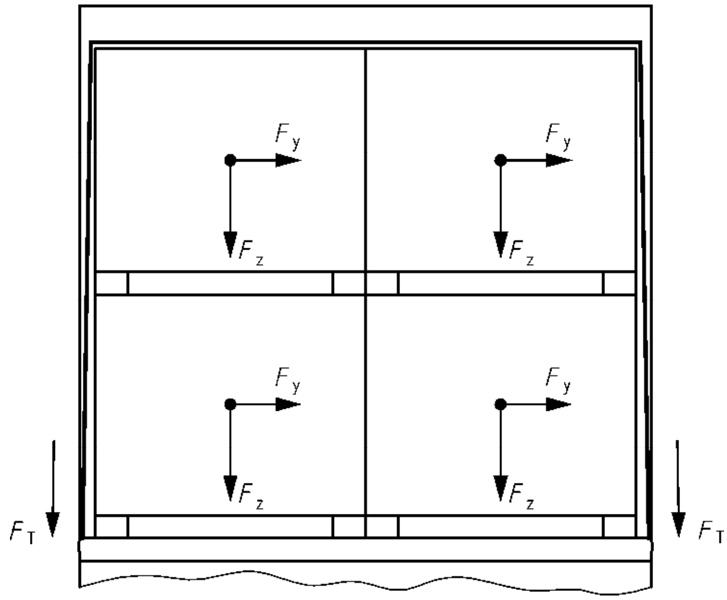


Figure A.5 — Over top lashing of load in two layers to prevent sliding sideways and rearwards

Calculation of over top lashing of the whole section and calculation of over top lashing for upper layer needs to be compared. The maximum number of lashing devices required of these cases is to be used.

Number of lashing devices to prevent upper layer from sliding sideways is as follows:

$$n \geq \frac{(0{,}5 - 0{,}3 \times 1{,}0) \times 1\,500 \times 9{,}81}{2 \times 0{,}3 \times \sin 90° \times 4\,000} \times 1{,}1 = 1{,}3$$

Two lashing devices per section will be required.

Number of lashing devices to prevent two layers from sliding is as follows:

$$n \geq \frac{(0{,}5 - 0{,}4 \times 1{,}0) \times 3\,000 \times 9{,}81}{2 \times 0{,}4 \times \sin 90° \times 4\,000} \times 1{,}1 = 1{,}0$$

One lashing device per section will be sufficient.

When using long supporting edge beams the number of lashing devices required to prevent five sections in two layers of load from sliding is as follows:

for upper layer

$$n \geq \frac{(0,5 - 0,3 \times 1,0) \times 7\ 500 \times 9,81}{2 \times 0,3 \times \sin 90° \times 4\ 000} \times 1,1 = 6,7$$

for two layers

$$n \geq \frac{(0,5 - 0,4 \times 1,0) \times 15\ 000 \times 9,81}{2 \times 0,4 \times \sin 90° \times 4\ 000} \times 1,1 = 5,1$$

Seven lashing devices per five sections are required.

Answer 2: **To prevent sliding sideways and rearwards 16 over top lashing devices are required. In case of use of long supporting edge beams twelve lashing devices are required. The vehicle superstructure is a curtainsider with sidewalls not designed for load securing.**

