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The effect of natural sand composition on concrete strength

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HIGHLIGHTS

- Natural sands vary in composition and may cause different concrete strength.
- We highlight some mechanical aspects regarding the use of sand from different origins.
- Sands containing smectite-type clays cause lower concrete strength.
- Na_2O content of sands is important for predicting the strength of concrete.

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ABSTRACT

Natural sands show a variety of mineralogic compositions and chemical characteristics; when sand is used in concrete aggregate, these properties may result in different concrete strengths. However, there is little data about the effects of different sand aggregates on concrete strength. In this work we highlight some mechanical aspects regarding the use of sand from different origins such as concrete aggregate. The sand samples were first tested to determine their mineralogic and chemical characteristics and their aggregate properties. Then, concrete test samples were prepared using these aggregates, and the properties of the fresh and hardened concrete were determined. The results show that although all the samples were found to be suitable for use as fine aggregate in high-strength concrete production, natural sands that contained smectite-type clays have poor aggregate quality compared with other sands. Conversely, the chemical composition of the natural sand samples, especially the Na_2O content, is important for predicting the strength properties of hardened concrete.

1. Introduction

Aggregates form the major constituent of concrete. They generally account for 75–80% of the volume of the concrete and would therefore be expected to have an important influence on the concrete's properties. Another constituent of concrete is natural sand, which makes up about 25–28% of the volume of aggregate used in the construction industry [1,2].

Good quality aggregate should consist of particles of adequate strength and desirable engineering properties as well as resistance to exposure conditions [3–5]. Aggregates containing materials such as coatings, reactive silica, sulfate, clay, feldspar, and mica can potentially cause damage to the short- and long-term performance of the concrete [6]. Aggregates with varying mineralogical composition produce concrete of diverse characteristics. According to Alexander [7], the aggregate properties affect the strength, stiffness, and long-term deformation of hardened concrete. For example, some aggregates may react negatively with cement or, in contrast, they may interact beneficially with the cement paste, enhancing the concrete's strength or stiffness. As a result, concrete properties such as elastic modulus, creep, or shrinkage can vary as much as 100% depending on the aggregate type. The type of aggregate also affects the interfacial transition zone (ITZ), which has an effect on the strength of the concrete. Finally, the type of aggregate influences the abrasion resistance of the concrete, particularly that of high-strength concrete. The coating, the layer of material covering the surface of the aggregate, can increase the demand for water and can impair the bond between the paste and the particles. Coatings are sometimes formed by materials that can interact chemically with the cement, which negatively affect the concrete [8,9]. In addition, natural sand, which consists primarily of uncrushed rounded particles, is often used in concrete mixes because it is generally less expensive, readily available and can be blended easily with other materials. However, natural sand has a smooth, rounded surface texture that greatly reduces the interlocking properties of the concrete, reducing its strength properties [10–14].

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The aim of this study is to evaluate the effects of the composition of natural sand of different origins on concrete strength. To date, many researchers have studied natural sand used for concrete production but there is little information on assessing natural sand samples of different origin for concrete strength.

2. Materials, methods and results

The samples used in this study were collected from sand quarries in different areas of the Marmara region, Turkey, and selected to represent different natural sands (Fig. 1 and Table 1). Sand from seven different areas was subjected to laboratory experiments. The study was conducted in four stages: (a) mineralogical and chemical analysis, (b) aggregate tests (percentage of fine materials, methylene blue absorption, sand equivalent, particle density, water absorption, loose bulk density, magnesium sulfate value, and alkali–silica reactivity), (c) scanning electron microscopy (SEM) to observe the effects of the alkali–silica reaction (ASR) and its products, and (d) concrete strength assessment; concrete samples were prepared using various sand samples, and the properties of the hardened concrete were determined.

2.1. Description of the selected natural sands

The studied sand was collected from seven different sand quarries in the Marmara region, Turkey, because there are different originated sands in these quarries. Table 1 displays the general characteristics of the studied sand; five sampling sites provided sand from terrestrial sources or river deposits while two sites provided sea sand.

