A NEW METHOD COASTAL LAND RECLAMATION

Dr. T.C. Kao of
Eastern Construction Co. Taiwan

Ing. J. van den Elshout
Project Manager IHC Holland

ABSTRACT

This paper describes a new type of plain suction dredger as a dredging tool for large scale reclamation projects.

Plain suction dredgers are well known as a valued tool for inshore sand reclamation Now the plain suction dredger can be used for offshore sand reclamation to an extent that is directly related to its capability to operate under the prevailing sea conditions.

The custom built heavy weather suction dredgers recently built for a project in Taiwan are excellent examples of the capability of operating plain suction dredgers at sea for large scale sand reclamation.

Keywords: Plain suction dredger, sand reclamation,

The project is being carried out in two areas (Fig. 3) :

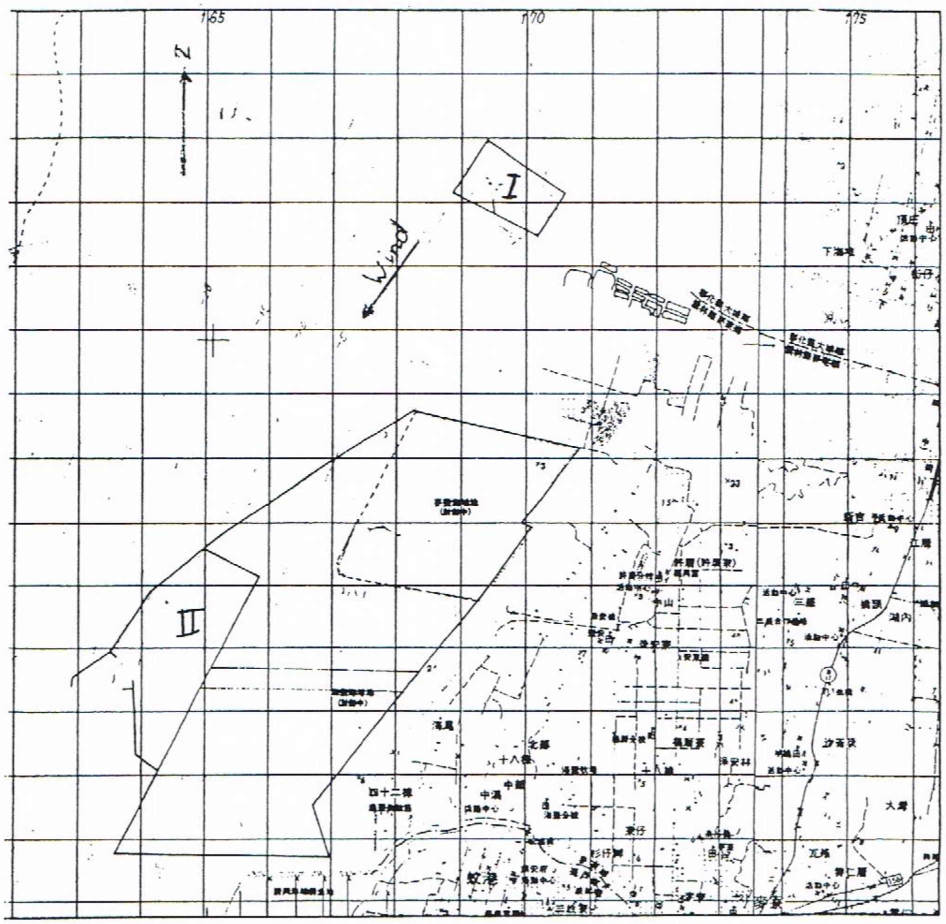

Figure 3: Map showing theproject areas

Borrow area I, containing a projected 13 million m^3 in a shoal, 2 km offshore, off a river mouth. Here dredging is restricted to a depth of 8 m and the tidal range is approx. 2 m. We have no information about the soil, but do expect lots of rubbish, such as plastic bags, tires, scrap etc., because that is the usual waste found in Taiwan's rivers during monsoons. The pumping distance here is about 5 to 7 km; geodetic rise in height approx. 4 m.

