

## **Annex 13**

### *Methods to assess the efficiency of securing arrangements for non-standardized cargo*

#### **1 Scope of application**

The methods described in this annex should be applied to non-standardized cargoes, but not to containers on containerships.

Very heavy units as carried under the provisions of chapter 1.8 of the Code of Safe Practice for Cargo Stowage and Securing (the Code) and those items for which exhaustive advice on stowage and securing is given in the annexes to the Code should be excluded. All lashing assemblies used in the application of the methods described in this annex must be attached to fixed securing points or strong supporting structures marked on the cargo unit or advised as being suitable, or taken as a loop around the unit with both ends secured to the same side as shown in annex 5, figure 2 of the Code. Lashings going over the top of the cargo unit, which have no defined securing direction but only act to increase friction by their pre-tension, cannot be credited in the evaluation of securing arrangements under this annex.

Nothing in this annex should be read to exclude the use of computer software, provided the output achieves design parameters which meet the minimum safety factors applied in this annex.

The application of the methods described in this annex is supplementary to the principles of good seamanship and shall not replace experience in stowage and securing practice.

#### **2 Purpose of the methods**

The methods should:

- .1 provide guidance for the preparation of the Cargo Securing Manual and the examples therein;
- .2 assist ship's staff in assessing the securing of cargo units not covered by the Cargo Securing Manual;
- .3 assist qualified shore personnel in assessing the securing of cargo units not covered by the Cargo Securing Manual; and
- .4 serve as a reference for maritime and port-related education and training.

#### **3 Presentation of the methods**

The methods are presented in a universally applicable and flexible way. It is recommended that designers of Cargo Securing Manuals convert this presentation into a form suiting the particular ship, its securing equipment and the cargo carried. This form may consist of applicable diagrams, tables or calculated examples.

## 4 Strength of securing equipment

**4.1** Manufacturers of securing equipment should at least supply information on the nominal breaking strength of the equipment in kilonewtons (kN)\*.

**4.2** "Maximum securing load" (MSL) is a term used to define the load capacity for a device used to secure cargo to a ship. "Safe Working Load" (SWL) may be substituted for MSL for securing purposes, provided this is equal to or exceeds the strength defined by MSL.

The MSLs for different securing devices are given in table 1 if not given under 4.3.

The MSL of timber should be taken as  $0.3 \text{ kN/cm}^2$  normal to the grain.

**Table 1 – Determination of MSL from breaking strength**

Material	MSL
shackles, rings, deckeyes, turnbuckles of mild steel	50% of breaking strength
fibre rope	33% of breaking strength
web lashing	50% of breaking strength
wire rope (single use)	80% of breaking strength
wire rope (re-useable)	30% of breaking strength
steel band (single use)	70% of breaking strength
chains	50% of breaking strength

**4.3** For particular securing devices (e.g. fibre straps with tensioners or special equipment for securing containers), a permissible working load may be prescribed and marked by authority. This should be taken as the MSL.

**4.4** When the components of a lashing device are connected in series (for example, a wire to a shackle to a deckeye), the minimum MSL in the series shall apply to that device.

## 5 Rule-of-thumb method

**5.1** *The total of the MSL values of the securing devices on each side of a unit of cargo (port as well as starboard) should equal the weight of the unit.†*

\*  $1 \text{ kN} \approx 100 \text{ kg}$ .

† The weight of the unit should be taken in kN.

**5.2** This method, which implies a transverse acceleration of  $1g$  ( $9.81 \text{ m/s}^2$ ), applies to nearly any size of ship, regardless of the location of stowage, stability and loading condition, season and area of operation. The method, however, takes into account neither the adverse effects of lashing angles and non-homogeneous distribution of forces among the securing devices nor the favourable effect of friction.

**5.3** Transverse lashing angles to the deck should not be greater than  $60^\circ$  and it is important that adequate friction is provided by the use of suitable material. Additional lashings at angles of greater than  $60^\circ$  may be desirable to prevent tipping but are not to be counted in the number of lashings under the rule-of-thumb.

## **6 Safety factor**

When using balance calculation methods for assessing the strength of the securing devices, a safety factor is used to take account of the possibility of uneven distribution of forces among the devices or reduced capability due to the improper assembly of the devices or other reasons. This safety factor is used in the formula to derive the calculated strength (CS) from the MSL and shown in the relevant method used.

$$CS = \frac{MSL}{\text{safety factor}}$$

Notwithstanding the introduction of such a safety factor, care should be taken to use securing elements of similar material and length in order to provide a uniform elastic behaviour within the arrangement.

## **7 Advanced calculation method**

### **7.1 Assumption of external forces**

External forces to a cargo unit in longitudinal, transverse and vertical directions should be obtained using the formula:

$$F_{(x,y,z)} = m \cdot a_{(x,y,z)} + F_{w(x,y)} + F_{s(x,y)}$$

where

$F_{(x,y,z)}$  = longitudinal, transverse and vertical forces

$m$  = mass of the unit

$a_{(x,y,z)}$  = longitudinal, transverse and vertical accelerations  
(see table 2)

$F_{w(x,y)}$  = longitudinal and transverse forces by wind pressure

$F_{s(x,y)}$  = longitudinal and transverse forces by sea sloshing.

