SOIL GENESIS AND PROBLEMATIC SOILS

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Abstract: *In the civil engineering, the soils represent a relatively loose material originating from the upper rock layers or from the soil profile itself. There are many soil – forming processes. Soil – forming processes vary with time but also with parent materials, topographical relief, vegetation, and climate. Poor soil conditions in terms of engineering increase the cost of construction. Fundamental soil properties such as cation exchange and shrink – swell properties are all influenced by molecular - scale differences in soil clay minerals. The following outlines of soil – forming processes are presented: gleization (develop anaerobic conditions in the upper part), paludization (is an accumulation of undercayed plant debris), podzolization (are soils characterized by the presence of a spodic horizon), ferrolysis (a hardpan of iron oxide may build up at the interface of the aerobic and anaerobic zones), ferrallitization, biocycling, lessivage is the process of clay accumulation; Lixiviation is a process of leaching of major cations from soil minerals and their loss from the soil in groundwater; melanisation, andisolization, vertization - is the physical soil overturning and mixing, characteristic of soils rich in swelling clays (smectites), which swell when wet and shrink when dry; anthrosolization - said, about any modification of properties, due to human activity, including soil modifications that may significantly influence soil development; salinization, solonization, cryoturbation. Quicksands are encountered in excavations made in fine sands that are below the watertable. Loess is, from this point of view, a typical collapsible material. The structural stability of collapsible soils is related to the suffusion process, that is the process of lateral and vertical removal of the fine soil particles by subsurface flow, often leading to settling, formation of potholes or piping. Chemical and hydrodynamic suffosion are distinguished. These volume changes can give rise to ground movements that may result in damage to buildings, and also in road construction. Severe erosion or worse, serious piping damage to embankments and piping failures of earth dams have occurred when dispersive soils have been used in their construction. Excessive settlement are the principal problems confronting the engineer working on a peat soil. A number of technique can be used to stabilize these soils.*

Key words: *soil forming, civil engineering, quicksands, collapsible, expansive, dispersive*

INTRODUCTION

During development of soil science, various concepts have been defined, e.g. geological, physical, chemical, agronomic, civil engineering and genetic concepts. Nowadays, the genetic concept, that views soils as independent natural bodies, prevails. One of the definitions (Dictionary of Soil Science, Elsevier) most used at present is: "a collection of natural bodies in the Earth's surface, in places modified, or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors".

In acoordance with WRB (Bridges, 1998), soils: (a) represent tridimensional bodies in/on Earth's surface; (b) they are made up of mineral compounds, organic compounds and living organisms interacting each other; (c) they result from pedogenetic processes associated with geologic and geomorphic conditions and processes acting over time; (d) they are able to continuously exchange energy and substance with the environment; (e) they ensure plant growth by furnishing them water and nutrients, and they represent the medium for the physical, chemical and biological processes that support plant growth; (f) they have their own specific organization and development.

In the civil engineering, the soils represent a relatively loose material originating from the upper rock layers or from the soil profile itself. It is considered as support for a construction or as a building material used e.g. in construction of dams, or even of ancient houses. The soil is considered as a foundation for constructions, as well as a factor in design of equipment for tillage and other management operations.

There are many soil – forming processes (Rogobete, 1993; Barshad, 1964; Retallack, 2005). The parent materials of soils are modified over thousands of years by physical, chemical, and biological influences, but few of these processes can be observed directly, like as podzolization. Soil – forming processes vary with time but also with parent materials, topographical relief, vegetation, and climate. For example, the parent material of a soil profile may consist of a variety of materials: it may be a solid rock, it may be a decomposed rock, it may be a soil material, or it may consist of a prior soil profile.

Any system of soil clasiification involves grouping soils into categories that possess similar properties, so providing a systematic method of soil description by which soils can be identified quickly. For purposes of engineering classification it is sufficient to consider their simple index properties which can be assessed easily, such as their particle size distribution and consistency limits. Plasticity also is used when classifying fine – grained soils, that is, silts and clays. WRB is also a tool for identifying pedological structures and their significance. It serves as a basic language in soil science. The classification of soils is based on soil properties defined in terms of diagnostic horizons and characteristics, which to the greatest extent possible should be measurable and observable in the field, into account their relationship with soil forming processes (WRB – Resources, 1998).

Poor soil conditions in terms of engineering increase the cost of construction by necessitating special foundation structures and/or mean that some type of engineering soil treatment is required (Bell, 2005).

