Genesis and recent revision of the Annex 13

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Introduction

In the early 1980s IMO had started to take a closer look to problems associated to the securing of cargoes other than containers in dedicated containerships. The initiative, so it appears today, came particularly from Sweden, who had observed some major accidents in their fleet of ro-ro-ships. But there was consensus among all IMO member states that something had to be done to compensate the negative effects from novel shipping and transport techniques and also from an apparent decay of traditional good seamanship.

In 1990 the first edition of the CSS-Code was completed and adopted by the Assembly in late 1991. This first edition already contained the three categories of "standardised stowage and securing systems", "semi-standardised stowage and securing" and "non-standardised stowage and securing". The first category was and is still taken care by technical rules of classification societies. The other two categories, however, were fairly left to the appreciation of stevedores and ship staff regarding the question "How much securing is needed?" in a given situation. To answer this question the introduction of a simple calculation method was proposed by some member states for further enhancing the CSS-Code.

This simple calculation method was developed in the years 1991 to 1994, and it was not easy to convince the plenary of the DSC-Sub-Committee at that time of the feasibility of this idea. Comments from some delegates like "We don't need this" or "That's too difficult for our poor seafarers" had to be overcome, while their true mistrust was related to suspected cost of proper cargo securing.

Eventually, a new Annex 13 to the CSS-Code containing the envisaged calculation method was approved by the Sub-Committee and adopted by MSC at its 65th session in 1995. This is now a good quarter of a century ago and since then the Annex 13 has been subjected twice to substantial revisions initiated by the shipping industry. That may be taken as a proof of its usefulness, feasibility and overall acceptance.

The character of the calculation method is similar to that used by classification societies for container stowage. Load assumptions of an agreed level of exceedance probability are confronted with the capacity of the selected securing arrangement, and these balances, separately taken for sliding and tipping of the cargo unit in question, should be "positive", i.e. with the greater figures on the securing side. Worth to emphasize, the method does not tell the user how to secure cargo but assures whether the chosen concept was or will be sufficient.

The core issue of the first revision, adopted by MSC in 2002, was the introduction of an "alternative calculation method", which also takes horizontal securing angles of lashings into account, however, at the expense of less convenient performance. The use of a suitable spread sheet is a must with this method, while the original more simple calculation can be performed with a pocket computer on a piece of paper the size of a beer mat.

1. Revision in 2019

The second major revision of the Annex 13 was finalised by the CCC Sub-Committee in September 2019 and adopted (Corona delayed) by MSC in November 2020. The key points of the revision are explained and commented in this presentation, assuming a reader who is fairly familiar with the former version of the Annex 13.

1.1 Expansion of scope of application (Chapter 1)

Following the broad employment of the Annex 13 by the industry, the scope of application of this Annex has from now on been expanded to explicitly include semi-standardised cargoes, and a new Appendix 4 was included, containing "Advanced provisions and considerations applicable to semi-standardized cargoes". Also the earlier reservation regarding the applicability for "very heavy cargo items" was clarified with reference to a new Appendix 3, containing "Advanced provisions and considerations applicable to very heavy and/or very large cargo items".

1.2 Welded stoppers (Paragraphs 4.5 and 4.6)

Provisional welding of stoppers, mainly for sliding prevention, in 1994 being a strict "taboo" in the eyes of classification societies and therefore not at all mentioned in the earlier Annex 13, has now been cautiously included on the basis of a rule of thumb. The text has to be taken literally as 4 kN per cm length of welded seam. The included Figure 16.1 shows seams on both sides of the plate and both seams lengths shall be added accordingly.

1.3 Warning of inhomogeneous securing arrangements (Paragraph 6.3)

This new text warns of parallel arrangement of stiff and flexible securing devices and limits their contribution in a calculated securing balance.

1.4 Operation in restricted areas (Paragraphs 7.1.3 to 7.1.6)

A major lack of clarification, the reduction of assumed accelerations for operation in a restricted area, has now been settled with the provision of computable facts. This matter had been persistently discussed for years under the heading "weather dependent lashing", particularly in the "Lashing@Sea" project.

