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Research/Technical Note

Use of Coal Mine Dust as an Improved Subgrade Material in Road Construction

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Abstract: Coal mining operation results in two general types of by-products. One is coarse coal refuse and another is fine coal refuse which is also termed as coal mine dust. In coal mine during the mining process a lot of coal mine dust produce. Proper disposal of this is a great problem. This research investigated on the use of nontraditional construction materials, specifically coal mine dust as an engineering material in subgrade of road construction. This investigation consist of performing laboratory tests to determine the engineering properties of the coal mine dust available at coal mine site. Along with the coal mine dust, local sand also used for improving the geotechnical properties of their mixture. MDD and CBR values were performed at first for coal mine dust and local sand sample alone and then for coal mine dust with sand in different proportions. Then the result is compared with the requirements of LGED, Bangladesh to find out the suitable samples for road sub-grade. So, according to the results found and "Road Pavement Design Manual-1999", it may be recommended that 30% coal mine dust mixed with 70% sand would be suitable for road subgrade construction.

Keywords: Coal Mine Dust, Local Sand, Barapukuria Coal Mine Company Limited, Road Subgrade, Improved Subgrade

1. Introduction

The industrial world is dependent on coal. Just over 40% of all electricity used worldwide is generated from coal. This 'steam coal' accounts for_70% of all coal extracted from the ground. The remaining 30% - known as 'coking coal' - is largely used in the production of steel and cement. Both the mining of coal and its use as fuel are highly problematic. This introduction, however, is concerned only with coal mine dust.

Coal dust suspended in air is explosive coal dust has far more surface area per unit weight than lumps of coal, and is more susceptible to spontaneous combustion.

It also results in non-productive use of land, air and water pollution.

As there is used a huge amount of coal to produce power, there is also a huge amount coal dust is also produced. This coal dust is not generally used for any engineering purposes, rather these wastes mostly are stored as heaps temporarily.

This study is about analyzing the geotechnical properties of coal mine dust collected from the Barapukuria Coal Mine and locally available sand collected from the Padma River and analyzing the capability of these materials and their various proportion whether they can be used as filling material as improved subgrade in road construction.

A few number of researches have been conducted to determine and compare the geotechnical properties of coal mine dust and to analyze the feasibility of using it for engineering purposes.

Allen and Richard S. U. (2006) led an investigation of the use of coal mine refuse for sub-base material and embankment fill in South Dakota. The results of this research concluded that coal mine refuse sampled at an abandoned mine site in South Dakota can be used as embankment fill material and can provide limited uses for sub-base applications.

Bian *et al*. (2007) carried out their investigation with coal mine dust & coal mine waste to get rid of the bad effect of coal mine dust & waste of Dongtan (DT), Nantun (NT) and Xinglongzhuang (XLZ) Coal Mines, China. They concluded as the first choice to treat mining dust & wastes should be filling subsided lands for construction purpose in terms of consumption amount, and then used for materials of bricks, filling underground cavity, filling subsided basin to reclaim lands for afforestation purpose and agricultural purpose.

Agarwal (2009) researched with coal mine dusts & refuses from different mines of Mahanadi Coalfields Ltd (MCL), Hindalco, and South Eastern Coalfields Ltd (SECL). This study concluded that some samples can be used for the purpose of backfilling without much treatment. But all other samples need some treatment such as removal of some fine particles, mixing with some amount of cement or some other binding material or other locally available materials.

Lewitt (2011) made a research with residues & dusts from coal mine. Significant deposits are present where large amounts of coal have been mined, a large proportion has been subjected to preparation and most residual material has been stored. The size and composition of each deposit of coal mining dust, residues must be determined to enable assessments of technical and economic feasibility of utilization to be assessed. This research concluded that the fine coal residue or coal mine dust can be recovered and reprocessed to produce coal. And for technical use, technologies, development or adaptation of technologies suited to the properties of the residues should be investigated.

2. Objectives and Scope of Study

A huge amount of coal mine dust product in Barapukuria Coal Mine Company Limited, Barapukuria, Dinajpur. These are dumped in the land surface. So, it creates a great problem for humen, animals as well as the environment. Proper disposal of coal mine dust is difficult and coastly. So, to get rid of this problem this study deals with the finding of engineering properties of coal mine dust and improvement of it for using in construction purposes like improved subgrade material in road construction.

3. Methodology

This study was based on materials collection, laboratory tests and compare the values with LGED standards. The tests were Specific Gravity Test, Modified proctor Test, California Bearing Ratio Test (soaked & un-soaked).

The materials were sand & coal mine dust. Sand was collected from talaimari, Rajshahi. Coal mine dust was collected from Barapukuria Coal Mine, Dinajpur.

Specific gravity test was conducted according to ASTM D 854-83 (2002).

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. In this study Modified Proctor Test was conducted according to Modified Proctor (ASTM D1557) – Modified rammer using 5 layers and 25 blows per layer.

CBR is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

The loads, for 2.5 mm and 5 mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. The values are given in the table below:

Table 1. Unit load for different *penetration level.*

Penetration (mm)	Standard load (kg)	Unit load (kg/cm²)
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

In this study CBR (soaked) test was conducted according to ASTM D 1883 - Standard test method for determination of California bearing ratio of soil.

4. Results

Specific gravity test

Table 2. *Specific gravity of sand & coal mine dust.*

Sample	Specific Gravity
Sand	2.37
Coal Mine Dust	1.463

Modified proctor test

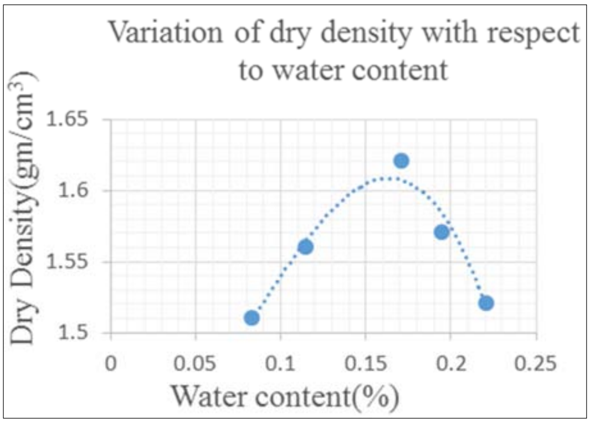

Figure 1. *Variation of dry density with respect to water content for sand.*

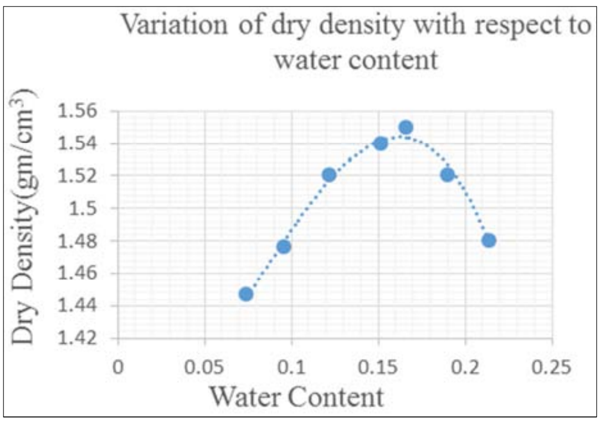

Figure 2. *Variation of dry density with respect to water content for sand: coal mine dust=90%: 10%.*

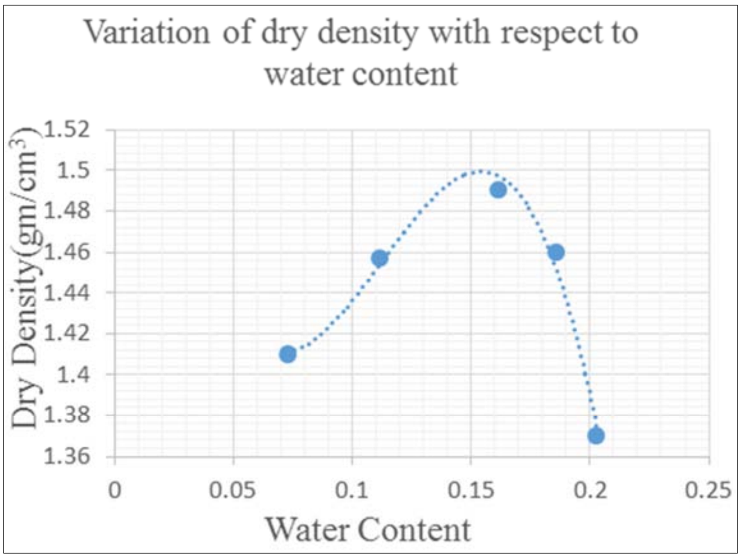

Figure 3. *Variation of dry density with respect to water content for sand: coal mine dust=80%: 20%.*

