A Comparable Study on Selection of Suitable Filling Materials for Plinth

Farheena Firdousi Islam
Assistant Professor
Department of Civil Engineering
Royal School of Engineering & Technology
Guwahati, Assam.

Uddipan Das
BE Civil Engineering
Royal School of Engineering & Technology
Guwahati, Assam.

Manas Pratim Mahanta
BE Civil Engineering
Royal School of Engineering & Technology
Guwahati, Assam.

Nabajit Thakuria
BE Civil Engineering
Royal School of Engineering & Technology
Guwahati, Assam.

Abstract- In a structure, the plinth and the foundation is the most important part as it transfers the load coming from the super structure and ground it to the earth. This plinth and the foundation are to be filled by some filling materials. So the selection of this filling material has to be done such that it is economic, easily available and transfers the load without failure. Here in this project we took different samples of the commonly used filling materials and other materials that can be used as filling materials and compared their properties, economy and the availability to find the best filling material that can be used.

I. INTRODUCTION

When a structure is constructed within the reach of civil engineering, the first and foremost criterion is to make it safe for the given load and economic. All the calculation is put in practice to make the load applied in the superstructure to pass to the sub structure beneath the earth level so that the load get easily dispersed in the earth's crust. This sub structure and the super structure is joined by the plinth. Plinth is that part of the structure that transfers the load from the super structure to the sub structure. The plinth of the structure is of certain height and is filled by the various materials. As the plinth is one of the important part of the structure the property of the filling materials used in the plinth is also important to know. As different material is used, each material will have different property and thus different effect in the structure. The different filling material that could be use is red clayey soil, stone dust, brick dust, sandy soil etc.

1.1. General: Sites of sample collection- There are three basic sites for collection of the materials.

- Guwahati: GPS Location: Latitude: 26.19° N
  Longitude: 91.75° E

- Goalpara: GPS Location: Latitude: 26^{o}17'73"N
  Longitude: 90^{o}62'46"E

- Hajo: GPS Location: Latitude: 26°25'3"N
  Longitude: 91°53'17"E

1.2. Samples- The samples that have been chosen for the test in the project are Red Soil, Brick Dust & Sandy soil. The properties of the samples are as follows:
Moreover Sample 1 of the samples taken is from Guwahati, Sample 2 from is Hajo and Sample 3 is from Goalpara.

1.3. Red Soil: Red soil is soil that has a reddish tinge as a result of the presence of iron compounds in it. There are a number of different kinds of soil that is red, and simply identifying the colour does not provide very much information about it other than verification that it is probably high in iron. For more information about a specific soil, testing is needed to learn about its composition. This type of soil tends to form in climates that are warm, temperate, and moist. Sometimes, red soil is left over from older climate conditions, and in regions where iron-rich sedimentary rock is present, the rock provides clues into the prior climate. The texture of red soils varies from sand to clay, the majority being loams. Their other characteristics include porous and friable structure, absence of lime, kankar and free carbonates, and small quantity of soluble salts. Their chemical composition include non-soluble material 90.47%, iron 3.61%, aluminium 2.92%, organic matter 1.01%, magnesium 0.70%, lime 0.56%, carbon dioxide 0.30%, potash 0.24%, soda 0.12%, phosphorus 0.09% and nitrogen 0.08%. However significant regional differences are observed in the chemical composition. In general these soils are deficient in lime, magnesia, phosphates, nitrogen, humus and potash. Intense leaching is a menace to these soils. On the uplands, they are thin, poor and gravelly, sandy, or stony and porous, light-coloured soils. But on the lower plains and valleys they are rich, deep, dark coloured fertile loam.

1.4. Brick Dust: Brick dust is the by- products of crushing of bricks of size 0 – 2 mm. Since it is of category of very fine aggregate it can be use as filling material because it forms a hard and load bearing surfaces. As it is a by product, its use make the work more economic.

1.5. Sandy Soil: The soil profile near the river consists of very loose sandy soil up to a depth of 3-4 m from the ground level. Sandy soil belongs to the light category due to its light weight and grainy texture. Due to its high sand content it is more porous than the others. Sandy soils are characterized by less than 18% clay and more than 68% sand in the first 100 cm of the solum. These soils have developed in recently deposited sand materials such as alluvium. They are weakly developed and show poor horizonation. Soils characterized by a high proportion of sand in the first 100cm can also correspond to the upper part of highly developed soils formed in weathered quartz-rich material or rock, as evidence by the development of a highly depleted horizon. Sandy soils are often considered as soils with physical properties easy to define, weak structure or no structure, poor water retention properties, high permeability, highly sensitivity to compaction with many adverse consequences. However, analysis of the literature shows that their physical properties are far from simple. This is particularly true in the tropics where sandy soils are subjected to a cycle of wetting and drying that greatly affects the soil with small differences in composition leading to significant differences of physical properties. Sandy soils are characterized by a lack of structure or that it is weakly development.

