# Evaluation of Subgrade Capacity of Black Cotton Soil by using Waste Iron Powder and Geomembrane

**Dr.Vageesha S. Mathada[1], Sharanakumar B.M[2], Priyanka[3]**

[1]*Professor, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*
[2]*Assistant Professor, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*
[3]*M.Tech student, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*

---***---

**Abstract-** Construction of pavement on expensive or soft subgrade soil needs great deal of attention. It is very much important to concentrate on strength of soil layers underlying the surface course, because the design life, strength and thickness of pavement are mainly depending upon the subgrade strength. Many alternative methods available to improve the strength of subgrade. Subgrade strengthening using geotextiles, geomembranes and geogrids as soil reinforcement are most widely used methods. Now days use of industrial wastes as additives for soil stabilization has become trendy to reduce the environmental hazards.

In the present study an attempt to strengthen the soft subgrade soil using workshops waste iron powder (W.I.P) as an admixture and geomembrane as an layers of soil reinforcement. The BC soil is alloyed with deviating percentages of waste iron powder i.e. 2%, 4%, 6%, 8% and 10%. For all these proportions compaction tests, Atterberg limits and laboratory CBR tests were conducted for unsoaked and soaked condition. From all these laboratory studies we have got an optimal percentage of waste iron powder i.e. 6%. Further tests will be carried out to know combined effect of geomembrane and waste iron powder on black cotton soil. Finally, the interaction of B.C soil-waste iron powder-geomembrane are estimated by adding the minimum percentage of waste iron powder i.e. 6%. The mixed proportions are as follows; B.C. soil+6% waste iron powder+ one layer geomembrane inserted at the middle, 1/3rd point from lower and upper side of the specimen respectively. BC soil+6% waste iron powder+2 layer of geomembrane inserted at 1/3rd points from both lower and upper side of the specimen. BC soil+6% waste iron powder +3 layers of geomembrane inserted at the middle and 1/3rd points from both lower and upper side of specimen. The unsoaked CBR values show considerable increase in strength than soaked CBR values.

***Key Words***: ***waste iron powder, geomembrane, MDD, OMC, CBR***

## 1.INTRODUCTION

Black cotton soil locally named as regur soil and it is obtained from basalt or trap due to chemical weathering. This soil exhibits significant change in volume (shrinkage and swelling) because of the existence of clay minerals and it very helpful for cotton cultivation because of its nature to retain water for a long time. This soil expands during the raining period and it shrinks or cracks in the time of dry period. Any structure built on this type of soil leads to failure by cause of its lower holding capacity of soil.

The group of geosynthetics includes geotextiles, geomembranes, geogrids, geo-nets, geocomposites, geo-synthetic clay liners (GCL's) and geotubes, etc. Among all these geosynthetic materials, the geomembrane is accustomed to control the migration of fluids as a coating or membrane barrier in a man-made design, structure or system and these are the waterproof sheets produced from polymeric materials.

In this current study, the weak subgrade is improved by using residual iron powder which is collected in the workshops as an admixture and geomembranes as an reinforcement layers.

The reason of using leftover iron powder is because of its easily available in many workshops and economical. Many researchers have worked to toughen the B.C soil using iron residue which is collected in iron manufacturing industries and some of them have also studied the difficulties for the shake of soft subgrade. and provided resolutions using geosynthetic substances such as geomembranes for construction on regur soil.

We have carried out experimental work to know the presentation of subgrade utilizing a geomembrane and left-over iron powder of differing percentages. Typically, the roadway design chiefly depends on the value of CBR, it is very important engineering properties of soil for the design of subgrade.

## 2. LITERATURE REVIEW

**1) Arash Barazesh** et.al., (2012); The study includes five different types of soils with initial plasticity indices of 26, 31, 35, 39 and 49. Plasticity indices of soil samples calculated with different percentages of iron powder and then compared with plasticity of original soils. Results shows that by adding different percentage of iron powder to the soil their liquid limit and plasticity index decreased.

