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The way of production of Metakaolin from natural material Soorh for Geopolymer Concrete

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ABSTRACT

Concrete, the world's most versatile construction material having consumption rate second only to water. Each year the world is producing 4.4 Billion tons of concrete. The production of concrete not only requires significant amount of energy i.e. 4GJ per annum but also contributes to (5-8) % of world's CO_2 emissions. An alternative to this concrete; is the Geopolymer concrete (GPC)-A concrete without cement. The Geopolymer concrete can reduce the CO_2 emissions up to 80%. In GPC, Flyash, Rise Hush Ash (RHA), Ground Granulated Blast Furnace Slag (GGBFS) and Metakaolin (MK) can be used as a binder. In Pakistan, very limited research is conducted on Geopolymer concrete by utilizing Metakaolin. This study is devoted to produce Metakaolin from local natural material Soorh present in District Thatta and then utilizing it in Geopolymer concrete. The kaolin clay (Soorh) is calcinated at 800^0 C for duration of 2 hours in an electric furnace having dimensions 14 x 24 x 10 cm. The X-ray fluorescence spectroscopy test (XRF) was then conducted to determine the chemical composition of Metakaolin. The Metakaolin when compared with ASTM standards, was found to be pozzolanic and can be utilized as a binder in Geopolymer concrete.

Keywords:

GPC
Soorh
Metakaolin

1. Introduction

Concrete is a widely used construction material that has gained the attention of the construction industry over the past many decades. As there is no rose without a thorn, similarly concrete has its own disadvantages. Each year, the world produces around 4.4 billion tons of concrete having cement as its major constituent. As per the increasing demand, every year 2.6 billion tons of cement is required. The cement is made by clinker process that not utilizes a huge amount of energy but also releases (5-7) % of world's total carbon dioxide gas emissions [1]. It's studied that 1 ton of cement releases 1 ton of CO_2 into the atmosphere. On the other hand, 1 ton of cement requires 1.7-2 tons of raw materials i.e. limestone and shale and due to the continuous mining, it is considered that there will be an acute shortage of limestone in 25-50 years [2], [3]. Thus to lead the world towards sustainable development, Joseph Davidovits in 1978 introduced an eco-friendly concrete known as the Geopolymer concrete [4][5]. The Geopolymer concrete

(GPC) is a green concrete that requires zero cement and its usage can reduce the CO_2 emissions up to 80% [6]. Instead of cement, the GPC utilizes the materials rich in silica and alumina such as Flyash, Rise Husk ash, Silica fume, and Metakaolin etc [7], [8], [9], [10]. These materials when react with an Alkaline Activator Solution *i.e.*, (NaOH or KOH and Na_2SiO_3 or K_2SiO_3) polymerizes into chain like structure and becomes binder. The binder then reacts with aggregates to form the GPC.

