EFFECT OF CONCRETE WASTE DUST AND SEA SHELL POWDER ON PHYSICAL PROPERTIES OF BLACK COTTON SOIL

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ABSTRACT: From an engineering point of view, working on black cotton soil can be very challenging and this study is an attempt to find a possible solution for making black cotton soil workable. The extensive research in the field of geotechnical engineering and soil stabilization has provided us with some great solutions like use of lime, geopolymers etc. But the big question for our generation is, “Sustainability”. Keeping this aspect into consideration, combination of concrete waste dust and sea shell powder was investigated, making this project both practical and sustainable. The goal was to see if we could enhance the soil’s property by use of these stabilizers and then find an optimum percentage of each of these required to achieve the best possible results. The optimum moisture content and maximum dry density was found out at different percentages of CWD and sea shell separately followed by finding the unconfined compression strengths. Similarly the above stated tests were repeated for various possible combinations of CWD and SSP to find an optimum amount of both of these, required to obtain greater stability. The effect of 7- day curing was also studied. The UCS value 230kN/m² for virgin soil jumped to 600kN/m² for 15% CWD alone (optimum value) and 320kN/m² on adding 16% SSP alone (optimum value). The combination of CWD and SSP at optimum value, (16%)) in BCS showed dramatic effect on UCS value and increase was observed to be1800kN/m ² from 230kN/m² for virgin soil.

Keywords: Black cotton soil(BCS), Seashell powder(SSP), Concrete Waste Dust(CWD), Optimum Moisture Content(OMC), Unconfined Compressive Strength(UCS), Differential Free swell index(DFSI).

1. **Introduction:** Black cotton soils are considered among fertile soils, but not good for pavements or foundations from geotechnical point of view. They are highly expansive clayey soils with high quotient of shrinking or swelling with variation in moisture content. This rigorous swelling- shrinking trends leads to failure of structures if constructed on such type of soils without exercising appropriate precautions. Soil stabilization is one such technique which helps to attain the desired properties to make the problematic soil suitable for construction. The key objective followed in this technique is to make soil proficient to achieve the essential strength for different engineering projects. In this study two admixtures i.e. seashell and concrete waste dust are used in different combinations. Seashell is a rigid, protective outer layer formed by aquatic fauna and empty seashells can be easily collected on beaches by collectors (Basically, seashell is a

waste material collected near the seashore). Crushed seashells in powder form is a rich source of Cao (About 90%) as reported by Kuzhali et.al. (2017). The seashells used in this study were collected from shores in Vizag and were pulverized and sieved through 150µ sieve. 'Recycled' aggregate is a reliable alternative of natural aggregates in concrete construction. Also there are instances of annoyance of tax for disposal of such waste in landfill. Since lot of research is going on for the ecofriendly utilization of waste concrete in the form of recycled aggregates but very limited work has been reported pertaining to the use of concrete waste in the field of geotechnical engineering. In the current study concrete waste dust is the second admixture which is used along with seashells in different combinations.

Kuzhali et al. (2017) conducted unconfined compressive strength test on two different soils which are classified as highly compressible clay (CH). After adding 8% seashell powder (optimum value) he observed that there is a huge increase in unconfined compressive strength varying from 266kPa to 1503kPa for sample No. 1 and from 102.2kPa to 1711kPa for sample No. 2.The increase in CBR value of stabilized soil reported in this study is 2.89 times that of ordinary soil. . The cost of untreated soil per km comes out to be Rs.21, 258,573 while soil treated with seashell powder per km comes out to be Rs.17, 518,305(Mishra. C. B., and Patel. A., 2017). In another study Saxena e.al., (2017) highlighted that upto 30% replacement of soil by marble powder there is a significant effect on the strength. Similar experimental works were carried out by various researchers like Chand et al.(2016), Dang et al. (2016), Lindeman et al (2016), Ramanth et al (2016), Sharma et al. (2016), Bisnal et al (2015), A. Paul et al (2014), Mounika et al . (2014), Yadu et al. (2014), Gundaliya et al. (2013), Sabat et al (2012), Peethamparan et al (2008), Mishra et al (2006).