Borrow area II, about 61 million m^3 in the planned port, approx. 4 km offshore. The port's depth must be 16 to 21 m and the pumping distance varies from 1 to 7 km.

The results of four soil investigations are known. These indicate silt containing fine to medium fine sand, with consolidated silt layers of some metres thickness. Since the dredging takes place in largely unprotected waters, meteorological conditions are of the utmost importance.

2. METEOROLOGICAL CONDITIONS

During the summer months (April to September) the surface of the sea is smooth, but there is a chance of an occasional typhoon. Local dredging men say that medium sized dredgers can work for between 100 to 120 days a year. During the winter months, a strong NNE wind prevails, with accompanying long, heavy swell. The nearest refuge harbours are Taichung, 60 km to the north and a small fishing port 50 km to the south.

3. REQUIREMENTS

- The project had to be completed within 4.5 years.
- For future projects the dredgers would have to be deployed for sand winning approx. 10 km offshore. The 74 million m^3 of the present project is barely 10% of the total volume to be dredged.

There was more to the 'IJsselmeer' that made the craft interesting for this project. Its concept with underwater pump in the ladder, directly driven through a pivoting heavy duty gearbox by deck mounted diesel engines (Fig. 5), combines high fuel efficiency, ease of control, longevity and relatively low cost, with an engine room on deck - rather than below where it might cause trouble in case of pump failure.

As can be seen in the general plan (Fig. 6) of the dredger 'IJsselmeer', the pump is driven by

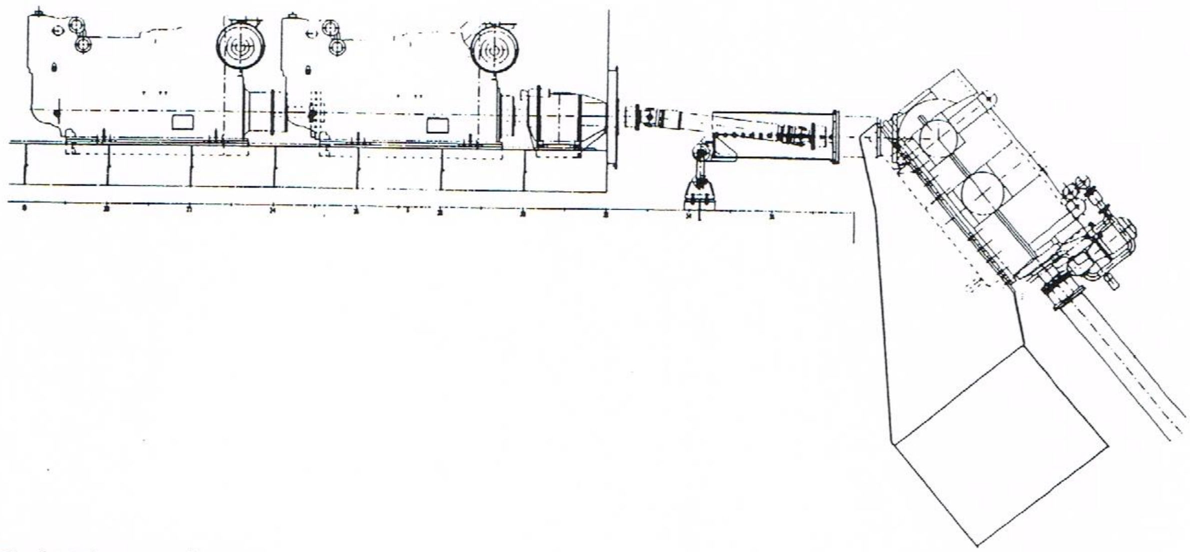

Fig. 5 The IJsselmeer

two diesel engines in tandem, working on a high speed primary shaft which, through a pivoting gearbox that moves with the ladder, drives a low speed pump shaft, which drives a high pressure pump. The deck-mounted engine room would further help in the Taiwanese dredgers to keep the hull simple, which was imperative because time was running out. Booster pumps were deemed necessary to bridge the large pumping distance. Two pump drives were chosen of the type used in the Beaver 3800 standard cutter dredgers. The double walled pumps had to be modified to withstand an end pressure of 24 bar. The drives, which used earlier developed, integrated gear boxes with built-in adjustable clutches and pump shaft bearings, could be delivered in time or were in stock. In fact, this concept promised a solution that could be delivered in time, give or take some details.

