CHAPTER 147

NEW METHOD TO CLOSE TIDAL RIVERS

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The closing of tidal rivers is still a risky project as the tidal flow alternates periodically its direction,velocity and level.
On the last essential section of the Eider dam project a new method for closing tidal rivers was invented and sucessful operated.Contrary to common methods the main channel of the river was closed only by hydraulic placement of sand under protection of two permeable pile walls with perforated steel panels.

1.Construction site
About halfway between the Elbe estuary and the Danish border the Eider River enters the North Sea.The Eider river forms the most important outlet of water for the lower region of Schleswig-Holstein with a drainage area of 2.000 sq.km.From 1967 to 1973 the estuarine mouth was closed by a 5 km long dam with a 200 m wide sluice in order to get a safer protection against storm surges and more advantageous draining and shipping.In the summer of 1972 the main channel south of the completed sluice was to be closed.The opened sluice caused only a little relief of the main channel in which the tidal flow got a flood velocity up to 3 m/s.The tidal volume amounted to 45 million cu.m with an average range of 3.2o m.The subgrade soil and bottom consists of silty finesand with included clay.

2.Method
At first it was projected to close the main channel with two walls out of stony material,but it became more advisable to use only sand by hydraulic placement so that an easy and quick reaction could become possible if any unexpected bottom erosion would happen.It was necessary to invent a method that protects the placed sand against the tidal race.The demands were :
- a safe and quick technical feasibility,
- a kind flexibility to bottom erosion,
- a low loading by impact of current and waves and
- little loss of sand.

The solution : two rows of steel piles should be driven through the river bed and between them perforated steel panels should be installed so that sand could be deposited even during strong tidal flow.
In a second step the main construction characteristics were investigated in a model test (Technical University Hannover). The fig. 1 shows the main result : the optimal shielding was to be expected with a perforation of the panels between 20 and 30 per cent and with a distance of the two pile walls between 15 and 20 m. For the further design of the steel construction the static and dynamic pressure of water, current and waves was estimated to a loading of 1 Mp/sq.m.

3. Closing

In respect to the investigated characteristics the two pile walls were constructed in a distance of 16 m to half-frames which gave a good substructure for transport system of material, machinery and other equipment. The perforated steel panels were formed out of light steel sheet piles in which holes of 10 cm diameter were stamped. The fig. 2 shows the schematic method in operation. The panels were installed by portal cranes between the rammed piles so that they reached just 2 m above the actual bottom level inside of the pile walls. The filling sand was pumped by a dustpan-dredger out of a depth between 30 and 40 m sea level via two distribution carriages which alternately connected with the central delivery pipeline. In this way the filling sand could bei placed at the bottom with a solid matter concentration of about 30 per cent and with an output of 1.000 cu.m per hour of solid material. The used sand consisted mainly of finesand with a mean grain diameter of 0.2 mm.
Fig. 3 shows the current velocity distribution during the closing operation. It shows a well distinguished sector of the weakened current : inside of these shielding sectors the sand settled and was demixed corresponding to the respective flow velocity of its sedimentation.