2. Methods and Materials

The soil used in this study is black cotton soil which is found in some parts of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Tamil Nadu. As per Unified soil classification system this soil fall under the category of highly compressible clay (CH). The various properties of soil are shown in Table No.1.

Table No.-1, Soil Properties of Virgin Soil

Soil Parameters	Value
Liquid limit	64%
Plastic limit	29.86%
Plasticity index	34.1 4% (highly plastic 20-40%)
Specific Gravity	2.53
Optimum moisture content	20%
Differential Free Swell index	71%
Max. Dry Density	13.5kN/m³
Unconfined Compressive Strength	230 kN/m²
Fine Soil Particles (passing through 75µ sieve)	83%
Coarse Soil Particles (retained on 75µ sieve)	17%

Sea shells used in this study were collected from shores of Vishakhapatnam same were pulverized and further sieved through 150µ sieve. Concrete Waste Dust is fine material left out from C&D waste, in this project CWD was obtained from the concrete laboratory of Guru Nanak Dev Engineering College, Ludhiana similarly the particle size used is also minus 150 µ.

3. Results and Discussion

Various tests such as Standard Proctor Test, Unconfined Compressive Strength, and Differential free swell index for different combinations as shown in Table No.-2

Table No. 2 Observations of test at different Proportions

Sample No.	Soil:CWD:SSP	OMC(%)	MDD(kN/m³)	UCS (k N/m²)	DFSI (%)
1.	100:0:0	19.6	13	230	71
2.	88:0:12	16.43	17.46	270	67
3.	86:0:14	16	17.5	296	54
4.	84:0:16	13	17.52	353	41
5.	82:0:18	12.7	17.63	310	39
6.	95:05:00	19	14.1	275.52	54
7.	85:15:00	16	14.8	561.86	29
8.	75:25:00	14	15.49	283.39	25
9.	73:15:12	13.6	15.4	785.23	61
10.	71:15:14	14	15.5	1230.98	55
11.	69:15:16	18.7	18.5	1859	39
12.	67:15:18	19	16	1246	35

3.1 Compaction Characteristics: Figure 1 to Figure 3 shows the variation of maximum dry density and optimum moisture content for various samples considered in this study. The MDD increased from 13.5kN/m^3 to17.63 kN/m^3 on the addition of maximum percentage of seashell powder i.e. 18%. OMC decreased from 20% to 12.7%. Similar trend was observed when CWD was alone added in the black cotton soil and maximum increase in dry density was observed to be 15.6 kN/m^{3}corresponding to 25% CWD and OMC reduces from 20% to minimum value of 13.8%. These variations in dry density may be due the improvement in gradation of soil matrix formed after the addition of admixtures which are relatively coarser than the virgin soil. Reduction in OMC may be attributed to the large specific surface area of additives.

