BABV

PENUTUP

Dari hasil tinjauan modifikasi KM. Dobonsolo yang telah dilakukan penulis, maka dapat disimpulkan beberapa hasil yang telah ditemukan oleh penulis, antara lain sebagai berikut:

V.1 KESIMPULAN

a. Dari hasil perhitungan tabel pelat dan pilar yang digunakan setelah kapal dimodifikasi yang telah dilakukan penulis maka dapat diketahui bahwa tebal pelat dan pilar yang digunakan sesuai atau memenuhi persyaratan dari klas BKI.

b. Perbadingan hasil perhitungan tabel pelat dan pilar sebelum dan setelah dimodifikasi adalah sebagai berikut:

a. Tebal pelat

Dek		Frame	Tebal Pelat (t)		Keterangan
			Yang Digunakan	Perhitungan	
Buritan	Dek 3 - 6	5 -24	7,5mm	7,6 mm	Memenuhi syarat
Midship	Dek3	48-88	14mm	13,553 mm	Memenuhi syarat
		88-124	16 mm	16,001 mm	Memenuhi syarat

b. Pillar

Dek		Frame	Pilar			Keterangan
			Dimensi	$A_{S\,req}$	A_p	
Buritan	Dek 2	10	200 x 10 + 100 x 10	3.600 cm^2	3800 m^2	Memenuhi syarat

Midship	Dek2	108	Ø=114,3t=8,6	1.200 cm^2	2854,323 m^2	Memenuhi syarat
	Dek 1	108	Ø=114,3t=8,6	2.000 cm^2	2854,323 m^2	Memenuhi syarat
Buritan	Dek3	172	Ø=4,5" 80 sch	1.300 cm^2	2854,323 m^2	Memenuhi syarat
	Dek2	172	Ø=4,5" 80 sch	3.500 cm^2	3602,839 m^2	Memenuhi syarat

3. Dari tinjauan yang telah dilakukan penulis, modifikasi bentuk konstruksi KM. Dobonsolo dari passenger ship menjadi car passenger cargo ship telah memenuhi persyaratan klasifikasi yang digunakan.

V.2 SARAN

Penulis menyadari bahwa masih banyak kekurangan dalam penulisan Tugas Ahkir ini, baik kurang spesifiknya tinjauan yang dilakukan oleh penulis karena keterbatasan waktu dan kurangnya data - data gambar detail yang diberikan oleh perusahaan terkait.

Penulis berharap dengan tinjauan yang dilakukan ini dapat dijadikan acuan dan mungkin ditinjauan kembali secara detail oleh kawan - kawan mahasiswa –mahasiswi Fakultas Teknologi Kelautan.

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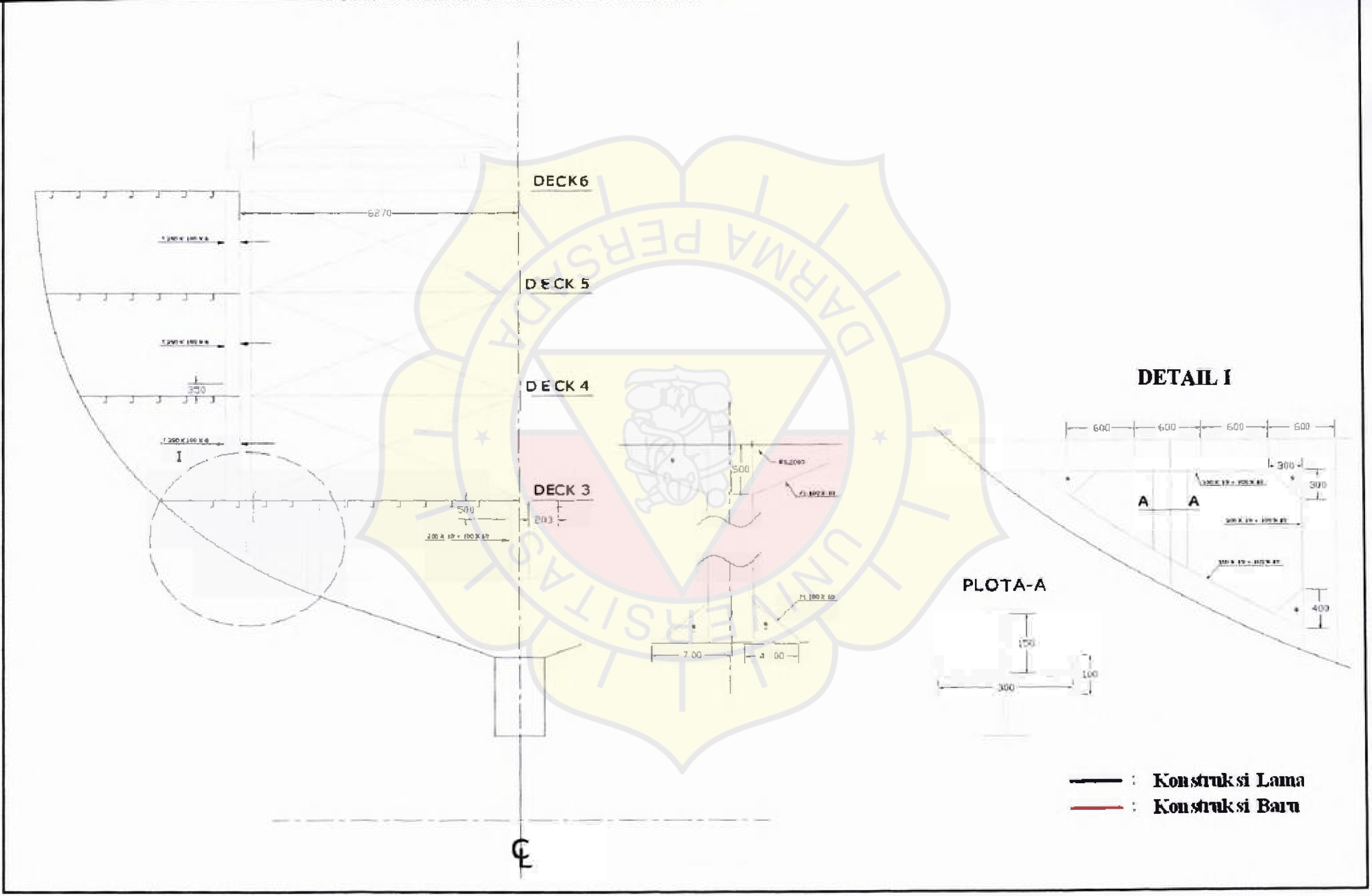
DECK6
6270
DECK 5
DECK 4
350
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DECK 3
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203
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7 00
4 00
DETAIL I
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PLOTA-A
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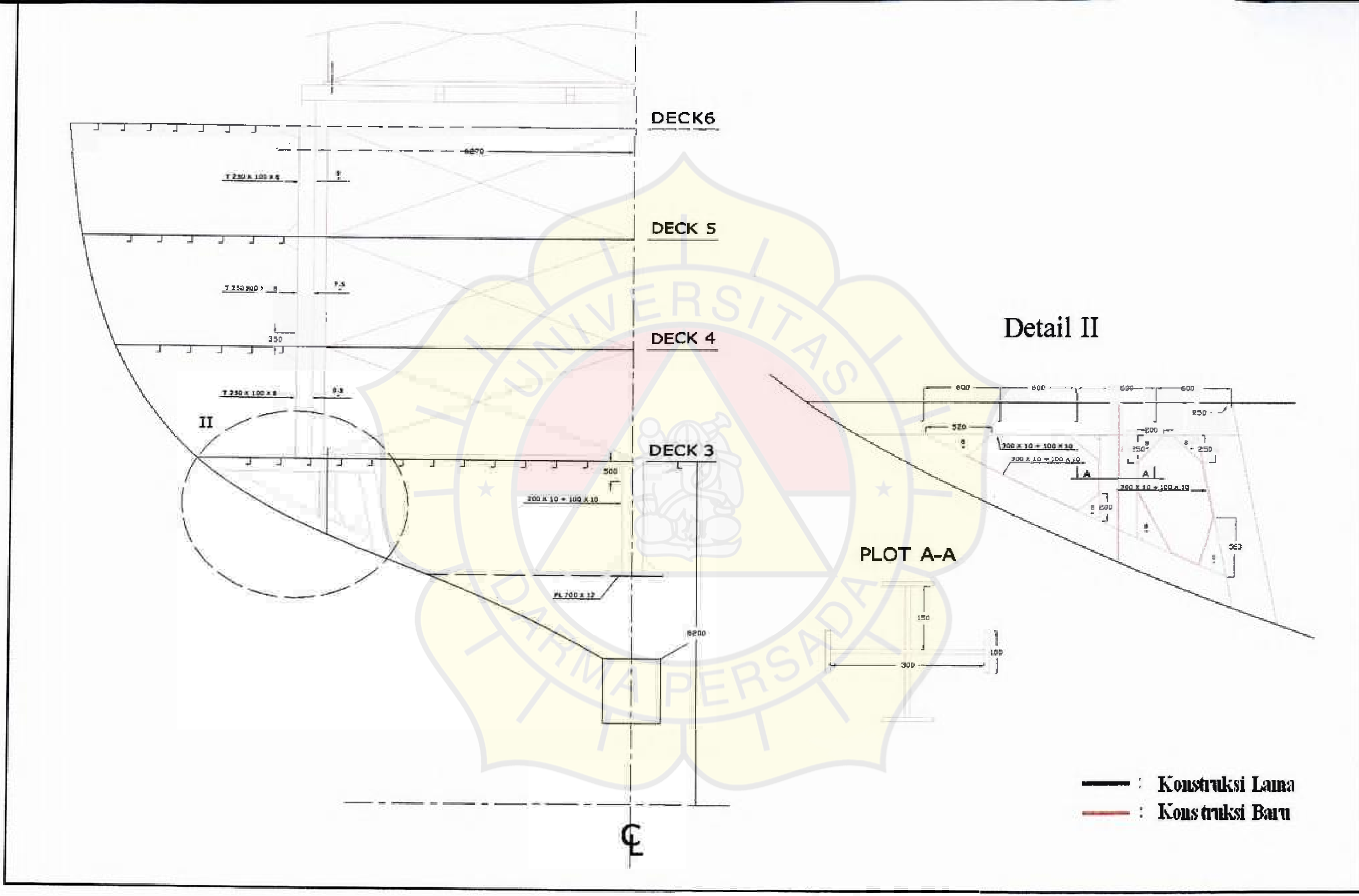
: Konstruksi Lama
: Konstruksi Baru


