Technical Report Documentation Page

1. REPORT No.
Lab. Project Auth. 88-R-6108

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
Report on Tests of Concrete-Filled Steel Pipes for Possible Use As Bridge Roller Bearings

5. REPORT DATE
October 1957

6. PERFORMING ORGANIZATION

7. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT No.
Lab. Project Auth. 88-R-6108

9. PERFORMING ORGANIZATION NAME AND ADDRESS
State of California
Department of Public Works
Division of Highways
Materials and Research Department

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

13. TYPE OF REPORT & PERIOD COVERED

12. SPONSORING AGENCY NAME AND ADDRESS

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Introduction

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The Structural Materials Section of this department was assigned the project of determining the bearing value that might be safely assumed with these rollers.

17. KEYWORDS

18. No. OF PAGES:
14

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1956-1958/57-23.pdf

20. FILE NAME
57-23.pdf

4281

State of California
Department of Public Works
Division of Highways
Materials and Research Department

October 1, 1957

Lab. Project Auth. 88-R-6108

Mr. F. W. Panhorst
Asst. State Highway Engineer
Bridge Department
Division of Highways
Sacramento, California

57-23

Dear Sir:

Submitted for your consideration is:

REPORT
ON
TESTS OF CONCRETE-FILLED STEEL PIPES
FOR POSSIBLE USE AS BRIDGE ROLLER BEARINGS

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work supervised by . . . . H. F. Kuhlman
Report prepared by . . . . H. F. Kuhlman and W. E. Faist

F. N. Hveem
Materials and Research Engineer

HFK/WEF:mw
cc: ALElliott
JWTrask
IOJahlstrom

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INTRODUCTION

An investigation concerning the feasibility of using concrete filled steel pipe as bridge roller bearings was inaugurated by letter from Mr. A. L. Elliott to Mr. F. N. Hveem dated February 13, 1957.

The Structural Materials Section of this department was assigned the project of determining the bearing value that might be safely assumed with these rollers.

TEST SPECIMENS AND PROCEDURE

Test specimens were constructed in accordance with the sketch submitted to the Materials and Research Department in Mr. Elliott's letter of February 19, 1957. The sketch is attached as Figure 1 showing the details of the bridge roller bearings.

The steel pipes used in this test were standard black steel pipe, nominal size 6", 9", and 12" diameters. The wall thickness of the 6" and 9" was 5/16", the 12" was 3/8". The rollers were fabricated with two one-inch keys, top and bottom, and then tamped full of dry grout. The grout was a 1:2½ mixture of coarse aggregate (passing 3/8") with sand and approximately 9½ sacks of cement. The test specimens were cured 28 days in air at which time 6 x 12 inch standard test cylinders had a crushing strength of 6280 pounds per square inch.

Three specimens of each size were constructed and tested to determine their capabilities of carrying loads somewhat similar to loads encountered in bridge structures.

The concrete pipe rollers were tested by two methods: (1) to determine their static load carrying capacity and (2) to determine their rolling load carrying capacity. The maximum load carrying capacity of a grout filled pipe roller (as reported herein) is the load at which the test roller failed either by excessive cracking or spalling and should not be considered as the ultimate load at rupture of a confined mass of grout. In performing the static load test, the deflection was measured at each end of the specimen and the average of these two readings is used as the deflection of the specimen.

The test assembly is typical of assemblies used in service; the pipe rollers were 20 inches long with 1-inch keys, and the bearing plates were 9 inches wide, 28 inches long, and 2 inches thick, drilled to receive the roller keys. Figure 3 shows a roller in place in the 440,000 pound Baldwin testing machine as the upper bearing plate is being brought down to receive the keys of a 12 inch diameter pipe roller. The lower bearing plate was mounted on six 1½ inch diameter steel roller bearings to allow a 1-inch movement of the roller under constant vertical loading. Eight-ton capacity hydraulic jacks were used to roll the pipe roller horizontally a total of one inch; one-half inch to either side of the vertical position of the pipe rollers in relation to their keys. This is referred to as one cycle.

TESTING DETAILS AND RESULTS

The test results are summarized in Figure 2, and the following is a description of the various tests performed.

