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SONISCOPE SURVEY, PAD 39-A CAPE KENNEDY, FLORIDA

by

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CORPS OF ENGINEERS
Vicksburg, Mississippi

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Foreword

The soniscope survey at Cape Kennedy, Florida, was authorized by teletype from the District Engineer, U. S. Army Engineer District, Canaveral, Merritt Island, Florida, dated 21 April 1965, to the Director, U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi.

The investigation was conducted by Messrs. H. T. Thornton, Jr., and R. F. Black of the WES Concrete Division, with the assistance of Mr. Joe Woodruff, Chief, District Laboratory, Canaveral District, and Mr. C. M. Stewart, Jr. This report was prepared by Mr. Thornton, under the supervision of Messrs. T. B. Kennedy, B. Mather, and E. E. McCoy, Jr., all of the WES Concrete Division.

Director of the WES during the conduct of this investigation and the preparation and publication of this report was Col. John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

Contents

Summary

Soniscope tests were conducted on concrete of pad 39-A at Cape Kennedy, Florida, to determine whether cracks present in the concrete were caused by placement of inferior quality concrete or by stresses imposed on normally good concrete. Compressive strength and pulse velocity tests were also conducted on 6- by 12-in. concrete cylinders made from a mixture comparable to that used in pad 39-A to aid in determining the quality of the concrete.

The tests revealed that the concrete is of generally good to excellent quality and that the cracking was caused by stresses of an undetermined nature.

SONISCOPE SURVEY, PAD 39-A, CAPE KENNEDY, FLORIDA

Introduction

Purpose

1. The purpose of this investigation was to examine concrete in areas of launch pad 39-A, as directed by Cape Kennedy personnel, to determine the general quality of the concrete used in the structure, and to try to determine if the cracking in the structure was associated with inferior quality concrete.

Test equipment

2. The equipment used in this survey was similar to that described in CRD-C 51-57.* The soniscope is an instrument that transmits pulses of ultrasonic waves through a material and electronically measures the time of travel from the transmitter to a receiver while each is held against the surface of the material a known distance apart. The velocity through the material is computed from the time of travel and the path length. This velocity provides an index to the condition, or quality, of concrete through which the readings are taken. The general rule of thumb used is:

Velocity, fps	Quality
Above 15,000	Excellent
12,000 to 15,000	Generally good
10,000 to 12,000	Questionable
7000 to 10,000	Generally poor
Below 7000	Very poor

Procedure

3. The procedure outlined for the investigation of pad 39-A was as follows:

a. Take velocity measurements through several sections of apparently undamaged concrete to establish a representative velocity for the good concrete.

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* U. S. Army Engineer Waterways Experiment Station, CE, Handbook for Concrete and Cement, with quarterly supplements (Vicksburg, Miss., August 1949).

b. In all areas, note any significant deviation in velocity which would indicate inferior quality concrete.

c. Take velocity measurements in areas where damage is evidenced by cracking.

d. Try to determine if the apparent damage was caused by placement of inferior quality concrete or by stresses imposed on normally good concrete.

e. Establish a correlation between pulse velocity and compressive strength by determining these two properties on several 6- by 12-in. cylinders made from a mixture comparable to that used for the concrete in pad 39-A.

Tests and Results

Field tests

4. A total of 123 velocity measurements were made in eight areas of pad 39-A. Of this number only 36 velocities were below 14,000 fps, and all of those were measured in areas where damage due to cracking was evident. The areas where tests were performed and the data obtained are described in the following paragraphs.

5. West wall of ECS building.

a. North end near ceiling. All readings in this area were taken diagonally through the wall from station 1 (plate 1) on the east face to stations located on the west face of the wall. The path of each reading passed through concrete in which damage by cracking was apparent. One measurement which produced a velocity of 15,245 fps seemed to be effected very little by the one crack in its path. However, the other eight readings in this area ranged between 12,030 fps and "too poor to read," thus showing the drastic effect that cracking can have on pulse velocity. Results of tests in this area are given in plate 1.

b. Just south of area discussed above. A total of 36 measurements were taken in this area (plate 2). Six of these were taken straight through the wall, and 30 were taken diagonally from stations on the west face to stations on the east face. The six straight-through readings averaged 15,400 fps. Most of the diagonal readings were taken through cracked areas and consequently showed velocities below 15,400 fps. However, since only six velocities were below 13,000 fps and the lowest of these was 10,295 fps, the effect of cracking on velocity in this area does not seem to be drastic. Three of the stations on the west face of the wall were located in patched areas, but the patches seemed to have very little, if any, effect on velocities. Results of tests in this area are given in plate 2.

