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## **The Kiel Canal**

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# The Kiel Canal (Nord-Ostsee-Kanal)

By JÖRG BROCKMANN, ANNE HEELING, MARTIN POHL and KLEMENS ULICZKA

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## 1. Introduction

The Kiel Canal (in German: Nord-Ostsee-Kanal, NOK) connects the Elbe estuary at Brunsbüttel with the Kiel Bight over a length of 98.64 km (53.3 nm). Thereby, it represents a direct connection between North and Baltic Sea. Cutting across the so-called ‘Cimbric Peninsula’ – consisting of the Danish Jutland and the German Schleswig-Holstein – the over-water route from Brunsbüttel to Kiel as compared to the Skagerrak-passage is reduced by approx. 960 km (520 nm; Fig. 1).

The NOK is the most frequented artificial waterway of the world. In addition to its importance as an international sea route – and, therefore, as an impulse to the economic centres Brunsbüttel, Rendsburg and Kiel – the so-called ‘highway of dream boats’ lures scores of tourists throughout the year who are offered a multitude of recreational activities. From the point of the regional economy, the canal is the basis for direct employment of approx. 2,500 people.

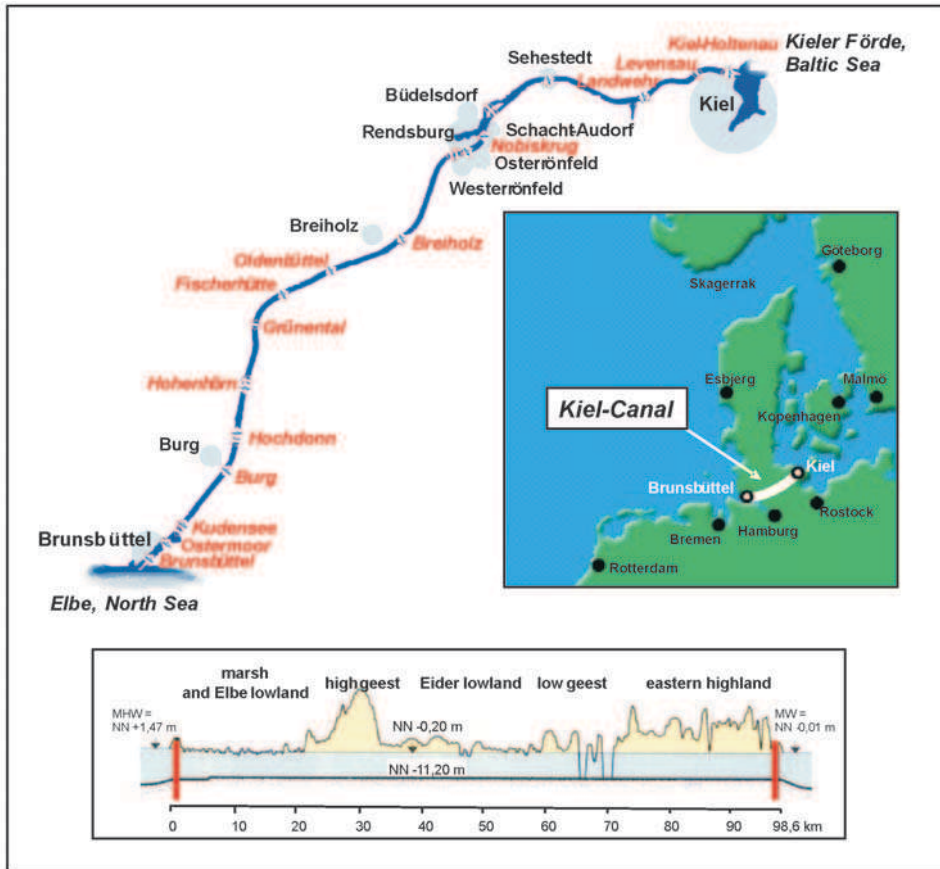


Fig. 1: The Kiel Canal (KIEL-CANAL, 2008; TAG NOK, 2008; WSA BRUNSBÜTTEL, 2008a and WSA KIEL-HOLTENAU, 2008)

## 2. History

„Great ventures are not the result of the moment, .... and thus, the NOK has its own history.“ („Große Unternehmungen sind nicht das Produkt des Augenblickes, und ... so hat auch der Nord-Ostsee-Kanal seine Geschichte.“; BESEKE, 1893):

The motivation for building an artificial waterway between North and Baltic Sea can be found in the abridgement of the passage and the resulting time savings. Consequently, the transport of perishable goods was made possible. Nowadays, fuel savings and the reduction of ensuing CO<sub>2</sub> emissions present an equal incentive. On the other hand, in the 19<sup>th</sup> century the sea passage around Jutland was considered particularly prone to accidents and disasters. For example, the Jammerbucht (*‘Bay of Misery’*) in the Northwest of Denmark owes its name to this fact. Already in the 7<sup>th</sup> century, the first plans were made to connect the Viking settlement of Haithabu at the Schlei fjord with the North Sea by a canal. These plans, however, were not realized.