The basic acceleration data are presented in table 2.

Table 2 – Basic acceleration data

Transverse acceleration $a_y$ in $m/s^2$										Longitudinal acceleration $a_x$ in $m/s^2$		
on deck, high	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8 2.9 2.0 1.5		
on deck, low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7			
'tween-deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2			
lower hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9			
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	L	
Vertical acceleration $a_z$ in $m/s^2$												
7.6 6.2 5.0 4.3 4.3 5.0 6.2 7.6 9.2												

**Remarks:**

The given transverse acceleration figures include components of gravity, pitch and heave parallel to the deck. The given vertical acceleration figures do not include the static weight component.

The basic acceleration data are to be considered as valid under the following operational conditions:

- .1 Operation in unrestricted area;
- .2 Operation during the whole year;
- .3 Duration of the voyage is 25 days;
- .4 Length of ship is 100 m;
- .5 Service speed is 15 knots;
- .6  $B/GM \geq 13$  ( $B$  = breadth of ship,  $GM$  = metacentric height).

For operation in a restricted area, reduction of these figures may be considered, taking into account the season of the year and the duration of the voyage.

For ships of a length other than 100 m and a service speed other than 15 knots, the acceleration figures should be corrected by a factor given in table 3.

Table 3 – Correction factors for length and speed

Length (m)	50	60	70	80	90	100	120	140	160	180	200
Speed (kn) 9	1.20	1.09	1.00	0.92	0.85	0.79	0.70	0.63	0.57	0.53	0.49
12	1.34	1.22	1.12	1.03	0.96	0.90	0.79	0.72	0.65	0.60	0.56
15	1.49	1.36	1.24	1.15	1.07	1.00	0.89	0.80	0.73	0.68	0.63
18	1.64	1.49	1.37	1.27	1.18	1.10	0.98	0.89	0.82	0.76	0.71
21	1.78	1.62	1.49	1.38	1.29	1.21	1.08	0.98	0.90	0.83	0.78
24	1.93	1.76	1.62	1.50	1.40	1.31	1.17	1.07	0.98	0.91	0.85

For length/speed combinations not directly tabulated, the following formula may be used to obtain the correction factor with  $v$  = speed in knots and  $L$  = length between perpendiculars in metres:

$$\text{correction factor} = (0.345 \cdot v / \sqrt{L}) + (58.62 \cdot L - 1034.5) / L^2$$

This formula shall not be used for ship lengths less than 50 m or more than 300 m.

In addition, for ships with  $B/GM$  less than 13, the transverse acceleration figures should be corrected by a factor given in table 4.

**Table 4 – Correction factors for  $B/GM < 13$**

$B/GM$	7	8	9	10	11	12	13 or above
on deck, high	1.56	1.40	1.27	1.19	1.11	1.05	1.00
on deck, low	1.42	1.30	1.21	1.14	1.09	1.04	1.00
'tween-deck	1.26	1.19	1.14	1.09	1.06	1.03	1.00
lower hold	1.15	1.12	1.09	1.06	1.04	1.02	1.00

The following cautions should be observed:

In the case of marked roll resonance with amplitudes above  $\pm 30^\circ$ , the given figures of transverse acceleration may be exceeded. Effective measures should be taken to avoid this condition.

In the case of heading into the seas at high speed with marked slamming shocks, the given figures of longitudinal and vertical acceleration may be exceeded. An appropriate reduction of speed should be considered.

In the case of running before large stern or quartering seas with a stability which does not amply exceed the accepted minimum requirements, large roll amplitudes must be expected with transverse accelerations greater than the figures given. An appropriate change of heading should be considered.

Forces by wind and sea to cargo units above the weather deck should be accounted for by a simple approach:

$$\begin{aligned} \text{force by wind pressure} &= 1 \text{ kN per m}^2 \\ \text{force by sea sloshing} &= 1 \text{ kN per m}^2 \end{aligned}$$

Sloshing by sea can induce forces much greater than the figure given above. This figure should be considered as remaining unavoidable after adequate measures to prevent overcoming seas.

Sea sloshing forces need only be applied to a height of deck cargo up to 2 m above the weather deck or hatch top.

For voyages in a restricted area, sea sloshing forces may be neglected.

## 7.2 Balance of forces and moments

The balance calculation should preferably be carried out for:

- transverse sliding in port and starboard directions;
- transverse tipping in port and starboard directions;
- longitudinal sliding under conditions of reduced friction in forward and aft directions.

In the case of symmetrical securing arrangements, one appropriate calculation is sufficient.

Friction contributes towards prevention of sliding. The following friction coefficients ( $\mu$ ) should be applied.

