Creative Construction Conference 2016

Investigating the Effectiveness of Beach Fill Projects in the Northeast Region of the United States

Keith A. Rahn[1]*, Megan M. McMullen[2]

[1]*Auburn University, 222 Gorrie Center, Auburn, Alabama, 36849, USA, kar0023@auburn.edu*
[2]*Auburn University, 118 Gorrie Center, Auburn, Alabama, 36849, USA, mmm0056@auburn.edu*

Abstract

The Atlantic coastline is constantly evolving with the persistent pressure of hurricanes and other coastal storm surges. Hurricane Sandy was the most recent hurricane to make landfall in the Northeast and although the eye of the storm was through New Jersey, the entire Atlantic coast from Maine to Florida was impacted. Sandy was the second costliest storm in US history with some damage estimates totaling as high as 75 billion dollars [1]. The storm also resulted in 233 direct and indirect fatalities [2]. This research study examines past hurricane and storm events that have led to the construction of beach fill projects in the northeastern region of the United States. A beach fill project consists of mechanically placed sand to fill a specified area known as a beach template. These massive mounds of sand create a physical barrier between the vulnerable structures on the shoreline and the Atlantic Ocean. The beach fills are designed to absorb and disperse the ocean wave energy in order to protect property from destruction and reduce the erosion of shorelines. These projects are designed and implemented by the US Army Corps of Engineers. Objectives of this study were to investigate the factors influencing the construction of these projects, identify the unique and challenging quality assurance process and identify the benefits and risks of beach fills to towns and states. This research specifically focuses on the town of Long Beach Island and the State of New Jersey. Through literature reviews, interviews and surveys there is strong evidence that beach fill projects are favorable to invested parties, they are attributed to protecting our coastal structures and coastal economies and the benefits far outweigh the risk.

Keywords: beach fill; coastline; erosion; property; quality

1. Introduction

1.1. *Background*

The damage from super storms and hurricanes can be devastating. Naturally, the federal government does everything in its power to prepare for such disasters. One attempt to mitigate the risk is through the use of coastal storm damage reduction projects. The first line of defense for heavily trafficked beach areas in the Northeast Region of the United States are construction projects known as beach fills. A beach fill project consists of mechanically placed sand to fill a specified area known as a beach template. These massive mounds of sand create a physical barrier between the vulnerable structures on the shoreline and the Atlantic Ocean. The beach fills are designed to absorb and disperse the ocean wave energy in order to protect these adjacent structures from destruction. These projects are designed and implemented by the US Army Corps of Engineers.

Hurricane Sandy was the most recent hurricane to make landfall in the Northeast and although the eye of the storm was through New Jersey, the entire Atlantic coast from Maine to Florida was impacted. Sandy was the second costliest storm in U.S. history with some damage estimates totaling as high as 75billion dollars [1]. The storm also resulted in 233 direct and indirect fatalities [3].

* Keith A. Rahn. Tel.: +1-334-844-8261; fax: +1-334-844-5386.
E-mail address: kar0023@auburn.edu

It is estimated that for every dollar the federal government spends on flood mitigation, it saves and average of $4 in disaster relief after the next devastating storm [6]. The Sandy Recovery Program consisted of 5.1 billion dollars. Storms similar in size and magnitude to that of Hurricane Sandy are capable of eroding large portions of beaches all the way back to the edge of homeowner properties. These storms have also been known to completely remove the dunes of sand that are much higher than the elevation of the normal ocean levels (Figure 1). Along with absorbing wave energy, the beach fills serve to reduce flood risk by preventing water from overtopping dunes and flooding communities situated behind the beach. Beach fills are designed to be sacrificial in nature, meaning that the oceans wave energy will eventually wash the sand into the ocean and there will be a need to mechanically place more sand. Currently, the budget allows for a fifty year replenishment cycle for beach fill construction projects. The replenishment of sand is dependent upon the severity of the storm. However, USACE typically replenishes the sand every two to five years per project.

