"Experimental Investigation on Geotechnical Properties of Chromium Contaminated Soil by Alcofine"

Md Saad Affan [1], Dr. Chethan[2], Md Khaja Moniuddin[3], Vishal Manohar[4]

[1]*PG student, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*
[2]*Associate Professor, Department of Civil Engineering, U.V.C.E, Bangalore*
[3]*Assistant Professor, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*
[4]*Assistant Professor, Department of Geotechnical Engineering, BKIT, Bhalki, Dist. Bidar*

Abstract -*Contamination is a present threshold issue whether it might be soil, air or water and this present study deals with the aim of decontaminating the soil.*

Agriculture, urbanization, mining activities and industrialization are the key reasons from which heavy metals in the soil come from. Mine action is taken as one among the most anthropogenic actions in world, among the above. Chromium is Group IVB metal which has three valence states (+2, +3, +6), among which +6 and +3 is most prevalent. We find that trivalent chromium is poisonous, while hexavalent chromium is highly carcinogenic and toxic. It forms low solubility carbonate, hydroxide, phosphate and sulfide compounds in the +3 valence state. Chromium can lead to insoluble product with barium or lead. In the +6 valence state,typically,Cr+6 products are then reduced to the trivalent state and then immobilized, reducing the solubility and toxicity and we can conclude that trivalent chromium is poisonous, while Cr+6 is carcinogenic and toxic.

Key Words: **MDD & OMC, CBR, Liquid Limit**

1. INTRODUCTION

Expansive soil is one amongst the challenging soils which has high possibility of swelling or shrinkage due to alter of water content. In India, they are commonly known as black cotton soils. In Deccan Plateau, Vindhyachal range their major occurrence is witnessed. The initial problem that occur in regard with black cotton soils is that the deformations are considerably more than elastic deformations and thus might not be predicted by the three i.e, elastic, classical theory or plastic theory. Proper remedial measures are to be opted to reduce its detrimental effects. The remedial actions might be diversified for designing, planning stages and post construction stages. Binders such as calcium chloride, rice husk, lime, cement etc. are also been used to alter the characteristics of black cotton soils. The characteristics which are of worry are permeability, compressibility and durability, to the design engineers. Mineralogical composition of the soils is the key for the selection of binders and the maximum amount of binders to be used [4]. And if this problematic soil is again contaminated with heavy metals it poses a heavy danger to the environment and humanity .In particularly the Liquid substances can just easily contaminate huge volume of the soil, because they can easily go through and scatter in the soil [8].Leachate from polluted soils also have potential to pollute the surface water supplies and ground water.

2. LITERATURE REVIEW

Beth C.Fleming et al. (1992) found that the oxidation state of chromium impacted the solidification/stabilization of chromium contaminated soils. Unconfined compressive strength, moisture content, wet/dry, permeability, durability, Atterberg limits, bulk density, Proctor density, specific gravity, cracking, slump, resistance to penetration, and bleed water were among the physical tests performed. Toxicity Characteristic Leaching Procedure (TCLP), as well as bulk chemistry studies. Binders increased the strength even more than 50 psi, according to the findings. Virgin and treated specimens both passed the TCLP threshold of 5.0 mg/L. The MWEP-l Limit of 0.05 mg/L was not exceeded by either virgin or treated samples.

Hexavalent chromium might be reduced to the trivalent chromium by the inclusion of reducing agents.

D.G. Grubb et al. (2009) examined the immobilization of tungsten and lead by Stabilization/solidification (S/S) processes, Artificially kaolinite was spiked with 10% lead and 1% tungsten by means of dry weight ,silica fume cement (SFC), cement kiln dust and Type I/II Portland cement were been used as binders. The S/S agents were introduced at dosages of 5, 10 and 15 % for different curing period of 1, 7and 28days.Crystalline mineral phases which was responsible for Pb and W immobilization was investigated by X-ray powder diffraction (XRPD) .Results indicated that leach ability of both W and Pb in all among the TCLP samples was mainly dependent on pH of the treatments. Results of TCLP showed that regardless of stabilizing agents and the clay type the lead concentrations was seen decreasing with increasing pozzolana content, PC was seen to be most effective stabilizing agent for immobilizing Pb when compared to SFC being silica enriched. While CKD was seen to be the most effective solidifying agent on SPLP-Pb leach ability.

3. MATERIAL AND METHODOLOGY

Metakaolin: Metakaolin is advanced kaolin clay which is fired up under careful prohibited conditions to generate the amorphous alumino silicate which is reactive in the concrete. Like different pozzolans, It reacts with lime byproducts formed during the cement hydration.

