EFFECTS OF TEMPERATURE CHANGE ON PLASTIC CRASH CUSHIONS, PHASE 2

By

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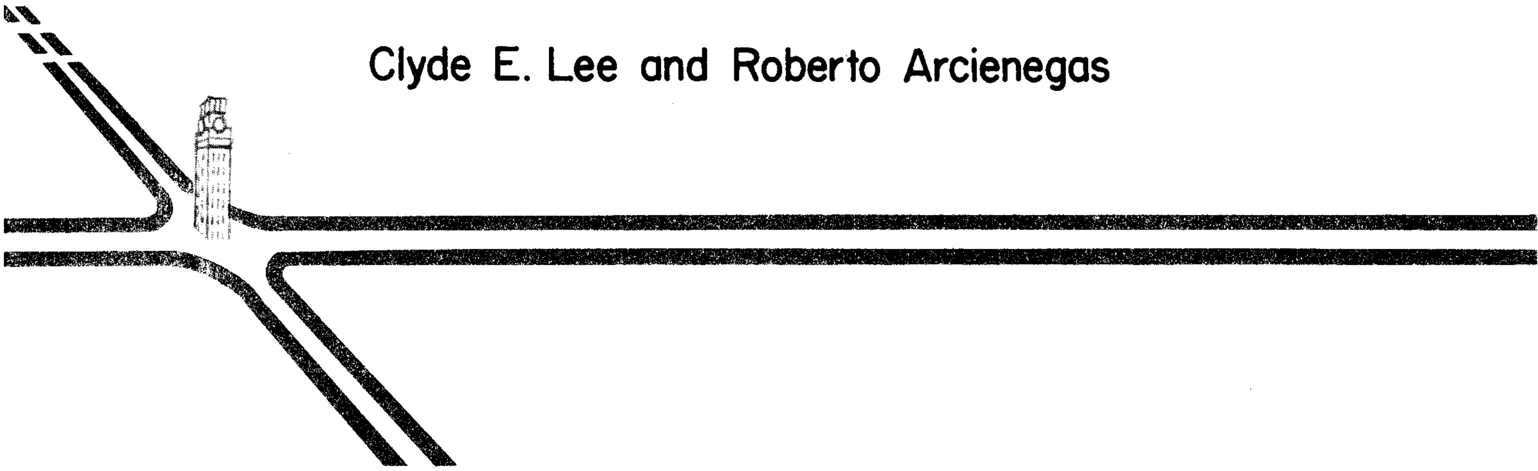

CENTER FOR HIGHWAY RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN
OCTOBER 1977

EFFECTS OF TEMPERATURE CHANGE ON PLASTIC CRASH CUSHIONS, PHASE 2

by

Clyde E. Lee
Roberto Arcienegas

Research Conducted for

Energy Absorption Systems, Inc.

Through

Bureau of Engineering Research

by

Center for Highway Research

The University of Texas at Austin

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INTRODUCTION

In a previous study (Ref 1), the ability of two types of commercially available plastic crash cushions to maintain their original shape and integrity when filled with sand to normal service load and exposed to large temperature variations was determined. The investigation that is described in this report was a follow-up study conducted to evaluate the effects of design and manufacturing modifications which have been incorporated into recent production models of 1,400-lb (635-kg)-capacity Energite units. These changes, which are described in an appended letter, were intended to overcome cracking problems in the inner container and lid-sagging tendencies that were observed in the earlier tests.

Two specimens of the current Energite product were subjected to the same series of controlled temperature changes that was used in the October-December 1975 tests. These specimens were then moved to an outdoor site for long-term observations as had been done in the previous evaluation.

TEST PROGRAM

The two samples that were selected by the manufacturer for testing arrived in Austin, Texas, early in June 1977 in sound condition even though the cardboard shipping containers were badly mutilated. Each unit consisted of three components: (1) a yellow-colored outer shell, or stabilizer; (2) a black five-pedestal inner module; and (3) a black lid which snaps over the top of the other two nested components. The units were marked E_1 and E_2 for identification and inspected for flaws; none was found.