**Table 5 – Friction coefficients**

Materials in contact	Friction coefficient ( $\mu$ )
Timber–timber, wet or dry	0.4
Steel–timber or steel–rubber	0.3
Steel–steel, dry	0.1
Steel–steel, wet	0.0

### 7.2.1 Transverse sliding

The balance calculation should meet the following condition (see also figure 1):

$$F_y \leq \mu \cdot m \cdot g + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \dots + CS_n \cdot f_n$$

where

$n$  is the number of lashings being calculated

$F_y$  is transverse force from load assumption (kN)

$\mu$  is friction coefficient

$m$  is mass of the cargo unit (t)

$g$  is gravity acceleration of earth = 9.81 m/s<sup>2</sup>

$CS$  is calculated strength of transverse securing devices (kN)

$$CS = \frac{MSL \cdot \alpha}{1.5}$$

$f$  is a function of  $\mu$  and the vertical securing angle  $\alpha$  (see table 6).

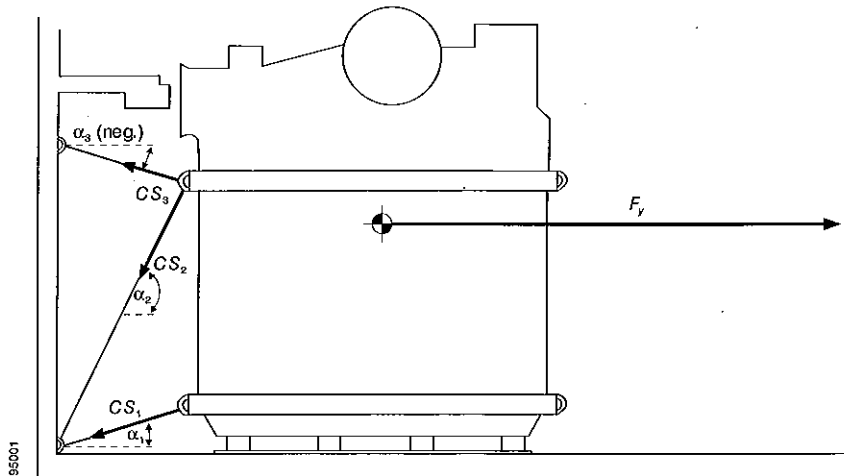


Figure 1- Balance of transverse forces

A vertical securing angle  $\alpha$  greater than  $60^\circ$  will reduce the effectiveness of this particular securing device in respect to sliding of the unit. Disregarding of such devices from the balance of forces should be considered, unless the necessary load is gained by the imminent tendency to tipping or by a reliable pre-tensioning of the securing device and maintaining the pre-tension throughout the voyage.

Any horizontal securing angle, i.e. deviation from the transverse direction, should not exceed  $30^\circ$ , otherwise an exclusion of this securing device from the transverse sliding balance should be considered.

Table 6 -  $f$  Values as a function of  $\alpha$  and  $\mu$ 

$\mu \backslash \alpha$	$-30^\circ$	$-20^\circ$	$-10^\circ$	$0^\circ$	$10^\circ$	$20^\circ$	$30^\circ$	$40^\circ$	$50^\circ$	$60^\circ$	$70^\circ$	$80^\circ$	$90^\circ$
<b>0.3</b>	0.72	0.84	0.93	1.00	1.04	1.04	1.02	0.96	0.87	0.76	0.62	0.47	0.30
<b>0.1</b>	0.82	0.91	0.97	1.00	1.00	0.97	0.92	0.83	0.72	0.59	0.44	0.27	0.10
<b>0.0</b>	0.87	0.94	0.98	1.00	0.98	0.94	0.87	0.77	0.64	0.50	0.34	0.17	0.00

Remark:  $f = \mu \cdot \sin \alpha + \cos \alpha$

As an alternative to using table 6 to determine the forces in a securing arrangement, the method outlined in paragraph 7.3 can be used to take account of transverse and longitudinal components of lashing forces.

### 7.2.2 Transverse tipping

This balance calculation should meet the following condition (see also figure 2):

$$F_y \cdot a \leq b \cdot m \cdot g + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \dots + CS_n \cdot c_n$$

where

$F_y$ ,  $m$ ,  $g$ ,  $CS$ ,  $n$  are as explained under 7.2.1

$a$  is lever-arm of tipping (m) (see figure 2)

$b$  is lever-arm of stability (m) (see figure 2)

$c$  is lever-arm of securing force (m) (see figure 2)

