Grain size distribution pattern of soils in Rae Bareilly district, Uttar Pradesh

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Abstract

Grain size analysis of Rae Bareilly District, U.P. have been done with the help of soil mechanics studies of the 90 soil samples, which have been collected in 2.5×2.5 sq km grid pattern. Soils have been classified based on the gradation curve in case of coarse grain soil and Atterberg's Limit test in case of fine grain soil. After grain size analysis two different maps are prepared one is "Soil Textural Classification Map" and another is "Soil Classification Map (Based on Soil Group)". With the help of above two different maps it was observed that soils of Rae Bareilly district gradationally change from sand to silt and then clay, with the change in the plasticity of the soils. In southern part, soils are non plastic, but the northern as well as north eastern and north western part soils are plastic in nature. Proper precaution is essential for designing the foundation of engineering structures in these areas and high rise buildings are not advisable.

1. Introduction:

Rae Bareilly district is located in the eastern part of the State of Uttar Pradesh and is bound by the Unnao, Barabanki, Pratapgarh, Allahabad, Lucknow, Fatehpur and Sultanpur districts. River Ganga flows in the southern part of the Rae Bareilly district (figure 1). The area covered is bounded by latitude 25°49′ - 26°36′ N and longitude 80°41′ - 81°34′ E and falls in parts of toposheet nos. 63 B/15, 16, 63F/2, 3, 4, 6, 7, 8, 11, 12, and 63 G/1, 5, 9. The distance between Lucknow city to Rae Bareilly City is 90 km. Sai *Nadi* is the tributary of Ganga River and the water source of the Rae Bareilly city Rae Bareilly district is located in the eastern part of the State. K. V. Nambiar and O. P. Singh (F.S. 1990-91) carried out systematic Quaternary geological and geomorphological mapping in the area adjoining east and north of the study area. They divided major landforms in this area into three morphostratigraphic units, namely i) Varanasi Older Alluvial Plain, ii) Ganga/Sai/Loni Older Flood Plain, representing T2 and T1 terraces, the former being an erosional surface, developed on either banks of these rivers. iii) Ganga/Sai/Loni Active Flood Plain. These three morphostratigraphic units correspond to the lithostratigraphic units of the area.

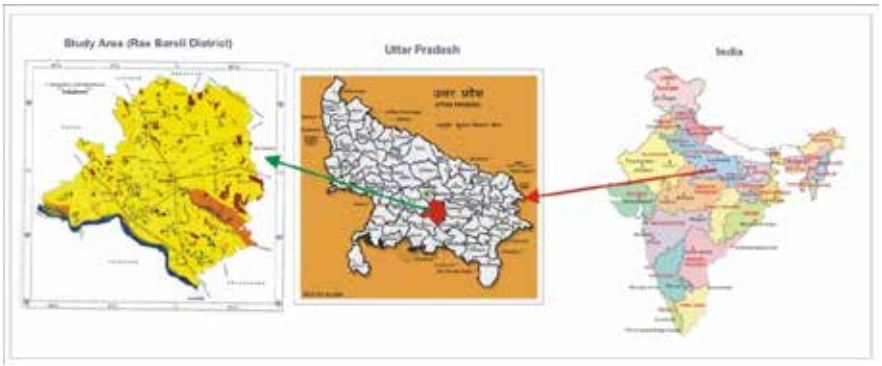

Figure 1 Location Map of Rae Bareilly District

The objectives of the present study is to determine the physico-mechanical properties of surface/sub surface soil samples and prepared Geotechnical Map of Rae Bareilly District for getting output. To getting the objective total 90 soil samples have been collected on the 2.5×2.5 grid pattern (figure 2). Out of these 90 soil samples, 15 soil samples are in situ soil samples (undisturbed) and 75 soil samples are disturbed soil sample.

All the soil samples have been collected removing topsoil, as well as removing organic matter. 75 nos. disturbed soil samples have been collected in the entire Rae Bareilly District from the depth 0.5m and 15 nos. of undisturbed soil samples were collected by excavating a pit below 1.5 m. depth.

2. Geology of the study area:

The study area forms a part of the Upper Ganga alluvial plain and is composed of medium to fine-grained sediments of sand-silt-clay group, deposited under predominantly fluvial conditions (B. P. Rawat, 2001). Geologically, the district consists of Quaternary sediments, which are differentiated into Older Alluvium and Newer Alluvium

The Quaternary alluvial deposits have been classified into two distinct formations–

1) Older Alluvium and
2) Younger Alluvium.

