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Design And Testing Of Classes "A" and "B"
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16. ABSTRACT

Test Method No. Calif. 312-E, for the "Design and Testing of Classes "A" and "B" Cement Treated Bases (CTB), specifies that the compression testing machine shall have a spherically-seated head and shall apply a continuous rate of load application.

Normally, CTB specimens are fabricated in the field or area laboratories cured for two days, and then shipped to the District Materials Laboratory for seven day compressive strength tests. This is usually done because the District Labs have testing machines with spherically-seated heads and these machines can be adjusted to apply continuous loading, without shock, at the specified rate of application.

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Introduction

Test Method No. Calif. 312-E, for the "Design and Testing of Classes "A" and "B" Cement Treated Bases (CTB), specifies that the compression testing machine shall have a spherically-seated head and shall apply a continuous rate of load application.

Normally, CTB specimens are fabricated in the field or area laboratories, cured for two days, and then shipped to the District Materials Laboratory for seven day compressive strength tests. This is usually done because the District Labs have testing machines with spherically-seated heads and these machines can be adjusted to apply continuous loading, without shock, at the specified rate of application.

Prior to revision of Test Method No. Calif. 312-D in October, 1967, our test method outlined a procedure for determining compressive strengths at the construction sites. The Compression Machine shown in Figure 1 was used for measuring specimen strengths. It was also used to apply compactive effort during fabrication of test specimens. Figure 1 shows arrangement of the apparatus for this operation, the specimen contained within the split mold. The same apparatus is currently being used for compacting specimens under existing Test Method No. Calif. 312-E. However, changes made to the procedure for testing CTB have essentially made this apparatus unsuitable for determining compressive strengths. The jack and frame do not meet two requirements:

(1.) Loading by means of a spherical head assembly.

(2.) Continuous loading without shock.

Because the existing test procedure does not specifically reject the use of this apparatus for compressive testing, confusion has resulted. Perhaps only slight modifications need be made to the apparatus so that it would be acceptable! Occasions arise where it may be desirable and considerably more convenient to perform strength tests in the field, if only for informational purposes.

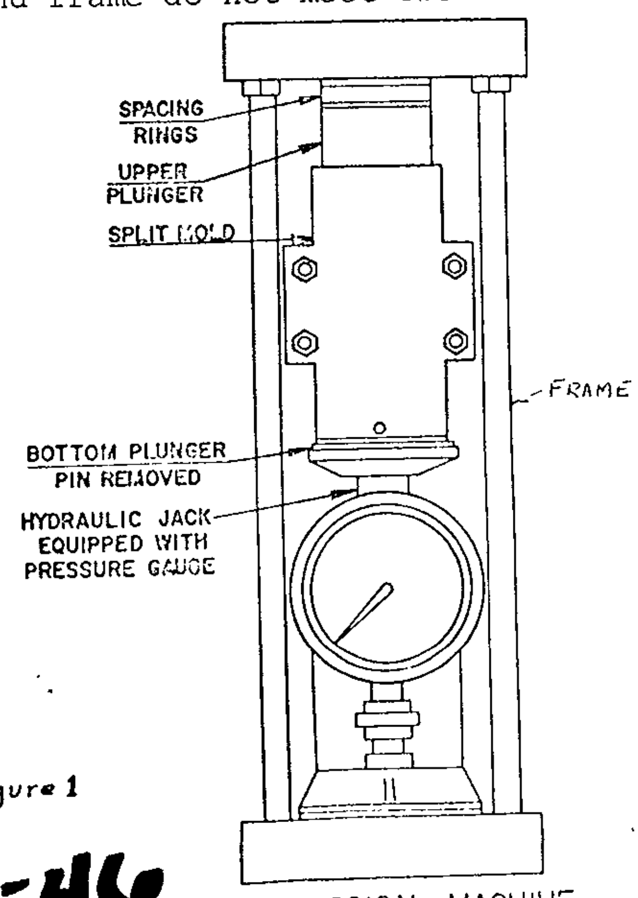

Figure 1

COMPRESSION MACHINE

71-46

The degree to which each of the two above stated deficiencies effect compressive strength results was unknown. It was believed that the provision of an adjustable spherically-seated head was most important. It is extremely difficult to cap CTB specimens so that their testing surfaces are exactly parallel to the bearing surfaces of the apparatus. Failure to do so results in non-uniform load distribution and compressive strength results are questionable.