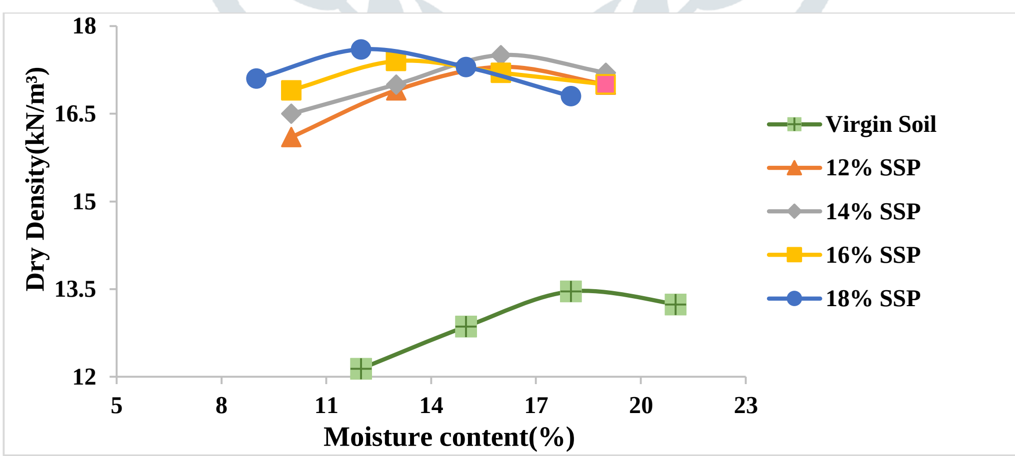

Fig 1. Moisture- Density Curve for Soil +SSP (0%, 12%, 14%, 16%, 18%) mix

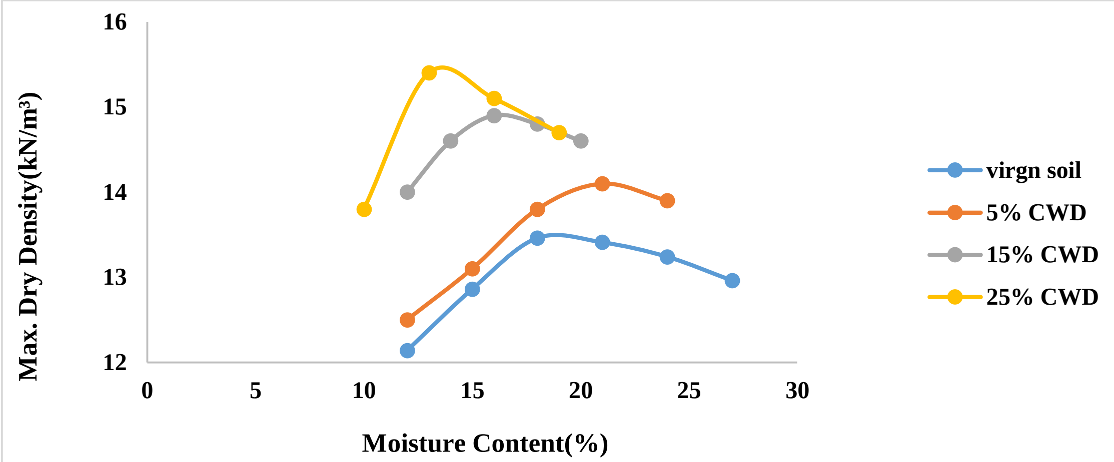

Fig2. Moisture – Density curve for Soil+ CWD (0%, 5%, 15%, 25%) mix

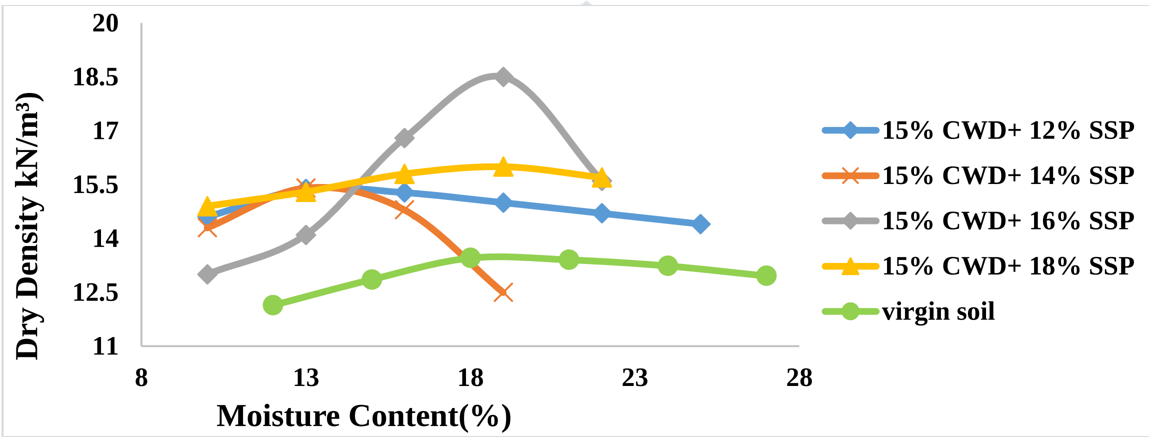

Fig 3. Moisture- Density Curve for Soil +15% CWD +SSP at different proportion

3.2 Unconfined Compressive Strength: Unconfined compressive strength tests were conducted for all the mix proportions considered in this study. From the test results it has been observed that UCS increases substantially when CWD and SSP are added independently in the virgin soil and the maximum increase is143% against optimum value of CWD i.e.15% and similarly 40.3% increase is observed when 16% SSP was added as an optimum value. After attaining