

TECHNICAL-EXPLOITATIVE CHARACTERISTICS OF NAVIGABLE CANALS OF THE HYDROSYSTEM DANUBE-TISA-DANUBE AND THE CONNECTION INTO THE INTERNATIONAL WATERWAYS NETWORK

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ABSTRACT

The network of canals of HS DTD is situated, practically, in the central part of the main European waterway North Sea-Black Sea, which provides extremely favourable conditions for connecting with the markets in the west, as well as those in the east of the Europe, especially of the neighbouring countries, especially Hungary and Romania. Total length of the basic canal network is 960 km, but only 664 km is available for navigation.

1. POSITION AND INTERACTING CONNECTION AND CONNECTION WITH THE INTERNATIONAL WATERWAYS

The new Pan European waterway with 3505 km of total length was done by opening of the waterway Rhine-Main-Danube for traffic. This waterway connects the North Sea from Rotterdam with the Black Sea at Sulina.

The main European waterway North Sea-Black Sea consists of following parts: part of the river Rhine from Rotterdam to Mainz (length 538 km), part of the river Main from Mainz to Bamberg (length 385 km); the canal Main-Danube from Bamberg to Kelheim (length 117 km) and waterway of the river Danube from Kelheim to Sulina (length 2411 km). This main European waterway connects inland waterways networks of 14 European countries (about 480 million citizens). The IV waterway category is provided in whole length, in accordance with unique ECE criterions.

The navigable system Danube-Tisa-Danube belongs to the Danubian navigable system. Connection of domestic inland navigation with the wide network of the European waterways is possible with in integration by the river Danube into the Pan European waterway "Rhine-Main-Danube" from the North Sea to the Black Sea. The farther lengthening of waterway, by Tisa to Tokaj in Hungary and by Navigable Begej to Timisoara in Romania, will be possible in addition.

Participation of our transport in turnover of cargos and development of transit transportation at the same time will be increased by using of this waterway in foreign trade of Serbia with countries of Western Europe. Serbia will be connected with large industrial centres in the framework of inland waterway network of Western Europe by this main waterway. It will be the cheapest transport way, which can be used of our economy for our products and for integration in international work distribution, by barter and transportation exchange.

The position of waterways of the Hydrosystem Danube-Tisa-Danube and relation to the main European waterway North Sea-Black Sea is shown on figure 1.

TABLE 1. LENGTHS OF THE RIVERBANKS OF COUNTRIES THAT ON THE EUROPEAN WATERWAY "RHINE-MAIN-DANUBE"

Country	Total left and right bank		Left bank		Right bank	
	length (km)	particip. (%)	length (km)	particip. (%)	length (km)	particip. (%)
Netherlands	343,7	4,90	167,6	4,78	175,9	5,02
Germany	2241,8	31,98	1135,6	32,40	1106,2	31,56
Austria	672,0	9,59	321,5	9,17	350,0	9,99
Slovakia	194,6	2,78	172,1	4,91	22,5	0,64
Hungary	692,4	9,88	275,2	7,85	417,4	11,91
Croatia	138,0	1,97	0,0	-	138,0	3,94
Serbia	807,5	11,52	358,0	10,21	449,5	12,82
Romania	1395,0	19,90	1020,5	29,12	375,0	10,70
Bulgaria	470,5	6,71	0,0	-	470,5	13,42
Moldavia	0,8	0,01	0,8	0,02	0,0	-
Ukraine	53,7	0,77	53,7	1,53	0,0	-
TOTAL	7010,0	100,00	3505,0	100,00	3505,0	100,00

