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1 ORIGIN OF SOILS

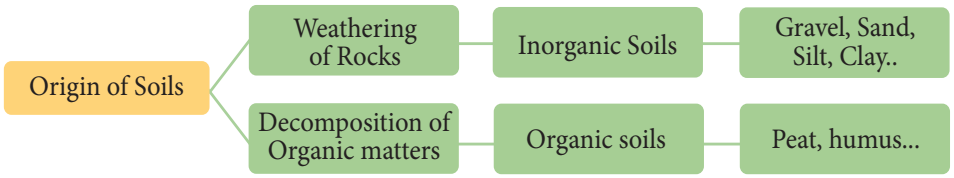
CHAPTER HIGHLIGHTS

- Soil
- Soil Formation and Soil Types
- Geological Cycle
- Field Names of Soil
- Forces Acting on Soil Mass

Soil

- Naturally occurring loose covering on the earth surface.
- Unconsolidated material produced by the **disintegration of rocks or decomposition of organic matters**.
- They are heterogeneous.
- Behaviour is usually inelastic, nonlinear, anisotropic, time dependent.
- Father of Soil Mechanics: **Karl von Terzaghi.**
- Study of soil: **Pedology.**
- Study of soil formation: **Pedogenesis.**

Soil Formation and Soil Types



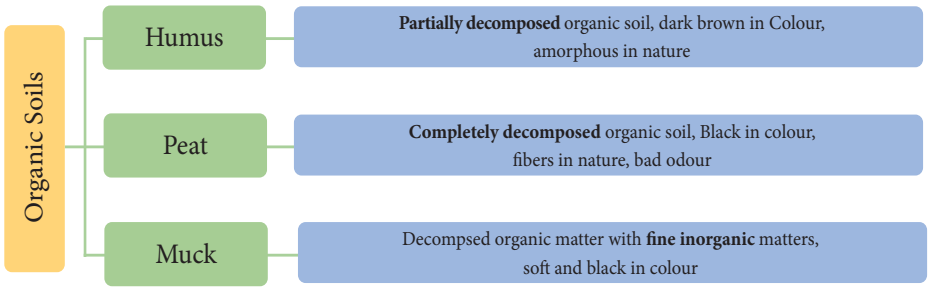
Classification of Soil Based on Geological Orgin

1. Inorganic Soils

- Soil are formed by **weathering of rocks** due to mechanical disintegration or chemical decomposition.

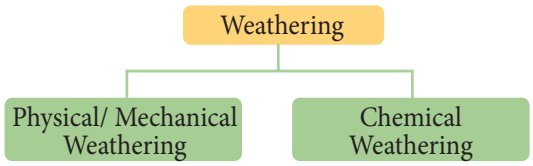
2. Organic Soils / Cumulose Soil:

- Contains high organic matter.
- Suitable for **agricultural purposes.**
- Extremely compressible.
- **Weak** for engineering applications



Weathering

- **Inorganic soils** are formed by weathering.
- Breaking down of rocks and their minerals through direct contact with atmosphere.



Note

- ***Sand dunes**: Occurs in arid regions and the leeward side of sea with sandy beaches and contain particles of **uniform size.***
- ***Loess/Collapsible soils: Silt deposit** with bearing capacity and high compressibility.*
- *Mixture of sand silt and clay in **equal proportion.** Weakly cemented by $Caco_3$ particles*
- ***Talus**: Contains irregular and coarse particles.*
- ***Till**: Directly made by melting of glaciers.*
- ***Outwash**: Soil carried by the melted water from glaciers.*

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- *Gravel mixed with red clay – **Moorum**.*
- *Laterite formed by the Process of – **Leaching**.*
- *Most commonly found soil in India – **Alluvial soil**.*

Confusing Facts

- ***Gravitational force** are predominant in **gravel & sands***
- *Surface force, electrical forces, chemical forces are predomonant in **clays.***

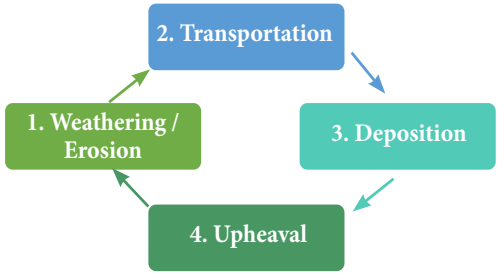
Note

Red Soil

- *Soil is formed due to the weathering of **granite, gneiss, and crystalline rocks.***
- *The soil gets its reddish colour due to the presence of **iron** in it.*
- *Parent rocks are **crystalline and metamorphic.***
- *Poor, Gravelly and porous*

