FINAL REPORT

NEOPRENE PADS FOR CAPPING CONCRETE CYLINDERS

by

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SUMMARY

The possibility of using neoprene pads as an alternate to sulfur mortar for capping concrete specimens subjected to compression tests was investigated.

In preliminary tests to determine the feasibility of the investigation, two batches of concrete were prepared. Subsequently, in the main part of the investigation 8 batches of concrete were made. Concrete cylinders measuring 6 x 12 in. were fabricated at strength levels of about 3,000 psi and 5,000 psi in steel and cardboard molds. For each mold type, specimens were tested for compression using both the neoprene pads and the sulfur mortar caps. The 1/2 in. thick, 6 1/8 in. in diameter neoprene pads had a 50-durometer hardness and were placed in extrusion rings 6 1/2 in. in diameter. In general, the specimens tested with neoprene pads yielded slightly lower compressive strengths than did those tested with sulfur mortar caps. However, at the 95% confidence level the differences were not statistically significant. There also was no significant difference between the results obtained with the specimens prepared in steel molds and those prepared in cardboard molds. The report includes recommendations for further tests.

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INTRODUCTION

In the testing of cylindrical concrete specimens for compressive strength, the importance of end conditions in securing uniform loading over the total bearing area is well recognized and emphasized in the literature.(1) In order to accomplish uniform loading, ASTM procedure C39-72 requires that the test cylinders be capped if the ends are not plane within 0.002 in. It also requires that the ends should not depart from perpendicularity to the axis by more than 0.5 degree. Nonuniform loading caused by small irregularities in the surface leads to erroneously low indications of compressive strengths and variable test results. Consequently, in testing laboratories hardened concrete cylinders used for compressive strength tests are routinely capped in accordance with ASTM C617-76 using mortars of sulfur, high-strength gypsum, or calcium aluminate cement. In the Research Council laboratories sulfur mortar is used as the standard capping material because of its high compressive strength and convenience of use. However, the application of sulfur mortar on both ends of a specimen is time-consuming and expensive. Its toxic fumes and the necessity for heating also constitute a safety and air pollution hazard. The use of neoprene pads over the ends of the cylinders has been suggested in the literature as an alternative method for sulfur mortar caps in obtaining uniform loading.(2) Work at the New York State Department of Transportation (NYSDOT) (2) has shown that cylinders tested with neoprene pads exhibit average compressive strengths slightly higher (149 to 172 psi) than cylinders with sulfur mortar caps. That work has indicated that the magnitude of this difference is so small that no corrections need to be made. Also, the testing variation for neoprene pads was found to be equal to or less than that of sulfur mortar caps. In the report on the New York research the economic advantage, ease of use, and safety benefits associated with neoprene pads are stated and its use as an acceptable substitute for sulfur mortar caps is recommended.

A prestressed concrete plant in Virginia aware of the research at the NYSDOT became interested in the use of neoprene pads. They initiated tests to verify the New York results and informed the Research Council of their interest. It appears that the advantages associated with the use of neoprene pads make it attractive and a wide use of this capping method can be expected if it is generally accepted as successful.

OBJECTIVE AND SCOPE

The objective of this study was to investigate the possible use of neoprene pads as an alternate to sulfur mortar caps. In a preliminary investigation of the feasibility of the study two batches of concrete were used. These,coupled with the eight batches used in the main study, made ten batches yielding sixty 6 x 12 in. specimens. Half of the specimens were capped with sulfur mortar and the remainder with neoprene pads. The specimens were tested under compression and a statistical analysis was made to determine if significant differences existed between the two capping methods at the 95% confidence level.

PROCEDURE

Capping Materials

The neoprene pads used were of the same size and characteristics as those used in the NYSDOT tests. The neoprene had a 50 durometer hardness and the pads were 1/2 in. thick and 6 1/8 in. in diameter. The pads were located in extrusion rings 6 1/4 in. in diameter and placed on both ends of the cylinder. The use of the 6 1/4 in. durometer ring in lieu of the 6 1/2 in. ring used by the NYSDOT was adopted because of the experience reported by the prestressed concrete plant in Virginia in its study of the NYSDOT procedure.(3) They found that the wider 6 1/2 in. ring permitted the neoprene pads to stretch and flow outside the extrusion ring. Consequently, the smaller 6 1/4 in. ring was constructed for use in this study. Figure 1 shows a sketch and a picture of a neoprene pad and extrusion ring.

The sulfur mortar used was a commercially available material normally used by the Research Council.