In 1784, the Schleswig-Holstein-Canal (from 1853: “Eider Canal”) was officially ope-

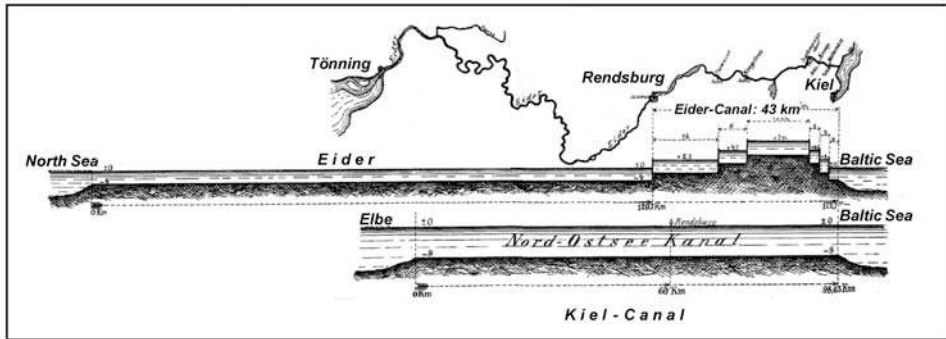


Fig. 2: Comparison Eider Canal / Kiel Canal (after BESEKE, 1893)

ned. The canal of a length of 43 km had been commissioned by the Danish King Christian VII. and joined Kiel at the Baltic Sea with the river Eider. It matches the eastern stretch of the present NOK.

Around 1850, the Eider Canal with a width of 18 m and a depth of 3.45 m could no longer satisfy the demands of a growing marine traffic. Travel times of 3 to 4 days needed for hauling the boats by horses on the trip of 180 km between Kiel (Baltic Sea) and Tönning (North Sea) became increasingly uneconomical.

More and more military aspects in connection with the canal were considered: first plans for a new canal were commissioned by Bismarck in 1864. The German fleet was to be capable to change its station from the Baltic Sea to the North Sea without *'having to pass under Danish canons'*. However, in 1873, these plans fell through due to the opposition of the generals Moltke and von Roon who preferred separate naval forces both in the North and Baltic Sea. Moreover, the question of who was absorbing the costs could not be solved.

In 1878, due to an initiative of the Hamburg shipowner Dahlström and the waterways engineer Boden investigations towards an optimized canal route were carried out. Ultimately, these investigations resulted in passing the Bismarck *'law for the construction of the canal'* in 1886.

This cleared the road towards building the NOK: on June 3, 1887, groundbreaking of the canal was carried out by Emperor Wilhelm I. in Kiel-Holtenau. Up to 8,900 workers were employed during the construction of the largest civil engineering works at the time. Floating bucket dredgers and a lorry railway system were developed especially for the canal construction in order to enable overall earth moving works of approx. 80 Mio. m<sup>3</sup>.

Contrary to its predecessor, the Eider Canal, the NOK is a breakthrough waterway without level differences (Fig. 2). Hence, locks at both ends at Brunsbüttel and Kiel-Holtenau were only necessary to compensate for water level variations. The following crossings were built:

- a road and railway bridge each at Grüental and Levensau,
- two railway bridges and a road swing bridge at Rendsburg,
- a railway swing bridge at Kudensee and
- a floating pontoon bridge at Kiel-Holtenau
- as well as 16 manually operated cable ferries.

At that time, the minimum size and carrying capacity of a ferry was designed to accommodate a four-in-hand hearse and the mourners.

After a construction period of 8 years and costs of approx. 156 Mio. Goldmarks (which was within the planned investment) the canal was officially opened by Emperor Wilhelm II. on June 20, 1895. To the surprise of the invited guests, the canal was christened “Kaiser-Wilhelm-Kanal”; the originally intended German name “Nord-Ostsee-Kanal – NOK” was only adopted in 1948.

Already after the first ten years of its operation – at that time vessel dimensions were at a length of up to 135 m, a width of up to 20 m and a draft of up to 8 m – the canal proved to be too small and the passage time of 13 hours too long. After the improvements of the canal bed of 1914 and 1966 (cf. 3.1.1) the passage takes only 8 hours today.

### 3. Development of Maritime Traffic

#### 3.1 Classification of Vessel Groups

The Maritime Waterways Code (Seeschiffahrtsstraßen-Ordnung – SeeSchStrO) and the concerning regular announcements of the Directorate of Waterways and Navigation (Wasser- und Schifffahrtsdirektion, WSD) North include the traffic regulations for the NOK.

In September 2006, a new computer-aided system for traffic guidance and safety (VSS-NOK) was introduced. Under a round-the-clock surveillance of the maritime traffic by an AIS (= Automatic Identification System) traffic is piloted by the nautical employees of the VSS on the basis of the sidings (lay-bys) along the canal.

Ships with a length of up to 235 m and a width of up to 32.5 m can pass the canal. For traffic regulation, they are classified and put into six groups according to their size (VG 1–VG 6; Tab. 1).

