Silicones as Admixtures for Concrete

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● A RECENT report of the Bureau of Public Roads (1) showed that given amounts of a certain silicone as an admixture for concrete were effective in preventing scaling caused by de-icing agents. This silicone also increased the compressive strength of the concrete but caused a marked retardation in the setting of the concrete. Because of these effects, additional tests were made to determine if other silicones used as admixtures would give similar results.

In these latter tests, eight different silicones manufactured by the three major producers were used. Tests were made to determine the effect of silicone admixtures on the properties of fresh concrete and on the strength and durability of hardened concrete. Tests using some of the silicones were limited due to insufficient quantities of the silicone samples.

MATERIALS

The tests were made on air-entrained concrete prepared with varying amounts of eight different silicone solutions. The physical and chemical properties of these silicone solutions are given in Table 1. The silicones are grouped into three general classes. Four of them (silicones A, B, C, and D) are classified as sodium methylsiliconates, two (silicones E and F) are classified as alkyl silane esters, and two (silicones G and H) as silicone resin emulsions. Typical infrared spectra of the silicones are shown in Figure 1. All silicones in each group show the same general characteristic spectra. With the exception of the two emulsions (silicones G and H), which were milky white liquids, all were colorless liquids. The solvent or thinner for six of the silicones (A, B, C, D, G, and H) was water; for the other two (E and F), it was an alcohol.

Except for the silicone admixtures, the same concrete materials were used for all of the tests. The cement was a Type I portland cement with an equivalent alkali content of 0.6 percent. The chemical analysis of the cement is given in Table 2. The aggregates were similar to those used in the previous investigation of a silicone as an admixture. These were a siliceous sand having a fineness modulus of 2.75 and a uniformly-graded crushed limestone of 1-in. maximum size. A commercially available aqueous solution of neutralized Vinsol resin was used to entrain air.

MIX DATA

The mix data for the concretes are given in Table 3. The concrete contained 6 bags of cement per cubic yard, the air content was approximately 5 percent, and the slump was about 3 in. A control or reference mix without silicone was made on each day, and the mixes containing silicone were compared to the corresponding control mix made on the same day. The average values for all the control mixes are given in footnote 1 of the table.

The total solids in the silicone solutions added to the mixes varied from 0.01 to 1.33 percent by weight of the cement. The concentration of the total solids in the eight silicone solutions varied. From literature furnished by the producers, the approximate percentage of total solids in each solution was assumed for convenience in designing the mixes. These values are given in footnote 1 of Table 3.

The actual percentage of total solids in six of the eight solutions was determined chemically (Table 1). These values were within five percentage points of those used.

TABLE 1

PHYSICAL AND CHEMICAL PROPERTIES OF SILICONE SOLUTIONS

| Property | Sodium Methylsiliconate (sodium salt of methyl poly-siloxane) | | | | Alkyl Silane Ester | | Silicone Resin Emulsion of R-23 Silicone Resin | |
	A	B	C	D	Methyl Chloro-silane "M" E	Ethyltri-Ethoxysilane F	Nonionic Type, G	Anionic Type, H
pH (electrometric method)	12.1	12.0	12.2	12+	2.6	7.2	7.2	8.4
Specific gravity 25 C/4 C	1.244	1.252	1.102	1.227	0.952	0.901	1.027	1.008
Chemical analysis:								
Total solids (non-vol. at 150 C, 90 min) (%)	33.5	33.3	33.1	30.1	---[2]	---[2]	41.4	16.9
Total sodium as Na_2O (%)	10.4	10.3	11.2	12.4	---	---	---	---
Silicon (%)	8.2	8.1	8.5	5.6	21.7	3.8	8.9	3.4
Chlorine (%)	---	---	---	---	None[3]	---	---	---
Silicone solids as $CH_3SiO_{1.5}$ (%)	19.6	19.4	20.3	13.4	---	---	---	---
Molecular ratio $(CH_3SiO_{1.5}/Na_2O)$	1.7	1.7	1.7	1.0	---	---	---	---
Infrared analysis of active constituent	All four materials found similar, showed methylsiliconate structure; D had more sodium carbonate impurity than others.				Spectra of both materials fairly similar, showing alkyl silane ester structure; F showed ethyl groups, E showed mostly methyl substitution.		Both materials showed similar spectra of presumably condensed silicones with ethyl substitution.	
Infrared analysis of vol. solvent or thinner					Both solvents appear alcohol type, but exact identification difficult because of some volatility of active constituent.			
Probable formula	$[CH_3Si(OH)_2O]Na^+$ [4] $[CH_3SiO_2Na]_n$ [5]				$(CH_3)_nSi(OCH_3)_{4n}$	$C_2H_5Si(OC_2H_5)_3$	$[R''O(R'_x)SiO_{4-x}]_nR'$ $\frac{}{2}$	

[1] Description.
[2] Not determined because of volatility of silicone material.
[3] Qualitative test.
[4] In dilute aqueous solution.
[5] In dry form.

for designing the mixes. For silicones E and F (the alkyl silane esters), it was impossible to determine the amount of total solids because of the volatility of the silicone materials.

