E. F. Gregory 3773

STATE OF CALIFORNIA
HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A PRELIMINARY REPORT OF LABORATORY TESTS PERFORMED ON ASBESTOS CEMENT PIPE AS A POSSIBLE ALTERNATIVE TO REINFORCED CONCRETE PIPE FOR USE IN HIGHWAY DRAINAGE SYSTEMS

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March 1966

MATERIALS & RESEARCH DEPARTMENT

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State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

March 1966

Proj. W. O. 463858

Mr. A. C. Estep
Engineer of Design
Design Department
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A PRELIMINARY REPORT OF

LABORATORY TESTS PERFORMED ON ASBESTOS CEMENT PIPE

AS A POSSIBLE ALTERNATIVE TO REINFORCED CONCRETE PIPE FOR

USE IN HIGHWAY DRAINAGE SYSTEMS

Study made by . . . . . Structural Materials Section
Under direction of . . . . . E. F. Nordlin
Supervised by . . . . . J. R. Stoker
Report prepared by . . . . . E. R. Post

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

EP:mw
Attach.
cc: JEMcMahon
LRGillis
JFJorgensen
PCSheridan

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TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	CONCLUSIONS	2
III.	SUMMARY OF TEST RESULTS	4
IV.	DISCUSSION	6
V.	TESTS	
	Test No. 1 - Flexure Test on a 13' Length by 24" Diameter ACP	8
	Test No. 2 - Drop Test on a 13' Length by 24" Diameter ACP	13
	Test No. 3 - Flexure Test on an 8' Length by 24" Diameter RCP	15
	Test No. 4 - Drop Test on a 4' Length by 24" Diameter RCP	19
	Test No. 5 - Tensile Test on a 10" Diameter ACP Coupler	20
	Test No. 6 - Flexure Test on an 8' Length by 24" Diameter ACP	23
	Test No. 7 - Placed Plastic Coupler on End of a 3' x 24" ACP	26
	Test No. 8 - 3-Edge Bearing Test on a 3' Length of 24" Diameter ACP	27
	Test No. 9 - 3-Edge Bearing Test on a 3' Length by 24" Diameter RCP	31
	Test No. 10 - 3-Edge Bearing Test on a 1' Length by 24" Diameter ACP	34
	Test No. 11 - 3-Edge Bearing Test on a 1' Length by 24" Diameter ACP	37
	Test No. 12 - Sodium Sulphate Resistance Tests on a 1' Length by 24" Diameter ACP (Class 3300)	39
	Test No. 13 - Absorption Test on a 24" Diameter ACP	42
	Test No. 14 - Abrasion Report on the Resistance of ACP	44

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I. INTRODUCTION

This is a preliminary report of the results of laboratory tests performed to date to assist in the evaluation of Class 4000 Asbestos Cement Nonpressure Pipe as a possible alternative to Class III Reinforced Concrete Nonpressure Pipe for use in California Division of Highways drainage systems. The data is limited as it is based on tests of small diameter (24" maximum) pipe only.

The mechanical and chemical tests were performed at the verbal request of the Division of Highways Design Department and in response to a letter dated August 9, 1965, from Mr. J. L. Goodspeed, Engineering Sales Representative for the Johns-Manville Pipe Division, to Mr. A. C. Estep requesting that Class 4000 Asbestos Cement Nonpressure Pipe be included in California specifications as an alternative to Class III Reinforced Concrete Nonpressure Pipe on all highway drainage systems.

The current 1964 California Standard Specifications under Section 71-1.02E permit the use of Asbestos Cement Pipe only in the construction of sewers.

Class 4000 Asbestos Cement Nonpressure Pipe and Class III Reinforced Concrete Nonpressure Pipe of the same length and diameter are considered by Johns-Manville to be equivalent in strength as determined in a 3-Edge Compression Bearing Test.

It is understood that facilities are now available to manufacture Class 4000 Asbestos Cement Nonpressure Pipe in diameters up through 36 inches as standard stock material. Diameters up through 42 inches are available on special order and larger diameters are contemplated for the future.

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II. CONCLUSIONS

Based upon the several laboratory tests conducted on 24" diameter Class 4000 asbestos cement nonpressure pipe and Class III reinforced concrete nonpressure pipe, the asbestos cement nonpressure pipe resisted greater applied static loads in both the flexure and 3-Edge Bearing tests.

Considerable difficulty was encountered in attempting to make a 10" diameter asbestos cement pipe coupler connection. The coupler connection designed to be accomplished by a man in the field required a load of 660 pounds to force the two pipe sections into the coupler, using a testing machine. The plastic coupler, which normally would be used in nonpressure applications, proved to be easily installed on a 24" diameter pipe and appears to be effective as a coupler.

The Sodium Sulfate Soundness and Expansion Tests to date showed no signs of adverse effects on Class 3300 asbestos cement pipe. This tends to indicate that this pipe, which is autoclaved (steam cured under pressure), has a sulphate resistance even though the cement used is not a sulphate resisting type. However, since sulphate exposure tests involve long periods of alternating cycles in sulphate solutions, final conclusive results may not be available for some time.

The absorption of Class 3300 asbestos cement pipe was 67% greater than the maximum permitted for reinforced concrete pipe. The significance of this parameter is not considered important with the absence of reinforcing steel.

The comparative abrasion resistance of asbestos cement pipe has not been conclusively established. It is understood that Johns-Manville will conduct comparative abrasion tests of asbestos cement pipe and reinforced concrete pipe in their research laboratory. This data will be furnished to the Division of Highways for evaluation when the tests are completed.

From the series of tests conducted in this study to date, Class 4000 Asbestos Cement Nonpressure Pipe up through 24 inches in diameter compares favorably from a structural standpoint with Class III Reinforced Concrete Pipe. It is more fragile than reinforced concrete pipe and greater care must be exercised in handling and installing it. However, it is a reasonably tough material, and being considerably lighter in weight than reinforced concrete it may be easier to handle more carefully.

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The Class 4000 Asbestos Cement Nonpressure Pipe is definitely stronger and less fragile than the Asbestos Cement Underdrain Pipe. This added strength is gained by greater wall thickness and a higher percentage of asbestos fibers.

If it is intended to use asbestos cement pipe in diameters greater than 24 inches, the industry should be requested to develop overfill tables. Such tables should be developed under the supervision of a competent engineer.

Until more conclusive data is available relative to its resistance to sulphate and acid attack, it is recommended asbestos cement pipe be restricted to use in environments where the pH of the soil and water is greater than 5.5 and the sulphate (SO_4) in soil and water samples are not greater than 1.5% or 15,000 ppm.

Also, until such time as more conclusive data is available on its abrasion resistance, it is recommended that the use of asbestos cement pipe be generally restricted to valley locations where the probable flow velocity, Q_{10}, will be less than 5 feet per second. It is suggested, however, that one or two installations of asbestos cement pipe appear warranted for experimental purposes in noncritical locations where flow velocities are greater and abrasive.

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III. SUMMARY OF TEST RESULTS

A. Flexure Tests on Class 4000 Asbestos Cement Nonpressure Pipe and Class III Reinforced Concrete Nonpressure Pipe.

Pipe Size	Maximum Applied Midspan Concentrated Test Load @ Failure (Kips) ACP	RCP
24" x 13'	41.5	-
24" x 8'	32.0	25.4

Note: There are no applicable specifications for flexure tests on 24" diameter ACP or RCP: however, 6" and 8" diameter ACP used in sewer construction must comply to the flexure requirements of ASTM C428 and the 1964 California State Specifications under Section 71.

B. 3-Edge Bearing Tests on Class 4000 Asbestos Cement Nonpressure Pipe and Class III Reinforced Concrete Nonpressure Pipe.

Pipe Size	Minimum Required* Ultimate Load (Kips)	Maximum Applied Test Load @ Failure (Kips) ACP	RCP
24" x 3'	12.0	14.8	13.4
24" x 1'	4.0	5.4	-
24" x 1'	4.0	5.0	-

* Note: Applicable Specifications.

	ASTM	AASHO	Calif. State
ACP (Sewer)	C428	-	Section 71
RCP	-	M170	Sections 65, 71

C. Absorption Test on Class 3300 Asbestos Cement Pipe.

Percent Absorption after soaking for 40 days and then drying for 24 days at a temperature of 230° F was 13.3.

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Note: a. There are no applicable specifications for absorption on asbestos cement sewer pipe.

b. The maximum allowable absorption of RCP is 8% as specified in the 1964 California State Specifications under Sections 65 and 71 and also under AASHO M170.

D. Sodium Sulphate Resistance Tests on Class 3300 Asbestos Cement Pipe.

There were no visual signs of disintegration of the 4 test specimens as a result of the exposure to the Na_2SO_4 solution.

E. Sodium Sulphate Expansion Test on Class 3300 Asbestos Cement Pipe.

Percent Expansion at 28 cycles was 0.028.

Note: The maximum permissible expansion according to Specification No. DC-6250, U. S. Department of Interior, Bureau of Reclamation, is 0.15% after 28 cycles.

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IV. DISCUSSION

This investigation was conducted in accordance with the following outline. Each test of the outline will be discussed individually. Hereinafter, Class 4000 Asbestos Cement Nonpressure Pipe and Class III Reinforced Concrete Nonpressure Pipe will be abbreviated as ACP and RCP respectively.

Test No.	Test Date	
1	9-22-65	Flexure test on a 13' x 24" ACP
2	9-22-65	Drop test on a 13' x 24" ACP
3	9-22-65	Flexure test on an 8' x 24" RCP
4	9-22-65	Drop test on a 4' x 24" RCP
5	10-14-65	Tensile test on a 10" ACP Coupler
6	10-15-65	Flexure test on an 8' x 24" ACP
7	10-15-65	Placed plastic coupler on end of a 3' x 24" ACP
8	10-15-65	3-Edge bearing test on a 3' x 24" ACP
9	10-15-65	3-Edge bearing test on a 3' x 24" RCP
10	10-15-65	3-Edge bearing test on a 1' x 24" ACP
11	10-15-65	3-Edge bearing test on a 1' x 24" ACP
12	9-13-65	Sodium sulphate resistance tests on 1' x 24" ACP (Class 3300)
13	9-22-65	Absorption test on a 1' x 24" ACP (Class 3300)
14	-	Abrasion report on the resistance of ACP by Johns-Manville

Attempts were made to obtain measurements necessary to determine the midspan deflections for flexure tests No. 1, 3, and 6. Dial indicators and steel tapes positioned as shown in Figures 1, 2, and 4 were used to obtain the measurements. The midspan deflections of the steel beams were calculated theoretically.

The absolute values of the midspan pipe deflections could not be determined accurately, however, as several variables were not taken into consideration. These variables are as follows:

a. Compressibility of a 3/4" Douglas fir plywood platen work table cover.

b. Compressibility of the pipe.

1. The pipe will tend to assume an elliptical shape.

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c. Longitudinal cracking.

1. As longitudinal cracking occurred in the immediate vicinity of the three bearing points, the cross section of the pipe in these areas would change considerably.

The general deflection formulas would have been as follows:

$$\Delta_T = \Delta_8 - (\Delta_1 + \Delta_2 + \Delta_3 + \Delta_4 + \Delta_5 + \Delta_6 + \Delta_7)$$

Where:

Δ_T = Total midspan deflection.

Δ_8 = Platform form movement (Dial No. 3).

Δ_1 = Average compression of lower supports (Dials No. 1 and 2).

Δ_2 = Compression of upper bearing point (Dial No. 4).

Δ_3 = Theoretical deflection of 14 BP 73.

Δ_4 = Theoretical deflection of 2-10 WF 21's (including added stiffness due to longitudinal stiffeners).

Δ_5 = Compressibility of 3/4" plywood platen cover.

Δ_6 = Compressibility of pipe.

Δ_7 = Change in pipe cross section due to longitudinal cracking.

Or

$$\Delta_T = \Delta_9 - (\Delta_8 + \Delta_2 + \Delta_6 + \Delta_7)$$

Where:

Δ_T, Δ_8, Δ_2, Δ_6, and Δ_7 (defined previously)

Δ_9 = Average of steel tape measurements.

Not considering the above mentioned variables, the approximate calculated midspan pipe deflections were small--less than 1/2" for any of the flexure tests. Because the midspan pipe deflections could not be accurately calculated due to the reasons stated, all data, calculations, graphs, and conclusions relevant to the deflections for the flexure tests are excluded in this report evaluation.

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TEST NO. 1

FLEXURE TEST ON A 13' LENGTH BY 24" DIAMETER ACP

The flexure test on the 13' x 24" ACP was set up for testing as shown in Figure No. 1 and Photographs No. 1 and 2. The dimensions of the test set up are shown in Figure No. 1.

The first indication of longitudinal cracking occurred at a load of 30 kips in the area of the two bottom bearing points. The end longitudinal cracking as shown in Photographs No. 3 through 6 gradually progressed to a length of approximately 15" at failure. At a load of 41.5 kips the midspan Douglas fir wooden bearing block began to split; therefore, the load was removed and the Douglas fir wooden block and 1/2" x 6" pad were replaced by two 1-1/2" x 8" x 19" elastomeric bridge bearing pads.

During the second loading cycle, a longitudinal crack occurred at a load of 30 kips in the area of the midspan loading point. Evidently circumferential asbestos fibers had yielded so that a permanent set occurred in the pipe cross section when the first cycle load was removed at 41.5 kips. During the second loading cycle these fibers continued to yield to a point to suddenly fail, thus explaining why the midspan longitudinal crack developed at a load less than that attained in the first cycle. Also, at a load of 30 kips a diagonal crack occurred 6" above the pipe bottom surface at each end. Both the midspan and diagonal cracks are shown in Photographs No. 5 through 9.

At a load of 40 kips during the second loading cycle, the pipe was considered as having failed. The magnitude of cracking at 40 kips is shown in Photographs No. 7 through 9. The pipe was not loaded to complete destruction as it was desired to use the same pipe, even though severely cracked, in the Drop Test (Test No. 2).

From the graph of midspan pipe deflections versus applied load, which was not included in this report, the ACP was elastic up to a load of 35,000 pounds. With this load the maximum longitudinal asbestos fiber stress in bending was determined to be 2180 psi, using the elastic beam formula ($f = \frac{PL}{4S}$).

No attempt will be made to analyze the circumferential stresses causing the longitudinal cracking which would be beyond the scope of this report.