DECK6
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T 250 x 100 x 8
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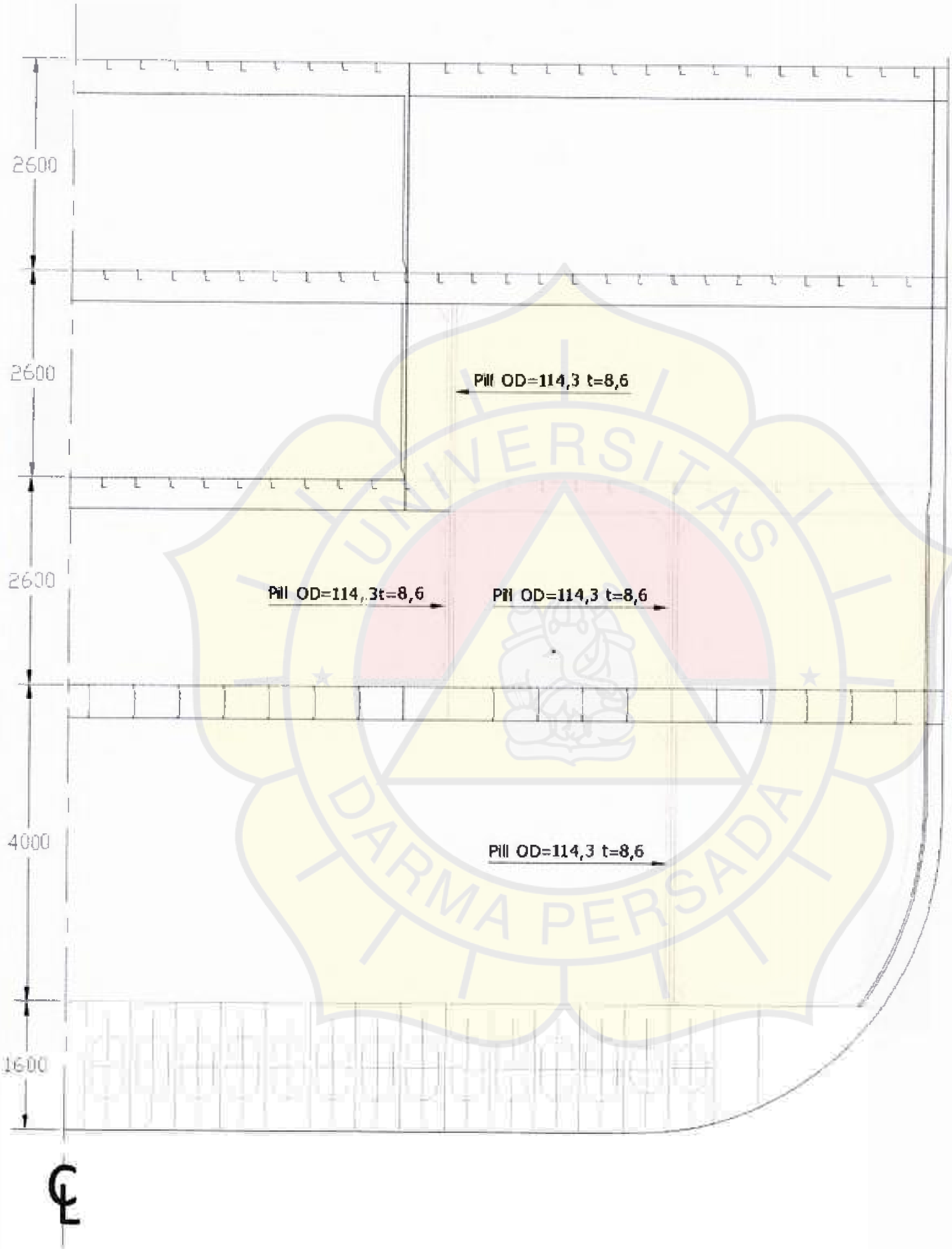
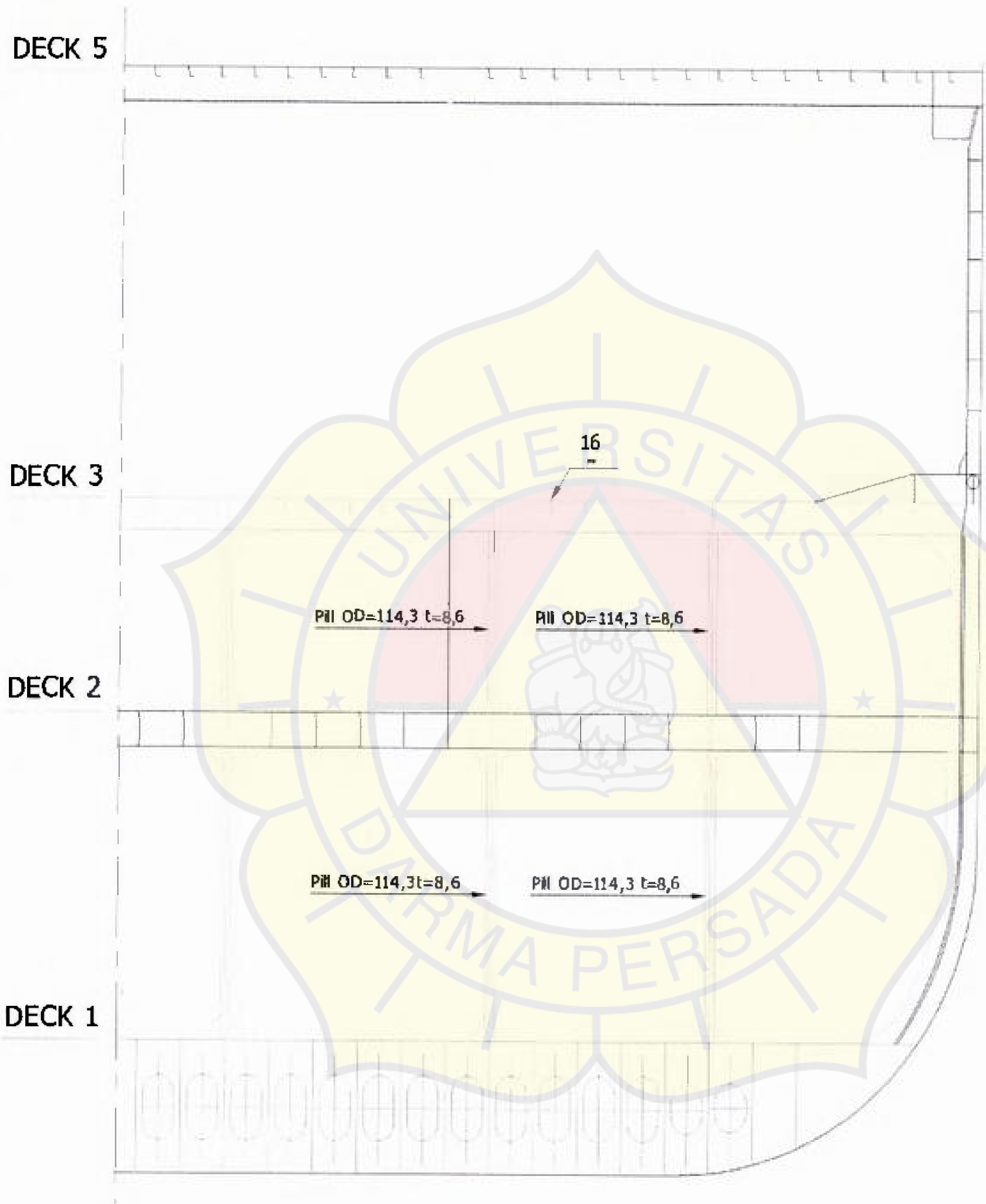
II
200 x 10 + 100 x 10
PL 700 x 12
6200
CL
Detail II
600
520
250
200
300 x 10 + 100 x 10
A
560
PLOT A-A
150
100
300
Konstruksi Lama
Konstruksi Baru