4.2 Improved seaworthiness

In order to increase yearly production and bring down the cubic metre price, the average number of operational days had to be doubled; the target became 240 or even 250 days. In other words: the dredgers had to be able to continue dredging at sea in heavy weather.

Experience with seaworthy stationary dredgers was limited, however, the only two other such craft being the deep winning dredgers 'Decima' and 'Gravelines'. They were designed for lower waves and unsuitable for dredging in shallow water.ate statistics for the area indicated that 2.75 m could be assumed as significant wave height, with a period of 7 to 9 seconds, which happens to be a dangerously long swell. If a craft could be designed to meet these conditions, only two would be needed for the 74 million m^3 job taking 4.5 years. The two parties agreed to base a preliminary design on the principles described; pressures of time led to

4.4 Connecting the conduit

Coupling the floating pipeline, however, which to a large extent dictates the maximum wave height in which the dredger can work, could be done near the centre of floatation. An added advantage was that here the pipeline would be well out of the way of the anchor cables, significantly reducing the risk of damage. As the general plan (Fig 8) shows, the craft is designed to meet the NNE wind on the stern, and the floating pipeline coupling consequently meets the wind under a certain angle. The funnel-shaped support (Fig. 7), made of anti-friction material, not only makes the coupling procedure easier, it also prevents kinks.

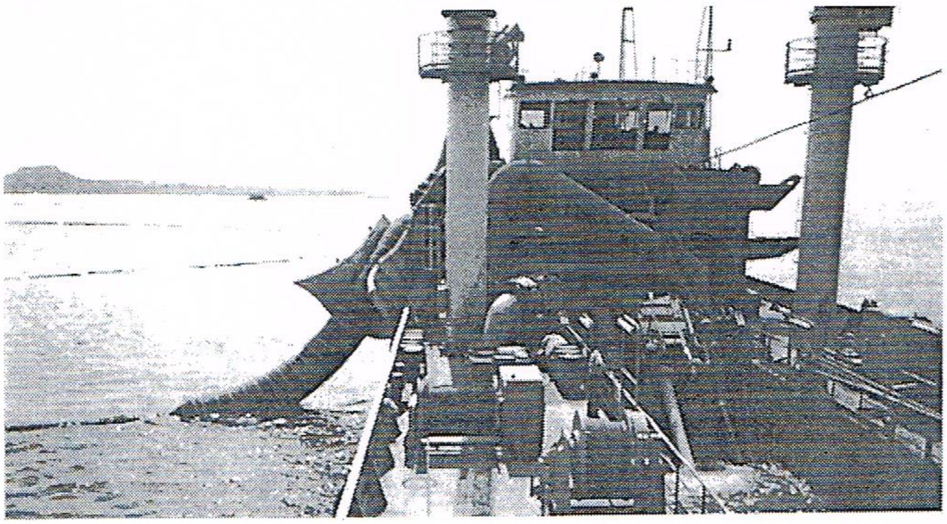

Fig. 7 The funnel shaped support of the pipeline coupling

The coupling can be used on port as well as starboard sides. For working in heavy seas, a quick coupling device, a guy line and a heavy winch are incorporated.

4.5 Anchoring system

The heaviest anchor winch is on the stern. Calculations indicated that an anchor cable of at least 700 m long would need a winch of 'only' 480 kN. Furthermore, the craft has 4 side winches on the quarters and also a bow winch, its cable led over the suction pipe's gantry. The floating pipeline has anchoring points every 70 m.

4.5 Model tests in wave tank

The many calculations concerning the motion of the craft and other design features were to be tank tested in the Ship Model laboratory of Marin, Wageningen. However, making a precision model required so much time that the model could not be completed before the entire design of the craft was ready. To attain the short delivery time, construction of both dredgers had already begun and in the end both dredgers and the model were completed more or less simultaneously.