It is possible to apply loads by manual jacking within the specified rate tolerances, however, this is not a continuously applied load and without shock. The importance of continuous loading on CTB specimens needed evaluation also.

It is realized that extensive modifications to the jack and frame could be expensive and probably not economically justified. However, it was considered necessary to determine if only slight modification could result in a satisfactory apparatus. It was decided to develop an inexpensive spherical head assembly for the frame. A limited testing program could then be performed to evaluate the apparatus and make recommendations.

By May 1970, a spherically-seated head assembly was designed. Two were fabricated by the Materials and Research machine shop at a cost of about $30 each. One of the assemblies was installed on a jack frame used by a District 04 area laboratory. The other was retained for evaluation in a limited research project by the Pavement Section.

Initial Test Program

A work plan was written and a testing program performed under "Miscellaneous Research" funds, 19107-762504-641139B. Results of this program were reported in a memo to R. L. Donner, dated July 28, 1970, under the subject title "Evaluation of CTB Test Apparatus". Although the work plan was closely followed, inconclusive results were obtained due to an unexpected problem with the regular capping plaster. The capping plaster was observed to "flow" or fail before reaching ultimate strength of the CTB specimens. Consequently, the resulting compressive strengths could not be used as measures of the apparatus performance.

Further investigation was made of the capping plaster strength and results are shown in Table 1.

Table 1

Compressive Strength Tests on 2-inch
Cubes of USG Regular Casting Plaster

Consistency of Paste	Water/ Plaster Ratio (by wt.)	Compressive Strength at various ages (psi)				
		30 min.	60 min.	1-1/2 hr.	17 hr.	24 hr.
Stiff. (difficult to cap more than one specimen per batch of paste)	0.51	942	980	922		
Plastic (slightly more stiff than used in testing program)	0.59	655	632	615	590	587
Wet (more fluid than used in testing program)	0.95	300	277	255		

Note: All cubes were aged at room temperature and humidity, and decreasing compressive strengths occurred with extended setting times prior to loading.

It is obvious that this type of casting plaster is unsuitable for testing CTB specimens that may reach compressive strengths in excess of 1000 psi.

Subsequently, a new high strength casting plaster called "Hydrocal" was obtained and tested by a similar program. Results of these tests were reported in a memo to C. Gates on October 20, 1970. Table 2 shows that "Hydrocal" provides high compressive strengths at all consistencies and setting times.

Table 2

Compressive Strength Tests on 2-inch Cubes of Hydrocal Casting Plaster

Consistency of Paste	Water/ Plaster Ratio (by wt.)	Compressive Strength at Various Setting Times (psi)				
		1/2 hr.	1 hr.	1-1/2 hrs.	17 hrs.	24 hrs.
Stiffest	0.32	3550	3850	3310	3570	3670
Medium (probably normal consistency used)	0.37	2230	2350	2740	3070	3110
Wettest	0.42	2220	2170	2470	2560	2520

Note: All cubes were aged at room temperature and humidity.

No problems occurred in capping specimens with this material although reduced water/plaster ratios are necessary to obtain desirable consistencies.

As a result of this study, this new material is now being used for capping all routine CTB specimens by the Materials and Research Department.

Final Testing Program

It was now possible to continue testing of the compression machine. A work plan was submitted and approved in December, 1970. The outlined procedure was similar to the previous work plan, with the exception that "Hydrocal" capping plaster was to be used in place of the regular capping plaster.

The chosen test program was designed to provide sufficient data with an absolute minimum amount of testing.

The objectives were to:

1. Determine the effect of loading CTB specimens with the manually-operated compression machine (hydraulic jack) as compared with our Riehle Compression Testing Machine.

2. Determine the advantages of a spherical head assembly in testing non-parallel capped specimens.

The testing program consisted of the following:

(a) Sufficient aggregate from a local source was obtained to fabricate 20 similar CTB specimens. Each specimen was mixed with 5% cement, and fabricated according to Test Method No. Calif. 312-E.