KONSTRUKSI MELINTANG
FRAME68



—— : **Konstruksi Lama**
—— : **Konstruksi Baru**

KONSTRUKSI MELINTANG
FRAME108



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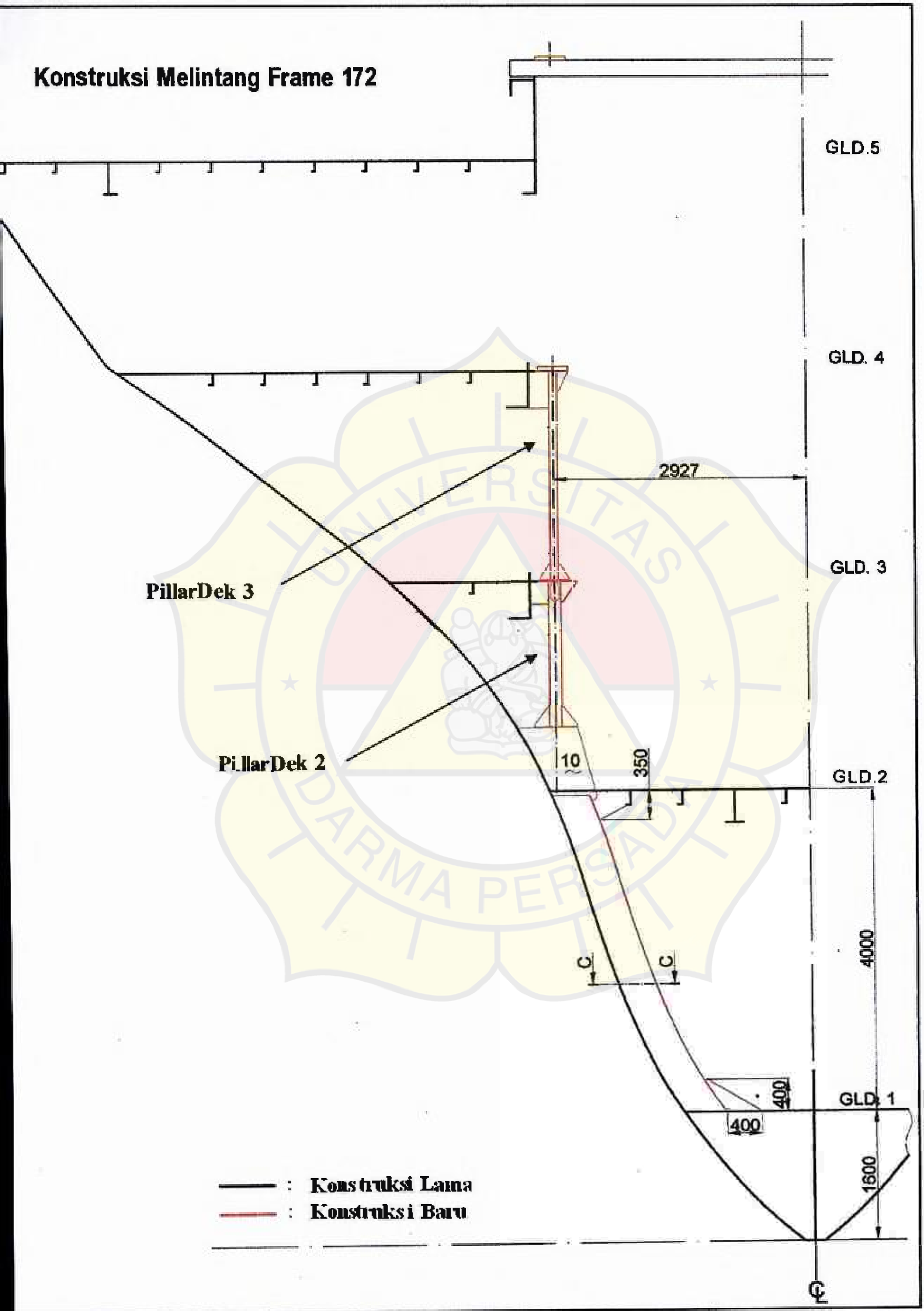
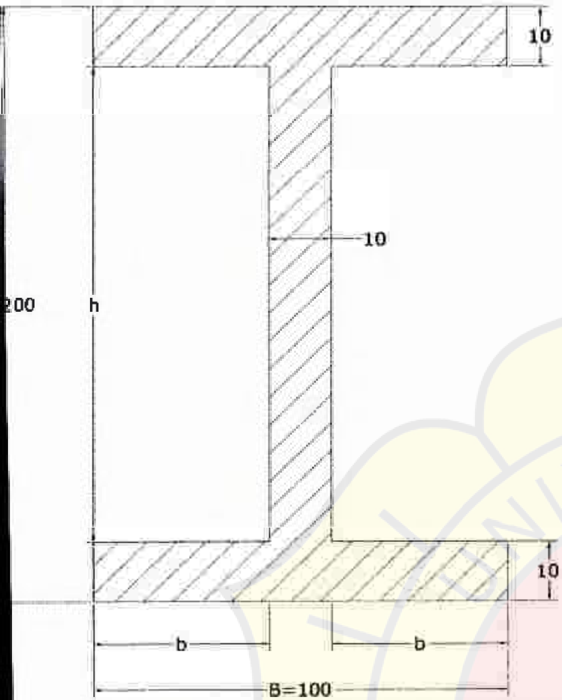
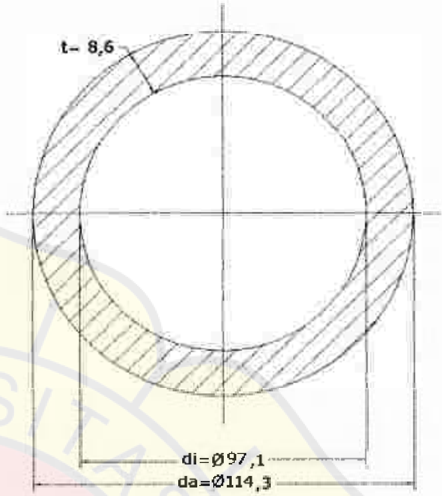
——— : **Konstruksi Baru**


Konstruksi Melintang Frame 172
GLD.5
GLD. 4
2927
GLD. 3
PillarDek 3
PillarDek 2
10
350
GLD.2
4000
C
C
400
GLD. 1
400
1600
CL
Konstruksi Lama
Konstruksi Baru

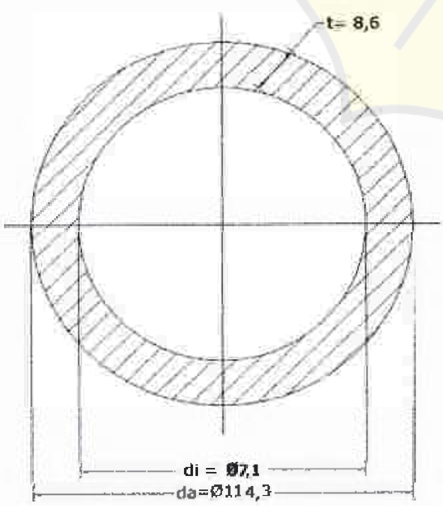
Dimensi Pilar Pada Midship Kapal Dek 2 & Dek 1



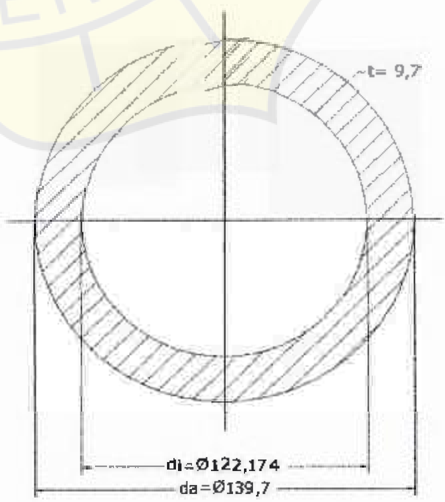
Dimensi Pilar Pada Midship Kapal Dek 2 & Dek 1