Each assembled unit was placed on a sheet of 3/4-inch (19-mm)-thick plywood and set on a separate four-wheeled cart (see Fig 1) so that the sand-filled units could be moved easily from one controlled-temperature chamber to the other. Reference markings (see Fig 2) were placed on the outer shell to facilitate height and circumference measurements after exposure to each temperature condition during testing.

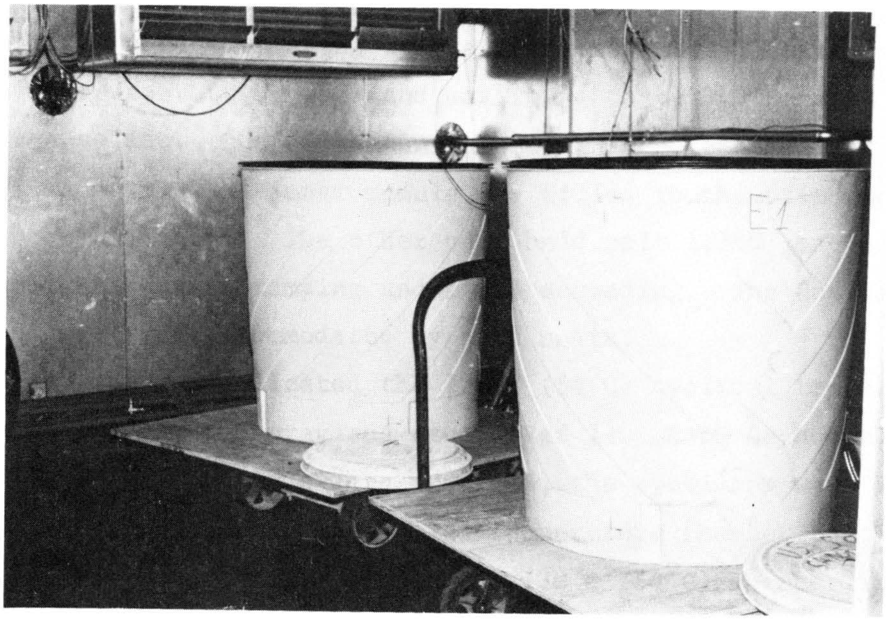

Fig 1. Assembled units on four-wheeled carts.

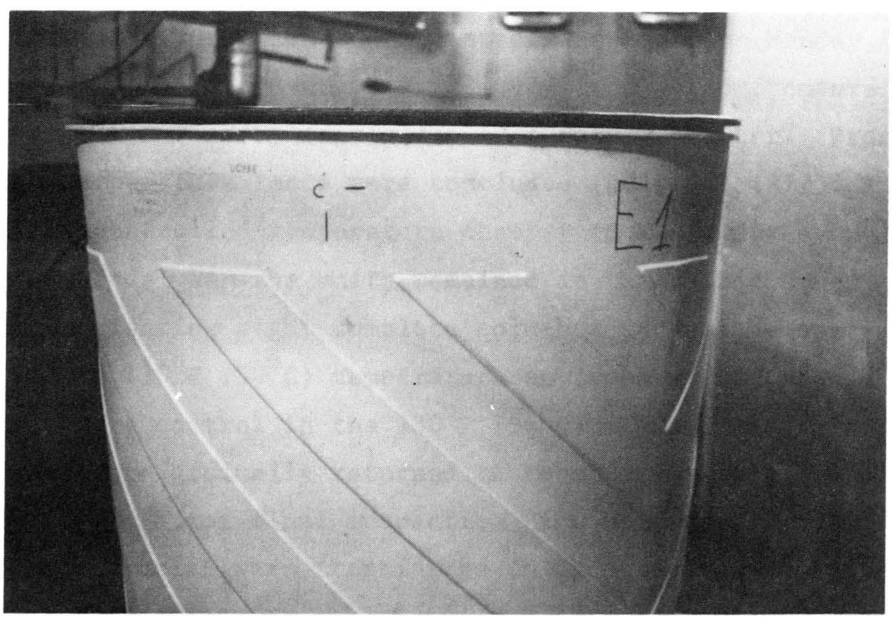

Fig 2. Reference marks for height and circumference measurements.

