terralab engineers international

Joe Wilson
ROOF TILE MANUFACTURING CO
1230 Railroad Street
Corona CA 91720

Analysis No.	16481
Report Date	25 January 1994
Date Sampled	Unknown
Where Sampled	Unknown
Sampled By	Client

This is to certify that we have examined: Roof Decks, Hail Resistance identified: Roof Decks identified: Sierra Shake or Corona Shake, Decra Tile, and Sierra Tile

When tested to the applicable requirements of:

NBS Series 23 "Hail Resistance of Roofing Materials"

The above identified products withstood hailstones up to 3 inches in diameter without damage. See failure evaluation method in paragraph 3.2 of the attached Report of Test. The products also withstood without damage by impact from 4 inch diameter hailstones. The 4 inch hailstones are not part of the NBS Series 23 and were shot for client information purposes only.

The attached Report of Test is an integral portion of this certificate.

TERRALAB ENGINEERS INTERNATIONAL #12 SLC

TEI© by Matthew MacGregor - Vice President

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NBS Series 23
HAIL RESISTANCE OF ROOFING PRODUCTS

Note: The initial numbers in this report correspond with the paragraph numbers of NBS Series 23. Paragraphs which do not apply to this particular application or are for laboratory use only have been omitted. No deviations from the standard(s) were made unless specifically noted.

Unless specifically noted, all portions of the following tests were conducted by and/or under the continuous direct supervision of Terralab Engineers International, Inc® personnel.

CLIENT:	ROOF TILE MANUFACTURING CO 1230 Railroad Street Corona CA 91720 USA
DATE SAMPLED:	Unknown
SAMPLE RECEIPT DATE:	20 January 1994
SAMPLE CONDITION:	3 Decks of each type were received in "NEW" condition
SAMPLE DESCRIPTION:	Roof Decks, Hail Resistance
SAMPLE IDENTIFICATION:	Roof Decks identified: Sierra Shake or Corona Shake, Decra Tile, and Sierra Tile

REPORT OF TEST

16481

ROOF TILE MANUFACTURING CO
Corona

Roof Decks, Hail Resistance

CAVEAT

Note: The values in this report are the values obtained under standard test conditions and thus may be used for purposes of demonstrating compliance or for comparison with other units tested under the same standard. **The results do not indicate the function of the unit under non-standard or field conditions.**

2. APPARATUS

2.1 Test Apparatus

The test equipment consisted of a compressed air gun calibrated for velocity by "Falcon" radar detector, for launching the hailstones, and a target area. The roof specimens were mounted on a roof deck as they would be in normal service by Roof Tile Manufacturing Company, and set into place ten (10) feet from the discharge end of the gun barrel. The compressed air gun is TEI® manufactured and operated with compressed air.

2.1.1 Calibration

The hail gun was calibrated using a Custom Signal, Falcon Radar gun, property of Murray City Police Department, S/N 257789. Calibration of the radar gun was by the State of Utah Department of Transportation Equipment Maintenance Lab 27 August 1993 due 27 February 1994.

2.2 Hailstone Carriers

The hailstone carriers were made of four (4) inch diameter styrofoam cylinders. The material was obtained as two (2) foot long cylinders, cut into one (1) foot lengths and split in half longitudinally. Each hemicylinder was truncated at one end at 45° to its long axis and milled with one of a series of sizes of hemispheres centered in the hemicylinder. The two halves were then reassembled with the hailstone to be shot at the roof sample.

2.3 Hailstone Molds

The hailstones were formed in balloons and sucker molds and frozen solid in the freezer compartment of a conventional freezer. Hailstones requiring sizing were shaved with wood rasps. The hailstones were measured with Peacock dial caliperes and weighed with a Sartorious Scale to determine hailstone compliance to the following tolerances:

HAILSTONE	TOLERANCE	grams	TOLERANCE
1.00	± 0.05 in	155	± 3.00
1.25	± 0.05 in	193	± 3.80
1.50	± 0.05 in	232	± 4.65
1.75	± 0.05 in	270	± 5.40
2.00	± 0.05 in	309	± 6.20
2.25	± 0.05 in	348	± 7.00
2.50	± 0.05 in	386	± 7.75
2.75	± 0.05 in	425	± 8.50
3.00	± 0.05 in	464	± 9.25
4.00	± 0.05 in	618	± 12.30

2.4 Specimen Construction
The samples were constructed by Roof Tile Manufacturing Company according to their standard method of construction.

3. PROCEDURES

3.1 The test deck was set against a backstop. A hailstone of the desired size was taken from the freezer, cleaned of any burrs or projections and placed into a carrier, which was slid as far as possible into the barrel of the hail gun. The gun was then pressurized with compressed air until the desired pressure was achieved. The valves between the gun and the tank were then closed to protect the gauge. The gun was then fired by opening the solenoid valve, which relieved the pressure behind the floating cylinder in the gun to expel the hailstone carrier. The carrier was propelled out of the gun and the carrier opened from air resistance permitting the hailstone to travel alone toward the target.

The indentation on the specimen was measured and the condition of the specimen recorded after each shot.

3.2 Evaluating Failure

Damage was determined by the two following methods: (1) Severe damage, which leads to penetration of the structure by the elements and (2) Superficial damage, which affects appearance but does not materially interfere with the performance of the roofing. Only fractures of the coating are called failures in this report.

4. RESULTS

(See Figures 1-9 of this report.)

SIERRA/CORONA SHAKE TILE (DECK 1)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
1	1.0	35.5, 12	2	0.059 deep indentation
2	1.0	27.8, 11.5	2	No indentation
3	1.0	29.5, 16.8	2	No indentation
4	1.25	43.3, 16.5	2	0.059 deep indentation
5	1.25	12.8, 15.3	2	0.039 deep indentation
6	1.25	22, 14.8	2	0.034 deep indentation
7	1.5	39.8, 2.8	2	0.292 deep indentation, stone chip loss
8	1.5	16.9, 1.8	2	0.243 deep indentation
9	1.5	19.5, 20	2	0.260 deep indentation
10	1.75	7.3, 20.3	2	0.395 deep indentation
11	1.75	29.5, 19.8	2	0.159 deep indentation
12	1.75	35.3, 19.5	2	0.456 deep indentation
13	2.0	15.5, 31.5	2	0.472 deep indentation, stone chip loss
14	2.0	30.8, 33	2	0.337 deep indentation
15	2.0	44.3, 24.8	2	0.187 deep indentation

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

SIERRA/CORONA SHAKE TILE (DECK 2)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
16	2.25	38.3, 24.8	2	0.558 deep indentation
17	2.25	26, 25	2	0.657 deep indentation
18	2.25	18.8, 30.5	2	0.306 deep indentation
19	2.5	14, 8.5	2	0.735 deep indentation
20	2.5	24.8, 4.5	2	0.421 deep indentation, stone chip loss
21	2.5	42.5, 3.5	2	0.220 deep indentation, stone chip loss
22	2.75	40.8, 8.5	2	0.385 deep indentation
23	2.75	31.5, 15.5	2	0.435 deep indentation
24	2.75	21, 16.5	2	0.621 deep indentation, stone chip loss

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

SIERRA/CORONA SHAKE TILE (DECK 3)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
25	3.0	20.5, 16	2	1.477 deep indentation, stone chip loss
26	3.0	33.5, 16.5	2	1.525 deep indentation, stone chip loss
27	3.0	35.5, 29.5	2	1.284 deep indentation, stone chip loss
28	4.0	20.5, 30	2	1.697 deep indentation, stone chip loss