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Figure 1

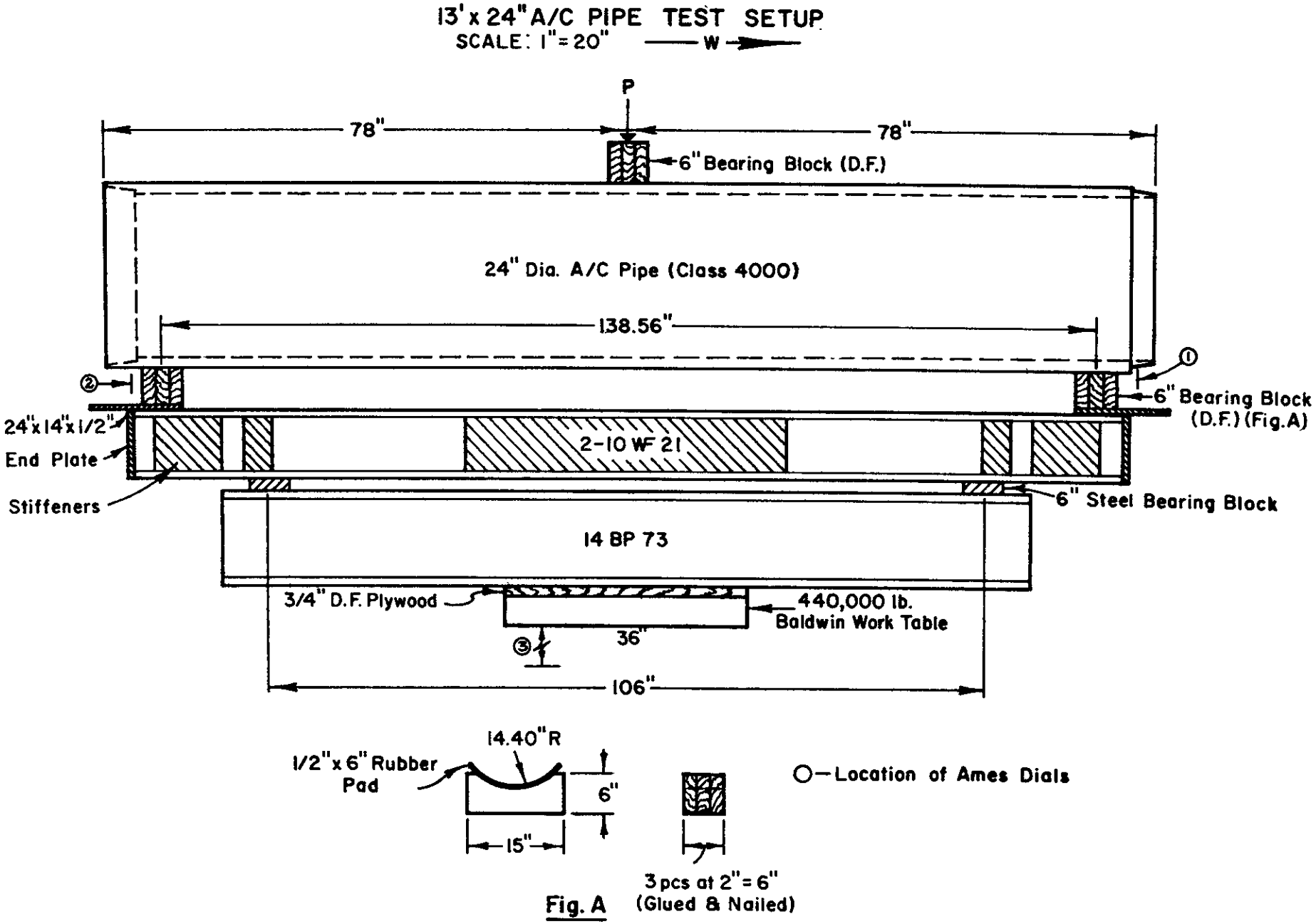
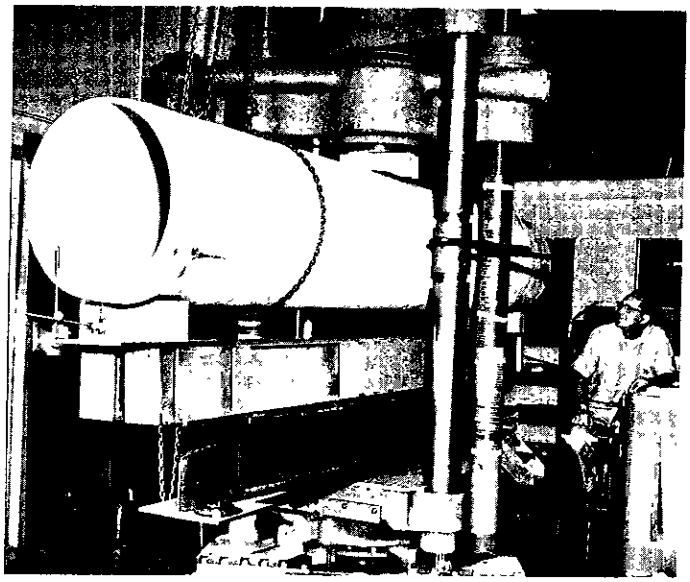


Fig. A

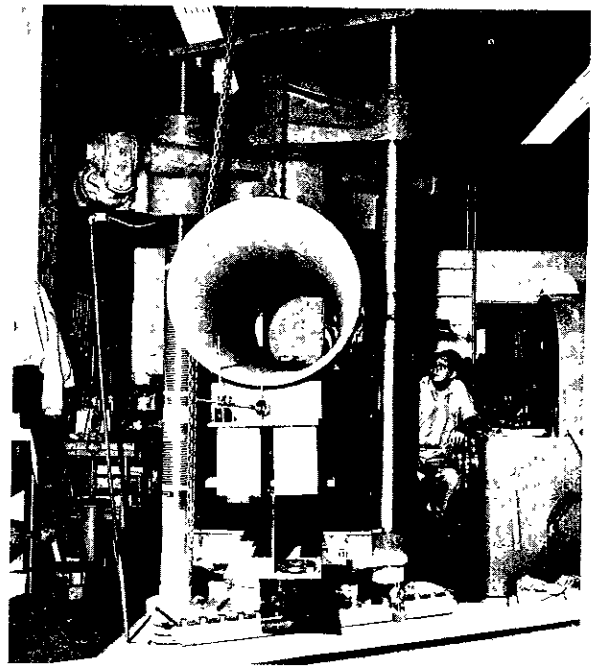
PHOTOGRAPHS OF 13' X 24" ASBESTOS CEMENT PIPE (Class 4000)

FLEXURE TEST NO. 1



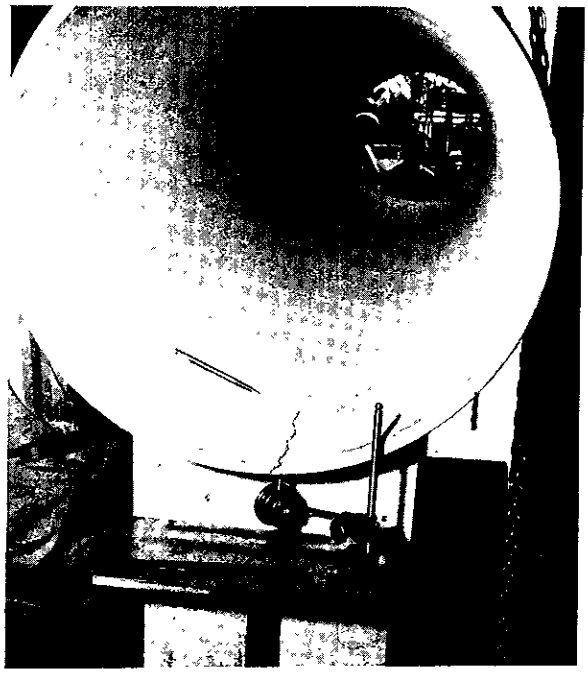
Photograph No. 1

Southwest View of Test Setup



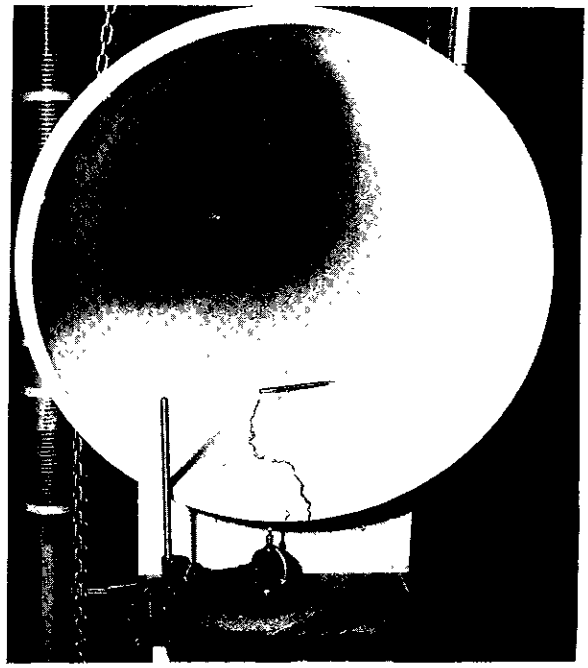
Photograph No. 2

East End View of Test Setup



Photograph No. 3

West End View of Longitudinal
Bottom Crack (12")
at a Load of 30 kips
(1st Cycle)



Photograph No. 4

East End View of Longitudinal
Bottom Crack (15")
at a Load of 40 Kips
(1st Cycle)

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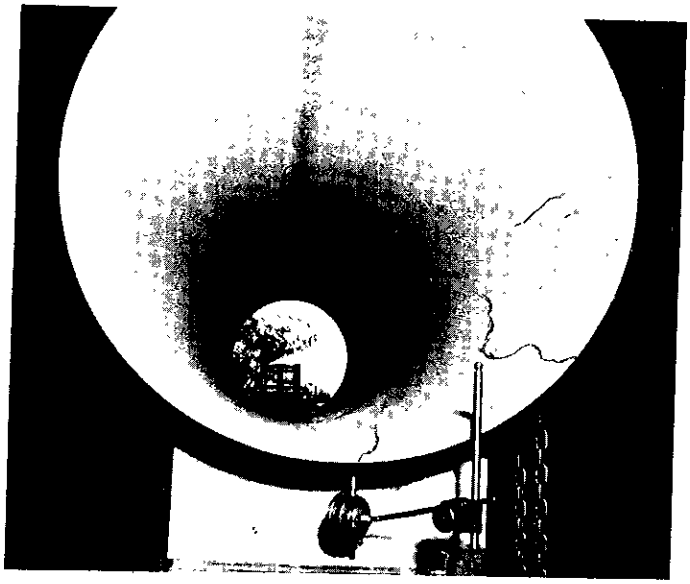
PHOTOGRAPHS OF 13' X 24" ASBESTOS CEMENT PIPE (Class 4000)

FLEXURE TEST NO. 1

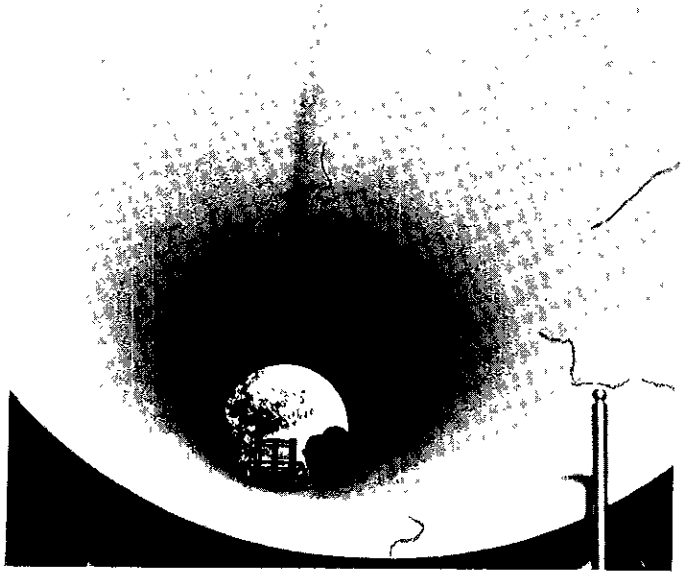


Photograph No. 5

West End View of Longitudinal Bottom and Top Cracks and Diagonal Side Cracks at a Load of 30 kips (2nd Cycle)

Photograph No. 7

East End View of Longitudinal Bottom and Top Cracks and Diagonal Side Cracks at a Load of 40 kips (2nd Cycle)



Photograph No. 6

West End View of Longitudinal Bottom and Top Cracks and Diagonal Side Cracks at a Load of 35 kips (2nd Cycle)

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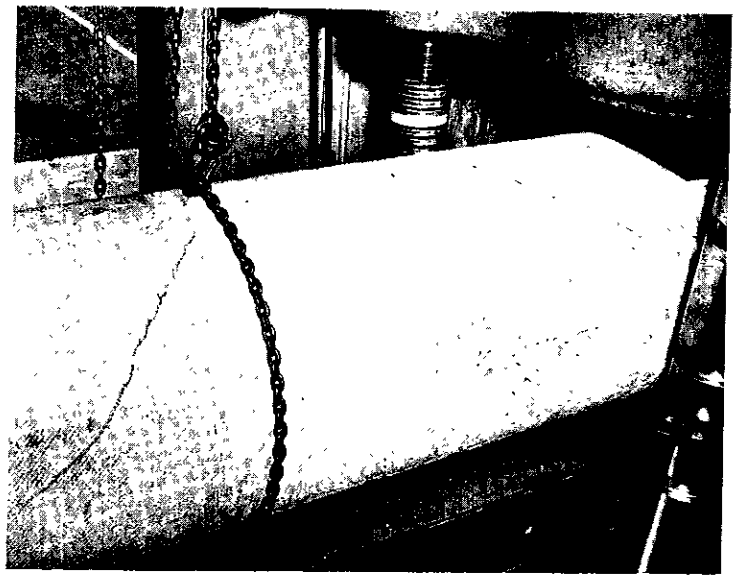
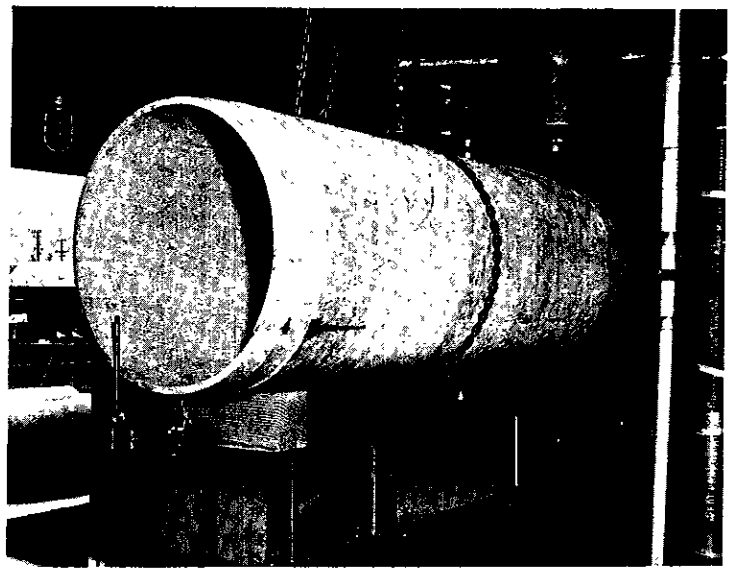
PHOTOGRAPHS OF 13' X 24" ASBESTOS CEMENT PIPE (Class 4000)

FLEXURE TEST NO. 1



Photograph No. 8

South Side View of Longitudinal
and Diagonal Cracks
at a Load of 40 kips
(2nd Cycle)



Photograph No. 9

Southwest View of Longitudinal
and Diagonal Cracks
at a Load of 40 kips
(2nd Cycle)

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TEST NO. 2

DROP TEST ON A 13' LENGTH BY 24" DIAMETER ACP

A 13' length x 24" diameter ACP (previously tested in flexure) was dropped from a height of approximately 5' as shown in Photograph No. 10.

