



## TECHNICAL COMMUNICATION

# The Punaise Underwater Dredger

Kris Visser† and Per Bruun‡

†J.G. Nelis  
P.O. Box 802  
Haarlem 2003 RV, The  
Netherlands

‡34 Baynard Cove Road  
Hilton Head Island  
SC 29928, U.S.A.

### ABSTRACT

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The latest decades have experienced a continued progress in dredging fields by which equipment already in use has been improved. That includes machinery, pumps, pipes, controls, maneuvering and propulsion equipment *etc.* New inventions like water-injection dredgers, underwater pumps, and crawl cats have entered the market. This brief article addresses the use of the PinPoint Dredging or Punaise System, which was developed and tested in The Netherlands.

**ADDITIONAL INDEX WORDS:** *Dredging, dredger, underwater pump, bypassing, fluidization.*



### THE PUNAISE

The development of this innovative dredger was in fact to provide an answer to a sand bypassing project (Figure 1) for which the workability of the existing conventional floating dredgers was considered to be inadequate.

The shape of the dredge gave it the name "The Punaise" (Dutch word for thumb-tack). The first "PinPoint" dredge, Punaise PN250, was commissioned in 1990, the second dredge Punaise PN400 was commissioned in late 1993 (BROUWER *et al.*, 1992).

### WORK PROCEDURES BY THE PUNAISE

#### The Working of the Punaise

The Punaise works on a very simple principle. A pump and suction pipe are connected to ballast tanks and then the entire structure is submerged to come to rest in the bottom where dredging is to be carried out.

The link to a small shore based control unit and energy supply is provided by cables and hoses while a pipeline is used to transport the dredged material. The submerged pump excavates by hydraulic erosion. It creates an unstable slope upon which sediment flows to the suction intake. The unique support system makes use of the suction pipe that is embedded into the bottom to a level below the dredging depth (1-3 m) thus providing both horizontal and vertical stability (Figure 2).

### Remote Controlled Operation

The unmanned dredge is controlled from an onshore unit fitted with Programmable Logic Controllers (PLC's). Fiber optics are used for transfer of information between the Punaise and the control unit. Once the initial data for a specific location has been processed and analysed, the system can function entirely automatically. The dredging instrumentation consists of normal density, velocity and pressure meters.

### APPLICATION OPTIONS

Application options depend on typical characteristics of the PinPoint Dredging technology such as:

- Continuation of production at any sea state
- Suction depth unlimited
- Automated operation
- Minimal manpower requirements
- Low investment

These characteristics are related to some typical dredging projects where the PinPoint Dredging technology is advantageous from a technical as well as an economic point of view. They include:

- Bypassing
- Beach replenishment
- Sand transfer at tidal entrances
- Reservoir dredging

The Punaise is now built for large as well as for smaller operations. To meet specific site conditions a custom build dredge may be the most economical solution. One of the latest developments is the Punaise PN200, specially designed for bypassing of sand at tidal entrances (the Florida Punaise).

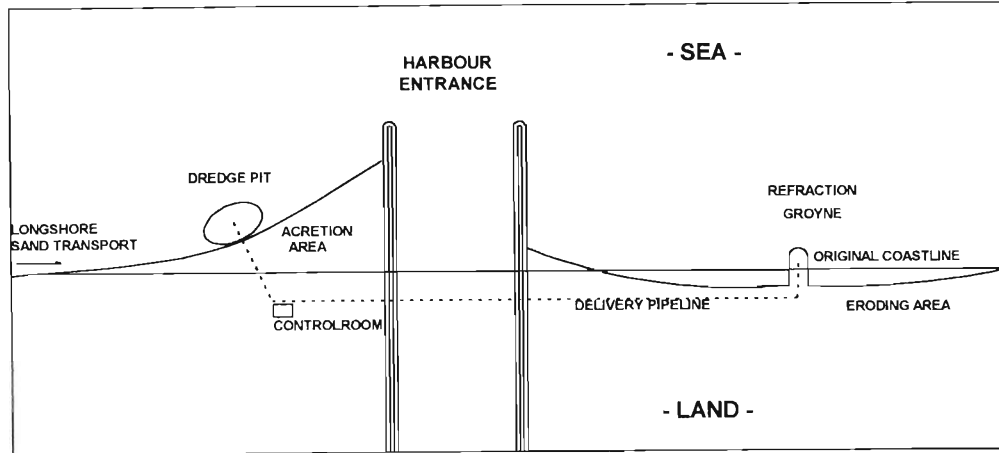


Figure 1. Bypassing by a "Punaise".

