REPAIR OF VULNERABLE CONCRETE

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Summary

For permanent repair of cracks in concrete caused by alkali-aggregate reaction the chemical process has to be stopped. The most obvious way of stopping the deleterious process is to reduce moisture content of concrete below critical point.

This paper shows the effect of various repair and renovation methods used on houses in the period 1979-1982 on the moisture content of exterior walls. The results already obtained show ventilated panels or claddings to be most effective. Impregnation with silanes/silicones have also shown most promising results.

Kay words: repair, renovation, moisture content, hydrophobing.

Preface

Icelandic cement contains a high amount of alkalies with Na_2O-eq~1,5%. Alkali reactive aggregates are not uncommon and measures have been taken to prevent deleterious expansions in structures known to be vulnerable to such reactions. Thus deleterious alkali aggregate reactions are unknown in hydraulic structures such as dams, harbours and bridges.

In concrete houses with insulation on the inside of exterior walls, the moisture content of the concrete was not considerd high enough for deleterious reactions to take place, and therefor no special preventive measures were taken. In an extensive survey of these structures, carried out in 1978, it was found that serious map cracking due to alkali aggregate reactions existed in the exterior walls of a great many houses. This was traced to sea dredged aggregates which were used increasingly in the period 1962-1979. In 1979 the use of silica fume in the cement and requirements of washing sea aggregates were considered to be sufficient measures to prevent further damage.

Stopping the processes

For repairing damage caused by alkali aggregate reaction in concrete it is essential to be able to stop the deleterious reactions. Looking at the influencing factors that have to be present simulaniously, for the reactions to take place, the only factor that can be removed is moisture. In analysing the origin of moisture in exterior walls it has been proven that the cause of the high moisture content is driving rain combined with capillary forces of the concrete. Thus by preventing external water penetrating the concrete while keeping the surface open enough for moisture to escape it should be possible to lower the moisture content of the concrete and thereby reduce the rate of reactions or stopping them altogether.

Field tests

A number of full scale repair projects were carried out in the period 1979-1982, aimed at lowering the moisture content in the concrete and stopping the deleterious reactions. The methods used were the following:

- Ventilated pannels or claddings with and without insulation.

- Rendering applied on insulation.
- A 6 cm thick layer of heavily reinforced shotcrete.
- Impregnation of silicones and silanes.
- Surface treatment with different types of paints.

Moisture content in the concrete was measured by three different methods,

a) by use of electrical moisture meter (protimeter concrete master) [Registrates moisture content close to the concrete surface (see fig. 1)]

b) by drilling cores without cooling water and driing and weighing in the laboratory

c) by use of RH-meters (Vaisala, see fig. 2).

The two latter methods make it possible to measure the moisture gradient through the cross section of the concrete.

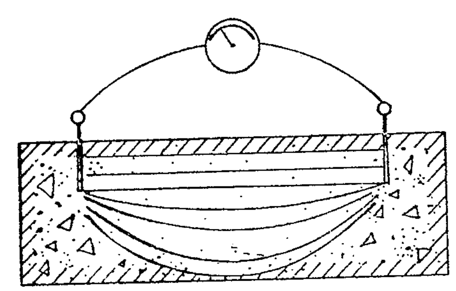

FIG.1- MOISTURE METER (PROTI-METER CONCRETEMASTER)

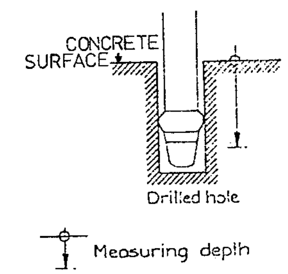

FIG.2- RH-METER (VAISALA)

In the following the main results already obtained will be presented:

Ventilated claddings.

12 houses with degree of damage from moderate to extensive, were included in the project. The main results were as follows: the concrete dries out without regard to the use of insulation, if care is taken to remove impermeable layers of paint from the concrete surface. Typical test results are shown in fig. 3 and 4. Fig. 3 shows moisture variation in concrete close to the surface measured by concrete master. The readings are calibrated for temperature. Fig. 4 shows moisture content in drilled cores before and after saturation.