A Johns-Manville representative predicted that even though the pipe was severely cracked, it would remain intact; however, as shown in Photograph No. 11, the pipe shattered into many pieces. Evidently asbestos cement pipe is more brittle than anticipated. Due to the condition of the pipe, however, such shattering was not surprising.

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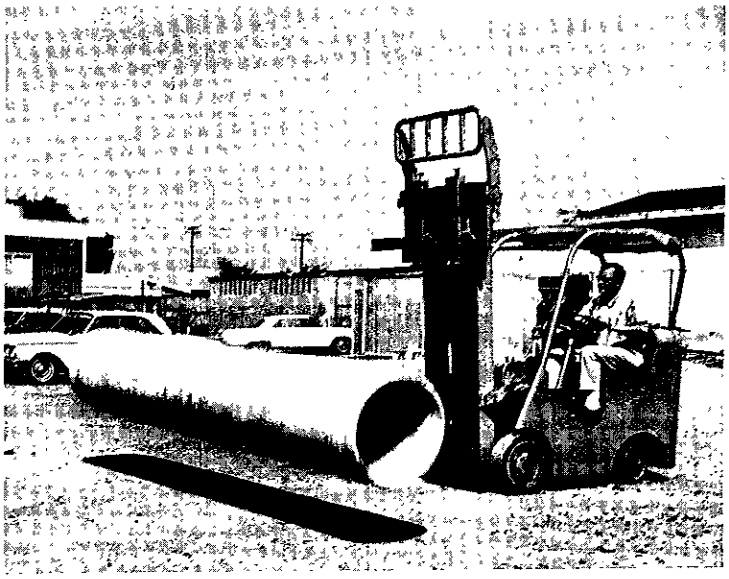
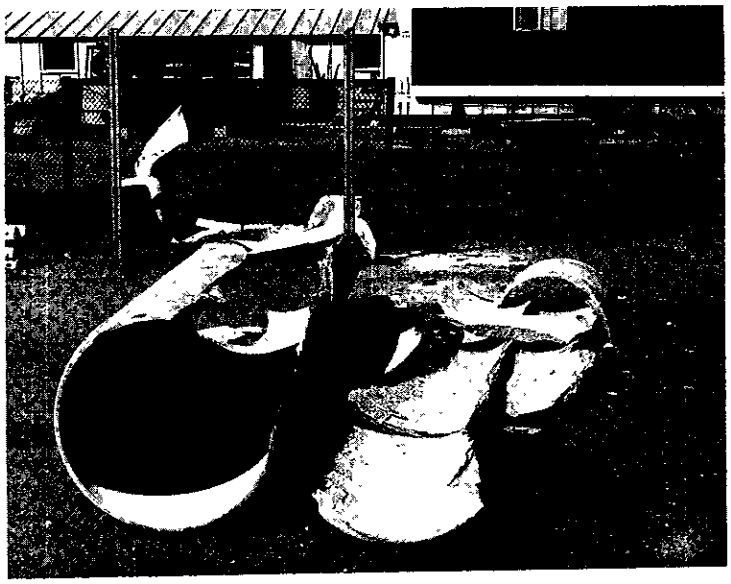
PHOTOGRAPHS OF 13' X 24" ASBESTOS CEMENT PIPE (Class 4000)

DROP TEST NO. 2



Photograph No. 10

Drop Height 5 Ft.



Photograph No. 11

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TEST NO. 3

FLEXURE TEST ON AN 8' LENGTH BY 24" DIAMETER RCP

The flexure test on the 8' length x 24" diameter RCP was set up for testing as shown in Photograph No. 12 and Figure No. 2. The dimensions of the test set up are shown in Figure No. 2.

A hairline crack continuous throughout the pipe length on the interior top and bottom surfaces occurred at a load of 25 kips. At a load of 25.4 kips the pipe failed suddenly, cracks occurring longitudinally throughout the pipe length approximately 90 degrees apart on vertical and horizontal planes as shown in Photographs No. 13, 14, and 15. Continuing the loading rate, with the load gradually decreasing, the pipe cracked circumferentially at midspan when the longitudinal steel wire failed as shown in Photographs No. 15, 16, and 17.

Because the circumferential and longitudinal reinforcing steel would have to be considered, no attempt was made to analyze the circumferential and longitudinal stresses which would be beyond the scope of this report.

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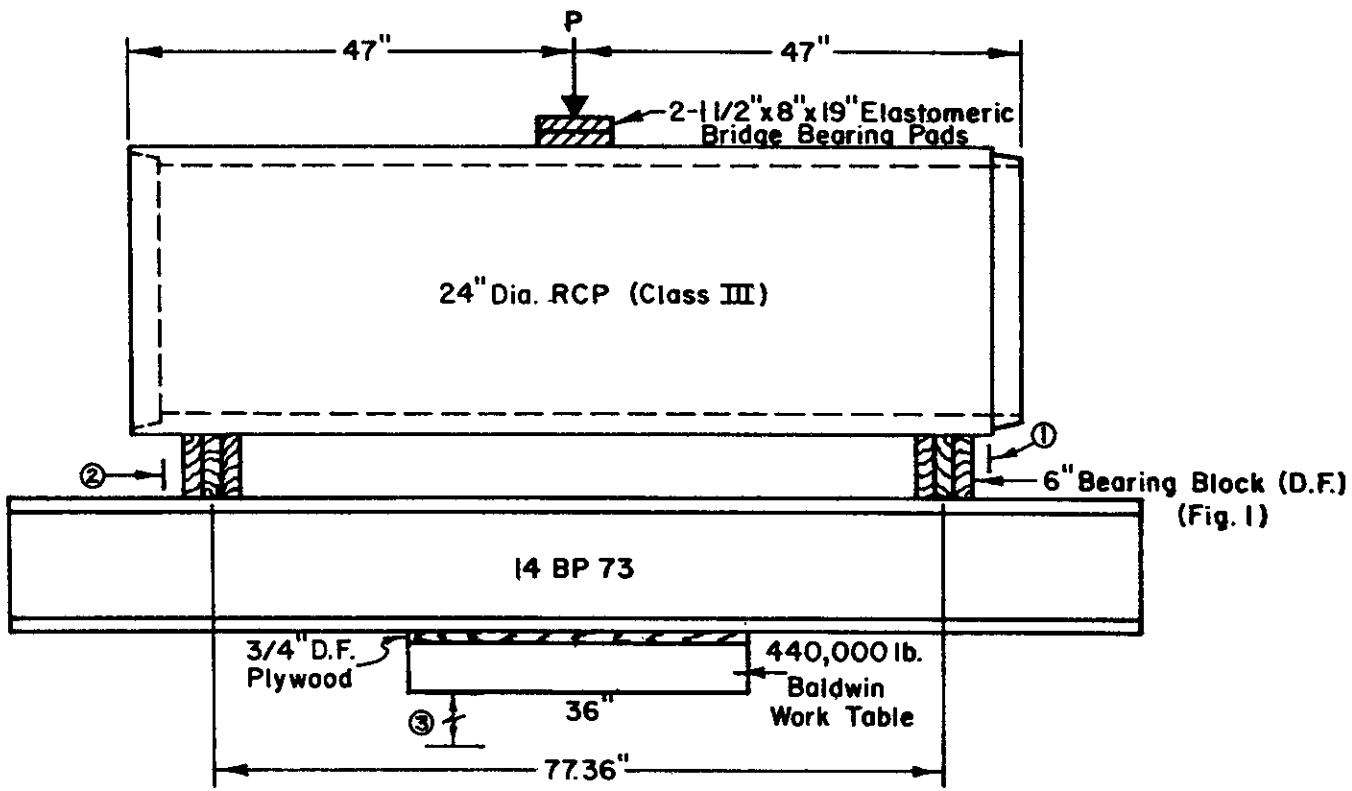
Figure 2

8' x 24" R.C. PIPE TEST SETUP

SCALE: 1" = 20" —W→



O - Location of Ames Dials

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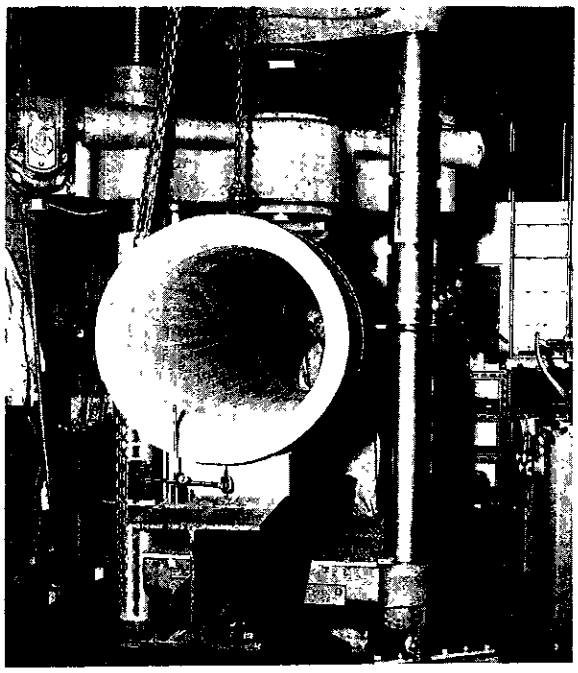
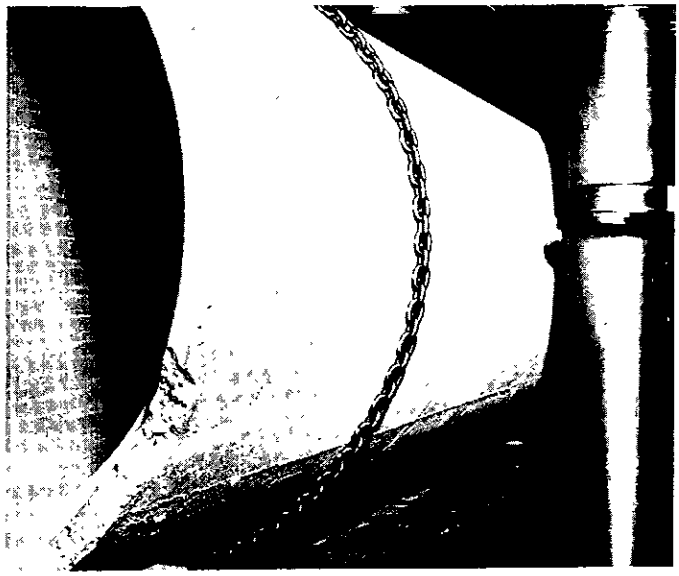
PHOTOGRAPHS OF 8' X 24" REINFORCED CONCRETE PIPE (Class III)

FLEXURE TEST NO. 3



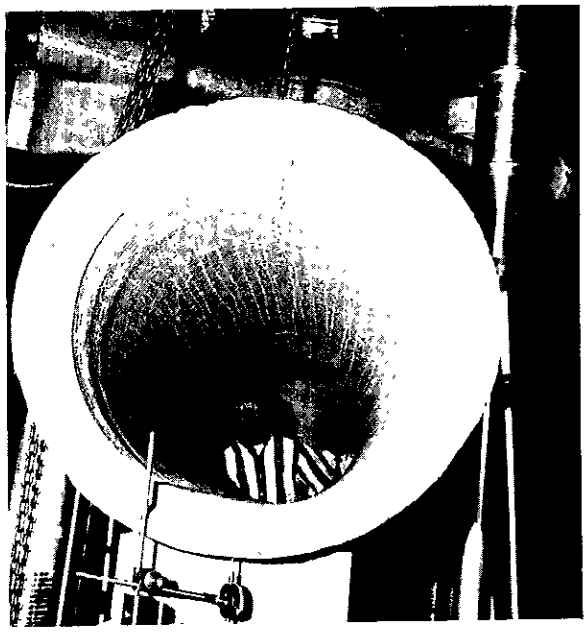
Photograph No. 12

East End View of Test Setup



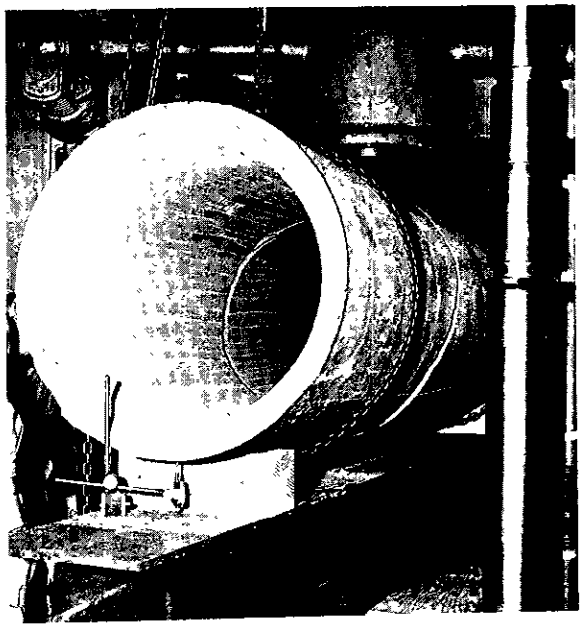
Photograph No. 13

Longitudinal Cracking
at a Load of 25.4 kips



Photograph No. 14

East End View of Longitudinal
Bottom, Side, and Top Cracks
at a Load of 25.4 kips



Photograph No. 15

Southwest View of Longitudinal
Bottom, Side, and Top Cracks
and Circumferential Fracture
at a Load of 25.4 kips

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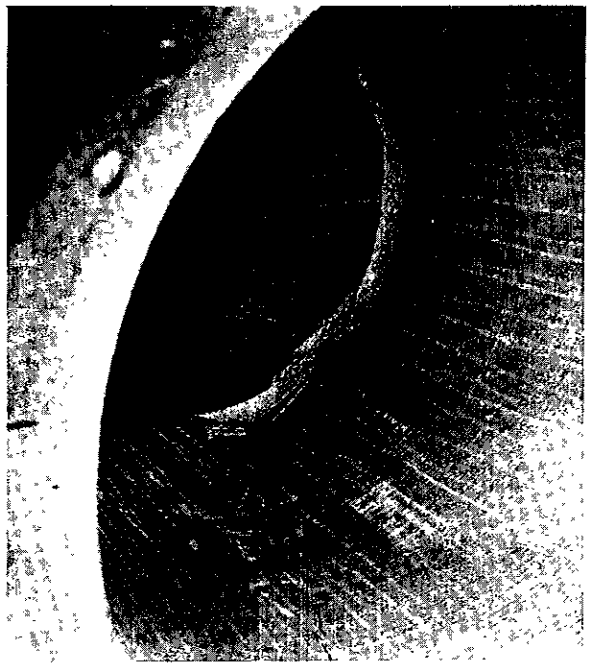
PHOTOGRAPHS OF 8' X 24" REINFORCED CONCRETE PIPE (Class III)

FLEXURE TEST NO. 3



Photograph No. 16

East End View of Longitudinal
Bottom Crack and Circumferential
Fracture at a Load of 25.4 kips

Photograph No. 17

South Side View of Longitudinal
Crack and Circumferential
Fracture at a Load of 25.4 kips

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TEST NO. 4

DROP TEST ON A 4' LENGTH BY 24" DIAMETER RCP

A 4' long x 24" diameter RCP obtained from the previous flexure test (8' long x 24" diameter RCP cracked circumferentially into 2- 4' lengths) which was cracked longitudinally on four sides approximately 90° apart was dropped three times from heights of 10', 12', and 15'.

