REPORT OF COMMITTEE ON CHARACTER AND USE OF ROAD MATERIALS

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This Committee has aimed to investigate and encourage research on the character and use of road materials Certain problems were suggested by the committee membership or through the Highway Research Board Some of these are included in the form of investigations as reported by different members of the Committee

In addition to the problems which were reported in "Proceedings of the Third Annual Meeting," investigations on the following subjects are now under way

The use of calcium chloride as an accelerator and curative agent in concrete highways —Considerable data are available on this subject, and something conclusive, relative to the recommendations of the merits of this material, may be expected in next year's report

Durability of high aluminum cement —The use of this material in the United States has been very limited to date There seems to be a demand for such a product in making replacements of concrete slabs and possibly in building short stretches of highways where it would be impracticable, or at least quite inconvenient, to establish detours

The possibilities of using a high aluminum or quick-hardening cement in testing concrete aggregates to accelerate results has many advantages —One series of results submitted by the Georgia State Highway Department on this problem is being studied

Character of bituminous materials for surface treatment on earth and gravel roads —The phase of this subject which we propose studying, is the character of that bituminous material which has been reported as successfully used under certain conditions

Zone paints from the standpoint of visibility for night and day travel — It is recognized that specifications for materials to be used for the same purpose differ widely in the various highway departments.

SOUNDNESS TESTS FOR COARSE AGGREGATES

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Inasmuch as the durability of the constituents of road surfaces when subjected to weathering conditions is one of the most important questions confronting the road builder in the selection of materials, the Committee feels that accelerative tests to determine the soundness of coarse aggregates are worthy of very thorough investigation Information is much needed to determine the true significance of the results of such tests when applied to aggregates for concrete Of the various classes of accelerative tests which have been used on rock-like materials, the one most indicative to the road builder is the crystallization test In tests of this class the pores of the test specimens are saturated with a solution which expands considerably on crystallizing and thus produces heavy strains in the pore walls By dessication of the specimens and resaturation, the number of cycles of expansive strains may be made sufficient to produce disintegration Since the expansive actions of the salt solutions used in the tests mentioned below is much greater than the expansion of water on freezing, disintegration is produced more rapidly in such tests than in nature, and they may be properly termed accelerative tests

Four types of crystallization tests have been used more or less for determining the soundness of stone and clay products

a The freezing and thawing test
b The sodium sulphate test
c The sodium chloride test
d The alkali test

Of these, tests b and d should be more thoroughly investigated to ascertain whether any chemical action results when they are applied to limestones or dolomites In addition to the four already mentioned, the absorption test has long been regarded as a more or less uncertain criterion of durability It is probable, however, that the time rate of absorption is a better index of resistance to freezing and thawing than the per cent absorption

The crystallization tests may be made as follows

Freezing and thawing test —A number of methods have been practiced in making these tests [1] Of these, that specified for drain tile by the American Society for Testing Materials[2] is recommended However, in order to determine the durability of crushed stone or gravel by this test, it will often be necessary to use one hundred or more cycles Apparently the only index of disintegration which is of much value is the rather uncertain criterion afforded by visual observation on the cracking and spalling of the test pieces after every five cycles during the test Judging from the results of Buckley's tests, in which the loss of weight and of strength were determined after forty cycles of freezing and thawing, it appears that neither of these factors afforded a satisfactory index of resistance to freezing and thawing

Sodium sulphate test [3]—In this test a 14 per cent solution of sodium

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[1] See Bulletin of Missouri Bureau of Geology and Mines, vol 2, Second Series, p 49 Bulletin 49, Engineering Experiment Station, Iowa State College, p 47, Proc A S T M, Vol 19, 1919, part 1, p 272

[2] See A S T M, Standards 1924, Standard Specifications for Drain Tile, Serial Des C4-24

[3] Based on the test reported by Professor E Orton Report of Committee C-3, Proceedings of the A S T M 1919, part 1, p 271 Also see Sodium Sulphate Tests of Drain Tile, Bulletin 49, Engineering Experiment Station, Iowa State College For further data on Brard's Test, see Trans A S C E Vol 33, p 246

sulphate is used, and the concentration of the solution is maintained constant by keeping the temperature at 70° to 80°F and the specific gravity between 1 13 and 1.14. Twenty or more samples of the material of the same dimensions are subjected to complete immersion for a period of 22 hours The specimens are then placed in a closed tank above water and steamed for one hour. They are then put into an oven which has been previously heated to 110°C, and dried for a period of 22 hours Heating in the oven must follow promptly the removal of the specimens from the solution After drying, the specimens are "thawed" thirty minutes in the salt solution and their condition is then observed On the completion of four additional cycles the rating of the material is determined by the appearance of the test pieces This test was used on brick with considerable success by Professor Orton

