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Asphalt Carriers from *Kraljevica Shipyard,* Croatia

Professional paper

This article is based on the materials presented by the experts from *Kraljevica Shipyard* at the annual meeting of the Croatian shipbuilding designers held in Kraljevica in October 2005. Asphalt tanker *Asphalt Seminole* and her sister-ships are rather sophisticated vessels having a complex hull structure, cargo space and cargo survey and control equipment. Therefore, firstly the technical data of the already delivered asphalt tanker *Asphalt Seminole* are given and then, the very interesting development of her design in presented. Special emphasis is given to the design of the cargo space, to the stability survey of the intact ship at various loading cases as well as to the damaged ship stability and floatability calculation in accordance with the pollution prevention regulations. Finally, a comparison of the present ship with various similar asphalt tankers in exploitation is made.

Keywords: *asphalt carriers, ship design, cargo spaces, stability.*

Brodovi za prijevoz asfalta iz *Brodogradilišta Kraljevica*

Stručni rad

Ovaj članak se zasniva na materijalima koje su prikazali stručnjaci *Brodogradilišta Kraljevica* na godišnjem sastanku hrvatskih brodograđevnih projektanata održanom tijekom listopada u Kraljevici. Asfaltni tankeri *Asphalt Seminole* i njegovi "blizanci" brodovi su velike složenosti sa složenom strukturom trupa, teretnim prostorom kao i opremom za nadzor i upravljanje teretom. Stoga su najprije dani tehnički podaci o nedavno isporučenom asfaltnom tankeru *Asphalt Seminole*, a zatim je opisan vrlo zanimljiv razvoj njegovog projekta. Posebni je naglasak dan osnivanju teretnog prostora, analizi stabiliteta neoštećenog broda za veliki broj stanja krcanja i proračunu stabiliteta i naplavljivosti oštećenog broda u skladu s propisima o sprečavanju zagađenja mora. Na kraju je dana usporedba prikazanog tankera s raznim sličnim asfaltnim tankerima koji su već u eksploataciji.

Ključne riječi: *brod za prijevoz asfalta, projektiranje broda, prostor za teret, stabilitet.*

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1 Introduction

At the moment, the world fleet of asphalt (and similar cargo) carriers numbers 92 ships with 732 302 dwt, which makes 0.2% of the world tanker fleet. In comparison with the world tanker fleet, whose average age was 19.1 years at the beginning of 2005, the average age of the asphalt carriers is 17.3 years.

In the last 5 years 22 asphalt carriers with 143 298 dwt have been ordered: 6 ships in Japan, 5 in China, 3 in Turkey, 2 in Italy and in Bulgaria and 4 ships in Croatia with 36 800 dwt, which makes about 26% of the total number of ordered asphalt carriers. The above mentioned countries are also the biggest shipbuilders of these peculiar ships.

If the following particulars of the market are taken into account:

- Increased demand for newbuilts
- Increase of transport fees
- Need for the replacement of the old fleet
- Relatively quick complementing of the free shipyard vacancies
- Change of the exchange rate EUR/USD (about 35%)
- Increased prices of newbuilts (about 50% for asphalt carriers)

then it follows that the asphalt carrier market is one of the niches on the world ship market that is accessible for the Croatian shipbuilders. For comparison, the comparative price trend in the last 5 years for the asphalt carriers of 9000 dwt and for the product carriers of 37 000 dwt is given in Figure 1.

The mentioned 4 asphalt carriers in Croatia were ordered in *Kraljevica Shipyard* at a price of USD 15.5 million, in competition with shipyards from the Far East (about USD 11 million), Spain (about USD 14 million.) and Netherlands (about USD 17 million).

In Table 1 the basic data (name, yard no., client, important dates) for the mentioned 4 ships are presented.

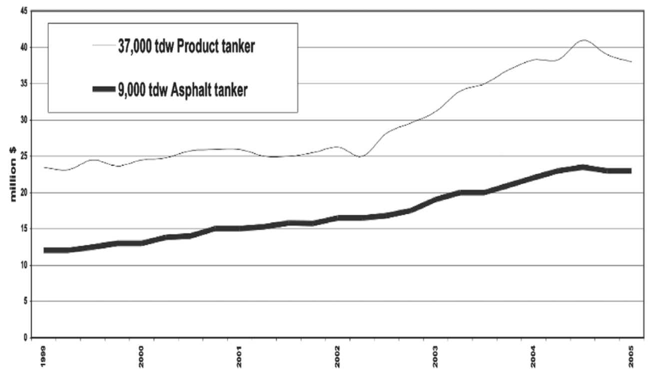


Figure 1 Price trends of asphalt carriers in comparison to product carriers
Slika 1 Kretanje cijena za tankere za prijevoz asfalta u usporedbi s *product carrierima*

Table 1 Asphalt carriers from *Kraljevica Shipyard*
Tablica 1 Tankeri za prijevoz asfalta iz *Brodogradilišta Kraljevica*

Yard no.	Name	Client	Status
531	*Asphalt Seminole*	*Asphalt (Caribbean) Ltd.,* Isle of Man	Delivered
532	*Asphalt Sailor*	*Asphalt (Gulf of Mexico) Ltd.,* Isle of Man	Launched
533	*Asphalt Transporter*	*Asphalt Transporter Shipping Company,* Cyprus	Launched
534	*Asphalt Carrier*	*Asphalt Carrier Shipping Company,* Cyprus	On the berth

2 Brief technical description of the ship

Before presenting in details some particulars in designing the asphalt carrier from Table 1, here are some technical data about her.