The pipe remained intact on the first two drops; however, on the third drop the pipe shattered over 1/4 of its surface area.

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TEST NO. 5

TENSILE TEST ON A 10" DIAMETER ACP COUPLER

The tensile test on the 10" ACP coupler connection was set up for testing as shown in Photograph No. 18 and Figure No. 3. The dimensions of the coupler are shown in Figure No. 3. Using a Johns-Manville Ring-Tite Lubricant on the contact areas of the coupler connection, attempts were made with no success to force the two pipe sections into the coupler by hand and also by the use of a 5# sledge hammer. The connection was finally accomplished by using a testing machine to press the two pipe sections into the coupler which required a load of 660 pounds. It would seem that the application of such a load in the field would be virtually impossible by any practical means. The representatives from Johns-Manville, however, claim that such a connection can readily be made in the field where the coupler would be rammed onto the end of a continuous length of pipe. Under these conditions a non-yielding length of pipe would be resisting the impact of the ramming action imparted to the coupler by the installer. Verification of this could readily be determined by observing a field installation.

Failure of the coupled connection occurred circumferentially through the two 7/8" diameter holes in the pipe section at a load of 8,520 pounds as shown in Photograph No. 19 and Figure No. 3. The calculated average tensile stress was 407 psi. The coupler itself did not fail. The maximum tensile stress adjacent to the two holes could theoretically have been three times the calculated average tensile stress. Since the asbestos fibers are somewhat brittle, the crack undoubtedly started adjacent to one of the holes and progressed to point where the remaining cross section of the pipe was reduced sufficiently in area to permit a sudden failure.

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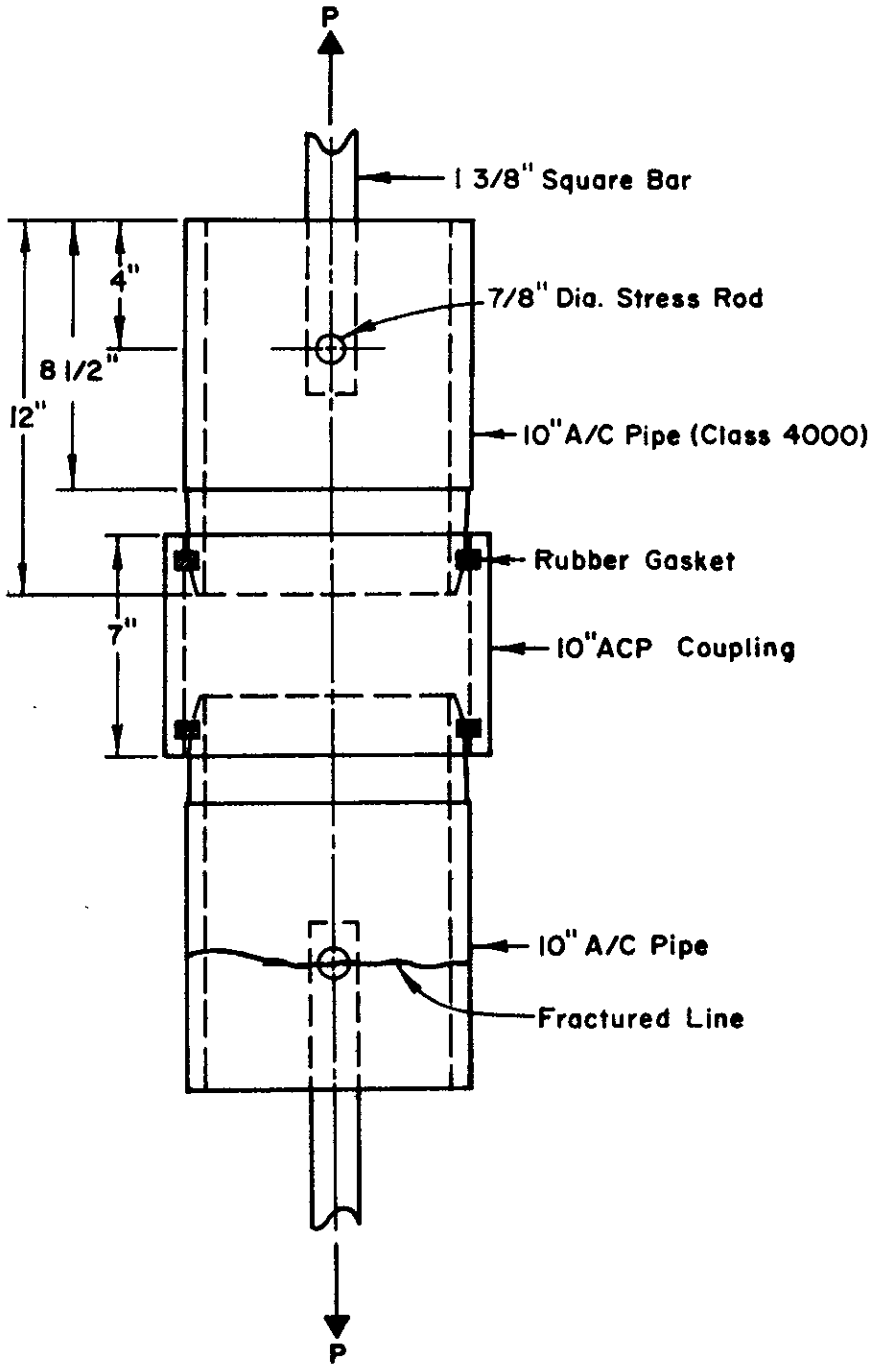
Figure 3

10" ACP COUPLING TEST

SCALE: 1" = 6"



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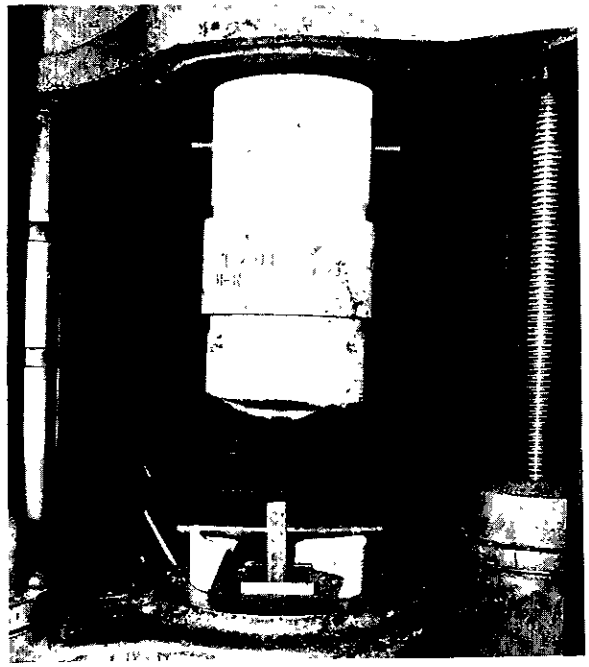
PHOTOGRAPHS OF 10" ASBESTOS CEMENT COUPLER (Class 4000)

TENSILE TEST NO. 5

Photograph No. 18

Test Setup



Photograph No. 19

Fracture of Coupler

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TEST NO. 6

FLEXURE TEST ON AN 8' LENGTH BY 24" DIAMETER ACP

The flexure test on the 8' length x 24" diameter ACP was set up for testing as shown in Figure No. 4 and Photograph No. 20. The dimensions of the test set up are shown in Figure No. 4.

The first indication of longitudinal cracking occurred in the area of the two end bearing supports at a load of 24 kips. The end longitudinal cracking as shown in Photographs No. 21 and 22 gradually progressed to a length of approximately 27" at failure. At a load of 32 kips a longitudinal crack (18") occurred in the area of top midspan loading point. Continuing the loading rate with a gradual drop-off of load, the midspan longitudinal crack progressed to a length of 60" as shown in Photograph No. 22, prior to complete failure of the pipe by a midspan circumferential crack as shown in Photograph No. 23.

From the graph of midspan pipe center deflections versus applied load, which was not included in this report, the ACP was elastic up to a load of 25,000 pounds. With this load the maximum longitudinal asbestos fiber stress in bending was determined to be 970 psi, using the elastic beam formula ($f = \frac{PL}{4S}$). No attempt was made to analyze the circumferential stresses in the areas of the bearing points which would be beyond the scope of this report.

One would expect the shorter 8' ACP length to be capable of resisting a larger midspan load than the 13' ACP length; however, as the primary mode of failure in both cases was by longitudinal cracking in the areas of the bearing points, it seems logical to assume that the 13' ACP processes a greater resistance to longitudinal cracking due to its longer length. Because only two tests were conducted, a conclusive comparison between the 8' and 13' ACP cannot be made.

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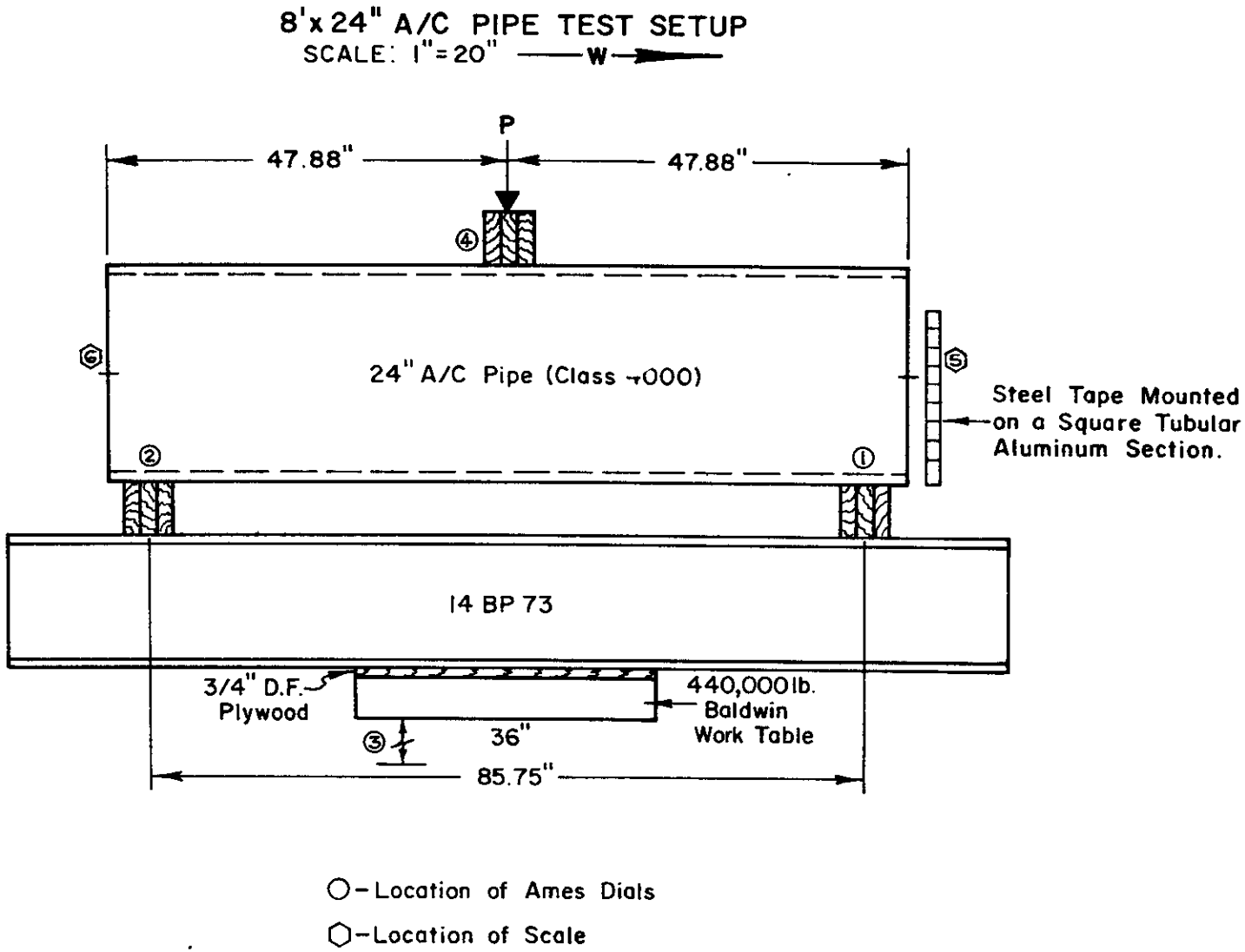
Figure 4