For six of the silicones (A, B, C, D, E, and F), the assumed concentration of the solutions was 30 percent total solids. For this concentration, 10 oz of the solution per bag of cement is equivalent to 0.2 percent total solids by weight of cement. In Table 3, the amount of the silicone solution used in each mix is given as the weight of total solids in the quantity of solution used expressed as a percentage of the weight of cement. It is also given as the number of ounces of the solutions per bag of cement.

Mixing and Curing

The mixing and curing was in accordance with standard laboratory procedures. The aqueous solution of each silicone was added with part of the mixing water to the cement and aggregates in the mixer before the addition of the aqueous solution of the air-entraining admixture.

ASTM standard methods were followed in making tests on the plastic concrete and in molding, curing, and testing the specimens of hardened concrete. The tests for outdoor scaling were made as described in an earlier report (1).

Water and Air Content

Data on the effect of silicones as admixtures on the water and air content of concrete are shown in Table 3 and Figure 2. The figure shows that concretes with the silicone admixtures generally needed less water for the same slump than reference concretes prepared on the same days. However, in most cases, the reduction in water was 3 percent or less.

SODIUM METHYLSILICONATES
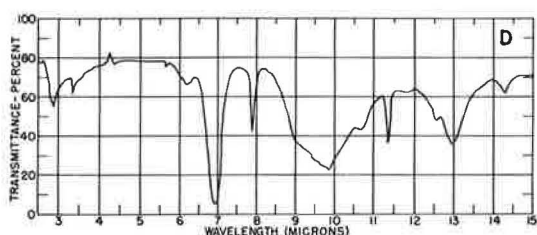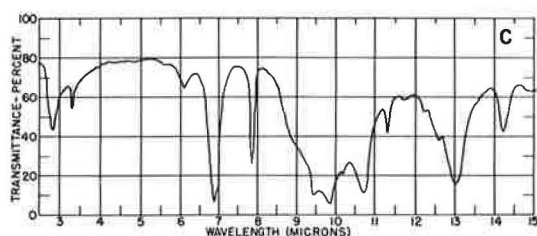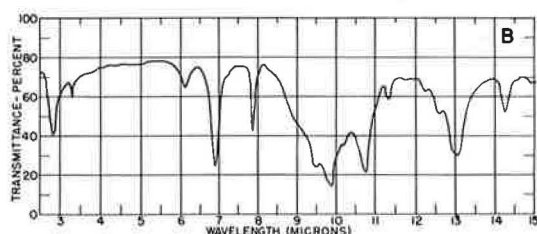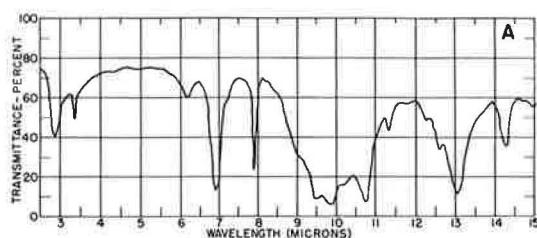
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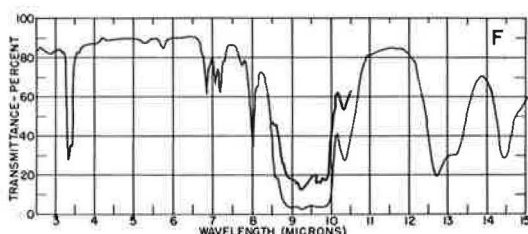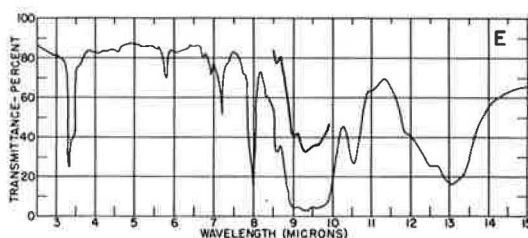
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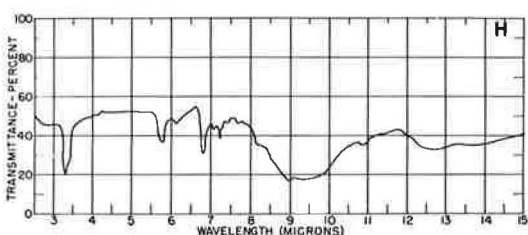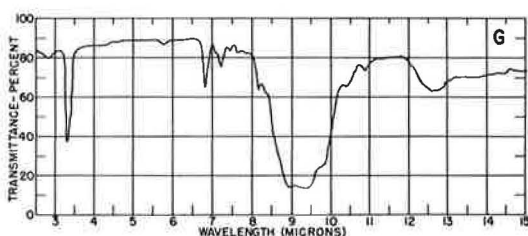
Figure 1.   Infrared spectra of silicone admixtures.