The solution is a simple heuristic formula that presents a reduction factor f_R to be applied to the accelerations obtained from the existing tables 2 to 4 in the Annex 13. This factor depends on the maximum (predicted or stochastic) significant wave height Hs during the intended voyage. There is no reduction in waves greater than Hs = 12 metres.

$$f_R = 1 - \frac{(Hs - 13)^2}{240}$$

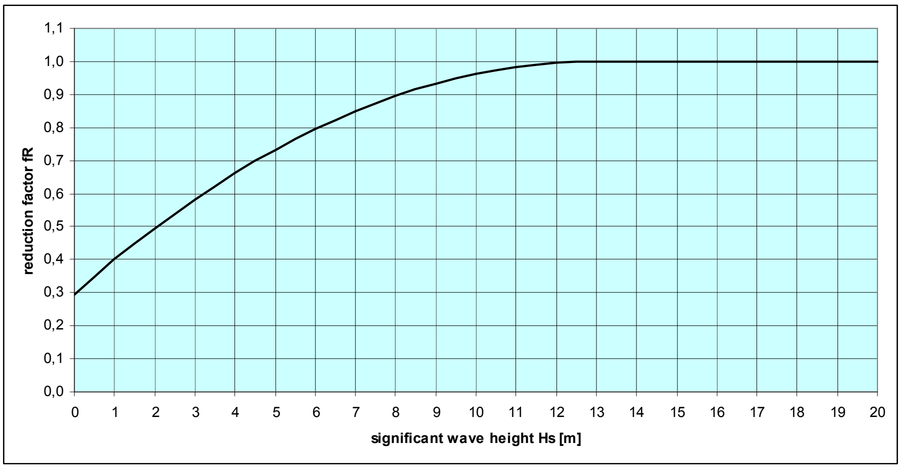

Fig. 1: Reduction factor for accelerations in restricted area

The figure of Hs is alternatively:

1. the maximum expected 20-year significant wave height in the area according to ocean wave statistics; or
2. the maximum predicted significant wave height on which the operational limitations are based; or
3. for voyages not exceeding 72 hours the maximum predicted significant wave height according to weather forecasts.

The application of the reduction is linked to operational procedures, specified in Paragraph 7.1.6, which require relevant instructions to be laid down in the Cargo Securing Manual or otherwise in the ship's safety management system.

A side note is, that the former mentioning of the duration of the voyage of 25 days in Paragraph 7.1.2 has been deleted in this context, although it still provides one important parameter for the basic acceleration data in Table 2.

1.5 Ships with large GM-values (Paragraph 7.1.8)

Another minor amendment, yet often requested by users, is the extension of table 4 for ships with extremely large GM-values. The hitherto applied extrapolation of this table for B/GM-relations less than 7 had provided unreasonably large factors. Thus an extension was modelled in consent with classification rules, leaving the previous figures unchanged.

B/GM	3	4	5	6	7	8	9	10	11	12	13 or above
on deck, high	2.64	2.28	1.98	1.74	1.56	1.40	1.28	1.19	1.11	1.05	1.00
on deck, low	2.18	1.93	1.72	1.55	1.42	1.30	1.21	1.14	1.09	1.04	1.00
'tween deck	1.62	1.51	1.41	1.33	1.26	1.19	1.14	1.10	1.06	1.03	1.00
lower hold	1.24	1.23	1.20	1.18	1.15	1.12	1.09	1.06	1.04	1.02	1.00

1.6 Consideration of friction increasing material (Paragraph 7.2.3)

Dedicated friction increasing material had previously been mentioned in the Annex 13 in a very conservative manner in the Appendix 2, item 4. Now a more constructive advice is given, yet combined with indications of limiting influences and again demanding specific instructions in the ship's Cargo Securing Manual.

1.7 Longitudinal sliding balance (Paragraph 7.2.6.1)

Another small but remarkable change regards the coincidence of longitudinal and vertical accelerations. For securing cargo in the longitudinal direction of the ship the "worst case" had been identified with the coincidence of maximum longitudinal acceleration and simultaneous maximum upward vertical acceleration. This coincidence reduces the friction to the ground as well as the resistance against tipping.

