

## **Submerged Tunnel**

A submerged tunnel is a sub-aqueous tunnel constructed by the prefabrication of tunnel units and then submerged and jointed on the seabed. It is usually advantageous to construct a submerged tunnel rather than a bored tunnel below the seabed because a cover of at least 10 m is required for the safe construction of a bored tunnel under the seabed.

The first cross harbor tunnel in Hong Kong is made of steel but reinforced concrete ones are preferred now. Reinforced concrete tubes are not only cheaper than steel ones but can be more easily made in rectangular cross sections, which were more suitable for multi-lane road tunnels. In addition, they can be constructed rather long to reduce the number of sinking and joint operations.

The principal operations in the construction of submerged tunnels are:

1. Initial fabrication
2. Trench preparation
3. Launching and sinking
4. Jointing
5. Sand jetting
6. Backfilling



### **1. Initial Fabrication**

Tunnel units are pre-fabricated in a dry dock. The dry dock is usually an excavated basin beside the seashore at a depth several meters below water level.

Besides the structural frame, fittings and accessories are installed onto the units. These include: lifting lugs, temporary support jacks, bearing plates & gaskets, ballast tanks, bulkheads, locating nibs, a control tower, and a survey tower.

### **2. Trench preparation**

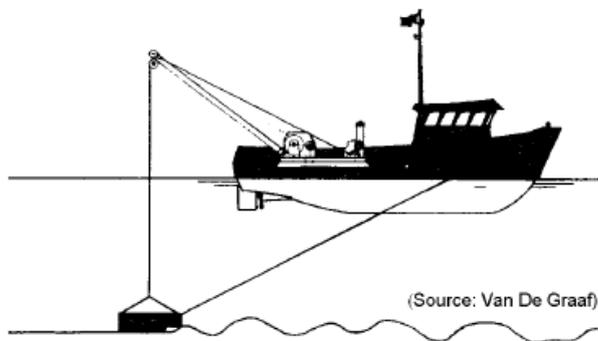
While the tunnel units are pre-fabricated in the dry dock, a trench on the seabed for laying the tunnel units will be prepared at the same time. The

trench may be excavated by dredging or by grabbing. The sides of the trench are usually sloped back to a stable angle.

To ensure the stability of the tunnel units on the seabed, the foundation shall be prepared. There are two methods for the preparation of the foundation:

- Screeding method, and
- Sand jetting method

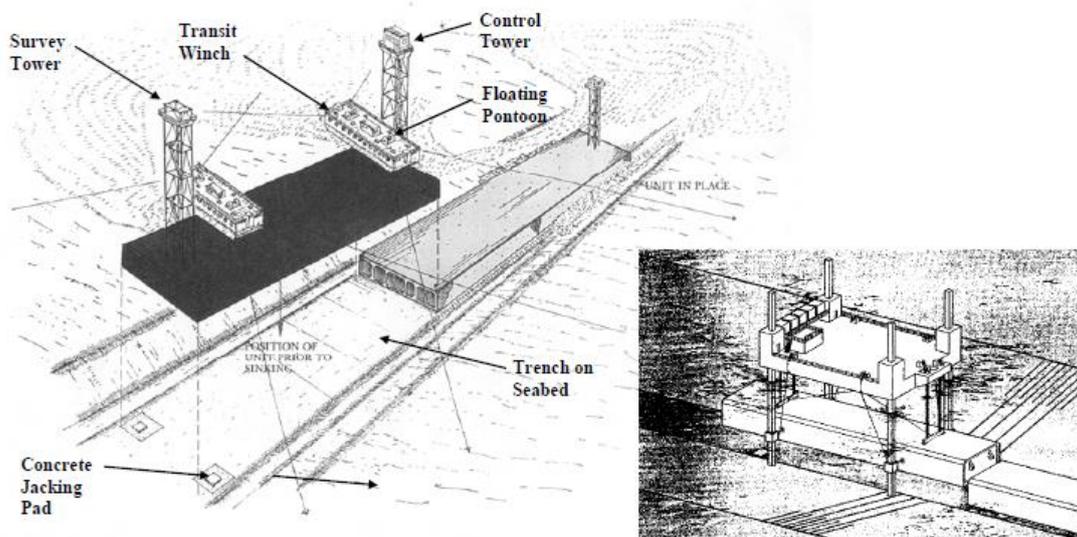
Screeding Method Granular trench bedding materials are laid on the trench bed and then smoothed by a leveler.



(Source: Van De Graaf)

### Seabed leveller

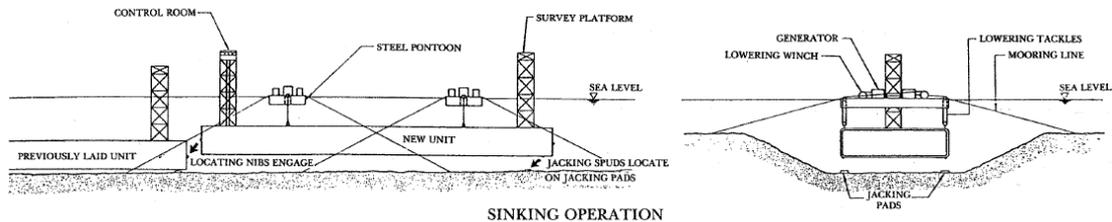
Sand Jetting Method Concrete pads are constructed at suitable locations on the trench bed for supporting hydraulic jacks. The tunnel bedding will be prepared by the sand jetting method after the tunnel segment has been placed.



