IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Maximum Soil Stabilization of Combination of Ceramic waste, Lime and CBC Soil

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ABSTRACT

Swelling and shrinkage of soil makes increase structural risk of any infrastructure, the Black cotton soil contains Montmorillonite clay mineral. Montmorillonite clay mineral made up by weak Van der waals force therefore water holding capacity of this soil is comparatively very high and also shows high swelling and shrinkage. In this experimental analysis contain resistance of expensive behavior of soil with respect to ceramic waste and Lime up to certain percentage. Objective of this study is to find optimum utilization of ceramic waste Lime in expensive soil stabilization in this study firstly find optimum use of ceramic waste is 4% than find optimum used of lime by taking constant replacement of ceramic waste as 4%. Optimum value of ceramic waste as 4% and optimum value of lime is found 5%.

Introduction

Expensive nature of soil

The Black cotton soil contains Montmorillonite clay mineral. Montmorillonite clay mineral made up by weak Van der waals force between the unit of clay structure and make therefore water holding capacity (7-10 Å gap Between) of this soil is comparatively very high and also shows high swelling and shrinkage, this property of the soil known as expensiveness of soil [2][3]. The expensive nature makes stability in structure because expensive soil can swell and shrink up to 250% [5]. Therefore it is avoided in construction infrastructure projects.

Geological feature of India Geographical location of India is at N-E quadrant or we can say in first quadrant, it is peninsula surrounded by Arabian sea and pacific ocean, there is variety of soils available

Structural resistance due to expensive soil

India large variety of soil like alluvial, Black soil, Red soil, Laterite, Desert soil, Mouintain soil and peaty soil etc. there is access amount of Black cotton soil major areas contain black cotton soil are good for agriculture point of view.

Figure 1 (Sourc : Soil profile of india pmfias.com government forest website)

Structural resistance due to expensive soil

Sub structure based on soil strata and expensive soil posses high swelling and shrinkage up to 250% of original soil therefore structural stability is reduces as well as structural risk of foundation is increases there is chance to cracks, differential settlement and increase swelling and shrinkage in soil.

Ceramic waste

Ceramic waste are waste produced in building demolition waste contains porcelain materials basically ceramic waste categories in two major categories red paste ceramic waste and white paste ceramic waste, red paste ceramic waste contains burnt clayey material whether white paste ceramic waste material contains china clay like material.

Structural stability of expensive soil due to lime

Lime (CaO) has great binding property, it is used to stabilization of soil to alter the properties of soil and enhance their physical properties. Usually stabilization process increases the shear strength and controls the swell-shrink properties of soil, therefore improvement in bearing capacity of soil.

Literature Support

Waste accumulation due to ceramic waste

Da Silva and V.M. Gois, (2020)- They use ceramic waste as binary and ternary product in clay brick manufacturing and found ceramic waste reduces 23%-82% control over shrinkage and swelling.

Amr S. El- Dieb (2018)- This study gives the composition of random ceramic waste by x-ray method, composition of ceramic waste contains mainly composed by silica(SiO_2) and alumina(Al_2O_3) these two mineral present in 80% of ceramic waste. They found chemical composition of ceramic waste generated by construction and demolition waste is Lime (CaO) 1.70% , silica(SiO_2) 68.60%, Alumina (Al_2O_3) 24.5% , Magnesium oxide (MgO) 2.50% , Iron tri-Oxide(Fe_2O_3) 0.80%, Sulphur tri-oxide 0.12% and Loss of ignition is 1.78%. This chemical composition shows SiO_2 and Al_2O_3 composition is more than 85%, Silica and Alumina is inert material by nature so they can easily replace by any inert material lime is also a constituent, lime have great binding and strengthening capacity.

F.P. Torgal and S. Jalali (2010)- This study is about the classification of ceramic waste on the bases of composition and color, they classify two broad categories one is the red paste ceramic waste and another is white paste ceramic waste.

Expensive nature of Black cotton soil

Oza and Gundaliya,(2013)- They studied Soil consist of Montmorillonite shows high liquid limit as 59.79 , Plastic limit as 36.80, and plasticity index as 22.99 which indicate high expensive nature of soil having high swelling and shrinkage.

Soil stabilization using Lime or ceramic waste-

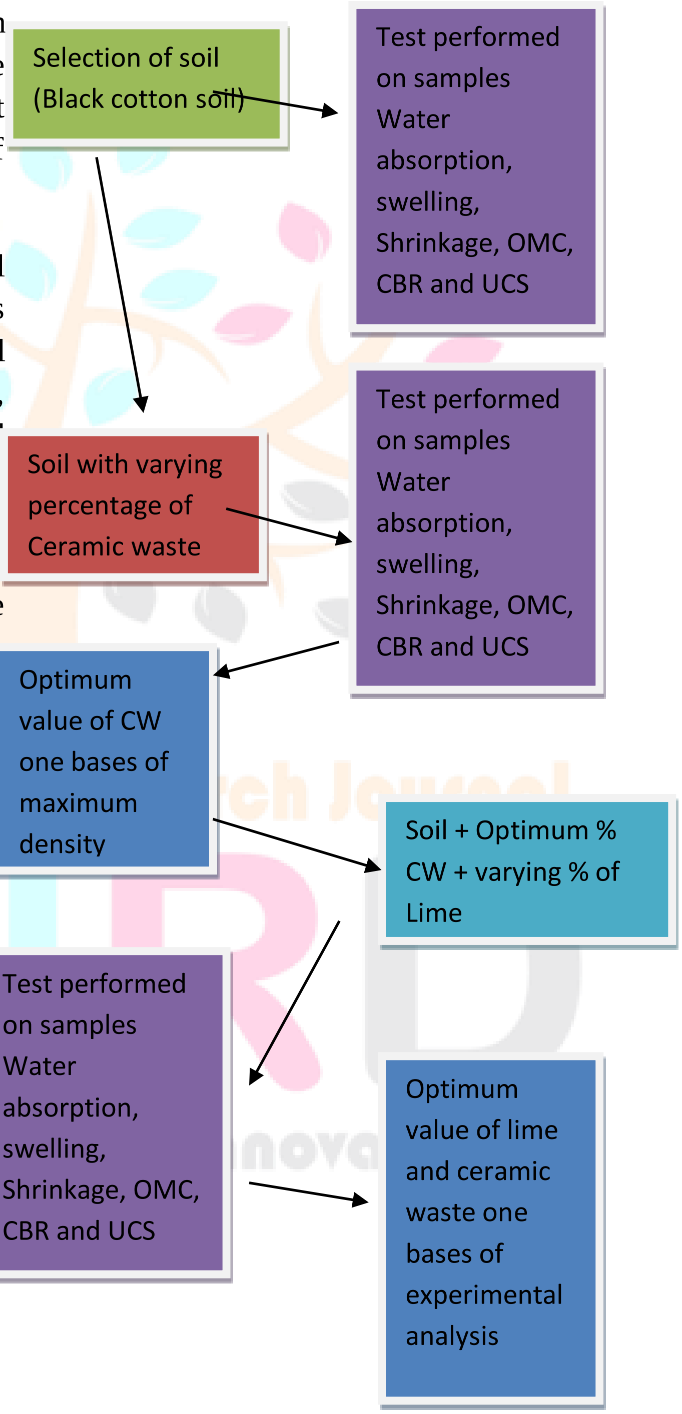
Minhas and Devi *et al* (2020)- They studied Alluvial soil stabilization by marble dust Optimum moisture content (OMC) is increases 8% to 12% by addition of marble dust in significant percentage (5%, 10% and 15%), CBR result also increases after addition of marble dust and bearing capacity reducing after addition of marble dust in alluvial soil sample.