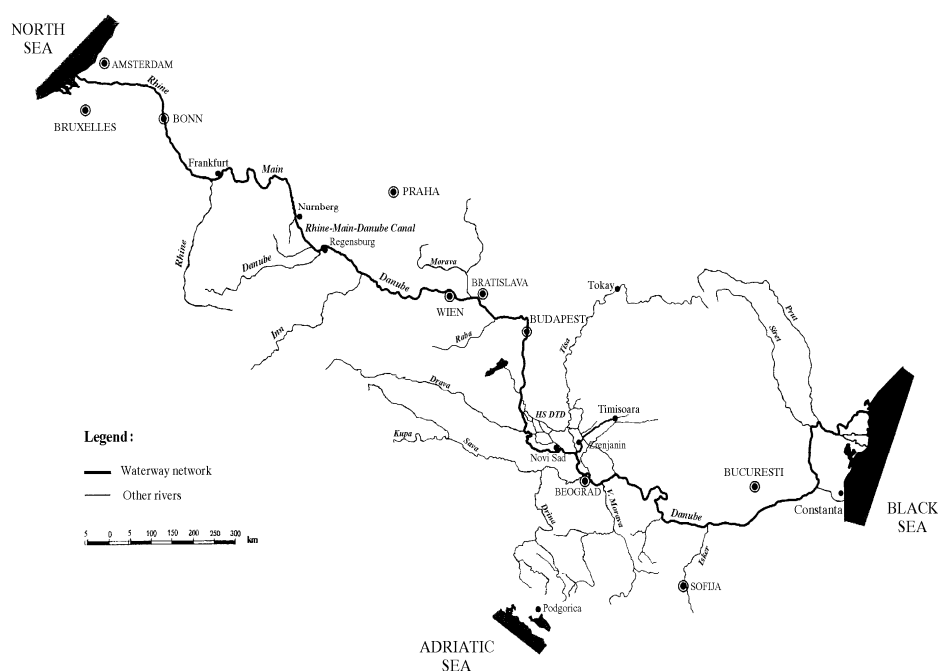


Figure 1. Position of waterways of the Hydrosystem DTD and relation to the main European waterway North Sea-Black Sea [3]

2. WATERWAYS

Total length of the basic canal network is 960 km, which includes large canals, Tamiš and present rivers as unique whole. Total length of 664 km is expected for navigation, but only 600 km of waterways is enabled until now. The navigable canal network DTD with marked positions of navigation locks is shown on figure 2.

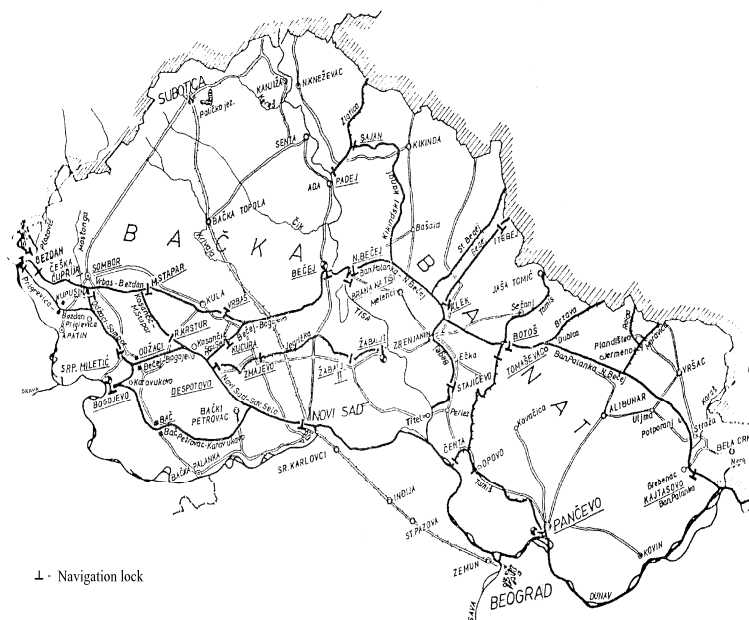


Figure 2.1. Navigable canal network of the DTD with marked positions of the navigation locks

Table 2. Dimensions of navigable canals of the HS DTD and their minimal radiuses of bends