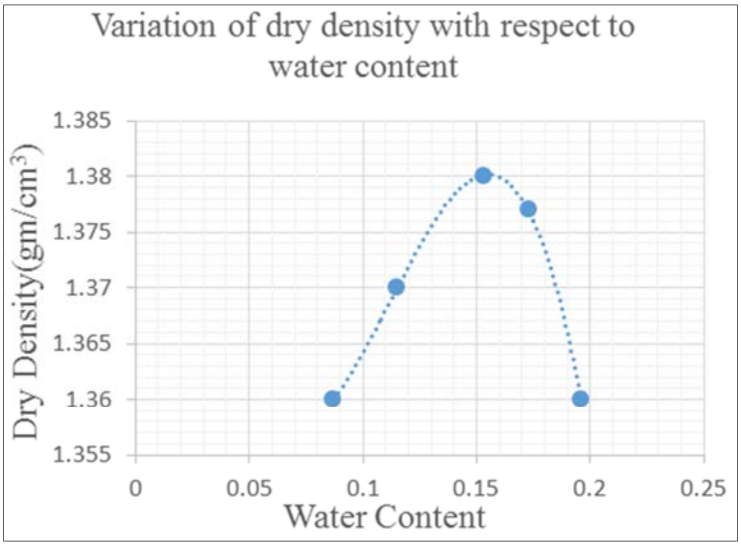

Figure 4. *Variation of dry density with respect to water content for sand: coal mine dust=70%: 30%.*

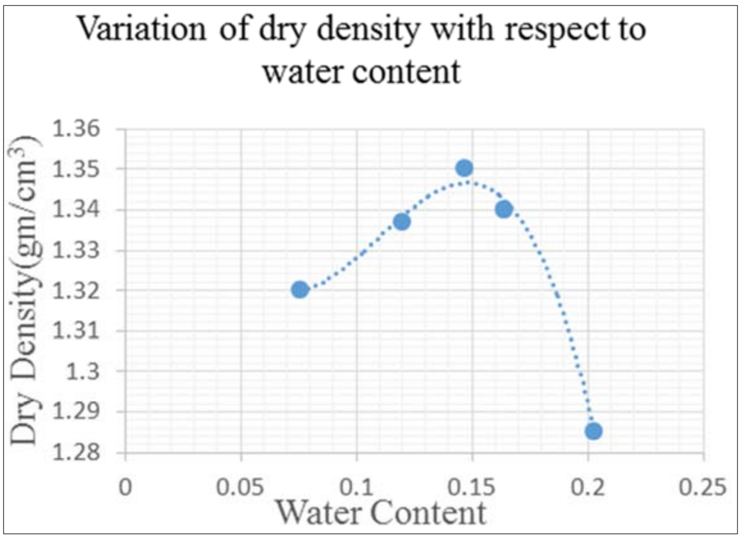

Figure 5. *Variation of dry density with respect to water content for sand: coal mine dust=60%: 40%.*

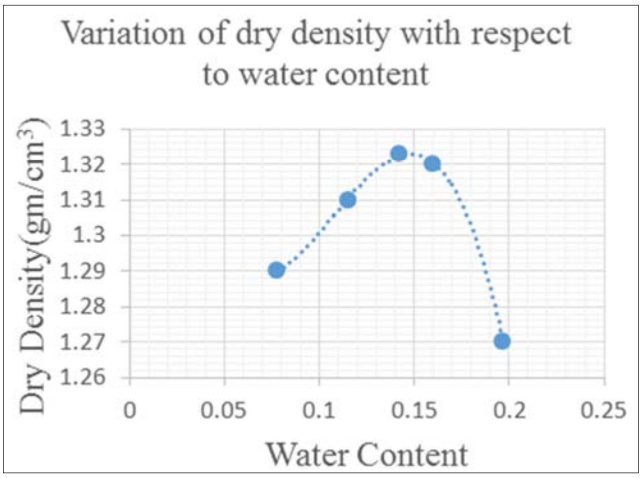

Figure 6. *Variation of dry density with respect to water content for sand: coal mine dust=50%: 50%.*

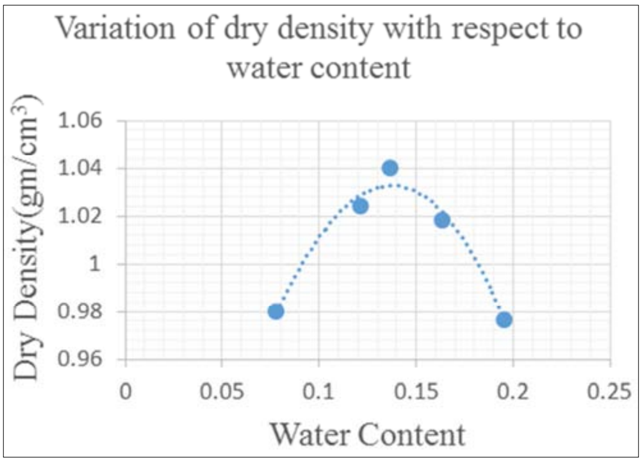

Figure 7. *Variation of dry density with respect to water content for coal mine dust.*

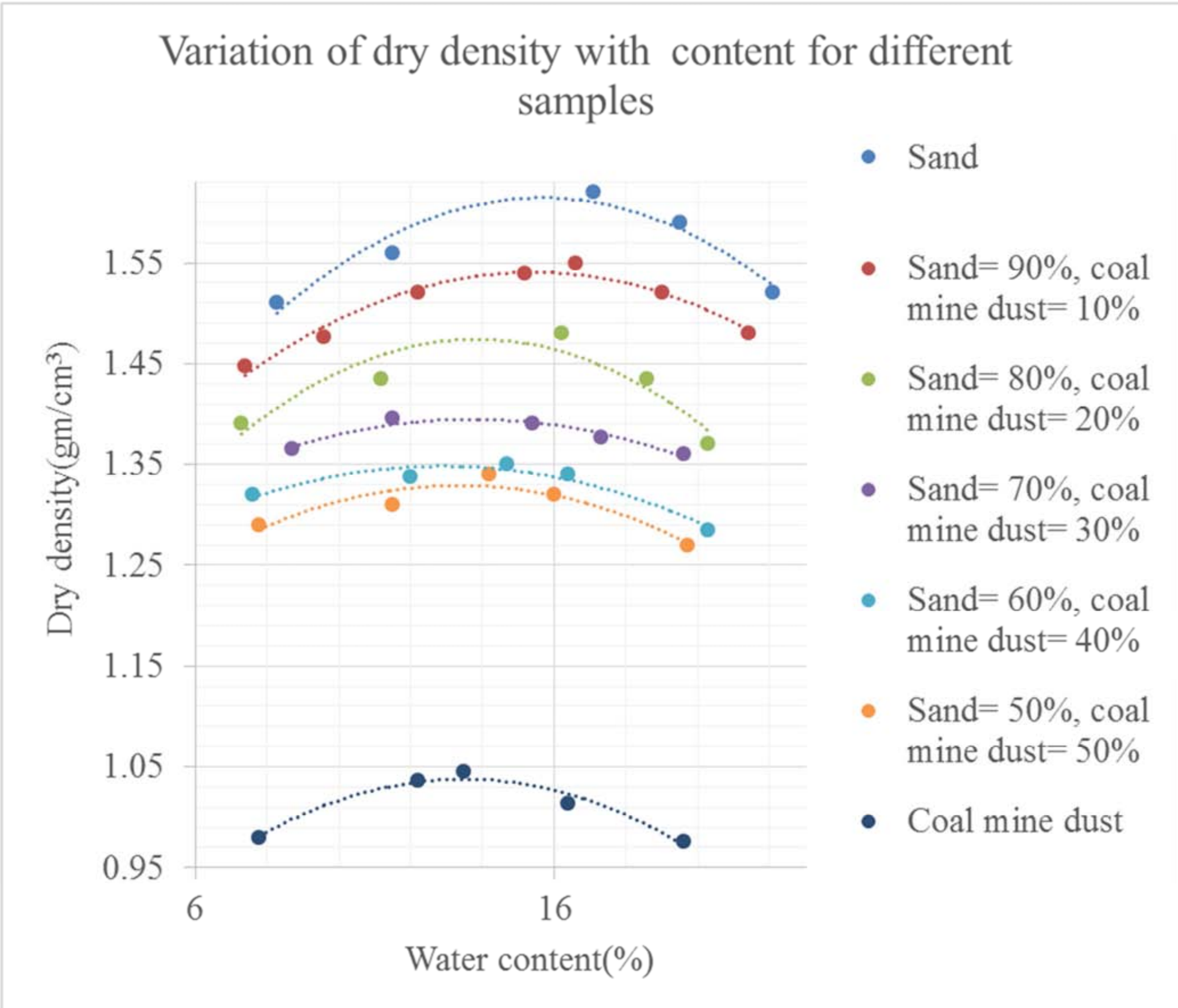

Figure 8. *Variation of dry density with moisture content for different samples.*

In all the experiments, density of the samples increase with the increase of water content firstly. But after a definite water content, density decrease with increasing water content. This water content is termed as optimum moisture content and at this water content maximum dry density is obtained.

Figure 8 shows the relative position of maximum dry density vs optimum moisture content curve of various composition of sand and coal mine dust. It is clear that, both optimum moisture content and maximum dry density decrease with the increase of percentage of coal mine dust. Because coal mine dust has lower dry density and optimum moisture content than coal mine dust.

