ESAME DI STATO PER L’ABILITAZIONE ALLA PROFESSIONE DI INGEGNERE
2ª SESSIONE 2013

Sezione A
Prova pratica di progettazione per l’abilitazione alla professione di ingegnere
(Classi 25/S, 26/S, 27/S, 31/S, 33/S, 36/S, 37/S, 61/S,
Nautica, Navale

Tema N° 1
Si studi il problema del trasferimento dalla banchina ad un pontone accostato di prora a quest’ultima di una nave avente le seguenti caratteristiche:

- Lunghezza fuori tutto  95.00 m
- Larghezza massima  10.00 m
- Altezza di costruzione  5.00 m
- Altezza al ponte più alto della sovrastruttura  10.00 m
- Peso al momento dell’imbarco  1200 t
- Quota verticale del centro di gravità  4.75 m
- Ascissa del centro di gravità da poppa estrema  45.00 m

La nave è imbarcata, con le sue invasature, per mezzo numerosi carrelli semoventi posti sotto le invasature dei quali sono noti i dati seguenti:

- Peso dei carrelli e delle invasature  250 t
- Altezza dell’attrezzatura di varo (carrelli + invasature)  1.50 m

Per semplicità si assume il peso della nave uniformemente distribuito e che la nave sia imbarcata senza causare inclinazioni trasversali del pontone. La banchina ha un’altezza rispetto al livello del mare che varia da 2.00 m (minima, con alta marea) a 2.50 m (massima, con bassa marea). L’operazione si attua in condizioni meteo-marine favorevoli ed in assenza di onda.

Si chiede al candidato:
1. di individuare le condizioni di carico ed i vincoli operativi più significativi ai fini del progetto del pontone, con riferimento sia all’altezza della marea sia alle diverse fasi operative;
2. di determinare le dimensioni principali di un pontone di forma parallelepipedo atto a ricevere a bordo e a trasportare la nave sopra descritta;
3. di individuare una disposizione di massima delle casse di zavorra del pontone, in modo idoneo a garantire le corrette condizioni di assetto in tutte le fasi dell’operazione di imbarco e trasferimento in mare;
4. di valutare, in prima approssimazione, la relazione tra la massima velocità del movimento dei carrelli durante l’imbarco e la portata del sistema di zavorra affinché sia mantenuto un assetto longitudinale del pontone pressoché diritto.

Il peso proprio del pontone può essere stimato in ragione di 0.15 t per unità di numero cubico (lunghezza*i larghezza*altezza).

Il candidato assume a suo motivato giudizio tutti gli ulteriori elementi tecnici necessari a risolvere il problema.
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Nautica, Navale

Tema N°

Con riferimento ai disegni allegati, relativi alla sezione maestra di una navetta da diporto, eseguire con calcolo diretto una verifica del dimensionamento degli elementi strutturali del fondo, del fianco e del ponte:

- Fasciami,
- Longitudinali comuni,
- Madieri e paramezzali
- Anguille e bagli,
- Costole,

descrivendo e giustificando opportunamente le ipotesi e le approssimazioni del calcolo.

Si assuma agente un carico locale uniformemente distribuito per ogni corso di fasciami sulla base delle caratteristiche della nave riportate in figura. I valori eventualmente non riportati nel disegno possono essere ipotizzati dal candidato con motivato giudizio.

Riporre i risultati in forma tabulare indicando tutti i parametri utilizzati per il dimensionamento e per l’esecuzione dei calcoli ed i risultati ottenuti.

Successivamente, confrontare i calcoli finora eseguiti con i valori ottenuti dalle formule regolamentari per il dimensionamento del fondo riportate nell’estrauto del regolamento RINA allegato e discutere brevemente le eventuali differenze riscontrate.

