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Review on a Comparative Study on Conventional Concrete Pavement and Concrete Pavement with Partial Replacement of Sand by Quarry Dust using Sulfonated Naphthalene Formaldehyde (SNF) as an Admixture

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Abstract : *Quarry dust gives improvement in quality of concrete as well as by saving the natural resources. This work investigate the possibility of replacement of fine aggregate by quarry dust after studying the physical and chemical properties, workability and compressive strength of the quarry dust concrete at different percentages of 0%, 25%, 40%, 55%, 75% and 100% replacement for M35 grade concrete. Mix design has been developed as per IRC 044 – 2017: Mix Design for Concrete Pavement, using Sulphonated naphthalene formaldehyde (SNF) as an admixture at 1%, 1.5% and 2%. Optimum strength and workability test values of concrete for various proportion of replacement of sand by quarry dust will be compared with concrete made up of natural sand after 7days and 28days curing. This paper is focusing to produce the concrete pavement of high quality with economical cost of construction by promoting less environmental impacts.*

Key Words: Quarry dust, Concrete pavement, Sulphonated Naphthalene Formaldehyde (SNF), Optimum, Compressive strength, workability.

I. INTRODUCTION

India has one of the largest road networks in the world with over 5 millions km. MoRTH has decided to move toward the construction of concrete pavement as the default mode of construction on National Highway. Concrete pavement is capable of withstanding heavy loads, such as heavy vehicles, with less deformation rather than asphalt. Concrete roads are widely preferred after taking into account the factors related to service life, fuel consumption, weather conditions, low maintenance cost, less prone to wear and tear defects like rutting, cracking etc. Concrete pavement promotes environment friendly construction practices in execution of road projects. Different admixture and material replacement method are applied nowadays in order to reduce construction cost. Quarry dust replacement method is also a means of reducing construction cost and sustainability of resources.The disposal of the huge quantity of dust has a serious environmental problem in country which does not have large free dumping area. Fine aggregate is obtained by sand mining along the river sites. It may cause adverse environmental problems and degradation to natural resources. Increase in demand and decrease in natural resource of fine aggregate has resulted in the need to identify new sources. So, we need to identify the feasibility of replacement of sands by quarry dust.

Quarry dust is obtained as a byproduct of crushing of rock and gravel to obtain fine and coarse aggregate. About 17 millions tones of dust is produced every year. The disposal of this huge quantity of dust has serious environmental problems in country of strongly populated like India. In order to rectify this great issue of disposal and demand recycling techniques are very much necessary. Chemical admixture like sulphonated naphthalene formaldehyde are also using widely as a super plasticizer. It can work in less water cement ratio with better workability and high strength concrete. We can use normally this super plasticizer up to 2% in hot climatic region like India.

II. Literature Review

R. Ilangova et al. [2008] It is reported used of quarry dust as an alternative material of sand in concrete at 40% or 50% replacement has more compressive strength, flexural strength and split tensile strength than made with other percentage.

Appukutty P & Murugesan R. [2009]. They showed that cement mortar for brickwork fines obtained from quarry dust has better performance than mortar made up of natural sands. There is cost reduction of about 12.5% in brickwork and 20.80% in stone masonry by replacing the sand. The utilization of quarry dust leads to eco friendly construction and economic construction.

Manessha Joel et al. [2010] For rigid pavement construction replacement of 20% of fine aggregates by quarry dust with 28 days curing is recommended for a economical cost of construction

Sivakumar & Prakash M [2011] In order to attain rheological properties, the fine quarry dust are proned to consume greater amount of super plasticizer needed for the quarry mixes. High fineness quarry dust has few uses because it induced more w/c ratio.

K. Subramanian & A. Kannan [2013] Stated that 20 percent replacement with traditional concrete is equivalent to the compressive strength. The young's modulus of concrete, compressive strength and flexural strength have shown greater value at 70:30 (quarry: river sand)ratio than conventional concrete. Quarry dust gives better strength with more SiO2 and Fe2O3 and less fines of up to 150 microns in size.