Table 1: Classification of vessel groups (VG) for NOK (WSA BRUNSBÜTTEL, 2008)

VG	Vessel/Push tow			Barge train		
	length up to	width up to	draught up to	length up to	width up to	draught up to
1	45 m	9.5 m	3.1 m	40 m	10 m	3.1 m
	55 m	8.5 m	3.1 m			
2	65 m	13 m	3.7 m	60 m	13.5 m	3.7 m
	85 m	11 m	3.7 m			
3	120 m	19 m	6.1 m	110 m	19 m	6.1 m
	140 m	17 m	6.1 m			
4	130 m	23 m	9.5 m	130 m	23 m	6.1 m
	160 m	20 m	9.5 m			
5	200 m	25 m	table	160 m	27 m	9.5 m
	210 m	27 m	table			
6	235 m	32.5 m	table	approved extreme barge trains		

Vessels without pilot support and a speed of less than 15 km/h may pass only during the day. Pleasure craft have to find a moorage before the end of daylight operation time.

### 3.2 Traffic Statistics

The NOK is the most frequented artificial waterway of the world: Without pleasure craft and other small ships, 114 vessels/day passed the NOK in 2006.

Fig. 3 shows the total number of ships and their payload for the years between 1996 and 2006. While the number of passages is fluctuating the payload increases distinctly.

A new payload record of almost 100 Mio. tons was reached in 2007 and showed the following statistics: 99,600,730 tons were transported in transit through NOK and on partial routes. Another record was the number of passages of 43,231 vessels. This number had been reached the last time in 1995. A specially high increase of 5.7 % could be noted for the transit traffic.

Even though the classification into traffic groups was changed during 2007, a distinct increase particularly for the groups 4 to 6 of larger vessels can be seen: In the comparison between 2007 and 2006, the number of largest vessels of the group 6 rose by 7 % to 264. In the future, this positive trend will be held and increased by the scheduled widening of the eastern reach (cf. 3.1.2) which will improve the possibilities of traffic encounter on the range, reduce waiting time in the sidings and, thereby, the passage time, too (WSA BRUNSBÜTTEL, 2008).

## 4. Structural Measures for Adaptation

### 4.1 Improvement of the Canal Bed

#### 4.1.1 Present Status

Responsibility for the NOK lies with the WSD North and its regional authorities (Waterways and Shipping Board, in German: Wasser- und Schifffahrtsamt, WSA) Brunsbüttel (west of km 49.46) and Kiel-Holtenau (east of km 49.46). Both regional authorities plan and carry out maintenance and improvement measures following the principle of 'ease and safety of maritime traffic'.

Between 1907 and 1914, the first deepening and widening of the original canal bed required approx. 242 Mio. Goldmarks and, thereby exceeded the cost of the original canal by far. However, this resulted in a reduction of the passage time from 13 to 10 hours.

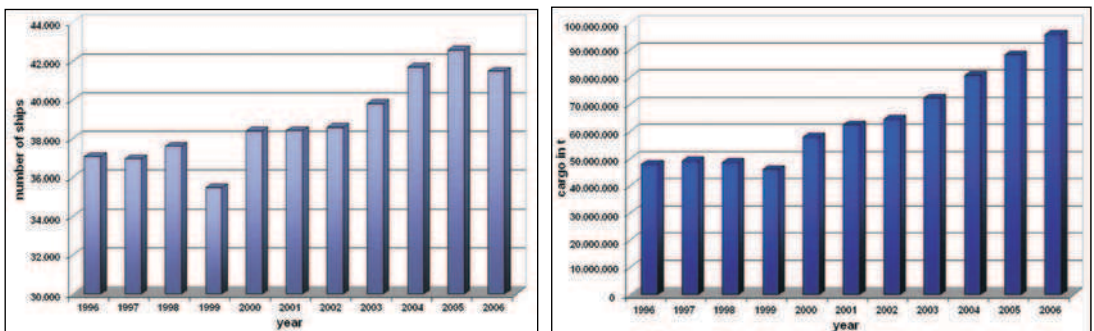


Fig. 3: Total number of ships and their payload during the years from 1996 to 2006 (KIEL CANAL, 2008)

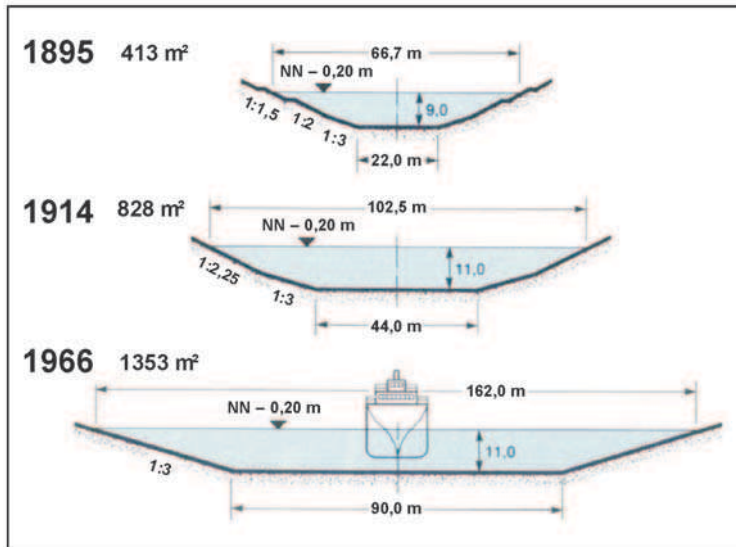


Fig. 4 Development of the cross-section of the canal (WSA BRUNSBÜTTEL, 2008)

Since 1966 the canal has been successively improved; construction measures west of km 79 are already completed.

