Literature Review of Storm Surges Barriers and Storm Surges Modeling

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Abstract

This is a literature review of storm surge barriers and numerical modeling work done in United States and other part of the world. A general presentation of data about storm surges issues and solutions is done, and a summary of some of the computer model used ,by the government or in the academic domain, to model storm surges to predict their effects on the coastal area is also presented.

Introduction

Hurricanes disastrous effects are no more to be presented here. They speak by themselves by their recent activities from Katrina (New Orleans 2005) to Ike (Galveston 2007) in the United State Golf Coast. To prevent the devastating effect of the flooding due to storm or tsunami surge several coastal protection structures have been building in some main cities around the world through the years. And the last century saw the construction of the new generation of storm surge barriers: the movable gate (Coastal Portal, 2010).

The construction of these storm surge movable barriers requires specific experience, and at present, there are only a handful of European countries that manage or construct large sea-resistant storm flood surge barriers. These are the United Kingdom, The Netherlands, Italy and Russia. So, knowledge of these unique objects is scarce and demands very specific knowledge and experience. Therefore, exchanging knowledge is important to learn from each other. Especially now when climate change and sea level rise are recognized facts that should be taken into account. The public administrations of these four countries recognize the usefulness of sharing knowledge and experience and decided to create an international network of storm surge barrier managers (Coastal Portal, 2010).

Through the years, computer models were developed to estimate the storm surges generates by a hurricanes. These models forecasts help to inform the population of the concerned area about disposition to take or to issue emergency evacuation. United State National Oceanographic and Atmospheric Administration (NOAA) has developed and use the computer model SLOSH (Sea, Lake, and Overland Surge from Hurricanes). Other computer models were developed and are being used by other organizations, especially in the academic domain. ADCIRC (Advanced Circulation) developed at the University of North Carolina at Chapel Hill is also in used (Luettich et at, 2004). These computer models use the hurricanes parameters (pressure, radius of max winds, location, direction, forward speeds) and the landing point topography and bathymetry (FEMA et al, 2003) to do their predictions.

Types of storm surge barriers

To protect people against floods, static structures like dams and dikes have been built. In the 20th century, society demanded that defenses should not have a major affect on their surroundings. The movable storm flood surge barrier was the result (Coastal Portal, 2010). Several of these movable barriers were constructed or are being constructed around the world to protect coastal populations (Figure 1).

Figure 1: Location of some movable storm or typhoon surge barriers

As examples of new types of storm or typhoon surge barriers, we have: - navigable lock and dam - fold-flat floating gate (Venice type) - rotating cylinder type (Thames River type) - swinging hinged gate (Netherlands) - fixed gate wall with floating caissons, and others. See pictures below (Courtesy PBS)

These new types of barriers structures are complex and costly. Netherlands's computer operated food defenses which were completed in 1997 cost about $8 billions. It was built to withstand the kind of tremendous flood estimated to occur only once in 10,000 years, the gates have so far done their job successfully. New Orleans flood gate which could close the Harvey canal in case of storm surge is estimated to cost $35 millions (Storm that drowned a city, PBS). The question is: Can these structures be used for other purposes?

Computer modeling of storm surges

The Sea, Lake, and Overland Surge from Hurricanes (SLOSH) is a computerized model developed by the National Weather Service (NWS) to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes. SLOSH is used by the National Hurricane Center (NHC) for the exclusive benefit of NWS, US Army Corps of Engineers (USACE), and Emergency Management personnel (FEMA et al, 2003). It is the primary computerized model used by US official to assess a foregoing hurricane effect on the predicted landing point to issue emergency evacuation if required.

Several other storm surge models were developed, especially in the academic domain. Advanced Circulation (ADCIRC) computer model was developed at the

University of North Carolina at Chapel Hill (Luettich et at, 2004) and is extensively used for hurricanes storm surges modeling.

The contribution of ADCIRC is that current applications require the ability to resolve complex fluid dynamics in shallow straits and near-coastal zones; however, this level of resolution is not possible with structured grid regional/global ocean model, such as HYCOM. Thus, development efforts have centered around enhancing the 3D baroclinic dynamics of an unstructured coastal model, ADFCIRC, which has been successfully validated against process-oriented tests on simplified domains and against laboratory data. The advantage of utilizing ADCIRC is its ability to map intricated shoreline and the corresponding topography needed to resolve complex fluid dynamics (Desback et al, 2010). ADCIRC unstructured grid allows modeling complex coastal regions at fine spatial scale (Chu et al, 2010)

Conclusion

Flooding generated by hurricane or typhoon storm surges is devastating and lethal. Therefore, barriers were constructed to prevent them; some are in construction and others scheduled due to the additional impact of the rising sea-level. These structures are complex and require special expertise. In addition, there are new efforts in storm surge modeling to forecast their effect using new unstructured grid to improve accuracy.

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