Assignment of the ship:

The ship and the entire equipment are designed for an unrestricted navigation and transportation of the following cargoes: crude oil products (heated and not heated), asphalt, bitumen, coal-tar, coal-tar pitch, coal-tar naphtha solvent, creosote, coal-tar and creosote (wood). The maximum specific gravity of the cargo is 1.25 t/m^3; the maximum temperature of the cargo is 250° C.

Main particulars:

Length over all	L_{oa}	= 108.5 m
Length between perpendiculars	L_{pp}	= 99.9 m
Breadth moulded	B	= 18.6 m
Depth (to main deck)	D	= 10.6 m
Draught, max	T_{max}	= 8.34 m
Deadweight	Dwt	= 9233 m.t.
Cargo tank capacity, 100% vol.	Δ	= 7748 m^3
Ship speed	V_S	= 13.42 kn

The general arrangement of the ship is presented in Figure 2.

The ship has a raised continuous deck ("trunk deck") in the cargo tank area, with a long forecastle, fore bulb, poop deck and transom stern. The engine room and the accommodation space are placed in the aft part of the ship.

The hull is divided by transverse watertight bulkheads that divide the ship into the following main spaces: fore peak, bow thruster space, cargo tank spaces, pump room (in the middle of the ship), engine room and aft peak.

In the cargo space area, there is a single bottom and a single side shell (except in the area of cargo tank no. 1) as well as underneath the pump room. A double bottom is in the engine room, where the water tanks, lubrication oil tanks as well as other tanks necessary for the main machinery and the ship systems are situated.

Cargo space:

The cargo space consists of three non-structural blocks of tanks:

- Block I - tank no. 1 placed in the front area of the cargo space
- Block II - (placed on the aft side of the pump room) consists of tank no. 2, tank no. 3L, tank no. 3D and tank no. 4
- Block III - (placed on the fore side of the pump room) consists of tank no. 5L, tank no. 5D and tank no. 6.

Pump room:

The pump room is a structural space situated between tank blocks II and III in the middle of the cargo space, which is separated by transverse watertight bulkheads forwards to the bow and aft to the stern.

The cargo pumps (of screw-type, two of them with the capacity of 400 m^3/h, and the third one with 150 m^3/h) are placed together with the relevant equipment in the pump room and are remote (hydraulically) controlled from the cargo control room that is placed on the 1st poop deck.

Cargo heating:

The cargo heating is accomplished by means of thermal oil at a maximum temperature of 250^{0}C. The thermal oil circulates through heating coils and towers inside the cargo tanks.

Two boilers, fired by heavy oil and with the capacity of 1 200 000 kcal/h each serve for heating the thermal oil; each boiler can independently satisfy the entire needs for the cargo heating. The boilers are placed in the thermal oil boiler room on the 1st poop deck.

Ship propulsion:

The ship propulsion is a single-screw propulsion assembly comprising:

- Main engine *Wärtsilä*, 8L32, 4000 kW at 750 rpm (diesel engine, 4-stroke, 8 cylinders in line, driven by high viscosity fuel up to 380 cSt/500 C);
- Flexible coupling;
- Reduction gearbox with integral thrust bearing; it reduces the revolution number to 130 rpm for driving the propeller shaft with the propeller; the oil distributor box for the controllable pitch propeller system is mounted on the gearbox;
- Controllable pitch propeller system consisting of a propeller shaft, a stern tube, bearings in the stern tube, a 4-bladed marine propeller and a hub built-in integral servo-cylinder;
- Shaft generator (1380 kVA) to PTO on the gearbox.