Table 1
Geological unit of the Rae Bareilly District.

Geological Unit	Lithology	Group	Age	
Channel Alluvium	Grey Micaceous fine to medium grained, loose sand , silt and clay	Newer Alluvium	Holocene	QUATERNARY
Terrace Alluvium	Grey Micaceous fine to coarse grained, immature sand , silt and clay			
Varanasi Alluviun	Brownish Yellow, silt-clay with *kankar* and micaceous sand. 1: Silt-sand facies 1s: Sandy facies	Older Alluvium	Middle-to late Pleistocene	

A. Older Alluvium:

This Formation occupies almost the entire area, and the alluvial plain formed by the exposed top part of these sediments, occurs at the highest topographic level ranging in height from 110 to 115 m above m.s.l. (Nambiar, et al, 1991). This plain is immune to flooding and is presently undergoing denudation. The Older Alluvium is composed of deep yellowish brown, pale buff to dark brownish grey coloured clays and silts in varying proportions with subordinate amounts of medium to fine-grained sand.

B. Younger Alluvium:

This Formation occupies a very small part of the study area and is restricted to its southern fringes. The sediments of this formation form the present flood plain of Ganga and its tributaries and have been deposited by the river in the valley carved out by it within the Older Alluvium. The plain formed by the exposed top part of these sediments, occurs at lower topographic level (below 108m above m.s.l. on an average) compared to the Older Alluvial plain.

3. Geomorphology of the study area:

Geomorphologically, Rae Bareilly is a part of Ganga Plain, differentiated in to lowland and upland. The upland area, generally known as Varanasi plain with elevations ranging from 100m to 120m above msl. It is mostly composed of silty to clayey soils and has relict some fluvial features such as *tals* and palaeochannels. On both sides of Sai *Nadi* it is topped by sandy soil (figure 2). The lowland, occurring along rivers, is separated by 5-10 m high bluffs from the upland area. It consists of Older Flood Plain (terraces T1 and T2) and Active Flood Plain with elevations ranging between 90m and 100m above msl. Geomorphologically the area can be classified into two morpho-stratigraphic units, on the basis of their respective surface-morphological features.

1. Ganga Flood Plain
2. Rae Bareilly Fill-Terrace

A. Ganga Flood Plain:

This unit is youngest in geological age and a small part of it is included in the southern fringe of the study area. It is composed of the recent sediments, categorized as Younger Alluvium and is restricted to the active flood plains of Ganga and its tributaries namely, Sai *Nadi.* The individual geomorphic landforms comprising this unit, are : (a) Point bars, (b) Channel bars, (c) Sand bars, (d) Stabilized islands and (e) Natural levees.

B. Rae Bareilly Fill-Terrace:

The top part of this comparatively older morpho-stratigraphic unit is designated locally as Rae Bareilly Fill Surface or simply Rae Bareilly Surface, which constitutes almost the entire part of the area and forms a vast alluvial plain. The Rae Bareilly surface, on which the town of Rae Bareilly is situated, occurs at a higher topographic level and is separated from the adjacent Ganga Flood Plain by a steep scarp/terrace bluff having an average height of 4m. This surface is immune to flooding and is presently undergoing degradation by sheet and gully erosion, and river entrenchment.

4. Methodology of the Geotechnical Studies:

A total 90 soil samples have been collected on the 2.5×2.5 grid pattern (figure 2). Out of these 90 soil samples, 15 soil samples are in situ soil samples (undisturbed) and 75 soil samples are disturbed soil sample. All the soil samples have been collected removing topsoil, as well as removing organic matter. 75 nos. disturbed soil samples have been collected in the entire Rae Bareilly District from the depth 0.5m and 15 nos. of undisturbed soil samples were collected by excavating a pit below 1.5 m. depth.

Soil samples are obtained in either disturbed or undisturbed condition. Both the disturbed and undisturbed soil samples are subjected to the following tests in the Laboratory.