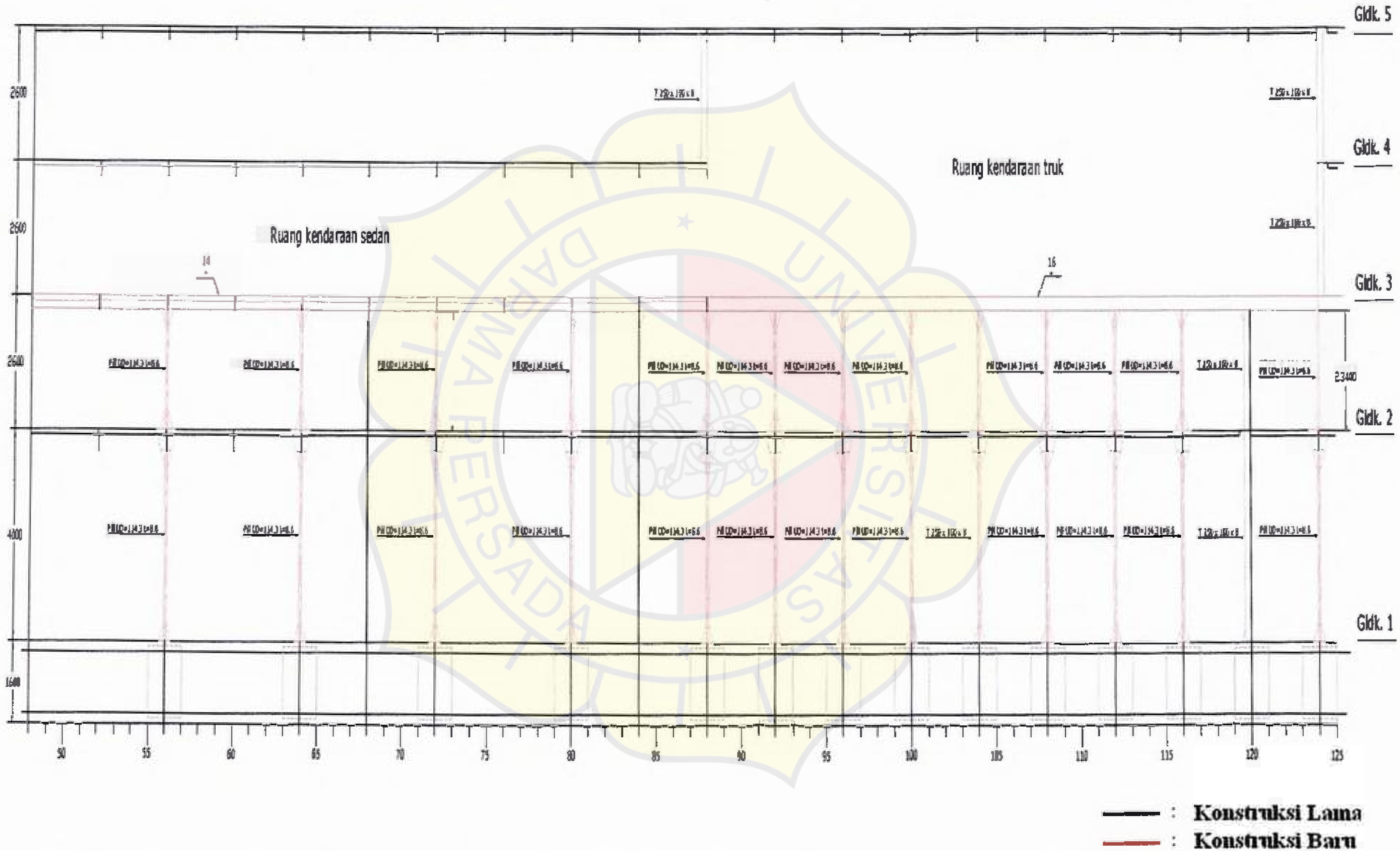
Dimensi Pilar Pada Haluan Kapal Dek 3

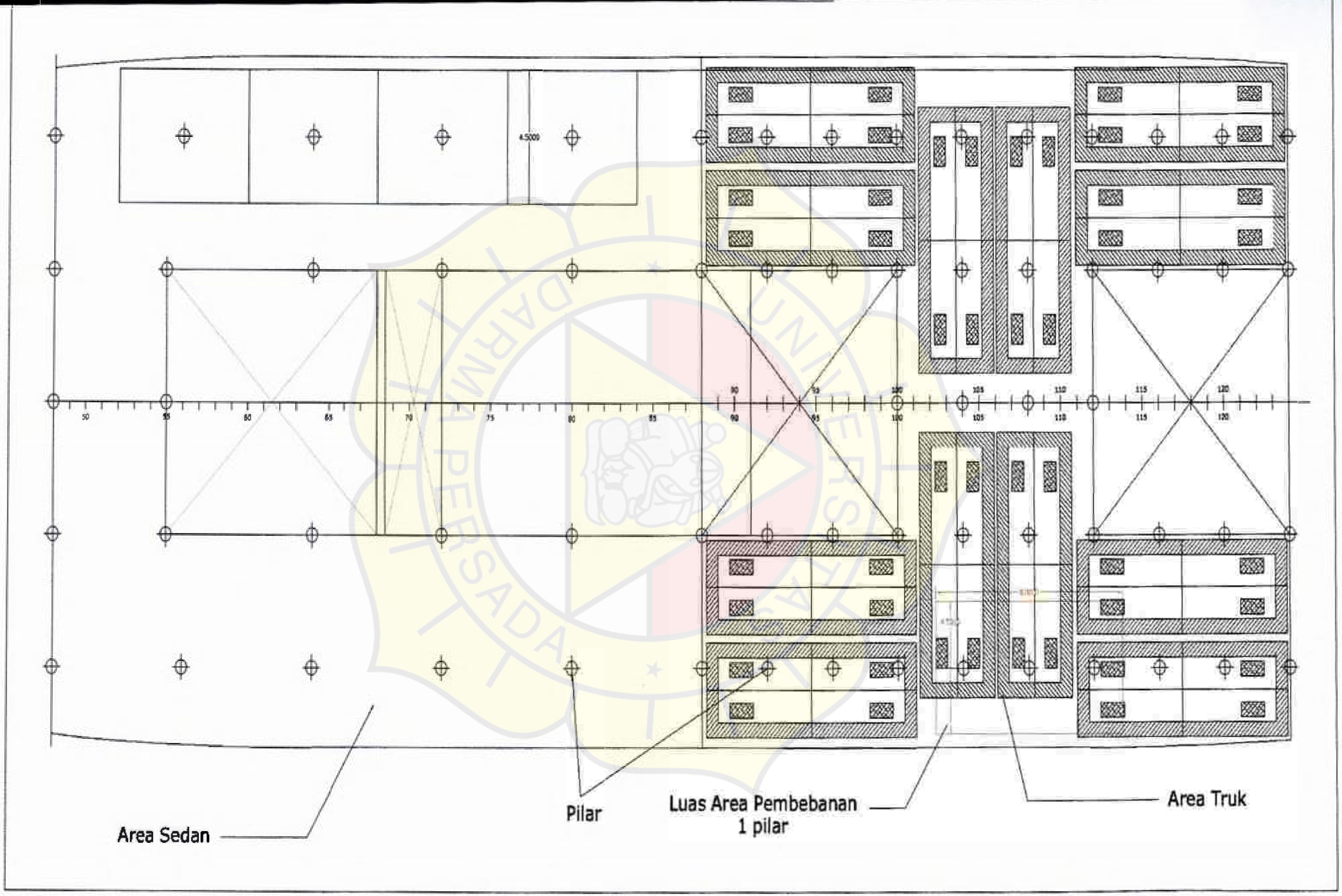


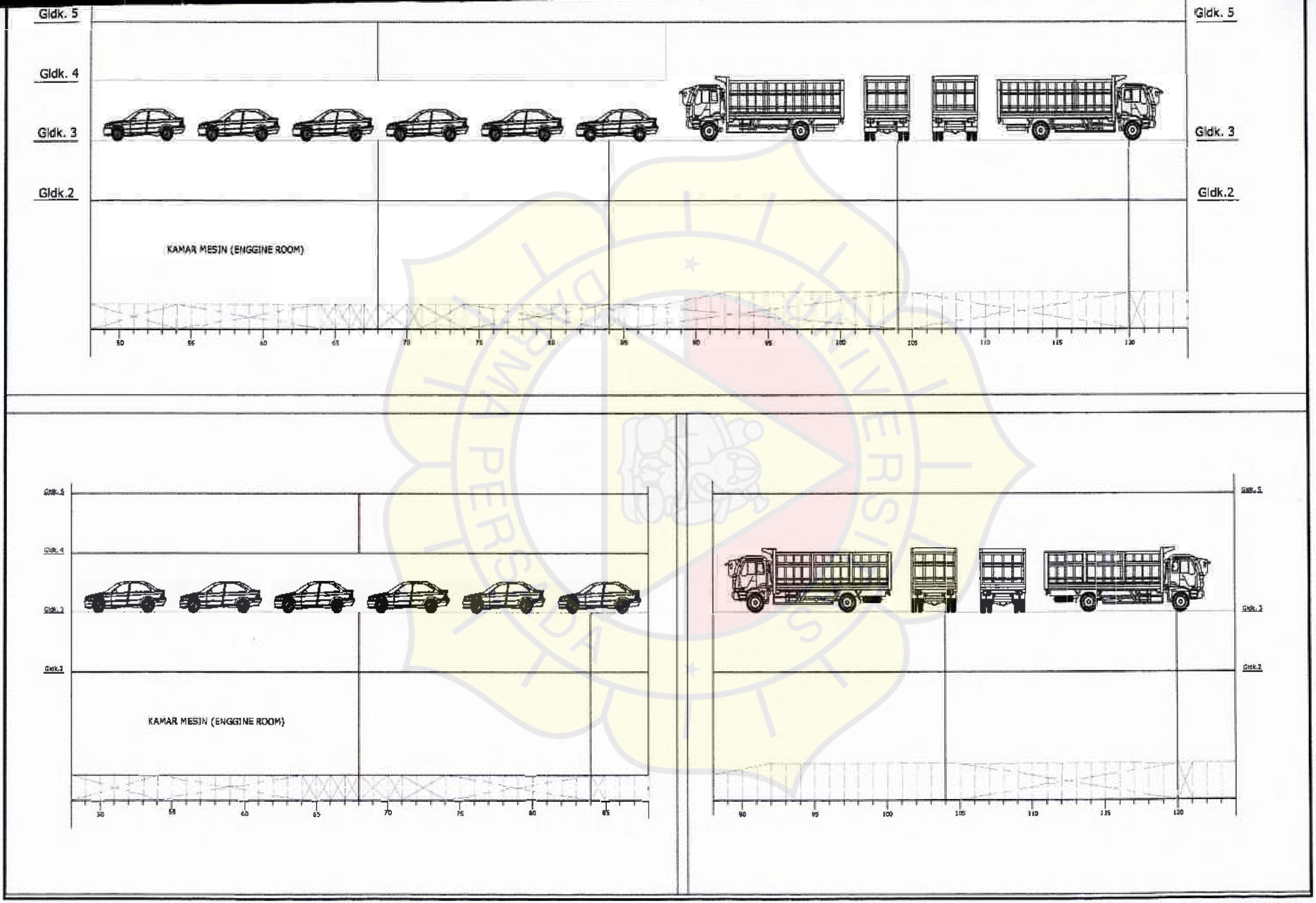
Dimensi Pilar Pada Haluan Kapal Dek 2



Longitudinal Section Frame 48 - 124




Area Sedan
Pilar
Luas Area Pembebanan 1 pilar
Area Truk


Gldk. 5
Gldk. 4
Gldk. 3
Gldk.2
KAMAR MESIN (ENGGINE ROOM)
50
55
60
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95
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110
115
120
KAMAR MESIN (ENGGINE ROOM)

Table 39: Schedule 80 Pipe Dimensions

Size Inches	Diameters: External Inches	Diameters: Internal Inches	Nominal Thickness Inches	Transverse Areas: External Sq. Ins.	Transverse Areas: Internal Sq. Ins.	Transverse Areas: Metal Sq. Ins.	Length of Pipe per Sq. Foot of: External Surface Feet	Length of Pipe per Sq. Foot of: Internal Surface Feet	Cubic Feet per Foot of Pipe	Weight per Foot Pounds	Number Threads per Inch of Screw
1/8	.405	.215	.	095 .129	.036	093	9. 431	17.750	.00025	.314	27
1/4	.540	.302	.119	.229	.072	.157	7.073	12.650	.00050	.535	18
3/8	.675	.423	.126	.358	.141	.217	5.658	9.030	.00098	.738	18
1/2	.840	.546	.147	.554	.234	.320	4.547	7.000	.00163	1.00	14
3/4	1.050	.742	1.54	.866	.433	.433	3.637	5.15	.00300	1.47	1 4
1	1.315	.957	.179	1.358	.719	.639	2.904	3.995	.00500	2.17	11½
1¼	1.660	1.278	.191	2.164	1.283	.881	2.301	2.990	.00891	3.00	11½
1½	1.900	1.500	.200	2.835	1.767	1.068	2.010	2.542	.01227	3.65	11½
2	2.375	1.939	.218	4.430	2.953	1.477	1.608	1.970	.02051	5.02	11½
2½	2.875	2.323	.276	6.492	4.238	2.254	1.328	1.645	.02943	7.66	8
3	3.500	2.900	.300	9.621	6.605	3.016	1.091	1.317	.04587	10.3	8
3½	4.000	3.364	.318	12.56	8.888	3.678	.954	1.135	.06172	12.5	8
4	4.500	3.826	.337	15.90	11.497	4.407	.848	.995	.0798	14.9	8
5	5.563	4.813	.375	24.30	18.194	6.112	.686	.792	.1263	20.8	8
6	6.625	5.761	.432	34.47	26.067	8.300	.576	.673	.1810	28.6	8
8	8.625	7.625	.500	58.42	45.663	12.76	.442	.501	.3171	43.4	8
10	10.750	9.564	.593	90.76	71.84	18.92	.355	.400	.4989	64.4	8
12	12.750	11.376	.687	127.64	101.64	26.00	.299	.336	.7058	88.6	
14	14.000	12.500	.750	153.94	122.72	31.22	.272	.306	.8522	107.0	
16	16.000	14.314	.843	201.05	160.92	40.13	.238	.263	1.117	137.0	
18	18.000	16.126	.937	254.85	204.24	50.61	.212	.237	1.418	171.0	
20	20 .000	17 .938	1.031	314. 15	252. 72	61.43	.191	.208	1.755	209.0	
24	24 .000	21 .564	1.218	452. 40	365. 22	87.18	.159	.177	2.536	297.0	

Section 2

Materials

A. General

1. All materials to be used for the structural members mentioned in the Construction Rules are to be in accordance with the Rules for Materials, Volume V. Materials the properties of which deviate from these Rule requirements may only be used upon special approval.

. Hull Structural Steel for Plates and Sections

Normal strength hull structural steel

1 Normal strength hull structural steel is a hull structural steel with a minimum nominal upper yield point R_{eH} 235 N/mm^2 and a tensile strength R_m 400-520 N/mm^2. e also Section 17.A.3.

2 The material factor k in the formulae of the following ctions is to be taken 1,0 for normal strength hull structural el.

