Experimental Electromechanical Module (MOSE) for Flood Control in Venice

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***Abstract*- Venice or Venezia is an Italian city, at the Adriatic Coast rising high in a deep lagoon. The city in northeastern Italy sits on a group of 118 small islands separated by canals and linked by bridges. Renowed for its setting and historical buildings the city is often called 'the most beautiful city', the "La Dominante", "Serenissima", "Queen of the Adriatic", "City of Water", "City of Masks", "City of Bridges", "The Floating City", and "City of Canals"[1]. But today Venice stands as an endangered wild life species because the ancient city which was built on numerous islands straddling the lagoon is sinking fast due to rise in water level[2]. As a result the Italian government proposed a project intended to save the city of Venice from flooding called the MOSE(Modulo Sperimentale Elettromeccanico, *Experimental Electromechanical Module*) project which is about to be commissioned by 2015. MOSE project is an integrated system of lock gates and various other structures that have been constructed at the various inlets of the Venetian lagoon so that the water entering the lagoon can be regulated during high tides. This case study analyses various pros and cons of this project including its technology as well as its impact on the nearby environment.**

Keywords:

I. INTRODUCTION

MOSE is an acronym for the Italian words "Modulo Sperimentale Elettromeccanico" which means experimental electromechanical module. This project was first taken as an experimental module that would include a series of mechanical structures which would be controlled electrically in order to protect the city of Venice from frequent flooding[3]. The city of Venice stands on 118 small islands that lie in a deep natural lagoon fed by its rivers. The lagoon has three outlets to Adriatic Sea viz- Lido, Malamocco and Chioggia. Every structure in Venice stands on pile foundations consisting of piles of Albanian wood that were driven deep into the sea many years back[4]. Due to the rise in water level in the sea Venice is subjected to frequent flooding especially during high tides. The problem was taken seriously when in 2002 the central square of Venice "Piazza San Marco" was badly hit by a flood due to a high tide amalgamated with rainy weather. MOSE included a series of gated structures constructed at the outlets of Lido, Malamocco and Chioggia fully synchronized electrically so that during inclement weather water entering the lagoon could be regulated.

II. TECHNICAL DETAILS

A. Operating principles

MOSE consists of a series of lock gates whivh are constructed at the three outlets which temporarily separate out the lagoon from the Adriatic sea during inclement weather and high tides.There are a total of 78 gates which have been divided into 4 barriers. The Lido inlet is the widest of all having two rows of gates of 21 and 20 elements respectively linked by an artificial island (the artificial island connecting the two rows of gates at the centre of the Lido inlet also accommodates the technical buildings including the system operating plant). Malamocco has one row of 19 gates while Chioggia inlet has one row of 18 gates. The gates are metal box type structures 20 metres (66 ft) wide, with a length varying between 18.5 and 29 metres and thickness from 3.6 to 5 metres (12 to 16 ft)[5]. The technological heart of the system is the hinges over which the gates are able to move. These hinges are constructed on a concrete housing that bear the hydrostatic pressure on the gates.

B. Procedure

The box type gates are hollow from inside. Under normal tidal conditions the gates are full of water and remain open since they rest on their housing structure due to the weight of water. During high tides or rainy season compressed air is introduced in the gates which expels water from the gates. The heavy gates now become very light causing them to rotate about their hinges and close the inlets. They emerge above the water to stop the tide from entering the lagoon thus protecting the lagoon. The gates are held in position by the heavy pressure provided by compressed air which also bears the hydrostatic pressure offered by the sea water. The entire setup of compressed air is constructed on the islands between the rows of gates and is fully synchronized with weather forecasting station and a control room at Venice.

The inlets are closed for 4-5 hours including 30 minutes time required for raising and lowering the gates. To avoid any interruption to the port of Venice a main lock has been provided to transit and shelter emergency vessels .each gate is independent in itself which means they can be raised fully or partially to any extent depending upon the height of tide. They can also oppose water in both the directions which means they are bi-directional.

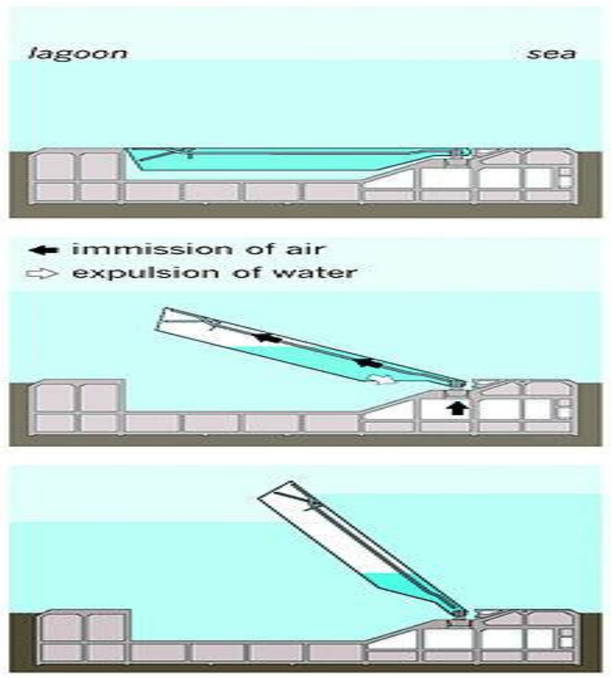

Fig 1: Gate movements during inclement weather.