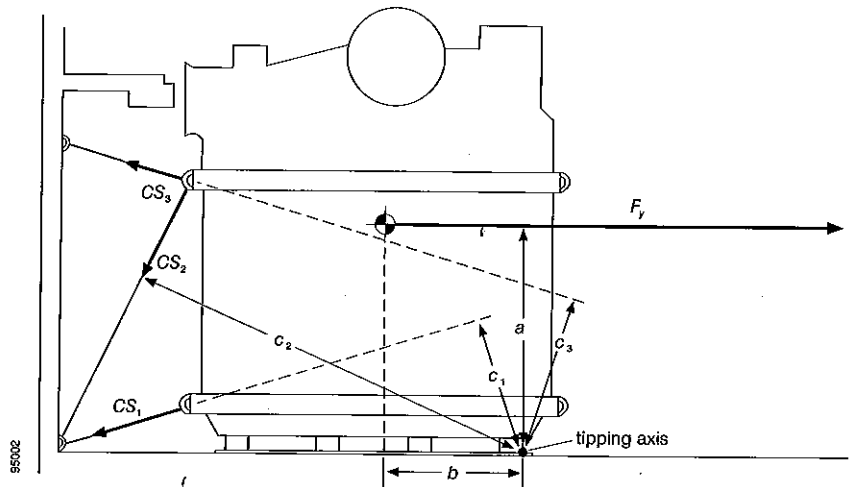


Figure 2 - Balance of transverse moments

### 7.2.3 Longitudinal sliding

Under normal conditions the transverse securing devices provide sufficient longitudinal components to prevent longitudinal sliding. If in doubt, a balance calculation should meet the following condition:

$$F_x \leq \mu \cdot (m \cdot g - F_z) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \dots + CS_n \cdot f_n$$

where

$F_x$  is longitudinal force from load assumption (kN)

$\mu$ ,  $m$ ,  $g$ ,  $f$ ,  $n$  are as explained under 7.2.1

$F_z$  is vertical force from load assumption (kN)

$CS$  is calculated strength of longitudinal securing devices (kN)

$$CS = \frac{MSL}{1.5}$$

*Remark:* Longitudinal components of transverse securing devices should not be assumed greater than 0.5 · CS.

### 7.2.4 Calculated example

A calculated example for this method is shown in appendix 1 of annex 13.

### 7.3 Balance of forces – alternative method

The balance of forces described in paragraph 7.2.1 and 7.2.3 will normally furnish a sufficiently accurate determination of the adequacy of the securing arrangement. However, this alternative method allows a more precise consideration of horizontal securing angles.

Securing devices usually do not have a pure longitudinal or transverse direction in practice but have an angle  $\beta$  in the horizontal plane. This horizontal securing angle  $\beta$  is defined in this annex as the angle of deviation from the transverse direction. The angle  $\beta$  is to be scaled in the quadrantal mode, i.e. between  $0^\circ$  and  $90^\circ$ .

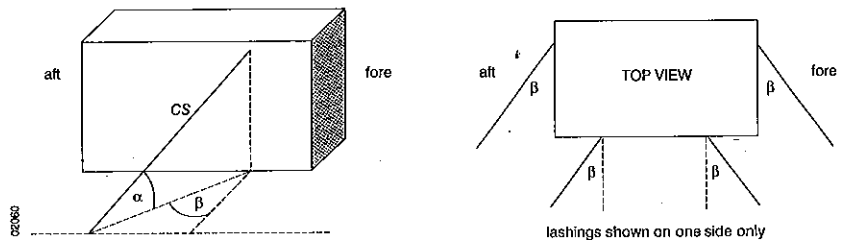


Figure 3 – Definition of the vertical and horizontal securing angles  $\alpha$  and  $\beta$

A securing device with an angle  $\beta$  develops securing effects both in longitudinal and transverse direction, which can be expressed by multiplying the calculated strength CS with the appropriate values of  $f_x$  or  $f_y$ . The values of  $f_x$  and  $f_y$  can be obtained from table 7.

Table 7 consists of five sets of figures, one each for the friction coefficients  $\mu = 0.4, 0.3, 0.2, 0.1$  and  $0$ . Each set of figures is obtained by using the vertical angle  $\alpha$  and horizontal angle  $\beta$ . The value of  $f_x$  is obtained when entering the table with  $\beta$  from the right while  $f_y$  is obtained when entering with  $\beta$  from the left, using the nearest tabular value for  $\alpha$  and  $\beta$ . Interpolation is not required but may be used.

The balance calculations are made in accordance with the following formulae:

$$\begin{aligned} \text{Transverse sliding: } F_y &\leq \mu \cdot m \cdot g + f_{y1} \cdot CS_1 + \dots + f_{yn} \cdot CS_n \\ \text{Longitudinal sliding: } F_x &\leq \mu \cdot (m \cdot g - F_z) + f_{x1} \cdot CS_1 + \dots + f_{xn} \cdot CS_n \\ \text{Transverse tipping: } F_y \cdot a &\leq b \cdot m \cdot g + 0.9(CS_1 \cdot c_1 + CS_2 \cdot c_2 + \dots + CS_n \cdot c_n) \end{aligned}$$

**Caution:**

Securing devices which have a vertical angle  $\alpha$  of less than  $45^\circ$  in combination with horizontal angle  $\beta$  greater than  $45^\circ$  should not be used in the balance of transverse tipping in the above formula.

All symbols used in these formulae have the same meaning as defined in paragraph 7.2 except  $f_y$  and  $f_x$ , obtained from table 7, and CS is as follows:

$$CS = \frac{MSL}{1.35}$$

A calculated example for this method is shown in appendix 1 of annex 13.

