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Preliminary Investigation Regarding Swelling Behaviour of Soil of Southern Region of KPK, Pakistan

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Abstract: This study is focused on the preliminary investigations of soil of southern district Bannu, KPK, Pakistan in the form of geotechnical and mineralogical details, obtained by performing various kinds of tests on soil samples collected from selected spots, where the unusual cracks were observed to have been appeared in the pavements, boundary walls and some other parts of the buildings. Similar cracks were observed in most parts of the world where the soil was found to be expansive which depends on clay mineralogy, binding agents, migration of water beneath the surface and the ability of soil to absorb water. X-Ray diffraction analysis was used to study the minerals present in the soil and its fabric was studied with the help of Scanning Electron Microscopy and those minerals were explored which are not involved in the swelling phenomenon such as kaolinites, chlorites, quartz and poligorskite. Geotechnical investigation was performed by digging the trial pits and collecting soil samples in polythene bags for determining its Atterberg, s limits and studying different geotechnical reports prepared by soil mechanics lab, UET Peshawar. The soil was found to lie within the range termed as low plasticity clay whose swelling potential is moderate to medium.

Keywords-Swelling, Semi-arid, climate, plasticity index

I. Introduction

District Bannu is located in Khyber pukhtunkhwah province of Pakistan between $32^0 52'$ North latitude and $70^0 37'$ East longitudes. The total area of Bannu is 118958 hectares out of which 62.3% is cultivated area; most of the area is barani while only 11% is irrigated (G. Saeed khan 1984). It can be concluded that Bannu is predominantly agricultural land. As far as the climate of Bannu is concerned it is nearly semi-arid region and in summer season sometimes there are very heavy rains and afterwards there is a period of drought. This leads to a potential problem of swelling being caused in the soil which may cause cracking of floors, pavements, boundary walls and similar light structures (Muawia.A.Dafelaand et.al 2012).The focused area is located along the main Dera Ismail Khan road, comprising of Bannu Campus, Smal Khoni, Dut Kalay and Kala Kalay. Excluding doctor colony the rest of the area is mostly agricultural and there is a network of drains and small canals through which these lands are frequently irrigated. This over irrigation may cause rise in ground water (Al-samad et al 1990). Since there are number of trees and expansion in argilicuos soils can occur when these trees are cut down before the construction (Samuels and Cheney 1974).

Figure 1 Map showing the study area

Starting from UET Bannu campus on the way to D I khan the ground water table becomes closer and closer to the ground surface nearly 10m to 15m as told by the local people. Now the presence of clay minerals like smectite, montimorilonite, illite, atapulgyte and kaolinite etc. would cause a big hazard of heave of soil and ultimately damaging the structures. These minerals have got the tendency to absorb more water and swell as the moisture content increases Clay mineral (montmorillonite) normally identified by its color which is darkish grey to radish grey, plays a very significant role in the swelling of expansive soils (Charles Lucian 2006).

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Fig-2 sample cracks appeared in the buildings

In order to avoid the hazard of swelling of soils and protect the buildings and infrastructure from future damages, it is necessary to evaluate the soil in terms of its geotechnical properties first as the liquid limit and plasticity index may be the preliminary indicators of expansive soil and further if the clay fraction is more than 11%, the danger of swelling may still be present (S N Abduljauwad 1994)

II Materials and Methodology

District Bannu lags far behind in case of planning and sound infrastructure. Excluding Bannu Township and
Bannu cantt most of the construction is haphazard. A survey was conducted of the main residential areas along Kohat road and D I khan road to collect information regarding the affected structures and facilities. It was found that the cracking of floors and boundary walls was very common occurrence in those areas, where houses were constructed mostly in agricultural lands. The irrigation was very frequent in these areas and drainage system was found to be very defective which led to the accumulation of rain water and its penetration into the ground. The migration of this water beneath the structures might be the reason for those cracks appearing in various parts of the houses. When some people of the concerned areas were consulted, they admitted that the depth of foundation in these areas were not more than 3ft which comes in the range of active zone, vulnerable to swelling hazard.
This study was carried out to explore the fundamental reason behind all this. This is to prove whether the clay and non-clay minerals are present in this soil or not. For this purpose trial pits were made in the regions marked by small circles in **Fig-1.** Samples were recovered in plastic bags and were taken to the soil lab. They were dried in the oven and then parts of them were tested for determination of liquid limit and plastic limit to yield plasticity index. While powdered samples were prepared for X-ray diffraction analysis and scanning electron microscopy