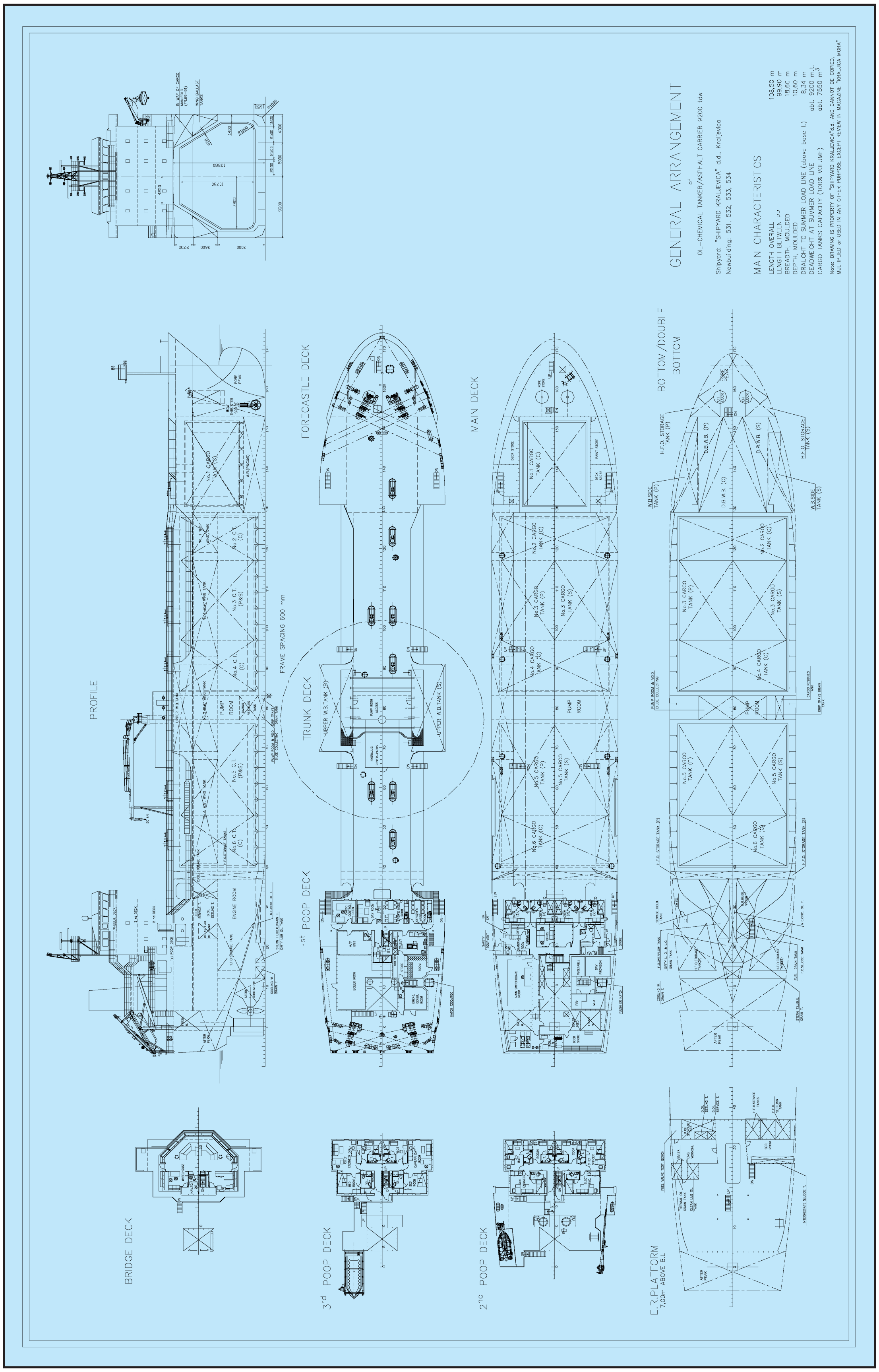


Figure 2 **General arrangement of the asphalt carrier *Asphalt Seminole***
Slika 2 **Opći plan tankera za prijevoz asfalta *Asphalt Seminole***

3 Design development

The design of the presented asphalt carrier has been developed in four phases:

- Initial design 03-56
- Altered design 05-71
- Design 05-01
- Final design.

3.1 Initial design 03-56

Initial design 03-56 was developed at *Brodotrogir Shipyard* in the year 1997 for a 9800 dwt multi-purpose cargo ship. The building of 5 ships was ordered. The client did not take two already launched hulls, so one of these hulls was offered to the American company *Sargeant Marine* to be reconstructed into an asphalt carrier.

The main particulars of the initial design were as follows:

Length over all	L_{oa} = 108.5 m
Length between perpendiculars	L_{pp} = 99.6 m
Breadth, moulded	B = 18.60 m
Depth	D = 10.60 m
Draught, design	T_d = 6.75 m
Draught, max.	T_{max} = 8.34 m
Deadweight on T_{max}	Dwt = 9800 t
Main engine power	2760 kW/720 rpm
Speed, trial on T_d, at 2700 kW	v_S = 13.75 kn
Three "box-shaped" holds, volume	Δ = 10652 m^3
TEU capacity	224 (in holds), 167 (on deck)

The general plan of the initial design is presented in Figure 3.

