Primers role in plastering systems on concrete surfaces

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Abstract. A drastic reduction in time frames between the manufacturing process of concrete units and the rendering phase (including prior priming) does not allow the concrete to dry well. This fact is also underlined by changes in concrete technology (denser concrete and denser concrete surfaces). The tests showed that the reduction of drying time (storage time) had a significant influence on the bonding properties of gypsum plaster on concrete surfaces. In such cases it is absolutely necessary to use an appropriate primer no matter what the processing temperature (2 °C to 20 °C) might be. In this publication the varying primer quality is shown.

1. Introduction

Indoor plasters have the primary task of covering substrates (walls and ceilings) for thermal, hygienic and aesthetic purposes. Gypsum plasters are remarkable for a variety of distinct advantages. Their most significant advantage is that they are able to create a pleasant room atmosphere. Their physical properties allow for the regulation of room climate, and their low thermal conductivity leads to a sense of cosiness. They are quick and easy to process; they dry easily. Apart from these factors, gypsum plasters also contribute to the improvement of fire protection qualities. Gypsum plasters can be applied on almost all kinds of substrates (background surfaces):

- Concrete
- Walls made of brick, lime-sandstone or aerated concrete
- Light excelsior boards (wood wool)
- Hard foam boards

Since the 1960s, their application has generally been based on dry mortars, and is carried out with the help of machines.

The adhesive mechanism of plasters on surfaces can be described as follows (cf. KHODA [23] and OHNEMÜLLER [11]):

- Adhesion of fresh plaster based on the negative pressure effect during roughcasting of plaster, air is dispelled and a zone of low pressure that enhances adhesion is created;
- Adhesion of fresh and hardened plaster based on interlocking surface coarseness of the substrate leads to interlocking with the plaster the crystals emerging from the hydration process in the interface layer also continue to partly develop in the pores of the substrate, thus resulting in additional mechanical interlocking;
- Adhesion of hardened plaster based on chemical bonding crystal in-growth between plaster and substrate requires similar or chemically related plastering surfaces; this, however, is a seldom occurrence.
Despite diverse and long-standing know-how [1-23], fractures between gypsum plasters and concrete surfaces sometimes occurred. Possible reasons cited were as follows: ([03, 04, 05, 07, 08, 09, 10, 12, 13, 16, 20, 21, 23]): Influences from within the plaster; concentration of anhydrite in interface layer; changes of structural gypsum crystal (i.e. change in crystal habits); plaster thickness; pH value; type of additives; longitudinal changes through total moisturisation; problematic plastering surface; too high moisture levels (unsatisfactory drying of plaster); too low capillarity; too low coarseness; concentration of particular chemical combinations on the surface (for concrete) e.g. portlandite, vaterite, alkalis; surface alkalinity (for concrete); deformations; cement quality (for concrete): cement composition, hydration level; separating agent for furring (for concrete); loose impurities (dust); influences of surrounding conditions; thermal load; air expansion in pores; failure to bond due to moisture influences.

A study of pertinent scientific literature shows that highly differentiated individual factors influence gypsum bonding on concrete surfaces. Contradictory data cannot be explained otherwise. The scope of this study has been to examine some of the factors described in the cited literature and to clarify their influences on bonding characteristics in present conditions. The following points were examined within the framework of this study:

- Given similar conditions, do different primers significantly influence adhesion characteristics of gypsum plasters on smooth concrete surfaces;
- To what extent the adhesion is dependent on the application temperature of the primer;
- The storage period of the concrete specimens, and thus the moisture conditions of the substrate, were varied for this purpose. Apart from that, the influence of additional moisturisation (on the back) of the concrete specimens and surface coarseness were also determined.

2. Preparation of specimens

Factory-made concrete plates (from WITTMER + KLEE, Waghäusel) with dimensions of 1000 mm x 700 mm were used for the study of the influence of various primers. These specimens were freed of surface residues and stored horizontally with the smooth surface facing upwards. Plaster application was carried out immediately on 6 plates (5 days after manufacturing), and 35 days later on the rest of the 6 plates (intended partial carbonation, superficial drying).

The client put eleven easily available primers (synthetic emulsions based on styrene acrylate and vinyl acetate polymer) at our disposal. These were prepared according to the instructions provided (partly diluted with water, and homogenised through stirring). They were then applied to the smooth side of the concrete plates (area of application 500 mm x 500 mm, respectively) with rollers. A comparative surface (reference test) was left untreated.

One day after the primers had been applied gypsum mortar made from specially supplied manual plaster of low quality with a water/plaster ratio of approximately 0.52 was mixed (2 measures of ready-made gypsum plaster, 1 measure of stucco, in order to determine the influence of the primers exactly). This mortar was applied manually at a thickness of approximately 8 mm on the horizontal specimens. Processing time was around 20 minutes.

3. Test methods

Tests for adhesive strength were carried out in accordance with the German Industrial Norm 18555 (DIN 18555), “Test of mortars with mineral bonding agents; hard mortar; determination of adhesive strength”.