MATERIAL AND METHODS

The purpose of this paper is the prediction of the soil behavior in response to specific land use or management soil melioration, based on inferences from soil characteristics and qualities. Soil interpretation procedure is qualitative or quantitative estimates or ratings of soil potentials, limitations or requirements for specific problematic soils, especially for the area from Banat region. Problematic soil is any soil having some characteristics that sharply decrease soil quality or the feasibility of soils management and of cropping. Eroded soils, saline soils, waterlogged soils, soils with extreme mechanical composition, over compacted soils, strongly acid or alkaline soils and polluted soils are example of problem soils.

RESULTS AND DISCUSSIONS

Soils are a dynamic part of the earth's geomorphic cycle of surficial weathering, erosion, deposition, sinking, diagenesis, metamorphosis, uplift and mountain building (Retallack, 2005). The mineralogical composition of soils influences that of the sedimentary rocks of which eroded soil material becomes a part, just as the rocks which serve as parent materials, in turn influence the chemical and mineralogical composition of soils. Other factors of soil formation, namely climatic, biotic, topographic, and time factors, may greatly influence, by controlling the weathering reactions. Chemical elements are translocated and deposited in deeper soil horizons; sometimes, these elements are returned to the upper horizons by biocycling, and sometimes they are removed from soil by leaching.

Clay minerals are responsible for many of the soil's most important and characteristic physical and chemical properties. These "clay minerals" crystallize in the aqueous environment at the Earth's surface from the constituent ions released by weathering primary minerals such as olivines, pyroxenes, feldspars, micas, quartz, and other that were formed under extreme heat and pressure deep within the Earth. Fundamental soil properties such as cation exchange and shrink – swell properties, as well as practical considerations such as how well a particular soil will attenuate a specific pollutant or how much fertilizer phosphorus will be fixed and unavailable to crops, are all influenced by molecular - scale differences in soil clay minerals. The most common and abundant clay minerals belong to a group of minerals called phyllosilicates or sheet silicates. A common structural theme is the presence of SiO_4 tetrahedral arranged into sheets. Octahedral arranged into sheets are also present in the structures of phyllosilicates and in some hydroxide minerals as well (Bell, 2005).

Phyllosilicates are divided into two groups, 1:1 and 2:1 – type minerals, based on the number of tetrahedral and octahedral sheets in the layer structure.

Other minerals that occur in soil clays, but usually only at low concentrations are : zeolites, allophone and imogolite, aluminum hydroxide minerals, iron oxide minerals, manganese oxide minerals, titanium oxide minerals, carbonates, sulfates and soluble salts.

Soil – forming processes

The study of soil – forming processes has informed both soil taxonomy and soil – profile terminology. The following outlines of soil – forming processes are presented, in resume, from warm wetlands to cold and arid lands (Rogobete, 1993).

1. **Gleization** (Rogobete, Grozav, 2007). Hydric soils are most often defined as soils that have formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Iron and manganese minerals are chemically reduced from the ferric to ferrous state when permanently saturated. Saturation or inundation when combined with microbial activity in the soil causes a depletion of oxygen. This anaerobiosis promotes biochemical processes such as the accumulation of organic matter and the reduction translocation with accumulation of iron and other reducible elements. The name is from the Russian "gley", meaning "mucky mass".

2. **Paludization** is an accumulation of undercayed plant debris as peat in the waterlogged surface layer (T horizon, SRTS) of Histosols. As swamp forests die from anoxia at the roots, peaty soils become overwhelmed by lakes, bayous, or lagoons. The rate of subsidence and accumulation of woody peats is between 0.5mm and 1mm per year.

3. **Podzolization**. Podzol are soils characterized by the presence of a spodic horizon. In this horizon amorphous compounds have accumulated consisting of organic matter and aluminium, with or without iron or other cations. The process is usually shown by the occurrence of an albic horizon underlain by a spodic horizon. The illuviation of organic compounds ("chilluviation") can often be demonstrated by the presence of thick cracked organic coatings on the sand grains within the spodic horizon.

4. **Ferrolysis** (Rogobete, 2009). The overall process of soil acidification by alternating iron reduction and oxidation is termed ferrolysis. A hardpan of iron oxide may build up at the interface of the aerobic and anaerobic zones if the water table tends to perch at a particular position in the soil profile or in which have been subject to illuviation of clay and downward percolation of moisture is slow, leading to the development of stagnic properties in the lower part of the albic horizon.

5. **Ferrallitization.** The chemical migration of silica out of the solum, accompanied by a residual concentration of sesquioxides (haematite, kaolinite and gibbsite) during intense weathering of well – drained tropical soils such as Oxisols.

