BEAM BENDING EXPERIMENTS ON POLYMER CONCRETES AND MORTAR MIXES

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Introduction

The USAF continues to deploy US military power worldwide to protect our nation, maintain peace, promote freedom and provide humanitarian assistance. Successful deployment of military power by air is dependant on operational airfield surfaces. The evaluation, rapid repair and maintenance of these surfaces become critical in a time dependant hostile environment. The use of polymer concretes and mortars for rapid airfield repair is promising, because polymers can be designed to cure in minutes, and bond to a variety of indigenous materials found throughout the world. The following tests were performed to investigate the bending strengths of polymer concretes and polymer mortar mixes for repair of spalls, craters, and cracks in runways.

Experimental Approach

Material bending tests were performed on an MTS Load Frame, Model #322.31 at a constant load-point deflection rate of .005 in/sec using ASTM C78 testing protocol. This is a flexural strength test using third point loading. (Fig 1)

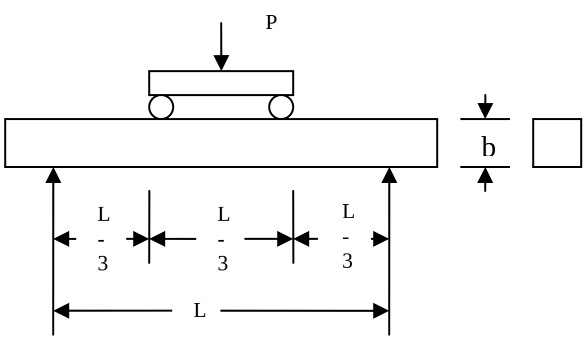

Fig 1 Third Point Loading

For square cross sections, the modulus of rupture (extreme fibre stress at rupture), R, can be calculated from Eqn 1.[1]

$$R = PL/b^3 \quad (1)$$

The distance L in Eqn. 1 was 9 in. and b was 2 in. P was the maximum load observed, and occurred at the appearance of the first crack. Concrete samples were cast by placing only graded aggregate (no sand) in a 2″x2″x10″ mold and percolating pre-mixed polymer thru it. The concrete samples averaged 40 to 60 percent polymer by volume. Two types of aggregate were used, crushed limestone (CL), and pea gravel or river run (PG). All aggregate was graded from 1/4″ to 1/2″. Mortar mixes were made by pre-mixing the polymer side (Part A) with siliceous river sand passing a #20 sieve. The hardener and catalyst (Part B) were then added, mixed, and the mixture poured into the mould. Mortar mixes consisted of 60% sand by volume. All samples were fully cured and then tested. The goal of these experiments was to measure bending strengths, to determine potential use of polymer concrete or mortar mixes for capping craters on airfields. The modulus of rupture, R, is an indication of the load carrying capacity of repairs using polymer-based materials.

Polymer Characteristics

Numerous polymer products are available for purchase on the commercial market. For these initial tests, two polyurethane materials were selected that were formulated for pavement repair. Both materials came from the Roklin® product line. The first polymer was an elastic material called Dopey Soup® (DS); and the second material was a rigid polymer called Concrete Welder® (CW). The characteristics reported on the dealer's web site are contained in Table 1.This report is published in the interest of science and technology, and does not constitute an official endorsement or rejection of the commercial products.

TABLE 1

MATL	SPECIFIC GRAVITY	TENSILE STRENGTH (PSI)	ELONGATION AT BREAK %	COMP STRENGTH (PSI)
DS	1.08	1600	150	1000
CW	1.07	4300	<10	4250

Test Results

Table 2 contains bending test results of fifteen beams constructed of six different combinations (A thru F) of polymer, aggregate type, and aggregate size. Column 1 is the test number and material mix. Column 2 is the polymer type. Column 3 is the fill material, which was sand for the mortar mixes, and various aggregates for the concretes. Column 4 is the modulus of rupture (R), column 5 the maximum load (P) carried by the beam and column 6 the percentage of aggregate fractured at failure.