5. THE DESIGN

Main particulars

Length overall	72.10 m
Beam	14.90 m

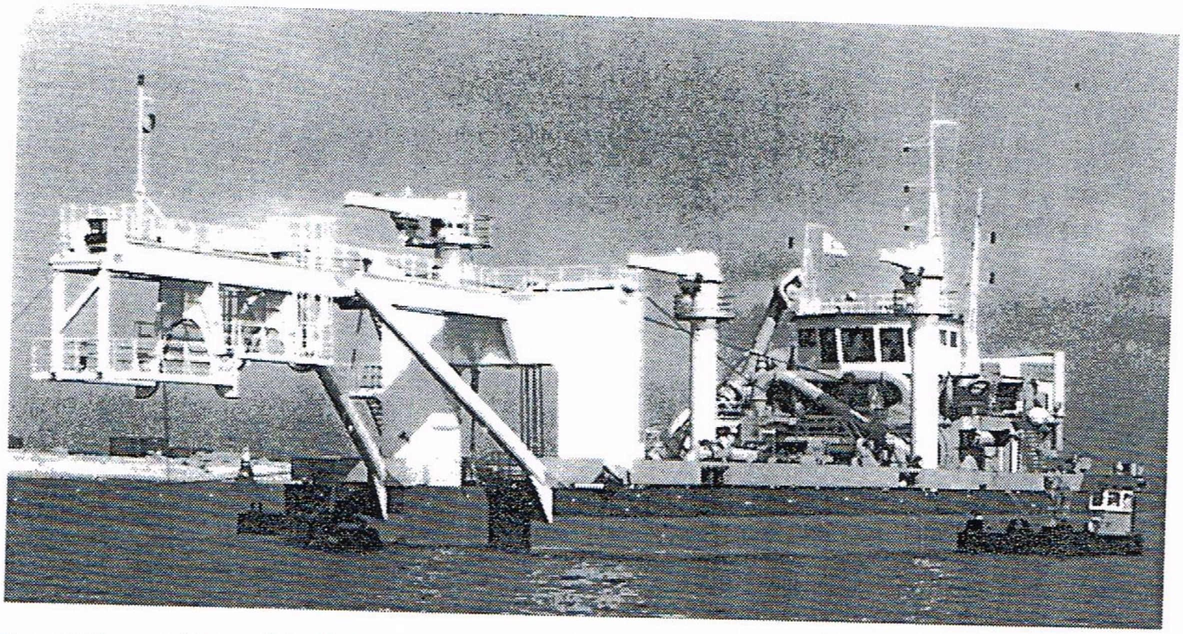

Fig . 9 The position of the booster pumps on deck outside the engine room

pump's suction pipe has a vacuum relieve valve. In the pipe between both boosters a combined velocity/concentration meter is placed. Since the shore-connection of the pipeline is virtually amidships, the in-board length of the pipe is short in order to by-pass one or two booster pumps.

The vessel's 'water management' depends on the pump room below. Here is found the eighth diesel generator set for the jet pumps and a considerable number of electric gland pumps. These are necessary for flushing the suction and the shaft sides of the three sand pumps. If in the future the owner should decide to convert the craft into a wheel dredger, the eighth diesel engine will be used to drive the hydraulic pumps of the dredging wheel. This conversion has been taken into account in designing the pump room as well as the ladder, the gantry and the other systems on board.

5.1 The design of the suction pipe and swell compensation system

The design criteria are:

- the dredging operation was to begin in very shallow water;
- optimum production required being able to dredge as deep as the authorities would allow (production of a plain suction dredger increases with the depth of the pit);
- the system must be able to follow vertical movements of about 10 m and yet retain enough stability to avoid production losses;
- the system must be able to follow horizontal movements of about 10 m fore and aft as well as athwartships and yet retain enough stability to avoid production losses
- compensation must preferably not be sought in the heavy wheel ladder, which would be complicated and hence prohibitively expensive;
- the suction tube must be able to dredge through layers of consolidated silt;
- the system should be able to survive the collapsing of a deep pit;
- the system must be able to free itself, by continuing the dredging process as well as by pulling the suction tube free in a controlled manner -in other words: the system should not need emergency hoisting gear;

Since active swell compensation must be fed from sensors and requires much energy, that option was ruled out. The accompanying drawing (Fig. 10) shows how the problems were finally been solved.

