Strength Enhancement of Clayey Soil Using Cement Kiln Dust and Recron Fiber

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Abstract. Due fast growth of economy, construction work is very rapid in India. The removal of poor layer of ground is uneconomical. Scarcity of land forces to search new material so that bearing capacity of poor ground can be improved. Therefore, alternative method is used for the stabilization of soil. Cement Kiln Dust (CKD) is a waste material obtained from the cement industries. This paper presents e stabilization soil having low bearing capacity by mixing CKD and Recron fiber. CKD has pozzolanic capacities which may improve the engineering behaviour of clayey soil. An experimental study was carried out by mixing CKD with soil in the ratio of 96:04, 92:08, 88:12, 84:16 and 80:20. It is found that the un-soaked California bearing ratio (CBR) increases from 6.7% to 12%. The Recron fiber also improves the soil properties of loose soil due to reinforcing action. The inclusion of fibers in the optimum mixture of soil and CKD is in the ratio of 0.1, 0.2, 0.4, and 0.8 percent by weight of mixture. The CBR value increases maximum for 0.4 % of Recron fiber from 12.35 % to 15.67 %. The stabilized soil may be used as subgrade for construction of road.

Keywords: Clayey soil, Cement Kiln Dust (CKD), Recron fiber, California bearing ratio (CBR).

1 Introduction

Clayey soils with low bearing capacity are extensively available. Therefore, it is impossible to avoid these sites for construction works. Many agencies use industrial waste material for the improvement of engineering properties of soil along with the feasibility of the project and its environmental effect. The productions of the waste materials have been increased tremendously in recent years in developing country. Cement kiln dust (CKD) is a fine, powdery material which contains reactive calcium oxide. The reactive behaviour of CKD depends upon the location of dust collection system, the type of operation and the type of fuel used. When the Recron fibers mixed with soil and CKD mixture shows improvement in engineering properties. Fiber increases the penetration and tensile resistance which keeps subgrade intact and avoids the problem like potholes, cracking & failure. Optimum moisture content of improve soil increases but cohesion decreases with addition of fibers content. The California

bearing capacity, unconfined compressive strength and bearing capacity increase with addition of fiber. Nicholson (1977, 1982) conducted a series of laboratory examinations on CKD and fly ash mixtures for stabilizing the sub-base materials with different aggregates and patent them. Napeierala (1983) reported that CKD can be used as stabilizing material for sandy soils in subgrade applications. Baghdadi and Rahman (1990) deliberate the application of CKD for stabilizing siliceous dune sand in highway construction. For the base materials mix proportion of 30% CKD and 70% sand gave best results. Baghdadi et al. (1995) reported a range of 12% to 50% of CKD was satisfactory to stabilize dune sand. Cement-kiln dust (CKD) enhancing the mechanical as well as the hydraulic properties of soils in arid lands evaluated the potential use of Mohamed (2002). Experimental results show good improvement in compressive strength of the soil stabilized with CKD (Peethamparan et al. 2008). Amadi (2014) assessed the durability by immersion tests on mixtures of black cotton soil 10% quarry fine and different percentage of CKD.

The Recron fiber reinforcement improves stress-strain patterns and progressive failure in place of quick post peak failure of plain samples. The unconfined compressive strength of soil is increased by 7 times with CKD and 9 times for CKD with fiber modification (Rao et al. 2012). Husain and Aggarwal (2015) reported that CBR value and unconfined compressive strength of soil increase with the addition of recron fibre. Sharma (2017) conducted different laboratory tests on different percentages of cement kiln dust without fiber and with fiber content and concluded that improvement in engineering properties. Das and Singh (2019) conducted a series of laboratory tests compaction test, unconfined compressive strength and California bearing ratio on soil reinforced with areca nut coir, water hyacinth stem and recron fibre. Results show the improvement in the geotechnical properties of soil.

In this paper the California bearing ratio test is carried out for strength analysis of natural soil and soil modified with the CKD along with recron fibers.

2 Materials and Method

The sample of soil is obtained from under construction site of ISBT Bariya Patna. From the Indian standard (IS 1498-1970) system of classification the soil from the test classified as medium plasticity clay and Table 1 shows the properties of clayey soil sample. Cement Kiln Dust from the laboratory of NIT Patna and Recron fiber from the market suppliers.