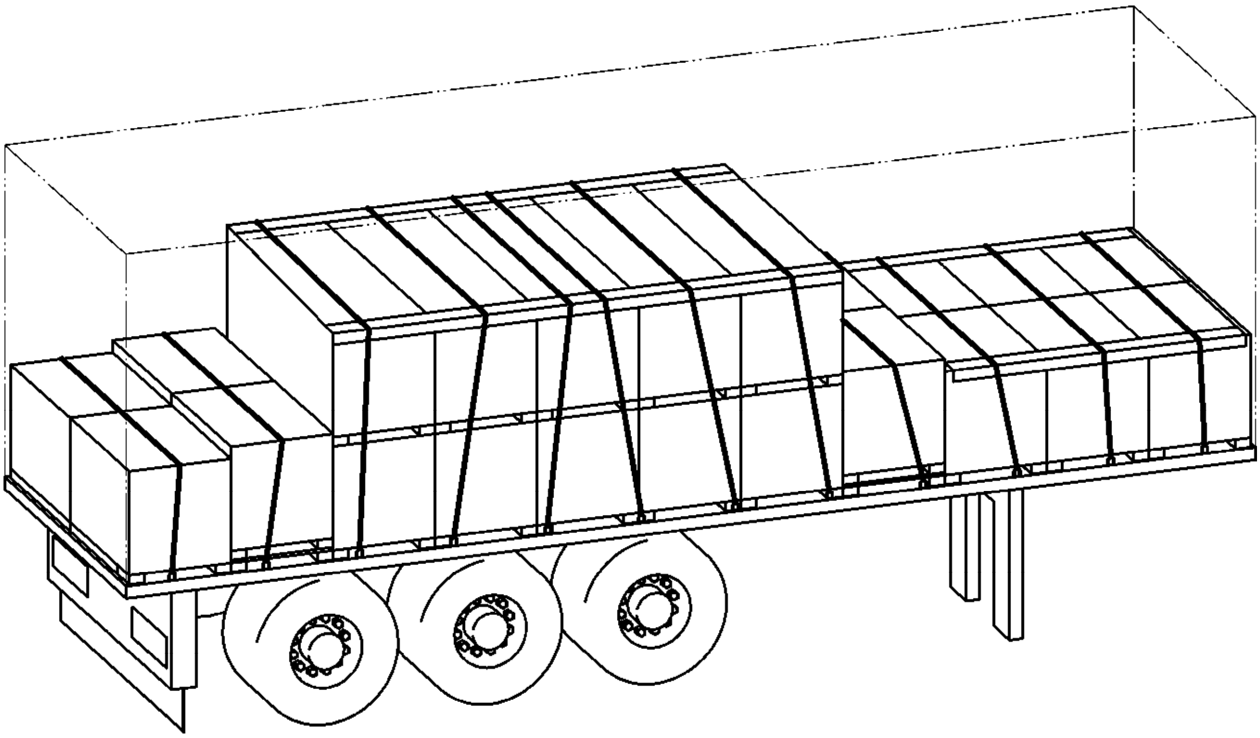


Figure A.6 — Over top lashing of load in two layers to prevent sliding sideways and rearwards in curtainsider with sidewalls not designed for load securing and use of long supporting edge beams

Annex B
(normative)

Friction

B.1 Practical methods for the determination of the friction factor μ

B.1.1 General

To determine the friction factor μ, in B.1.2 and B.1.3 two alternative methods are given.

B.1.2 Inclination test

The friction factor μ states, how lightly a cargo will slide if the loads platform is tilted. A method to find μ is to incline a load platform carrying the cargo in question and measure the angle at which the cargo starts to slide. This gives the friction factor $\mu = 0{,}925 \times \tan \alpha$. Five tests have to be done under practical and realistical conditions, the largest and the lowest result shall be cancelled. The medium of the three counting results is the friction to be used.

In the report it has to be included whether the result is valid for dry and/or wet conditions.

Great care should be taken by using e.g. blocking devices in a short distance to the load to prevent the cargo from falling off the platform during the test.

B.1.3 Pulling test

The test rig consists of the following components:

— horizontal floor with a surface representing the loads platform;

— test device for tensile tests;

— connecting device between the test equipment and the bottom of the loading unit;

— PC-based evaluation system.

The tensile device shall meet EN ISO 7500-1.

The test conditions have to correspond with real ones; the contact surfaces have to be "swept clean" and free from impurities. If tests are carried out in laboratories they should be executed as standard in an atmospheric condition 5 in accordance with EN ISO 2233:2001 at a temperature of + 20 °C and 65 % relative humidity.