Portland cement: Solidification, that involves blending Portland cement into contaminated soil, protects the humanity by immobilizing heavy metal within the blended material. The cement reacts chemically with the water in substance being treated, that creates the changes in its chemical and physical properties that solidify these toxic constituents and thus prevent their escape into the environment.

Gypsum: To investigate the influence of a wet environment on the durability and stability of stabilised gypsum–clay soil, recycled gypsum was blended with cement and lime in various ratios in the dry state, and varied amounts of admixtures were blended with the tested soil. Due to gypsum'ssolubility in water, using recovered gypsum as a stabilizer material in a moist environment poses a number of problems.

Alcofine 1203: To establish a comprehensive adsorption-solidification/stabilization technique for fixing and inactivating the poisonous heavy metal chromium, as well as to introduce various cost-effective sorbents for the process of irreversible chromium cation fixation, an attempt by a material of composition CaO+Al2O3+SiO2+glass content is made which was found to be appropriate and this composition was found in alccofine 1203, a compound of new generation, a micro fine product which has particle size smaller than other products like cement etc. which is manufactured in the India and introduced by the Ambuja Cement Ltd in the month of march 2013, will be used. The selected sorbents demonstrated fast retention kinetics and high capacities for the contaminants.

4. RESULTS AND DISCUSSION

4.1 EXPERIMENTAL ANALYSIS OF GEOTECHNICAL PROPERTIES OF VIRGIN SOIL

4.1.1 TESTS CONDUCTED ON VIRGIN SOIL: The virgin soil samples were procured from different locations from nargund taluk,naganuur.The soil collected were sieved through a 10 mm sieve. Rocks and other large substances which were not passing through the sieve were removed. This samples were then systematically mixed to ensure the uniformity and was stored at room temperature for consequent use in the experiments. Prior to artificial spiking of chromium,index and engineering properties were conducted on this virgin soil.Starting with the determination of water content as per IS:2720(part IV) 1985. and dry density ,the grain size analysis was carried out as per IS 2720 (part IV) 1985,consistency limits as per IS 2720 (Part V) 1985 ,pH measurements were conducted as per pH - IS 2720 part (XXVI), 1973, Modified proctor test as per IS 2720 (Part VII) 1983, Free swell as per - IS 2720 (part 40)1977,strength was analyzed by unconfined compressive strength.

RESULTS AND DISCUSSIONS

The moisture content of soil was found to be 27.74,with a dry density of 1.38gm/cc. .Grain size analysis was carried out and the soil contained 0%

gravel, 5.13 % of coarse sand, 5.15% of medium sand, 20.76 of fine sand and 67.02% of silt and clay. With the Modified proctor test the OMC came to be about 32% with a dry density of about 1.4175. Specific gravity came out to be 2.56.pH was found to be 8.5 for this sample. the swell index for the soil was seen 60%

Variation of Consistency Index

When atterberg tests were conducted the liquid limit for virgin soil came to be 84% and plastic limit to be 42.9% ,plasticity index as 41.1%.this demonstrated that the soil was inorganic clay of high plasticity.

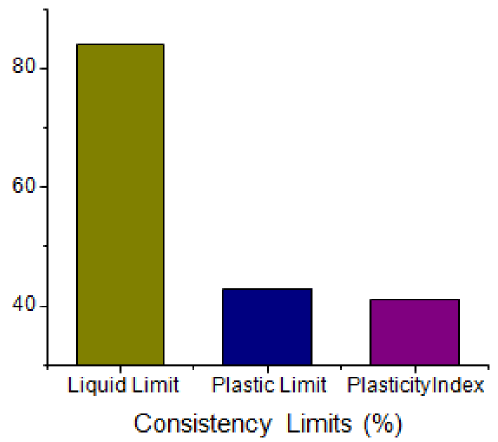

Figure 4.1. Consistency limit variations of virgin soil

Graph representing Flow Index of 11.2,Toughness Index of 3.66,Consistency Index of 1.3722 and Liquidity Index of -0.369 of virgin soil.The result showed that the soil under investigation was stiff or hard in nature.

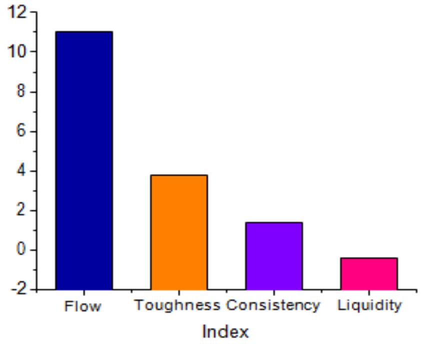

Figure 4.2. Variation of flow, toughness, consistency and liquidity index

4.1.2 Variation of UCS with Water Content

The unconfined compressive strength was carried out for five different water content of the soil. i.e for 28%,30%,32%,34% and 36%, and the strength was found to be 102.8,104.1,79.3,68.1and 53.7 respectively. The strength of the soil reduced as the water content increased. As the curing period was enhanced, the strength of the product improved as well.