In 9 of the 11 mixes showing a reduction in water of more than 3 percent, more than 10 oz of the silicone solution per bag of cement (0.2% total solids by weight of cement) was used. The data for reduction in amount of mixing water are erratic for some of the silicones. Due to time and mold limitations, not all the mixes prepared with the different amount of any one silicone were made on the same day, and they were there-fore compared with a different control mix. This would account for some of the erratic results. For silicones B and E, except for one mix for each, a progressive reduction in mixing water was found with increases in the amount of the silicone. Silicone H also

TABLE 2

PHYSICAL AND CHEMICAL PROPERTIES
OF PORTLAND CEMENT

Property	Value
Chemical composition (%):	
Silicone dioxide	20.9
Aluminum oxide	6.0
Ferric oxide	2.5
Calcium oxide	65.3
Magnesium oxide	1.4
Sulfur trioxide	2.2
Loss on ignition	0.7
Insoluble residue	0.19
Sodium oxide	0.14
Potassium oxide	0.75
Chloroform soluble	0.007
Free lime	0.76
Equiv. alkali as Na_2O	0.63
Computed compound composition (%):	
Tricalcium silicate	57
Dicalcium silicate	17
Tricalcium aluminate	12
Apparent specific gravity	3.14
Specific surface (Blaine)(Cm^2/g)	3,250
Autoclave expansion (%)	0.05
Normal consistency	24.2
Time of setting (Gillmore test) (hr):	
Initial	4.25
Final	6.83
Compressive strength (1:2.75 mortar) (psi):	
3 days	2,850
7 days	3,830
28 days	5,170
Mortar air content (%)	9.4

caused a reduction in the mixing water when silicone solids of 0.5 percent or more were used. Silicones C and F reduced the mixing water requirement until about 0.5 percent silicone solids were used, but when greater amounts were used, more water was required.

Although the general trend is for greater reductions in the water required with increases in the amount of silicone used, these data fail to show that the silicones used are effective water-reducing agents.

The use of silicones as admixtures had some effect on the air content of the concrete. Table 3 gives the amount of air-entraining agent needed in the mixes prepared with the silicone admixtures as a percentage of the amount of agent needed in the control concrete made on the same day. This is also shown in the upper portion of Figure 3. In general mixes prepared with less than 0.2 percent total silicone solids, less air-entraining agent was needed than in the control mix. However, for mixes prepared with larger amounts of the silicones, more air-entraining agent was required than for the control mix. For silicone D, more air-entraining agent was required for all mixes except one.

When silicone E was used, the concrete expanded during the hardening process. With the largest amount of silicone E (0.5% solids by weight of cement) the concrete expanded 1 in. above the top of the 6- by 12-in. cylinder molds. The air content of this plastic concrete, determined immediately after mixing, was 4.5 percent. The unit weight of the hardened concrete for each of the mixes prepared with silicone E was determined on the cylinders before testing for compressive strength. These weights are given in

Table 3 and the lower portion of Figure 3. The weight of the control concrete was 149.1 pcf, whereas the weight of the concrete prepared with 0.5 percent silicone solids was only 135.9 pcf. As the weights of the two plastic concretes immediately after mixing were nearly the same, this shows that the concrete containing 0.5 percent silicone solids expanded about 10 percent.

Tests were made to determine the cause of the expansion of the concrete prepared with silicone E. It was found that when this silicone solution is treated with saturated limewater, it hydrolyzes and produces a mixture of alcohol containing perhaps both methyl and ethyl types. Inasmuch as the parent silicone is an ester, such hydrolysis would be expected. The same result could be expected when the material is added to concrete, where lime is immediately produced as a result of reaction of cement with mixing water. If the alcohols are produced in a gaseous form, this would account for the foaming (swelling) observed.
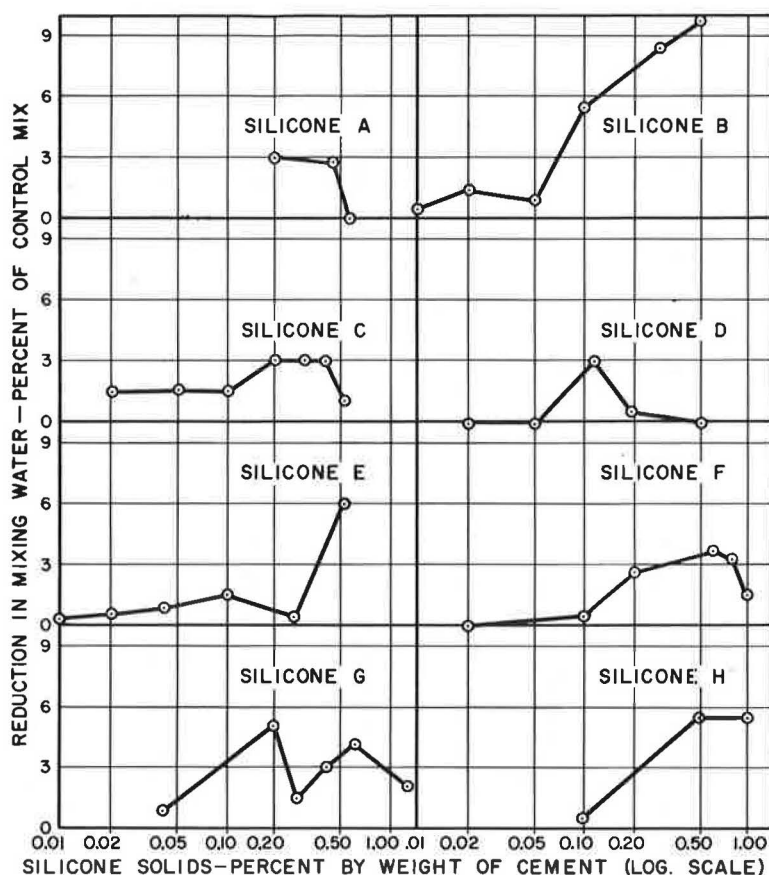
Figure 2. Effect of silicone on reduction in amount of mixing water, based on control mix.

