Materials and Structures/Matériaux et Constructions, Vol. **34**, August-September 2001, pp 387-388

RILEM TC 167-COM: CHARACTERIZATION OF OLD MORTARS

Recommendations

The text hereafter is a draft for general consideration. Comments should be sent to the TC Chairman: Dr. Caspar Groot, Delft University of Technology, Faculty of Civil Engineering and Geosciences, Stevinweg 4, NL-2628 CN Delft, The Netherlands; email: C.Groot@citg.tudelft.nl by 31 March 2002.

COM-C1 Assessment of mix proportions in historical mortars using quantitative optical microscopy

C.1.0 CONTENTS

C.1.1 SCOPE

Determination of the mix proportions in mortars containing carbonate aggregate or a high content of lime lumps. Correction of wet chemical determinations of acid-soluble CaO contents for the presence of carbonate in the aggregate.

C.1.2 SAMPLE PREPARATION

The analysis is performed on thin sections. The area of the sample should if possible be at least 30*50 mm^2. The thickness is preferably between 20-40 microns.

C.1.3 APPARATUS

Optical microscope equipped for polarising microscopy and preferably fluorescent microscopy. Device for point counting or alternatively linear traverse measurement or area analysis using computerised image analysis.

C.1.4 DEFINITIONS

Paste: the hardened binder in the mortar, lime lumps: parts of the paste without aggregate and with a different density and chemistry.

C.1.5 SAMPLING

The samples should be intact mortar samples. Their size should follow the recommendations in paragraph C.1.2. There may be one or more pieces in a single thin section.

C.1.6 PROCEDURE FOR DETERMINATION OF MIX PROPORTIONS

In the analysis the points are evenly distributed over the sample. The number of points counted depends on the required precision. It can also be related to the sampling error, which depends on the sample size, aggregate

size distribution and homogeneity of the mortar. Preferably at least 600 points should be counted.

The amount of aggregate, lime paste, lime lumps and air are quantified separately. It is also possible to quantify other properties such as the amount of admixtures and the aggregate composition.

C.1.7 CALCULATION OF MIX PROPORTIONS

The aggregate/binder proportion (F) is calculated using Equation (1):

$$F = \frac{\alpha * volume\ \ aggregate}{volume\ \ paste} \quad (1)$$

The term a is calculated according to Equation (2):

$$\alpha = \frac{density\ \ aggregate * molecular\ \ mass\ \ CaCO_3}{1{,}1 * density\ \ paste * molecular\ \ mass\ \ Ca(OH)_2} \quad (2)$$

The term 1.1 is a correction assuming the presence of about 10% by weight of water in the binder. The lime lumps should be treated as part of the aggregate if the purpose of the analysis is to obtain a mix proportion with similar properties as the original. If the aim is to quantify the total amount of binder the lime lumps should be included in the binder.

C.1.7 EXPRESSION OF RESULTS

Results are obtained in weight proportions of dry slaked lime but may be recalculated as volume proportions using the values in Table 1. Note that the lime putty usually contains 30-50 % weight of water.

C.1.8 PROCEDURE FOR CORRECTION OF ACID SOLUBLE CaO IN MORTARS CONTAINING CALCITE

The content of carbonate particles in the aggregate is quantified separately during point counting. The contribution of $CaCO_3$ from paste and aggregate are calculated according to formulas 3 and 4.

$$CaCO_{3(paste)} = density\ \ paste * part\ \ by\ \ volume\ \ paste \quad (3)$$

$$CaCO_{3(aggregate)} = \frac{density\ \ carbonate\ \ aggregate * part\ \ by\ \ volume\ \ carbonate\ \ aggregate}{} \quad (4)$$

The $CaCO_3$ value obtained from the chemical analysis is corrected using Equation (5). For CaO the $CaCO_3$ chem and cor terms are replaced by CaO chem and cor:

$$CaCO_{3(cor)} = \frac{CaCO_{3(chem)} * CaCO_{3(paste)}}{CaCO_{3(aggregate)} + CaCO_{3(paste)}} \quad (5)$$

The $CaCO_3$ values can be recalculated as CaO using Equation (6):

$$gCaO = \frac{gCaCO_3 * molecular\ \ mass\ \ CaO}{molecular\ \ mass\ \ CaCO_3} \quad (6)$$

Table 1 – Densities and molecular mass used in the calculations

	kg/m^3	Compound mass	Molecular
Air lime	500-650	CaO	56
Sand, natural moist loosely packed	1350	H_2O	18
Sand, particle density	2700	CO_2	44
Putty lime	1450	$Ca(CO_3)$	100
Lime cement paste	1500	$Ca(OH)_2$	74
Lime paste	1300		
Lime cement mortar	2000		
Lime mortar	1800		

C.1.9 EXPRESSION OF RESULTS

The corrected amount of acid-soluble $CaCO_3$ (or CaO) can be used when calculating the hydraulic properties of the binder or the mix proportions.

C.1.10 TEST REPORT

The test report should include the following information, if relevant:

a) Name and address of the testing laboratory
b) Identification number of the test report
c) Name and address of the organisation or the person who ordered the test
d) The purpose of the test
e) Method of sampling and other circumstances (date and person responsible for the sampling)
f) Name and address of the supplier of the tested object
g) Name or other identification of the object
h) Description of the tested object
i) Date of supply of the tested object
j) Date of the test
k) Test method
l) Any deviation from the test method
m) Test results
n) Size of the measured area
o) Date and signature.

C.1.11 BIBLIOGRAPHY

NT BUILD 370: Mortar, hardened: Cement content and aggregate binder ratio. NORDTEST 1991.

Larbi, J. A. & Heinen, W. M. M. 1997: Determination of the cement content of five samples of hardened concrete by means of optical microscopy. Heron vol. 42, 125-137.