The practical application of this algorithm during the last 25 years had persuaded many users that this approach was "too harsh". A closer look and analysis of the mutual relation of simultaneous longitudinal and vertical accelerations has resulted in the introduction of a correction factor f_z which gently reduces the simultaneous vertical acceleration. Thus the future longitudinal sliding balance will read:

$$Fx \leq \mu \cdot (m \cdot g - f_z \cdot Fz) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$$

where f_z is a correction factor for the vertical force, depending on the bottom friction μ following a small table.

μ	0.0	0.1	0.2	0.3	0.4	0.6
f_z	0.20	0.50	0.70	0.80	0.85	0.90

At the first glance the role of friction in this context surprises. But with a closer look it becomes clear that the influence of simultaneous vertical accelerations on the securing demand is linked to the friction. Thus, in order to obtain a certain justified relief of securing effort the decrease of the detrimental upward vertical acceleration must be greater with small friction coefficients. That is shown in the table. This table has of course been developed by accurate analysis of the matter.

1.8 Modification of the term "service speed" (Paragraph 7.2.6.3)

The role of the ship's service speed is in principle linked to the acceleration correction factor for length and speed in Table 3. The reason for conceding a modification under the issue of "longitudinal sliding" is the up to now unfruitful application of the Annex 13 regime for certain deck cargoes like pipes or bundled timber. Such cargoes are difficult to secure against longitudinal sliding and the prevention of cargo shifting in head seas is practically based on deliberate speed reduction.

Therefore a reduced operational speed may be explicitly used for determining longitudinal and vertical accelerations in the assessment of the longitudinal securing arrangement. Again, this procedure shall be guided by instructions and control measures specified in the ship's Cargo Securing Manual. Transverse accelerations are excluded from this relaxation.

1.9 New Appendix 3 to the Annex 13

The unhesitant application of the Annex 13 for large and heavy cargo items by the industry in the past 25 years has initiated a number of useful amendments. In order not to disturb the present straight forward structure of the main body of the Annex the working group in CCC 6 has decided to adjoin a new Appendix 3 for accommodating these amendments, as already mentioned above. This appendix with the title **"Advanced Provisions and Considerations Applicable to Very Heavy and/or Large Cargo Items"** deals with the following issues:

1.9.1 Longitudinal tipping (Paragraph 1)

Although the risk of longitudinal tipping is not restricted to heavy and/or large cargo items, this aspect has been embedded into this appendix for "editorial reasons". The respective balance formula reads:

$$Fx \cdot a \leq b \cdot (m \cdot g - f_z \cdot F_z) + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n \quad [kN \cdot m]$$

where the factor f_z is obtained by the applicable relation of b/a from a small table:

b/a	0.1	0.2	0.3	0.4	0.6	1.0	2.0	3.0
$\mathbf{f_Z}$	0.50	0.70	0.80	0.85	0.90	0.94	0.98	1.00

The logical source of this table is the same as for the longitudinal sliding balance. The term "a" represents the vertical distance and the term "b" the horizontal distance of the cargo centre of gravity from its tipping axis. A critical relation b/a can be greater than 0.6. The table has been extended accordingly.

1.9.2 Rotational inertia of large cargo items (Paragraph 2)

The algorithm generally used for defining the tipping moment acting on a distinct cargo item replaces the physical extent of the item by its centre of gravity. For this "point mass" the tipping moment depends only on its vertical distance to the tipping axis.

Larger items, however, will develop a substantial additional tipping moment by their rotational inertia against the rotational acceleration of the ship in rolling or pitching motions. This additional tipping moment M_{add} is independent from the stowage position of the item in the ship and is always positive, i.e. intensifying the tipping impulse and therefore requires additional securing measures. Thus it must be added to the ordinary tipping moment $F_{x,y} \cdot a$.

It is obvious that most shippers will have problems to supply a figures of the transverse and longitudinal rotational inertia of their cargo items. Therefore the complex computation of such figures has been replaced by simple approximations with two options:

- homogeneous mass distribution within the cargo item or
- peripheral mass concentration of the cargo item.

Cargo items with peripheral mass concentration (e.g. hollow bodies) present the greater rotational inertia. The correct value will in most cases remain between the two options.