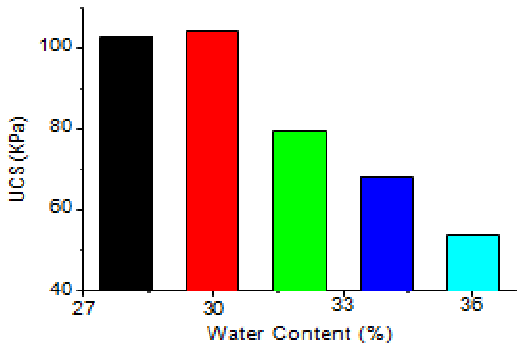

Figure 4.1.2 Variation of UCS with water content

4.2 EXPERIMENTAL ANALYSIS OF GEOTECHNICAL PROPERTIES OF CONTAMINATED SOIL

4.2.1 Variation of pH with Concentration

pH was found to be 8,8and 8.2 for 2500,3000,3500ppm concentration respectively.The pH decreased for varying concentrations when compared with virgin soil.while it remained constant with varying concentrations.

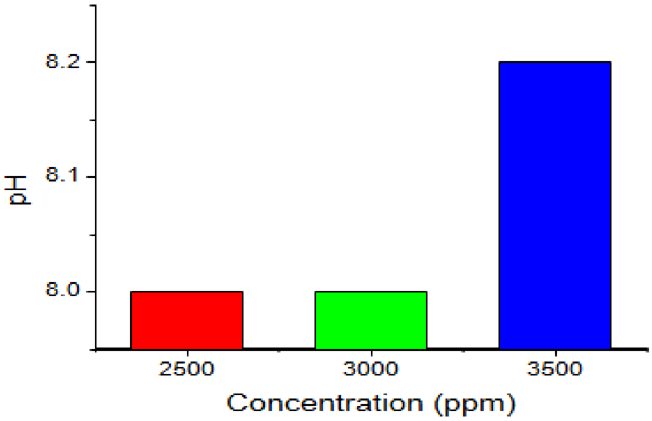

Figure 4.2.1. Variation of pH with concentration

4.2.2 Variation of Consistency Index

For the atterberg tests conducted the liquid limit for chromium spiked soil came to be about 77.3%,75.2% and 73.5%,plastic limit to be 41.94%,46.58% and 38.29%,plasticity index as 35.36%,28.62% and 35.21%, for 2500,3000 and 3500ppm concentrations respectively.This results demonstrated that on chromium spiking with virgin soil there was no much change in the consistency limits for three different 2500, 3000 and 3500ppm concentrations selected for the study.The same for chromium contaminated soil was found to be decreasing when compared to virgin soil.While the liquid limit, plastic limit showed a slight downward trend for different concentrations while plastic index remained constant.This is because when soil was polluted with heavy metal,composition of mineralogy in soil may be changed.This slight decrease may be due to the reaction of chromium metal with clay particles by the crystallization,dissolution,cation exchange and precipitation,Cr+3 had substituted Ca2+,Na+,K+, and Mg2+ in the soil under acidic conditions,that caused the diffusion layer to get thinner,which caused the decrease in hydrate water.

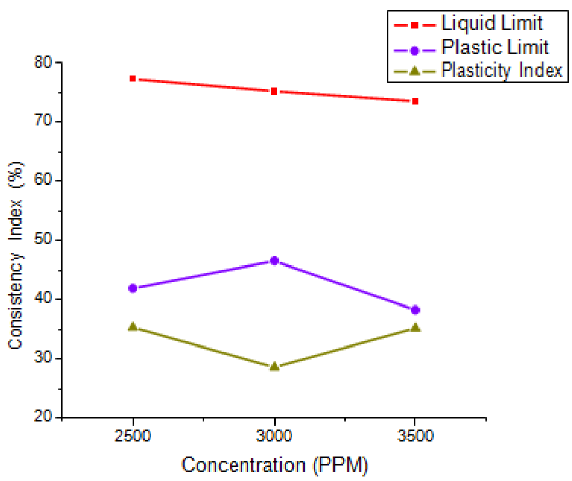

Figure 4.2.2 Variation of consistency Index with concentration.

