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Structural Testing of AMT Wall and Roof Panels

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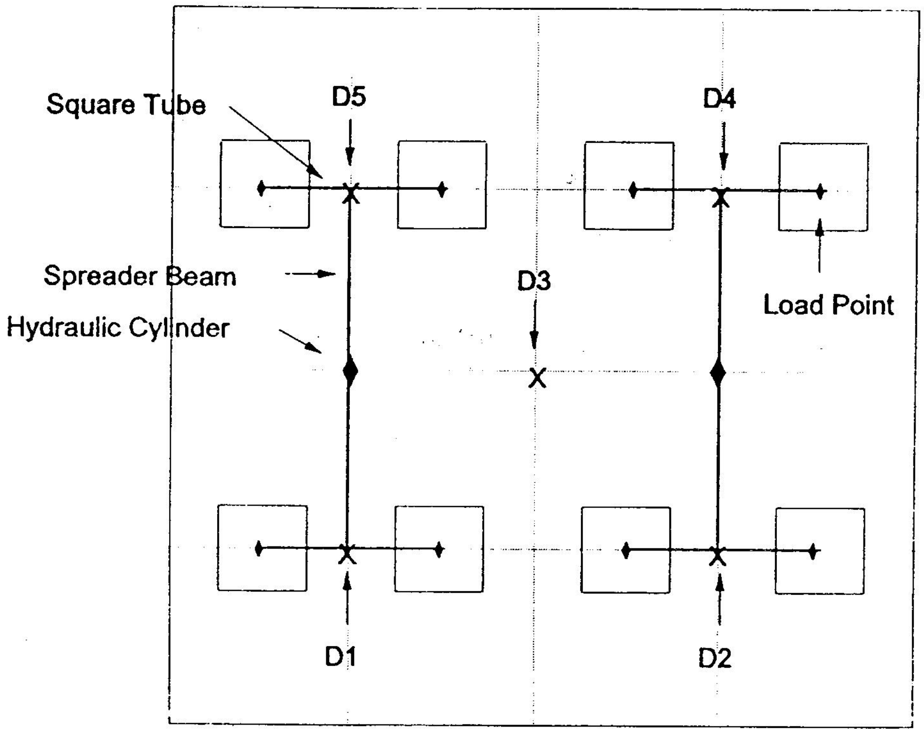

Phase I-A
final

report

Engineering Research Institute
Iowa State University

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Table of Contents

Introduction..1

Test Specimens and Procedure..1

Test Results/Data..2

Summary and Conclusion..4

Recommendations for Future Phases/Testing..5

Preliminary Testing

STRUCTURAL TESTING OF AMT WALL AND ROOF PANELS

Introduction

During October 1994, several tests were performed to determine the uniform load (simulated wind load) capacity of wall and roof panels manufactured by AlphaGen Materials Technologies, Inc. These preliminary tests were conducted at Iowa State University's Auxiliary Structural Engineering Laboratory as the initial Phase I part of the Research Plan Proposal under the auspices of the Engineering Research Institute.

Test Specimens and Procedure

The 8'x8' wall and roof panel test specimens as submitted to the Structural Laboratory differed in construction somewhat from panels anticipated to be used in actual field installations. For example, perimeter construction of wall panels utilized integral bonded 2x10's thus eliminating the suggested column-type of flexural support on two edges. For this condition and based upon an expected mode of failure, boundary elements for the wall panel consisted of four wide flange beams to provide a uniform flexural stiffness. Support conditions for the roof panel involved two wide flange beams for vertical restraint within the testing frame and were oriented along east and west edges only.

Both wall and roof specimens were subjected to loading using the arrangement as illustrated in Figure 1. This configuration was designed to spread the load from two hydraulic cylinders to a total of eight load points in effort to simulate a uniform panel load similar to that caused by wind loading. As well, the load pattern and boundary conditions were selected in order to observe and verify an expected *yield line* failure in the wall panel.

All test panels were electronically instrumented with position transducers for measuring deflection at five locations as noted on Figure 1. The instrumentation was consistent for the initial wall and roof panel tests and the wall panel for a *second test*. A hand operated hydraulic pump actuated two load cells which were used to monitor the applied load.

