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INVESTIGATIONS ON BUILDING MATERIALS

Part I. Characterization of SurfaceSoil

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Soils around five towns viz Gujranwala, Gujrat, Wazirabad, Kamoki and Kasur have been analysed for their pH, moisture, electrolytes, total soluble salts content and for their grain size, plasticity index and plastic limit. They constitute the sediment load transported by the Indus and its tributaries and in this respect they are similar to the soils in other river basins. The irrigation practice is responsible for salnising the soil and as such quite a few samples from the study area were found to be alkaline, to contain high amount of total soluble salts and to have low plasticity index. They are therefore not suitable for agriculture or for making bricks. They can, however, be stabilized by using lime, portland cement or pozzolana. Samples in the remaining areas are good for agriculture and also for use as building material e.g. brick making and civil engineering construction.

Key words: Soils, Analysis, Building materials.

INTRODUCTION

Fairly detailed geological and minerological mapping has been carried out through the Reconnaissance Soil Survey undertaken by the Directorate of Soil Survey, Pakistan in collaboration with UNDP and FAO in 1965-68 [1]. The study, however, lacks data for soil characterization in terms of building material usage and for civil engineering construction. Since the process of urbanization has, as in other countries, been exerting high pressure on agricultural land which is being converted into housing colonies, it is pertinent that such data should be available. Realising the importance of such a study, the mapping of the soils with respect to their physical and chemical properties has been initiated in the various areas of the country where intensive construction activity has been undertaken. The present paper is the first in the series and describes certain characteristics of the soil around Gujranwala, Gujrat, Wazirabad, Kamoki and Kasur cities/towns.

The soil pertinent to civil engineering construction comprises surface soil upto two metre in depth and constitutes the massive sediment load transported by the Indus and its tributaries [2]. The soil is therefore not likely to be very different from that in the other river plains located elsewhere e.g. in northern India and Bangladesh where the sediment transprted by the Ganges and Brahamputra is of similar origin and where soil formation has taken place under similar conditions of rainfall and surface run-off [3]. The surface soil of the study area has, according to the Reconnaissance survey, formed in alluvium laid down by the Jhelum, Chenab, Ravi, Beas and Sutlej, the main tributaries of the Indus. The soil texture of the area could be described as silty clay loam. There are small areas with silt loam, clays and sandy loam and some with sandy patches on the surface but it is invariably underlain by sand at various depths. It has been greatly disturbed by the faulty irrigation practice and has been salinized at a number of places.

Earth is man's oldest building material and is still the most popular [4]. It has been used in the construction of the Great Wall of China and the city of Shibam, South Yemen, sometimes called the "Manhattan of the Desert" which has buildings upto eight stories high. Despite the image of mud being unfit for anything but primitive huts, architects estimate that some 15 percent of the farm-dwellings in France, Scandinavia, Britain and West Germany continue to be made of this ubiquitous material [4]. France inaugurated in November, 1985 an entire community of raw-earth homes in the new town of L'Isle Abeau. Thus there is a strong case for developing countries like Pakistan to have a policy to go mudward.

Mud houses constitute 60 percent in the rural and 20 percent in the urban areas of Pakistan [5]. These dwelling units have been constructed out of unbaked bricks with mud finish. Low-cost houses can be constructed by using soil bricks or blocks stabilized with cement, lime, asphalt or lime pozzolana. The selection of the stabilizing agent depends upon the characteristic properties of the soil [6] for which published local data are not available. The present study is therefore concerned mainly with the mapping of the soil with respect to its various properties which determine its suitability as building material and for undertaking civil construction in the said five towns of the Punjab.

MATERIALS AND METHODS

Samples for this study were collected from the locations noted below using an auger machine fabricated in the