RETARDATION OF SETTING TIME

The effect of various amounts of the silicone solutions on the retardation of the setting time of the concrete was determined by use of the Proctor penetration test (ASTM C 403). This test was made as described in a previous report on retarders (2). Retardation is the difference in time required for concrete prepared with the silicone admixtures and the control concrete made on the same day to support penetration loads of 500 psi. The results of these tests are given in Table 4. Readings were taken for about 15 hr or until about 11 PM. If the test specimens had not reached a penetration load of 500 psi by that time, the readings were resumed the next morning. Usually, the concrete had set up before then.

The results of these tests for a penetration load of 500 psi are shown in Figure 4. When silicones B, C, D, E, or F were used in amounts of only 0.05 percent silicone solids, the retardation was approximately 6 hr. When 0.2 percent silicone solids were used, the retardation was estimated to be about 12 hr. Further increase in the amount of silicone used is estimated to cause only a small increase in the retardation. It was estimated that, when 0.5 percent solids were used, the retardation would be between 15 and 20 hr. These five silicones are considered to retard the setting of the concrete more than would be desirable for normal construction purposes.

The use of 0.2 percent solids of silicones A and G retarded the setting of the concrete of 4 hr and $\frac{3}{4}$ hr, respectively, based on a 500-psi load in the Proctor test. Silicone H had no appreciable effect on the retardation of the concrete.

TABLE 3

MIX DATA[1]

Iden.	Silicone Amount Used — Total Solids[2] (% by wt. of cement)	Liquid (oz./ bag of cement)	Slump (in.)	Reduction in Water[3] (%)	Air (%)	A.E.A.[4] (%)	Weight-Hardened Concrete[5] (pcf)
A	0.20	10	3.1	2.9	5.3	100	---
	0.40	20	3.3	2.9	5.7	100	---
	0.60	30	2.5	0	4.9	75	---
B	0.01	0.5	2.9	0.5	5.3	94	---
	0.02	1.0	3.1	1.4	5.5	94	---
	0.05	2.5	3.2	0.9	4.7	100	---
	0.10	5.0	3.0	5.4	4.9	80	---
	0.30	15.0	3.1	8.4	5.0	120	---
	0.50	25.0	3.3	9.9	5.5	160	---
C	0.02	1.0	3.2	1.6	5.0	93	---
	0.05	2.5	3.2	1.6	5.2	93	---
	0.10	5.0	3.2	1.5	5.0	80	---
	0.20	10.0	2.6	3.0	5.0	100	---
	0.30	15.0	2.9	3.0	5.0	117	---
	0.40	20.0	2.5	3.0	5.5	125	---
	0.50	25.0	3.0	1.1	5.1	174	---
D	0.02	1.0	2.5	0	5.0	100	---
	0.05	2.5	3.0	0	5.4	120	---
	0.10	5.0	2.7	3.0	5.5	117	---
	0.20	10.0	2.8	0.5	5.1	120	---
	0.50	25.0	2.8	0	5.4	140	---
E	0.01	0.5	2.9	0.4	5.9	65	148.7
	0.02	1.0	3.0	0.6	6.0	70	146.4
	0.04	2.0	3.0	0.9	6.8	80	144.2
	0.10	5.0	3.7	1.5	8.0	188	142.0
	0.25	12.5	4.2	0.4	4.7	200	139.5
	0.50	25.0	2.7	6.0	4.5	167	135.9
F	0.02	1.0	3.3	0	7.2	70	---
	0.10	5.0	3.2	0.5	6.8	70	---
	0.20	10.0	3.0	2.5	6.0	80	---
	0.60	30.0	3.5	3.8	4.2	287	---
	0.80	40.0	3.0	3.3	4.5	437	---
	1.00	50.0	3.5	1.5	4.5	313	---
G	0.040	1.5	3.2	0.9	6.3	50	---
	0.20	7.5	3.4	5.1	9±	0	---
	0.27	10.0	4.7	1.5	9±	80	---
	0.40	15.0	4.2	3.1	8.0	200	---
	0.60	20.0	2.9	4.2	5.1	100	---
	1.33	50.0	2.5	2.1	5.1	200	---
H	0.10	10	2.5	0.6	5.0	60	---
	0.50	50	3.0	5.4	8.5	187	---
	1.00	100	3.0	5.4	5.0	125	---