Test Results/Data

Wall Panel Specimen - Test One

The wall panel specimen was tested to a "proof load" of 4239 lbs., which is equivalent to 66.2 lb/ft^2 over the panel surface. This loading value corresponded to the first major event of the testing, which involved the cracking and separation of the outer ceramic layer from the inner fiberglass layer. The maximum recorded deflection was 2.1 in. at location D4, and occurred following the first major event. The maximum deflection prior to the first major event was 1.94 in. at location D4. One other localized crack was noted before the first major event at 2025 lbs. The testing was terminated at a point where the ceramic outer layer began cracking around the perimeter of the specimen beyond the northeast and northwest corners. Additional load that would have been carried by the panel if testing had continued until failure of the fiberglass layer was not determined at that time. The ultimate load capacity of the wall panel was investigated by a second test conducted on October 20, 1994.

Load/deflection data for the center of the wall panel (instrument position D3) is illustrated in Figure 2.

Roof Panel Specimen

The roof panel specimen was tested beyond the first major event to the full maximum collapse load of 22597 lbs., which is equivalent to 353 lb/ft^2 over the panel surface. The first major event was observed at 17200 lbs., at which time the ceramic outer layer on the bottom cracked along the supports and peeled off from the fiberglass layer. Subsequent load was applied until the total collapse near the east support at the noted maximum load. At the collapse load, total shear failure originated at the north edge and progressed toward the south edge approximately 1/3 of the panel length. The maximum recorded deflection prior to the collapse of the panel was 3.37 in. at location D3. See Figure 3 for a plot of load v. deflection at the center of the roof panel.

Wall Panel Specimen - Test Two

Additional Phase I load capacity testing on the composite wall panel was performed on October 20, 1994. The purpose of this second test was to determine load and deflection values corresponding to failure of the inner fiberglass membrane which did not occur during initial testing conducted on October 13, 1994. For this test, the frame setup, support conditions and simulated uniform load pattern for the wall panel specimen was the same as for the first test. However, as highlighted on the Loading Configuration in Figure 1, measurements of panel deflections at locations D4 & D5 were reversed. This anomaly has been adjusted in appropriate figures consistent with test one.

The wall panel specimen was tested to a "failure/collapse load" of 5,320 lbs. This load was an applied load and in keeping with the other tests, included an approximate 500 lb. dead load for beams, rollers and other materials used to simulate uniform load distribution. The failure load is equivalent to a load of 83.1 lb/ft^2 uniformly distributed over the panel surface.
The first "major event" of this second test involved cracking and separation of the outer ceramic layer from the inner fiberglass layer. During the first test, two localized corner crack/separation patterns were initiated, one in the northwest and another in the northeast corners of the specimen. Previously, testing was stopped after hairline cracks had progressed about the perimeter of the panel. However, it should be noted that most of the observed crack propagation along the longitudinal joint lines of the 2x10 frame and the panel membrane is not

an indication of imminent failure, but rather, the result of brittle "tension failure" of the ceramic material due to rotation of the membrane adjacent to the wood frame.

During the second test, a pattern emerged wherein the previous localized crack/separation patterns at the corners continued to enlarge. At a total load of 4,470 lbs., localized crack/separation patterns at southeast and southwest panel corners nearly matched those of the above corners, although with somewhat less separation between the ceramic and fiberglass layers. In addition, at this load/deflection level, apparent separation of the ceramic material from the fiberglass membrane was sufficient to observe that the ceramic material seemed to have separated from itself. It appeared at least two coats (and curing cycles) of ceramic material had applied to the panel in a rather uneven manner. See Figure 4 for a schematic of the crack patterns observed during both wall panel tests.

The maximum recorded deflection for the failure load of 5,320 lbs., was 1.9 in. at location D4. The fiberglass layer failed in flexural tension at the northeast panel corner consistent with *yield line failure behavior* which indicates failure along panel diagonals (usually at corners) for materials with a large span/thickness ratio and similar support conditions. Figures 5 and 6 illustrate nearly identical linear load/deflection plots for positions D3 and D4 respectively. This phenomenon is consistent with yield line failure theory.

