Silicone water-repellents for masonry

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Silicon Water-Repellents for Masonry

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Silicones are synthetic materials made up of the elements silicon and oxygen combined with organic groups. The silicon and oxygen are linked to provide a large molecular structure in the form of chains or networks. Depending on the nature of its organic group and on the conditions of its compounding, the silicone may be an oily, resinous or rubbery material. The term silicone, therefore, does not refer to a specific chemical composition but to a large family of materials, any member of which may have quite different properties from those of other members of the family. As silicones are intermediate in composition between inorganic and organic materials, however, their properties reflect the influence of both constituents. Their silicon-oxygen portion provides, among other things, good heat resistance; and organic groups spaced along the silicon-oxygen chain provide flexibility and solubility in organic solvents.

As early as 1872 chemists were preparing silicones, but large-scale commercial production and application did not take place until recent years. In the 1950's, for example, the remarkable water-repelling property of certain silicones led to many applications such as those for the treatment of textiles, leather and paper. The water-repellency and invisibility of silicones led also to their use as a treatment of masonry units and walls, which occasionally suffer damage from the effects of excessive wetting by rain.

Two types of silicone have been formulated for application to masonry. Both change the nature of the masonry surfaces so that instead of absorbing water they repel it. The first is a silicone resin in a solvent solution (mineral spirits) generally containing about 5 per cent by weight of silicone; applied to a masonry wall, the solution wets the surface and penetrates to some extent into the pores of the masonry, carrying the silicone with it. The silicone adheres to the masonry after the solvent has evaporated. The second type is a water-soluble material, sodium methyl siliconate, which is applied as a very dilute water solution; with exposure to the carbon dioxide of the atmosphere it is converted to a water-insoluble resin. This latter type is not as a rule used as a treatment for walls but as a treatment of masonry units in the manufacturing plant particularly to reduce the excessively high water absorption of certain units.

If application of silicone to a masonry wall could make its surface so water-repellent that rain could not pass through the surface to the interior, it would eliminate or decrease the severity of several important problems with masonry buildings, including rain penetration, efflorescence and deterioration of masonry materials. It is the purpose of this Digest to review the effectiveness of silicone in connection with these problems.

Rain Penetration

Rain penetration of walls of brick and other masonry units, which has long been a problem, has given rise to many attempts to prevent rain from passing through them. Heavy renderings such as stucco as well as thin coatings such as paint have been applied over wall surfaces for this purpose; and in order to maintain the original appearance of walls much use has also been made of transparent "waterproofers." These materials included a wide variety of waxes, oils, resins, gums, fats and soaps, which were applied to walls in solutions from which the solvent evaporated, leaving behind a film of the "water-proofer." To this long list of materials has now been added silicones, which generally provide a greater degree of water-repellency than the previously-mentioned materials and are generally considered to have a much longer life, usually estimated to be about 5 to 10 years.

When rain passes through a masonry wall it has three possible routes to take through the individual masonry units, through the mortar, or through openings between the unit and mortar. Certain bricks, concrete blocks and other masonry units may allow water to pass through them, but the amount is usually so small that it does not constitute a significant proportion of the total amount of water coming through a wall in a prolonged, heavy rain; similarly, the amount of water passing through the body of the mortar is usually of little significance. The resistance of a wall to rain penetration therefore hinges in large measure on the presence of openings between the unit and the mortar, that is, on the completeness of the bond between them.

Unbonded areas at the interface result from the use of too little mortar as well as from the use of incompatible units and mortars; for example, use of a high-suction brick with a mortar of low plasticity usually results in an incomplete extent of bond, with channels that allow water to pass through the wall. In addition to these channels at the unit-mortar interface, others may be present if the wall becomes cracked as a result of excessive structural stresses, differential movements, and other causes. The effectiveness of a treatment of a wall that suffers from rain penetration will therefore depend on how well the treatment "plugs" the openings, including the large pores of the units, the openings between units and mortar, and cracks that may be present in the wall.

Many brick walls have been tested for resistance to water penetration by the Division of Building Research to determine what properties of bricks and mortars influence "tightness" of walls. The method of test is quite simple. Water is sprayed on the wall to form a film over its surface, such as occurs with wetting by heavy rain; in addition, the wetted surface is subjected to a higher air pressure than that on the back of the wall, simulating the effect of wind pressure against the wall. Records are made of the time taken for dampness to appear on the back of the wall, the rate at which water flows off the back, and the extent of dampness that develops in a test lasting many hours. A number of walls tested in this way have subsequently been treated with a silicone solution of 5 per cent silicone in mineral spirits, then tested again to determine its influence on the resistance of the wall to water penetration.

All the walls of a group of twenty-four made of a variety of bricks and mortars leaked to various degrees in the first test, but only three silicone-treated walls showed no dampness or leakage in the second test; a fourth wall became damp but did not suffer from leakage, that is, no water flowed off its back surface. Most of the remaining walls in the group showed improvement in performance after silicone treatment in that it took longer for dampness to appear on the back of the wall in the second test than in the first; in addition, the amount of leakage was reduced from that occurring in the original test. In four walls, however, the amount of water that leaked through the walls in the second test exceeded that of the original test.

It should be noted that the three walls that were rendered resistant to water penetration by silicone treatment were the most water-resistant of those originally tested. The effectiveness of the silicone treatment apparently depended on the tightness of the wall before treatment. In a practical situation this means, unfortunately, that the badly-leaking wall of a building will probably not be cured by applying silicone unless an attempt is first made to close the pores of the units, the voids at the unit mortar interface, and any cracks in the masonry. If such a "stopping-up" procedure is carefully and effectively carried out, then it will probably not be necessary to apply silicone. It may be possible to assess the effectiveness of a proposed treatment by applying silicone to a small test area of a wall that leaks and observing the performance of the test area when wetted by rain or water sprayed on it.