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

DECRA TILE (DECK 1)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
1	1.0	22.5, 5	2	No indentation
2	1.0	13.5, 7	2	0.050 deep indentation
3	1.0	32.8, 7	2	0.048 deep indentation
4	1.25	39.5, 6.5	2	0.050 deep indentation
5	1.25	27, 8.5	2	0.062 deep indentation
6	1.25	26.5, 15.3	2	0.039 deep indentation
7	1.5	39.8, 15	2	0.051 deep indentation
8	1.5	43, 14.5	2	0.045 deep indentation
9	1.5	41.8, 21.3	2	0.068 deep indentation
10	1.75	31.8, 20.3	2	0.198 deep indentation
11	1.75	21.8, 20.3	2	0.307 deep indentation, stone chip loss
12	1.75	14.3, 20.5	2	0.150 deep indentation
13	2.0	15.5, 30.5	2	0.045 deep indentation, stone chip loss
14	2.0	27, 29	2	0.102 deep indentation
15	2.0	41, 28	1	0.263 deep indentation, 1.0 tear

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

DECRA TILE (DECK 2)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
16	2.0	37.3, 27.3	2	0.276 deep indentation, stone chip loss
17	2.0	30, 27	2	0.358 deep indentation, stone chip loss
18	2.0	17.5, 28.5	2	0.195 deep indentation
19	2.25	16.5, 4.5	2	1.493 deep indentation
20	2.25	31.5, 6	2	0.409 deep indentation
21	2.25	43.3, 5	2	1.350 deep indentation
22	2.5	44, 24.8	2	1.518 deep indentation, stone chip loss
23	2.5	10.5, 24	2	0.333 deep indentation
24	2.5	11.3, 35.3	2	0.480 deep indentation

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

DECRA TILE (DECK 3)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
25	2.75	12, 35	1	0.711 deep indentation, 1.5 inch tear
26	2.75	28.5, 33.5	2	1.011 deep indentation
27	2.75	37, 33.5	2	1.577 deep indentation, stone chip loss
28	2.75	38.3, 20.5	2	1.055 deep indentation
29	3.0	38, 13	2	1.013 deep indentation
30	3.0	27, 12	2	0.785 deep indentation
31	3.0	19, 13	2	0.807 deep indentation
32	4.0	21.5, 20.3	2	1.510 deep indentation

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

SIERRA TILE (DECK 1)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
1	1.25	25.5, 18.8	2	0.067 deep indentation
2	1.0	23.6, 25.5	2	No indentation
3	1.0	14, 6.3	2	0.052 deep indentation
4	1.0	26.8, 6.2	2	No indentation
5	1.25	12.5, 18.8	2	0.088 deep indentation
6	1.25	15.6, 23.5	2	No indentation
7	1.5	35.5, 23.3	2	0.060 deep indentation
8	1.5	39.3, 9.5	2	0.100 deep indentation
9	1.5	39, 14.5	2	0.050 deep indentation
10	1.75	47, 38.8	2	0.118 deep indentation
11	1.75	25, 37.3	2	0.047 deep indentation, stone chip loss
12	1.75	15.6, 24.6	2	0.239 deep indentation, stone chip loss
29	4.0	10, 8	2	2.335 deep indentation (Shot 01 Feb 94)

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

SIERRA TILE (DECK 2)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
13	2.0	15, 28.5	2	0.040 deep indentation, stone chip loss
14	2.0	22.5, 13.5	2	0.263 deep indentation
15	2.0	35.3, 21.5	2	0.014 deep indentation
16	2.25	32.5, 29	2	0.081 deep indentation
17	2.25	27.8, 10.3	2	0.307 deep indentation
18	2.25	32.3, 12	2	0.235 deep indentation
19	2.5	16, 20.5	2	0.849 deep indentation
20	2.5	11.8, 31	2	0.194 deep indentation, stone chip loss
21	2.5	27.3, 37	2	0.307 deep indentation
30	4.0	15.5, 8.5	2	2.452 deep indentation (Shot 01 Feb 94)

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

SIERRA TILE (DECK 3)				
SHOT	HAIL SIZE	LOCATION*	DAMAGE	OBSERVATIONS
22	2.75	30, 36.5	2	1.465 deep indentation, stone chip loss
23	2.75	36.3, 17	2	0.766 deep indentation, stone chip loss
24	2.75	17.5, 25.3	2	1.009 deep indentation
25	3.0	10, 21.5	2	1.690 deep indentation
26	3.0	18, 14	2	0.745 deep indentation
27	3.0	39.3, 12	2	1.010 deep indentation
28	4.0	24.5, 7.5	1	1.505 deep indentation, 1.5 inch tear

* Impact locations are given in inches in the format (A,B) in which A is the distance from the left edge and B is the distance vertically from the top.