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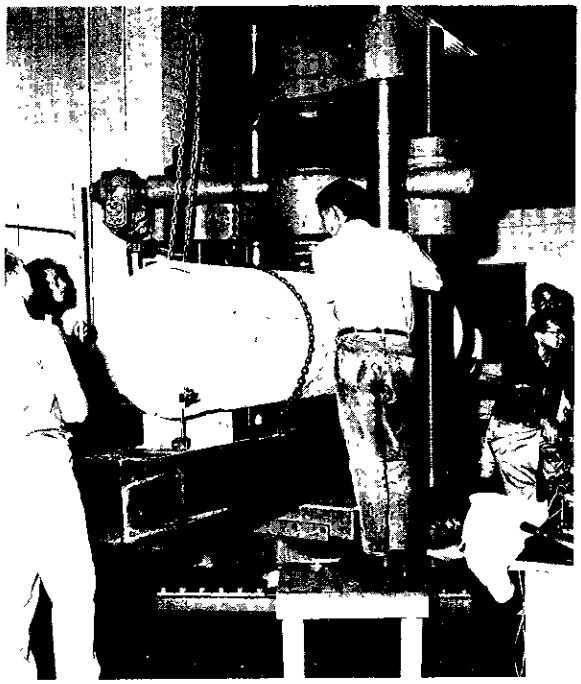
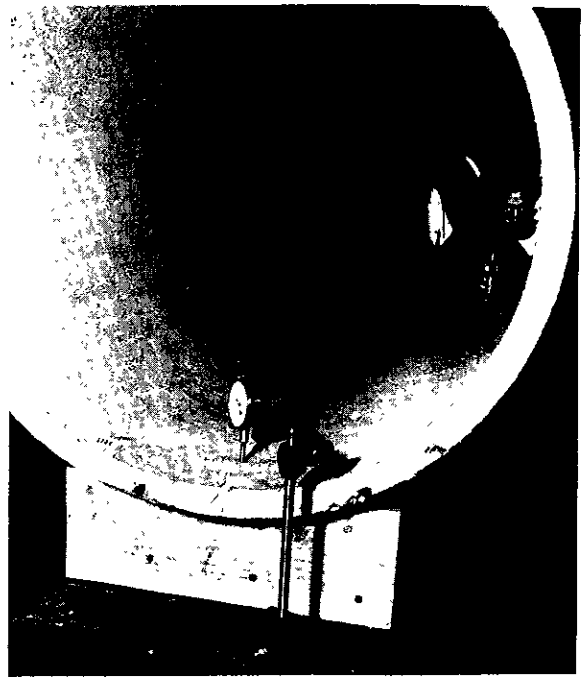
PHOTOGRAPHS OF 8' X 24" ASBESTOS CEMENT PIPE (Class 4000)

FLEXURE TEST NO. 6



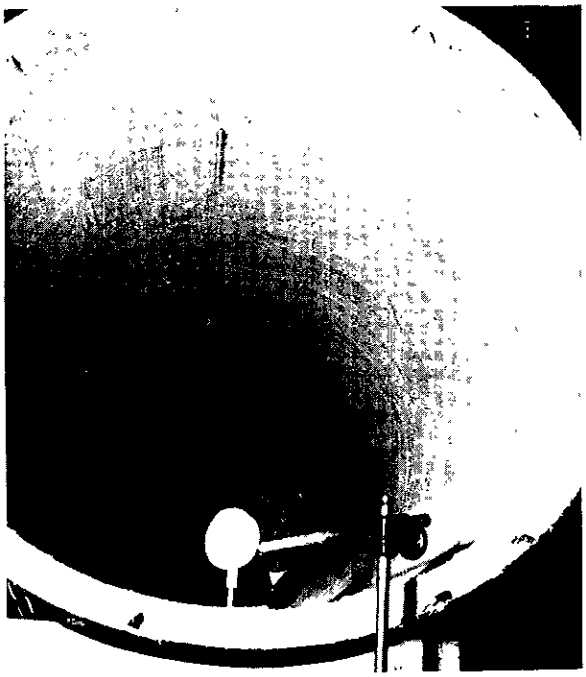
Photograph No. 20

Southwest View of
Test Setup



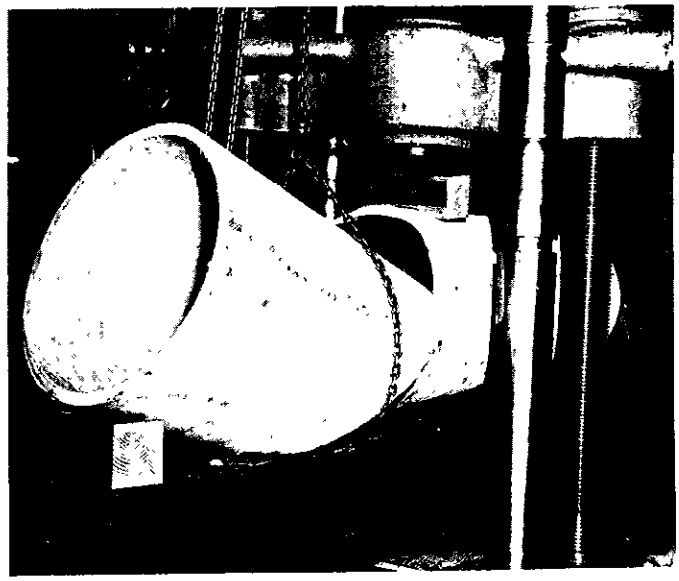
Photograph No. 21

East End View of Longitudinal
Bottom Crack (16")
at a Load of 24 kips



Photograph No. 22

East End View of Longitudinal
Bottom and Top Cracks
at a Load of 32 kips



Photograph No. 23

Southwest View of
Circumferential Fracture
Load 32 kips

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TEST NO. 7

PLACED PLASTIC COUPLER ON END OF A 3' BY 24" ACP

A plastic coupler (7/32" x 10") was driven on the end of a beveled 3' length 24" diameter ACP (Class 4000) using a ball peen hammer to demonstrate the ease of application. No difficulties were encountered in placing the plastic coupler. The plastic coupler appeared to make an effective watertight joint but one which would allow the pipe joint to separate under longitudinal load if permitted.

No attempt was made to physically evaluate the plastic coupler proposed for use as a culvert coupler as two mating sections were not available. However, the material used for this coupler, a polyethylene plastic, possesses adequate strength and elongation for its purpose and is chemically inert. It is sensitive, however, to ultra violet light embrittlement as are a number of plastics. Care therefore must be exercised in the storage of such material.

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TEST NO. 8

3-EDGE BEARING ON A 3' LENGTH BY 24" DIAMETER ACP

The 3-Edge Bearing test on the 3' length x 24" diameter ACP was set up for testing as shown in Figure No. 5 and Photograph No. 24, except a 12" diameter stationary head was used in place of a swivel head, the ½" x 5" expansion joint fiber board was omitted, and a 1½" x 8" x 19" elastomeric bridge bearing pad was placed between the stationary head and the steel beam. The test data of the applied loads and remarks are tabulated in Table No. 1.

The manufacturer's guaranteed minimum ultimate strength of the pipe is 12.0 kips (4000 lb./ft. x 3'). At a load of 14.8 kips the top interior surface of the pipe cracked with a subsequent reduction in load to 10 kips. Continuing loading, the pipe again began to support additional load. The interior bottom surface of the pipe cracked at a load of 14.4 kips with once again a subsequent reduction in load to 8.5 kips. The top and bottom cracks are shown in Photograph No. 25. Continuing the loading rate, the sides of the pipe cracked simultaneously at a load of less than 8.5 kips. Photograph No. 26 shows the pipe prior to collapsing into four pieces.

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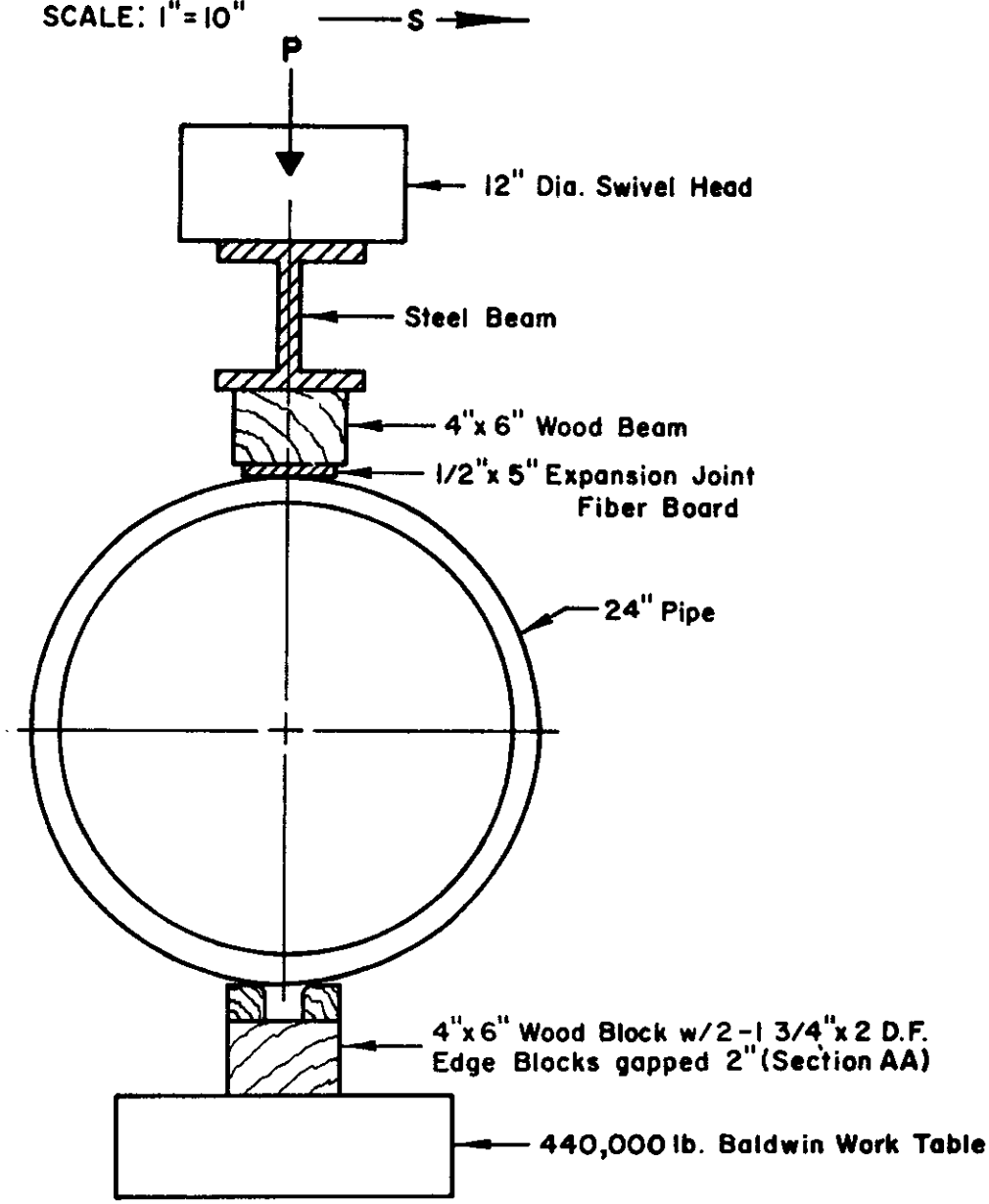
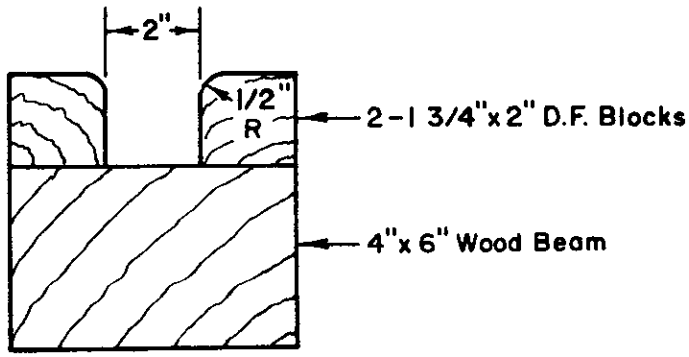
FIGURE 5

3-EDGE BEARING TEST SETUP

SCALE: 1" = 10"





(Section - AA)

SCALE: 1" = 4"

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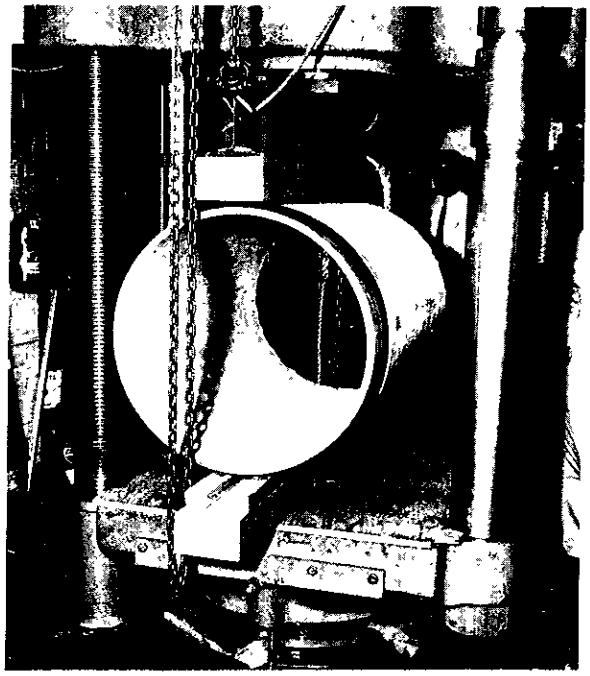
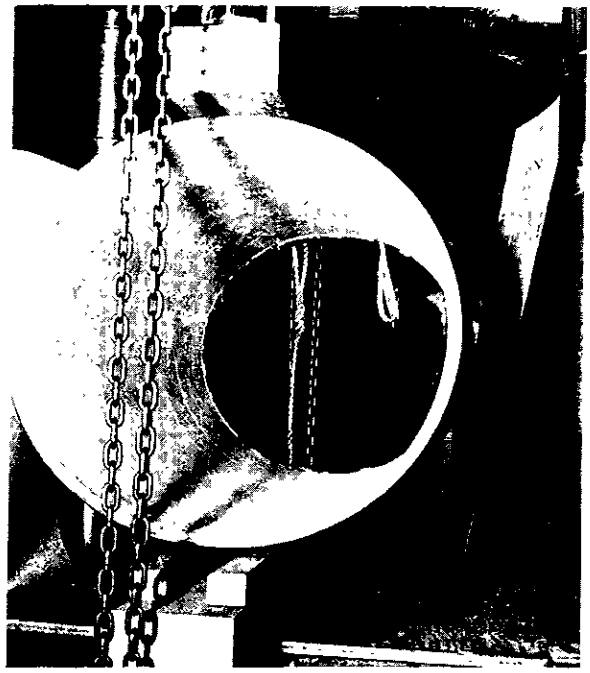
PHOTOGRAPHS OF 3' X 24" ASBESTOS CEMENT PIPE (Class 4000)

3-EDGE BEARING TEST NO. 8



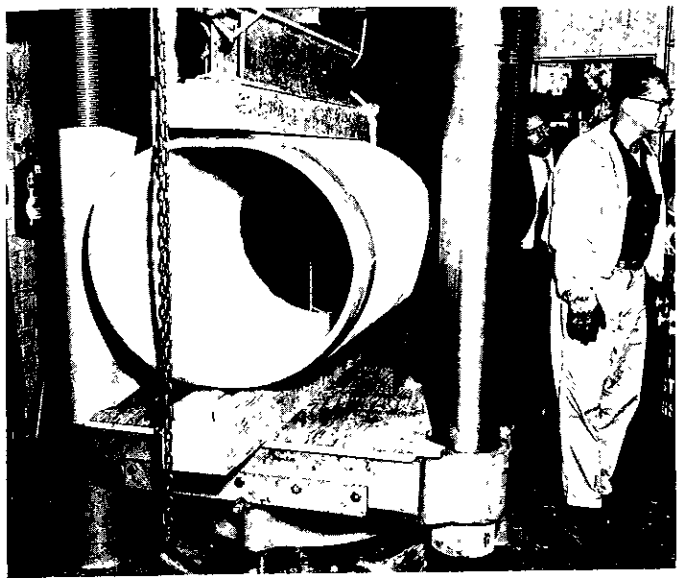
Photograph No. 24

East End View of Test Setup



Photograph No. 25

East End View of Longitudinal Bottom and Top Cracks at a Load of 14.4 kips



Photograph No. 26

East End View of Longitudinal and Circumferential Cracks at a Load of 8.5 kips

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TABLE NO. 1

3-EDGE BEARING TEST DATA

3' x 24" ASBESTOS CEMENT PIPE (Class 4000)

Load (kip)	Remarks
14.8	Top Crack Along Entire Length -- Load Fell Off to 10.0 kips.
14.4	Bottom Crack Along Entire Length -- Load Fell Off to 8.5 kips.
8.5	Both Sides Cracked Along Entire Length -- Complete Failure.

