CORROSION DAMAGES CAUSED BY CAST MAGNESITE FLOOR SCREED

KORROSIONSSCHÄDEN DURCH MAGNESIAESTRICH

DÉGÂTS DE CORROSION DUS AUX CHAPES EN CIMENT MAGNÉSIEN

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SUMMARY

The use of cast magnesite floor screed demands special protective measures for steel and reinforced concrete because of the release of chloride. Considering a case of damage, the consequences of neglecting corrosion protection are demonstrated. Evolution of the damage is followed up for three years.

ZUSAMMENFASSUNG

Der Einsatz von Magnesiaestrich erfordert besondere Korrosionsschutzmaßnahmen für Stahl und Stahlbeton, da der Estrich Chlorid freisetzt. Am Beispiel eines Schadens werden die Konsequenzen unzureichender Schutzmaßnahmen dargestellt. Die Schadensentwicklung wird über drei Jahre verfolgt.

RESUME

L'utilisation de chapes en ciment magnésien nécessite des précautions spéciales de protection contre la corrosion pour l'acier et le béton armé, ceci en raison de la libération de chlorures par la chape. A l'aide d'un exemple d'un dégât, les conséquences de mesures de protection insuffisantes sont montrées. L'évolution des dégâts est suivie sur une période de trois ans.

KEYWORDS: Magnesite Screed, Corrosion, Chloride, Concrete, Reinforcement, Headed Studs

1 MAGNESITE SCREED

Magnesite screed is used mainly in industrial buildings and exclusively in interiors, where the following characteristics are required:

- high abrasion resistance
- high resistance against impact
- dustlessness (with appropriate care)
- low heat conductivity
- stability against mineral oils, solvents and fuels
- pleasant appearance
- easy cleaning and repair

It is made of caustic magnesia, additions (fillers), an aqueous salt solution of bivalent metals – generally magnesium chloride – and additives (like colouring materials). Magnesium chloride is an acid, hygroscopic and therefore corrosive salt.

After hardening, the pores are filled with magnesium chloride solution. Magnesium chloride does not dry within relative humidities >32%. Consequently magnesite screed affects corrosively usual building metals and alloys (steel, galvanised steel, some stainless steels). In this connection already very early special preventive measures were prescribed: The paper A50 of "Industrial Building e. V." [1] demands 1962 for example:

- "The concrete must be and remain dry" and
- "All metal parts coming into contact with the lining are to be protected adequately "

With reference to fittings made of metal, DIN 18560, part 3 [2] states: "metal fittings must be, if necessary, provided with a corrosion protection adapted to the bonding agent of the screed". Further, DIN 18560, part 3 claims in table 2: "On reinforced concrete, a barrier layer is to be planned".

As several cases of damage from the last years show, these regulations are not sufficiently considered. This publication would like to demonstrate the importance of corrosion protection in connection with magnesite.

2 CASE OF DAMAGE

2.1 GENERAL

An industrial building, built in 1997 showed local bulging of the screed (ME 60 and ME 80) in the proximity of columns (fig. 1), where headed studs with relatively small concrete cover were cast in the floor slab. Since the damage arose systematically and was found exclusively within areas with magnesite screed, a connection with the screed works was assumed. The Otto-Graf-Institut was charged with the investigation of the damage.

Fig. 1: Bulges in the floor near column

2.2 INVESTIGATIONS AND RESULTS

In a first visual investigation some of the bulged spots (diameter approx. 25 cm) were opened and examined. Bulging always started from headed studs with small concrete cover (< 2 cm), corroded on top (fig. 2).

