Use of Construction and Demolition Waste for Ground Improvement

Pratik Patil
UG student of Vidyavardhini's College of Engineering and Technology
Mumbai University
Mumbai, India

Prakash Panda
Assistant Professor at Vidyavardhini's College of Engineering and Technology
Mumbai University
Mumbai, India

Mehul Neman
UG student of Vidyavardhini's College of Engineering and Technology
Mumbai University
Mumbai,India

Sangram Mhetre
UG student of Vidyavardhini's College of Engineering and Technology
Mumbai University
Mumbai, India

Bhavik Sankhe
UG student of Vidyavardhini's College of Engineering and Technology
Mumbai University
Mumbai, India

***Abstract*—-The construction industry is the 2nd largest economic activity in India. New buildings are constructed and old buildings are demolished regularly. The Objective of this project is to use the demolished waste obtained from slab of a building to improve the strength of a weak soil like Black Cotton soil. Coarser construction and demolition waste particles can be used over finer particles to improve the required properties of a weak soil. Stabilization of weak soil by using suitable waste materials as stabilizers can prove to be an effective and economic method. Tests have to be carried out on black cotton soil and the construction and demolition waste graded between 2.36mm and 4.75mm. Tri-axial test carried on various proportions of waste mixed with soil (0%, 5%, 10%, 15%, 20%) can provides the optimum percentage of waste that should be mixed for maximum strength improvement.**

Keywords—: Concrete waste, Black cotton soil, Triaxial testing, optimum waste percentage, etc.

I. INTRODUCTION

As seen in the 11th five-year plan, construction industry in India is the largest economic activity second only to agriculture. The quantity of waste materials generated per annum from construction and demolition activities vary from 0.25 to 5.14 million tons. Because of the significant expansion of the construction industry, it will be appropriate to link construction and demolition waste generation with the Indian economic growth.

Thus, there is a need to transform these ineffective earth materials into effective subgrade materials. Long term performance of Foundation structure depends on the stability of the underlying soils. Therefore, suitable practices are needed to handle Construction and demolition (Construction and demolished) waste in order to propose a sustainable approach.

There are different types of soils all having varying strength. The construction and demolition waste can be used to improve the strength of soils that are weak. The use of this waste will help reduce the load on dumping grounds and also pave way to sustainable development.

II. LITERATURE REVIEW

Construction over black cotton soil is always a great challenge due to its low load bearing capacity, swelling and shrinkage and low shear strength. It is a general practice to replace the whole soil for a pavement construction or for construction of high-rise building. Such total replacements are generally costly for a low rising structure, mostly rural areas. So, for such constructions, methods of soil stabilization to improve the properties of soil by replacing some part of soil with particular materials can be undertaken.

2.1.1 Archit Jain and Arpit Chawda from RKDF SOE, Indore worked on Stabilization on expansive soil using local demolished waste (Both coarse and fine at different percentage.) they concluded that the specific gravity increased with increase in stabilizer, the plasticity index decreased with increase in stabilizer; Maximum dry density increased and Optimum Moisture content decreased with increase in concrete content and CBR value increased with increase in recycled content. It also Reduced the cost of construction, Environmental Hazards and increased the life of the structure [1].

2.1.2 Fayaz Bhat and Dr. Rakesh Gupta (2018) from SRMEIT, Ambala provided with Summaries of various researches regarding use of construction and demolished waste in pavement subgrade. They concluded that the use of C&D waste enhanced properties of sub-grade, reduced the cost of landfilling. They observed that coarser aggregates were used but finer aggregates were avoided which could be used for improving the packing density of soil [2].

2.1.3 Ashutosh Kumar and Pankaj Rathod (2018) studied various papers and identified the gaps present in them. They observed that coarser particles were used and finer particles were avoided. They also suggested use of fibres for improving the properties of soil [3].

2.1.4 Mr. Kerin, Mr. Sonthwal and Mr. Jain (2015) reviewed stabilization of clayey soil using demolished waste material and its various methods. They concluded that Swell percentage and swelling pressure are significantly reduced by addition of rubber to expansive soil and that Wood ash can't be used as substitute for lime [4].

2.1.5 Anant Kumar and Ankur Dobariya (2014) worked on development of roads in weak soils using brick waste as stabilizer. They concluded that 40% of optimum demolished brick waste content is to be used; Maximum dry density is obtained at 40% mix (1.954 gm./cc) than that of 0% (1.92 gm./cc); Highest CBR value is obtained at 40% Demolished Brick waste; Optimum moisture content for 0% was 13.66 Higher than moisture content at 10, 20, 30, 40, 50 Percentage & Unconfined compressive strength value for 60:40% had increment of 100% than that for virgin soil [5].