Normal strength hull structural steel is grouped into grades KI-A, KI-B, KI-D, KI-E, which differ from each er in their toughness properties. For the application he individual grades for the hull structural members, 3.

If for special structures the use of steels with yield perties less than 235 N/mm^2 has been accepted, the erial factor k is to be determined by:

$$k = \frac{235}{R_{eH}}$$

Higher strength hull structural steels

Higher strength hull structural steel is a hull structural l, the yield and tensile properties of which exceed those ormal strength hull structural steel. According to the es for Materials, Volume V, for four groups of higher ngth hull structural steels the nominal upper yield stress has been fixed at 265, 315, 355 and 390 N/mm^2 ectively. Where higher strength hull structural steel is l, for scantling purposes the values in Table 2.1 are to sed for the material factor k mentioned in the various ions.

higher strength hull structural steel with other nominal stresses, the material factor k may be determined by ollowing formulae:

$$k = \frac{295}{R_{eH} + 60}$$

Note

Especially when higher strength structural steels are used, limitation of permissible stresses due to buckling and fatigue strength criteria may be required.

Table 2.1 Material factor

R_{eH} [N/mm^2]	k
265	0,91
315	0,78
355	0,72
390	0,66

2.2 Higher strength hull structural steel is grouped into the following grades, which differ from each other in their toughness properties:

KI-A 27 S

KI-D 27 S

KI-E 27 S

KI-A 32/36/40

KI-D 32/36/40

KI-E 32/36/40

KI-F 32/36/40

In Table 2.3 the grades of the higher strength steels are marked by the letter "H".

2.3 Where structural members are completely or partly made from higher strength hull structural steel, a suitable notation will be entered into the Ship's Certificate.

2.4 In the drawings submitted for approval it is to be shown which structural members are made of higher strength hull structural steel. These drawings are to be placed on board in case any repairs are to be carried out.

2.5 Regarding welding of higher strength hull structural steel, see Rules for Welding, Volume VI, Section 12.

3. Material selection for the hull

3.1 Material classes

For the material selection for hull structural members material classes as given in Table 2.2 are defined.

Section 3

Design Principles

A. General

1. Scope

This Section contains definitions and principles for using the formulae in the following Sections as well as indications concerning structural details.

2. Permissible stresses and required sectional properties

In the following Sections permissible stresses have been stated in addition to the formulae for calculating the section moduli and cross sectional areas of webs of frames, beams, girders, stiffeners etc. and may be used when determining the scantlings of those elements by means of direct strength calculations. The permissible stresses may be increased by up to 10% where exact stress analyses are carried out in accordance with approved calculation methods, e.g. where the finite element method is applied or else proof is presented by full scale measurements.