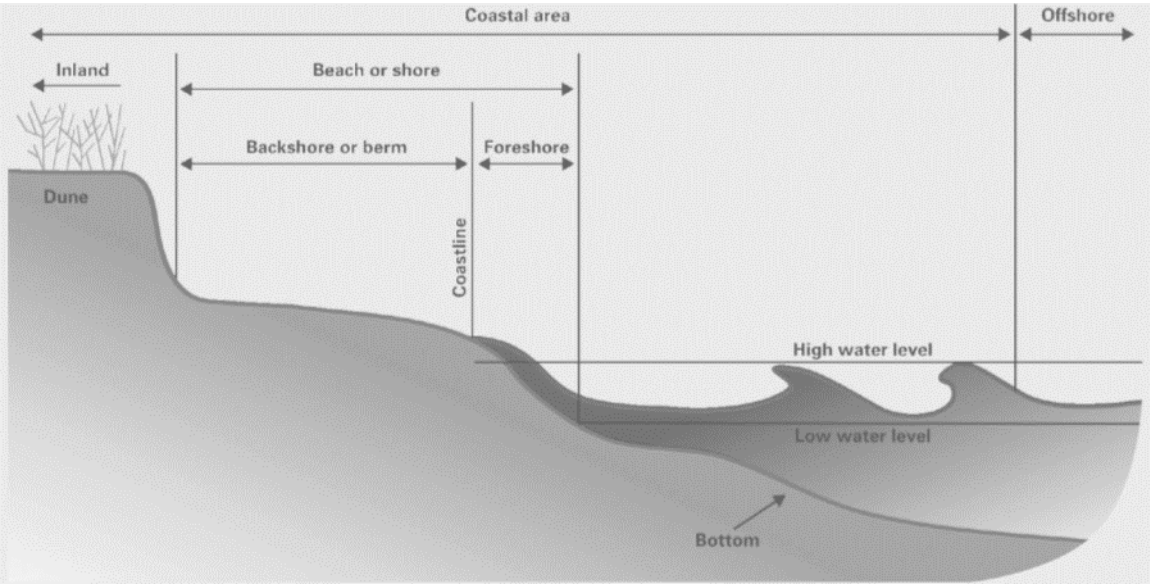

Figure 1. The Components of a Coastal Beach System [6].

1.2. *Research aim and objectives*

The aim of this research is to investigate the effectiveness of USACE beach fill construction projects and explore quality assurance procedures and processes associated with beach fill projects. Goals of research were established as follows:

- Determine the effectiveness of beach fills on storm damage reduction
- Determine the factors influencing the construction of beach fill projects
- Determine Quality Assurance processes/procedures
- Investigate benefits and risks from beach fill construction projects through state and federal employees

2. Literature review

2.1. *Overview*

A beach fill construction project consists of the placement of a large quantity of sand to a specified profile or design template. This template is authorized by congress to effectively reduce the threat of coastal storm damage on structures adjacent to the shoreline. These projects include an increase in the width and height of the beach or berm area and the construction of a sand dune placed landward of the sand berm. The dune is necessary to prevent damage from larger storm surges as these storms drive the sea level higher due to strong winds and pressure systems. The dune provides a significant quantity of sand higher than the berm elevation designed to dissipate the oceans wave energy when the forces of these waves threaten the coastal structures along the Atlantic [7]. The berm width can vary depending on the rate of erosion. However, the maximum authorized placement of sand is limited by the distance allowed by Congress [5].

Beach fill design template parameters are established for each project. Berm and dune elevations and widths are established. The design event is potential storm consequences that dictate the project design. For example, the West Shinnecock Inlet Project is designed for the 44-year storm event. This means the chance of a storm meeting or exceeding the design event is 1 in 44 in any given year. The Army Corps uses a cost benefit analysis to determine the dune height and width. The benefits are computed using the value of the structures that the dune is protecting. The costs are the full construction costs associated with completing the projects. To justify a project, the computed benefits divided by the construction costs must be above one. This is called the benefit to cost ratio.