the optimum values of CWD and SSP, third attempt was made to study the effect of mixture of both these additives at optimum values (15CWD + 16SSP) for curing period varying from 1day to seven days. Results of this trail are highly encouraging and there is an approximate increase of 640% in the unconfined compressive strength. The increase in UCS may be mainly due to the pozzolanic reaction due the presence of sufficient amount of Cao and pozzolanic materials in both the additives. Improved gradation may also be responsible partly for this increase. The decrease in UCS when CWD percentage is increased beyond 15% and SSP beyond 16% may be due to lower specific gravity of these additives.

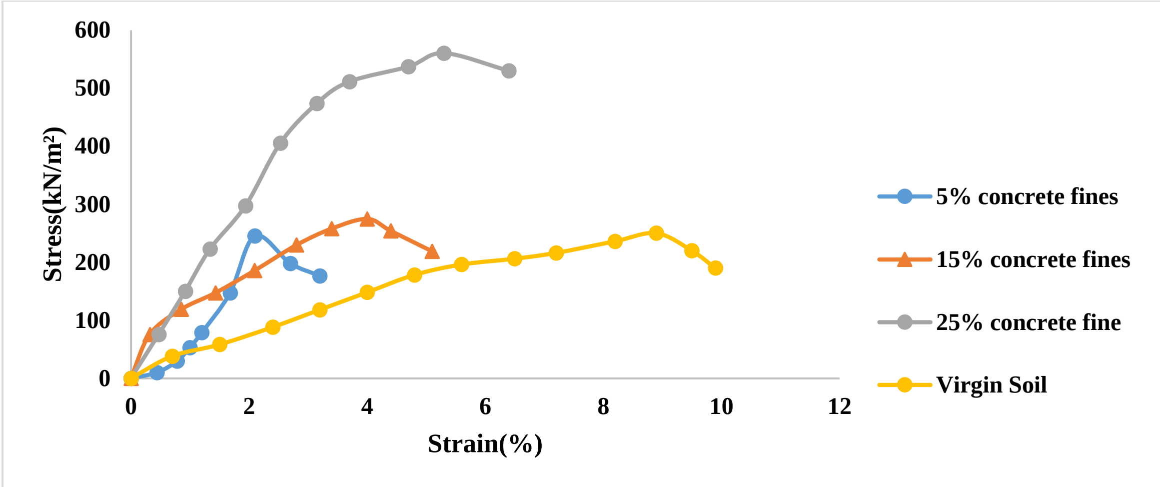

Fig 4. Stress-Strain Curve for Soil +CWD (0%,5%, 15%, 25%)

