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Using Soil Taxonomy Information In Land Evaluation For Building Site Development

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ABSTRACT: Sixty-four benchmark soils belonging to eight orders: Entisols, Inceptisols, Alfisols, Oxisols, Ultisols, Mollisols, Aridisols and Vertisols have been evaluated for shallow excavations, dwellings without basement and construction of local roads and streets. Psamments are poorly suited for shallow excavations. Fluvaquents have severe limitations due to seasonal ponding and high-water table. Ustochrepts, Eutrochrepts and Dystrochrepts with fine loamy family have good suitability. Natrustalfs have average suitability for all the building-site development works. Typic, Vertic and Aeric subgroups of Ochraqualfs are poorly suited. Eutrorthox and Haplorthox have average to good suitability for shallow excavations and dwellings. Chromusterts and Pellusterts with fine to very fine family are poorly suited for any building-site development work. Special designs and pretreatments are necessary to use these soils safely. Salorthids and Natragrids are poorly to moderately suited and Camborthids and Paleargids have good suitability rating for shallow excavations, dwellings and construction of local roads and streets. Different taxa of Soil Taxonomy have also been evaluated for their contribution to interpretations for non-agricultural uses. Soil family has been found to provide the maximum information for making such interpretation.

(Key words: Benchmark soils, land evaluation, non-agricultural uses)

Introduction

Engineering structures, regardless of the material of which they are constructed, rest ultimately on soil or rock. In many cases, absorption, retention, and flow of water causes important stresses in the soil and changes in its stress resisting properties which may affect the structure [10]. Pioneering works of Dr. Karl Terzaghi during earlier decades of this century have materially advanced the science of foundations and provided rational basis for interpretation of actual settlement observations. Based on his long-term experience in the application of soil survey principles in the foundation engineering practices; advocated the use of soil profile as the basis for quantitative extrapolation of knowledge basic to foundation design was suggested [1]. The present

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study is not a soil mechanics investigation, rather it is an attempt to make aware the users and managers of the soil to utilize the Soil Taxonomy [9] for evaluating different types of soils for building-site development purposes.

Methodology: A benchmark soil is one of large extent within one or more major land resource areas. It is one that holds a major position in the soil classification system for which there is a large amount of data. It has distinct importance to one or more significant land uses, or one that is of substantial ecological importance. In this investigation sixty-four bench mark soil series classified in the Benchmark Soils of India [8] have been evaluated for three building-site development works.

Dwellings without basement: Such dwellings are generally less than three storeys high and usually have foundations resting on undisturbed soils. Soil suitability for this purpose is influenced by depth to bedrock, depth to cemented pan, ponding, depth to water table, flooding, slope, stones >7.5cm, shrink- swell potential and Unified soil grouping.

Shallow excavations: These involve digging for pipelines, sewers, telephone and power transmission lines, open ditches, cemeteries etc. Suitability of the soils for this purpose depends upon all the above-mentioned factors excepting shrink swell potential; and texture, soil order and bulk density.

Local roads and streets: These have an all-weather surface capable of carrying light to medium traffic throughout the year. These consist of a subgrade of the underlying soil material, a base of gravel, crushed rock fragments or soil stabilized with lime or cement and a flexible or rigid surface of asphalt or concrete [4]. Suitability of the soils for local roads and streets is influenced by ten factors; which includes first eight factors mentioned in case of dwellings without basement, plus soil strength and susceptibility to frost action.

Qualitative rating of different soil groups for some of the engineering properties such as: soil strength, shearing strength, compressibility, permeability etc. has been done as per the guidelines of USDA [11,12]. Based on soil characteristics suitability ratings for each of the building-site development work have been selected from the tables provided by USDA. [12]. Final

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suitability rating has been decided by the factor with maximum degree of limitation. Following definitions of the various degrees of limitations have been adopted:

Slight: No limitation for the intended use or the limitation that occur are easy to overcome.
Moderate: Soil limitations can be overcome by average management and proper design of structure.
Severe: Soil has limitations that are difficult to overcome and require special attention for using safely for the purpose under consideration.

Soils with slight, moderate, and severe limitations have been respectively rated for their suitability as good, average, and poor for the intended use.