Summary and Conclusion

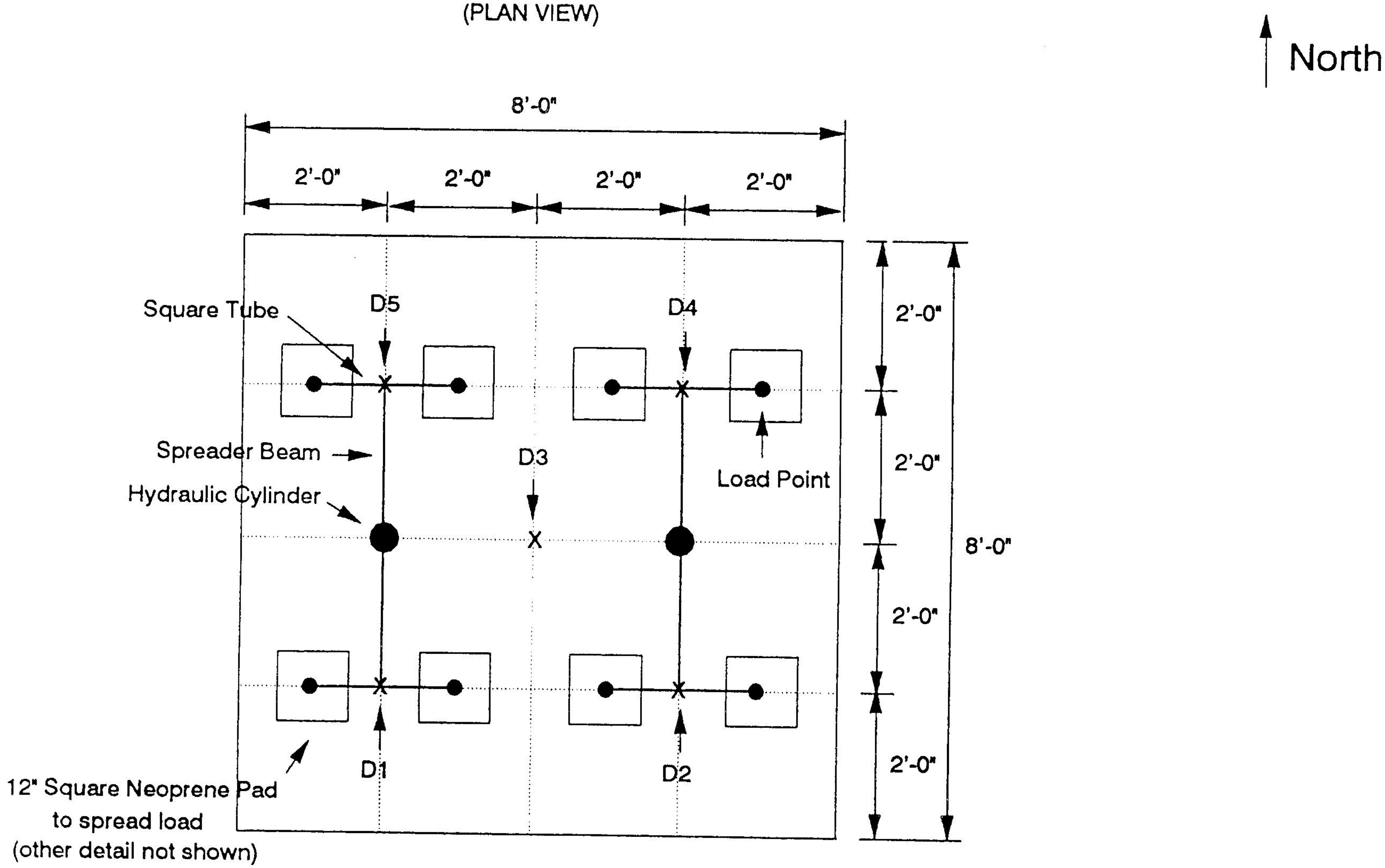
The data from these tests is sufficient to provide a basis for a preliminary static load analysis of a simple structure. This statement should not be construed to mean that enough information has been provided for a comprehensive design analysis. Material mechanical properties, composite panel material geometry and data from other test procedures must be combined with building code criteria and appropriate design/analysis procedures.

