Chapter 4

SODIUM SILICATE

Review of Recent Investigations

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Louisiana Investigation

The Louisiana Highway Commission constructed an experimental project (No. 5800) which included sections cured with wet earth, ponding, calcium chloride admixture and sodium silicate surface

TABLE XIII

Compressive Strength of Cores

LOUISIANA PROJECT 5800

Cement Factor 1 56 bbls per cu yd

Curing Method	Date of Construction 1930	Length of section Feet	No of cores	Ave Age of cores at time of test Months	Compressive Strength Lb per sq in		
					Max	Min	Ave
Calcium Chloride Admixture	Feb 25–Mar 20	12,373	24	4 8	6980	5220	6260
	Mar 24–Apr 1	2,618	5	4 2	6930	6420	6710
	May 5–May 10	4,751	10	2 9	6660	4710	5810
Totals and weighted averages		19,742	39	4 2	—	—	6210
Sodium Silicate	Mar 31	600	1	4 2	—	—	6670
	Apr 4–Apr 15	9,195	19	3 8	6890	4300	5950
	Apr 16–Apr 19	1,762	3	3 5	5850	5770	5830
	Apr 23–May 2	4,910	10	3 2	6220	5870	6400
Totals and weighted averages		16,467	33	3 6	—	—	6100
Ponding	May 10–May 22	2,040	14	2 6	6800	4940	5940
Wet Earth	May 23–May 30	4,904	10	2 3	6990	4990	6290
Grand totals and weighted averages		48,153	96	3 6	—	—	6140

application This pavement is slightly more than nine miles long and approximately one-third was cured with a surface application of sodium silicate

The pavement was constructed during February 25 to May 30, 1930 Cores were drilled at intervals of 500 feet between June 27 and July 4, 1930, and all were tested on August 4, 1930 Since the age at time of test varied from 2 1 to 5 2 months it is difficult to make adequate comparisons of the strengths attained under different methods of curing The core strength data are given in Table XIII

On account of the range in age of the cores at the time of test no attempt has been made to study in detail the possible effect of weather conditions on strength However, general information with respect to the weather during the period of construction is of interest and data taken from weather reports of the Louisiana State University at Baton Rouge which is located about 60 miles distant from the project are given in Table XIV These data show that air tempera-

TABLE XIV

DATA FROM MONTHLY WEATHER REPORTS

LOUISIANA STATE UNIVERSITY, BATON ROUGE, 1930

	March	April	May
Temperature Degree F			
Maximum	75 March 18	86 April 22	90 May 18
Mean Maximum	65	80	84
Minimum	33 March 4	49 April 1	55 May 26
Mean Minimum	48	58	67
Mean	56	69	75
Humidity			
At 7 00 A M			
Maximum	100 March 17 & 22	100 April 3, 11, 12 & 13	100 May 19
Minimum	57 March 3	55 April 25	56 May 24 & 26
Average	82	84	85
At 7 00 P M			
Maximum	92 March 18	97 April 2	93 May 28
Minimum	16 March 30	24 April 7	47 May 24 & 26
Average	66	65	74
Days of rain (More than 01 inch)	12	4	8
Days cloudy	10	2	4
Days partly cloudy	13	11	20
Days clear	8	17	7
Total precipitation (Inches)	4 58	1 76	5 63
Maximum precipitation in 24 hours (Inches)	2 69 March 1	0 92 April 16	4 81 May 19

tures were on the increase during the three-month period of construction, mean temperatures increasing from 56° F in March to 75° F in May The records of humidity indicate conditions favorable to good curing throughout the construction period Figure 13 shows the averages for 47 years of the intervals of rainfall in days for the different months of the year from three widely separated weather stations The average annual relative humidities for these stations are also given

Table XV summarizes data from a number of pavement projects in Louisiana which were cured by different methods It was found

