Exercise

Ship Design

Introduction Roll On/Roll Off Ships

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Excercise 6

Introduction Roll On / Roll Off Ships

1. Which are the typical areas of operation of RoRo ships?
2. Please state the major design drivers for RoRo ships.
3. Please explain the specialities in the design of the lines of RoRo ships.
4. Please state the most relevant cargo unit for RoRo ships. Which other typical cargo unit do you know for this shiptype?
5. Please state, by which characteristics RoRo ships can be subdivided into different classes.
6. Please state the typical propulsion concept for RoRo ships and explain, why this concept is mostly used for this shiptype.
7. Which intact stability rules have to be applied for RoRo ships and where do you find them?
8. Which damage stability rules are applicable for newbuild RoRo ships and in which guideline do you find them?
9. Please sketch a typical righting lever arm curve (stillwater) for a RoRo- and a Containership. Please explain the differences.
10. Which parts of a vessel may be considered for the calculation of the righting lever arm curve? Where is this defined?
11. At which point does the righting level arm curve mandatorily end? Where is this defined?
12. Which is the typical limiting stability criterion for a RoRo-Ship with three, four and five decks?
13. Please explain why it is reasonable to design the vehicle deck of of RoRo-Ship at least 20 m wide?
14. Why are anti-heeling and anti-rolling system important on RoRo ships? What is the difference between anti-heeling and anti-rolling systems?
15. What is the difference between a RoRo-Ship and a Pure-Car-Carrier (PCC)?
RO - RO 2700

22 KNOTS, 2700 LANE METERS,
14,200 t DEADWEIGHT,
12 DRIVERS
Flensburger’s new RoRo carriers are state-of-the-art designs for fast and economic services. Because these vessels represent the best possible solution for maximum cargo area, high service speed and lowest fuel consumption, they are the logical choice for every operator and every route. It was the competitive price and value for money which for example convinced the Turkish shipping company UND RoRo to order 6 vessels for their Istanbul-Trieste service.

**MAIN DIMENSIONS**

- Length (overall) : 193.00 m
- Length (between perpendiculars) : 182.39 m
- Breadth : 26.00 m
- Depth to main deck : 8.60 m
- Depth to upper deck : 16.70 m
- Draught (summer load) : 7.40 m
- Draught (design) : 5.70 m

**DEADWEIGHT / TONNAGE**

- Design : abt. 7,730 t
- Summer load : abt. 14,200 t
- Gross tonnage : abt. 22,900 GT
- Net tonnage : abt. 8,670 NT

**CLASSIFICATION**

DNV + 1 A1 General Cargo Carrier RoRo, EO, ICS, DG-P, W1

**MAIN ENGINE**

- Two (2) four-stroke medium speed diesel engines
- 2 x MAK 9M 43
- MCR 8,100 KW each, 500 rpm
- Fuel: 380 cSt at 50° C or MDO

**SPEED & F.O. CONSUMPTION**

- Service Speed 21.6 Knots
- (at design draught of 5.70 m, 90% MCR (14,580 KW), 10% sea margin and shaft generators engaged (abt. 800 KW)
- Max. cruising range abt. 10,000 sea miles
- Consumption 61.2 t/day
CARGO CAPACITY

<table>
<thead>
<tr>
<th>Trailer / lm</th>
<th>Lanes</th>
<th>Trailer (13.6+0.4m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper deck</td>
<td>6.8 m high / 3.0 m wide</td>
<td>1,200 lm</td>
</tr>
<tr>
<td>Main deck</td>
<td>6.8 m high / 3.1 m wide</td>
<td>955 lm</td>
</tr>
<tr>
<td>Tank top</td>
<td>5.0 m high / 2.9 m wide</td>
<td>485 lm</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,640 lm</td>
</tr>
</tbody>
</table>

DRIVER AND CREW CABINS / BEDS

<table>
<thead>
<tr>
<th>Deck</th>
<th>Driver cabins</th>
<th>Driver beds</th>
<th>Crew cabins</th>
<th>Crew beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 House deck</td>
<td>10 officer class</td>
<td>10</td>
<td>9 single crew</td>
<td>9</td>
</tr>
<tr>
<td>1 House deck</td>
<td>6 two bed cabins</td>
<td>12</td>
<td>6 single crew</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>6 cabins</td>
<td>12</td>
<td>25 cabins</td>
<td>25</td>
</tr>
</tbody>
</table>
CARGO HOLD VENTILATION
Cargo hold ventilation will be 20 air changes per hour in harbour condition and 10 air changes per hour in sea condition.