**Table 7 -  $f_x$  values and  $f_y$  values as a function of  $\alpha$ ,  $\beta$  and  $\mu$**

**Table 7.1 for  $\mu = 0.4$**

$\beta$ for $f_y$	$\alpha$														$\beta$ for $f_x$
	-30	-20	-10	0	10	20	30	40	45	50	60	70	80	90	
0	0.67	0.80	0.92	1.00	1.05	1.08	1.07	1.02	0.99	0.95	0.85	0.72	0.57	0.40	90
10	0.65	0.79	0.90	0.98	1.04	1.06	1.05	1.01	0.98	0.94	0.84	0.71	0.56	0.40	80
20	0.61	0.75	0.86	0.94	0.99	1.02	1.01	0.98	0.95	0.91	0.82	0.70	0.56	0.40	70
30	0.55	0.68	0.78	0.87	0.92	0.95	0.95	0.92	0.90	0.86	0.78	0.67	0.54	0.40	60
40	0.46	0.58	0.68	0.77	0.82	0.86	0.86	0.84	0.82	0.80	0.73	0.64	0.53	0.40	50
50	0.36	0.47	0.56	0.64	0.70	0.74	0.76	0.75	0.74	0.72	0.67	0.60	0.51	0.40	40
60	0.23	0.33	0.42	0.50	0.56	0.61	0.63	0.64	0.64	0.63	0.60	0.55	0.48	0.40	30
70	0.10	0.18	0.27	0.34	0.41	0.46	0.50	0.52	0.52	0.53	0.52	0.49	0.45	0.40	20
80	-0.05	0.03	0.10	0.17	0.24	0.30	0.35	0.39	0.41	0.42	0.43	0.44	0.42	0.40	10
90	-0.20	-0.14	-0.07	0.00	0.07	0.14	0.20	0.26	0.28	0.31	0.35	0.38	0.39	0.40	0

**Table 7.2 for  $\mu = 0.3$**

$\beta$ for $f_y$	$\alpha$														$\beta$ for $f_x$
	-30	-20	-10	0	10	20	30	40	45	50	60	70	80	90	
0	0.72	0.84	0.93	1.00	1.04	1.04	1.02	0.96	0.92	0.87	0.76	0.62	0.47	0.30	90
10	0.70	0.82	0.92	0.98	1.02	1.03	1.00	0.95	0.91	0.86	0.75	0.62	0.47	0.30	80
20	0.66	0.78	0.87	0.94	0.98	0.99	0.96	0.91	0.88	0.83	0.73	0.60	0.46	0.30	70
30	0.60	0.71	0.80	0.87	0.90	0.92	0.90	0.86	0.82	0.79	0.69	0.58	0.45	0.30	60
40	0.51	0.62	0.70	0.77	0.81	0.82	0.81	0.78	0.75	0.72	0.64	0.54	0.43	0.30	50
50	0.41	0.50	0.58	0.64	0.69	0.71	0.71	0.69	0.67	0.64	0.58	0.50	0.41	0.30	40
60	0.28	0.37	0.44	0.50	0.54	0.57	0.58	0.58	0.57	0.55	0.51	0.45	0.38	0.30	30
70	0.15	0.22	0.28	0.34	0.39	0.42	0.45	0.45	0.45	0.45	0.43	0.40	0.35	0.30	20
80	0.00	0.06	0.12	0.17	0.22	0.27	0.30	0.33	0.33	0.34	0.35	0.34	0.33	0.30	10
90	-0.15	-0.10	-0.05	0.00	0.05	0.10	0.15	0.19	0.21	0.23	0.26	0.28	0.30	0.30	0

Table 7.3 for  $\mu = 0.2$ 

$\beta$ for $f_y$	$\alpha$														$\beta$ for $f_x$
	-30	-20	-10	0	10	20	30	40	45	50	60	70	80	90	
0	0.77	0.87	0.95	1.00	1.02	1.01	0.97	0.89	0.85	0.80	0.67	0.53	0.37	0.20	90
10	0.75	0.86	0.94	0.98	1.00	0.99	0.95	0.88	0.84	0.79	0.67	0.52	0.37	0.20	80
20	0.71	0.81	0.89	0.94	0.96	0.95	0.91	0.85	0.81	0.76	0.64	0.51	0.36	0.20	70
30	0.65	0.75	0.82	0.87	0.89	0.88	0.85	0.79	0.75	0.71	0.61	0.48	0.35	0.20	60
40	0.56	0.65	0.72	0.77	0.79	0.79	0.76	0.72	0.68	0.65	0.56	0.45	0.33	0.20	50
50	0.46	0.54	0.60	0.64	0.67	0.67	0.66	0.62	0.60	0.57	0.49	0.41	0.31	0.20	40
60	0.33	0.40	0.46	0.50	0.53	0.54	0.53	0.51	0.49	0.47	0.42	0.36	0.28	0.20	30
70	0.20	0.25	0.30	0.34	0.37	0.39	0.40	0.39	0.38	0.37	0.34	0.30	0.26	0.20	20
80	0.05	0.09	0.14	0.17	0.21	0.23	0.25	0.26	0.26	0.26	0.26	0.25	0.23	0.20	10
90	-0.10	-0.07	-0.03	0.00	0.03	0.07	0.10	0.13	0.14	0.15	0.17	0.19	0.20	0.20	0