Since sodium sulphate crystallizes in three forms which are of different density, the expansive action will depend upon the type of crystal formed Hence it is necessary to control conditions carefully during this test in order to keep constant the severity of the disintegrating forces

The sodium chloride test is made by soaking cylindrical cores of stone or other material in a 15-per cent solution of common salt for 17 or 18 hours, drying in an oven at 60°C. for 6 hours, and repeating this cycle until marked disintegration occurs For stone, the cores are 2 inches in diameter and 2¼ inches high According to D W Kessler,[1] the test is about seven times as severe in its effect upon Indiana limestone as the freezing and thawing test

The alkali test[2] is made by soaking specimens of uniform shape and size for 24 hours in a solution consisting of ½ per cent of sodium chloride, ½ per cent of sodium sulphate, and ½ per cent of magnesium sulphate, then allowing the specimens to air-dry for 24 hours Cycles of alternate soaking and drying are continued until there is visible disintegration In order to standardize this test, there should be control of the humidity of the air during the drying of the specimens

Suggested modifications of the foregoing tests —In making any of the foregoing tests on samples of crushed stone or gravel, it will not, in general, be feasible to provide specimens of uniform size and shape It is suggested that a representative sample consisting of ten pieces of aggregate, each of which weighs in grams 24 to 28 times the specific gravity of the rock, be used in the suggested tests, and, further, it is suggested that, in addition to observations at the end of the test on the appearance of the samples, a sieve analysis be run and the fineness modulus calculated By determining the percentage loss in fineness modulus during the test, a quantitative measure of the amount of disintegration may be obtained

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[1] This test has been developed at the U S Bureau of Standards, and is now being used in an extensive study of the durability of various building stones

[2] This laboratory test has also been used by the U S Bureau of Standards for determining the resistance of concretes to alkali attack

RESUMÉ OF SODIUM SULPHATE TESTS FOR SOUNDNESS MADE ON VARIOUS STONES

(DIVISION OF TESTS—*Minnesota State Highway Department*)

The tests reported in Bulletin No 20 of the Minnesota State Highway Department furnish good examples of the behavior of various types of stone when subjected to a sodium sulphate soundness test In making these tests the sample, which consisted of ten small pieces weighing about 1000 grams and ranging in size from ¾ inches to 1½ inches in diameter, was immersed in a saturated solution of sodium sulphate at 70° F for 24 hours It was then dried at 100° C for 4 hours After the condition of the specimens had been noted, the cycle was repeated twenty times. At the end of the twentieth cycle each rock sample was

TABLE I

SUMMARY OF PHYSICAL TESTS

No of sample	Kind of rock	Formation	No of tests	Specific gravity	Absorption per cent	Average per cent loss by abrasion	Average toughness
1	L S	Platteville	7	2 57	2 24	4 01	10 71
2	L S	Oneota	3	2 46	4 28	8 60	5 75
3	L S	Oneota	5	2 57	2 76	4 33	9 45
4	L S	Oneota	4	2 49	3 75	5 63	8 70
5	L S	Oneota	1	2 63	2 63	6 41	4 10
6	L S	Oneota	3	2 59	1 46	5 79	8 42
7	L S	Platteville	1	2 56	3 73	4 32	12 50
8	L S	Platteville	1	2 61	2 98	3 10	12 00
9	L S	Platteville	1	2 67	0 80	3 06	11 50
10	L S	Oneota	1	2 58	2 34	5 00	7 70
11	L S	Oneota	1	2 70	1 14	3 77	6 66
12	L S	Platteville	10	2 61	1 56	3 66	8 52
13	L S	Galena	5	2 35	5 14	8 86	6 40
14	L S	Oneota	4	2 65	1 86	4 65	7 75
15	L S	Platteville	14	2 61	1 85	3 60	9 98
16	L S	Platteville	6	2 66	1 37	2 96	14 32
17	L S	Platteville	2	2 60	1 74	3 51	14 50
18	L S		1	2 24	4 50	10 92	5 25
19	Trap		1	2 92	0 04	1 60	
20	Trap		1	2 94	0 31	2 50	13 33
21	Trap						
22	Trap		1	2 90	0 25	1 20	28 2
23	Quartzite		1	2 67	0 30	1 39	27 0
24	Trap		1		0 18	1 94	20
25	Quartzite		1	2 69	0 90	2 38	13 5
26	Quartzite		1			2 16	11 0
27	Granite		1	2 73	0 44	2 67	16 5
28	Granite						
29	Quartzite						