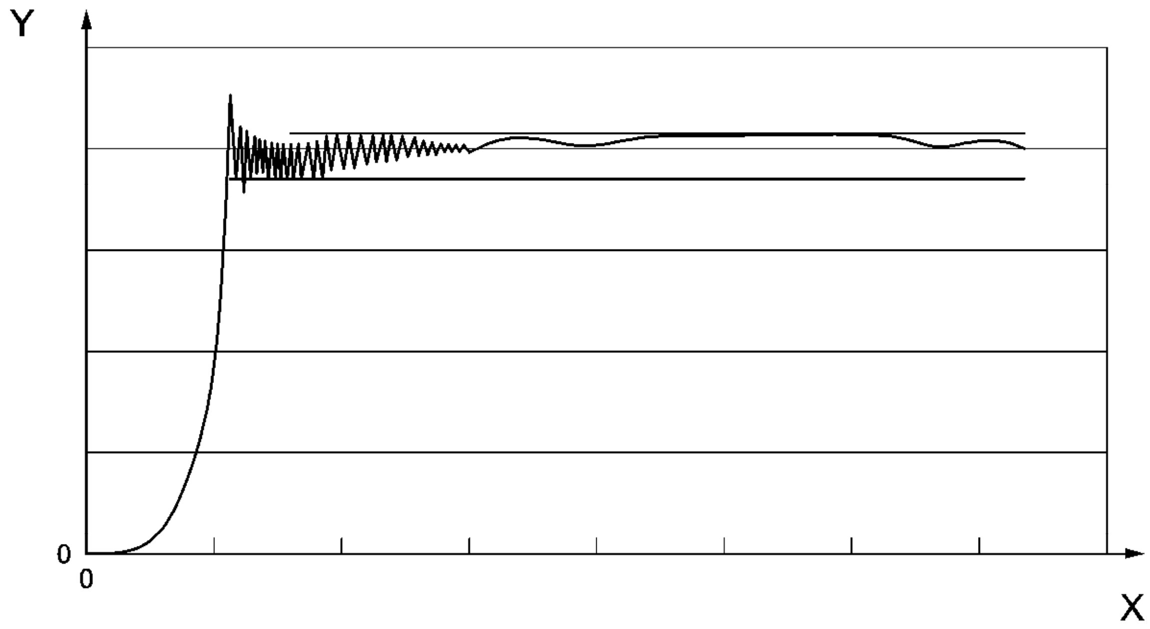
The test speed should be 100 mm/min.

The sampling rate shall be at least 50 Hz.

A measurement of pulling force and way of displacement is made with the same test object in one arrangement with a respective glide path of 50 mm to 85 mm for each stroke. At least three individual strokes have to be carried out with an intermediate unloading of at least 30 % of the pulling force per measurement,

A measurement series consists of three measurements for each of the three strokes.

The test piece and/or anti-slip material has to be repositioned for each measurement, so that any influence of material wear on the result of the measurement can be excluded.



Key

X way of displacement
Y pulling force

Figure B.1 — Determination of the minimum and maximum pulling force of a measurement

The friction factor μ has to be determined according to Equation (B.1) taking into account the three medium values of each of the three measurements.

$$\mu = (\text{pulling force} \times 0{,}95) / (\text{weight} \times 0{,}925) \quad \text{(B.1)}$$

For a most realistic determination of frictional forces and coefficients of friction multiple measurement series should be executed, each with different test samples for loading area, anti-slip mat and load bearer or load.

B.2 Friction factors μ of some usual goods and surfaces

For the use in the equations of this European Standard some often used friction factors μ are given in respect of the safety factor f_S for frictional lashing, the conversion factor for direct lashing f_μ and the factor 0,925 given in 6.1 as calculation basis.