Esempio tabella di calcolo:

<table>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sintesi</td>
<td>z(p,d,u)</td>
<td>h(f)</td>
<td>p(g)</td>
<td>b(i)</td>
<td>a(i)</td>
<td>I(i)</td>
<td>==</td>
<td>M(max)</td>
<td>(mm) - (cm^3)</td>
<td>(mm) - (cm^3)</td>
</tr>
<tr>
<td>u.d.m.</td>
<td>(m)</td>
<td>(m)</td>
<td>(kN/m^2)</td>
<td>(mm)</td>
<td>(kN/m)</td>
<td>(m)</td>
<td></td>
<td>(kN/m)</td>
<td>(mm) - (cm^3)</td>
<td>(mm) - (cm^3)</td>
</tr>
</tbody>
</table>
5.3.2 Displacement yachts

For the purpose of the evaluation of the design pressure for the bottom, sailing yachts with or without auxiliary engine are also included as displacement yachts.

The pressure \( p_t \) in \( \text{kN/m}^2 \), for the scantlings of hull structures, plating and stiffeners located below the full load waterline is to be taken as equal to the value \( p_t \), defined as follows:

\[
p_t = 0.24L^{0.8} \cdot \left( 1 - \frac{h_0}{2L} \right) + 10 \cdot (h_0 + a \cdot 1)
\]

where \( h_0 \) and \( a \) are as defined in [5.3.1].

The pressure \( p \) is, in any case, not to be assumed \(<10 \text{ D} \).

- \( h_0 \) : vertical distance, in m, from pdr to the full load waterline;
- \( a \) : coefficient function of the longitudinal position of pdr, equal to:
  - 0.036 aft of 0.5 L
  - 0.04/(C_3 - 0.024) in way of PpAV
  - values for intermediate positions obtained by linear interpolation:
SECTION 5  PLATING

1 Definitions and symbols

1.1

1.1.1

s  : spacing of ordinary longitudinal or transverse stiffener, in m
p  : scantling pressure, in kN/m², given in Ch 1, Sec 5
K  : factor defined in Sec 2.

2 Keel

2.1 Sheet steel keel

2.1.1 The keel plating is to have a width \( b_{Ck} \) in mm, throughout the length of the yacht, not less than the value obtained by the following equation:

\[ b_{Ck} = 4.5 \cdot L + 600 \]

and a thickness not less than that of the adjacent bottom plating increased by 2 mm.

2.2 Solid keel

2.2.1 The height and thickness of the keel, throughout the length of the yacht, are to be not less than the values \( h_{CH} \) and \( t_{CH} \), in mm, calculated with the following equations:

\[ h_{CH} = 1.5 \cdot L + 100 \]

\[ t_{CH} = (0.35 \cdot L + 6) \cdot K^{0.5} \]

Lesser heights and thicknesses may be accepted provided that the effective area of the section is not less than that of the Rule section.

Lesser heights and thicknesses may also be acceptable if a centre ginder is placed in connection with the solid keel.

The garboard strakes connected to the keel are each to have a width not less than 750 mm and a thickness not less than that of the bottom plating increased by 10%.

3 Bottom and bilge

3.1

3.1.1 Bottom plating is the plating up to the chine or to the upper turn of the bilge.

The thickness of the bottom plating and the bilge is to be not less than the greater of the values \( t_1 \) and \( t_2 \), in mm, calculated with the following formulae:

\[ t_1 = k_1 \cdot k_2 \cdot k_3 \cdot s \cdot (p \cdot K)^{0.5} \]

\[ t_2 = 8 \cdot s \cdot (1 - K)^{0.5} \]

where:

\[ k_1 = 0.11, \text{ assuming } p = p_1 \]

\[ 0.07, \text{ assuming } p = p_2 \]

\[ k_3 \text{ coefficient as a function of the ratio } S/h \text{ given in Tab 1 below where } S \text{ is the greater dimension of the plating, in m.} \]

\[ k_s \text{ curvature correction factor given by } 1 - h/s \text{ to be taken not less than 0.7 where } h \text{ is the distance, in mm, measured perpendicularly from the chord } s \text{ to the highest point of the arc of plating between the two supports (see Fig 1).} \]

The thickness of the plating of the bilge is, in any event, to be taken as not less than the greater of the thicknesses of the bottom and side.