Transverse tipping:

$$M_{add} = m \cdot \left(\frac{w^2 + h^2}{12} \right) \cdot \frac{36 \cdot GM}{B^2} \ [kN{\cdot}m]$$ for homogeneous mass distribution

$$M_{add} = m \cdot \left(\frac{(w + h)^2}{12} \right) \cdot \frac{36 \cdot GM}{B^2} \ [kN{\cdot}m]$$ for peripheral mass concentration

Longitudinal tipping:

$$M_{add} = m \cdot \left(\frac{l^2 + h^2}{12} \right) \cdot \frac{25}{L} \ [kN{\cdot}m]$$ for homogeneous mass distribution

$$M_{add} = m \cdot \left(\frac{(l + h)^2}{12} \right) \cdot \frac{25}{L} \ [kN{\cdot}m]$$ for peripheral mass concentration

m = mass of cargo item [t]
l = length of cargo item [m]
w = width of cargo item [m]
h = height of cargo item [m]
GM = metacentric height of ship [m]
B = moulded breadth of ship [m]
L = length of ship between perpendiculars [m]

1.9.3 Separate consideration of wind and sea sloshing (Paragraph 3)

This minor amendment encourages the user to compile the external tipping moment with separate tipping levers for inertia forces, wind pressure and impact of heavy water spray, if the vertical positions of centre of gravity, centre of wind attack and centre of spray impact differ markedly.

1.9.4 Interpretation of "on deck high" (Paragraph 4)

The stowage level "on deck high" in table 2 of the Annex 13 has been positioned at a distance above the water line of about 2/3 of the ship's breadth. With extremely large cargo items this level can easily be exceeded. In order to avoid uncertainties in the determination of transverse and longitudinal accelerations in such cases, it is recommended to use the original mathematical model, which is the basis for the acceleration tables in the Annex 13.

This model is now attached in the Appendix 3 and may easily be programmed, e.g. in a suitable spread sheet. The acceleration figures obtained with this model differ only slightly from those obtained with the tables 2 to 4 in the Annex 13 for mathematical reasons. The description of the model reads:

> The longitudinal, transverse and vertical accelerations acting on a cargo item may be obtained by the set of formulas as follows:
>
> $$a_x = c_1 \cdot c_2 \cdot c_3 \cdot a_{x0} \cdot g \ \ [\mathrm{m/s^2}]$$
> $$a_y = c_1 \cdot c_2 \cdot c_3 \cdot a_{y0} \cdot g \ \ [\mathrm{m/s^2}]$$
> $$a_z = c_1 \cdot c_2 \cdot c_3 \cdot a_{z0} \cdot g \ \ [\mathrm{m/s^2}]$$
>
> a_x: longitudinal acceleration (gravity component of pitch included)
> a_y: transverse acceleration (gravity component of roll included)
> a_z: vertical acceleration (component due to static weight not included)
> c_1: correction factor for navigation area, taken as 1.0 worldwide in annex 13
> c_2: correction factor for season, taken as 1.0 for whole year in the annex 13
> c_3: correction factor for 25 navigation days, taken as $0.6 + 0.1 \cdot \log_{10} 25 = 0.74$ in annex 13
>
> $$a_{x0} = \pm a_0 \cdot \sqrt{0.06 + A^2 - 0.25 \cdot A}$$
>
> $$a_{y0} = \pm a_0 \cdot \sqrt{0.6 + 2.5 \cdot \left(\frac{x}{L} + 0.05\right)^2 + K \cdot \left(1 + 0.6 \cdot K \cdot \frac{z}{B}\right)^2}$$
>
> $$a_{z0} = \pm a_0 \cdot \sqrt{1 + \left(5.3 - \frac{45}{L}\right)^2 \cdot \left(\frac{x}{L} + 0.05\right)^2 \cdot \left(\frac{0.6}{C_b}\right)^{3/2}}$$
>
> therein:
>
> $$a_0 = 0.2 \cdot \frac{v}{\sqrt{L}} + \frac{34 - 600/L}{L}; \qquad A = \left(0.7 - \frac{L}{1200} + \frac{5 \cdot z}{L}\right) \cdot \left(\frac{0.6}{C_b}\right)$$
>
> $$K = R \cdot \frac{13 \cdot GM}{B}, \text{ but never less than 1.0;} \qquad R = \left(\frac{B}{7 \cdot GM}\right)^{\left(\frac{GM}{B}\right)}, \text{ but never greater than 1.0}$$
>
> L = length between perpendiculars [m]
> B = moulded breadth of ship [m]
> GM = metacentric height of ship [m]
> C_b = block coefficient of ship
> x = longitudinal distance from amidships to calculating point, positive forward [m]
> z = vertical distance from actual waterline to calculating point, positive upward [m]
> v = service speed [knots]
> g = gravity acceleration = 9.81 [m/s^2]