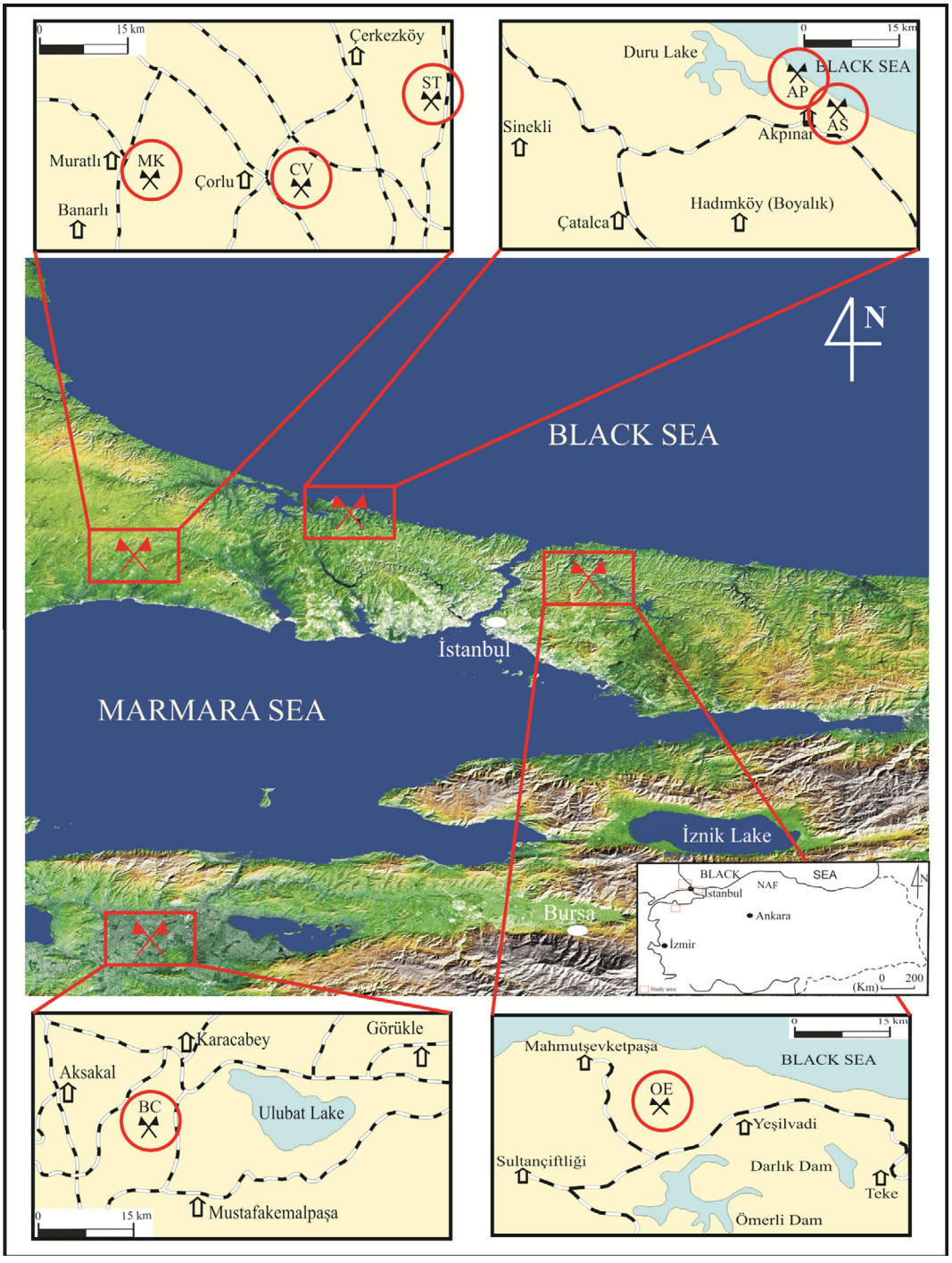

Fig. 1. Location map of the natural sands tested.