6. **Biocycling**. A term sometimes used to designate a part of the biological cycle of elements, namely the cycling translocation and return of soil elements through plants. Through biocycling elements involved in the geologic cycle are taken away, and biophile elements accumulate in the upper horizons.

7. **Lessivage – Lixiviation**

Lessivage or argilluviation is the process of clay accumulation, consisting in mechanical translocation (in suspension) of clay (and Fe) from an upper to a lower horizon. This is a common soil – forming process in the forested soils of humid climates, particularly Alfisols and Ultisols.

Lixiviation is a process of leaching of major cations from soil minerals and their loss from the soil in groundwater and represents the progress of the hydrolysis chemical reaction. Lixiviation describe the beginnings of this process in soils such as Entisols and Inceptisols.

8. **Melanization** is the process of darkening light – coloured minerals of consolidated soil materials by addition of organic matter. Such processes are common in Ah horizons, in mollic and umbric horizons, the fertile dark crumb – textured soils of grasslands.

9. **Andisolization** is the formation of fertile mineralogically amorphous low – density horizons within soils of volcanic ash. Andisolization is not sustainable for more than a few thousand years unless there are colloids (such as imogolite) weather to oxides and clay minerals.

10. **Vertization** is the physical soil overturning and mixing, characteristic of soils rich in swelling clays (smectites), which swell when wet and shrink when dry. At the surface a linear frequency of microknolls and depressions may occur (gilgai). In the subsoil a typical vertic structure develops has either slickensides, or wedge – shaped with shiny and grooved curved surfaces. During the dry season they open up in a system of cracks, which are then partly filled by wall collapse.

11. **Anthrosolization**. Said, about any modification of properties, by design or unintentional, due to human activity, including soil modifications that may significantly influence soil development. Included, e.g. are soils strongly modified by cultivation, affected by construction leveling and terracing, land filling, mining and waste disposal. Archaeological ruins and artefacts are important clues to prior occupation of a site. Phosphorous content is an indicator of human use (1000-2000ppm, versus 10-20ppm in a normal soil).

12. **Salinization** is the precipitation of salts in soils. A process of increasing the soil soluble salt content up to more than that of the normal soils (>0.1%). It is found mostly in desert soils (Aridisols) or in the soils with an upward capillary movement of water from a saline groundwater.

13. **Solonization**. A complex process consisting in sodication associated with illuvial accumulation and dispersion of clay. A dens subsurface horizon (a natric B horizon) with a higher clay content than the overlying horizons results and a higher pH than 9-10.

14. **Cryoturbation** or frost churning is the process which mixes soil material, resulting in disrupted soil horizons, involutions, organic intrusions, organic matter accumulation in the subsoil, oriented rock fragments, silt – enriched layers and silt caps on stones and boulders. The ice can form disseminated crystals, hair – like threads, thin bands or vertical cracks, in climates where the mean annual temperature is less than -4^0C.

Problematic soils

1. Quicksands

Quicksands are as water flows through sands or silts and slows down; its energy is transferred to the particles past which it is moving that, in turn, creates a drag effect on the particles. Quick conditions frequently are encountered in excavations made in fine sands that are below the watertable. Liquefaction of potential quicksands also may be brought about by sudden shocks caused by the action of heavy machinery, blasting and earthquakes. Liquefaction is the loss of shear strength of a saturated cohesionless soil due to increased pore water pressures and the corresponding reduction in effective stress during cyclic loading. In simple term, when the pore water pressure increases, the effective stress on the particle structure will reduce and as it approaches zero, the shear resistance on the soil will als approach zero. There is also a possibility of a quick condition developing in a layered soil sequence containing fine sands (Bell, 2005)

2. Collapsible soils

A soil or a loose sediment with a low shear strength, easily compacting under its own weight or under an applied stress when thoroughly wetted. Loess is, from this point of view, a typical collapsible material. Loess deposits are very silty (dominated by quartz particles), but they may also contain quite significant amounts of clay and very fine sand. Loess is an unconsolidated rock, and has a high porosity and some large vertical cracks. It shows little or no stratification. Truly collapsible soils are those in which collapse occurs on saturation since the soil fabric cannot support the weight of the overburden. The maximum load that such soils can support is the difference between the saturation collapse and overburden pressures. The structural stability of collapsible soils is related to the suffosion process, that is the process of lateral and vertical removal of the fine soil particles by subsurface flow, often leading to settling, formation of potholes or piping. Chemical and hydrodynamic suffosion are distinguished. Chemical suffosion is the process of suffosion referring to originally cemented particles, carried away as a consequence of cement dissolution.