SPECIAL FEATURES
- Maximum cargo capacity
- Excellent speed - power performance
- Low fuel oil consumption
- Excellent seakeeping behaviour
- Flume stabilisation system
- Maximum deadweight capacity
- Low noise and vibration levels

AUXILIARY ENGINES
Auxiliary diesel engines 2 pcs. 1,500 KW
Generators (diesel driven) 2 pcs. 1,800 KVA
Shaft generator 2 pcs. 2,000 KVA
EM. generator (diesel driven) 1 set 450 KW

TANK CAPACITIES
Water ballast tanks abt. 3,650 m$^3$
Fresh water tanks abt. 160 m$^3$
Heavy fuel oil tanks abt. 1,300 m$^3$
Diesel oil tanks abt. 160 m$^3$

STEERING EQUIPMENT
Steering gear of ram type, two
high lift rudders of spade type, max rudder angle 45°
1 bow thruster 1,400 KW controllable pitch prop.

CARGO ACCESS EQUIPMENT
Access ramp aft 1 pc. 17 m wide x 15 m + 3 m flap
Internal fixed ramp 1 pc. main deck to upper deck with watertight guillotine door, 7 m wide
Internal fixed ramp 1 pc. main deck to tank top with watertight cover, 3.5 m wide
RO - RO 3750

22 KNOTS, 3,750 LANE METERS,
11,200 t DEADWEIGHT,
12 DRIVERS
Flensburger designers never stop. Not content with having built a highly successful 4-deck RoRo carrier, we have made it even better. With over 500 lane meters more the benefits for the owner speak for themselves.

**MAIN DIMENSIONS**

- Length (overall) : 193.00 m
- Length (between perpendiculars) : 182.39 m
- Breadth : 26.00 m
- Depth to main deck : 8.60 m
- Depth to upper deck : 16.70 m
- Draught (summer load) : 7.00 m
- Draught (design) : 6.45 m

**DEADWEIGHT / TONNAGE**

- Design abt. 9,050 t
- Summer load abt. 11,200 t
- Gross tonnage abt. 28,870 GT
- Net tonnage abt. 8,660 NT

**CLASSIFICATION**

DNV + 1 A1 General Cargo Carrier RoRo, EO, ICS, DG-P, W1

**MAIN ENGINE**

- Two (2) four-stroke medium speed diesel engines
- 2 x MAK 9M 43
- MCR 8,100 kW each, 500 rpm
- Fuel: 380 cSt at 50°C or MDO

**SPEED & F.O. CONSUMPTION**

- Service speed 21.5 knots
- (at design draught of 6.45 m, 90% MCR (14,580 kW), 10% sea margin and shaft generators engaged (abt. 800 kW))
- Max. cruising range abt. 10,000 sea miles
- Consumption 61.2 t/day
<table>
<thead>
<tr>
<th>Cargo Capacity</th>
<th>Driver and Crew Cabins / Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailers/Im</td>
<td>Lanes</td>
</tr>
<tr>
<td>Top deck</td>
<td>4.3 m high / 3.0 m wide</td>
</tr>
<tr>
<td>Upper deck</td>
<td>4.3 m high / 3.0 m wide</td>
</tr>
<tr>
<td>Main deck</td>
<td>6.8 m high / 2.9 m wide</td>
</tr>
<tr>
<td>Tank top</td>
<td>5.0 m high / 2.9 m wide</td>
</tr>
<tr>
<td>Total</td>
<td>3,726 Im</td>
</tr>
</tbody>
</table>
CARGO HOLD VENTILATION
Cargo hold ventilation will be 20 air changes per hour in harbour condition and 10 air changes per hour in sea condition.