1.9.5 Structural strength assessment (Paragraph 5)

This little text can beneficially be used for clarification when the matter of concentrated loads on ship structures is discussed between charterer's super-cargo and master of the vessel. It highlights the importance of transferring concentrated loads by purposefully arranged bedding material to the bearing structures of the vessel, instead of blindly trying to spread the concentrated load to a greater area by flooring with vast amounts of timber. In designing a bedding arrangement the stress parameters (shear forces and bending moments) should be observed, which are the basis for the allocation of permissible loads per square metre in the ship's documents.

1.9.6 Weather routeing (Paragraph 6)

Weather routeing services have become an established business today. The text reminds to quality essentials and to the specific routeing criteria for protecting sensitive cargo items against heavy ship motions rather than keeping speed and saving fuel.

1.9.7 Other considerations (Paragraph 7)

The text addresses some issues related to huge deck cargoes:

- observation of sight line requirements,
- unimpeded radar transmission,
- visibility of navigations lights.

1.10 New Appendix 4 to the Annex 13

This appendix with the title **"Advanced Provisions and Considerations Applicable to Semi-Standardised Cargoes"** contains advice that may be considered for the stowage and securing of such cargoes in addition to provisions lined out in Chapter 4, Annex 4 and Annex 13 of the CSS-Code.

1.10.1 Performance factor for short voyages (Paragraph 1)

Semi-standardised cargoes are mainly shipped in ro-ro vessels, where fast cargo handling and dispatch is a crucial service parameter. There is no time for considering individual cargo characteristics. Therefore cargo securing manuals are designed on the basis of maximum vehicle gross weight, unfavourable lashing angles and other enveloping parameters. These pre-conditions sum up to a probabilistic surplus of safety that justifies the application of a performance factor, when using the Annex 13 calculation methods for assessing securing arrangements. The default value of this performance factor is 1.15. That means, the applied securing effort may be given a bonus of 15% under certain operating conditions, which are lined out in the text and must be reflected in the applicable Cargo Securing Manual.

1.10.2 Asymmetrical securing arrangements (Paragraph 2)

This text reminds to make separate balance calculations if a securing arrangement shows distinguished asymmetry of the fore and aft end of a cargo item with regard to securing geometry or friction to the stowage ground. It is not mentioned in the text that this advice may also apply to other, non-standardised cargoes.

1.10.3 Safety factor (Paragraph 3)

The number of unidirectional lashings on most ro-ro cargoes does not exceed two. Therefore the arrangement is close to a state of statical determinacy. This justifies a reduced safety factor of 1.2 for obtaining the CS from an MSL of a lashing following specific advice in the Cargo Securing Manual.

Note: In road traffic this safety factor is 1.00 in fact.

1.10.4 Friction coefficients (Paragraph 4)

This text provides some new friction coefficients for different types of rubber tyres on a steel deck.

1.10.5 Effect of parking brake and wheel chocks (Paragraph 5)

The text considers the limited securing effect of wheel chocks and parking brakes.

2. Comments and recommendations

The above listed revision items of the Annex 13 represent an important step towards proper of cargo securing in a broader scope of application. Yet, there are some comments to be made which might be suitable for the understanding and implementation of the now updated document.

2.1 Safety margins of balance calculations

The brief characterisation of the Annex 13 calculation approach in the introduction above has compared it with the method used by classification societies for securing containers in the standardised mode of stowage. There is, however, one remarkable difference. Containers are units designed and fabricated according to ISO-standards. They have a defined structural stiffness and this stiffness is incorporated by class rules into the transverse balance of forces, differentiated for front-end and door-end of the container. Thus the applied securing concept takes the deformation of the container stack under external loads into account.

