Strength Characteristics of Fiber Reinforced Quarry Dust Stabilized Fly Ash

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Abstract- Effects of quarry dust and polypropylene fiber on compaction properties, shear strength parameters, and California bearing ratio (CBR) of a fly ash have been discussed in this paper. Quarry dust was added to a fly ash from 0 to 60% at an increment of 10%, compaction and soaked CBR tests were conducted on fly ash-quarry dust mixes and the optimum percentage of quarry dust was found out to be 40%. Polypropylene fiber was added to fly ash stabilized with optimum percentage of quarry dust, from 0 to 1.5% at an increment of 0.25%. Compaction, shear strength and soaked CBR tests were conducted on fly ash-quarry dust-polypropylene fiber mixes. From the test results the optimum percentage of polypropylene fiber was found out to be 1%.At the optimum percentage addition of quarry dust and polypropylene fiber there is slight decrease in maximum dry density and optimum moisture content, 28% increase in cohesion, 45% increase in angle of internal friction, and 597% increase in soaked CBR of the fly ash.

Key word: Quarry dust, polypropylene fiber, shear strength parameters, soaked California bearing ratio, fly ash.

I. INTRODUCTION

Fly ash is the solid waste produced from combustion of pulverized coal in thermal power plants. The annual production of fly ash, from different thermal power plants in India is about 163.56 million-tons [1]. The production of this huge quantity of fly ash not only pollutes the environment but also requires large space for their disposal. It is estimated that an area of 160 km^2 is covered by fly ash landfills in India [2]. Fly ash has been found to be a good geotechnical material because of its low specific gravity, high shear strength, less compressibility, good drainage characteristics and pozzolanic nature [3]. Fly ash can substitute soil for different geotechnical constructions. Stabilization and reinforcement are two prominent techniques normally adopted separately or combined to improve the engineering properties of soil [4]-[13].Similar techniques can be adopted to improve the engineering properties of fly ash by stabilizing it with quarry dust and reinforcing the fly ash-quarry dust mixes with polypropylene fiber. The new composite material fly ash-quarry dust-polypropylene fiber can be used for construction of subgrade/sub base of pavements.

Extensive literature is available regarding improvement of engineering properties of fly ash using, moorum [14], fiber [15], copper slag and dolime [16], cement and granulated blast furnace slag [17], gypsum and lime[18], sand and lime [2], lime sludge [19], lime [20] . Study regarding the effects of quarry dust and fiber on engineering properties of fly ash is limited in literature.

The objective of the present investigation is to study the compaction properties, shear strength parameters, soaked CBR of a fly ash stabilized with optimum percentage of quarry dust and reinforced with polypropylene fiber.

II. MATERIALS AND METHODOLOGY

A. Materials

The materials used in the experimental programme are mainly fly ash, quarry dust and fiber.

Fly ash: Fly ash used in the experimental programme was collected from a power plant located in Odisha. It is a class –F fly ash. The geotechnical properties of fly ash are - i) Grain size : - a) Gravel size-0% b) Sand size – 14.22% c) Silt size - 83.46% d) Clay size:-2.32% ii) Specific Gravity :- 2.21 iii) Compaction Properties a) MDD-12.83 kN/m^3 b) OMC- 24% iv) soaked CBR-3.21% v)Shear strength parameters a) Cohesion-18 kPa b) Angle of internal friction-31^0.

Quarry dust: The quarry dust was collected from a local crusher unit. The geotechnical properties of quarry dust are - i) Grain size : -a) Gravel size- 3% b) Sand size -81% c) Silt size- 16% ii) Specific Gravity :-2.77.

Fiber: The fiber used in the experimental programme is polypropylene fiber having length12mm aspect ratio 300, specific gravity 0.91 and it was purchased from the market.

B. Sample Preparation and Testing

First of all fly ah –quarry dust mixes were prepared by addition of quarry dust to fly ash from 0 to 60% at an increment of 10%. Modified Proctor compaction tests and soaked CBR tests were conducted on fly ash-quarry dust mixes. The optimum percentage of quarry dust was found out to be 40%. Polypropylene fibers were added to fly ash stabilized with 40% quarry dust from 0 to 1.5% at an increment of 0.25% by replacement of fly ash with polypropylene fiber. Modified Proctor compaction, direct shear, and soaked CBR tests were conducted on fly ash-quarry dust-polypropylene fiber mixes. Compaction tests were conducted to find OMC and MDD to prepare samples for direct shear and soaked CBR tests. The tests are conducted according to the procedures given in relevant Indian Standard Codes.

III. ANALYSIS OF TEST RESULTS

Fig.1 shows the variation of MDD of fly ash with quarry dust. The MDD goes on increasing with increase in percentage addition of quarry dust. The MDD reaches a value of 17.5 kN/m^3 from 12.83 kN/m^3 when the addition of quarry dust is 60%.

