Proper packing of CTUs - key to safe shipping

IUMI Webinar

20. April 2021

Capt. Uwe-Peter Schieder

Vice Chair of IUMI´s Loss Prevention Committee

GDV
DIE DEUTSCHEN VERSICHERER

What are we talking about?

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Agenda

1. Quick Guide
2. CTU-Code
3. Incidents
4. Practical Use

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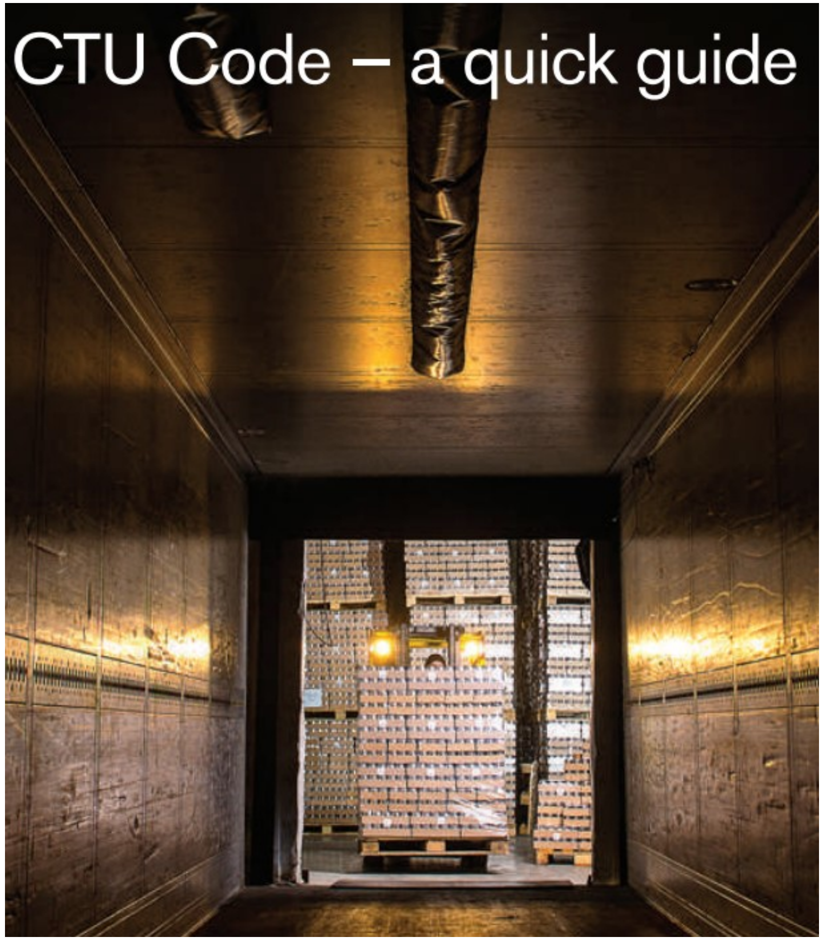
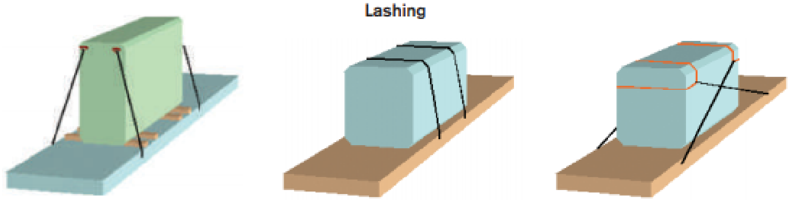


Lashing

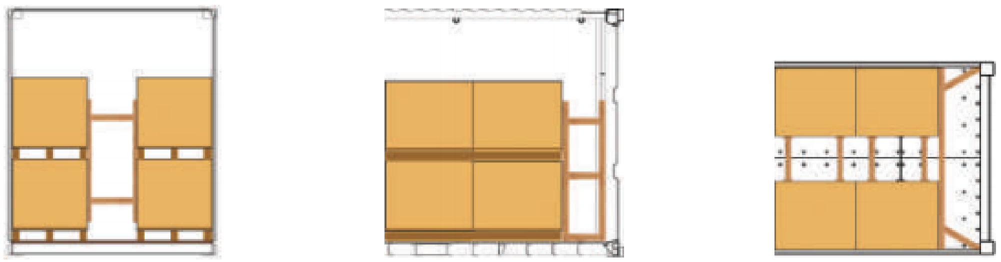


10.0 Securing
(for container packing see Checklist questions 24-26)

10.1 Packing planning should aim at producing either a **tight stow** (where all cargo packages are placed tightly within the boundaries of the side and front walls of the CTU) or a **secured stow** (where packages do not fill the entire space and will therefore be secured within the boundaries of the CTU by blocking, bracing, shoring and/or lashing). See in the Code Annex 7 section 1 *Planning of Packing.*

CTU Code Annex 7

Bracing



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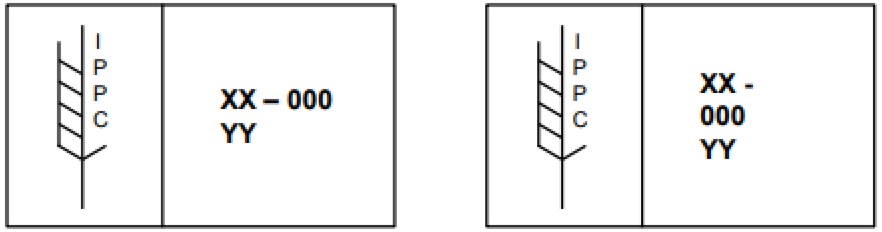


Figure 7.1 Phytosanitary mark

Figure 7.2 Timber temporary floor

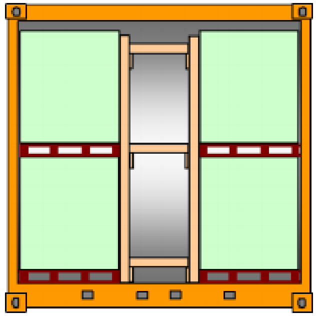


Figure 7.3 Centre gap with transverse bracing

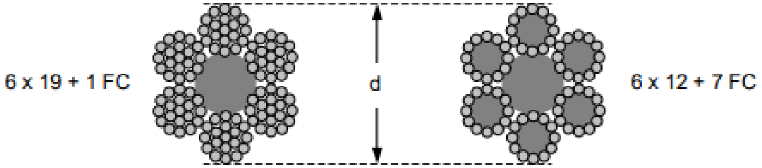


Figure 7.13 Typical lashing wire rope construction

	Compressive strength normal to the grain	Compressive strength parallel to the grain	Bending strength
Low quality	0.3 kN/cm²	2.0 kN/cm²	2.4 kN/cm²
Medium quality	0.5 kN/cm²	2.0 kN/cm²	3.0 kN/cm²

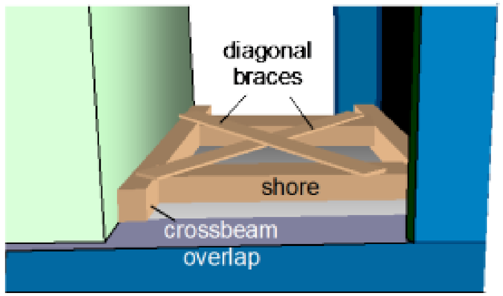


Figure 7.4 Shoring arrangement showing cross beam overlap and diagonal braces

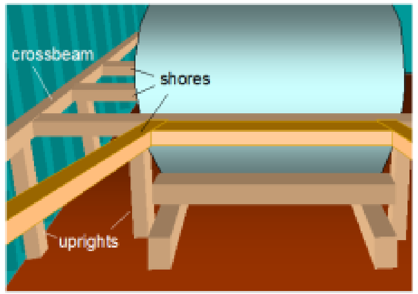


Figure 7.5 Shoring arrangement with uprights and crossbeam

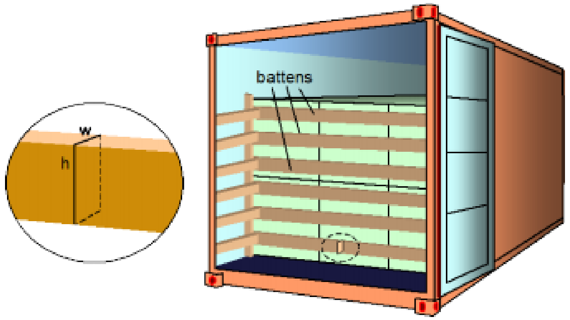


Figure 7.6 General layout of fence battens for door protection in a CTU

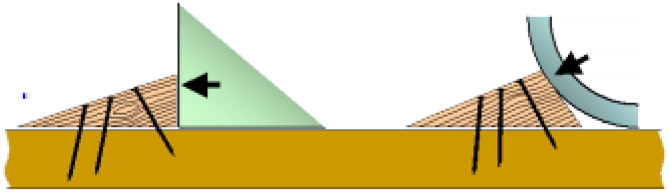


Figure 7.7 Properly cut and nailed wedges

Figure 7.8 Cargo firmly secured to pallets by textile lashings

Figure 7.9 Gap filled with a central dunnage bag

Figure 7.10 Irregular shaped packages blocked with dunnage bags

Material	MSL
shackles, rings, deck eyes, turnbuckles of mild steel	50% of breaking strength
fibre ropes	33% of breaking strength
web lashings (single use)	75% of breaking strength[1]
web lashings (reusable)	50% of breaking strength
wire ropes (single use)	80% of breaking strength
wire ropes (reusable)	30% of breaking strength
steel band (single use)	70% of breaking strength[2]
chains	50% of breaking strength

[1] Maximum allowed elongation 9% at MSL.