Iravanian and Saber (2020)- It is a review study focused on ceramic waste production and utilization, in his study use ceramic waste powder in soil structure stabilization and improvement, in this study found that unit weight improved and decrease the permeability of soil.

Saygili Altug (2015)-They use of the waste material marble dust for the stabilization of clayey soil in this research paper consists the improvement of physical mechanical and chemical properties of swelling soils, with the help of marble dust, additives was mixed and tested at the proportion of 0%, 10%, 20% and 30% by weight of dry soil. Test results indicate the improvement in strength parameters and reduction in swelling and also better performance in unconfined compressive strength tests (UCS).

Methodology

This experimental study is two stage experimental procedures in the first stage determine the optimum percentage of lime and in the second stage determine the optimum percentage of ceramic waste by taking constant value of lime (optimum value).



Above given flow chart is the 2 stage procedure of soil stabilization by using Lime and ceramic waste.

Location of collection sample collection is Simaria Tal Dabra M.P. (India).

The being conducted on B.C. soil with partial replacement of dry soil, collected sample is distributed for different tests. clay is classify as expensive due to high plasticity having G_s= 2.47 and fineness = 78.2% .

The following test performed on the soil samples as

Grain Size Distribution

Liquid Limit

Plastic Limit

Plasticity Index

Specific Gravity

Standard Proctor Test

Differential Free Swell (D.F.S.)

California Bearing Ratio (C.B.R.) Test

Unconfined Compressive Strength (UCS) test

This experimental work is done with four distributed samples as following

i. Sample of expensive soil with no additive stabilizer or in the other words zero percentage of ceramic waste and lime.

ii. Sample of expensive soil with ceramic waste additive with various percentage as 2.5%, 5%, 7.5%, 10% and so on up to achieve optimum on bases of test conducted.

iii. Sample of expensive soil with lime additive or lime stabilizer with various percentage 2%, 4%, 6% and so on up to achieve optimum point of addition.

iv. Sample of expensive soil with ceramic waste and lime both, in this sample ceramic optimum percentage of lime is used with varying percentage of ceramic waste up to achieve optimum of combination.

Comparison done with various test conducted as following-

i. Specific gravity test

ii. Atterberg's limit

iii. Differential free swell test

iv. Unconfined compressive strength (UCS) test

v. Standard penetration test (SPT)

vi. California bearing ratio(CBR) test

These tests are conducted on every four samples and comparison done with respect to the above tests.

Sample nomenclature as following table-

Sample	content
BC-0	Soil with zero adulterants
BC-CWN	soil with ceramic waste adulterants where CW represent ceramic waste and N is percentage of ceramic waste.
BC-LN	soil with Lime Adulterants where L represents Lime and N is percentage of ceramic waste.
BC-CWN-LN	Soil with ceramic waste and lime adulterants Example- BC-CW4-L5 mean Black cotton soil contain 4% ceramic waste and 5% Lime.

Result

Liquid limit test (L.L):

Liquid limit is decreasing with respect to ceramic waste and lime percentage increase, decrement rate in liquid limit is more in case of ceramic waste.

Fig. 4.1:- Variation of liquid limit for BCS-Ceramic waste content

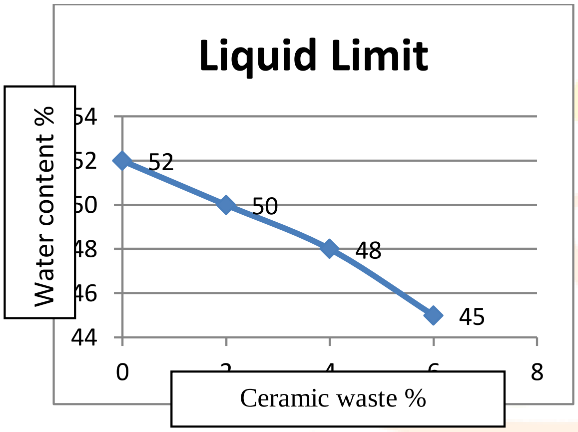


Fig.4.2:- Variation of liquid limit for BCS-Lime content

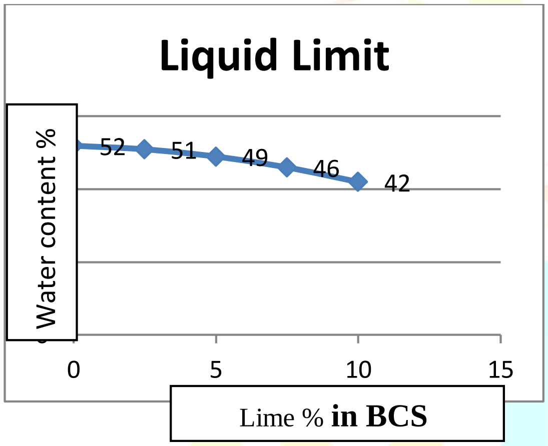
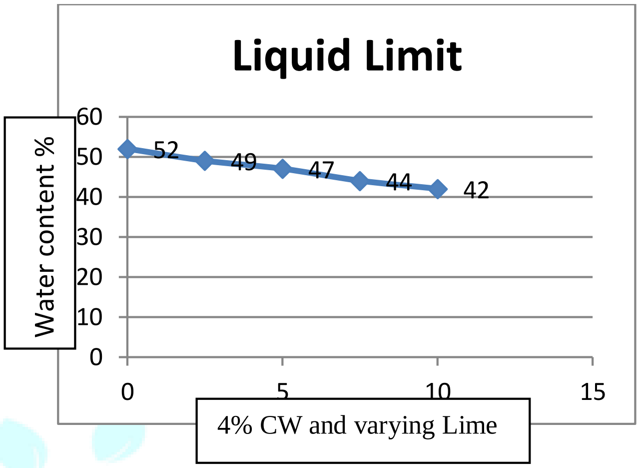