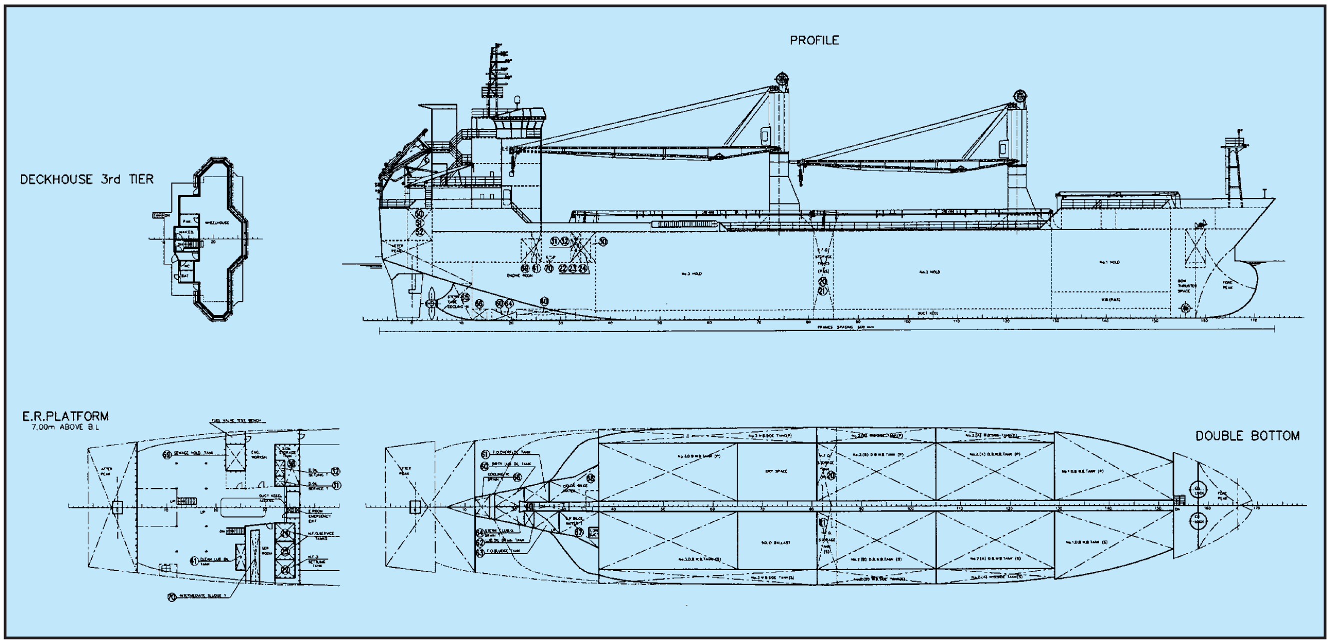


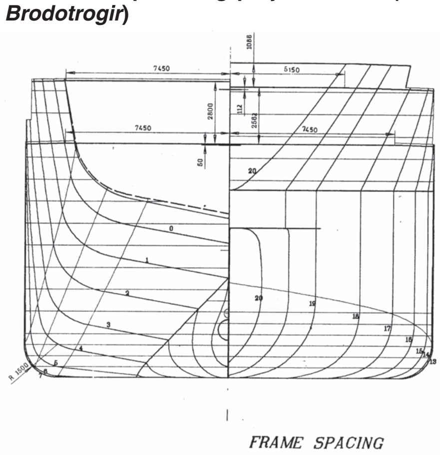
Figure 3 **General plan of initial design 03-56 (*Brodotrogir Shipyard*)**
Slika 3 **Opći plan početnog projekta 03-56 (*Brodogradilište Brodotrogir*)**

Concerning the hull form, a very successful solution was chosen for the bow. It has been developed for tankers ordered by *Sovchart*, only the form was slightly finer due to the greater relative speed. The stern is a very simple form with skeg. The cross-sections are fuller in the lower part to enable the shifting of the "box-shaped" hold no. 3 as much as possible towards the stern. Some numerical features concerning the hull form are given in Table 2, and the body-plan lines are presented in Figure 4.

Table 2 **Some features about the hull form of the initial design 03-56 (*Brodotrogir Shipyard*)**
Tablica 2 **Neke značajke forme trupa početnog projekta 03-56 (*Brodogradilište Brodotrogir*)**

	Δ (t)	C_B	C_W	C_P
T_d (6.75 m)	9754	0.761	0.853	0.767
T_{max} (8.34 m)	12194	0.770	0.868	0.775

Figure 4 **Body-plan lines of the initial design 03-56 (*Brodotrogir Shipyard*)**
Slika 4 **Plan rebara početnog projekta 03-56 (*Brodogradilište Brodotrogir*)**



The design was checked and improved by means of model tests in *Brodarski Institute* in Zagreb. A controllable pitch propeller *Wärtsilä* with the diameter of D=4.0 m, A_E/A_0 = 0.475 and P/D=1.02 was chosen. The installing of bow thrusters was foreseen.

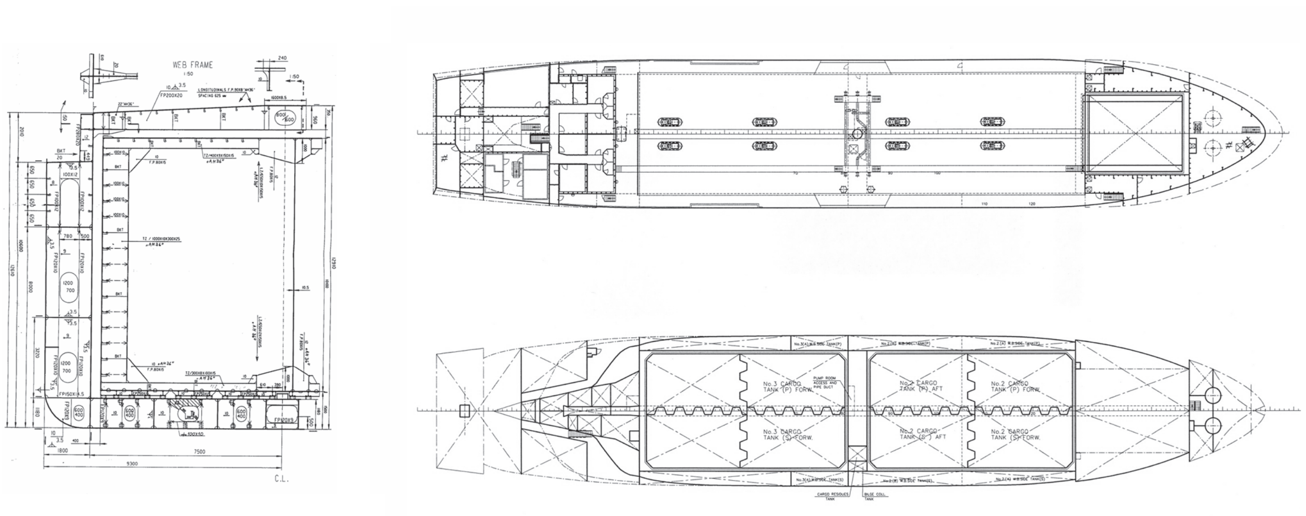
3.2 Altered design 05-71

Brodotrogir Shipyard made the altered design 05-71 and entered into serious negotiations with the owner of the unfinished hull *Sargeant Marine*, because that could be a solution for the unfinished hulls.

The altered design was developed under the following assumptions:

- The cargo tanks (4 tanks in one block) are assembled and insulated outside the ship, and after that are put down by a crane into the cargo space;
- The cargo tank capacity should be as big as possible, i.e. about 8000 m^3;
- The planned clearance to the longitudinal walls of the side tanks and the transverse bulkheads of the cargo space should be about 200 mm, which means that the access to these spaces for the survey and maintenance needs would not be possible;
- Cargo pumps and driving electric motors are placed in the fuel tank space between holds no. 2 and 3;
- Ballast tanks in the double skin are still in function and the double bottom is cut out to enable the access to the bottom of the cargo tanks;
- The hatch covers are replaced by a fixed deck, and the hatch coamings remain unchanged.

In Figure 5a a typical midship section is presented, and in Figure 5b the cargo space disposition.



(a) (b)

Figure 5 **Midship section (a) and cargo space disposition (b) of the altered design 05-71 (*Brodotrogir Shipyard*)**
Slika 5 **Glavno rebro (a) i raspored teretnog prostora (b) projekta preinake 05-71 (*Brodogradilište Brodotrogir*)**

3.3 Design 05-01

Due to the fact that the reconstruction negotiations did not give any results, the owner of the hull addressed *Kraljevica Shipyard* and signed a contract for building 2 ships according to the design 05-71.