Physical/ Mechanical Weathering	Chemical Weathering
Breakdown of rocks due to **physical action** of agents such as; • Temperature Changes • Penetration of roots of plants • Wedging action of Ice • Abrasion …	Breakdown of rocks due to **Chemical action** between rock and agents like; • Oxidation • Carbonation • Hydration • Leaching …
No change in Chemical composition	Chemical composition may change
Soil with **friction**	Soil with **cohesion**
Cohesionless Soils e.g., Sand, Gravel	Cohesive Soils e.g., Clay

Geologic Cycle



Classification of Soil Based on Mode of Transportation

1. Residual Soil/ Sedentary Soil:

- Soils which remain at or **near the parent rock.**

  eg : Block cotton soil & Laterite soils.

2. Transported Soil:

- Soils which transported **away from parent rock.**

Soil	Transported by	Examples
Aeolian Soil	Wind	Dune Sand, Loess (Collapsible soils)
Colluvial Soil	Gravitational Action	Talus
Glacial Soil	Glaciers	Till, Drift, Outwash
Alluvial Soil	Water (deposited in River Beds)	Khadar soil, Bhangar soil
Lacustrine Soil	Water (deposited in Lakes)	Varved Clay
Marine Soil	Water (deposited in Sea)	Marl

Field Names of Soil

1. Black Cotton Soil

- Parent rock is **Basalt or Trap.**
- Residual clayey soil.
- Contains higher percentage of **Montmorillonite** clay mineral.
- Highly plastic.
- Exhibits **high swelling and shrinkage**.

2. Bentonite

- Forms from weathering of **volcanic ash.**
- High percentage of **montmorillonite** clay mineral.
- Exhibits high swelling plastic and shrinkage.
- Used as **drilling mud**.
- Low shear strength.

3. Tuff

- Very small particles formed from volcanic explosion.
- Deposited by **Wind or water.**

4. Marl

- Stiff marine calcareous clay or greenish clay.
- High percentage of **Calcium carbonate.**

5. Diatomaceous Earth

- Fine, light grey, soft **sedimentary deposit**.

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- Remains of skeletons of diatoms.

6. Caliche

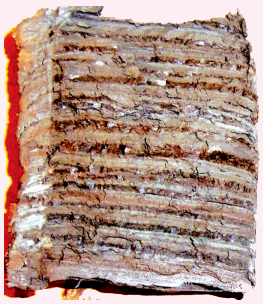
- Contains Gravel, sand and silt.
- Cemented by **Calcium Carbonate.**

7. Loam

- Mix of **sand, silt and clay** in equal proportions.

8. Varved Clay

- Alternative thin layers of **silt and clay**.



Varved clay

Marl

9. Moorum Soil

- Consist of small pieces of disintegrated rock or shale.
- **Red** in colour.

10. Laterite Soil

- Residual soil rich in **Iron and Aluminium**.
- Very soft when freshly cut, and becomes hard after long exposure.
- Type of soil formed due to **leaching & accumulation of ironoxide**
- Generaly formed in **hilly areas** having humid climate. Rusty-red in colour (presence of Iron oxide).

11. Kankar

- Impure form of **lime stone.**
- Mix of **Calcium Carbonate and some siliceous mineral**.

12. Hardpan

- A cemented or compacted clayey layer.
- Offer great **resistance to drilling tools.**
- Do not disintegrate when submerged in water.

13. Fill

- **Manmade** soil deposit.

14. Tundra

- Mat of **peat and shrubby** vegetation.
- Deeper layers are permanently frozen

Forces Acting on the Soil Mass

- Gravitational force or Body force
- Surface force

1. Body Force

- Force that acts throughout the volume of a body.
  Eg: Forces due to gravity, electric fields and magnetic fields.
- Predominant in **sand and gravel.**

2. Surface Force

- Surface forces which are exerted to **the surface of an object**.
  Eg : Cohesion
- Predominant in **clay.**

Note

- ***Regional Soil Deposits in India***
  1. *Alluvial Soil*
  2. *Desert soil*
  3. *Laterites and Lateritic Soil*
  4. *Black cotton soil*
  5. *Marine Deposits*
  6. *Boulder Deposits*

Note

- *In case of **silty soil** both both **body force** and **surface force** are equally important*