4. Results and discussion

Generally speaking, almost all the primers fulfilled expectations that were attributed to them in the gypsum plaster/concrete system. It can be assumed that a gypsum plaster possesses sufficient bonding characteristics with the concrete when adhesive strength is measured at 0.2 N/mm². However, a limiting value for guidelines and norms does not exist. It also became clear that a primer must definitely be used in the conditions chosen by us.
In a majority of the specimens, fracturing occurred in the interface between gypsum plaster and primer (adhesion fracture). In the case of some primers with high adhesive strength (primers 2 and 7), the fracture occurred partly in the interface between primer and mortar, and partly in the mortar itself (adhesion-cohesion fracture).

Plaster adhesion of non-stored concrete units was very high with some primers (2, 7 and 11). A lack of adhesion during the application of gypsum plaster without primer, as also was the case with primer 9, could be determined. Primers 1 and 8 showed low adhesive values.

It can be assumed that five-week storage leads to superficial drying and partial carbonation of the surface. Due to these reasons, adhesion characteristics of the plasters changed. All specimens that originally showed low or average adhesive qualities increased their adhesive strength significantly. Only the reference test (specimen without primer) showed absolutely no adhesive characteristics even in this case.

The test results could prove the differences in quality of the 10 primers used. We therefore recommend that users get appropriate information from manufacturers as a form of reassurance. Sufficient adhesive strength (0.2 N/mm²) should be achieved by primers in the concrete/primer/gypsum plaster interface. In order to determine the efficiency of a primer it is not only necessary to determine adhesive strength - fracture patterns are equally important.

**Table 1.** Adhesive strength of gypsum plasters on concrete depending on type of primer.

| Primer no. | Application of primer without storage | Application of primer after 35-day storage |
|-----------|---------------------------------------|------------------------------------------|
| 0         | ≈ 0                                   | ≈ 0                                      |
| 1         | 0,19                                  | 0,10                                     |
| 2         | 1,37                                  | 1,06                                     |
| 3         | 0,58                                  | 0,77                                     |
| 4         | 0,54                                  | 0,70                                     |
| 5         | 0,36                                  | 0,80                                     |
| 6         | 0,41                                  | 0,77                                     |
| 7         | 1,35                                  | 1,10                                     |
| 8         | 0,19                                  | 0,66                                     |
| 9         | ≈ 0                                   | 0,16                                     |
| 10        | 0,34                                  | 0,30                                     |
| 11        | 1,23                                  | 1,19                                     |
5. Conclusions

On the one hand, dihydrate crystals of the plaster must grow into the substrate in order to achieve sufficient adhesive properties. This requires certain capillarity of the substrate, and a sufficient moisture gradient between plaster and concrete. On the other hand, detachment and changes in crystal habits caused by subsequent drying must be kept at a minimum so that the gypsum/concrete bonding is not weakened. For this reason the substrate must possess sufficient capillarity; it should not, however, be too moist.

Damages at a later stage cannot be ruled out when time frames between the manufacturing process of concrete walls and the rendering phase are extremely short.

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References

[1] Ludwig U, Kuhlmann J 1974 Tonindustrie-Zeitung 98 1
[2] Lucas G 1974 Tonindustrie-Zeitung 98 5
[3] Poch W 1974 Tonindustrie-Zeitung 98 7
[4] Haerter M 1974 Tonindustrie-Zeitung 98 13
[5] Lange J 1974 Tonindustrie-Zeitung 98 15
[6] Kollmann H, Strübel G and Trost F 1977 Zement-Kalk-Gips 30 224
[7] Hurbanic M, Schicht R and Scholze H 1977 Tonindustrie-Zeitung 98 232
[8] Engelke H 1979 Zement-Kalk-Gips 32 560
[9] Grunau E B 1980 Stuckgewerbe 17
[10] Ostrowski C. 1980 baustoffindustrie 8
[11] Scholze H, Hurbanic M and Engelke H 1981 Zement-Kalk-Gips 34 560
[12] Manns W, Wisotzky T and Zimbelmann R 1983 Schriftenreihe des Otto-Graf-Institutes 77 1
[13] Grün I 1983 Bau 367
[14] Moisset J 1984 Tonindustrie-Zeitung 108 289
[15] Aeppli E 1984 Tonindustrie-Zeitung 108 383
[16] Khoda F 1985 Tonindustrie-Zeitung 109 694
[17] Moldan D 1986 Ursachen für mangelhaftes Haften von Maschinenputzgips auf Beton (RWTH Aachen, Dissertation)
[18] Khoda F 1986 WTA Seminar ‘Schadensfreier Putz’ 59
[19] Koslowski T and Ludwig U 1986 WTA Seminar ‘Schadensfreier Putz’ 64
[20] Böttcher R 1988 Der Stuckateur 6
[21] Schütz P 1992 BMI, Universität Innsbruck 37
[22] Khoda F 1992 BMI, Universität Innsbruck 45
[23] Khoda F 1992 Stuck · Putz · Trockenbau 10