Table 3. *Tabulated results of maximum dry density & optimum moisture content for all samples.*

Coal Mine Dust (%)	Dry Density (gm/cm^3)	OMC (%)
0	1.61	16.5
10	1.54	16
20	1.5	15.5
30	1.38	15.2
40	1.34	14.7
50	1.324	14.2
100	1.032	13.7

California Bearing Ratio (CBR) Test (soaked)

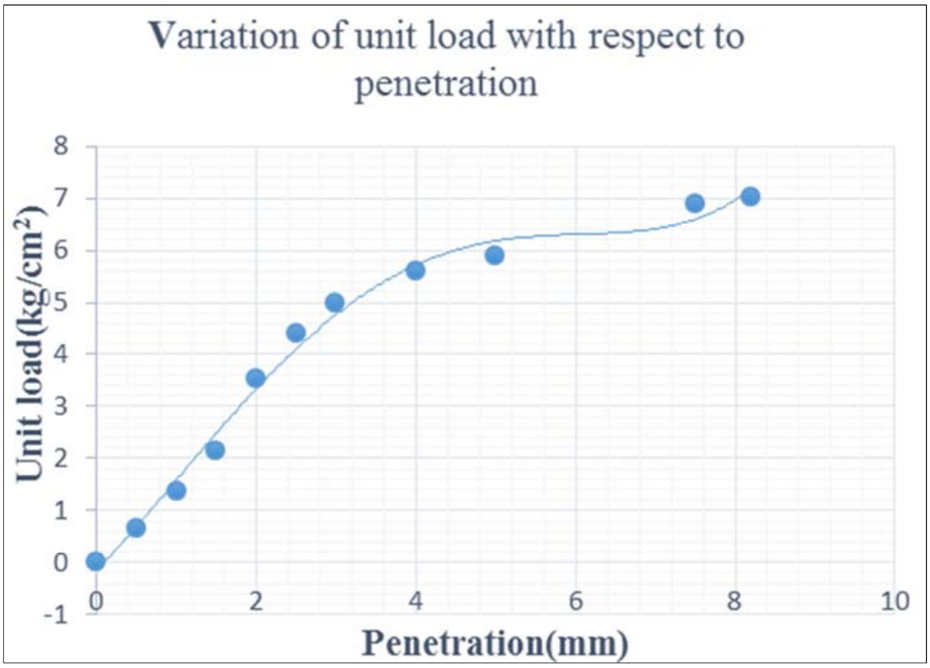

Figure 9. *Variation of unit load with respect to penetration for sand.*

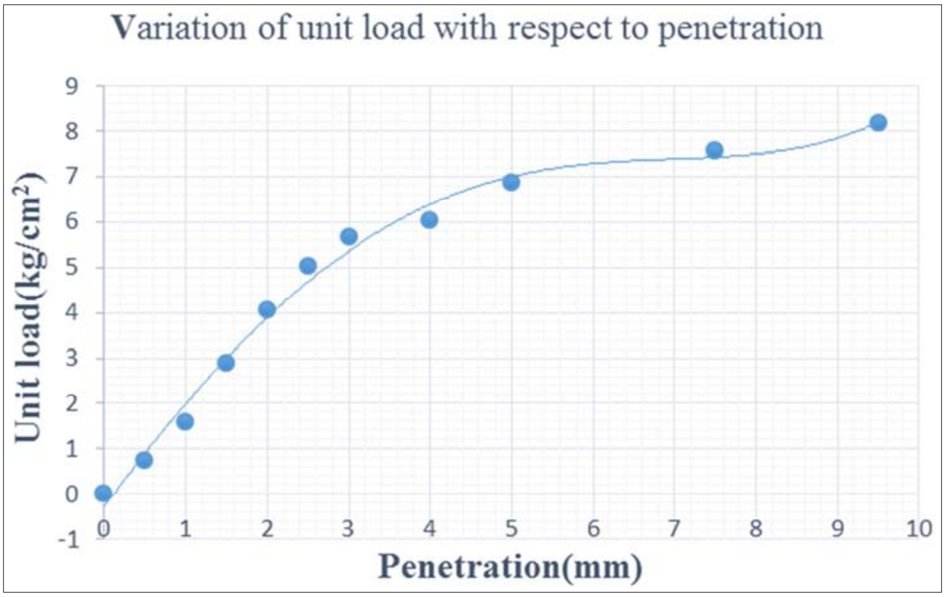

Figure 10. *Variation of unit load with respect to penetration for sand: coal mine dust= 90%: 10%.*

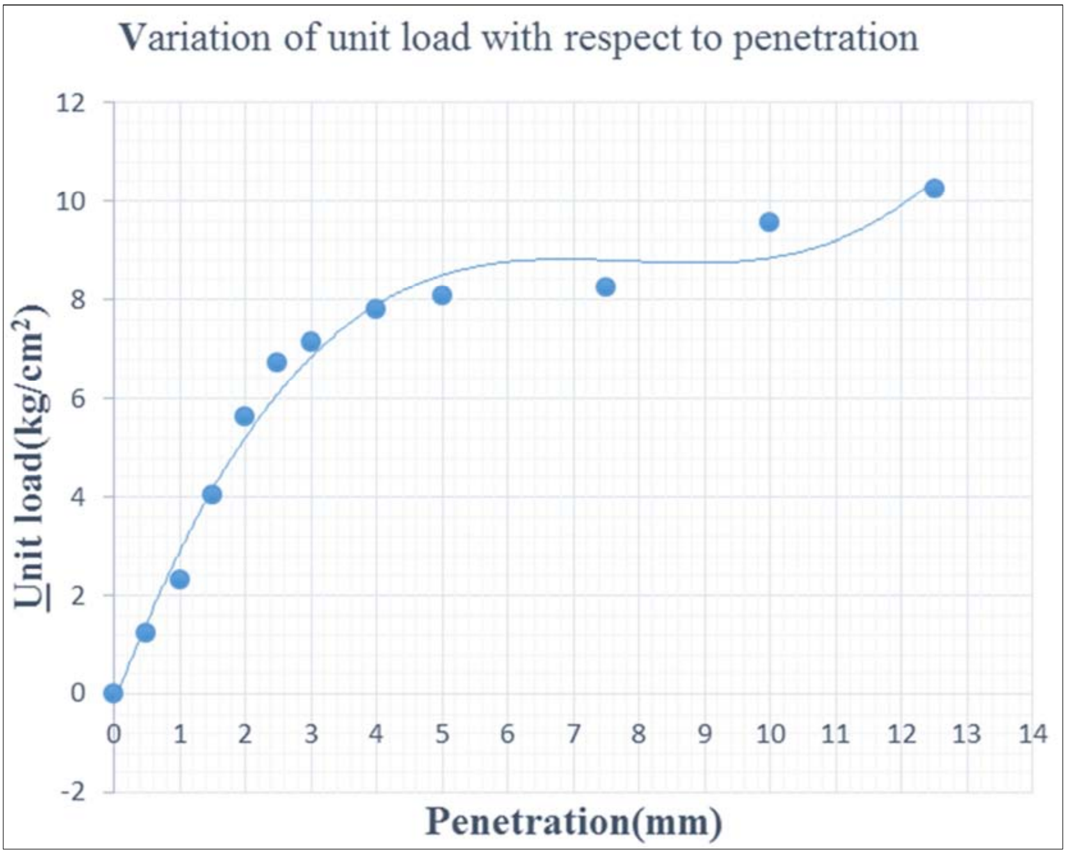

Figure 11. *Variation of unit load with respect to penetration for sand: coal mine dust= 80%: 20%.*

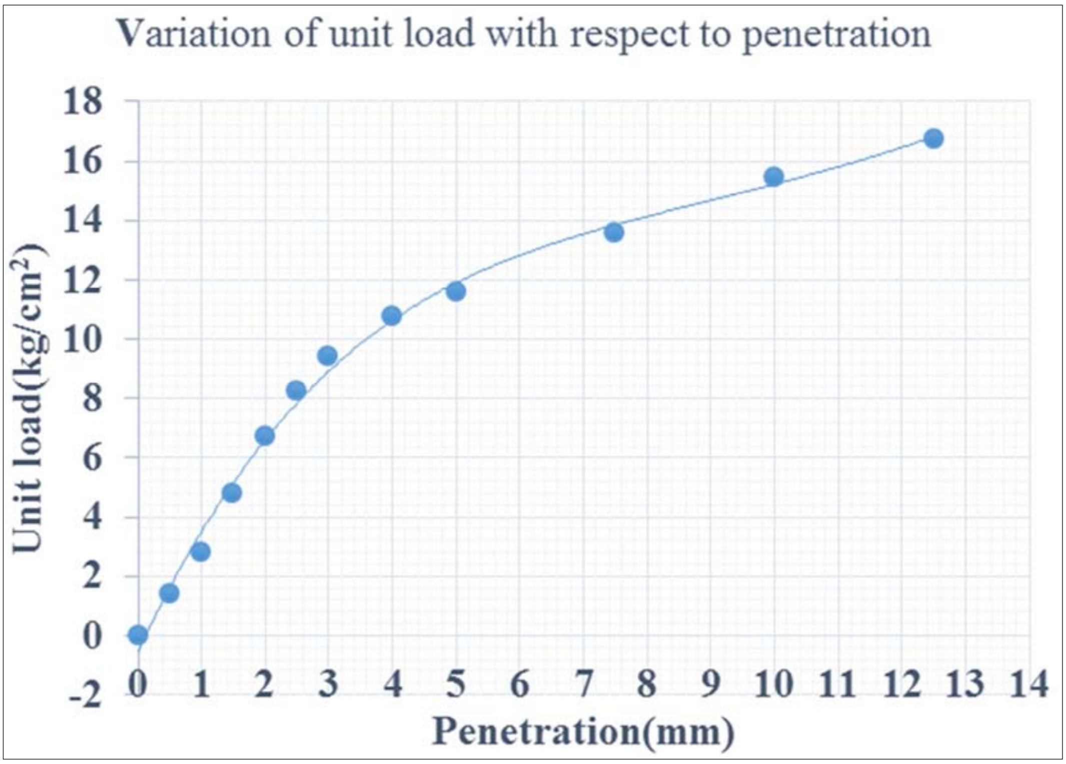

Figure 12. *Variation of unit load with respect to penetration for sand: coal mine dust= 70%: 30%.*