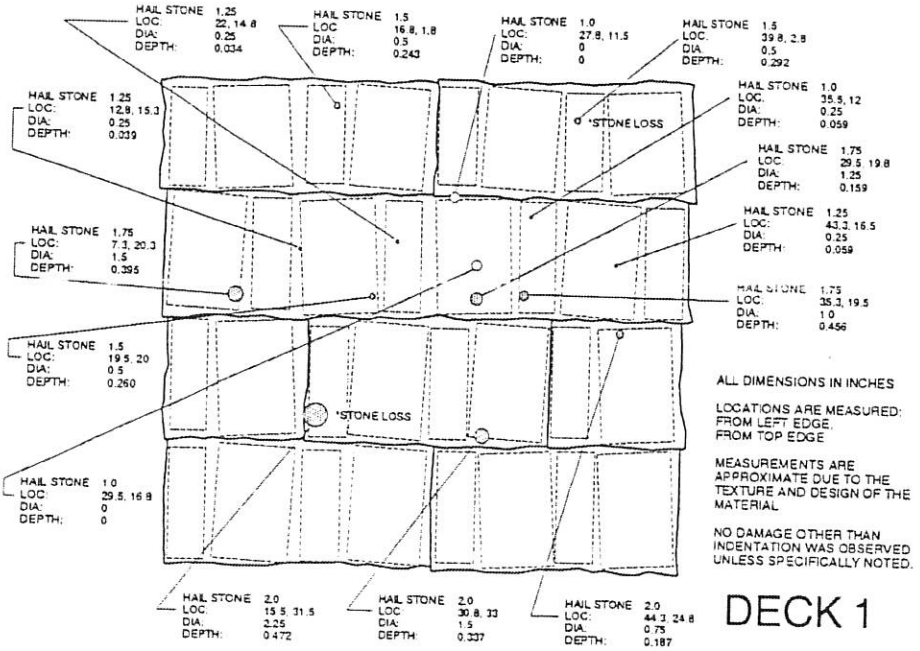


Figure 1 Sierra/Corona Shake Tile

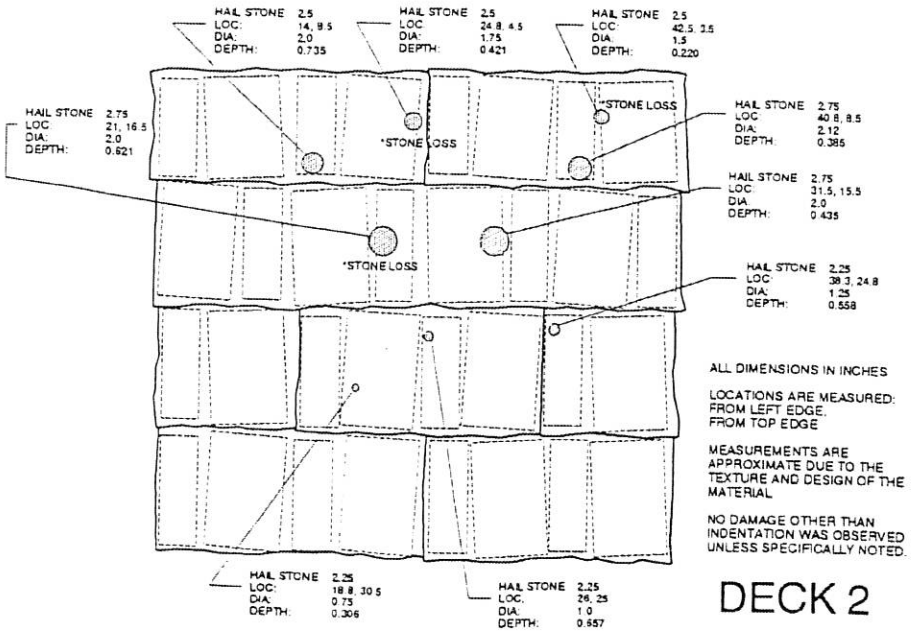


Figure 2 Sierra/Corona Shake Tile

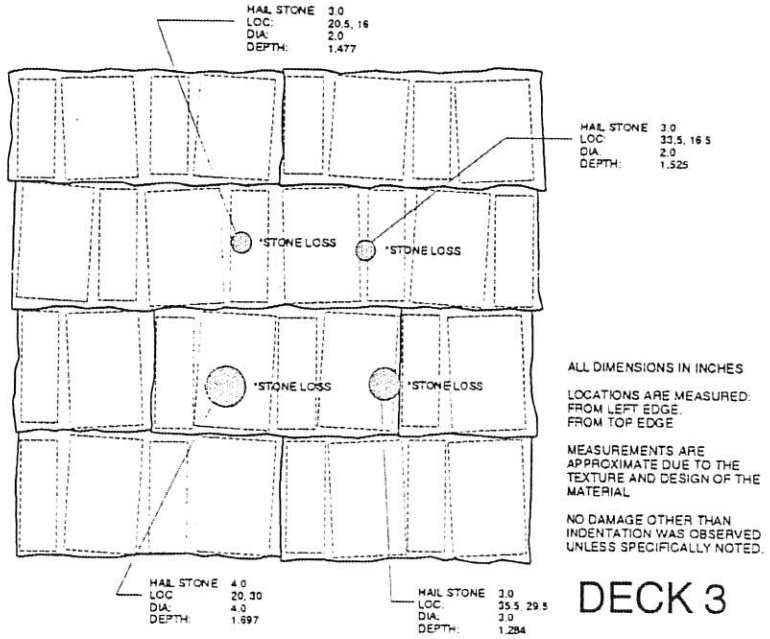


Figure 3 Sierra/Corona Shake Tile

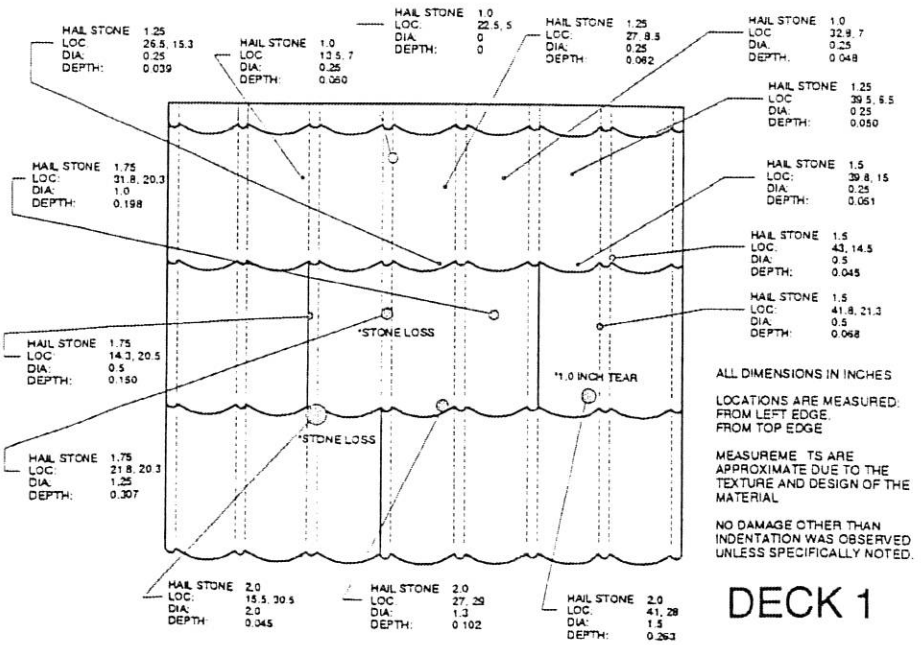


Figure 4 Decra Tile

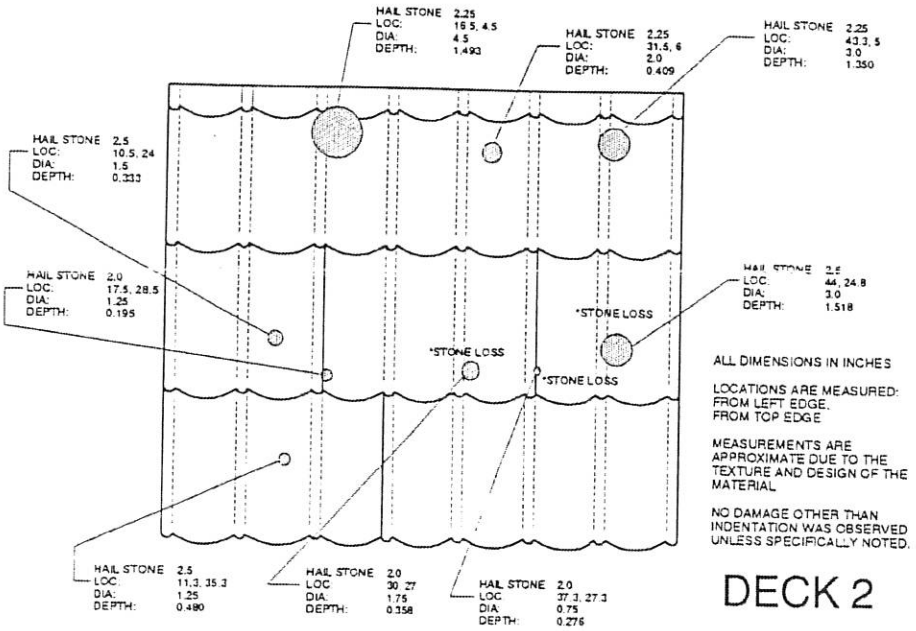