Civic surveys were also carried out in these areas. The main objective of this survey was to determine
- Use of soil available in day to day activities.
- Quality of soil based on people's observation
- Any difference of soil in comparison to earlier times.

The tests that are performed in this project are the Standard Proctor test and California Bearing Ratio test. The apparatus that have been used in the Standard Proctor test are the conventionally used apparatuses and they are a hammer weighing 2.5 kg, a mould of 1000cc volume. Number of blows given is 25 per layer and the soil is compacted in 3 different layers.

II. EXPERIMENTS

2.1. Experiment: Standard proctor test-
2.2. Parameters of Standard Proctor Test:

- Moist unit weight γ = (weight of the compacted moist soil) / (volume of mould.)
- Dry unit weight (γd) = γ / (1 + w (%)/ 100); ***w: water content.***
- Plot a graph showing γd vs. w (%) and determine the maximum dry unit weight of compaction, γd (max).

- Also determine the optimum moisture content corresponding to γd(max).

2.3. *Description of soil: Red soil sample***:**

Volume of mould = 1000cm^{3,} Weight of hammer = 2.5kg, No. of blows / layer = 25, No. of layers = 3

TABLE 1: Standard Proctor test results of Red soil sample 1, 2 & 3.

Parameters	1 (5% wc)	2 (7% wc)	3 (10% wc)	4 (13% wc)	5 (15% wc)
γ (gm/cm^3)					
Sample 1	1.92	2.00	2.05	1.97	1.94
Sample 2	1.91	2.04	2.08	2.04	1.98
Sample 3	1.95	2.07	2.10	2.05	2.01
w **(%)**					
Sample 1	10.8	12.5	13.79	15.8	16.2
	12.5	14.2	15	17	21
Sample 2	10.1	15	16.3	18.1	22
Sample 3					
γ_d (gm/cm^3)					
Sample 1	1.74	1.78	1.80	1.70	1.67
Sample 2	1.69	1.78	1.80	1.74	1.60
Sample 3	1.77	1.80	1.80	1.77	1.65

Figure A: OMC curve for Red Soil Sample 1.

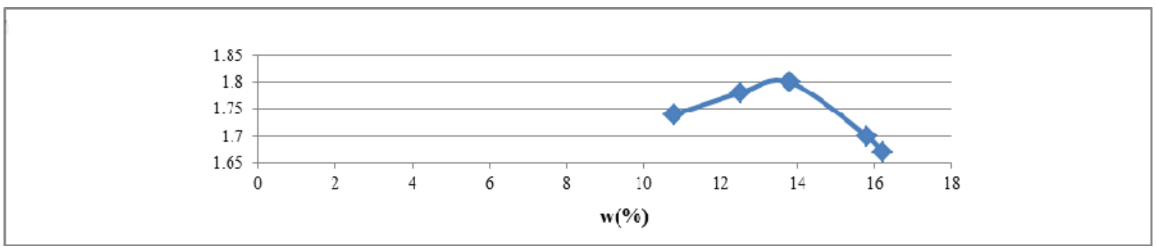


Figure B: OMC curve for Red Soil Sample 2..

