COMPRESSION AND FLEXURAL PROPERTIES OF A NOVEL RECYCLED PLASTIC MATERIAL

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Introduction

This test report describes the results of experiments performed to characterize the mechanical response of a material made from recycled plastics. Test specimens were produced and supplied by Innovative Research Corporation (IRC). The production method uses IRC's patented Solvent Based Plastic Recycling Process (SBPRP). This process involves the chemical reaction of a solvent with several species of plastic resins commonly found in the post consumer plastic waste stream. The product of the chemical reaction is a new plastic resin with good adhesive properties. The plastic resins which do not react chemically are placed in suspension in the new plastic resin while it cures into a hardened form. In final form the end product represents a plastic conglomerate analogous to concrete. The conglomerate may be compression molded or extruded at room temperature into a number of products which are made from the commingled, unsorted plastics in the residential and commercial solid waste streams.

Test Methods and Results

Axial compression and three-point flexural tests were performed at room temperature using an 1125 Instron load frame.

Compression Tests

The objectives of the compression tests were to measure initial elastic (Young's) modulus, compression strength, and Poisson's ratio, as well as to obtain the complete compression stress-strain response of the material. Specimens (6.0 to 7.5 inches long, 3.85 inches wide, and 1.6 to 1.8 inches thick) were loaded in axial compression between two steel platens in the Instron load frame. Tests were at a crosshead rate of 0.2 inches/minute. Forces were measured with a 20,000 pound load cell and specimen axial strain was measured in two ways. The first was with an extensometer clipped between two metal brackets that were attached to one side of the specimen and spaced at a gage length of 2.0 inches. The second method of measuring axial strain was a deflection gage attached to the movable crosshead of the 1125 Instron, which measured the change in length of the specimen. Lateral strains necessary for Poisson's ratio calculations were measured with an extensometer mounted on the side opposite the axial extensometer and oriented to measure the strain transverse to the load axis. On specimen #5 both extensometers, on opposite sides of the specimen, were mounted in the axial direction.

Compression stress-strain curves are plotted in Figure 1 and values of compression modulus, strength and Poisson's ratio are listed in Table 1. Strains in Figure 1 are calculated from crosshead displacement and the initial length of the specimen. Normally extensometer strain values from the gage section would be used. However, with an axial extensometer on only side of the specimen, the measured axial strain contained some bending strains of unknown magnitudes. Bending did occur because all specimens were slightly bowed and their ends were not cut exactly flat and parallel. Therefore, we used axial strains based on crosshead displacement values divided by the initial specimen length. This approach neglected any errors that might be introduced by end constraints.

TABLE 1. SUMMARY OF AXIAL COMPRESSION TESTS

SPECIMEN NUMBER	FABRICATION PROCESS	MAXIMUM LOAD (lb)	MAXIMUM STRESS (psi)	YOUNG'S MODULUS (psi)	POISSON'S RATIO
1	COMPRESSION	15,500	2,550	140,000	0.25
2	COMPRESSION	13,400	2,200	120,000	0.29
3	COMPRESSION	12,850	2,015	113,000	0.29
4	EXTRUSION	14,800	2,240	120,000	0.30
5	EXTRUSION	13,850	1,965	125,000	---
	average	*14,080*	*2,194*	*123,600*	*0.28*

NOTES:

1. Extensometers attached to specimen to measure axial and lateral strains.
2. Ends of specimens not exactly parallel.
3. Specimens slightly bowed resulting in suspect extensometer data because of specimen bending.
4. Stress-strain curves based on total length of specimen, not extensometer data.
5. Modulus is tangent value of steepest part of stress/strain curve.
6. Nominal specimen dimensions: length=6.0 to 7.5 inches, width=3.85 inches & thickness=1.6 to 1.8 inches.

The curves in Figure 1 were used to calculate the elastic modulus and to obtain the compression strength. The elastic modulus was taken as the tangent value of the steepest part of the stress-strain curves. The initial part of most curves was ignored since the low stiffness "tail" in this region occurs because of initial non-uniform loading while the non-parallel ends are being deformed until they are parallel. Poisson's ratio was calculated using transverse strain divided by the specimen axial strain based on crosshead deflection. Failure of the compression specimens were along an approximately 45° shear plane. In some specimens failure initiated at the end and in others it initiated in the gage section.

Two further comments regarding the compression test results. First, note that the specimens were fabricated by two methods: compression molding and extrusion. The properties of specimens processed by the two methods appear to be comparable. Secondly, it should be noted that specimen #5 had axial extensometers attached to both sides. The strains from these were averaged to cancel out bending strains to yield what should be accurate axial strain values. For this specimen, the elastic modulus value based on the averaged strains of the two extensometers was about 20% higher than the elastic modulus reported in Table 1. These results suggest that the elastic moduli reported in Table 1 are lower bounds and that the actual values may higher. A recommendation for any future testing is that two axial extensometers be used, one on each side of the specimen.

Flexural Tests

Three-point flexural test were performed to obtain the flexural modulus and flexural strength (tensile failure) for comparison with results from the compression tests. Specimens of about 1.06 inches width and 1.6 inches thickness, cut from extruded beams, were supported at a span of 8.0 inches and loaded at midspan at a crosshead speed of 0.1 inch/minute. Midspan deflection was measured with an extensometer. Test procedures followed the guidelines of ASTM D-790 and stresses and strains were calculated using Eq. (1) in the ASTM standard. Flexural stress-strain curves are plotted in Figure 2 and values of maximum stress and flexural modulus are listed in Table 2. All flexural specimens failed on the tension side.