2.1.6 Abhijit B S, Kavya S P and Vivek Murthy studied the Effectiveness in Improving Montmorillonite clay soil by construction and Demolition waste. They observed that the plasticity index was found to be decreasing with increase in percentage of Construction and demolition waste; The MDD was found to be increasing in percentage of C & D waste. OMC was observed to be decreasing with increase in waste percentage. 10% C &D waste blended soil was considered optimum after observing compaction characteristics [6].

2.1.7 Parimal kumar, Vivek Shukla and Mallikarjun worked on improving bearing capacity of black cotton soil and its strength at different water content. They concluded that the plasticity index of soil decreased with increase in stabilizer. The MDD increased and OMC decreased; Soil bearing capacity increased [7].

2.1.8 Omar Ibrahim and Firat Ali Cabalar used crushed waste concrete to improve properties of soil. They observed that the liquid limit and the plasticity index of the organic soil decreased as the Crushed waste concrete percentage increased. The increase of CWC content increased the maximum dry density of the organic soil and caused increase in swelling percentage up to certain limit and then started to decrease. The strength of organic soil represented by Unconfined Compressive Strength increases with increase in CWC percentage [8].

2.1.9 S Saravanan, C Venkata and K. Ramkrishnan worked on strength improvement of rural roads and evaluating the effects of powdered waste bricks and prolonged stored cement in the formation of rural roads. They concluded that Soil partially replaced with powdered bricks can be used as a very poor Sub grade Material; soil partially replaced with prolonged cement can be used as a very good Sub grade Material; to optimize the performance of the pavement this can be applied in the rural road formation [9].

2.1.10 Hanna Paul and Sobha Cyrus worked on Suitability of using crushed demolished concrete waste as a stabilizer for weak sub grade soil like Kaolinite soil in flexible pavement. They concluded that the OMC was decreased from 26% to 22 % and MDD increased from 1.24gm/cc to 1.46 gm/cc with 40% addition of aggregate; CBR value increased from 3.4% to 11.2% and with further addition decreased (With 40% addition of this the original CBR value can be increased up to 3.2 times); There was 25 cm decrease in the pavement thickness which accounted to be 45% of the original thickness [10].

2.1.11 MS Akshatha and Bharath worked on improvement in CBR of black cotton soil using brick powder (Demolished brick masonry waste) and Lime. They observed that Black cotton soil after stabilization required CBR value of 8% according to IRC is achieved by stabilizing with replacement of BC soil by 50% BP,4% lime and 30% BP + 1.5% lime [11].

2.1.12 Robert Brooks and Mehmet Cetin worked on aplplication of C&D waste to get pavement thickness for most economical design. They concluded that when the sub grade is strengthened with CDW and CKD and Sub Base of CDW and CKD is used for the most economical pavement design a reduction of 12 inches of sub base thickness is achieved while keeping the top two layers thicknesses the same. When the sub grade is strengthened with CDW and CKD and Sub Base of CDW and CKD is used for the commonly used layer thickness a reduction of 2 inches is gained both in the thickness of surface course and base course [12].

It was observed that coarser aggregates were used and finer aggregates were neglected for soil stabilization. Percentage of construction and demolition waste with respect to soil can be varied between 10% to 40%. It is also possible to use various other additives along with construction and demolition waste. Various tests like CBR, water content, swelling index, particle size distribution and liquid limit have been performed based on which conclusion has been made.

IV MATERIAL AND METHODOLOGY

Black cotton soil is collected from Rachannawadi, Taluka: Chakur, District: Latur. Approximately 200Kg of wet soil is collected. Construction waste are collected from the Bank near the Borivali railway station where the renovation work was taking place. Waste is completely free from wood, broken bricks etc. various tests are conducted for only soil or soil waste and combined mixture of these two to observe the changes.

Step 1: Collection of soil sample and Construction waste.
Step 2: Finding basic properties of soil.
Step 3: Tests to be performed on Soil: Water absorption, Sieve analysis, Specific Gravity, Atterberg's Limits, Standard proctor, etc.
Step 4: Tests to be performed on waste Material: Water absorption, Carbonation, etc.
Step 5: Plotting Deviator vs settlement, Deviator stress vs percentage waste graphs etc.
Step 6: Find the optimum percentage of Construction waste based on Deviator stress

A. Materials properties.

Initially the properties of soil and concrete waste are determined by using various tests as per recommendations of IS code in geotechnical engineering la. Various properties are given below in table I and table II.