(b) After the normal curing period, each specimen was capped by the following method. One surface was capped perpendicular to the vertical axis of the specimen. The other cap was formed at a prescribed angle by means of an inclined plane and a small level. Based on past experience of operators familiar with this phase, it was decided to cap all specimens so that 1/8" deviation from normal was obtained across the 4-inch diameters. Figures 2 and 3 depict the capping operation.

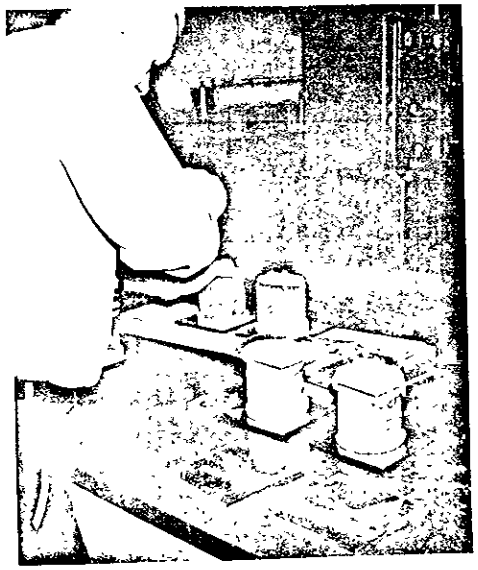

Figure 2

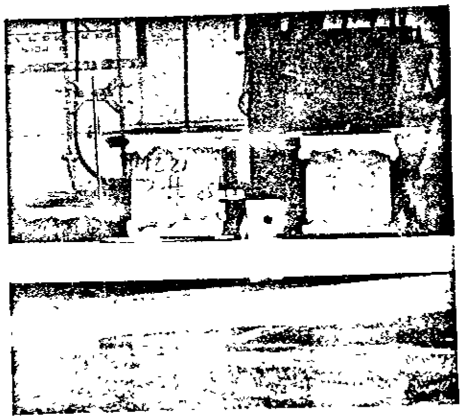

Figure 3

(c) The following four methods were used in performing compression tests. Loading by each method was within the specified 12,000± 2000 pounds per minute.

(1) Five specimens were tested by continuous loading described in Test Method No. Calif. 312-E using the Riehle Compressive Testing Machine, but with locked spherically-seated head (Figure 4).

(2) Five specimens were tested by continuous loading described in Test Method No. Calif. 312-E using the Riehle Compression Testing Machine, with spherically-seated head (Figure 5).

(3) Five specimens were tested using the field apparatus consisting of jack and unmodified frame, i.e. fixed upper plate. Load applied in increments (Figure 6).

(4) Five specimens were tested for compressive strength using the field apparatus consisting of jack and frame with attached spherically-seated head assembly. Load applied in increments (Figure 7).