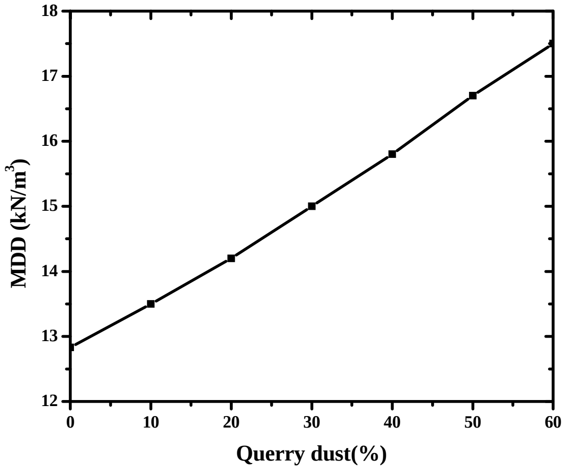

Fig.1 Variation of MDD with Quarry dust (%)

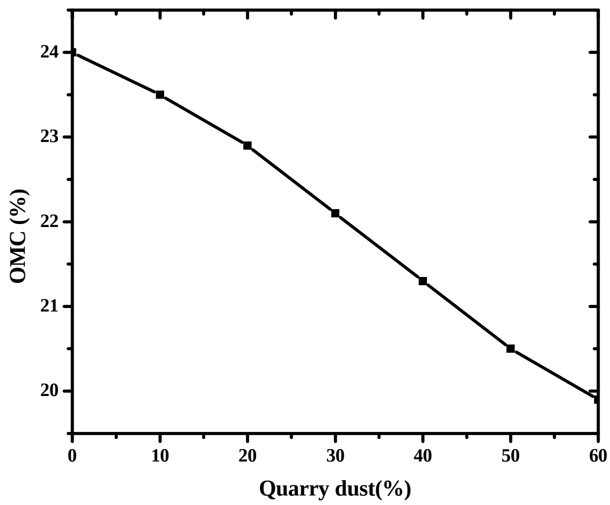

Fig.2 Variation of OMC with Quarry dust (%)

Fig.2 shows the variation of OMC of fly ash with quarry dust. The OMC goes on decreasing with increase in percentage addition of quarry dust. The OMC reaches a value of 19.9% from 24 % when the addition of quarry dust is 60%.

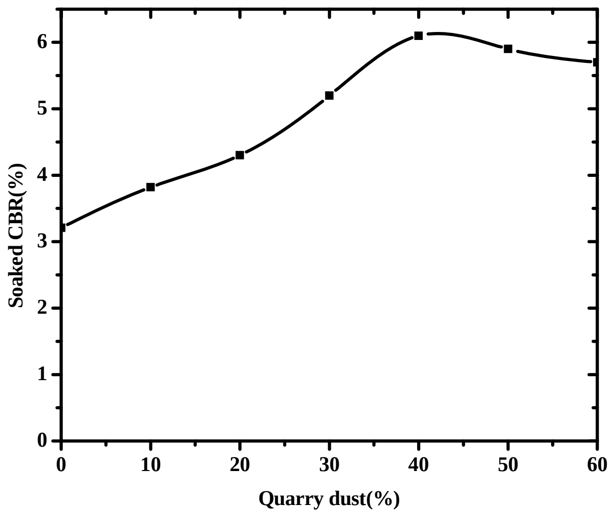

Fig.3 Variation of Soaked CBR with Quarry dust (%)

Fig.3 shows the variation of soaked CBR of fly ash with quarry dust. The soaked CBR goes on increasing with increase in percentage addition of quarry dust reaches highest value when the addition of quarry dust is 40% and then it decreases. The soaked CBR reaches a value of 6.1% from 3.21% when the addition of quarry dust is 40%.

From the result of soaked CBR tests it is found that the optimum percentage of quarry dust for stabilization of fly ash is 40%.

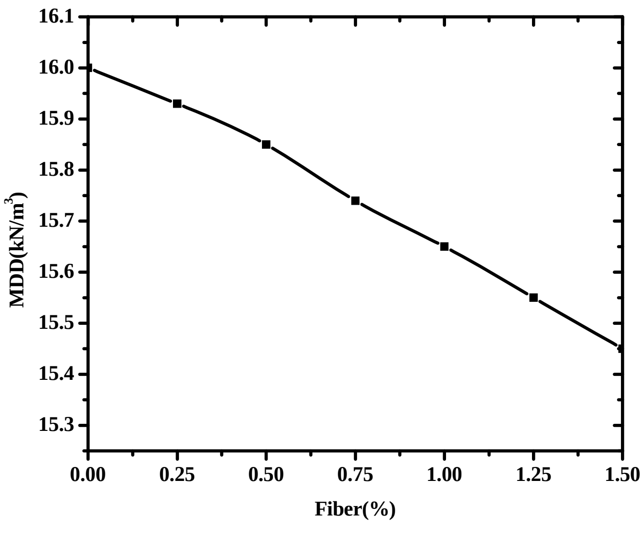

Fig.4 Variation of MDD of fly ash-quarry dust mixes with fiber (%)

Fig.4 shows the variation of MDD of fly ash-quarry dust mixes with fiber. From the figure it is found that the MDD goes on decreasing with addition of fiber, the MDD decreases to15.53 kN/m^3 from 16 kN/m^3 when the addition of fiber is 1.5%.