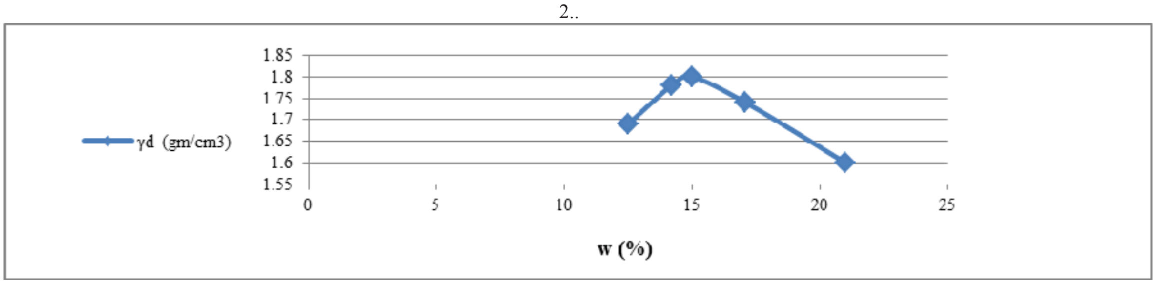
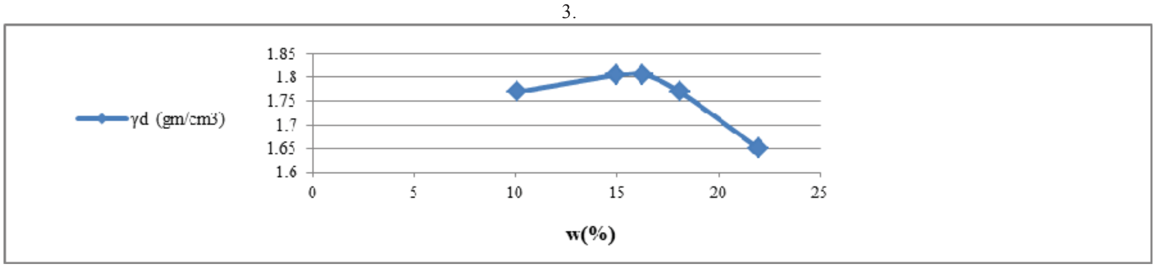


Figure C: OMC curve for Red Soil Sample 3.



2.4. Description of soil: Brick Dust sample:

Volume of mould = 1000cm^{3,} Weight of hammer = 2.5kg, No. of blows / layer = 25, No. of layers = 3

TABLE 2: Standard Proctor test values of Brick Dust sample 1, 2 & 3.

Parameters	1 (7% wc)	2 (10% wc)	3 (13% wc)	4 (16% wc)	5 (19%wc)
γ (gm/cm^3)					
Sample 1	1.72	1.76	1.72	1.68	1.65
Sample 2	1.73	1.77	1.72	1.69	1.62
Sample 3	1.72	1.76	1.73	1.70	1.65
w **(%)**					
Sample 1	13.3	16.6	22	25	27.5
Sample 2	12.5	13.6	15	18.5	20
Sample 3	14	15.2	17.1	19.5	20
γ_d (gm/cm^3)					
Sample 1	1.51	1.52	1.41	1.35	1.30
Sample 2	1.53	1.55	1.52	1.4	1.35
Sample 3	1.51	1.53	1.48	1.4	1.38

Figure D: OMC curve for Brick Dust Sample 1.

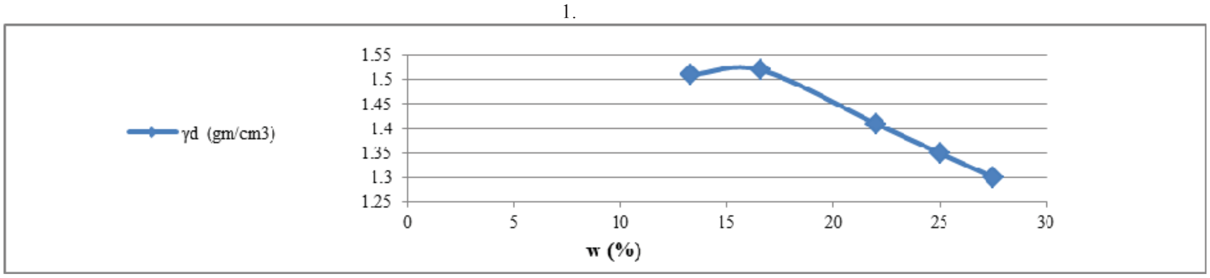


Figure E: OMC curve for Brick Dust Sample 2.