The required section moduli and web areas are related on principle to an axis which is parallel to the connected plating.

For profiles usual in the trade and connected vertically to the plating in general the appertaining sectional properties are given in tables.

Where webs of stiffeners and girders are not fitted vertically to the plating (e.g. frames on the shell in the flaring fore body) the sectional properties (moment of inertia, section modulus and shear area) have to be determined for an axis which is parallel to the plating.

For bulb profiles and flat bars the section modulus of the inclined profile can be calculated simplified by multiplying the corresponding value for the vertically arranged profile by sin α where α is the smaller angle between web and attached plating.

Note

For bulb profiles and flat bars α in general needs only be taken into account where α is less than 75°.

Furthermore, with asymmetric profiles where additional stresses occur according to **L** the required section modulus must be increased by the factor k_{sp} depending on the type of profile, see **L**.

3. Plate panels subjected to lateral pressure

The formulae for plate panels subjected to lateral pressure as given in the following Sections are based on the assumption of an uncurved plate panel having an aspect ratio $b/a \geq 2{,}24$.

For curved plate panels and/or plate panels having aspect ratios smaller than $b/a = 2{,}24$ the thickness may be reduced as follows:

$$t = C \cdot a \sqrt{p \cdot k} \cdot f_1 \cdot f_2 + t_k$$

C = constant, e.g. $C = 1{,}1$ for tank plating

f_1 = $1 - \frac{a}{2r} \geq 0{,}75$

f_2 = $\sqrt{1{,}1 - 0{,}5\left[\frac{a}{b}\right]^2} \leq 1{,}0$

r = radius of curvature

a = smaller breadth of plate panel

b = larger breadth of plate panel

p = applicable design load

t_k = corrosion addition according to K.

The above does not apply to plate panels subjected to ice pressure according to Section 15 and to longitudinally framed side shell plating according to Section 6.

4. Fatigue strength

Where a fatigue strength analysis is required or will be carried out for structures or structural details this shall be in accordance with the requirements of Section 20.

B. Upper and Lower Hull Flange

1. All continuous longitudinal structural members up to z_o below the strength deck at side and up to z_u above base line are considered to be the upper and lower hull flange respectively.

2. Where the upper and/or the lower hull flange are made from normal strength hull structural steel their vertical extent $z_o = z_u$ equals 0,1 **H**.

On ships with continuous longitudinal structural members above the strength deck a fictitious depth $\mathbf{H}' = e_B + e'_D$ is to be applied.

e_B = distance between neutral axis of the midship section and base line in [m]

e'_D see Section 5, C.4.1

Where cantilevers are fitted at a greater spacing the effective width of plating at the respective cross section may approximately be taken as the distance of the cross section from the point on which the load is acting, however, not greater than the spacing of the cantilevers.

F. Proof of Buckling Strength

1. Definitions

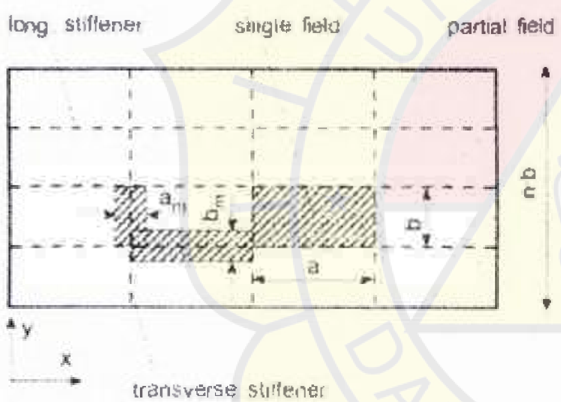
a = length of single or partial plate field in [mm]

b = breadth of single plate field in [mm]

α = aspect ratio of single plate field

$= \frac{a}{b}$

n = number of single plate field breadths within the partial or total plate field



longitudinal : stiffiner in the direction of the length a
transverse : stiffiner in the direction of the length b

Fig. 3.2 Definition of plate fields subject to buckling

t = nominal plate thickness in [mm]

$= t_a - t_K$ [mm]

t_a = plate thickness as built in [mm]

t_K = corrosion addition according to K. in [mm]

σ_x = membrane stress in x-direction in [N/mm²]

σ_y = membrane stress in y-direction in [N/mm²]

τ = shear stress in the x-y plane in [N/mm²]

Compressive and shear stresses are to be taken positive, tension stresses are to be taken negative.

Guidance

If the stresses in the x- and y-direction contain already the Poisson - effect, the following modified stress values may be used:

$$\sigma_x = \frac{\sigma_x^* - 0,3 \cdot \sigma_y^*}{0,91}$$

$$\sigma_y = \frac{\sigma_y^* - 0,3 \cdot \sigma_x^*}{0,91}$$

σ_x^*, σ_y^* = *stresses containing the Poisson-effect*

ψ = edge stress ratio according to Table 3.3

F_1 = correction factor for boundary condition at the long. stiffeners according to Table 3.2

Table 3.2 Correction Factor F_1

Correction factor F_1		
1,0	for stiffeners sniped at both ends	
Guidance values *	1,05	for flat bars
where both ends	1,10	for bulb sections
are effectively	1,20	for angle and tee-sections
connected to	1,30	for girders of high rigidity
adjacent structures	(e.g. bottom transverses)	
*	Exact values may be determined by direct calculations.	

σ_e = reference stress

$= 0,9 \cdot E \left(\frac{t}{b}\right)^2$ [N/mm²]

E = Young's modulus

$= 2,06 \cdot 10^5$ [N/mm²] for steel

$= 0,69 \cdot 10^5$ [N/mm²] for aluminium alloys

R_{eH} = nominal yield point in [N/mm²] for hull structural steels according to Section 2, B.2.

= 0,2% proof stress in [N/mm²] for aluminium alloys

S = safety factor

= 1,1 in general

= 1,2 for structures which are exclusively exposed to local loads

= 1,05 for combinations of statistically independent loads

An exact evaluation of notch stresses is possible by means of finite element calculations. For fatigue investigations the stress increase due to geometry of cut-outs has to be considered, see Section 20.C, Table 20.3.

Note

These notch factors can only be used for girders with multiple openings if there is no correlation between the different openings regarding deformations and stresses.

K. Corrosion Addition and Corrosion Control

1. Corrosion addition

1.1 The scantling requirements of the subsequent Sections imply the following general corrosion addition t_K:

$$t_K = 1{,}5\,\text{mm} \qquad \text{for } t' \leq 10\,\text{mm}$$

$$= \frac{0.1\,t'}{\sqrt{k}} + 0.5\ \text{mm, max. } 3.0\ \text{mm}$$

for $t' > 10$ mm

t' = required rule thickness excluding t_K in [mm]

k = material factor according to Section 2, B.2

1.2 For structural elements in specified areas t_K is not to be less than given in Table 3.6

Table 3.6 Minimum corrosion addition

Area	t_{Kmin} [mm]
In ballast tanks where the weather deck forms the tank top, 1,5 m below tank top[1].	2,5
In cargo oil tanks where the weather deck forms the tank top, 1,5 m below tank top. Horizontal members in cargo oil and fuel oil tanks.	2,0
Deck plating below elastically mounted deckhouses	3,0
[1] t_K = 2,5 mm for all structures within topside tanks of bulk carriers	
With longitudinal bulkheads exposed to grab operation and assigned to the notation G the corrosion addition is t_K = 2,5 mm.	

For corrosion protection see Section 38.

1.3 For structures in dry spaces such as box girders of container ships and for similar spaces as well as for hatch covers of dry cargo holds the corrosion addition is

$$t_K = \frac{0.1 \cdot t'}{\sqrt{k}}, \text{ max. } 2.5\ \text{mm}$$

however, not less than 1,0 mm.

1.4 Corrosion addition for hatch covers and hatch coamings are to be determined according to Section 17.

2. Corrosion control

2.1 Where an effective protection against corrosion is employed approval may be given for the reduction of material thickness - even to less than the minimum thickness by the following values Δt_K:

Extent of protection*	Δt_K
both sides protected	t_K, max. 2 mm
one side protected	$t_K/2$, max. 1 mm

* For corrosion protection see Section 38.

2.2 Where structural elements are subjected to compression, the reduction of thicknesses is permissible only where proof of adequate buckling strength is submitted in accordance with F.1.4.

2.3 Where this rules is applied, the Classification of Notation "CORR" will assigned.

2.4 In the drawing to be submitted for approval both the envisaged reduced material thicknesses and the rules thicknesses required by the Construction Rules are to be indicated. The drawings are to be placed on board the ship.

2.5 Together with the drawings, a description of the envisaged corrosion protection system as well as particulars on its suitability for the respective ranges of application are to be submitted.

