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Neapolitan Yellow Tuff as raw material for lightweight aggregates in lightweight structural concrete production

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Abstract

The possibility of using Italian zeolitized volcanoclastites for the production of lightweight aggregates in the building industry has been tested.

The present paper definitely demonstrates the good attitude of the Neapolitan Yellow Tuff (NYT) for the production of lightweight expanded aggregates (LEA) with bulk densities ranging between 0.9 and 1.1 g/cm^3. LEAs showing these features, usually manufactured with clays, are mainly used in the production of lightweight structural concretes (LSC). The physical characterization of LEAs was carried out by means of: grain size analysis, loose weight, mean density of the single grain, water absorption after 30 min and 24 h, and strength of particles (UNI-7549). Afterwards, LEAs were mixed with sand, cement and water to prepare cubic concrete blocks following the UNI specifications (UNI-7549-12). On these specimens, the unit weight and uniaxial compressive strength after 28 days were determined.

The investigated parameters measured both on LEAs and concretes, are comparable with those measured on materials commonly traded in Italy.

The obtained results foresee interesting potential applications of a raw material characterized by a low exploitation cost and a widespread availability on the Italian territory.

Keywords: Neapolitan Yellow Tuff; Zeolite; Lightweight expanded aggregate; Lightweight structural concrete

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1. Introduction

Lightweight expanded aggregates (LEA) are defined as materials lighter than water and other aggregates such as sands, gravels and ground rocks (Klinefelter, 1960; Dower, 1987; Loughbrough, 1991). The raw materials usually used for the production of LEAs are sedimentary or low-grade metamorphic rocks such as clays, schists and slates. A quick heating of these materials at high temperature causes considerable bloating that produces low-density expanded products. A successive prompt cooling of these materials develops an external glassy film that makes the outer surface impervious to water, homogeneous and mechanically resistant (de Gennaro et al., 2001).

The industrial applications of LEAs are undoubtedly due to the physical properties linked to their low unit weight which gives them a high technological interest. In fact, the occurrence of voids and pores in these aggregates yields good thermal and acoustic insulating properties and a good fire resistance. This latter characteristic likely prevents a collapse of the macroporous framework at temperatures lower than the soaking temperature. This is the reason why LEAs offer important functional and economical advantages to the industry and, in particular, to the housebuilding industry (Anonymous, 1977; Benbow, 1987). LEAs are widely used in the production of cement and plasters, as components in manufacturing processes, or as different kinds of bearing materials in agriculture (Bush, 1974). However, LEAs showing mean densities higher than 1 g/cm^3 are also marketed for manufacturing lightweight structural concretes (LSC). The Italian normative law, stated with Departmental Order 91–96 (Suppl. Ord. G.U.R.I., 1996b) defines LSCs as concretes with density ranging between 1400 and 2000 kg/m^3, and characteristic compressive strength not lower than 15 MPa after 28 days.

Some zeolitized volcanic tuffs with specific chemical and mineralogical features (zeolite grade higher than 50% and SiO_2/fluxing (Fe_2O_3+Na_2O+K_2O+MgO+CaO) ratio higher than 3) can be used in this sector (de Gennaro et al., 2004). On the basis of previous results from the most important Italian zeolitized deposits (de'Gennaro et al., 1995; de'Gennaro and Langella, 1996), the purpose of this work is to examine the possibility to manufacture LEAs by using Neapolitan Yellow Tuff (NYT) aggregates and to present these aspects concerning their possible use in the production of LSC.

2. Materials

Neapolitan Yellow Tuff formation (NYT) is the product of a huge eruption dated about 12,000 years B.P. in the Phlegrean Field volcanic area (Southern Italy) (Scarpati et al., 1993). The estimated volume of this formation is of about 50 km^3. It is characterized by two facies, a lithified one with typical yellow color, mostly cropping out in areas proximal to the vent and with maximum thickness of about 100 m, and a grey unlithified one, locally known as *pozzolana*, cropping out even in the most distal areas. The lithified member has been involved in epigenetic mineralization (de'Gennaro et al., 2000).

The alkali-trachytic composition of this material, characterized by a low Si/Al ratio of the glass (≤3), along with a high concentration of alkaline ions led to the crystallization of phillipsite as main authigenic phase and subordinate chabazite and analcime (de'Gennaro et al., 1982, 1995, 2000; de'Gennaro and Langella, 1996). The total zeolite content of the lithified member is greater than 50 wt.% reaching in places 80–85 wt.%. This feature promoted a large number of studies in the last 20 years aiming at evaluating possible technological application of this zeolite-bearing material (Colella et al., 1995; Mumpton, 2000). The current consolidated sector of application is zootechnics even though other fields are currently under investigation.

Samples used for the present study were collected in a quarry located at Grotta del Sole (Quarto, Naples) and belong to the zeolitized member of the NYT formation.

3. Methods

Mineralogy of the raw materials and the LEAs was investigated with X-ray powder diffraction analyses (XRPD) using a Philips PW1730 (CuKα radiation, 40 kV, 30 mA). Quantitative mineralogical analysis was performed using the Reference Intensity Ratio method (RIR) (Chipera and Bish, 1995); whenever possible, reference standards were separated from the rocks investigated.

The chemical analyses of the materials were carried out by ICP-OES (Varian, Liberty 200). Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P were determined following the experimental procedures described by Mingazzini et al. (1998), with an experimental error=1%. Water content was measured on calcined samples (LOI by firing at 1000 °C).

Fusibility tests were carried out using a Leitz heating microscope. Cubic samples (2 mm side) were heated at a