Both units were filled with locally available washed sand of the type that is normally used for making concrete in the Austin, Texas, area. The average moisture content of the sand was found to be 3.9 percent of the weight of the solids. One of the units, E_1 , accepted the full 1,400 lbs (635 kg) of sand when the inner module was filled to the brim and screeded to a slightly conical shape. The other unit held only 1,350 lbs (612 kg) of sand after light surface tamping and final screeding. The nominal design mass of sand was thus accommodated by both units.

The test program duplicated the 130^{o}F (54^{o}C) cyclical temperature sequence utilized for the previous study (Ref 1). Each 48 hours, except for weekends when 72-hour periods were provided, the specimens were moved through connecting doorways from one controlled-temperature chamber to the other. Dimensional measurements were made in the 130^{o}F (54^{o}C) chamber immediately after the units were moved into this chamber from the 0^{o}F (-18^{o}C) chamber or just before the units were moved out. These determinations, which required less than 15 minutes, were thus made under consistent conditions. Each unit was carefully examined at the end of every cycle for evidence of distortion or cracking.

Testing of the two crash cushion specimens began on Monday, June 13, 1977, when both sand-filled units were moved from a room temperature of 78^{o}F (26^{o}C) into the 0^{o}F (-18^{o}C) controlled-temperature chamber. From then until the cyclical temperature tests were concluded (July 20, 1977), the units were moved from one controlled-temperature chamber to the other every 48 hours except for weekends when the units remained in the same chamber for 72 hours.

After experiencing eight complete cold-hot cycles the specimens were subjected to the 130^{o}F (54^{o}C) temperature environment for an additional seven days. Temperature control in the 130^{o}F (54^{o}C) chamber was then discontinued and the temperature gradually returned to room temperature (76^{o}F = 24^{o}C) over a 72-hour period. After final inspection, the sand was removed from the specimens and the units were transferred to an outdoor site for subsequent long-term observation.

TEST RESULTS

In addition to careful visual inspection for cracking or distortion, height and circumference measurements were made periodically on each unit as mentioned previously. Figures 1 and 2 show the location of the reference marks used for these measurements. The circumference planes were at 3 in. (76 mm) and at 2 ft 9 in. (838 mm) above the bottom, and height measurements were made vertically to targets in these planes at three locations 120^{o} apart (locations A, B, and C).

Figure 3 shows the height measurements made at location B. A small change in the height from the bottom to the lower plane occurred in the first few temperature cycles, but the remaining readings were practically constant. Height changes between the lower and upper planes due to temperature change were consistent throughout the series of tests and indicated a change in height of about 0.3 inch (7.6 mm) over the 2 ft 6 in. (762 mm) height, or approximately 1 percent.

Circumference changes with time and temperature are illustrated in Figs 4 and 5. The difference in circumference between successive measurements remained essentially constant throughout the test; however, a slightly larger contraction in the lower circumference was observed in both units during the fourth and fifth cycles. The usual circumference excursion was on the order of 7/8 to 1 inch (22 to 25 mm), or about 0.9 to 1 percent change.

On July 12, 1977, during the seventh cold cycle, the lids of both units were removed. The sand had settled about 3-1/2 inches (90 mm) in both units (see Fig 6), and a series of random cracks was seen in the surface of the sand. Frozen drops of water were clinging to the lid (see Fig 7).

A thorough visual inspection of both specimens on August 1, 1977, before and after unloading the sand, revealed no cracking nor distortion. The lids did not sag as in previous tests. Dimensions of the units were virtually unchanged from the initial measurements. The lower circumference of unit E_1 was approximately 3/16 inch (5 mm) greater at the end of the test than at the beginning. The appearance and integrity of both specimens were unaffected by the cyclical temperature tests.