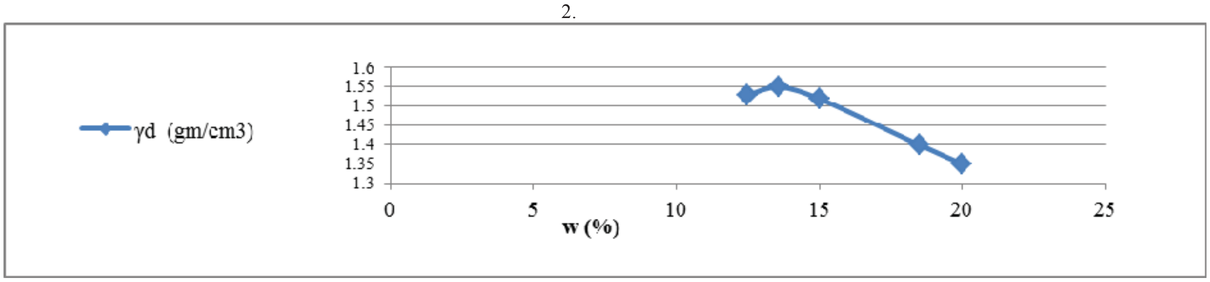
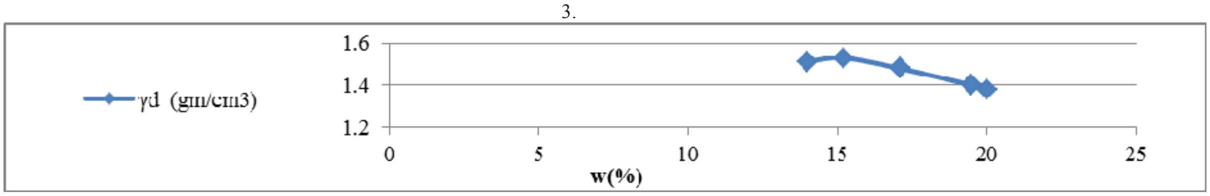


Figure F: OMC curve for Brick Dust Sample 3.



2.5 Description of soil: Sandy soil sample:

Volume of mould = 1000cm^{3,} Weight of hammer = 2.5kg, No. of blows / layer = 25, No. of layers = 3

TABLE 3: Standard Proctor test values of Sandy soil sample 1, 2 & 3.

Parameters	1 (10% wc)	2 (13% wc)	3 (16% wc)	4 (19% wc)	5 (21% wc)	6 (23% wc)
γ (gm/cm^3)						
Sample 1	1.72	1.77	1.93	1.97	1.94	1.93
Sample 2	1.73	1.79	1.91	1.98	1.95	1.93
Sample 3	1.73	1.78	1.91	1.98	1.94	1.92
w (%)						
Sample 1	9	13	15	18	23	25
Sample 2	8	13.3	15.5	17	19.4	22.8
Sample 3	11	14.3	17.1	18.5	20.2	22.3
γ_d (gm/cm^3)						
Sample 1	1.58	1.57	1.65	1.67	1.58	1.54
Sample 2	1.6	1.65	1.68	1.69	1.64	1.57
Sample 3	1.55	1.59	1.64	1.66	1.62	1.57

Figure G: OMC curve for Sandy Soil Sample 1.

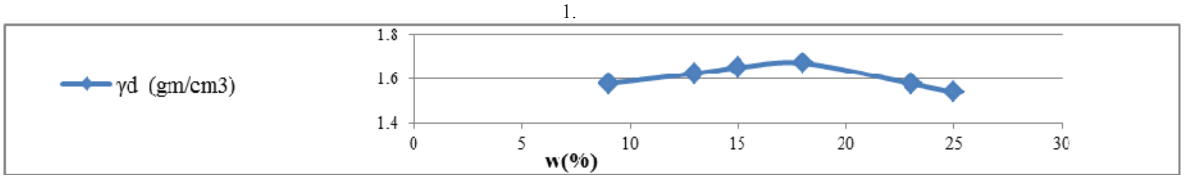


Figure H: OMC curve for Sandy Soil Sample 2.

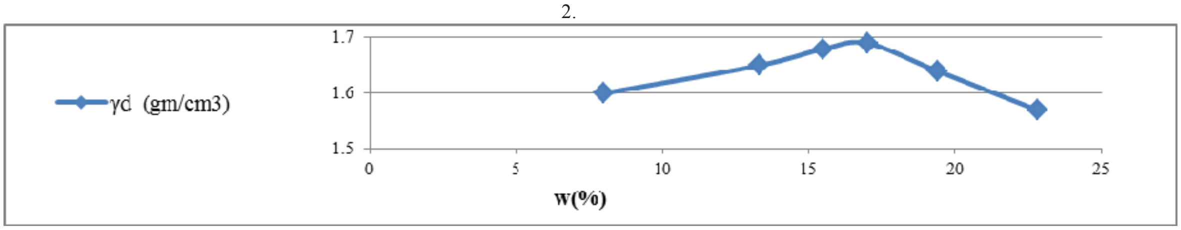
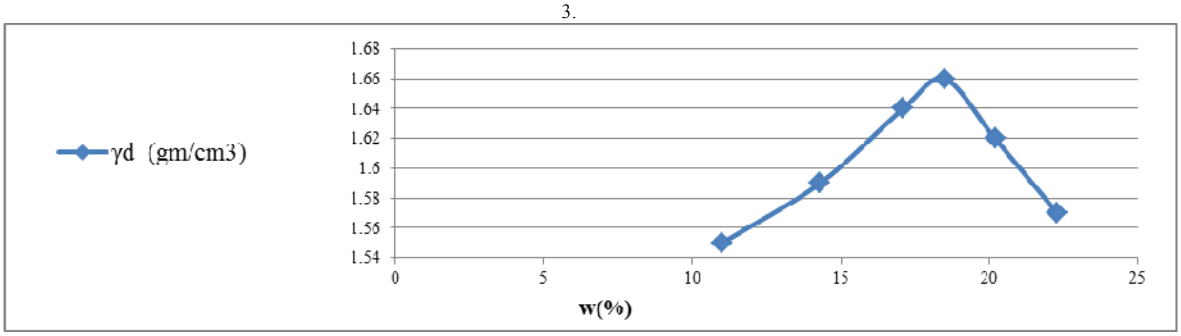