Variation of Toughness Index of 1.318, 2.36 and 2.79 and flow index of 26.82,12.11 and 12.62 with varying Concentrations of 2500ppm,3000ppm,3500ppm respectively was observed. This results depicted that toughness index got decreased while flow index remained constant when compared with virgin soil.

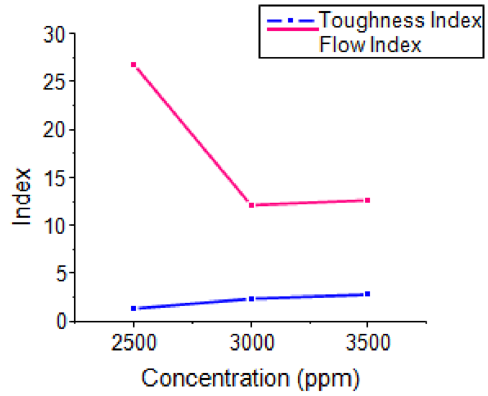

Figure 4.2.3 Flow index and toughness index variation with concentration

4.2.4 Variation of Specific Gravity

Specific gravity was found to vary as 2.61, 2.62 and 2.64 for 2500,3000 and 3500 ppm respectively.This results demonstrated that there was increase in specific gravity when compared to virgin soil and not much change when compared to varying concentrations. This increase may be due to chromium adsorbtion on clay minerals of the soil by dissolution,ion exchange, complexation, crystallization,precipitation and thus on chromium reaction with soluble salts ,precipitate was seen to be formed,So as the density of precipitate is greater then the soil specific gravity got increased.

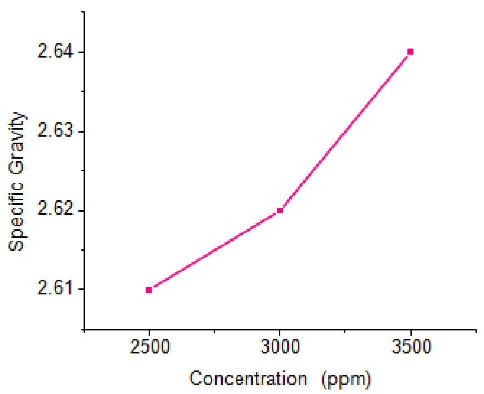

Figure 4.2.4. Variation of specific gravity with concentration.

4.2.5 Variation of unconfined compressive strength

For 2500ppm concentration unconfined compressive strength was carried out for 0,7,28 and 45 days and results were 76.8 kPa,123 kPa,227.7 kPa and 274.5 kPa respectively. Similarly for 3000ppm concentration the results were 71.55 kPa,117 kPa,232.5 kPa,277.9 kPa respectively and for 3500ppm concentration results came out to be 66.86 kPa,95 kPa,215 kPa,267.5 kPa respectively.This results showed that Strength decreased for varying concentration of the contaminant when compared to virgin soil. While there was slight change in strength for 2500,3000 and 3500ppm concentrations.

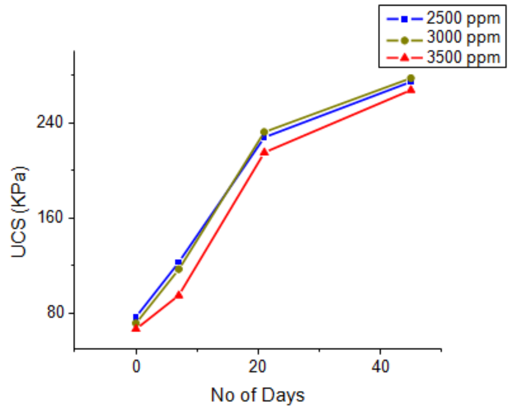

Figure 4.2.5 Variation of UCS with duration and concentration

4.2 STABILIZATION/SOLIDIFICATION OF CHROMIUM CONTAMINATED SOIL BY ALCCOFINE

4.2.1 Variation of pH for varying concentration and varying dosages of binder.

The pH of chromium spiked soil sample was found to be 8.1 for all binder dosages of 2%, 5% and 8% of 2500 ppm concentrations, for 3000 ppm concentration it was found to be 8 for all the binder percentage of 2%, 5% and 8%.And for 3500ppm concentrations pH was found to be 8 for all the binder dosages of 2%, 5% and 8%. pH of binder added soil decreased when compared to virgin soil.Also there was no much decrease in pH with different percent of concentrations and binders.