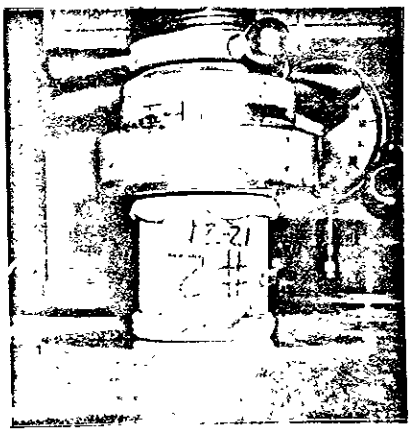

Figure 4

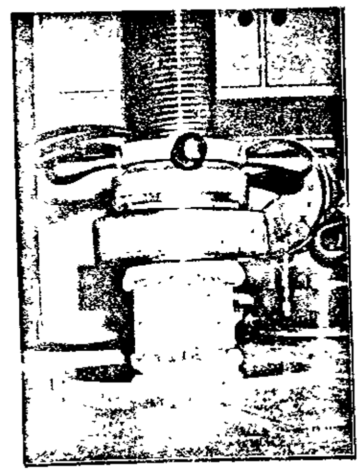

Figure 5

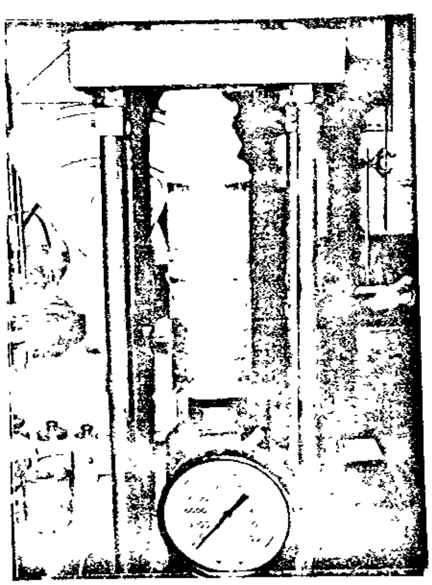

Figure 6

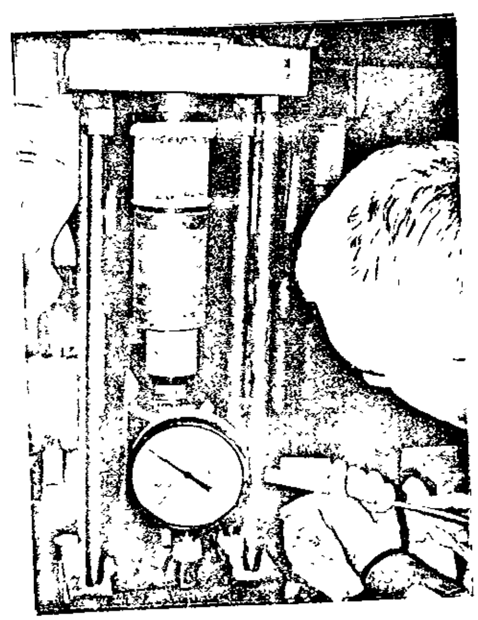

Figure 7

Test Results

Table 3 shows the results obtained by the testing program. None of the test results were discarded or omitted for purposes of the following analysis. Variations in densities and compressive strengths are considered to be within the accuracy or repeatability of compression test results on CTB specimens. All testing was performed by one operator. This served to eliminate variance between test results due to procedural differences by two or more operators.

Table 3

Method of Testing	Test No.	Dry Density lbs./cu.ft.	Compressive Strength* lbs./sq.in.
Riehle Press, fixed upper head, uniform rate of load at 12,000 lbs./min.	1	139.0	912
	2	139.1	800
	3	139.3	752
	4	139.3	784
	5	138.8	528
	Average	139.1	755
Riehle Press, spherically-seated head, uniform rate of load at 12,000 lbs./min.	6	139.9	1088
	7	139.1	976
	8	139.2	1072
	9	138.6	928
	10	138.6	1040
	Average	139.1	1021
CTB Frame & Jack, fixed upper head, non-continuous load at approx. 12,000 lbs./min.	11	138.6	611
	12	138.7	459
	13	138.5	576
	14	138.8	576
	15	138.3	496
	Average	138.6	544
CTB Frame & Jack spherically-seated upper head, non-continuous load applied at approx. 12,000 lbs./min.	16	138.2	768
	17	138.3	720
	18	139.0	846
	19	138.7	846
	20	138.7	888
	Average	138.6	813

*Compressive strengths shown for the jack gage are corrected values, obtained from calibration with the Riehle gage. The Riehle machine itself was checked recently and found to be within calibration. The Riehle rate of loading was controlled by a dial pacer. Jack loading was controlled with the aid of a stopwatch.

Observations

1. All 10 test specimens loaded with fixed upper bearing plates were observed to bulge and crack as shown in Figure 8. Cracks formed on successive failure planes as loading increased. These cracks extended through the capping plaster. Figure 5 shows a typical failed specimen.

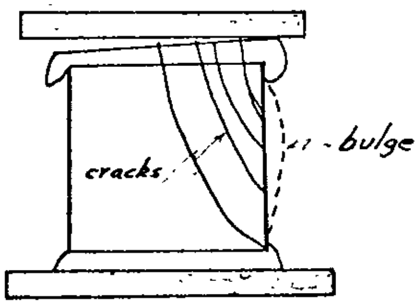

Figure 8

2. All 10 specimens, loaded using the spherically-seated head assemblies, were observed to fail by exhibiting "cone-type" failure patterns, as shown in Figure 9.