Through the consultations between *Kraljevica* and *Brodotrogir* shipyards, which followed after the above mentioned contract had been signed, it was concluded that the newbuilt should not follow the limitations superimposed by using the existing hull of the multi-purpose cargo ship.

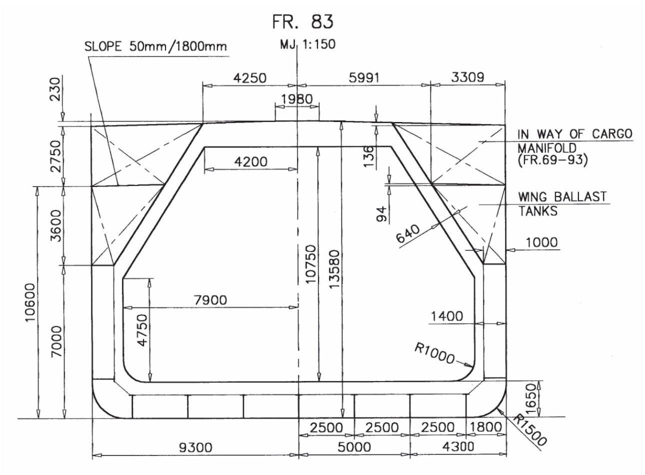
Therefore, the cargo space was redesigned under the assumptions that the cargo tanks will be erected inside the hull. In such a way, from the design 05-71 of *Brodotrogir* the design 05-01 of *Kraljevica* was developed.

In accordance with the above assumptions it was necessary to ensure much greater clearances around the cargo tanks while preserving the earlier declared cargo space capacities. A satisfactory solution was found in the form of the hull with a “trunk deck”.

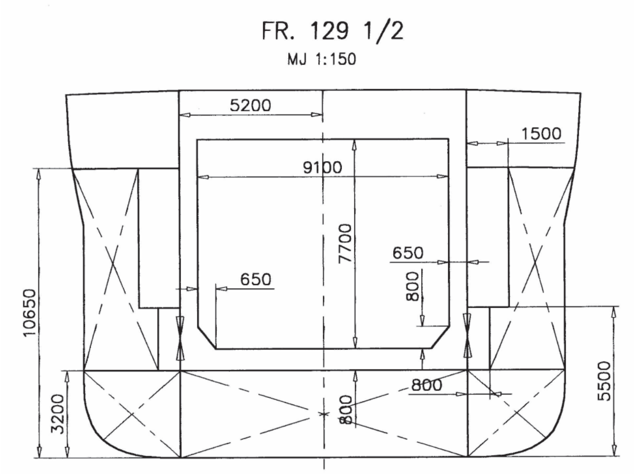
The fore part of the ship (fore peak, bow thruster room, hold no. 1 with high double bottom), from frame 129 to frame 174, did not change, see Figure 5a.

The cargo space from frame 45 to frame 129 contains only one big block with 10 tanks, without a double bottom and a double skin, only with wing tanks. The clearance to the bottom is 1.65 m, to the side 1.4 m, to the wing tank 0.64 m and to the deck 1.18 m, see Figure 6b.

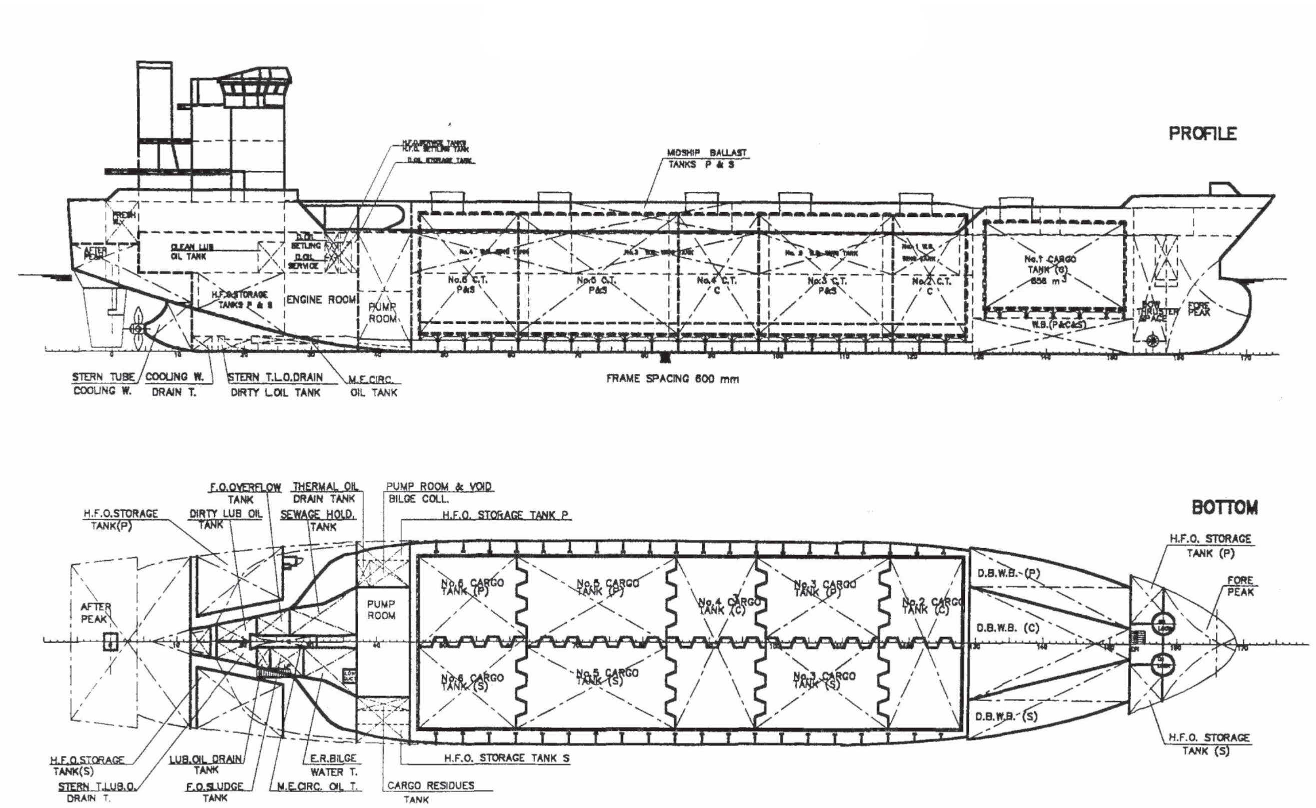
The capacity of the tanks is just 8000 m^3. The cargo pump room is situated between the engine room and the cargo space, see Figure 6c.