FIG. 1

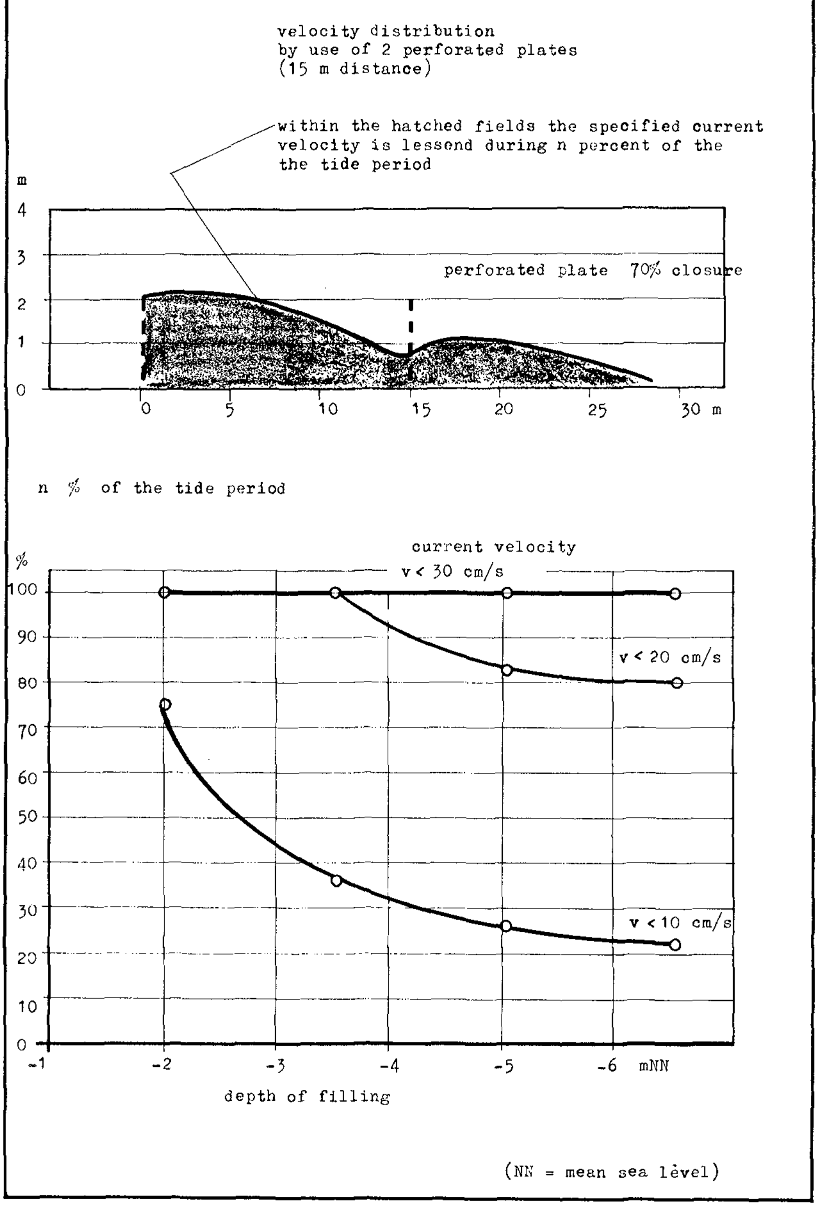
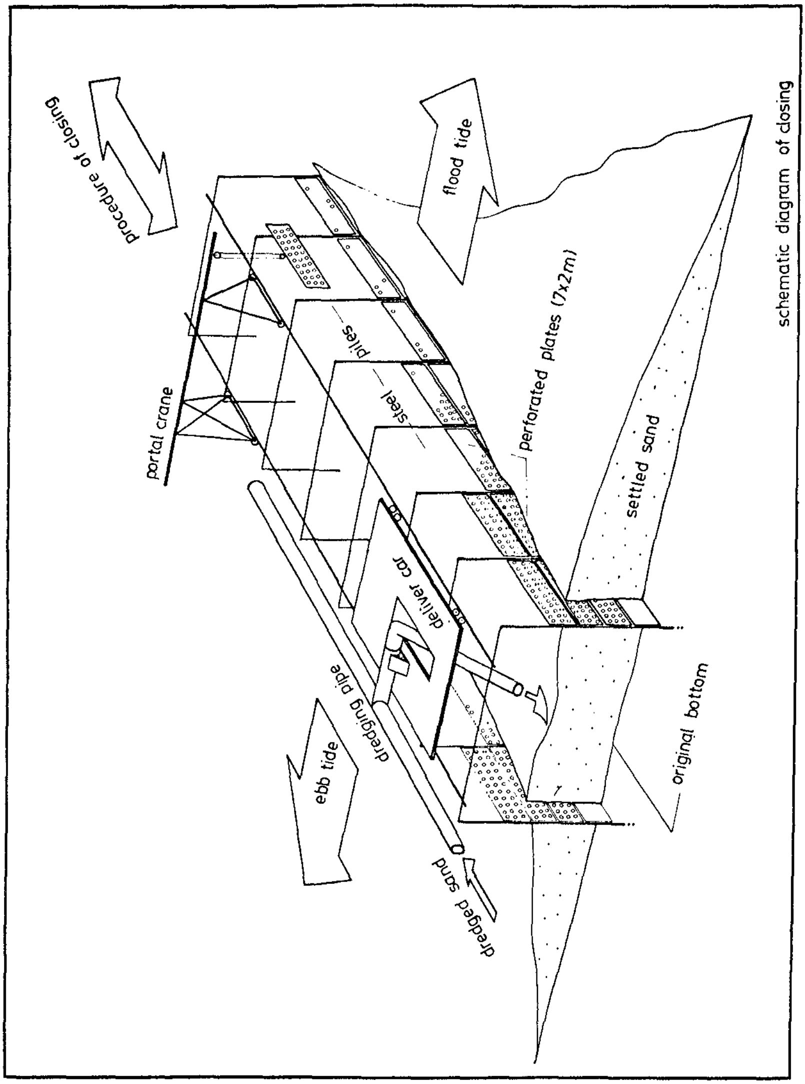

velocity distribution
by use of 2 perforated plates
(15 m distance)
within the hatched fields the specified current velocity is lessend during n percent of the the tide period
m
4
3
2
1
0
perforated plate 70% closure
0
5
10
15
20
25
30 m
n % of the tide period
current velocity
%
v < 30 cm/s
100
90
80
70
60
50
40
30
20
10
0
v < 20 cm/s
v < 10 cm/s
-1
-2
-3
-4
-5
-6 mNN
depth of filling
(NN = mean sea lèvel)