Such an approach is, understandably, not feasible for the vast variety of non-standardised cargo items. The Annex 13 balances consequently ignore the elastic deformation of the cargo and of the stowage ground underneath, as well as the elasticity of securing devices and any pre-tension applied. The calculational consideration of these parameters would complicate the securing assessment unduly, not only by the more complex calculations, which in fact could be managed by appropriate software, but in the first place by their restricted availability.

But physics inevitably demand, that securing devices be elongated or compressed to reach their calculated securing force CS under the impact of an external load to the cargo. This is only achieved by the elastic deformation of the cargo item and/or the stowage ground, supported by the flexibility of traditional timber bedding. If this aggregate resilience is not sufficient, the cargo item will slide or tip a little until it is retained by the securing arrangement.

Suitable calculations, supported by full scale tests, have shown what really happens. Cargo items of varied flexibility, stowed on grounds of varied stiffness and secured by arrangements of varied elasticity, create a certain spectrum of combinations of securing forces with bottom friction. The present Annex 13 appears to meet the core of this spectrum quite well.

However, the width of this spectrum justifies the more conservative load assumptions and safety margins presented by the Annex 13. This should be kept in mind by distinguished users who may be tempted to apply – in the manner of cherry pickers – more venturous ship design related acceleration models from classification societies and combine them with the residuary elements of the Annex 13 methods. Such practice demonstrates the acceptance of an unknown risk.

2.2 Application criteria for tipping balances

The newly introduced evaluation of longitudinal tipping and, moreover, of the additional tipping moment, has caused concern about possible extra work load in assessing a securing arrangement. Therefore, the request for simple application criteria came up, but this wish could not really be satisfied, although the text in the Appendix 3 contains a raw guess saying "The additional tipping moment should be applied if $(w^2+h^2) > 50\ m^2$ or $(l^2+h^2) > 50\ m^2$".

A closer look shows that this application criterion is not fail-proof, because it would include any 40'-trailer stowed on a ro-ro ship for checking the additional longitudinal tipping moment.

The truth is, there is no simple criterion available, e.g. like that for transverse tipping of cargo items in road vehicles. There we have a uniform transverse acceleration of 0.5 g and this permits to discard a tipping check if the stabilising lever b is greater than half of the tipping lever a. But on board a vessel we have a variety of transverse accelerations in view of the stowage position and for longitudinal tipping the variation of the vertical acceleration adds to it. Thus the effort to apply the application criterion is the same as for doing the test itself.

A good reason to check the additional tipping moment is anyway given, when the ordinary tipping moment comes close to the critical limit. And the mentioning of the balance of longitudinal tipping in the Appendix 3, dedicated to "very heavy and/or very large cargo items", should not detract from the risk of longitudinal tipping of a box shaped domestic refrigerator stowed in Hatch No.1 of a cargo vessel.

2.3 Welding procedures within cargo securing

Temporary welding of fittings and stoppers has now been addressed. They shall be prepared by "qualified welders in accordance with established welding procedures". This fundamental advice, which certainly includes fire protection measures during welding and also during cutting the fittings after use, should be supplemented by the warning against welding to sensible ship structures made of high tensile steel and to areas adjacent to vulnerable tank coating.

2.4 References to the Cargo Securing Manual

Several new provisions in the revised Annex 13 refer to details to be specified in the Cargo Securing Manual. This means explicitly that the manuals of numerous ships have to be updated before the new provisions can beneficially be applied. These provisions are found in:

Paragraph 7.1.4.2 – Procedures for observing operational limits of significant wave height in the context of using the acceleration reduction factor.

Paragraph 7.1.6 – Procedures to be followed and documented in applying "weather dependent lashing".

Paragraph 7.2.3 – Specific advice on the application and maintenance of special friction increasing material or deck coating.

Paragraph 7.2.6.3 – Conditions and control of deliberate speed reduction in head sea as a supportive element of cargo securing.

Appendix 4, introduction – Conditions to be observed for applying the performance factor.

Appendix 4, item 3 – Instructions for the proper use of a reduced safety factor for determinate securing arrangements.

Final remark:

The amount of small amendments and greater enhancements to the Annex 13 may appear worrying at the first glance. But a closer look will show that the basic structure of the document has been maintained and what is new will readily fit to beneficial application. If, however, still questions arise, GDV will be prepared to procure an answer.