MINISTRY FOR INFRASTRUCTURE AND TRANSPORT
VENICE WATER AUTHORITY
Concessionary
Consorzio Venezia Nuova

Safeguarding Venice and its lagoon: mobile barriers to regulate tides in the lagoon

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INTRODUCTION

The Italian Republic has defined the problem of safeguarding Venice and its lagoon as one of "primary national importance" (Special Law no. 171/73).
The General Plan of Interventions delegated to the state has been drawn up on the basis of the instructions of the Committee as per art. 4 of Law no. 798/84 and contains the conclusions of years of comparisons, studies and general design work to examine various alternatives and evaluate the feasibility of the projects in terms of environmental compatibility.
The Plan has been approved by the Technical Committee of the Water Authority, by the Committee ("Comitatone") as per art. 4 of Law no. 798/84 in 1991 and by Parliament who referred to it in Special Law 139/92 as a basis for the development and funding of the measures planned, completed and still underway.
This plan of works, currently underway, has been developed by the Ministry of Infrastructure and Transport - Venice Water Authority through the Consorzio Venezia Nuova.
The Consorzio Venezia Nuova consists of a group of Italy's leading construction companies of international importance and local cooperatives and firms with considerable experience of operating in the lagoon.
To carry out its work as State concessionary responsible for studies, experimental activities, projects and works, the Consorzio Venezia Nuova has developed a structure able to plan, organise, manage and control the safeguarding measures during the various phases of implementation, while at the same time acting as the operational interface between the granting administration (the Venice Water Authority) on one hand and those carrying out the work on the other (designers, experts responsible for studies and experiments and companies carrying out the work).

Since the beginning of the 1900s, high tides have become more frequent and intense. The common image of Venice "sinking" reflects a real problem. The lagoon area floods ever more frequently because the relationship between water and land has been profoundly modified, particularly during the last hundred years. This can be attributed to the combined effect of a rise in sea level and a drop in land level (subsidence). As a result, urban centres in the lagoon are today an average of 23 cm lower in relation to sea level than they were at the beginning of the 20th century.
The problems caused by flooding for inhabitants and for architecture and buildings are becoming more serious and reach an ever greater area as water levels increase.
There is also the high risk of a catastrophic event such as the flood of November 4, 1966 when Venice, Chioggia and other urban centres in the lagoon were completely submerged by a metre of water.
In recent years, successions of closely spaced high tides have increased in frequency, such as during the period between November 15 and December 6, 2002 when there were 15 tides exceeding 100 cm, with nine above 110 cm, five above 120 cm and a peak of 147 cm.
In the future, the problem of high waters could worsen due to the predicted rise in sea level produced by the greenhouse effect.

The Mose project

The Venetian lagoon has three openings to the Adriatic sea: Lido, Malamocco and Chioggia (800 m, 400 m and 380 m wide, respectively) (Fig. 1). The inlets are delimited by long jetties built between 1800 and 1900. These have been suitably consolidated in the 1990s and thus serve as support to the high water defence system.

Fig. 1

The system of defences (Mose project) at the inlets has been designed to protect the lagoon area, its inhabitants, its extraordinary towns and cities and its inestimable historical, artistic and environmental heritage from all high TIDES, including extreme events.
It consists of mobile barriers to isolate the lagoon from the Adriatic during tides exceeding the established level and a series of fixed "complementary" structures designed to increase friction in the inlet channels, attenuating the vivacity of the tidal currents and thus reducing the levels of the most frequent tides. Integration and "collaboration" between the mobile barriers and the complementary structures (together with raising of quaysides and paving in the lowest lying urban areas, underway for some time now) represent an extremely functional defence system, enabling the number of times the inlets need to be closed to be reduced to a minimum (3/5 times per year with the current sea level). Water quality, safeguarding of the morphology and landscape and port activities are thus guaranteed.
This system of defences therefore represents an environmental protection and restoration "tool" in the broad sense, the result of a lengthy and complex design process which always considered the complexity, quality and "sensitivity" of the surrounding context and all the interconnections linking the various components of the ecosystem, including the constraints imposed by socio-economic conditions and land use(Fig 2)