Allocations of $500,000 were provided by Public Law 113-2 to complete a Performance Evaluation Report to evaluate the effectiveness of Army Corps projects during Hurricane Sandy and to include a compilation of recommendations for further improvements. They found six projects in the New York and New Jersey region experienced greater than a 200-year storm event. Eight projects experienced between a 30-year and a 200-year events. The projects were found to be effective in reducing storm damage with an estimated aversion of 1.9 billion dollars in loss. Report recommendations consisted of seven key strategies for further reducing damage risks due to these events. The following seven key strategies included:

- Employ a broader approach to project planning in these coastal regions
- Gather more data
- Use the Regional Sediment Transport to monitor the movement of material along the coast
- Develop Adaptive Management Plans to be implemented
- Address Back Bay flooding
- Evaluate the efficacy of dunes
- Incorporate a wider range of project benefits

Congress most recently passed an updated Water Resources Development Act which gives the Army Corps of Engineers the authorization to employ these engineered beach fill projects to a specified template with federal funding to reduce the impacts of super storms like Hurricane Sandy in October of 2012. The legislation allows for indefinite extension of beach fill projects, which demonstrates federal government support for beach fills as the most efficient and effective way of reducing coastal storm damage risk.

2.2. *Project hurdles*

Although the design of these projects may appear simple on paper, the Corps of Engineers has numerous hurdles to clear when executing the high dollar projects. Studies have been ongoing for decades to source sand from offshore borrow areas and the permitting process is very complex. The process of approval for borrow areas span several federal and state agencies to include the Department of the Interior, the Environmental Protection Agency, US National Marine Fisheries Service, US Fish and Wildlife, the National Oceanic and Atmospheric Administration and coordination with each state's Fish and Gaming Agencies, Department of Environmental Protection, Water Quality Certifying Agencies and Coastal Zone Management Agencies to name a few [3].

Although some towns are very receptive to building more beach and dunes, other towns may object to the construction of the projects and the federal template because it may impede homeowner view of the ocean when gazing from the structures adjacent to the beach. Also, walking to the beach takes more energy to cross over the dune because it is constructed at a much higher elevation. Many residents complain of the steep slopes over the constructed dunes. Even when the community fully supports the beach fill project, individual homeowners can still disrupt the placement of sand.

Property boundaries for some beachfront properties extend to the beach and even to the waterline in some cases. This creates the need to secure real estate and easements prior to contract award. The real estate is required to prevent dunes far from the mainland which would leave it more vulnerable to erosion. The easement areas are necessary for accessing the beach with heavy construction equipment. Where shore areas are heavily populated, the price of real estate is often very high. If a project sponsor is unable to acquire the necessary real estate, easements, and staging areas, this can ultimately delay construction significantly. Eminent domain litigation may be required if cooperation from the home owners in certain areas cannot be secured. Once all the real estate is acquired, the US Army Corps of Engineers can award the beach fill construction contract to a dredging contractor available to dredge in the timeframe allocated for completion.

2.3. *Dredges*

There are two types of hydraulic dredge methods that can be utilized for these types of beach fills. The hopper dredge works by lowering drag arms down to the ocean floor and sucking up a sand slurry mix (approximately

30% sand / 70% water) from the designated borrow area by creating a vacuum in the ships large hoppers through mechanical pumps. Once the hopper is loaded with sand, it then navigates closer to sand placement point where there may be multiple discharge hookup locations with pipes leading to the beach. The proximity to the beach is dependent on the ships draft in the water.

A cutterhead pipeline dredge is the other type of hydraulic dredge often utilized to complete these beach fill projects. Instead of drag arms that lower to the bottom, there is a cutterhead arm. This cutterhead is a mechanical device that has rotating blades or teeth and is lowered to the ocean floor to swivel back and forth to cut through and suck up the sand. The sand is broken up by the blades and sucked through the intake pipe. The Cutterhead Dredge is connected to a floating pipeline which runs to the sands placement site so a continuous stream of sand slurry can flow.

2.4. *Studies*

Studies have been ongoing for decades to source sand from offshore borrow areas. Each borrow area is carefully studied for not only for environmental impacts, but also for the compatibility of the sand gradation to match the gradation where the sand is to be placed. Geotechnical engineers at the Army Corps study sand borings at each borrow area to ensure the correct gradation. Capacity of each borrow area must also be measured to ensure there is enough sand to supply the massive volumes of sand to be placed. Sediment transport studies are then required along the Atlantic Coast and the migration of sand over time due to the ocean currents [3].