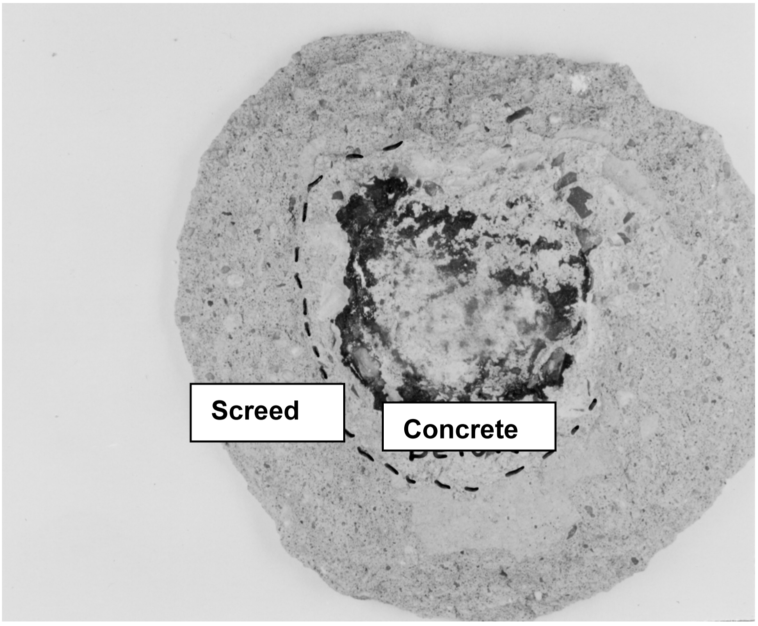

Fig. 2: Bulge (bottom side) with rust stains from headed stud

For further investigation 3 cores were drilled. At the boundary screed/concrete no apparently recognisable intermediate layer was found (fig. 3). The reinforcing steel with concrete cover of ≥ 4 cm was not yet corroded. From the drill cores samples were prepared for chloride analysis. The resulting chloride profile is given in fig. 4. In a depth of 2 cm (at the head of the studs) a chloride content of 0,3 to 0,9 % (related to cement weight) was found, in a depth of 4 cm (at the reinforcement) the concentration decreases to 0,15 to 0,2%.

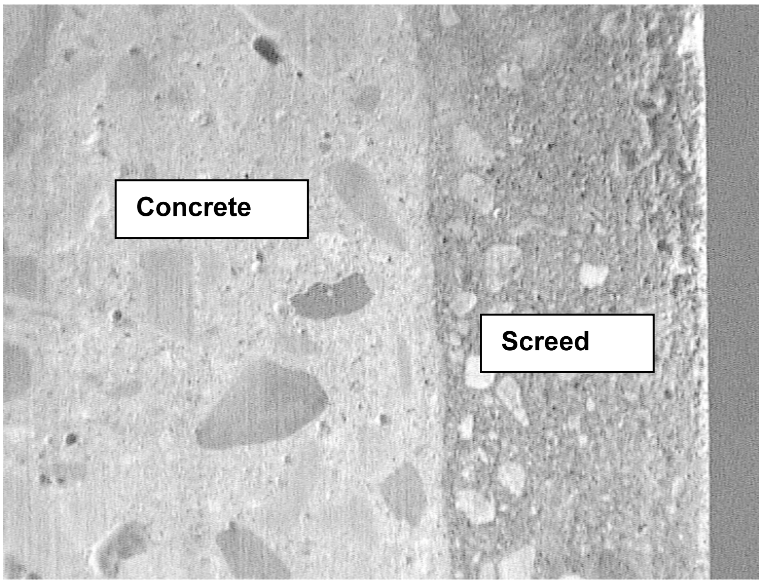

Fig. 3: Drill core (no visible barrier layer)