c. Between roll-up door and large opening. Four readings were taken through the section of wall between the roll-up door and the large opening north of the door (plate 3). Two of these readings, taken through the undamaged area, produced velocities of 14,610 and 14,925 fps. The two readings taken through the cracked area gave velocities of 13,770 and 12,425 fps. Plate 3 shows results of tests in this area.

d. South end. Thirty-two measurements were made in this area of the west wall (plate 4). Fifteen straight-through readings averaged 14,570 fps. Of the seventeen diagonal readings taken, the six which did not cross cracks averaged 14,835 fps, and the 11 which crossed cracks averaged 14,270 fps. The hairline cracks in this area had very little effect on velocity.

6. Roof adjacent to west wall of ECS building. Fill dirt was excavated from the roof at four sites adjacent to the west wall. Stations A, B, C, and D were located on the topside of the roof, one at each of the four excavated sites. Stations bearing the same letters (A, B, C, and D) were then located on the underside of the roof directly beneath the four stations on the top. From each of these stations on the underside of the roof, an array of points was established and numbered for the purpose of exploring the surrounding concrete with a series of diagonal measurements from the station on top to the station and points underneath. Fig. 1 shows the location of the four stations on the

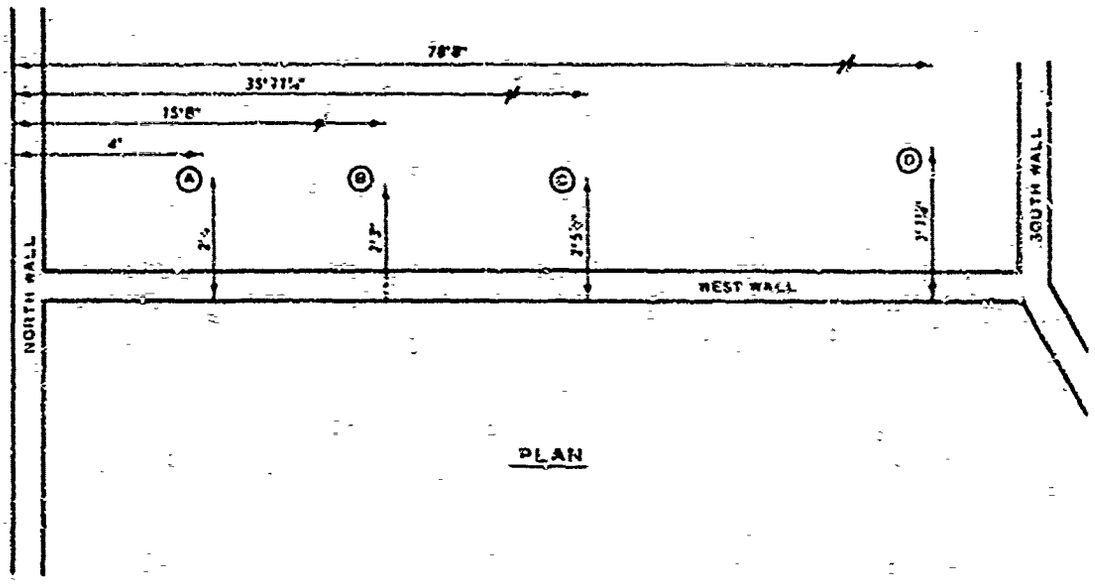


Fig. 1. Station locations on roof of ECS building

rooftop. Plates 5, 6, 7, and 8 show the locations of points around each of stations A, B, C, and D on the underside of the roof. These plates also give the results of tests at each of the four sites. There was no apparent cracking in the vicinities of stations A and D, nor did the velocity measurements reveal anything unusual. The areas around stations B and C did show some cracking, and the results obtained at these two sites are discussed below.

a. Station B. The roof in the vicinity of station B was cracked in several places (plate 6). The straight-through reading showed a velocity of 16,665 fps. The remaining seven readings produced velocities between 15,285 and 12,415 fps. Lower readings were obtained as the number of cracks in the path of the signal increased.

b. Station C. There was only one visible crack in the vicinity of station C (plate 7). The four velocities which were significantly lower than the others were apparently affected by this crack. The remaining velocities in this area were uniform, and nothing unusual was indicated.

