2.2.2.3 The friction values given in appendix 2 to this annex are valid for swept clean dry or wet surfaces free from frost, ice, snow, oil and grease. When a combination of contact surfaces is missing in the table in appendix 2 or if the friction factor cannot be verified in another way, the maximum friction factor to be used in calculations is 0.3. If the surface contact is not swept clean, the maximum friction factor to be used is 0.3 or the value in the table, when this is lower. If the surface contacts are not free from frost, ice and snow a friction factor $\mu = 0.2$ should be used unless the table shows a lower value. For oily and greasy surfaces or when slip sheets have been used a friction factor $\mu = 0.1$ should be used. The friction factor for a material contact can be verified by static inclination or dragging tests. A number of tests should be performed to establish the friction for a material contact (see appendix 3 to this annex).

2.2.3 Friction increasing materials like rubber mats, sheets of structured plastics or special cardboard may provide considerably higher friction factors, which are declared and certified by the manufacturers. However, care should be taken in the practical use of these materials. Their certified friction factor may be limited to perfect cleanliness and evenness of the contact areas and to specified ambient conditions of temperature and humidity. The desired friction increasing effect will be obtained only if the weight of the cargo is fully transferred via the friction increasing material, this means only if there is no direct contact between the cargo and the stowage ground. Manufacturer's instructions on the use of the material should be observed.

2.3 Blocking and bracing material and arrangements

2.3.1 Blocking, bracing or shoring is a securing method, where e.g. timber beams and frames, empty pallets or dunnage bags are filled into gaps between cargo and solid boundaries of the CTU or into gaps between different packages (see figure 7.3). Forces are transferred in this method by compression with minimal deformation. Inclined bracing or shoring arrangements bear the risk of bursting open under load and should therefore be properly designed. In CTUs with strong sides, if possible, packages should be stowed tightly to the boundaries of the CTU on both sides, leaving the remaining gap in the middle. This reduces the forces to the bracing arrangement, because lateral g-forces from only one side will need to be transferred at a time.

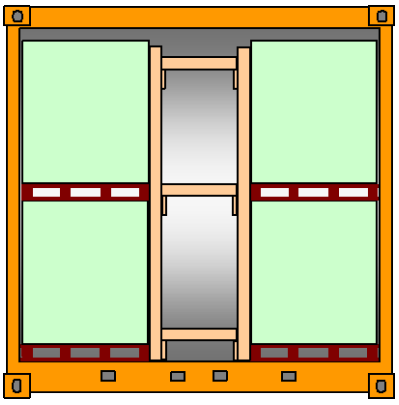

**Figure 7.3 Centre gap with transverse bracing**

2.3.2 Forces being transferred by bracing or shoring need to be dispersed at the points of contact by suitable cross-beams, unless a point of contact represents a strong structural member of the cargo or the CTU. Softwood timber cross-beams should be given sufficient overlaps at the shore contact points. For the assessment of bedding and blocking arrangements, the nominal strength of timber should be taken from the following table:

| | **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 |

2.3.3 A bracing or shoring arrangement should be designed and completed in such a way that it remains intact and in place, also if compression is temporarily lost. This requires suitable uprights or benches supporting the actual shores, a proper joining of the elements by nails or clamps and the stabilizing of the arrangement by diagonal braces as appropriate (see figures 7.4 and 7.5).

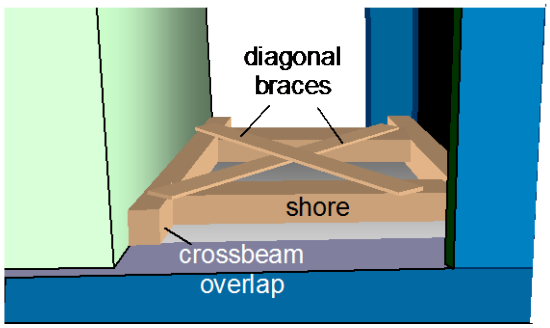


**Figure 7.4 Shoring arrangement showing cross beam overlap and diagonal braces**

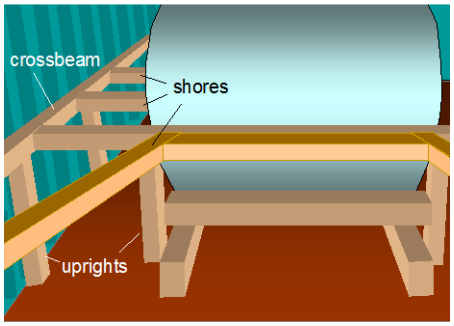


**Figure 7.5 Shoring arrangement with uprights and crossbeam**

2.3.4 Transverse battens in a CTU, intended to restrain a block of packages in front of the door or at intermediate positions within the CTU, should be sufficiently dimensioned in their cross section, in order to withstand the expected longitudinal forces from the cargo (see figure 7.6). The ends of such battens may be forced into solid corrugations of the side walls of the CTU. However, preference should be given to brace them against the frame structure, such as bottom or top rails or corner posts. Such battens act as beams, which are fixed at their ends and loaded homogeneously over their entire length of about 2.4 metres. Their bending strength is decisive for the force that can be resisted. The required number of such battens together with their dimensions may be identified by calculations, which is shown in appendix 4 to this annex.