Table B.1 — Friction factors μ of some usual goods and surfaces to be used in calculations

Combination of materials in the contact surface [a]	Friction factor μ
Sawn wood	
Sawn wood – fabric base laminate/plywood	0,45
Sawn wood – grooved aluminium	0,4
Sawn wood – shrink film	0,3
Sawn wood – stainless steel sheet	0,3
Plane wood	
Plane wood – fabric base laminate/plywood	0,3
Plane wood – grooved aluminium	0,25
Plane wood – stainless steel sheet	0,2
Plastic pallet	
Plastic pallet – fabric base laminate/plywood	0,2
Plastic pallet – grooved aluminium	0,15
Plastic pallet – stainless steel sheet	0,15
Steel and metal	
Steel crate – fabric base laminate/plywood	0,45
Steel crate – grooved aluminium	0,3
Steel crate – stainless steel sheet	0,2
Concrete	
Concrete rough – sawn wood battens	0,7
Concrete smooth – sawn wood battens	0,55
anti-slip mat	
Rubber	0,6 [b]
Other material	as certified [c]

[a] Surface, dry or wet but clean, free from oil, ice, grease.

[b] May be used with f_{μ} = 1,0 for direct lashing.

[c] When special materials for increased friction like skid-inhibiting mats are applied, a certificate for the friction factor μ is required.

It has to be ensured that the used friction factors are applicable to the actual transport. If the surface contacts are not swept clean, free from frost, ice and snow a friction factor larger than μ = 0,2 (for sea transport μ = 0,3) shall not be used. Special precautions should be taken for oily and greasy surfaces.

Annex C
(informative)

Load securing protocol

If a securing protocol is needed, the example given in Table C.1 may be used.

Table C.1 — Example for a load securing protocol (no copyright)

Those responsible for the securing of load into a unit e.g. vehicle, trailer, semi-trailer, container, flat, swap-body or other should provide this protocol. Document No.:	This load securing protocol is valid for: Cross Y or N for each option Y – YES, N – NO
Company (Name, Address, Country) Responsible person:	

				
☒ Y Road	☐ Y ☐ N Road and Sea - A	☐ Y ☐ N Road and Sea - B	☐ Y ☐ N Road and Sea - C	☐ Y ☐ N Road and Rail

Load carried

Proper shipping name:	Place of loading: Date of loading:	Shipping documents No.:	
Weight of the load:	Identified from:	No. of packages:	Instructions for load securing used:

Cargo Transport Unit

Unit identification no.:	**Type of unit:**	**Certified CTU:**	**Front wall**	**Side walls**	**Rear wall**
	☐ Lorry ☐ Trailer ☐ Semi-trailer ☐ Swap-body ☐ Container/Flat ☐ Other…………	☐ EN 12642 – L ☐ EN 12642 – XL ☐ EN 283 ☐ Other……………. ☐ NO	☐ YES ☐ NO	☐ Box - type body ☐ Sideboards ☐ Sideboards & cover/stake ☐ Curtainsider ☐ Other………………………. ☐ NO	☐ Box - type body ☐ Sideboards ☐ Sideboards & cover/stake ☐ Other………………………. ☐ NO

Blocking equipment used

☐ Front stanchions	……….pcs	☐ Coil well/wedges	……….pcs	☐ Blocking tracks	……..pcs
☐ Side stanchions	……….pcs	☐ Coil well stanchions	……….pcs	☐ Shoring poles	……..pcs
☐ Rear stanchions	……….pcs	☐ Blocking walls	……….pcs	☐ Other ………….................	……..pcs

Lashing equipment used

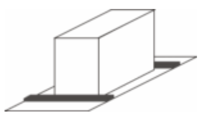
				☐ Lashing points	……..pcs
☐ Web lashings	……….pcs	LC = ……….............daN	S_{TF} = ………………daN	☐ Lashing tracks	……..pcs
☐ Lashing chains	……….pcs	LC = ……….............daN	S_{TF} = ………………daN	☐ Lashing winches	……..pcs
☐ Other..........................	……….pcs	LC = ……….............daN	S_{TF} = ………………daN	☐ Other……………………….	……..pcs