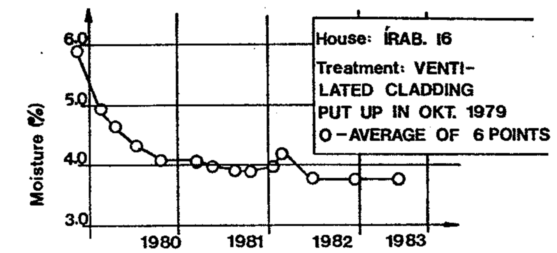

FIG.3 - MOISTURE DEVELOPEMENT IN CONCRETE SURFACE (0-5cm) AFTER A VENTILATED CLADDING WAS PUT UP.

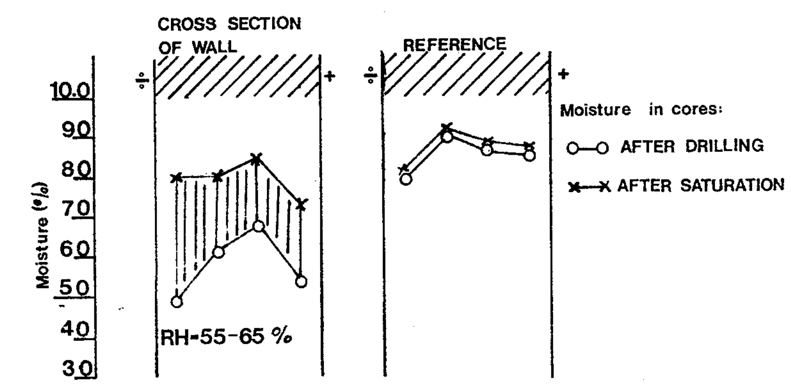

FIG. 4 - MOISTURE IN THE SAME WALL (fig.3) MEASURED IN DRILLED CORES TAKEN IN AUG 1982

Renderings on insulation.

Two basic types were used, hydraulic renderings with steel reinforcement and so called thin renderings with reinforcement of fine mesh fiberglass fabric. Two houses of the former type and three of the latter were included.

Some decrease of moisture in the concrete has been registered in all cases. The hydraulic renderings have shown some fine cracks while no cracks or other damage has been observed in the thin wall ones which were of the ISPO and Dryvit systems. Measurements will be continued but fig. 5 shows moisture variation measured with concrete master were ISPO system was applied. No accumulation of moisture in the insulation has been registered.

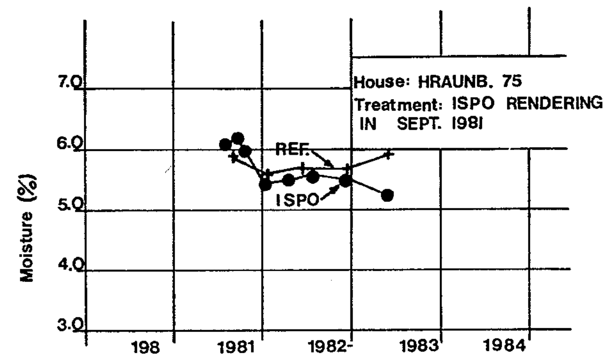

FIG. 5 – MOISTURE DEVELOPEMENT IN CONCRETE SURFACE (0-5cm) AFTER THIN RENDERING WAS APPLIED ON 1½" POLYSTYRENE INSULATION (ISPO-SYSTEM)

Shotcrete.

In the two experiments carried out with somewhat different design, some cracks developed in both cases during the first year. No decrease of moisture has been registered.

Impergnation with silicones and silanes.

Hydrophobing the surface of the concrete by applying silicones or silanes to the walls has given most promising results. In all experiments, made with different types of silicones/silanes a marked decrease in moisture has been registered even on surfaces with fine map cracking. In cores drilled with dry method a dry alkali gel has been observed indicating that the moisture content has decreased below the critical point.

Fig. 6 and 7 show typical results.