III. Results and Tables

Geotechnical Considerations

In the first stage the undisturbed soil sample recovered from the trial pits were tested in the lab for the determination of its liquid limit and plastic limit as per ASTM D4318
In collaboration to lab work various geotechnical reports were consulted to grasp more and more information about the nature of soil of Bannu. **Table -1** gives a summary of the results of tests conducted on samples collected from various parts of District Bannu. These results clearly indicate the fact that liquid limit of almost all the samples is 30 or above 30 and all of them lies on the plasticity chart in the range of low plasticity clay (CL) as demonstrated in **fig-5**. The liquid limit of Doctor Colony is an exception in this case as its liquid limit is very low as compared to the other samples. While performing the tests it was observed that the soil was found to be very sensitive to variation in moisture content. Increasing the moisture content by minute amount the soil changed its behavior in abrupt manner. Therefore the location of ground water table and drainage system for rain water plays a major part in the stability of structures erected on this particular soil type, while both these problems exist and can be predominantly observed in residential areas of Bannu which leads to the origination of cracks in the buildings and causes the damage which should not exist at this stage.

X-Ray Diffraction Analysis

High energy rays are emitted from cathode and they are made to fall upon the anode of an evacuated tube. The anode contains the target element from which the electrons are forced to discharge due to cathode rays giving rise to the generation of X-Rays. Bragg equation is used to determine the crystal spacing (d) in angstrom which is the basis for characterizing particular minerals. The famous Bragg equation is as under

$$n\lambda = dsin\alpha$$

Where λ wavelength and d is is spacing between planes of crystal. Cu was used as a source of X-rays. Four Powdered samples were prepared from the soil obtained from Doctor Colony, kala kalay, small khoni and dat kaly and their diferactometer records have been shown in **fig-3.** It is quite obvious from the diferactometer records that all the samples are consistent in phase and peaks with each other and clearly indicate the absence of clay minerals responsible for absorption of moisture and causing heave because all these minerals lie in the range of very low values of 2Ɵ ranging from 4 to 8 and yielding larger values of d-spacing from 14 up to $17A^0$ (Muawia.A.Dafella et al 2012). No such pattern can be observed in the peaks represented in **fig-3**. This is in accordance with the

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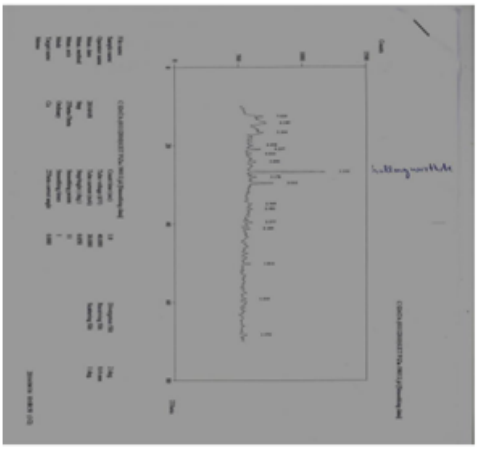
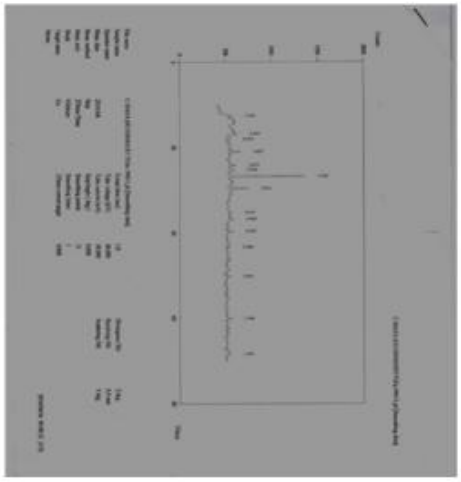
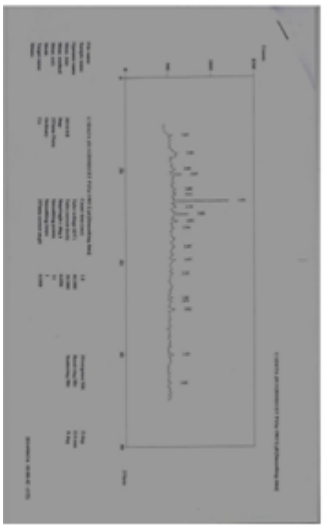
fact that the liquid limits of the soil samples are not more than 41. While in the presence of these clay minerals like smectite, montmorilonite and illite the soil samples yield liquid limits more than 50 and can be placed as CH or MH on the plasticity chart shown in **fig-5.**

Scanning Electron Microscopy

The morphological structure of minerals and its chemical characterization is almost impossible without the aid of this versatile instrument which enlarges an object by enlarging the optical angle through lenses. The four powdered samples were examined by this instrument at PCSIR Lahore, Pakistan to explore the structure of minerals contained by them on micro level. The images obtained are given in **Fig 5.** These images are showing platelets and sheets of silica with the thickness of 4 and 5 micron meter. They are mostly kaolinites with some mixes of chlorite, helloycite and quartz (courtesy PCSIR lab report).