### Sinking of Submerged Tunnel Unit

### 3. Launching and sinking

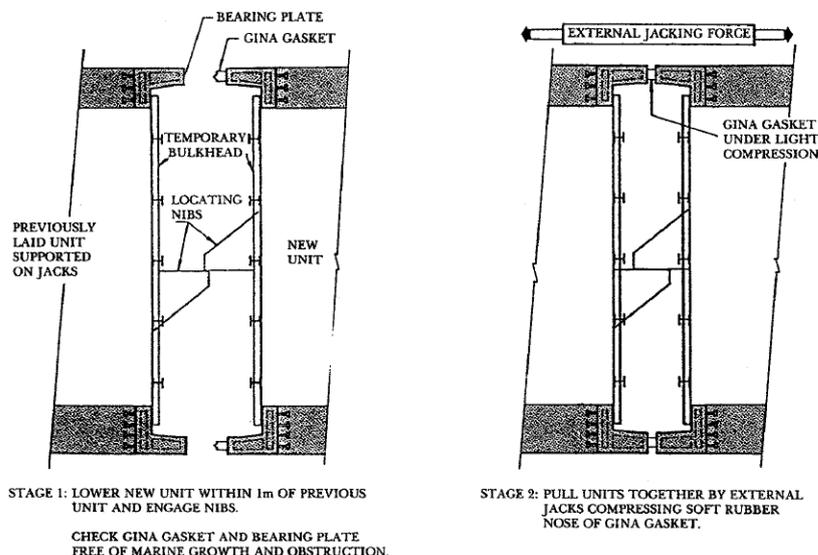
The open ends of the units will be closed with watertight temporary steel bulkheads to enable them to float. The floodgate of the casting basin is opened to let the seawater flow in. The unit is then floated and towed to its final position.



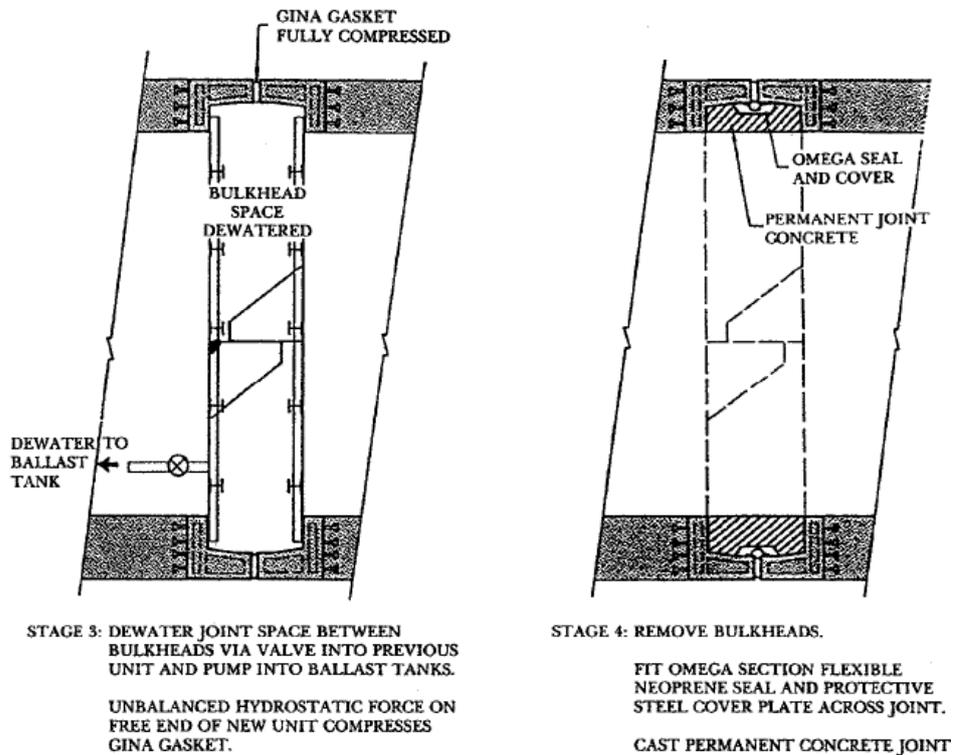
The unit can be laid by a fixed-leg platform, or more often nowadays by floating pontoons. In the latter case, two pontoons are placed on top of the tunnel unit to be sunk. There are transit winches on the pontoons for adjusting the position of the pontoons. The wires from the winches are tied to heavy concrete block anchors on the seabed. The sinking operation starts with water ballasting of the unit so that 2% negative buoyancy is established for sinking. Its position underwater is carefully controlled using the surveying tower.

### 4. Jointing

At an end of each tunnel unit, there is a bulkhead with a locating nib, and a Gina gasket or a steel bearing plate installed. The unit is lowered slowly until the locating nibs are engaged. Now the moving of the unit is taken over by hydraulic jacks.