Fig4.3:- Variation of liquid limit for BCS and Ceramic waste-Lime content



Plastic limit test (P.L):

Plastic limit is decreasing with respect to ceramic waste and lime percentage increase, decrement rate in plastic limit is more in case of ceramic waste.

Fig 4.4:- Variation of plastic limit for BCS-Ceramic waste content

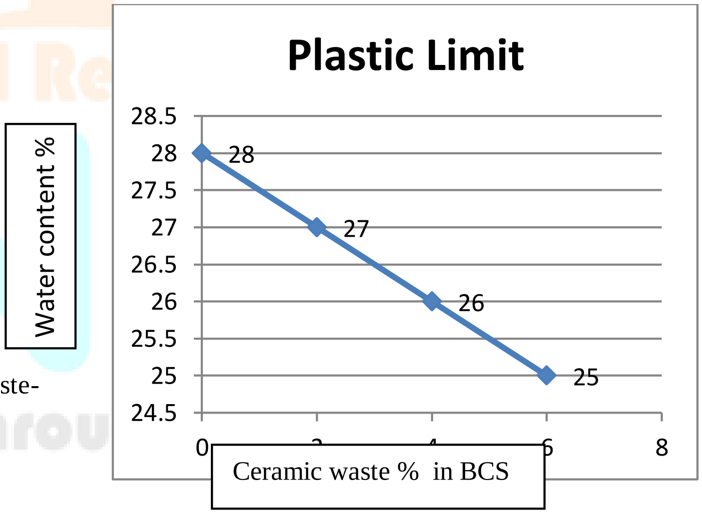
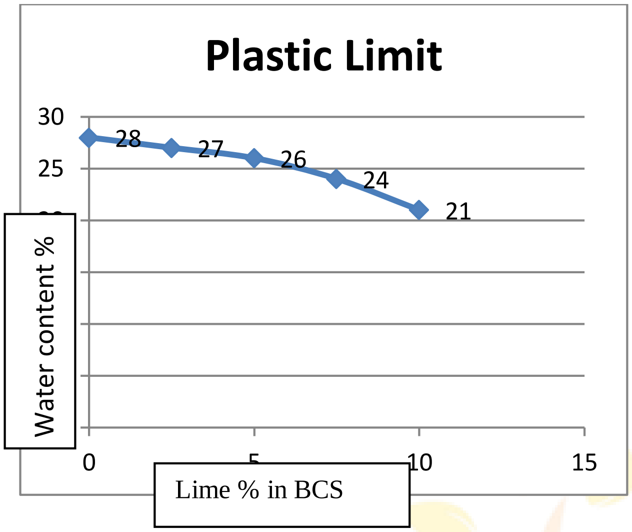


Fig.4.5 :- Variation of plastic limit for BCS-Lime content



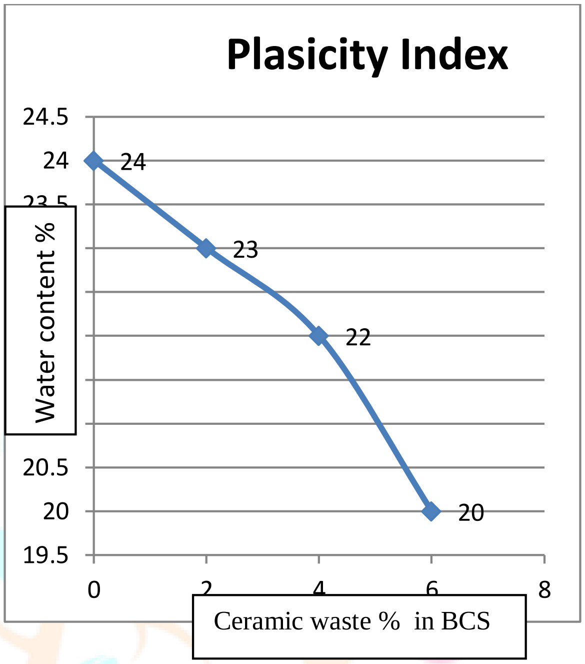
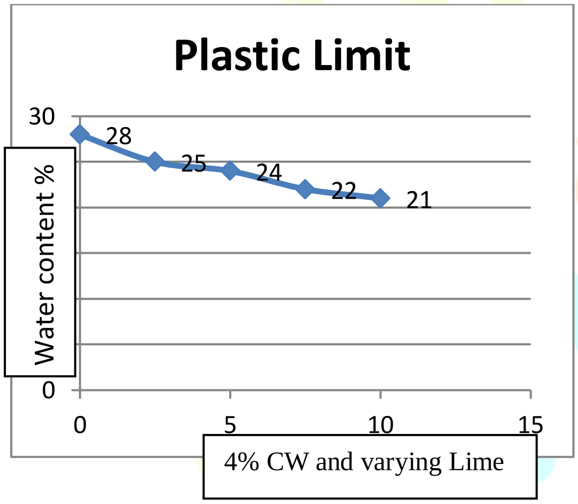


Fig.4.6 :- Variation of plastic limit for BCS and Ceramic waste-Lime content

Fig.4.8:- Variation of plastic limit for BCS-Lime content



Plasticity Index (P.I):

Plasticity index also show continue decrease graph with ceramic waste addition while addition of lime gives initial rise in PI then decreasing.