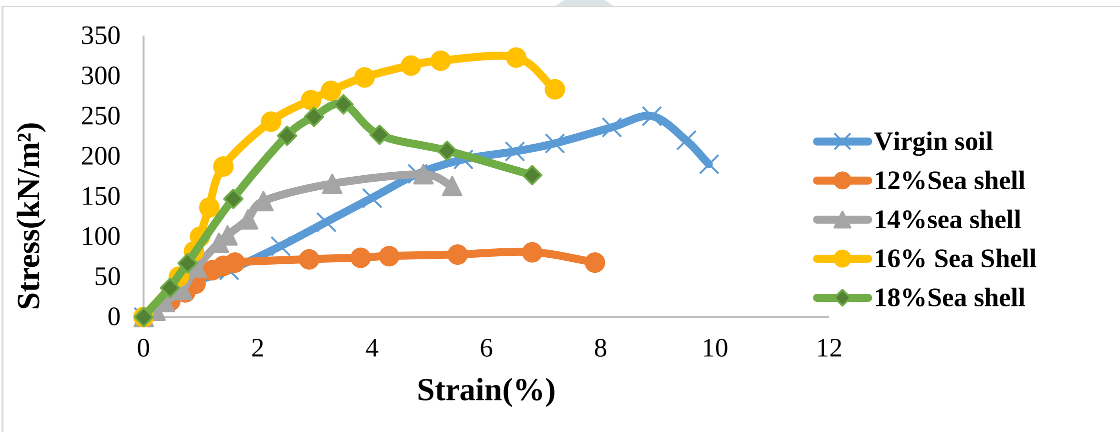

Fig5. Stress-Strain Curve for Soil + SSP (12%, 14%, 16%, 18%)

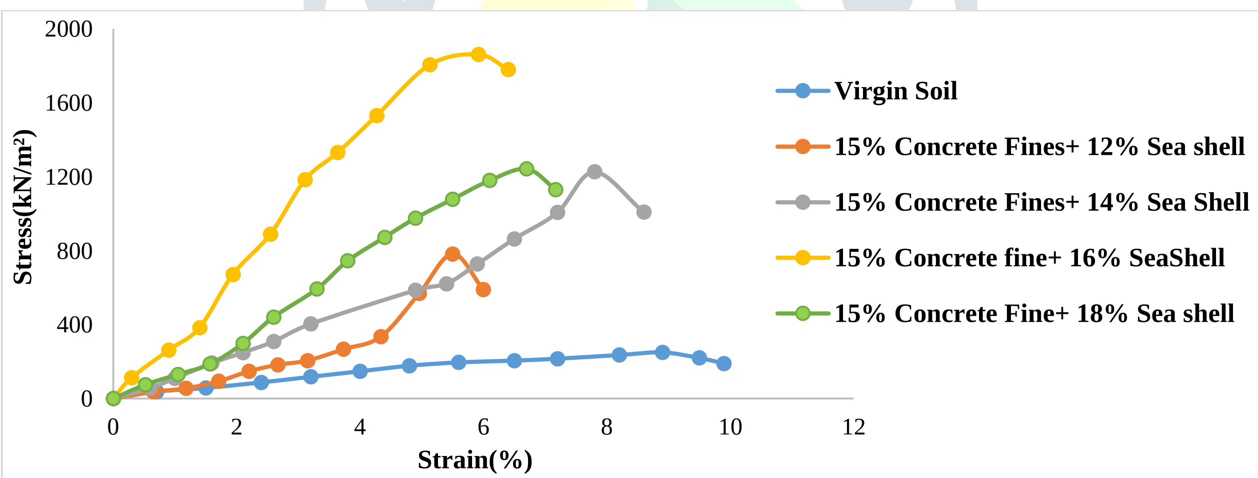

Fig6. Stress-Strain Curve for Soil + CWD (15%)+SSP (12%, 14%, 16%, 18%)

3.3 DIFFERENTIAL FREE SWELL INDEX FEATURES

Bar graphs shown in Figure No.6 to Figure No. 8 exhibits the reduction in DFS index for various mixes as planned in this study. Show case all the combination of specimens tested to determine free swell index. The virgin BCS being highly expansive had DFSI value of 71% and it reduces to 25% when 25% CWD is added. Similar trend was observed when SSP was added as an additive. When optimum value of CWD and SSP (15% CWD and 16% SSP) were added DFSI reduces from 71% to 33%. This positive effect on DFSI again may be attributed to the pozzolanic reaction.