Figure I: OMC curve for Sandy Soil Sample 3.



2.6. Experiment: California Bearing Ratio (CBR)-

CBR % = [(P/P_s) * 100%]

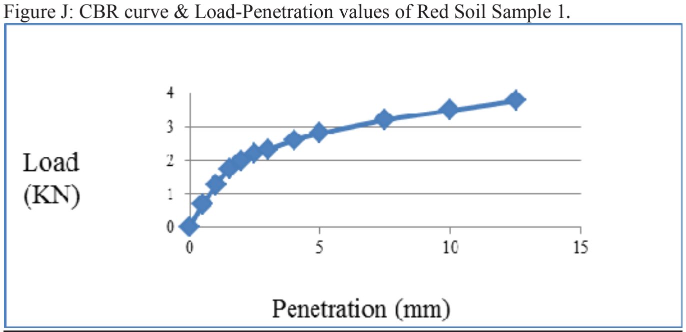
P = measured pressures for site soils (N/mm^2)

P_s= pressure to achieve equal penetration on standard soil (N/mm^2)

2.6.1. RED SOIL SAMPLE 1

Dry density = 1.9 (From Proctor test). OMC = 13.3%

Figure J: CBR curve & Load-Penetration values of Red Soil Sample 1.

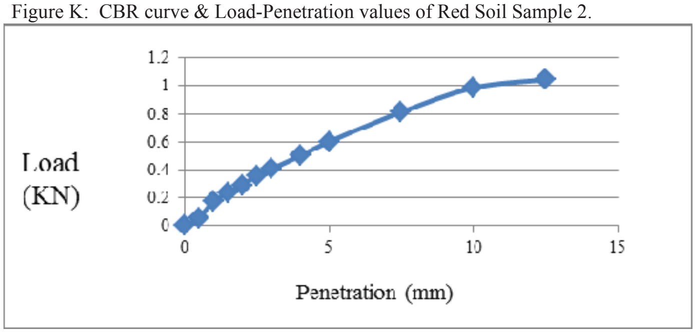


Penetration (mm)	Load (KN)
0.5	0.7
1	1.27
1.5	1.74
2	1.97
2.5	2.2
3	2.32
4	2.6
5	2.8
7.5	3.2
10	3.48
12.5	3.77

2.6.2. RED SOIL SAMPLE 2:

Dry density = 1.82 (From Proctor test). OMC = 15.4%

Figure K: CBR curve & Load-Penetration values of Red Soil Sample 2.

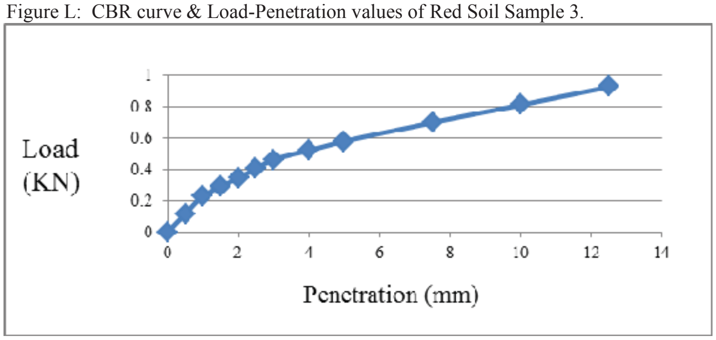


Penetration (mm)	Load(KN)
0.5	0.058
1	0.174
1.5	0.232
2	0.29
2.5	0.34
3	0.406
4	0.5
5	0.6
7.5	0.812
10	0.986
12.5	1.044

2.6.3. RED SOIL SAMPLE 3:

Dry density =1.805 (From Proctor test). OMC = 16.75%

Figure L: CBR curve & Load-Penetration values of Red Soil Sample 3.