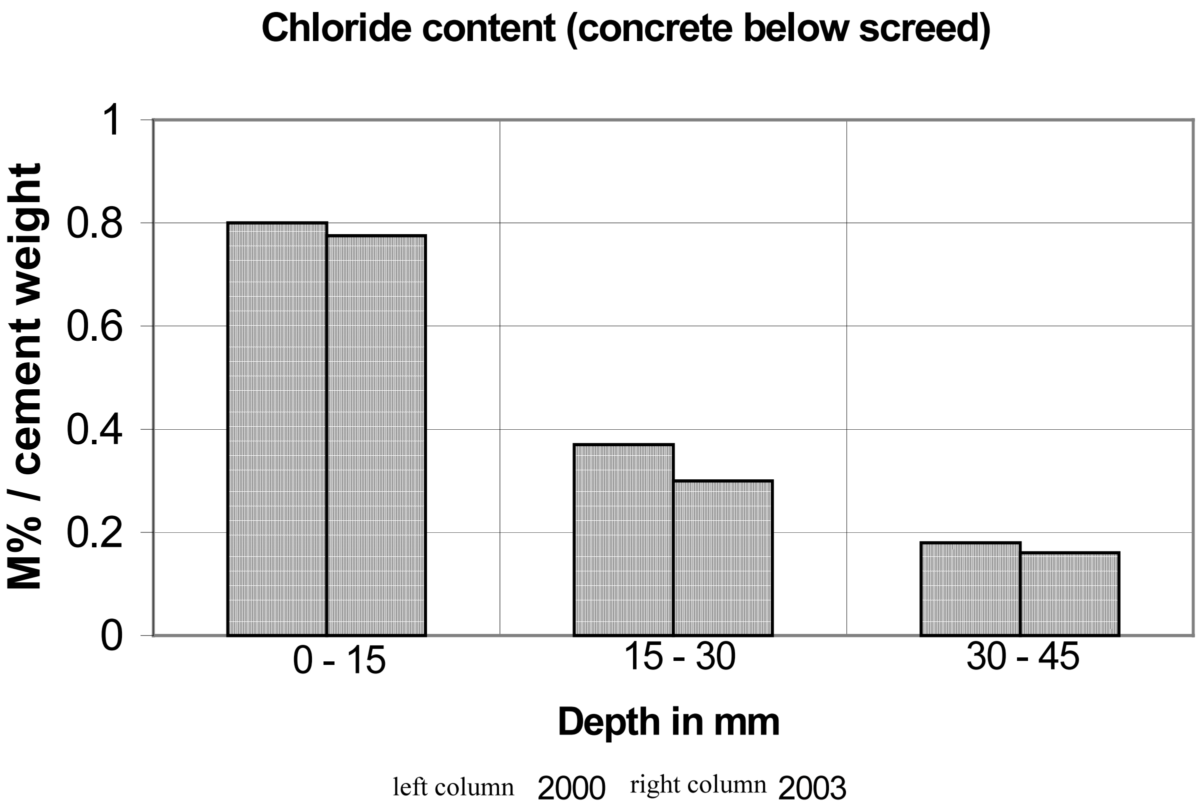

Fig. 4: Chloride profile in the years 2000 and 2003

Closer investigation of the boundary layer magnesite screed/concrete by means of differential thermal analysis (DTA) and thermogravimetry (TGA) showed that on the concrete an organic layer had been applied. However did the chloride profiles point clearly to the absence of "sealing"- or "barrier"-characteristics of this layer.

To detect early stages of corrosion, potential measurements were performed. The measurements resulted in potentials within a relatively narrow range from - 140 to - 50 mV against the saturated calomel electrode. Evaluation of the results by means of statistic methods [3] gave a critical potential value of -80 mV.

2.3 CAUSE OF THE DAMAGE

The systematic uniformity of the apparent damage on all the areas covered with magnesite screed and the agreement of the chloride profiles in different places of the building permitted the conclusion that magnesium chloride solution had penetrated into the concrete and depassivated inserted steel with small concrete cover. The bulging and spalling was the effect of pressure, produced by corrosion products. The majority of the reinforcement of the floor slab did not seem concerned yet, as the results of potential measurements and the low chloride content in this depth (around 0,2 %) suggest.

The cause for the penetration of chloride was the absence of the barrier layer between magnesite screed and reinforced concrete according to DIN 18560 part of 3, table 2. The applied bonding layer was no barrier layer in the sense of DIN 18560.

2.4 PROGNOSIS, REPAIR

At the time of the investigations a chloride profile with decreasing concentration was found. Critical chloride contents had to be assumed only in a depth less than 3 to 3,5 cm. I the course of time, due to the concentration gradient, chloride transport to deeper layers had to be expected. At the same time potentials were expected to increase (due to drying) and critical chloride contents to decrease (because of the higher potential). Chloride diffusion substantially depends on the water content of the concrete and on the kind of the cation. For magnesium chloride, diffusion coefficients three to four times higher than for the more usual sodium chloride were found in laboratory experiments [4].

Because of the above mentioned complications, prognosis regarding chloride ingress and corrosion was not possible with reasonable accuracy from the available data. Therefore it was suggested to repeat potential measurements and chloride analysis at a later time. In a first step, repair was restricted to visibly bulged, hollow spots, were concrete was removed to a depth of 4 cm and replaced by a special repair mortar after cleaning the studs by means of sandblasting.

2.5 FOLLOW-UP INVESTIGATIONS

In the years 2002 and 2003 the potential measurements were repeated at the same spots. Chloride profiles were also acquired again in 2003. At this time, additional bulging around six of the columns was found. Potentials are summarised in tab.1. An example of potential readings (2000 and 2003) is given in fig 5. The majority of potentials decreased in the course of time, but the critical value also was found to be lower by 25 mV. Anyway, active corrosion was still indicated at a remarkable number of measuring points, even in areas without headed studs.

Table 1: Results of potential measurements 2000 to 2003

Screed	Potential in mV (GKE)								
	2000			2002 [1)]			2003 [1)]		
	min.	max.	critical	min.	max.	critical	min.	max.	critical
ME 60	- 140	- 50	- 80	- 120	- 20	- 40	- 204	- 22	- 105
ME 80	-	-	-	- 110	- 5	- 55	- 98	± 0	- 55