Estimated volume to be added or removed is measured by comparing a proposed template to an existing hydrographic survey. These hydrographic surveys are crucial for establishing the largest definable feature of work for beach fill projects, which is the volume. Because this is a very specialized field of construction and the costs to operate may be extraordinary, there are only a limited amount of resources, or dredge ships, to complete these types of jobs. Many of the jobs require 10 to 15 nautical miles between borrow source and final placement area. This is when the price can become highly dependent on the dredge method.

2.5. *Munitions and explosives*

Quality Assurance for these projects by the Army Corps is uniquely challenging and has evolved in recent years due to the possibility of pumping Munitions and Explosives of Concern (MEC) onto the beach. MEC can be transported through the pipes with the sand slurry mix from the borrow area to the beach and poses a real threat to the safety of the construction workers and beach goers since there is a possibility of the explosives being live.

The Coastal Storm Damage Reduction Project in Surf City, NJ in 2008 spawned the need to screen the sediment intake and outfall to all future beach fill jobs in New Jersey and New York. During the environmental study of the borrow area, there was no evidence of MEC. There was no MEC found until after the first 1.6 miles of the 18 mile stretch was completed. Once MEC started to surface, the Army Corps was forced to close down the beach for public safety concerns. The Army Corps were also forced to screen the majority of sand that was pumped by using ¾ inch screens.

Total amount to screen the berm volume came to a total of 17.7 million dollars, which was almost three times the amount of the project cost itself. This project caused all future beach fill projects in New York and New Jersey to screen all the sand at the dredge pipe intake to one and a half inches, and also at the pipe outfall to ¾ inches. The specifications of each beach fill job now contain language about MEC procedures and new information about the borrow area. The borrow area for the Long Beach Island beach fill project is located in the vicinity of a known World War I dumping site for Discarded Military Munitions (DMM) [4].

3. Methodology

Qualitative research utilizing a random sample of 12 interviews was given to New Jersey State employees and U.S. Army Corps of Engineer (Federal) employees. Participants were asked to respond to questions regarding the beach fill project benefits and risks to the Town of long Beach Island and the State of New Jersey. In an effort to validate interviews, the participants also completed a survey that based on a numerical scale.

A survey was completed by each participant. Survey questions were then rated on scale. The scale was expressed numerically from one to ten on how beach fills are either beneficial or risky to the Town of Long Beach Island and the State of New Jersey. One (1) served as the least beneficial or least risky to the town and state and ten (10) served as extremely beneficial or extremely risky to the state.

Case study was completed with research questions based on the Long Beach Island (LBI), New Jersey, beach fill construction project. This specific Northeastern Region project, contracted by the USACE Philadelphia

District, covers twelve miles of beach. Nine Philadelphia District USACE employees and eight New Jersey state employees are tasked with completion of this undertaking.

4. Results and findings

4.1. *Benefits*

Forty-eight percent of interviewees responded with key words "increases protection, minimizes damages", making this the most common theme among interviewees. The majority of the respondents described the project dunes as protection of life, beach, property, and infrastructure. Respondents referred back to Hurricane Sandy of 2012 and described communities with beach fill projects versus communities without the beach fill. Participants described the communities with the project to have far less damage when compared to the town without protective dunes. 21% of participants also felt the increase to the beach area served as a benefit, allowing more room for recreational activities. The same percentage of people (21%) who liked the idea of more recreational area, felt the elongated beach helped with flood reduction. Only 5% of participants felt the beach fill project actually provided security to residential and vacation homes, and increased tourism. When asked how they felt this project increased tourism, one respondent answered "more beach, more visitors."

Benefits cited specific to the State of New Jersey were also reported. 44% of interviewees describe the biggest benefit to the State was the protection of tourism. Interviewees described the beaches to be a huge source of revenue, an economic driver and a multibillion dollar industry in New Jersey. 31% of participant's described the beach fill project as protecting the states interests such as jobs, schools and state revenues. Less common themes consisted of saving the state from insurance claims, saving funding on state emergency services, and increased tourism due increased beach area.