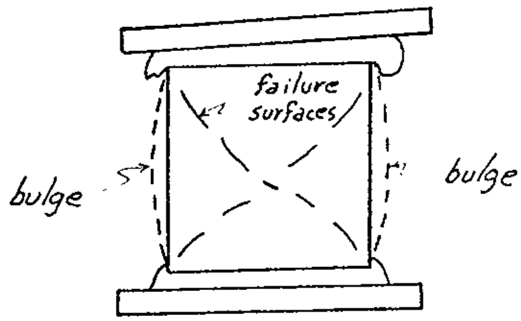

Figure 9

Figure 10 shows a typical cap surface after specimen failure. The cap does not show any cracks or visible signs of failure.

Figure 10

Discussion of Test Results

The highest average compressive strength was obtained using the Riehle Press with the adjustable spherically-seated head attachment and continuous loading. Lowest compressive strength results were obtained with the CTB compression machine when used with the manual jacking method of applying incremental loads, and with no upper head attachment, i.e. (specimen's bearing against the fixed upper frame plate). The difference between average test results by these two methods amounts to 477 psi and is attributed to two factors; type of bearing surface and continuity of loading.

1. Effect of bearing surface:

For tests with the Riehle Press, a locked head resulted in an average compressive strength of 755 psi. This is approximately 74% of the average compressive strength obtained with the Riehle Press and the adjustable head. For tests with the CTB Compression Machine, specimens loaded against a fixed upper plate had approximately 67% of the recorded strength of similar specimens tested with the spherically-seated head assembly.

2. Effect of continuity of loading:

A comparison of strengths obtained by the Riehle and Compression Machine methods, when both machines were equipped with spherically-seated head attachments, reveals the effect of the two types of loading. Only 80% of the Riehle method average strength was obtained by non-continuous, incremental loading with the manual jack.

The effect of continuity of loading is shown also by comparing average compressive strength results obtained with the Riehle and Compression Machine when both were used with rigid (or fixed) upper bearing platens. In this case 72% of the strengths by continuous loading were obtained by the jacking method.

In summary, the data shows that type of bearing and continuity of loading have very significant effects on compressive strength test results. The spherically-seated head assembly influenced test results in this program slightly more than continuity of loading. Under different conditions, particularly when different capping perfection is obtained, the relative effects of these two factors may be considerably different.

Conclusions and Recommendations

1. The initial test program revealed that U.S.G. Regular Casting Plaster is unsuitable for capping CTB specimens that reach compressive strengths of 1000 psi or greater. It is recommended that a high strength capping material be specified,

such as "Hydrocal" casting plaster, which has a minimum of 2000 psi compressive strength. The appropriate change should be made to the apparatus under Part V of Test Method No. Calif. 312-E for capping material.

2. Compressive strength test results obtained by the Field CTB Compression Machine are not acceptable. Use of the spherically-seated head assembly for this apparatus will result in higher strength results, however, non-continuous load application by manual jacking causes unacceptable test results for construction control purposes. It is not recommended that this apparatus be used for determining CTB compressive strengths. Test Method No. Calif. 312-E requires clarification and should specifically reject this apparatus for compression test purposes. All CTB specimens must be sent to a laboratory for testing by a suitable compression testing machine.

Recommendations for Further Study

1. Consideration should be given to specifying a capping "stand" and a commercially available "thermal setting" capping compound, such as those used for concrete cylinder caps.

2. The possibility of supplying district "area labs" with portable compression testing machines may be worthy of investigation. These machines are commercially available with electric pump attachments.

3. Indications are that use of the spherically-seated head assembly on the CTB compression machine results in higher compressive strengths when this attachment is used during sample fabrication. This is possibly due to more uniform compaction of the CTB specimens. This may be a desirable feature, however, it requires further investigation.

4. Determine whether conversion of the lever-operated jack to a crank operated jack would be justified to enable compression tests on the construction sites with the CTB compression machine.