Case Studies in Construction Materials 1 (2014) 77–82

Contents lists available at ScienceDirect

Case Studies in Construction Materials

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

Case Study

Diagnosis of the surface layer damage in a 1960s reinforced concrete building

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ARTICLE INFO

Article history:
Received 22 November 2013
Received in revised form 17 April 2014
Accepted 20 April 2014
Available online 9 May 2014

Keywords:
Carbonation
Concrete
Corrosion
Bricks
Efflorescences
Black crusts

ABSTRACT

This work aimed to determine the degradation causes of the Palace of Public Works located in S. Giovanni square in Turin (Piedmont, Italy). The samples collected from the surface layer were characterized by means of scanning electron microscopy (SEM), X-ray diffraction (XRD), thermogravimetric coupled with differential thermal analysis (TG-DTA), mercury intrusion porosimetry measurements (MIP) and phenolphthalein test. Metallographic and elemental analyses were also carried out on the steel reinforcing bars. An exhaustive picture of the main causes of deterioration was drawn in order to design the intervention of rehabilitation.

1. Introduction

The project of the architects Garbaccio, Passanti and Perona won in 1956 the second prize of the "Competition for the preliminary design work on the offices of Public Works of the Turin City located in Piazza S. Giovanni" (the first prize was not awarded) and was built in 1961. The "New Palace of Public Works in Turin" filled a void due to the demolition of the 17th century building of the Italian architect Amedeo di Castellamonte bombed during 2nd World War. The six floors building (23 m in height) consisted of a reinforced concrete structure with brick infill (Fig. 1(a–c)).

Direct exposure to weathering and air pollutants involved soon damage to concrete pilasters and facing bricks. During 42 years, numerous patches and repairs were carried out, without never facing the problem in depth. In 2004, the state of degradation of the Palace of Public Works was widespread throughout the building: it was considerable in the eastern and western façades and very marked in the northern elevation (Fig. 1, suppl. mat.), but was minor in the southern façade. Sometimes, concrete covers were easily removed manually (Fig. 1d and e) (sample 11 – Table 1). Steel reinforcing bars showed a variable state of corrosion, sometimes very pronounced, with a certain loss of structural integrity, while in other areas they were not corroded at all. Regarding facing bricks and brick laying mortar, the most diffuse degradations were lacunas, pulverization, delamination, cracking, presence of efflorescences, patina and black crusts, dissolution and leaching of mortar between brick courses and the presence of salts inside the masonry (Fig. 2, suppl. mat.).

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http://dx.doi.org/10.1016/j.cscm.2014.04.006

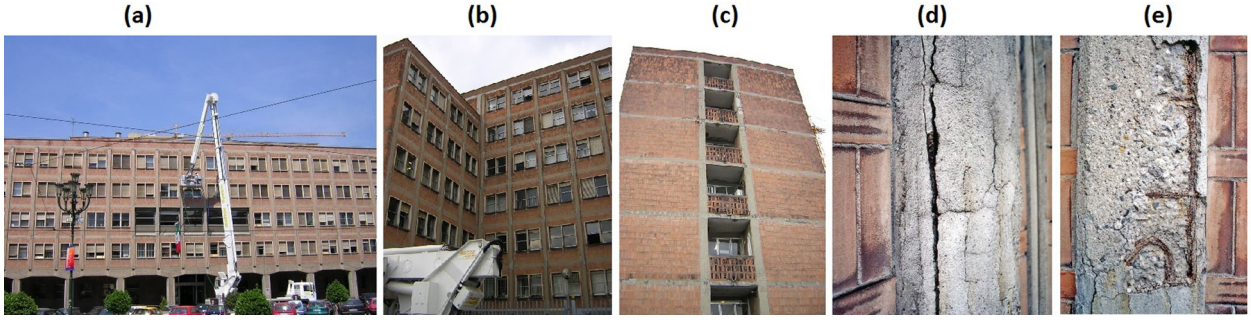

Fig. 1. Palace of Public Works in S. Giovanni square (Turin-Italy): eastern (a) and northern façades (b–e).

2. Materials and methods

More than 30 samples were investigated to determine the nature of concrete, mortars, bricks and steel reinforcing bars and of degradation products in view of a rehabilitation intervention (Table 1). Freshly cut cores of reinforced concrete were extracted by drilling for carbonation depth measurement. Samples of bricks and mortars were collected with a scalpel. Incoherent efflorescences were sampled by means of a brush from brick surface. Black crusts were removed with a bistouri.

Table 1
Visual analysis, sampling points, analysis planning.

Samples no.	Visual analysis Material/degradation	Diagnostic aim	Analysis planning					
			XRD	TG-DTA	MIP	CD	SEM	MM
Northern façade								
1	Mortar/intact	Reference	☑		☑			
2	Brick/pulverized	Degradation products	☑					
3	Brick/Efflorescence	Salts identification	☑	☑				
4	Steel RB (sample 8)/intact	RB corrosion						☑
5	Steel bracket (samples 8)/corroded	Corrosion						☑
Northern-East façade								
6	Original RC (plastered)/spalling	Carbonation	☑		☑	☑		
Northern façade								
7	Original RC pillar/intact	Carbonation	☑	☑	☑	☑		
8	Steel RB (sample 9)/oxidized	RB Corrosion						☑
9	Original RC beam/spalling	Carbonation	☑		☑	☑		
10	Mortar/degraded	Degradation products	☑		☑			
11	RC cover/spalling	Degradation products	☑		☑			
12	Mortar/pulverized	Degradation products	☑					
Western façade								
13	Original RC/spalling	Carbonation	☑		☑	☑		
14	Original concrete (plastered)/degraded	Carbonation	☑		☑	☑		
15	Original RC/spalling	Carbonation/RB corrosion	☑		☑	☑		☑
16	Brick/black crust	Degradation products	☑		☑		☑	
17	Efflorescence on brick	Salts identification	☑	☑				
18	Mortar/degraded	Degradation products	☑		☑			
Eastern façade								
19	Brick/intact	Reference	☑		☑			
20	Original concrete (plastered)/intact	Reference	☑		☑	☑		
21	Original concrete beam/intact	Carbonation	☑		☑	☑		
22	Concrete repair mortar (core 19)	Nature/degradation	☑					
23	Original concrete beam	Carbonation	☑		☑	☑		
24	RC/carbonated	Carbonation/RB corrosion	☑		☑	☑		
25	RC/carbonated	Carbonation/RB corrosion				☑		
26	RC/carbonated	Carbonation/RB corrosion				☑		
27	RC/carbonated	RB corrosion						
28	RC/carbonated	Carbonation/RB corrosion				☑		
29	RC/carbonated	Carbonation/RB corrosion	☑		☑	☑		☑
30	RC/carbonated	Carbonation/RB corrosion			☑	☑		
31	RC/carbonated	Carbonation/RB corrosion	☑		☑			☑

RC, reinforced concrete; RB, steel reinforcing bar; CD, carbonation depth measurement; MM, metallographic microscopy observations.