Friction and corner protection

Resultant friction factor (see table on the back side) μ = ………………………………….. Skid-inhibiting mats in use? ☐ YES ☐ NO	Do sharp edges affect the safety adversely? ☐ YES ☐ NO Edge protectors in use? ☐ YES ☐ NO

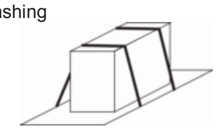
Securing method

☐ Blocking



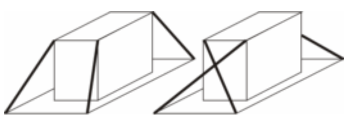
Forwards
☐ FULLY ☐ PARTLY ☐ NO
Sideways
☐ FULLY ☐ PARTLY ☐ NO
Rearwards
☐ FULLY ☐ PARTLY ☐ NO

☐ Over top lashing



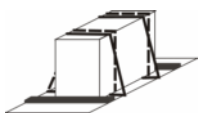
Number of lashings:.............

☐ Slope & diagonal lashing (straight / cross)



Number of lashings: ....

☐ Loop lashing



Number of pairs of lashing: ....

☐ Spring lashing
1 lashing **2 lashings**

Number of lashings: ....

I herewith certify that the load has been secured in accordance with EN 12195-1.

Date: Signature:

Annex D
(normative)

Practical tests for determination of the efficiency of cargo securing arrangements

D.1 Dynamic driving test

The efficiency of a securing arrangement can be tested by a dynamic driving test carried out according to the instructions EN 12642:2006, B.4 and B.5.

D.2 Inclination test

D.2.1 Description of test

The efficiency of a securing arrangement can be tested by a practical inclining test according to the following description.

The cargo (alternatively one section of the cargo) is placed on a lorry platform or similar and secured in the way intended to be tested.

To obtain the same loads in the securing arrangement in the inclining test as in the calculations according to Clause 5, the securing arrangement is to be tested by gradually increasing the inclination of the platform to the required test angle φ as shown in the diagram below.

The theories behind the calculation of the required test angle φ are given in D.2.3.

The test angle φ to be used in the test is a function of the horizontal acceleration coefficient c_x and c_y for the intended direction (forward, sideways or backward) and the vertical acceleration coefficient c_z.

a) To test the efficiency of the securing arrangement in the **lateral direction**, the greatest of the following test angles shall be used:

   1) the angle determined by the friction factor μ (for the sliding effect, for blocking or frictional lashing arrangements);

   2) the angle determined by the factor $\mu \times f_\mu$ (for the sliding effect for direct lashing arrangements);

   3) the angle determined by the ratio of $\frac{B}{N \times H}$ (for the tilting effect of cargo unit or section with the centre of gravity close to its geometrical centre); or

   4) the angle determined by the ratio of $\frac{b_{sideways}}{d}$ (for the tilting effect of a cargo with the centre of gravity away from its geometrical centre).

b) To test the efficiency of the securing arrangement in the **longitudinal direction**, the greatest of following test angles φ shall be used:

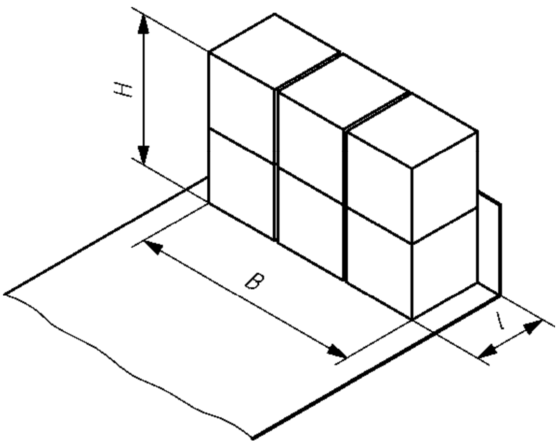
   1) the angle determined by the friction factor μ or the factor $\mu \times f_\mu$ (for the sliding effect); or

2) the angle determined by the ratio of $\frac{l}{H}$ (for the tilting effect of cargo unit or section with the centre of gravity close to its geometrical centre); or

3) the angle determined by the ratio of $\frac{b_{forward,backward}}{h}$ (for the tilting effect of a cargo with the centre of gravity away from its geometrical centre).