a) Frame 129



b) Frame 83



c) Longitudinal section and deck plan

Figure 6 **Design 05-01 (*Kraljevica Shipyard*)**
Slika 6 **Projekt 05-01 (*Brodogradilište Kraljevica*)**

3.4 Final design

In the design 05-01 certain weaknesses were discovered, such as:

- Unfavourable interaction between the stiff and long cargo tank and the flexible ship structure (without double bottom, double skin and transverse bulkheads);
- Complexity of the cargo loading/unloading system due to an unfavourable position of the pump room with respect to the tanks and the manifold.

Although the concept of the design 05-01 was already certified from the strength, stability and damaged stability survival aspects, the owner decided to give up some of the cargo tanks capacity for a “moderate”, i.e. less “avant-garde” solution. The result was the division of one big block of cargo tanks into two smaller ones and the return of the pump room space in the middle the ship. The hydraulic drive of the cargo pumps is applied. The electro-hydraulic power units are put into a new deck house directly behind the manifold, and the heaters of the thermal oil are transferred from the engine room onto the 1st poop deck. The entire capacity of the cargo tanks is reduced by about 250 m^3. The number of cargo tanks was successfully reduced from 11 to 9 by using the stability analysis (particularly Reg. 25A of MARPOL: Stability during the loading/unloading). This has resulted in proportional savings in all cargo systems.

Thus, the final design, described in section 2 of this article and presented in Figure 2, was obtained.

The stability survey is carried out according to the "Code on Intact Stability for All Types of Ships Covered by IMO Instruments", the previous Res. A. 749(18). For this purpose, 23 characteristic loading conditions, including two conditions of the ship loaded to the "tropical loading line" (T = 8.514 m), have been chosen.

Table 3 **List of damage cases of the final design (*Kraljevica Shipyard*)**
Tablica 3 **Lista slučajeva oštećenja konačnog projekta (*Brodogradilište Kraljevica*)**