[1] Control mix (avg. values): proportions = 94-200-300; cement = 6.0 bags per cu yd; slump = 3.0 in.; water = 5.58 gal per bag; air-entraining agent = 20.7 ml/bag; weight of hardened concrete = 149.1 pcf; and air content = 5.2%.
[2] Based on total solids for each silicone, from information furnished by producers, 30% solids for silicones A, B, C, D, E, and F, 40% for silicone G, and 15% for silicone H.
[3] Reduction in water as compared with that required for control mix made on same day.
[4] Relative amount of air-entraining agent used, amount used in control mix considered 100%.
[5] Weight determined on cylinders before testing for compressive strength.
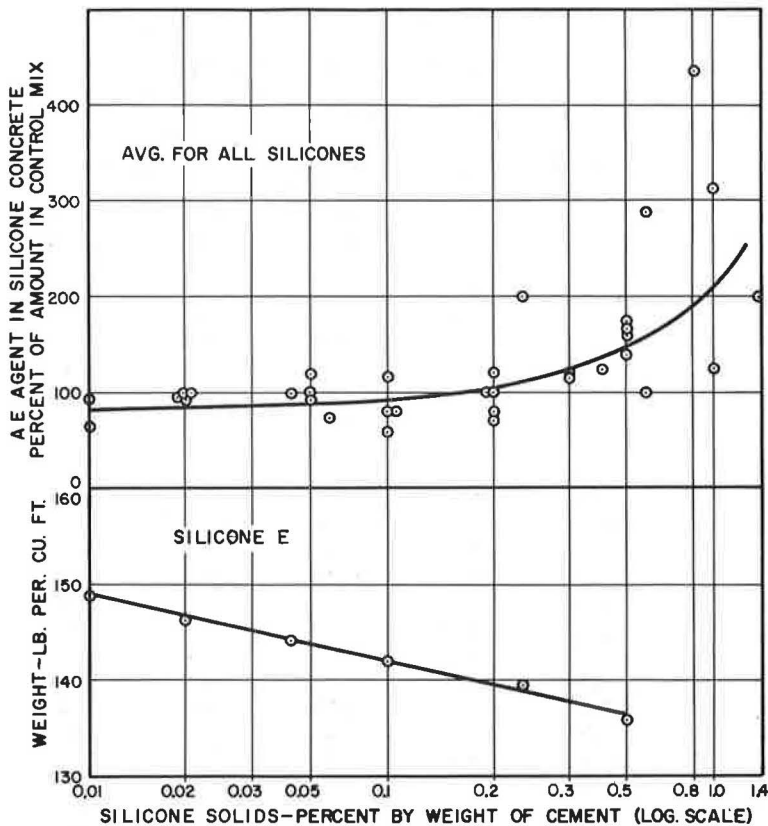
Figure 3. Effect of silicones on amount of AE agent needed and of one silicone on unit weight of concrete.

STRENGTH TESTS

Compressive strength tests were made at ages of 7 and 28 days on concrete prepared with various amounts of the silicone admixtures. These strengths were compared with the strengths of the control concrete made and tested on the same days. Table 4 gives the strength of the concrete prepared with silicone admixtures as the percentage of that of the corresponding control concrete. The relative compressive strengths at 28 days are shown in Figure 5.

Concrete prepared with all amounts of silicones A, B, C, and D (the sodium methyl-siliconates) had higher strength than the control concrete in all cases except one.

When silicone E was used in amounts of less than 0.02 percent solids, the strengths were slightly higher than those obtained on the control mix. When amounts greater than 0.02 percent were used, the strengths decreased considerably as the amount of silicone used increased. When 0.50 percent solids were used, the strength was only 18 percent of the corresponding control mix. This loss in strength is related to the previously-mentioned foaming of the concrete.

For several mixes containing silicones F and G, the strengths were lower than for the control concrete. However, the data show that these mixes contained 6.0 percent or more air.

Only three amounts of silicone H were used. With 0.50 percent solids of this material, a reduction in strength of 21 percent was obtained. However, this mix had an air content of 8.5 percent. The other two mixes containing silicone H both showed slight reductions in strength.