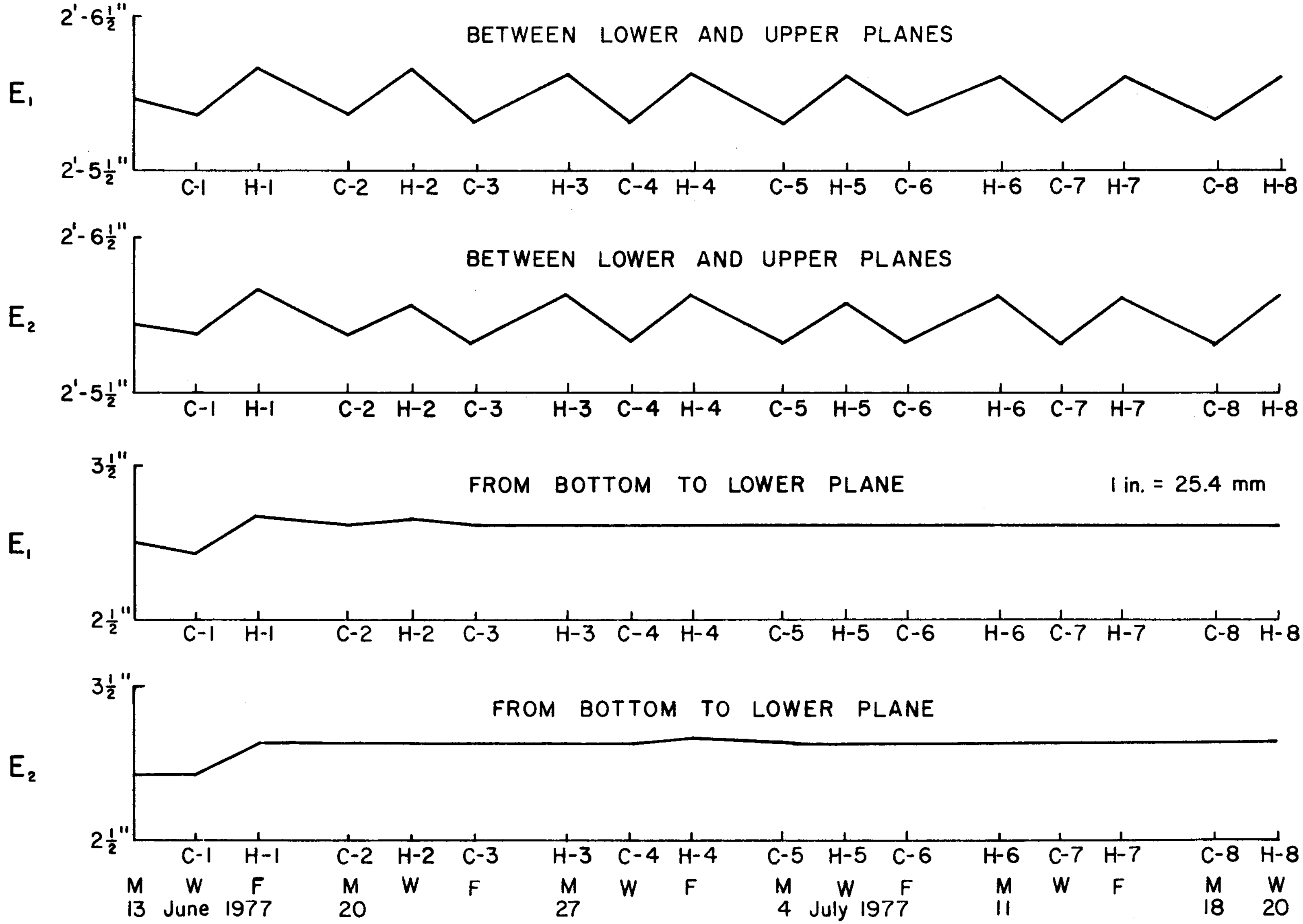

Fig 3. Height measurements at location B.

