

WHY DOES FACADE CERAMIC TILING FAIL?

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ABSTRACT

Although ceramic tile manufacture and adhesive technology have achieved significant developments throughout the years, ceramic tile facades still show a critical number of problems. It can be said, in some situations, that the number of pathologies has increased.

In this context, two main origins of problems arise: insufficient understanding of installation technology and a lack of systematic approach in order to develop designing processes of ceramic tiling that take into consideration performance and durability.

Although we can consider that a number of features regarding ceramic tiling facades are still not very well understood - such as the actual stress level of each layer of the adhered system and the amount of flexibility necessary for setting and grout materials - several guidelines can be used in practice to contribute to the successful final performance of tiling.

The most common and severe problem of facade ceramic tiling is bond loss. This failure can be related to three main different causes: inadequate specification of adhesive to each specific application, absence of control joints to dissipate stress and insufficient amount of adhesive to guarantee minimum coverage of tile reverse. While the first two factors are directly related to the design process, the third is associated with factors such as: tile-settling techniques, workmanship training, use of correct tools and efficiency of quality control during execution.

This work shows examples of ceramic tiling facade failures and discusses major efforts to avoid them. Particular attention is dedicated to showing how designing is important to achieve expected tiling performance. A comparison of problems and solutions also allows demonstrating that ceramic tiling building facade demands more accurate and controlled methods of installation to guarantee suitable durability.



Figure 1. View of building facade where the bond between adhesive and tile broke. Correction requires removing of tiles and preparation of surface when cement-sand rendering remains adequate.



Figure 2. Detail shows bond installation problem but tiling also presents inadequate joint thickness, no control joint and very rigid adhesive mortar and grout.

1. INTRODUCTION

Brazil, like many others countries in the world, has important characteristics that recommend the use of ceramic tiling systems. Ceramic tilings also have the best cost-benefit relationship among systems available in the market, most of all if we consider maintenance costs. Nevertheless, many problems have been occurring with ceramic tile, particularly in high rise building facade applications. These problems are mainly related with appropriate design, installation techniques, planning, control and material specification.

As strange as it may sound, facade problems are growing in number and consequences, clearly showing that technology development is urgent. Pathologies and building defects are the visible face of ceramic tiling application problems. Among these, rupture of substrate and bonding problems deserve special attention, mostly due to risks of accidents involved. Figures 1 to 6 show different features of the problems. These two problems can be considered critical because of the three following features:

- lost of integrity is generally of the entire tiling or substrate;
- correction is complex and expensive;
- risks of accidents is involved.

On the other hand, if the tiling keeps its expected performance during its life-time, many advantages arise when comparing tiling with other finishing systems. The most important advantages are: aesthetics, geometric facility of the composition, cleanability, improved damp resistance, general performance, economic value and durability.



Figure 3. Tiles removed from the facade show problem of fixing. Inadequacy of setting together with wrong specification of material caused failure.



Figure 4. Cement-sand render substrate shows rupture. Inadequate specification of mortar was considered main cause here. Creep of concrete framework and differential movements of masonry infilling contribute to the situation. There were horizontal joints but they were incorrectly positioned.



Figure 5. Here the entire system has been removed. This costs about 100 % more than initial costs but there was no other way to fix the problem.



Figure 6. View of facade where old ceramic tiling has been removed. Surface cleaning was necessary to allowing bonding new layers.

2. CAUSES OF TILING FAILURE.

A large number of causes can interfere in the mechanism of tiling failure. Among 17 cases studied by the author, there are three causes that arise as the most important and common. These causes are discussed briefly in the following points.

2.1. ABSENCE OF CONTROL JOINTS

Positioning and sizing of control joints are very important to the performance of facade ceramic tiling. If adequately designed, controls joints can dissipate stresses generated from the exterior environment (temperature and humidity changes) and from the interior of the building (creep, shrinkage and other differential movements of the background). The number, size and positioning of joints depend on other several variables. The most important of these are:

- size and colour of tile;
- modulus of elasticity of tile;
- flexibility of adhesives and grouts;
- sealant Movement Accommodation Factor - MAF - as described in BS 6213 (1982);
- expected long term deformation of concrete framework (creep and shrinkage);
- amount of differential movement between framework and;
- masonry infillings, height of building.

Buildings higher than 28 m usually require a horizontal joint at every floor level. Vertical joints are specially recommended for large panels without openings. These joints are normally spaced between 5 to 10 m.

2.2. INSUFFICIENT AMOUNT OF ADHESIVE TO GUARANTEE FULL COVERAGE OF TILE.

While the previous cause is related directly to the designing process, lack of adhesive coverage is more complex and associated with the following main factors:

- tile-setting techniques;
- training of workmanship;
- use adequate tools;
- efficiency quality control during application.

Quality control of application is essential to the performance and durability of ceramic tiling. It involves design constructibility evaluation and fulfilment of techniques and material use before, during and after the application process. Figures 7 and 8 show differences between correct and wrong tile setting techniques in adhesive coverage.

In facade applications, tile-setting techniques are very important. In these cases, double fixing technique is essential to achieve good results. Double fixing setting includes application of mortar on tile reverse and on substrate or background surface. When applying mortar on surface, the tile fixer should first use the flat edge then the notched edge of the trowel as shown in Figures 9 and 10.

Workmanship needs training according to the method specified in the design. Most projects involve particular techniques and therefore specific training is required. Training rarely exceeds a couple of hours when the contractor is really professional.



Figure 7. Left: full coverage where accurate setting was used. Right: the lack of adhesive material often causes failure. Technique, tools and quality control play an important role.