AUXILIARY ENGINES
Auxiliary diesel engines 2 pcs. 1,500 kW
Generators (diesel driven) 2 pcs. 1,800 kVA
Shaft generator 2 pcs. 2,000 kVA
EM. generator (diesel driven) 1 set 450 kW

TANK CAPACITIES
Water ballast tanks abt. 3,650 m$^3$
Fresh water tanks abt. 160 m$^3$
Heavy fuel oil tanks abt. 1,300 m$^3$
Diesel oil tanks abt. 160 m$^3$

STEERING EQUIPMENT
Steering gear of ram type,
2 high lift rudders of spade type, max. rudder angle 45°
1 bow thruster 1,400 kW, controllable pitch propeller

CARGO ACCESS EQUIPMENT
Access ramp aft 1 pc. 17 m wide x 15 m + 3 m flap
Internal fixed ramp 1 pc. main deck to upper deck with watertight guillotine door, 7 m wide
Internal fixed ramp 1 pc. main deck to tank top with watertight cover, 3.5 m wide
Internal fixed ramp 1 pc. upper deck to top deck, 4.0 m wide

SPECIAL FEATURES
- Maximum cargo capacity
- Excellent speed-/power performance
- Low fuel oil consumption
- Excellent seakeeping behaviour
- Flume stabilisation system
- Maximum deadweight capacity
- Low noise and vibration levels
RoRo 3900

23 knots, 3831 lane meters
10,400 t deadweight
CLASSIFICATION
LR + 100 A1 Roll on - Roll off cargo ship, IWS, NAV 1, IBS, Ipe Class 1D + LMC, UMS

MAIN DIMENSIONS
Length (overall) 199.80 m
Length (between perpendiculars) 190.29 m
Breadth 26.50 m
Depth to main deck 9.40 m
Depth to upper deck 16.95 m
Draught (scantling) 7.35 m
Draught (design) 6.95 m

DEADWEIGHT / TONNAGE
Design 8,780 t
Scantling 10,407 t
Gross tonnage 32,289 GT
Net tonnage 9,686 NT

MAIN ENGINE
One (1) two-stroke marine diesel engine
MAN B&W 9L60 MC-C
MCR 20,070 kW, 123 rpm
Fuel: 700 cSt at 50° C or MDO

SPEED & F. O. CONSUMPTION
Service speed 23 knots
(at design draught of 6.95 m, 90% MCR (18,063 kW), 15% sea margin)
Max. cruising range abt. 8,300 sea miles
Consumption 73.70 t/day

AUXILIARY ENGINES
Auxiliary diesel engines 4 pcs. 1,720 kW
Generators (diesel driven) 4 pcs. 2,080 kVA
EM. generator (diesel driven) 1 set 450 kW

TANK CAPACITIES
Water ballast tanks abt. 4,020 m³
Fresh water tanks abt. 100 m³
Heavy fuel oil tanks abt. 2,035 m³
Diesel oil tanks abt. 130 m³

STEERING EQUIPMENT
Steering gear (electric hydraulic)
1 twist flow rudder
2 bow thrusters, 1,100 kW each, controllable pitch prop.
2 stern thrusters, 880 kW each, controllable pitch prop.

SPECIAL FEATURES
Quick loading and discharge capability
Maximum cargo capacity
Excellent speed / power performance
Low fuel oil consumption
Excellent seakeeping behaviour
Maximum deadweight capacity
Low noise and vibration levels
Interim stabilisation system
SAT Lashing System
Auxiliary engines fitted with
SCR (Selective Catalytic Reduction)

CARGO ACCESS EQUIPMENT
Access ramp aft
Internal fixed ramp
Internal fixed ramp
Internal hoistable ramp
Side doors
Hoistable car decks

CARGO HOLD VENTILATION
25 air changes per hour in harbour condition
10 air changes per hour in sea condition

CARGO CAPACITY
Trailer slots: 14.40 m x 2.9 m / 3.0 m
Weather deck 1,272 86 4.70 m
Upper deck 1,137 74 4.70 m
Main deck 1,046 68 4.2-4.8 m
Tank top 376 25 5.20 m
Total 3,831 253