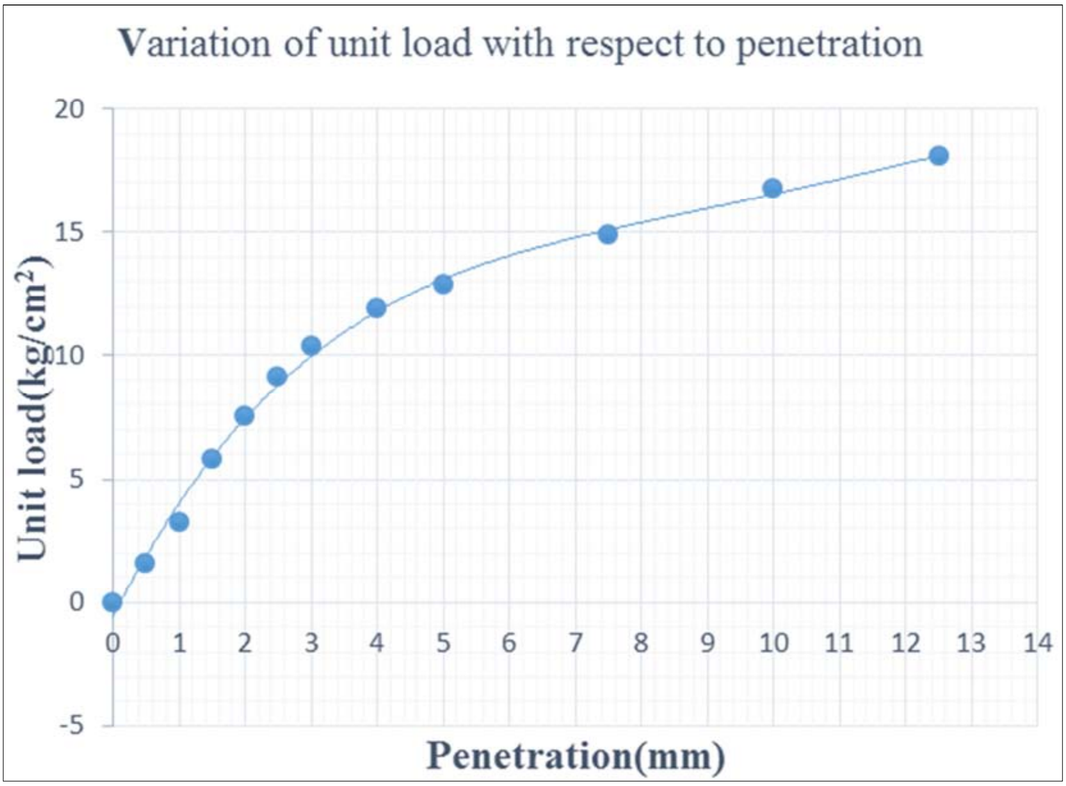

Figure 13. *Variation of unit load with respect to penetration for sand: coal mine dust= 60%: 40%.*

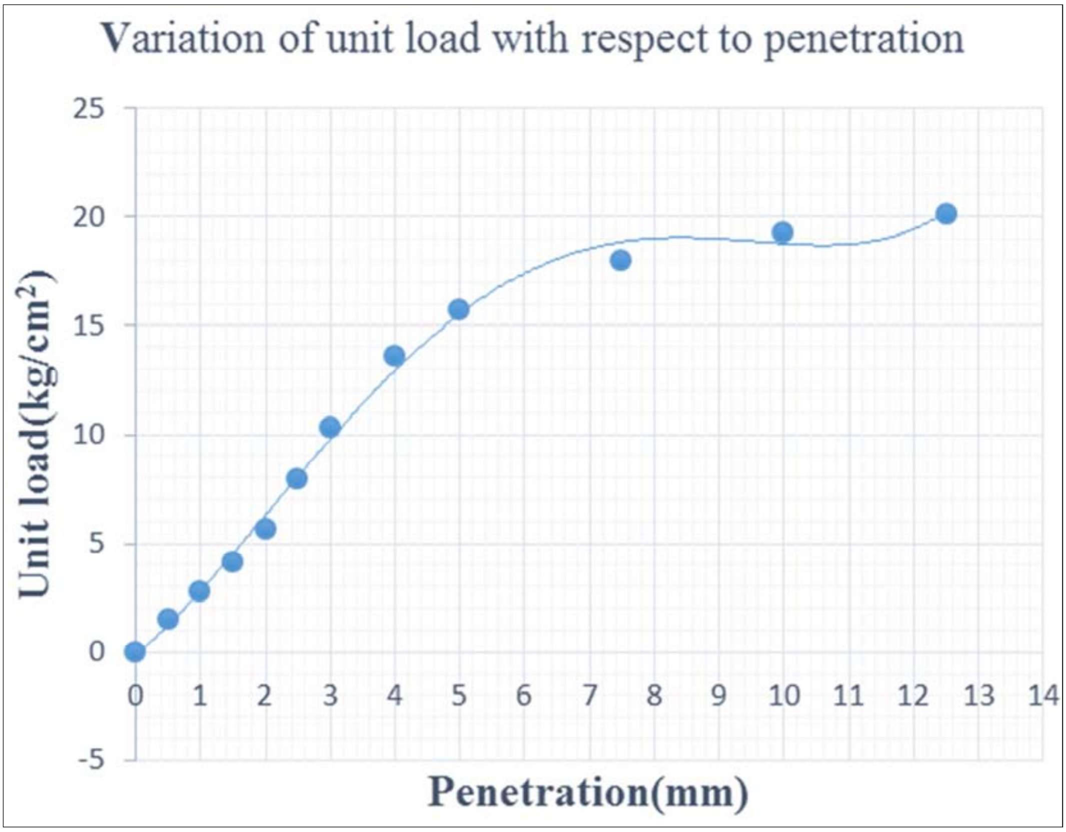

Figure 14. *Variation of unit load with respect to penetration for sand: coal mine dust= 50%: 50%.*

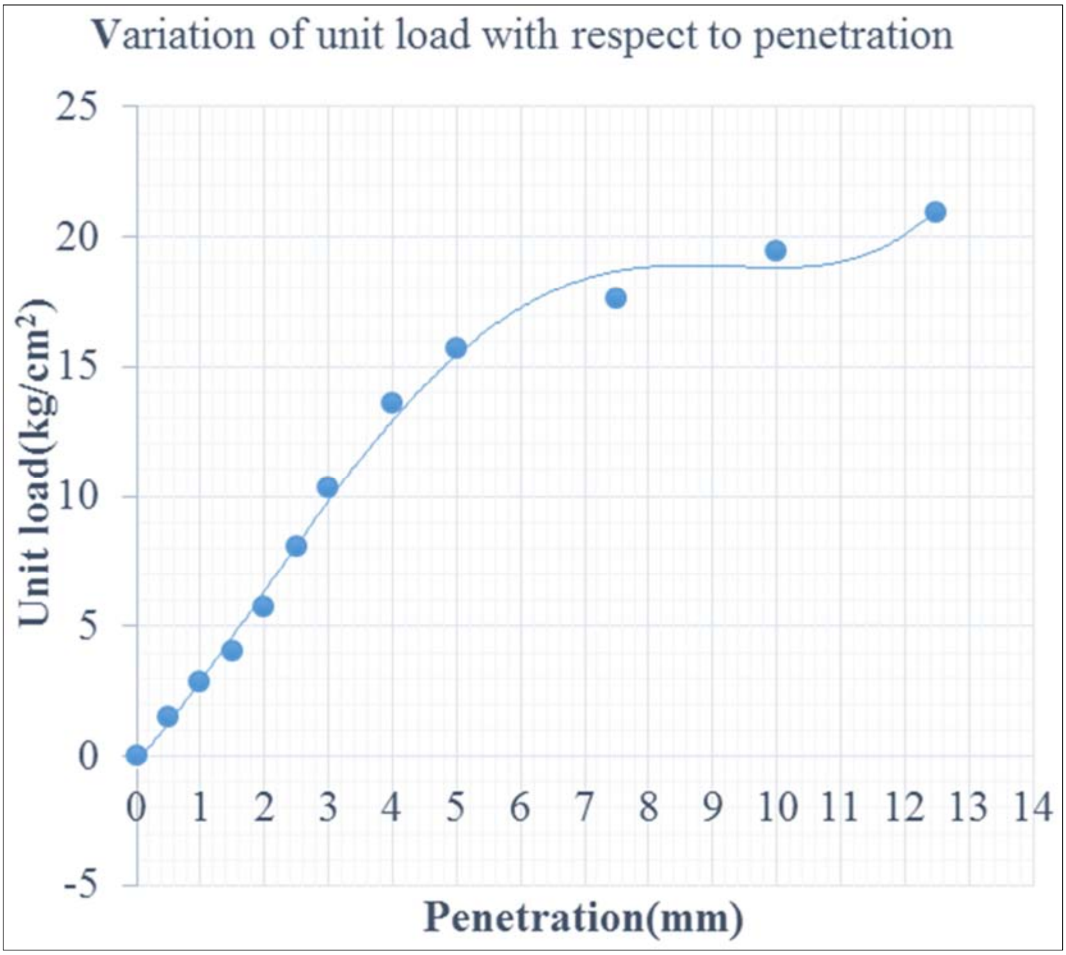

Figure 15. *Variation of unit load with respect to penetration for sand: coal mine dust= 50%: 50%.*