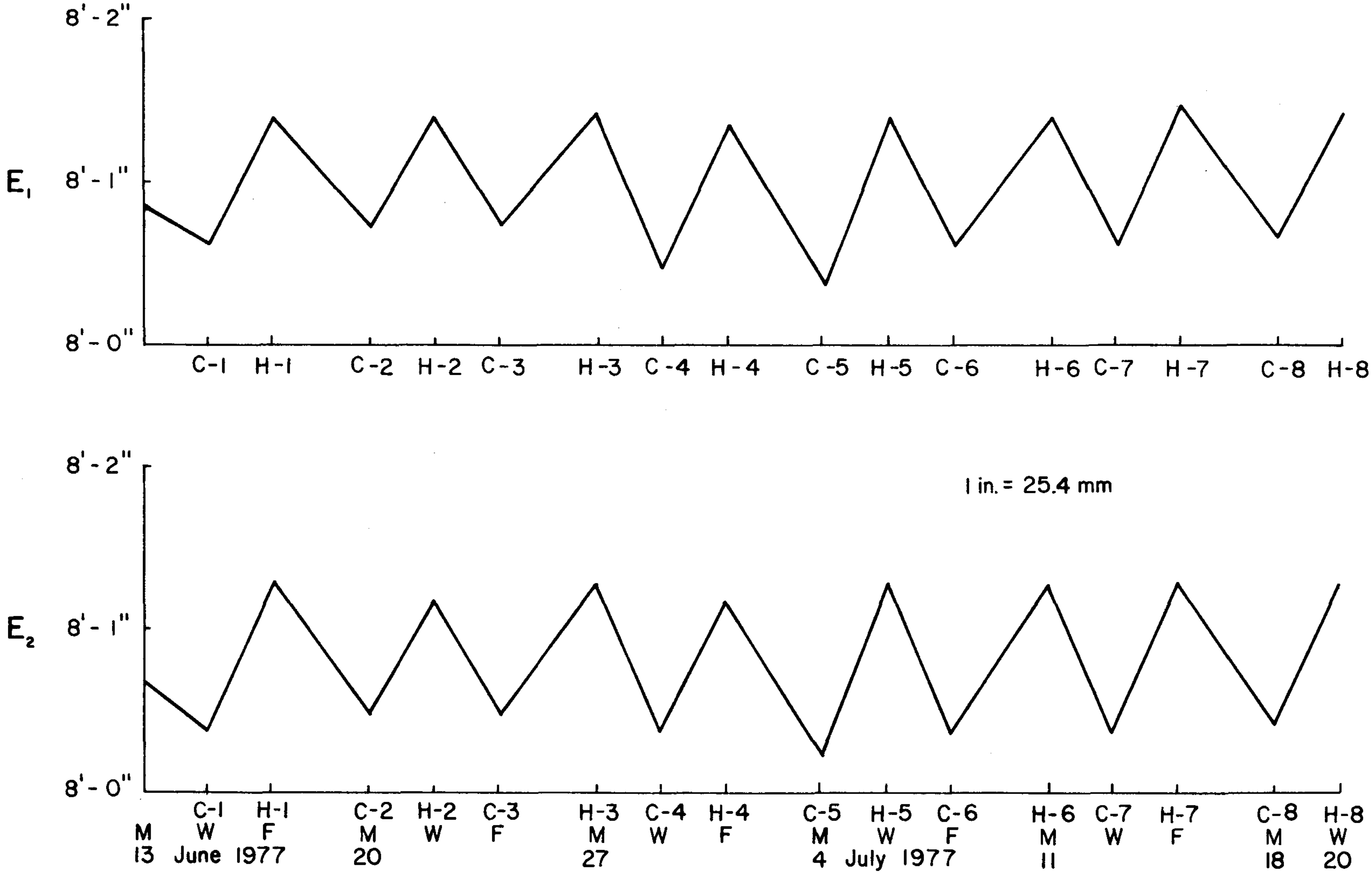

Fig 4. Circumference measurements in a plane 3 inches above bottom.