**2) E.A. Meshida** et.al., (2013); Conducted a study on Strength properties of Black Cotton Soils blended with different percentage of steel mill dust i.e. 5%, 10%, 15%, 20% and 30%. For the soil with 30% steel mill dust maximum unconfined compressive strength and CBR values obtained. MDD increased by 28% and OMC lowered by about 45% by the addition of steel mill dust to black cotton soil. The addition of 30% steel mill dust increases the Un-soaked CBR of the black cotton soil by about 90%.

**3) Dharmesh lal** et.al., (2020); The study is carried out on the improvement of soil characteristics by using jute fiber sheet as reinforcement. They conducted triaxial and C.B.R tests on jute fiber reinforced normal soil. From the tests they determined that by placing the layers of fiber reinforcement significantly boosted the strength and rigidity characteristics of the soil. From the result they concluded that placing of 2 layers jute fiber reinforcement is more effective compared to 1 and 3 layers.

## 2.1 SCOPE AND OBJECTIVES

This work will be limited to the usage of leftover iron dust as a soil additive in the evolution of subgrade capacity. This would involve the collections of soil materials and determinations of their geotechnical properties. After which the geomembrane would be combined into the soil sample and their geotechnical properties also determined in both the soaked and un-soaked cases.

The result would be examined and effect of the geomembrane on the tested soil sample would be assessed and the suitable recommendations would be made for their best use.

The aim of this investigate work is to assess the different types of geosynthetics available and to estimate the efficiency of the geomembrane and the powder of iron waste in the evolution of capacity of the subgrade. To achieve this goal, the following points have been recognized.

- To decide the California bearing ratio value of various pavements.
- Effect of geomembrane and waste iron powder on CBR of subgrade.
- To combine the geomembrane and powder of waste iron(collected from workshop) in some collected soil materials and evaluate the performance.
- To analyses the results and make appropriate recommendations for optimal use.
- Comparison the results by changing the vertical spacing of geomembrane.
- Comparison the results by changing the numbers of geomembrane.

## 3. MATERIALS AND METHODOLOGY

### 3.1 Materials

In present study of the project, we have used three materials namely black cotton soil, powder of iron waste which is collected in the workshop and a geomembrane.

**3.1.1 Black cotton soil:** The soil is taken from the area of Bhalki at a depth of 1.5m to 2m to obtain satisfactory result. The soil is sieved through the IS sieves relative to the tests.

**Fig -1**: Black cotton soil

#### 3.1.2 Geomembrane:

Geomembranes are one of the geosynthetic material and "These are thin sheets of flexile polymeric materials and they are impermeable in nature thus provides a barrier to the movement of water and fluids or other materials of solvable nature".

In this project, a geomembrane of thickness 500micron is used.

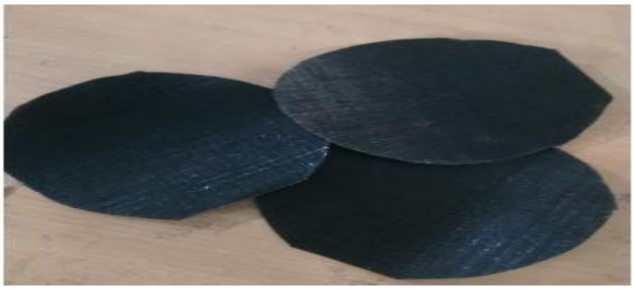

**Fig -2**: Geomembrane

#### 3.1.3 Waste Iron Powder (W.I.P):

The W.I.P used in this research study is gathered from the WORKSHOP. Due to its resilient nature, it will help in enhancing the strength of soil. The organic compounds of waste iron powder are listed as follows.

**Table -1:** Organic compounds of Iron powder

| Sl No | Properties | Percentage (%) |
|---|---|---|
| 1 | Ferric Oxide($Fe_2O_3$) | 98.06 |
| 2 | Silica ($SiO_2$) | 0.27 |
| 3 | Alumina ( $Al_2O_3$) | 0.83 |
| 4 | Sulphur (S) | 0.008 |
| 5 | Specific Gravity | 5.10 |