Sheet steel of plating connected to the stem or to the sternpost or in way of the propeller shaft struts is to have a thickness, in mm, not less than the value \( t_w \) given by:

\[ t_w = (0.05 \cdot L + 6) \cdot K^{0.5} \]

and, in any event, equal to the thickness of the bottom increased by 50%.

<table>
<thead>
<tr>
<th>S/h</th>
<th>( K_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.5</td>
</tr>
<tr>
<td>1.2</td>
<td>19.6</td>
</tr>
<tr>
<td>1.4</td>
<td>20.9</td>
</tr>
<tr>
<td>1.6</td>
<td>21.6</td>
</tr>
<tr>
<td>1.8</td>
<td>22.1</td>
</tr>
<tr>
<td>2.0</td>
<td>22.3</td>
</tr>
<tr>
<td>&gt;2</td>
<td>22.4</td>
</tr>
</tbody>
</table>
SECTION 6  SINGLE BOTTOM

1 General

1.1 Scope

1.1.1 This Section stipulates the criteria for the structural scantlings of a single bottom, which may be of either longitudinal or transverse type.

1.2 Longitudinal structure

1.2.1 The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors. The floors may be supported by girders, which in turn may be supported by transverse bulkheads, or by the sides of the hull.

1.2.2 A centre girder is to be fitted. Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.2.3 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to extend beyond the engine room for a suitable length and are to be connected to any existing girders in other areas.

1.2.4 Additional bottom stiffeners are to be fitted in way of the propeller shaft struts, the rudder and the ballast keel.

1.3 Transverse structure

1.3.1 The transverse framing consists of ordinary stiffeners arranged transversally (floors) and placed at each frame supported by girders, which in turn are supported by transverse bulkheads or reinforced floors.

1.3.2 A centre girder is to be fitted. Where the breadth of the floors exceeds 6 m, sufficient side girders are to be fitted so that the distance between them and the centre girder or the side does not exceed 3 m.

1.3.3 In way of the propeller shaft struts, the rudder horn and the ballast keel, additional floors are to be fitted with sufficiently increased scantlings.

1.3.4 The bottom of the engine room is to be reinforced with a suitable web floor consisting of floors and girders; the latter are to be fitted as a continuation of the existing girders outside the engine room.

1.3.5 Floors of increased scantlings are to be fitted in way of reinforced frames at the sides and reinforced beams on the weather deck. Any intermediate floors are to be adequately connected to the ends.

2 Definitions and symbols

2.1

2.1.1

\( s \) : spacing of ordinary longitudinal or transverse stiffeners, in m;

\( p \) : scantling pressure, in \( \text{kN/m}^2 \), given in Chapter 1

\( K \) : coefficient defined in Sec 2.

3 Longitudinal type structure

3.1 Bottom longitudinals

3.1.1 The section modulus of longitudinal stiffeners is to be not less than the value \( Z \), in \( \text{cm}^3 \), calculated with the following formula:

\[
Z = k_1 \cdot s^2 \cdot K \cdot p
\]

where:

\( k_1 \) : 0.83 assuming \( p = p_1 \)

\( k_1 \) : 0.36 assuming \( p = p_2 \)

\( S \) : conventional span of the longitudinal stiffener, in m, equal to the distance between floors. The bottom longitudinal stiffeners are preferably to be continual through the transverse members. Where they are to be interrupted in way of a transverse watertight bulkhead, brackets are to be provided at the ends.

3.2 Floors

3.2.1 The section modulus of the floors at the centreline of the span \( S \) is to be not less than the value \( Z_{w} \), in \( \text{cm}^3 \), calculated with the following formula:

\[
Z_{w} = k_1 \cdot b \cdot S^2 \cdot K \cdot p
\]

where:

\( k_1 \) : defined in [3.1]

\( b \) : half the distance, in m, between the two floors adjacent to that concerned

\( S \) : conventional floor span equal to the distance, in m, between the two supporting members (sides, girders, keel with a dead rise edge \( \geq 12^\circ \)).