Location of the samples

Sample No.	Location	Reference point	Distance from the reference point
Gujralwala			
1.	Sousra gorea	Interaction by-pass road and Sheikhupura road	1.5 km towards south
2.	Subzi Mandi residential	Intersection of by-pass and Sheikhupura road	0.5 km towards west
3.	Theri Sansi	Intersection of by-pass and Sheikhupura road	1 km towards south
4.	Mandiala Mir Shakaran	Canal by-pass Sheikhupura side	5 km to the west of canal and 1 km south of by-pass
5.	Badu Khel	Mandiala Mir Shakaran and by-pass Sheikhupura side	5 km to the west of Mandiala Mir Shakaran and 1.5 km south of by-pass
6.	Loyan Wala	Sialkot by-pass G.T. road	1 km from G.T. road
7.	Wanyan Wala	Loyan Wala Sialkot by-pass	3.5 km to the west of Loyan Wala
8.	Jandiala Bagh Wala	Wanyan Wala Sialkot by-pass	3 km to the east of Wanyan Wala
9.	Kotli Mughlan Wala	Jandiala bagh wala	3.5 km to the west of Jandiala bagh
Gujrat			
1.	Summa	G.T. Road, River Chenab	2 km from the river and and 1 km to the west of G.T. Road
2.	Mohla	Summa and by-pass	2 km to the north of Summa and 1 km to the West of by-pass
3.	Teen Ka Khurd	Mohla and by-pass	2 km to the north of Mohla 1 km tothe east of by-pass
4.	Heryanwala	Teer Ka Khurd and by-pass	2.5 km from Teerks and 1 km east of the by-pass
5.	Adowala	Heryanwala and by-pass	2.5 km to thenorth of Heryanwala and 1 km to the West of by-pass
6.	Shadman residential scheme.	G.T. Road and district courts	North of G.T. Road near district courts.
7.	Medina	Bhimber Road	1 km tothe east of Bhimber road
8.	Bola	Jalalpur Road	2 km tothe north of Jalalpur road
9.	Kalra Khas	G.T. Road	3 km tothe east of the city and 1 km to the north of G.T. Road
Wazirabad			
1.	Dhonkal Kalan	G.T. Road	4 km to the south of city and 1 km to the east of G.T. Road
2.	Karam Abad	Sialkot Road	3 km from the city and to the west of Sialkot road
3.	Chak sudya	Sialkot Road	4.5 km to the east of city on Sialkot Road
4.	Thatta Faruiq Wala	River Chenab and by-pass	4 km to the east of the river and 1 km to the north of by-pass
5.	Waro ki cheema	River Chenab and by-pass	7 km to the east of the river and 1 km to the north of by-pass
Kamoki			
1.	Sardar Town	G.T. Road	3 km to the north of the town and 1 km to the west of G.T. Road
2.	Neva Koona	G.T. Road	2 km to the south of the town and 1 km to the east of G.T. Road
3.	Kanyan Ki Ajmar Darbar	G.T. Road	3.5 km to the south of town and 0.5 km to the east of G.T. Road.
Kasur			
1.	Bangla Kamovan	Ferozepur Road Depalpur Road	3.5 km from Ferozpur road on the left side of Depalpur Road
2.	Darbar Maskeen Shah	Ferozepur Road	On the left side of the road
3.	Gulberg Colony	Steel Bagh	Site of Gulberg Colony near Steel Bagh.
4.	Rai-Wind Road	Steel Bagh	3.5 km from Steel Bagh off the Rai-Wind Road
5.	Rai-Wind Road	Steel Bagh	5 km from Steel Bagh Off Rai-Wind Road
6.	Ferozepur Road	Steel Bagh	1 km from steel Bagh towards Lahore, Off the Ferozepur road.

(Continued .....)

laboratories [7]. The diameter of the auger was 20 cm. Samples were collected from a depth between one to two metre. The samples were preserved by sealing in high density polythene bags.

pH of the soil was determined by mixing 10 gm of the dried sample with 20 ml of distilled water to make a paste. pH of the paste was determined with the help of a pH meter.

The physical and chemical parameters were determined as folows: 20 gm of the dried sample was added to 100 ml of distilled water. The mixture was heated, with stirring, to 80° and kept at this temperature for about 2 hours. The whole mix was filtered through paper pulp to get a clear solution and the volume was made up to one litre. This solution was used for the determination of various electrolytes by standard methods [9]. All other parameters were determined by methods reported in the literature [10].