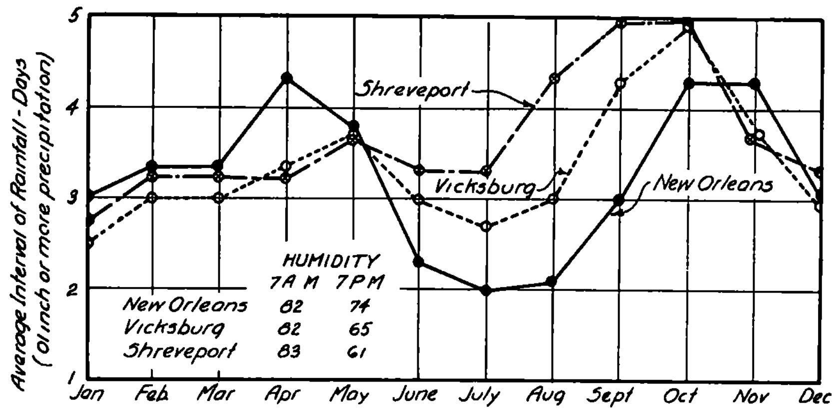

Figure 13 Louisiana Rainfall Data, Averages of 47 Years

possible to arrange the data from several of these projects by age groups and cement factors and thus make direct comparisons of the ponding and sodium silicate methods These comparisons are shown graphically in Figure 14

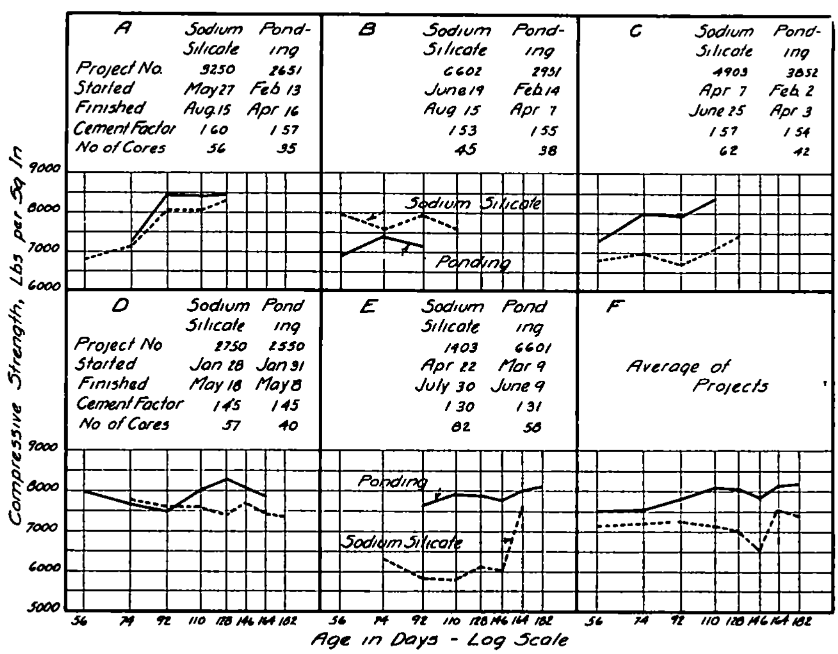

Figure 14 Comparison of Projects Cured by Ponding and by Sodium Silicate Louisiana Data.

TABLE XV

COMPRESSIVE STRENGTH OF CORES

LOUISIANA

Project Number	Length Miles	Cement Factor Bbl per cu yd	Average Age at time of test Months	Number of Cores	Compressive Strength Lbs per Sq In		
					Max	Min	Ave
CURING METHOD—WET EARTH							
2350	6 83	1 50	3 7	36	7302	5739	6795
3804	4 38	1 59	2 2	23	8719	6451	7860
Totals and Weighted Averages	11 21	1 54	3 1	59	—	—	7210
CURING METHOD—PONDING							
1900	8 72	1 45	6 5	47	8445	4820	7250
2651	6 74	1 57	2 9	35	8905	5496	7954
2951	7 41	1 55	2 4	38	8342	5603	7141
3852	7 88	1 54	2 6	42	8764	6228	7816
6601	10 93	1 31	4 4	58	8793	6223	7914
2550	7 49	1 45	3 4	40	8680	5761	7853
Totals and Weighted Averages	49 17	1 46	3 8	260	—	—	7661
CURING METHOD—CALCIUM CHLORIDE ADMIXTURE							
1902	11 81	1 38	4 9	56	8462	5546	6634
3451	6 80	1 30	4 3	36	8445	6034	7501
Totals and Weighted Averages	18 61	1 35	4 7	92	—	—	6973
CURING METHOD—SODIUM SILICATE							
1403	14 03	1 30	3 9	82	8734	4794	6194
1502	11 17	1 29	3 3	57	7990	3158	6710
2601	9 65	1 55	4 9	68	8330	4262	6248
3502	13 26	1 52	3 4	72	8520	4885	6938
6602	8 65	1 53	2 9	45	8765	7580	7788
7100	10 04	1 44	2 8	53	8765	5575	7454
7200	3 40	1 57	1 6	17	8576	5996	7430
7301	19 71	1 25	5 1	117	8379	4081	6585
2750	10 94	1 45	4 0	57	8765	5890	7551
3250	10 87	1 60	2 8	56	8793	5512	7585
4300	10 66	1 28	3 6	56	8567	5996	7550
4903	11 14	1 57	3 2	62	8520	4502	7006
4750	8 90	1 61	4 5	46	8765	6376	8146
6105	9 26	1 56	4 5	48	7676	4746	6046
Totals and Weighted Averages	151 68	1 44	3 8	836	—	—	6979