**Fig -3**: Iron powder collected from workshop

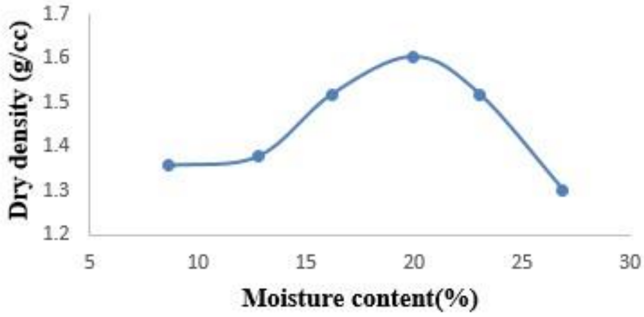


**Fig-4: Compaction Curve of only BC Soil**

## 3.2 Methodology:

The BC soil is alloyed with deviating percentages of waste iron powder i.e. 2%, 4%, 6%, 8% and 10%. For all these proportions OMC and MDD is calculated by conducting compaction test. Atterberg limits are estimated for all the proportions & also CBR tests were performed to know the Load-settlement nature of soft subgrade soil. From all these laboratory studies an optimal percentage of W.I.P is obtained.

Further tests will be done to know the combined effect of geomembrane and W.I.P on weak subgrade soil. At the end the interconnection of BC soil-W.I.P-geomembrane are estimated by merging the minimum percentage of W.I.P i.e. 6%.

The mixed proportions are as follows; BC soil+6% WIP+ one layer geomembrane inserted at the middle, 1/3$^{rd}$point from lower and upper side of the specimen respectively. BC soil+6% WIP +2 layer of geomembrane inserted at 1/3$^{rd}$ points from both lower and upper side of the specimen. BC soil+6% WIP +3 layers of geomembrane inserted at the middle and 1/3$^{rd}$ points from both lower and upper side of specimen.

## 4. RESULT AND DISCUSSION

### 4.1 Standard proctor test

This test were executed to assess the values of O.M.C and M.D.D of a BC soil by adding 2%,4%,6%, 8% and 10% of the waste iron powder by weight of the soil.

The capstone point on the compaction graph is called as "maximum dry density" and also directive level of humidity of that capstone point is generally designated as "optimum moisture content".

The Black cotton soil had OMC=19.22% and MDD=1.603gm/cc

### 4.1.1 Variation of O.M.C &M.D.D of B.C soil with varying percentage of W.I.P.

BC soil is blended with deviating percentage of waste iron powder varies from 2 to 10 at an interval of 2%. Compaction tests were operated to estimate the OMC and MDD values for BC soil .

**Table -2:** fluctuation of OMC & MDD of soil with variable percent of W.I.P

| S.NO | Description. | M.D.D (gm/cc) | O.M.C (%) |
|---|---|---|---|
| 1 | B.C soil | 1.603 | 19.93 |
| 2 | BC soil+2% W.I.P | 1.703 | 20.20 |
| 3 | BC soil+4% W.I.P | 1.82 | 23.22 |
| 4 | BC soil+6% W.I.P | 1.90 | 18.81 |
| 5 | BC soil+8% W.I.P | 2.46 | 22.32 |
| 6 | BC soil+10% W.I.P | 1.88 | 24.58 |