(A) Undisturbed Soil Samples:

1. Natural Moisture Content (NMC) & Density
2. Sieve and sedimentation analysis
3. Atterberg's Limits

(B) Disturbed Soil Samples:

1. Sieve and sedimentation analysis
2. Atterberg's Limits

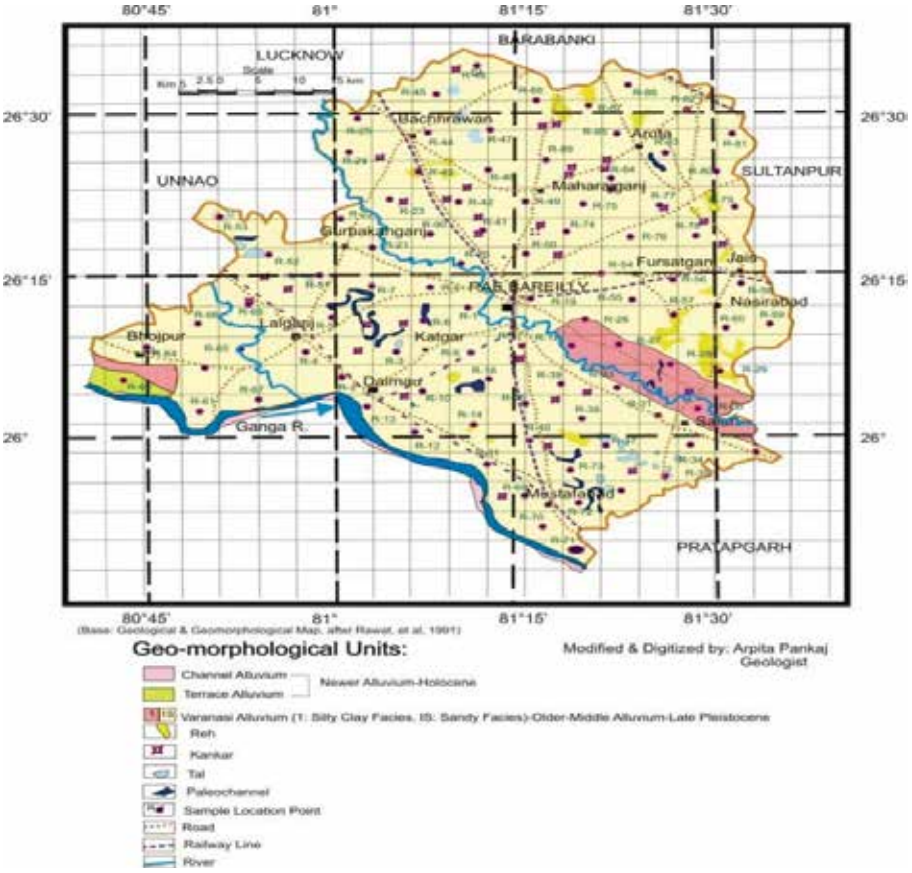

Figure 2 Geological and geomorphological map of Rae Bareilly district showing sample location points.

5. Results and Discussions:

90 soil samples have been subjected to grain size analysis test. All the samples were tested for mechanical analysis and only 84 soil samples have been tested for sedimentation test (out of 100 gms sample, pan material i.e. if soil fraction passing 75-microns IS sieve is greater than 10 gms, then sedimentation test is performed). The results of particle size analysis (sieve and sedimentation analyses) are plotted on semi–logarithmic logs and grain–size distribution curves are prepared. The particle diameters are plotted in semi-log scale, and the corresponding percent finer in arithmetic scale. In the gradation curve it was seen that 15 nos. of soils are well graded, 20 nos. soils are uniformly graded and 55 nos. soil are poorly graded.