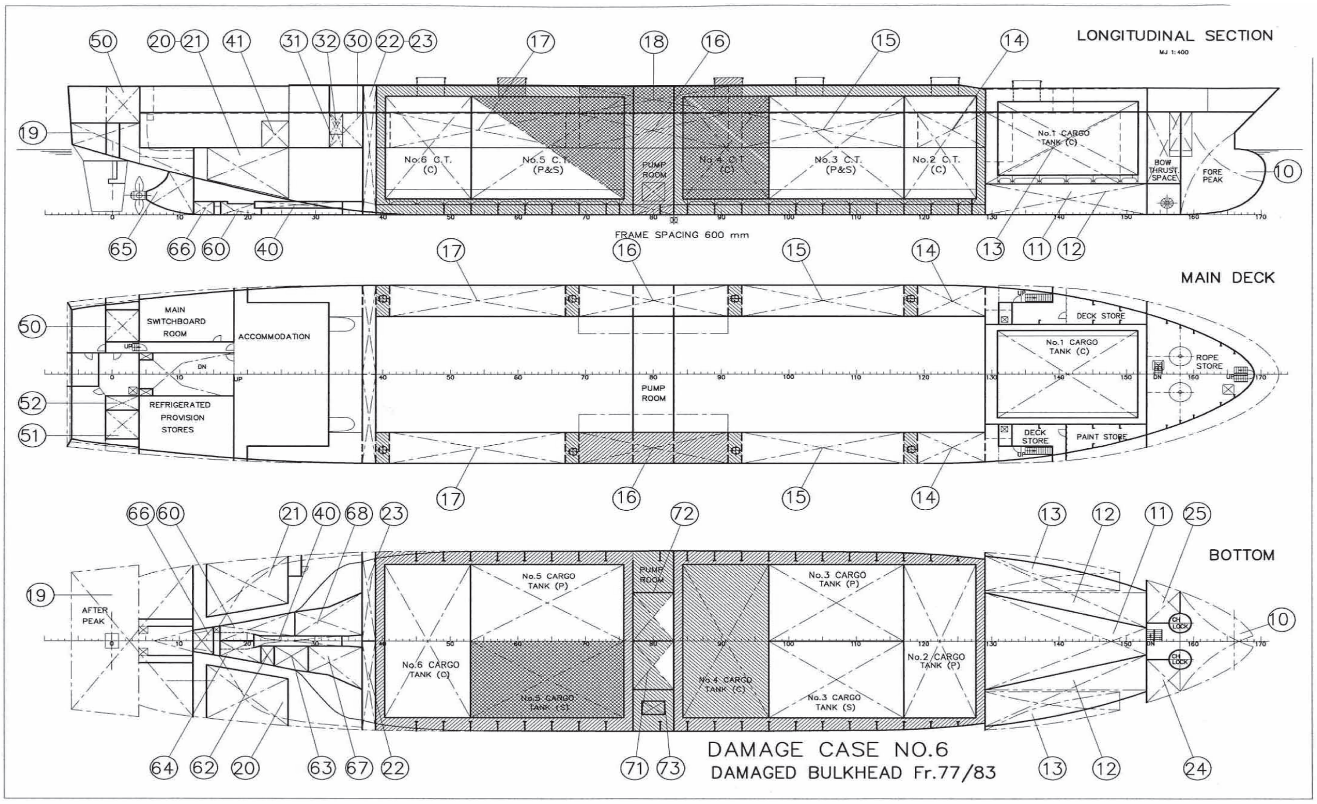
SUMMARY OF LOADING CONDITIONS

No.	DESCRIPTION	DISPL (t)	CARGO WEIGH T (t)	DRAUG. AFT (m)	DRAUG. FORW (m)	TRIM (m)	MG (m)	MAX SWBM (kNm)
1	BALLAST CONDITION, DEPARTURE	6899	--------	5.417	4.147	1.270	1.140	211165
2	BALLAST CONDITION, INTERMEDIATE	6522	--------	4.743	4.347	0.396	1.302	184630
3	BALLAST CONDITION, ARRIVAL	6472	--------	5.115	3.920	1.195	1.330	206624
4	LOADED WITH CARGO 1.10 t/m³ TO SUMMER LL, DEPARTURE	12910	8374	8.636	8.039	0.597	0.732	-82109
5	LOADED WITH CARGO 1.10 t/m³ TO SUMMER LL, INTERMEDIATE	12532	8374	8.174	8.117	0.057	0.733	-99948
6	LOADED WITH CARGO 1.10 t/m³ TO SUMMER LL, ARRIVAL	12482	8374	8.431	7.750	0.681	0.710	-95911
7	LOADED WITH CARGO 0.9 t/m³ (HEATED BITUMEN), DEPARTURE	11628	7092	7.916	7.288	0.628	0.644	24893
8	LOADED WITH CARGO 0.9 t/m³ (HEATED BITUMEN), INTERMEDIATE	11250	7092	7430	7.381	0.048	0.671	23675
9	LOADED WITH CARGO 0.9 t/m³ (HEATED BITUMEN), ARRIVAL	10750	7092	7.139	7.087	0.052	0.637	-54436
10	ARRIVAL WITH 1.10 t/m³ CARGO, SEGREGATION 1 (TANK No.1) DISCHARGED,	12312	7449	8.537	7.411	1.126	1.147	-101530
11	ARRIVAL WITH 1.10 t/m³ CARGO SEGREGATION 2 (TANKS No.2,4, & 6) DISCHARGED,	8753	4964	6.240	5.888	0.651	0.68	47110
12	ARRIVAL WITH 1.10 t/m³ CARGO, SEGREGATION 3 (TANKS No.3 & 5) DISCHARGED,	8250	4333	5.687	5.546	0.14	0.602	129880
13	ARRIVAL WITH 1.10 t/m³ CARGO, SEGREGATIONS 1 & 2 (TANKS No.1, 2,4 & 6) DISCHARGED,	8710	4040	6.164	5.617	0.548	1.278	49193
14	ARRIVAL WITH 1.10 t/m³ CARGO, SEGREGATIONS 1 & 3(TANKS No.1,3 & 5) DISCHARGED,	8079	3409	5.820	5.195	0.624	1.259	124155
15	ARRIVAL WITH 1.10 t/m³ CARGO, SEGREGATIONS 2 & 3(TANKS No.2,3,4,5 & 6) DISCHARGED,	6551	925	4.962	4.171	0.792	0.595	214473
16	PARTLY LOADED CONDITION WITH CARGO 1.25 t/m³ IN TANKS No.1,3 & 5, DEPARTURE WITH 50% STORES	9919	5628	6.749	6.486	0.263	0.657	46491
17	PARTLY LOADED CONDITION WITH CARGO 1.25 t/m³ IN TANKS No.1,2,4 & 6, DEPARTURE WITH 50% STORES	9203	4912	6.386	5.991	0.395	0.817	141293
18	PARTLY LOADED CONDITION WITH CARGO 1.25 t/m³ IN TANKS No.3 & 5, DEPARTURE WITH 50% STORES	9849	4579	6.898	6.234	0.664	1.134	42425
19	PARTLY LOADED CONDITION WITH CARGO 1.25 t/m³ IN TANKS No.2,4 & 6, DEPARTURE WITH 50% STORES	9358	3864	6.531	6.026	0.505	0.964	124067
20	STABILITY CHECK TO MARPOL Reg.25 DURING CARGO DISCHARGE / BALLASTING	10614	6052	8.050	5.869	2.181	0.444	24076
21	DOCKING CONDITION	4645	------	3.695	2.999	0.696	3.376	187218
22	PROPELLER AFLOAT REMOVAL CONDITION	5147	------	3.111	4.162	-1.051	2.592	207174
23	TROPICAL LOAD LINE - DEPARTURE	13202	8667	8.574	8.478	0.096	0.761	-93737
24	TROPICAL LOAD LINE - ARRIVAL	12800	8667	8.337	8.258	0.078	0.740	-102298

The damaged ship stability and floatability calculation was carried out in order to access the ship's compliance with following requirements:

a) IMO Regulations for the Prevention of Oil Pollution from Ships, Annex 1 of MARPOL 73/78 (Regulation 25, Subdivision and Stability) and Amendments 1992 to Annex (Regulation 13F);
b) International Code for the Construction and Equipment of Ship Carrying Dangerous Chemicals in Bulk (IBC Code), Volume 1, Chapter 2, Ship Survival Capability and Location of Cargo Tank, January, 1989;
c) Regulation 27 of the 1966 Load Line Convention (LLC).

