Construction and Building Materials 458 (2025) 139504

Contents lists available at ScienceDirect

Construction and Building Materials

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

Investigation on the effectiveness of fourier shape analysis in classifying milled aggregates

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ARTICLE INFO

Keywords:
Fourier shape descriptor
Texture
Form
Angularity
Supervised classification
Geometric shape descriptor

ABSTRACT

Material that constitute aggregate depend on their packing efficiency that is defined by the shape distribution of aggregates. Geometrical shape descriptors would not capture morphological aspects of different dimensional scales and frequencies, failing to wholistically numerically represent shape in material prediction models. Fourier shape descriptors are used to analyse single particle morphology, but efficiency to characterize shape of lump samples has not been assessed. This study analyses aggregates milled for different number of revolutions (0, 200, 500 and 1000) in a Los Angeles Abrasion Value instrument, that contrives morphological alterations of different scales. Means of zonal frequency components amplitudes (form, angularity and texture) are statistically different for all classes with more than 99 % confidence. Support Vector Machine and K Nearest Neighbour algorithms classified pairwise classification with an accuracy above 0.8 between milled and unmilled aggregates. Classification of different degrees of milling had significantly lower accuracy (0.57 – 0.65). Mean of texture zone amplitudes was dominant in feature importance in classifying milled and unmilled aggregates while mean of general form zone amplitudes dominated in classification of different degrees of milling (200 – 1000). The amplitude of the 45th frequency component is the dominant feature when all 53 frequency components are used as features, in classifying milled and unmilled aggregates, while 4th to 6th frequency components are dominant in classifying aggregates of different degree of milling.

1. Introduction

Aggregates are a primary constituent of various construction materials, ranging in size from several millimeters (sand/fine aggregates) to several meters (boulders). Its intended use determines the size of aggregates chosen. For example, fine and coarse aggregates used in concrete range in size between 1 – 2 mm and 5 – 20 mm, respectively, as constituents in concrete production, where applications as ballast would range in meters at large. All these civil engineering applications, however, depend on the mix design to determine the material performance for the intended applications [1,2]. The performance characteristics of such materials, emphatically depends on how optimally these aggregate particles are packed, to give rise to a stable structure, that in turn can withstand stresses and contribute to compressive and flexural strength [3-5]. While most conventional concrete applications depend primarily on the strength of material with as low porosity as possible (optimum packing), several other applications such as pervious concrete and permeable structures such as Gabian Walls depend on both strength (meeting a minimum requirement) and permeability characteristics [6-8]. In these applications (porous structures), the intended purpose is not only to withstand stresses but also to let water and other fluids (or slurry) seep/transported through [9-11].

Packing of aggregates would predominantly depend on size and shape distribution of particles, where more often that not, the particles are assumed to be mono-size (of a single size, in diameter) and of spherical in shape [12-14,5,15]. In natural aggregates however, particles rarely assume neither spherical shape nor equal size [16,2,5]. When packing is considered with spherical equal-sized particles, more uniform packing in the arrangement of predominantly face-centered-cubic (FCC) or body-centered-cubic (BCC) or even at some instances simple-cubic (SC) structures are assumed [17-19]. A uniform theoretical packing also theoretically yields the same packing density (or porosity)

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https://doi.org/10.1016/j.conbuildmat.2024.139504
Received 22 October 2024; Received in revised form 24 November 2024; Accepted 5 December 2024