Table 7.4 for  $\mu = 0.1$ 

$\beta$ for $f_y$	$\alpha$														$\beta$ for $f_x$
	-30	-20	-10	0	10	20	30	40	45	50	60	70	80	90	
0	0.82	0.91	0.97	1.00	1.00	0.97	0.92	0.83	0.78	0.72	0.59	0.44	0.27	0.10	90
10	0.80	0.89	0.95	0.98	0.99	0.96	0.90	0.82	0.77	0.71	0.58	0.43	0.27	0.10	80
20	0.76	0.85	0.91	0.94	0.94	0.92	0.86	0.78	0.74	0.68	0.56	0.42	0.26	0.10	70
30	0.70	0.78	0.84	0.87	0.87	0.85	0.80	0.73	0.68	0.63	0.52	0.39	0.25	0.10	60
40	0.61	0.69	0.74	0.77	0.77	0.75	0.71	0.65	0.61	0.57	0.47	0.36	0.23	0.10	50
50	0.51	0.57	0.62	0.64	0.65	0.64	0.61	0.56	0.53	0.49	0.41	0.31	0.21	0.10	40
60	0.38	0.44	0.48	0.50	0.51	0.50	0.48	0.45	0.42	0.40	0.34	0.26	0.19	0.10	30
70	0.25	0.29	0.32	0.34	0.35	0.36	0.35	0.33	0.31	0.30	0.26	0.21	0.16	0.10	20
80	0.10	0.13	0.15	0.17	0.19	0.20	0.20	0.20	0.19	0.19	0.17	0.15	0.13	0.10	10
90	-0.05	-0.03	-0.02	0.00	0.02	0.03	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.10	0

Table 7.5 for  $\mu = 0.0$ 

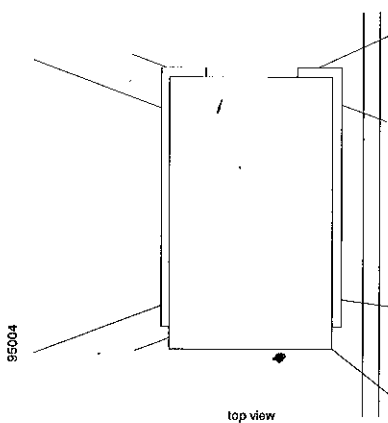
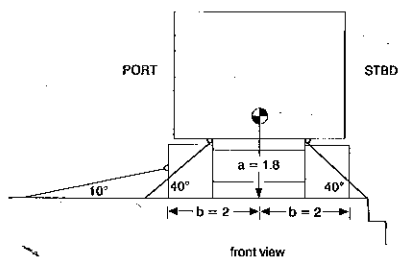
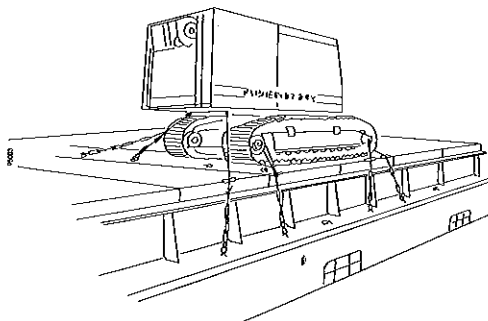
$\beta$ for $f_y$	$\alpha$														$\beta$ for $f_x$
	-30	-20	-10	0	10	20	30	40	45	50	60	70	80	90	
0	0.87	0.94	0.98	1.00	0.98	0.94	0.87	0.77	0.71	0.64	0.50	0.34	0.17	0.00	90
10	0.85	0.93	0.97	0.98	0.97	0.93	0.85	0.75	0.70	0.63	0.49	0.34	0.17	0.00	80
20	0.81	0.88	0.93	0.94	0.93	0.88	0.81	0.72	0.66	0.60	0.47	0.32	0.16	0.00	70
30	0.75	0.81	0.85	0.87	0.85	0.81	0.75	0.66	0.61	0.56	0.43	0.30	0.15	0.00	60
40	0.66	0.72	0.75	0.77	0.75	0.72	0.66	0.59	0.54	0.49	0.38	0.26	0.13	0.00	50
50	0.56	0.60	0.63	0.64	0.63	0.60	0.56	0.49	0.45	0.41	0.32	0.22	0.11	0.00	40
60	0.43	0.47	0.49	0.50	0.49	0.47	0.43	0.38	0.35	0.32	0.25	0.17	0.09	0.00	30
70	0.30	0.32	0.34	0.34	0.34	0.32	0.30	0.26	0.24	0.22	0.17	0.12	0.06	0.00	20
80	0.15	0.16	0.17	0.17	0.17	0.16	0.15	0.13	0.12	0.11	0.09	0.06	0.03	0.00	10
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