Laboratory tests on various materials are performed with according to IS code of 2720 different parts. The specific gravity tests (IS 2720-3-1-1980), consistency limit tests (IS 2720-5 1985) and the standard Proctor tests (IS 2720-7-1980) is performing in laboratory. The particle size distribution of clay is given in Fig.1. The IS 2720-16 (1979) is used for California bearing ratio tests. The mould size is of 150mm diameter and 125mm height. The different type of sample is compacted in CBR mould of standard size at maximum dry density and optimum moisture content for un-soaked test. A surcharge of 50N weight is used for testing. A 50mm diameter and 100mm

long metal plunger is used for penetration of sample at the rate of 1.25 mm/minute using in CBR testing machine.

Table 1. Engineering Properties of Collected Soils

Property	Soil
Specific gravity	2.612
Atterberg limits	
Liquid limits, (%)	46.50
Plastic limits, (%)	23.8
Plasticity index, (%)	22.7
Soil classification	CI
Compaction parameters	
Optimum Moisture Content (%)	13.5
Maximum dry unit weight, (g/cm^3)	1.767
CBR (%)	7.6

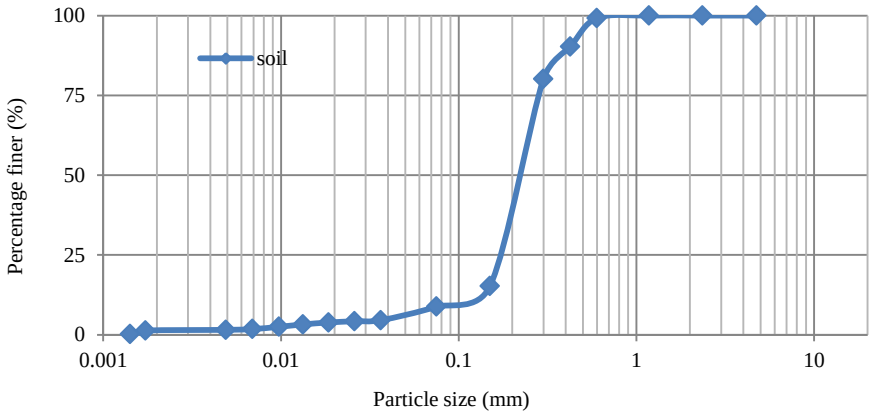

Fig. 1. Particle size distribution of clayey soil

3 Results and Discussion

3.1 Compaction Tests

The proctor test behaviour of clayey soil modified with the different percentage of CKD is shown in the Fig 2. The CKD mixed in the soil in the proportion of 4%, 8%, 12%, 16% and 20%. The maximum dry density of soil increase with the addition of CKD up to 12% then reduction is observed. The increment in the maximum dry density may be due the pozzolanic action and the presence of Calcium ions in the CKD. The maximum increment for maximum dry density is observed at 12% addition of

CKD. Fig. 3 shows that optimum moisture content of the mixture. The optimum moisture content initially decreases with the addition of CKD up to 12% then increases. The reason behind this behaviour is due to initial proper mixing of soil and CKD and reacts with each other. After optimum percentage of CKD, proper mixing is less.

