Composite Bridging for Military and Emergency Applications

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Introduction

The Military (U.S. Army, Navy) and Federal Emergency agencies are sponsoring the development of the next generation of deployable bridges using high-performance light-weight composite materials for increased mobility. Current deployable (or temporary) bridging was developed in the 1940-1960's and is composed of aluminum and/or steel for at most Military Load Class (MLC) 70 tons wheeled and tracked vehicles. This includes the 30,000 lb 19-meter folding assault bridge (AVLB) (see Figure 1) and the 65,000 lb 45-meter medium girder bridge (MGB) (see Figure 2) for tactical/support applications that is constructed by a team of 25-33 U.S. Marines. But the current inventory of deployable bridges is nearing the end of its operational life and cannot support the current heavily armored (MLC-85+) military vehicles.

Fig 1 Armored Vehicle Launched Bridge (AVLB)

Fig 2 Medium Girder Bridge (MGB).

Composite materials provide an opportunity for lighter, stiffer, and stronger solutions than existing metallic bridges. The larger military vehicle loads and the extreme operating environment (-40^{o}F to +160^{o}F) require that graphite and epoxy are used along with low-cost (out of the autoclave) manufacturing processes for the bridge superstructure and roadway decks. Metallics are used for the launcher interface components and high density polyurethane coatings are used on the roadway surfaces. The benefits of using composite materials has lead to bridges with greater vehicle capacity, longer bridge spans, or fewer larger parts for quicker hand assembly. Since these bridges must be easily assembled, disassembled, stored and reused with a variety of components, it is critical that the design is robust. In the current paper, an overview is presented for short-span deployable emergency bridging and short-span (MLC-100) assault bridging.

Short-Span Emergency Bridging

The US military (Army and Marines) have a need for light-weight, minimum constant depth, short-span bridging system to increase mobility on the battlefield or in the aftermath of natural disasters. It is required that the bridging system be capable of crossing gaps up to 4 m (157 in) in length supporting MLC-30 track and wheel vehicles as well as the 43-ton Palletized Load System (PLS) trucks. The thin (4-inch) constant depth requirement, which is a severe constraint, is imposed so that these bridge planks can be used to repair damaged aircraft runways and roadways. The UCSD developed trackways consist of carbon/epoxy skins with a cellular fiberglass/foam webbed sandwich core [1]. See Figure 3. The parallel trackways are fabricated using the VRTM process, where bonded aluminum endcaps and a 0.100 inch high density polyurethane coating are used to protect the bridge from vehicle impact loads.

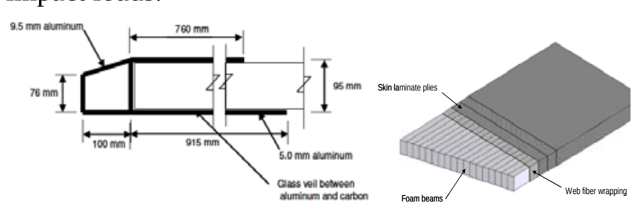

Fig 3 Illustration of end-cap and trackway cut away.

The bridge was first proof tested to 1.33 working load (172kN (39,000 lb) per trackway) at UCSD, before being field tested by the U.S. Army at Aberdeen Test Center and Fort Leonard Wood, Missouri and then tested by the Marines at 29 Palms, California. Vehicles tested included a 43-ton PLS truck and a modified M60 tank (Figure 4).

Fig 4 Field testing using a PLS truck and an M60 tank.

Composite Army Bridge (CAB)

A full MLC-100 qualified 14-meter (12-meter gap) composite assault bridge was developed with DARPA support to prove that composite bridges could outperform existing metallic assault bridges at both a lower weight and lower cost [2]. The UCSD developed bridge design involves twin trackways (Figure 5), where each trackway has an arc-like upper deck surface and twin enclosed hull superstructures (Figure 6). The upper deck is SCRIMP [3] infused carbon/epoxy with a 3 inch thick balsa core. The superstructure hulls are SCRIMP infused carbon/epoxy with 1.5 inch thick lower unidirectional lower tension rails and thin stitched [45/0/-45] sidewalls, where sandwich core bulkheads are bonded at 30-inch spacing to resist sidewall buckling. The carbon/epoxy bridge structure is protected with bonded aluminum end-caps at the ends for impact resistance and a thin coating of high-density polyurethane to act as a wear surface.

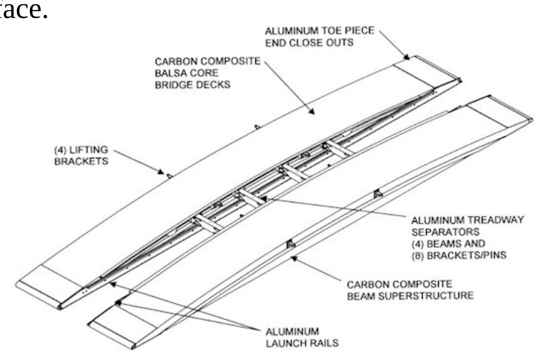

Fig 5 Composite Army Bridge (CAB) design features.

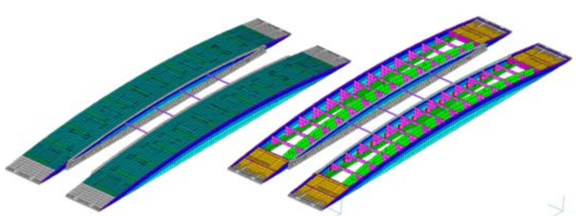

Fig 6 Composite Army Bridge internal structure

The bridge program was validated by first failure testing a single trackway at UCSD to 375,600 lbs (1670 kN), followed by a field testing with nearly 2080 crossings by an M1A1-tank (MLC-70) and a Heavy Equipment Transporter (MLC-100) at Aberdeen Test Center (Figure 7). Lastly the bridge underwent 18,000 additional simulated M1-A1 crossings in the U.S. Army Selfridge bridge testing laboratory. Post test inspection of strain gauges, accelerometers, and acoustic emission sensors revealed no damage.

Fig 7 CAB field testing: M1A1 and HET.

Conclusions

The Military and Federal Emergency Agencies are developing lightweight composite deployable bridges to replace aging and under-performing metallic bridges. These new bridges, which are fabricated of stitched carbon fabrics and epoxy resin using the SCRIMP (or VRTM) process, have exceeded all current and planned future vehicle load requirements and have proven successful in extreme field trials. Current programs are underway to develop more composite bridging including; long-span (40-meter) infantry bridges, culvert bridging, floating (or ribbon) bridges, long-span assault bridges, and configurable (45-meter) tactical/support bridging.

References

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3. Seemann, W. H. (1990). U.S. Pat. 4,902,215 “Plastic Transfer Molding Techniques for the Production of Fiber Reinforced Plastic Structures.”