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ScienceDirect

Energy Procedia 97 (2016) 546 – 553

Energy Procedia

European Geosciences Union General Assembly 2016, EGU
Division Energy, Resources & Environment, ERE

Relevant Petrological Properties and their Repercussions on the Final use of Aggregates

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Abstract

Amphibolite, meta-gabbro or schist are among the rock types used for construction purposes. Generally selected depending on the availability and the mechanical characteristics, a deeper information about the properties of aggregates could optimize their use. Although some efforts have been made e. g., trying to include some limitation to the mineralogy, the evaluation of other relevant properties such as the grain structure are still overlooked. Thus, this paper aims to expose the missing link between petrological characteristics of the rocks and their possible applications in the construction field, attempting to improve the dialogue between specialists and producers.

Peer-review under responsibility of the organizing committee of the General Assembly of the European Geosciences Union (EGU)

Keywords: Petrology; Grain Texture; Mineralogy; Construction; Quarry

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doi:10.1016/j.egypro.2016.10.073

1. Introduction

A petrographic analysis is a technique used to investigate the properties of rocks. Macro- and microscopic characteristics such as grain size or mineral orientation are evaluated to estimate the quality of aggregate materials. While the method has been recognized as a valid technique in the concrete field [1], its application in other construction branches is still very limited.

The petrographic analysis is generally carried out during the exploration phase of a planned quarry to determine the quality of the rock. While this information could be used to predict the in-use behavior hence the best application of the material, its great value is often overlooked. Petrographic analyses are also a valuable tool for follow-up and control of a quarry during its service life. But again – the method has a higher value than what is normally taken to benefit.

Besides the limitation of sulphides, carbonates and alkali reactive silica minerals for concrete applications, other fields limit the requirements for rock material to shape, gradation, and mechanical and absorption characteristics. However, mineralogy and internal structure of rocks which form the aggregates are responsible for these properties, and generally they are not taken into account by technicians and producers. Minerals such as chalcedony or opal, as well as some rock types containing strained quartz can react adversely and expansively with the alkalis present in the pore fluid of the cementitious binder and cause cracking by the well-known alkali-silica reaction [2-4] while the chemical weathering of granites is a rapid process produced by the dissolution of their feldspar minerals resulting in kaolinite clay minerals which can compromise the mechanical resistance of the rock mass [5, 6]. In addition, silica minerals are usually responsible for the low adhesion between the binder and the aggregates in asphalt mixtures negatively affecting the durability of the pavement surface [7]. Also in areas of metamorphic rocks, the partly decomposition of feldspars into sericite and saussurite can affect the properties of the aggregate, both mechanically and regarding surface properties (positive) when used as concrete aggregate [8]. The internal structure of the aggregate also contributes in defining its final use: the percentage, size, distribution, connectivity and continuity of rocks porous media have a direct influence on permeability, water absorption and thus, durability of the aggregates [9]. Rocks with water absorption coefficient less than 2 % generally produce good quality aggregates while aggregates with more than 4 % of water absorption coefficient produce bad quality aggregates [10, 11]. In addition, pore sizes less than 5 μm decrease the durability of rock materials. The small size of the pores does not let the circulation of fluids inside the rock, helping to increase the effects of damaging process such us freeze-thaw [12, 13]. Foliated rocks also may produce elongated or flaky shapes on crushed aggregates, which can have negative effect when used as road material, coarse concrete aggregate and ballast for railways. These elongated or flaky shapes decrease the mechanical resistance of the material affecting to the stability of the railway structure [14] or road surface layer, and causes less workability for fresh concrete. The foliation can very often be connected to a content of mica minerals in parallel orientation, and the content and texture of mica will in many cases be a key issue when performing petrographic analysis [8].

Therefore, in this paper, the petrographic analysis of different crushed aggregates from Norway and Spain will be performed. The aim of this study is to stablish a connection between the geological properties (mineralogy and internal structure) of these aggregates and their final use.

2. Study cases

Four aggregate types were considered in this study: a combination of schist and paragneis, an amphibiolite, a meta-graywacke and a meta-gabbro. Thin sections were examined under the microscope in order to determine the grain structure (Fig. 1) while their mineralogy was evaluated through the X-Ray Diffraction method (Table 1). The Los Angeles test was used to evaluate the mechanical characteristics of the aggregates (Table 2) [15].

While the other quarry faces where characterized by one rock type, in the case of schist and paragneis it was difficult to separate the lithologies for production purposes because of the complex geological setting of the exploitation. In this research this first case will therefore be considered a single compound although the petrographic analysis was carried out on both rock types. Schist appeared to have a medium grain size and a high content of mica (weak mineral with hardness of about 2.5-3 in Mohs scale, e.g. quartz has a hardness of 6-7) compared to