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RoRo 5200

22 knots, 5,156 lane metres, 12,750 t deadweight
CLASSIFICATION
DNV + 1 A1 General Cargo Carrier Ro/Ro, EO, DG-P, NAUT-AW, LCS, LCS

MAIN DIMENSIONS
Length (overall) 199.80 m
Length (between perpendiculars) 189.63 m
Breadth (moulded) 29.50 m
Depth to main deck 12.75 m
Depth to upper deck 18.85 m
Draught (design) 6.85 m
Draught (stabilised) 6.95 m

DEADWEIGHT/TONNAGE
Design 12,750 t
Gross tonnage 38,000 GT
Net tonnage 11,400 NT

MAIN ENGINE
Two (2) four-stroke medium speed diesel engines
MCR 21,600 kW, 500rpm
Fuel: 380 cSt at 50°C or MDO

AUXILIARY ENGINES
Auxiliary diesel engines 2 pcs. 1,350 kW
Generators (diesel driven) 2 pcs. 1,750 kVA
Shaft generators 2 pcs. 1,750 kVA
EM generator (diesel driven) 1 set 380 kW

TANK CAPACITIES
Water ballast tanks abt. 5,700 m³
Fresh water tanks abt. 100 m³
Heavy fuel oil tanks abt. 1,600 m³
Diesel oil tanks abt. 180 m³

SPEED & FUEL CONSUMPTION
Service speed 22.0 knots
(at design draught of 6.85 m, 90% MCR (19,440 kW), 10% sea margin)
Max. cruising range abt. 10,000 sea miles
Consumption 81.60 t/day

STEERING EQUIPMENT
2 Steering gears (electric hydraulic)
2 twin flow rudder
2 bow thrusters, 1,100 kW, controllable pitch prop.

CARGO ACCESS EQUIPMENT
Access ramps aft  1 pc. 3.70 m wide (SB) x 15.0 m x 3.0 m flap
Internal fixed ramp  1 pc. main deck to upper deck, 3.70 m wide, 7° incline
Internal fixed / hoistable ramp  1 pc. main deck to lower decks, 3.70 m wide, 7° incline
Internal tiltable ramp  1 pc. upper deck to weather deck, 3.70 m wide, 7° incline

CARGO HOLD VENTILATION
20 air changes per hour in harbour condition
10 air changes per hour in sea condition

CARGO CAPACITY
Trailer slots: 13.60 m x 2.95 m / 2.0 m
Weather deck  1,387
Upper deck  1,300
Main deck  1,270
Tweem deck  624
Tank top  515
Total  5,156

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Solution 6

1. Which are the typical areas of operation of RoRo ships?
   Europe and Japan (Short-Sea-Shipping)

2. Please state the major design drivers for RoRo ships.
   
   (a) Steel structure of the cargo decks (minimum of or preferably no vertical rests)
   (b) Stability (small displacement, large side lateral area)
   (c) Slow Speed Manoeuvring (frequent calling of ports)
   (d) Propeller-induced vibrations
   (e) EEDI

3. Please explain the specialities in the design of the lines of RoRo ships.
   In the shipping route areas there are mostly restrictions for the draught in the ports. Furthermore RoRos are rather fast vessels, therefore they have rather slender fore- and aftbodys with a corresponding low block coefficient. Additionally the machinery and the heavy ramp are normally located in the aft of the vessel, which would lead to large stern trim. In order to avoid this the LCB of the vessel has to be shifted in direction of the aft end and if necessary the deckhouse has to be arranged in the bow or trim water has to be used in the forepeak. Following from this the longitudinal bending moment increases. However this is usually not critical because RoRos have many decks expanding over the full ship length, which leads to a high section modulus. Anyway the longitudinal strength has to be checked for RoRos as well as for any other vessel. Additionally RoRos are usually twin-screw Vessels

4. Please state the most relevant cargo unit for RoRo ships. Which other typical cargo unit do you know for this shiptype?

   The most relevant cargo units are roadtrailers. In Europe they are normally 13.60 m (+0.4 m) long, 2.55 m wide and 4.00 m high and they have a maximum weight of 39 t.

