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XRD Analysis of Natural sand, Quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete☆

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Abstract

The successful research and development of a new building material, or component using wastes as raw materials, is a very complex and multidisciplinary task, having technical, environmental, financial, marketing, legal and social aspects. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns. One such by-product is Quarry dust and the disposal problems laid by waste plastics (ldpe). In this study emphasis was made on the feasibility of usage of quarry dust as a replacement of natural sand along with waste plastic as filler in concrete. In this study Matrix densification has been studied qualitatively through petro graphical examination using digital optical microscopy. The materials were studied using XRD for natural sand, quarry dust and waste LDPE. This research has been motivated by the economic and environmental concerns over the disposal of wastes with the costs of traditional engineering materials.

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Keywords: Natural sand; quarry dust ; waste plastic;XRD

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1. Introduction

The main Ingredients of Conventional concrete are cement, sand and aggregate. Performance of concrete is affected by properties of aggregate, so fine aggregate is an essential component of concrete. The mostly used fine aggregate is the sand extracted from river banks. Natural sand is costly due to the excessive cost of transportation from natural sources. Also large-scale extraction of river banks depletes natural resources. To endeavor this aim , one way is to go for long lasting solutions i.e., To opt for sustainable building materials for construction from the byproducts that are generated by manufacturing industries, mines , as waste is certainly a good potential resource and a lot of energy can be recovered from it; and the term 'green' in the present scenario implies to take into consideration use of long term materials like stone dust or recycled stone, recycled metal and other products that are not harmful , ca be reused and recycled. In addition to this suitable substitution for the replacement of natural aggregates in concrete is a matter of concern. As a result reasonable researches with intended solutions have been done to find the feasibility of quarry dust in conventional concrete. Quarry dust is a byproduct that is generated from the crushing plants and which is abundantly available to an extent of millions of tonnes per year associated with disposal problems and serious environmental effects.

2. Brief Review

Research has been done to investigate the use of quarry fines in various concrete applications. The International Center for Aggregates Research (ICAR) identified the use of micro fines (particles below 75 μm) in concrete. Studies suggested that artificial fine aggregate mortars with high fines content had higher flexural strength, improved abrasion resistance, higher unit weight and lower permeability due to filling of pores with micro fines. Hence concrete can be manufactured using all of the aggregate, including micro fines from 7 to 18% without the use of admixtures (Ahn and Fowler, 2001)[9]. Hanson considered structural concrete (Craig-yr-Hesg) using 12% unseparated sandstone quarry fines. The product is being sold as standard C35 strength concrete (35 N/mm2). However results showed that the strength of the ultimate product would be considerably higher than 35 N/mm2 after 28 days. Hence, it was put forth that, if the filler material was to be replaced , and then much higher content of the coarser grained material have to be mixed , while retaining the desirable strength value (Lamb, 2005)[6]. Galetakis and Raka (2004) [7] studied the effect of varying replacement proportion of sand with quarry dust (20, 30 and 40%) on the properties of concrete in both fresh and hardened state. Saifuddin (2001)[8] studied the influence of partial replacement of sand with quarry dust and cement with mineral admixtures on the compressive strength of concrete (Gambhir, 1995), whereas Celik and Marar[10] investigated the effect of partial replacement of fine aggregate with crushed stone dust at different percentages in the properties of fresh and hardened concrete . It is worthy to consider that the hardened concrete properties as tensile and flexure strength can be increased by incorporating closely spaced fibers. These fibers may arrest the propagation of micro cracks, resulting in delay of onset of tensile cracks and enhancing the tensile strength of the material. (Zainab Z. Ismail, Enas A. AL-Hashmi, 2007)[5]. The study carried out by B.V.Bahoria, D.K.Parbat (2013)[1],[2],[3],[4] on M20 concrete revealed that the optimum modifier content as 6% the strength was found to be comparable with the conventional concrete. From the test results it was observed that the compressive strength value of the concrete mix increased with the addition of quarry dust and waste plastic fibers as modifier.

3. Research Significance

Determining the effect that micro fines with different characteristics have on concrete performance can lead to a better understanding of the function of micro fines as a part of the concrete and the benefits or disadvantages that result from their inclusion. It is unwise to categorically allow the use of all manufactured fine aggregate particles in concrete without a careful analysis of their characteristics and effects on performance. Dust of fracture versus clay minerals in the very fine size fractions is a very important issue. The mineralogy, size distribution, shape, and texture of these aggregates may all influence concrete properties. Keeping this in mind the study of mineralogy of the materials used, all the three materials acting as fine aggregate i.e Natural sand (sample1); Quarry dust (sample2); Waste plastic (sample3) were tested for XRD.