Results and discussion:

Suitability and site limitations of each soil series that affect its use for shallow excavations, construction of dwellings without basement and for local roads and streets are presented order wise which is the highest category of the Soil Taxonomy [9]. are discussed in the subsequent section.

Entisols: Soils of loamy skeletal family of Ustorthents and Udorthents with Lithic subgroup have poor suitability for any building-site development purpose because of moderately steep to steep slopes of the terrain. However, if the limitations due to slope are overcome by terracing etc., these may prove good for dwellings without basements (Table 1). Typic Ustipsamments have severe limitations due to sandy texture and moderate restriction due to slope; thus, these are poorly suited for shallow excavations and have average to good suitability for the construction of local roads and dwellings without basement. Typic Torrifluvents with coarse loamy family have good suitability for all the three building-site development purposes. Aeric fluvaquents have severe limitations due to seasonal ponding, high water table and poor soil strength. Thus, these are poorly suited for any building-site development purpose.

Inceptisols: Fine silty, Mollic Haplaquepts represented by Wahthora series have only moderate limitations due to seasonal ponding, water table and potential frost action. Thus, these are average suited for any building-site development works (Table 2). Suitability of Aeric and Vertic subgroups of Halaquepts is poor because of severe limitations due to high water table and poor soil

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strength. Fine silty and fine loamy family of Typic Ustochrepts, Udic Ustochrepts, Fluventic Eutrochrepts, Typic Dystochrepts and clayey skeletal family of Oxic Dystrochrepts have good suitability for the three building-site development works, exception being Madhupur and Jaihing soils having average suitability for the construction of local roads and streets due to fair shearing strength. Ustochrepts, Eutrochrepts and Ustochrepts with Vertic, Lithic Vertic or Paralithic Vertic subgroups have poor suitability for any building-site development work, because of severe limitations due to ponding, poor soil strength and shrinking and swelling type of clays.

Alfisols: Soils of Typic and Oxic subgroups of Haplustalf and Paleustalf great groups, Ustic Paleustalfs, Oxic and Udic subgroups of Rhodustalfs and Plinthustalfs have good suitability for shallow excavations, construction of roads, streets and dwellings without basement (Table 3). Exception being Gogji Pather soils which have poor shearing strength, severe limitations when subjected to frost action and thus are average suited for local roads and streets. Natrustalfs have average suitability for all the three building and site development purposes excepting Sakit soil series which has poor suitability for shallow excavations owing to high water table. Soils of Typic and Ultic subgroups of Hapludalf great group have average to poor suitability because of moderate to severe limitations due to soil depth and slope. Soils of Typic, Vertic or Aeric subgroups of Ochraqualf are poorly suited for any building and site development purpose because of severe limitations due to wetness, high water table, flooding, and poor soil strength.

Oxisols: As compared to shrinking and swelling clays, soils with kaolinitic family have been rated one class better. Tropeptic Eutrorthox soils have average suitability for all building and site development works because of moderate limitation due to slope as indicated in Table 4. Clayey skeletal, Haplorthox has good suitability for all the three purposes.

Ultisols: The Bhubaneswar soil series classified as fine loamy, Typic Haplustult has poor suitability for shallow excavations and average suitability for the construction of dwellings and local roads etc. because of severe limitations due to soil depth as indicated in Table 4.

Mollisols: The Haldi soil series classified as coarse loamy Typic Hapludoll has only slight limitations and these are rated as good for the three building and site development works. Acid

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sulphate soils Ambalapuzha series - an acid sulphate soil is poorly suited for any such work because of multiple limitations as indicated in Table 4.

Vertisols: All the thirteen-soil series belonging to Chromustert and Pellustert great groups with family ranging from fine to very fine have poor suitability for the three building and site development purposes (Table 5). High clay content, smectite nature of clays leading to high shrink swell potential, and poor soil strength are major restrictive features for any safe use of the Vertisols. Expansive properties of smectite may be ameliorated by treatment with lime or other chemicals [6,2]. Lime produces a dramatic decrease in plasticity index; first by increasing the plastic limit, and second by producing hydrated Ca-Al silicate cementing agents. Cementing agents are produced by usual pozzolanic reactions that occur during the first week after lime is added to materials containing Al, Si and H_2O. Lime is apparently adsorbed as a monolayer on the external surface of the clay [5]. This is unusual in view of the fact that smectite reactions generally involve the interlayer space [3].