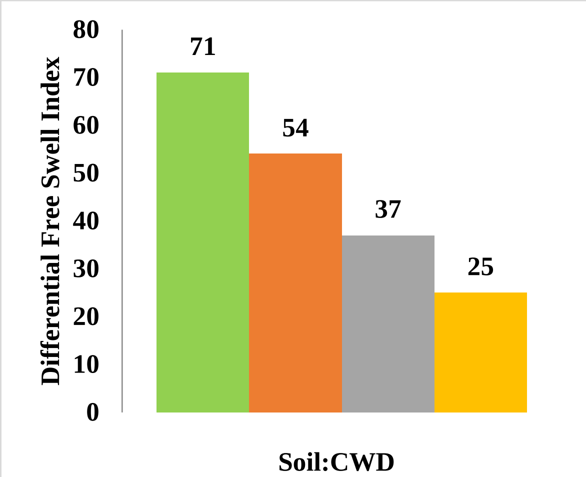

Figure 7: DFSI- Soil: CWD

(0%, 5%, 15%, 25%)

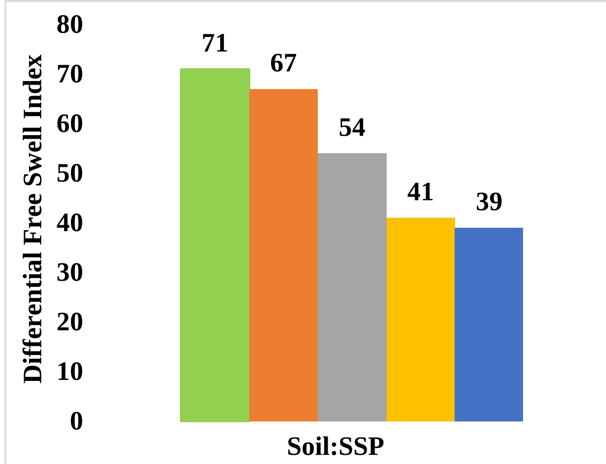

Figure 8: DFSI- Soil: SSP

(0%, 12%, 14%, 16%, 18%)

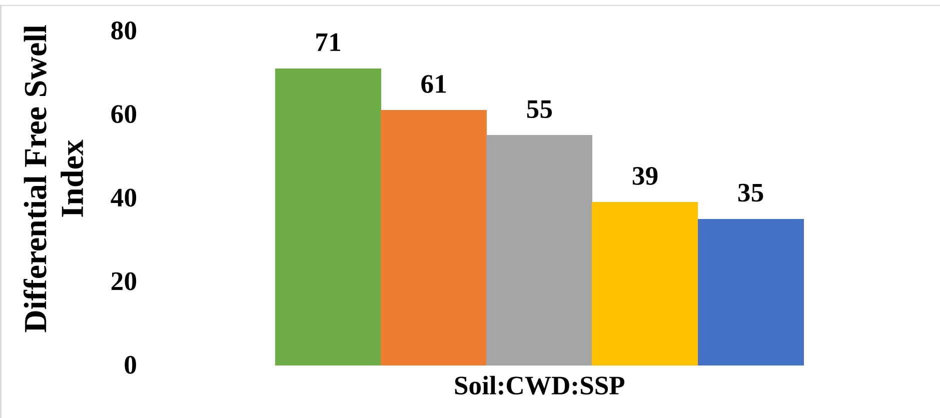

Figure 9-DFSI- Soil:CWD(15%):SSP(12%,14%, 16%, 18%

4. CONCLUSION

This study was focused at using the chosen set of ingredients for alteration of engineering properties of black cotton soil. On the basis of the tests conducted, following conclusions are drawn:

1. Dry density continuously increases in both the cases i.e. addition of SWD and SSP up to certain value (15% for CWD and16% for SSP) and there after starts reducing. Whereas OMC for both the cases reduces consistently.