Figure 5 Decra Tile

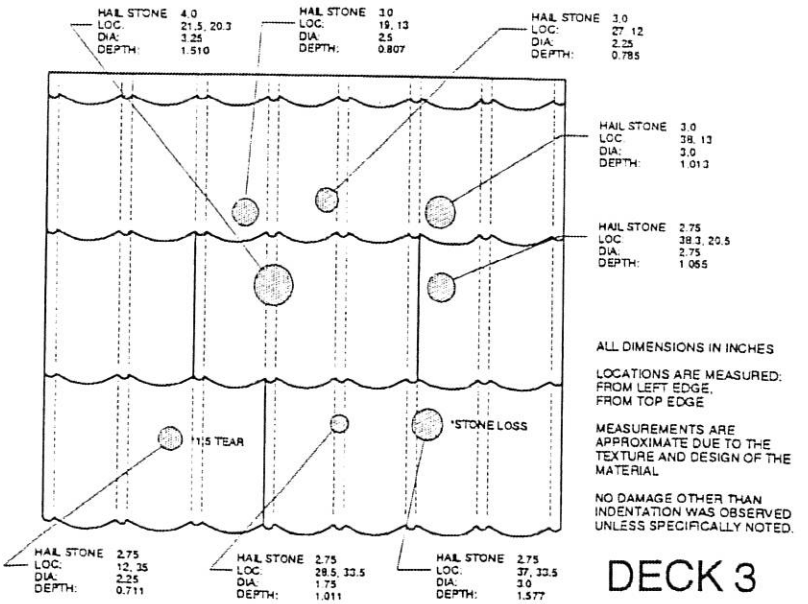


Figure 6 Decra Tile

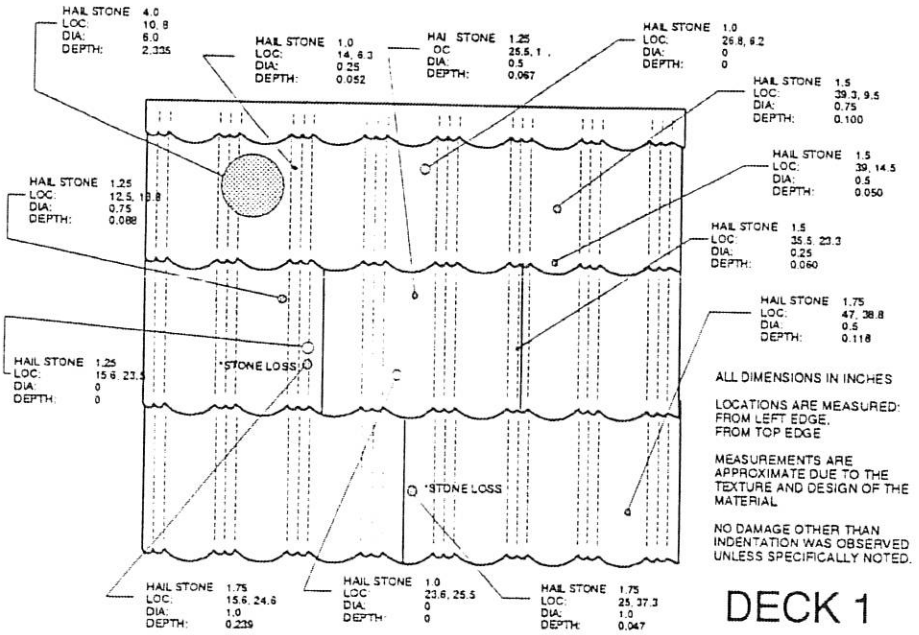


Figure 7 Sierra Tile

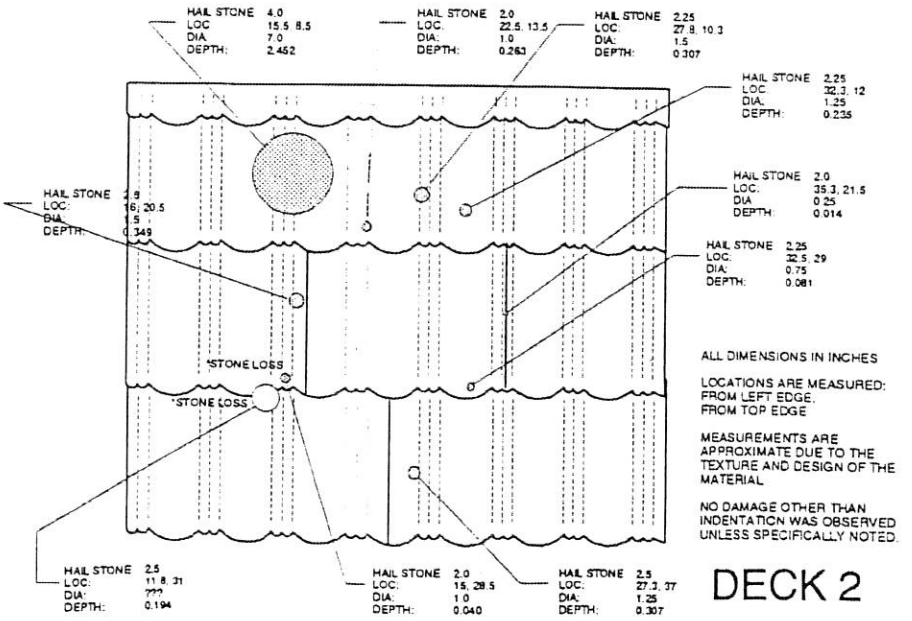


Figure 8 Sierra Tile

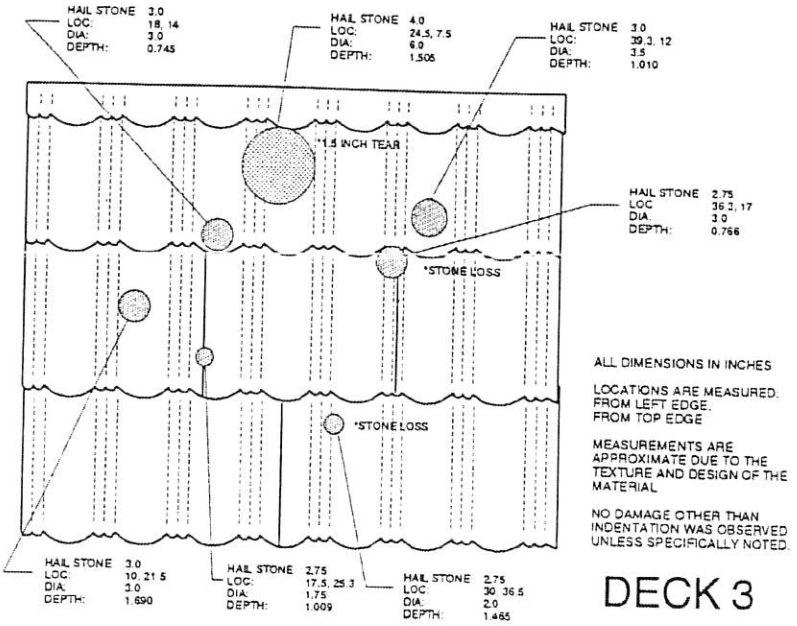
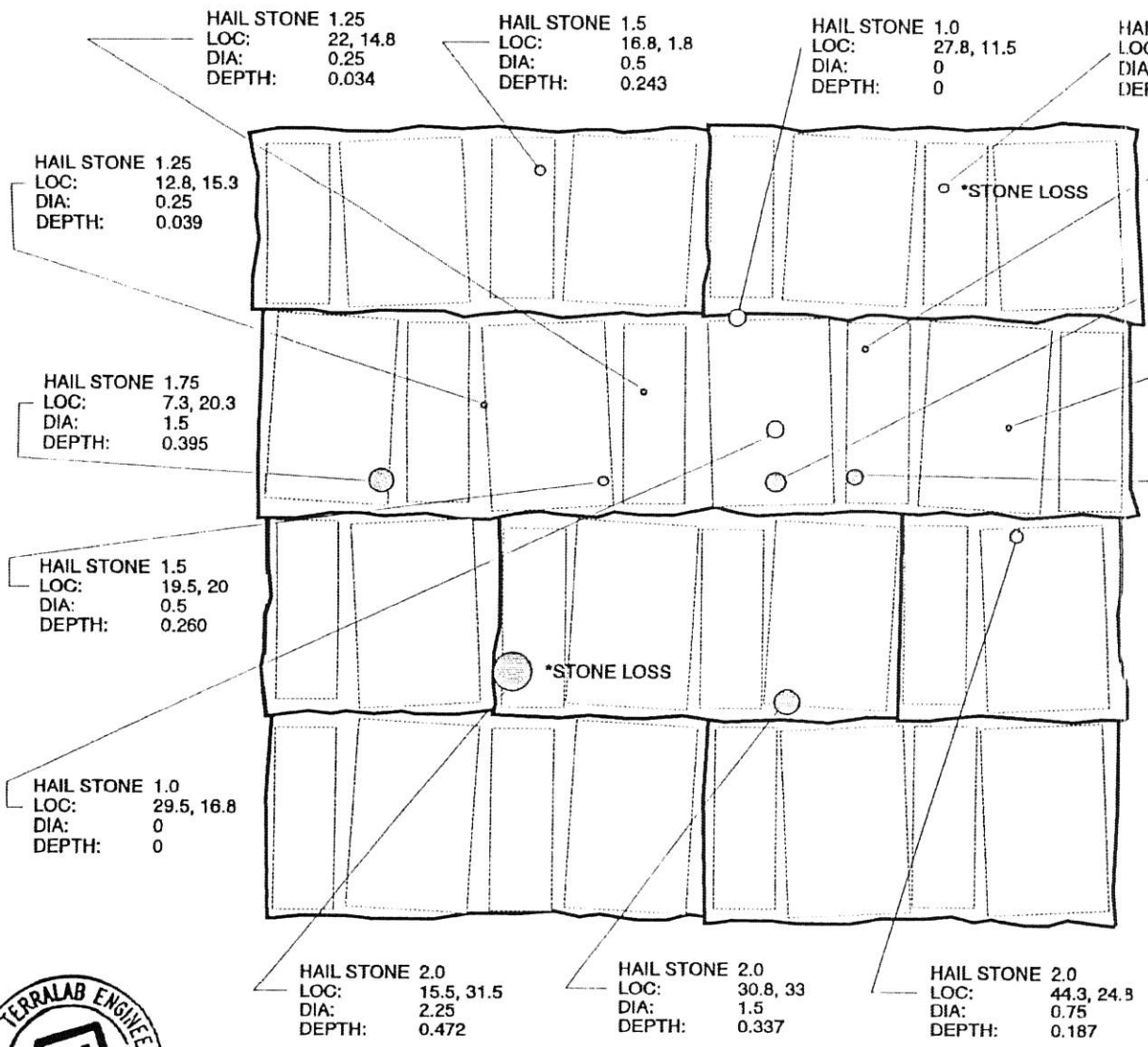