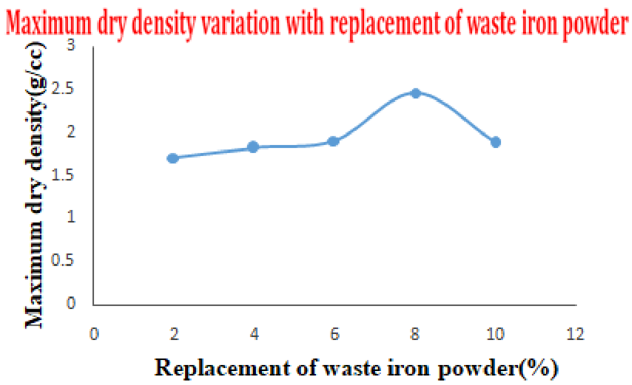


**Fig-5:** Fluctuation of MDD values of soil at varying percentage of W.I.P

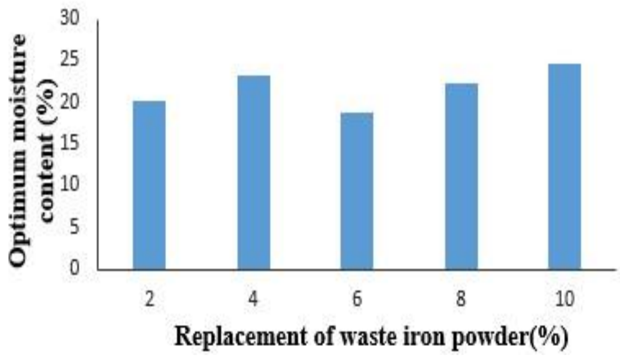


**Fig-6:** Fluctuation of O.M.C values of soil at varying percentage of W.I.P

Fig. 5 and 6 shows the fluctuation of OMC and MDD of a soil with varying percentage of W.I.P. When BC soil and waste iron powder are blended, particles of iron powder intrude into the voids of soil leading to decrease in permeability of soil there by density of soil is increased. Hence with increasing the percentage of waste iron powder MDD of soil get increased upto 8% of W.I.P after that there is descending order in the MDD values. Fig.6 shows the fluctuation of OMC for BC soil blended with different percentages of waste iron powder. From the table-2 it is observed that soil blended with 6% W.I.P shows MDD at minimum OMC, therefore 6% waste iron powder is the optimum content for BC soil.

### 4.2 Consistency Limits

**Table -3:** Fluctuation of Consistency Limits with varying proportion of W.I.P

| Sl.no | Replacement of W.I.P in the soil(%) | Liquid Limit (%) | Plastic Limit(%) | Plasticity Index |
|---|---|---|---|---|
| 1 | 2% | 69 | 28 | 41 |
| 2 | 4% | 62 | 25 | 37 |
| 3 | 6% | 55 | 23 | 32 |
| 4 | 8% | 48 | 21 | 27 |
| 5 | 10% | 41 | 20 | 21 |

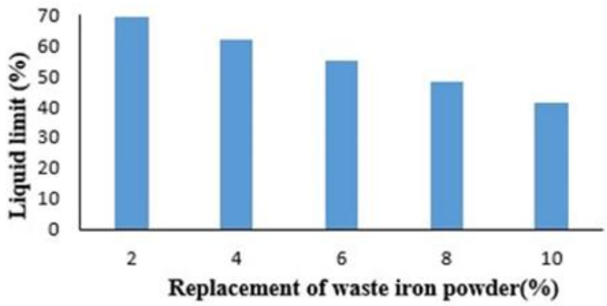


**Fig -7**: Liquid limit of BC soil with varying percentage of W.I.P

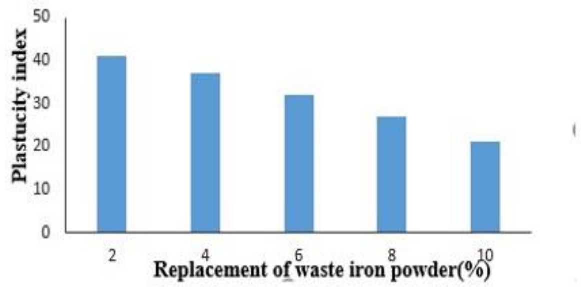


**Fig -8**: Fluctuation of plasticity index of B.C soil at varying percentage of W.I.P

Table-3 shows consistency limits of BC soil with varying proportion of W.I.P. From the figure 7 & 8 it is cleared that with increase in the addition of W.I.P. the consistency limits values decreases. With the reduction in liquid limit of soil, volume change characters (contractive and expansive) of soil will also be reduced.

### 4.3 California bearing ratio test

California bearing experiment was performed to obtain the C.B.R value of a soil sample. Initially C.B.R of BC soil were determined meanwhile later the C.B.R of soil was resolved by adding 2%, 4%, 6%, 8% and 10% of the WIP by the weight of the regur soil.