Aridisols: Typic Camborthids have good suitability for construction of dwellings (without basement), local roads and streets. However, due to sandy texture these are poorly suited for any shallow excavation work (Table 5). Lithic Calciorthids have poor suitability for shallow excavations and construction of dwellings, and average suitability for road construction due to shallow depth and fair soil strength. Typic Salorthids have poor suitability for all three building and site development purposes because of the problems due to high water table, seasonal flooding, smectite clays and high shrink swell potential. Typic Natrargids have poor suitability for shallow excavations and average suitability for construction of dwellings, local roads, streets, etc. Typic Paleargids have good suitability for all three building and site development purposes.

Non-agricultural interpretation from soil taxonomy

Results obtained from the interpretation of soil data for three building-site development purposes were further grouped at Soil Taxonomy order level to understand the extent of interpretation from the formative elements in the names of the soil taxa (Table 6). It is observed that formative elements of various soil taxa reveal on an average 73 per cent of total limitations of the soils. The least (40%) being in Oxisols/Ultisols and most in Inceptisols (83%). Furthermore, of

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the various taxa, soil family provided more than half of the information. This confirms the importance of family level of Soil Taxonomy in the non-agricultural interpretations. Limitations which are not well indicated by formative elements include stoniness, slope, soil depth, ponding, and flooding.

Table 6. Extent of interpretation from the formative elements of Soil Taxonomy

Order	No. of soil series	Total no. of limitations	Limitations indicated by the formative elements of Soil Taxonomy (% of total)	Nature of limitations not indicated by the formative elements of Soil Taxonomy
Entisols	7	34	17 (50)	Slope, stoniness
Inceptisols	16	82	68(83)	Depth, slope, ponding, flooding
Alfisols	18	77	62(81)	Depth, slope
Oxisols, Ultisols, Mollisols	4	10	4(40)	Depth, slope
Aridisols	5	26	14(54)	Depth, slope
Vertisols	13	106	70(66)	Depth, ponding

Soil depth is an important characteristic which is generally not clearly revealed by the formative elements except in case of lithic or paralithic contact (50 cm depth only). Formative elements in the Soil Taxonomy classification of Trivandrum soil series with 52 cm depth (clayey, skeletal Oxic Dystropept), Palathurai soil series with 57 cm depth (fine loamy, Typic Haplustalfs), Dialong soil series with 61 cm depth (loamy-skeletal, Ultic Hapludalfs) and Hungund soil series with 81 cm depth (fine, Typic Chromusterts); do not give any indication about the soil depth. Thus, there is need for further sub division of depth notations to make it more interpretive at least for the non-agricultural uses. Slope is important for deciding the suitability of a soil for the building and site development works, however, it is rarely indicated by any formative element. Alike slope, stoniness plays an important role in deciding the land use. Effects of occasional flooding and seasonal ponding are generally indicated by the profile morphology and are well explained through the taxonomic notations. However, in Hanrgram (Vertic Eutropept), Sadhu (Vertic Ustochrept) and Kalathur (Udorthentic Pellustert) soil series, formative elements have not been able to indicate the problem of ponding. Besides above mentioned few cases; Soil Taxonomy has proved to be an excellent means for making interpretations for building-site development purposes. There is need

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to strengthen the soil family criteria further especially with respect to soil depth and slope. Information provided in this paper is not a substitute for the actual field testing. Rather it is designed as a tool for the planners to help them recognize some of the soil related problems, that are generally overlooked in building-site development projects.