3.1. X-Ray Diffraction

Characterizing the mineralogy (Jane Stewart, March 2006) [11] of the micro fines can be done in several ways. X-ray diffraction can be used to identify compounds and minerals present in powdered specimens such as micro fines. It can also be used to identify the presence or absence of clay. Alternatively, scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) allows high resolution identification of elements and compounds present in prepared 2-D cross-sections of aggregate samples. In x-ray diffraction, x-rays are scattered by atoms in a pattern that indicates lattice spacing's of elements present in the material being analyzed. When the x-rays are in phase, they will give constructive interference and produce a wavelength peak in the x-ray diffraction pattern. By measuring the x-ray wavelengths over a wide range of angles, the inter planar spacing's of the material can be found. "In order to identify an unknown substance, the powder diffraction pattern is recorded with the help of a [diffractometer] and a list of [interplanar spacing's] and the relative intensities of the diffraction lines are prepared. These data are compared with the standard line patterns available for various compounds in the Powder Diffraction File (PDF) database" (Chatterjee, 2001)[12] this process can lead to a qualitative determination of the elements and compounds present in the substance analyzed. Figure 1, 2, 3, 4 shows the XRD of natural sand, quarry dust and waste plastic.

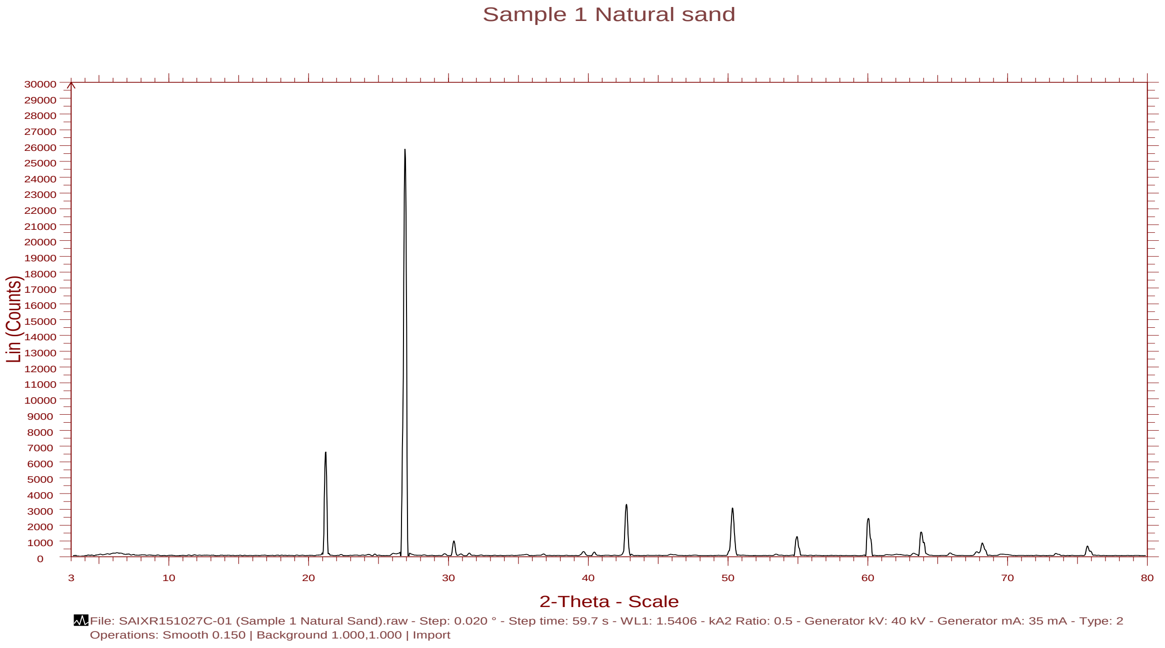

Fig.. 1 Typical graph of microfine x-ray diffraction analysis (ICAR-107)