TABLE 4

RESULTS OF RETARDATION AND STRENGTH TESTS

Iden.	Silicone		Air (%)	Proctor Penetration Test, Retardation[1] at 500 Psi (hr:min)	Crushing Strength[2] (%)	
	Amount Total Solids Used (% by weight of cement)				7 Days	28 Days
A	0.20		5.3	4:15	107	114
	0.40		5.7	6:15	104	108
	0.60		4.9	6:30	100	111
B	0.01		5.3	1:30	104	104
	0.02		5.5	2:30	105	104
	0.05		4.7	6:45	112	106
	0.10		4.9	12[3]	116	119
	0.30		5.0	--	110	114
	0.50		5.5	--	107	111
C	0.02		5.0	2:35	107	105
	0.05		5.2	6:35	108	108
	0.10		5.0	11:30[3]	108	113
	0.20		5.0	--	113	112
	0.30		5.0	--	109	110
	0.40		5.5	--	109	109
	0.50		5.1	15[3]	106	104
D	0.02		5.0	1:10	100	103
	0.05		5.4	5:00	102	103
	0.10		5.5	9:45	112	110
	0.20		5.1	--	105	106
	0.50		5.4	--	100	99
E	0.01		5.9	2:20	106	104
	0.02		6.0	5:15	102	99
	0.04		6.8	8:40	100	91
	0.10		8.0	--	65	67
	0.25		4.7	--	21	18
	0.50		4.5	--	18	17
F	0.02		7.2	3:45	95	99
	0.10		6.8	10[3]	97	95
	0.20		6.0	11[3]	114	109
	0.60		4.2	12[3]	113	111
	0.80		4.5	--	102	99
	1.00		4.5	--	93	95
G	0.04		6.3	0:35	95	92
	0.20		9±[4]	0:40	77	79
	0.27		9±[4]	1:35	72	69
	0.40		8.0	1:40	102	101
	0.60		5.1	2:10	107	111
	1.33		5.1	3:15	98	99
H	0.10		5.0	0	100	96
	0.50		8.5	0:20	79	78
	1.00		5.0	0:05	90	90

[1] Delay in time of hardening of concrete containing silicones as compared with control concrete made on same days; average time for control concrete to reach Proctor penetration load of 500 psi was 4 hr 15 min, and 7 hr 20 min for 4,000 psi.
[2] Ratio of strength of concrete containing silicones to strength of control concrete made on same day; average strength of control concrete was 4,140 psi at 7 days and 5,220 psi at 28 days.
[3] Estimated.
[4] Content high, strength values disregarded.

Except for silicones E and H, there appears to be an optimum amount of the other silicones which gives the maximum strength.

LABORATORY FREEZING AND THAWING TESTS

Laboratory freezing and thawing tests were made on a number of the mixes included in the strength tests. The tests were made on 3- by 4- by 16-in. beams frozen in air and thawed in water in accordance with ASTM Method C 291. These tests were continued through 1,000 cycles of freezing and thawing (at 300 cycles, only one of the mixes showed a loss in N^2 of over 10%). Table 5 gives the durability factors of the concretes prepared with the various silicones at 1,000 cycles as well as of the control mix. In addition, the relative durability factor is also given for
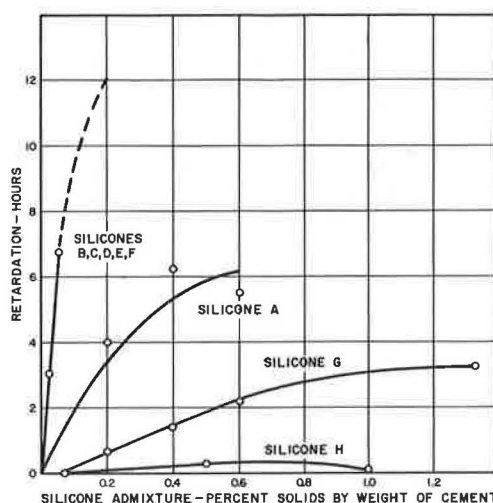
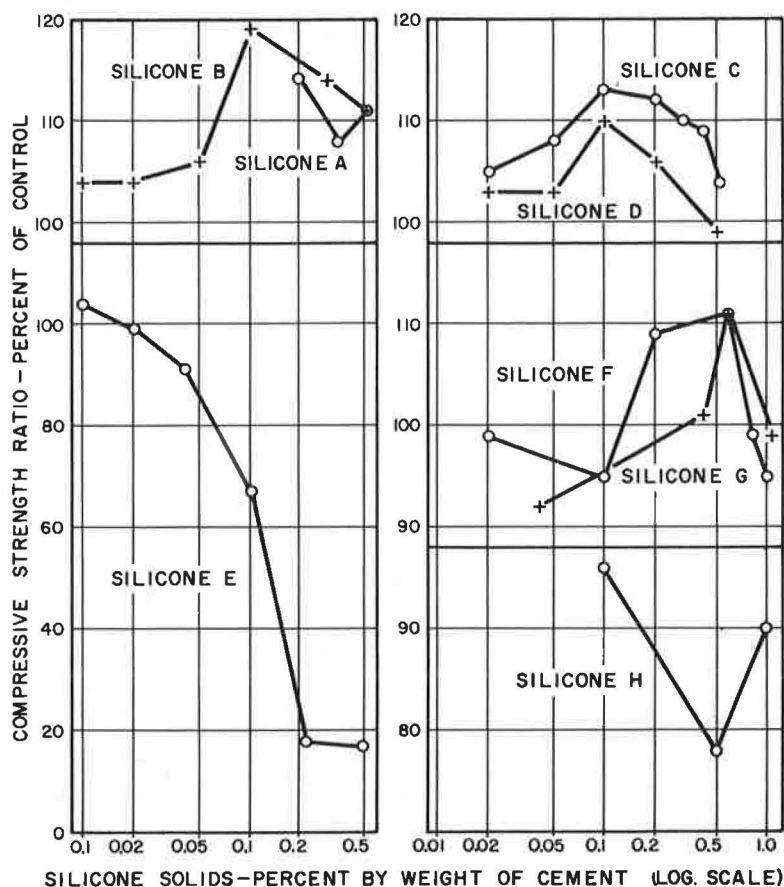Figure 4. Relation between amount of silicone added and retardation.