The name of the canal	Canal section (from km to km)	Canal dimensions (m)		Minimal radius of bend (m)
		bottom width	navigable depth	
Bečej-Bogojevo	00,00-8,88	15,00	2,15	150
	8,88-39,46	15,00	2,00	600
	39,46-47,24	15,00	2,15	300
	47,24-90,20	15,00	2,15	1500
Vrbas-Bezdan	00,00-6,30	14,00	2,15	350
	6,30-80,90	7,00	2,00	280
Novi Sad-Savino Selo	00,00-4,30	42,00	2,15	3000
	4,30-39,10	16,00	2,15	1000
Canal Bajski	00,00-12,70	7,00	1,50	-
Odžaci-Sombor	00,00-27,80	14,00	2,15	300
Bački Petrovac-Karavukovo	00,00-20,00	10,00	2,00	550
	20,00-40,00	8,00	2,00	150
	40,00-52,00	6,00	1,50	260
Prigrevica-Bezdan	00,00-31,70	14,00	2,00	300
Kosančić-Mali Stapar	00,00-3,80	9,50	2,10	600
	3,80-21,10	10,50	1,80	600
Banatska Palanka-Novi Bečej	00,00-8,70	45,00	3,00	650
	8,70-26,00	24,00	2,15	650
	26,00-27,50	9,50	2,15	400
	27,50-45,00	24,00	2,15	650
	45,00-57,00	20,00	2,15	400
Begej	57,00-85,00	16,00	2,15	400
	85,00-147,30	17,00	2,15	650
Begej	00,00-34,80	16,00	2,15	200
Navigable Begej	00,00-29,00	14,00	2,15	-
Canal Kikindski	00,00-32,00	10,00	2,00	100

2.1. DIMENSIONS AND NAVIGATION LOCKS

Dimensions of navigable canals are shown in table 2.

On the navigable canals of the Hydrosystem Danube-Tisa-Danube there are 17 navigation locks, but 4 of them are old partially reconstructed and 13 are new. Two navigation locks on the rivers: on the Tisa (as part of the dam in Novi Bečej) and on the Tamiš (near to Pančevo), were also built in the Hydrosystem Danube-Tisa-Danube.

Complete ship locking duration is about 30-40 minutes, in dependence of water level, or denivelation that must to be surmounted. Locations and dimensions of the navigation locks are shown in table 3.

Table 3. Locations and dimensions of navigation locks on the canal network Danube-Tisa-Danube

The canal	The name of the navigation lock	Year of construction	Location (km)	Dimensions		
				length (m)	width (m)	depth (m)
Bečej-Bogojevo	Bečej	1970	0,16	85,00	12,00	3,00
	Kucura	1962	47,30	85,00	12,00	3,00
	Bogojevo	1963	89,45	85,00	12,00	3,00
Vrbas-Bezdan	Vrbas	1963	6,20	85,00	12,00	3,00
	Mali Stapar	1802	34,40	62,40	8,00	2,50
	Bezdan	1856	80,80	68,00	9,10	2,50
Novi Sad-Savino Selo	Novi Sad	1963	4,30	85,00	12,00	3,00
Odžaci-Sombor	Srpski Miletić	1961	6,00	85,00	12,00	3,00
	Sombor	1965	27,40	85,00	12,00	3,00
Banatska Palanka- Novi Bečej	Kajtasovo	1979	8,70	85,00	12,00	3,00
	Botoš	1971	85,60	85,00	12,00	3,00
	Novi Bečej	1972	147,00	85,00	12,00	3,00
Begej	Stajićevo	1971	9,20	85,00	12,00	3,00
Navigable Begej	Klek	*	0,70	64,00	10,00	2,40
	Srpski Itebej	*	29,00	72,10	10,00	2,40
River Tisa	Dam on the Tisa	1977	63,00	85,00	12,00	3,00
River Tamiš	Pančevo	1973	0,55	85,00	12,00	3,00

* - beginning of the XX century

2.2. CATEGORIZATION

On European inland waterways there are seven distinctive categories (classes) (based on resolution of Commission of ministers of transport of European Community, which was established by European Economic Commission - EEC). Categories of waterways are formed in dependence of dimensions and carrying capacity of ships and compositions (tows), that can navigate without any undisturbed.