Fig.4.7:- Variation of plastic limit for BCS-Ceramic waste content

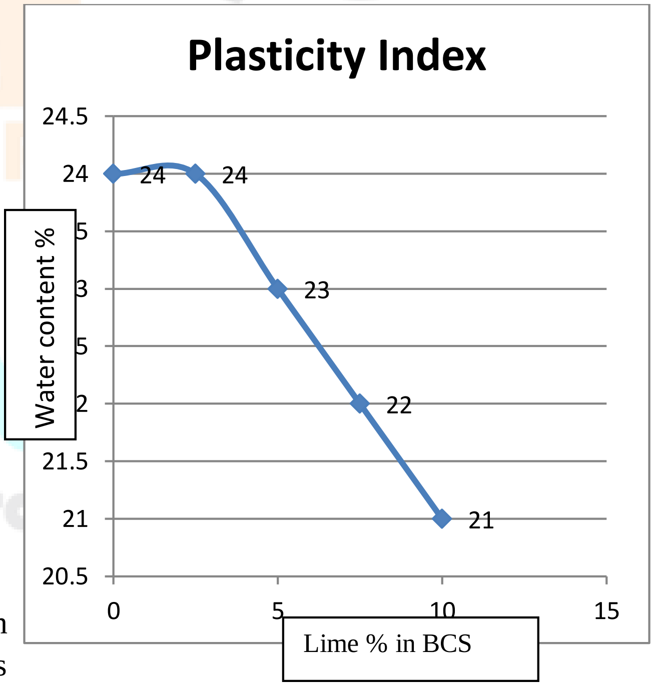
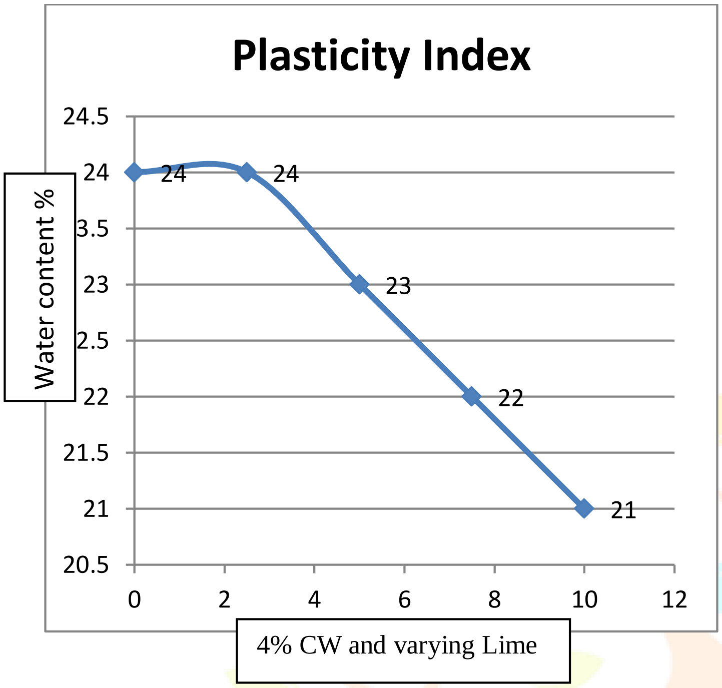


Fig.4.9 :- Variation of plastic limit for BCS and Ceramic waste-Lime content



Specific gravity test:

Specific gravity of the soil is incresing with addition of ceramic waste and decreasing with addition of lime in soil.

Fig.4.10:- Variation of specific gravity for BCS-Ceramic waste content

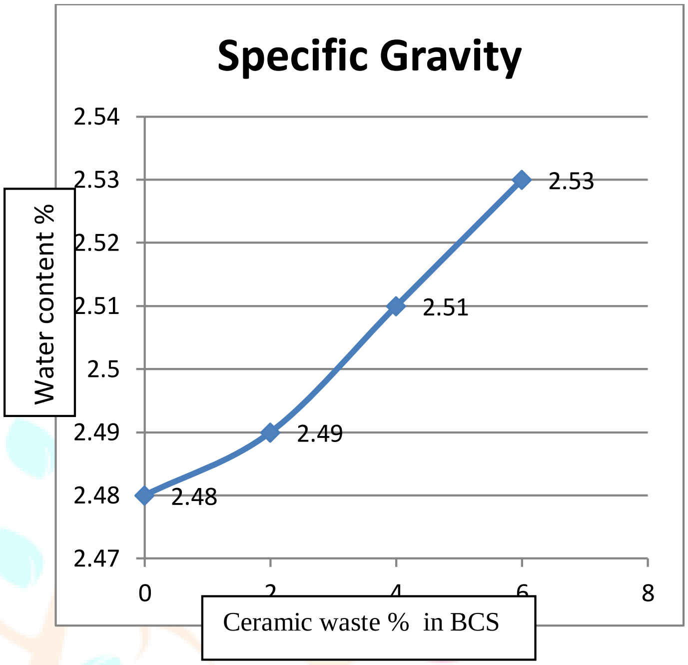


Fig.4.11:- Variation of specific gravity for BCS-Lime content

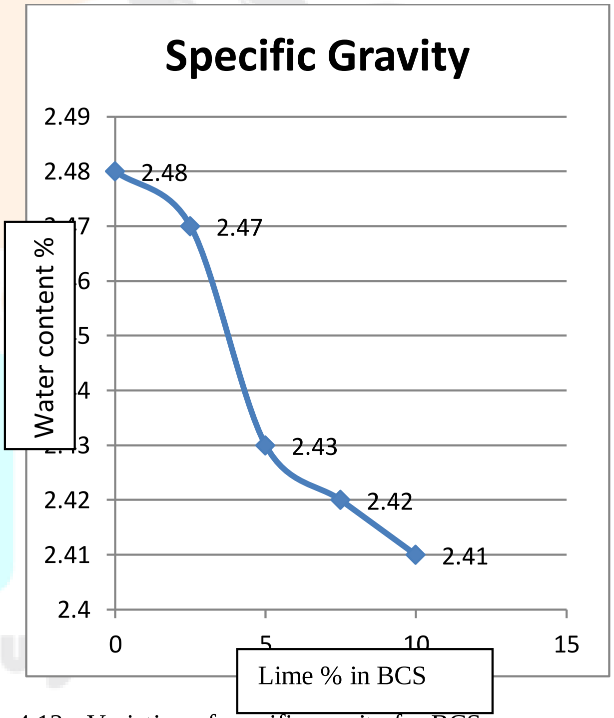
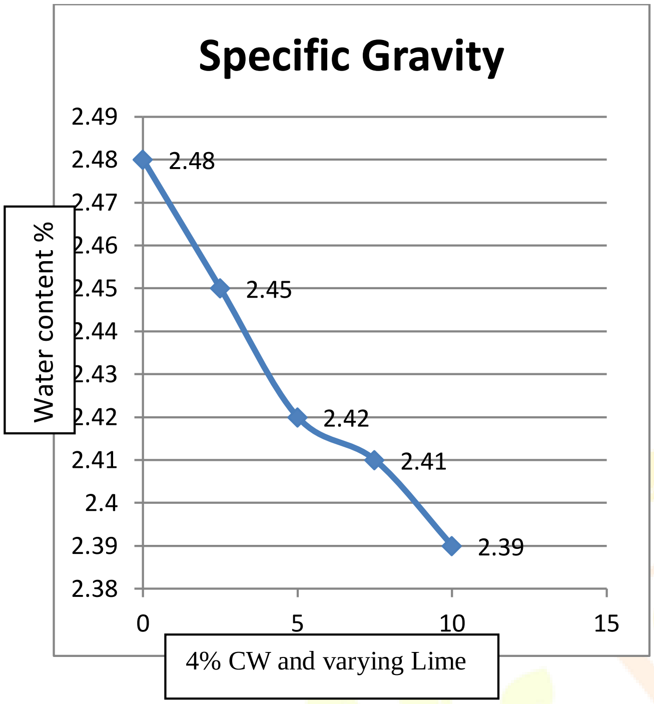