[2] It is recommended to use 50%.

Figure 7.11 Poor edge protection

Figure 7.12 Edge protectors

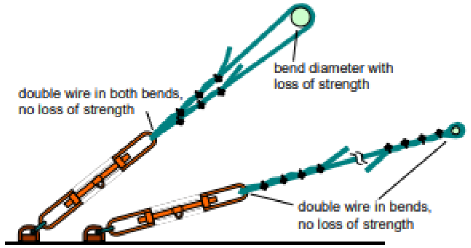


Figure 7.14 Recommended assemblies for wire rope lashing

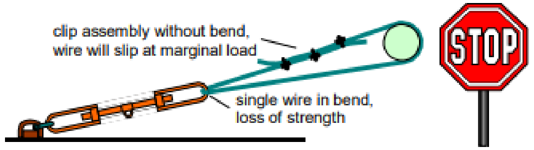


Figure 7.15 Improper assembly for wire rope lashing

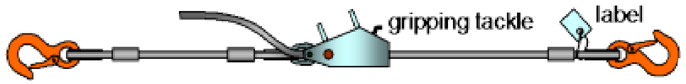


Figure 7.16 Standard wire lashing used in road transport with gripping tackle

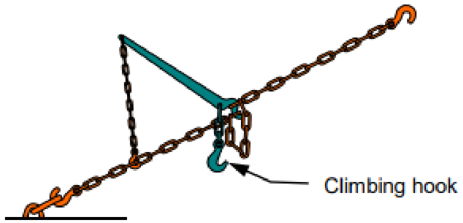


Figure 7.17 Long link lashing chain with lever tensioner

Figure 7.19 Metal ingots unitized by steel banding (securing not completed)

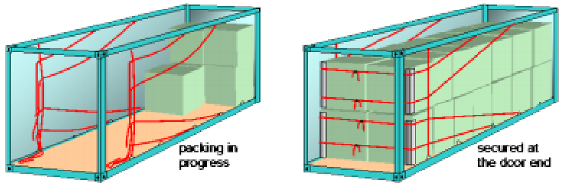


Figure 7.20 Modular lashing system

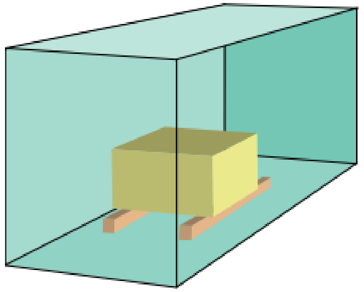


Figure 7.21 Load transfer beams

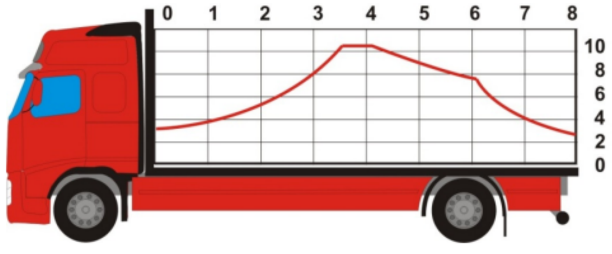


Figure 7.22 An example of a load distribution diagram for a rigid truck

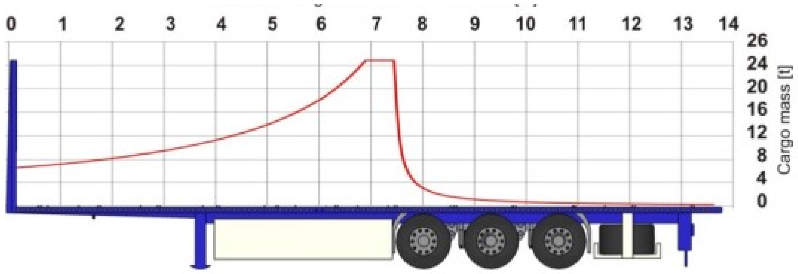


Figure 7.23 An example of a load distribution diagram for a semi-trailer

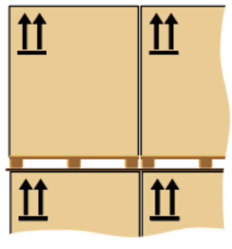


Figure 7.24 With intermediate board

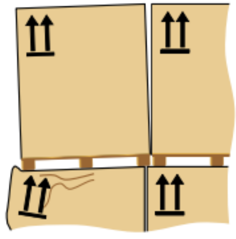


Figure 7.25 Without intermediate board

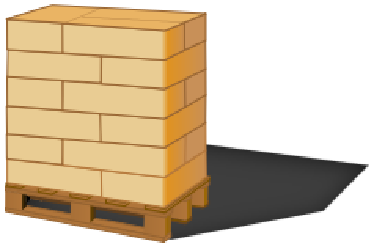


Figure 7.26 Cross-tie stowage

Figure 7.27 Mixed stow, dry over wet goods

Figure 7.28 Mixed stow, use of pallets

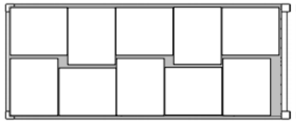


Figure 7.29 Packing 1,000 x 1,200 mm unit loads into a 20-foot container

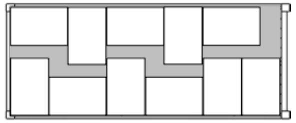


Figure 7.30 Packing 800 x 1,200 mm unit loads into a 20-foot container

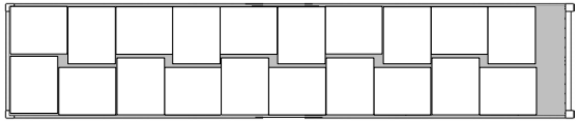
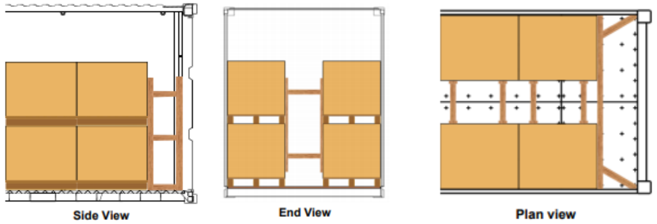