Previous improvement works on the canal bed are carried out to:

- enhance the stability of the embankments by establishing an overall slope of 1:3 for minimization of slope erosion,
- enhance the alignment by straightening and/or increasing the radii of curves (1914: breakthrough at Rade) and, thereby guarantee the 'ease and safety of maritime traffic',
- enlarge cross-sections to permit the passage of larger vessels.

Within the framework of improvement measures, the canal was widened by almost 100 m and deepened by 2 m compared to its original dimensions. Bottom width has been more than quadrupled and, consequently, the cross-section more than tripled. Fig. 4 depicts the development of the NOK cross-section from its inauguration in 1895 to the present status as of 1966.

#### 4.1.2 Scheduled Improvement of the Eastern Range

As a consequence of the increase in shipping traffic and the modification of the fleet structure on the Kiel Canal, the narrow curves and the reduced cross-sectional width of the 1914s between Königsförde and Kiel-Holtenau in the eastern range (NOK-km 80–96) increasingly prove to be a bottleneck to the traffic flow. Detailed preliminary investigations have led to the choice of an improvement variant which shows the best possible benefit for maritime traffic together with a minimum encroachment on nature and landscape.

The adaptation works are divided into two sections (Fig. 5). In the first section (■) the curves at Landwehr and Wittenbek as well as the transition to the passing place at Schwarzenbek are to be opened up. The piers of the Landwehr ferry are repositioned and renewed. The second section (■) includes the straight stretch Königsförde, the curve 'Groß-Nordsee' and the reach of the high bridges at Levensau.

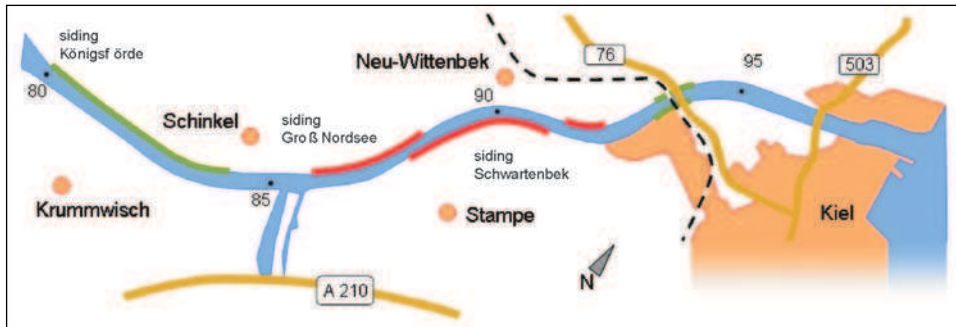


Fig. 5: Schematics of the eastern reaches to be improved (WSA KIEL-HOLTENAU, 2008)

By digging off the insides of the curves and widening the straight reach at Königsförde the bottom width is increased to 70 m with a water depth of 11 m. This new cross-section permits the passage of larger and deeper-drawing vessels. Altogether, earth movements are in the order of 8.5 Mio. m<sup>3</sup>.

Presently, vessels with dimensions of (length, width, draft in [m]) 235/32.5/7.0 resp. 175/24.0/9.5 can navigate the NOK. Future dimensions will be 280/32.5/9.5. The project will be completed in 2014.

## 4.2 Structures

The locks in Brunsbüttel and Kiel-Holtenau are the access structures to the NOK. Nowadays, a road and a pedestrian tunnel (both at Rendsburg), four elevated highway and two railway bridges, two elevated combined road-rail bridges, two motorway (Autobahn) bridges as well as 13 freely operating ferries and a suspended ferry permit the crossing of the NOK. Due to a decree of the Emperor Wilhelm all crossings are free of charge.

### 4.2.1 Locks

In 1914, during the first expansion of the NOK two 'new' large locks were constructed to the existing 'old' Wilhelminian-style locks at Brunsbüttel and Kiel-Holtenau. These access structures designed as double-locks are almost identical concerning their characteristic dimensions (Table 2).



Table 2: Characteristica of the locks (KIEL-CANAL, 2008)

	Small (Old) Locks, 1895	Large (New) Locks, 1914
Effective length:	125 m	310 m
Effective width:	22 m	42 m
Sill elevation:	Brunsbüttel: NN -10.2 m	NN -14.0 m
	Kiel-Holtenau: NN -9.8 m	
Lock gates:	per chamber: 2 ebb- und 2 flood mitring gates	per chamber: 3 sliding gates; the centre gate (doubles as a reserve gate) allows for a faster operation in a shorter chamber
Filling procedure:	by 2 side channels with 12 branches each	Brunsbüttel: by recirculation flow through gates
		Kiel-Holtenau: by two side channels with 29 branches each
Passage time:	30 minutes	45 minutes

Based on the water level in the canal (NN -0.20 m) and the average tidal elevation of the North Sea (NN +1.47 m) or the mean water level of the Baltic Sea an average lifting range of approx. 1.7 m (Brunsbüttel) and 0.2 m (Kiel-Holtenau) results. Due to the different geological situation at both locations the foundations of the locks are designed differently (Fig. 6 and Fig. 10):

- Brunsbüttel (marsh): the Small (Old) Lock have a foundation floating in the sand-layered marsh soil. The load of the chamber walls of the Large (New) Lock, designed as gravity structures, are carried into the sustainable Pleistocene sandy subsoil by piles at about NN -20 m. The heads are built on shallow foundations on the Pleistocene sand.
- Kiel-Holtenau (eastern highlands): both lock foundations are built on a varying layering of sustainable till and sand.