Table XVI shows the average values and the statistical characteristics of the compressive strengths of cores of comparable ages from the projects in Figure 14. The ages of the cores ranged from 74 to 92 days with an average of 83 days.

TABLE XVI

	Sodium Silicate	Ponding
Minimum, Pounds Per Square Inch	4,832	5,496
Maximum, Pounds Per Square Inch	8,793	8,793
Range (Min. to Max.) Pounds Per Square Inch	3,961	3,297
General Average, Pounds Per Square Inch	7,185	7,653
Average Deviation (Per cent)	12.6	8.3
Standard Deviation (Per cent)	13.9	10.3
Number of Cores	124	90

The cores cured by ponding are the more uniform, but both show uniformity characteristics within practical limits. 70 per cent of the sodium silicate cores and 88 per cent of the cores cured by ponding are within 15 per cent of the average strength.

Missouri Investigation

This investigation covered numerous methods of curing including ponding, 24-hour burlap, 72-hour burlap, sodium silicate, calcium chloride both as surface application and admixture, surface application of bituminous materials, and waterproof paper.

The conclusions with respect to sodium silicate are summarized in the following statement which is quoted from page 42 of the report.

"*Sodium Silicate.* The results obtained by this method of curing show that it is satisfactory from the standpoints of temperature constancy, strength, volume change, cracking and surface defects. However, the sodium silicate method showed no advantage over the 24-hour wet burlap treatment, which is the first step in curing with sodium silicate."

Table XVII is a summary of the average compressive strengths expressed as percentage of average strength of ponded sections.

TABLE XVII

RELATIVE COMPRESSIVE STRENGTH

Method of Curing	Projects	14 Days	28 Days	40 Days	360 Days	Average of All Ages
	Warsaw	100	100	100	100	100
Ponding	Ashland	100	100	100	100	100
Wet Burlap	Warsaw	88	100	83	94	91
24 hours	Ashland	90	96	80	87	88
Average		89	98	81.5	90.5	89.5
Sodium	Warsaw	94	95	83	100	93
Silicate	Ashland	89	89	82	87	87
Average		91.5	92	82.5	93.5	90.0

Table XII, Chapter 3 shows the relative compressive strengths of the 24 hour wet burlap treatment and the other curing methods used in the Missouri investigation

In Table XI, Chapter 3 is given the relation of sodium silicate to other curing methods as shown by the maximum top surface temperature compared with air temperature and maximum daily drop in top surface temperature compared with air temperature

Figures 9-10, Chapter 3 depict the data from the Missouri investigation relating to the effects of temperature drop upon volume changes of slabs cured with sodium silicates and by other methods, and Figure 11 shows the relative lengths of crack intervals

Ohio Investigation

In order to study the effectiveness of sodium silicate as a curing agent, portions of two state projects in Ohio were cured by this method in comparison with wet curing and calcium chloride surface application, during the summer of 1934

A project in Union County consisting of 594 feet of wet earth curing, 9865 feet of calcium chloride surface application and 4089 feet of sodium silicate was built in April, May, and June Sections of calcium chloride and sodium silicate were built while the average daily temperature was only 47° F and sections of all three types were built when the average daily temperature was about 65° F

In Licking County the experimental sections, built in July and August comprised 805 feet of wet straw, 6042 feet of calcium chloride and 4829 feet of sodium silicate curing The average daily temperature prevailing during this work was in the vicinity of 80° F

Comparisons were based on compression tests of cores cut and tested at 7 and 28 days of age The data are shown in Table XVIII

In the opinion of the authors of the report, sodium silicate (Baumé 36 to 37°) applied evenly over the surface of the pavement after the removal of the burlap at the rate of one pound per square yard was comparatively as effective a curing agent as calcium chloride surface application, earth and water, and straw and water

Study of Moisture Loss Data

There is evidence to indicate that the amount of mixing water retained in concrete during the early curing period is an important index of the effectiveness of curing methods