Figure 5. Effect of silicones on 28-day compressive strength.

TABLE 5

LABORATORY FREEZING AND THAWING[1]

Iden.	Silicone Amount Total Solids Used (% by weight of cement)	Air (%)	Durability Factor[2] (%)	Relative Durability Factor[3] (%)
Control	None	5.1	83	---
A	0.05	5.8	92	111
B	0.01	5.3	91	110
	0.02	5.5	90	108
	0.05	5.7	93	112
	0.10	4.9	83	100
	0.30	5.0	82	99
	0.50	5.5	81	98
C	0.02	5.0	82	99
	0.05	5.2	80	96
	0.20	6.5	87	105
	0.50	6.1	74	107
E	0.01	5.9	91	110
	0.04	6.4	89	107
F	0.02	7.2	94	113
	0.10	6.8	92	111
	0.20	6.0	75	90
G	0.20	9±	81	98

[1] Each value an average of tests on three 3- by 4- by 16-in. beams. Beams frozen and thawed in accordance with ASTM Method C 291.
[2] Based on loss in N^2 after 1,000 cycles of freezing and thawing.
[3] Ratio of durability factor of concrete containing silicone to durability factor of control concrete made on same day.

each mix. This is the ratio of the durability factor of the silicone concrete to that of the control mix. A relative durability of 80 percent or more for concrete prepared with admixtures is acceptable, as is specified in AASHO Specification M 154 for air-entraining admixtures and is in the proposed specification for retarders of Subcommittee III-h of ASTM Committee C-9 (ASTM Designation C 494-62 T). On this basis, all the silicones used are acceptable. There appears to be an optimum amount of silicone admixture for maximum durability. However, these tests are too limited to develop this quantity.

OUTDOOR SCALING TESTS

Outdoor exposure tests were made on 16- by 24- by 4-in. slabs to determine the effect of silicone admixtures on the resistance of concrete to scaling caused by de-icing agents. A description of the test is given elsewhere (1). The same report gives the results of tests in which silicone similar to silicone A was used. Those tests show that the use of silicone in proper amounts was effective in preventing scaling.

Similar tests were made using silicones B and C. At the time this report was prepared, these specimens had been exposed for only one winter. At the last inspection, neither the control nor the slabs containing silicone showed any appreciable amount of scaling. All were given a rating of less than 2. These tests are being continued.

SUMMARY

The four silicones classified as sodium methylsiliconates (silicones A, B, C, and D) gave the best results. These materials were all furnished in about the same concentration (about 30% solids). Three (B, C, and D) retarded the setting time of the concrete much more than would be desirable for ordinary usage.

From the available data, if these three silicones had been used in amounts of 0.2 percent silicone solids by weight of the cement, the retardation of set would have been over 10 hr. With this same amount, the retardation caused by silicone A was only 4 hr. Concretes having 10 to 20 percent higher strength than the control mixes were obtained with all four silicones. The most favorable results were obtained with 0.1 to 0.2 percent silicone solids. Freezing and thawing tests in the laboratory showed concretes prepared with silicones A, B, and C to have practically the same or greater durability than the control concrete. Tests for durability were not made on concretes prepared with silicone D due to lack of material.