PRACTICE QUESTIONS

1. The term 'Soil Mechanics' was coined by

A. Terzaghi B. Casagrande
C. Newmark D. Rankine

2. The soil in which highest percentage montmorillonite mineral is present is

A. Laterite soil B. Bentonite
C. Varved clay D. China clay

3. The soil transported by running water

A. Alluvial soil B. Marine soil
C. Lacustrine soil D. Aeolian soil

4. Till, Drift, Outwash are transported by

A. Wind B. Gravitational Action
C. Glaciers D. All of these

5. During the process of soil formation, soils transported by gravitational forces are termed as

A. Cumulose soils B. Lacustrine
C. Colluvial soils D. Aeoline deposits

6. Ecologic cycle for the formation of soil, is

A. Upheaval → transportation → deposition → weathering
B. Weathering → upheaval → transportation → deposition
C. Transportation → upheaval → weathering → deposition
D. Weathering → transportation → deposition → upheaval

7. Laterite soil is rich in:

A. Phosphorus B. Calcium carbonate
C. Potassium D. Iron oxide

8. Which of the following has smallest size soil particles?

A. Gravel B. Silt
C. Clay D. Sand

9. A mixture of sand, silt, and clay forms

A. Loamy soil B. Clayey soil
C. Sandy soil D. Wet soil

10. Tuff is_____?

A. Sea water algae B. Water
C. Volcanic ash D. Consolidated ash

11. _____ is the rock from which the soil was formed.

A. Weathered rock B. Parent rock
C. Humus D. Sub rock

12. The soil formed by weathering action on rock and remain at the place of formation is called as:

A. Alluvial soil B. Residual soil
C. Marine soil D. Aeolian soil

13. Weathering is the process of breaking up the rocks by weather changes such as

A. Moisture B. Precipitation
C. Temperature D. All of these

14. Which of these weathering processes is/are considered as physical weathering?

A. Frost Action B. hydrolysis
C. Oxidation D. Carbonation

15. Select the correct option regarding the statements I and II.

I: Deforestation results in soil erosion.

II: The roots of plants cause cracks in rocks, leading to weathering

A. Both I and II are correct, and II is the correct explanation for I.
B. Both I and II are correct, and II is not the correct explanation for I.
C. I is correct. II is wrong.
D. II is correct. I is wrong

16. Which of the following statement is correct

A. Non-cohesive soils are formed by physical weathering
B. Non-cohesive soils are formed by chemical weathering
C. Cohesive soils are formed by physical weathering
D. Cohesive soils are formed by physical or chemical weathering.

- **Non-cohesive soils** are formed by **physical weathering**
- **Cohesive soils** are formed by **chemical weathering**

17. Which of the following statement is correct

A. **Sand Dunes** are glacial deposits
B. **Loam** is gravel mixed with red clay
C. **Black Cotton soil** exhibits high swelling and shrinkage
D. **Humus** is inorganic soil

- Sand dunes are Aeolian deposits
- Loam is mix of sand, silt and clay
- Black Cotton soil exhibits high swelling and shrinkage
- Humus is organic soil

18. Clay mineral present in black cotton soil

A. Montmorillonite B. Illite
C. Kaolinite D. Hallysite

Black cotton soil

- Parent rock is Basalt or Trap.
- Residual clayey soil.
- Contains higher percentage of Montmorillonite clay mineral.
- Highly plastic.
- Exhibits high swelling and shrinkage.

19. Examples of glacier deposits

A. Drift B. Outwash
C. Both of the above D. None of the above

- Examples of glacier deposits: **Drift, till, outwash**

20. Match list I with list II and select the correct answer

Ans

1. A
2. B
3. A
4. C
5. C
6. D
7. D
8. C
9. A
10. C
11. B
12. B
13. D
14. A
15. B
16. A
17. C
18. A
19. C
20. D

List I	List II
A. Loess	1. Deposited from suspension in running water
B. Peat	2. Deposits of marine origin
C. Alluvial soil	3. Deposits by wind
D. Marl	4. Organic soil

A. A3 B4 C2 D1 B. A4 B3 C1 D2
C. A4 B3 C2 D1 D. A3 B4 C1 D2

Source of Transportation	Type of Soil
River	Alluvial soil Eg:Khadar soil, Bhangar soil
Lakes	Lacustrine soils Eg: Varved soil
Sea	Marine soils Eg:Marl
Wind	Aeolian soils Eg: Sand dunes, Loess(collapsible soils)
Gravitation	Colluvial soils Eg:Talus
Glacier	Glacier-deposited soil Eg:Till, Drift, Outwash