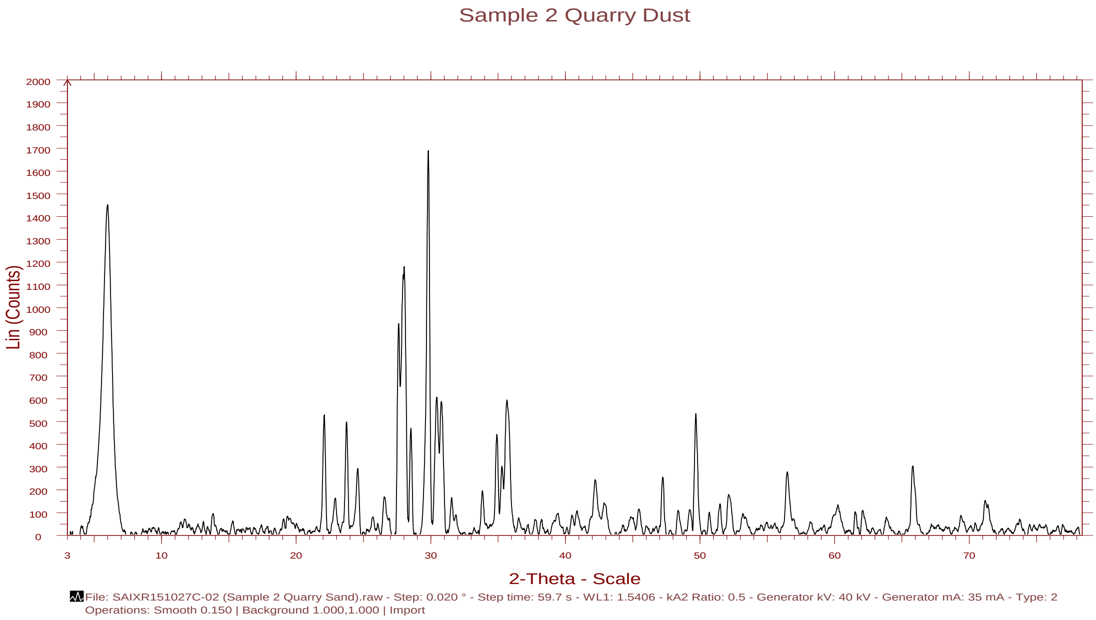

Fig.2 XRD of Quarry Dust

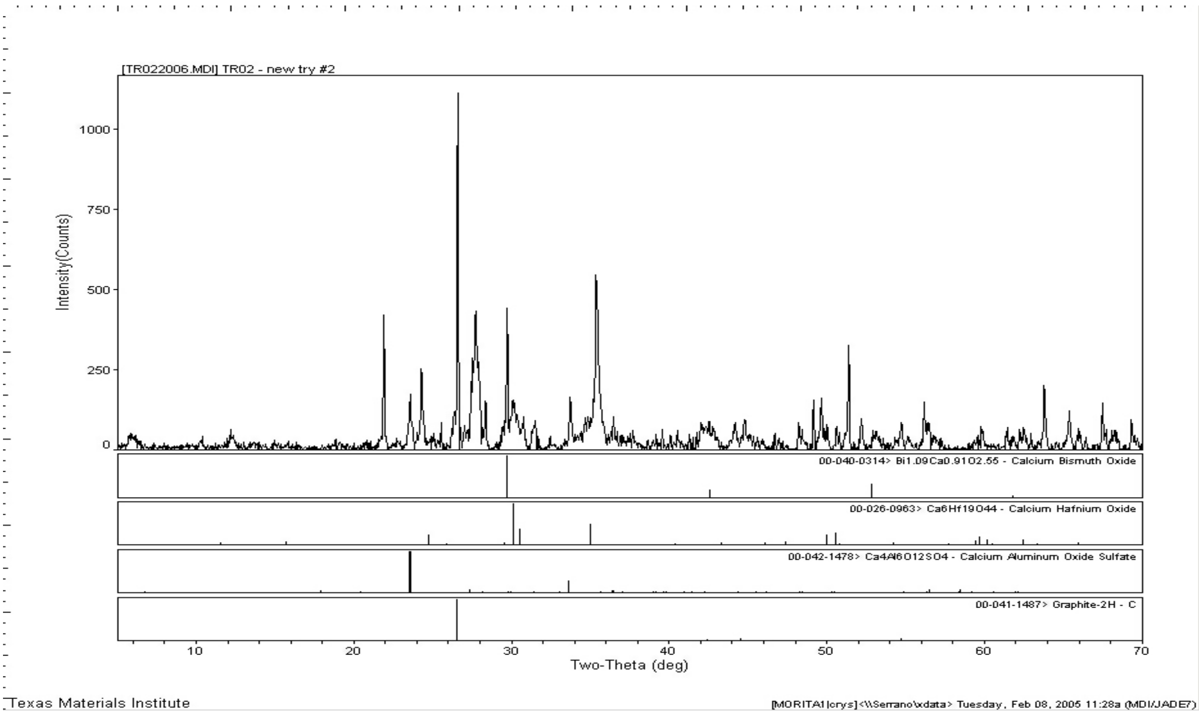

Fig. 3 XRD of TR02 (ICAR-107)