**ADVANTAGES ASSOCIATED WITH THE PUNAISE**

**Harbour Dredging**

Such advantages can be explained by the description of the project for dredging of the outer harbours at Ijmuiden and Flushing in The Netherlands. Figure 3 shows how a Punaise was placed in the bottom of the outer harbours where siltation is concentrated in the navigation channel.

The total quantity to be dredged yearly in Ijmuiden is 3,000,000 m<sup>3</sup> and 800,000 m<sup>3</sup> in Flushing. Silt density is 1.2 t/m<sup>3</sup>.

Dredging silt with the PinPoint Dredging system, therefore, is a continuous preventive operation under all weather conditions. By monitoring it was observed that up to a density of approximately 1.15 t/m<sup>3</sup> the silt behaves more or less as a liquid showing low shear stresses. The P.I.A.N.C. (Permanent International Navigation Congress) defines the "navigation depth" as the depth where the density of bottom material is 1.2 t/m<sup>3</sup> (BRUUN, 1990, Chapter 2).

The Punaise pumps the newly settled unconsolidated silt back to the sea during certain tide periods. Consolidated silt must be dredged by a hopper dredge or it is ploughed to the Punaise. A combination with water injection dredgers is under discussion. The Punaise PN250 has a nominal flow capacity of 1,000 m<sup>3</sup>/h; the revolution of the centrifugal dredge pump is frequency controlled so that the maximum power is available at all speeds and flow is optimized with the density. The area which is maintained by a Punaise from one point has a diameter of 600 m. In the harbour of Flushing, the Punaise was allowed to create its own pit in the sand bottom which enlarged the influenced area to dredge (Figure 4).

Maintenance dredging in the harbour of Flushing was carried out in 1992 and 1993 for a contract price of dfl 1.30 (\$0.50) per m<sup>3</sup> silt (volume weight 1.2 t/m<sup>3</sup>). The dredged silt was transported by pipeline to a dumping place in the Westerschelde estuarium over a distance of 600 m<sup>1</sup>.

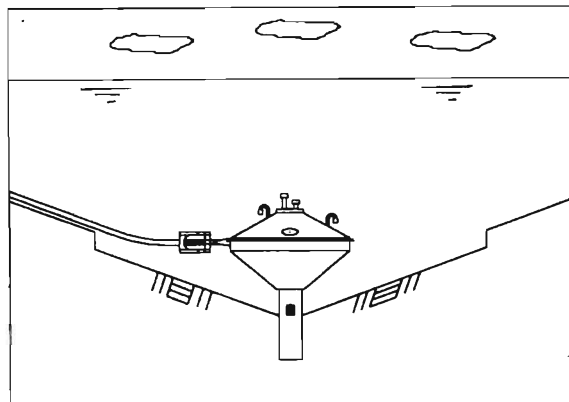


Figure 2. "Punaise" working principle in sand dredging.

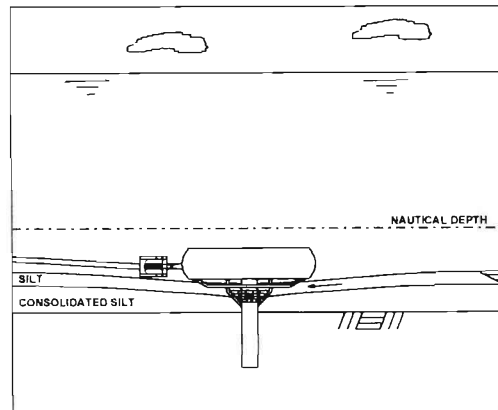


Figure 3. "Punaise" positioned for maintenance dredging of silt.