21. Talus is the soil transported by

A. Water B. Wind
C. Ice D. Gravitational force

- Talus is soil transported by **gravitational force**

22. Which of the following statement is correct

A. Body forces are predominant in gravel and sand
B. Surface force is absent in clay
C. Body forces are predominant in clay
D. Surface forces are predominant in gravel and sand

- Body forces are predominant in **gravel and sand**
- Surface force is predominant in **clay**

23. Which of the following statement is correct

A. Tundra soil has alternate thin layers of silt and clay
B. Marl is an Aeolian deposit
C. Peat is inorganic soil
D. Loam is a mix of sand, silt and clay

- Varved clay has alternate thin layers of silt and clay Marl is an marine deposit Peat is organic soil Loam is a mix of sand, silt and clay
- Loam is mix of sand, silt and clay
- Black Cotton soil exhibits high swelling and shrinkage
- Humus is organic soil

24. Sequence of geological cycle for soil formation-

A. Transportation - weathering - deposition - upheaval
B. Weathering - transportation - deposition - upheaval
C. Weathering - deposition - upheaval - transportation
D. Upheaval - weathering - transportation - deposition

- Sequence of geological cycle for soil formation: **Weathering-transportation-deposition-upheaval**

25. Bentonite is a material obtained due to weathering of

A. Volcanic ash B. Basalt
C. Moorum D. Varved clay

- Bentonite is a material obtained due to weathering of volcanic ash

26. Residual soils are formed by

A. Glaciers B. Wind
C. Water D. None of the above

- Soils formed at the place of their origin are known as residual soil.

  Examples: Black cotton soils, laterite soils
- Soils deposited at a place away from the place of their origin, are called transported soil.
- The soils formed at a place may be transported to other place by agents of transportation, such as water, wind, ice and gravity

27. Which of the following name is related to soil engineering? [2014]

A. Blaise Pascal B. James Watt
C. Rankine D. Mannings

Rankine Theory of Earth Pressure

The earth retained may be filled up earth or natural soil in case of retaining structures. These backfill materials may apply lateral pressure to the wall. If the **wall is rigid** and does not move in response to pressure, the soil behind the wall will be in an **elastic equilibrium.**

28. Soil formed by the accumulation of decaying and chemically deposited vegetable matter under conditions of excessive moisture is [2014]

A. Alluvial soil B. Aeoline soil
C. Colluvial soil D. Cumulose soil

- On the basis of geological origin, soils may be organic or inorganic types.
- **Organic soils** are extremely compressible and their use as a foundation material is avoided.
- Soil containing organic matters are of spongy nature.
- **Peat, muck and humus** are organic soils. Organic oil also known as **cumulose soil.**
- Inorganic soils are formed by **weathering of rocks** due to mechanical disintegration or chemical decomposition

29. Most fertile soil is [2017]

A. Alluvial B. Black soil
C. Laterite soil D. Red soil

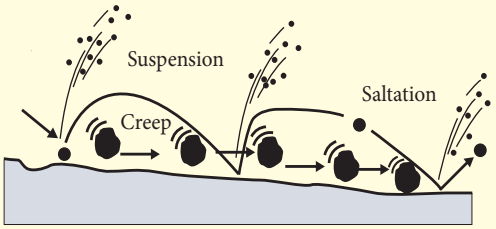
- **Alluvial soil** : India is one of the richest countries in the world in terms of alluvial soil, which covers **more than 46%** of its total land area

Ans

21. D
22. A
23. D
24. B
25. A
26. D
27. C
28. D
29. A
30. A

30. Among the three types of movements envisaged through mechanism of wind erosion which of the following is responsible for transporting the maximum portion of the soil along the surface of the ground ? [2023]

A. Saltation
B. Suspension
C. Surface creep
D. Both saltation and suspension combinedly



Ans
31. C
32. B
33. B
34. A
35. B
36. C

- **Suspension:** Fine particles **less than 0.1 mm** in size are moved parallel to the surface and upward into the atmosphere by strong winds. The most spectacular of erosive processes, these particles can be carried high into the atmosphere, returning to earth only when the wind subsides or they are carried downward with precipitation. Suspended particles can travel hundreds of miles.
- **Saltation:** Movement of particles by a series of short bounces along the surface of the ground, and dislodging additional particles with each impact. The **bouncing particles** ranging in size from **0.1 to 0.5 mm** usually remain within 30 cm of the surface. Depending on conditions, this process accounts for **50 to 90% of the total movement** of soil by wind.
- **Soil Creep**: The rolling and sliding of larger soil particles along the ground surface. The movement of these particles is aided by the bouncing impacts of the saltating particles described above. Soil creep can move particles ranging from **0.5 to 1 mm** in diameter, and accounts for **5 to 25% of total soil** movement by wind.