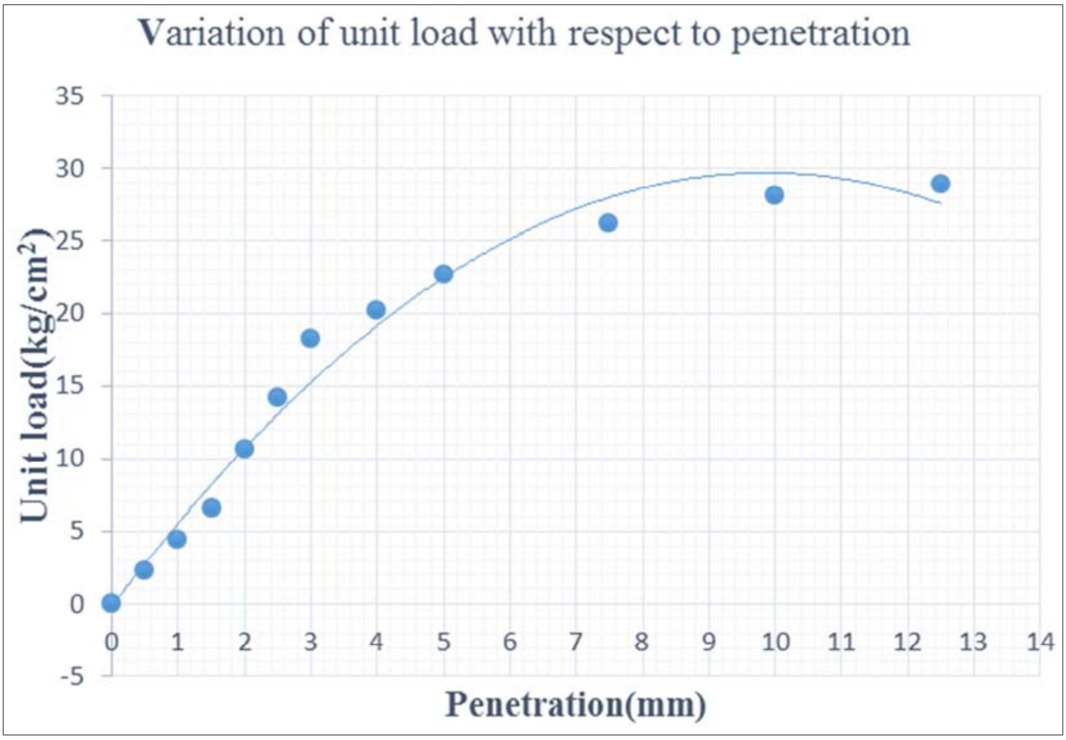

Figure 16. *Variation of unit load with respect to penetration for coal mine dust.*

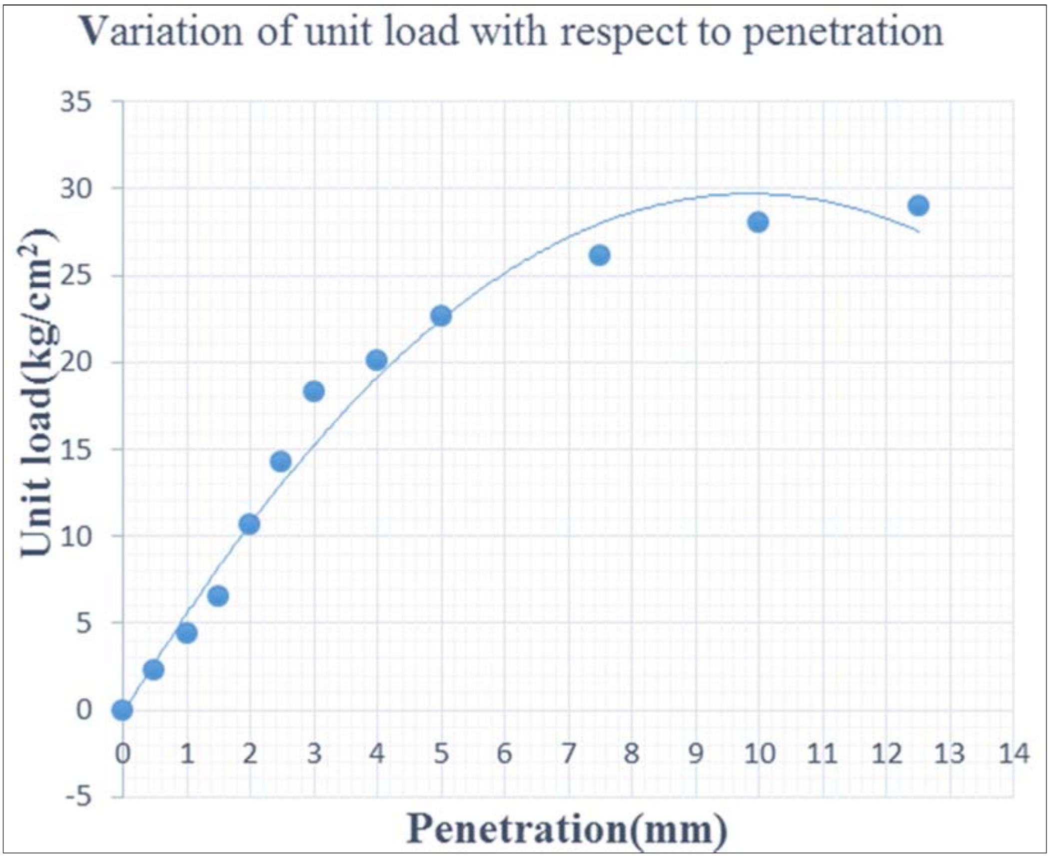

Figure 17. *Variation of unit load with respect to penetration for coal mine dust.*

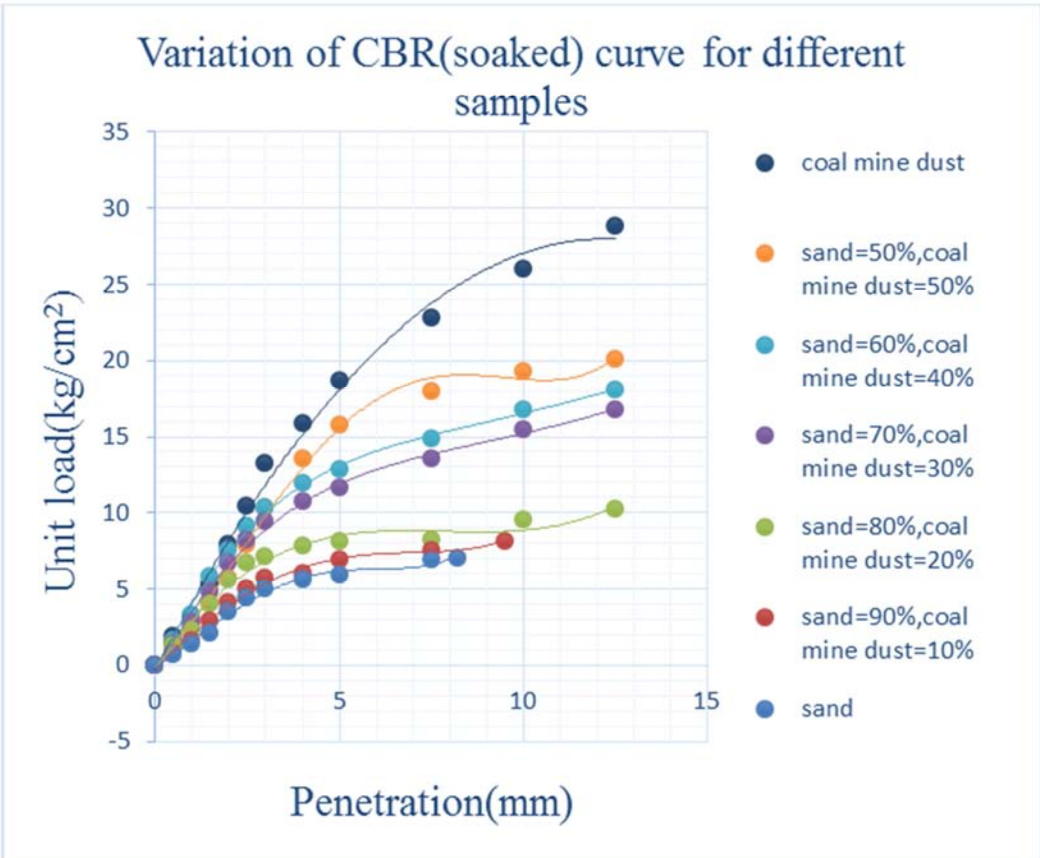

Figure 18. *Variation of CBR(soaked) curve for different samples.*

From this graph, it is clear that CBR of coal mine dust is higher than sand. And with the increase of percentage of coal mine dust CBR gradually increase. It is also found that, sand fails earlier than coal mine dust. Again, expansion ratio of coal mine dust is higher than sand. And expansion ratio decreases with the decrease of percentage of coal mine dust.

