Construction and Building Materials 164 (2018) 589–602

Contents lists available at ScienceDirect

Construction and Building Materials

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

Review

Application of chopped basalt fibers in reinforced mortar: A review

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HIGHLIGHTS

- Application of chopped basalt fibers for mortar design was reviewed extensively.
- Chopped basalt fibers were assessed for several properties.
- Mix design of fiber-reinforced mortar was analyzed from the studied literature.
- Physico-mechanical, durability and dynamic properties of mortars were reviewed.
- Application of suitable chopped basalt fiber proportion in mortar is examined.

ARTICLE INFO

Article history:
Received 15 June 2017
Received in revised form 6 November 2017
Accepted 29 December 2017

Keywords:
Chopped basalt fibers (CBF)
Reinforced mortar design
Physico-mechanical
Durability and dynamic properties

ABSTRACT

Appropriate mortar design is one of the key challenges as connections between two structural elements play a significant role in building construction. Appropriate design refers to the selection of suitable constituents with their relative proportion for producing mortar of required workability, strength and durability in a cost effective manner. The mortar designed with suitable fiber reinforcement shall significantly help to enhance the fresh, mechanical, durability and dynamic properties. In view of the significance of chopped basalt fibers (CBF) for mortar strengthening, the present study elaborates the application of CBF for mortar design. The CBF manufacturing, the engineering properties and relevant advantages of its application are elaborated in the study. The study is extended further with relevant literature indicating the challenges of mix design of appropriate CBF reinforced mortar, various test methods and standards used to evaluate its performance and possible applications in civil engineering. The improved performance of the CBF reinforced mortar not only signifies its potential use for the application, but also is helpful to standardize the process of reinforced mortar design.

Contents

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https://doi.org/10.1016/j.conbuildmat.2017.12.245
0950-0618/

1. Introduction

Conventional mortar in construction primarily contains binder and fine aggregate in a specific proportion along with water. Although, it is being used to bind two structural elements like brick to brick or any end connection of beam and column, due to high compressive strength, there is always a challenge for the application due to its brittle behavior, easy to crack because of the shrinkage of the materials, concentration of stress, low tensile strength and weakness in impact resistance, etc. [1]. As a result, the structures begin to suffer degradation after a specific time. To develop a sustainable engineering structure, a number of previous studies have shown that the optimum percentage and type of fiber can increase the workability, slump flow prevention, setting time, fluidity [2–4] and mechanical properties like impact resistance, splitting tensile and flexural strength [5,6] of mortar. The use of fibers in the mortar can also significantly enhance the bond strength between the old substrate and the repair materials, which is one of the most important requirements for a successful repair [1,7–10]. In addition, utilizing fibers in the mortar also substantially improves the fracture toughness and flexural post cracking behavior of the mixture. Likewise, the presence of fibers also lowers width and number of cracks in the mortar due to bridging action of them [11,12] and improves the durability properties of mortar, like abrasion resistance and freeze thaw resistance [13,14].

The present study briefs the possible application of various cement composites reinforced with chopped basalt fibers. The paper further elaborates the origin and development of chopped basalt fibers. The physico-mechanical property investigation of chopped basalt fibers is also discussed. To enhance the properties of chopped basalt fibers, several studies indicating the desired treatments are studied further. The influence of these chopped basalt fibers for various mix designs of several mortar mix is briefly discussed along with relevant tests related to fresh, mechanical, durability, functional and dynamic mortar properties including specific civil engineering applications. The findings of the literature study signify the potential use of chopped basalt fibers as better reinforcement to cement mortar. It also helps to standardize the design process of reinforced mortar.

2. Chopped basalt fibers

In order to improve the structural integrity, conventional mortar needs to be reinforced with fibers. Although, various fibers such as carbon, organic, glass, and synthetic may be applied for the strengthening of mortar, the present paper, reviews the application of chopped basalt fibers as they are extracted from volcanic basalt rock, and thus is natural and need lesser energy. Chopped basalt fibers are manufactured by thermo-chemical process with the volcanic basalt rock as the raw material (Tables 1 and 2). Basalt fibers are manufactured by melting the washed acidic basalt rock (silica >46% white) at around 1400 °C. The major examples of the constituent mineral of considered an igneous (basalt) rock includes plagioclase: Na ($AlSi_3O_8$)-Ca (Al_2SiO_8); pyroxene: $XY_2[(Si, Al)_2O_6]$ (where X represents Ca, Mg, Fe^{2+} and Y represents Fe^{3+}, Al, Ti); and olivine: $(Fe, Mg)_2\ SiO_4$ [15]. The rheological characteristics such as primarily surface tension, density, crystallizability, the viscosity and behavior of basalt melts determine the elemental chance of producing a continuous fiber from it [16]. The melted material is forced through a platinum-rhodium bushing. The fibers are then extruded under hydrostatic pressure and are formed in a certain range of temperature and viscosity. Corresponding to these phenomena, the melt's viscosity at the outlet of the bushing and its temperature is considered as the lower limit of the operating viscosity and the upper limit of the operating temperature range

Table 1
Element ratios of high temperature basalt rock ore [15].

	Si	Al	Fe	Ca	Na	K	Mg	Ti	Mn	P	B	Ba	Sr	Zr	Cr	S
Wt (%)	23.5–28.8	8.7–9.3	6.0–6.6	4.0–4.5	2.1–2.3	1.4–1.8	0.1–1.6	0.4–0.6	0.1–0.2	0.05–0.1	0.02–0.08	0.03–0.05	0.02–0.04	0.01–0.04	0.01–0.03	0.01–0.03