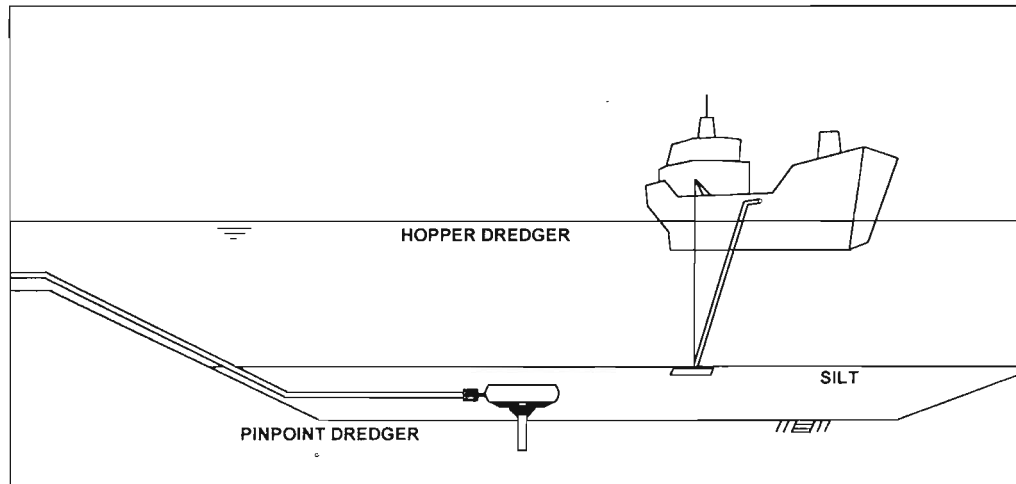


Figure 4. "Punaise" in the harbour with a trailing suction hopper dredge.

### DREDGING FOR BEACH REPLENISHMENT

An example of that is the project at Zandvoort and Bloemendaal beaches, southwest of the harbour of IJmuiden in The Netherlands. For this project of 610,000 m<sup>3</sup> sand the PinPoint Dredging method with the Punaise PN400 was used. A beach replenishment project executed in the traditional way uses hopper dredgers which pump the sand to the beach. The risk of bad weather is an uncertain factor in the price calculation. Delay percentage of 40% is normal. With the PinPoint Dredging system, a dumping pit is created by the Punaise at the desired water depth for dumping the required sand with Hopper dredgers (for this project at 7 m, distance from shore: 1,000 m). The Punaise pumps the sand ashore under all occurring weather conditions (Figure 5). After finishing the job, the dumping pit is filled to its original level from April to June 1994. The beach replenishment pro-

ject at Bloemendaal/Zandvoort was executed. In total 610,000 m<sup>3</sup> of sand was placed on the beach in a period of 9 weeks. Daily production rate was 20,000 m<sup>3</sup> in 24 hours. A breakdown percentage of 15% was registered.

The unit price for this project was dfl 8.50 (\$5.20) per m<sup>3</sup> (\$3.60/cu. yd.). The three price components were:

- (a) Dumping with a hopper dredge (sailing distance 20 km) a dfl 3.40 (\$2.10) per m<sup>3</sup>
- (b) Dredging with the "Punaise" a dfl 3.90 (\$2.40) per m<sup>3</sup>
- (c) Handling the sand on the beach a dfl 1.20 (\$0.70) per m<sup>3</sup>

### SPECIFIC USE OF THE PUNAISE FOR BYPASSING OF SAND AT TIDAL ENTRANCES

The present shortcomings in bypassing technology are dealt with by WHALIN (1993) and BRUUN (1993). As shown

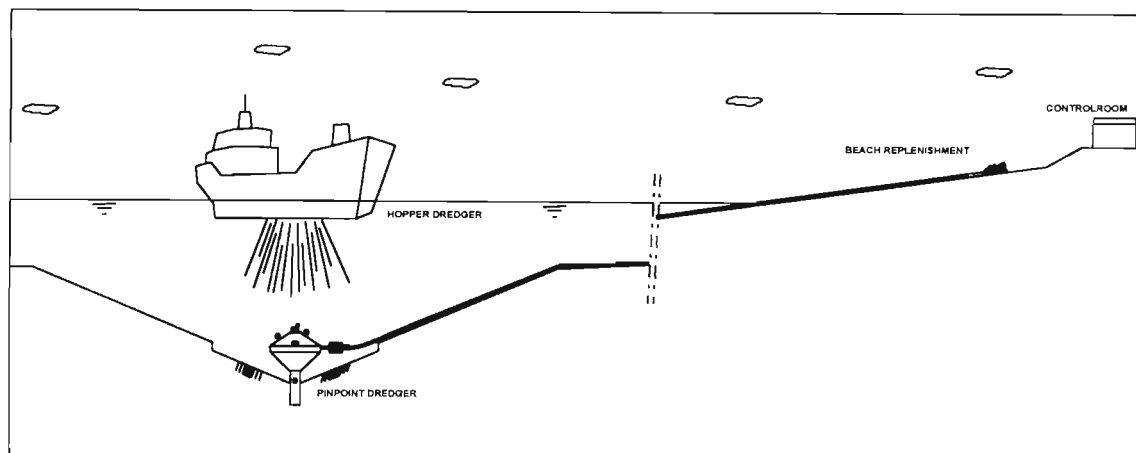


Figure 5. Dumped sand by a hopper dredge is pumped with a "Punaise" to the beach for a replenishment project.