California Bearing Ratio (CBR) Test (un-soaked)

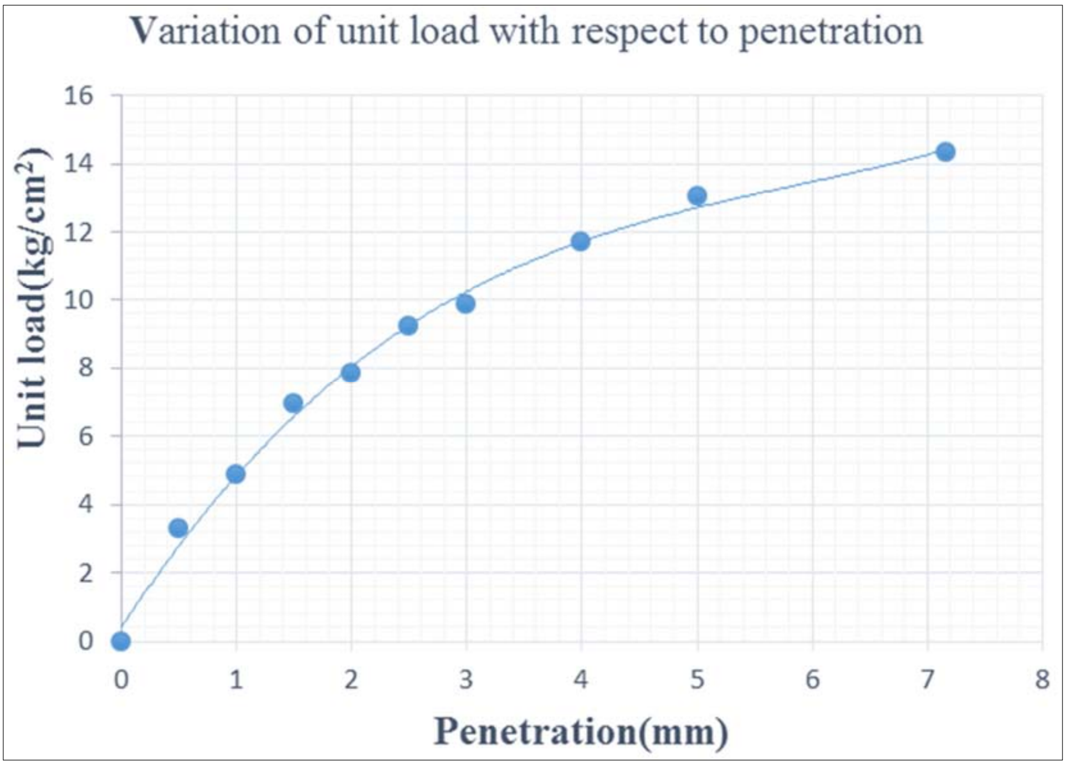

Figure 19. *Variation of unit load with respect to penetration for sand.*

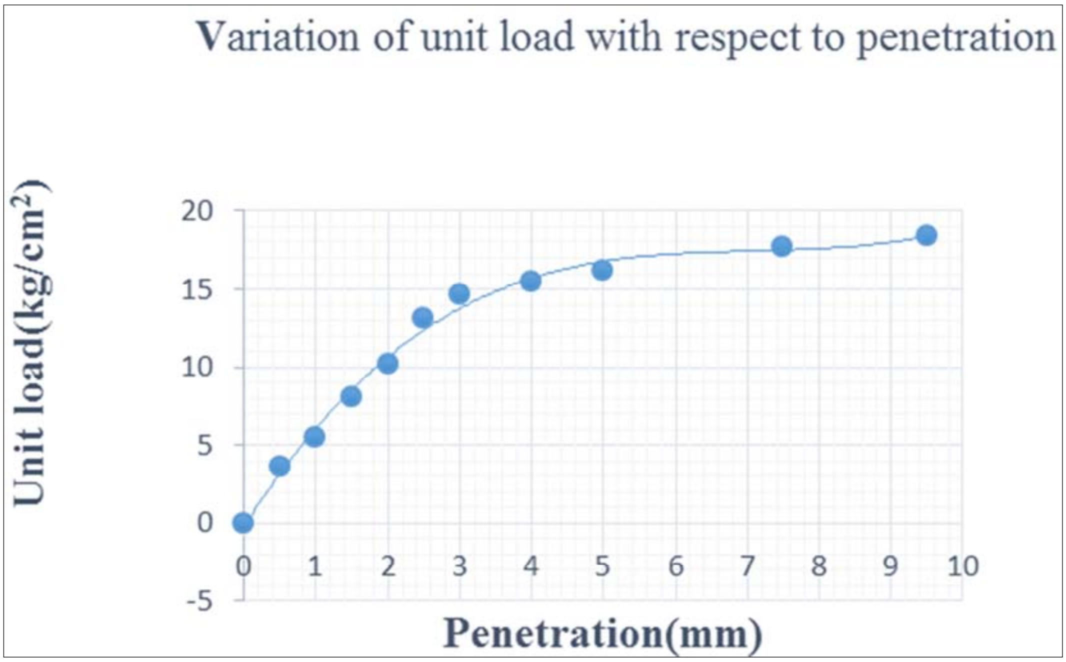

Figure 20. *Variation of unit load with respect to penetration for sand: coal mine dust= 90%: 10%.*

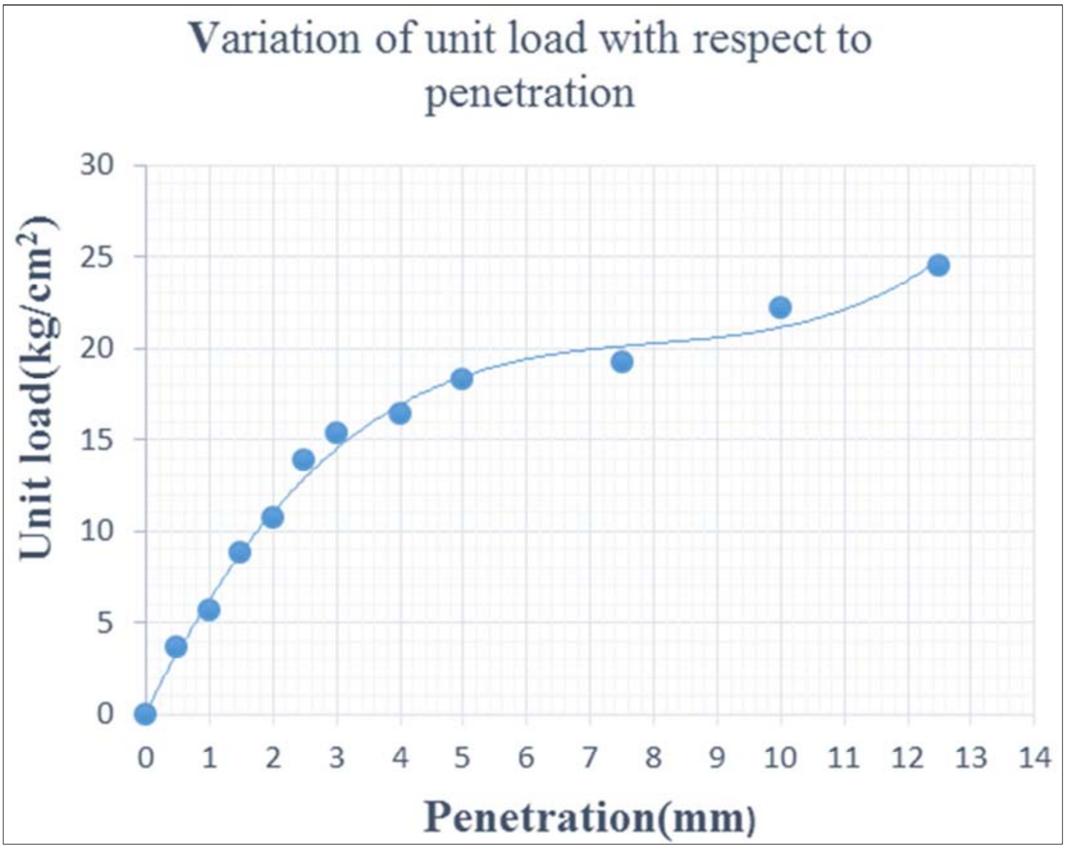

Figure 21. *Variation of unit load with respect to penetration for sand: coal mine dust= 80%: 20%.*