Figure 15 shows a graphical summary of all available information on the early moisture loss in concretes and mortars which were cured with surface applications of sodium silicate Five separate investigations are represented, three of which were made in the laboratory and two in the open air One of the latter (Curve 5) was a field

TABLE XVIII
Curing Data
OHIO STATE HIGHWAY DEPARTMENT

Project	Curing Method	Mean Daily Temperature Degree F			No of Cores	Age at Test Days	Compressive Strength		
		Max	Min	Average			Lb per Sq In	Per Cent of water cured concrete in these Tests	Per cent of Average water cured concrete for 1933
Union County	Calcium Chloride Surface Application	58	39	47	31	7	2777		106
	Sodium Silicate	58	39	47	5	7	2756		105
	Wet Earth	73	58	65	8	7	3028	100	116
	Calcium Chloride Surface	73	58	65	19	7	3216	106	123
	Sodium Silicate	73	58	65	14	7	3196	105 5	122
	Wet Earth	73	58	65	10	28	3122	100	80
	Calcium Chloride Surface	73	58	65	19	28	4055	130	104
	Sodium Silicate	73	58	65	14	28	3934	126	101
Licking County	Wet Straw	98	64	81	4	7	3505	100	129
	Calcium Chloride Surface	96	73	85	25	7	3662	104 5	135
	Sodium Silicate	91	67	79	20	7	3622	103 3	134
	Wet Straw	98	64	81	4	28	4637	100	114
	Calcium Chloride Surface	96	73	85	4	28	4240	91 5	105
	Sodium Silicate	91	67	79	4	28	4050	87 5	100

test in which the specimens rested on a wet subgrade, in the other out-of-door test the specimens were placed in a metal container The significant feature of this figure is that at seven days the moisture losses from four of the five investigations show remarkable uniformity Comparing curves 2, 3, 4, and 5 at this period (7 days), the observed maximum difference is only 2 5 per cent This includes two out-of-door and two laboratory tests

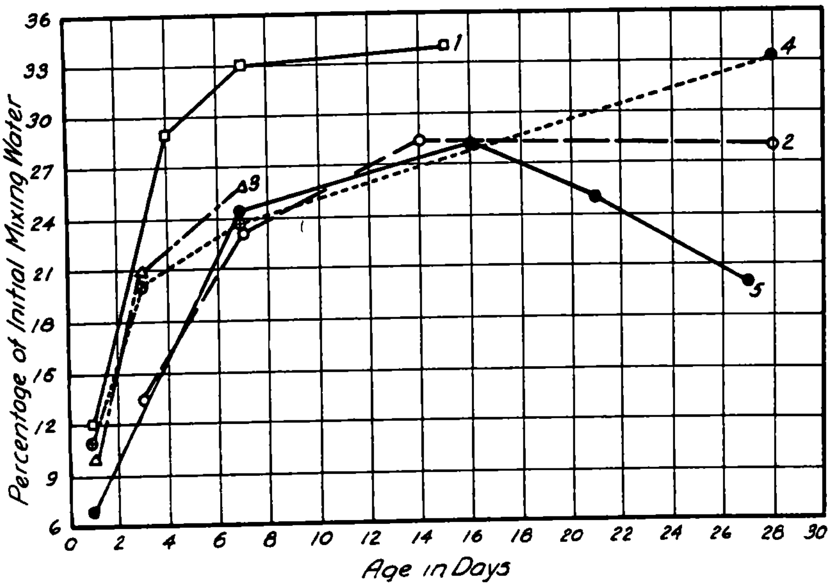

Figure 15 Relation of Loss of Initial Mixing Water to Age of Concrete or Mortar Specimens Cured with Sodium Silicate

1—Missouri Highway Commission, Concrete, Laboratory
2—Portland Cement Association, Concrete, Laboratory
3—Grasselli Chemical Company, Concrete, Outside
4—Iowa Highway Commission, Mortar, Laboratory
5—Bureau of Public Roads, Concrete, Outside

That the loss of initial mixing water has a direct effect on the strength of the concrete is illustrated by a few data in Figure 16 Although there are not sufficient data to define specifically a relationship between moisture loss and strength for similar curing methods, it appears that such a relationship may exist

In the Missouri investigation tests were made to determine the amounts of moisture retained in the concrete cured by the various methods Samples of the concrete were removed from each of the experimental sections immediately, two hours, one day, three days and ten days after finishing, and were tested for the amounts of moisture that could be evaporated in drying to constant weight at

105° C The average determinations on the several sections of each curing method are given in Table XIX