In the case of a keel with a dead rise edge \( \leq 12^\circ \) but \( > 8^\circ \), the span \( S \) is always to be calculated considering the distance between girders or sides; the modulus \( Z_{w} \) may, however, be reduced by 40%.

If a side girder is fitted on each side with a height equal to the local height of the floor, the modulus \( Z_{w} \) may be reduced by a further 10%.
SECTION 7 DOUBLE BOTTOM

1 General

1.1

1.1.1 This Section stipulates the criteria for the structural scantlings of a double bottom, which may be of either longitudinal or transverse type.
The longitudinal type structure is made up of ordinary reinforcements placed longitudinally, supported by floors.
The fitting of a double bottom with longitudinal framing is recommended for planing and semi-planing yachts.

1.1.2 The fitting of a double bottom extending from the collision bulkhead to the forward bulkhead in the machinery space, or as near thereto as practicable, is requested for yachts of $L > 50$ m.

On yachts of $L > 61$ m a double bottom is to be fitted, as far as practicable, outside the machinery space extending forward to the collision bulkhead and aft to the after peak bulkhead.

On yachts of $L > 76$ m the double bottom is to extend, as far as this is practicable, throughout the length of the yacht.
The double bottom is to extend transversally to the side so as to protect the bottom in the bilge area, as far as possible.

1.1.3 The dimensions of the double bottom, and in particular the height, are to be such as to allow access for inspection and maintenance.

In floors and in side girders, manholes are to be provided in order to guarantee that all parts of the double bottom can be inspected at least visually.
The height of manholes is generally to be not greater than half the local height in the double bottom. When manholes with greater height are fitted, the free edge is to be reinforced by a flat iron bar or other equally effective reinforcements are to be arranged.

Manholes are not to be placed in the continuous centre girders, or in floors and side girders below pillars, except in special cases at the discretion of RINA.

1.1.4 Openings are to be provided in floors and girders in order to ensure down-flow of air and liquids in every part of the double bottom.

Holes for the passage of air are to be arranged as close as possible to the top and those for the passage of liquids as close as possible to the bottom.

Bilge wells placed in the inner bottom are to be watertight and limited as far as possible in height and are to have walls and bottom of thickness not less than that prescribed for inner bottom plating.

In zones where the double bottom varies in height or is interrupted, tapering of the structures is to be adopted in order to avoid discontinuities.

2 Minimum height

2.1

2.1.1 The height of the double bottom is to be sufficient to allow access to all areas and, in way of the centre girders, is to be not less than the value $h_{BP}$, in mm, obtained from the following formula:

$$h_{BP} = 288 + 32(T + 10)$$

The height of the double bottom is in any event to be not less than 700 mm. For yachts less than 50 m in length, RINA may accept reduced height.

3 Inner bottom plating

3.1

3.1.1 The thickness of the inner bottom plating is to be not less than the value $t_i$, in mm, calculated with the following formula:

$$t_i = (0.04L - 5s - 1) \frac{k}{10}$$

where:

$s$ : spacing of the ordinary stiffeners, in m.

For yachts of length $L \leq 50$ m, the thickness is to be maintained throughout the length of the hull.

For yachts of length $L > 50$ m, the thickness may be gradually reduced outside 0.4 L amidships so as to reach a value no less than 0.9 $t_i$ at the ends.

Where the inner bottom forms the top of a tank intended for liquid cargoes, the thickness of the top is also to comply with the provisions of Sec 10.

4 Centre girder

4.1

4.1.1 A centre girder is to be fitted, as far as this is practicable, throughout the length of the hull.
The thickness of the centre girder is to be not less than the following value $t_{gir}$ in mm:

$$t_{gir} = (0.008h_{BP} - 2) \frac{k}{10}$$

5 Side girders

5.1

5.1.1 Where the breadth of the floors does not exceed 6 m, side girders need not be fitted.

Where the breadth of the floors exceeds 6 m, side girders are to be arranged with thickness equal to that of the floors.
A sufficient number of side girders are to be fitted so that the
distance between them, or between one side girder and the
centre girder or the side, does not exceed 3 m.
The side girders are to be extended as far forward and aft as
practicable and are, as a rule, to terminate on a transverse
bulkhead or on a floor or other transverse structure of ade-
quate strength.