TABLE I. INITIAL PROPERTIES OF SOIL

Properties	Result
Specific gravity	2.5788
Liquid limit	79%
Plastic limit	42.1%
Plasticity index	36.9%
Optimum moisture content	40%
Maximum dry density	1.397g/cc
Type of soil based on plasticity chart	MH or OH (Silt or organic soil with high compressibility)

TABLE II INITIAL PROPERTIES OF CONCRETE WASTE

Properties of concrete waste	Value obtained
Water absorption	5.898%
Carbonation test	Carbonated

B. Preparation of soil sample and testing

Construction waste obtained from site is crushed manually and sieved through 4.75 mm sieve and construction waste passing through 4.75mm and retained on 2.36mm is collected separately and stored in polythene bags for further use. The airdried soil sample is sieved and soil passing through 425-micron sieve is collected and stored in polythene bags. Approximately 180 -200 grams of soil is taken which is sufficient to make sample for testing. Depending upon the trials the Construction waste is added to the soil (0%, 5%, 7.5%, 10%, 15%, 20%, 25%, 30%). Optimum moisture content (Some extra water is also added to compensate the water absorption by construction waste) is then added to this soil to make a representative sample. Soil specimen is then trimmed I nto height of 76 mm and diameter of 38 mm. The specimen is then enclosed in a 38mm diameter and about 100mm long rubber membrane, using the membrane stretcher. Spreading back the ends of the membrane over the ends of the stretcher and applying suction between the stretcher and the rubber membranes does by inhalation. The membrane and stretcher easily slide over the specimen, the suction is released, and membrane is unrolled from the ends of the stretcher. Non-porous plates were used on either side of the specimen as neither any pressure is to be measured nor any drainage of air or water is allowed. Removing the fly nuts the porous cylinder is removed from its base. O rings are used to make the specimen water tight.

Fig. 1a.

Fig. 1b.

Fig. 1c.

Fig. 1d.

Fig. 1: a. Testing Machine, b. Used Sample, c. Mix of soil and waste, d. Fresh sample

Prepared specimen is then gently placed over base of the Triaxial cell. After fixing the upper part of the triaxial cell the cell pressure is increased to the required value. When the cell is completely filled with water upper opening is closed and one constant cell pressure is maintained inside the Triaxial cell. Plunger is brought down and kept in contact with the top of the upper porous plate. Proving Ring Dial Gauge and S.D.R. is set to zero initially. When the loading starts the Proving ring dial gauge reading corresponds to various settlement is observed and tabulated. After calculations various graphs of Deviator stress Vs Settlement are plotted and conclusions are made.

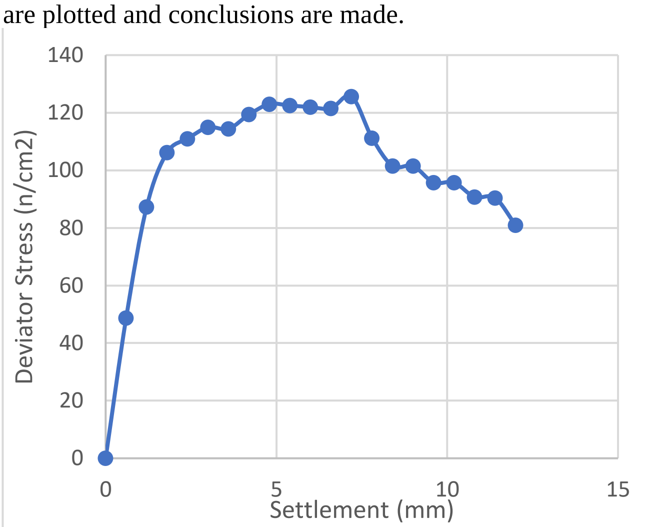

Fig.2: Deviator stress Vs Settlement for Pure soil

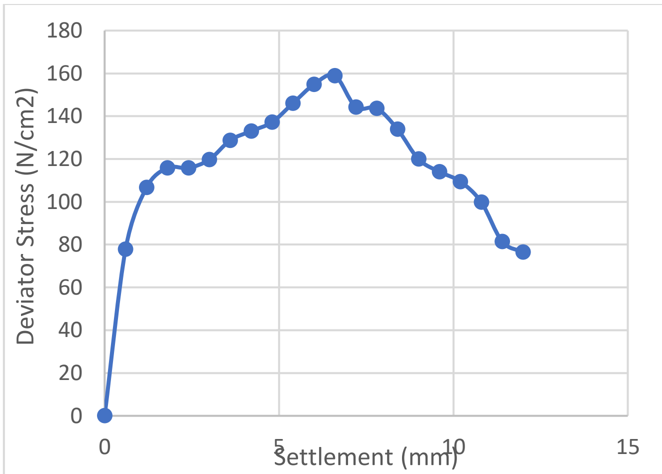

Fig. 3: Deviator stress Vs Settlement for 10% Construction waste.

