TEN YEARS OF FACADE PATHOLOGY INVESTIGATIONS

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Over the last ten years we have dealt with ceramic tile systems. How to prepare a suitable substrate, selection of cladding materials, how to install, standards, testing and inspection have been our daily questions. In this work we try to summarize our experience in the field of facade pathology diagnoses.

First, we should identify the major characteristics of facades built in our country in this period of time (Figure 1). The ceramic tile is directly adhered, the adhesive is dispersive powder polymer-modified cement mortar and the installation method is thin bed. The joints between pieces of cladding are filled with polymer-modified cement grout and movement joints filled with silicone or urethane sealant. The ceramic tiles size range is from 50 mm x 50 mm up to 400 mm x 600 mm, but the small sizes are more abundant. They are glazed and usually belong to BI and BIIa water absorption groups.

Figure 1.(a)

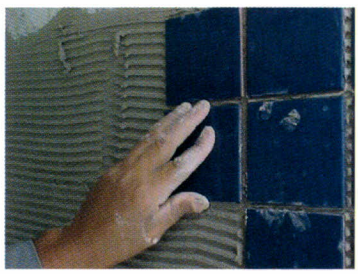

Figure 1.(b)

Figure 1.(c)

Figure 1.(d)

Figure 1. Facade characteristics. (a) and (b) directly adhered ceramic tile installed in thin bed with dispersive powder polymer-modified cement mortar. (c) Grouting with polymer-modified cement grout. (d) Movement joints filled with sealant. In all these photos the use of small glazed ceramic tiles pieces (100 mm x 100 mm) can be observed.

The main defects we have verified are bond failure, crazing of ceramic tile glaze, surface cracking of grout material, efflorescence, structural movement cracks and failure of movement joints (Figure 2). Among these defects, bond failure is considered the most important. The result of bond failure is typically pieces or sections of cladding, which fall off and pose a serious risk to public safety. Also, re-installation is very expensive and often the owners have to pay for this.

On the pathologies evaluations, to assess the causes of bond failure, first we make a visual inspection on the building to characterize the facade and the defects present. Then, we try to collect some complementary information from construction contractors and owners. After that, we evaluate possible building

structural movement and the locations where critical stresses will occur. In addition, we analyze the results of uniaxial tensile adhesion tests and we determine ceramic tile moisture expansion. Sometimes, samples of cladding cross-section are obtained for visual examination and other necessary tests.

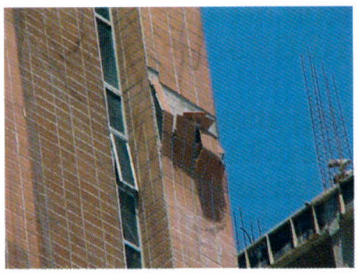

Figure 2.(a)

Figure 2.(b)

Figure2.(c)

Figure 2.(d)

Figure 2.(e)

Figure 2.(f)

Figure 2. Facade main defects. (a) Bond failure. (b) Crazing of ceramic tile glaze. (c) Surface cracking of grout material. (d) Efflorescence. (e) Structural movement cracks. Marked by arrows, we can see diagonal cracking originating at a corner of window and horizontal cracks coinciding with the intersection of the top of the back-up wall and structural element above. (f) Failure of movement joint.

In most cases in which we have participated, bond failure was a result of a combination and confluence of factors and rarely caused by a single mechanism. Among the common causes, some are related to the adhesive. Incorrect adhesive specification, improper application of adhesive due to poor workmanship and lack of adequate equipment for mixing, and unsuitable bedding of ceramic tile into the adhesive are the most important factors. Also we could observe stress concentration and failure caused by the increase in dimensions of ceramic tiles (high moisture expansion) and lack of movement joints for stress relief. Sometimes, we verify cohesive failure in back-up substrates and, more recently, the occurrence of adhesive failure at scratch coat mortar-concrete interface has been a problem.

Depending on the causes, we would typically suggest two corrective actions. The first consists of removal and re-installation of all the defective cladding system. The other situation is removal and re-installation of only some pieces in the areas where we verify the presence of echo (loss of bond) and construction of movement joints. In this last case, systematic maintenance and control of the system is required to provide safety and prevent catastrophic bond failure. Some of theses causes of facade failure are already controlled and the focus is now on the new construction technologies in order to develop a broad base of knowledge and to accumulate empirical experience.