Figure 9 Sierra Tile

*** Larger Figure drawings are appended ***

END OF TEST REPORT



ALL DIMENSIONS IN INCHES

LOCATIONS ARE MEASURED:
FROM LEFT EDGE,
FROM TOP EDGE

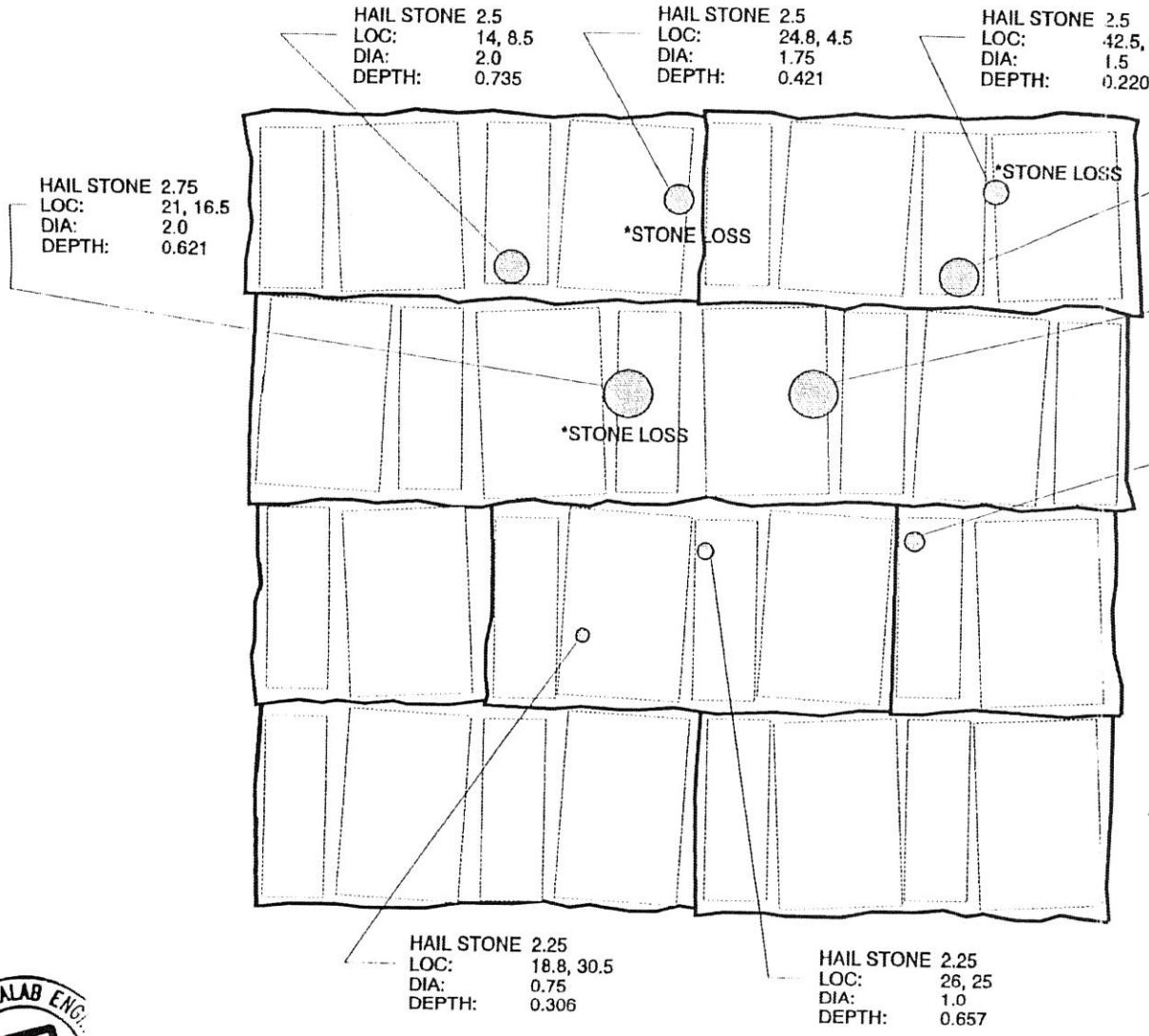
MEASUREMENTS ARE APPROXIMATE DUE TO THE TEXTURE AND DESIGN OF THE MATERIAL

NO DAMAGE OTHER THAN INDENTATION WAS OBSERVED UNLESS SPECIFICALLY NOTED.

DECK 1

FIGURE 1

TERRALAB ENGINEERS INTERNATIONAL #1 SLC



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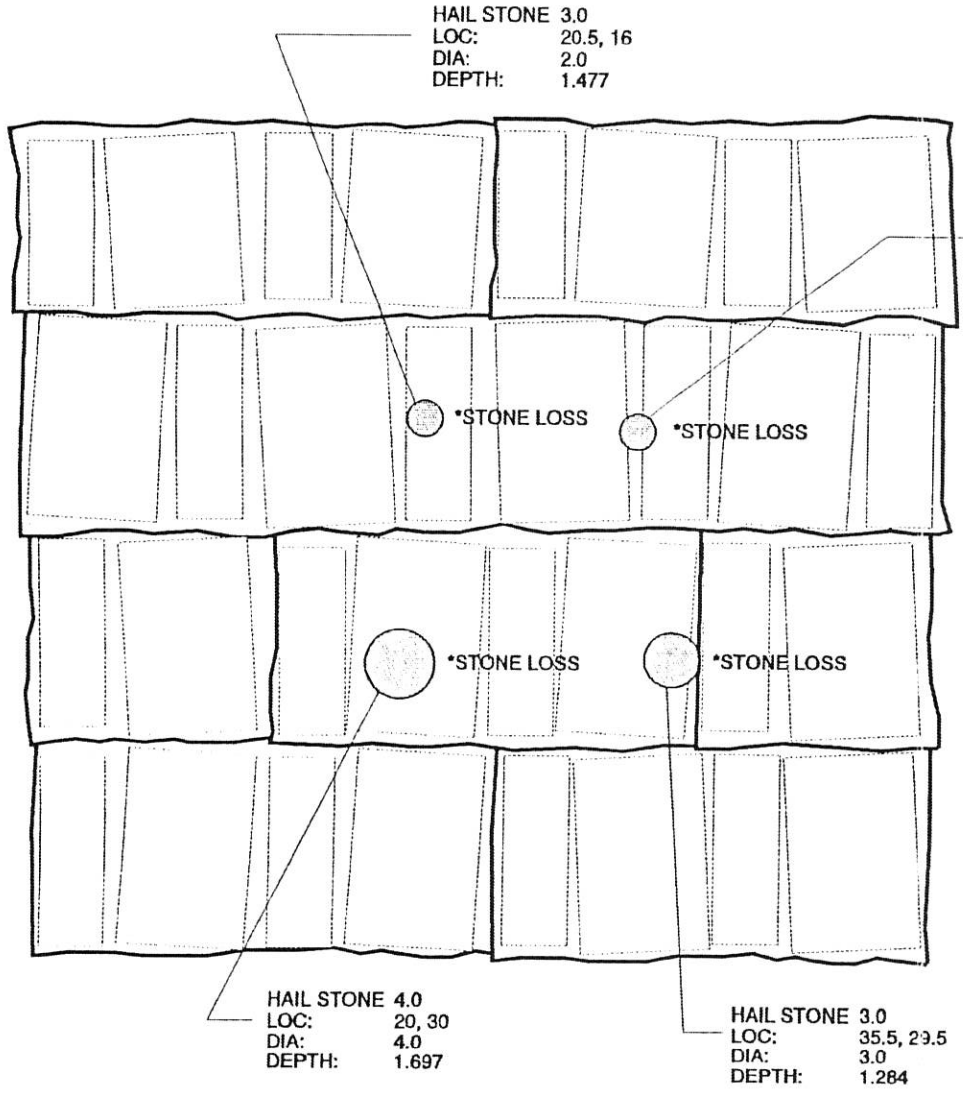
DECK 2