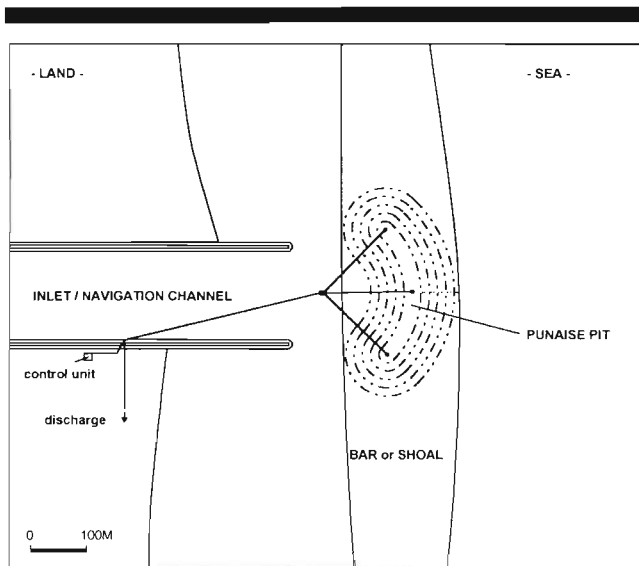


Figure 6. "Punaise" placed in active shoals.

in Figure 6 a Punaise may be placed strategically in active shoals where it digs itself down forming a large cone. If the height of the cone is *e.g.* 10 m and the slope in sand is 1:3, the volume of the cone will be  $\sim 10,000 \text{ m}^3$ . This volume may then be kept in reserve as a trap for bypassing, the pump being activated automatically when a certain volume (weight) of sand has been deposited in the trap by tidal and/or long-shore currents. With an upper cone width of 60 m, the cone may cover a substantial part of an offshore shoal or bar. There are two ways in which the active volume may be increased. One is by putting one or more additional traps in the shoals, *e.g.* in a line. The other is by placing fluidization pipelines extending from the pump, *e.g.* in a star as shown in Figure 7a and b: (a) straight pipes covering a total of 220 meters of length through an offshore ebb, and bar and (b) other shoal (Figure 8). The width of the channel generated thereby depends upon the depth of the pipes below the bottom level. If depth is 4.5 m the width of the double pipe string channel will be about 40 m. See BRUUN, 1990, 1993, 1995 and BRUUN and WILLIKES, 1992.

The equipment needed for such project includes: a Punaise PN200 operating solely (or in a row) powered by a cable from shore and 600 m of 0.3 m pipeline for transfer downdrift. Alternatively a Punaise PN200 combined with two 100 meter long, 0.3 m diameter perforated pipes or 400 meter fluidization pipelines connected to a three stage 8-9 bar pressure pump, placed on slope 1:100 with depth at the Punaise trap of 5.5 m below bottom level (Figures 7 and 8). If channel navigation depth is 4.5 m, which would be normal for many tidal entrances for small and pleasure crafts, the lower point of the pipe-string at the trap would be about 10 m below sea level and 9 m below sea level at the extreme ends of the pipes. For deeper navigation depths, *e.g.* 9 m, depths are increased by an additional 4.5 m and a third pipe-string may be added to widen the channel to 60 m.