Laboratory tests

7. Sixteen 6- by 12-in. concrete cylinders were tested for pulse velocity and then broken in compression. The cylinders were made from samples of concrete used in several areas of pad 39-B, which was comparable to the concrete used in pad 39-A and was proportioned to have a compressive strength of 3000 psi at 28 days age. Six of the specimens had compressive strengths ranging between 2785 and 3810 psi at 7 days age and velocities ranging between 13,600 and 14,570 fps. The remaining ten specimens had compressive strengths ranging between 3350 and 5310 psi at 28 days age and velocities between 13,975 and 16,450 fps. The data on these specimens are shown in the following tabulation.

	7 Days Age			28 Days Age	
Specimen No.	Compressive Strength, psi	Velocity fps	Specimen No.	Compressive Strength, psi	Velocity fps
59-A	2890	13,785	30-D	5310	15,940
59-B	2785	13,600	30-E	4415	16,450
59-C	2785	13,785	30-F	4945	15,940
60-A	3775	14,165	A-2	4840	14,570
60-B	3810	14,365	B-2	4700	14,365
60-C	3775	14,570	C-2	4735	14,365
			1-C	4985	14,169
			28-A	3350	13,975
			28-B	4380	13,975
			28-C	4415	13,975

Using the data given in the preceding tabulation, a plot of compressive strength versus pulse velocity was made and the least-squares straight line was calculated (fig. 2).