[1)] Number of measuring points: 194

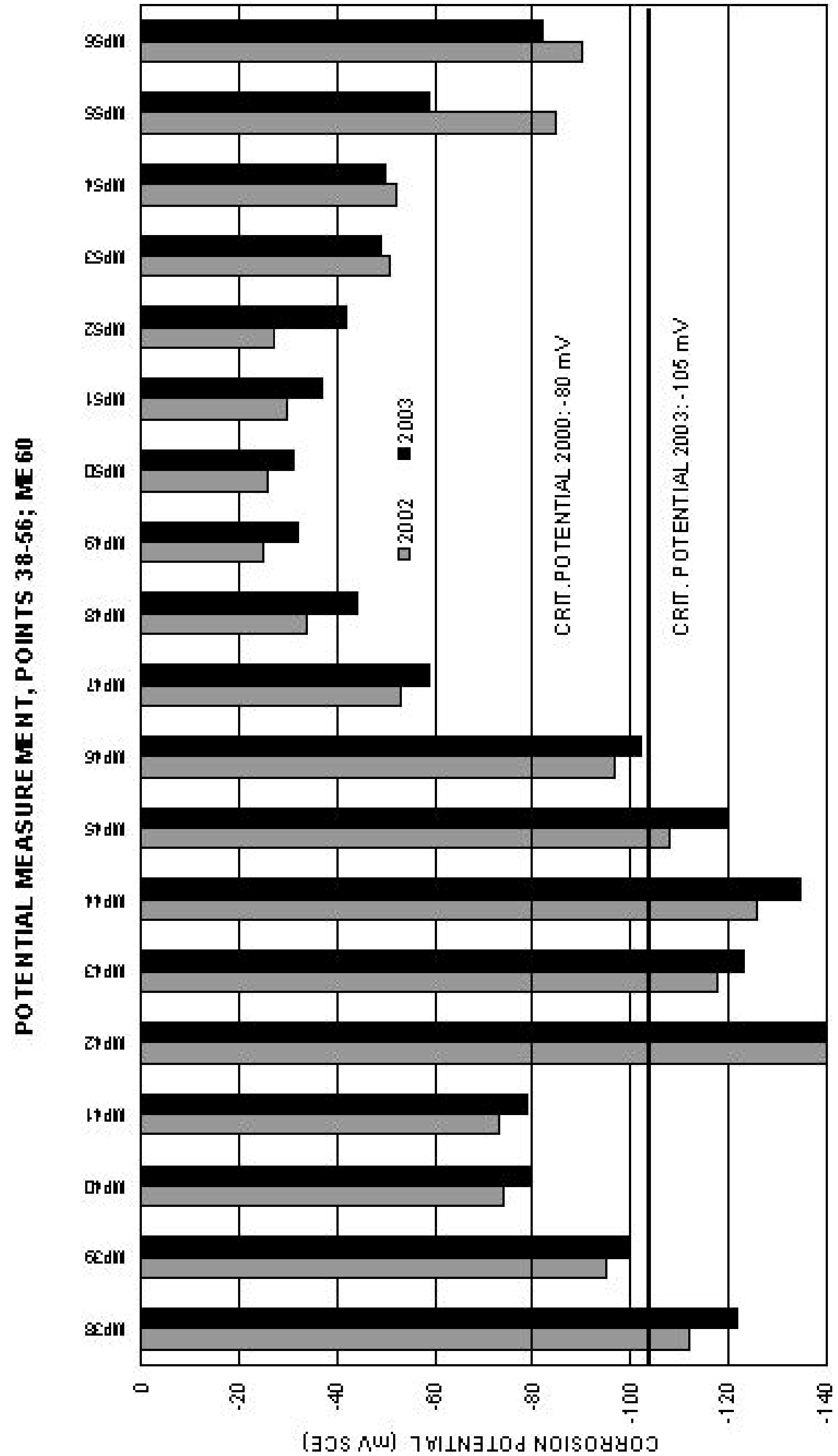

Fig. 5: Example of Potential Readings 2000 and 2003

Mean values for the chloride profiles 2000 and 2003 are given in fig.4. Unexpectedly, the concentration changes with time were found to be very small.

3 CONCLUSIONS

Neglection of protective measures, especially regarding the "barrier-layer" on top of reinforced concrete floors leads to serious corrosion damages, caused by the ingress of chloride from the cast magnesite screed. Corroding spots can be detected by means of potential measurements (potential mapping). Chloride ingress will be very slow after drying of excess-water in indoor conditions. Nevertheless, active corrosion is still progressing after 3 years, implicating a series of repair measures in the course of time.

REFERENCES

[1] Arbeitsgemeinschaft Industriebau e. V.: Arbeitsblatt A50, 1962

[2] DIN 18560, Teil 3, Estriche im Bauwesen – Verbundestriche, Ausgabe Mai 1992

[3] Elsener, B., Böhni, H.: Früherkennung von Bewehrungskorrosion: Potentialfeldmessung und galvanostatische Impulsstechnik. Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V., Symposium Zerstörungsfreie Prüfung im Bauwesen, 27.2. – 1.3.1991 in Berlin

[4] Hetek, Chloride Penetration into Concrete: State of the Art*,* Report No. 53, The Road Directorate, Copenhagen, 1996.