The age of the Large (New) Lock at Brunsbüttel as well as disruptions of operations require a basic overhaul. A cost-benefit-analysis showed that the highest value of benefit would be obtained through an accelerated new construction of a lock on the sluice-island ('5<sup>th</sup> chamber', Fig. 7) and the consecutive overhaul of the existing lock. Presently, the new structure is being planned to avoid an interference with traffic flow by the overhaul of the Large (New) Lock.

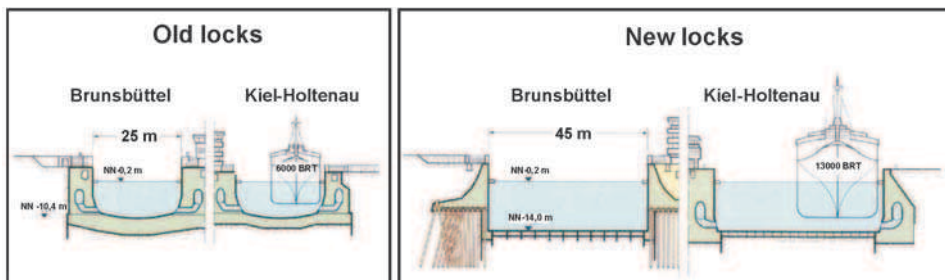


Fig. 6: Cross-section of the lock structures (WSA BRUNSBÜTTEL, 2008)

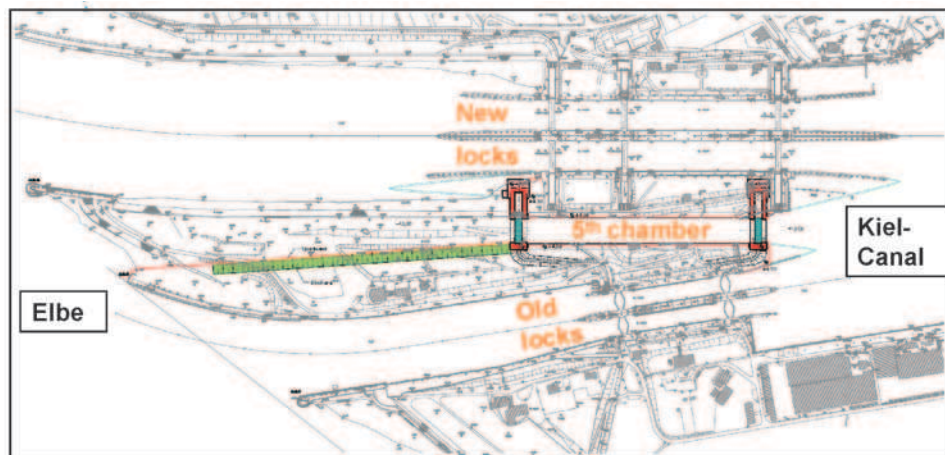


Fig. 7: Planned location for the 5th chamber (WSA BRUNSBÜTTEL, 2008)

In the projected construction area the present power supply of the locks exists. This has to be relocated before construction begins. For that purpose, a new culvert for pipes and cables, having a walkable cross-section of an inner diameter of 2.2 m, has to be driven underneath both locks at a depth of approx. NN -31 m.

#### 4.2.2 Bridges

Together with the construction of the NOK two elevated compact railway and road bridges at Grünental and Levensau were built in the first instance. Today, ten solid bridges with a guaranteed clearance for vessels of 42 m span the canal. The following table compiles the technical specifications of the bridges:

Table 3: Bridges across the NOK (WSA BRUNSBÜTTEL, 2008)

Structure	NOK-km	Length [m]	Steel used [to]	Year of construction
Elevated road bridge Brunsbüttel	6.123	2,826	5,000	1979/83
Elevated railway bridge Hochdonn	18.778	2,218	14,900	1915/20
Elevated motorway bridge Hohenhörn	24.882	390	4,200	1985/89
Elev. railway/road bridge Grünental	31.115	405	3,600	1983/86
Elev. railway bridge Rendsburg	62.664	2,486	17,740	1911/13
Elev. motorway bridge Rade	68.114	1,498	14,020	1969/72
1. Elev. railway/road bridge Levensau	93.478	180	2,600	1893/94
2. Elev. road bridge Levensau	93.581	365	4,310	1980/83
1. Elev. road bridge Holtenau	96.589	445	3,650	1992/95
2. Elev. road bridge Holtenau	96.623	518	3,380	1969/72



Fig. 8: Elevated railway bridge (STADT RENDSBURG, 2008)

The elevated railway bridge at Rendsburg (Fig. 8), built in 1913, was the largest steel construction in Europe at that time; it replaced the original railway swing bridge. Simultaneously, the framework construction of the elevated bridge served as the carrying base for a suspended ferry, which is unique in Germany and under protection as a historical monument.