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TEST NO. 9

3-EDGE BEARING TEST ON A 3' LENGTH BY 24" DIAMETER RCP

The 3-Edge Bearing test on the 3' length x 24" diameter RCP was set up for testing as shown in Figure No. 5 and Photograph No. 27. In addition, the vertical and horizontal deflections of the pipe were measured at each end using four steel tapes. The test data of the applied loads, deflections, and remarks are tabulated in Table No. 2.

The manufacturer's guaranteed minimum load for the 0.01" crack and the ultimate strength are 8.1 kips (1350 lbs./ft.^{2} x 3' x 2') and 12.0 kips (2000 lbs./ft./ft. x 3' x 2') respectively. The 0.01" crack continuous along the top and bottom surfaces as shown in Photograph No. 28 occurred at a load of 12.4 kips with a subsequent reduction in load to 8.8 kips. Continuing the loading rate, the utlimate strength of the pipe was 13.4 kips. Photograph No. 29 shows the pipe at failure.

The pipe made by a hand packing method had an extremely rough exterior and interior surface finish and would have been rejected for poor workmanship under the California state specifications.

No comparison can be made between the 3' x 24" ACP and RCP for the vertical and horizontal deflections as no deflection measurements were taken on the ACP.

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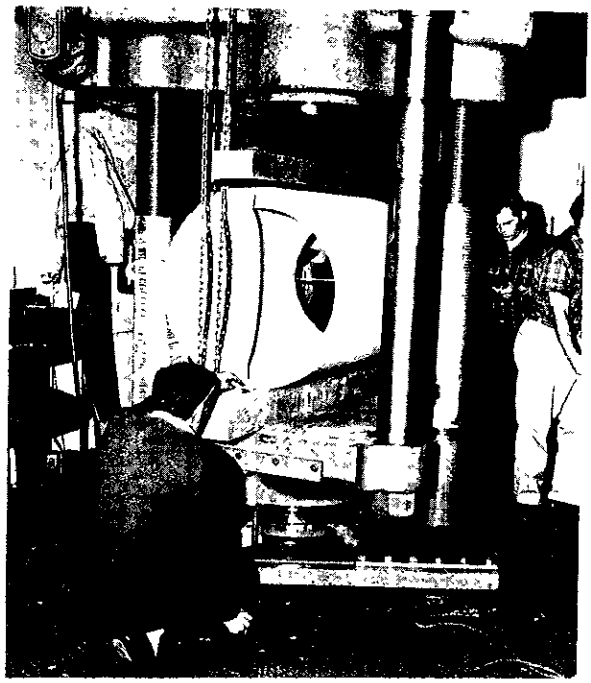
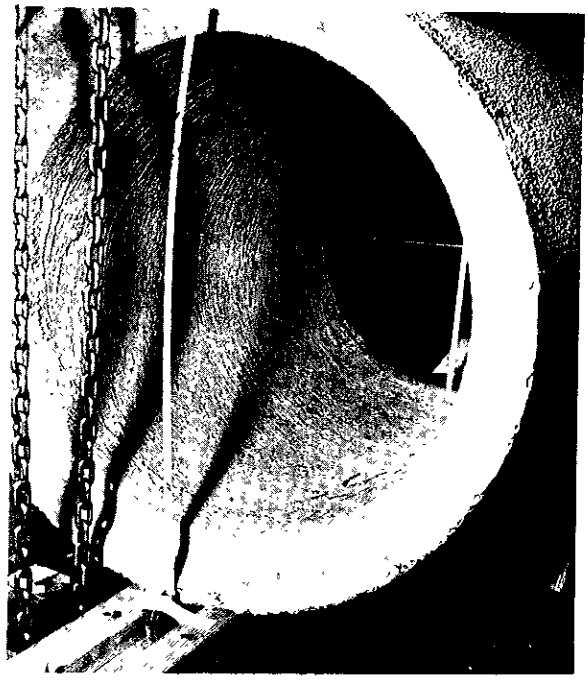
PHOTOGRAPHS OF 3" X 24" REINFORCED CONCRETE PIPE (Class III)

3-EDGE BEARING TEST NO. 9



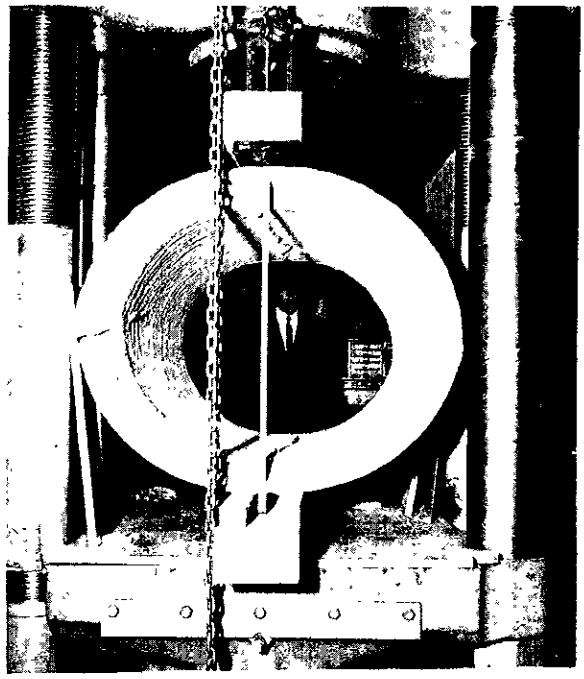
Photograph No. 27

East View of Test Setup



Photograph No. 28

East End View of 0.01" Crack
at a Load of 12.4 kips



Photograph No. 29

East End View of Longitudinal
Cracks
at a Load of 13.4 kips

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TABLE NO. 2

3' x 24" REINFORCED CONCRETE PIPE (Class III)

Load (kip)	Scale No. 1 (in.)	Scale No. 2 (in.)	Scale No. 3 (in.)	Scale No. 4 (in.)	Remarks
0.2	0.000	0.000	0.000	0.000	
2.0	+0.012	0.000	0.000	0.000	
4.0	+0.012	0.000	0.000	-0.012	
6.0	+0.024	0.000	0.000	-0.012	
8.0	+0.024	0.000	0.000	-0.012	
10.0	+0.024	-0.012	+0.012	-0.012	
12.0	+0.024	-0.012	+0.024	-0.036	
12.4	+0.060	-0.048	+0.084	-0.060	0.00" Crack (Bottom)
8.8	-----	-----	-----	-----	Load Drop Off-- Pipe Cracked
11.6	+0.240	-0.204	-----	-----	
13.4	+0.564	-0.504	+0.720	-0.624	Ultimate Strength

Note: Scale Nos. 1 and 3 Were Horizontal Measurements.
Scale Nos. 2 and 4 Were Vertical Measurements.

Comments: The Pipe Which Was Made by a Hand Packing Method Had an Extremely Rough Exterior and Interior Finish.

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TEST NO. 10

3-EDGE BEARING TEST ON A 1' LENGTH BY 24" DIAMETER ACP

The 3-Edge Bearing Test on the 1' length x 24" diameter ACP was set up for testing as shown in Figure No. 5. In addition, the vertical and horizontal deflections were measured at each end using four steel tapes. The test data of the applied loads, deflections, and remarks are tabulated in Table No. 3.

The manufacturer's guaranteed minimum ultimate strength is 4.0 kips (4000 lb./ft. x 1'). At a load slightly greater than 5.4 kips the bottom of the pipe cracked with a subsequent reduction in load. Continuing the loading rate, the top and then the two sides of the pipe cracked at a load of 4.7 kips.

The vertical and horizontal deflections are plotted graphically as shown in Figure No. 6.

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FIGURE 16

DEFLECTIONS OF 1' x 24" CLASS 4000 A/C PIPE 3 EDGE BEARING TESTS

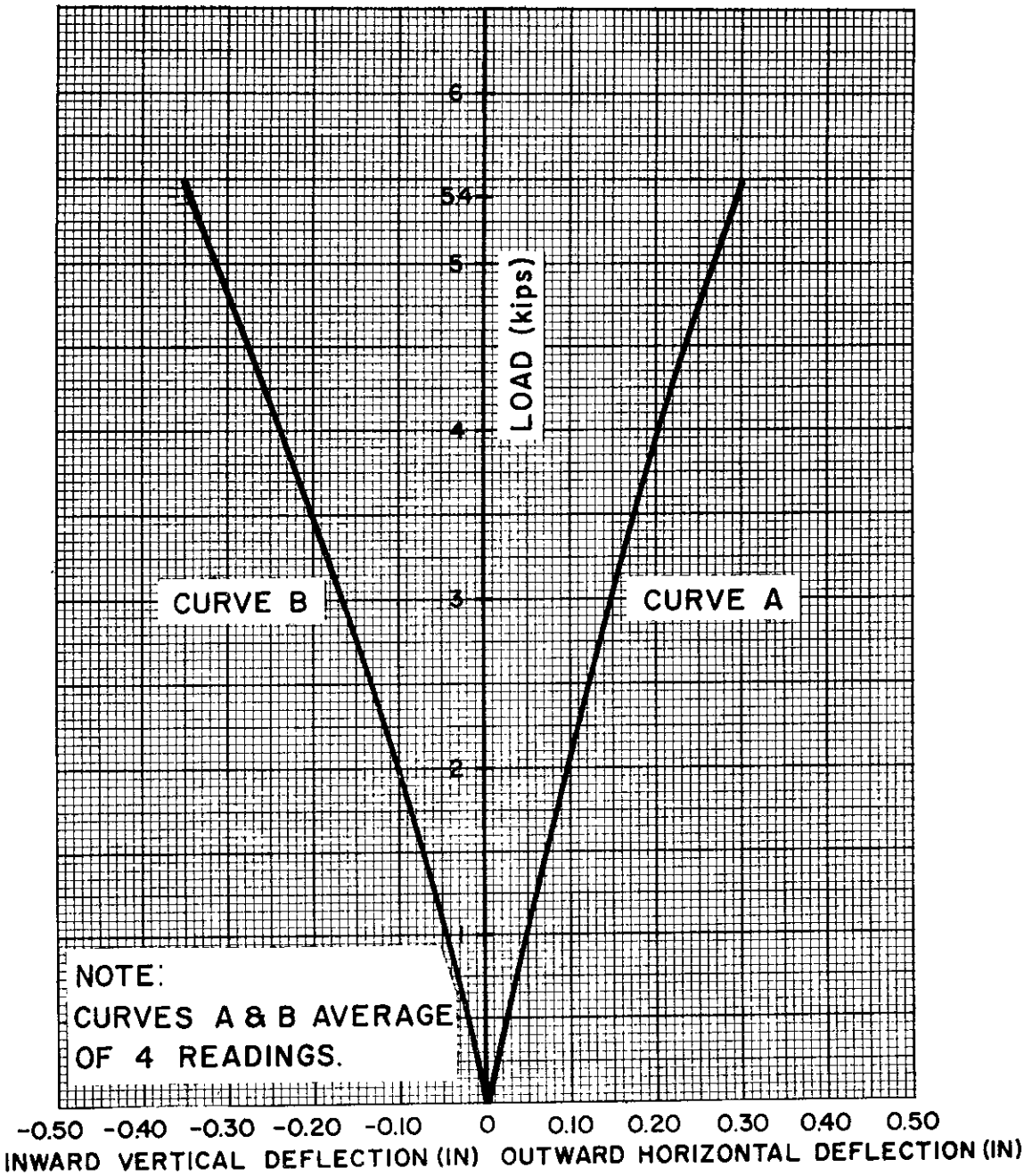

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TABLE NO. 3

3-EDGE BEARING TEST DATA

1' x 24" ASBESTOS CEMENT PIPE (Class 4000)

Load (kip)	Scale No. 1 (in.)	Scale No. 2 (in.)	Scale No. 3 (in.)	Scale No. 4 (in.)	Remarks
0.2	0.000	0.000	0.000	0.000	
1.2	+0.036	-0.060	+0.036	-0.048	
1.4	+0.048	-0.060	+0.060	-0.060	
1.6	+0.060	-0.060	+0.072	-0.072	
1.8	+0.072	-0.072	+0.084	-0.084	
2.0	+0.096	-0.096	+0.084	-0.084	
2.4	+0.132	-0.132	+0.120	-0.096	
2.8	+0.132	-0.144	+0.132	-0.132	
3.2	+0.156	-0.180	+0.144	-0.168	
3.6	+0.180	-0.204	+0.156	-0.192	
4.0	+0.204	-0.240	+0.216	-0.204	
4.2	+0.216	-0.252	+0.216	-0.216	
4.3	+0.228	-0.264	+0.216	-0.240	
4.4	+0.228	-0.264	+0.216	-0.252	
4.6	+0.240	-0.276	+0.228	-0.264	
4.8	+0.252	-0.300	+0.300	-0.288	
5.0	+0.276	-0.312	+0.264	-0.300	
5.2	+0.300	-0.324	+0.264	-0.312	
5.4	+0.312	-0.348	+0.276	-0.324	
5.4	-----	-----	-----	-----	Bottom Crack
4.7	-----	-----	-----	-----	Top Crack, then Side Cracks, Complete Failure

Note: Scale Nos. 1 and 3 Were Horizontal Measurements.

Scale Nos. 2 and 4 Were Vertical Measurements.

Comments: A ½" x 5" Expansion Joint Material Was Placed Between the Top of the Pipe and Wood Block.

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TEST NO. 11

3-EDGE BEARING TEST ON A 1' LENGTH BY 24" DIAMETER ACP

The 3-Edge Bearing test on the 1' length x 24" diameter ACP was set up for testing as shown in Figure No. 5, except the ½" x 5" Expansion Joint Fiber Board was omitted. In addition, the vertical and horizontal deflections were measured at each end using four steel tapes. The test data of the applied load, deflections, and remarks are tabulated in Table No. 4.