Fig.4.12:- Variation of specific gravity for BCS and Ceramic waste-Lime content



Optimum moisture content:

Fig.4.13:- Variation of optimum moisture content for BCS-Ceramic waste content

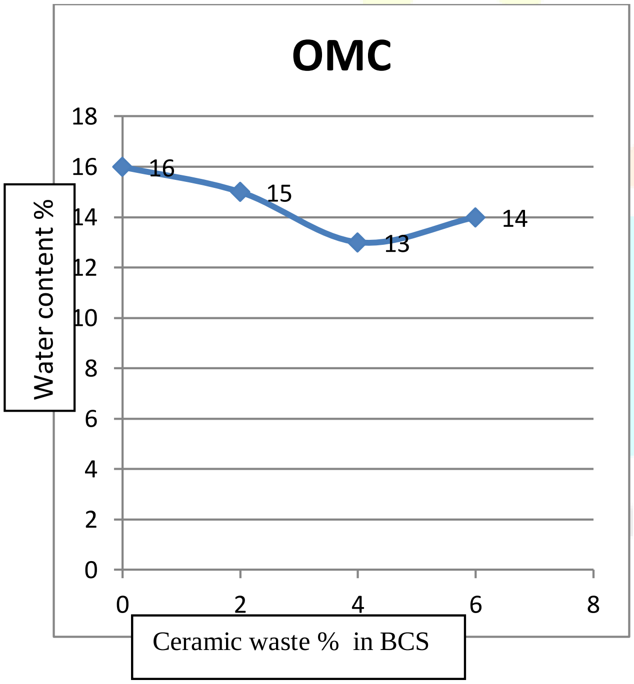


Fig.4.14:- Variation of optimum moisture content for BCS-Lime content

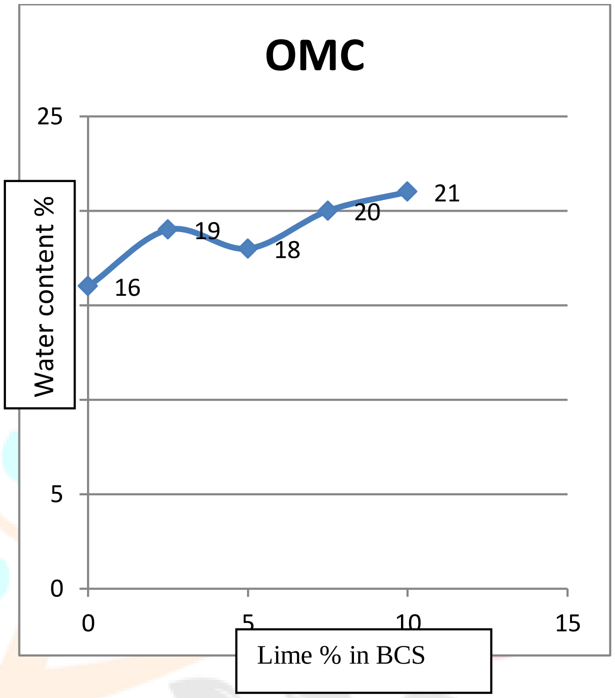
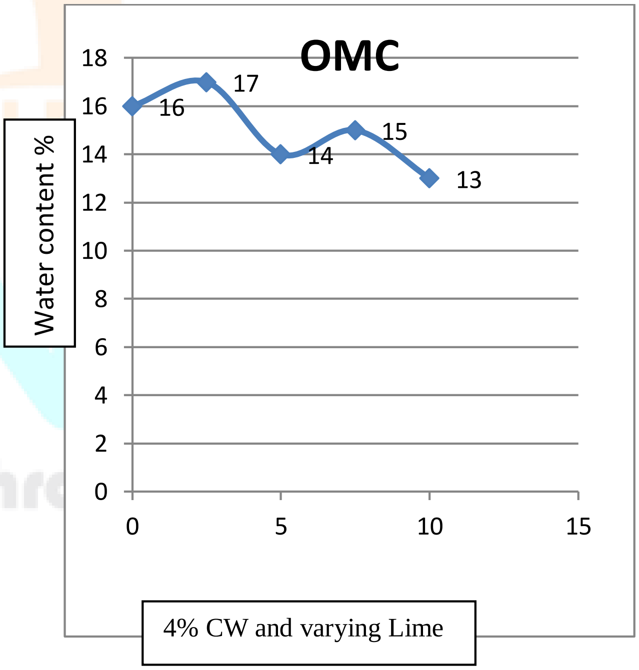


Fig.4.15 :- Variation of optimum moisture content for BCS and Ceramic waste-Lime content



Maximum dry density:

Fig.4.16 :- Variation of maximum dry density for BCS-Ceramic waste content

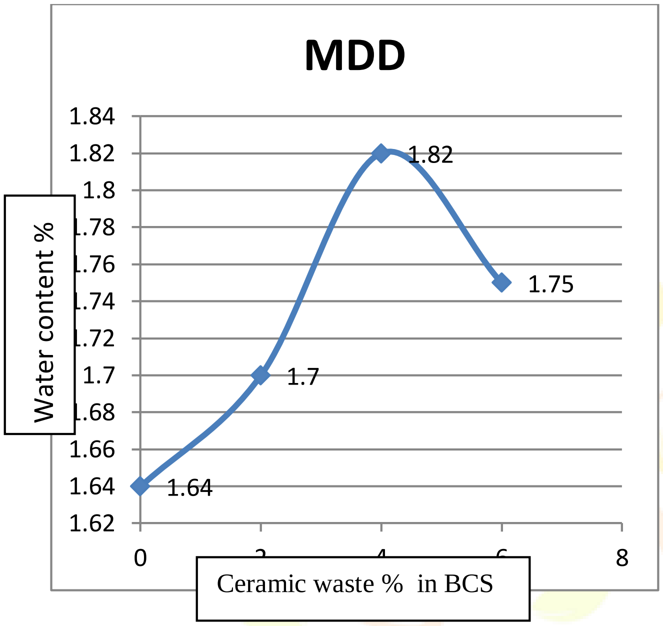


Fig.4.17:- Variation of maximum dry density for BCS-Lime content

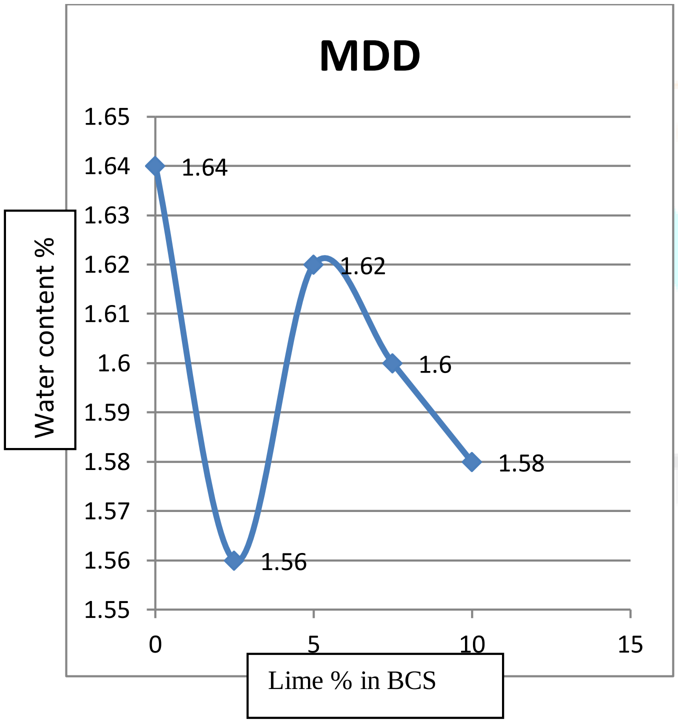
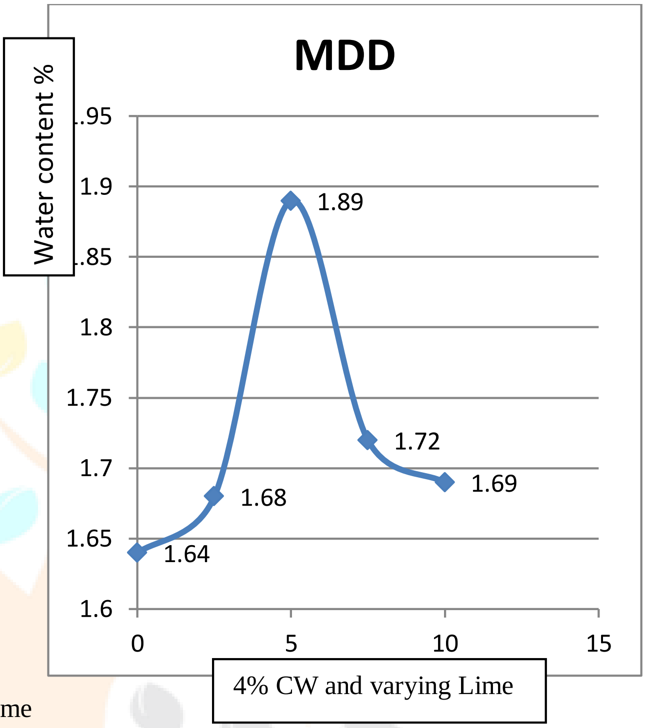
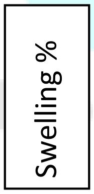


Fig.4.18 :- Variation of maximum dry density for BCS and Ceramic waste-Lime content



Differential free swell test:

Fig.4.19 :- Variation of differential free swell for BCS-Ceramic waste content



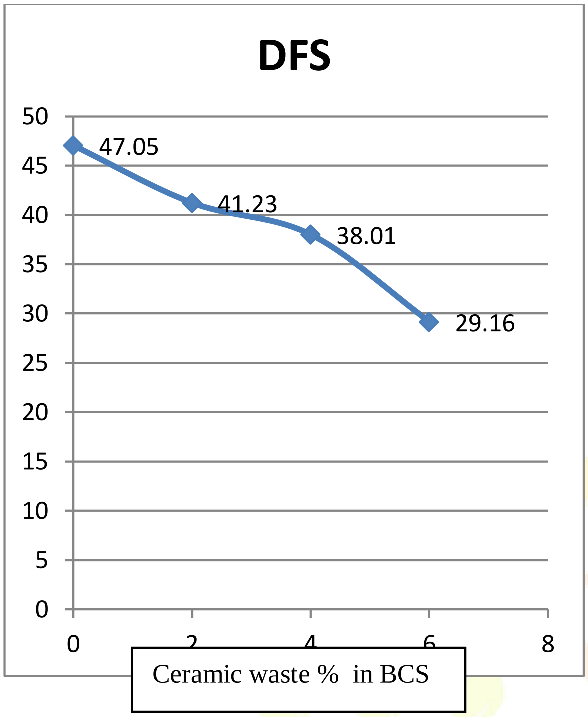


Fig.4.20 :- Variation of differential free swell for BCS-Lime content

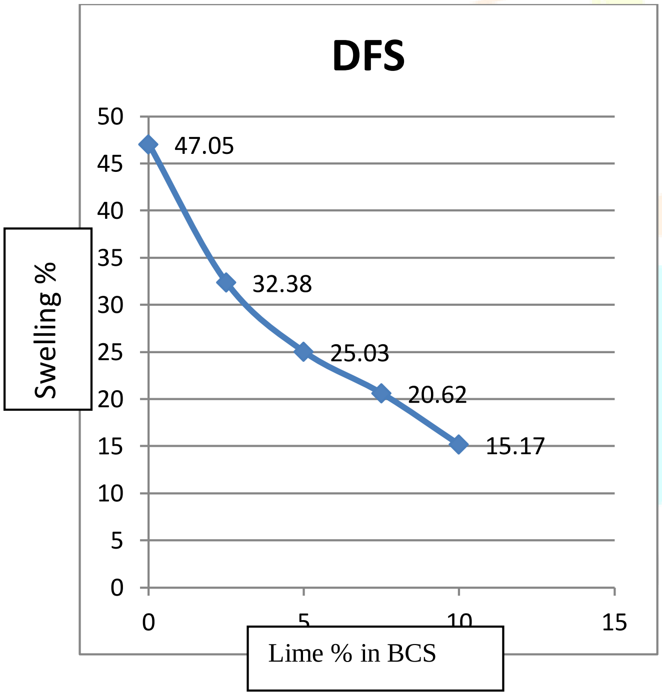
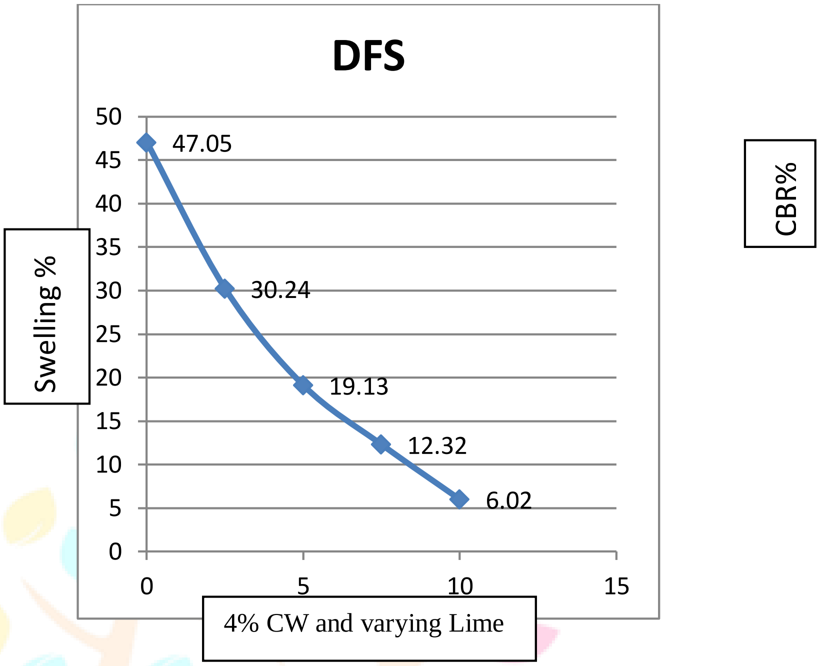


Fig.4.21:- Variation of differential free swell for BCS and Ceramic waste-Lime content



California bearing ratio:

Fig. 4.22:- Variation of CBR for BCS-Ceramic waste content

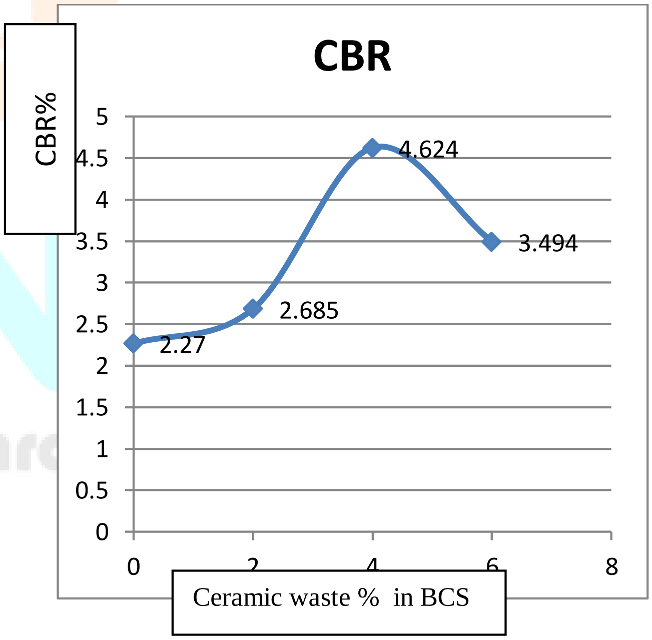
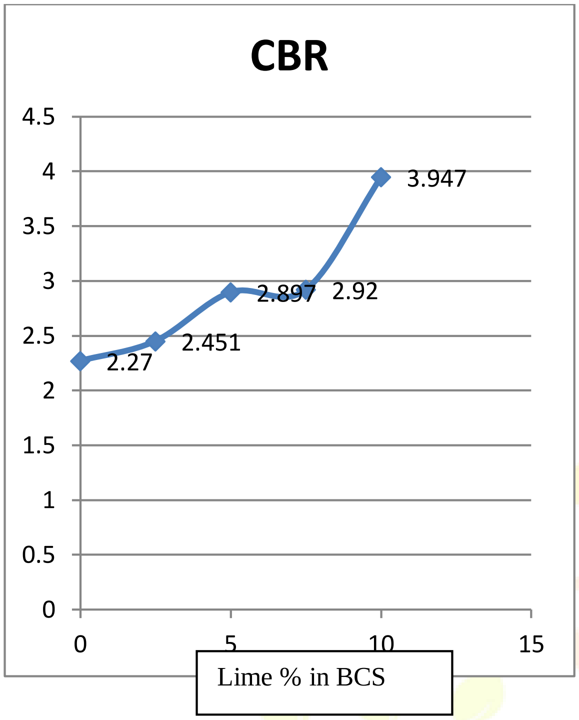
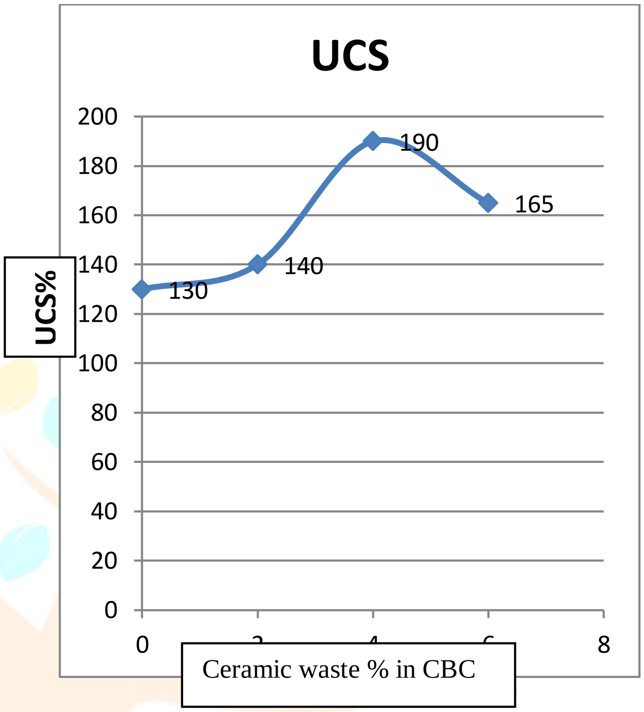