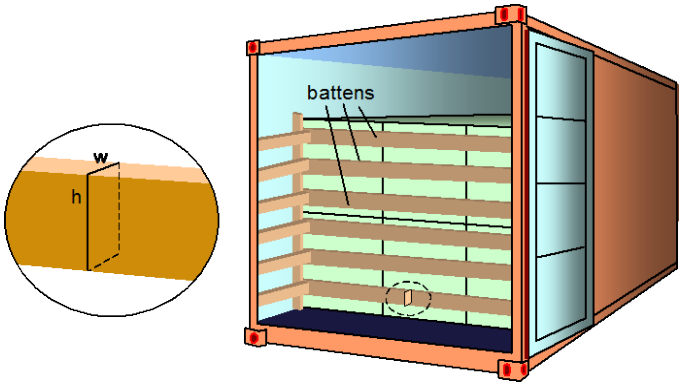


**Figure 7.6 General layout of fence battens for door protection in a CTU**

2.3.5 Blocking by nailed on scantlings should be used for minor securing demands only. Depending on the size of the nails used, the shear strength of such a blocking arrangement may be estimated to take up a blocking force between 1 and 4 kN per nail. Nailed on wedges may be favourable for blocking round shapes like pipes. Care should be taken that wedges are cut in a way that the direction of grain supports the shear strength of the wedge. Any such timber battens or wedges should only be nailed to dunnage or timbers placed under the cargo. Wooden floors of closed CTUs are generally not suitable for nailing. Nailing to the softwood flooring of flatracks or platforms and open CTUs may be acceptable with the consent of the CTU operator (see figure 7.7).

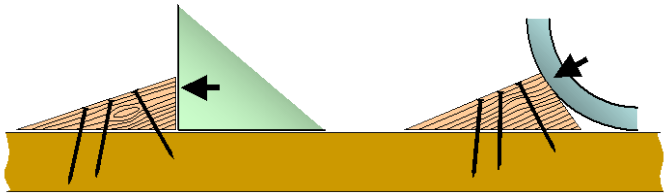

**Figure 7.7 Properly cut and nailed wedges**

2.3.6 In the case of form locking, void spaces should be filled and may be favourably stuffed by empty pallets inserted vertically and tightened by additional timber battens as necessary. Material which may deform or shrink permanently, like rags of gunny cloth or solid foam of limited strength, should not be used for this purpose. Small gaps between unit loads and similar cargo items, which cannot be avoided and which are necessary for the smooth packing and unpacking of the goods, are acceptable and need not to be filled. The sum of void spaces in any horizontal direction should not exceed 15 cm. However, between dense and rigid cargo items, such as steel, concrete or stone, void spaces should be further minimized, as far as possible.

2.3.7 Gaps between cargo that is stowed on and firmly secured to pallets (by lashings or by shrink foil), need not to be filled, if the pallets are stowed tightly into a CTU and are not liable to tipping (see figure 7.8). Securing of cargo to pallets by shrink foil wrapping is only sufficient if the strength of the foil is appropriate for above purpose. It should be considered that in case of sea transport repetitive high loadings during bad weather may fatigue the strength of a shrink foil and thereby reduce the securing capacity.

**Figure 7.8 Cargo firmly secured to pallets by textile lashings**

2.3.8 If dunnage bags are used for filling gaps[2], the manufacturer's instructions on filling pressure and the maximum gap should be accurately observed. Dunnage bags should not be used as a means of filling the space at the doorway, unless precautions are taken to ensure that they cannot cause the door to open violently when the doors are opened. If the surfaces in the gap are uneven with the risk of damage to the dunnage bags by chafing or piercing, suitable measures should be taken for smoothing the surfaces appropriately (see figures 7.9 and 7.10). The blocking capacity of dunnage bags should be estimated by multiplying the nominal burst pressure with the contact area to one side of the blocking arrangement and with a safety factor of 0.75 for single use dunnage bags and 0.5 for reusable dunnage bags (see appendix 4 to this annex).

**Figure 7.9 Gap filled with a central dunnage bag**

**Figure 7.10 Irregular shaped packages blocked with dunnage bags**

2.3.9 The restrictions on the use of blocking and bracing materials with regard to quarantine regulations, in particular for wood or timber, should be kept in mind (see sections 1.13 and 1.14 of this annex).

[2] Dunnage bags (inflated by air) should not be used for dangerous goods on US railways.