In the abutments of the first elevated bridge at Levensau (arch bridge) an overall of approx. 6,000 bats hibernate. This makes the bridge the most important wintering grounds of the noctule bat (“Großer Abendsegler”) in Central Europe.

#### 4.2.3 Tunnels

The increase in maritime and road traffic and the ensuing long waiting periods at the road swing bridge at Rendsburg necessitated its replacement by two tunnels:

The road tunnel Rendsburg was built between 1957 and 1961 and carries the highway B 77. With a closed tunnel reach of 640 m, its overall length is 1,278 m. In its lowest point, the upper edge of the tunnel is at NN -14.55 m, approx. 1.5 m below the canal bed.

The pedestrian tunnel Rendsburg (Fig. 9, cf. 6.3) was built between 1962 and 1965. With an inner diameter of 4.5 m, it is 130 m long. The peak of the top edge of the structure is at NN -17.1 m. Access to the tunnel is provided by cascade-shaped caissons housing in addition to an elevator, one of the longest escalators in Europe (55.9 m).

### 5. Maintenance of the Navigation Channel

The amount of sediments entering NOK from outside through the locks at Brunsbüttel and Kiel-Holtenau or via affluents is negligibly small. Settled material comes nearly exclusively from erosion of the slopes. Because of this, the embankments of the western range,

where sandy material prevails, have been regarded to a consistent slope of 1:3. Under maintenance aspects, reconstruction of the relatively stable till slopes of the eastern range could be deferred for the time being.

Noteworthy maintenance dredging works concentrate on the western access of the canal: In the outer and inner harbour basins and in the locks at Brunsbüttel between 6.0 and 7.6 Mio. m<sup>3</sup> of a watery mud were dredged annually between 1998 and 2006.

In comparison, only between 0.008 and 0.3 Mio m<sup>3</sup>/a dredged spoils were removed from the outer harbours and the locks at Kiel as well as from the entire canal reach during the same period, predominantly from the western range.

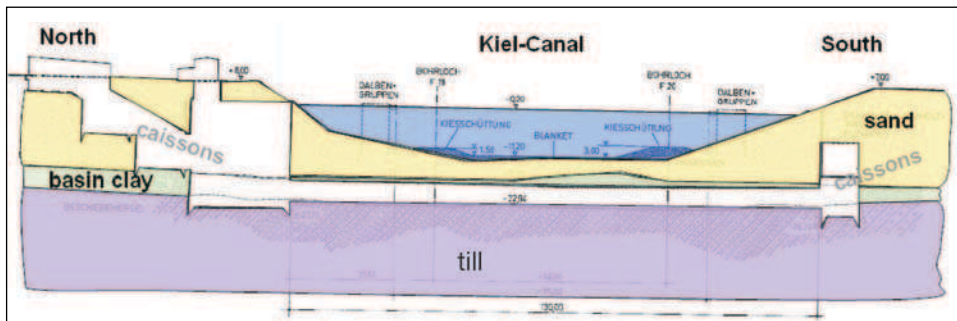


Fig. 9: Longitudinal cross-section of subsoil conditions at the Pedestrian Tunnel Rendsburg (BAW, 2007)

## 6. Monitoring and Analysis of the Canal System

### 6.1 Geotechnical Survey for the Improvement Measures

The geological structure of the upper layers along the canal is dominated by glacial and post-glacial processes (Fig. 10).

While in the West non-cohesive sediments (sand) prevail the East is characterized by cohesive material (till):

- The oldest sediments in the West – sands and till of the Saale glaciation at the high geest – were eroded by melt water and only loom like islands in the surrounding post-glacial marshes and river lowlands composed of marsh soil and sand.
- The eastern highlands consists of moraines from the Weichsel glaciation: during this latest glaciation period in Northern Germany, Scandinavian glaciers coming from Northeast advanced till east of Rendsburg, scratched out the Kiel Bight and dumped till.
- In front of this glacier barrier and because of the melt water, the lower geest and its sand and gravel developed. Locally, glacial basin sediments such as fine sand, silt and clay can be found.
- During the excavation of the canal bed, naturally occurring layers of soil were removed and used for the embankment dams.

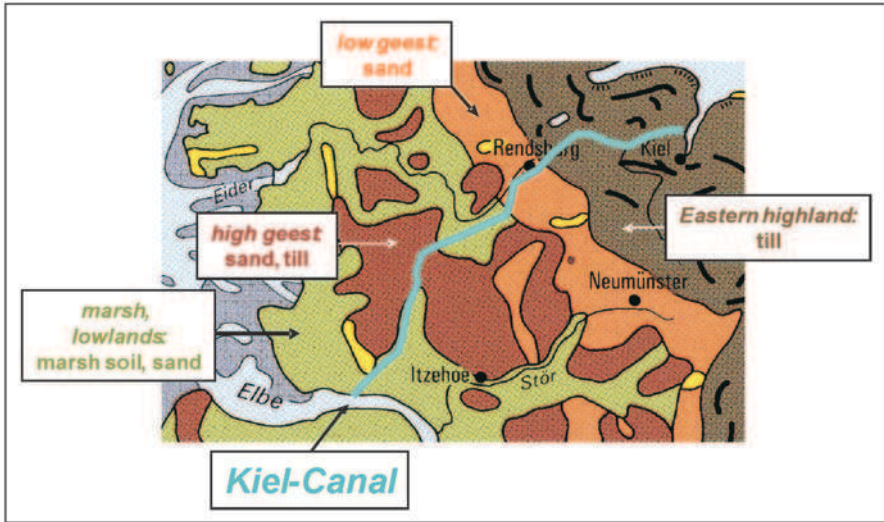


Fig. 10: Geological structure of the region around the NOK (after SCHMIDTKE, 2007)