The results obtained are compared appropriately with the findings of (ICAR-107) and interpretation is done accordingly. As can be seen, similar materials are signified by similar composition, the natural sand & (NS01) was primarily composed of quartz along with the presence of calcite. Quarry dust & diabase or trap rock (TR02) contained graphite along with calcium oxides. The smallest particles are often where clays and other deleterious products often exist. In order to determine if any of the micro fines contained clay or other deleterious materials, samples containing only minus two micrometer particles were extracted using a sedimentation cylinder like that used in the hydrometer test. Samples were removed from the top of the sedimentation cylinder after six hours of settling. The water filled with microfines < 2 μm was then placed on a glass plate and left to dry. These samples were then exposed to the x-ray diffractometer. The results from these tests are in Table 1.

Table. 1X-ray Diffraction Analysis of Minus Two Micrometer Material

Aggregate	Minerals
NS01	Calcite-$CaCO_3$
	Quartz-Sio_2
PF01	Dolomite- $CaMg(CO_3)$
TR01	Calcite-$CaCO_3$
TR02	Clinochlore-l Mllb-$(Mg,Fe)_6(Si,Al)_4O_{10}(OH)_S$
	Nimite-lMllb-$(Ni,Mg,Al)_6(Si,Al)_4O_{10}(OH)_S$

The minus two micrometer fractions of TR02 all contain minerals in the chlorite group. These particular minerals are micaceous. Mica, along with clays, is part of the phyllosilicates class of minerals. The inclusion of mica has been found to have undesirable effects on the performance of concrete. However, the effect is primarily dependent on the type of mica rather than how much mica is present (Muller 1971)[13].

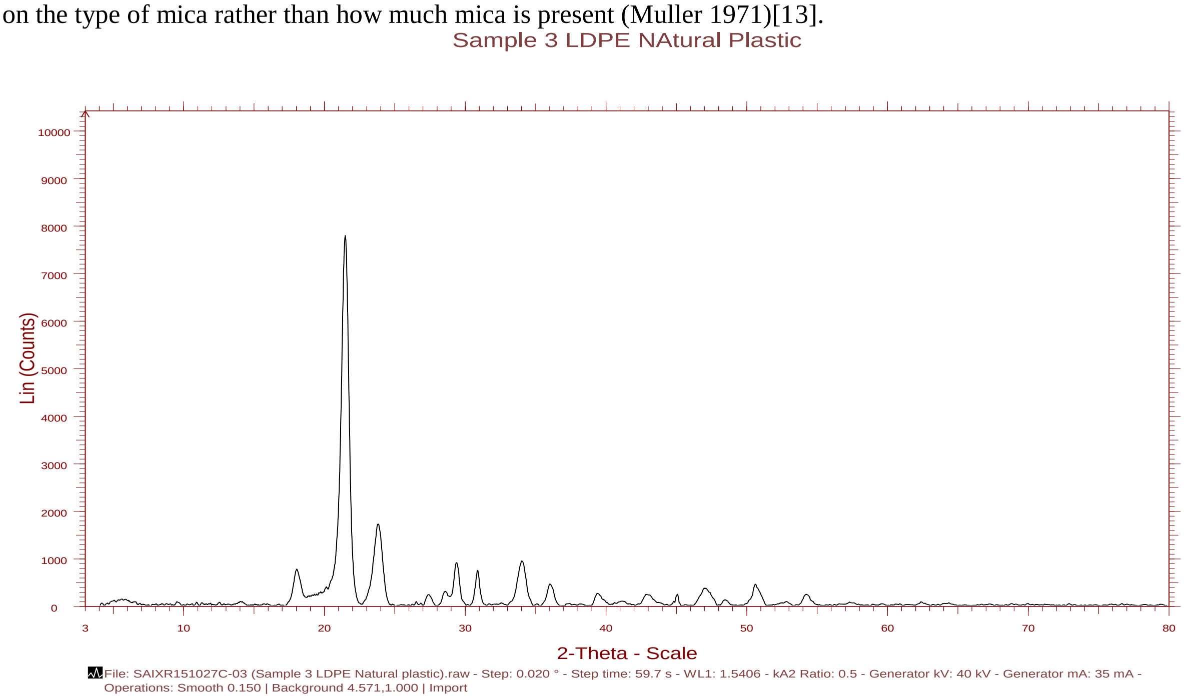

Fig.4 XRD of LDPE (Waste plastic)