Figure 7.31 Packing 1,000 x 1,200 mm unit loads into a 40-foot container



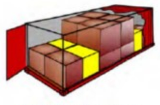


Figure 7.33 Threshold by height

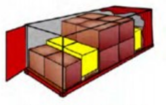


Figure 7.34 Threshold by elevation

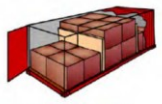


Figure 7.35 Threshold by board

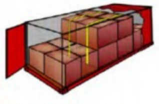


Figure 7.36 Round turn lashing

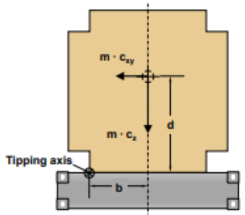


Figure 7.37 Tipping criterion

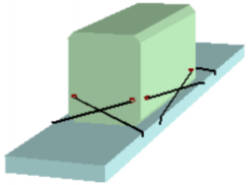


Figure 7.38 Direct lashing against sliding

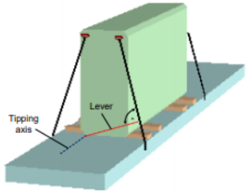


Figure 7.39 Direct lashing against tipping

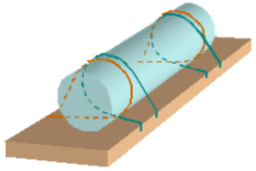


Figure 7.41 Vertical half-loop lashing

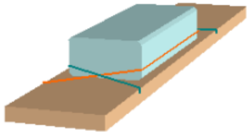


Figure 7.42 Horizontal half-loop lashing

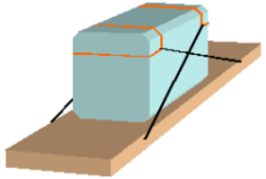


Figure 7.43 Spring lashing

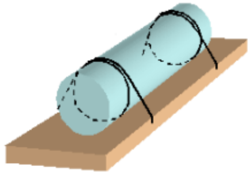


Figure 7.44 Silly-loop lashing

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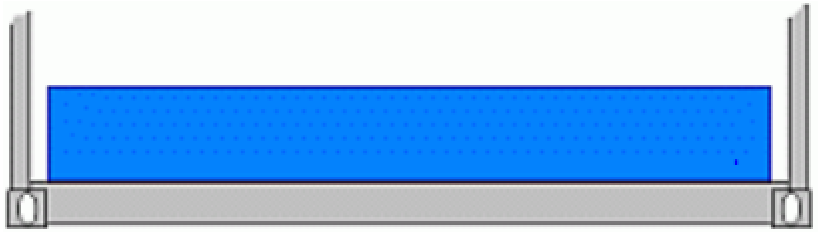
Container Handbook

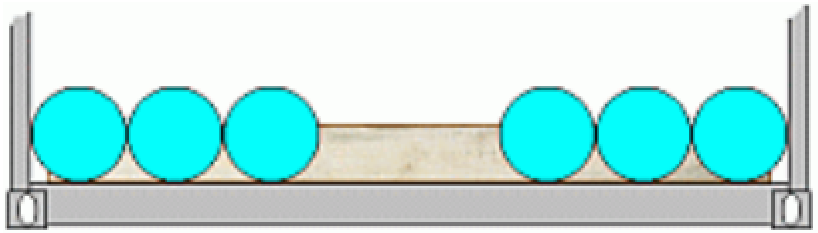
Wooden buffer member at the container front end wall



Round bar from the cargo as buffer

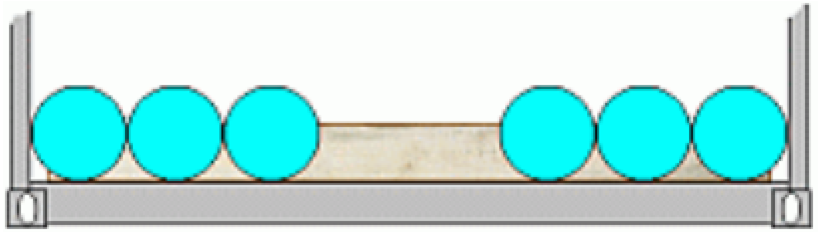
Container Handbook

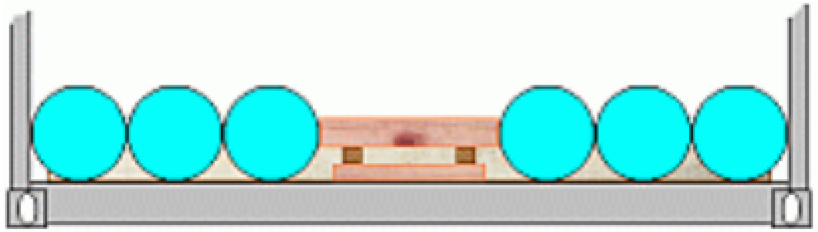
Round bars stowed against the front end wall buffer