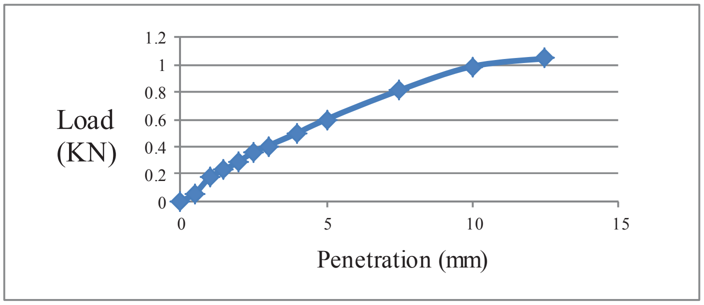


Penetration (mm)	Load (KN)
0.5	0.116
1	0.232
1.5	0.29
2	0.348
2.5	0.406
3	0.464
4	0.522
5	0.58
7.5	0.7
10	0.812
12.5	0.928

2.6.4. BRICK DUST SAMPLE 1

Dry density =1.525 (From Proctor test). OMC =16.6%

Figure M: CBR curve & Load-Penetration values of Brick Dust Sample 1.

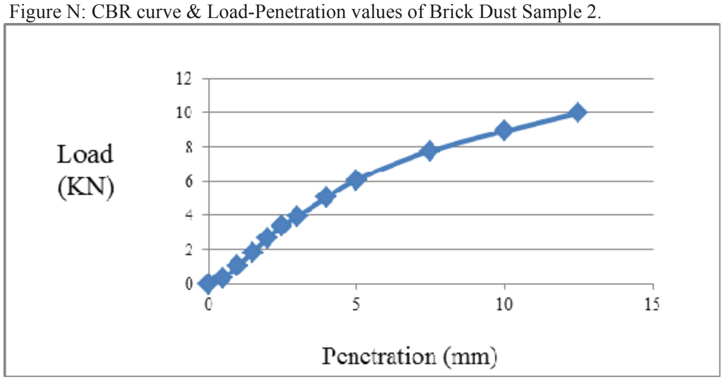


Penetration(mm)	Load (KN)
0.5	0.406
1	1.102
1.5	1.914
2	2.7
2.5	3.422
3	3.944
4	4.93
5	5.8
7.5	7.192
10	8.2
12.5	9.28

2.6.5. BRICK DUST SAMPLE 2:

Dry density = 1.55 (From Proctor test). OMC = 13.5%

Figure N: CBR curve & Load-Penetration values of Brick Dust Sample 2.

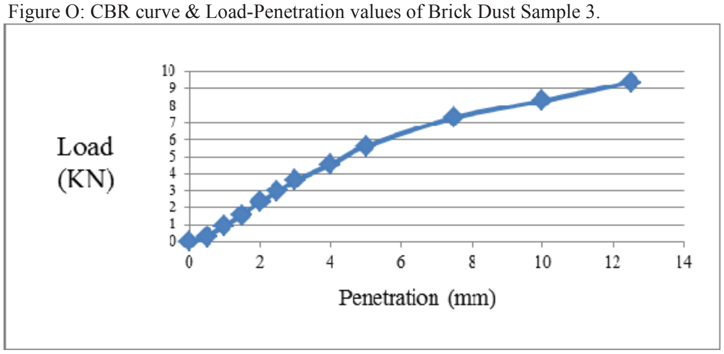


Penetration (mm)	Load (KN)
0.5	0.348
1	1.044
1.5	1.856
2	2.668
2.5	3.364
3	3.944
4	5.046
5	6.09
7.5	7.772
10	8.932
12.5	9.976

2.6.6 BRICK DUST SAMPLE 3:

Dry density = 1.56 (From Proctor test). OMC = 15.1%

Figure O: CBR curve & Load-Penetration values of Brick Dust Sample 3.