To make dredging in shallow water possible, a short suction pipe was chosen, another advantage of this being that the forces involved are manageable if the suction pipe is caught in its pit. In order to allow the suction pipe in this situation to be dredged free, an outer pipe has been fitted, with integrated suction basket. The underside of the suction mouth has been made adjustable making it possible to regulate the mixture's concentration; it also has a number of low pressure jets for improving the mixture.

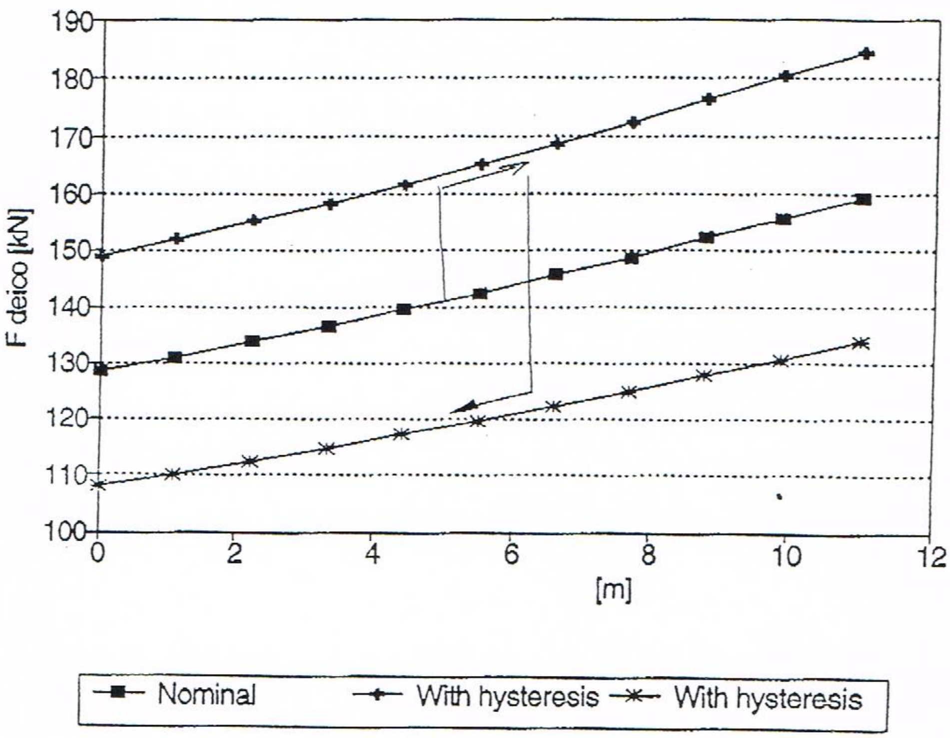

Fig. 11 The effect of the friction of various sheaves

Swell compensation takes place from the top of the suction pipe, which is suspended from one heavy wire. This was deemed preferable to a double reeved wire, which would, given the vertical movement of 10 to 11 m and a wave frequency of 7 to 9 seconds, accelerate the swell compensator's cylinder too much. Now the wire runs via this cylinder to the suction tube winch with a 5.5 m turn. Like the swell compensation in trailing dredgers, this system is also based on pre-pressurising the hydraulic oil in the cylinder by using a pressure vessel, in order to take up much of the weight of the suction tube. The idea is that while the ship heaves, pressure on the suction pipe foot will always remain within acceptable values - that is to say between being hoisted free from the seabed and hitting it too hard. Variation of forces in the hoisting wire caused by waves and determined by a set pressure is graphically illustrated. The effect of the various sheaves' friction can clearly be seen (Fig. 11) (Hysteresis effect).

The ground pressure is a function of the suction pipe's weight, influenced, for example, by mixture concentration, pressure of jets and acceleration forces on the intermediate pipe minus the swell compensation wire's pull. Although developing this system was not exactly simple