5.2

5.2.1 Where additional girders are foreseen in way of the
bedplates of engines, they are to be integrated into the
structures of the yacht and extended as far forward and aft
as practicable.

Girders of height no less than that of the floors are to be fitted
under the bedplates of main engines.

Engine foundation bolts are to be arranged, as far as practi-
cable, in close proximity to girders and floors.

Where this is not possible, transverse brackets are to be fitted.

6 Floors

6.1

6.1.1 The thickness of floors $t_m$, in mm, is to be not less
than the following value:

$$t_m = (0.008h_d + 0.5)k_c$$

Watertight floors are also to have thickness not less than
that required in Sec 10 for tank bulkheads.

6.2

6.2.1 When the height of a floor exceeds 900 mm, vertical
stiffeners are to be arranged.

In any event, solid floors or equivalent structures are to be
arranged in longitudinally framed double bottoms in the fol-
lowing locations:

- under bulkheads and pillars
- outside the machinery space at an interval no greater
  than 2 m
- in the machinery space under the bedplates of main
  engines
- in way of variations in height of the double bottom

Solid floors are to be arranged in transversely framed dou-
ble bottoms in the following locations:

- under bulkheads and pillars
- in the machinery space at every frame
- in way of variations in height of the double bottom
- outside the machinery space at 2 m intervals.

7 Bracket floors

7.1

7.1.1 At each frame between solid floors, bracket floors
consisting of a frame connected to the bottom plating and a
reverse frame connected to the inner bottom plating are to
be arranged and attached to the centre girder and the mar-
gin plate by means of flanged brackets with a width of
flange not less than 1/10 of the double bottom depth.

The frame section modulus $Z_r$ in cm$^4$, is to be not less
than:

$$Z_r = k_1 \cdot S \cdot p \cdot K$$

where:

- $k_1$: 0.63 assuming $p=p_1$
- 0.36 assuming $p=p_2$
- $S$: frame span, in m, equal to the distance between
  the mid-spans of the brackets connecting the
  frame/reverse frame.

The reverse frame section modulus is to be not less than
85% of the frame section modulus.

Where tanks intended for liquid cargoes are arranged above
the double bottom, the frame and reverse frame section moduli
are to be no less than those required for tank stiffeners
as stated in Sec 10.

8 Bottom and inner bottom longitudi-

nals

8.1

8.1.1 The section modulus of bottom stiffeners is to be no
less than that required for single bottom longitudinals stipu-
lated in Sec 6.

The section modulus of inner bottom stiffeners is to be no
less than 85% of the section modulus of bottom longitudi-
nals.

Where tanks intended for liquid cargoes are arranged above
the double bottom, the section modulus of longitudinals is
to be no less than that required for tank stiffeners as stated
in Sec 10.

9 Bilge keel

9.1 Arrangement, scantlings and connec-
tions

9.1.1 Arrangement

Where installed, bilge keels may not be welded directly on
the shell plating. An intermediate flat, or doubler, is
required on the shell plating.

The ends of the bilge keel are to be snipped at an angle of
15° or rounded with large radius. They are to be located
in way of a transverse bilge stiffener. The ends of the inter-
mEDIATE flat are to be snipped at an angle of 15°.

The arrangement shown in Fig 1 is recommended.
**Dimensioni principali**

- $L_{FT} = 42.0\text{m}$
- $L_{PP} = 39.5\text{m}$
- $L_{WL} = 39.4\text{m}$
- $B = 8.5\text{m}$
- $D = 4.3\text{m}$
- $T_{PC} = 2.0\text{m}$
- $\Delta_{PC} = 228\text{t}$

Ossat. rinforzate ogni 1000mm

Materiale: acciaio normale da scafo

$\sigma_{snev} = 235\text{MPa}$

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**SEZIONE D-D**

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