FIGURE 2

TERRALAB ENG. SLC NATIONAL



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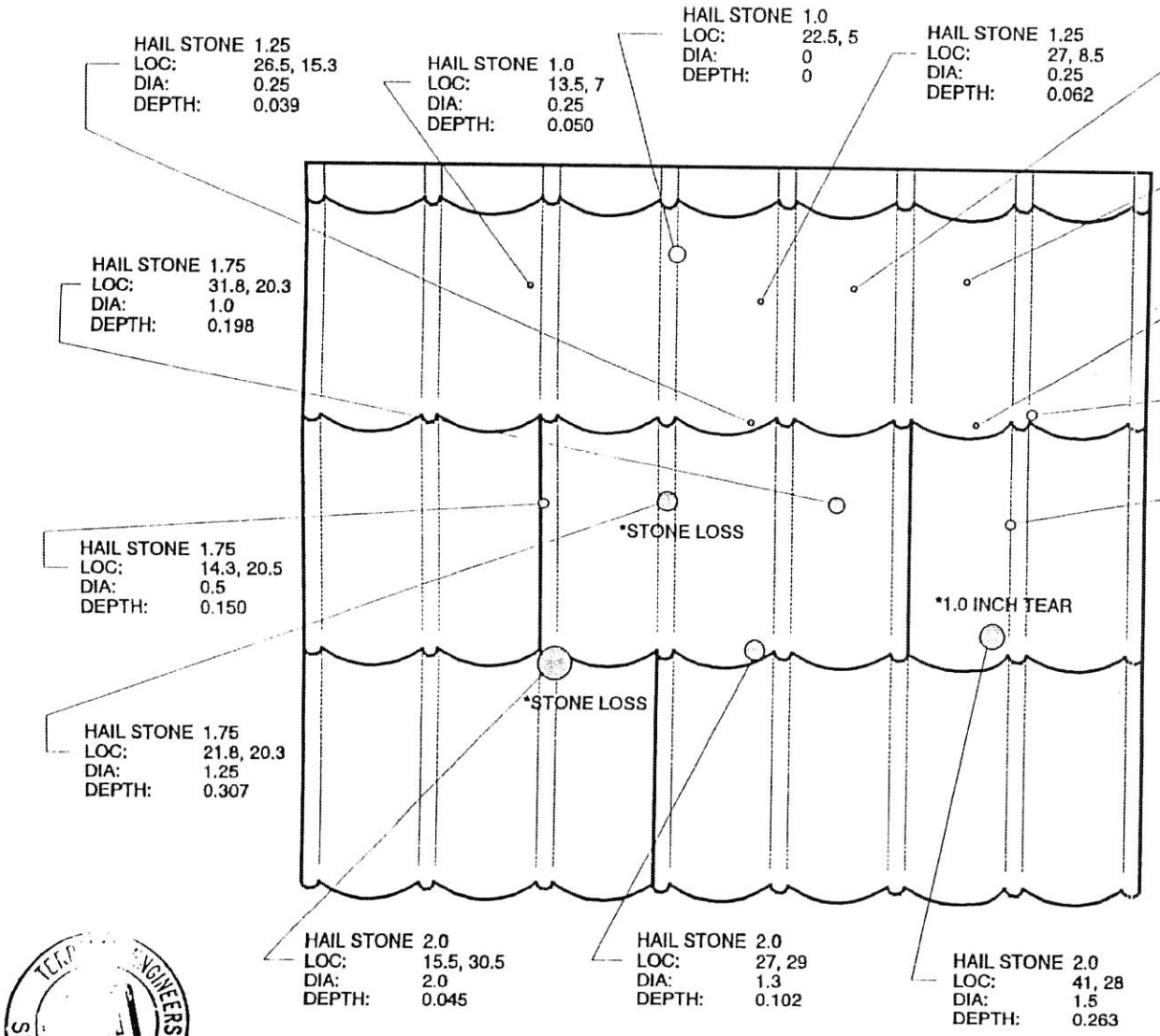
DECK 3

FIGURE 3

SLC INTERNATIONAL



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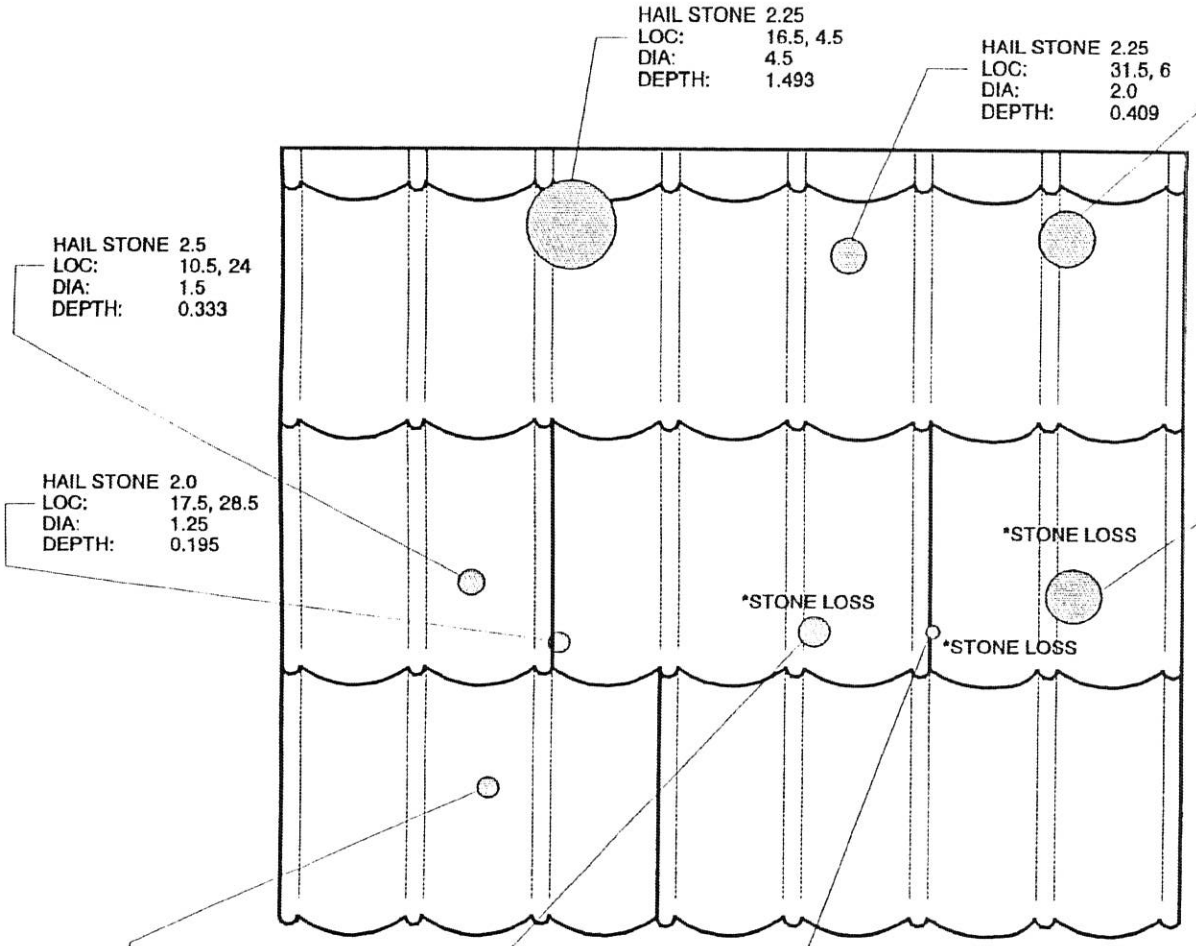
DECK 1