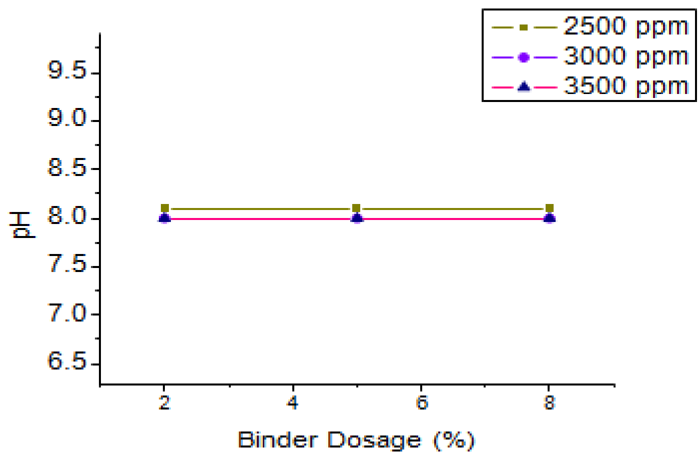

Figure 4.2.1 pH variation with binder addition

4.2.2 Variation of Consistency Index with different Binder Dosages

Atterberg limit tests were carried out for 2500ppm concentration with binder percent of 2%, 5% and 8% ,and for which liquid limit came out to be 74.5%,76.4%, and 76.75%,plastic limit as 41.216,38.58 and 39.255.and plasticity index as 33.284%,37.82% and 37.495% respectively.On addition of alccofine 1203 to chromium contaminated soil there was slight decrease in atterberg limits when compared to virgin soil.

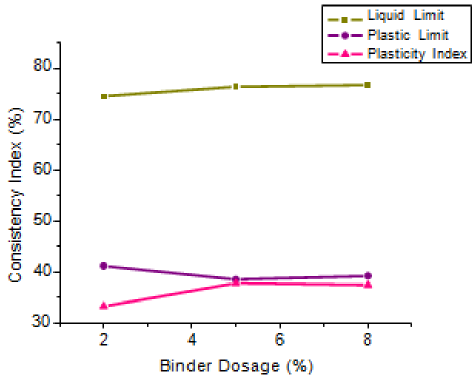

Figure 4.2.2 Variation of consistency limits with binder dosage

4.2.3 Variation of Toughness Index of 2.894,2.154 and 2.53 and flow index of 11.5,17.552 and 15.819 with Varying Binder Dosages of 2%,5%,8%. for 2500 PPM Concentration of the Contaminant was observed

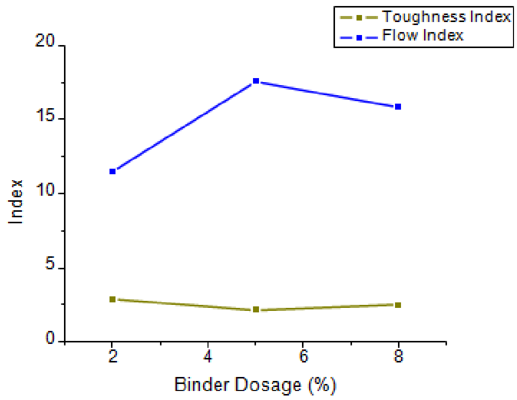

Figure 4.2.3 Toughness index and flow index variation with binder

4.2.4 Consistency index tests were carried out for 3000ppm concentration with binder percent of 2%, 5% and 8% , and for which liquid limit came out to be 74.06%, 74.67% and 74.32%,plastic limit as 40.68,36.855 and 37.29 and plasticity index as 33.3%,37.815% and 37.03% respectively. On addition of alccofine 1203 to chromium contaminated soil there was decrease in consistency limits when compared to virgin soil.There is no variation in consistency limits with the increase of binder dosages.

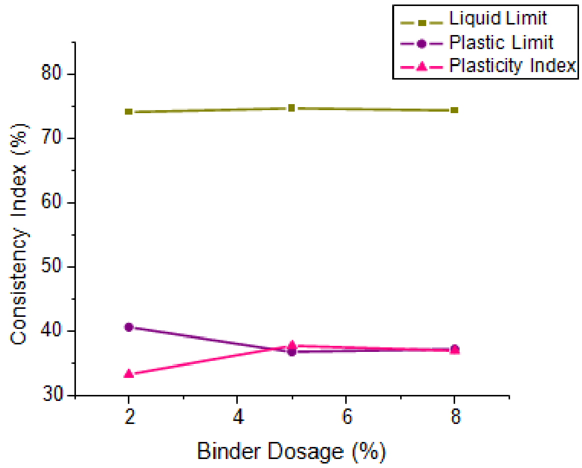

Figure 4.2.4 Variation of consistency limits with binder dosage

4.2.5 Variation of Toughness Index of 2.63,2.148 and 2.046 and flow index of 12.67,17.61 and 18.09 with varying Binder Dosages of (2%,5%,8%) for 3000 PPM Concentration of Contaminant was observed.