Recommendations for Future Phases/Testing

Continued development of this composite product should involve a complete study of basic material properties as well as combined material properties. Although individual wall or roof specimen components may utilize materials with known mechanical properties, it is unclear how these may act together in terms of tensile, compressive and shear stress capacities. Such information is critical not only in testing and analyzing other configurations or panel sections but also in optimization of a proposed structure for maximum strength versus minimum self-weight.

Figure 1

LOADING CONFIGURATION
(PLAN VIEW)



D1...D5 ARE POSITIONS OF DEFLECTION MEASUREMENT

Figure 2

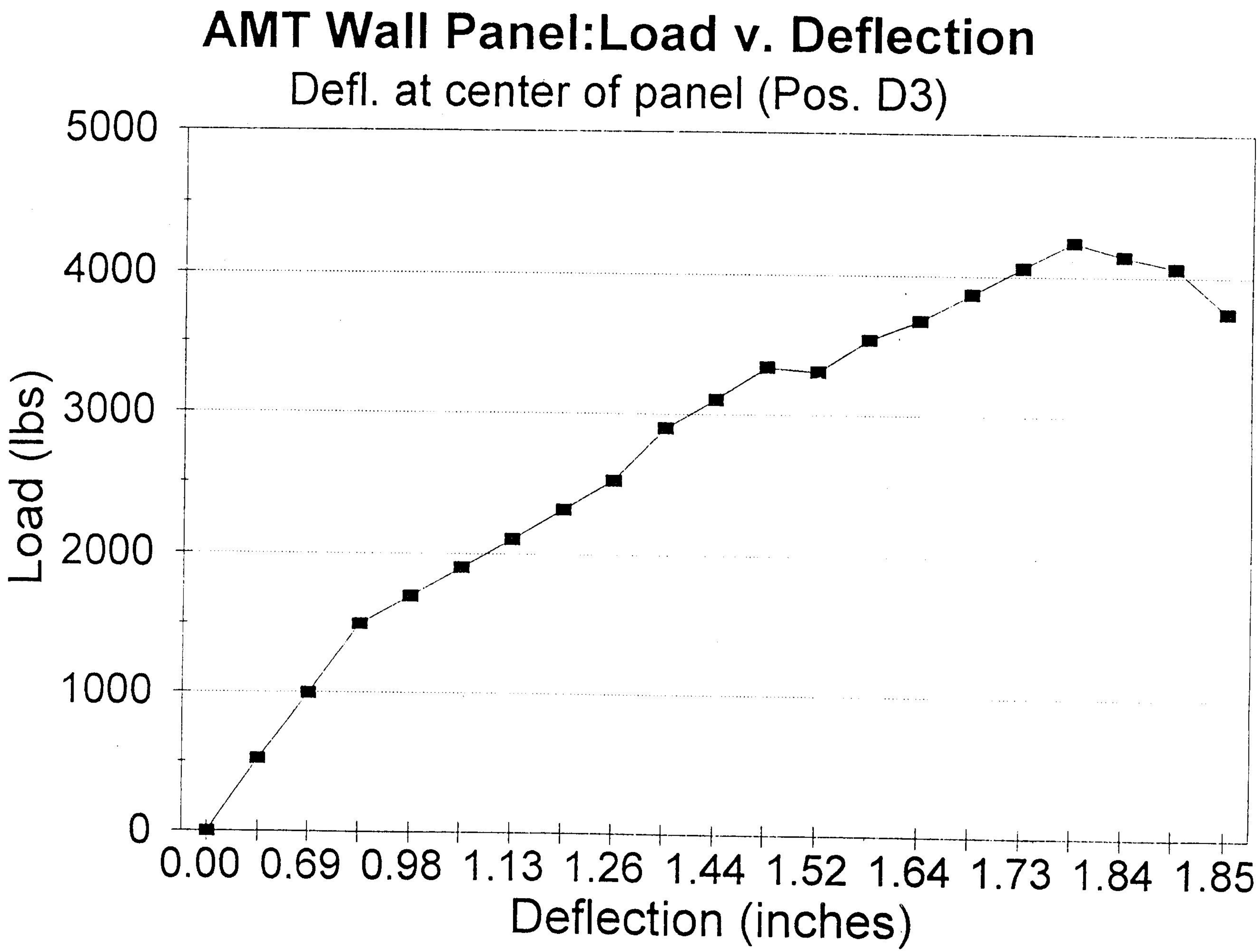

AMT Wall Panel:Load v. Deflection
Defl. at center of panel (Pos. D3)
Load (lbs)
5000
4000
3000
2000
1000
0
0.00
0.69
0.98
1.13
1.26
1.44
1.52
1.64
1.73
1.84
1.85
Deflection (inches)

