

## Grout Bag Engineering: Proserve Contractor: GLF, Malamocco and Lido San Nicolo Inlets



Flooding in Venice will soon become a thing of the past with the help of MOSE barrage project. This is currently being constructed to the sea inlets of the lagoon.

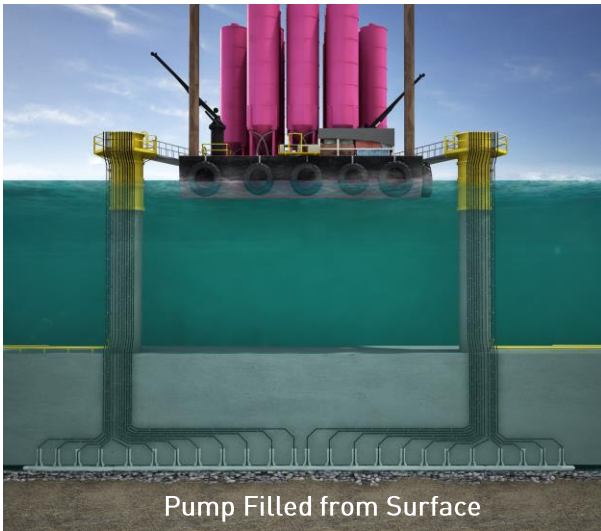
The project consists of a line of large steel box flap gates positioned across the sea inlets to Venice lagoon. The flap gates are raised by pumping air into them when high sea levels threaten to flood Venice. These are hinge connected to concrete caissons which are founded using Proserve's automated foundation Grout Bag System at the Malamocco and Lido San Nicolo inlets.

Many of the caissons have already been precast on the shore, at the casting yard just south of the Malamocco inlet with the grout bag system is being pre-fixed to the bottom of caissons.

The concrete caissons weigh some 20,000 tonnes and are typically 48m wide x 60m long. After casting, 2.5m wide x 24m long grout bags made from a porous, grout tight woven fabric are fixed to the bottom of the caisson condensed inside a PVC protective cover. Prefabricated filler sleeves are connected to vertical hoses prefixed to the caisson sides and grout sensors placed inside upstanding vents to signal when the grout bag is full during grouting operations. The automated foundation Grout Bag System has been designed and manufactured by Proserve using appropriate marine risk management techniques as the grouting process is irreversible once the caissons are placed.



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Pump Filled from Surface



Bags Pre-Fitted with Filler Hoses



Grout Bag Testing

Trenches have been constructed in the Malamocco and Lido San Nicolo inlets to accommodate the barrage foundations. The alluvia strata in the bottom of the trenches is strengthened by driven precast concrete pin piling and a capping layer of compacted crushed rock.

The caissons are to be lowered into the water via a ship lift at the Malamocco casting yard from where they will be towed to their inlet. CFD modelling has been used to determine the hydraulic forces on the bottom of the caisson and the grout bag system during towing. The knowledge gained has enabled the design of robust condensed grout bag fixings and a suitable protective cover and release mechanism. Once above the barrage trench, the caissons will be lowered into position by a lowering barge and accurately levelled and supported by hydraulic jacks on temporary foundations.

Foundation grout bag filling will then be undertaken largely automatically working from the surface with a grouting barge mixing and pumping neat cement grout before individual grout sensors are activated. Automated filling overcomes the problem of restricted diver access due to high tidal flows in the inlets. The caisson foundations can be grouted over a period of some 2 days.

Appropriate development testing plus full-scale reliability testing of the automated foundation grout bags system was undertaken in 2009. Proserve first developed the system for use on the Second Severn Crossing, U.K. in 1993 and has since applied it successfully to many major international projects. At Venice, the automated foundation grout bag system gives the following principle benefits: -

- Automated foundation grouting
- Avoids wash out
- Controls uplift pressure
- Improved risk management (by subdivision)
- Accommodates bed undulations

Caisson immersion for the Lido San Nicolo and Malamocco inlets is due for commencement in late 2013 with the barrage expected to hold back high tides and flooding in 2015.