Chandana Sukesh et al. [2013] The test carried out at 50 percent replacement showed that the ratio of water-cement increased to 1.6 when the cone completely failed.

Anitha Selva Sofia S. et.al. [2013] If used together with super plasticizer, quarry dust enhances its concrete mechanical properties. When the traditional fine aggregate is completely replaced by quarry dust, the compressive strength is increased by around 85 percent with 1 percent dose of super plasticizer.

G. Balamurugan & Dr. P. Perumal [2013] Showed that increased in strength of concrete with respect to control concrete is 24 and 6 percent in M20 and M25 concrete respectively. Whereas after heated to 100^{o}C, the decreased percentage of strength is 6.67 and 13.8 percent in M20 and M25 concrete respectively. But the optimum compression test value is obtained at 50 percent replacement of sand by quarry dust.

Akshay C Shank & M Bidar [2014] Reported that partial replacement of sand by quarry dust by a proportion of up to 75 percent increase the compressive strength of concrete. By incorporating fly ash. 100 percent sand replacement method can be achieved.

Soman. K et al. [2014] This paper shows the possibility of replacement of cement quantity by granite sludge up to 7.5 percent. The result indicates that there is no loss of compressive strength in the replacement at this percentage. The use of quarry dust in concrete can minimize carbon emissions. As a result of decreased in cement use the culture of green building technology is inhibited and landfill cost and illness are reduced.

N. Mani Barathi et al. [2014] The percentage of water absorption of quarry dust concrete content up to 40 percent is lying between 0 percent to 20 percent and then began to increase by 40 to 60 percent dust content. Whereas optimum strength is obtained in 40 percent dust content.

Priyadharshni & A.Krishnamoorthi [2014] It has been stated that because of the presences of lot of finer in quarry dust than sand results in decreased the workability of concrete. After the experimental investigation it is found that by using super plasticizer and optimum fiber content of 1 percent can compensate the workability issue.

Sumit L Chauhan & Raju A. Bondre [2015] A mixture ratio of 1:1.5:3 (cement: aggregate :sand quarry dust) has been stated to provide maximum strength in this experiment. Up to 50 percent compressive strength is directly proportional to the percentage of dust content. However the strength value for 28days is greater than the strength for 7 days.

Amit Kumar Singh et al. [2015] It is stated that if the amount of quarry dust that replaced the fine aggregate is increased then there is suddenly decreased in slump (mm) of the concrete. However, it is also mentioned that the optimum strength of concrete is obtained at 60 percent replacement. So, stone dust has capability to be used as an alternative ingredient of concrete instead of fine aggregates in the event that natural sand is not available at a fair cost.

A.Vijayakumar et al. [2015] Concluded that the properties of concrete made up of quarry dust instead of river sand is same as that of conventional concrete. In order to achieve the optimum strength up to 50 percent of replacement is recommended. It is also noted that under 15 days there is no weight change in steel reinforcement under harsh condition.

K. Syamprakash [2016] Reported that the optimum strength is occurred at 40 percent replacement and the strength gradually decreases from 50 percent of quarry dust replacement. Also it is mentioned that water cement ratio of 0.45 concrete has more strength than water cement ratio of 0.5.

Arfat Saiyad et al. [2016] The optimal results were obtained when replacement of quarry dust and fly ash at 15 percent. At this percentage of replacement the concrete are quite durable when it is supposed to curing for 28days in Sulphuric acid and sodium chloride.

Harsh Banshal et al. [2018] For plain cement concrete quarry dust can be used effectively than river sand. For M30 grade concrete replacement of 30 percent of quarry dust instead of fine aggregates improved the compressive strength up to 8 to 10 percent.

Kankipati Dinesh Kumar et al. [2018] The compressive strength of concrete can be promoted by replacing the cement in concrete by combined effects of quarry dust and rice husk together. But the density is decreased with increased in percentage. It can reduce construction cost and increased. The optimum

percentage of replacement is found to be 35 percent for a better performance.