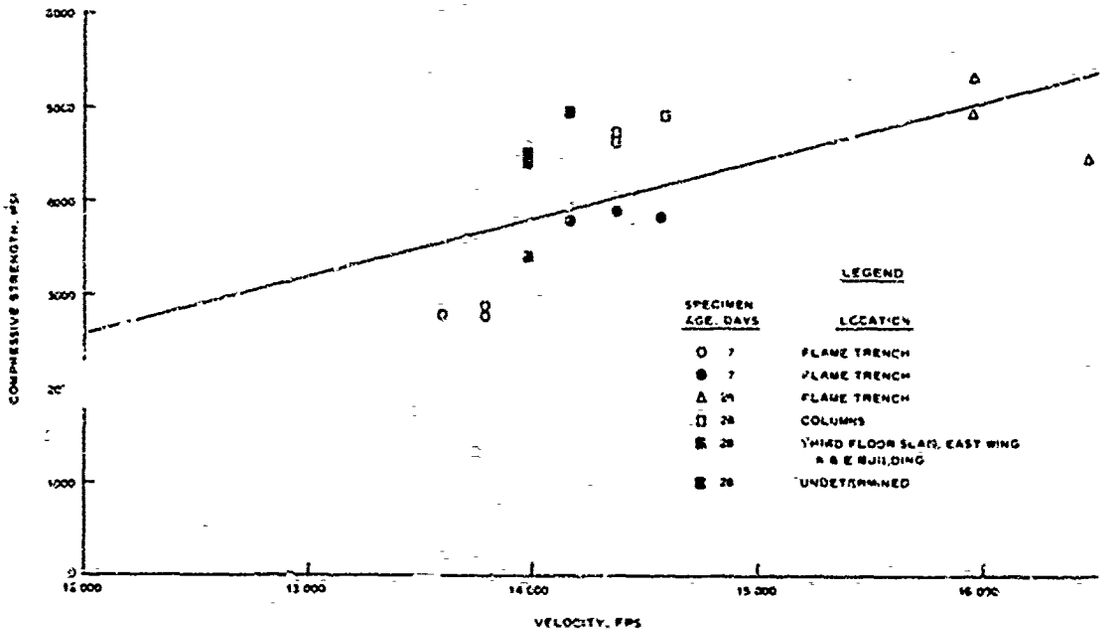


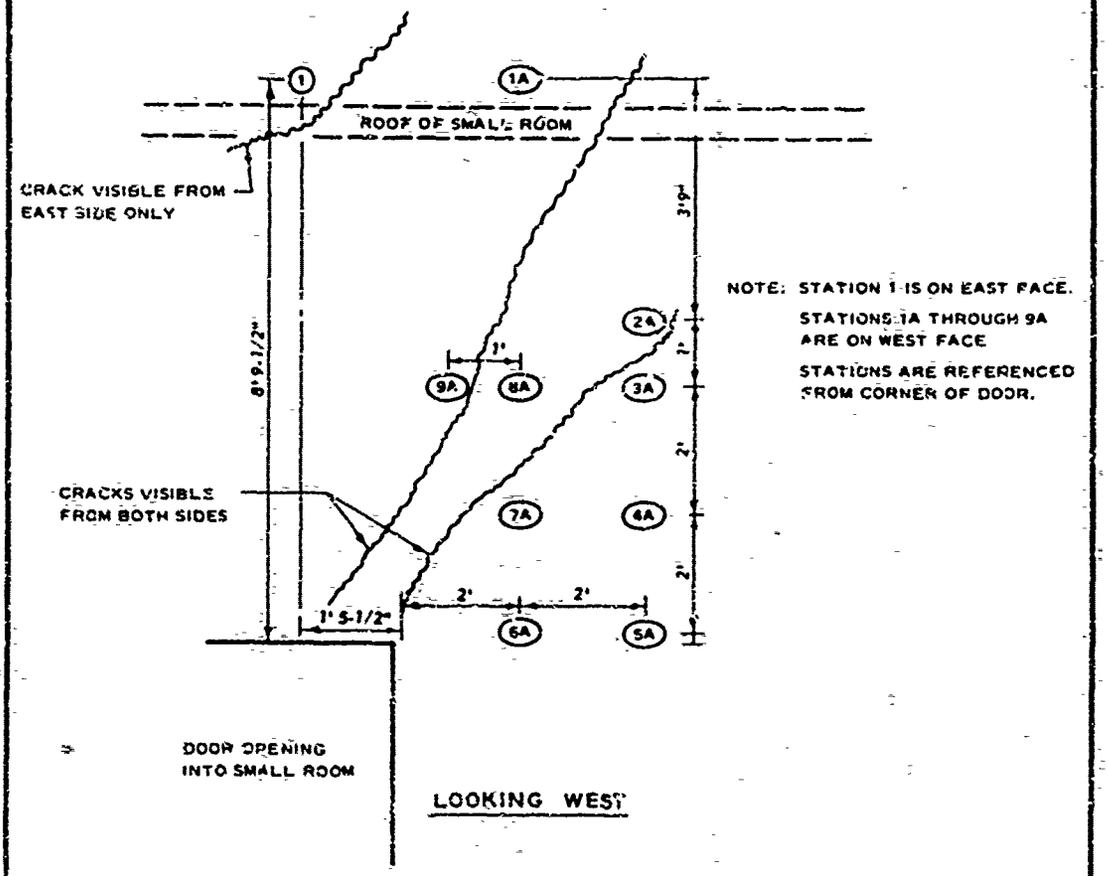
Fig. 2. Compressive strength versus velocity for 6- by 12-in. cylinders

Conclusions

8. The velocities measured in the areas of undamaged concrete ranged generally between 14,000 and 16,000 fps. These velocities indicate generally good to excellent quality concrete. Of the 113 velocity measurements made at pad 39-A, only 36 were below 14,000 fps. All of these 36 were made across or in the vicinity of damaged concrete.

9. Results obtained from the compressive strength-pulse velocity tests performed on the 6- by 12-in. cylinders which were made from a concrete mixture comparable to that used in pad 39-A indicate that a velocity of 14,000 fps represents a compressive strength of at least 3000 psi.

10. Since examination of data obtained from all tests performed seems to indicate that the undamaged concrete in the areas tested is of generally good to excellent quality (compressive strength of at least 3000 psi), it is concluded that the cracking in the structure was caused by stresses of an undetermined nature.