TABLE 2. SUMMARY OF FLEXURAL TESTS

SPECIMEN NUMBER	FABRICATION PROCESS	MAXIMUM STRESS (psi)	FLEXURAL MODULUS (psi)
1	EXTRUSION	930	106,000
2	EXTRUSION	1,095	123000
3	EXTRUSION	1,105	127000
4	EXTRUSION	1,250	121000
	average	*1,095*	*119,250*

NOTES:
1. 3-Point bend test with support span of 8 inches.
2. Deflection at mid-span (under load ram) measured with an extensometer.
3. Stress & strains calculated with Strength of Material equations using specimen & test data.
4. Flexural modulus is tangent value of steepest part of stress/strain curve.
5. Nominal specimen dimensions: width=1.055 inches & thickness=1.6 inches.

The Figure 2 and Table 2 data indicate that the tensile strength of the recycled plastic material is approximately 1100 psi or about one-half the ultimate compression stress. Table 2 data also show that the flexural elastic modulus is of the same magnitude as the compression modulus.

FIGURE 1. AXIAL COMPRESSION STRESS-STRAIN CURVES

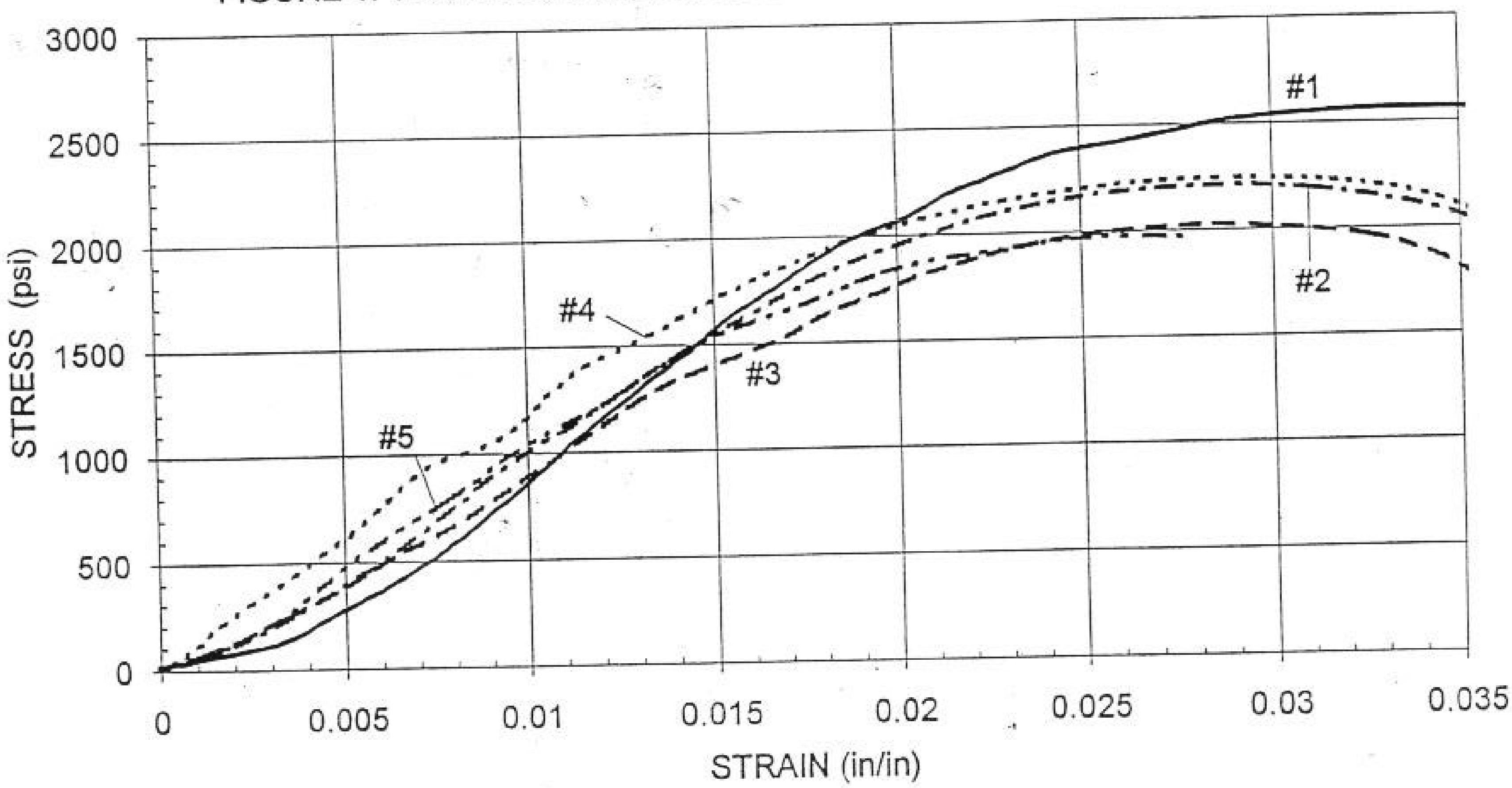

FIGURE 2. THREE-POINT FLEXURAL STRESS-STRAIN CURVES