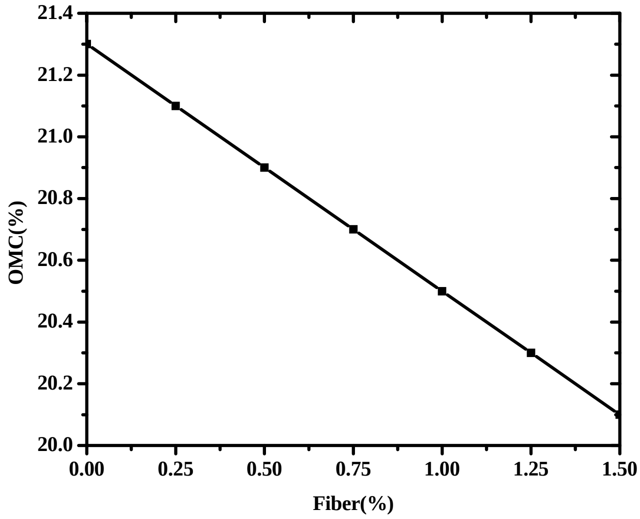

Fig.5 Variation of OMC of fly ash-quarry dust mixes with fiber (%)

Fig.5 shows the variation of OMC of fly ash-quarry dust mixes with fiber. The OMC goes on decreasing with addition of fiber, the OMC decreases to 20.1% from 21.3% when the addition of fiber is 1.5%.

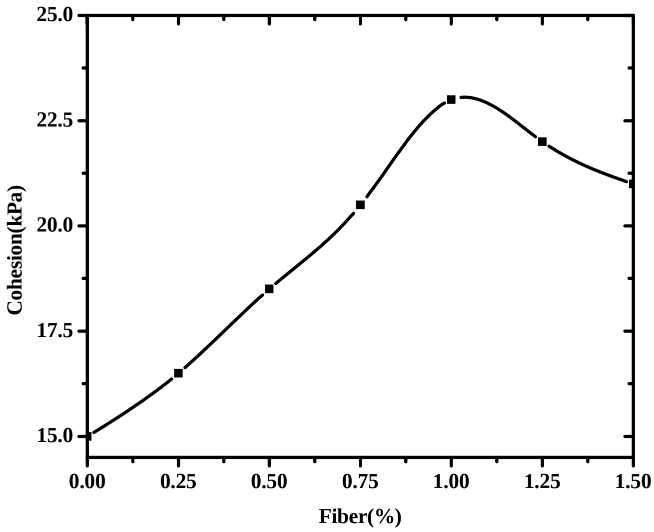

Fig.6 Variation of Cohesion of fly ash-quarry dust mixes with fiber (%)

Fig.6 shows the variation of cohesion of fly ash-quarry dust mixes with fiber. With addition of 40% of quarry dust the cohesion of fly ash reduces to 15 kPa from 18 kPa. The cohesion goes on increasing with increase in percentage addition of fiber reaches highest value when the addition of fiber is 1% and then it decreases .The cohesion reaches a value of 23 kPa from 15 kPa when the addition of fiber is 1%. There is 28% increase in cohesion as compared to unstabilized and unreinforced fly ash and 53% increase in cohesion as compared to quarry dust stabilized fly ash at this percentage addition of quarry dust and fiber.

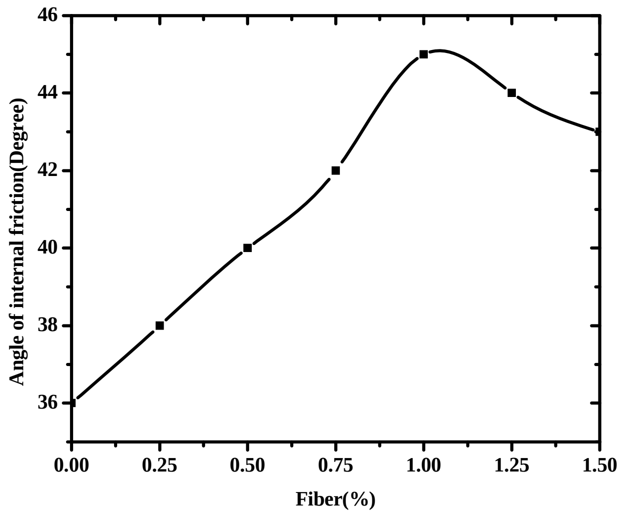

Fig.7 Variation of Angle of Internal Friction of fly ash-quarry dust mixes with fiber (%)