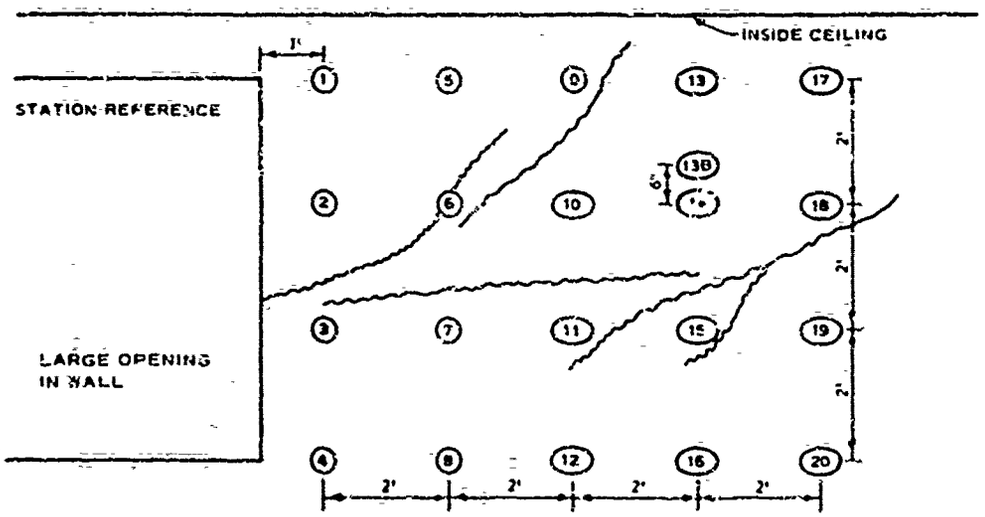


STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS
1 TO 1A	2.50	15,245	
1 TO 2A	4.72	5,915	
1 TO 3A	6.40	4,015	
1 TO 4A	8.00	5,715	
1 TO 5A			TOO POOR TO READ
1 TO 6A	9.10	7,025	
1 TO 7A	7.20	6,515	
1 TO 8A	5.38	7,310	
1 TO 9A	5.10	12,010	

NOTE ALL READINGS WERE TAKEN DIAGONALLY THROUGH THE WALL

STATION LOCATION AND PULSE VELOCITY DATA, NORTH END OF WEST WALL ECS BUILDING

PLATE 1



LOOKING WEST

NOTE: STATIONS 1 THROUGH 20 ARE LOCATED ON EAST FACE.

STATIONS 1A, 5A, 9A, 13A, AND 17A ARE ON WEST FACE OPPOSITE STATIONS 1, 5, 9, 13, AND 17, RESPECTIVELY.

STATION 13B IS LOCATED ON BOTH FACES FOR A STRAIGHT-THROUGH READING.

STATIONS 1A, 13A, AND 17A WERE IN A PATCHED AREA

STATIONS ARE REFERENCED FROM CORNER OF LARGE OPENING IN WALL

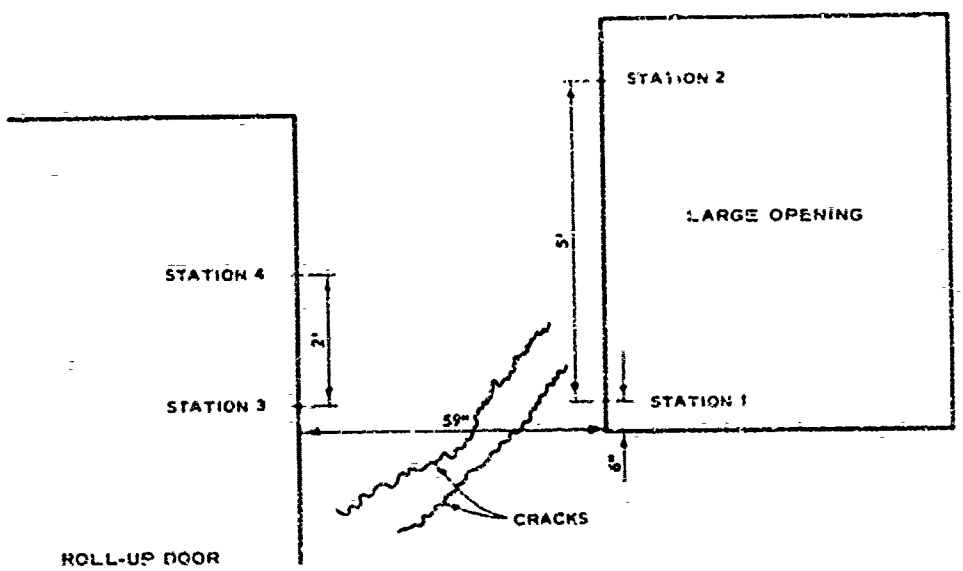
STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	DIRECTION OF READINGS THROUGH WALL	STATION NUMBER	PATH LENGTH FT	VELOCITY, FPS	DIRECTION OF READINGS THROUGH WALL
1 TO 1A	1.50	14,705	STRAIGHT	9A TO 11	4.27	13,555	DIAGONAL*
1A TO 2	2.50	15,150	DIAGONAL	9A TO 12	6.18	13,735	DIAGONAL
1A TO 3	4.27	14,675	DIAGONAL*	9A TO 4	7.31	14,390	DIAGONAL*
1A TO 4	6.18	14,610	DIAGONAL*	9A TO 2	4.75	14,845	DIAGONAL*
1A TO 5	2.50	13,890	DIAGONAL	9A TO 20	7.31	10,295	DIAGONAL*
1A TO 6	3.17	14,090	DIAGONAL*	9A TO 18	4.75	12,180	DIAGONAL*
1A TO 7	4.71	11,555	DIAGONAL*	13 TO 13A	1.50	15,625	STRAIGHT
1A TO 8	6.52	13,960	DIAGONAL*	13A TO 14	2.50	14,705	DIAGONAL
5 TO 5A	1.50	14,850	STRAIGHT	13A TO 15	4.27	13,345	DIAGONAL*
5A TO 6	2.50	14,535	DIAGONAL*	13A TO 16	6.18	14,045	DIAGONAL*
5A TO 7	4.27	13,430	DIAGONAL*	13B TO 13B	4.75	11,390	DIAGONAL*
5A TO 8	6.18	13,675	DIAGONAL*	15 TO 17A	1.50	16,130	STRAIGHT
5A TO 9	2.50	14,795	DIAGONAL	15 TO 17A	1.50	15,955	STRAIGHT
5A TO 10	3.17	11,125	DIAGONAL*	17A TO 18	2.50	14,705	DIAGONAL
5A TO 11	4.71	12,695	DIAGONAL*	17A TO 19	4.27	14,140	DIAGONAL*
5A TO 12	6.52	13,470	DIAGONAL*	17A TO 20	6.18	14,475	DIAGONAL*
9 TO 9A	1.50	15,150	STRAIGHT	17A TO 15	4.75	14,395	DIAGONAL*
9A TO 10	2.50	14,535	DIAGONAL*	17A TO 16	6.52	14,620	DIAGONAL*