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Table 1. Soil suitability and site limitations for building-site development for Entisols

Bench mark series Sr. .no.	Bench mark series name	Classification	Soil suitability and site limitations for					
			Shallow excavation		Dwellings without basement		Local roads and streets	
			Suitability ratings	Restrictive features*	Suitability Ratings	Restrictive features*	Suitability ratings	Restrictive features*
3	Chinwali	Loamy skeletal Lithic Ustorthent	Poor	1,2,3	Poor	1,2,3	Poor	1,2,3
4	Phullen	Loamy skeletal Lithic Udorthent	Poor	1,2,3	Poor	1,2,3	Poor	1,2,3
7	Fatehpur	Typic Ustipsamment	Poor	2	Average	2	Average	2
28	Chomu	Typic Ustipsamment	Poor	2	Good	-	Good	-
26	Thar	Typic Torripsamment	Poor	2	Poor	2	Poor	2
27	Masitwali	Coarse loamy, Typic Torripsamment	Good	-	Good	-	Good	-
17	Kanagarh	Fine silty Aeric Fluvaquent	Poor	4,5,6	Poor	4,5,6	Poor	4,5,6

*1: depth to bedrock, 2: soil texture 3: slope 4: seasonal ponding and flooding 5. seasonal water table 6: poor soil strength

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Table 2. Soil suitability and site limitations for building-site development for Inceptisols

Series no.	Series name	Classification	Soil suitability and site limitations for					
			Shallow excavation		Dwellings without basement		Local roads and streets	
			Suitability ratings	Restrictive features*	Suitability ratings	Restrictive features*	Suitability ratings	Restrictive features*
2	Wahthora	Fine silty, Mollic Haplaquept	Average	3,4	Average	3,4	Average	3,10,11
12	Hirapur	Fine loamy, Aeric Halaquept	Poor	4	Poor	4	Poor	4,10,11
60	Motto	Fine, Vertic Halaquept	Poor	1,3,5,9	Poor	3,5,8	Poor	3,5,8,10
8	Kanjli	Fine loamy Typic Ustochrept	Good	-	Good	-	Average	11
31	Singpura	Fine loamy, Typic Ustochrept	Good	-	Good	-	Good	-
9	Nabha	Fine silty, Udic Ustochrept	Good	-	Good	-	Average	11
15	Bijaipur	Fine silty, Udic Ustochrept	Good	-	Good	-	Average	10,11
11	Sadhu	Very fine,Vertic Ustochrep	Poor	3,9	Poor	3,8	Poor	3,8,10,11
30	Kamliakheri	Very fine,Lithic Vertic Ustochrep	Poor	1,2,8, 9	Poor	1,2,8,9	Poor	1,2,8,9,10
16	Basiaram	Fine silty, Typic Eutrochrept	Poor	4	Poor	4	Average	4.10,11
18	Madhupur	Fine silty,Fluventic Eutrochrept	Good	-	Good	-	Average	10,11
19	Hanrgram	Fine, Vertic Eutrochrept	Poor	3,4,9	Poor	3,5,8	Poor	3,5,8,10,11
21	Jaihing	Fine loamy, Typic Dystrochrept	Good	-	Good	-	Average	10
55	Coimbatore	Fine, Vertic Ustropept	Poor	1,3,9	Poor	1,3,8	Poor	1,3,8,10
48	Chinnaloni	Fine,Paralithic Vertic Ustropept	Poor	1,9	Poor	1,8	Poor	1,8,10
52	Trivandrum	Clayey skeletal, Oxic Dystropept	Good	-	Good	-	Good	-

*1: slope 2: depth to bedrock 3: seasonal ponding and flooding 4: potential frost action 5: high water table 6: sandy texture 7: stoniness 8: high clay content 9. shrink swell clays 10: poor soil strength 11: poor shearing strength

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Table 3. Soil suitability and site limitations for building-site development for Alfisols