If over-stowed, the lowest coefficient of friction between the cargo and the platform or between the cargo units shall be used.

The definitions of H, B, l, N, b and d are according to Figures D.1 and D.2.



NOTE l is always the length of one section also when several sections are placed behind each other.

Figure D.1 — Cargo unit or section with the centre of gravity close to its geometrical centre (*l*/2, B/2, H/2)

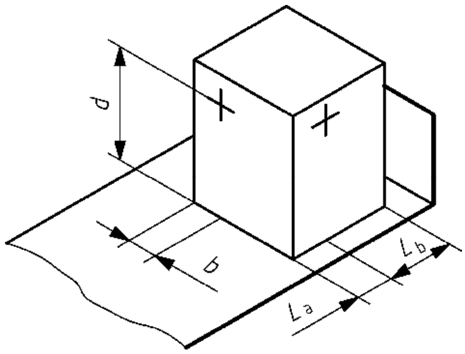


Figure D.2 — Cargo unit with the centre of gravity away from its geometrical centre

The required test angle φ shall be taken from Figure D.3 as a function of:

— c_x or c_y (0,8 g, 0,7 g, 0,6 g or 0,5 g);

and the minimum of (as applicable):

— μ;

— $\mu \times f_\mu$;

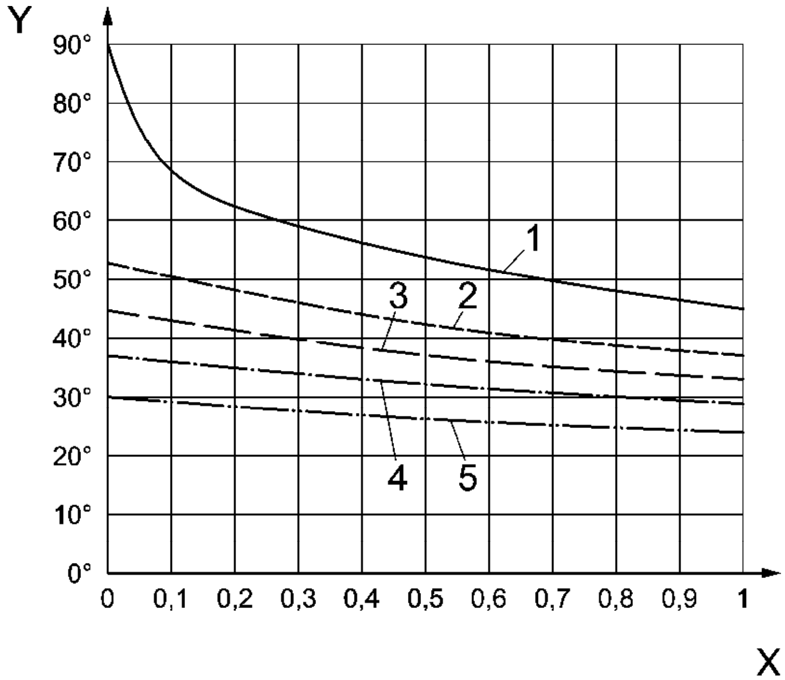
— $\frac{B}{N \times H}$;

— $\frac{b_{sideways}}{h}$;

— $\frac{l}{H}$; or

— $\frac{b_{forward,backward}}{h}$

hereafter named γ.