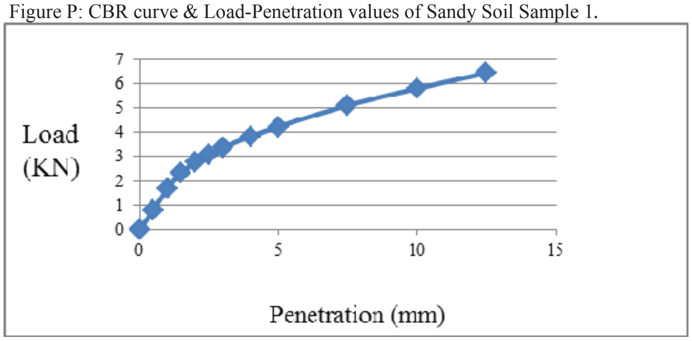


Penetration (mm)	Load (KN)
0.5	0.29
1	0.928
1.5	1.566
2	2.32
2.5	2.958
3	3.596
4	4.524
5	5.626
7.5	7.308
10	8.294
12.5	9.396

2.6.7. SANDY SOIL SAMPLE 1:

Dry density = 1.7 (From Proctor test). OMC =17.5 %

Figure P: CBR curve & Load-Penetration values of Sandy Soil Sample 1.

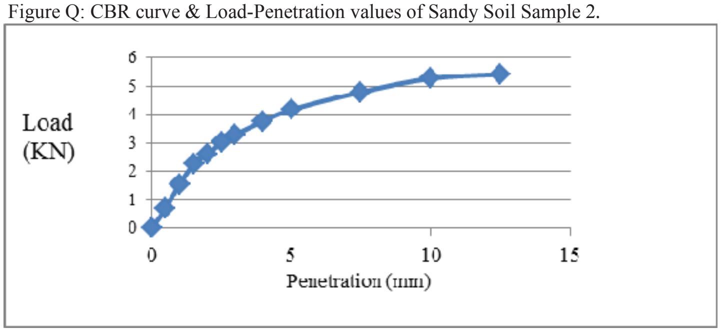


Penetration(mm)	Load (KN)
0.5	0.812
1	1.682
1.5	2.32
2	2.784
2.5	3.074
3	3.364
4	3.828
5	4.234
7.5	5.104
10	5.8
12.5	6.438

2.6.8. SANDY SOIL SAMPLE 2:

Dry density = 1.65(From Proctor test). OMC = 15.52%

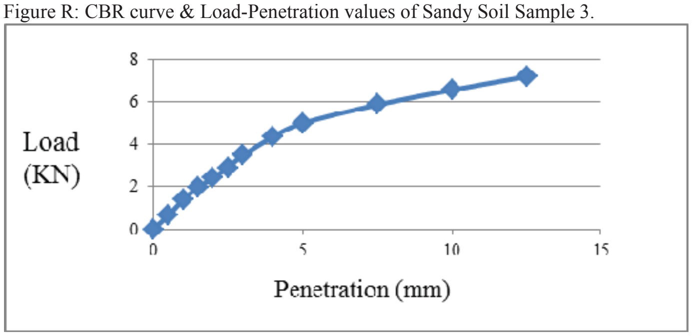
Figure Q: CBR curve & Load-Penetration values of Sandy Soil Sample 2.



Penetration(mm)	Load (KN)
0.5	0.696
1	1.566
1.5	2.262
2	2.61
2.5	3.016
3	3.306
4	3.77
5	4.176
7.5	4.8
10	5.278
12.5	5.452

2.6.9. SANDY SOIL SAMPLE 3:
Dry density = 1.65 (From Proctor test). OMC = 18.55%

Figure R: CBR curve & Load-Penetration values of Sandy Soil Sample 3.



Penetration (mm)	Load (KN)
0.5	0.638
1	1.392
1.5	1.97
2	2.4
2.5	2.9
3	3.48
4	4.35
5	4.988
7.5	5.858
10	6.554
12.5	7.192

III. RESULTS

Sample	Dry density	OMC	CBR at 2.5mm penetration	CBR at 5mm penetration
Red Soil				
Sample 1	1.9	18.55	16.38%	13.90%
Sample 2	1.82	15.4	2.5%	2.9%
Sample 3	1.805	16.75	3.02%	2.87%
Brick Dust				
Sample 1	1.525	16.6	29.3%	28.7%
Sample 2	1.55	13.5	25.05%	30.2%
Sample 3	1.56	13.5	22.031%	27.93%
Sandy Soil				
Sample 1	1.7	17.5	22.89%	21.023%
Sample 2	1.65	15.52	22.46%	20.73%
Sample 3	1.65	18.55	21.76%	24.76%

3.1. Comparison:

Different samples have been chosen that can be used as filling material. Samples have been selected from different zones of Guwahati, Goalpara and Hajo where the samples are easily available. These samples were taken and test was performed on them to check the parameters that could fulfil the criterion of a filling material and the economy. Economy is very much necessary as the amount required is very high. The following are the compared result we get from our observation.

