

# Ceramic tiling inspection system

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## Abstract

This paper presents a proposal of an expert system for inspection and diagnosis of defects in adhesive ceramic wall or floor tiling (ACT), specifically developed for recent buildings. The system proposed includes a classification of the ACT defects and their most probable causes in different groups, as well as the relationship between defects and all the causes and inter-defects, presented in correlation matrices. The system was validated via field work that included standardized inspections of 155 ACT cases. Its main purpose is to help the inspector to be more objective in his *in situ* activities and, at the same time, to standardize procedures.

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## 1. Introduction

Ceramic tiling is one of the noblest and most versatile systems of cladding in buildings in Mediterranean and Latin countries, due to the singular importance that was attached to it throughout the centuries. The development that adherent ceramic tiling systems (ACT) have undergone lately, due to technological innovation of the industry that produces ceramic tiling and laying materials, as well as the growing variety of background types where this cladding is applied, have not been adequately followed by the direct actors of the construction process. In addition, ACT is the cladding solution most sensitive to the quality of materials used, application methods, workmanship and precision of the building frame, when compared with cementitious and synthetic finish stuccos and stone [1]. As a result, an ever-growing frequency of pathological phenomenon at early ages of the cladding is observed.

Therefore, since investment in maintenance/repair of the built heritage has been increasing, it is urgent to create, calibrate and disseminate tools that may be useful to an ade-

quate maintenance strategy of ACT. To implement such strategy it is necessary to create an inspection system (to collect *in situ* data) and a classification of the defects detected during inspections, as well as of all the factors that contribute to their diagnosis and repair, in order to normalize the resulting reports and support correct diagnoses [2]. Such an inspection system is proposed in this paper, and has been tested and calibrated within a Masters thesis [3], via field data collected in a visual survey of 155 ACT. There are already many expert systems developed for the field of inspection and maintenance of buildings and they seem to become of increasing importance for decision taking in different fields [4,5]. The second author of the paper has supervised the development of inspection systems concerning stains in facades' rendering [6] and epoxy resin industrial floor coatings [7].

## 2. Pathology

The classifying system proposed (Fig. 1) includes all the defects (damage types in the terminology adopted in [4,5]) liable to be identified in ACT as well as their causes. To complete the system, the most adequate diagnosis methods to characterize the defects and causes described were selected as well as the repair techniques needed to repair

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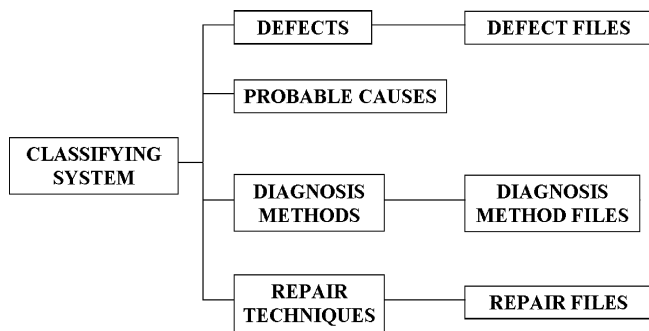


Fig. 1. Classification system to back inspections (adapted from [8]).

the former and eliminate the latter. A classification of the diagnosis methods and of the repair techniques has also been prepared, as well as defects files (containing a damage atlas as in [4,5]), diagnosis methods files and repair files. The descriptions of these parts of the expert system are not included in this paper but had been the object of another paper already submitted for publication [9]. Nevertheless, it must be pointed out that these files, together with the qualitative correlation matrices described below, are the tools necessary to complement visual inspection in order to diagnose situations where visual observation is insufficient and to propose therapy measures.

In Brazil, a methodology of diagnosis and rehabilitation of facades ACT has recently been presented. In this methodology, the need for an inspection system of this type of cladding to allow a systematic approach to pathological phenomena has been highlighted, in order to reflect the multiple and complex layers that constitute these systems [10]. This is the type of approach chosen to build the system proposed in this paper.

In this point, the classification of the defects in ACT is presented first, followed by the classification of the direct and indirect causes of these defects.

### 2.1. Classification of the defects

ACT defects are often classified in existing literature in direct relation with their causes. This makes these classifications inadequate for inspection purposes, leading to unwanted pre-diagnosis conclusions.

There are some authors [11] who make a distinction between ACT defects in walls and in floors, presenting a defect classification for each application. Nevertheless, they conclude that ACT defects and corresponding causes are similar in both applications. The distinction lies in the consequences of the defects in each application and in the rate of the ACT deterioration process after a defect occurs. Therefore, the ACT defects classification proposed in this paper is applied equally to ACT in walls and floors.

In another publication [12], an ACT defects classification is presented that has been organized according to the ACT layers where the defect occurs and in direct relation with the causes of the defects: defects in the tiles – expansion due to water absorption, glaze defects; defects in the

tiles bed – use of inadequate tile bed; inaccurate bedding, bedding made with poor workmanship; defects in the background – due to buildings movements, creep or shrinkage of concrete substrates, or due to thermal shock.

Another defects classification has been made according to the ACT layers [13]: defects in the ACT external layer – staining, change of colour or texture of the tiles surface, dimensional mishaps in tiles, cracking of tiles, chemical attack, staining, change of colour or efflorescence in joints; defects in the ACT system – damping of all the ACT layers, adhesion failure of the tiles, cracking, adhesion failure and detachment of tiles bedded on support expansion joints.

Based on these and other expert references, it is now possible to propose an ACT defects classification that concerns all types of defects that affect walls and floors, making use of experience in observing many pathological cases in this cladding. The criteria used to organize the defects in the classifying system proposed were division of the defects in groups unequivocally distinct and characterized; distinction of groups according to the consequences they have on durability and performance of the ACT and its elements; within each defects group, distinction of the defects according to their immediate consequences: affecting only an ACT element (e.g. tiles or tiles joints), affecting all elements of the ACT exterior layer (tiles, tiles joints and tiles bed) or affecting all elements of the ACT system.

The resulting defects classification includes four groups, three of which are divided into subgroups, thus resulting in seven main defects. These are presented in Table 1, together with the elements and the cladding system affected by each of them.

D – adhesion failure and/or detachment of ceramic tiling. The group is subdivided in: D.t\_b – the defect only reaches the outer layer of the cladding system (tiles, their joints and tile bed), in terms of consequences to be directly observed (Fig. 2); D.s – the defect reaches all elements of the ceramic cladding system.

C – cracking of the ACT elements stated in each case. The group is subdivided in: C.t\_b – the defect only reaches the outer layer of the cladding system (tiles and bedding layer), in terms of immediate consequences; C.s – the defect reaches all elements of the ceramic cladding system (Fig. 3).

Dt – deterioration limited to the elements of the ceramic cladding system indicated, directly influencing their perfor-

Table 1  
Elements of the cladding system affected by each defect [14]

Defect designation	Elements of the ACT system affected			
	Complete cladding system	Ceramic tile	Tile bed	Grout
D.t_b		x	x	
D.s	x			
C.t_b		x	x	
C.s	x			
Dt.t		x		
Dt.j				x
A.s	x			

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