The main intention of geological surveys lies in the specification of the generally known stratigraphic sequence and in the analysis and description of the geotechnical properties of the sediments according to the actual questions (investigation of stability of crossing structures and slopes, planning of earth moving works, preservation of evidence for project approval procedures etc.).

## 6.2 Erosion Stability in the Western Range

Natural and lock-induced currents have no detrimental effect on sediment movement. However, ship-generated waves can cause erosion on embankments, particularly in the western range with its sandy sediments. Therefore, in view of the future evolution of maritime traffic, the Federal Waterways Engineering and Research Institute (Bundesanstalt für Wasserbau, BAW) carried out hydraulic model and field investigations to determine the hydrodynamic ship-generated loads and the erosion stability of canal embankments and bed (BAW, 1998; BAW, 1999).

### 6.2.1 Hydrodynamic Investigations

Hydraulic model investigations towards the interaction vessel-canal were carried out by BAW on the basis of Froude's model laws at a scale of 1 : 33.3, resulting in design data (drawdown, return current, squat and change of bed pore pressure). Fig. 11 shows an example of the ship-induced drawdown generated by two-way traffic.

In addition, based on a cooperation with the WSA Brunsbüttel field measurements were carried out and were compared with prognoses generated by SOCIETE GRENOBLOISE D'ETUDES ET D'APPLICATIONS HYDRAULIQUES (SOGREAH, 1966), as follows:

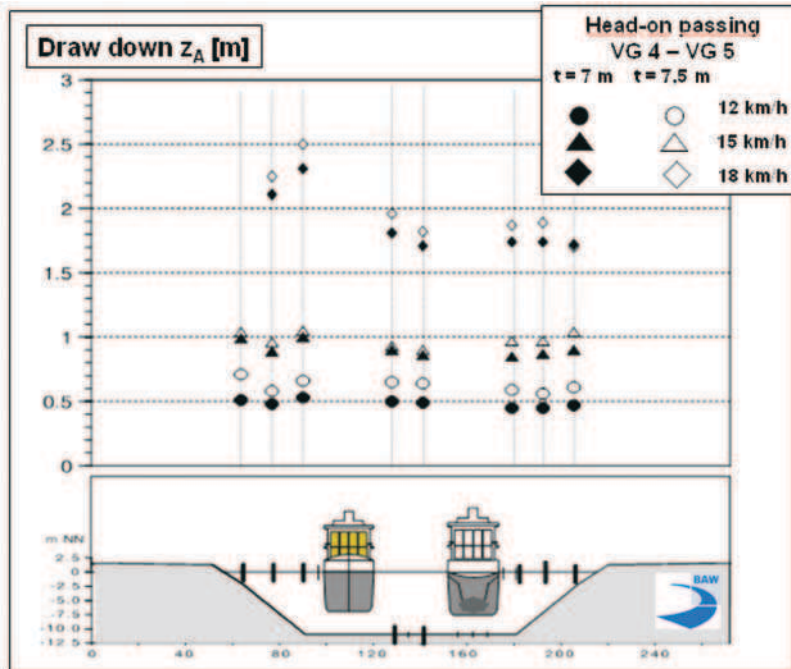


Fig. 11: Exemplary ship-induced drawdown load at two-way traffic VG 4-VG 5 in a monitored cross-section of the western range of NOK (BAW, 1998)

- Measurements of the hydrodynamic ship-induced load and of the pore pressure on the underwater embankment of a stretch at Hohenhörn which is susceptible to erosion.
- 2D-echosounding in the Hohenhörn stretch; comparison of results with the standard dimensions of the cross-section.

For 535 analyzed ship passages, drawdown events of  $z_A < 0.4$  m and return currents of  $v_R < 0.6$  m/s were recorded. Maximum values in the centre channel came up to  $z_A = 1.66$  m and  $v_R = 2.14$  m/s. There was a satisfactory agreement between field investigations and model tests.

Results also pointed at the necessity of systematic hydraulic model tests for a prognosis of ship-induced loads – even in a quasi-homogenous waterway such as the NOK.

Based on model results, the utilization of characteristic diagrams of draft- and speed-dependent ship travel for various traffic groups, travel outside the centre line, two-way, parallel and passing traffic has been supported by field measurements.

## 6.2.2 Measurements of Pore-Water Pressures

During the hydrodynamic investigations, in a stretch at Hohenhörn pore-water pressure measurements on the underwater-embankments and the canal bed were carried out.

The parameter pore-water pressure is of major importance for the stability and safety against erosion of the embankment slopes. Due to the comparatively high permeability of the



local medium sand, pore-water pressure values are relatively small when measured at various elevations during the passage of a vessel. Still, for the worst case and for the duration of the drawdown, the net weight of the soil is reduced by up to 20 % due to the current load resulting from the pore-water pressures.