RESULTS AND DISCUSSION

The results of the laboratory tests are presented in Tables 1 to 5 while typical graphs for grain size distribution are presented in Fig. 1 to 5. A town-wise description of the soils/and the analysis of the results follows:

Gujranwala. Soil around Gujranwala is dark Yellowish-brown and consists of silty clay loams, with a sp. gravity 2.37 to 2.54 and moisture content varying between 2.60 to 37.76. Kankar zone is absent upto a depth of 1.5m. pH of the soil samples collected from this city varies from

Table 1. Gujranwala soil properties

Sample No.	T.S.S. (%)	Moisture (%)	Carbonates (%)	Bi-carbonates (%)	Sulphate (%)	Calcium (%)	Specific gravity	pH	Plastic Limit	Plasticity Index
1.	0.14	9.50	Nil	0.006	0.1024	0.004	2.41	7.80	11.9	34.6
2.	0.35	2.60	"	0.070	0.0896	0.0052	2.44	7.90	9.0	30.6
3.	0.36	17.46	"	0.099	0.1152	0.0044	2.39	8.30	21.5	40.8
4.	0.16	14.30	"	0.036	0.1088	0.0096	2.43	7.80	12.1	18.6
5.	0.28	10.75	"	0.042	0.096	0.0064	2.37	7.90	14.2	20.2
6.	0.24	37.76	"	0.012	0.096	0.0128	2.38	6.65	19.4	28.9
7.	0.32	16.58	"	0.20	0.0768	0.0032	2.40	7.80	17.1	24.9
8.	0.32	7.82	"	0.038	0.1024	0.0168	2.54	7.90	Sandy samples	–
9.	0.32	17.22	"	0.096	0.1344	0.0080	2.48	8.30	19.8	36.2

Table 2. Gujrat soil properties

Sample No.	T.S.S. (%)	Moisture (%)	Carbonates (%)	Bi-carbonates (%)	Sulphate (%)	Calcium (%)	Specific gravity	pH	Plastic Limit	Plasticity Index
1.	0.20	17.50	Nil	0.024	0.096	0.0080	2.38	8.40	14.8	19.4
2.	0.48	19.52	"	0.044	0.0896	0.0080	2.41	9.05	21.2	20.3
3.	0.23	17.78	"	0.055	0.0640	0.0040	2.42	8.70	12.6	25.0
4.	0.12	9.41	"	0.050	0.0576	0.0032	2.43	8.80	20.1	1.9
5.	0.45	17.32	"	0.055	0.0672	0.0096	2.42	8.85	8.9	27.6
6.	0.12	16.09	"	0.047	0.0640	0.0160	2.37	8.60	15.6	23.8
7.	0.09	8.00	"	0.011	0.0896	0.0128	2.44	8.60	15.1	24.4
8.	0.12	5.16	"	0.035	0.0960	0.0224	2.44	8.90	Sandy sample	–
9.	0.28	42.93	"	0.072	0.0704	0.0160	2.49	8.70	21.3	26.1

Table 3. Wazirabad soil properties

Sample No.	T.S.S. (%)	Moisture (%)	Carbonates (%)	Bi-carbonates (%)	Sulphate (%)	Calcium (%)	Specific gravity	pH	Plastic Limit	Plasticity Index
1.	0.20	14.43	Nil	0.025	0.096	0.0096	2.39	7.70	11.8	21.3
2.	0.50	8.86	"	0.112	0.064	0.0064	2.45	8.70	17.8	14.8
3.	0.16	15.70	"	0.103	0.096	0.0080	2.44	7.80	12.6	12.5
4.	0.42	7.76	"	0.043	0.0512	0.0040	2.39	7.90	18.4	30.1
5.	0.56	11.63	"	0.010	0.0384	0.0160	2.35	8.50		

Table 4. Kamoki soil properties

Sample No.	T.S.S. (%)	Moisture (%)	Carbonates (%)	Bi-carbonates (%)	Sulphate (%)	Calcium (%)	Specific gravity	pH	Plastic Limit	Plasticity Index
1.	0.20	15.05	Nil	0.0089	0.0640	0.0100	2.43	7.60	12.9	27.2
2.	0.82	13.64	"	0.122	0.0320	0.0096	2.42	8.85	15.8	22.2
3.	0.14	2.53	"	0.036	0.0768	0.008	2.40	7.90	Sandy sample	–

Table 5. Kasurt soil properties

Sample No.	T.S.S. (%)	Moisture (%)	Carbonates (%)	Bi-carbonates (%)	Sulphate (%)	Calcium (%)	Specific gravity	pH	Plastic Limit	Plasticity Index
1.	0.64	3.64	Nil	0.246	0.064	0.0256	2.40	9.20	11.2	17.1
2.	1.12	14.48	"	0.244	0.384	0.0184	2.38	9.20		
3.	1.22	20.98	"	0.172	0.064	0.0160	2.33	8.90	12.6	15.2
4.	0.14	10.49	"	0.040	0.0896	0.0192	2.41	8.60	16.4	9.3
5.	0.14	10.62	"	0.044	0.0512	0.0104	2.46	8.40	16.6	12.6
6.	0.20	9.05	"	0.048	0.0768	0.0136	2.43	8.60	Sandy sample	–
7.	0.66	11.50	"	Nil	0.544	0.0352	2.32	8.45	20.9	4.75