   Other cargo units are e.g.: "MAFs Doublestackers" (Watch out for the height of the cargo decks!), SECU-Boxes (13,8mx3,6mx3,6m ; 90t; Rolls of paper,...)

5. Please state, by which characteristics RoRo ships can be subdivided into different classes.

   (a) Number of parking positions for roadtrailers
   (b) Lanemeters: a typical lane is 2.9 m wide
   (c) Number of decks

   Furthermore RoRo-ships are classified into "Volume Carriers" (mainly cargo with a small volume-specific weight) and "Deadweight Carriers".

6. Please state the typical propulsion concept for RoRo ships and explain, why this concept is mostly used for this shiptype.

   2 x 4 stroke medium speed with CPP with PTOs => high manœuvreurability
   Very rarely: 1 x 2 stroke slow speed with FPP and numerous thrusters
7. Which intact stability rules have to be applied for RoRo ships and where do you find them?

RoRo ships are pure cargo ships. Following from this the same rules and regulations have to be applied as for container ships. Therefore the answer are the Rahlola-criteria and the weather criterion as described in the IS Code 2008.

8. Which damage stability rules are applicable for newbuild RoRo ships and in which guideline do you find them?

RoRo ships are pure cargo, therefore SOLAS 2009 Part B-1 (new probabilistic damage stability)

9. Please sketch a typical righting lever arm curve (stillwater) for a RoRo- and a Containership. Please explain the differences.

RoRo: high initial stability, low additional stability by form
Containerschiff: low initial stability, low additional stability by form

Abbildun 1: Righting lever curve of a Containership
10. Which parts of a vessel may be considered for the calculation of the righting lever arm curve? Where is this defined?

“everything that is weathertight”
IS-Code: 3.5 Calculation of stability curves
3.5.1 The calculations should take into account the volume to the upper surface of the deck sheathing....
3.5.2 Superstructures..., which may be into account
3.5.2.1 ..., complying with regulation 3(10)(b) of... Load Line Convention....
=> and in the Load Lines 3(10)(b) iii) you find, that the openings have to be weathertight.

11. At which point does the righting lever arm curve mandatorily end? Where is this defined?

At the 'downflooding angle', which ist the angle where non-weathertight opening are submerged (e.g. engine room ventilation inlets)

IS-Code: 3.5.2.8. In cases where the ship would sink due to flooding through any openings(die nicht wetterdicht und nicht wasserdicht sind => MR-Lüfter), the stability curve should be CUT SHORT at the corresponding angle of flooding ("downflooding angle") and the ship should be considered to have entirely lost its stability!

12. Which is the typical limiting stability criterion for a RoRo-Ship with three, four and five decks?

3-Decks: Solas 2009 Part B-1
4-Decks: Solas 2009 Part B-1
5-Decks: Intaktcode 749 Weather Criterion (large side lateral area, large resulting lever of wind force and counteracting force by the water as well as small displacement)

13. Please explain why it is reasonable to design the vehicle deck of a RoRo-Ship at least 20 m wide?

To be able to turn the road trailers on the cargo decks. The loading and unloading of the vessel can be done a lot faster this way and no bow door has to be installed.

14. Why are anti-heeling and anti-rolling systems important on RoRo ships? What is the difference between anti-heeling and anti-rolling systems?

Anti-Heeling-Systems: to avoid torsion of the ramp whilst the ship is loaded or unloaded asymmetrically.
Anti-Rolling-Systems: to avoid cargo shifts in heavy seaways, which could lead to capsizing of the vessel. Whilst a container ship loses its uppermost containers due to high rolling accelerations (reduced VCG) in a RoRo the trailers are only shifted sideways (constant VCG). To prevent this the trailers have to be lashed. If by effective roll damping the lashing can be omitted quicker loading and unloading can be achieved.

15. What is the difference between a RoRo-Ship and a Pure-Car-Carrier (PCC)?

RoRo ships have frequent calling of ports (short-sea-shipping) and not more than 5 decks. PCCs have the same shipping profiles as large container ships and for this reason they are normally equipped with a two-stroke slow speed engine and a fixed pitch propeller. Additionally PCCs usually transport only relatively light vehicles which can be stored on hanging tween decks.