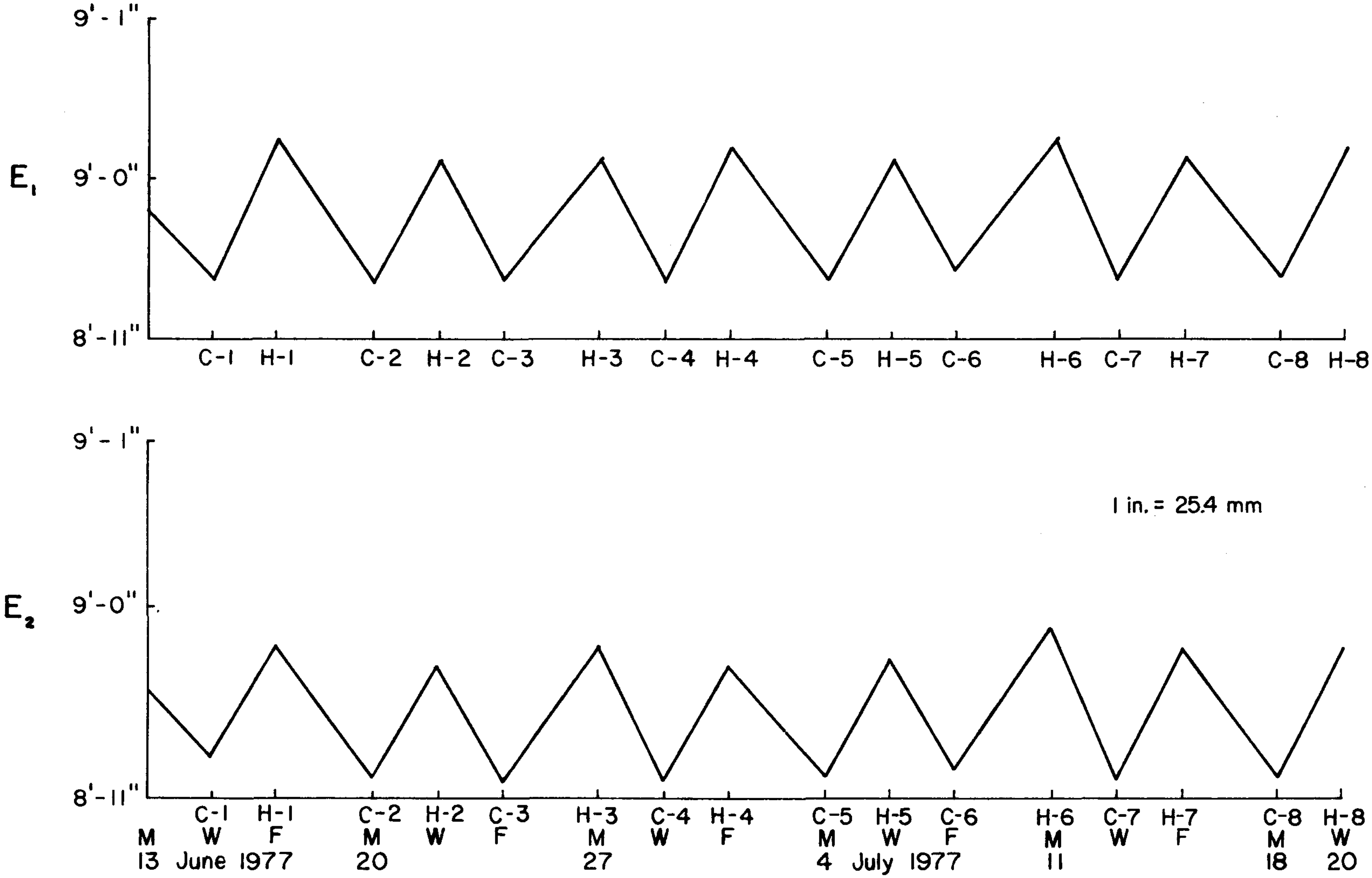

Fig 5. Circumference measurements in a plane 2 feet 9 inches above bottom.