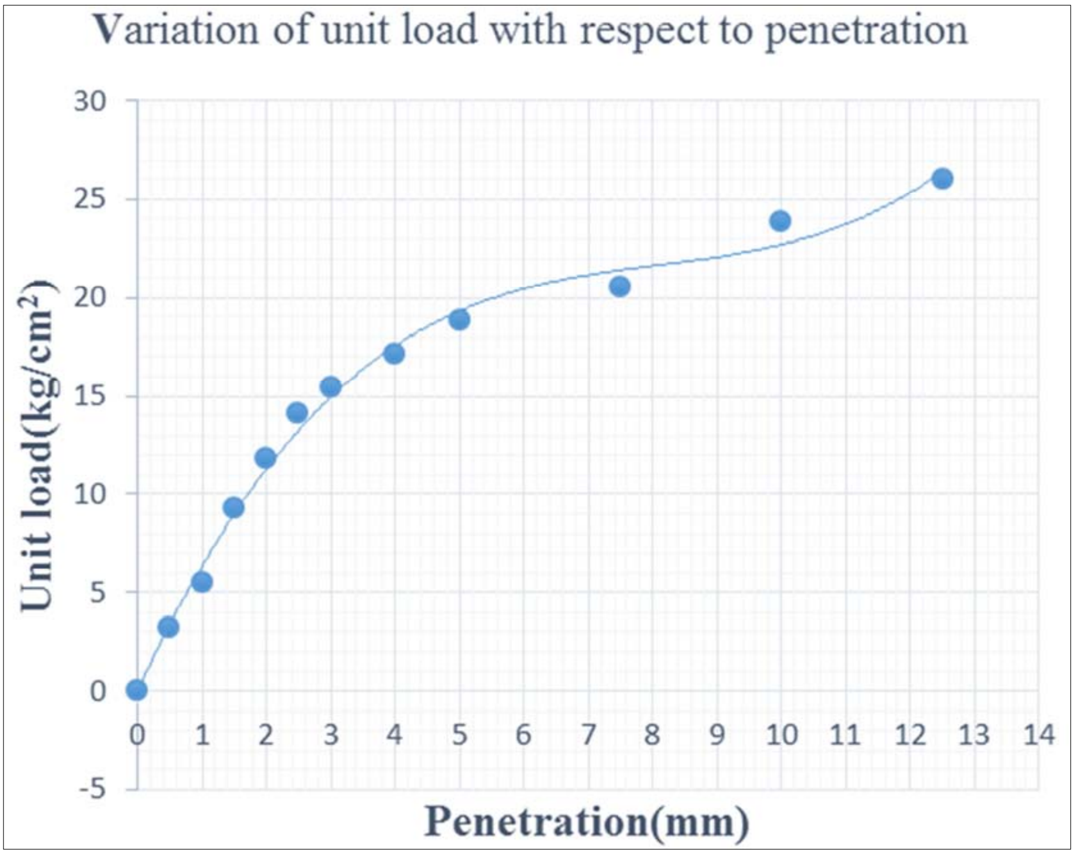

Figure 22. *Variation of unit load with respect to penetration for sand: coal mine dust= 70%: 30%.*

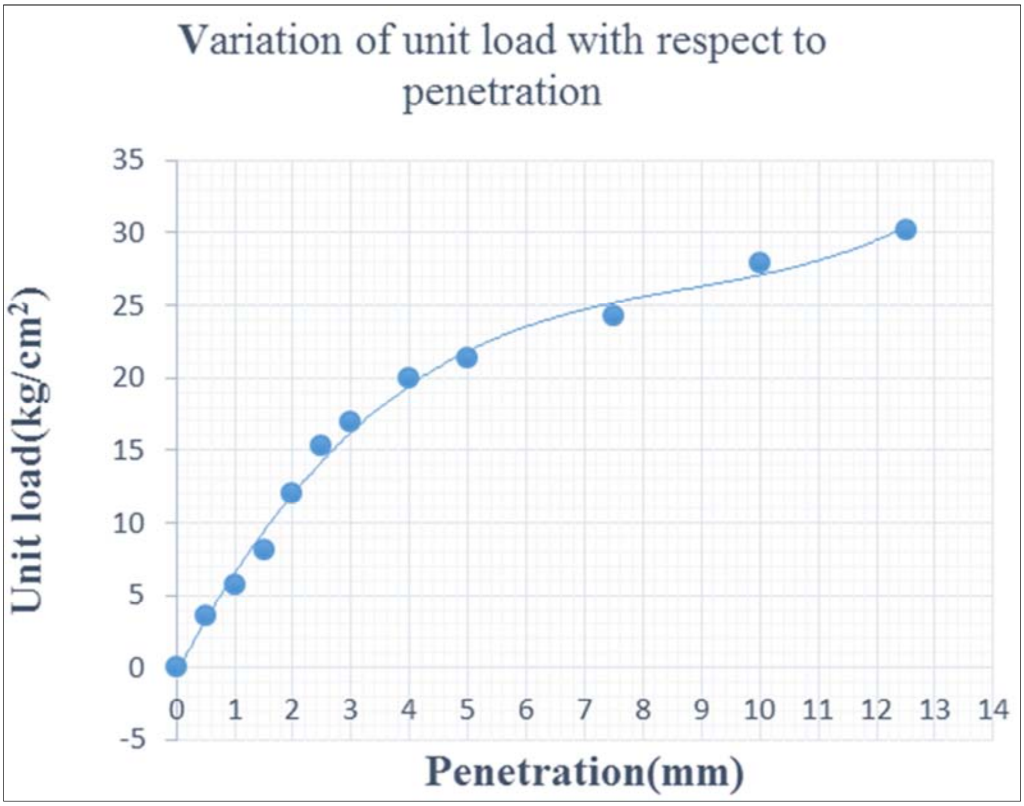

Figure 23. *Variation of unit load with respect to penetration for sand: coal mine dust= 60%: 40%.*

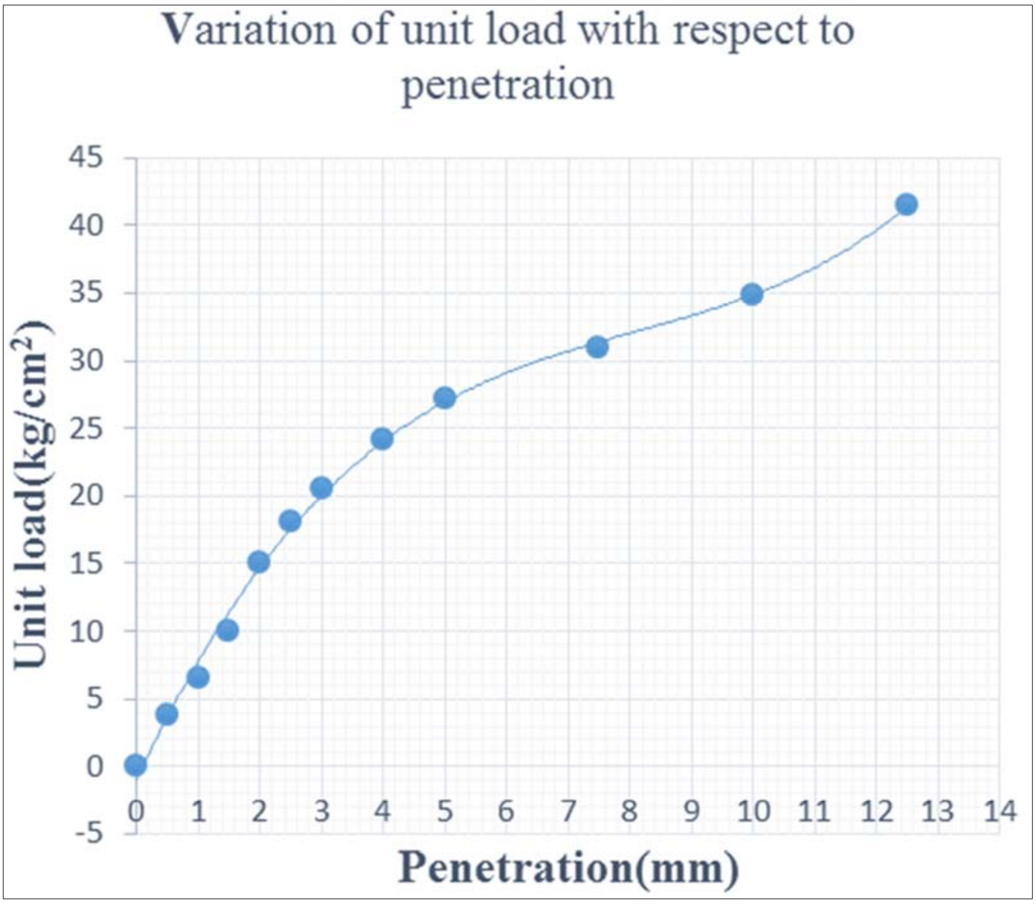

Figure 24. *Variation of unit load with respect to penetration for sand: coal mine dust= 50%: 50%.*

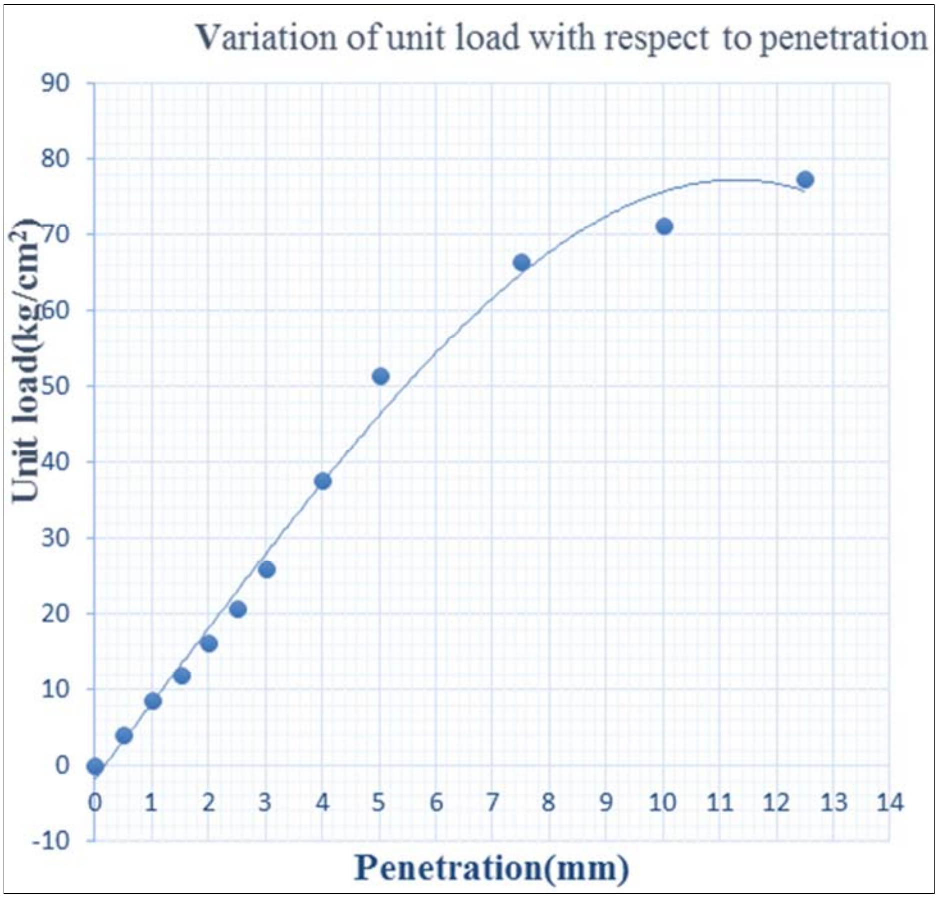

Figure 25. *Variation of unit load with respect to penetration for coal mine dust.*