Key
Y test angle
X γ-factor
1 $c_x = 1{,}0$
2 $c_{x,y} = 0{,}8$
3 $c_y = 0{,}7$
4 $c_y = 0{,}6$
5 $c_{x,y} = 0{,}5$

Figure D.3 — Test angle φ

D.2.2 Example

Question: **To which test angle shall a frictional lashing system for non-rigid goods be tested in transverse direction if μ is 0,45 and $\frac{B}{N \times H}$ is 0,3, and if the arrangement should be used for North Sea transport ($c_y = 0{,}7$)?**

Answer: **The angle according to the diagram above at $c_y = 0{,}7$ and $\mu = 0{,}45$ is 37°. The angle according to the diagram above at $c_y = 0{,}7$ and $\frac{B}{N \times H} = 0{,}3$ is 39°. The largest angle is 39° and the arrangement shall thus be tested up to this angle as a minimum.**

The securing arrangement is regarded as complying with the requirements if the cargo is kept in position with limited movements when inclined to the prescribed test angle φ.

The test method will subject the securing arrangement to stresses and great care should be taken to prevent the cargo from falling off the platform during the test. If large masses are tested the entire platform should be prevented from tipping as well.

D.2.3 Theoretical background

D.2.3.1 Introduction

Below equations are set up for the required static test angle to obtain the same forces in securing arrangements as in calculations according to Clause 5.

D.2.3.2 Sloped lashing device – Sliding

Required static inclination angle in longitudinal direction as a function of $\mu \times f_\mu$, c_x and c_z to achieve the same force F_R in a sloped lashing arrangement as when calculated according to 5.5.2.

According to Equation (19) in 5.2.2 the required F_R is:

$$F_R = m \times g \frac{(c_{x,y} - \mu \times f_\mu \times c_z)}{2\,(\cos\alpha + \mu \times f_\mu \times \sin\alpha)} \text{ (N)} \qquad \text{(D.1)}$$

In an inclined situation the required horizontal restraining force F_R in the lashing device is calculated according to the following figure and equation:

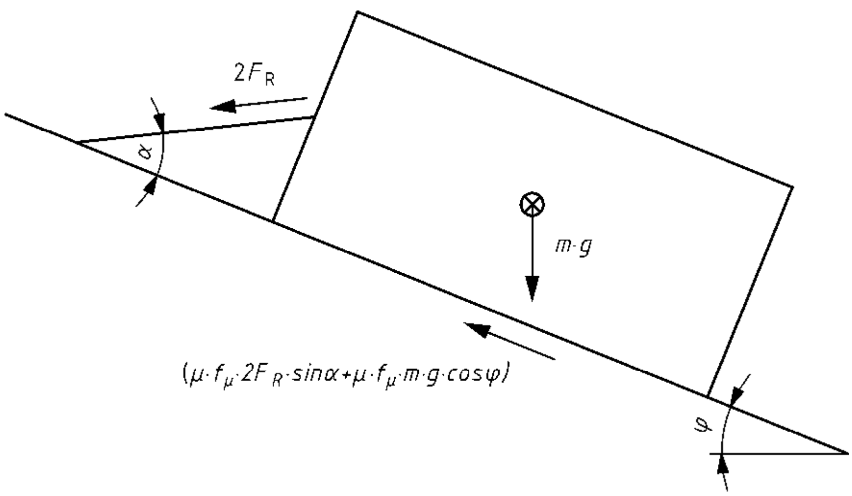


Figure D.4 — Test principle

$$2F_R \times \cos\alpha + \left(\mu \times f_\mu \times 2F_R \times \sin\alpha + \mu \times f_\mu \times m \times g \times \cos\varphi\right) = m \times g \times \sin\varphi$$

$$F_R = \frac{m \times g \times \left(\sin\varphi - \mu \times f_\mu \times \cos\varphi\right)}{2 \times \left(\cos\alpha + \mu \times f_\mu \times \sin\alpha\right)} \text{ (N)} \qquad \text{(D.2)}$$