* ACROSS-CRACK READING.

STATION LOCATION AND PULSE VELOCITY DATA, WEST WALL JUST SOUTH OF AREA IN PLATE 1

ECS BUILDING

PLATE



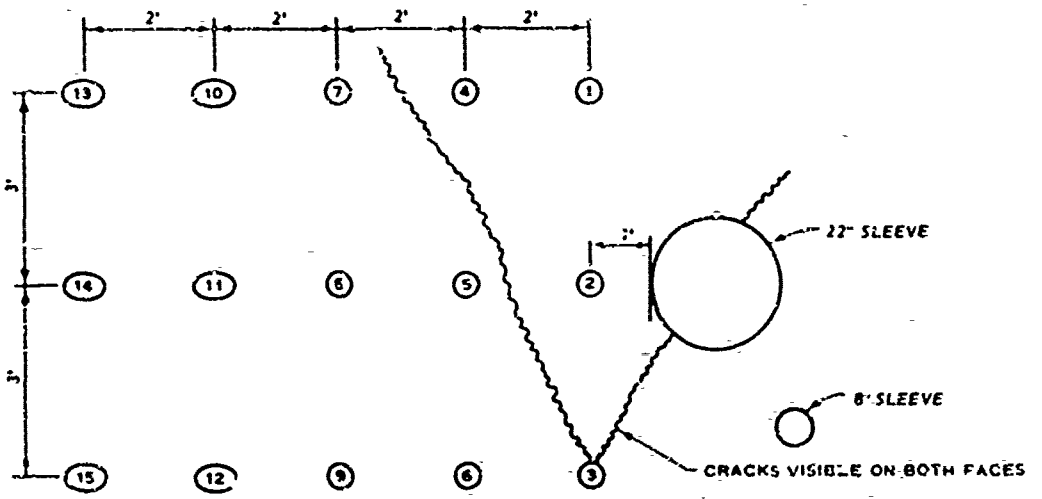
LOOKING WEST

NOTE: STATIONS 1 AND 2 ARE LOCATED IN CENTER OF SOUTH FACE OF OPENING
STATIONS 3 AND 4 ARE LOCATED IN CENTER OF NORTH FACE OF DOOR

STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS
1 TO 3	4.92	12,425	THROUGH CRACKS
1 TO 4	5.30	10,770	THROUGH CRACKS
2 TO 3	7.00	14,925	
2 TO 4	5.77	14,610	

STATION LOCATION AND PULSE VELOCITY DATA, WEST WALL BETWEEN ROLL-UP DOOR AND LARGE OPENING ECS BUILDING

PLATE



LOOKING EAST

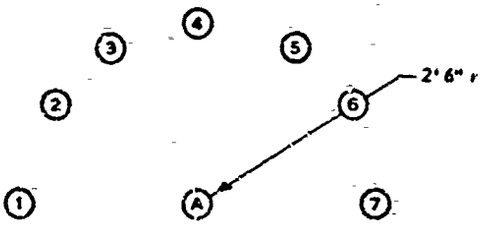
NOTE: STATIONS 1 THROUGH 15 ARE LOCATED ON WEST FACE.
IDENTICALLY LOCATED STATIONS ON EAST FACE ARE NUMBERED 1A THROUGH 15A.
STATIONS ARE REFERENCED FROM NORTH SIDE OF 22-IN. SLEEVE.

STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS	STATION NUMBER	PATH LENGTH, FT	VELOCITY FPS	REMARKS
1 TO 1A	1.50	13,425	*	10 TO 10A	1.50	13,850	*
2 TO 2A	1.50	14,705	*	11 TO 11A	1.50	14,285	*
3 TO 3A	1.50	15,295	*	12 TO 12A	1.50	15,150	*
4 TO 4A	1.50	14,285	*	7 TO 4A	2.50	14,705	**†
5 TO 5A	1.50	14,150	*	8 TO 1A	5.22	14,540	**†
6 TO 6A	1.50	14,150	*	9 TO 2A	5.22	13,955	**†
2 TO 4A	3.96	15,115	**	7A TO 11	3.96	15,470	**
2 TO 6A	3.96	13,800	**†	9A TO 11	3.96	14,045	**
3 TO 4A	6.50	14,190	**†	13 TO 13A	1.50	15,305	*
3 TO 6A	3.96	13,945	**†	14 TO 14A	1.50	14,285	*
1A TO 6	6.50	14,410	**†	15 TO 15A	1.50	14,850	*
1A TO 5	3.96	15,055	**†	11 TO 13A	3.96	15,590	**
2 TO 5A	2.50	14,490	**†	11 TO 14A	2.50	14,535	**
7 TO 7A	1.50	14,850	*	11 TO 15A	3.96	14,245	***
8 TO 8A	1.50	14,285	*	1 TO 15A	10.00	13,985	**†
9 TO 9A	1.50	14,705	*	3 TO 13A	10.00	1,910	***

* DENOTES READINGS STRAIGHT THROUGH THE WALL
** DENOTES READINGS TAKEN DIAGONALLY THROUGH WALL
† ACROSS-CRACK READING.

STATION LOCATION AND PULSE VELOCITY DATA, SOUTH END OF WEST WALL EGS BUILDING

PLATE 5



WEST WALL

PLAN

NOTE: STATION A WAS MARKED ON TOP AND ON UNDERSIDE OF ROOF.
STATIONS 1 THROUGH 7 WERE LOCATED ON UNDERSIDE OF ROOF.
THERE WAS NO VISIBLE DAMAGE IN THIS AREA.

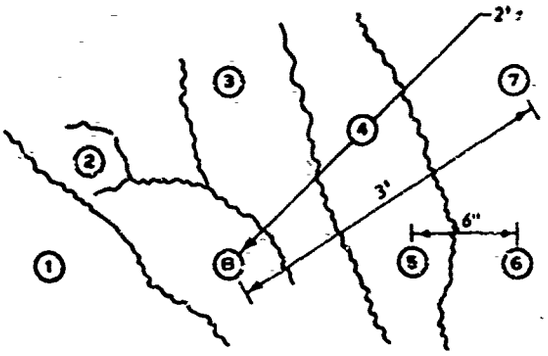
STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS
A TO A	2.50	16,025	*
A TO 1	3.54	15,000	**
A TO 2	3.54	15,130	**
A TO 3	3.54	13,875	**
A TO 4	3.54	14,935	**
A TO 5	3.54	15,130	**
A TO 6	3.54	15,260	**
A TO 7	3.54	15,325	**

* DENOTES VERTICAL READING STRAIGHT THROUGH THE ROOF.