Remark:  $f_y = \cos \alpha \cdot \cos \beta + \mu \cdot \sin \alpha$        $f_x = \cos \alpha \cdot \sin \beta + \mu \cdot \sin \alpha$

## Appendix 1 of annex 13

**Calculated example 1**

(refer to paragraph 7.2, Balance of forces and moments)

Ship:  $L = 120$  m;  $B = 20$  m;  $GM = 1.4$  m; speed = 15 knotsCargo:  $m = 62$  t; dimensions =  $6 \times 4 \times 4$  m;  
stowage at  $0.7L$  on deck, low

**Securing material:**

wire rope: . . . . . breaking strength = 125 kN;  
 MSL = 100 kN  
 shackles, turnbuckles, deck rings: breaking strength = 180 kN;  
 MSL = 90 kN  
 stowage on dunnage boards: . . . . .  $\mu = 0.3$ ; CS =  $90/1.5 = 60$  kN

**Securing arrangement:**

side	n	CS	$\alpha$	f	c
STBD	4	60 kN	40°	0.96	—
PORT	2	60 kN	40°	0.96	—
PORT	2	60 kN	10°	1.04	—

**External forces:**

$$F_x = 2.9 \times 0.89 \times 62 + 16 + 8 = 184 \text{ kN}$$

$$F_y = 6.3 \times 0.89 \times 62 + 24 + 12 = 384 \text{ kN}$$

$$F_z = 6.2 \times 0.89 \times 62 = 342 \text{ kN}$$

**Balance of forces (STBD arrangement):**

$$384 < 0.3 \times 62 \times 9.81 + 4 \times 60 \times 0.96$$

$$384 < 412 \quad \text{this is OK!}$$

**Balance of forces (PORT arrangement):**

$$384 < 0.3 \times 62 \times 9.81 + 2 \times 60 \times 0.96 + 2 \times 60 \times 1.04$$

$$384 < 422 \quad \text{this is OK!}$$

**Balance of moments:**

$$384 \cdot 1.8 < 2 \times 62 \times 9.81$$

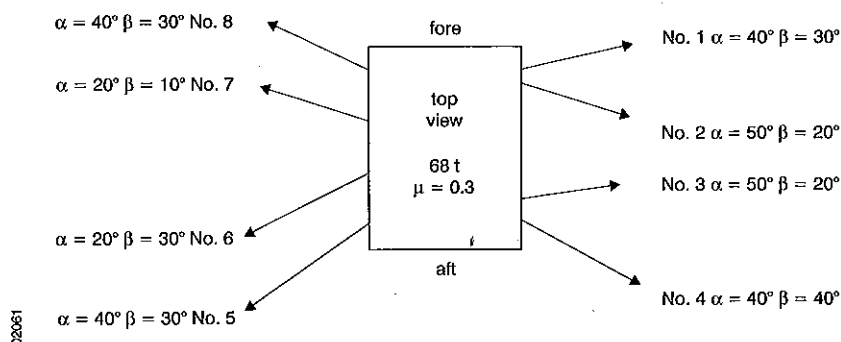
$$691 < 1216 \quad \text{no tipping, even without lashings!}$$

## Calculated example 2

(refer to paragraph 7.3, Balance of forces - alternative method)

A cargo unit of 68 t mass is stowed on timber ( $\mu = 0.3$ ) in the 'tween deck at 0.7L of a vessel.  $L = 160$  m,  $B = 24$  m,  $v = 18$  kn and  $GM = 1.5$  m. Dimensions of the cargo unit are height = 2.4 m and width = 1.8 m. The external forces are:  $F_x = 112$  kN,  $F_y = 312$  kN,  $F_z = 346$  kN.

The top view shows the overall securing arrangement with eight lashings.



### Calculation of balance of forces:

No.	MSL (kN)	CS (kN)	$\alpha$	$\beta$	$f_y$	$CS \times f_y$	$f_x$	$CS \times f_x$
1	108	80	40° stbd	30° fwd	0.86	68.8 stbd	0.58	46.4 fwd
2	90	67	50° stbd	20° aft	0.83	55.6 stbd	0.45	30.2 aft
3	90	67	50° stbd	20° fwd	0.83	55.6 stbd	0.45	30.2 fwd
4	108	80	40° stbd	40° aft	0.78	62.4 stbd	0.69	55.2 aft
5	108	80	40° port	30° aft	0.86	68.8 port	0.58	46.4 aft
6	90	67	20° port	30° aft	0.99	66.3 port	0.57	38.2 aft
7	90	67	20° port	10° fwd	1.03	69.0 port	0.27	18.1 fwd
8	108	80	40° port	30° fwd	0.86	68.8 port	0.58	46.4 fwd