2. At optimum proportioning of both additives (15%CWD+ 16%, SSP) the UCS value of the soil sample proliferates to eight times (1859kN/m^2) as compare to that of the UCS value of virgin soil (250kN/m^2).

3. Significant reduction is observed in DFS index values when optimum percentage of additives are mixed in the virgin soil.

4. Curing imparts significant gain in strength as both the additives contains sufficient amount of Cao and pozzolanic materials.

REFERENCES

1. A.K. Saxena (2017). "*Improvement in engineering properties of locally available expensive soil using C& D waste and marble waste powder*". International Journal for Research in Applied Science and Engineering Technology. Vol. 5. Issue-8.

2. Anu Paul (2014). "*Studies on improvement of clayey soil using egg shell powder and quarry dust*". International Journal of Engineering Research and Application. Vol.4 pp. 55-63.

3. Bisanal (2015). "*Study on stabilization of soil using sea shell and bitumen emulsion*". International Conference on Research and Innovations in Science, Engineering and Technology. Vol. 4. Issue 7.

4. Canacki (2016). "*Stabilization of clay using waste beverage cans*". Geotextiles and Geomembranes, .161: pp. 595-599.

5. Chand (2016). "*Effect of sea shell powder on the UCS of BCS*". International Journal of Scientific and Engineering Research. Vol.7.

6. Dang (2016). "*Behavior of expansive soil stabilized with hydrated lime and bagasse fibers*". International Conference on Transportation Geotechnics. Vol.143 pp. 658-665.

7. Gundaliya (2013). "*Study of BCS characteristics with CWD and lime*". International Conference on Engineering. 51(2013). Pp. 110-118.

8. Hassan (2016). "*Remediation of expansive soils using agriculture waste bagasse ash*". Nebraska Department of Roads- In house Research July 2016.

9. Kuzhali (2017). "*Behavior of expansive soils treated with seashell powder*". International Journal of Civil Engineering Vol.8 pp. 576-581.

10. Mishra (2006). "*Use of aggregates from recycled CNDW in concrete*". Resources Conservation and Recycling. 50(2006). Pp. 71-81.

11. Mishra (2017). "*Performance of sea shell powder on sub grade soil stabilization*". International Conference on Research and Innovations in Science, Engineering and Technology. Vol. 1. Pp. 150-156.

12. Mounika (2014). "*Influence of sea shell powder on BCS*". International Journal of Advance in Engineering and Technology. Vol.7 pp. 1476-1482.

13. Peethamparan (2008). "*Study the effectiveness of CKD in stabilizing Na- Montmorillonite clay*". Journal of Material Civil Engineering. 20(2).pp. 137-146.

14. Ramanath (2016). "*Sea shell and natural fibers composites: A review*". Material Today: 5(2018) 1846- 1851. PMME.

15. R.K Sharma (2016). "*Effect of fly, CDW and lime on geotechnical characteristics of clayey soil, a comparative study*". Environmental Earth Science. 75:377.

16. Sabat (2012). "*A study on some geotechnical properties of lime to stabilized expansive soil- Quarry dust mixes*". International Journal for Research in Applied Science and Engineering Technology. Vol.1. Issue-2.

17. Sabat (2016). "*A review of literature on stabilization of expansive soil using solid waste*". Electronic Journal of Geotechnical Engineering. Vol. 19. 6251-6267.

18. Yadu et.al. (2014). "*Comparison of fly ash and rice husk ash stabilized BCS*". International Journal of Earth Science and Engineering. Vol.4 .pp. 42-45.

19. IS 2720: (Part V- 1985) "Determination of Liquid Limit and Plastic Limit".

20. IS: 2720: (Part VII- 1980) Determination of maximum dry density by standard proctor test.

21. IS: 2720: (Part X- 1991) Determination of Unconfined compressive strength

22. IS 2720: (Part XL -1977) Determination of Free swell index of soil".