In accordance with unique criterions for categorization of the European inland waterways, the navigable canals network of the Hydrosystem Danube-Tisa-Danube consists of canals that belong the following categories: the most represented are the canals of IV category in length of 321 km; then canals of I category in length of 128 km; canals of III category in length of 120 km; canals of V category in length of 22

km and canals of II category in length of 8,3 km. Categorization of navigable canals of the Hydrosystem DTD is given in table 4.

Table 4. Categorization of navigable canals of the Hydrosystem DTD in accordance with ECE criterions

The name of the canal	The canal section (from km to km)	Length of section (km)	Category of waterway (EEC criterions)
Bečej-Bogojevo	00,00-39,46	39,46	category IV
	39,46-47,30	7,84	category III
	47,30-90,20	42,90	category IV
Vrbas-Bezdan	00,00-6,30	6,30	category III*
	6,30-80,90	74,60	category I
Novi Sad-Savino Selo	00,00-4,30	4,30	category V
	4,30-39,10	34,8	category IV
Canal Bajski	00,00-12,70	12,70	without category
Odžaci-Sombor	00,00-27,80	27,80	category IV
Bački Petrovac-Karavukovo	00,00-20,00	20,00	category III
	20,00-40,00	20,00	category I
	40,00-52,00	12,00	category I
Prigrevica-Bezdan	00,00-31,70	31,70	category III
Kosančić-Mali Stapar	00,00-3,80	3,80	category II
	3,80-21,10	17,30	category I*
Banatska Palanka-Novi Bečej	00,00-8,70	8,70	category V
	8,70-26,00	17,30	category IV
	26,00-27,50	1,50	category III
	27,50-147,30	119,80	category IV
Begej	00,00-9,20	9,20	category V
	9,20-34,80	25,60	category IV
Navigable Begej	00,00-29,00	29,00	category III
Canal Kikindski	00,00-32,00	32,00	category III

* Sufficient canal depths demanded by the stated waterway category are not provided on these sections

3. NAVIGATION CONDITIONS

3.1. Navigation possibilities

Navigation possibilities of the canal network of the Hydrosystem Danube-Tisa-Danube can be explained as:

- In large canals, which dimensions are similar with the canal Novi Sad-Savino Selo, (dimensions at low navigable level: width on bottom $b=47,0$ m, average profile depth $h_{sr}=3,15$ m and transversal section area $F_{\square}=117,0$ m²), during navigation of cargo ships with 1000 t of carrying capacity which velocity in motionless water is $v=8,0-8,5$ km/h, hydraulic mutation can deteriorate canal banks are not observable.
- In accordance with researches which were done it could be concluded that coefficient of ship resistance increasing in canal is in interval: $k_{kn}=1,80-2,96$, and for zone of navigation speeds in motionless water $v=5,00-8,50$ km/h.
- Two barges (1000 t of carrying capacity) can navigate in canal in the tow as form tug or push boat and composition 1+1 only exceptionally.

The most regular case in navigation is tow "small tug or push boat + one barge with 1000 t of carrying capacity".

- In canals which dimensions are similar with the canal Novi Sad-Savino Selo maximal engine power of canal tugs or push boats should not be greater than 150 kW. These ships should not be longer than 20 m, to navigate as freely as possible on canals and pass through the navigation locks.
- The towing or pushing of two barges with 1000 t of carrying capacity is very rare, because of their engine power needn't be greater. Suggested type of tug or push boat (150 kW) can tow or push two barges (1+1) in canal, but with lower speed.