**Table -4:** CBR test result for varying proportion of W.I.P in B.C soil

| SL.NO | Replacement of iron powder in soil (%) | CBR (%) | |
|---|---|---|---|
| | | Un-soaked | Soaked for 4 days |
| 1 | 0 | 3.57 | 2.59 |
| 2 | 2 | 3.89 | 2.59 |
| 3 | 4 | 4.55 | 2.59 |
| 4 | 6 | 5.20 | 3.24 |
| 5 | 8 | 6.17 | 3.24 |
| 6 | 10 | 7.18 | 3.43 |

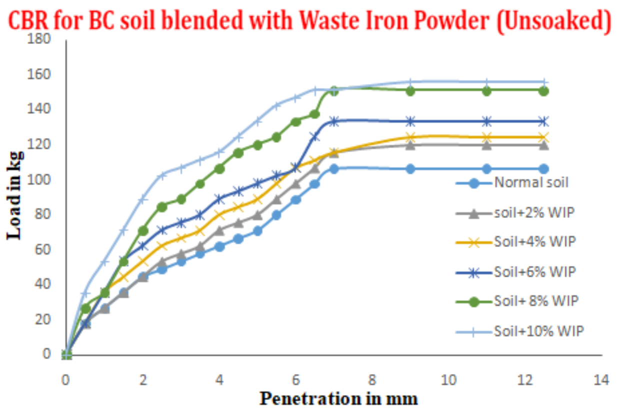


**Fig-9:** Load-Penetration curve for BC soil blended with different percentage of waste iron powder (unsoaked)

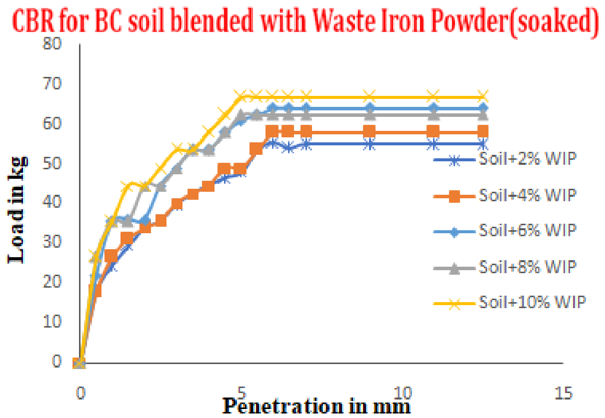


**Fig-10:** Load-Penetration curve for BC soil blended with different percentage of waste iron powder (soaked)

From figure 9 & 10 it is figured that the unsoaked and soaked California Bearing Ratio of BC soil is gradually increased with increase in the replacement of waste iron powder and there by increasing the penetration resistance of subgrade i.e. the bearing capacity of soil.

### 4.4 CBR result for BCS + W.I.P + geomembrane

From the table-9 it is noticed that 6% waste iron powder is the optimal percentage. Here we attempted to assess the combined effect of the optimal percentage of W.I.P and geomembrane on the resistance behavior of a weak subgrade.

**Table -5:** CBR for B.C soil + 6% W.I.P + geomembranes

| Sl. NO | Description | CBR(%) | |
|---|---|---|---|
| | | Unsoaked | Soaked for 4 days |
| 1 | BC soil + 6% W.I.P + 1 layer of geomembrane at the middle of specimen | 5.85 | 2.59 |
| 2 | BC soil + 6% W.I.P + 1 layer of geomembrane at 1/3rd point from the lower side of specimen | 6.50 | 2.59 |
| 3 | BC soil + 6% W.I.P + 1 layer of geomembrane at 1/3rd point from the upper side of specimen | 7.14 | 2.59 |
| 4 | BC soil + 6% W.I.P + 2 layers of geomembrane inserted at 1/3rd point from both lower and upper side of specimen | 7.80 | 2.92 |
| 5 | BC soil + 6% W.I.P + 3 layer of geomembrane inserted at middle and 1/3rd point from both upper and lower side of specimen | 4.87 | 2.59 |

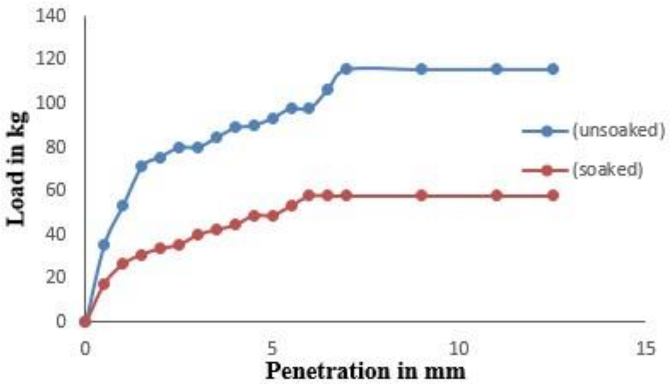


**Fig -11***:* Load-Penetration curve of BCS+6%W.I.P+one layer geomembrane @ the of middle of specimen

Figure 11 shows C.B.R values of 5.85% for unsoaked case and 2.59% for soaked case respectively. When BC soil is mixed with 6% W.I.P and one layer of geomembrane placed at the middle of specimen.

