# Utilization of Sodium Silicate Solution as A Curing Compound of Fresh Concrete

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**Abstract:** Concrete treated with a sodium silicate solution helps to significantly reduce porosity in most masonry products such as concrete, plasters. A chemical reaction occurs with the excess Ca $(OH)_2$ (portlandite) present in the concrete that permanently binds the silicates with the surface making them far more wearable and water repellent. It is generally advised to apply this treatment only after the initial cure has taken place (7 days or so depending on conditions). These coatings are known as silicate mineral paint. Sodium silicate solution is a clear water-soluble, premium sodium silicate concrete hardener that assists in the curing*, hardening and dust proofing of concrete. It is easy to apply, leaves no residue and dries quickly. It is ideal for use on newly placed or existing, interior or exterior concrete in our present work for sub-sea concrete coated pipelines and its suitable also for floor slabs, sidewalks, driveways, beams, olumns.

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**Key Words**: Sodium silicate solution and curing fresh concrete.

## 1. Introduction

An acidified sodium silicate solution precursor of irreversible gels was used as binder to consolidate silica-based aggregates in basic medium. The existence domains and the reactivity of gel–silica and gel–sand binaries depend on the size of aggregates. The increase in the particles size involves a shift of the existence domain to lower gel content. The microstructure of ternary samples reveals the presence of the three components with a partial attack of grain surface confirmed by FTIR experiments during the monitoring of synthesis.

When silica and gel contents increase, mechanical properties of materials increase suggesting a possible reaction between the both components. The main reaction involved during the material consolidation is a dissolution/precipitation reaction which is promoted with decreasing particle size and evidenced by FTIR experiments, *(Séka S. K., et al (2011).*

Sodium silicate solutions with 5 wt.% $SiO_2$ and various $SiO_2$ : $Na_2O$ molar ratios (1.00–4.00) were prepared; then, hot dip galvanized (HDG) steel sheets were immersed in these solutions to obtain silicate coatings at these HDG-layer surfaces. The silicate solutions and silicate coatings were analyzed using a variety of analytical techniques. The results obtained are as follows:

1. When the $SiO_2$ : $Na_2O$ molar ratio of solutions is different types of Si–O linkages and distribution of types of silicate anion in these solutions are different. With the increase in the $SiO_2$ : $Na_2O$ molar ratio from 1.00 to 3.00, the degree of polymerization of silicate ions increases, and silicate structures change from simple to complex (from one- to two- and three-dimensional) structures. When the molar ratio is 3.00 – 4.00, types of Si – O linkages and their distribution are close, (*Mei-rong Y. et al, 2011).*

Sodium silicate has been used as an inhibitor and passivator to improve corrosion resistance of metals for many years due to its effective inhibitory properties and low cost, *(Shi X.C. et al.*, 2006).

The influence of various parameters on the sand consolidation by sodium silicate solutions. Thermal and gravimetric analysis and SEM observations have shown that the grain size and silicate solution dilution affect the silicate content in the granular system. The drying temperature is an important parameter because it imposes the physical chemistry of the consolidation. It has been demonstrated that the mechanical performance of the studied materials are directly influenced by all these parameters, *( Lucas S. et al. ,2011).*

## 2- Experimental

The present work aims to study engineering properties of sodium silicates as a curing compound of fresh concrete such as (specific gravity, color, flash point, flammability, spreading rate, volume of solid content, inspection of membrane, core test after application the silicate curing and dry density.

### 2-1 Specific gravity

The specific gravity using ASTM D 1475 is carried out in PETROJET concrete, coating plant (Port Said).

### 2- 2 Appearance/ color

The color of our samples is tested in Egyptian Petroleum Research Institute.

**2-3 Flash points**

The flash point of our samples is tested in Egyptian Petroleum Research Institute.

**2-4 Flammability**

The flammability of our samples is tested in Egyptian Petroleum Research Institute.

**2-5 Spreading rate**

The spreading rate test is carried out in PETROJET concrete, coating plant (Port Said).

**2-6 Volume of solid content**

The volume of solid content using ASTM D 2369 and ASTM 2697 is carried out in PETROJET concrete, coating plant (Port Said).

**2-7 Water absorption of coupon concrete sample**

The EPRI liquid curing compound were sprayed for representative concrete coating samples, the samples allowed to dry and weighed to the nearest gram and marked as (A), then the sample submerged in water at room temperature for 24 hours, the sample is withdrawn from the water and the excess surface moisture removed, then weight the sample and marked as (B). In accordance to ASTM C 642 the water absorption ratio shall be calculated as (B-A) / Ax100 to ensure the performance and efficiency of EPRI and PETROJET liquid membrane in sealing the sample pores.