The two silicones classified as alkyl silane esters (silicones E and F) were unstable. It was not possible to determine the amount of total solids in these solutions because of the volatility of the silicone materials. These two silicones used as an admixture caused excessive retardation of the setting time of the concrete. Silicone E caused a reduction in the concrete strength due to foaming during hardening. There was a corresponding reduction in the weight of the hardened concrete. Concrete prepared with silicone F had strengths 10 to 15 percent greater than that of the control concrete when 0.2 to 0.6

percent solids were used. There is no apparent reason for the differences in the behavior of these two similar materials. Concrete prepared with either of these materials had good durability, but only a few mixes were tested and these all contained more air than the control concrete.

The use of silicones G and H, which were classified as silicone resin emulsions, had beneficial effects on the properties of the concrete only in isolated cases. They gave unpredictable results on reduction in mixing water and air content. It appears that if either were used in construction, very careful control of the amount of silicone would be required. Silicone G caused only a modest amount of retardation of setting time of concrete, whereas silicone H had practically no effect. When used in amounts which did not give excessive amounts of entrained air, both silicones furnished concretes having 90 to 109 percent of the strength of the control concrete. Only one concrete prepared with silicone G was tested for resistance to freezing and thawing. Although this concrete had low strength, its air content was high and the relative durability was almost equal to that for the control concrete.

The retardation of the setting time offers a problem that must be resolved before this material can be used commercially. However, the tests reported here show that, when some of these silicones are used as admixtures in concrete, both the strength and durability of the concrete will be improved.

CONCLUSIONS

Based on tests using only one brand of cement, the results of the tests warrant the following conclusions. These conclusions apply specifically to concrete prepared with the materials, mixes, and mixing procedures described in this paper.

1. When used as admixtures in certain amounts, solutions of sodium methylsiliconates increased the compressive strength and durability of concrete.

2. The alkyl silane esters and the silicone resin emulsion types of silicones in most cases either had no effect or were detrimental to the compressive strength and durability of concrete.

3. There appears to be a critical amount of silicone admixture needed to obtain maximum compressive strength or durability of the concrete. This amount varies with the properties of the silicones.

4. In most cases, silicones retarded the setting time of the concrete. In the majority of cases, when the silicones were used in amounts needed to obtain maximum strength or durability of concrete, the retardation of the set was greater than can be tolerated for normal construction purposes.

5. The use of silicones as admixtures had no appreciable effect on the water required for a given slump or on the air content of the concrete.

REFERENCES

1. Grieb, W. E., Werner, G., and Woolf, D. O., "Resistance of Concrete Surfaces to Scaling by De-Icing Agents." Public Roads, 32:3 (Aug. 1962).
2. Grieb, W. E., Werner, G., and Woolf, D. O., "Water-Reducing Retarders for Concrete." Public Roads, 3:6 (Feb. 1961).

Discussion

HOWARD NEWLON, JR., Highway Research Engineer, Virginia Council of Highway Investigation and Research. —The data presented in the paper certainly show that there can be considerable variation in the effects of the various materials marketed as silicones and that at the present state of development there is very little to justify their acceptance for use in highway concrete. It would appear that whatever benefit is derived from the admixture is largely the result of its ability to effect water reduction.

In this regard it is of interest to compare some of the data presented by Mr. Grieb with some limited data developed by the writer using a silicone commercially available under the same trade name as that designated silicone B in the paper.

TABLE 6

CEMENT ANALYSIS

Computed Compound Composition				Other Oxides				Fineness (Blaine)
C_3A	C_3S	C_2S	C_4AF	SO_3	Na_2O	K_2O	$Na_2O_{(eq.)}$	
5	42	34	13	1.80	0.09	0.55	0.45	3,450

This silicone was used as an admixture in concrete which in mix proportions and characteristics was essentially like that studied by Mr. Grieb. The only important differences were that the cement was Type II with the characteristics shown in Table 6 and the coarse aggregate was a natural siliceous gravel. The silicone was added with the mixing water to give a concentration of 0.3 percent by weight of cement, the dosage recommended by the manufacturer.

In these tests it was found that a significant water reduction was obtained for the admixtured concrete as compared with plain concrete having the same slump. The average water reduction based on 4 replicate batches for each condition was 13 percent. The data in Figure 2 would indicate a water reduction of almost 9 percent for the same silicone dosage. In spite of usual between-laboratory variation, the differences in the data are not great, considering the differences between aggregates and cements. For example, admixtures such as these are usually more effective with Type II than with Type I cements. The strength data reflected the effects of this water reduction. The extended delay of setting found by Grieb was also found in our tests.

It appears from both sets of data that silicone B causes a water reduction that increases with silicone content, whereas the other sodium methylsiliconate types do not. Table 1 and Figure 1 indicate that silicones A, B, and C are essentially the same. The difference in performance of silicone B would indicate that there is some characteristic that has not been detected. It might be that pursuit of this matter by those interested would lead to an improvement of performance as well as a better understanding of the mechanism of action of these materials.