Cargoes can be secured using a combination of lashing grommet, chain, turnbuckle and shackles.

The basic laws of securing the load

Knowing Newton's three laws of motion will help you understand the forces acting on cargo in transit, advises safety expert Richard Krabbendam.

There are costs involved in securing a load, both in terms of equipment and additional time. However, against this must be set the costs of the potential consequences of load shift, such as product damage, vehicle damage, delays, death or injury, and prosecution in the event of an accident.

To understand how to safely lash and secure cargo to withstand the forces of motion on a vehicle like a trailer, railcar or ship, we should start with the basics. Newton's three laws of motion form the basics of all forces acting on cargo when it is moving. When we understand these principles, the rest will be relatively simple.

1. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
2. The relationship between an object's mass (m), its acceleration (a), and the applied force (F) is F = ma. Acceleration and force are vectors; in this law the direction of the force vector is the same as the direction of the acceleration vector. As an example, in Figure 1 (see p106), if resultant force Fr is pointing over the two black supporting points, the briefcase will tip. If we turn the briefcase through 90°, thereby increasing the base support points, the resultant force will remain within the support points and the briefcase will not tip.
3. For every action there is an equal and opposite reaction.

In order to calculate the acceleration and deceleration of our transport vehicle, we need to know what order of magnitude the accelerations and decelerations are in all three directions (and we term these X, Y and Z directions).

The forces acting on the cargo depend on the acceleration/deceleration of the vehicle. Since we as users do not know the accelerations and decelerations of our vehicles, some guidelines have been drawn up, primarily based on the EN 12195-1:2010 standard but they also include examples of safe practices from throughout the entire road transport sector.

To safely secure cargo on trailers for road transport, the EN 12195 norm is based on a maximum forward deceleration equal to 0.8 g = 0.8 * 9.81 = 7.85 m/s², backwards of 0.5 g = 4.90 m/s2 and a side force in either direction of 0.5g = 4.90 m/s², as shown in Figure 2.

On the road

For road transport, you just need to calculate the forces on the cargo with Newton's Second Law which shows that if the cargo weighs 100 tonnes, the forces in X, Y direction are: F=m*a = 100,000 * 7.85 = 785,000 Newton = 785,000/9.81 = 80,020 kg (80 tonnes).

Depending on the angle under which the lashings are applied, we can calculate the force S and establish the correct number of lashings. See Figure 3 overleaf:

In Figure 3, when we use lashings which have an Maximum Securing Load (MSL) of 10 tonnes, we need a minimum of 9.24

Figure 1: The briefcase tipping point

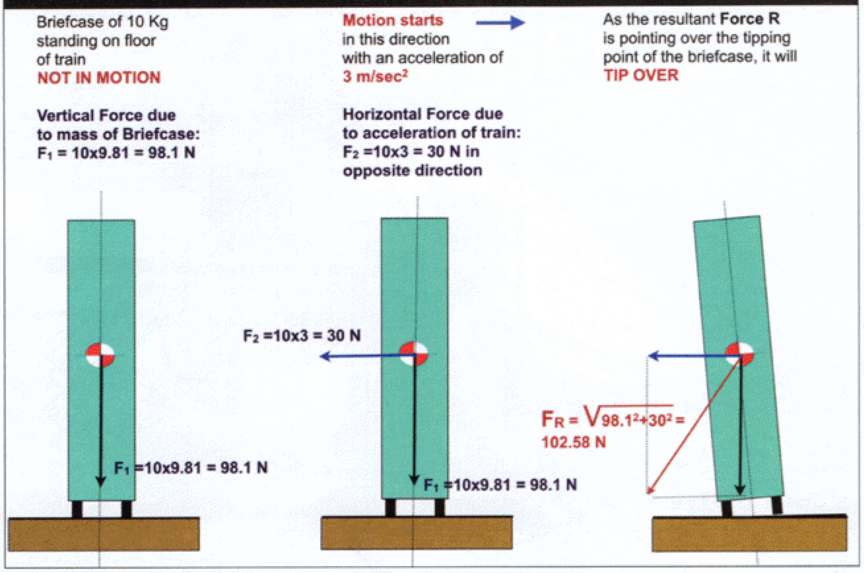


Figure 2: Safely securing cargo on trailers for road transport

1) 0,8 g deceleration in the forward direction;
2) 0,5 g acceleration in the rearward direction and
3) 0,5 g acceleration in the lateral direction.