FIG. 2


procedure of closing
flood tide
schematic diagram of closing
perforated plates (7x2m)
steel piles
portal crane
settled sand
deliver car
original bottom
dredging pipe
ebb tide
dredged sand

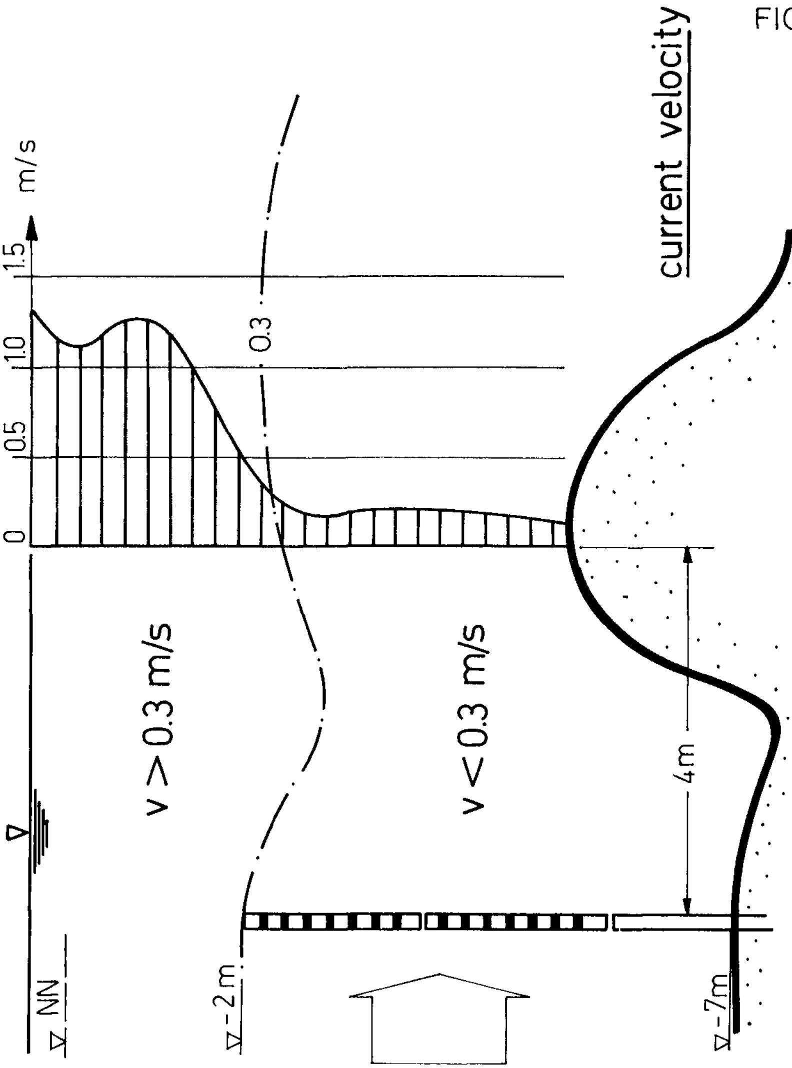


FIG. 3

The under water slopes outside of the pile walls became a good indication of the coincidence between model test and nature. The fig. 4 shows in a cross-section the slopes at two different times of closing.
The sequence of closing from the original bottom to high water tide is shown in the fig. 5. The under water slopes varied their inclination corresponding to the height of closure and to their depths. To demonstrate this variation the slopes in the sections of 10, 8 and 5 m under mean sea level were separated and are shown in the fig. 6 as a relation between height of closure and depth of section. The slopes flattened after installation of panels, became steeper with filling of sand and finally stabilized with an inclination between 1:10 and 1:20 - corresponding to the mean grain diameter of sand.

The main channel was closed within 6 weeks up to high water tide with about 600.000 cu.m of sand inside and outside of the pile walls. A saving of about 40 per cent to other common methods could be achieved. This point may emphasise the practical use and technical feasibility of this method.