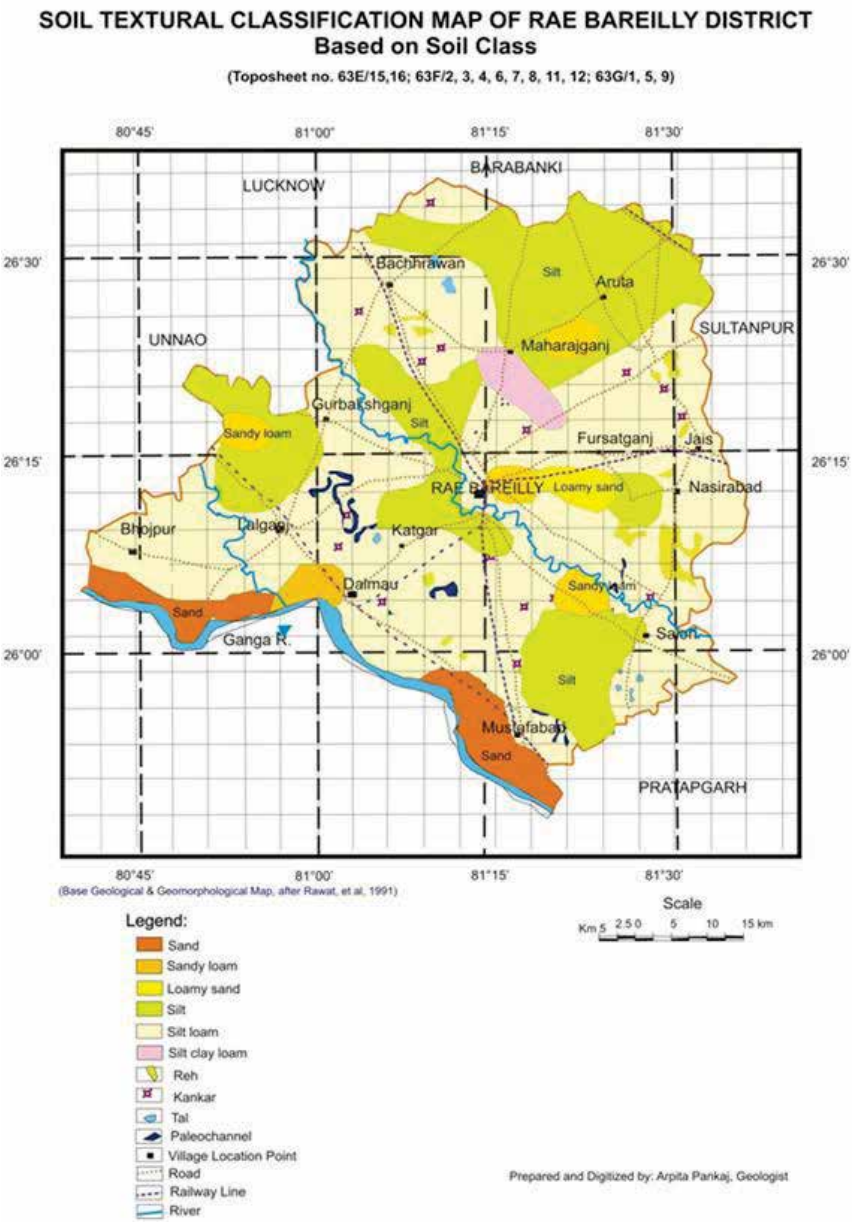

Figure 3 Soil textural classifications map of Rae Bareilly district.

Soil textures are classified by the fractions of each soil (sand, silt, and clay) present in a soil. Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes, e.g. "sandy clay" or "silty clay." A fourth term, loam, is used to describe a roughly equal concentration of sand, silt, and clay, and lends to the naming of even more classifications (USDA), e.g. "clay loam" or "silt loam." In the Rae Bareilly area only 6 soil class have been identified, Sand Class, Sandy Loam Class, Loamy Sand Class, Silt Class, Silt Load Class and Silt Clay Loam Class. Out of 90 soil samples, 6 nos. of soil present in the Sand Class, 5 nos. of soil present in the Sandy Loam Class, 1 no. of soil present in the Loamy Sand Class, 30 nos. of soil present in the Silt Class, 46 nos. of soil present in the Silt Load Class and 2 nos. of soil present in the Silt Clay Loam Class.