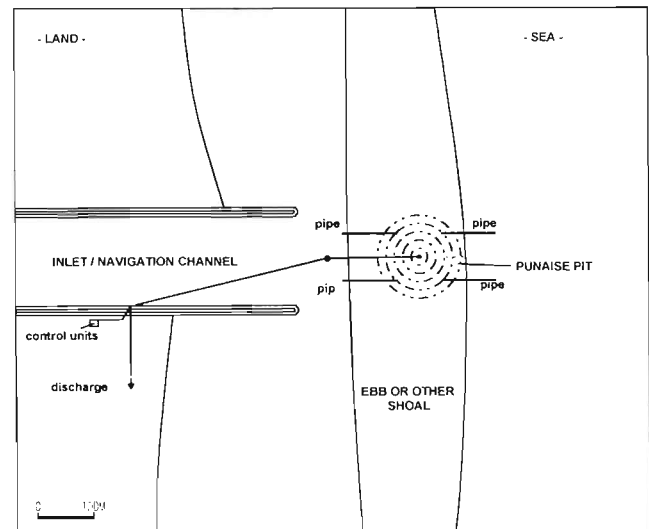
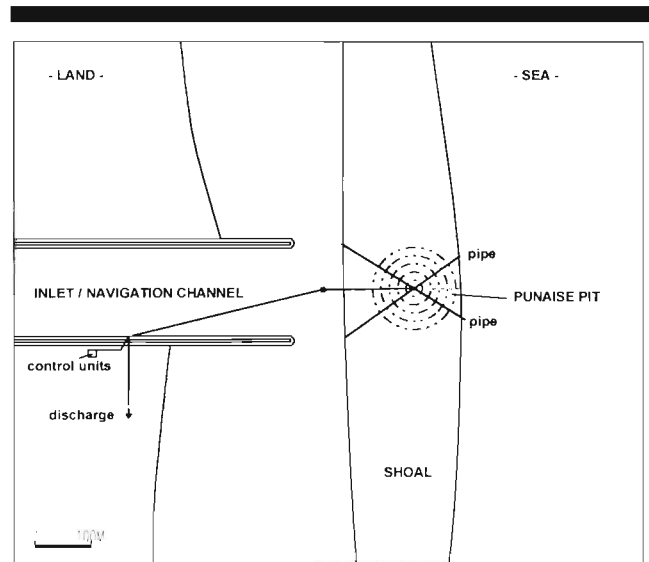


Figure 7. (a) Top, "Punaise" with fluidization pipelines in a star. (b) Bottom, "Punaise" trap inside tidal entrance with fluidization pipeline.

### COST FIGURES

The cost of a Punaise PN200 placed in an inlet shoal with power supply by cable from shore and a 600 m discharge pipe placed one meter below bed level runs about \$1,200,000. The cost of 2 pipe-strings of 0.3 m<sup>3</sup> pipes with two 3 mm holes for every 0.05 m, placed 4.5 m below bed level runs about \$600 per m pipeline. A three stage pressure pump with connecting pipes or hoses will cost about \$200,000. In addition a 0.3 m discharge pipe will cost about \$300 per m. The pressure pump handles one pipe-string of 100 meters length at a time with a minimum flow rate of 30 m<sup>3</sup>/min. The combination unit cost for such operation will be \$3-4 per m<sup>3</sup> (\$2-3/cu. yd.).

### CONCLUSION

(1) The Punaise offers many advantages for harbour maintenance, beach renourishment and for bypassing of sand at tidal entrances on littoral drift shores. This includes:

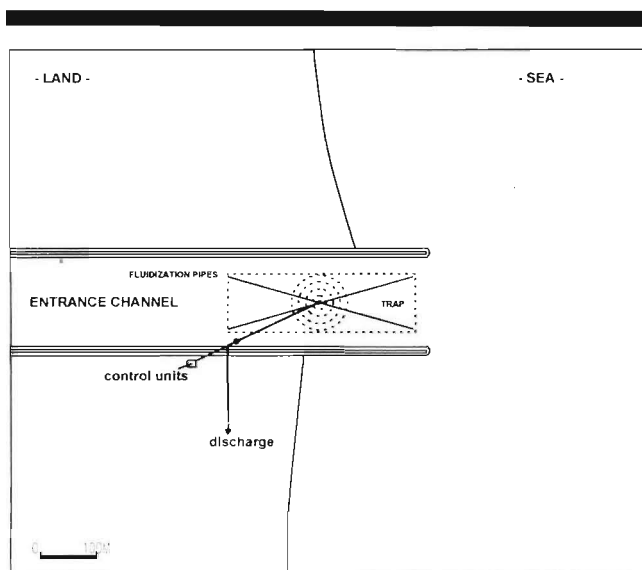


Figure 8. Punaise with fluidization pipelines to widen the channel.

- (a) a central transfer station for dredging or for beach nourishment that may be operated automatically.
  - (b) a silent, not weather dependent and without problems to navigation transfer system to downdrift beaches.
- (2) A guarantee of depth availability for given navigation criteria.
- (3) Economic advantages compared to other systems.

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