Figure 7 **Plan of damaged (flooded) spaces for damage case no. 6 from Table 3**
Slika 7 **Plan oštećenih (naplavljenih) prostora za slučaj oštećenja br. 6 iz tablice 3.**

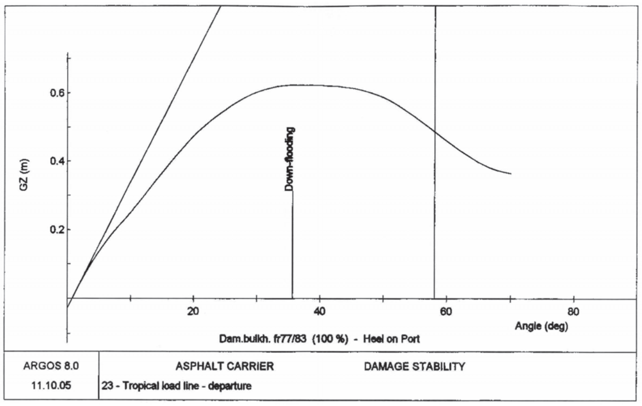


For this purpose the characteristic load cases chosen from the *Loading Manual* were checked, where also the contents of the damaged tanks correspond to the relevant loading condition. For this design, 15 damage cases were chosen, which are presented in Table 3.

In Figure 7 the plan of the damaged (flooded) spaces of the damage case no. 6 from Table 3 is shown.

In Figure 8 the typical curve of stability levers for the given damage case no. 6 from Table 3 is presented.

Figure 8 **Typical curve of stability levers for damage case no. 6 from Table 3**
Slika 8 **Tipična krivulja poluga stabiliteta za slučaj oštećenja br.6 iz tablice 3.**



4 Correlation instead of conclusion

Due to the fact that this is only the 1st part of the integral presentation of the given asphalt carrier, and that the final conclusions will be given at the end of the 2nd part, only some correlating features of the final design are presented here.

The measurements performed on the delivered ship *Asphalt Seminole* confirmed the design (contracted) predictions concerning the deadweight and the speed, see Table 4.

Table 4 **Comparison of the final design predictions with the full-scale measurements**
Tablica 4 **Usporedba prognoze konačnog projekta s rezultatima mjerenja u naravi**

	Design	Measurement
Deadweight at T_{max} = 8.34 m	9200 t	9230 t
Service speed (15%), 3128 kW, T_d = 6.75 m	13.7 kn	13.74 kn
Service speed (15%), 3128 kW, T_{max} = 8.34 m	13.4 kn	13.42 kn

At the end of this part a correlation of the most significant features of the final design and of several asphalt carriers already in exploitation is made and presented in Table 5.

Table 5 **Correlation of the features of the final design and of asphalt carriers in exploitation**
Tablica 5 **Usporedba značajki konačnog projekta i tankera za prijevoz asfalta u upotrebi**

	" BITF JORD "	" RATHROWAN "	" STELLA MARIS "	" CARANTEC "	" THEODORA "	" RATHBOYNE "	" ALCEDO "	" ASPHALT SEMINOLE "
Description	*Oil-Bitumen / Chemical IMO2*	*Bitumen / Chemical*	*Bitumen, Oil & Chemical tanker IMO2, ICE 1D*	*Bitumen / Oil tanker*	*Bitumen, Oil & Chemical tanker IMO2, ICE 1C*	*Oil-Asphalt tanker / Chemical IMO2*	*Bitumen tanker*	*Oil-Asphalt tanker / Chemical IMO2*
Deadweight (m.t.)	1986	4059	4552	4853	6616	6649	abt. 8000	9230
Lenght O.A. (m)	85,20	96,00	106,00	89,90	110,66	113,45	116,87	108,50
Lenght P.P. (m)	79,80	90,70	98,72	83,60	103,00	108,05	110,15	99,90
Breadth (m)	12,20	14,50	15,83	15,80	17,00	15,80	18,00	18,60
Depth (m)	6,50	8,30	9,75	8,20	9,36	9,50	10,20	10,60
Draught, max. (m)	4,10	5,90	6,30	6,67	7,06	6,65	7,50	8,34
Lenght of cargo block (m)	49,3	31,7	28,5	49,4	-	36,4	-	26,0 (48,8)
% of Lpp	61,8	35,0	29,0	59,0	-	33,7	-	26,0 (48,8)
Cargo tank volume 100% (m3)	1910	3900	4307	4503	5260	5434	7248	7748
Ballast tanks volume (m3)	-	1363	-	1503	-	2525	-	2620
Fuel tanks volume (m3)	-	185	-	-	-	500	-	740
Cargo temperature (oC)	250	250	250	160 (bitumen)	250	250	250	250
Cargo pumps	2 x Screw	-	2 x 450 m3/h	2 x electric	3 x 375 m3/h	2 x 450 m3/h, hydr.	3 x 500 m3/h	2 x 400 m3/h, 1 x 150 m3/h hydr.
Cargo heating	2 x heaters	-	2 x heaters	-	2 x heaters	2 x heaters	-	2 x heaters
Main engine (kW/rpm)	1176/375	-	2880/600	-	3000/750	3690/750	4350	4000/750
Auxes. (No x kW)	2 x 175	-	3 x 390	-	4 x 215	3 x 388	-	2 x + shaft
Bow thruster (kW)	184	yes	300	250	275	350	yes	360
Service speed (kn)	10,0	13,3	abt. 13,0	-	14,0	14,0	15,0	13,4

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