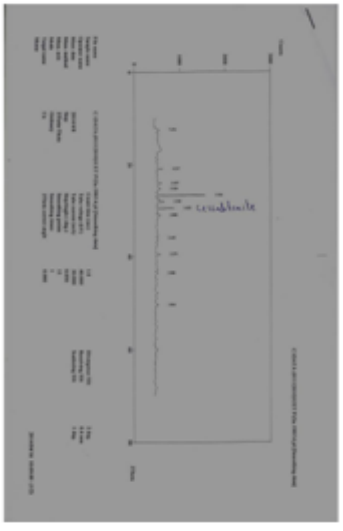


Fig3 XRD patterns for various samples (a) kala kalay (b) Doctor colony (c) small khoni (d) dat kala (courtecentralized research lab, physics department, University of Peshawar

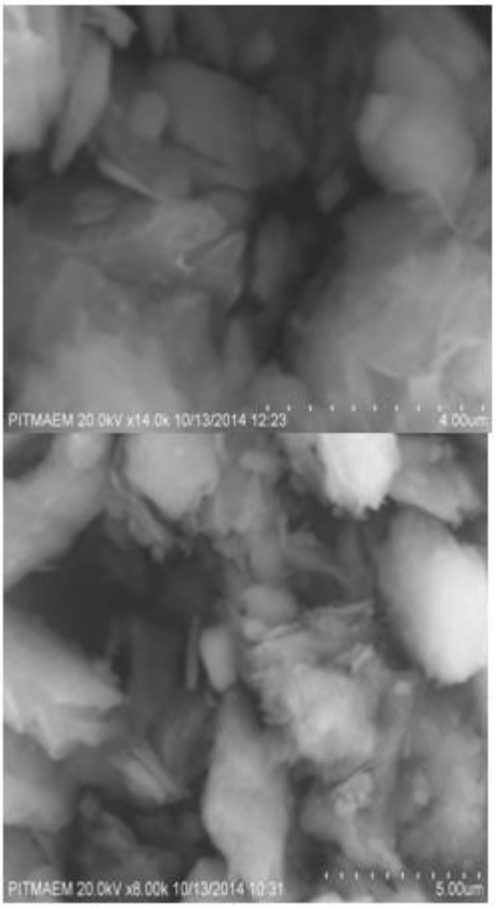


Fig-4 Images from scanning electron microscopy (courtesy PCSIR Lahore)

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Table 1 summary of geotechnical characteristics of soil samples from District Bann

S. No	Location	Depth (m)	Source of sample	LL (%)	PL (%)	Plasticity Index	UCS Classification
1	UET Bannu campus	1.5	BH	31.78	9.83	21.95	CL
2	Doctor colony	1	TP	21.34	11.67	9.67	CL
3	Smal khoni	1	TP	31.78	25.64	12.14	CL
4	Dat kala	1	TP	37.58	27.05	10.53	ML
5	Kala kala	1.5	TP	31.2	21.67	9.52	CL
6	FG school Bannu cantt	3	BH	34	19	15	CL
7	Medicarecentre Bannu city	1	TP	41.5	25.8	15.7	CL
8	Officer colony Bannu cantt	1.5	BH	29.7	19.1	10.6	CL
9	General bus stand Bannu cantt	1.5	BH	30.6	20.1	10.5	CL
10	Passport office Bannu township	1.5	BH	38	22.9	15.1	CL

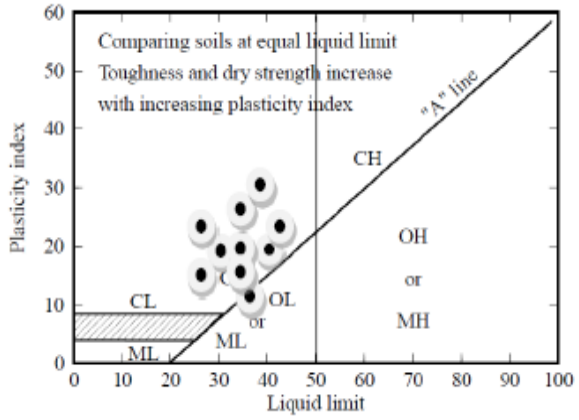

Figure 5 Plasticity Chart

IV. Conclusion

This whole study can be concluded in the following manner.

- The big reason which is causing problems in the residential settlements of District Bannu is the infiltration of water inside the ground due to defective drainage and over irrigation
- The Type of soil is found to be (CL) low plasticity clay which changes its behavior abruptly with the increase in moisture content
- The liquid limit and plasticity index is not that much greater as to cause the hazard of heaving of clays catastrophically

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