By putting F_R in Equations (D.1) and (D.2) equal, the following equation is obtained:

$$m \times g \times \left(c_x - \mu \times f_\mu \times c_z\right) = m \times g \times \left(\sin\varphi - \mu \times f_\mu \times \cos\varphi\right) \iff \sin\varphi - \mu \times f_\mu \times \cos\varphi = c_x - \mu \times f_\mu \times c_z) \qquad \text{(D.3)}$$

D.2.3.3 Solution of equations

With $\gamma = \mu \times f_\mu$ from Equation (D.3), Equation (D.4) is obtained:

$$\sin\varphi - \gamma \times \cos\varphi = c_{x,y} - \gamma \times c_z \qquad \text{(D.4)}$$

This same basic equation will be obtained for any type of lashing or blocking arrangement with γ representing μ, $\frac{B}{N \times H}$, $\frac{b_{sideways}}{h}$, $\frac{l}{H}$ or $\frac{b_{forward,backward}}{h}$. The most simple way is to solve γ in this equation as a function of c_x, c_y, c_z and φ:

$$\gamma = \frac{c_{x,y} - \sin\varphi}{c_z - \cos\varphi} \tag{D.5}$$

In the table below the required test angle φ is calculated for different γ-factors at the longitudinal and transverse acceleration factors = 1,0, 0,8, 0,7, 0,6 and 0,5 and the vertical acceleration factor c_z = 1,0. From the table the test angle φ can be plotted as a function of the γ-factor.

Table D.1 — Test angle

$c_{x,y}$ / γ-factor	1,0	0,8	0,7	0,6	0,5
	Required test angle φ [°]				
0,00	90,0	53,1	44,4	36,9	30,0
0,05	74,5	51,4	43,3	36,2	29,6
0,10	69,3	49,9	42,4	35,5	29,2
0,15	65,7	48,5	41,5	35,0	28,8
0,20	63,0	47,3	40,7	34,4	28,4
0,25	60,7	46,3	39,9	33,9	28,1
0,30	58,8	45,3	39,2	33,4	27,7
0,35	57,1	44,4	38,6	32,9	27,4
0,40	55,7	43,6	38,0	32,5	27,1
0,45	54,3	42,8	37,4	32,1	26,8
0,50	53,1	42,1	36,9	31,7	26,6
0,55	52,0	41,5	36,4	31,3	26,3
0,60	51,0	40,8	35,9	31,0	26,0
0,65	50,1	40,2	35,4	30,6	25,8
0,70	49,2	39,7	35,0	30,3	25,6
0,75	48,4	39,2	34,6	30,0	25,3
0,80	47,6	38,7	34,2	29,7	25,1
0,85	46,9	38,2	33,8	29,4	24,9
0,90	46,2	37,7	33,4	29,1	24,7
0,95	45,6	37,3	33,1	28,8	24,5
1,00	45,0	36,9	32,8	28,6	24,3

Annex E
(informative)

Documentation of practical tests

When practical tests are performed, the basic conditions and the test results should be documented according to the instructions below.

The documentation should as a minimum include the following information:

- place and date of the practical tests;
- responsible organization and person;
- purpose of the tests;
- list of persons attending the tests;
- test conditions; weather and temperature;
- used test method; static or dynamic;
- used test equipment; type of lashing devices, battens, inclination equipment, etc.;
- tested level for the cargo securing arrangement; road, rail, Sea area A, Sea area B and/or Sea area C;
- description of the tested cargo including a specification of the cargo and the packaging as well as weights, dimensions, coefficient of friction, etc.;
- description of the load pattern and securing arrangement of the tested cargo;
- results of the tests;
- conclusions regarding required securing arrangement to prevent sliding and tipping forward, backward and sideways for different combinations of loading configurations, modes of transport as well as type of cargo transport unit (box or open type of vehicle, container, etc.);
- photos from the tests.

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