The first 6" pipe roller was loaded statically to a maximum of 92 kips. The total deflection was 0.10 inches. The load was reduced to 36 kips, then reloaded to 76 kips three times. This showed an apparent set of approximately 0.02 inches at 36 kips and some spalling of fine sand and cement.

The second 6" pipe roller was statically loaded to 98 kips twice. The maximum deflection obtained was 0.08 inches with permanent set of 0.02 inches after the second loading. The specimen was then loaded to 50 kips and rolled ½ cycle; the deflection increased 0.02 inches and the load dropped off 5 kips. The load was then increased to 50 kips again, and the specimen rolled through one complete cycle; the deflection increased 0.01 inches, and the load dropped off 5 kips. The average total deflection after this series of movements was 0.08 inches at 50 kips. There was some spalling of fine sand and cement. After this test the testing fixtures were modified to increase the loading capacity to 250 kips. The third 6" pipe roller was loaded in 20 kip increments. The roller was rolled through two complete cycles at each loading increment. The first crack appeared at 100 kip load during the first cycle. This loading was continued to 135 kips when the concrete began to spall from the end of the roller.

The first specimen of the 9" pipe rollers was statically loaded to 144 kips. The deflection at this load was 0.05 inches. The pipe roller was first rolled at the 144 kip load; a vertical crack appeared on the second cycle, and the concrete began spalling on the fifth cycle.

The second 9" roller was loaded in 20 kip increments, and the roller was rolled through two cycles at each increment. The first crack appeared at 90 kips. This loading was continued to a maximum of 140 kips when the concrete began to spall.

The third 9" roller was loaded the same as the second with the first crack appearing at 100 kips. Spalling began about 110 kips.

The first test on the 12" pipe rollers was static loading to 200 kips; the deflection was approximately 0.08 inches. A hairline crack was visible on each end. The steel was then cut away from the concrete, and the concrete was then loaded statically in the same position that the rollers were tested. A penetrant dye was applied to the cracks to determine their depth into the roller. The penetrant dye indicated that the cracks had not progressed beyond the keys. The ultimate strength of the concrete was 110 kips. Figure 7 shows the break.

The second 12" roller was statically loaded. The first crack appeared at 170 kips with 0.07 inches deflection. A load of 200 kips was maintained for twenty minutes, and the deflection increased from .08" to .085" in the twenty minute period. The permanent set was 0.02 inches. There was a continual spalling of fine sand and cement during this period.

The third 12" roller was loaded in 20 kip increments, and the roller was rolled through two cycles at each increment. The first crack appeared at 100 kips. At 160 kip load the concrete spalled, and the load dropped off 25 kips. The cracks opened approximately 1/8".

The load was then taken to 192 kips, and the testing machine was set at this load. The roller continued to spall and deform for five minutes, then it stabilized and maintained a static load of 165 kips.

CONCLUSIONS

1. The maximum load carrying capacity that grout filled steel pipe bridge roller bearings, shown on the Bridge Department sketch dated February 13, 1957, can be expected to carry without distress is 80 to 90 kips regardless of the diameter of the pipe, if the load is of a dynamic type.

2. If the roller bearings are to be used where there will be a large amount of movement, the life expectancy should be reduced. This is based upon the amount of spalling or surface peeling of fine sand and cement that occurred under a moving load; this spalling began in many cases at as low as 34 to 40 kip loading.

3. The carrying capacity of grout filled steel pipe bridge roller bearings is greater under static conditions than dynamic. The static loading could be as high as 150 kips without evidence of distress, but if there was any movement at this load cracking of the grout could be expected.

4. The quality of grout and the compactive effort used in its placement had a marked effect on the load carrying capacity of the roller. The first 6 inch specimen tested in a static condition showed a deflection of 0.03 inches greater on one end than the other. Examination of the specimen after testing showed a much better consolidation of the grout in the stiffer end. Figure 7 shows two 9 inch specimens where one has good consolidation with a small amount of spalling and the other poor consolidation and a large amount of spalling; both of these specimens were tested under dynamic conditions.

APPENDIX

Figure 1. Bridge Department sketch.

Figure 2. Test results.

Figure 3. 12 inch pipe roller in loading position in the testing machine.

