21st International Conference **ENGINEERING MECHANICS 2015**
Svratka, Czech Republic, May 11 –14, 2015
Paper **#096**, **pp. 242–243**

Mechanical Properties of Fiber Reinforced Lime-Based Mortar Evaluated from Four-Point Bending Test

Michal Přinosil[a] *, Petr Kabele[b]

Czech Technical University in Prague, Faculty of Civil Engineering,
Thákurova 7, 166 29, Praha 6, Czech Republic

[a]michal.prinosil@fsv.cvut.cz, [b]petr.kabele@fsv.cvut.cz

Keywords: lime-based mortar, fiber composite, tensile strength, strain hardening

Abstract: In this paper, tensile properties of a high-performance fiber reinforced lime-based mortar is experimentally investigated using four-point bending test. In the study, we consider several sets of the mortar with two types of the matrix (pure lime, lime-metakaolin) and two types of polyvinyl alcohol fibers in four volume fractions (0.5÷2.0%). As the reference, we consider two sets of specimens made of plain mortar without reinforcement. The main investigated parameters are cracking strength (initiation of the first crack), ultimate tensile strength and Young's modulus of elasticity. Moreover, we deal with the character of stress-displacement diagram, whether after initiation of cracking occurs softening or the response has hardening character and the specimen breaks in multiple cracking.

Introduction

Lime-based mortars were used in history for construction of buildings and monuments. At the present time, when maintenance and restoration are performed, it is desirable to use material with the same composition in order to ensure compatibility (in terms of mechanics, transport processes, aesthetic look, etc.) [1]. These materials could be characterized by low strength and low deformation capacity, which result in a poor durability of repairs.

In order to avoid these drawbacks, our team develops a new high-performance lime-based mortar reinforced with short synthetics fibers. Our intention is to systematically design the composition, so that under tensile loading the composite exhibits tensile hardening, multiple cracking and material retains its macroscopic integrity [2]. The main objective of this work is to clarify influence of matrix composition and fiber reinforcement on tensile characteristics evaluated using four-point bending test. This paper follows a previous study focused on fracture properties [3].

Materials

The composite consists of the matrix and the fiber reinforcement. The filler is represented by fine grained quartz sand with maximum particle size 0.3 mm (manufactured by Sklopísek Střeleč, a.s.) and the binder is represented by hydrated air lime powder CL90 (made by Čertovy schody a.s.) and metakaolin Mephisto L05 (made by ČLUZ s.r.o., Nové Strašecí). As the fiber reinforcement, we selected two types of polyvinyl alcohol fibers REC 15×12 and RSC 15×8 (made by Kuraray Company, Ltd.).

In our previous work, we optimized composition of pure matrix with regard to tensile strength and Young's modulus of elasticity [4]. Based on the results, we proposed grading curve, ratio of the filler and the binder (3:1 in mass), ratio of the lime and the metakaolin (3:1 in mass) and water ratio (0.3, calculated as ratio of weight of water and all dry ingredients). In this work, we consider two types of the matrix (pure lime - L, lime-metakaolin - LM), both types of fibers (REC, RSC) in four volume fractions (0.5%, 1.0%, 1.5%, 2.0%).

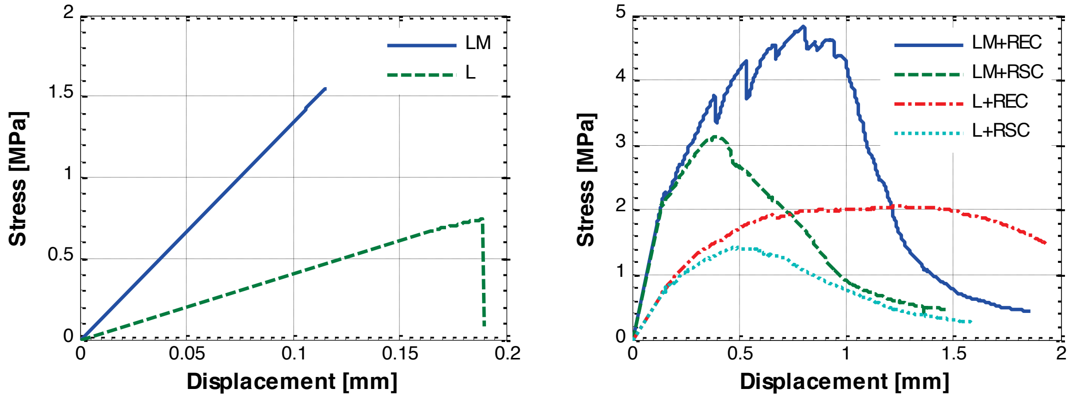

Fig. 1: Typical stress-displacement diagrams of specimens: without reinforcement (left), with fiber reinforcement in volume fraction 0.5% (right)

Methodology and testing set-up

From each proposed mixture, a set of 6 standard beams 40×40×160 mm was prepared and stored in laboratory conditions approximately for one year. Four-point bending test was performed using the MTS Alliance RT/30 machine with controlled crosshead displacement. The span of outer supports was 120 mm and the span of inner supports was 60 mm. During the test, all important data (applied force, crosshead displacement) were continuously recorded. Moreover, high resolution images of front side of each specimen were taken for digital image analysis of crack development. Bending stress was calculated from applied force and the geometry.

Results and conclusions

Figure 1 shows typical stress-displacement diagrams for specimens without reinforcement (left) and with reinforcement in volume fraction $V_f = 0.5\%$ (right). The results reveal that the mortar with lime-metakaolin matrix has higher values of tensile strength (cracking and ultimate) and Young's modulus of elasticity. Response of pure mortar is brittle, but even a small volume fraction of fibers improves it to softening character and for several configurations (the most obvious for lime-metakaolin matrix reinforced with REC 15×12) the response has hardening character and the mortar exhibits multiple cracking. The amount of cracks was determined using image analysis.

Acknowledgement: The presented research has been carried out with the financial support of the Czech Technical University in Prague, as part of the project no. SGS15/031/OHK1/1T/11.

References

[1] J. Lanas, J.I. Alvarez, Masony repair lime-based mortars: Factors affecting the mechanical behavior. Cement and Concrete Research. 33 (2003) 1867-1876.

[2] V.C. Li, C.K.Y. Leung, Steady-state and multiple cracking of short random fiber composites, ASCE Journal of Engineering Mechanics. 118 (1992) 2246-2264.

[3] M. Přinosil, P. Kabele, Fracture Properties of Fiber Reinforced Lime-Based Mortar, in: T. Plachý, et al. (Eds), Proceedings of the 5th Conference Nano & Macro Mechanics. CTU in Prague, Prague, 2014, pp. 143-152.

[4] M. Přinosil, P. Kabele, Influence of composition on tensile and fracture properties of lime-based mortar, in: T. Plachý, et al. (Eds), Proceedings of the Conference Nano & Macro Mechanics 2013. CTU in Prague, Prague, 2013, pp. 163-170.