TABLE II

SUMMARY OF SOUNDNESS TESTS

No of sample	Kind of rock	Formation	% loss in fineness modulus	Scaling started	Cracking started	Condition of rock at end of test
1	L S	Platteville	10 1	9	13	9 pieces cracked, 1 piece scaling
2	L S	Oneota	0 025	16	16	3 pieces cracked, 1 piece scaling
3	L S	Oneota	2 25	9	10	3 pieces cracked, 4 pieces scaling, 1 piece disintegrated
4	L S	Oneota	1 01	13	9	3 pieces cracked, 2 pieces scaling
5	L S	Oneota	5 96	2	2	4 pieces cracked, 6 pieces scaling
6	L S	Platteville	3 58	9	9	1 piece cracked, 1 piece disintegrated, 2 pieces scaling
7	L S	Platteville	61 00	2	7	Completely disintegrated
8	L S	Platteville	1 76	8	6	8 pieces cracked, 2 pieces scaling
9	L S	Oneota	0 25	13		1 piece scaling
10	L S	Oneota	1 65	2	2	8 pieces cracked, 2 pieces scaling
11	L S	Platteville	42 2	9	2	Whole sample badly disintegrated
12	L S	Galena	34 7	3	11	Whole sample badly disintegrated
13	L S	Galena	33 4	3	11	Whole sample badly disintegrated
14	L S	Oneota	0 41	9	10	2 pieces cracked, 4 pieces scaling
15	L S	Platteville	25 3	2	6	Whole sample badly disintegrated
16	L S	Platteville	1 42	12	10	5 pieces cracked, 5 pieces scaling
17	L S	Platteville	2 74	10	13	6 pieces cracked, 1 piece scaling
18	S S		5 5	11	11	1 piece cracked, 9 pieces scaling
5a[1]	L S	Oneota	0 162	13	20	1 piece cracked, 1 piece scaling

[1] No 5a was sample from an old ledge of same quarry as No 5

washed, dried, and weighed, the fineness modulus calculated, and the percentage of loss in fineness modulus determined

In this series of tests, four samples of trap rock, five of quartzite, two of granite, seventeen of limestone, and one sample of sandstone were experimented upon The trap rock, quartzite and granite samples were practically unaffected The samples of limestone were in certain cases very badly disintegrated during the test, and the sample of sandstone was somewhat affected. The results of these tests are summarized in Tables I and II. Table I gives the physical properties of the stones under test, and Table II contains a summary of the indications afforded by the soundness test "Chemical analyses made on the different limestones indicate that the total per cent of insoluble residue, while important, only partially indicates the durability of the rock when exposed to weathering" Much depends upon the distribution of the constituents of the stone. If the stone is impregnated with layers of shale or clay, it will be more easily disintegrated than stone of similar constitution having the shale or clay diffused throughout its mass

Figures 1, 2, and 3 show the influence of the sodium sulphate test on a sample of limestone from the Oneota formation, which is of satisfactory hardness and toughness for road construction. Figures 4, 5,

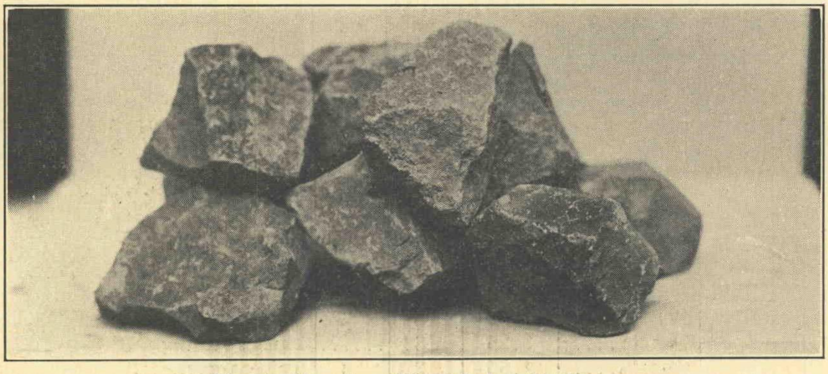

Fig. 1. Limestone No. 4 before Testing.