FIGURE 4



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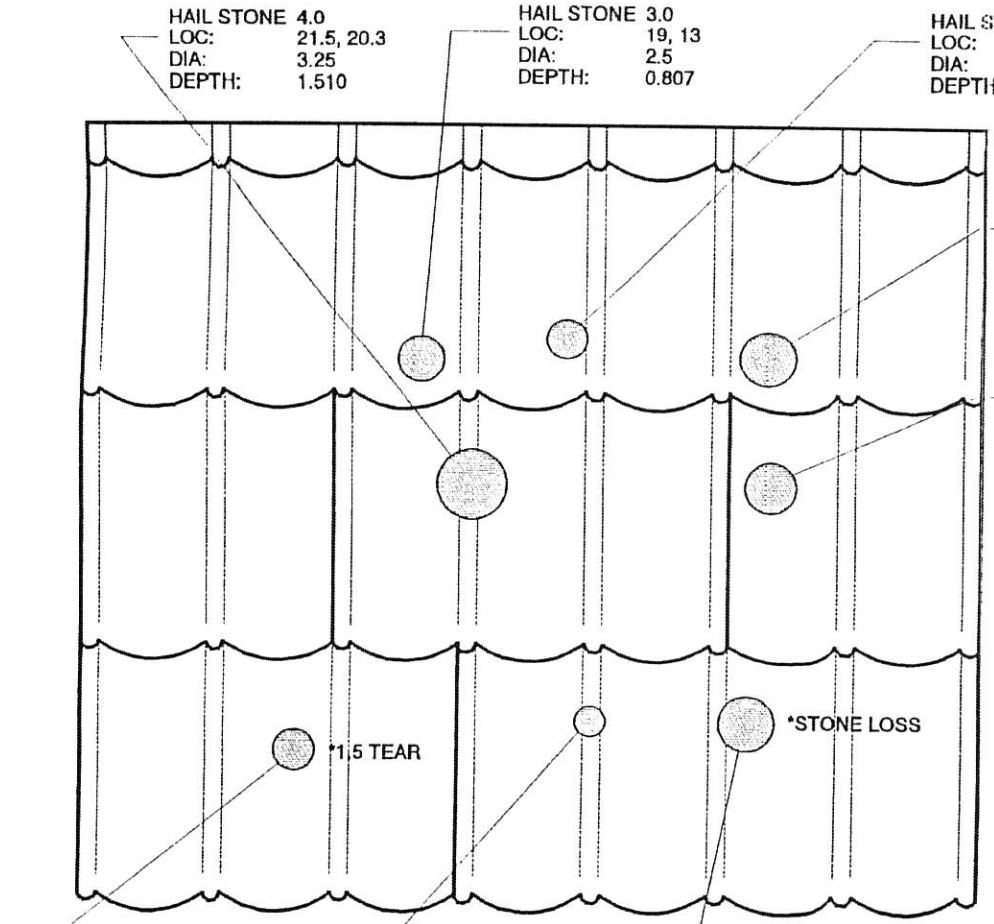
DECK 2

FIGURE 5

TERRACON ENGINEERS INTERNATIONAL SLC



ALL DIMENSIONS IN INCHES

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FROM TOP EDGE

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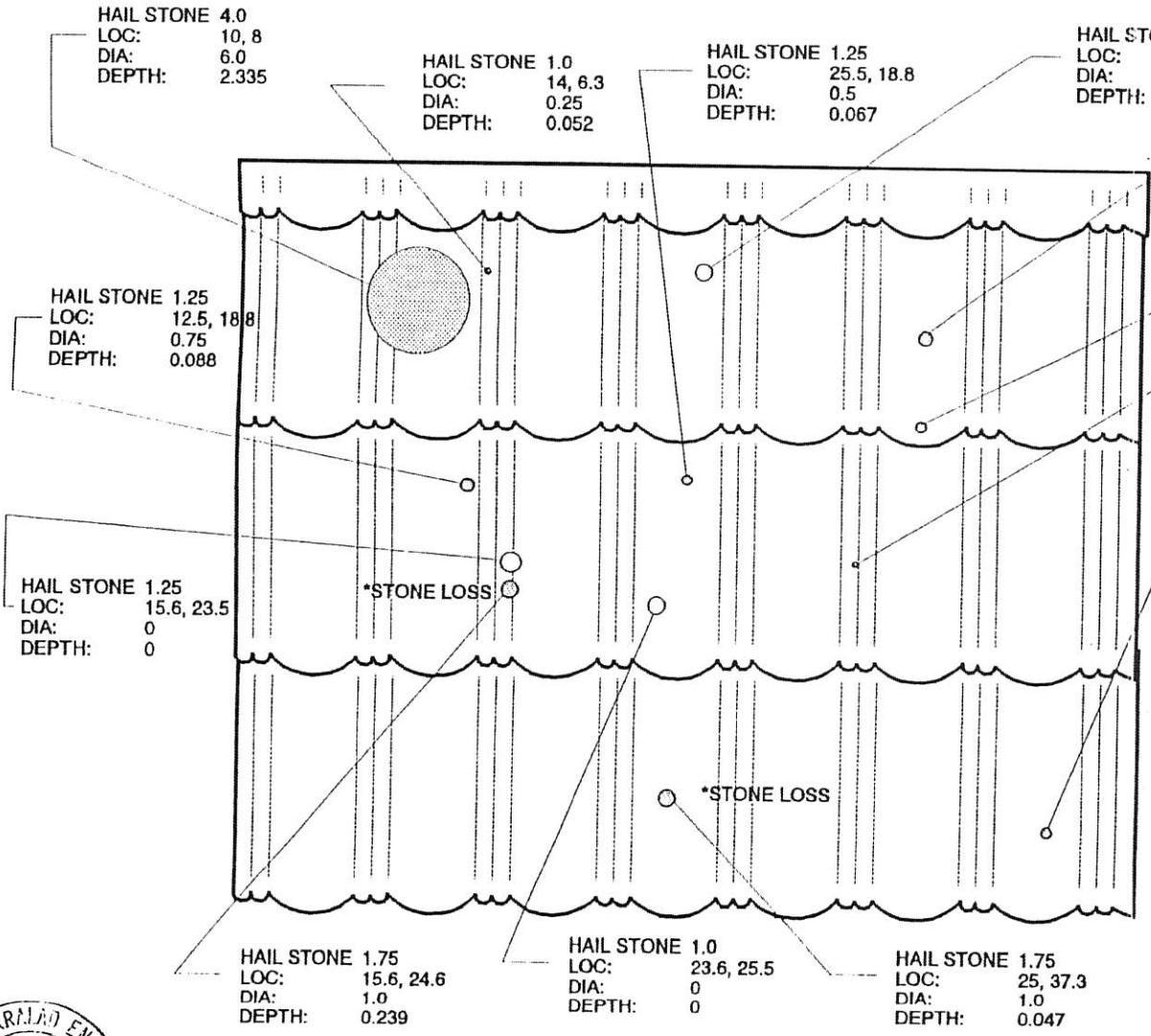
DECK 3