Series no.	Series name	Classification	Soil suitability and site limitations for					
			Shallow excavation		Dwellings without basement		Local roads and streets	
			Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*
1	Gogji Pather	Fine silty, Typic Haplustalf	Good	-	Good	-	Average	9,10
54	Palathurai	Fine loamy, Typic Haplustalf	Good	-	Good	-	Average	9
45	Vijayapura	Fine, Oxic Haplustalf	Good	-	Good	-	Average	9
43	Jamakhandi	Fine, Typic Paleustalf	Good	-	Good	-	Average	9
44	Tyamagondalu	Fine, Oxic Paleustalf	Good	-	Good	-	Average	9
56	Pusaro	Fine loamy, Ultic Paleustalf	Good	-	Good	-	Good	-
58	Mrignidhi	Fine loamy, Ultic Paleustalf	Good	-	Good	-	Good	-
50	Patancheru	Clayey skeletal,Udic Rhodustalf	Average	6	Good	-	Average	6
46	Channasandra	Clayey skeletal, Oxic Rhodustalf	Average	6	Good	-	Average	6
10	Zarifa viran	Fine loamy, Typic Natrustalf	Average	3	Average	3	Average	3
13	Sakit	Fine loamy, Typic Natrustalf	Poor	3,5	Average	3	Average	3,5
42	Chougel	Fine loamy, Plinthustalf	Good	-	Good	-	Good	-
6	Selsekgiri	Fine, Typic Hapludalf	Poor	1,6,11	Poor	1,6	Poor	1,6,9
22	Gemotali	Fine loamy, Typic Hapludalf	Average	6	Average	6	Average	6
5	Dialong	Loamy skeletal, Ultic Hapludalf	Poor	1,2,7	Poor	1,2,7	Poor	1,2,7,9,10
57	Hathiapthar	Fine, Typic Ochraqualf	Poor	3,5,11	Poor	3,5	Poor	3,5,9
20	Jagdishpur	Fine, Vertic Ochraqualf	Poor	3,4,5,11	Poor	3,4,5,8	Poor	3,4,5,8,9,11
14	Itwa	Fine, Aeric Ochraqualf	Poor	3,4,5,11	Poor	3,4,5	poor	3,4,5,9,11

*1: slope 2. : depth to bedrock 3. seasonal ponding and flooding 4. potential frost action 5. high water table 6 texture 7: stoniness 8. high clay content 9. soil strength 10. shearing strength 11. Shrink swell clays,

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Table 4. Soil suitability and site limitations for building-site development for Oxisols, Ultisols and Mollisols

Series no.	Series name	Classification	Soil suitability and site limitations for					
			Shallow excavation		Dwellings without basement		Local roads and streets	
			Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*
Oxisols								
51	Thekkadi	Fine,Tropeptic Eutrorthox	Average	1	Average	1	Average	1
53	Kunnamanglam	Clayey skeletal, Typic Haplorthox	Good	-	Good	-	Good	-
Ultisols								
59	Bhubaneswar	Fine loamy, Typic Haplustult	Poor	2	Average	2	Average	2
Mollisols								
23	Haldi	Coarse loamy, Typic Hapludoll	Good	-	Good	-	Good	-
Acid sulphate soil								
62	Ambalapuzha	-	Poor	1 to 5, 9,10	Poor	1 to 5,9 10,	Poor	1 to 5,9,10

*1: slope 2. : depth to bedrock 3. seasonal ponding and flooding 4. potential frost action 5. high water table 6 soil texture 7: Stoniness 8.high clay content 9. poor soil strength 10. Shrink swell clays,

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Table 5. Soil suitability and site limitations for building-site development for Aridisols and Vertisols

Series no.	Series name	Classification	Soil suitability and site limitations for					
			Shallow excavation		Dwellings without basement		Local roads and streets	
			Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*	Suitability ratings	Restrictive Features*
Aridisols								
24	Chirai	Coarse loamy, Typic Camborthid	Poor	2	Good	-	Good	-
25	Pali	Fine loamy, Lithic Calciorthid	Poor	1	Poor	1	Average	1,10
63	Dandi	Fine, Typic Salorthid	Poor	3,4,5, 6	Poor	3,4,5,8	Poor	3,4,5,6
64	Lakhpat	Fine, Typic Natrargid	Poor	6	Good	-	Good	-
37	Adesar	Fine, Typic Paleargid	Average	6	Good	-	Good	-
Vertisols								
29	Sarol	Fine, Typic Chromustert	Poor	2,5,6,7	Poor	2,5,6,7	Poor	2,5,6,7
32	Kheri	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
36	Barsi	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
34	Jambha	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
39	Hungund	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
40	Kagalomb	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
47	Kadirabad	Very fine, Typic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
35	Linga	Very fine, Udic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
33	Marha	Fine, Entic Chromustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7
38	Achmatti	Very fine, Typic Pellustert	Poor	3,2,5,6,7	Poor	3,2,5,6,7	Poor	3,2,5,6,7

*1: depth to bedrock, 2: soil texture 3. Seasonal ponding and flooding 4. high water table 5. Shrink swell clays 6.high clay content 7. soil strength