Figure 3

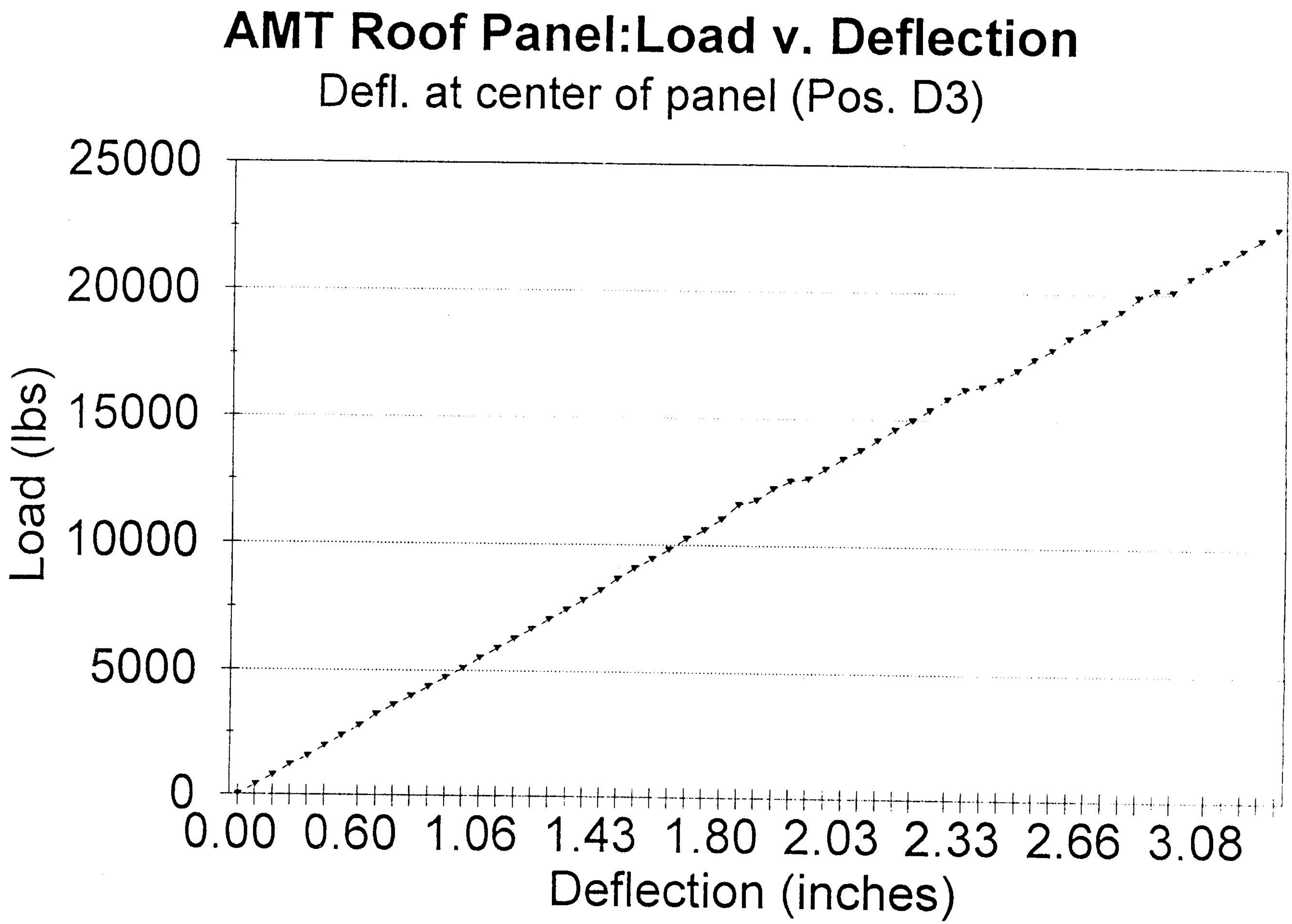
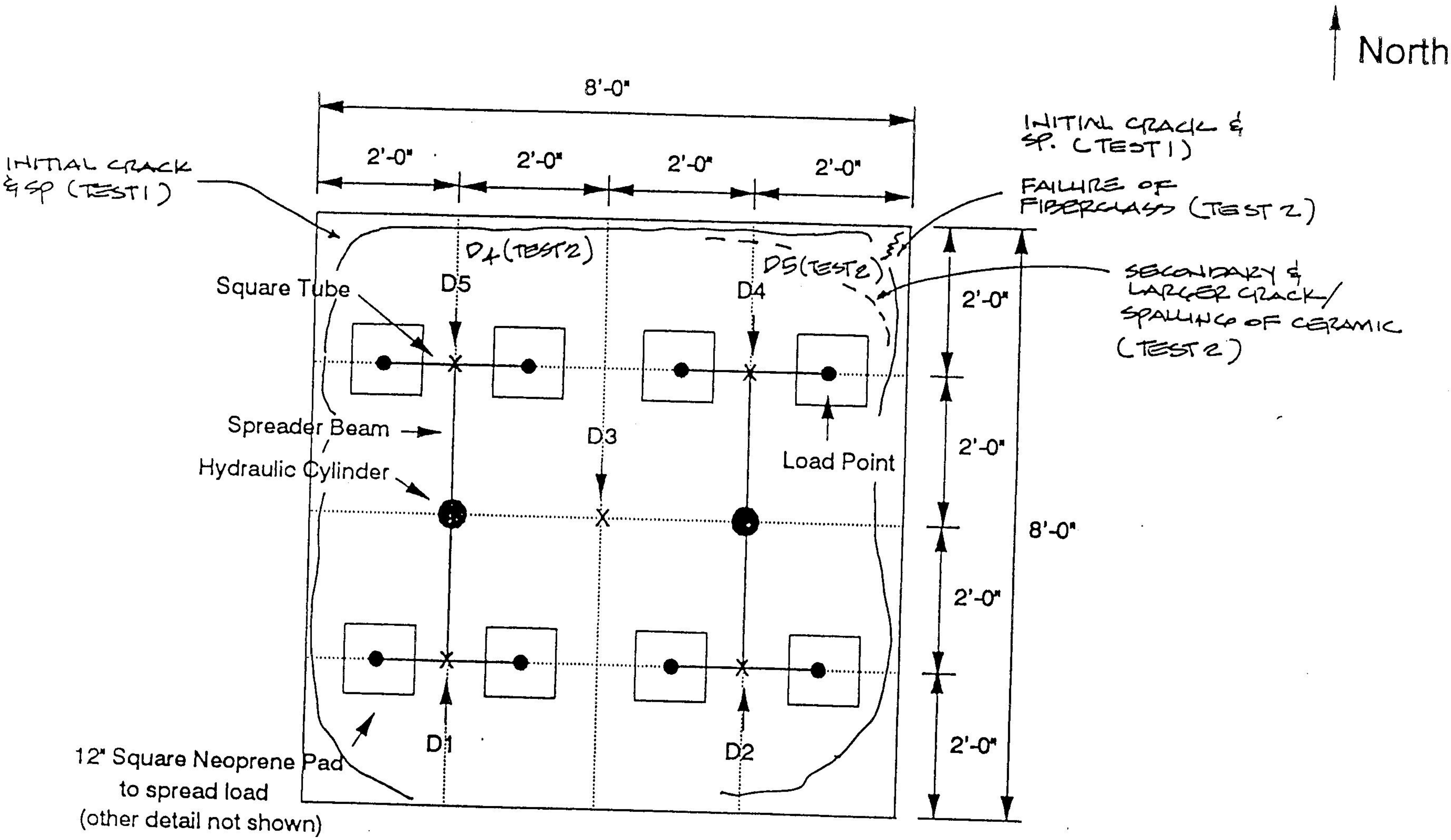

AMT Roof Panel:Load v. Deflection
Defl. at center of panel (Pos. D3)
25000
20000
15000
10000
5000
0
Load (lbs)
0.00
0.60
1.06
1.43
1.80
2.03
2.33
2.66
3.08
Deflection (inches)