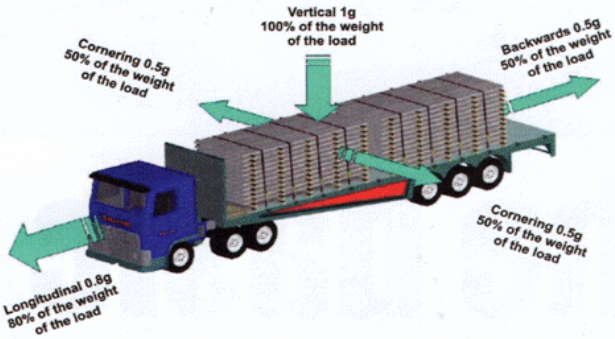
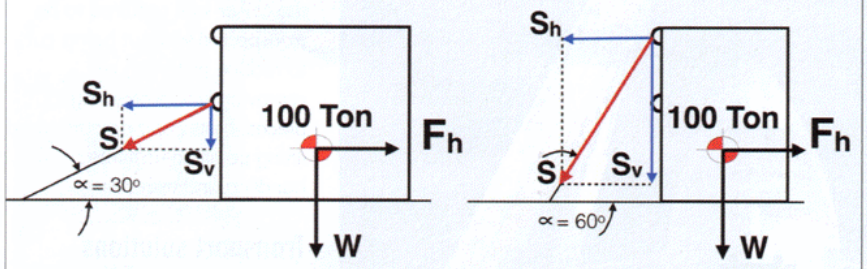


Figure 3: Calculating the correct number of lashings



S = Fh / (cos á x n) (in which n = number of lashings)
Number of required 10 tonne SWL lashings: n = Fh / (cos x 10tSWL)
n = 80 tonnes / (cos 30 x 10t) = 9.24 (so we need 10 lashings of 10 tonnes)

lashings, which is rounded up to 10 lashings.

The same basic principles apply for cargo on board heavy lift vessels, barges or other floating objects. When we want to calculate the lashing forces, we again need to know the accelerations and decelerations of the cargo on board the vessel.

Figure 4: ensuring that cargo is secured firmly in place during transit is an essential part of the loading process.

As this greatly depends on the stability of the vessel and the sea state it is sailing in, the DNV Cargo Securing Model Manual has drawn up some guidelines that can help calculate the forces on cargo. Depending on the vessel operator, the accelerations can be established using shipowners' own rules: rules defined by the classification societies and custom-made computer analysis.

Methods

Restraining methods are principally locking, blocking, direct lashing, top-over lashing and combinations of methods in conjunction with friction.

The restraining method(s) used should be able to withstand the varying climatic conditions (temperature, humidity and so on) likely to be encountered during the journey. Cargoes can be secured using a combination of lashing grommet, chain, turnbuckle and shackles. See lead picture at the start of this article and Figure 4.

Also, cargo can be locked-in using so-called stoppers, which are welded to the deck of the vessel and stop the cargo from moving in a horizontal direction.

Remember, always place friction material (plywood, rubber mats or anti-friction mats) between the cargo and the steel deck and never place steel on steel surfaces, as the friction between steel and steel is approximately one third of that between wood and steel.

Risk assessment and a loading plan prepared by someone competent are the keys to good load security. This does not have to be an onerous process but 'thinking through' the operation in advance may identify potential issues before they become a problem.

HLPFI

Please note, this article is intended for guidance only. While every care has been taken to ensure the accuracy of the contents, no responsibility will be accepted by the publishers for any errors.

Richard Krabbendam was a heavy lift specialist during his whole working career, after which he formed Krabbendam Advisory Service. A Master of Mechanical Engineering from Delft University of Technology, he has worked with BigLift and Mammoet, and was a co-founder of ITREC. He helped to set up Jumbo Offshore and was involved in the development of its super heavy lift carrier fleet, the J-Class, which uses two 900-tonne mast cranes for subsea installation works. Since his retirement from Jumbo he has been working as a freelance trainer/engineering consultant.

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