Dome Fiberglass Summary

In August 2007, an inspection was done on the exterior fiberglass shell of each dome. This inspection was conducted by multiple fiberglass experts including UC Davis Professor Dawn Cheng and UC San Diego Professor Karbhari. At that time Dawn Cheng offered to take a sample of the material to assess the true service-life of the material.

In August 2009, one of the three foam companies approached about the foam repair project, failed to bid on the project because of their concern for the fiberglass structure. It was suggested that the weight of the foam could hurt the structures integrity.

In December 2009, Student Housing approached Dawn Cheng regarding taking a sample of the fiberglass to test the material. On July 26, 2010, a fiberglass sample was taken from Dome 10 to be tested by Dawn Cheng. Student Housing received the report on October 8, 2010. The report shows the testing steps and results. In the email from Dawn Cheng's containing the fiberglass report, she stated the following:

> *Based on the lab results of the 5 standard samples we did in the lab, the average tensile strength of the fiberglass material is 49.03 MPa and the average tensile modulus is about 7.71 GPa. Based on what I know, this fiberglass layer was applied by external professionals using a typical spray-up process (old but inexpensive) during the construction stage back in 1972. It is typically difficult, with this method, to control the fiber volume fraction (content) as well as the thickness, which highly depend on operator skill. The tensile strength of the product is normally lower than what other manufacturing methods can offer. However, since this fiberglass layer in the dome does not need to carry much load (maybe snow and some occasional branches from trees), the remaining tensile strength and modulus of the fiberglass layer obtained from the tests appear to be sufficient (even though on the slightly low end) to serve its current purpose. Since we don't know much about the original fiberglass (type and content) and the resin system that was originally used, it's a bit tricky to say if the material degraded overtime or not (no baseline to compare). The direct visual inspection of the coupons gave me an impression that the quality of the fiberglass layer was reasonable for a typical spray-up process (but there are voids, bumps and valleys on the surface). No delamination or crack was shown on the sample panel. I tend to think that they are still in OK service condition at this point. It would be ideal to perform further durability tests on more coupons and duplicate some samples using the similar method in the lab.*

Fiberglass Coupon Test Results

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Baggins End Innovative Housing – also known as The Domes – was constructed using a spray-up fiberglass shell. Built in 1972, the use of fiberglass in residential housing was not as common as it is today. As a result, there exists very little data pertaining to durability of the material used for construction of the housing community.

To evaluate the integrity of the fiberglass shell, a sample section was removed from one of the dome structures and used to make coupon specimens. The specimens were tested to determine material properties according to ASTM D3039-07, Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.

Sample Preparation

In order to test the fiberglass shell, a sample panel (10×10") was removed from the wall of one of the domes. The raw material sample, shown in Figure 1, contained three layers. The middle layer consisted of the fiberglass material, which was made of chopped fibers and a blue-green epoxy resin. The inner and outer layers consisted of polyurethane insulation and paint, respectively.

Since the middle layer of the specimen was the fiberglass structural layer that was needed for testing, the insulation and the paint layers were removed first. The paint layer of the raw sample was removed with flathead screw drive or a chisel, and rough sand paper to get rid of the residuals. Over the years, The Domes have received several fresh coatings of paint, so the outer paint layer actually consisted of many thinner paint layers. Shown in Figure 2, most of the paint was easily removed with the hand tools. The paint nearest the fiberglass, however, was a thin latex layer. This layer was sanded away to reveal the fiberglass beneath it, as shown in Figure 3.

Figure 1 - Sample panel cut from the dome

Figure 2 - Paint removal

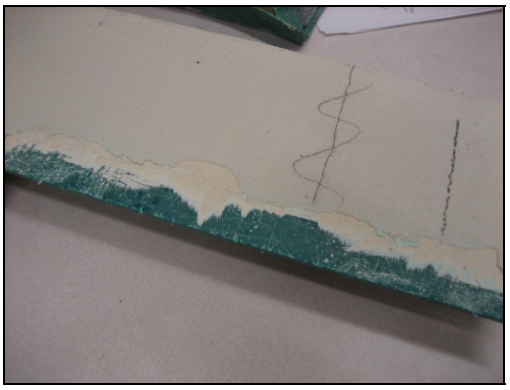

Figure 3 – Additional sanding after paint removal

After the paint layer was removed, the insulation foam was then removed only from an area of fiberglass that was sufficiently large enough to make test specimens. Although the foam was easily removed, several patches of adhesive residue remained in the natural valleys formed by the chopped fibers. To avoid potential bonding issues later in the sample preparation, the remaining patches of residue were sanded away as much as possible. Figures 4 and 5 show the foam removal and fiberglass surface, respectively.

Figure 4 - Insulation removal

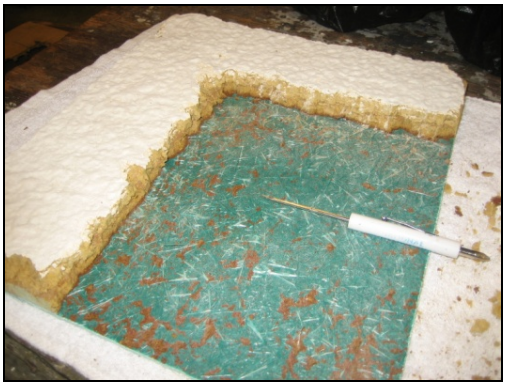

Figure 5 - Sanded sample area

Following sanding, the sanded sample area was cut into 6 standard coupon strips (1×10”) for ASTM tensile testing using a model MK-100 Tile Saw in the Composite Lab at CEE. To aid in the proper transfer of forces to the specimens, tabs made of glass fiber were made to both ends of each coupon strip. The tabs were then applied to the top and bottom ends of each coupon, as shown in Figure 6.

Figure 6 - Coupon Specimen

Figure 7 - Coupon test setup

Test Results

All tensile tests were conducted using an 810 Material Testing System available at CEE, shown in Figure 7. Specimens 1, 2, 3, 5, and 6, were each loaded successfully to failure (Specimen 4 failed unexpectedly due to some error). Figure 8 shows the typical failure on the front and back sides of the specimens. The test results are summarized in Table 1 below, where **the average tensile strength of the coupons was 49.03 MPa and the average tensile modulus was 7.71 GPa**.

Figure 8 - Typical tensile failure of specimens: left (front side), right (back side)

Table 1 – Test Results on Tensile Strength and Modulus

Specimen	F^{tu} (MPa)	E (MPa)	E (GPa)
DC 1	52.111	6808.922	6.809
DC 2	48.092	8838.035	8.838
DC 3	44.560	7675.297	7.675
DC 4	-	-	-
DC 5	51.988	7504.032	7.504
DC 6	48.406	7719.689	7.720
Note: All measurements in millimeters.			