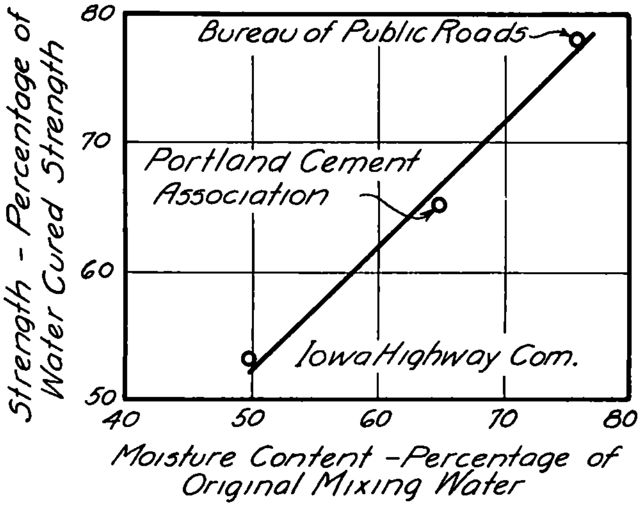

Figure 16 Relation of Strength to Amount of Mixing Water Retained Sodium Silicate Curing.

With the exception of the sections cured with bituminous coatings the concrete was covered with burlap as soon as practicable after finish This burlap was kept wet until from 7 to 9 o'clock the following morning when it was removed, except in the case where it was left for 72 hours The Hunt and Curcrete coatings were applied at about the same interval after finishing as the burlap

TABLE XIX

Method of Curing	Percentage of Moisture—Averages				
	Immediate	2 Hours	1 Day	3 Days	10 Days
Ponding	7 3	6 1	3 4	3 7	3 3
Wet Burlap 72 hours	8 1	6 1	3 8	4 6	3 4
Wet Burlap 24 hours	8 1	7 1	4 5	3 4	3 3
Sodium Silicate	7 6	5 8	3 9	3 5	3 1
Calcium Chloride—Surface	8 6	8 0	4 5	3 1	3 3
Hunt Process	7 5	6 4	3 8	2 6	2 6
Curcrete	8 1	6 5	3 8	2 6	2 6

Strength Data Summary

The new data from the Missouri, Louisiana, and Ohio Highway Departments do not differ greatly from the average field results contained in the progress report of the Committee on Curing of Concrete Pavement Slabs in the Proceedings of the Highway Research Board, Vol 10, 1930 The comparisons are shown in Table XX

TABLE XX

Source of Data	Compressive Strength of concrete cured with sodium silicate after one day of wet burlap expressed as a percentage of the strength of corresponding concrete cured with wet earth or straw or by ponding	Number of Specimens Tested	
		Sodium Silicate	Wet
1930 Progress Report, Average of 18 Projects	93 (a)	368	
Louisiana {Special Project Table I}	103 (a)	33	10
	97 (b)	33	14
Louisiana {Similar Projects Table III}	91 7 (b)	302	213
Louisiana {All Projects Table III}	91 (b)	836	260
Missouri {Two Projects Table V}	90 (b)	160	360
Ohio {Two Projects Table VI}	108 (a)	52	26

(a) Based on wet earth or straw
(b) Based on ponding

The Action of Sodium Silicate as a Curing Agent

The theory for the use of sodium silicate for curing concrete pavements is that the surface will be covered with a thin varnish like film which will also fill the pores and surface voids, thus sealing the surface and preventing the evaporation of water from the concrete Although it is true that such sodium silicate films are not permanent it is expected that the solutions used for curing will last long enough for the curing to be accomplished before the film becomes discontinuous or is decomposed by reaction with the air and the chemicals of the concrete

Study of the available references relating to the constitution of sodium silicate films tends to corroborate the evidence shown in Figure 15 that the films formed in curing are not impermeable and therefore retard rather than prevent the evaporation of water from the concrete

In view of the importance of the moisture content of the concrete during the curing period comprehensive tests should be made to determine more exactly the relation between rate of moisture loss and strength This is one of the fundamental factors in the Committee's project for the development of a test for determining the efficiencies of curing methods

Sodium Silicate for Surface Hardening

In order to avoid confusion brief mention should be made of the use of silicate of soda as a surface hardener of concrete The action and methods involved are distinct from those of curing For this purpose the silicate is applied on hardened concrete since a considerable degree of penetration is desired The effectiveness of the process depends upon the ability of the silicate on decomposition to fill the interstices with silica and insoluble calcium silicates

References on Sodium Silicate

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