The jacks pulled the newly sunk unit towards its neighbor until sufficient contact pressure is established between the Gina and the bearing plate. This initial compression provides isolation of the water inside the gap from the outside.

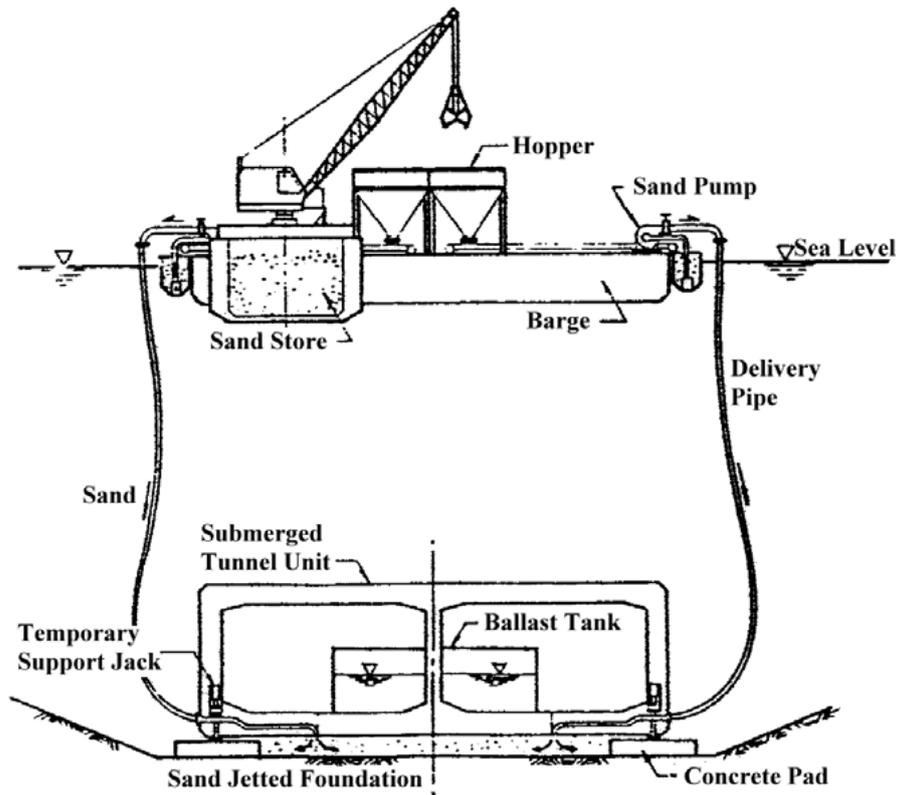


Thereafter the water is discharged from the joint. The unbalanced hydrostatic pressure on the further end of the new unit will press the units tightly together.

The bulkheads at the joints are then removed. The waterproofing of the joint is further reinforced by installing an omega seal and covered with a steel plate by welding. Finally the joint is filled with concrete or cement grout.

## 5. Sand Jetting

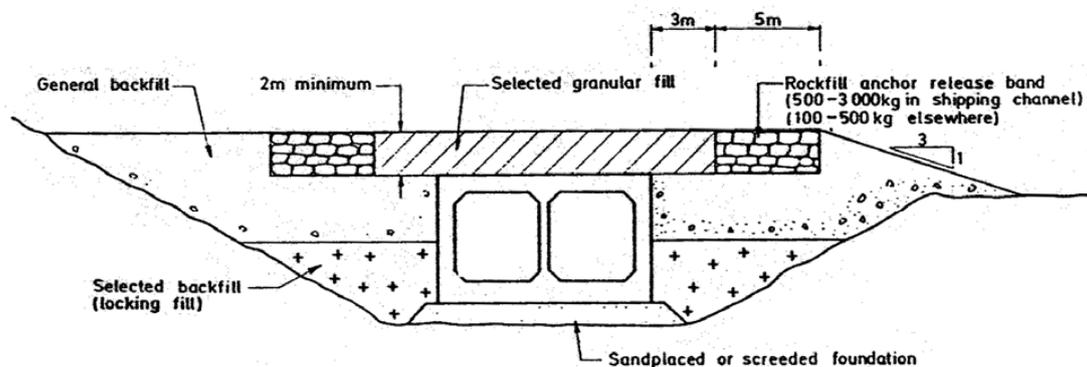
If the tunnel bedding is placed by sand jetting, the sand and water are mixed and pumped down from a barge through delivery pipes to nozzles beneath the tunnel unit which are placed at 4 to 8 m intervals. Following the sand jetting bentonite/cement grout may be injected into the sand foundation for additional reinforcement.



## Sand Jetting for Submerged Tunnel Bedding

### 6. Backfilling

Selected backfill comprising of granular material which will compact naturally underwater is placed at mid-way of the tunnel depth. General fill or granular fill material which would not cause damage to the tunnel waterproofing is placed on top until a cover of at least 2 m for the tunnel unit is attained. Rock armor should also be provided near the shore for protection of the tunnel from damage by vessels.



Typical backfill/anchor protection