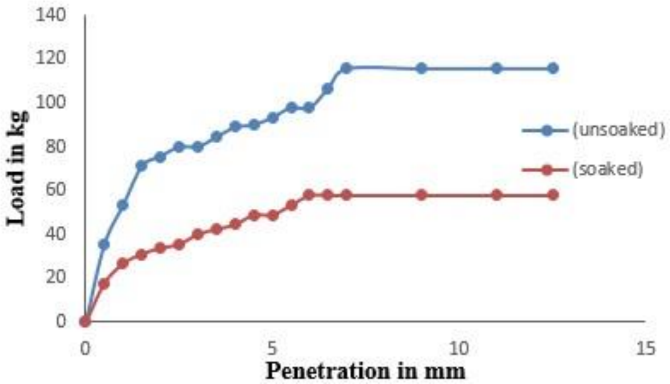


**Fig -12***:* Load-Penetration curve of BCS + 6% W.I.P + one layer geomembrane @ 1/3rd point from the lower side of specimen

Figure 12 shows C.B.R of 6.50% for the case of unsoaked where as 2.59% for soaked case respectively.

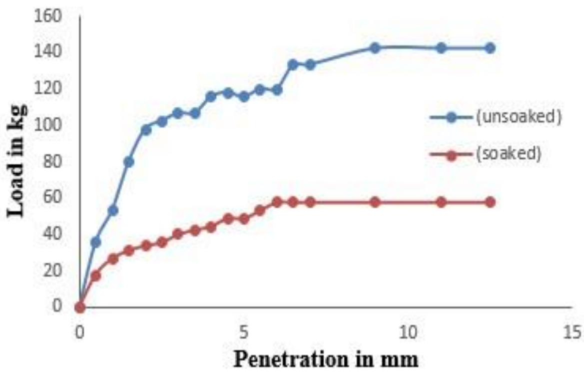


**Fig -13***:* Load-Penetration curve of BC soil + 6% W.I.P. + one layer of geomembrane at 1/3rd point from upper side of specimen.

Fig.13 shows CBR of 7.14% for un-soaked case and 2.59% for soaked case respectively for B.C soil + 6% WIP + one layer of geomembrane inserted at 1/3rd point from upper side of specimen.

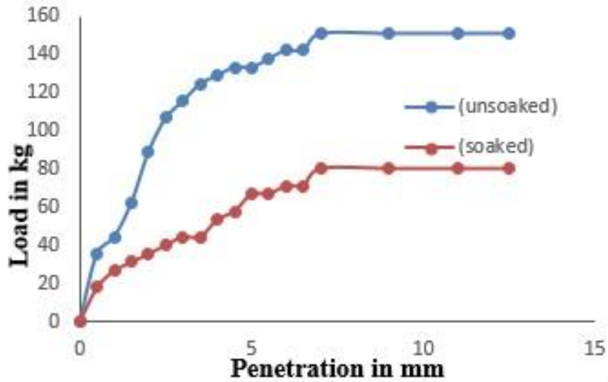


**Fig -14**: Load-Penetration curve of B.C soil + 6% W.I.P + 2 layers of geomembrane inserted at 1/3rd point from both upper and lower side of specimen.

Figure 14 shows CBR of 7.80% for un-soaked case and 2.92% for soaked case respectively when the BC soil mixed with 6% WIP and 2 layers of geomembrane inserted at 1/3rd point from upper side and 1/3rd point from lower side of specimen respectively.