Hinges and Locks

The hinges are of ball bearing supported over pin joints .They are in turn fastened to a pedestal made up of prefabricated concrete. Each hinge is 42 ton in weight.
The locks are in a series of parallel walls of gates. They are four in number. They allow the passenger port of Venice to remain open even if MOSE is closed. The gates are inclined at 45 degrees while they are closed and they are kept in position by adjusting the amount of water in the gates which acts as a ballast.

III. OTHER RECONSTRUCTION PROJECTS

A. Venice Arsenal

The historical port of "Empire of Venice' has been reconstructed . The control centre of MOSE is located here. Old crumbling buildings have been restored to their pristine glory to accommodate these activities[6]. The smallest gate is 18.5 by 20 by 3.6 metre (61 ft × 66 ft × 12 ft) (Lido–Treporti row) while The largest gate is 29.5 by 20 by 4.5 metres (97 ft × 66 ft × 15 ft) (Malamocco row).

B. Other projects

Other projects include strengthening of the entire city to bear the stagnation of water. These include various launching aprons, paved borders, guide banks, marginal embankments especially at the Grand Canal etc.

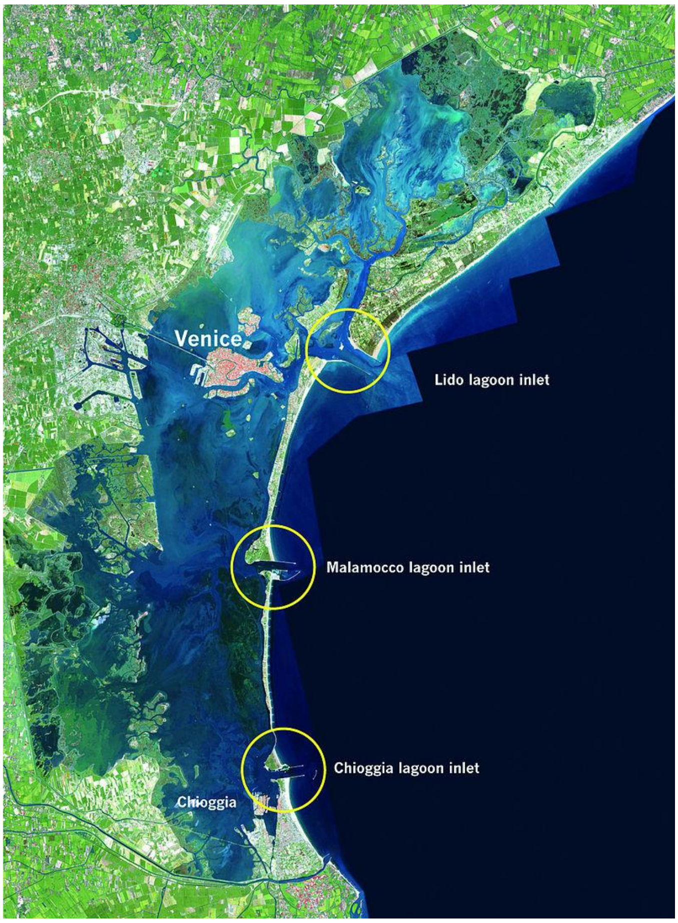

Fig 2 : MOSE sites as seen from satellite

IV. ENVIRONMENTAL CONCERNS AND CRITICISM

A. Cost

The project has widely been criticized by a large number of economists and environmentalists. The project cost has reached to €5.496 billion, up €1.3 billion from initial cost projections[7]. This has burdened the Venetian government to an extent that they had to various undergoing restoration works on various historical buildings of Venice. Critics were of the view of using less costly techniques like fuel injection to raise the city of Venice and dredging the canals instead of constructing such costly project.

B. Sediment Issues

The construction of gates would raise the water level in the lagoon. In order to accommodate the afflux, the city had to be raised by dredging the canals making them deeper.The deepening of channels to accommodate the cement frames for caissons has intensified the tidal flow. Also when the lock gates are opened, the water currents are further intensified causing enormous erosion in the lagoon. This would affect the already delicate ecosystem of the various migratory birds since the lagoon is a wetland.

C. Effects on Sea weeds

The enormous pressure put by dredging and sediment loss has led to malnutrition of various sea weeds which is a source of food for various migratory birds. This has affected the natural habitat of such animals in a negative way.

D. Physical impacts of construction materials

There is also great concern about the physical materials being used for construction such as Zinc, anti-rust and anti-foul chemicals like TBT compounds, assorted heavy metals and solvents. These chemicals have to be dosed regularly which would increase their concentration in the water. These chemicals are toxic to the aquatic life in the lagoon .[8]

E. Safety Concerns

There have been raised issues against the potential safety of the project also. Bi-directional gates have never been used earlier on such a large expanse. Risk of leakage between the seals of caissons always looms on the Venetians. If the water keeps on rising gates would be used frequently further aggravating the condition.

V. CONCLUSIONS

As of 2015, 92% of the work has been completed. The project has various environmental impacts on the delicate ecosystem of Venetian lagoon. However MOSE is also the only lifeline of the sinking Venice. The project should be gradual, to permit the evaluation of results and permit the changes and recommendations to the original plan. The project was envisaged to be reversible and experimental however MOSE doesn’t seem to be. In order to inculcate the various remedies to solve the environmental side effects of this project and safety factors, a comprehensive plan has to be formulated otherwise Venice would remain serene only to humans and not to other organisms in near future.

VI. REFERENCES

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