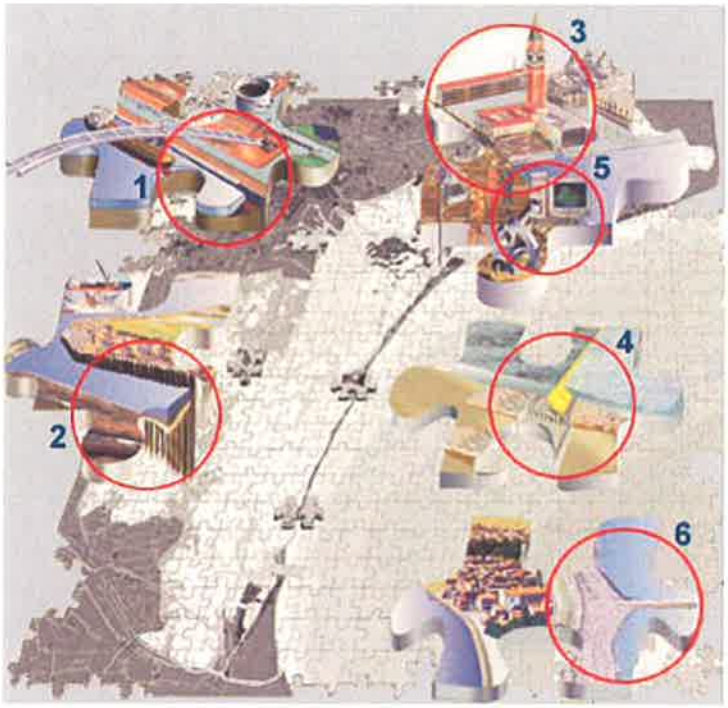

Fig 2: The system of interventions delegated to the state are:

1. **Environmental defence:** securing the banks of polluted canals, improvement of water and sediment quality

2. **Environmental defence:** protection and reconstruction of mudflats and salt marshes habitat and structure

3. **Defence from high waters:** local defences of urban centres

4. **Defence from high waters:** Mose system - work to regulate tidal floods

5. **Control and management:** studies, surveys, monitoring, data banks

6. **Defence from sea storm:** beach and dunes reconstruction

The mobile barriers are the heart of this system of works and consist of rows of gates installed in the inlet channels. When not in operation, the gates are full of water and rest in caissons on the bed (Fig.3a).
When tides exceeding safeguarding level are forecast, an emission of compressed air empties the flap-gates of water until they emerge (Fig. 3b and 3 c). In this way, it is possible to temporarily isolate the lagoon from the sea thereby blocking the flow of the tide. The inlets remain closed for the duration of the high water and for the time it takes to manoeuvre the flap-gates (on an average a total of 4.5 hours).
The gate-opening manoeuvres follow precise procedures, taking account of the possible increase of water in the lagoon due to input from rivers, rain, local rises caused by wind or the passage of water between one gate and the next. The Mose can protect the lagoon and the urban centres from a tide level of 3 metres.

How the floodgates work

Fig. 3a

Fig. 3b

Fig. 3c

In the future, the phenomenon of high waters could be further aggravated by the predicted rise in sea level produced by the climate change. With regard to this problem, Mose (with the reinforcement of the coastal strip) has been designed on the basis of a precautionary criterion to cope with an increase of up to 60 cm in sea level, in other words, higher even than the latest estimates from the IPCC (Intergovernmental Panel on Climate Change) which predict an increase in sea level of between 18 and 59 cm during the next 100 years. Management of Mose is flexible enough to cope with an increase in high waters in various ways, depending on the characteristics and scale of the tidal event. Depending on the situation, the defence strategies can involve simultaneous closure of all three inlets, closure of one inlet at a time, or partial closure of each inlet, as the gates are all independent.