Figure 4. Initial crack in a 12 inch roller (Specimen #3). This is typical of all the rollers at 100 kip loading and 10 cycles of rolling.

Figure 5. 12 inch roller (Specimen #3) beginning to spall at approximately 160 kip load and 16 cycles of rolling.

Figure 6. Same roller as shown in Figure 3 and Figure 4 after a loading of 192 kips and 18 cycles of rolling. Note the deformation of the steel pipe.

Figure 7. Two 9 inch rollers after testing. One is cracked and just beginning to spall; the other roller shows severe spalling.

Figure 8. Shows the dense structure concrete used to fill the pipe rollers. This roller was cut free of the steel pipe and loaded statically. It failed at 110 kips.

Submitted with letter from
Mr. A. L. Elliott to F. N. Hveem
dated February 13, 1957.

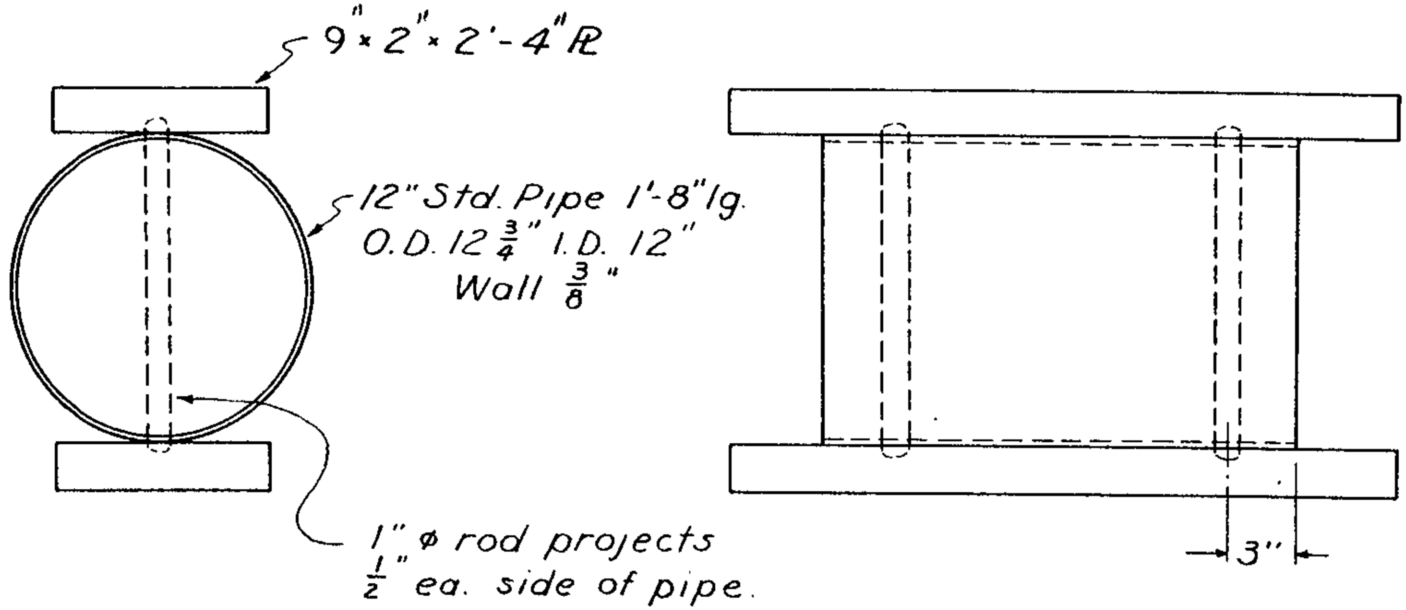

Fig. 1.

Pipe filled with 1:2-1/2 grout
Grout to be sand and pea gravel, so dry that particles will not adhere except when rammed, to be rodded in layers in pipe.

Question--What loads per lin. in. are filled pipes good for?

Say 6-8-12 sizes.

Pipe rollers used at
Br. #35-28 Pescadero Crk
Br. #35-30 San Gregorio Crk
on IV-S.M.-56-B
Constructed in 1941
Special report by H. P. O'Donnell in 1952 says rollers are O.K.