Fig.7 shows the variation of angle of internal friction of fly ash-quarry dust mixes with fiber. With addition of 40% of quarry dust the angle of internal friction of fly ash increases to 36^0 from 31^0. The angle of internal friction goes on increasing with increase in percentage addition of fiber reaches highest value when the addition of fiber is 1% and then it decreases .The angle of internal friction reaches a value of 45^0 from 36^0 when the addition of fiber is 1%.There is approximately 45% increase in angle of internal friction as compared unstabilized and unreinforced fly ash and 25 % increase in angle of internal friction as compared to quarry dust stabilized fly ash at this percentage addition of quarry dust and fiber.

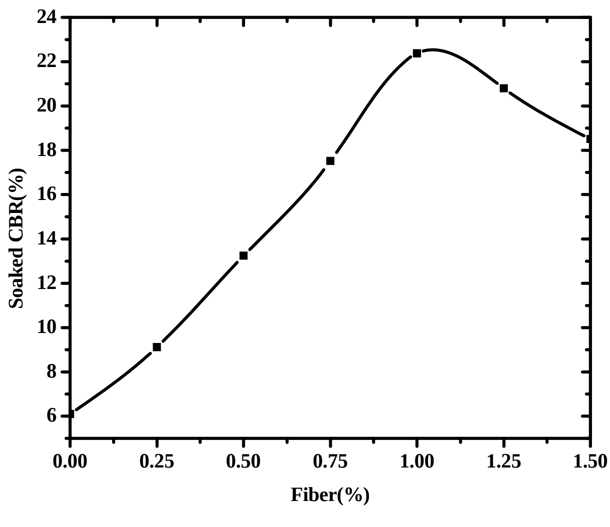

Fig.8 Variation of Soaked CBR of fly ash-quarry dust mixes with fiber (%)

Fig.8 shows the variation of soaked CBR of fly ash-quarry dust mixes with fiber. CBR goes on increasing with increase in percentage addition of fiber reaches highest value when the addition of fiber is 1% and then it decreases. The soaked CBR reaches a value of 22.38% from 6.1% when the addition of fiber is 1%. There is 597% increase in soaked CBR as compared unstabilized and unreinforced fly ash and 267% increase in soaked CBR as compared to quarry dust stabilized fly ash at this percentage addition of quarry dust and fiber.

From the analysis of test results it is found that the optimum percentage of quarry dust for stabilization of fly ash is 40% and the optimum percentage of fiber (polypropylene fiber) for reinforcement of quarry dust stabilized fly ash is 1%.

IV. CONCLUSION

The following conclusions are drawn from the study.

- The optimum percentage of quarry dust for stabilization of fly ash is 40%.
- The optimum percentage of polypropylene fiber for reinforcement of fly ash stabilized with optimum percentage of quarry dust is 1%.
- There is 28% increase in cohesion as compared unstabilized and unreinforced fly ash and 53% increase in cohesion as compared to quarry dust stabilized fly ash at the optimum percentage addition of quarry dust and polypropylene fiber.
- There is 45% increase in angle of internal friction as compared unstabilized and unreinforced fly ash and 25% increase in angle of internal friction as compared to quarry dust stabilized fly ash at the optimum percentage addition of quarry dust and polypropylene fiber.
- There is 597 % increase in soaked CBR as compared unstabilized and unreinforced fly ash and 267 % increase in soaked CBR as compared to quarry dust stabilized fly ash at the optimum percentage addition of quarry dust and polypropylene fiber.

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AUTHOR PROFILE

Dr. Akshaya Kumar Sabat has more than 17 years of experience in teaching. He has published 26 papers in National and International Journals and 67 papers in National/International conference/seminar/workshop Proceedings. He has received 4 Awards for his research papers from the Institution of Engineers (I) Odisha chapter, and 3 Awards from Orissa Engineering Congress. He has also received the 'Outstanding Teacher Award' from KIIT University where he had served for more than 13 years. His Biography has been published in *Marquis Who's Who in the world* in the 32^{nd} Edition 2015.He is reviewer of the manuscripts of a number of International Journals, some of the prominent International Journals are, Geotechnical and Geological Engineering, Environmental Earth Sciences, Measurement, Neural Computing and Applications, and International Journal of Environment and Waste Management. He has guided 10 M.Tech. theses and presently guiding 4 M.Tech. theses and 2 Ph.D. theses.

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