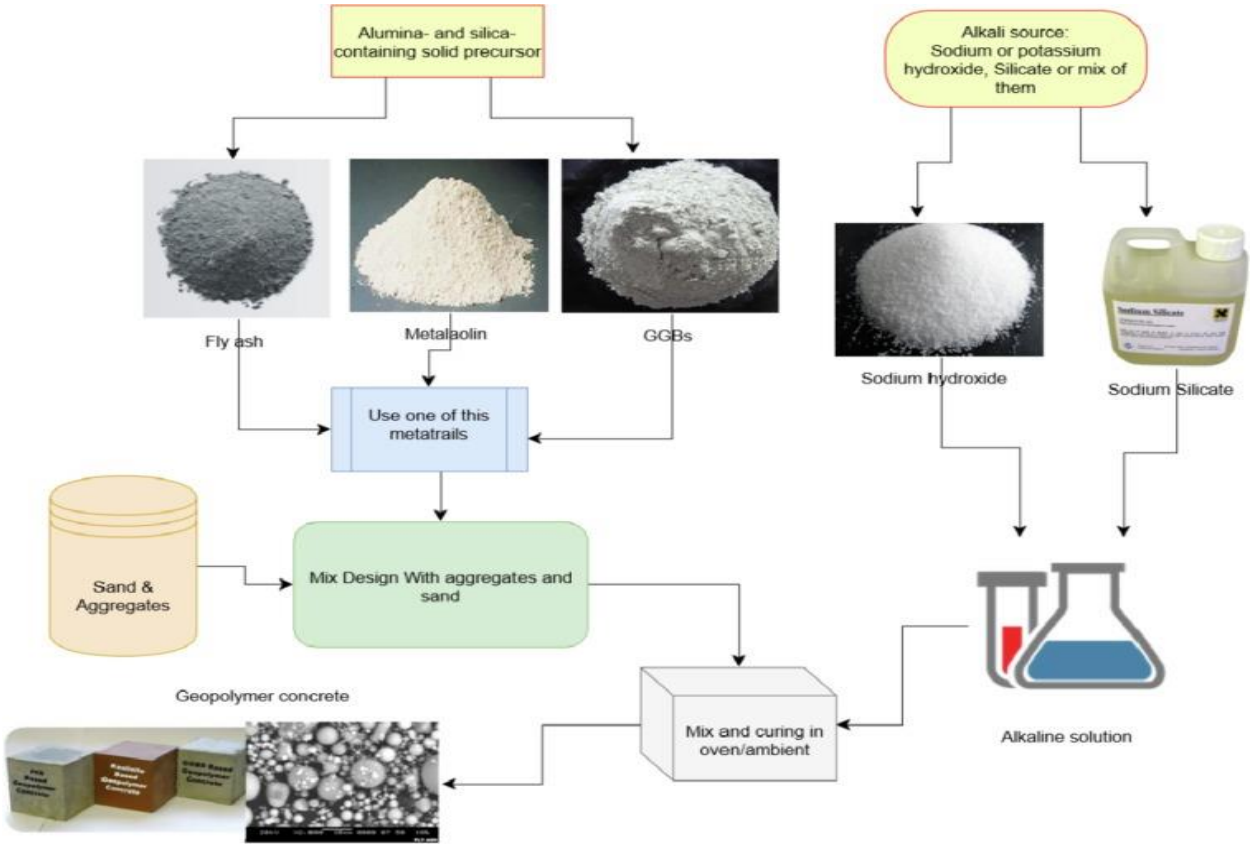

Fig. 01: Formation of Geopolymer concrete

In Pakistan, very limited work is done on Geopolymer concrete by utilizing Metakaolin. In this research, Soorh, available in district Thatta of Sindh, Pakistan is utilized to form the Metakaolin. Previously, Al Shathr etal investigated that locally manufactured Metakaolin can be used to form GPC. Saand etal utilized Soorh to form Metakaolin by heating it at 650, 700, 750 and 800, 900 and 1000 ^{0}C for duration of 2, 3 and 6 h and found the best results at 800 ^{0}C for 2h [11]. Chen etal manufactured the GPC with Metakaolin cured under different temperatures such as (20, 40, 60, 80

and 100 ^{0}C) with curing period of 24, 72 and 168 h and found satisfying results at 60 ^{0}C for 168h [12]. Khalil etal produced Metakaolin by heating the kaolin clay at 700 ^{0}C for 2h [13]. Rafik Abbas etal used the Egyptian Kaolin clay and calcinated at an elevated temperature of 850 ^{0}C to form the Metakaolin and then utilized it to produce GPC[14]. Rajiwala etal in his research found that the GPC showed better results than the conventional concrete with compressive strength 1.5 times, split tensile strength 1.45 times and tensile strength 1.6 times than the ordinary Portland cement concrete[15].

2. Materials and methodology

In this Research, the natural material Soorh deposited at District Thatta, Sindh, Pakistan is utilized for the production of Metakaolin and the methodology for the manufacturing of MK is followed as described by Saand etal.

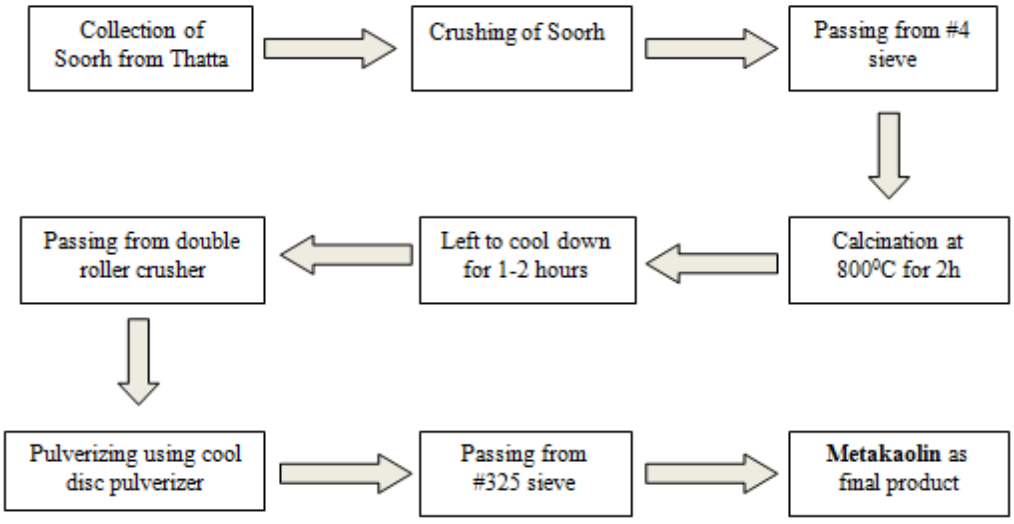

Fig. 02: Flowchart of Metakaolin Production

(a) Soorh Deposits at Thatta

(b) crushing of Soorh

(c) Soorh before Calcination

(d) Electric furnace

(e) Calcination of Soorh in Furnace

(f) Metakaolin after Calcination

(g) Crushing from Double Roller

(h) Pulverizing using cool disc

(i) After Pulverization

(j) Final product Metakaolin

Fig. 03: Pictorial view of different steps in Metakaolin Production

3. Results and Discussion

The physical and chemical properties of manufactured Metakaolin were determined by using Specific Gravity Test and XRF Test. The following results were found.

Table 01: Physical and Chemical properties of synthesized Metakaolin

Composition	**Percentage by wt. of Metakaolin**	**ASTM Standards for Class N**
Silica + Alumina + Iron oxide ($SiO_2 + Al_2O_3 + Fe_2O_3$), Min %	71.53	70
Silica (SiO_2), %	48.86	-
Alumina (Al_2O_3), %	15.98	-
Iron oxide (Fe_2O_3), %	6.69	-
Calcium Oxide (CaO), %	0.88	Report only
Specific Gravity	2.52	2.2-2.6
Loss on Ignition, Max %	7-8	10
Amount retained when wet sieved from #325 sieve, Max %	22	34

4. Conclusion

It can be observed that the manufactured Metakaolin was found to be pozzolanic as per ASTM C618-19. However, it can be concluded that the natural material Soorh present in district Thatta can be used to manufacture Metakaolin by heating at an elevated temperature of 800 ^{0}C for 2 hours. This product can be utilized to manufacture the Geopolymer concrete also known as green concrete or zero cement concrete. This research is a huge step towards the sustainable development by reducing the amount of CO_2 emissions that occurs due to ordinary Portland cement concrete.

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