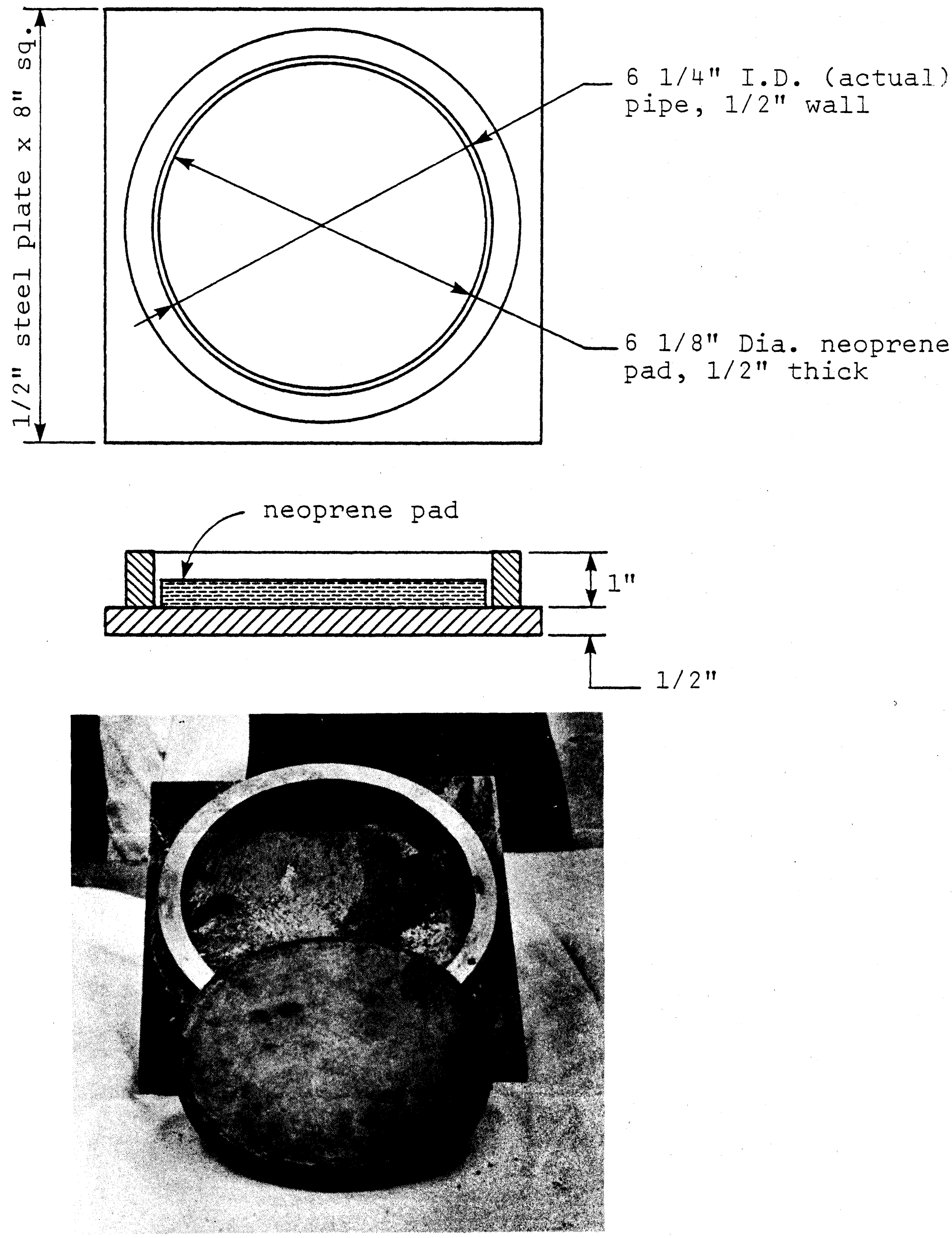

Figure 1. Sketch and photo of neoprene pad and extrusion ring.

Preliminary Laboratory Study

A preliminary lab study was performed to determine whether a more extensive study in this area utilizing 6 1/4 in. extrusion rings and the neoprene pads would be feasible and warranted.

Samples and Mix Proportions

Six 6 x 12 in. cylinders were prepared from each of two batches of concrete. The mixture proportions of the two batches are shown in Table 1. Batch 1 utilized IP cement and Batch 2 used Type I cement with fly ash. The air content of the former was 5% and that of the latter was 10%.

Table 1

Mix Proportions in Pounds Per Cubic Yard

Batch No.	Cement	Fly Ash	Water	C. A.	F. A.
1	588	---	270	1,924	1,112
2	506	125	270	1,922	1,063

Specimens were moist cured for 28 days. Half of the specimens were capped with sulfur mortar and the other half with neoprene pads in extrusion rings. All were tested at 28 days.