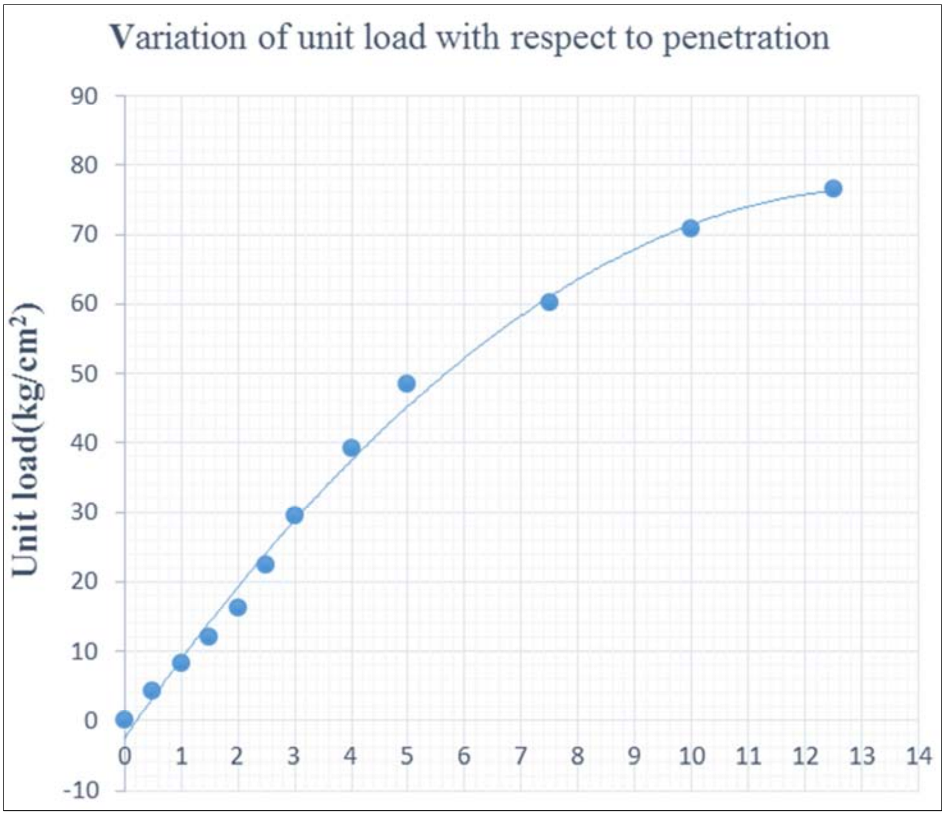

Figure 26. *Variation of unit load with respect to penetration for coal mine dust.*

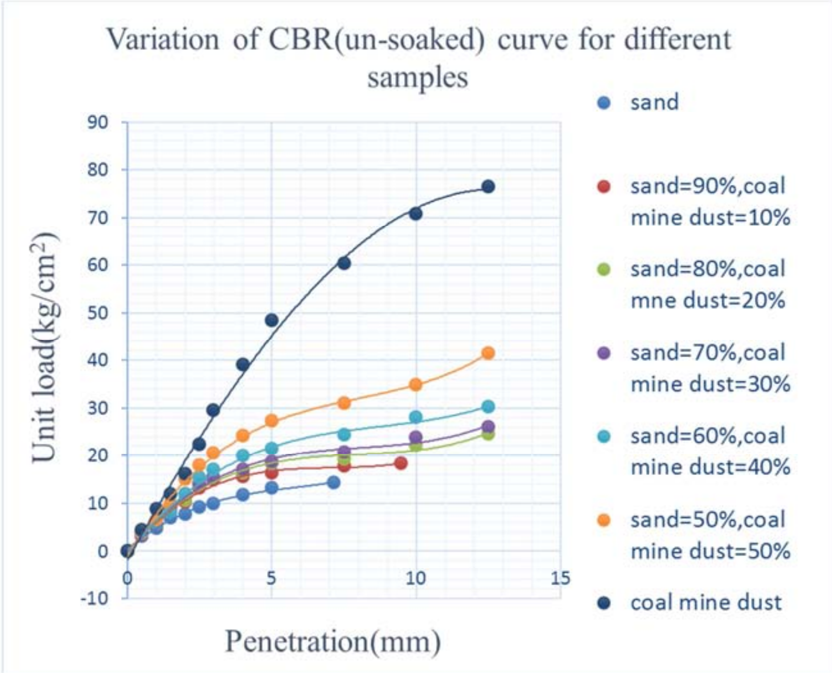

Figure 27. *Variation of CBR (un-soaked) curve for different samples.*

This graph shows that un-soaked CBR of coal mine dust is higher than sand. And with the increase of percentage of coal mine dust CBR gradually increase. For coal mine dust, CBR at 5mm is higher than 2.5mm. It is also found that, sand fails earlier than coal mine dust.

Table 4. *Tabulated results of CBR value & expansion ratio for soaked condition and CBR value of un-soaked condition.*

Sample	CBR (%) Soaked	Expansion Ratio (%)	CBR (%) Un-soaked
Sand	5.87	0.15	13.15
Sand: Coal mine dust = 90%: 10%	6.71	0.304	17.85
Sand: Coal mine dust = 80%: 20%	8.86	0.61	18.29
Sand: Coal mine dust = 70%: 30%	11.43	0.86	18.57
Sand: Coal mine dust = 60%: 40%	12.71	1.02	20.71
Sand: Coal mine dust = 50%: 50%	14.76	1.24	25.43
Coal Mine Dust	21.05	1.93	42.85

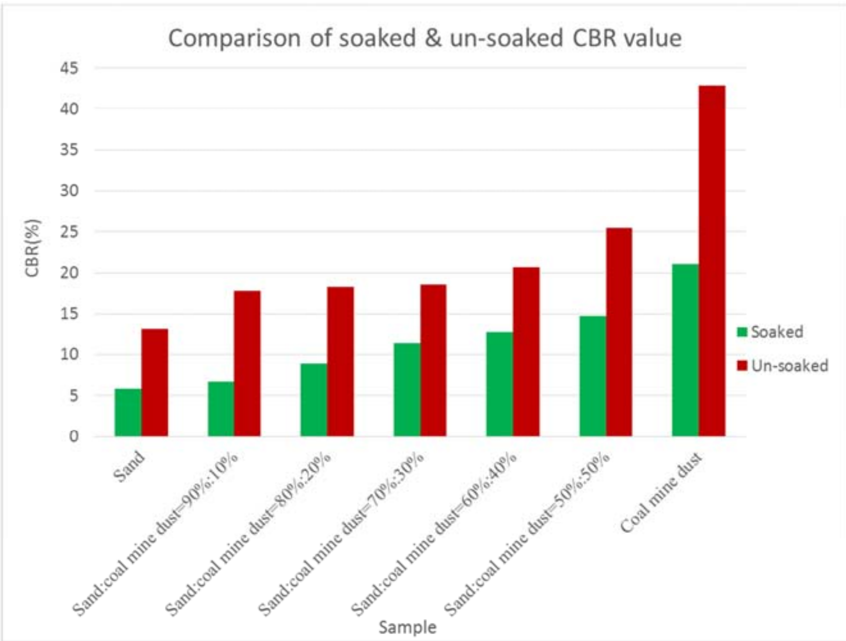

Figure 28. *Comparison of soaked & un-soaked CBR value for different samples.*

LGED requirements for improved subgrade

According to "Road Pavement Design Manual (1999)" provided by LGED, Bangladesh, subgrade materials should have the following requirements-

- Expansion Ratio must be less than 1%.
- For improved subgrade minimum CBR should be= 5%.
- If CBR value of the sub-grade or improved sub-grade material is more than 30%, in that case no sub-base is required.

5. Conclusion

According to the study above, we may find the following conclusions-

Specific gravity, MDD, CBR for soaked & un-soaked for sand were respectively 2.37, 1.61gm/cm^3, 5.87%, 13.15% and for coal mine dust were respectively 1.463, 1.03gm/cm^3, 21.05%, 42.85%.

With the increase of percentage of coal mine dust, CBR (both soaked & un-soaked) value increase & expansion ratio also increase.

Analyzing the results and comparing them with LGED requirements it may be concluded that, 30% coal mine dust mixed with 70% sand would be the suitable proportion for using as subgrade material.

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