3.2. NAVIGATIONAL PERIOD

The navigation suspension on main canal network is defined every year (from 21 December to 21 March of next year) by the "Regulations book about the way and conditions of exploitation of water resources management objects of the main canal network of the Hydrosystem Danube-Tisa-Danube". It means that navigational period is $365-91=274$ days.

The "Regulations book.." should regulate the possible navigation in period from 21 December to 21 March next year, if there is no ice on the canals of the Hydrosystem DTD, this certainly can prolong the navigational period.

4. THE POSSIBILITY AND PERSPECTIVE OF OBTAINING THE STATUS OF INTERNATIONAL WATERWAY

Surely there is an interest that certain parts on major routes of the HS DTD network, of the whole system of canals of DTD obtain the status of international waterway.

If the following provision of decree are considered carefully:

- a) Memorandum of Understanding the Development of the Pan-European Transport Corridor VII (the Danube), annex 3, which originated as a result of the third Pan-European conference on transport (Helsinki, 1997) under 2: the definition of the corridor it is stated that *the Danube-Tisa canal* is a component part
- b) European Agreement on Main Inland Waterways of International Importance (AGN), Geneva 1996, accepted by the ECE – Inland Transport Committee. It defined the network of inland waterways of international importance, the network of the E category waterways. In the annex I named "Inland waterways of international importance" it stands that:
 - The river Danube from Kelheim to Sulina is treated as the main waterway and has E 80 mark;
 - The river Tisa from its mouth into the Danube to Szeged and the river Begej from its mouth into Tisa to Timisoara are treated as a branch of the main waterway (Tisa has E80-01 mark) and as a branch of a branch of the main waterway (Begej has E 80-01-02 mark)

The same document in the annex II "Inland navigation ports of international importance" includes the following ports as those of international importance: Belgrade (P 80-48 mark), Smederevo (P 80-49 mark) and Prahovo (P 80-52 mark), even though the government of FRY with its decree "Decision of determining the ports for international traffic" (Official booklet of the FRY, number 2, from January 1996) under 2, for international river traffic determines the following ports on the Danube: Apatin, Backa Palanka, Novi Sad, Belgrade, Pancevo, Smederevo and Prahovo, and on Tisa it is Senta.

At the same time according to the provision of the law of marine and inland navigation (Official booklet of the FRY, number 12/98) all the canals of the HS DTD (except the section Novi Sad-Savino Selo from km 0,00 to km 1,255) in the legal terms belong to national waterways of Serbia.

Foreign vessels can navigate on inland waterways on which international regime of navigation is valid. However, foreign vessels can navigate on other inland waterway for the purposes of entering Serbian ports opened for international traffic according to the conditions given by the government of Republic of Serbia.

5. THE CONCLUDING CONSIDERATIONS

1. The network of canals of HS DTD is situated, practically, in the central part of the main European waterway North Sea-Black Sea, which provides extremely favourable conditions for connecting the industrial centres, situated on the banks of the canals, with the markets in the west, as well as those in the east of the Europe, especially of the neighbouring countries, especially Hungary and Romania.
2. The network of canals of HS DTD is ranked into 4 categories, of which the most common is IV as the best for navigation. It allows two-way navigation of motor cargo ships of registered capacity of 1000 t. On these canals the navigation of tows made of two barges, one behind the other, each carrying 1000 t, towed by a tug boat is also possible.
3. On the canals of HS DTD there are no ports, considering the criteria of being technically equipped, except the one in Novi Sad, which cannot be considered to be in the canal because the water level on its harbour area depends on the Danube's water level.
4. Navigational period on the canals of HS DTD is relatively short and it is 274 days, which is regulated by "Regulations book about the way and conditions of exploitation of water resources management objects of the main canal network of the Hydrosystem DTD". The same regulations book completely defines all the parameters needed for the organization of navigation, navigation and being at anchor of vessels and other navigation objects on the network of canals.

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