Results

The compressive strength values of the specimens are summarized in Table 2. These results indicate that cylinders broken with neoprene pads failed at slightly lower strengths than those with sulfur mortar caps. For the first batch the difference in average strength was 290 psi, which is 5% of the strength obtained utilizing sulfur-mortar caps. The 190 psi difference for the second batch is also 5% of that attained by specimens with sulfur mortar. The standard deviations for cylinders tested with neoprene pads were smaller than those for the cylinders with sulfur mortar caps. However, because of the limited amount of data no significance can be attached to these results.

Table 2

28-Day Compressive Strength Values
(Average of 3 Specimens)

Batch No.	Cap	Compressive Strength	Standard Deviation
1	Neoprene pad	5,230	10
1	Sulfur mortar	5,520	110
2	Neoprene pad	3,630	140
2	Sulfur mortar	3,820	156

Main Testing Program

In view of the favorable results in the preliminary laboratory studies, a more extensive series of specimens were prepared and tested.

Samples and Mix Proportions

It was desired to test cylinders at the lower and upper strength levels expected to be attained in the field. The widely used A3 concrete has a 28-day minimum design strength of 3,000 psi and the A5 concrete used in prestressed elements has a minimum of 5,000 psi. Concretes prepared in the laboratory using the A3 or A5 specifications would normally yield compressive strengths considerably higher than the minimum design strengths. Therefore, the specifications were not completely adhered to and an attempt was made to prepare specimens at about the 3,000 psi and 5,000 psi levels. For each desired strength level 4 batches of concrete were prepared. For the 3,000 psi concretes, a high air content of about 10% and a cement content of 376 lb./yd.^{3} were used in proportioning the mixtures. For the 5,000 psi mixtures, 588 lb. of cement per cubic yard was used and air entrainment was omitted to minimize variability. The coarse aggregate utilized in all the mixtures was a locally available granite gneiss with a specific gravity of 2.78 and a dry rodded unit weight of 103.3 lb./ft.^{3} The fine aggregate was a quartz sand with a specific gravity of 2.62 and a fineness modulus of 2.8. The same Type II cement was used in all the mixtures. The mixture proportions for the low and high strength concretes are given in Table 3.

The slump, air content, and unit weight of each batch are given in Table A-1 of the Appendix. The average mixture data for low and high strength concretes and the corresponding standard deviations are summarized in Table 4.

Table 3

Mixture Proportions in Pounds Per Cubic Yard

Strength Level	Cement	Water	C. A.	F. A.
Low	376	199	1,869	1,378
High	588	286	1,869	1,416

Table 4

Mixture Data (Average of 4 Batches)

Strength Level	Slump, in.		Air Content, %		Unit Weight, lb./ft.^{3}	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Low	1.2	0.2	10.6	1.2	140.2	0.4
High	2.6	0.2	2.2	0.1	151.1	0.2

Six 6 x 12 in. cylinders were prepared from each of 8 batches of concrete. Half of these cylinders were cast in steel molds and the other half in cardboard molds. For each mold type, half of the specimens were tested under compression using sulfur mortar caps and the other half using the neoprene pads and extrusion rings.

Results

The compressive strength test results for all the specimens are shown in Table A-2 of the Appendix. A three-level analysis of variance test was performed using the data in Table A-2 to determine if any significant differences existed among compressive strengths based on the three variables, namely, the mold type, capping type, and strength level. The batches were prepared using the same proportions for each strength level and were not assumed to be variables. The results indicated that, as expected, at the 95% confidence level there was a significant difference between the two strength levels. However, there were no significant differences between the specimens prepared in cardboard and steel molds and tested with either neoprene or sulfur mortar caps.

Also a statistical test was done to determine whether the variabilities in compressive strengths were different for cylinders capped with neoprene pads and sulfur mortar for each strength level. Cylinders cast in both types of mold were included. The average compressive strength values and the standard deviations are summarized in Table 5. The results from the F test indicated that at the 95% confidence level variations in the compressive strengths for the two capping methods were not significant.

Table 5

Average Compressive Strength Values and Standard Deviations for the Two Capping Types

Strength Level	Neoprene Pad		Sulfur Mortar	
	Average, psi	Std. Dev.	Average, psi	Std. Dev.
Low	3,030	174	3,090	126
High	5,170	118	5,270	180

The specimens tested with neoprene pads tended to exhibit a splitting type of failure rather than the widely observed conical type of failure of specimens with sulfur mortar caps as illustrated in Figure 3. However, certain breaks were observed to be similar in both capping methods.

