

INVESTIGATION ON THE PRESENCE OF DETACHMENTS OF GLAZED CERAMIC TILE PANELS BY MEANS OF NON DESTRUCTIVE ACOUSTIC MAPPING

SYNOPSIS

This Report includes the theoretical background and the results of an assessment of the ACooustic Energy Absorption Device (ACEADD) as a means to reveal the presence of hidden decay in azulejo panels, namely detachments from the supporting wall and glaze delaminations. The project results from a cooperation between the Institute of Acoustics and Sensor - O. M. Corbino of the Italian National Research Council (CNR_IDASC), which developed the device and successfully tested it on partially detached frescos, and Laboratório Nacional de Engenharia Civil which is engaged in a planned effort to develop means of diagnose and intervention for the conservation of azulejo tiles and panels.

RESUMO

O relatório inclui os princípios teóricos e os resultados da avaliação do ACooustic Energy Absorption Device (ACEADD) como instrumento para revelar destacamentos ocultos e delaminações do vidrado em painéis de azulejos. O estudo resultou de uma colaboração entre o Institute of Acoustics and Sensor - O. M. Corbino do National Research Council (CNR_IDASC) italiano, que desenvolveu o equipamento e o experimentou com sucesso em frescos parcialmente destacados, e o Laboratório Nacional de Engenharia Civil que tem em curso projectos de investigação tendentes ao diagnóstico e intervenção em painéis azulejares, com vista à sua conservação.

**INVESTIGATION ON THE PRESENCE OF DETACHMENTS IN AZULEJOS
BY MEANS OF NON-DESTRUCTIVE ACOUSTIC MAPPING**

PAGE INDEX

	Page
1- INTRODUCTION.....	1
2- EXECUTIVE SUMMARY.....	4
3- THE COLLABORATION BETWEEN LNEC AND CNR_IDASC.....	6
4- THE IMPORTANCE OF THE PORTUGUESE AZULEJO HERITAGE.....	8
4.1- A historic overview	8
4.2- Some relevant forms of decay	9
5- ACCOUSTIC PROPERTIES OF GLAZED CERAMIC TILES	11
5.1- Multilayer structure	11
5.2- Detachments and delaminations	12
5.3- Theoretical model of a vibrating surface	13
5.4- Boundary conditions	14
5.5- The effect of cavities	15
5.6- Forced vibration	16
5.7- Damping mechanisms	19
5.8- Acoustic energy absorption coefficient	20
5.9- Real cases	21
6- THE ACOUSTIC DIAGNOSTIC METHOD AND DEVICE: ACEADD.....	22
7- THE LOCATION.....	26
8- THE MEASURING PROCEDURE.....	28
9- DATA ANALYSIS.....	31
9.1- Repeatability of measurements	31
9.2- The experimental results	34
9.3- Detachments	35
9.4- Delaminations	47
10- CONCLUSIONS.....	55
Acknowledgements	57
Bibliographical references	58
 ANNEXES	
ANNEX 1 – GLOSSARY.....	62
ANNEX 2 – RESSONANCE FREQUENCY EVALUATION.....	69
ANNEX 3 – REPEATABILITY TEST.....	73

INVESTIGATION ON THE PRESENCE OF DETACHMENTS IN AZULEJOS BY MEANS OF NON-DESTRUCTIVE ACOUSTIC MAPPING

FIGURE INDEX

Figure

1-	Integration of glazed tile ornamental coverings into architectural structures	9
2-	Delamination between clay bisque and glaze a) numerical model; b) actual tile	10
3-	Generalized decay of an interior panel (Igreja de Jesus – Setúbal)	10
4-	Examples of detachment in a multilayer structure	12
5-	Curves for different values of the damping ratio in a mass-spring-damper system	17
6-	Characteristic sound absorption curves showing the low-frequency resonance ...	21
7-	Scheme of the ACEADD device and reflection of a spherical acoustic wave ...	22
8-	Incident and reflected waves and Cepstrum traces ...	23
9-	The ACEADD system: the scan units and the transceiver unit	25
10-	The Madre de Deus Convent	26
11-	Locations at the Madre de Deus Convent where in situ measurements were made	27
12-	The panels selected for acoustic mapping	27
13-	Front panel of the software package configured for the ACEADD system	30
14/17-	Correlation functions, impulse response and absorption coefficient at a test point	33/34
18-	Fracture profiles in single tiles at 1st location and point arrangement for acquisition	35
19-	Dispersion of indicator values	36
20/21-	Acoustic maps of the two test zones NMA1 and NMA2 at the first azulejo panel	42
22-	Map of detachment as detected by the martelletto (knocking) technique	43
23-	Combined acoustic image of the first panel where three thresholds were applied	43
24-	Frequency analysis applied to the most relevant points of NMA1 and NMA2	44
25-	Acoustic maps at test zone NMA3 of the second azulejo panel	45
26-	Frequency analysis applied to row 15 of NMA3 in the lower part of the map	46
27-	Glaze delaminations in azulejo panels located in the upper cloister at NMAz	47
28-	Dispersion of indicator values in NMA4, NMA5, NMA6	48
29/30-	Results at NMA4	50/51
31/32-	Results at NMA5	52/53
33-	Results at NMA6	54