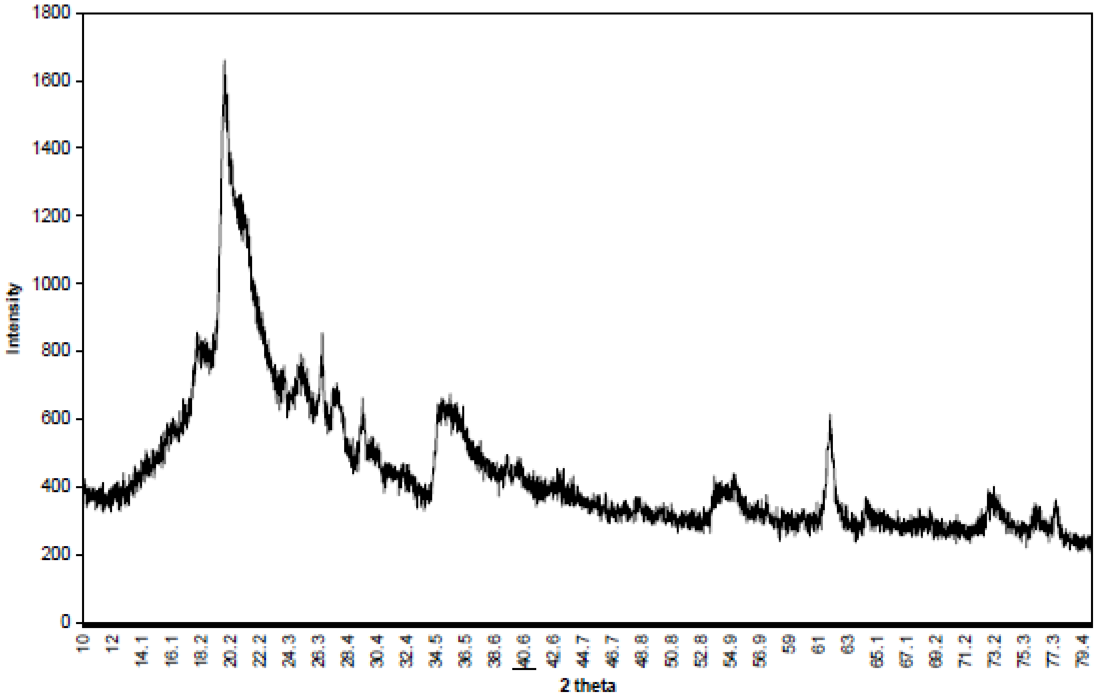

Fig. 5. XRD diffractogram of LDPE ((Supri A.G 2008) [14]

Figure 4, 5 shows the XRD diffractogram for LDPE. It can be seen that LDPE is partly crystalline and partly amorphous structure due to the existence of sharp narrow diffraction peaks and broad peak. The d-spacing at $2\theta=19.8°$ is 4.479 Å. XRD diffraction for LDPE/nanoclay 2.5 phr and 5 phr composite at Figure 5 shows a crystalline pattern structure with the d-spacing value at $\theta=21.96°$ and $2\theta=21.32°$ are 4.043 Å and 4.163 Å respectively. The peak shifts to a higher angle compare with the LDPE, which correspond to the distance between interlayer decreases. The lower d-spacing value is at filler loading 2.5 phr. As the filler loading increases the composite become more crystalline due to the present of sharp narrow diffraction peaks.

4. Conclusions

1. Quarry fines below 6 mm may be included in an end product (for example, aggregate), be a product in their own right (for example, fine aggregate) or be surplus to market demand, namely excess fines which remain unused. The fines may include a high proportion of ultra fine (dust) particles (below 75 µm), which may also be part of an aggregate product, or be produced in excess, or be produced as a by-product. .
2. With manufactured sands, produced from sound durable rock, it is possible that the passing 75 micron material will be composed of finely ground rock flour with little deleterious mineralogy. It is possible that high quantities of inert fines with a high specific surface could still cause an increase in water demand. However, the tests indicated that inert, passing 75 micron fines in manufactured sand can act as filler and as part of the binder, increasing the workability of the mix in the plastic state and reducing porosity in the hardened state.
3. With the introduction of quarry dust there has been gradual recognition that much of the passing 75 µm materials will be ground primary minerals and not clay minerals. This material will act as a rock flour or filler and may have advantages in the concrete mix.
4. It can be concluded from the test results that the addition of alternative fine aggregate material such as quarry dust along with waste plastic in concrete can be a potential application for mass concreting works in order to

reduce the river sand depletion. Further it can be concluded that the utilization of dust along with waste plastics leads to eco friendly and economic construction.

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