Hydrodynamic suffosion is the process of suffusion referring to direct carrying away of fine particles by flowing water. In other words, their metastable texture collapses as the bonds between the grains break down when the soil is wetted, in some cases in the order of metres. These have led to foundation failures. In order to stabilize collapsible soils, there are some methods: moistening and compaction (vibro-compaction, additives such as cement or lime, ponding and infiltration wells).

3. Expansive clays

Said about clays that have a variable space between the tetrahedral and the octahedral sheets, such as montmorillonite. This is dependent on the degree of hydration of the cations that compensate the permanent negative charge, or on the size of the adsorbed molecules. A clay showing visible shrinking and swelling characteristics. Swelling is a process, consisting in an increase of the total soil volume with an increasing moisture content. It is larger when the soil clay content is higher than 45%.

Shrinking is a process consisting in a decrease in the volume of a soil sample as a consequence of a decrease in its moisture content. Some of the best examples are provided by Vertisols. Expansive soils are responsible for significant national costs due to damage caused to property. For example, in the United States, the cost of repair of damage to property built on expansive clay exceeds two billion dollars annually (Bell, 2005).

The depth of the active zone in expansive soils, in which swelling and shrinkage occurs in wet and dry seasons, can be between 50 cm and 125 cm, with maximum intensity.

Alternating wet and dry seasons may produce significant vertical movements, with a process of turn – over of soil material. Vertisols are a low hydraulic conductivity and stickiness when wet and a high flow of water through the cracks when dry. They become very hard when dry. These volume changes can give rise to ground movements that may result in damage to buildings, and also in road construction. It is necessary a foundation that can tolerate movements, and can be insolated or controlled.

4. Dispersive soils

Dispersion (peptisation, deflocculation) is the separation of a flocculated colloidal system, due to specific dispersion agents, leading to formation of a disperse system. It is the first stage in soil structure degradation, of main interest being their dispersion into clay particles, by spontaneous mechanical and/or chemical processes. The main dispersing agent of interest for soils is Na (up to 12%). The sodium adsorbtion ratio (SAR), used to quantify the role of sodium in the pore water is defined as:

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

where the total Na, Ca and Mg concentrations are expresses as meq.L^{-1}.

In SRTS – 2012 a SAR greater than 13 is indicative of dispersive soils (Solonetz) between 4-13 as intermediate, and less than 4 as non-dispersive. High amounts of exchangeable Na induce clay dispersion, low permeability, increase in pH (>9-10). Severe erosion or worse, serious piping damage to embankments and piping failures of earth dams have occurred when dispersive soils have been used in their construction. It is indicates that if an earth dam is built with careful construction control and incorporates filters, then it should be safe enough. Alternatively, hydrated lime, pulverised fly ash, gypsum or aluminium sulphate have been used to treat dispersive soils used in earth dams.

5. Peat soils

Peat soils or Histosols form on parts of landscapes where there is concentration of run-off, retention of precipitation or discharge of groundwater. The main process is the accumulation of organic materials under anaerobic conditions. The pressure of overlying layers on the underlying ones is small. This is the cause that peat has a spongy structure with a high pore volume, very high water content and a law consolidation constant. As lowering of the water level gives the same increase of the grain pressure as for mineral soils, this increase is more important, compression of the layers, oxidation of organic matter cause subsidence.

Excessive settlement are the principal problems confronting the engineer working on a peat soil. Serious shearing stresses are induces even by moderate loads. Because of the potential problem of settlement arising from loading peat, especially in the construction of embankments carrying roads, some method of dealing has to be employed: bulk excavation of peat if the deposit is less than 3m in thickness; precompression, when the deposit exceeds 3m.

When peatlands are drained artificially, the ground level has significant subsidence (1-4m).

CONCLUSIONS

In the civil engineering the soil is considered as support for a construction or as a building material used in construction of dams. There are many soil – forming processes and the parent materials are modified over thousands of years in soil profile. Clay minerals are responsible for many of the soil's characteristic properties. The following soil – forming processes are considered as the most important: gleization, paludization, podzolization, ferrolysis, ferrallitization, byocycling, lixiviation, lessivage, melanization, andisolization, anthrosolization, salinization, solonization, cryoturbation, vertization. Problematic soils, that provide problems for the engineer are: quicksands, collapsible soils, expansive clays, dispersive soils and peat soils. A number of technique can be used to stabilize these soils.

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