Container Handbook

Round bars stowed against the front end wall buffer



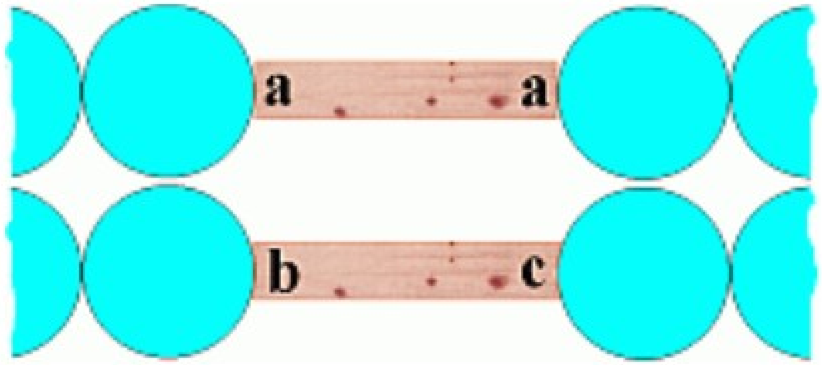


Gap between round bars filled with bracing

Container Handbook

Wooden bracing to fill the gaps between the bars

Enlargement of contact area

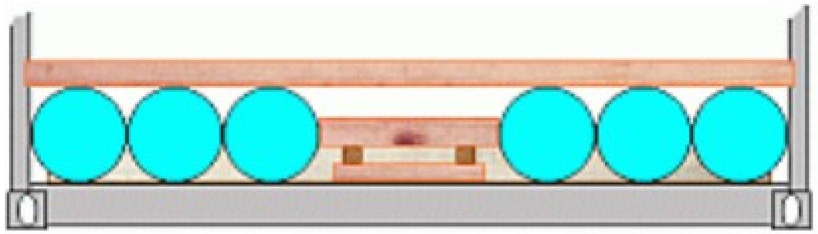


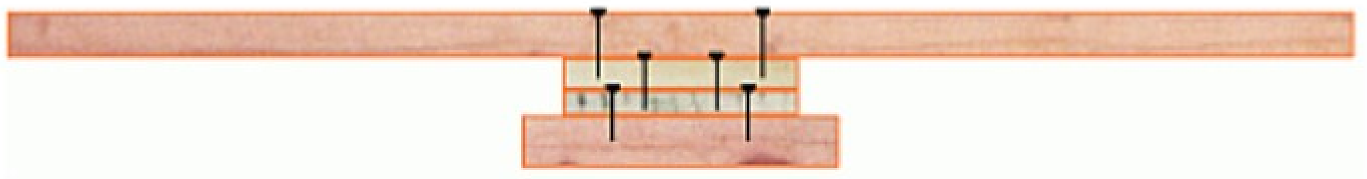
Container Handbook

Placement of cross braces - plan view

Container Handbook

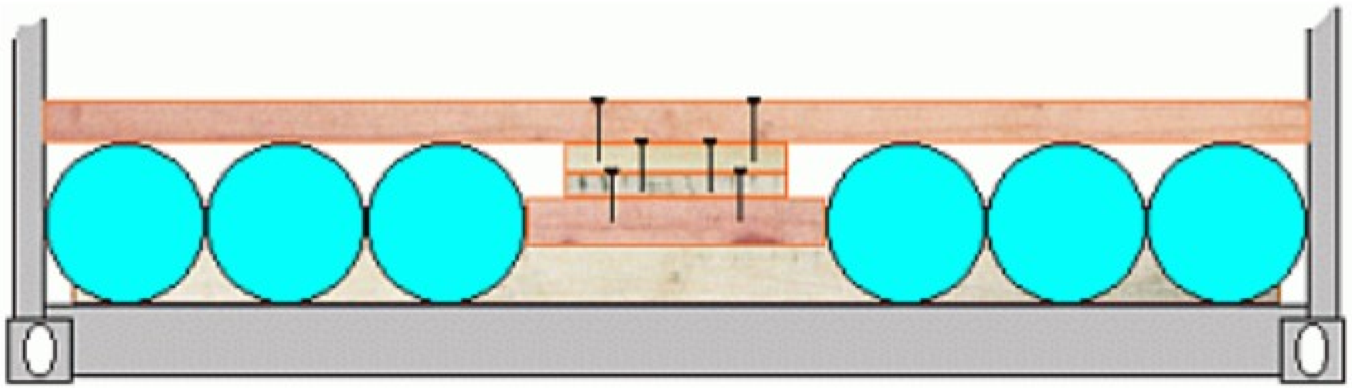
Bracing and base member for shoring





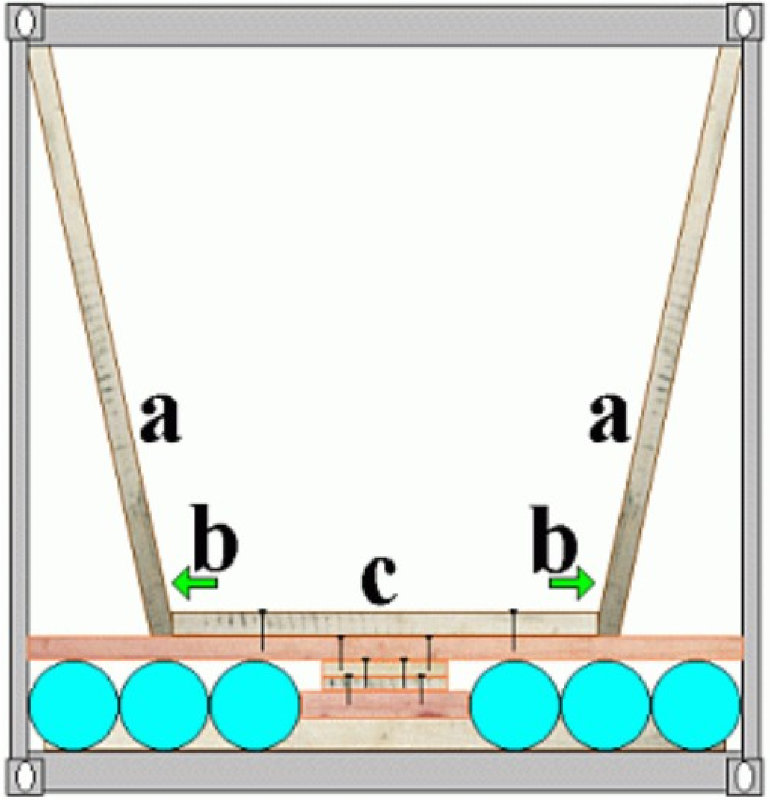
Combined wooden member for suspension from above

Container Handbook



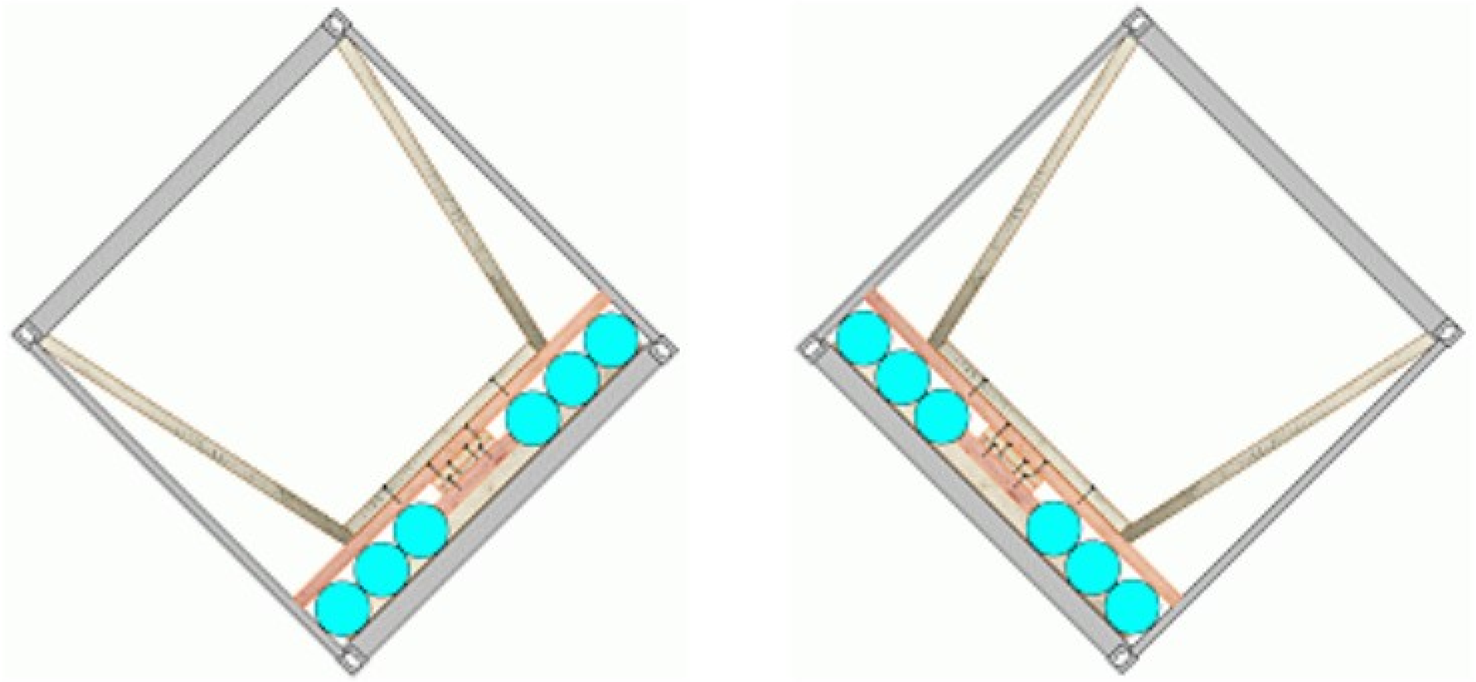
"Combined member" in place

Container Handbook



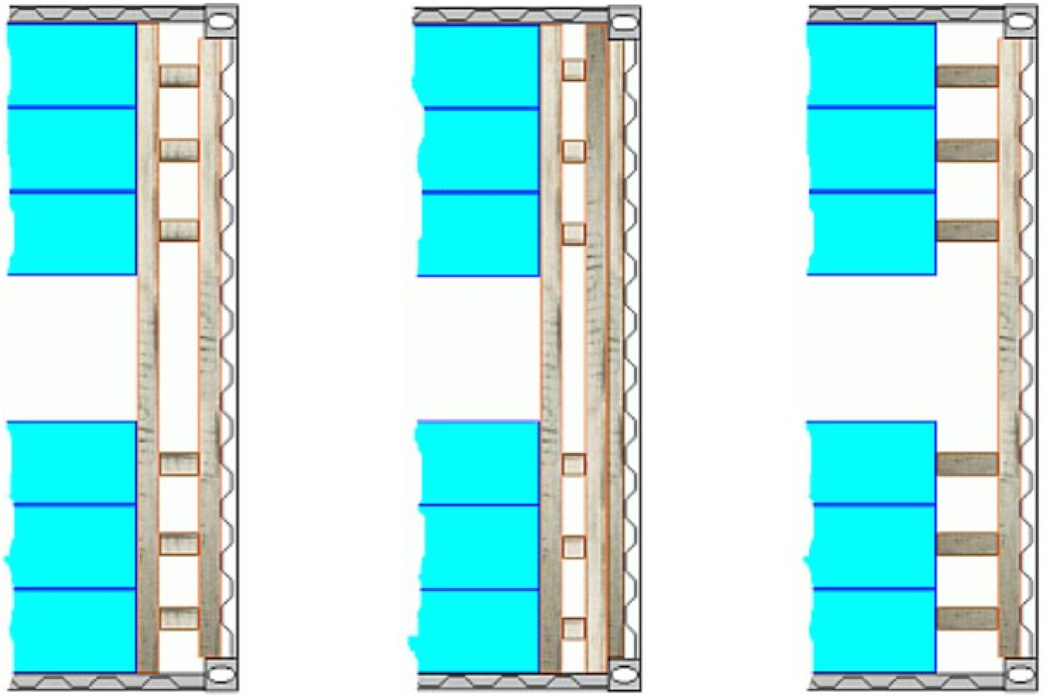
Shoring for securing round bars

Container Handbook



Effectiveness of shoring at a tilt of 45° to the side

Container Handbook



Lengthwise bracing variants

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Prof. Kapt. Hermann Kaps

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2.4.2 Arrangement "Eye to side"

The arrangement "Eye to side", where the coils rest in the container with transverse coiling axis, is used with coils of all sizes, in particular, if stuffing by crane and C-hook is not envisaged (see Container Handbook, chapter 5.2.14.4).

For this arrangement the coils are placed in front of the open container door on a bedding made from two longitudinal square timbers, fastened to them and then pushed into the container by an accordingly strong forklift. Since the forklift may generally not enter the container, the coils are moved the last end by means of adapted timber scantlings, together with their bedding. As a stuffing example of this method, Figures 3 and 4 show the positioning of a heavy cable drum into a container.

Coils which are fastened to solid skids (Figure 5), are placed into a container in the same manner.

Furthermore, it is possible to roll a coil on top of longitudinal beddings into the container and stabilise it in the desired position by means of cross-timbers.