FIG. 4

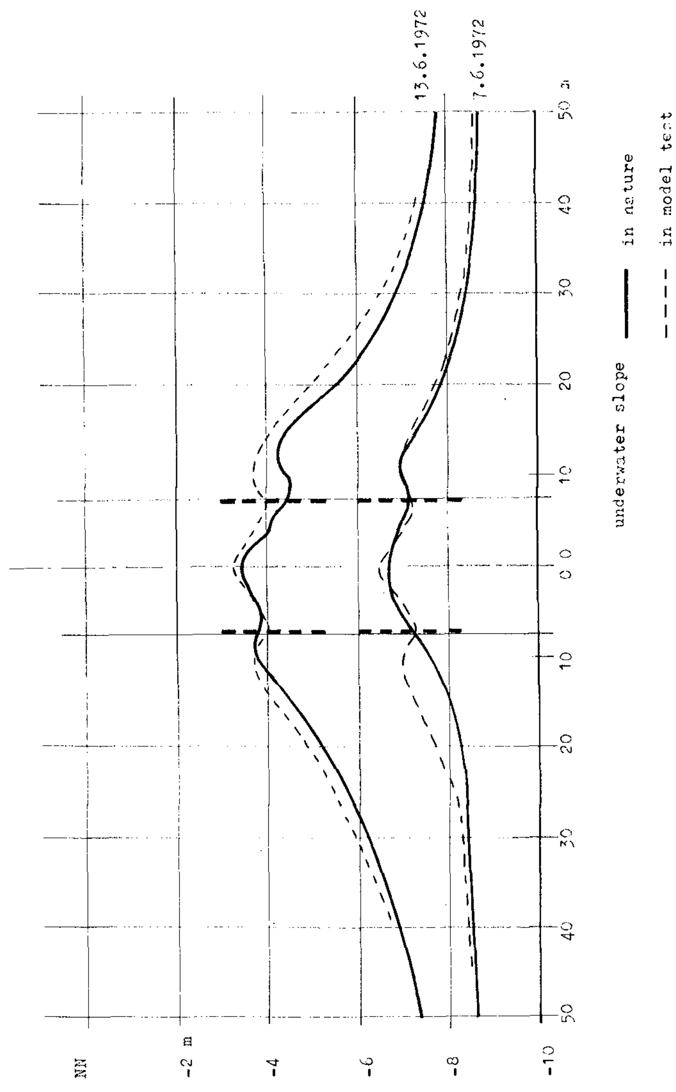
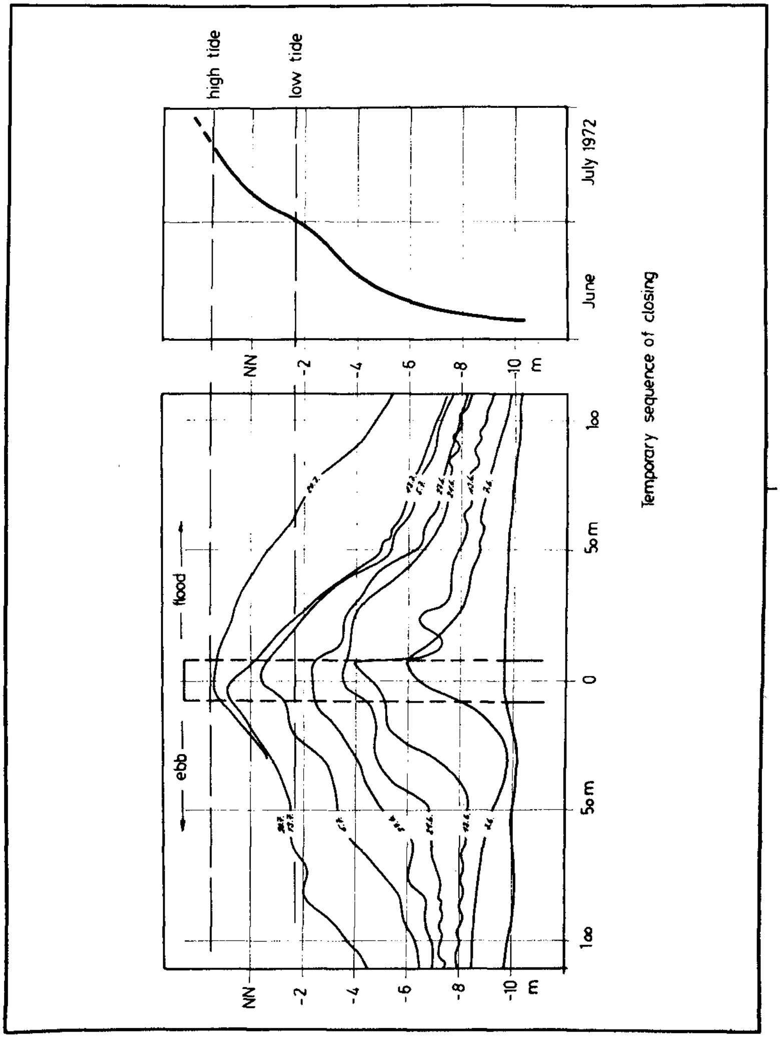
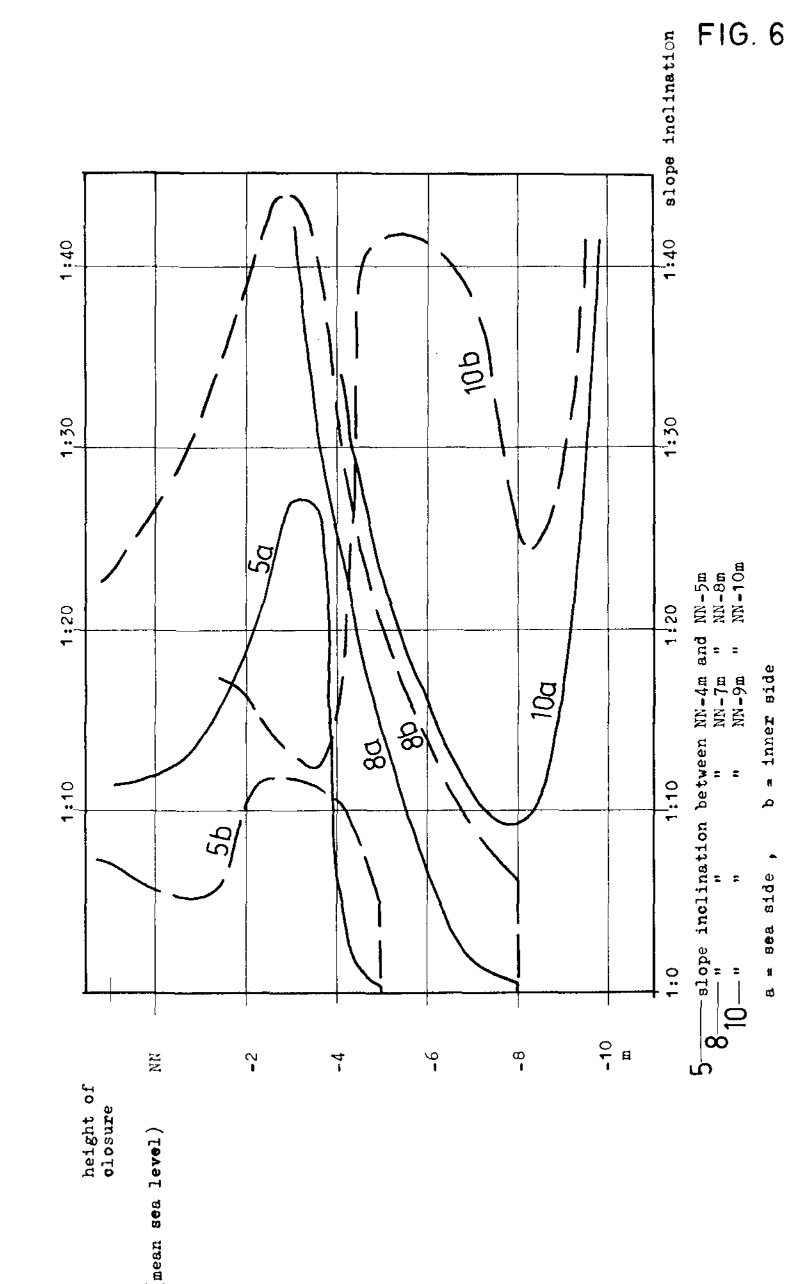

13.6.1972
7.6.1972
underwater slope
in nature
in model test
NN
-2 m
-4
-6
-8
-10
50 m
40
30
20
10
0
0
10
20
30
40
50

FIG. 5


high tide
low tide
ebb
flood
NN
-2
-4
-6
-8
-10
m
100
50 m
0
July 1972
June
Temporary sequence of closing



slope inclination
1:0
1:10
1:20
1:30
1:40
height of closure
(mean sea level)
NN
-2
-4
-6
-8
-10
m
5a
5b
8a
8b
10a
10b
5 —— slope inclination between NN-4m and NN-5m
8 —— " " " NN-7m " NN-8m
10 —— " " " NN-9m " NN-10m
a = sea side , b = inner side

FIG. 6