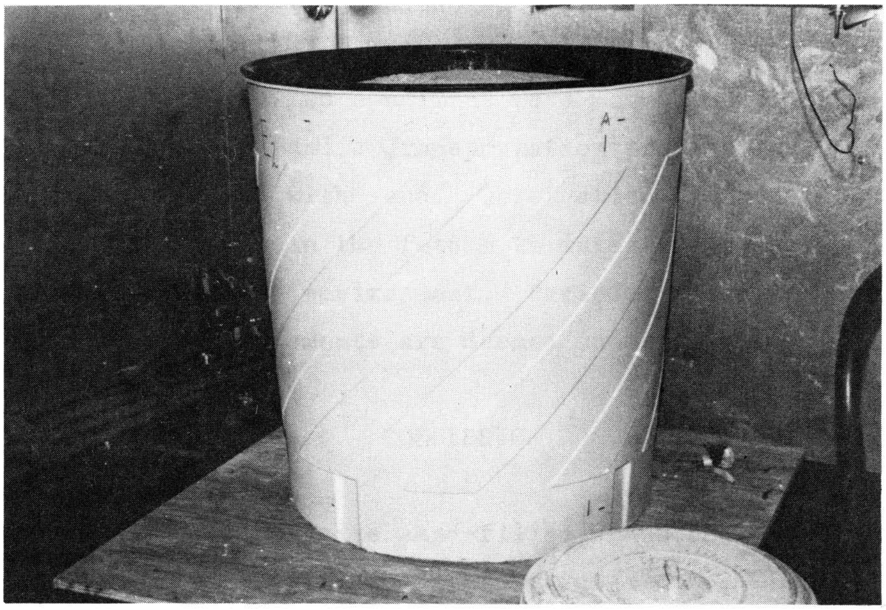

Fig 6. Unit E_2 after seven temperature cycles showing settlement of sand.

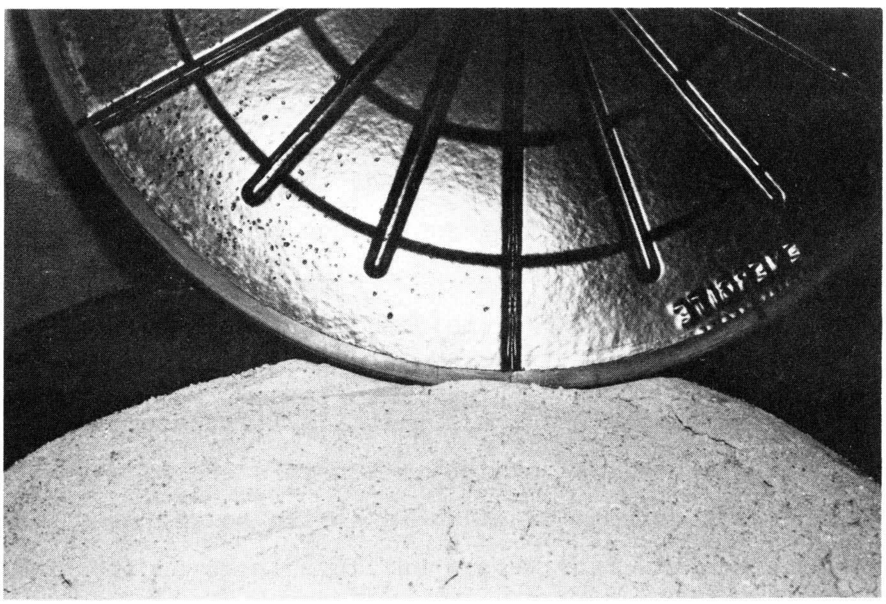

Fig 7. Frozen water clinging to lid.

CONTINUING TEST

On August 1, 1977, the two specimens were moved to a site on State Department of Highways and Public Transportation property at Camp Hubbard in Austin, Texas, and refilled with sand. Observation of these units will continue for several months in the future to determine the effects of long-term exposure to the outdoor environment. Periodic visual inspections will be made, but dimensional measurements are deemed unnecessary.

CONCLUSION

The two specimens of Energite sand-filled crash cushions that were subjected to a series of extreme temperature variations, $0^{o}F$ to $130^{o}F$ ($-18^{o}C$ to $54^{o}C$) during a two-month period exhibited no visible evidence of cracking or distortion. Recent modifications in the materials used for manufacturing the units and in the configuration of the components overcame the weaknesses exhibited in earlier tests. Effects of long-term loading under in-service conditions will be determined in the continuing tests of these specimens.