The determination of the pore-water pressure parameter  $b$  solely on the grounds of the hitherto knowledge derived from inland waterways would have resulted in an overestimation of its value. Thus, the stability of the NOK embankment slopes would have been underestimated. As a consequence, a proof of stability can presently only be produced on the basis of actually measured pore-water pressures.

Findings from these field investigations lead to the conclusion that – already nowadays – due to the increased traffic load and in passing traffic situation in stretches with weak cohesive soil the required stability during the entire event of a drawdown doesn't exist. These events can lead to grain-relocation in the slopes favouring an erosion which is already triggered by return currents during such passages.

The evaluation of the present erosion behaviour of the underwater embankments in the western range of NOK must be based – in addition to the knowledge of the present status – on the consideration of the various development stages of the unprotected underwater slopes. Since expansion activities have modified the state of the unprotected slopes and the hull shapes of ships and the ship-induced loads have changed as well during the 1960s, a calculation of erosion rates can no longer be carried out based on the erosion diagrams published by SOGREAH (1966). Thus, BAW recommended to the WSV that permanent monitoring and evaluation of the conditions of underwater slopes and canal bed under varying loads should be carried out.

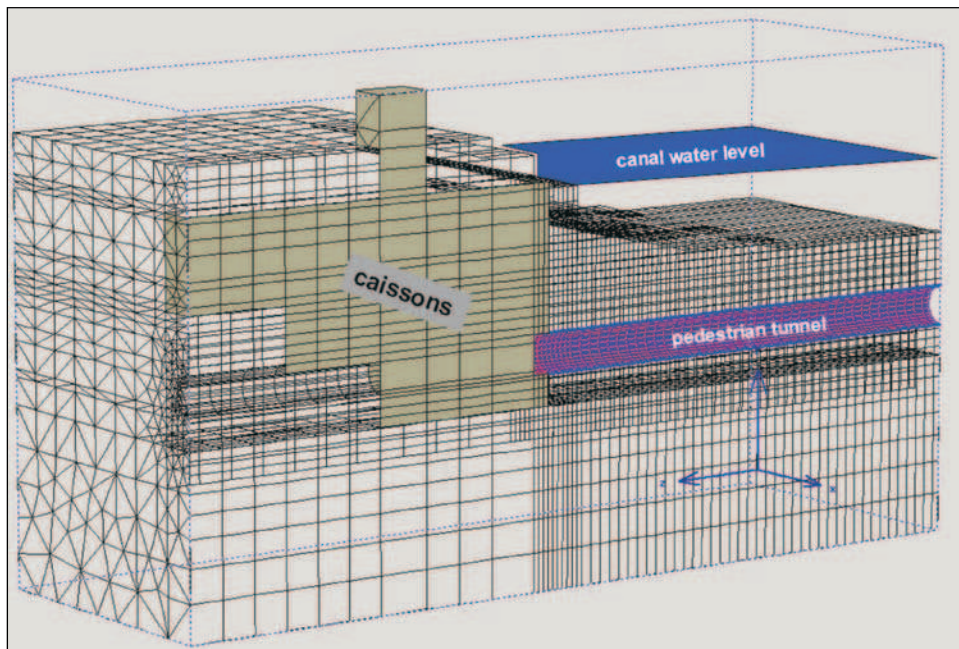


Fig. 12: Numerical quarter-model of the Rendsburg pedestrian tunnel (BAW, 2007)

### 6.3 Pedestrian Tunnel Rendsburg

After completion of the pedestrian tunnel at Rendsburg the time-settlement of the tunnel structure (cf. 3.2.3) have been measured and recorded. While the head structures, built as caissons, settle the tunnel under the canal bed heaves. The internal forces and the static exploitation of the tunnel were, therefore, investigated with a 3-D Finite Element Model (Fig. 12).

The numerical simulation was carried out for the various phases of the construction focussing on the excavation lengths, the materials used and the air pressure in the tunnel. Soil layers were reproduced by applying a constitutive law which considers volume and shear straining. Creep in the cohesive soil layers was simulated by an incremental reduction in stiffness since laboratory data of time-settlement curves of the cohesive soil layers (till and glacial basin clay) did not exist. Thus, the deformation behaviour over the past till present could be reproduced quite well.

The numerical calculations showed that the tunnel excavation governs the internal forces. The present deformations due to the tunnel's lifetime result in modified internal forces and their distribution leading to an additional stressing. This is true for the normal forces in tunnel length direction, the transverse (shear) forces in the cross-section and the bending moments due to bending around the tunnel length axis.

In-situ measurements of stresses at the cast-iron tubbings confirm the internal forces obtained through the numerical simulations. Moreover, results from both methods permit to conclude on residual stress due to the manufacturing process in the cast-iron tubbings.

More simulations with reduced stiffness serve to predict admissible deformations which would not endanger the stability and/or usability of the tunnel.

## 7. Conclusions

The Kiel Canal is the second gateway to the Baltic Sea. Being in direct competition to the Skagen route, it has served national and international navigation for more than 100 years. As part of the Trans-European traffic network it substantially helps to relieve the overland traffic that moves fast towards its capacity limits.

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