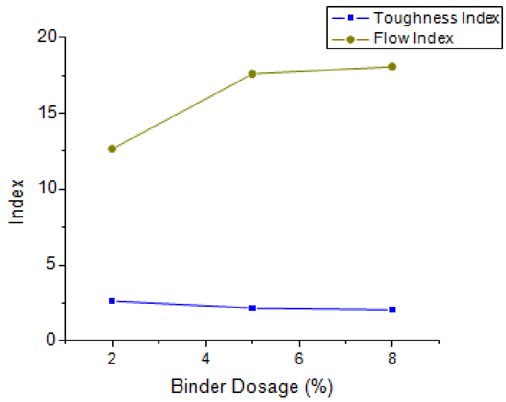

Figure 4.2.5 Toughness index and flow index variation with binder

4.2.6 Similarly the Atterberg limit were also carried out for 3500ppm concentration with binder percent of 2%, 5% and 8% and for which liquid limit came out to be 73.9%, 73.35% and 72.75% , plastic limit to be 39.9%,35.539%, 36.58% and plasticity index as 34%,37.811% and 36.17% respectively. On addition of alccofine 1203 to chromium contaminated soil there was decrease in consistency limits when compared to virgin soil.

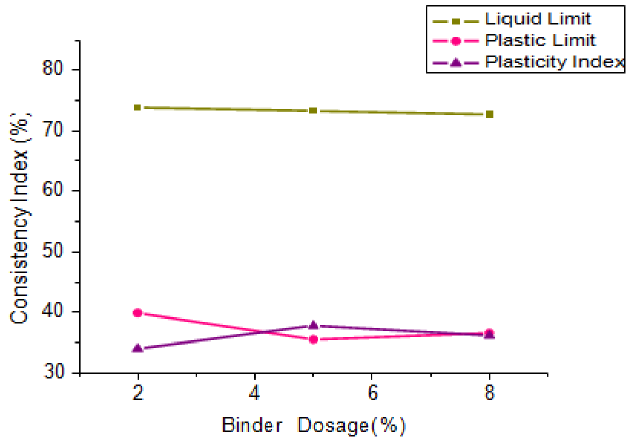

Figure 4.2.6 Variation of consistency limits with binder dosage

4.2.7 Variation of Toughness Index of 2.394,2.138 and 1.668 and flow index of 14.197,17.68 and 20.08 with varying Binder Dosages of (2%,5%,8%) for 3500 PPM Concentration of Contaminant was observed.

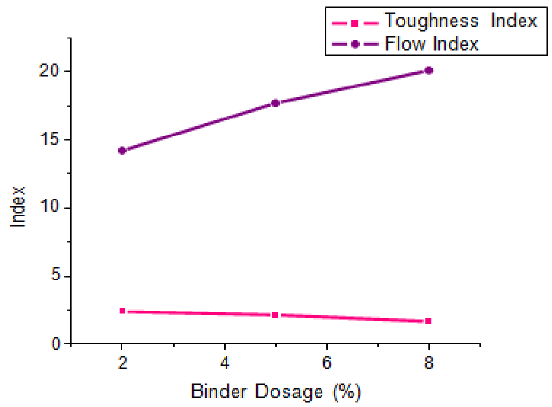

Figure 4.2.7 Toughness index and flow index variation with binder

4.2.8 Variation of Specific Gravity with Binder Dosage

Specific gravity for solidified soil for 2500 ppm, 3000 ppm and 3500ppm concentration with binder percent of 8% were 2.63, 2.65 and 2.67 respectively there was no much change in specific gravity with varying binder addition.

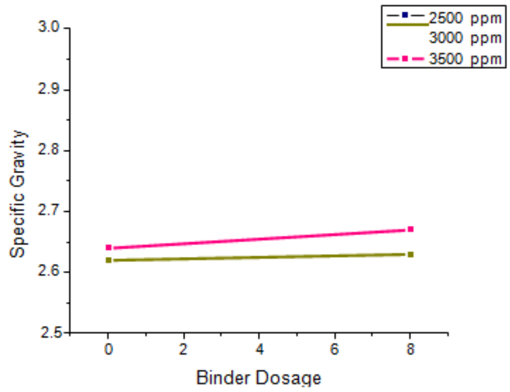

Figure 4.2.8 Variation of specific gravity with binder.