The manufacturer's guaranteed minimum ultimate strength is 4.0 kips (4000 lb./ft. x 1'). At a load slightly greater than 5.0 kips the top of the pipe cracked with a subsequent reduction in load. Continuing the loading rate, the bottom and then the two sides of the pipe cracked at a load of 4.4 kips.

The vertical and horizontal deflections are plotted graphically as shown in Figure No. 6. No RCP of a 1' length was tested; therefore, no direct comparison can be made as to strength and deflections in this length.

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TABLE NO. 4

3-EDGE BEARING TEST DATA

1' x 24" ASBESTOS CEMENT PIPE (Class 4000)

Load (kip)	Scale No. 1 (in.)	Scale No. 2 (in.)	Scale No. 3 (in.)	Scale No. 4 (in.)	Remarks
0.2	0.000	0.000	0.000	0.000	
1.0	+0.084	-0.048	+0.036	-0.060	
1.5	+0.096	-0.084	+0.060	-0.072	
2.0	+0.120	-0.108	+0.096	-0.096	
2.5	+0.144	-0.144	+0.156	-0.144	
3.0	+0.180	-0.180	+0.156	-0.156	
3.5	+0.216	-0.204	+0.168	-0.192	
4.0	+0.240	-0.240	+0.180	-0.228	
4.5	+0.276	-0.288	+0.228	-0.276	
5.0	+0.288	-0.348	+0.252	-0.312	
5.0+	-----	-----	-----	-----	Top Crack
4.4	-----	-----	-----	-----	Bottom Crack, Then Side Crack-- Complete Failure.

Note: Scale Nos. 1 and 3 Were Horizontal Measurements
Scale Nos. 2 and 4 Were Vertical Measurements

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TEST NO. 12

SODIUM SULPHATE RESISTANCE TESTS ON A 1' LENGTH BY 24" DIAMETER ACP (CLASS 3300)

A 1' length x 24" diameter ACP (Class 3300 - 1" wall thickness) was cut into three sections.

One section of the pipe was placed on its side with the two ends projecting upward (concave upward) in the sulphate exposure P.C.A. Test Pond No. 2 on August 13, 1965. The pond consists of HOH and 3% Na_2SO_4.

This asbestos cement pipe sample was inspected on February 18, 1966, for signs of distress. As of this date, after approximately 6 months exposure to the sulphates, there was no sign of expansion due to chemical reaction. The only sign of distress was at the high water line where the pipe had undergone an unknown number of cycles of wetting and drying in addition to exposure to sulphate waters. At this line there was a slight softening of the pipe, making it possible to disturb the asbestos fibers rather easily by scratching with a stick.

As the pond is out-of-doors, the wetting and drying cycles were caused by water fluctuation due to rain and wind. The long range effect of the softening is not known at this time. This test is tentatively scheduled to last for two years.

From the second section of pipe, four 6" x 6" test samples were cut and subjected to 5 cycles of Na_2SO_4 soundness testing. The test results are tabulated in Table No. 5. A cycle consists of the following steps:

1. Wash each sample thoroughly.
2. Dry each sample for four hours at a temperature of 230° F.
3. Weight each sample.
4. Immerse each sample in a saturated Na_2SO_4 solution containing an excess of crystals for not less than 16 hours nor more than 18 hours.
5. Dry each sample for 4 hours at a temperature of 230° F.
6. Repeat with Step No. 4.

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After the fifth cycle, the four samples were reweighed and percent loss in weight of each sample was to be determined, but instead of a percent weight loss each of the four samples had a percent weight gain. The test procedure previously outlined for each cycle is quite similar to the test procedure used on aggregates according to Test Method No. Calif. 214-D. Four hours of drying at 230° F is sufficient to dry aggregates to a constant weight; however, as indicated in the absorption test (Test No. 13) approximately 20 or more days are required to dry the ACP to a constant weight, which explains why the four ACP test samples had a weight gain after five cycles. The four ACP test samples showed no visual signs of disintegration as a result of the exposure to the Na_2SO_4 solution.

From the third section of pipe, four 1" x 1" x 11¼" bar samples were cut and subjected to 28 cycles in a Na_2SO_4 solution to determine the amount of expansion.

The test data results are tabulated in Table No. 6. The test was conducted in accordance with the procedure given in Para. 60, p. 65, of Specification No. DC-6250, U. S. Department of Interior, Bureau of Reclamation. Each cycle involves subjecting the bars to 16 hours of soaking in a 0.05N-Na_2SO_4 solution, followed by 8 hours of drying at 130° F. The specification permits a maximum expansion of 0.15% after 28 cycles.

The average expansion of the four bars after 28 cycles was 0.0280%.

The remainder of the third portion of the pipe remains in the concrete lab as a control specimen or for further tests if desired.

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TABLE NO. 5

SODIUM SULPHATE SOUNDNESS TESTING ON CLASS 3300 ACP

	Sample Number			
	A	B	C	D
Original Weight	953	881	983	935
Final Weight	1000	920	1029	985
Weight Gain	47	39	46	50
% Weight Gain	4.9	4.4	4.7	5.3

% Wt. Gain = (Wt. Gain / Orig. Wt.) x 100

TABLE NO. 6

SODIUM SULPHATE RESISTANCE TESTS ON CLASS 3300 ACP

	A	B	C	D	Avg. Exp. (%)
Initial	10.0514	10.0684	10.0297	10.0480	0.000
7 Cycles	560	732	346	524	0.047
14 Cycles	560	734	345	522	0.046
28 Cycles	540	715	328	506	0.028

$$\% \text{ Exp.} = (L - L_0) / L_0 \times 100$$

L_0 = Original Length

L = New Length

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TEST NO. 13

ABSORPTION TEST ON A 24" DIAMETER ACP

The ACP absorption test sample was removed from the tapered end of a 24" diameter pipe. The length (parallel to pipe) and width were approximately 12-1/8" and 9-1/2" respectively. The test data is presented in Table No. 7.

The test sample was soaked in water for 40 days. At this point the wet volume of the sample was calculated to be 137.64 in.^{3} (2,256 cc). The soaked sample was then placed in a drying oven maintained at a temperature of 230° F. The absorption of the sample after 24 days of drying was 13.3% as determined by the following formula:

$$\% \text{ Absorption} = \frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100$$

RCP is required to have an absorption of less than 8% by weight according to the current 1964 California Standard Specifications under Sections 65 and 71 and also AASHO Specifications M170.

ACP which is currently permitted for use in sewer construction only has no requirement as to absorption in the current California Standard Specifications under Section 71 and ASTM C428.

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TABLE NO. 7

ABSORPTION TEST ON A 24" ACP (CLASS 4000)

1. Wet Volume

Specimen Weight in Air = 4884 gm.

Specimen Weight in HOH = 2628 gm.

Wet Volume = 2256 cc.

= 137.64 in.^{3}

2. Absorption Test

Soaking Cycle

Date	Weight (gm)	Date	Days	Weight (gm)	Loss (gm)
10-20-65	----	11-29-65	0	4884	0
10-27-65	4831	11-30-65	1	4655	229
11-01-65	4854	12-01-65	2	4598	286
11-08-65	4867	12-03-65	4	4528	355
11-15-65	4872	12-07-65	8	4436	448
11-22-65	4877	12-15-65	16	4327	557
11-29-65	4884	12-16-65	17	4320	564
		12-17-65	18	4317	567
		12-20-65	21	4311	573
		12-23-65	24	4309	575

$$\% \text{ Absorption} = (W - W_0) / W_0 \times 100 = 13.3$$

Where: W = Wet Weight

W_0 = Dry Weight

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TEST NO. 14

ABRASION REPORT ON THE RESISTANCE OF ACP

Tests on abrasion have not been performed to date by Johns-Manville nor the Materials and Research Department.

Representatives of Johns-Manville are of the opinion that the abrasion resistance of asbestos-cement pipe is equal to that of concrete pipe. Attached as their supporting evidence of this is a letter written to Mr. Eric F. Nordlin on November 22, 1965, by Mr. J. L. Goodspeed of Johns-Manville.

Also attached and submitted by Mr. Goodspeed is a reprint of an article from Skillings' Mining Review, July 21, 1962, as further evidence of the abrasion resistance of Asbestos-Cement Pipe.

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PIPE DIVISION

MAILING ADDRESS:
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STOCKTON, CALIF.

November 22, 1965

Mr. Eric Nordlin,
Assistant Research Engineer
State Division of Highways Lab
5900 Folsom Boulevard
Sacramento, California

Dear Mr. Nordlin:

As we discussed following the tests at the Highway Lab on October 15, 1965, we have contacted our Division Headquarters and Research groups in New York and they have provided the following information regarding abrasion resistance of asbestos-cement pipe:

> "TRANSITE Pipe has been used quite extensively for water and sewer applications since 1930. To date we estimate that there has been over 35,000 miles of TRANSITE Sewer Pipe installed in this country; and we know of no failures due to abrasion.
>
> On September 12, 1960, Hartley Sandt, Group Product Manager, sent a questionnaire to all of our District Managers in the Pipe Division to determine if any areas in the country were experiencing any abrasion problems with TRANSITE Sewer Pipe and to determine whether Research should be requested to set up a test program to establish the abrasion resistance of TRANSITE Sewer Pipe. No abrasion problems were reported. At that time, Research estimated that the cost to establish a program designed to give abrasion resistance data in terms of field conditions such as varying flow rates, velocities, percentages and sizes of abrasive solids, etc., would be $40,000 or so. Since we were not experiencing any abrasion failures in the field, it was decided that such a test program was not economically feasible.
>
> Accelerated tests, such as laboratory roll tests, high velocity slope tests with 30-50% solids content, etc., are of little or no value since these tests do not in any respect simulate actual field conditions.
>
> The Allegheny County, Pa. Sanitary Authority has conducted abrasion resistance tests on clay, concrete and TRANSITE Pipe. It is our understanding that the results of these tests indicated that TRANSITE was superior to both clay and concrete in abrasion

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resistance. On the other hand, there have been laboratory roll tests which have shown that clay and concrete are superior to TRANSITE in abrasion resistance.

There are many considerations which must be properly evaluated concerning abrasion in storm drain applications. Many of these are related to the design of storm drain pipes and the number of times per year which the storm drain pipe will actually be in service.

Storm drain design is most often based on the "rational method" using the formula Q = CiA. In this formula "i" is the average rainfall intensity, in inches per hour, for the period of maximum rainfall of a given frequency of occurrence having a predetermined duration. The storm frequency commonly used is five years for storm sewers in residential areas. This means that Q is computed for the worst storm expected to occur in a five-year period. For important highway or expressway drainage projects the worst storm expected to occur in twenty-five to fifty years may be used in design. The value of Q obtained from the "rational method" is then used in the Manning formula -

$$Q = A \frac{1.486}{n} R^{2/3} S^{1/2}$$

to compute the pipe sizes required.

Since pipe design capacity is thus based on the worst storm expected in a number of years, the pipes will seldom run near full and will usually run at very shallow depths. At shallow depths of flow the actual velocity in the line will be much less than design velocities and potential abrasion problems will be reduced.

Since storm drains are only used when it rains the frequency of usage is only a fraction of the usage of sanitary sewers which carry flow every day. WPCF MOP #9 states "In the case of concrete sewers where high-velocity flow is continuous and grit erosion is expected to be a problem, the limiting velocity is often taken at about 10 fps". Note the word "continuous".

Many failures which have been attributed to abrasion, especially in the steel pipe industry, were in fact due to a combination of corrosion and abrasion. Oxides which build up on the metallic surfaces to retard corrosion are scraped off by abrasive particles thus exposing new metallic surfaces for further corrosion. It is also known that portland cements tend to lose lime when exposed to water for long periods of time. Could some of the failures of concrete pipe attributed to abrasion have been caused by a combination of corrosion and abrasion? TRANSITE Pipe with a free lime content less than 1% will not be subject to this type failure.

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Since abrasion does seem to be a question which engineers raise concerning storm drain pipe, we plan to establish a test program at Research in which we hope to simulate actual field conditions. Flow rates, velocities, percentages and sizes of abrasive solids, etc., will be varied and a family of curves will be drawn from this data. This test program will be expensive and we estimate that it will be one to two years before the program is completed.

In summary, we are of the opinion that potential storm drain pipe abrasion problems are few because of conservative pipe size design and only occasional usage. In addition, TRANSITE Pipe should perform as well as concrete or corrugated metal for those occasions where abrasion could be a problem."

Based on the above we believe the history of Johns-Manville's TRANSITE Pipe abrasion resistance, along with the results of the tests conducted at the State Highway Lab warrants inclusion of asbestos-cement pipe in the Highway Guide as an alternate to RCP with a maximum flow of 10 feet per second.

Very truly yours,

J. L. Goodspeed

J. L. Goodspeed

JLG:mg

cc: Mr. H. L. Olson, District Manager
Johns-Manville Sales Corporation

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Asarco's Mission Open Pit Copper Mine in Arizona

By *David N. Skillings Jr.*

NOW NEARING the end of its first year of operation, American Smelting & Refining Co.'s Mission open pit copper mine, 15 miles south of Tucson in the Twin Buttes district of Arizona, is producing at the rated capacity of 45,000 tons of finished copper per year. The $33 million property, situated 3200 ft. above sea level, is the major factor in this old zinc-lead mining district, which over the past several years has rapidly developed into the newest large low grade copper mining district in the world.

With the expansion under way or planned by the three older producers, Banner Mining Co. and Pima Mining Co., both adjoining Mission, and the copper division of Duval Sulphur & Potash Co., 8 miles farther south, this district in the foothills of southern Arizona's Sierrita Mountains is destined to become of greater importance in the future. The Mission mine becomes the second open pit copper mining operation of Asarco in Arizona, as it becomes an addition to the Silver Bell property, 40 miles northwest of Tucson, the source of about 18,000 tons of marketable copper per year since it was opened by the company in 1954.

Named for the San Xavier Mission, nine miles north, the Mission orebody, buried beneath 200 ft. of gravel wash, was discovered by scout drilling of a favorable area indicated by geological interpretations of ore deposits to the southwest. The ore minerals, essentially chalcopyrite with some oxide copper in a thin, discontinuous zone of secondary chalcocite, lie in sedimentary rocks intruded by monzonite porphyry. Disseminated pyrite and chalcopyrite pervade all rocks within a large zone, but ore grade copper mineralization occurs principally along certain sedimentary horizons to form gentle to moderately steep dipping tabular bodies from a few to over 200 ft. thick.

STAFF PHOTO

East section of the Mission copper mine showing the crushing plants and concentrator in the background.

From the standpoint of structure as well as mineralization, the Mission orebody may be divided into three parts: east, central and west. On the east where the grade is somewhat higher than the average, the ore-bearing beds are bounded partly by a series of northerly striking faults on which considerable movement has resulted in a horst graben. To some extent these faults, representing sharp ore-waste contacts, have localized stronger copper mineralization. In the north central portion the ore is confined to a thin layer just above barren limestone lying at a relatively shallow depth. On the west the ore mineralization is much more continuous along the bedding, but the grade is generally lower than the average for the Mission deposit.