** DENOTES DIAGONAL READINGS TAKEN FROM STATION A ON TOP TO POINTS ON UNDERSIDE OF THE ROOF.

STATION LOCATION AND PULSE VELOCITY DATA, STATION A ON ROOF
ECS BUILDING

PLATE 5



WEST WALL

PLAN

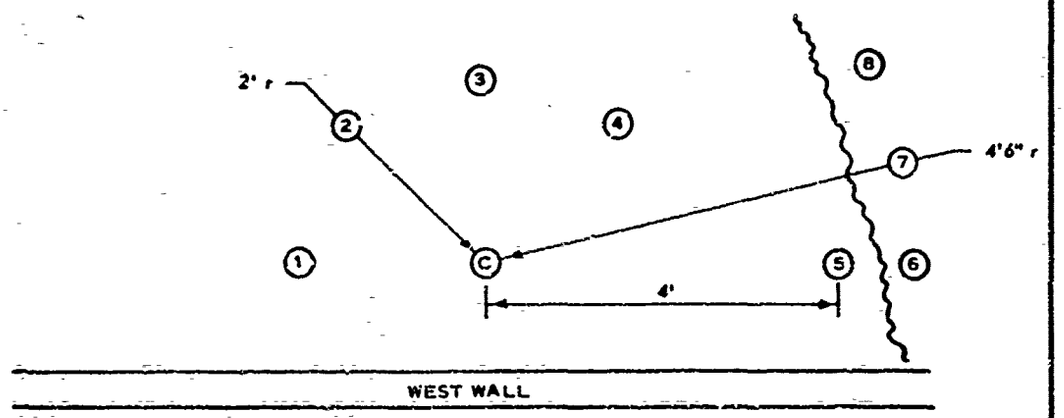
NOTE: STATION 8 WAS MARKED ON TOP AND ON UNDERSIDE OF THE ROOF.
STATIONS 1 THROUGH 7 WERE LOCATED ON UNDERSIDE OF THE ROOF.

STATION NUMBER	PATH LENGTH, FT	VELOCITY FPS	REMARKS
8 TO 8	2.50	16,665	*
8 TO 1	3.24	15,285	**†
8 TO 2	3.24	15,140	**†
8 TO 3	3.24	15,285	**†
8 TO 4	3.24	13,555	**††
8 TO 5	3.24	13,445	**††
8 TO 6	3.54	12,510	**‡
8 TO 7	3.91	12,415	**‡

* DENOTES VERTICAL READING STRAIGHT THROUGH ROOF.
** DENOTES DIAGONAL READINGS TAKEN FROM STATION 8 ON TOP TO POINTS ON UNDERSIDE OF THE ROOF.
† ACROSS-CRACK READING.
†† READING TAKEN ACROSS TWO CRACKS.
‡ READING TAKEN ACROSS THREE CRACKS.

STATION LOCATION AND PULSE VELOCITY DATA, STATION 8 ON ROOF
ECS BUILDING

PLATE



PLAN

NOTE: STATION C WAS MARKED ON TOP AND ON UNDERSIDE OF THE ROOF. STATIONS 1 THROUGH 8 WERE LOCATED ON UNDERSIDE OF THE ROOF.

STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS
C TO C	2.50	15,925	*
C TO 1	3.24	15,355	**
C TO 2	3.24	15,140	**
C TO 3	3.24	15,140	**
C TO 4	3.24	15,355	**
C TO 5	4.72	13,300	**
C TO 6	5.15	13,995	**†
C TO 7	5.15	14,070	**†
C TO 8	5.15	13,805	**†

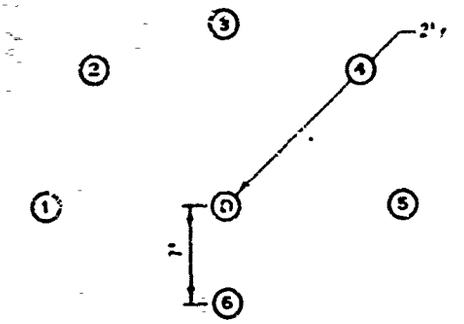
* DENOTES VERTICAL READING STRAIGHT THROUGH THE ROOF.

** DENOTES DIAGONAL READINGS TAKEN FROM STATION C ON TOP TO POINTS ON UNDERSIDE OF THE ROOF.

† ACROSS-CRACK READING.

STATION LOCATION AND PULSE VELOCITY DATA, STATION C ON ROOF
ECS BUILDING

PLATE 7



WEST WALL

PLAN

NOTE: STATION D WAS MARKED ON TOP AND ON UNDERSIDE OF THE ROOF. STATIONS 1 THROUGH 6 WERE LOCATED ON UNDERSIDE OF THE ROOF. THERE WAS NO VISIBLE DAMAGE IN THIS AREA.

STATION NUMBER	PATH LENGTH, FT	VELOCITY, FPS	REMARKS
D TO D	2.50	16,665	*
D TO 1	3.24	15,730	**
D TO 2	3.24	15,880	**
D TO 3	3.24	15,960	**
D TO 4	3.24	16,040	**
D TO 5	3.24	16,615	**
D TO 6	2.70	16,875	**

* DENOTES VERTICAL READING STRAIGHT THROUGH ROOF.

** DENOTES DIAGONAL READINGS TAKEN FROM STATION D ON TOP TO POINTS ON UNDERSIDE OF THE ROOF.

STATION LOCATION AND PULSE VELOCITY DATA, STATION D ON ROOF
ECS BUILDING

PLATE 9