4.3 Variation of Unconfined compressive strength

4.3.1 Variation of UCS with Binder Dosage for 2500ppm

Unconfined compressive strength tests were carried out for different curing periods, for solidified soil of 2500 ppm concentration and 0th day standard curing with binder percent of 2%, 5% and 8% were found to be 76.88,92.54 and 84.31kPa respectively.UCS for 2%, 5% and 8% solidified soil sample of 7 th day standard curing were 284.91,573 and 507.24kPa respectively and for 2%, 5% and 8% solidified soil sample of 21 th day standard curing was found to be 380,1047 and 769.4kPa respectively.For 45 standard cured days and for 2%, 5% and 8% solidified soil sample results came out to be 765 kPa,1068.25 kPa and 815.7 kPa respectively.A maximum strength was achieved for optimum dosage of 5% alccofine 1203.For 2% alccofine added there is no much strength gain when compared to virgin and contaminated soil.

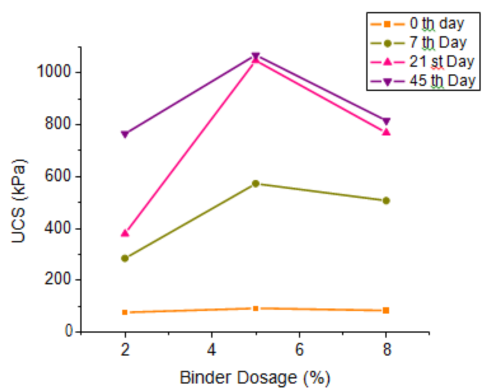

Figure 4.3.1 Variation of UCS with varying durations and binder

4.3.2 Variation of UCS with Binder Dosage for 3000 PPM.

Unconfined compressive strength tests were carried out for different curing periods, for solidified soil of 3000 ppm concentration and 0th day standard curing ,with binder percent of 2%, 5% and 8% were found to be 100.86,114.36 and 98.29kPa respectively.UCS for 2%, 5%

and 8% solidified soil sample of 7th day standard curing were 271.55,557.23 and 509.75kPa respectively and for 2%, 5% and 8% solidified soil sample of 21th day standard curing was found to be 347.8,797.26 and 755.3kPa respectively. For 45 standard cured days and for 2%, 5% and 8% solidified soil sample results came out to be 630 kPa, 962.5kPa and 837 kPa respectively.This results demonstrate that the strength achieved by addition of 5% alccofine was high .Also the strength gained by solidified sample was much high when compared to contaminated sample.

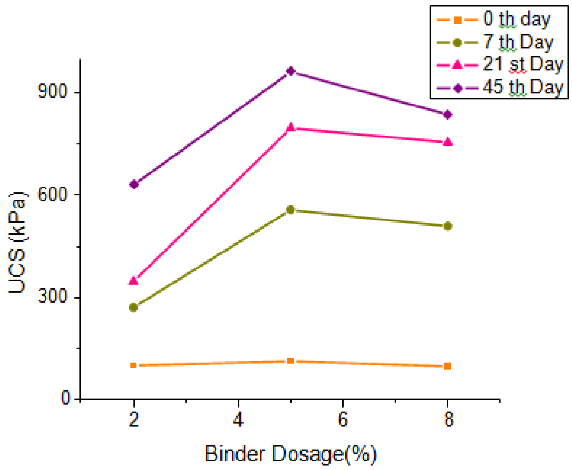

Figure 4.3.2 Variation of UCS with varying durations and binder

4.3.3 Variation of UCS with Binder Dosage for 3500ppm.

Unconfined compressive strength tests were carried out for different curing periods, for solidified soil of 3500 ppm concentration and 0th day standard curing ,with binder percent of 2%, 5% and 8% were found to be 93.54,106.55 and 84.93kPa respectively.UCS for 2%, 5% and 8% solidified soil sample of 7th day standard curing were 289.31,576.61 and 514.27kPa respectively and for 2%, 5% and 8% solidified soil sample of 21th day standard curing was found to be 376.78,1095.77 and 838.925kPa respectively. For 45 standard cured days and for 2%, 5% and 8% solidified soil sample results came out to be 587.3 kPa, 945.4kPa and 864 kPa respectively.A early gain in strength was noticed by the addition of alccofine 1203.