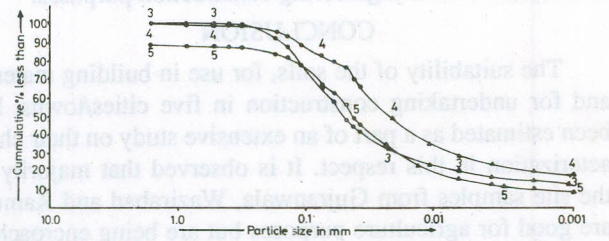

Fig. 1. Kasur 3, 4 and 5

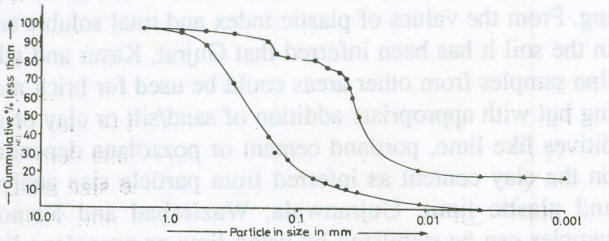

Fig. 2. Kamoki 1 & 3

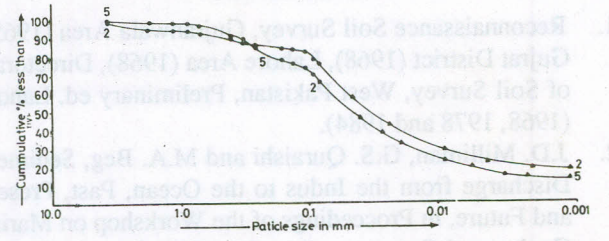

Fig. 3. Gujranwala 2 & 5

6.65 to 7.9 except two samples which have a pH of 8.3, and is accordingly in the range which is ideal for the growth of most of the crops. Total soluble salts in the samples are low. They range between 0.14 and 0.36%. The carbonates are absent, bicarbonates range between 0.006 and 0.99%, sulphates between 0.76 and 0.13 while Ca lies between 0.004 and 0.016%.

Grain size analysis shows that all the samples contain

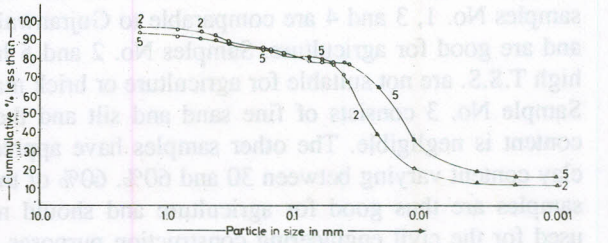

Fig. 4. Wazirabad 2 & 5

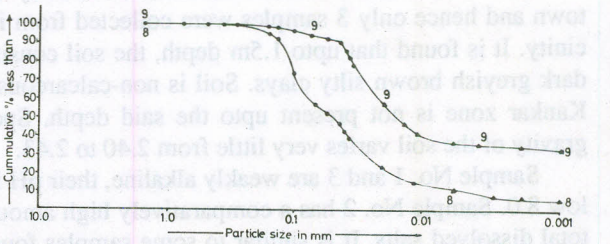

Fig. 5. Gujrat 6 & 9

60-70% clay except sampel No. 8, which contains less than 10% clay. Plasticity index values of the samples range between 20.22 and 40.85 while their plastic limit lies between 9.01 and 21.50%. These values suggest that in case of soil stabilization, lime can be used for all the samples except No. 8 in which case portland cement is to be preferred [11] and also that the soil around Gujranwala is ideally suited for agricultural purposes and should not be allowed to be used for civil engineering construction purposes.

Gujrat. Soil around Gujrat is dark brown and consists of sandy loams. The samples collected from this area have moisture content varying between 5 and 42%; clay content between 40 and 60% and their pH between 8.0 and 9.05. This suggests that they are alkaline and are at the most marginal in character for agriculture. Samples No. 2 and 5 have comparatively high T.S.S. Sample No. 8 is very low in clay content and is not suitable for agriculture. Thus the land may be used for residential purposes. It is seen also that samples No. 1, 4 and 8 may be utilized for making bricks

because they have comparatively low clay content [7]. Soil samples No. 8 and 4 may be stabilised with portland cement while the rest of the samples may be stabilised with lime and/or pozzolana. Their plastic limit lies within acceptable range except samples No. 5 and 8, however, their high T.S.S. content limits the use in brick making.