3.2. Compared observation of the samples:

RED SOIL	BRICK DUST	SANDY SOIL
The optimum moisture content of the red soil is found to be nearly about 16.5.	The optimum moisture content of the brick dust is found to be nearly about 14.25.	The optimum moisture content of the sandy soil is found to be nearly about 17.23.
The CBR value of the red soil is about 7.43%	The CBR value of the brick dust is about 29.08%	The CBR value of the sandy soil is about 23.37%
Availability of red soil is uniform and maximum throughout the year but using red soil as filling materials destroys the nature as most of the red soil is found in mountains.	Availability of brick dust isn't much because it is formed by the crushed bricks formed in the brick factory. And sufficient amount isn't available.	Sandy soil is generally available throughout the year. Sandy soil is generally available near the river and thus taking out this soil isn't going to harm the nature. In fact it benefits the river as it can store more water and can be used in future.
Local rates of red soil are less if the location is near hilly or mountain region.	Local rates of brick dust are generally more as it not easily available.	Local rates of sandy soil are less where the location is near riverside area.
Red soil takes much time to be fully settled.	Settlement of brick dust is not uniform	Settlement of the faster than the two.

IV. CONCLUSION

The project undertaken was to determine the suitability of different soil samples of Guwahati as filling material and in this criterion we have been successful. The soil samples were collected from various places of Guwahati and test were performed on it to determine the dry density, optimum moisture content and the CBR values of the collected samples. The results of the various tests are shown with the help of tables and graphs.
Conclusive points from the various results -
The CBR value of the Red soil sample 1, Red soil sample 2 and Red soil sample 3 are found to be 16.38%, 2.9% and 3.02% respectively.

The CBR values of the Brick dust sample 1, Brick dust sample 2 and Brick dust sample 3 are found to be 29.3%, 30.02% and 27.93% respectively.
The CBR values of the Sandy soil sample 1, Sandy soil sample 2 and Sandy soil sample 3 are found to be 22.89%, 22.46% and 24.76% respectively.
The average CBR value of the Red soil sample, Brick dust sample and the Sandy soil sample are 7.43%, 29.08% and 23.37% respectively.
From the above conclusive points we can conclude that the brick dust sample has the highest value of the parameters (all for Guwahati sample) which means it has high bearing strength. It can bear heavy loads effectively and is very less prone to failure. So the brick dust sample is best suitable to be used as a filling material only by the bearing strength whereas the red soil sample is least suitable as the parameters value are very low. But if all the criterion of filling materials is considered sandy soil provides the best filling materials both effectively and economically.

V. SCOPE OF FUTURE STUDY

As the present study has been done only for a particular area in a region, it is difficult to give any definite conclusion. The project emphasizes on the suitability of different samples as filling material. However the suitability is not demonstrated only by the above tests performed. So there is a scope for more detailed research study of the suitability of the materials to be used as filling material.
The project contains only three samples which are tested for the suitability to be used as filling material. However there are many more samples available which have not been tested in the project. Thus there is a scope for future study of those samples which were not tested in the project work.
Further Direct Shear Test can also be performed to find the suitability. In the CBR test the value of penetration can be taken more frequently to get a better result and if the graph is deviated from the normal shape correction factor can be applied to get a better and accurate result.

REFERENCES

[1] BS 1377, Part 1 – 4 (1990) "Methods of test for Soils for civil engineering purposes. British Standards Institution". London. UK. Coduto, D.P., Yeung, M.R., Kitch, W.A. (2011). Geotechnical Engineering: Principles and Practices. IS 2720 Part –8 "Method of test for Soil-Determination of Water Contenent,Dry density relation using a heavy Compaction".
[2] Standards Australia, (2003a). Methods of testing soils for engineering purposes – soil compaction and density tests – determination of the dry density/moisture content relation of a soil using standard compactive effort, AS 1289.5.1.1, Sydney.
[3] Standards Australia (2007). Methods of testing soils for engineering purposes – soil compaction and density tests – determination of field density and field of a soil using a nuclear surface moisture – density gauge – direct transmission mode, AS 1289.5.8.1, Sydney.