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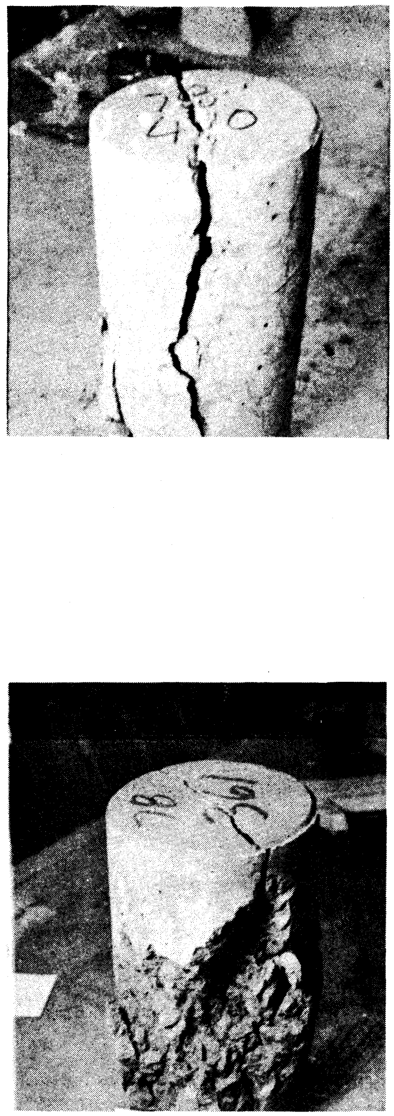

Figure 3. Photographs of failed specimens tested with neoprene pads.

Some of the high strength cylinders tested with neoprene pads ruptured explosively, but none of the sulfur mortar capped specimens showed the same intense failure at the levels of strength encountered. At present, there is no explanation for this difference. It is noted that in other work at much higher strengths the sulfur mortar caps were also found to rupture explosively.

CONCLUSIONS

In general, the specimens tested using the neoprene pads of 50 durometer hardness in 6 1/4 in. extrusion rings gave average compressive strengths slightly lower than similar specimens (from the same batches) tested with sulfur mortar caps. However, based on the limited number of tests performed in this study, at strength levels of 3,000 psi and 5,000 psi the differences noted were not statistically significant at the 95% confidence level. There also was no significant difference between the results obtained with specimens prepared in steel molds and those prepared in cardboard molds.

Cylinders tested with neoprene pads tended to exhibit a splitting type failure, whereas those capped with sulfur mortar displayed more of a conical failure mode. However, some specimens exhibited similar breaks with both capping methods.

RECOMMENDATIONS

It is recommended that, for a period of one year, from selected field and laboratory projects specimens be fabricated for testing with both capping methods. Ultimately, if differences continue to be not significant, testing with neoprene caps should be an acceptable standard method of capping in the Department.

In the laboratory it would be desirable to investigate the effect of varying the diameter of the extrusion ring and the hardness of the neoprene pad on the compressive strength of cylinders.

Precautions should be taken in testing high strength cylinders with neoprene pads because of a possible explosive type rupture.

ACKNOWLEDGEMENT

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Special thanks go to Stephen Runkle for his generous assistance in the statistical phase of the study. Thanks are given to Clyde Giannini and Mike Burton for their invaluable help in the preparation and testing of specimens.

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2. Grygiel, J. S., and D. E. Amsler, "Capping Concrete Cylinders with Neoprene Pads", Research Report 46, New York State Department of Transportation, New York, 1977.

3. Personal communications with Tom Ellis, Chief Engineer, Bayshore Concrete Products Corporation, Cape Charles, Virginia.

Table A-1

Mixture Data of the Batches Used in The Main Testing Program

Batch No.	Strength Level	Slump, in.	Air, %	Unit Weight, lb./ft.^{3}
1	Low	1.4	11.4	140.2
2	Low	1.0	11.8	140.6
3	Low	1.2	9.5	139.6
4	Low	1.2	9.5	140.4
5	High	2.4	2.2	151.1
6	High	2.6	2.1	150.9
7	High	2.8	2.0	151.1
8	High	2.6	2.3	151.3

Table A-2

Compressive Strength Test Data in PSI for Specimens Using Neoprene and Sulfur Mortar Caps in Cardboard and Steel Molds

Batch No.	Strength Level	Cardboard Mold				Steel Mold			
		Neoprene		Sulfur		Neoprene		Sulfur	
1	Low	2,785	2,811	2,856		2,953	2,900	2,856	
2	Low	3,068		3,112	3,139	3,201		3,165	3,236
3	Low	3,130	3,130	3,112		2,900	3,050	3,236	
4	Low	3,006		3,077	2,997	3,395		3,077	3,165
5	High	5,367	5,131	5,287		5,199	5,119	5,570	
6	High	4,881		5,358	5,049	5,164		5,314	4,863
7	High	5,164	5,199	5,199		5,111	5,296	5,438	
8	High	5,234		5,287	5,287	5,128		5,208	5,349