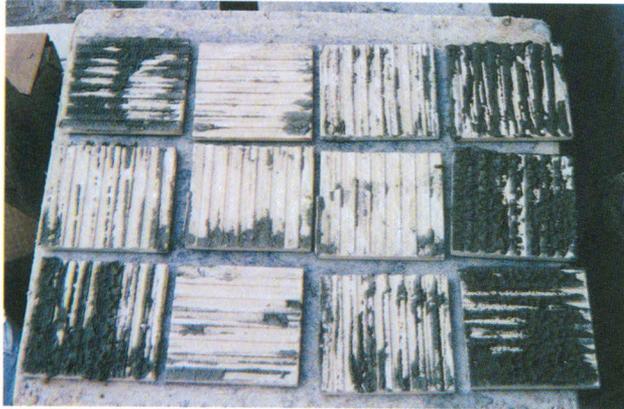


Figure 8. Different tile fixers achieve different results when training and control are put into practice. Here the coverage is not enough. A facade requires a 100% covered surface.



Figure 9. Adhesive mortar is spread first with the flat edge of the trowel to guarantee coverage of the background. In this case, a square shaped, 8mm height notched trowel was used.



Figure 10. The notched edge of the trowel is used to prepare the surface for adequate fixing. Horizontal stripes are preferable to avoid eventual water leakage.



Figure 11. Tiles are positioned by offsetting them from their final place so the adhesive can be fully spread. The technique is very simple but gives good results to improve coverage.



Figure 12. The tiles are pressed against the background, not only to improve coverage but also to prevent slipping. The material is isotropic and squeezes when pressed by percussion.



Figure 13. Joint cleaning is very important to let the grout fill the joints completely. Here a brush is used.



Figure 14. View of the cleaned ceramic tiling, ready for the application of joint grout.



Figure 15. A rubber trowel designed for jointing is used here for adequate filling.



Figure 16. Primary cleaning of grout that spills out of the joint and remains on the surface of tiles. A sponge is used.



Figure 17. Secondary cleaning of the tiling surface. Beyond this step only final cleaning is required.



Figure 18. Back-up tape is used to avoid sealant bonding to the back of the control joint. The technique is essential to sealant behaviour and durability.



Figure 19. Sealant is applied in the control joint. Jointing is necessary after the preset time of the material. Note that tape used to protect tile edges.

Tools are an important part of the application method and their correct utilisation depends also on training. The trowel is the most important tool in ceramic tiling but mixers and brushes play an important role too. Adhesives and grouts must be mechanically mixed and joint grouting requires previous accurate cleaning. The height and shape of the teeth are important parameters for the adequate selection of the trowel. Figure 11 to 19 shows some features of the application method.

2.3. INADEQUATE SPECIFICATION OF ADHESIVE AND GROUT

The most important properties of adhesives and grouts for ceramic tiling are bond resistance and flexibility. Open time is also an important property of adhesive mortar, however its importance varies a lot according to tile setting technique, training and quality control. Bond resistance can be evaluated through pull-out and shear tests, but pull out is simpler and reproducible. It can also be done at the work site and is prescribed by Brazilian standards. (ABNT, 1998).

Although the flexibility specification and evaluation are full of controversy, there is a clear and easy procedure prescribed by UEAtc (1990) to test it. Several different adhesive mortars were tested according to this method, showing very good results. Table 1 proposed initially by MEDEIROS (1999) suggests a possible classification of these materials according to the deformation of the specimen under the test procedure.

FLEXIBILITY CLASS	MINIMUM SPECIMEN DEFORMATION BEFORE CRACKING (mm)
1	1,5 to 2,0
2	2,0 to 2,5
3	2,5 to 3,5
4	3,5 to 4,5
5	> 4,5

Table 1. Proposed classification of adhesive mortar based on the flexibility test prescribed by UEAtc (1990).

Specimen preparation is shown in Figure 20. The apparatus shown in Figure 21 was developed specifically for this purpose. Classes 3 to 5 are adequate for exterior use. The classification can also be used for the selection of grouts.

Figure 20. Flexibility test specimen is under preparation. Moulding the specimen in-groups avoids deviation of results. The specimen is simple to prepare and showed good results as described by MEDEIROS et al. (1998).



Figure 21. The apparatus shown was designed and built to make the flexibility test easier and cheap. Goods results showed its applicability. The apparatus costs about US\$ 1,000.



3. CONCLUSION

The genesis of ceramic tiling problems lies in the designing process. It includes material and application technique specification, training and controlling criteria definition. Appropriate designing and application are fully worthwhile when the maintenance cost is take into consideration.

Several experiences conducted by the author over the last few years showed that the total cost of well designed, planned and controlled ceramic tiling increases from 10 to 25 % when compared to a risky situation. The correction costs of defects and pathologies can exceed 100 % of the initial costs. Construction companies should consider their institutional image, market credibility, risks of accidents and the insurance costs involved.

All the information necessary for an adequate application of facade ceramic tiling can be set in order by design. If correctly and systemically understood it plays a very special role, serving as an essential tool for application. (MEDEIROS , 1999)

The author suggests below a list of research themes that can be considered important for the technology development of ceramic tiling in order to avoid the present problems. Those are:

- Influence of polymer and cement type and content in the flexibility of adhesive mortars;
- Performance of joint grouts: lab and field tests;
- Influence of workmanship in the performance of ceramic tiling;
- Quality control methods for facade application;
- Use of crack suppression membranes in facade ceramic tiling;
- Prediction of movements in facade ceramic tiling;
- Method of analysis of stress of ceramic tiling layers;
- Definition of criteria for the design of ceramic tiling control joints;
- Maintenance of ceramic tiling: techniques and methods.

4. REFERENCES

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