TABLE 2

TEST NO.	MATL	ADDITIVE	R (PSI)	P (LBF)	% of Aggregate Fractured
1A	DS	SAND	1788	1589	N/A
2A	DS	SAND	1170	1040	N/A
3A	DS	SAND	1576	1401	N/A
1B	DS	1/4 -1/2 PG	1440	1280	90
2B	DS	1/4 -1/2 PG	1158	1029	80
3B	DS	1/4 -1/2 PG	965	858	75
1C	DS	1/4 -1/2 CL	1032	917	90
2C	DS	1/4 -1/2 CL	1043	927	95
3C	DS	1/4 -1/2 CL	1200	1067	100
4C	DS	1/4 -1/2 CL	1241	1103	80
1D	DS	1/4-5/16 CL	1514	1346	85
1E	DS	1/4 -3/8 CL	1520	1351	80
1F	CW	1/4 -1/2 CL	2104	1870	100
2F	CW	1/4 -1/2 PG	2086	1854	97

Observations and Conclusions

The polymers tested are very sensitive to moisture. Several samples of mortar and concrete were made from components extracted from outdoor stockpiles. The samples foamed, and had reduced bending strengths. As a result all samples reported here were made from oven-dried components.

Insufficient data points were obtained to fully understand all the parameters affecting bending strengths, but study of Table 2 indicates the Dopey Soup has a trend of higher bending strengths with reduced aggregate size. For this material, on the average, the mortar mixes (Tests 1A-3A) carried more load than the concretes, and Tests 1D and 1E had higher bending strengths than any of the 1/4-1/2 inch aggregate concretes.

The Concrete Welder material was more brittle, but the samples had higher bending capacity than the Dopey Soup. As seen in Tests 1F and 2F, aggregate fracture was very high for the two samples tested. This would be expected considering the difference in tensile and compressive strengths reported in Table 1.

The load-displacement curves also reflected the differences in elasticity between the two polymers. Typical maximum displacements before failure for the Dopey Soup approached 1 inch, resulting in a highly non-linear load deflection curve (Fig 2). The material Also exhibited strong memory characteristics. It returned to its original shape within minutes to hours of plastic set. The Concrete Welder also showed non-linear characteristics (Fig 3), but failed catastrophically at maximum deflections approaching one tenth that of the Dopey Soup. Its brittle failure was more characteristic of Portland cement concretes.

Polymer concrete has good potential for rapid repair of runways. Additional research is needed to develop formulations insensitive to water, to further study bonding to less than ideal materials (such as reclaimed concrete) and to develop equipment to deliver or mix the polymers.

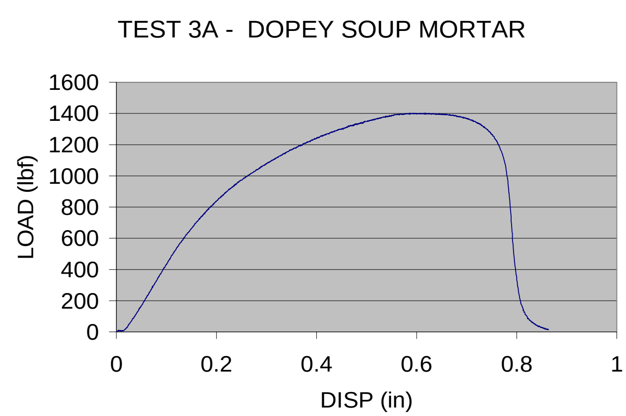

Fig 2-Load Deflection Curve

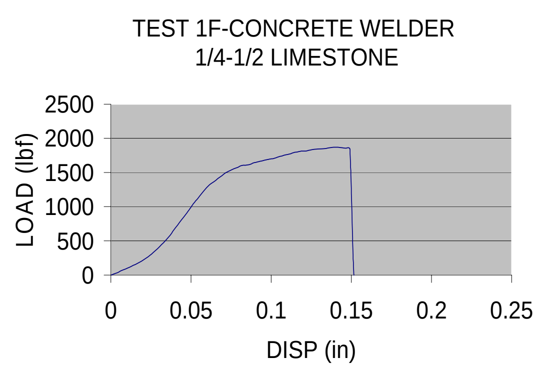

Fig 3-Load Deflection

References

1.1991 Annual Book of ASTM Standards, Section 4, Vol. 0402 Concrete and Aggregate -ASTM: C78-84