**2-8 Core test after application the silicate curing**

The core test after application the silicate curing using ASTM C 42 and ASTM C is carried out in PETROJET concrete, coating plant (Port Said).

**2-9-Dry density**

The dry density using ASTM C 642 is carried out in PETROJET concrete, coating plant (Port Said).

**3- Result and Discussion.**

**3-1 Specific gravity**

The ratio of the mass of a solid or liquid to the mass of an equal volume of distilled water at 4°C (39°F) or of a gas to an equal volume of air or hydrogen under prescribed conditions of temperature and pressure, also called relative density. The specific gravity of samples is ranging from 0.830 to 0.850 gr/cm$^3$.

**3-2 Appearance/ color**

Appearance is composed of color, gloss, and texture. All three factors are important in visual uniformity of products. Color can be measured with a colorimeter and gloss with a gloss meter, EPRI samples color is colorless.

**3-3 Flash points**

The lowest temperature at which a liquid in a specified apparatus will give off sufficient vapor to ignite momentarily on application of a flame, EPRI samples are have not flash points because it is water base.

**3-4 Flammability**

Historically, flammable and inflammable mean the same thing. However, the presence of the prefix in- has misled many people into assuming that inflammable means "not flammable" or "noncombustible", sodium silicate curing compound material is not flammable because it is water base.

**3-5 Spreading rate**

The rate, usually in tens of millimetres a year, at which two adjacent lithospheric plates are separating. The spreading rate varies along a constructive margin and is at a maximum of 90° from the pole of rotation. Some authors use 'spreading rate' when 'half spreading rate' (i.e. the rate of movement of a plate from the relevant ridge) would be more accurate, the sodium silicates spreading rate is same result of sample of PETROJET oil base.

**3-6 Volume of solid content**

| Wt | Dish | Ceramic pan |
|---|---|---|
| Pan (W1) | 11.270 | 35.961 |
| Pan + sample Before heating | 13.370 | 37.574 |
| Pan + sample after heating at 110º C (W2) | 11.666 | 36.281 |
| Sample before heating | 2.10 | 1.613 |
| Sample after heating | 0.396 | 0.32 |
| Solid content % | 18.8 | 19.8 |

**Plate 1**

**(A)**

Photograph showing curing compound preparation for solid content test

**(B)**

Photograph showing weight sample.

**(C)**

Photograph showing heating sample

**(D)**

Photograph showing residue of solid content

The solid content of sodium silicate ranging from 18.8 to 19.8 % and according the application requirement we can control solid content amounts.

**3-6 Water absorption of coupon concrete sample**

The performance of concrete subjected to many aggressive environments is a function, to a large extent, of the penetrability of the pore system. In unsaturated concrete, the rate of ingress of water or other liquids is largely controlled by absorption due to capillary rise. The water absorption of a concrete surface depends on many factors including: (a) concrete mixture proportions; (b) the presence of chemical admixtures and supplementary cementations materials; (c) the composition and physical characteristics of the cementations component and of the aggregates; (d) the entrained air content; (e) the type and duration of curing; (f) the degree of hydration or age; (g) the presence of microcracks; (h) the presence of surface treatments such as sealers or form oil; and (i) placement method including consolidation and finishing. Water absorption is also strongly affected by the moisture condition of the concrete at the time of testing. The results obtained indicate that the EPRI sample (A & C) more or less is the same of PETROJET material as illustrated in the following table:

**3-7-1 The result obtained of EPRI samples (Water base).**

| EPRI curing compound | Dry Weight (A) gram | Saturated weight (B) gram | Water absorption (by volume) | Average |
|---|---|---|---|---|
| A-1 | 2115 | 2227 | 5.296 | 3.840 |
| A-2 | 2159 | 2255 | 4.447 | |
| A-3 | 2196 | 2269 | 3324 | |
| A-4 | 2875 | 2941 | 2296 | |
| B-1 | 2170 | 2263 | 4286 | 4.186 |
| B-2 | 2856 | 2968 | 3922 | |
| B-3 | 2000 | 2087 | 4350 | |
| C-1 | 2266 | 2347 | 3575 | 3.918 |
| C-2 | 2266 | 2363 | 4281 | |
| C-3 | 2642 | 2745 | 3899 | |
| D-1 | 2185 | 2274 | 4.073 | 4.116 |
| D-2 | 2310 | 2407 | 4199 | |
| D-3 | 2061 | 2145 | 4.076 | |
| E-1 | 2037 | 2131 | 4.615 | 4.764 |
| E-2 | 2240 | 2350 | 4.911 | |
| E-3 | 1953 | 2043 | 4.608 | |
| E-4 | 1706 | 1790 | 4.924 | |

| Plate 2 | |
|---|---|
| (A) | (B) |
|  |  |
| Photograph showing weight sample. | Photograph showing EPRI sodium silicate solution samples. |
| (C) | (D) |
|  |  |
| Photograph showing spraying sodium silicate solution on the samples. | Photograph showing samples after drying. |