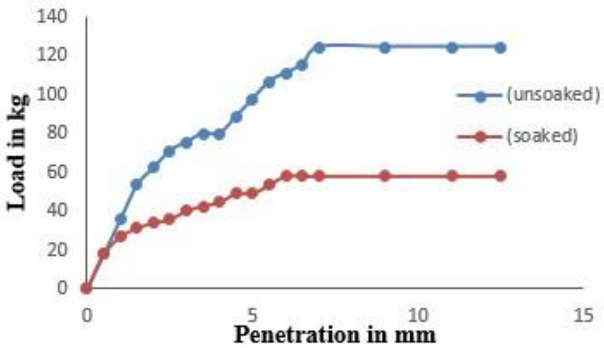


**Fig -15**: Load-Penetration curve of BC soil + 6% W.I.P. + 3 layers of geomembrane inserted at the middle and 1/3rd point from both upper and lower side of specimen.

From Fig.15 it is clear that CBR of 4.87% for un-soaked case and 2.59% for soaked case respectively when BC soil mixed with 6% W.I.P and 3 layers of geomembrane inserted at the middle, bottom and top of specimen.

## 5. CONCLUSION

Most of the investigators studied on the improvement of weak subgrade soil by using the geosynthetic materials like geogrids, geomembrane and geotextile as soil reinforcement and additionally the properties of weak soils are improved through utilization of commercial wastes as an additive. In present analysis the geomembranes are used as soil reinforcement and workshop W.I.P as admixture. In the present work we've made an attempt to know the combined effect of geomembrane and W.I.P on strength properties of soft subgrade soil.

- When the workshop W.I.P was mixed with BC soil, it interpolates into the voids of soil thereby soil permeability of soil reduces leading to decrease in shrinkage and swelling of B.C soil, thus the density of soil gets improve.

- With the increment in the percentage of W.I.P. the consistency limits of soil decrease there by volume change properties like shrinkage and swelling of soil gets reduced leading to improvement of soil efficiency.
- In the usage of 6% of W.I.P at minimum water content we get the MDD. Therefore 6% is the minimal percentage of W.I.P.
- CBR of BC soil increases with increment in the % of W.I.P there by strength of the soil get increased.
- Utilization of geomembrane inside the soft subgrade results in better distribution of applied loads. Thus enhance the serviceable life of roadway.
- Placing of 2 layers of geomembrane is more effective compared to 1 and 3 layers of geomembrane.

## REFERENCES

[1] Arash Barazesh "The effect of adding iron powder Atterberg limits of clay soils", International Research Journal of Applied and Basic Science( IRJABS) ,volume:3, 2012.

[2] A Y Pratiwi " Stabilization of soft soil using industrial waste" IOP conf. series: Earth and environmental science 2021.

[3] Bharti Joshi "stabilization of BC soil using Iron Powder" SSRG International Journal of Civil Engineering, volume:3 , July 2016.

[4] Dharmesh Lal "stabilization of expensive soil by using Jute fiber"3rd International congress on Advances in Mechanical sciences, IOP conf. series; material science and engineering (2020).

[5] E.A. Meshida "The study of the strength characteristics of B.C.soil by using steel mill dust ", International Journal of Scientific and Engineering Research ( IJSER), volume: 4 , May 2013.

[6] Kruthika D M "Evaluation of subgrade capacity of BC soil using iron powder and Plastic Mesh", International Journal of Innovative Research and Creative Technology (IJIRCT) , volume: 4 , 2018.

[7] M Rupas Kumar "stabilization of expansive soil by utilizing Iron dust", International Journal of Engineering Research and General Science(IJERGS) , Volume: 3 , July-August 2015.

[8] Mukesh A. Modi, Ahmedabbas S Rajpura "study of performance of sub grade by stabilizing it with Industrial Iron sludge" (IJAERD) ,volume: 4 , May 2017.

[9] Vijet. B. Gaonkar "stabilization of GGBS treated BC soil using iron powder" (IRJET), volume:6, May 2019.

## BIOGRAPHIES

Dr. Vageesha S.Mathada, Professor, Dept. of Civil Engineering BKIT, Bhalki, Karnataka, India. Experience:30 years

Sharanakumar B.M Assistant Professor, Dept. of Geotechnical Engineering BKIT, Bhalki, Karnataka, India. Experience:05 years

Priyanka received the B.E degree from V.T.U University, in 2018. Currently a final year M.Tech student of Bheemanna Khandre Institute of Technology, Bhalki