Construction and Building Materials 25 (2011) 2146–2156

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Inspection and diagnosis system for gypsum plasters in partition walls and ceilings

A. Pereira, F. Palha, J. de Brito *, J.D. Silvestre

DECivil-IST, Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisbon, Portugal

ARTICLE INFO

Article history:
Received 18 August 2010
Received in revised form 29 October 2010
Accepted 13 November 2010
Available online 10 December 2010

Keywords:
Inspection system
Gypsum plaster
Defect
Pathology
Diagnosis
Repair

ABSTRACT

This paper presents an expert system to support the inspection and diagnosis of gypsum plasters applied to partition walls and ceilings (inner gypsum plasters – IGP). This system includes the classification of the defects that may affect IGP and their probable causes, which is complemented by the correlation matrices between defects, and between defects and probable causes. It is completed by a classification of the diagnosis methods and the repair techniques suitable for each IGP defect. Individual files containing a complete characterization of defects, diagnosis methods and repair techniques are also exemplified. This inspection system was validated through standard inspections of 119 IGP applied in walls or ceilings in 23 buildings.

1. Introduction

Nowadays, gypsum-based plasters are the most common interior coating of walls and ceilings of buildings in Portugal. Named *gypsum plasters* in the European standard EN 13279-1 (dedicated to gypsum binders and plasters), they are produced in a factory and sold ready-mixed, only requiring the addition of water. Gypsum plasters made with synthetic binders (usually called "synthetic gypsum plasters") are also used for the interior coating of walls and ceilings, but they have a smaller market share. Nevertheless, this solution has been gaining momentum and diversity thanks to the development of the chemical industry. This paper is focused only on gypsum plasters, despite the fact that some of the conclusions presented could be extrapolated to synthetic gypsum plasters.

Gypsum plasters made on-site (also called "traditional gypsum plasters") are outside the scope of this paper. The technology and pathology characterization of traditional gypsum plasters and the definition of their most important repair techniques, mainly when applied in ancient buildings, have already been published by the same research team in refereed journals [1–4]. But no works specifically related to inspection systems for gypsum plasters applied to partition walls and ceilings (inner gypsum plasters – IGP) have been found in refereed journals or conference proceedings. The methodology used in this paper has also been tried and tested by the same research team for other construction elements [5–9]. These previous works, along with specialized literature related to IGP technology and the thorough study of some pathological processes of wall coatings ([10–15], for example) delineate the principles of the development of the inspection system of IGP proposed in this paper. Each module of the inspection system, such as the defects or diagnosis classification method, was subsequently developed based on the corresponding specialized references.

The quality of partition wall and ceiling coatings has a significant influence on the indoor habitability conditions. It is essential that coatings fulfil all aesthetic, durability, health, thermal and hygrothermal comfort demands. But the quality of the coatings has been declining thanks to the faster pace of construction, unskilled labour, and increasing diversity of coating solutions and materials. Defects in coatings should therefore be prevented and the most common ones must be well known for their causes to be correctly diagnosed and the most suitable repair solutions prescribed. This research work sets off from these principles, on the assumption that only a full understanding of the characteristics of the materials and construction technology related to IGP, and the rigorous observation, recording and analysis of the defects will allow them and their causes to be eliminated and similar pathological phenomena prevented. The inspection system of IGP proposed in this paper is simultaneously innovative and scientifically validated in other studies [16,17]. The inspection procedure was calibrated through an inspection programme that included the pathological characterization of 119 IGP applied in 74 walls and 44 ceilings in 87 rooms in 23 buildings (22 residential and one office building), 83% of which are in the Lisbon area, in Portugal. This inspection programme was designed to simultaneously validate

* Corresponding author. Tel.: +351 218419709; fax: +351 21 8497650.
E-mail addresses: ap.cascais@clix.pt (A. Pereira), fpalha@gmail.com (F. Palha), jb@civil.ist.utl.pt (J. de Brito), jds@civil.ist.utl.pt (J.D. Silvestre).

0950-0618/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.conbuildmat.2010.11.015

the classification systems and correlation matrices [5]. The standard inspections consisted solely of a visual observation of the IGP (no in-situ or laboratory tests were performed) and were documented in standard inspection and validation files. Three hundred and thirty-one defects (only one defect of each type was recorded for each IGP) were identified in the sample, which gave an average of 2.78 defect types per IGP. The average number of probable causes associated with each defect was 9.5. Nevertheless, the statistical analysis of the results of this inspection programme is beyond the scope of this paper.