**3-7-2 The result obtained of PETROJET sample (oil base).**

| PETROJET curing compound | Dry Weight (A) gram | Saturated weight (B) gram | Water absorption (by volume) | Average |
|---|---|---|---|---|
| F-1 | 1934 | 2016 | 4.240 | 3.617 |
| F-2 | 2792 | 2897 | 3.761 | |
| F-3 | 2302 | 2398 | 4.170 | |
| F-4 | 2871 | 2937 | 2.299 | |

**3-8 Core test after application the silicate curing**

Yes, you can cut cores anytime after 7-14 days (so long as concrete is hard enough not to disintegrate). Normally, they should be extracted and tested at 28 days strength, but 3 months is also OK. Remember that concrete continues to gain strength after 28 days, so this factor needs to be kept in mind.

The cylinder core sample was cdrilled from cure coated sample for compressive strength test, the readings indicates that the results obtained comply with oil base curing compound and its ranging from 45 to 55 N/sq.mm.

**3-9 Dry density**

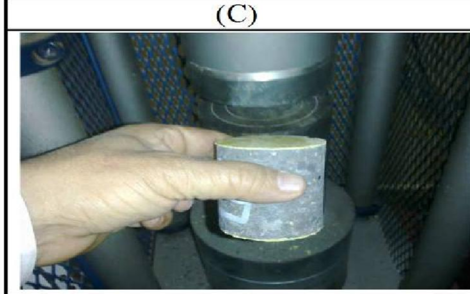
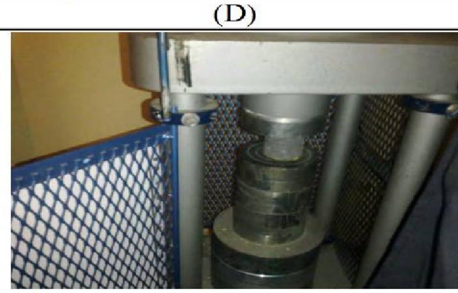
A cylindrical core cutter is a seamless steel tube. For determination of the dry density of the soil, the cutter is pressed into the soil mass so that it is filled with the soil. The cutter filled with the soil is lifted up. The mass of the soil in the cutter is determined. The dry density is obtained as

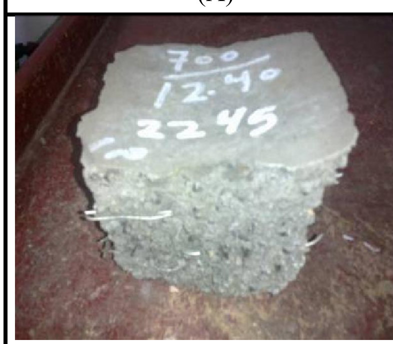
$$\rho = \frac{\gamma}{1 + w} = \frac{(M / V)}{1 + w}$$

Where:
M= mass of the wet soil in the cutter

V= internal volume of the cutter
W= water content.

The coupon sample was cutted from concrete coated pipes sprayed by silicate curing compound and the calculation of dry density and water absorption carried out using special equipment used to weight the sample dry, suspended in water then give the dry density results which ranging from 2900 to 3020 kg/cm$^3$.

| Plate 3 | |
|---|---|
| (A) | (B) |
|  |  |
| Photograph showing coated pipe for core testing. | Photograph showing drill core sample. |
| (C) | (D) |
|  |  |
| Photograph showing testing of core sample. | Photograph showing compressive test machine. |

| **Plate 4** | | |
|---|---|---|
| (A) | (B) | (C) |
|  |  |  |
| Photograph showing coupon sample from coated pipe. | Photograph showing dry density calculation equipment. | Photograph showing sample immersed in water. |

**4- Conclusion:**

* Sodium silicate solutions (prepared by EPRI) provides continuous film on the concrete surface and retain moisture or promote proper cement hydration in freshly placed concrete.

* The water absorption, the volume of solid content and spreading rate allowed for concrete curing and achieved the same compressive strength of oil base curing material.

* EPRI Sodium silicate is water base and not causes any hazard for applicator and friendly environmental users.

* EPRI Sodium silicate solution is the same specification, but cheaper in price comparing with the oil base.

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