Figure 4
Schematic of Crack Patterns



D1...D5 ARE POSITIONS OF DEFLECTION MEASUREMENT

Figure 5

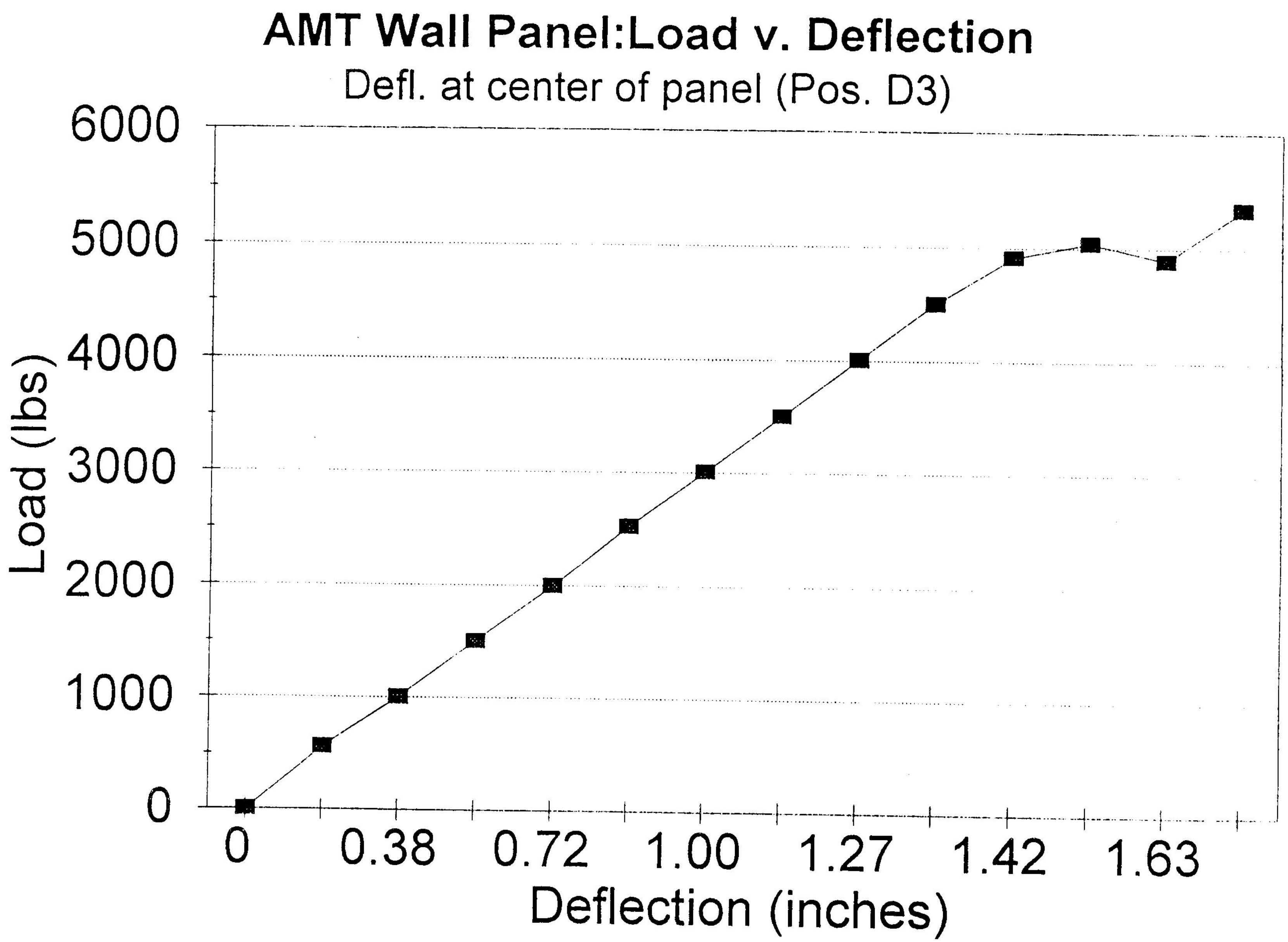
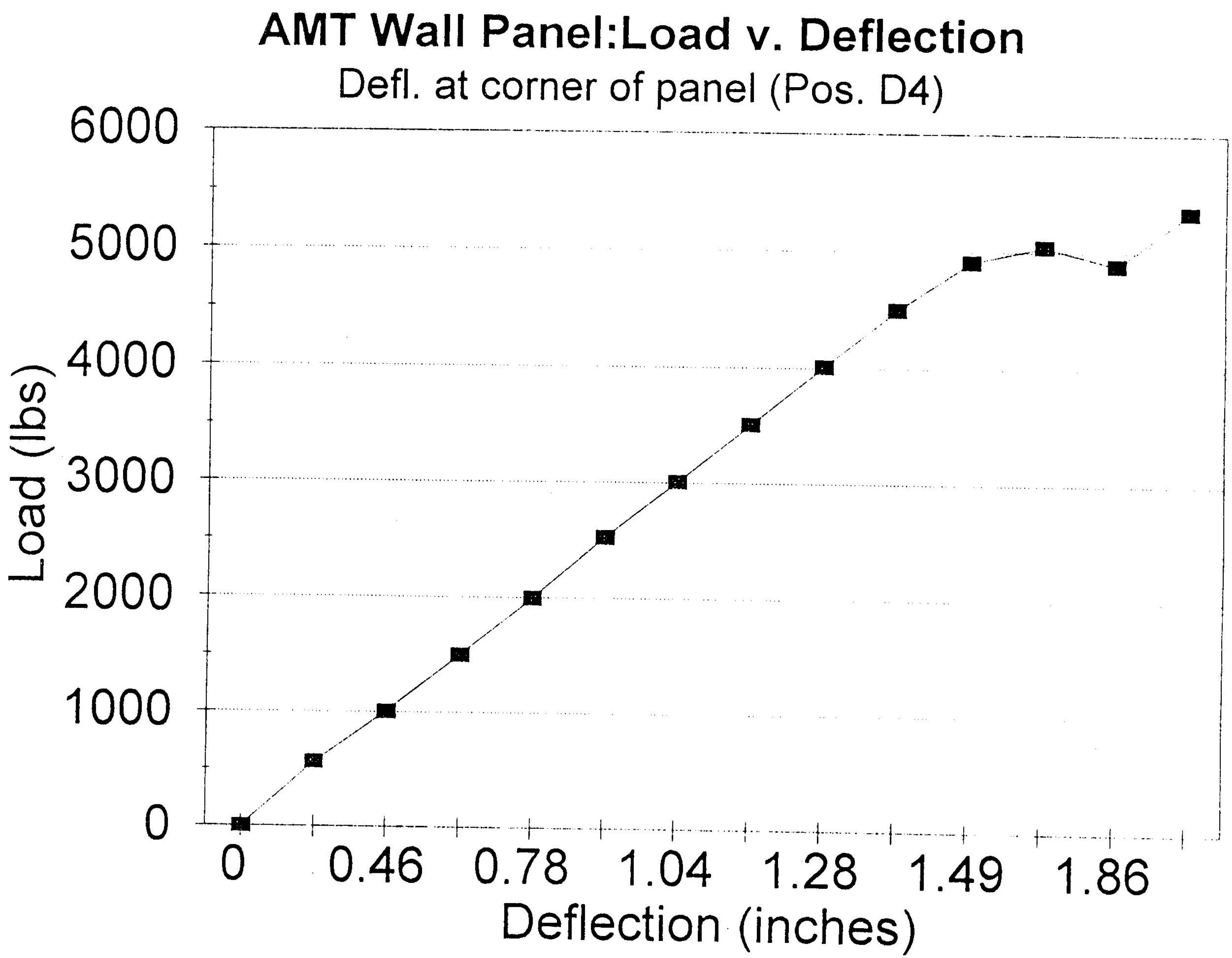

AMT Wall Panel:Load v. Deflection
Defl. at center of panel (Pos. D3)
Load (lbs)
6000
5000
4000
3000
2000
1000
0
0
0.38
0.72
1.00
1.27
1.42
1.63
Deflection (inches)

Figure 6


AMT Wall Panel:Load v. Deflection
Defl. at corner of panel (Pos. D4)
6000
5000
4000
3000
2000
1000
0
Load (lbs)
0
0.46
0.78
1.04
1.28
1.49
1.86
Deflection (inches)