Foam Bridging for Surf Zone Breaching Operations

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LONG-TERM GOALS

The goal of this project is to demonstrate the potential of rigid polyurethane foam (RPF) as a building material to allow building of bridges for transport of heavy material and troops over an obstacle and mine field. In the future such a bridge could be constructed in transit or near the anticipated landing site with very large savings in lift required over traditional bridging techniques.

OBJECTIVES

The objective of this project is to demonstrate an alternative non-explosive approach to breaching the surf-zone in an amphibious assault or rapid follow-on phase. Specifically this effort was to show the feasibility of this concept, identify any major technical hurdles with the proposed concept, and provide an initial model for analysis of the full-scale system.

APPROACH

This project built on the effort of Dr. Ron Woodfin and his team at Sandia National Laboratories who over the last several years have been developing and testing a foam technology for this application. Their efforts identified the most promising foam for this application and performed operational type testing including explosive testing, roadway survivability, and setup in water.

In order to demonstrate the potential for a foam bridge as an alternative to explosive clearance the approach was to develop a simple model of the floating bridge to estimate forces on the flexible sections. Next, we built a scale model of the foam bridge based on the model, and simulated on the model the motion of a large load in a wave environment.

As part of the concept assessment process the results of this feasibility development will be examined next year from an operational perspective and assessed against other concepts.

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WORK COMPLETED

Coastal Systems Station and Sandia National Laboratories combined efforts to produce a 1/5-scale foam bridge model to demonstrate its feasibility for rapid follow-on clearance. The demonstration took place at CSS on 16-18 September. The bridge consisted of three sections; a hexagonal float section, and two barge sections. The individual hexagon shaped floats, the float section and the two barges, were made of Rigid Polyurethane Foam (RPF). The overall assembly is illustrated in Figure 1.

Figure 1. Assembled Foam Bridge at CSS Test Pond

CSS engineers developed a dynamic computer model of the entire bridge assembly. This model helped predict how the bridge would react under both loaded and wavy conditions. CSS engineers also designed and built the molds used for the fabrication of the hexagon shaped floats. This design also included the internal PVC conduit used as rope channels for the float assembly. In addition, CSS shops manufactured the two cloth-laminated vinyl envelope bags, which made up the shell of the barges. Finally, CSS manufactured the ½" thick plywood spacers, which acted as washers between all the adjacent faces of the float assembly. Sandia manufactured the individual hexagon shaped floats, and also filled the vinyl envelope bags with foam upon receipt from CSS. After completion, all components were shipped to CSS for assembly.

CSS assembled the hex section, which consisted of 58 whole hexagon floats and 10 half floats. The final assembly was tied together using 3/8", 3-strand nylon rope. The hex float assembly, which had a plan dimension of approximately 8'x 8', was tied between the two barges, which were each approximately 16' long by 8' wide. The purpose of the hex float section is to act as a flexible joint for the bridge, thus preventing buckling of the bridge when it is subjected to wave action and vehicle load. The flexibility of this joint was controlled by the tightness of the 3/8" rope, which was threaded through each float, via the PVC conduit, in three axes. The optimum flexibility was accomplished by several iterations under the direction of Dr. Ron Woodfin of Sandia National Laboratories.

Once the foam bridge was assembled, it was trucked to the CSS demo pond in preparation of the first phase of the demonstration, which took place on September 16. The assembly was then placed in the pond with one end tied next to the shore and the other end anchored out in the pond, perpendicular to the shore. Video coverage of the test event area was provided.

To simulate the effects of an M1A1 tank (1/5 scale) on the bridge, Sandia purchased a properly scaled cart. This cart had four wheels, but was eventually modified with an extra set of wheels (6 total) to better simulate the loading distribution of a tank track. A lead clump weighing 1080 Lbs. was strapped to the top of the cart, for a total weight of approximately 1160 Lbs. The weighted-cart was then placed at the center of the outboard barge, and was not secured in any way.

EOD personnel placed a five-pound explosive charge at a depth of approximately three feet and a distance of ten feet to the side of the center of the hex section. The weighted-cart was then placed over the seam between the outboard barge and the hex float section. With both the video and still cameras rolling, EOD personnel detonated the five-pound charge. The weighted-cart was then moved to the center of the outboard barge. A second five-pound charge was then placed in the general vicinity of the first charge and detonated. The bridge was inspected for damage; none was found.