4.2. *Risks*

The next question addressed risks to the Town of Long Beach Island. 29% of respondents felt safety was the biggest risk of the project to the town. The following safety risks were noted by the participants: hazardous materials on the berm, construction equipment on the beach, munitions and explosives from borrow areas, dangerous slope of beach as a result of the beach fill, and typical safety issues that come with any construction project (pedestrians, employees getting hurt). One anonymous interviewee stated "the new beach fill material has to be closely monitored for any foreign debris or hazardous materials. If there were to be an issue with the material placed on the beach, it could result in beach closures for an unspecified amount of time, resulting in loss tourism and loss local business which is a huge potential risk for the town." This could be the said the same for munitions and explosives of concerns pumped on to the beach.

Costs and maintenance of the project were also common themes amongst participants of the interview. The federal government funds the initial project and then it could possibly become the responsibility of the town to maintain the project. If a storm hits and it is declared a national emergency by the President, the government will fund the project. If storm hits and it is not declared an emergency, then it is declared as cautionary. When these projects are declared cautionary, they are funded through a cost sharing between federal government funding (65%), state funding (10%) and the town funding (25%) of the project costs. The major cost risk to the town is if federal funding is not considered in the future for this project or the cost sharing agreement changes with political administrations, the full project costs could potentially be a burden of the town residents.

Many participants felt the same risks that applied to Town of Long Beach Island also applied to the State of New Jersey. One additional risk that participants felt the State encountered was wildlife and ecological concerns. The New Jersey State Department of Environmental Protection monitors specific wildlife and endangered species. It is the responsibility of the state to protect the natural habitat of these species. If it is discovered that the natural habitat is endangered during the construction of the beach fill, the construction site will be shut down, causing scheduling and (potential) financial delays.

5. Conclusion

The Atlantic coastline is forever evolving with the persistent pressure of hurricanes and other coastal storm surges. Hurricane Sandy is just one of the latest storms to dramatically reshape highly vulnerable areas. The sacrificial dune and berm constructed by the US Army Corps of Engineers in Long Beach Island, NJ seemed to withstand the forces of Hurricane Sandy. Twenty five miles north of Long Beach Island, there was a major breach in the barrier island town in Mantoloking, NJ. The difference in damages between the two very similar geographic locations is attributed to the effectiveness of protective dunes created by the beach fill projects.

Research supported the effectiveness of USACE beach fill construction projects. The construction template of the protective dune and sacrificial berm reduces damages to coastal structures. This research also provided the quality assurance procedures and processes to include construction safety, specification adherence, and removal of munitions and explosives of concern. The construction of the project spans multiple organizations starting with the Army Corps of Engineers. Once the borrow sources are identified and beaches designed, the plans and specifications can be awarded to one of the few contractors that specialize in this area of expertise.

References

[1] Administration, N. O. a. A., 2014. *National Centers for Environmental Information.* [Online] Available at: https://www.ncdc.noaa.gov/billions/events [Accessed 6 October 2015].

[2] Diskakis, M., Deligiannakis, G., Katsetsiadou, K. & Lekkas, E., 2015. Hurricane Sandy Mortality in the Caribbean and Continental North America. *Disaster Prevention and Management: An International Journal,* 24(1), pp. 132-148.

[3] Engineers, U. A. C. o., 1995. *Engineer Manual 1110-2-3301: Engineering and Design: Design of Beach Fills.* Washington D.C.: Department of Army.

[4] Follett, G., 2008. *Dredging in Sediment Containing MEC.* Baltimore: U.S. Army Corps of Engineers.

[5] Koper, D. W., 2015. *Civil Engineer* [Interview] (28 September 2015).

[6] U.S. Army Corps of Engineer, 2013. *North Atlantic Division Hurricane Sandy: Response, Recovery, Resilience and Risk Reduction.* [Online] Available at: http://www.usace.army.mil/Portals/2/docs/Emergency%20Ops/Hurrincane%20Sandy/SandyPresentation.pdf [Accessed 4 October 2015].

[7] Vietri, M. J. et al., 2015. *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk.* [Online] Available at: http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_Media%20Webinar_Jan2015.pdf [Accessed 6 October 2015].