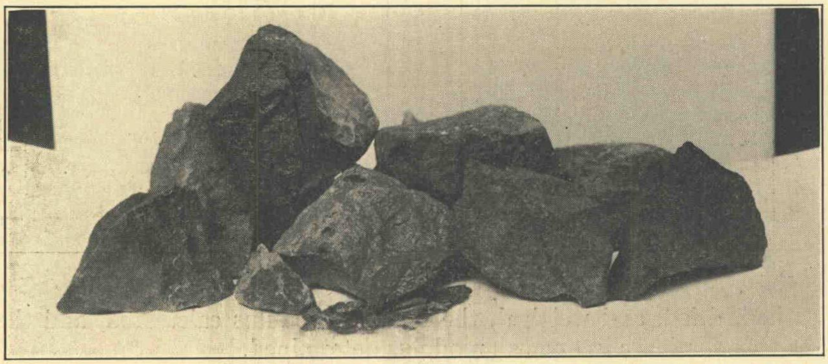

Fig. 2. Limestone No. 4 after Fifteen Immersions in Sodium Sulphate.

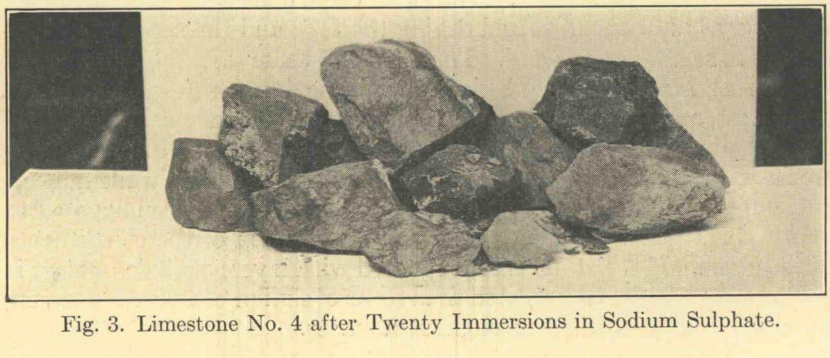

Fig. 3. Limestone No. 4 after Twenty Immersions in Sodium Sulphate.

and 6 show effects of this test on a sample of limestone from the Platteville formation. Figures 7, 8, and 9 show the appearance of rather soft sandstone after having been subjected to this test.

Fig. 4. Limestone No. 7 before Testing.

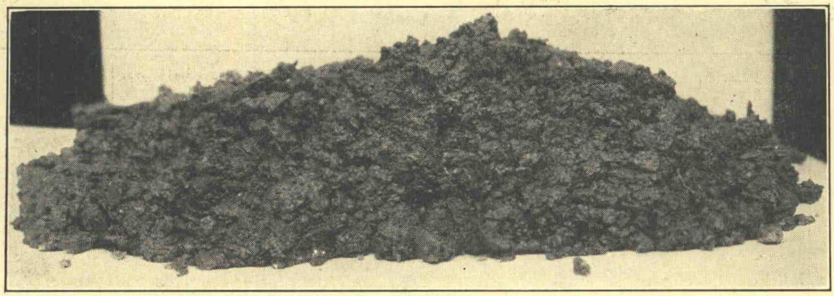

Fig. 5. Limestone No. 7 after Fifteen Immersions in Sodium Sulphate.

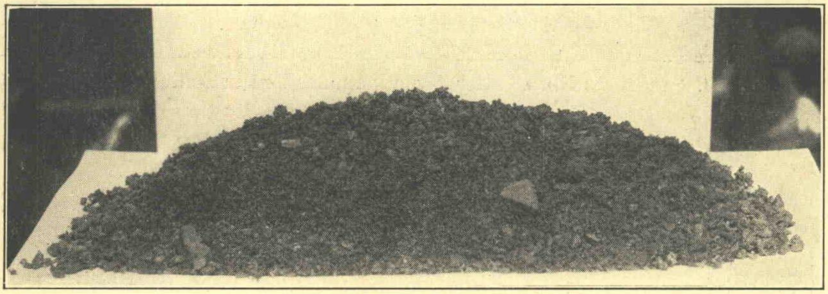

Fig. 6. Limestone No. 7 after Twenty Immersions in Sodium Sulphate.

Fig. 7. Sandstone No. 18 before Testing.