Mobile barriers

Type of gate: disappearing, oscillating, buoyancy flap gate
Number of gates: 78 in four rows (Lido-Treporti: 21; Lido-San Nicolò: 20; Malamocco: 19; Chioggia: 18)
Gate dimensions: Thicknesses vary from 3.6 m (row at Lido-Treporti) to 5 m (row at Chioggia); lengths vary from 18.5 m (row at Lido-Treporti) to 29.6 m (row at Malamocco) (Fig. 4); the width is 20 m for all rows
Average inlet closure time: 4 to 5 hours (including gate opening and closure times)
Maximum difference in level between sea and lagoon: The gates are designed to withstand a difference of 2 m between the sea and lagoon. They are therefore able to cope with the possibility of a considerable increase in sea level during the next 100 years.

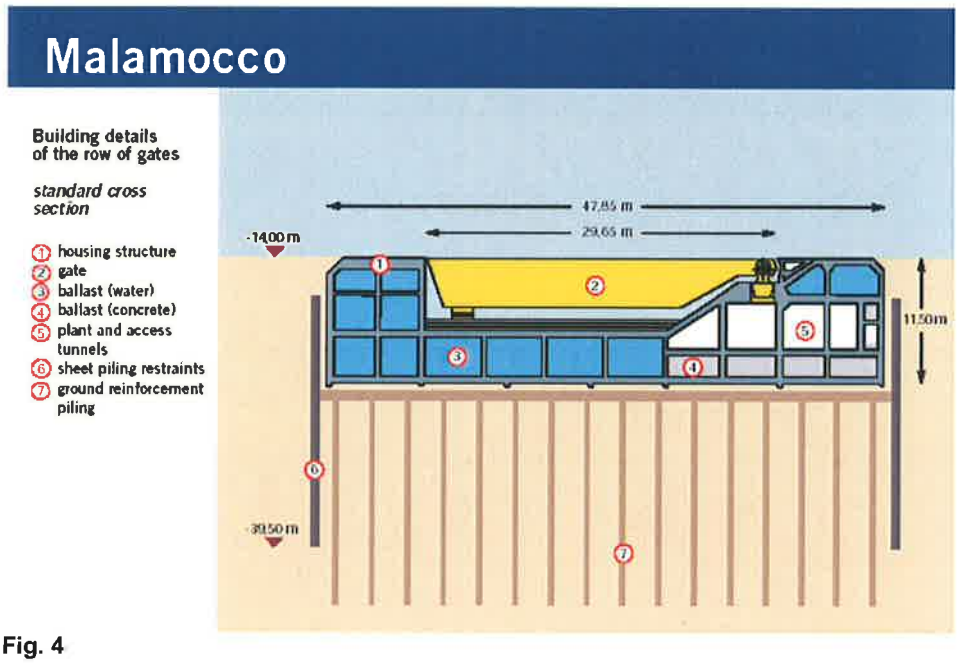

Fig. 4

Complementary measures

Breakwaters outsides the lagoon inlets: The riprap and acropods breakwaters will have a length of 1000 m in Lido , 1280 m in Malamocco and 520 m in Chioggia respectively
Raising of the bed at the Malamocco inlet: Raising of the bed from –16 m to –14 m is envisaged to reduce the volume of water exchanged between the sea and the lagoon, together with the breakwaters outside the inlets, contributing to attenuating water levels in the lagoon during the most frequent tides
Lock at the Malamocco inlet: Useful length: 370 m; Width: 50 m.

Activities at the Venice Arsenale

As well as activities at the inlets and to construct the barriers, work is also underway in the north Venice Arsenal where maintenance of Mose and management of the system will be based.
These activities will be located in a large area granted in concession by the State to the Consorzio Venezia Nuova.
To date, the six 16th century buildings ("Tese") which will accommodate the management activities (integrated environmental monitoring, operational control of the Mose barriers etc.) have been restored and recovered and construction of the infrastructure is currently underway.
Functional reorganisation of the large and medium dry docks where maintenance of the Mose gates, other components of the system and service vessels will be located is also in progress.
For the north Arsenal, these new activities represent a real opportunity for development in connection with Mose and sea defences and environmental protection in general.
After a decline in the 1900s, the Arsenal can now become a centre for research and production, technological excellence and innovation creating high levels of specialised employment.