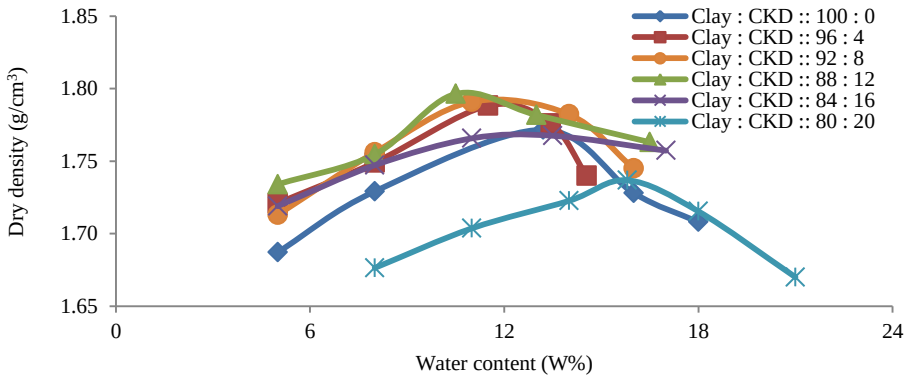

Fig. 2. Variation of dry density of different percentage of Clay and CKD

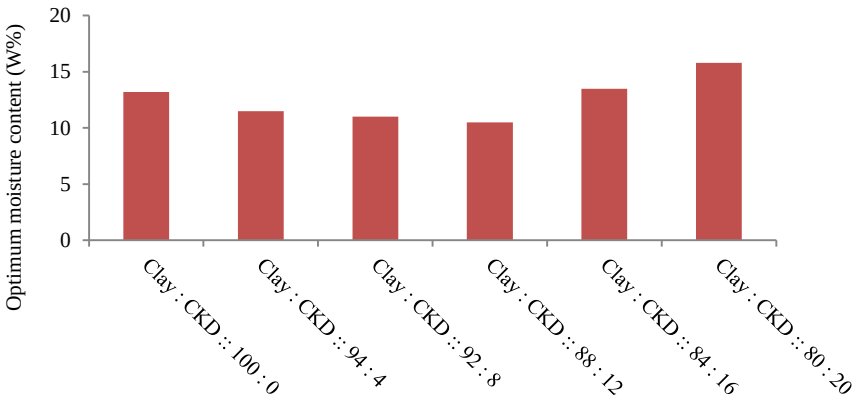

Fig. 3. Variation of optimum moisture content of different percentage of Clay and CKD

Fig. 4 shows the variation of dry density with water content for clay and CKD optimum mix and Recron-3S fiber. The results show that with the addition of fiber maximum dry density reduces this is due to the light weight and less specific gravity. Fig. 5 shows the variation of optimum moisture content with the variation of fiber. It is also observed that with the addition of fiber, the moisture increases little due to the surface roughness of the fiber.

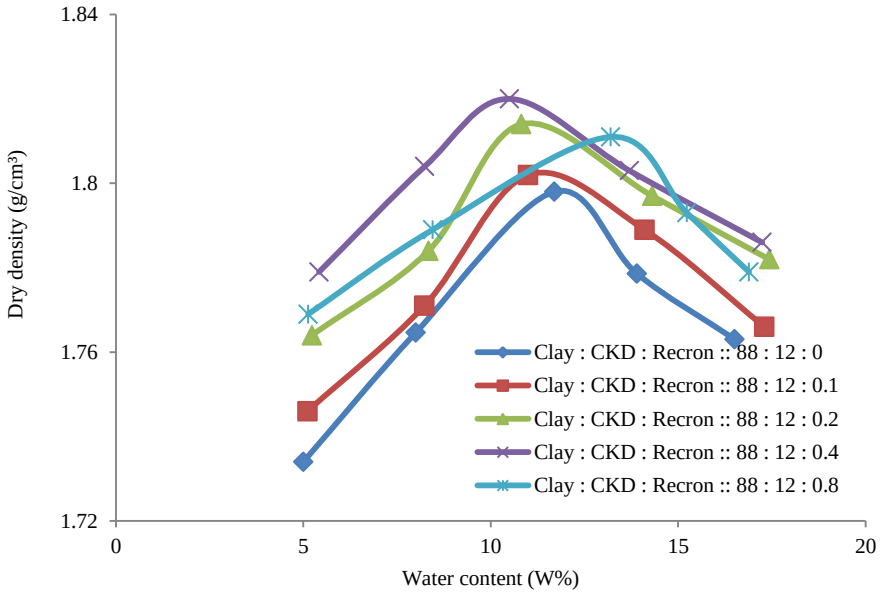

Fig. 4. Variation of dry density of different percentage of Clay and CKD

3.2 California bearing test

Fig. 6 shows the variation of California bearing ratio value of clay and clay with different percentage of CKD. The CBR value increase up to optimum mixture of 88% clay and 12% CKD then decreases little bit which is not significant.