Figure 3: Timber structure for bedding a cable drum in front of a container

Figure 4: Cable drum on its bedding in the container

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Figure 3: Timber structure for bedding a cable drum in front of a container

Figure 4: Cable drum on its bedding in the container

3.1 Loading the bottom in transverse direction

The minimum inner dimensions of a 20'-container are 5.867 x 2.330 m. So the permissible load in tonnes per metre bottom length P1 = P / 5.867 [t].

The transverse distance of the centres of the corner fittings is 2.26 m. When loaded homogeneously, the bottom of the container has to bear shear forces and bending moments as shown in Figure 6.

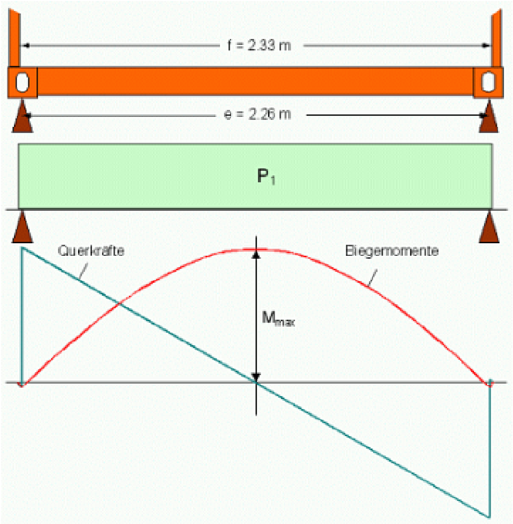

Figure 6: Shear forces and bending moments in the container bottom from a homogeneous load

The maximum bending moment from the load P1 (for one metre) is calculated as:

$$M_{max} = \frac{P_1 \cdot g}{8} \cdot (2e - f) = P_1 \cdot g \cdot 0.274 \;\; [kN{\cdot}m] \qquad (1)$$

For a longer or shorter distance t in longitudinal direction the moment is obtained as:

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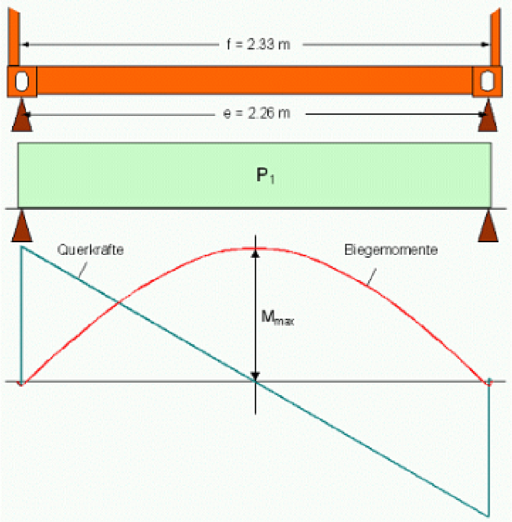

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For a longer or shorter distance t in longitudinal direction the moment is obtained as:

$$M = m_c \cdot g \cdot \frac{2 \cdot e - 2 \cdot s}{8} = m_c \cdot g \cdot \frac{4.52 - 2 \cdot s}{8} \ [kN \cdot m] \qquad (2)$$

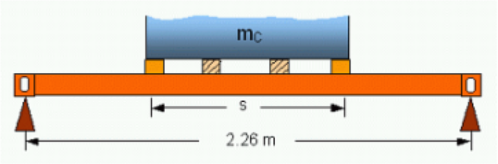

Figure 7: Load on two longitudinal beams in the container

This bending moment must not exceed the limiting value presented by equation (1a). The mass m_C must therefore be restricted to:

$$m_c = P_1 \cdot \frac{2.19 \cdot t}{4.52 - 2 \cdot s} \ [t] \qquad (3)$$

This equation is of restricted validity for values of s greater than 1.7 m. If the spread s comes close to the width of the container, the equation yields very large m_C-figures, which may exceed the longitudinal strength of the container. Then the limiting value for m_C is the coil mass determined by assuring the longitudinal strength. But concerns regarding the vertical shear loads in the bottom girders are unfounded.

Notice: The two dashed beams in Figure 7 between the two outer longitudinal beams are often found in skids supplied with the coil. They do not support the coil in the shown load case, because the container bottom deflects elastically, the coil, however, does not follow this deflection due to its greater stiffness. The inner beams are therefore not necessary, but also not harmful. If they would be bearing however, the bending moment in the container bottom would become greater than shown by equation (2).

A favourable option for shipping small coils on longitudinal beams is shown in Figure 8. Also for this case the equations (2) and (3) are valid with the corresponding value of s.

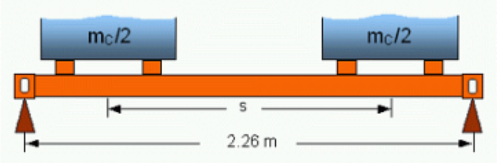

Figure 8: Two loads transverse in the container

3.3 Bedding-diagram

The equations (3) and (6) shown in this chapter may be transformed into a diagram that allows a fast decision on the correct bedding arrangement for coils in a container.

By entering with the "relative coil-mass m_C/P" the diagram in Figure 13 delivers the necessary length of the beams, depending on their spread s (set of curves to the left). For coils of less than 0.5 P there is only the spread of importance.

For heavier coils, of which only one can be loaded at a time, the entry with the relative coil-mass first of all yields the minimum length t of beams necessary for safeguarding the longitudinal strength (limiting curve to the right). Only if the spread is so small that it demands longer beams, then of course the greater value applies (set of curves above the limiting curve).

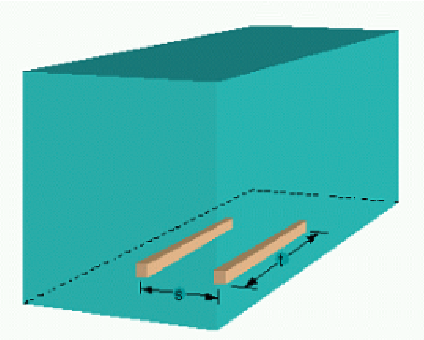

Figure 12: Spread s and length t of bedding timbers or steel beams

Example 1: m_C = 6 t; P = 28 t; m_C/P = 0.214; spread of beams s = 1.0 m: Necessary length t of longitudinal beams per coil = 1.45 m.

Example 2: m_C = 9 t; P = 26 t; m_C/P = 0.346; spread of beams s = 1.2 m: Necessary length t of longitudinal beams per coil = 1.96 m.

Example 3: m_C = 17 t; P = 28 t; m_C/P = 0.607; s = 1.4 m: Necessary length t of longitudinal beams = 2.80 m. For longitudinal strength a length t = 2.06 m would have been sufficient (blue curve).

Example 4: m_C = 20 t; P = 27 t; m_C/P = 0.741; s = 1.8 m: Necessary length t of longitudinal beams = 3.81 m. For the transverse strength with s = 1.8 m a length t of just under 1.9 m would have been sufficient.

Container Hand Book

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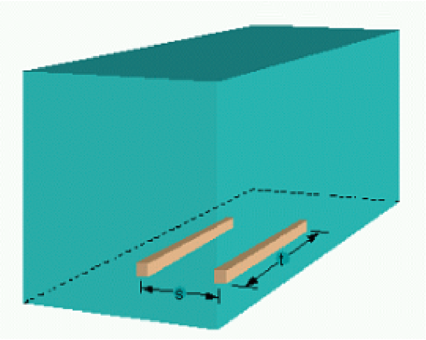

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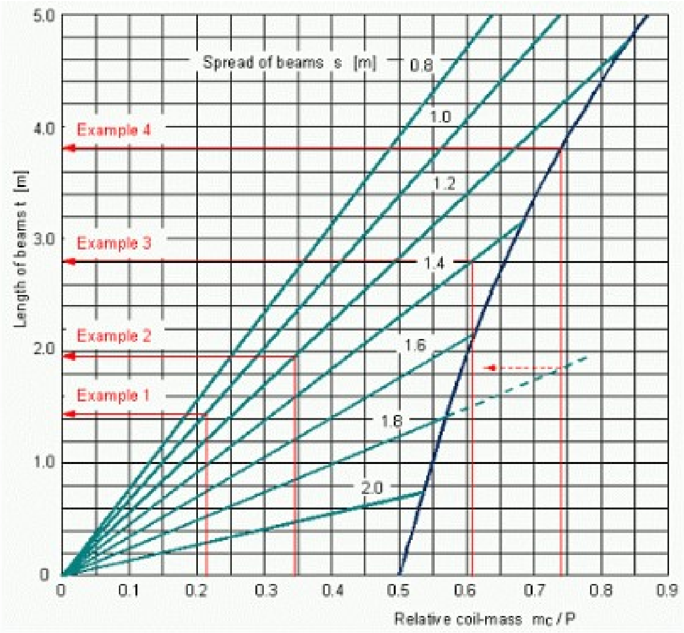

Figure 13: Diagram for the determination of necessary bedding dimensions

4.1 Section modules and permissible loads

The employed timber or steel beams are subject to bending and must therefore have a sufficient section modulus. The section modulus W of a timber beam with rectangular cross-section of the width b and the height h has the value:

$$W = \frac{b \cdot h^2}{6} \quad [cm^3] \qquad (8)$$

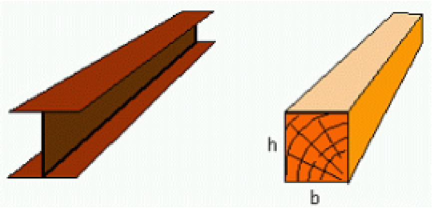

Figure 14: Steel beam and timber beam

When applying timber beams it should be noted that the traded dimensions my fall short by the width of the saw cut and by shrinkage from drying of up to 4 %. If in doubt, the dimensions should be measured. The section modules of steel beams should be taken from tables used in the steel trade.