Wazirabad. Soil around Wazirabad is darkbrown with specific gravity varying from 2.35 to 2.45 and moisture content between 7.76 and 44%. The soil consists of sandy loams. Kankar zone is absent upto a depth of 1.5m. pH of the samples collected from this town varies within the ideal range for almost all the crops excepting samples No. 2 and 5 which have a pH above 8.5. Total soluble salts in these samples range between 0.16 to 0.56%. In this respect samples No. 1, 3 and 4 are comparable to Gujranwala soil and are good for agriculture. Samples No. 2 and 5 having high T.S.S. are not suitable for agriculture or brick making. Sample No. 3 consists of fine sand and silt and the clay content is negligible. The other samples have appreciable clay content varying between 30 and 60%. 60% of the soil samples are thus good for agriculture and should not be used for the civil engineering construction purposes while the others are not suitable for use in building material or construction.

Kamoki. There is not much construction activity in this town and hence only 3 samples were collected from its vicinity. It is found that upto 1.5m depth, the soil consists of dark greyish brown silty clays. Soil is non-calcareous, and Kankar zone is not present upto the said depth. Specific gravity of the soil varies very little from 2.40 to 2.43.

Sample No. 1 and 3 are weakly alkaline, their pH is below 8.0. Sample No. 2 has a comparatively high amount of total dissolved salts. It is similar to some samples found in Kasur with regard to its T.S.S. and pH. Calcium content of the soil here is comparatively low.

Soil sample No. 3 consists of fine sand and medium silt. This is not suitable for brick making but may be used for making blocks of stabilised soil. The soil from this area may be stabilized with portland cement. Sample No. 2 shows that it contains less than 10% clay. Its plasticity index shows that it may be stabilized with lime or pozzolana-lime. Soil sample No. 1 may also be stabilized with lime or pozzolana but this soil is quite good for agriculture as far as its pH, structure, T.S.S. and carbonate alkalinity etc. are concerned. Areas 1 and 2 are good agricultural lands and should therefore not be utilized for civil engineering construction.

Kasur. The soil around Kasur city has specific gravity between 2.32 and 2.46, its moisture content varies from 9.05% to 20.98%. The colour of the soil is brown to dark brown and it contains fine sandy loams which are moderately calcareous. No Kankar Zone is found upto a depth of 1.5m. The soil is alkaline and its pH varies from 8.4 to 9.2. Sample No. 2 and 3 have high soluble salts. The sulphate content of the samples ranges from 0.05 to 0.54% and carbonates are between 0.04 and 0.024%.

Plasticity index values are below 18 for all the samples which shows that the soil may be used for brick making [7]. Samples No. 1, 2 and 3 may be stabilized by the addition of 6.14% lime while samples 4, 6 and 7 may be stabilized with portland cement since their plasticity index is below 9 [12]. Grain size analysis confirms the results of plasticity index. Samples No. 4, 6 and 7 have clay content less than 10% while 1, 3 and 5 have a clay content of 40, 30 and 20% respectively. Samples No. 1, 2, 3 and 7 are not good for agriculture and hence the extension of residential colonies cold be planned on the site of these samples and the soils used for civil engineering construction purposes.

CONCLUSION

The suitability of the soils, for use in building material and for undertaking construction in five cities/towns, has been estimated as a part of an extensive study on their characterization in this respect. It is observed that majority of the site samples from Gujranwala, Wazirabad and Kamoki are good for agriculture purposes but are being encroached upon by the process of urbanization. This, however, can not be helped because the alternative land has been salinized and is suitable neither for construction nor for brick making. From the values of plastic index and total soluble salts in the soil it has been inferred that Gujrat, Kasur and alkaline samples from other areas could be used for brick making but with appropriate addition of sand/silt or clay or additives like lime, portland cement or pozzolana depending on the clay content as inferred from particle size analysis and plastic limit. Gujranwala, Wazirabad and Kamoki samples can be stabilized by using lime or pozzolana-lime while those from Gujrat and Kasur can be stabilized by using portland cement or pozzolana lime.

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