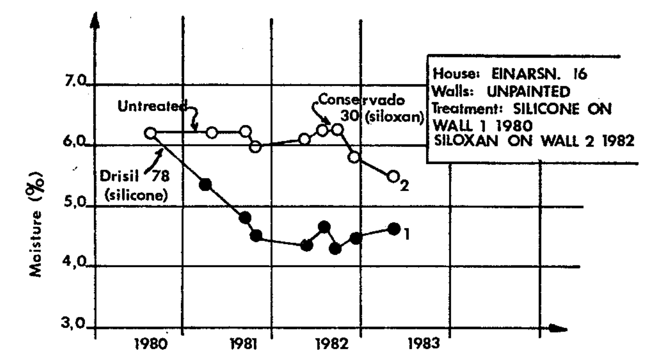

FIG. 6 – MOISTURE DEVELOPEMENT IN CONCRETE AFTER IMPREGNATION WITH SILICONE (DRISIL 78) AND SILOXAN (CONSERVADO 3o)

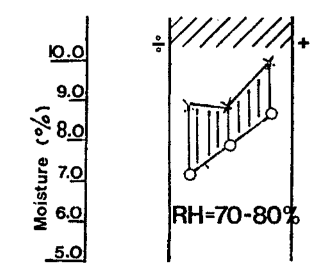

FIG. 7 – MOISTURE IN WALL 1 (fig 6)
MEASURED IN DRILLED CORES
TAKEN IN JAN. 1983
O—O MOISTURE AFTER DRILLING
X—X -"- -"- SATURATION

To distinguish between different types of silicones/silanes the following laboratory method was developed: standard mortar bars, 4x4x16 cm, were oven dried. Then the mortar bars were soaked in silicone/silane for 30 seconds. The specimens were then placed under hydraulic pressure ranging from 0-80 cm depth. The moisture absorption was then measured after 7 and 24 hours. Typical results are shown in fig. 8, showing silanes to be most effective, even to considerable hydrostatic pressure.

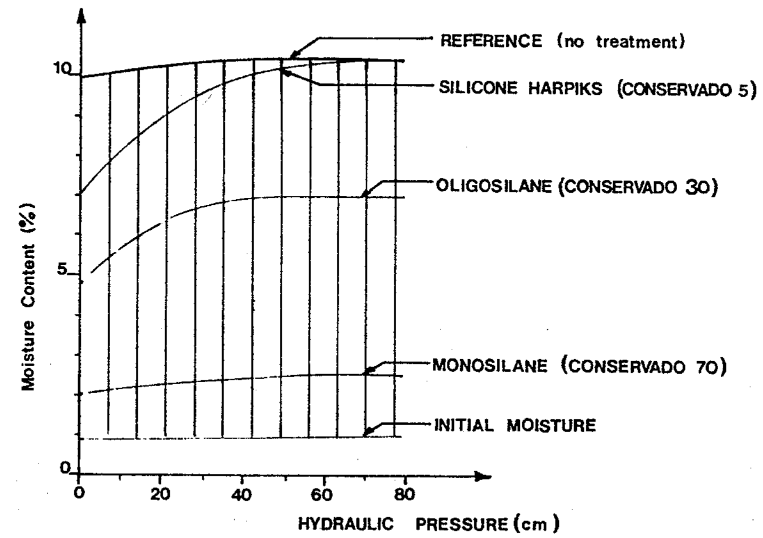

FIG. 8 - EFFECT OF SOME SILANES/SILICONES ON WATER ABSORPTION OF MORTAR PRISMS UNDER HYDRO-STATIC PRESSURE IN 24 HOURS.

Paints.

A wide variety of paints have been tested on numerous houses. The findings are that when applied to walls already damaged and thus with high moisture content paints with low moisture permeability do more harm than good, while paints with intermediate to high moisture permeability can be applied with some success, at least delaying the rate of cracking, depending on the micro-climate and the maintenance of the paint. A combination of silanes/silicones used with moisture permeable paints has not been extensively studied but in view of the effect of silicones/silanes alone this may proof advantageous.

Consult for maintenance

The field tests mentioned in this paper along with some laboratory testing has led to the following general consult for maintaining exterior concrete walls with map cracking caused by alkali aggregate reaction:

1. Close the horizontal top of walls (a number of methods).

2. Unpainted walls with starting map cracking:
   Use silicones/silanses, the latter being more durable.

3. Painted walls with starting map cracking:
   3.1 Use silicones/silanes
   3.2 Use moisture permeable paints
   3.3 Use combination of the two applying the silicones/silanes first (choose silicones/silanes that do not affect adhesion of the paints).

4. Walls with extensive map cracking:
   4.1 Close wide cracks (different methods) then see 3.
   4.2 Ventilated claddings (remove impermable paint).
   4.3 Thin renderings applied on insulation.

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