The following figures are only for reference and used in chapter 6.

dimensions in cm	10 x 10	12 x 12	15 x 15	20 x 20
section modulus in cm³	152	263	513	1217

Table 1: Section modules of timber beams (with 3 % shrinkage)

dimensions in cm	12 x 12	14 x 14	16 x 16	18 x 18
section modulus in cm³	144	216	311	426

Table 2: Typical section modules of IPB steel beams

For the purpose of transport bedding, the permissible tensile stress of conifer timber may be appointed to 1 kN/cm², the same for mild steel to 15 kN/cm².

These figures already include safety margins that are required for vertical accelerations during sea transport, where it has been taken into account that the aforementioned extreme value of 1 g only scarcely occurs. Also the restricted duration of the sea transport justifies the mentioned figures.

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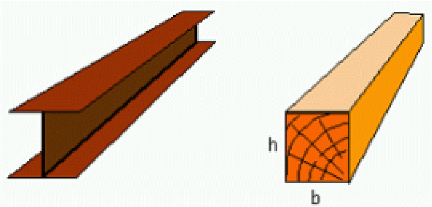

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4.2 Prevailing load case

In the applicable load case the beam rests on the internal bottom of the container with its entire length t and carries a symmetrical homogeneous load m over the length r (Figure 15). Under the assumption of a homogeneous load distribution from below and from the top the beam is subject to a bending moment of the magnitude:

$$M = \frac{m \cdot g \cdot (t - r)}{8} \quad [kN \cdot cm] \quad \text{(t and r must be entered in cm)} \qquad (10)$$

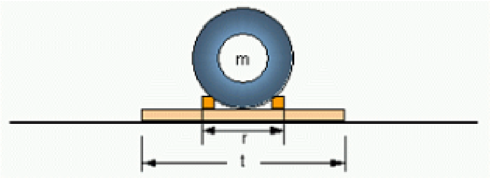

Figure 15: Beam with linear load and linear support

The required section modulus results

for timber beams: $$W = \frac{m \cdot g \cdot (t - r)}{8} \quad [cm^3] \qquad (11)$$

for steel beams: $$W = \frac{m \cdot g \cdot (t - r)}{120} \quad [cm^3] \qquad (12)$$

In this load case the **effective length** t must be limited against r, because a too long beam would lift its ends off the ground and would no longer transfer the load fairly evenly to the ground. For this limitation the following rules of thumb are given:

Timber beams 10 x 10 cm: t_{max} = (1.2 · r + 0.8) m, but not more than (r + 1.0) m

Timber beams 15 x 15 cm: t_{max} = (1.2 · r + 1.5) m, but not more than (r + 2.0) m

Timber beams 20 x 20 cm: t_{max} = (1.2 · r + 2.0) m, but not more than (r + 3.0) m

Steel beams 12 x 12 cm: t_{max} = (1.2 · r + 3.0) m, but not more than (r + 4.0) m

Steel beams 14 x 14 cm: t_{max} = (1.2 · r + 3.2) m, but not more than (r + 4.2) m

Steel beams 16 x 16 cm: t_{max} = (1.2 · r + 3.4) m, but not more than (r + 4.4) m

Steel beams 18 x 18 cm: t_{max} = (1.2 · r + 3.6) m, but not more than (r + 4.6) m

4.3 Beam-diagrams

The solutions of equation (11) for timber beams are presented graphically in Figure 16. The load m varies between 1 and 12 t, and the extension of the beam (t - r) varies between 0 and 400 cm. With these entries all relevant cases may be covered.

It becomes clear however, that for coils of the weight class XH, where the beam length t must be greater than 2.7 m according to Figure 13 and hence the expected beam extension (t - r) greater than 1.5 m, a proper load distribution with timber beams cannot be obtained with reasonable expense. Therefore, a similar diagram in Figure 17 shows the solutions of equation (12) for steel beams.

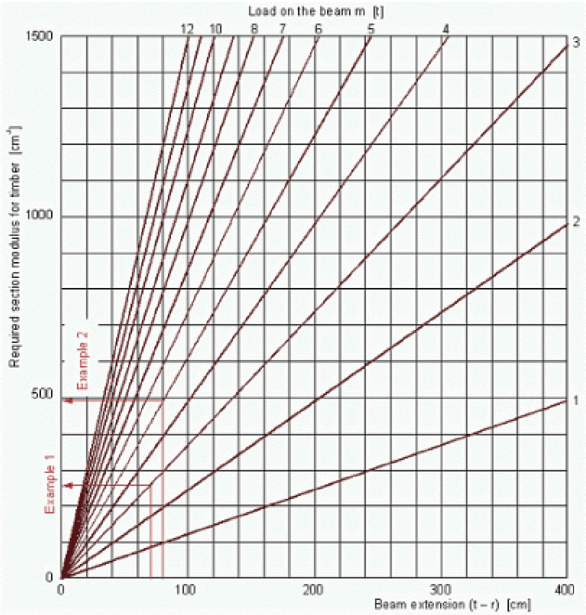

Figure 16: Required section modulus for timber beam bedding

Example 1: A coil of 6 t mass on skids of 0.9 m length of timbers is placed on two longitudinal beams of 1.6 m length. The beam extension (t - r) is 70 cm. Each beam is loaded with 3 t. The diagram in Figure 16 shows a required section modulus of about 260 cm³. Hence, beams of 12 x 12 cm are necessary (see Table 1).

Example 2: A coil of 10 t mass on skids of 1.0 m length of timbers is placed on two longitudinal beams of 1.8 m length. The beam extension (t - r) is 80 cm. Each beam is loaded with 5 t. The diagram in Figure 16 shows a required section modulus of about 490 cm³. Hence, beams of 15 x 15 cm are just sufficient (see Table 1).

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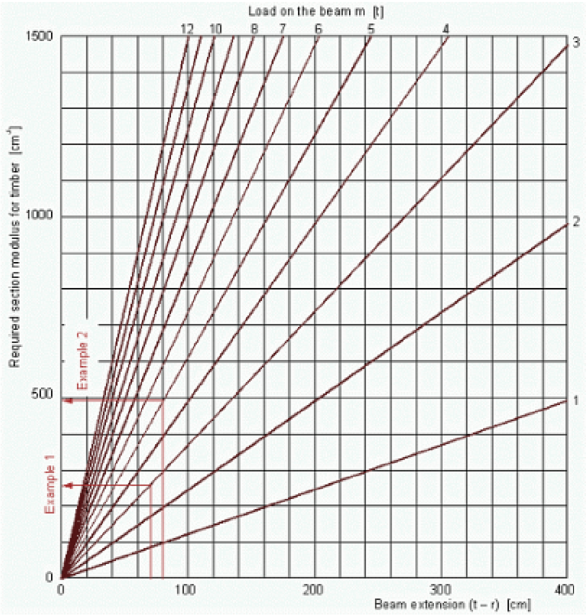

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5.2 Securing methods

When coils are stowed **"Eye to side"**, lashings taken as half loops through the eyes of the coils act only longitudinally in the container. Since the securing points in the bottom area of the container have an MSL of about 1000 kg (about 10 kN) only, and not all securing points can be put into effect simultaneously, additional pressure elements to the end walls and corner posts must be applied in general and also the coils stiffened to each other with timber.