. **Ganeeshsa Mogaveer et al. [2020]** At 28 days, 25% replacement of quarry dust give better compressive strength and bond strength in cement mortar.

III. MATERIAL USED AND METHODOLOGY

1. CEMENT

The important parameter of cement selection is the ability of cement type that can produce improved microstructure in concrete including factors like fineness, heat of hydration, alkali content, tri calcium aluminate (C_3A) content, tricalcium silicate (C_3S) content, dicalcium silicate (C_2S) content etc. The compatibility of the chemical and mineral admixtures with cement should also be ensured. OPC of 43Grade having fineness modulus not less than 225 m^2/kg conforming to IRC 015-2011 is used in this experimental work.

2. COARSE AGGREGATE

The physical and chemical characteristic test will be conformed to as per IS 383-2016. According to IRC 044 – 2017, the maximum size of aggregate is 31.5 mm and retained on 4.75 mm sieve. The combined flakiness and elongation index shall not be more than 35%. Aggregate impact value shall not be more than 30%. Aggregate which has water absorption more than 2% shall not be used. Wherever aggregate of water absorption 2% are not available, higher value of water absorption subjected to maximum value of 3% may be allowed if other engineering properties are satisfied as per IS: 383-2016.

3. FINE AGGREGATE

Fine aggregate (FA) used in this investigation was the natural river sand passing completely through 4.75 mm sieve size and conforming to zone II as per IS:383-2016 specification. The required physical and chemical properties of fine aggregate has to be conformed to as per IS 383-2016.

4. WATER

The pH value of water is an essential parameter in order to produce good quality concrete as it chemically participates in the formation of hydration product, C-S-H gel. Commonly, water fit for drinking is considered as fit for making concrete. For the present investigation, IRC 015 -2011 is recommended to follow the requirement of quality of water.

5. SULPHONATED NAPHTHALENE FORMALDEHYDE

Sulfonated Naphthalene formaldehyde (SNF) is also known as super plasticizer because it works in a high range water reducer admixture. It can reduce 15% - 25% of water and give better results in hot climatic condition like India. They are produced from naphthalene by Oleum or SO3 sulphonation, subsequently reacts with formaldehyde to polymerization and then the Sulphonic acid is neutralized with the sodium hydroxide or lime.

Some properties of super plasticizers (SNF) are follows as :

- Water content of a concrete mix can be reduced for a given workability in order to increase strength and durability.
- Workability can be increased for a given water cement ratio and strength.
- It can reduce the cement quantity of concrete for a same workability, strength and water cement ratio.

So, it has more advantages than others admixture. According to IRC 44, up to 2% of chemical admixture by mass of cementitious material is recommended to be used. It is available in market at a cost around Rs 65/ kg.

6. METHODOLOGY

A systematic experimental work is prepared to study the mechanical properties of concrete on replacement of sand by quarry dust at various percentages using sulphonated naphthalene formaldehyde as an admixture. The main parameter of concrete to investigate in this work is workability and compressive strength of concrete. The required experimental programs are followed as:

Collection of material.

i) Testing of material.
ii) Development of mix design of M35 grade.
iii) Workability test of concrete mix.
iv) Preparation of concrete cubes and curing.
v) Execution of Compressive strength test.
vi) Test results and data analysis.

IV. CONCLUSIONS

i) Concrete made up with quarry dust can reduces the environmental effects of quarry waste and solve disposal problems.
ii) Concrete pavement promotes environment friendly construction practices in road projects.
iii) By using sulphonated naphthalene formaldehyde as an admixture up to 2 % to add to workability and strength of concrete can be investigated experimentally.

iv) Replacement of sand by quarry dust in concrete using admixture can reduce cement quantity in concrete. So it will give an economical cost of construction.

v) Quarry dust is the only alternative material that can replace sand in concrete in order to conserve natural sand mining sites for future generation.

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