For details on the part played by Transite Pipe at Asarco's Mission pit, see Page 4.

During 1953 Asarco optioned state and federal lands adjoining Pima Mining Co. on the south and west and commenced drilling in the east section of the present pit. Four years later the right to mine adjacent land on the San Xavier Indian reservation to the north was acquired. A total of 346 diamond drill holes, amounting to 200,000 ft., indicated the existence of a large tonnage of ore averaging less than 1% copper that could be exploited by open pit methods.

To confirm the drilling results and supply bulk samples for metallurgical tests, Asarco in 1958 sunk a 375-ft. shaft and performed 2300 ft. of drifting, crosscutting and raising. The tests were conducted at the Arizona State Bureau of Mines pilot plant at the University of Arizona in Tucson and showed excellent copper recoveries.

Upon making the decision to develop the property in July 1959, Asarco commenced to strip the overburden and engaged Western Knapp Engineering Co., San Francisco, Calif., to start detailed mill design. Early the next year the construction contract for the crushing plant and the concentrator also was awarded to W.K.E.

After 23 months of mine preparation and construction and after 46.4 million tons of material including 1.2 million tons of ore were removed from the mining area, the Mission property was placed on a tune-up basis on Aug. 1, 1961, six months ahead of schedule and at a cost of $10.5 million below the original estimate. Characterized by a smooth breaking-in period, the concentrator reached the full capacity of 15,000

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tons of ore per day in September and has been operating at this rate since that time.

Mining

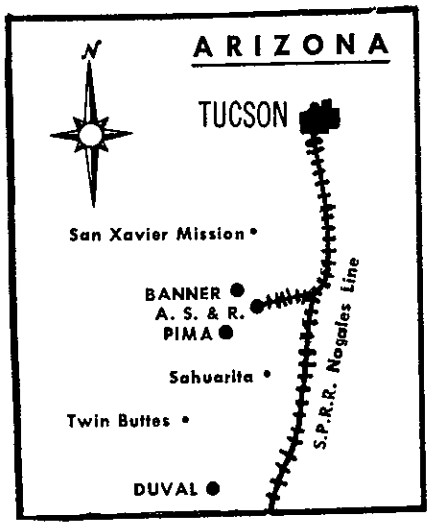
Working the Mission pit on a six-day per week schedule, Asarco currently is moving a total of 100,000 tons of material per day of which 15,000 tons are ore. This higher than normal stripping ratio will continue until the pit has been more thoroughly developed. The present diameter of the mining area is 2600 ft., north to south, 3200 ft., east to west, and it is 380 ft. deep.

The company has opened seven benches of which four are in waste and three are in ore. The first benches in gravel were developed 50 ft. high and those in rock and ore 40 ft. high. All new benches in both waste and ore will have a height of 40 ft.

To remove the 200 ft. of gravel overlying the Mission orebody, Asarco evaluated a number of methods including shovel and trucks, German-type excavating wheels and scrapers, belt conveyors with draglines, and an inclined skipway. The first was selected because it offered maximum flexibility for placing waste in disposal areas and promised full life use of all major equipment.

With main haulage road grades of 7%, the working slope of the Mission pit averages 23°. As the pit lengthens it can be deepened two benches a year within the planned ultimate slope of 37° (1.33:1) in alluvium and 45° (1:1) in rock, plus allowance for haul roads. A minimum of 3000 lineal feet of ore is exposed on operating mining benches to maintain a daily production rate of 5 tons per foot of bench.

For rotary drilling of blast holes at the Mission mine, Asarco has two Reich C850 machines, one with a 9⅜-in. bit and the other with 12¼-in. bit, and one Bucyrus-Erie 40R with a 9⅜-in. bit. The holes are loaded with an explosive charge composed of a 94% ammonium nitrate and 6% fuel oil mixture, consumed at the rate of about 250 tons per month.



Mining is accomplished through the use of three P&H 1800 shovels with 9-cu. yd. dippers, one Bucyrus-Erie 190B with a 9-cu. yd. bucket, and another Bucyrus-Erie with a 10-cu. yd. bucket. Currently the company is operating three shovels per shift of which two are in ore and one is in waste. Working in various parts of the pit according to ore blending plans, the shovels load Asarco's fleet consisting of 29 twin-engine Euclids of 60-ton capacity and six single-engine Darts of 55-ton capacity. From the mining areas the waste is carried 1 to 1.5 miles to the north and east dumps, whereas the ore is hauled about 0.5 mile to the primary crusher.

Crushing

As there was no side hill on the Mission property, the primary crusher was housed in a 100 by 100 by 117-ft. deep hole, the largest mill site excavation in the project. The 54-in. Traylor gyratory crusher serving the Mission mine is one of the larger in the U. S. serving copper mines, only the 60-in. machines being larger. It is designed to handle 3000 tons per hour and is equipped with a grizzly for each of the two truck dumping points.

After the run-of-mine ore is crushed to minus 7½ in., it is fed by a 750-ft. stacker conveyor to intermediate storage, maintained at 125,000 tons of which 20,000 tons is considered live. From the surge facility the ore is conveyed on parallel belts to the fine crushing plant, where it is reduced to minus ¾ in. in two stages by two 7-ft. Symons standard cone crushers and two 7-ft. Symons shorthead cone crushers. The final stage is in open circuit, but the plant is designed so that this can be closed merely by adding two screens. Upon arrival at the fine ore storage area at the concentrator building, the ore is fed by a traveling tripper conveyor, controlled from the fine crushing plant to the 20,000-ton mill bin.

Concentrating

Operating on a seven-day per week basis, the Mission concentrator has a designed capacity of 15,000 dry tons per day of ore of average grade and hardness, or a total of 5,400,000 tons per year. This will yield 165,000 tons of concentrate per year, from which

750-ft. stacker conveyor feeding ore to intermediate storage at the Mission copper mine.

45,000 tons of finished copper will be extracted. The mill utilizes a highly developed system of centralized control with more than average instrumentation.

The grinding circuit of the mill, divided into four sections, consists of four 10½ by 15-ft. Allis-Chalmers rod mills followed by eight ball mills of the same dimensions and manufacture. The compactness of the concentrator is due partly to the use of 32 Krebs classifying cyclones to close the grinding circuit rather than the screw-type classifier.

After reduction to minus 65 mesh the ore is fed to the flotation section containing a total of 328 cells arranged in 36 banks. Automatic sampling takes place as pulp is distributed. The rougher flotation time of 10 minutes gives a good metallurgical recovery of the copper content of the ore that principally is in the form of chalcopyrite. Two 7-ft. 7-in. by 13-ft. Marcy ball mills are employed in the regrinding circuit. To recover its copper content, dust, collected at various points in the concentrator building and primary and secondary crushing plants, is pumped as a slurry to the flotation section.

By gravity the tailing flows to the disposal area, two miles northeast, through a 24-in. Transite pipeline with tilted circular concrete drop boxes to maintain a constant velocity. From the mill the final concentrate

(Continued on page 9)

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Asarco's Mission Open Pit Copper Mine

(*Continued from page 7*)

is pumped to a separate thickening and filtering building, equipped with a 90-ft. concentrate thickener and two 8-ft. 10-in disc filters. The filtered concentrate is conveyed directly to railroad cars.

Water Supply

Water is returned from the tailing pond, the two 125-ft. middling thickeners, and the two 275-ft. thickeners to keep the use of fresh water to a minimum. To reduce water loss through seepage, a patented sealing agent was used on the thickeners. The Mission mine consumes 13 million gallons of water per day, of which 8.5 million gallons are recovered.

The 4.5 million gallons of fresh water required daily by the mill are supplied from three 20-in. wells, 500 ft. deep, that were drilled in the Sahuarita Valley to the east. From the 100,000-gal. gathering tank at the wells, each equipped with a 1600-gal. per minute submersible pump, the water is piped through an 18-in. coated line 17,000 ft. to the 600,000-gal. receiving tank at the mill.

To supply the 8.5 million kwh per month for the 27,000 hp. connected, The Tucson Gas, Electric Light & Power Co. built a 138,000-volt transmission line to the Mission property from the Tucson generating plant. At the mill substation the incoming power is reduced to 4160 volts.

To handle shipment of copper concentrate and incoming freight, the Southern Pacific R.R. and American Smelting & Refining Co. entered into an agreement whereby they constructed a six-mile spur from the S.P. Tucson-Nogales branch to the Mission mine. From the property the concentrate is moved in 86-ton railroad cars to the A.S.&R. smelters at Hayden, Ariz., or El Paso, Texas.

Comprising the operating staff at the Mission mine, where A.S.&R. currently employs a total of 360 personnel, are the following: Robert B. Meen, superintendent; P. A. Lewis, assistant superintendent; John J. Sense, mine superintendent; John D. Vincent, mill superintendent; Scott L. Burrill, assistant mill superintendent; Stanton L. Tainter, chief engineer; and Charles W. McClain, mechanical engineer.

STAFF PHOTO

The 15,000-ton per day Mission concentrator showing conveyor over which crushed ore is fed to the mill bin.

Pictured is an aerial view of American Smelting & Refining Co.'s new Mission open pit copper mine 15 miles south of Tucson in the Twin Buttes district of Arizona. Looking in a westerly direction, the picture shows the pit at the top with the primary crusher, live ore storage, secondary and tertiary crushing plants, water tanks and concentrator building in the upper middle. In the lower center are the tailing thickeners, water storage and offices.

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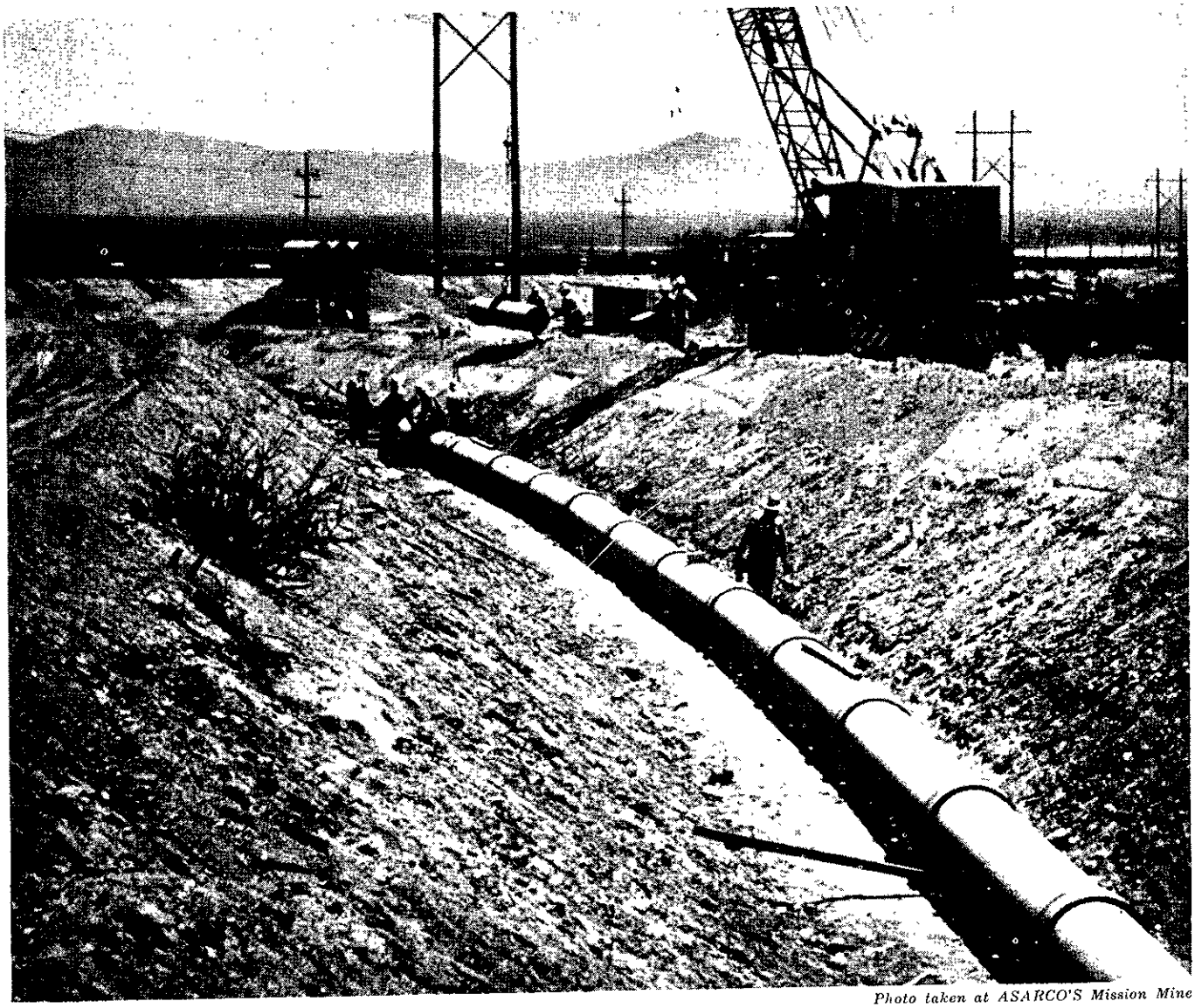

Photo taken at ASARCO'S Mission Mine

50% solid tailings have no effect on 5½-mile Transite Line

The American Smelting and Refining Company has built an unusual system for disposing of concentrated copper tailings . . . a system that called for the unique advantages of Johns-Manville Transite® Pressure Pipe.

The ground surface between the plant and the tailing disposal pond has a natural slope averaging 2.7% away from the mill, so that the flow to the pond is by gravity. A 24-inch Transite Pipe with tilted, circular, concrete drop boxes, forms the main line. The horizontal runs between boxes maintain an average slope of 0.5% and the distance between vertical drops depends on ground slope as the natural grade varies from 0.5% to 3.0%.

At the tailing pond, this 24-inch line splits off into two, 20-inch Transite distribution lines which completely circle the pond area on a natural gradient from the last drop box to build up head. The lines are carried flat around the berm. Tailing flow can be diverted either way through the two, 20-inch lines.

The tailings from the plants gravitate through this 5½-mile system as a water suspension consisting of 50% solids. Total tonnage of solids handled through the system is approximately 99% of the feed sent through the plant each day and amounts to over 14,000 tons.

Why was Transite chosen? This rugged asbestos-cement pipe is built to withstand the constant scouring action of 50% solid wastes. What's more, because of its unusual resistance to corrosion, Transite provides long-term protection against costly system breakdowns. Add to this Transite's leak-proof Ring-Tite® Coupling and many installation economies and it's easy to see why this white pressure pipe was the choice.

For full details on Transite Pressure Pipe's more than 20 years' experience in tailings lines, write to Johns-Manville, Box 362, MW-5, New York 16, N. Y. In Canada: Port Credit, Ontario. Cable: Johnmanvil.

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