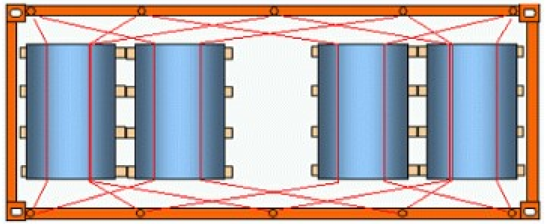

Figure 18: Longitudinal securing of coils by means of half loops

The remaining transverse securing with that arrangement should exclusively be realised by pressure elements. Care should be taken that the transverse shores are not set directly against the side walls of the container (Figure 19), but transfer their securing load through longitudinal cross-beams onto as many corrugations of the container wall as possible (Figure 20). Additionally, the actual shores must be stabilised by nailed-on longitudinal scantlings in a way, that they retain their function after occasionally falling slack.

Figure 19: Improper transfer of pressure to the container walls and poor stabilising of shores

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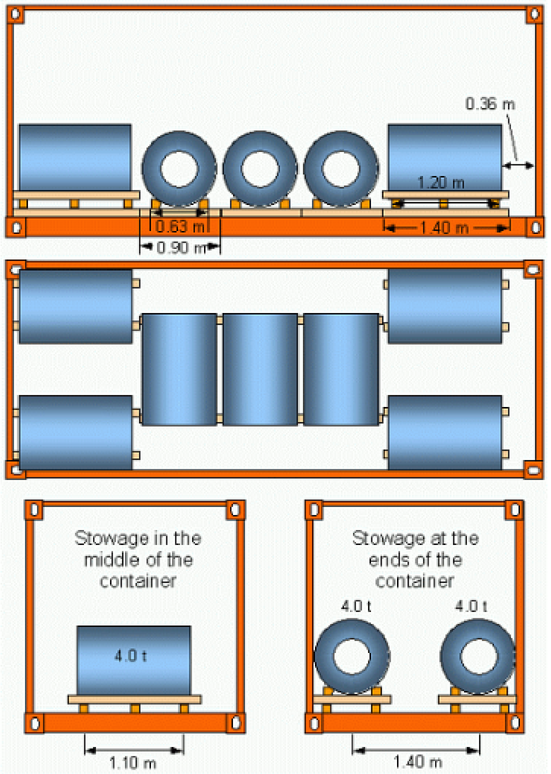
6. Stowage examples

6.1.1 Checking transverse and longitudinal loads to the container

The coils stowed transversely in the middle of the container rest on longitudinal beams of a spread s = 1.10 m. With this, the diagram in Figure 13 displays with an entry of m_C/P = 0.142 a minimum length of the longitudinal beams of t = 0.90 m. This requirement is just met.

The coil couples of 2 x 4 = 8 t stowed longitudinally at the ends of the container keep a distance (middle to middle) of s = 1.40 m. With this, the diagram in Figure 13 displays with an entry of m_C/P = 0.284 a minimum length of the longitudinal beams of t = 1.35 m. This requirement is met with 1.40 m.

The longitudinal bending moment in the container will actually be smaller than with a homogeneous load due to the heavier loaded ends of the container. A check by calculation may therefore be omitted.



6.1.2 Checking the loads to the timber beams

The coils stowed at the container ends rest on two beams of 10 x 10 cm cross-section and a length of t = 140 cm. The loaded length from the coil is r = 120 cm. With a beam extension of (t - r) = 20 cm and a load of 2 t, the necessary section modulus for each beam is taken from the diagram in Figure 16 with about 50 cm³. The beams have a section modulus of 152 cm³ (Table 1). Also the extension is well within permissible limits.

The coils stowed transversely in the middle of the container rest on three longitudinal timbers of 10 x 10 cm cross-section, of which the middle one does not bear due to the deflection of the container bottom. The outer timbers of t = 90 cm are loaded fairly evenly over a length of r = 63 cm. With the extension of (t - r) = 27 cm and the load of 2 t the necessary section modulus for each beam is taken from the diagram in Figure 16 with about 65 cm³. Also this value is less than the existing section modulus of 152 cm³. Also the extension of 27 cm is well within permissible limits.

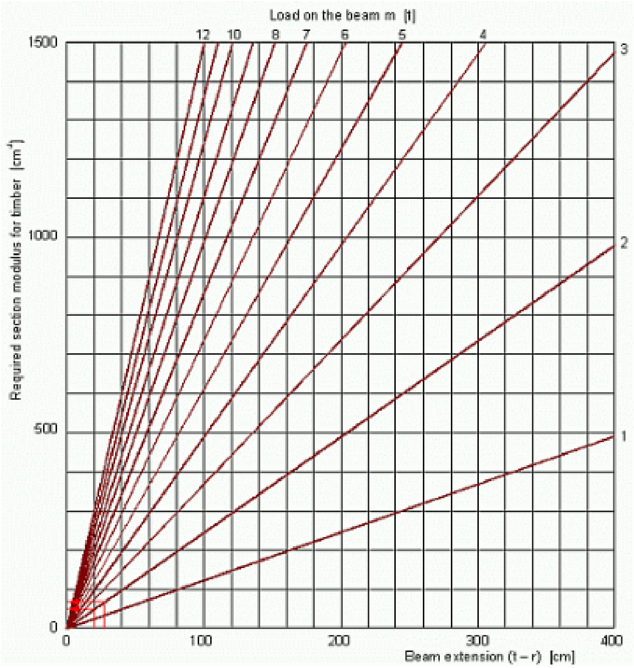


Figure 16: Required section modulus for timber beam bedding

Container Hand Book

6.2.1 Checking transverse and longitudinal loads to the container

The transversely stowed coils rest on longitudinal beams with a spread of = 1.50 m. Using this, the diagram in Figure 13 provides a minimum length of the beams of t = 1.30 m with the entry m_C/P = 0.319. This requirement is met with t = 1.40 m.

The longitudinal strength of the container is safeguarded by observing the aforementioned stowage rule. A calculated check is therefore not necessary.

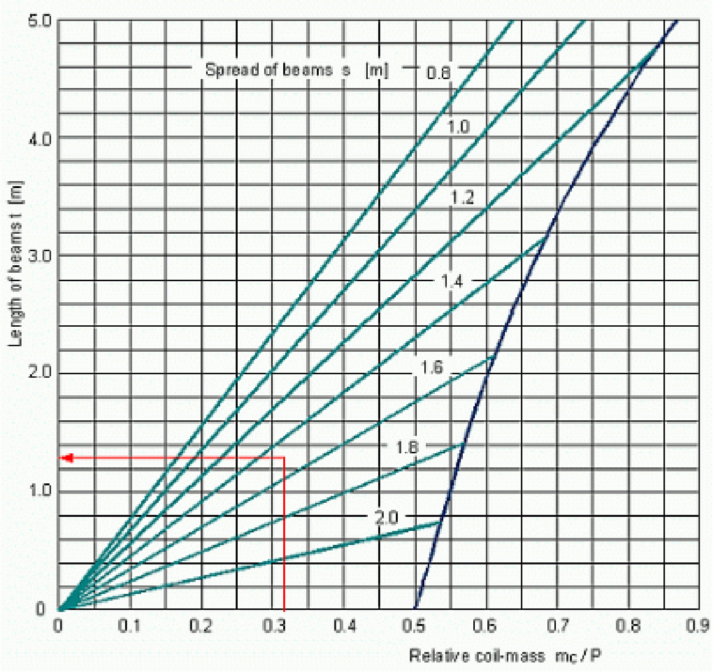


Figure 13: Diagram for the determination of necessary bedding dimensions

6 Stowage examples

In this example two coils of 13.6 t each shall be loaded into a container of P = 27.780 t. Thus, each coil has a mass of 49 % of the payload. The diameter is d = 1.40 m and the breadth is b = 1.42 m. The coils are tendered on skids. The bottom scantlings of these skids have a cross-section of 15 x 15 cm and a length of 1.40 m.

The coils are stowed transversely into the container. With a spread of the outer scantlings of 1.25 m, the bedding length must be extended by longitudinal beams of at least 2.64 m length, according to the diagram in Figure 13. The coils are arranged as shown in Figure 28, according to the rule (1/4, 3/4) in chapter 3.2. This arrangement is symmetric in longitudinal and transverse direction.