FIGURE 6

TERRALAD ENGINEERS INTERNATIONAL SLC #1



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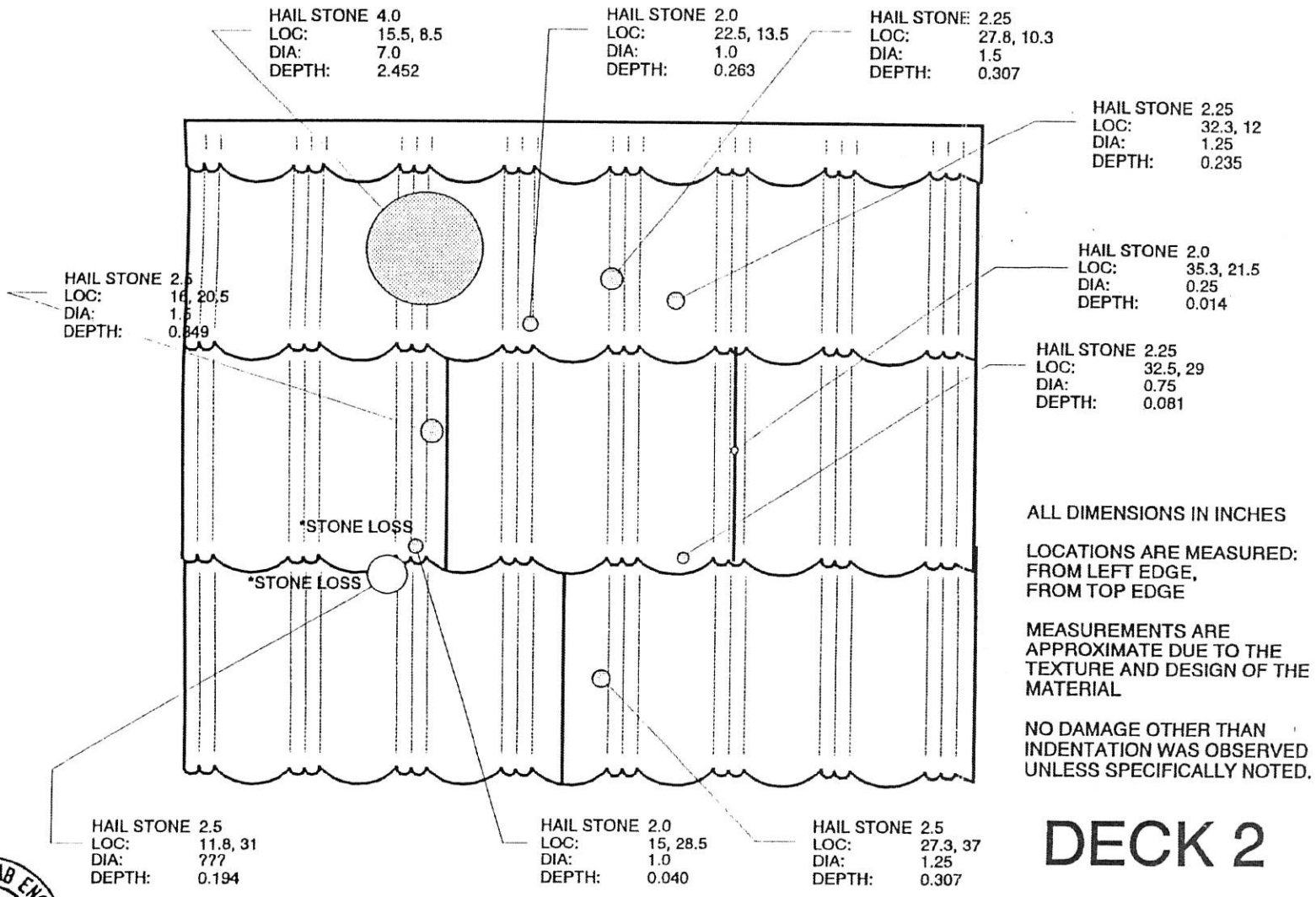
DECK 1

FIGURE 7



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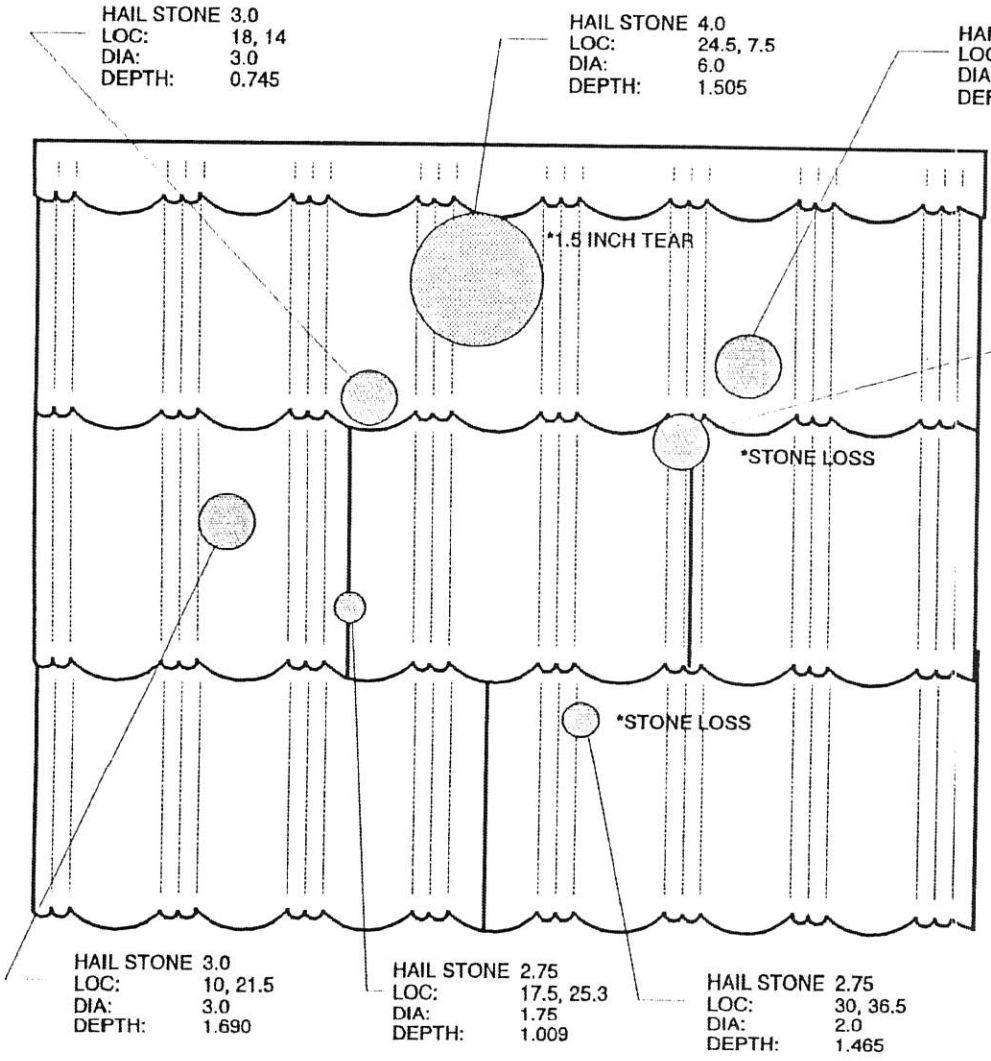
DECK 2

FIGURE 8

TERRALAB ENGINEERS INTERNATIONAL SLC



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DECK 3

FIGURE 9

TERRALAB ENGINEERS INTERNATIONAL SLC #1