2.6 When selecting the materials in accordance with Section 2, B the unreduced Rule Thicknesses are decisive.

L. Additional Stresses in Non-Symmetric Sections

1. Additional stresses for fatique strength analysis

The additional stress σ_h occurring in non-symmetric sections may be calculated by the following formulae:

$$\sigma_h = \frac{Q \cdot \ell_f \cdot t_f}{c \cdot W_y \cdot W_z}\left(b_1^2 - b_2^2\right) \quad [\text{N/mm}^2]$$

Q = load on section parallel to its web within the unsupported span ℓ_f in [kN]

= $p \cdot a \cdot \ell_f$ [kN] in case of uniformly distributed load p in [kN/m²]

ℓ_f = unsupported span of flange in [m]

t_f, b_1, b_2 = flange dimensions in [mm] as shown in Fig. 3.11

b' = breadth of deckhouse

B' = largest breadth of ship at the position considered.

Except for the fore castle deck the minimum load is:

$p_{DAmin} = 4$ [kN/m²]

5.2 For exposed wheel house tops the load is not to be taken less than

p = 2,5 [kN/m²]

C. Cargo loads, Load on Accommodation Decks

1. Load on cargo decks

1.1 The load on cargo decks is to be determined according to the following formulae:

$p_L = p_c\,(1 + a_v)$ [kN/m²]

p_c = static cargo load in [kN/m²]

if no cargo load is given: $p_c = 7 \cdot h$ for 'tween decks but not less than 15 kN/m²

h = mean tween deck height in [m].

In way of hatch casings the increased height of cargo is to be taken into account.

a_v = acceleration factor as follows:

$= F \cdot m$

$F = 0{,}11\ \dfrac{v_0}{\sqrt{L}}$

$m = m_0 - 5\,(m_0 - 1)\,\dfrac{x}{L}$ for $0 \le \dfrac{x}{L} \le 0{,}2$

$= 1{,}0$ for $0{,}2 < \dfrac{x}{L} \le 0{,}7$

$= 1 + \dfrac{m_0 + 1}{0{,}3}\left[\dfrac{x}{L} - 0{,}7\right]$ for $0{,}7 < \dfrac{x}{L} \le 1{,}0$

$m_0 = (1{,}5 + F)$

v_0 = see A.2.2. v_0 is not to be taken less than $\sqrt{L}$ [kN]

.2 For timber and coke deck cargo the load on deck is to be determined by the following formulae:

$p = 5 \cdot h_s\,(1 + a_v)$ [kN/m²]

h_s = stowing height of cargo in [m].

.3 The loads due to single forces P_E (e.g. in case of containers) are to be determined as follows:

$P = P_E\,(1 + a_v)$ [kN].

.4 The cargo pressure of bulk cargoes is to be determined by the following formulae:

$p_{bc} = p_c\,(1 + a_v)$ [kN/m²]

p_c = static bulk cargo load

$= 9{,}81 \cdot \rho_c \cdot h \cdot n$ [kN/m²]

h = distance between upper edge of cargo and the load centre in [m]

$n = \left[\tan^2\left(45° - \dfrac{\gamma}{2}\right)\sin^2\alpha + \cos^2\alpha\right]$

α = angle in degrees between the structural element considered and a horizontal plane

γ = angle of repose of the cargo in degrees

2. Load on inner bottom

2.1 The inner bottom cargo load is to be determined as follows:

$p_i = 9{,}81 \cdot \dfrac{G}{V} \cdot h\,(1 + a_v)$ [kN/m²]

G = mass of cargo in the hold in [t]

V = volume of the hold in [m³](hatchways excluded)

h = height of the highest point of the cargo above the inner bottom in [m], assuming hold to be completely filled.

a_v = see 1.1

For calculating a_v the distance between the centre of gravity of the hold and the aft end of the length **L** is to be taken.

2.2 For inner bottom load in case of ore stowed in conical shape, see Section 23.B.3.

3. Loads on accommodation and machinery decks

3.1 The deck load in accommodation and service spaces is:

$p = 3{,}5\,(1 + a_v)$ [kN/m²]

3.2 The deck load of machinery decks is:

$p = 8\,(1 + a_v)$ [kN/m²]

3.3 Significant single forces are also to be considered, if necessary.

D. Load on Tank Structures

1. Design pressure for filled tanks

1.1 The design pressure for service conditions is the greater of the following values:

$p_1 = 9{,}81 \cdot h_1 \cdot \rho\,(1 + a_v) + 100 \cdot p_v$ [kN/m²]

or

Table 4.1 Distribution factors for sea loads on ship's sides and weather decks

Range		Factor c_D	Factor c_F [1]
A	$0 \le \frac{x}{L} < 0{,}2$	$1{,}2 - \frac{x}{L}$	$1{,}0 + \frac{5}{C_B}\left(0{,}2 - \frac{x}{L}\right)$
M	$0{,}2 \le \frac{x}{L} < 0{,}7$	1,0	1,0
F	$0{,}7 \le \frac{x}{L} \le 1{,}0$	$1{,}0 + \frac{c}{3}\left(\frac{x}{L} - 0{,}7\right)$ $c = 0{,}15\,L - 10$ where $L_{min} = 100$ m $L_{max} = 250$ m	$1{,}0 + \frac{20}{C_B}\left(\frac{x}{L} - 0{,}7\right)^2$

[1] Within the range A the ratio x/L need not be taken less than 0,1, within the range F the ratio x/L need not be taken greater than 0,93

Fig. 4.1 Longitudinal sections A, M, and F according to Table 4.1

1.3 Where deck cargo is intended to be carried on the weather deck resulting in load greater than the value determined according to 1.1, the scantlings are governed by the greater load (see also C).

Where the stowage height of deck cargo is less than 1,0 m, the deck cargo load may be required to be increased by the following value:

$p_z = 10\,(1 - h_s)$ [kN/m²]

h_s = stowage height of the cargo in [m]

. Load on ship's sides and of bow and stern structures

.1 Load on ship's sides

he external load p_s on the ship's sides is to be determined ccording to 2.1.1 and 2.1.2.

1.1 For elements the load centre of which is located below ad waterline:

$$= 10(T - z) + p_0 \cdot c_F\left(1 + \frac{z}{T}\right) \quad [kN/m^2]$$

r wave directions with or against the ship's heading.

$$= 10(T - z) + p_{01}\left[1 + \frac{z}{T}\left(2 - \frac{z}{T}\right)\right]\frac{2\,|y|}{B} \quad [kN/m^2]$$

wave directions transverse to the ship's heading including asi-static pressure increase due to heel.

y = horizontal distance between load centre and centreline [m]

2.1.2 For elements the load centre of which is located above the load waterline:

$$p_s = p_0 \cdot c_F\,\frac{20}{10 + z - T} \quad [kN/m^2]$$

for wave directions with or against the ship's heading.

$$p_s = p_{01}\,\frac{20}{5 + z - T} \cdot \frac{|y|}{B} \quad [kN/m^2]$$

for wave directions transverse to the ship's heading including quasi-static pressure increase due to heel.

2.2 Load on bow structures

The design load for bow structures from forward to 0,1 L behind F.P. and above the ballast waterline in accordance with the draft T_b in 4.1 is to be determined according to the following formulae:

$$p_e = c\left[0{,}20 \cdot v_0 + 0{,}6\sqrt{L}\right]^2 \quad [kN/m^2]$$

with $L_{max} = 300$ m.

c = 0,8 in general

$$= \frac{0{,}4}{(1{,}2 - 1{,}09 \cdot \sin\alpha)}$$

for extremely flared sides where the flare angle α is larger than 40°.

The flare angle α at the load centre is to be measured in the plane of frame between a vertical line and the tangent to the side shell plating.

For unusual bow shapes p_e can be specially considered.

p_e must not be smaller than p_s according to 2.1.1 or 2.1.2 respectively.

B. Lower Decks

1. Thickness of decks for cargo loads

1.1 The plate thickness is not to be less than

$$t = 1{,}1 \cdot a \sqrt{p_L \cdot k} + t_K \quad [mm]$$

$$t_{min} = (5{,}5 + 0{,}02\,L)\sqrt{k} \quad [mm]$$

for the 2nd deck

= 6,0 mm for other lower decks

L need not be taken greater than 200 m.