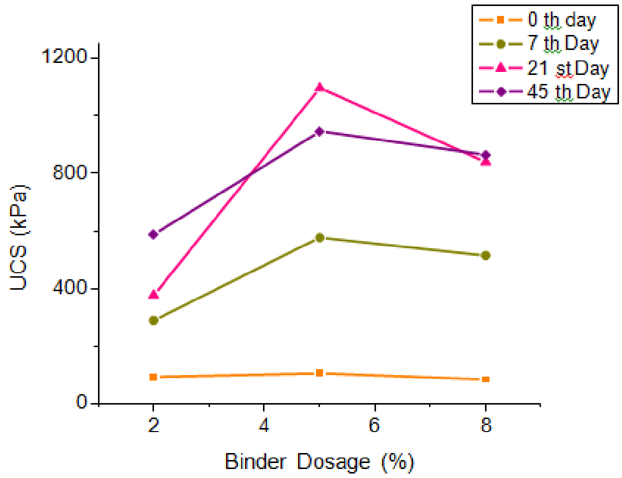

Figure 4.3.3 Variation of UCS with varying durations and binder

5. CONCLUSIONS

The soil pH after contamination was found to decrease with respect to virgin soil and specific gravity was slightly effected and was found to increase. However on chromium spiking with virgin soil there was no much change in the same for three 2500, 3000 and 3500ppm concentrations selected for the study. For the consistency limits for chromium contaminated soil was found to be decreasing when compared to virgin soil. While the liquid limit, plastic limit demonstrated a slight downtrend for different concentrations and plastic index and strength remained constant even with varying concentration of the contaminant.

On addition of alcofine 1203 to chromium contaminated soil there was decrease in liquid limit and plastic limit, plasticity index when compared to virigin soil. Also for chromium contaminated soil there was no much variation in liquid limit ,plastic limit and plasticity index when solidified with alcofine 1203.There is no variation in consistency limits with the increase of binder dosages and variation of concentration of chromium.Strength was seen to be increasing for alcofine added soil when compared to both virgin and contaminated soil. There was a decrease in pH on binder addition when compared to virgin soil. However for 2500ppm concentration the strength obtained by alcofine addition was same when compared to the contaminated soil. Also when there was a comparative study conducted on strength gain of different curing periods(0,7,21 and 45 days) ,a early gain in strength was noticed by the addition of alcofine 1203.Also a maximum strength was achieved for optimum dosage of 5% alccofine 1203.There was no much variation in strength with varying contaminant concentrations.There was a very high strength gain in alccofine 1203 solidified samples when compared to other binders.

REFERENCES

1 Afshin Asadi, Nader Shariatmadari, Hossein Moayedi, Bujang B. K. Huat (2011) "Effect of MSW Leachate on Soil Consistency under Influence of Electrochemical Forces Induced by Soil Particles." Int. J. Electrochem. Sci., 6, 2344 – 2351.

2 Arpita V Patel (2014) "A Study on Geotechnical Properties of Heavy Metal Contaminated Soil." Indian Journal of Research.,Volume : 3, Issue : 6

3.D.G.grubb,D.H.moont.Reillym.Chrysochoou,D.Dermatas(2009)"stabilization/solidifi cation (s/s) of pb and w contaminated Soils using type i/ii portland cement, silica fume cement and Cement kiln dust." Global NEST Journal., Vol 11, No 3,267-282

4 D.M. Hamby "Site Remediation Techniques Supporting Environmental Restoration Activities: A Review." University of Michigan, Ann Arbor.

5 Evangeline, Y. Sheela John, Raji Ann (2010) "Effect of Leachate on the Engineering Properties of Different Bentonites." Indian Geotechnical Conference – 2010.

6 Fleming, Beth C. and Cullinane, Jr, M. John(1992), "Properties of Solidified/Stabilized Chromium Contaminated Soil". US Army Research., 85.

7 Fusheng ZHA , Jingjing LIU, Xueqin Zhang , Chengbin Yang and Kerui, Cui "The stress-strain properties of the cement stabilized/solidified chromium contaminated soils eroded by sodium chloride."15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering.

8 Jung-Wook Kim , Myung Chae Jung (2010)"Solidification of arsenic and heavy metal containing tailings using cement and blast furnace slag" Environ Geochem Health.,33:151–158 .

9 Kayal Rajakumaran (2015) "An Experimental Analysis on Stabilization of Expansive Soil with Steel slag and fly ash" International Journal of Advances in Engineering & Technology.

10 Kasha Krishna ,K. Rama Mohan ,N. N. Murthy ,V. Periasamy ,G. Bipinkumar ,K. Manohar ,S. Srinivas Rao(2012),"Assessment of heavy metal contamination in soils around chromite mining areas, Nuggihalli, Karnataka, India". Environ Earth Sci.

11 Khitam Abdulhussein Saeed, Khairul Anuar Kassim, Hadi Nur,and Nor Zurairahetty Mohd Yunus.(2014) "Strength of Lime-Cement Stabilized Tropical Lateritic Clay Contaminated by Heavy Metals".KSCE Journal of Civil Engineering.,19(4):887-892.

12 O. A. B. Hassan(2010) "Experimental study on utilizing iron slag to stabilize Cr(VI)- contaminated soils" Waste Management and the Environment.,Vol 140.