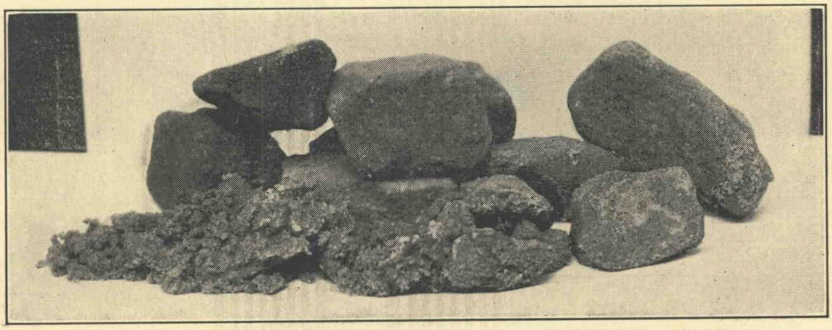

Fig. 8. Sandstone No. 18 after Fifteen Immersions in Sodium Sulphate.

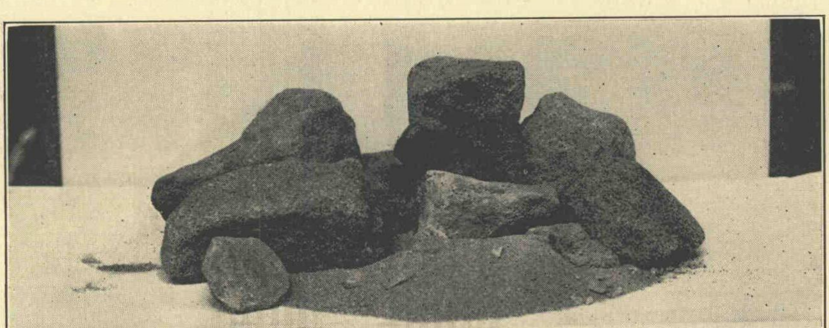

Fig. 9. Sandstone No. 18 after Twenty Immersions in Sodium Sulphate.

SOUNDNESS TEST FOR CONCRETE

A large number of tests of concrete drain tile subjected to alternate freezing and thawing have been made and the results reported in Bulletin No. 36 of the Engineering Experiment Station, Iowa State College, Ames, Iowa. A study of the methods used in making these tests will be of value to anyone interested in this subject.

In making accelerated tests to determine the durability of concrete to ordinary weathering conditions, it is desirable to avoid the inclusion of injurious treatments which differ materially in their effects from those produced by natural agencies Consequently, it is doubtful if the sodium sulphate test,[1] as outlined in the previous problem, can be considered a satisfactory criterion for measuring the resistance of concrete to freezing and thawing It would seem highly desirable, however, to carry on freezing and thawing tests of concrete, modeling the tests after the specification of the A S T M Ser Des C4–24, Sec C, but running the tests for one hundred or more cycles Also it would seem desirable to run sodium chloride accelerative tests like the one described under Problem 1, in parallel with the freezing and thawing tests In these tests, it would be desirable to include as variables, different brands of cement, variation in richness of proportions, aggregates of different degrees of durability, and differences in grading of aggregates which would produce marked differences in the density of the concretes made from these aggregates The accelerated test should be made on concretes at least one month old It would also be well to have auxiliary tests made to determine the cross-bending and the compressive strengths of the concrete before and after the soundness test To ascertain the influence of the soundness test on the dimensions of the specimens, measurements of the linear expansion and contraction of the specimens should also be included

The durability of concrete to alkali waters has been studied quite extensively Information concerning the resistance of drain tile, and a bibliography of the more important literature on the subject may be found in Technologic Papers, Nos 44, 95, and 214 of the U S Bureau of Standards An interesting paper on "Laboratory Investigations of the Influence of Curing Conditions and Various Admixtures on the Life of Concrete Stored in Sulphate Solutions as Indicated by Physical Changes," by D. G. Miller, is reported in the Proceedings of the A. S T. M Vol 24, 1924. A report on the durability of concrete drain tile when embedded in peat soils, and bibliography on the literature bearing upon this subject will be found in a paper entitled, "Effect of Organic Decomposition Products from High Vegetable Content Soils upon Concrete Drain Tile," by G R B Elliott, Journal of Agricultural Research, Vol XXIV No 6, 1923

GRADING OF AGGREGATES

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The present status of our knowledge on this subject is as follows A large amount of research work has been done in the endeavor to ascertain the laws governing the relationships of the raw materials in Portland cement concrete with the result that several methods have been proposed and more or less extensively used, for evaluating the

[1] This test appears to produce chemical as well as mechanical disintegration when applied to concrete