Figure 2. Assembled Foam Bridge Subjected to Nearby Explosion

After the completion of the explosive phase of the demonstration, the entire bridge assembly was moved to the nonmagnetic test pond. The second phase of the demonstration took place on September

17-18. The purpose of the second phase of the demonstration was to determine how the bridge would react when subjected to a moving load (M1A1 scaled cart) under both calm and wavy conditions. In addition, the ability of the bridge assembly to be towed was demonstrated. One video camera and two still cameras were used to collect the data. A total of 12 triangular, incremented, optical targets were attached to one side and the outboard end of the bridge assembly. They were evenly spaced and positioned to enable the 3" mark to be level with the waterline. Their purpose was to enable the testing team to determine the displacement of the bridge assembly at various locations as the weighted-cart passed over the bridge. The bridge assembly was placed in the pond perpendicular to the side and secured by ropes tied to existing cleats located on the side of the pond.

A crane was used to place the weighted-cart at the center of the outboard barge. A rope was then tied between the cart handle and the hitch of a truck. The truck then pulled the cart slowly over the entire length of the bridge assembly. This procedure was performed numerous times with the cart rolling down the center of the bridge. The centerline of the cart was then moved to a location approximately 2.5 feet from the side of the bridge and the procedure was repeated. A small RHIB boat was then placed in the pond to produce waves. The boat operator was instructed to run in circles near the bridge assembly until a consistent wave pattern persisted. At that point, the weighted-cart was pulled down the length of the bridge numerous times, both at the center and side location. The video and still cameras collected all the data. The weighted-cart was then removed from the barge assembly, and the barge assembly was untied from the cleats. The RHIB boat then connected a towline to the bridge assembly and towed it around the test pond for a few laps. Once again, both photographs and video were taken for future reference.

Finally, the barge assembly was taken out of the water and disassembled. One barge section was placed back in the test pond by itself to perform an incline test. The weighted-cart was then placed at various locations on the barge and the angle of incline was determined by the use of an inclinometer. The hex float section was then placed in the pond and the same procedure was repeated.

RESULTS

The September demonstration/test of the Foam Bridge project provided some significant results and lessons learned. The 1/5 scale foam bridge proved to be easy to assemble and transport. However, the assembly was performed on land in a controlled environment. A full-scale model may prove to be difficult to assemble on a ship at sea. This can likely be improved by redesigning the hex matrix section as an integral unit and designing a better system for connection to the barges. The foam bridge assembly was easily towed by a small boat and appeared to be very stable. The hex float section proved to be a very efficient flexible joint between the barge sections. It provided stress relief for the bridge assembly when the bridge was subjected to waves, rolling and stationary load and shock produced by the detonation of a five-pound explosive charge. Without the flexible hex float joint, the bridge assembly would most likely buckle when subjected to these conditions. The hex section also provided a better than expected platform for the cart to roll over. The hex floats displaced in a group instead of individually when subjected to point loading by the cart's wheels. This made for a much smoother slope and thus, a smoother surface for the cart to ride on. However, it is imperative that the hex floats are tied together at the proper tightness. If the section is too loose, it is difficult to roll anything over it without a wheel getting stuck. If the section is too tight, the advantages of the flexible joint are eliminated.

The barge sections of the bridge assembly had remarkable buoyancy, and were not significantly affected by the addition of the weighted-cart. The 1/5 scale foam bridge was hardly affected by the rolling load except at the hex foam section.

Finally, the data collected from the test, especially the incline and displacement tests performed on the individual sections, will enable the CSS hydrodynamics group to accurately computer model the entire bridge assembly. This will provide a better understanding of the capabilities of the bridge assembly and aid in a future full-scale design, if warranted.

IMPACT/APPLICATIONS

The foam bridging technology demonstrated under this effort and the related Sandia effort illustrates the potential military use of expanding foam. Further development of this technology and development of larger pumping systems could lead to a system capable of quickly deploying a bridge in a moving surf environment to carry heavy equipment. Many other uses have been envisioned including large fabric filled pontoons, roadways over swampy ground, ship protection from underwater explosions, and many auxiliary military uses.

TRANSITIONS

This effort completed with a demonstration described in this report. Further development of large pumping systems for this foam is feasible, but will require an industry partner.

RELATED PROJECTS

This effort was part of the Concept Assessment task for FY98. The effort builds on the earlier work done by Sandia National Laboratories under a joint Department of Energy/Department of Defense Memorandum of Understanding for Countermine Warfare.

REFERENCES

R.L. Woodfin, D.L. Faucett, et al, 1998: “Rigid Polyurethane Foam (RPF) Technology for Countermines (Sea) Program - Phase II,” SAND 98-2278, September.