2. Pathology

This section includes the identification and characterization of the most common defects in IGP and of their causes. The relationship between defects and causes and the index that measures the coincident occurrence of different defects are presented in correlation matrices. Finally, the defect file concept is shown together with the information that must be included in it. This module of the inspection system was built based on a number of scientific Refs. [4,12,14,15,18–26].

2.1. Defect classification system

It is not common to find defects in IGP. The ones found most frequently, however, can be ranked in three groups to distinguish the pathological problems caused variously by physical, chemical or mechanical actions.

Generally, the most recurrent defects of a physical nature are dirt and damp. The latter justifies special attention since it is one of the most aggressive problems that can affect modern buildings and, consequently, the IGP. The destructive power of damp is related to the open porosity and hydroscopic nature of IGP which ease the percolation of water through its micro-structure. This leads to the development of a variety of aggressive actions: physical, due to the modification of the inter-crystalline structure of the gypsum; chemical, caused by the presence of soluble salts in the substrate and the IGP; and biological, via the development of mould and fungus (Fig. 1). The consequence of all these actions is the decline of the habitability and durability conditions of the indoor area and, in a limited number of cases, the irreversible degradation of the coatings, which necessitates their replacement in the short-term.

The second group of defects comprises those that are caused by chemical phenomena: actions that result in the development of mould or bacteria on the coating, known as bio-deterioration; the volumetric expansion of the salts within the coating or the substrate, which results in efflorescence or crypto-florescence phenomena; the adhesion failure of the coating that results in the detachment, warping or loosening of part of the coating (Fig. 2).

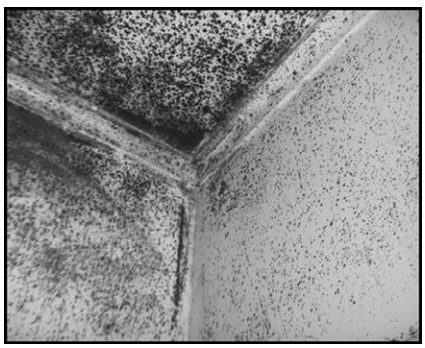

Fig. 1. IGP on wall and ceiling with fungus and mould [17].

The last group contains pathological phenomena of a mechanical nature, such as: dimensional changes to the substrate that can cause cracking; impacts and other mechanical actions on the IGP surface (Fig. 3); loss of cohesion or disintegration of the IGP.

Table 1 presents these three groups of defects. Each defect has an acronym: a D (for 'defect') plus a hyphen and the group reference – P for Physical, C for Chemical and M for Mechanical. A sequential number follows this second letter. The causes of the defects, the diagnosis methods and the repair techniques are classed using a similar labeling.

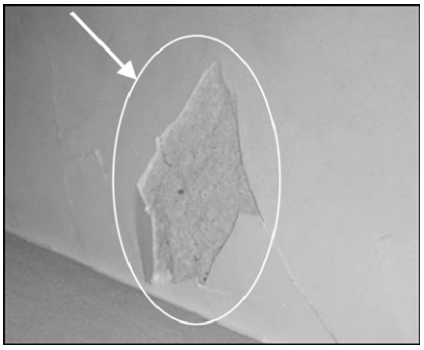

Fig. 2. Detachment of an area of IGP [17].

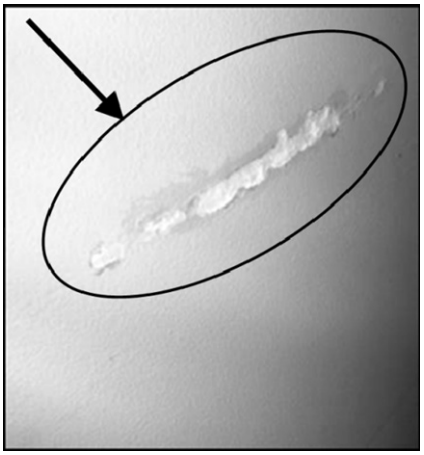

Fig. 3. Result of impact on the IGP in normal use by the users [17].

Table 1
Classification of defects in IGP [17].

Code	Defect
D-P	PHYSICAL NATURE
D-P1	Excessive damp
D-P2	Dirtiness
D-C	CHEMICAL NATURE
D-C1	Bio-deterioration
D-C2	Efflorescence/crypto-florescence
D-C3.1	Adhesion failure – detachment
D-C3.2	Adhesion failure – warping
D-C3.3	Adhesion failure – loosening of an area
D-M	MECHANICAL NATURE
D-M1.1	Cracking – superficial/*craquelé*
D-M1.2	Cracking – average
D-M1.3	Cracking – linear and deep
D-M2	Impact and other mechanical actions
D-M3	Loss of cohesion/disaggregation