### Transverse balance of forces (STBD arrangement) Nos. 1, 2, 3 and 4:

$$312 < 0.3 \times 68 \times 9.81 + 68.8 + 55.6 + 55.6 + 62.4$$

$$312 < 443 \quad \text{this is OK!}$$

### Transverse balance of forces (PORT arrangement) Nos. 5, 6, 7 and 8:

$$312 < 0.3 \times 68 \times 9.81 + 68.8 + 66.3 + 69.0 + 68.8$$

$$312 < 473 \quad \text{this is OK!}$$

**Longitudinal balance of forces (FWD arrangement) Nos. 1, 3, 7, 8:**

$$112 < 0.3(68 \times 9.81 - 346) + 46.4 + 30.2 + 18.1 + 46.4$$

$$112 < 237 \quad \text{this is OK!}$$

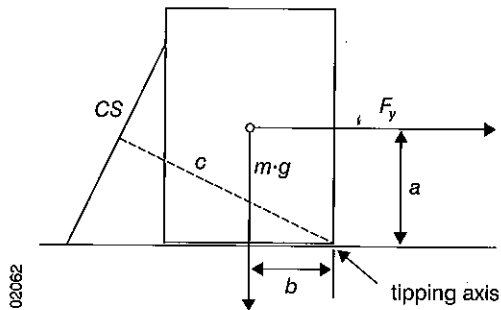
**Longitudinal balance of forces (AFT arrangement) Nos. 2, 4, 5, 6:**

$$112 < 0.3(68 \times 9.81 - 346) + 30.2 + 55.2 + 46.4 + 38.2$$

$$112 < 266 \quad \text{this is OK!}$$

**Transverse tipping**

Unless specific information is provided, the vertical centre of gravity of the cargo unit can be assumed to be at one half the height and the transverse centre of gravity at one half the width. Also, if the lashing is connected as shown in the sketch, instead of measuring  $c$ , the length of the lever from the tipping axis to the lashing CS, it is conservative to assume that it is equal to the width of the cargo unit.



$$F_y \cdot a \leq b \cdot m \cdot g + 0.9 \cdot (CS_1 \cdot c_1 + CS_2 \cdot c_2 + CS_3 \cdot c_3 + CS_4 \cdot c_4)$$

$$312 \times 2.4/2 < 1.8/2 \times 68 \times 9.81 + 0.9 \times 1.8 \times (80 + 67 + 67 + 80)$$

$$374 < 600 + 476$$

$$374 < 1076 \quad \text{this is OK!}$$

## Appendix 2 of annex 13

**Explanations and interpretation of "Methods to assess the efficiency of securing arrangements for non-standardized cargo"**

- 1 The exclusion of very heavy units as carried under the provisions of chapter 1.8 of the Code from the scope of application of the methods should be understood to accommodate the possibility of adapting the stowage and securing of such units to specifically determined weather conditions and sea conditions during transport. The exclusion should not be understood as being a restriction of the methods to units up to a certain mass or dimension.
- 2 The acceleration figures given in table 2, in combination with the correction factors, represent peak values on a 25-day voyage. This does not imply that peak values in x, y and z directions occur simultaneously with the same probability. It can be generally assumed that peak values in the transverse direction will appear in combination with less than 60% of the peak values in longitudinal and vertical directions.

Peak values in longitudinal and vertical directions may be associated more closely because they have the common source of pitching and heaving.

- 3 The advanced calculation method uses the "worst case approach". That is expressed clearly by the transverse acceleration figures, which increase to forward and aft in the ship and thereby show the influence of transverse components of simultaneous vertical accelerations. Consequently there is no need to consider vertical accelerations separately in the balances of transverse forces and moments. These simultaneously acting vertical accelerations create an apparent increase of weight of the unit and thus increase the effect of the friction in the balance of forces and the moment of stability in the balance of moments. For this reason there is no reduction of the force  $m \cdot g$  normal to the deck due to the presence of an angle of heel.

The situation is different for the longitudinal sliding balance. The worst case would be a peak value of the longitudinal force  $F_x$  accompanied by an extreme reduction of weight through the vertical force  $F_z$ .

- 4 The friction coefficients shown in the methods are somewhat reduced against appropriate figures in other publications. The reason for this should be seen in various influences which may appear in practical shipping, as: moisture, grease, oil, dust and other residues, vibration of the ship.

There are certain stowage materials available which are said to increase friction considerably. Extended experience with these materials may bring additional coefficients into practical use.

- 5 The principal way of calculating forces within the securing elements of a complex securing arrangement should necessarily include the consideration of:

- load-elongation behaviour (elasticity),
- geometrical arrangement (angles, length),
- pre-tension

of each individual securing element.

This approach would require a large volume of information and a complex, iterative calculation. The results would still be doubtful due to uncertain parameters.

Therefore the simplified approach was chosen with the assumption that the elements take an even load of CS (calculated strength) which is reduced against the MSL (maximum securing load) by the safety factor.

- 6 When employing the advanced calculation method, the way of collecting data should be followed as shown in the calculated example. It is acceptable to estimate securing angles, to take average angles for a set of lashings and similarly to arrive at reasonable figures of the levers *a*, *b* and *c* for the balance of moments.

It should be borne in mind that meeting or missing the balance calculation just by a tiny change of one or the other parameters indicates to be near the limit anyway. There is no clear-cut borderline between safety and non-safety. If in doubt, the arrangement should be improved.