1.2 For the critical deck thickness see A.5.2.

2. Thickness of decks for wheel loading

2.1 The thickness of deck plating for wheel loading is to be determined by the following formulae:

$$t = c \sqrt{P\,(1 + a_v)\,k} + t_K \quad [mm]$$

P = load in [kN] of one wheel or group of wheels on a plate panel a · b [1]

$$= \frac{Q}{n}$$

Q = axle load in [kN]

For fork lift trucks Q is generally to be taken as the total weight of the fork lift truck

n = number of wheels or group of wheels per axle

a_v = see Section 4, C.1.1

= 0 for harbour conditions

c = factor according to the following formulae:

for b/a = 1:

$$c = 1{,}87 - \sqrt{\frac{f}{F}\left[3{,}4 - 4{,}4\frac{f}{F}\right]} \quad \text{for } 0 < \frac{f}{F} < 0{,}3$$

$$= 1{,}20 - 0{,}40\,\frac{f}{F} \quad \text{for } 0{,}3 \le \frac{f}{F} \le 1{,}0$$

for b/a ≥ 2,5:

$$c = 2{,}00 - \sqrt{\frac{f}{F}\left[5{,}2 - 7{,}2\frac{f}{F}\right]} \quad \text{for } 0 < \frac{f}{F} < 0{,}3$$

$$= 1{,}20 - 0{,}517\,\frac{f}{F} \quad \text{for } 0{,}3 \le \frac{f}{F} \le 1{,}0$$

[1] Where no data available P is to be taken as 25 kN

for intermediate values of b/a the factor c is to be obtained by direct interpolation

f = print area of wheel or group of wheels

F = area of plate panel a · b according to Fig. 7.2

a = width of smaller side of plate panel (in general beam spacing)

b = width of larger side of plate panel

F need not be taken greater than $2{,}5\,a^2$.

In case of narrowly spaced wheels these may be grouped together to one wheel print area.

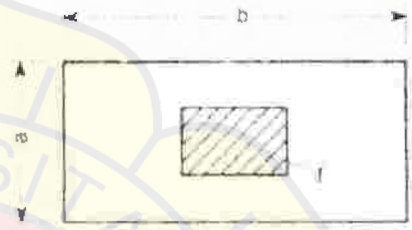


Fig. 7.2 Footprint of wheel

2.2 Where the wheel print area is not known, it may approximately be determined as follows:

$$f = \frac{50 \cdot n \cdot P}{p} \quad [cm^2]$$

p = specific wheel pressure according to Table 7.1.

2.3 In deck beams and girders, the stress is not to exceed 165/k [N/mm²].

Table 7.1 Specific wheel pressure

Type of vehicle	Specific wheel pressure p [bar]	
	Pneumatic tyres	Solid rubber tyres
private cars	2	-
trucks	8	-
trailers	8	15
fork lift trucks	6	15

3. Machinery decks and accommodation decks

The scantlings of machinery decks and other accommodation decks have to be based on the loads given in Section 4, C.3.

The thickness of the plates is not to be less than:

$$t = 1{,}1 \cdot a \cdot \sqrt{p \cdot k} + t_K \quad [mm]$$

$$t_{min} = 5 \quad [mm]$$

3.4 Where deck beams are to be attached to hatchway coamings and girders of considerable rigidity (e.g. box girders), brackets are to be provided.

3.5 Within 0,6L amidships, the arm lengths of the beam brackets in single deck ships are to be increased by 20%. The scantlings of the beam brackets need, however, not be taken greater than required for the Rule section modulus of the frames.

3.6 Regarding the connection of deck longitudinals to transverses and bulkheads, Section 9, B.1. is to be observed.

4. Girders and transverses

4.1 The section modulus W and shear area A_w are not to be less than:

$$W = c \cdot e \cdot \ell^2 \cdot p \cdot k \qquad [cm^3]$$

$$A_w = 0,05 \cdot p \cdot e \cdot \ell \cdot k \qquad [cm^2]$$

4.2 The depth of girders is not to be less than 1/25 of the unsupported span. The web depth of girders scalloped for continuous deck beams is to be at least 1,5 times the depth of the deck beams.

Scantlings of girders of tank decks are to be determined according to Section 12, B.3.

4.3 Where a girder does not have the same section modulus throughout all girder fields, the greater scantlings are to be maintained above the supports and are to be reduced gradually to the smaller scantlings.

4.4 End attachments of girders at bulkheads are to be so dimensioned that the bending moments and shear forces can be transferred. Bulkhead stiffeners under girders are to be sufficiently dimensioned to support the girders.

4.5 Face plates are to be stiffened by tripping brackets according to Section 3, H. 2.5. At girders of symmetrical section, they are to be arranged alternately on both sides of the web.

4.6 For girders in line of the deckhouse sides under the strength deck, see Section 16, A.3.2.

4.7 For girders forming part of the longitudinal hull structure and for hatchway girders see E.

5. Supporting structure of windlasses and chain stoppers

5.1 For the supporting structure under windlasses and chain stoppers, the following permissible stresses are to be observed:

$$\sigma_b = \frac{200}{k} \qquad [N/mm^2]$$

$$\tau = \frac{120}{k} \qquad [N/mm^2]$$

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2} = \frac{220}{k} \qquad [N/mm^2]$$

5.2 The acting forces are to be calculated for 80% and 45% respectively of the rated breaking load of the chain cable, i.e.:

- for chain stoppers 80%
- for windlasses 80%, where chain stoppers are not fitted.
- for windlasses 45%, where chain stoppers are fitted.

See also Rules for Machinery Installations, Volume III, Section 14, D. and Rules for Materials, Volume V, Section 12, Table 12.7.

C. Pillars

1. General

1.1 Structural members at heads and heels of pillars as well as substructures are to be constructed according to the forces they are subjected to. The connection is to be so dimensioned that at least 1 cm^2 cross sectional area is available for 10 kN of load.

Where pillars are affected by tension loads doublings are not permitted.

1.2 Pillars in tanks are to be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

1.3 For structural elements of the pillars' transverse section, sufficient buckling strength according to Section 3, F. has to be verified. The wall thickness of tubular pillars which may be expected to be damaged during loading and unloading operations is not to be less than:

$$t_w = 4,5 + 0,015\, d_a \quad [mm] \quad \text{for } d_a \le 300 \text{ mm}$$

$$t_w = 0,03\, d_a \quad [mm] \quad \text{for } d_a > 300 \text{ mm}$$

d_a = outside diameter of tubular pillar in [mm]

1.4 Pillars also loaded by bending moments have to be specially considered.

2. Scantlings

The sectional area of pillars is not to be less than:

$$A_{s\ req} = 10 \cdot \frac{P_s}{\sigma_p} \qquad [cm^2]$$

σ_p = permissible compressive stress.

$$= \frac{\kappa}{S} \cdot R_{eH}$$

κ = reduction factor

$$= \frac{1}{\phi + \sqrt{\phi^2 - \lambda_s^2}}$$

$$\phi = 0,5\left[1 + n_p\,(\lambda_s - 0,2) + \lambda_s^2\right]$$

n_p = 0,34 for tubular and rectangular pillars

= 0,49 for open sections

S = safety factor

= 2,00 in general

= 1,66 in accommodation area

D. Cantilevers

1. General

1.1 In order to withstand the bending moment arising from the load P, cantilevers for supporting girders, hatchway coamings, engine casings and unsupported parts of decks are to be connected to transverses, web frames, reinforced main frames, or walls.

1.2 When determining the scantlings of the cantilevers and the aforementioned structural elements, it is to be taken into consideration that the cantilever bending moment depends on the load capacity of the cantilever, the load capacity being dependent on the ratio of rigidity of the cantilever to that of the members supported by it.

1.3 Face plates are to be secured against tilting by tripping brackets fitted to the webs at suitable distances (see also Section 3, H.2.).

1.4 Particulars of calculation, together with drawings of the cantilever construction are to be submitted for approval.

2. Permissible stresses

2.1 When determining the cantilever scantlings, the following permissible stresses are to be observed:

.1 Where single cantilevers are fitted at greater distances:

bending stress:

$$\sigma_b = \frac{125}{k} \quad [N/mm^2].$$

shear stress:

$$\tau = \frac{80}{k} \quad [N/mm^2].$$

.2 Where several cantilevers are fitted at smaller distances (e.g. at every frame):

bending stress:

$$\sigma_b = \frac{150}{k} \quad [N/mm^2].$$

shear stress:

$$\tau = \frac{100}{k} \quad [N/mm^2]$$

equivalent stress:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2} = \frac{180}{k} \quad [N/mm^2].$$

.3 The stresses in web frames are not to exceed the values specified in .1 and .2 above.

E. Hatchway Girders and Girders Forming Part of the Longitudinal Hull Structure

1. The scantlings of longitudinal and transverse hatchway girders are to be determined on the basis of strength calculations. The calculations are to be based upon the deck loads calculated according to Section 4, B. and C.

2. The hatchway girders are to be so dimensioned that the stress values given in Table 10.1 will not be exceeded.

Table 10.1 Maximum stress values σ_ℓ for hatchway girder

Longitudinal coaming and girders of the strength deck	All other hatchway girders
upper and lower flanges: $\sigma_\ell = \frac{150}{k}$ [N/mm²] deck level: $\sigma_\ell = \frac{70}{k}$ [N/mm²]	$\sigma_\ell = \frac{150}{k}$ [N/mm²]

3. For continuous longitudinal coamings the combined stress resulting from longitudinal hull girder bending and local bending of the longitudinal coaming is not to exceed the following value:

$$\sigma_L + \sigma_\ell \le \frac{200}{k} \quad [N/mm^2]$$

σ_ℓ = local bending stress in the ship's longitudinal direction

σ_L = design longitudinal hull girder bending stress according to Section 5, E.4.