Figure 2

TEST RESULTS

Specimen No.	Pipe Roller Diameter (inches)	Method of Loading: Static	Method of Loading: Rolling	First Crack (kips)	Spalling (kips)	Maximum Load Applied (kips)	Maximum Deflection (inches)	Permanent Set (inches)
1	6 (5/16" wall)	x		None Visible	Some fines	92	0.10	0.02
* 2	6	x	x	None Visible	Some fines	98	0.08	0.02
** 3	6		x	100	135	135	***	***
* 1	9 (5/16" wall)	x	x	144	144	144	0.05	***
** 2	9		x	90	140	140	***	***
** 3	9		x	100	110	140	***	***
1	12 (3/8" wall)	x		200	Some fines	200	0.08	***
2	12	x		170	200	200	0.08	0.02
** 3	12		x	100	160	192	***	***

* Specimens were not rolled until maximum loading was reached.

** Specimens were loaded in 20,000 lb. increments and rolled 2 cycles at each increment.

*** Deflections too small to be considered significant.

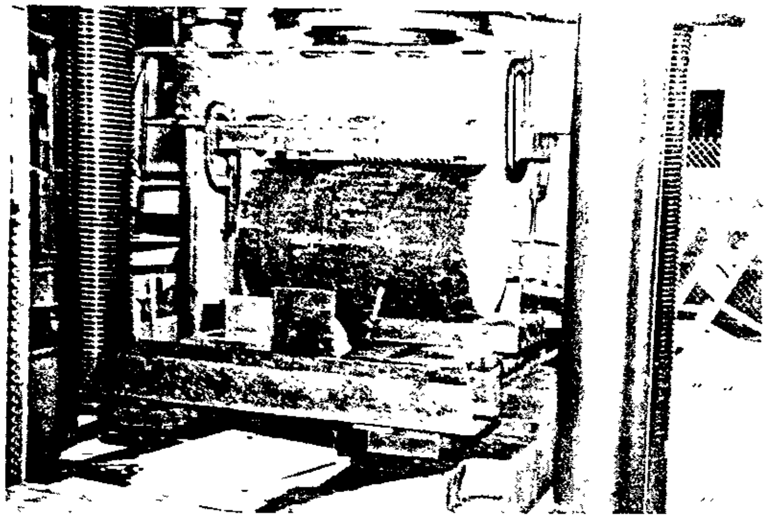

Figure 3

12 inch pipe roller in loading position in the testing machine.

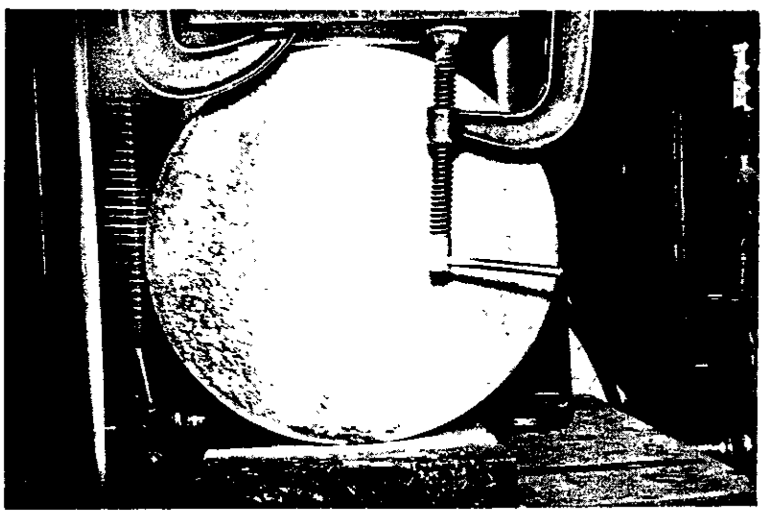

Figure 4

Initial crack in a 12 inch roller (specimen #3). This is typical of all the rollers at 100 kip loading and 10 cycles of rolling.