Efflorescence

Another building problem to which silicones have been applied as a remedy is that of efflorescence, defined as the formation of salts, generally white in colour, on the surface of a masonry wall. The salts that cause efflorescence on brick walls usually originate in the mortar, although bricks occasionally contain enough soluble salts to contribute to the problem.

Experiments have shown that silicone applied to the surface of a brick usually prevents efflorescence from forming on that surface. A method of demonstrating this effect is to treat all but one surface of a brick with silicone, then place the untreated face in contact with a solution of a salt such as sodium sulphate. The solution is absorbed by the brick through its untreated surface. An untreated brick similarly placed in the solution becomes covered with efflorescence owing to the evaporation of the solution's water from the brick surfaces, a process that is accompanied by the deposition of the salts. A silicone-treated brick, however, remains free of surface salts, presumably because the solution cannot migrate through that part of the brick near the outer surface where the material has been made water-repellent. The evaporation of the water carrying the salts must therefore take place inside the brick beneath the surface, with the salts deposited in the pores.

Silicone treatment of a brick wall for efflorescence is frequently successful, but the means by which this success is attained forcing evaporation to take place beneath the surface introduces an element of hazard to the masonry. This is particularly true if the masonry units and mortar are relatively weak, since the disruptive pressure of the crystallization of salts within them may cause spalling.

Silicone as a "Preservative"

Silicone treatment of masonry walls has occasionally been undertaken with the object of preserving a wall from decay or of arresting decay, the theory being that such treatment will prevent the masonry materials from being wetted by rain. In theory, two of the major agents of decay are removed: frost action, by which water in the pores freezes to ice with disruptive expansion, and salt crystallization, by which crystallization from the salt solutions formed in the wet material produces disruptive pressure within the pores when the water evaporates from the solution.

Although the theory is sound, the practical situation is that silicone treatment of a wall rarely provides absolute protection against rain, and none at all against wetting caused by condensation of water vapour migrating through the wall from within the building. In addition, water that enters the units and mortar of a silicone-treated wall is less readily lost through evaporation than is that from an untreated wall.

Although tests of water vapour permeability of thin slabs of identical masonry material, silicone-treated and untreated, usually show no significant difference in the amount of water vapour passing through them (i.e., the silicone "breathes"), tests of the rate of evaporation of water from silicone-treated and untreated materials show that the rate for treated materials is lower than that for untreated materials. This situation probably results from the fact that water within the untreated material is able to migrate freely and directly to the surface to evaporate, whereas that in the silicone-treated material has to evaporate within the material.

Rather than keep a wall dry, therefore, silicone treatment may increase its moisture content over that of the untreated wall. As the damage from freezing of a masonry material generally increases with increasing moisture content, the effect of a silicone treatment may thus promote decay rather than prevent it. Indications of such adverse influence on the durability of masonry materials were obtained in an extensive study carried out in Great Britain involving silicone treatments of the stonework of old buildings. In many cases the decay of the stonework was accelerated as a result of the treatment. [Stone Preservation Experiments, by B. L. Clarke and J. Ashurst. Great Britain, Department of the Environment, 1972.]

Plant-Applied Silicones

Many manufacturers of bricks and other masonry units apply silicone to their products as a part of the manufacturing process. If certain bricks, for example, are excessively high in suction they may be silicone-treated to reduce the suction to a value that allows the brick to bond better with the mortar, thus achieving a more rain-resistant wall. A silicone treatment of excessively-permeable units may also be beneficial in making them impermeable to the passage of rain, although on occasion highly permeable units have been found to be even more permeable to water after silicone treatment.

The manufacturer of a silicone-treated masonry unit should not use the treatment in an attempt to convert a material of doubtful durability into a durable one, even if the lower water absorption values of the treated units indicate enhanced durability. Before being treated with silicone the product should meet durability and other requirements of the standards for that particular masonry material.

Conclusions

Silicone water-repellents have been extensively used in recent years to treat masonry walls for a variety of faults relating to wetting by rain. They have also been used to treat masonry units in the course of their manufacture in an effort to improve the performance of walls built with them. Application of silicones to walls has even been made in anticipation of problems, but such a procedure cannot be recommended. The wall to which silicone is to be applied should suffer from a clearly-defined fault that the treatment holds promise of correcting.

In dealing with rain penetration of masonry walls it is, unfortunately, impossible to predict how effective a silicone treatment will be, except, perhaps, from previous experience with walls of the same masonry materials used in buildings of the same design exposed to the same weather conditions. The effectiveness of a silicone treatment depends on too many factors, particularly on how leaky the wall is and how large are its openings.

When, however, it has been decided to apply silicone to a wall, the application should be made with careful attention to the manufacturer's directions. These usually require that the solution should be applied to a surface-dry wall that has been patched to fill cracks and openings, the new mortar having been allowed to age for at least a month.

Silicone treatment of walls should never be undertaken for the purpose of "preserving" masonry, particularly that in old buildings. Experience has shown that silicone applied to the walls of old masonry structures tends to promote decay rather than prevent it. Similarly, walls of materials of doubtful durability in modern buildings cannot be made durable with silicone. In addition, if silicone treatment is to be used to correct efflorescence, the masonry units must be strong and durable