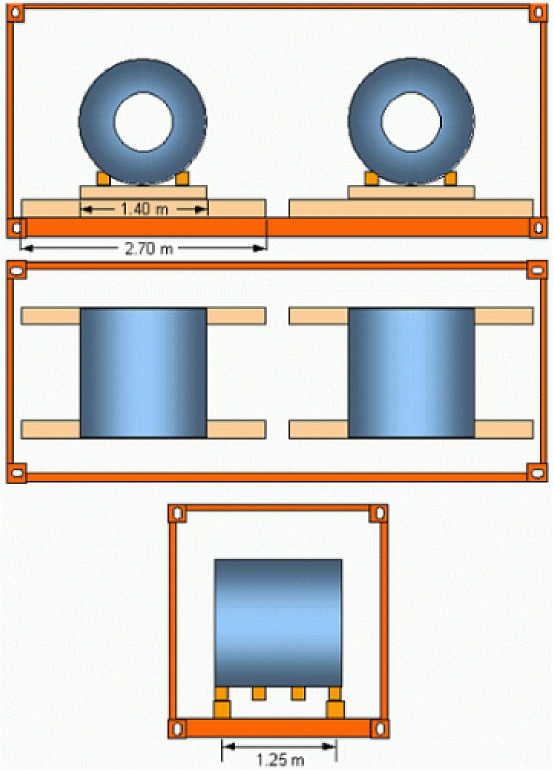


Figure 28: Stowage of "medium" coils with full payload (limit weight)

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6.3.3 Securing of the coils

The coils are secured according to the principles in chapter 5. The friction coefficient is taken as 0.4 due to form fit with the skids and the contact timber/timber below. Thus, a residual securing demand remains against longitudinal accelerations of 0.6 g and transverse accelerations of 0.4 g.

The residual longitudinal securing effort of 27.2 · 0.6 · 9.81 = 160 kN is achieved by lashings and additional pressure elements to the end walls and corner posts. Also between the coils there are longitudinal braces. These pressure elements consist of four timbers of 15 x 15 cm cross-section at the end walls and three timbers of 15 x 15 cm cross-section in the intermediate space, secured against falling loose. Due to the arrangement of the securing points, only six of them bear simultaneously.

The residual transverse securing effort of 27.2 · 0.4 · 9.81 = 107 kN is exclusively realised by 4 timber braces of 12 x 12 cm cross-section to each side.

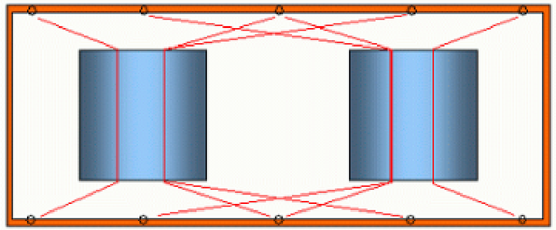

Figure 29: Longitudinal lashing of the coils

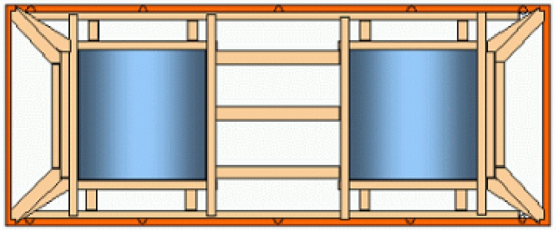

Figure 30: Longitudinal and transverse bracing of the coils

The arrangement is checked by a balance:

Longitudinally: $1 \cdot 9.81 \cdot 27.2 \leq 0.4 \cdot 27.2 \cdot 9.81 + (6 \cdot 10 + 4 \cdot 255 \cdot 0.3) / 1.5$

$267 \leq 107 + 220$

$267 < 327$ Balance is well met!

.de/ **ransversely:** $0.8 \cdot 9.81 \cdot 27.2 \leq 0.4 \cdot 27.2 \cdot 9.81 + (4 \cdot 144 \cdot 0.3) / 1.5$

Container Hand Book

longitudinal beams of 1.6 m, according to the diagram in Figure 13.

This spread cannot be realised with a coil diameter of 1.86 m. The maximum possible spread of 70 % of that diameter is 1.30 m. This however, requires a beam length t = 3.10 m.

Eventually, a spread of s = 1.25 m with a length of beams t = 3.20 m is selected according to the diagram in Figure 13. The permissible extension of 1.1 m is maintained by laying shorter beams of 2.1 m length in between. The arrangement is shown in Figure 31.

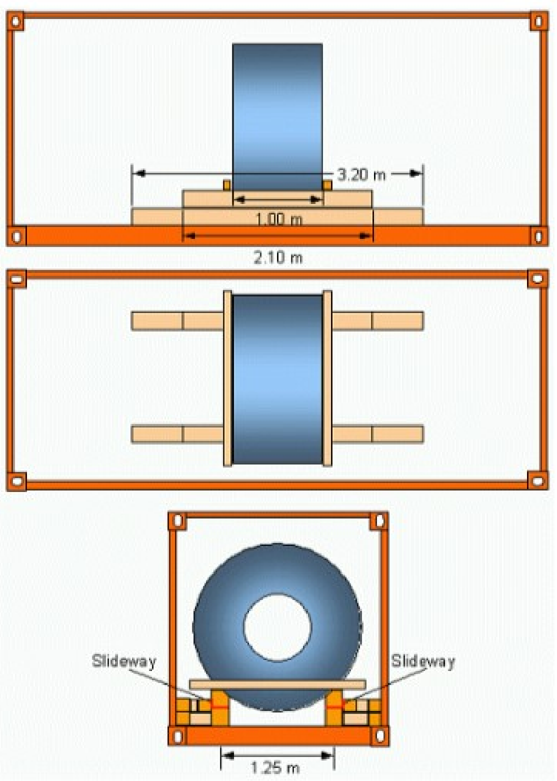

Figure 31: Longitudinal stowage of a "heavy" coil

6.4.1 Checking transverse and longitudinal loads to the container

The spread of the longitudinal beams is s = 1.25 m. The selected length of beams t = 3.20 m, obtained by entering the diagram in Figure 13 with m_C/P = 0.60, satisfies the requirements of the transverse strength of the container.

For safeguarding the longitudinal strength of the container, a length of beams t = 2.00 m would have been sufficient, according to the diagram in Figure 13.

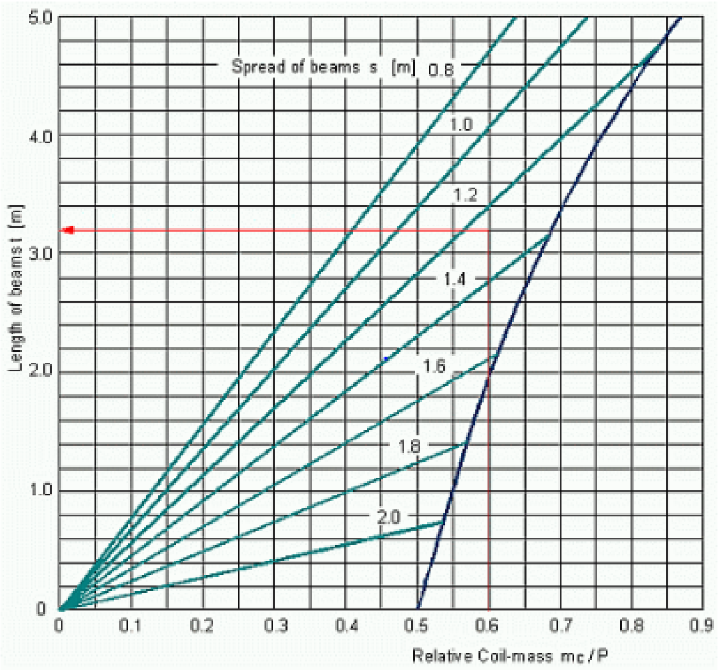

Figure 13: Diagram for the determination of necessary bedding dimensions

6.4.2 Checking the loads to the timber beams

The coil rests on two lower beams of 20 x 20 cm cross-section and a length t = 320 cm. The loaded length from each beam on top is r = 210 cm. With the extension of (t - r) = 110 cm and the load of 8.5 t the necessary section modulus for each beam of about 1150 cm³ is obtained from the diagram in Figure 16. The same situation applies to the upper beams loaded directly by the coil with r = 100 cm.

The beams have a section modulus of 1217 cm³ (Table 1). Also the extension of 110 cm is well within permissible limits.

dimensions in cm	10 x 10	12 x 12	15 x 15	20 x 20
section modulus in cm³	152	263	513	1217

Table 1: Section modules of timber beams (with 3 % shrinkage)


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Conclusion

Container Stuffing:

CTU-Code
Quick Guide
Container Handbook

1. **is an art of craftsmanship**
2. **has to be learned in detail**
3. **needs a lot of Know How**
4. **is a job full of responsibility**
5. **protects life at sea, on the tracks and on the road**
6. **the tools are online…it simply needs to be taught**