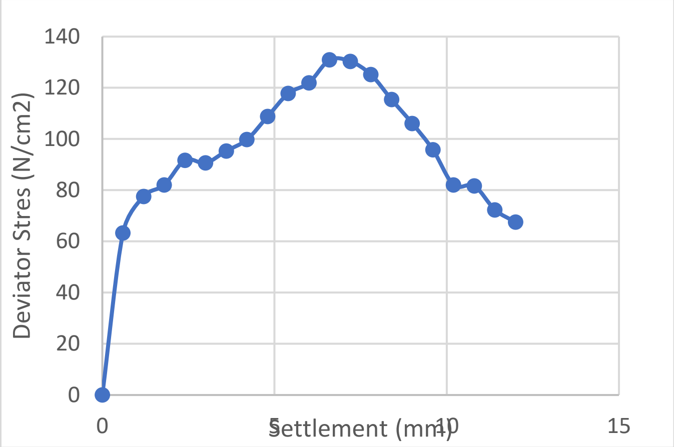

Fig. 4: Deviator stress Vs Settlement for 15% Construction waste.

IV.CONCLUSION

After performing various tests with different proportions of construction waste replaced by black cotton soil, it is observed that there is a increase in load bearing capacity of soil with the addition of construction waste and this load bearing capacity is maximum when the replacement of soil is of 10%.The load bearing capacity of soil increased by 26.49% at 10% replacement, increased by 3.52% at 15% replacement, decreased by 9.64% at 20% replacement , decreased by 61.897 at 30% replacement. Thus, the maximum deviator stress for pure soil increased from 125.66 Kg/cm^2 to 158.95 Kg/cm^2 for soil with 10% replacement with construction waste. Thus, is can be concluded that this method of stabilizing the soil by replacing it with 10% construction waste improves the load bearing capacity and the strength of the poor black cotton soil. The expansive soil present 1m below the foundation level and 1m beyond boundaries of the single storey building is excavated and replaces with the mix of soil and construction waste for more stability.

REFERENCES

[1] A. J. Arpit Chawda, "APPRAISAL OF DEMOLISHED CONCRETE COARSE AND FINES FOR STABILIZATION OF CLAYEY SOIL," International Journal of Engineering science and research technology, Sept. 2016.

[2] F. A. Bhat and D. R. Gupta, "Study of soil stabilization with cement and Demolition waste in Highway subgrade: A review," International Journal for Research in Applied Science and Engineering technology,, vol. 6, July 2018.

[3] A. Kumar and P. Rathod, "Soil Stabilization using demolished concrete waste," International Journal for scientific research and development, vol. 6, pp. 249-251, Jan 2019.

[4] V. Kerni, S. V. Kumar and U. Jain, "Review on Stabilization of Clayey Soil Using Fines Obtained from Demolished Concrete Structures," International Journal of Innovative research in science, Engineering and Technology, vol. 4, May 2015.

[5] A. Kumar, S. Agarwal and A. Dobariya, "Stabilization of cohesive soil using demolished brick waste," Innovations and Advances in Civil Engineering Towards Green and Sustainable Systems , 2014.

[6] Abhijit B S, V. S. Murthy and K. S P, "Study of the effectiveness in improving Montmorillonite clay soil by construction and demolition waste," Journal of Civil Engineering and Environmental Technology, vol. 1, pp. 1-4, August 2014.

[7] V. Shukla, P. Kumar and Mallikarjun, "Stabilization of expansive soils using construction and demolition waste," IRJET, vol. 5, no. 6, pp. 291-295, June 2018.

[8] Omar. A. Adnan and F. A. Cabalar, "IMPROVING SOME GEOTECHNICAL PROPERTIES OF AN ORGANIC SOIL USING CRUSHED WASTE CONCRETE," International Journal of Natural and Engineering science, pp. 100-112, January 2018.

[9] S. Saravanan, C. Venkata, D. Muthu and K. Ramakrishnan, "Construction of Rural roads using construction and demolition waste materials," Indian Journal of science and technology, vol. 9(27), July 2016.

[10] H. Paul and S. Cyrus, "STABILIZATION OF WEAK SUBGRADE SOIL USING DEMOLISHED CONCRETE AGGREGATE," in Indian Geotechnical Conference, IIT Madras, Madras, Dec 2016.

[11] Akshata. R and Bharat. H M, "Improvement in CBR of black cotton soil using Brick powder (Demolition Brick masonry waste) and lime," International Journal of Innovative research in science, Engineering and Technology, vol. 5, Sept 2016.

[12] R. M. Brooks and M. Cetin, "Application of construction and demolition waste for improving performance of subgrade and sub base layers," IJRRAS, vol. 12, Sept 2012.