PHASE 1 SPECIMENS REVISITED

The two Energite specimens that were first subjected to extreme temperature changes and then placed under long-term service condition exposure on December 30, 1975, were re-examined on August 1, 1977. The earlier-design unit which experienced bulging, cracking, and sagging during the cyclical temperature tests had continued to deteriorate (see Fig 8). The newer design 1975 test specimen was still standing erect and showed no external effects of long-term exposure to the elements except for quite noticeable fading of the yellow color. Examination of the black inner module, after unloading the sand, revealed further opening of the cracks that had appeared during cyclical temperature tests in 1975. No appreciable amount of sand had passed through these cracks, however. This specimen was reloaded with sand and retained for further observation.

Fig 8. View of early-design Energite specimen after cyclical temperature test and 19 months of outdoor exposure.

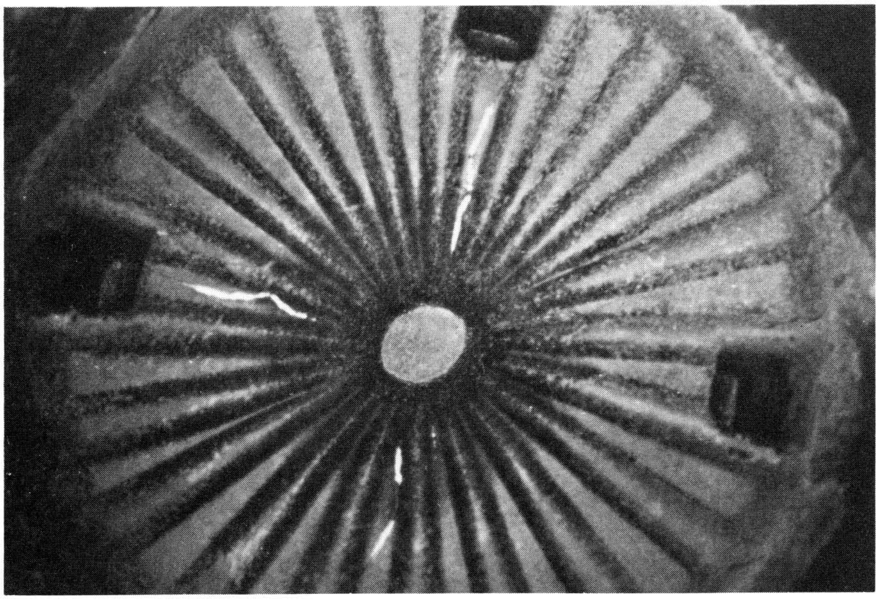

Fig 9. Inner module of new-design 1975 specimen on August 1, 1977.

REFERENCES

1. "Effects of Temperature Change on Plastic Crash Cushions," by Victor N. Toth and Clyde E. Lee, Research Report No. 514-1F, Center for Highway Research, The University of Texas at Austin, Austin, Texas, January 1976.

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ENERGY ABSORPTION SYSTEMS, INC.
860 S. River Rd., West Sacramento, CA 95691
916/371-3900 TELEX: 377332

September 1, 1977

Mr. Clyde E. Lee
Director
Center for Highway Research
The University of Texas at Austin
Austin, Texas 78712

Re: Energite Modules

Dear Mr. Lee:

Mr. J. Mike Essex, our Vice President of Sales, asked me to describe the general changes that had been made to the modules used in the recent freeze-thaw test as compared with the ones used in your earlier test series.

Perhaps the most important of these was the change in material formulation. This resulted in a final product having an increased elasticity. The material thus is able to withstand loads applied slowly, yet retains its frangibility when loaded quickly, such as happens during an impact.

Dimensional changes have also been made. For instance, the wall thickness of both the inner module and the stabilizer has been increased by increasing the amount of material used in each. Because the parts are rotomolded, adding more material uniformly increases the thickness all over.

In addition, an annular ring was added to the bottom of the stabilizer and additional radial ribs were added to the lid in December, 1975.

Other minor changes were made, as the need became apparent, to improve the fit between inner containers and stabilizers.

Mr. Clyde E. Lee
September 1, 1977
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I hope the above will give you a general description of some of the modifications made to the product between the two test series.

Very truly yours,

ENERGY ABSORPTION SYSTEMS, INC.

Bruce O. Young

Bruce O. Young, P. E.
Vice President, Engineering

BOY/dh

cc: J. M. Essex