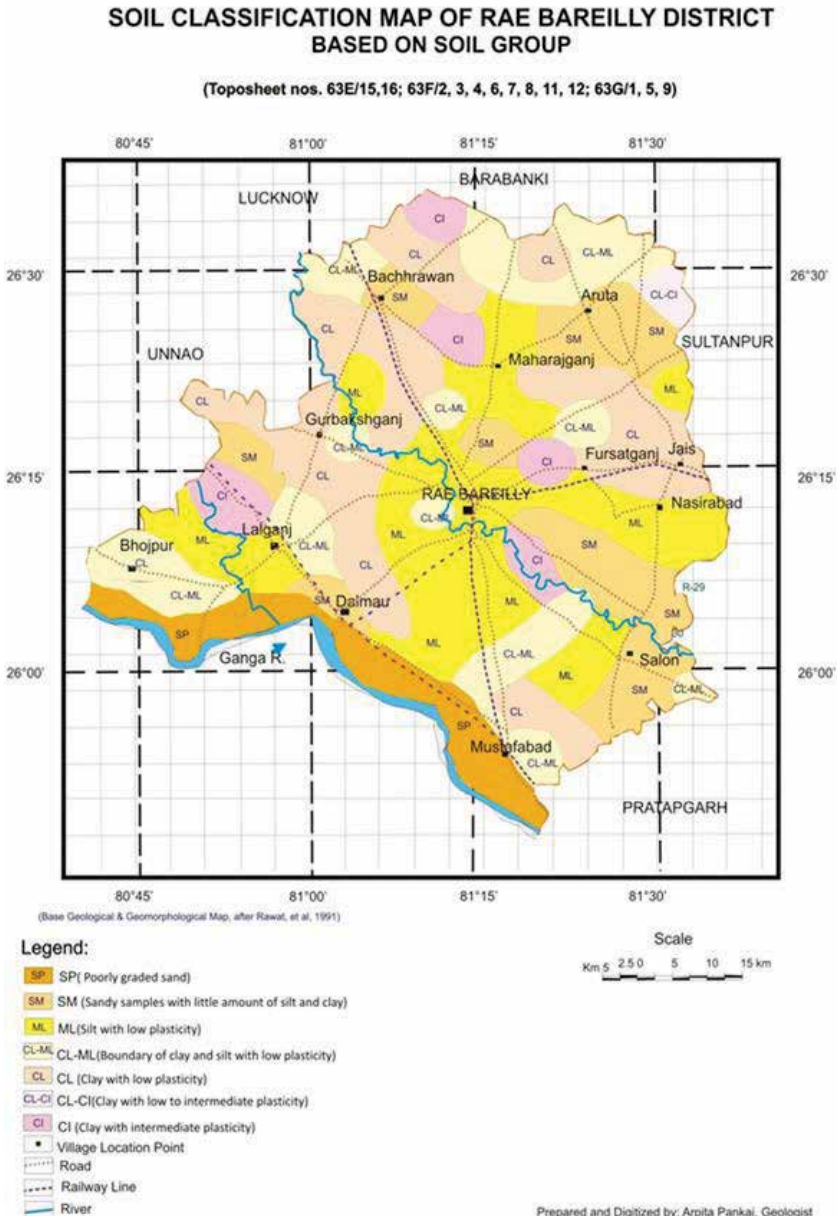

Figure 4 Soil Classification Map of Rae Bareilly District.

Out of 90 soil samples 6 soil samples are sandy in nature, 25 non-plastic in nature and 59 soil samples are plastic in nature. In the 59 plastic soil samples, liquid limit ranges from 20.04 to 38.55, plastic limit ranges from 14.47 to 24.30, plasticity index ranges from 2.003 to 17.680, shrinkage limit ranges from 13.33 to 22.44 and shrinkage ratio ranges from 1.65 to 1.94. Interpretation based on the Liquid Limit-Plasticity chart, brought out that out of 59 soil samples 17 soil samples belong to the CL-ML class (Boundary of clay and silt with low plasticity), 22 soil samples belong to CL (Clay with low plasticity), 14 samples belong to ML (Silt with low plasticity), 5 soil samples belong to CI (Clay with intermediate plasticity) and 1 soil sample belong to CL-CI (Clay with low to intermediate plasticity). Out of 25 non-plastic samples, 12 soil samples belong to SM Group (Sand samples, with little amount of Silt), 2 samples belong to SM-SC (Sandy samples with little amount of silt and clay), 1 sample belong to SW-SM (Well graded sandy sample with little silt) and 10soil samples belong to ML (Silt with low plasticity) Group. On the other hand 6 sandy samples belong to the SP (Poorly graded sand) Group.

6. Conclusions:

In "Soil Textural Classification Map" it was observed (figure 3) that, south of Rae Bareilly district, near Ganga River, soils are sandy; south eastern and south western parts soils are sandy loam; in between soils are loamy; northern and central parts of soils are silty and rest of the soils are silty loam with silt and clay.

- In the "Soil Classification Map" it was observed (figure 4) that 59 soil samples are plastic and rest are non-plastic. The soils near Ganga river are SP (poorly graded sand) group, north of that areas are ML (silt with low plasticity) and central part are belongs to CL-ML (clay and silt with low plasticity) and most of the northern, north eastern and north western parts are CL (clay with low plasticity) group.

It was also observed that soils of Rae Bareilly district gradationally change from sand to silt and then clay, along with the changes in the plasticity of the soils. In southern parts, soils are non plastic, but Northern as well as north eastern and north western parts soils are plastic in nature. So, proper precaution is essential for designing the foundation of engineering structures in these areas.

7. Recommendations:

- Soils with organic matter noticed in the investigation include topsoil as well as sandy fill with organic matter. As a cautionary measure, consideration must be given to removing of such soils from any planned construction. This is especially crucial in areas designated for structural fill, buildings, roadways and driveways.
- The data generated in the Rae Bareilly district area has been synthesized and made use of for the preparation of different thematic maps which may be utilized by the scientific community for further research in the area.

References:

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