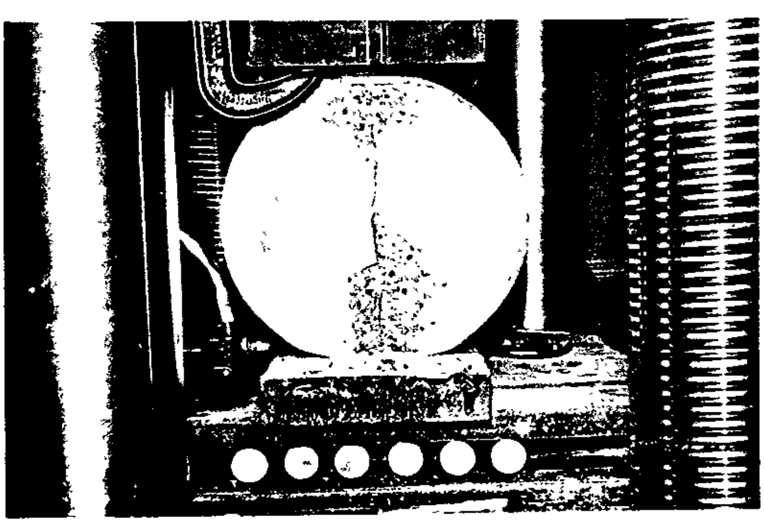

Figure 5

12 inch roller (specimen #3) beginning to spall at approximately 160 kip load and 16 cycles of rolling.

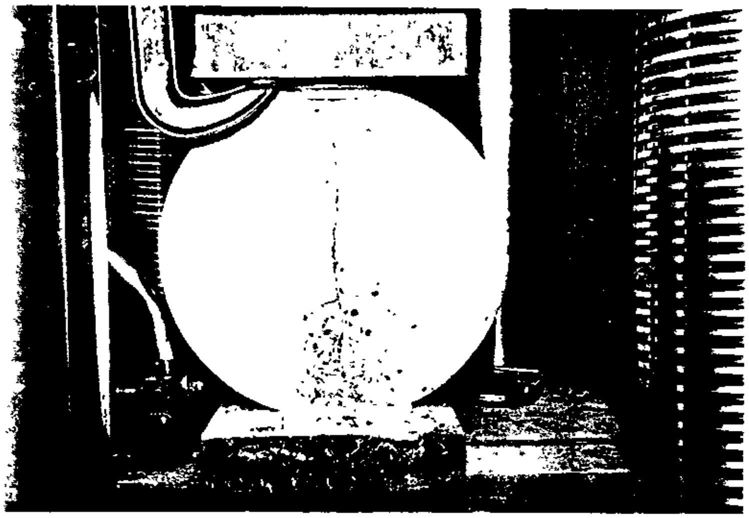

Figure 6

Same roller as shown in Figure 3 and Figure 4 after a loading of 192 kips and 18 cycles of rolling. Note the deformation of the steel pipe.

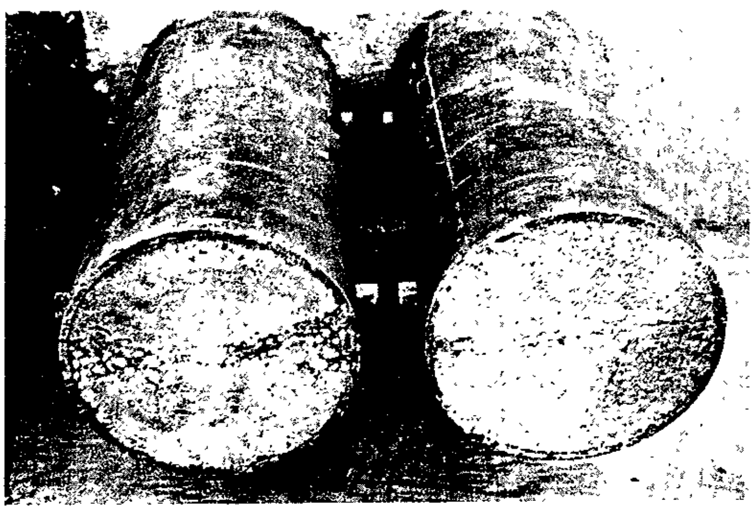

Figure 7

Two 9 inch rollers after testing. One is cracked and just beginning to spall; the other roller shows severe spalling.

Figure 8

Shows the dense structure concrete used to fill the pipe rollers. This roller was cut free of the steel pipe and loaded statically. It failed at 110 kips.