Fig.4.23 :- Variation of CBR for BCS-Lime content



Unconfined compressive strength test:

Fig.4.25:- Variation of UCS for BCS-Ceramic waste content



UCS%

Fig.4.24:- Variation of CBR for BCS and

Ceramic waste-LIME content

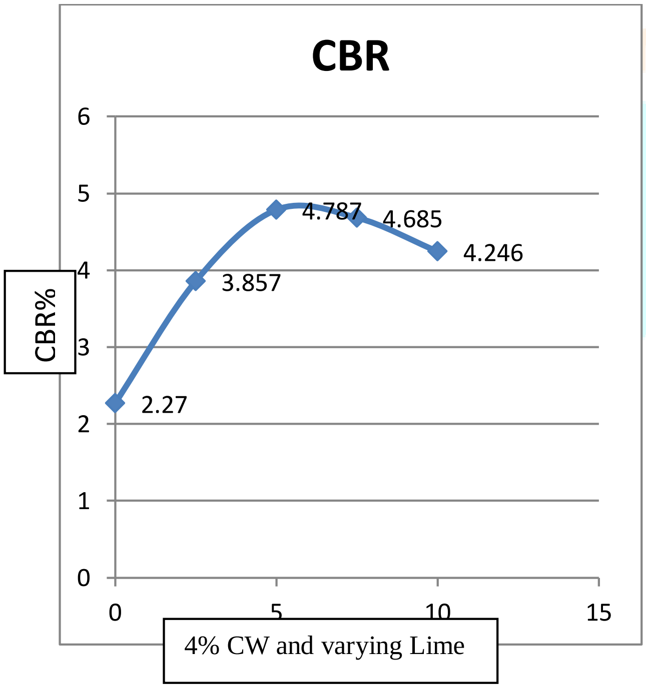


Fig.4.26:- Variation of UCS for BCS-LIME content

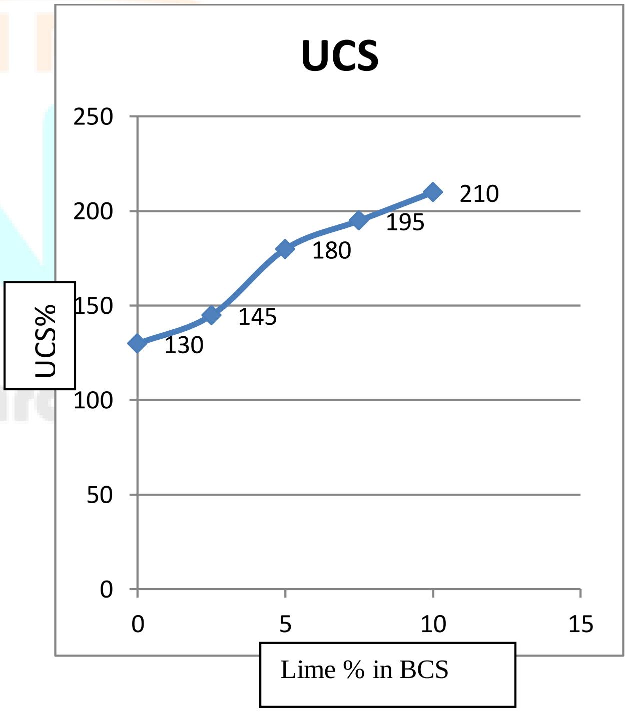
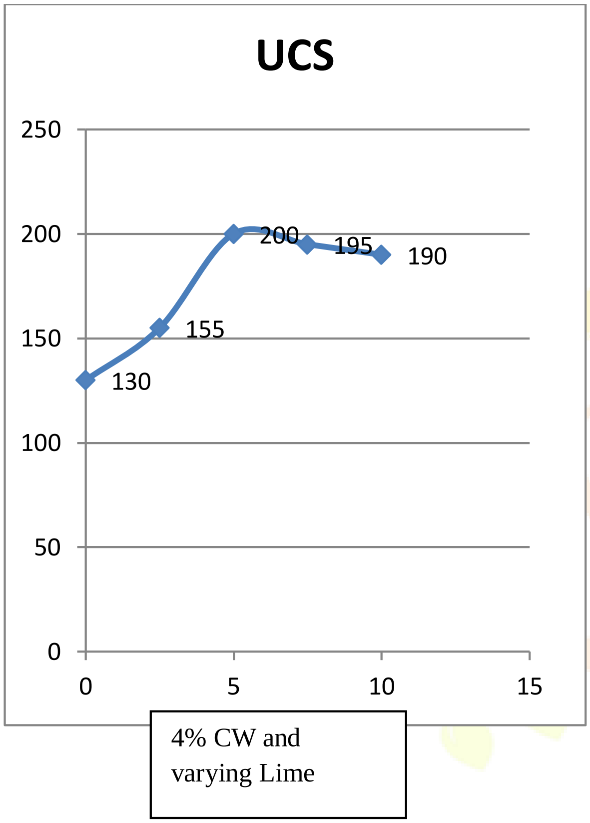


Figure 48:- Variation of UCS for BCS and Ceramic waste-LIME content



Conclusion-

Optimum percentage of ceramic waste and lime adulterant in CBC soil on the bases of adobe parameter given as maximum dry density, optimum moisture content, CBR value, and strength.

Ceramic waste gives assent in dry density, CBR value, Strength (UCS), up to 4%.

Lime gives assent in dry density, CBR value, Strength (UCS).

Combination of ceramic waste and lime gives gives assent in dry density, CBR value, Strength (UCS), up to 5% (Lime).

Therefore optimum utilization of ceramic waste and lime is 4% and 5% respectively.

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