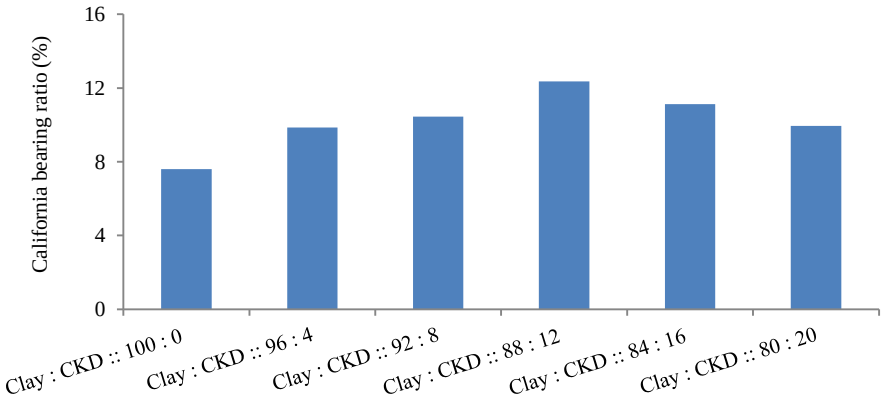

Fig. 6. Variation of California bearing ratio of different percentage of Clay and CKD

Fig. 7 shows the variation of optimum mix of clay and CKD with the addition of fiber. The results show that with the addition of fiber the CBR value increases. The Recron fiber also improves the soil properties of loose soil by reinforcing action. The inclusion of fibers in the optimum mixture of soil and CKD is in the ratio of 0.1, 0.2, 0.4, and 0.8 percent of weight of mixture. The CBR value increases maximum for 0.4 % of Recron fiber from 12.35 % to 15.67 %. The stabilized soil may be used as subgrade for construction of road. The addition fiber increases the penetration resistance due to better combination of bonding between the soil-CKD-fiber. After a certain limit higher percentage of fiber not combined properly segregate the soil and lower value of CBR is obtain for 8% of fiber addition.

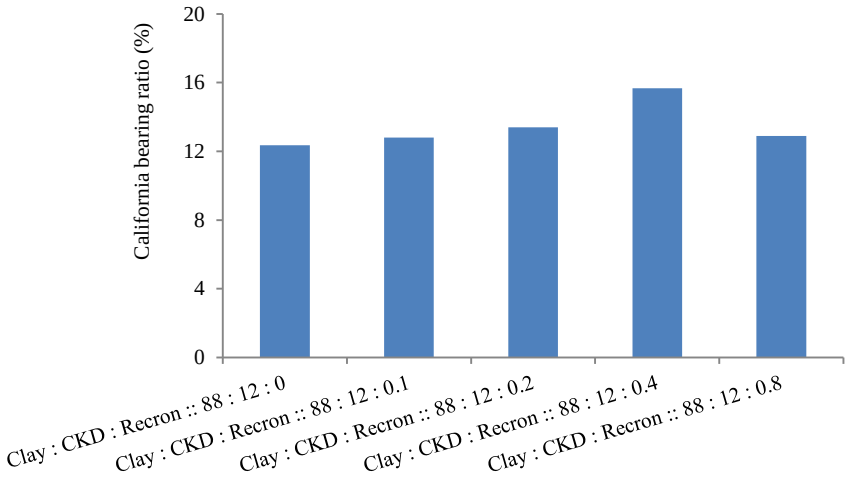

Fig. 7. Variation of California bearing ratio of different percentage of fiber with optimum percentage of Clay and CKD mix

4 Conclusion

On the basis of various laboratories test and its results, following conclusions are drawn:

1. Compaction test results show the addition of CKD to the soil the maximum dry density increase up to 12% addition of CKD then after decreases. At higher percentage the pozzolanic action decreases due to unavailability of reactive site.
2. Addition of Recron fiber the maximum dry density decreases due to light weight nature of fiber.

3. California bearing ratio test shows optimum mix has maximum (88% soil and 12% CKD) value due to higher maximum dry density and lower moisture content.
4. Strength of soil can be increased to the certain extent by using Recron fibers in soil and CKD optimum mix.
5. Due to addition of fiber the tensile, abrasion and penetration properties of subgrade increases which keeps road surface intact and free from cracking and failure.

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