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Practical method for mix design of cement-based grout

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Abstract

Cement-based grout is made of mixed water and cement, which is sometimes also added with sand and admixtures. It is commonly used for soil improvement, for repairing the damages on concrete and masonry, or for the construction of preplaced-aggregate concrete. Currently there are hardly any available practical methods which can be used to carry out the grout mix design. The practical method to carry out cement-based grout mix designs suggested in this paper is based on some graphics and or empirical equations, which are derived from regression analyses of laboratory test results data to simplify the mix design process.

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Keywords: flowability, flow cone test, gradation, grout, mix design, gradation, water-cement ratio

1. Introduction

Cement-based grout is made of mixed water and cement, which is sometimes also added with sand and admixtures. It is commonly used for soil improvement, such as dam curtain walls using jet grouting methods [1-5], for masonry wall crack repairs [6], or for preplaced-aggregate concrete applications [7-12].

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In the application the grout is placed by using injection methods, with pressure or by its own weight only. Therefore it is necessary for the grout to have adequate flowability so that the injection process can be easily carried out; additionally, it is also necessary for the grout to have adequate mechanical properties such as compressive and tensile strengths. However, currently there are hardly any available practical mix design methods of cement-based grout. Commonly the grout mix design is carried out by trial-and-error in laboratories. Meanwhile, a variety of grout mix is needed to satisfy the required physical and mechanical properties. For instance, high flowable neat grout or paste grout that contains only a mix of water and cement is needed for injection into small cracks so that the grout can easily penetrate them. For wide cracks on the other hand, the mortar grout mix with coarser sand is preferable to minimize the cost and the shrinkage.

Therefore, it is important to develop a practical method of grout mix design that can be easily used and adapted on-site as will be discussed in this paper. The suggested practical mix design is based on empirical equations found from regression analyses of laboratory test results where the grout flowability was measured using standard flow cone methods, based on ASTM-C939 [13].

Nomenclature

f'_m	grout compressive strength
F_c	correction factor
G_c	specific gravity of cement
G_s	specific gravity of sand
G_w	specific gravity of water
s	volumetric portion of sand
V_c	the need of cement volume per cubic meter
V_{cc}	the corrected need of cement volume per cubic meter
V_s	the need of sand volume per cubic meter
V_{sc}	the corrected need of sand volume per cubic meter
V_w	the need of water volume per cubic meter
V_{wc}	the corrected need of water volume per cubic meter
w	volumetric portion of water
W_c	the need of cement weight per cubic meter
W_{cc}	the corrected need of cement weight per cubic meter
W_s	the need of sand weight per cubic meter
W_{sc}	the corrected need of sand weight per cubic meter
W_w	the need of water weight per cubic meter
W_{wc}	the corrected need of water weight per cubic meter
w/c	water-cement ratio in weight
w/c_{min}	minimum water-cement ratio in weight that still satisfy the flow cone test
γ_c	unit weight of cement
γ_s	unit weight of sand
γ_w	unit weight of water

2. Literatures review

2.1. Studies of grout mix

Cement-based grout mix design is commonly carried out based on volumetric ratio to avoid unpractical on-site weighting procedures [1]. The range of the volumetric ratio between water and cement is around 6 : 1 to 0.6 : 1 for common applications. If sand is to be used as filler, the weight ratio of sand to cement is normally not more than 2. To modify the grout performance, normally admixtures are used, e.g. accelerators to speed up the hydration process, retarders to prolong the hydration process, fluidifiers to increase the flowability, water reducers to reduce the applied