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Submerged Floating Tubes with Free Spans over 4000 m

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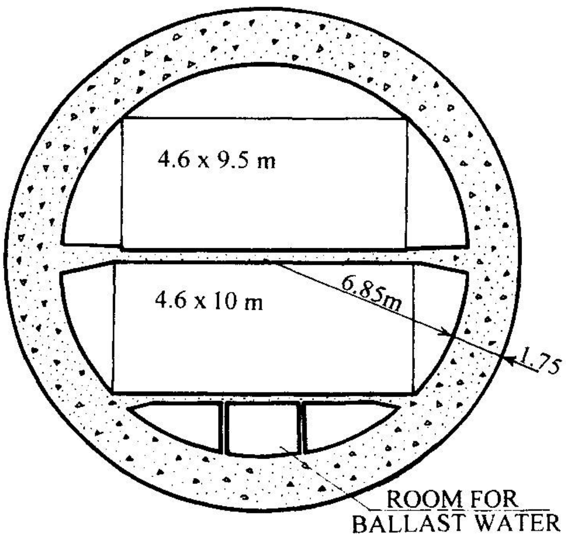
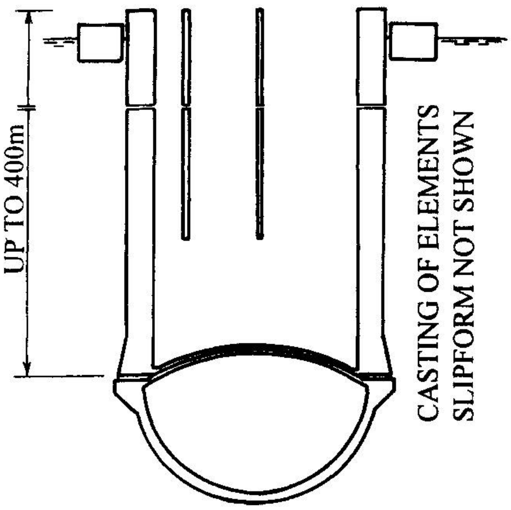
The purpose of this poster is to argue that the max. free span of abutment-anchored submerged floating tubes can be more than 4 km. It should contribute to a general acceptance of free spans of up to 2 km. Analysis of these structures will be presented in a handout available at the Congress in Kobe.

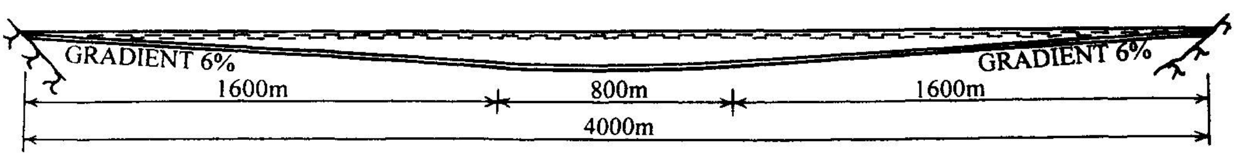
The proposed tube is made from concrete with cube strength up to 95 MPa. Elements more than 200 m long can be cast by slipforming. When the elements have been up-ended, they are to be joined together by the usual Dutch method. When the whole tube is assembled it will be installed between the abutments.

During production the buoyancy of the tube can be checked with great precision. When finished, the tube should have a buoyancy equal to about half the max. traffic load. The magnitude of the axial force may be monitored by monitoring the frequency of the horizontal vibrations. Thus little permanent load needs to be considered for the design. Earthquakes have not been considered in this design

Slow changes in dead load, creep and shrinkage will give alterations of the desired shape of the tube. These changes can be counteracted by altering the amount of asphalt or ballast water.







In the serviceability limit state the traffic load is very important. This load is at a maximum when traffic is brought to a standstill. It can be considerably reduced if traffic is not allowed into the tube whenever stoppages lead to undesirable deflections. The corresponding reduction in traffic capacity will be small. The ultimate limit state should be based on max. traffic load.

The tube lies so far below sea level that stresses due to 7 m high waves will be unimportant in the design. The magnitude of thecurrent depends on the site. The current is always strongest at the surface. For this project the average current and the current 50 m under sea level are assumed to be 0.7 $^{m}/_{sec}$. Vertical hydroelastic vibrations will be insignificant for this current.

Deflections due to in-line vibrations never exceed 0.15 times the diameter of the tube. Stresses due to in-line vibrations will be small when there are less than 4 points of inflection along the tube. The moment vector due to in-line vibrations is perpendicular to the moment vector due to vertical loads. Thus moderate stresses due to in-line vibrations have little influence in design. The resulting oscillations will cause accelerations that will not be noticed by the public.

Along the tunnel there is likely to be a great difference between the speeds of currents which last long enough to build up in-line vibrations. More research is needed to decide whether in-line vibrations will be harmful to the suggested tunnel.

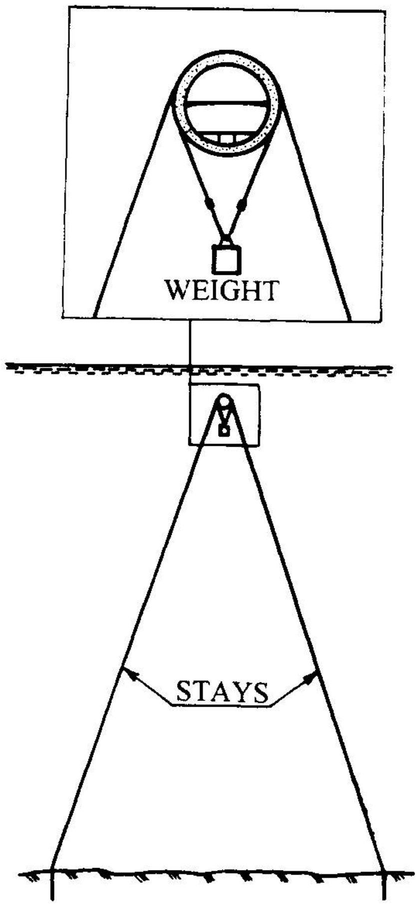
At sites where currents and waves cause high stresses the following remedies can be used:

1. Fins attached to the tube can reduce the chance of hydroelastic vibrations. The shape of the fins should be influenced by the fact that the currents are parallel to the surface.

2. Inclined cables to the bottom from points less than 1300 m from the abutments. Cables in the middle of the span would hamper expansion due to temperature.

3. Same as 2, but the cables should be swung over the tube as shown in the drawing. The stays are kept in tension by the weight of a concrete bucket fastened to a pulley that sits on the cables under the tube.

The weight of the bucket can be adjusted by adding or removing sand. Friction between the cables and the tube will dissipate the energy of the vibrations. Stoppers could be fastened to the cable at each side of the pulley to limit horizontal movement of the tube.



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