31. Which among the following has the minimum specific gravity?

A. Bentonite B. Quartz
C. Peat D. Clay

- Peat- It is organic soil with **fibrous** aggregates formed from vegetable matter in increase moisture (e.g. in swamps), highly compressible **not suitable for foundation.**
- **Specific gravity**
  Bentonite-2.69 Quartz - 2.64
  Peat - 1.4 Clay- 2.67

32. Which soil is crystalline and are formed due to meteoric weathering of the ancient crystalline rocks?

A. Laterite soils B. Red soils
C. Forest soil D. Black soil

- **Red soil** are formed due to meteoric weathering of ancient crystalline rocks. Red soil generally desired from **crystalline rock**, It has **low water holding capacity.**

33. A sticky, plastic, dark coloured clay is defined as

A. Marl B. Gumbo
C. Peat D. Muck

- **Gumbo soil :** a mixture which often has some small amounts of **sand** and/ or **organic material,** but is typically defined by the over whelming presence of **very fine particles of clay**. It is **sticky, plastic** and **dark coloured clay**.

34. Lacustrine soils are the soils

A. Deposited in lake beds
B. Transported by glaciers
C. Deposited in sea beds
D. More than one of the above

- **Pressure of water** does not affect the suction capacity of soil. When the dry soil is submerge under water meniscus is destroyed resulting in reduction of soil suction to zero value.

35. Moment of deposition of sand and other matters in zig-zag manner due to drifting at coast is a phenomenon known as:

A. Beach drift B. Littoral drift
C. Sand boiling D. Sand blasting

- **Littoral drift**- It is the term used for the transport of **non-cohesive sediments** i.e. mainly **sand**, along the foreshore and the shore face due to action of the breaking waves and the longshore current.
- **Beach drift**- It is defined as the **progressive movement** of sand and sediment along the beach.
- **Sand boiling** - It is the floatation of particle of **cohesionless soil** like fine gravel and sand due to **vertical upward seepage flow**.
- **Sand blasting** – It is also known as **abrasive blasting**, it is a process of smoothing and cleaning a hard surface by forcing solid particles across that surface at high speed using compressed air.

36. The strength of a soil in the dry state is an indication of a high amount of

A. Sand B. Silt
C. Clay D. Gravel

- Clay consists of microscopic and sub particle derived from the **chemical decomposition of rocks**. It contains large quantity of a clay minerals. It can be made plastic by adjusting the water content. It exhibits considerable strength when dry.

37. Arrange the following lists of soils in increasing order of surface areas?

A. Silt, sand, colloids, clay
B. Sand, silt, colloids, clay
C. Sand, silt, clay, colloids
D. Clay, silt, sand, colloids

- **Specific surface area** - The specific surface area is the total surface area per unit of mass or bulk volume.
- Increasing order of surface area is Sand < silt < clay < colloids
- It also depends on the particle shape.

Soil type	Specific surface(m^2/g)
Sand	<10
Sand loan	5 – 10
Clay	>25
Organic matter	500 – 800
Colloids	600 – 800
Bentonite	100 – 200

38. Consider the following statements:
1. Indurated clay is a type of clay which does not soften under prolonged wetting.
2. Peat is an inorganic soil whereas muck is an organic soil.
3. Peat and muck are organic soils.
Which of these statements is/are correct?
A. 1,2 and 3 B. 2 only
C. 3 only D. 1 and 3 only

39. Presence of organic matter in soil makes it
A. Swell at low moisture content
B. Spongy in nature
C. Shrink with increasing moisture content
D. None of these

- Presence of organic matter in soil makes **it spongy in nature**. In addition to providing nutrients and habital to organisms living in the soil, organic matter also binds soil particles into aggregates and improves the **water holding capacity of soil**. Most soils **contains 2-10% organic matter.**

40. Assetion(A): Black cotton soils are clays and they exhibit characteristic property of swelling
Reason(R): These clays contain montmorillonite which attracts external water into its lattice structure **[ESE2001]**
A. Both A and R are true and R is the correct explanation of A
B. Both A and R are true but R is not a correct explanation of A
C. A is true but R is false
D. A is false but R is true

For Black cotton soil
- Liquid limit = 40% to 100%
- Plasticity index = 20 to 60 %
- Shrinkage limit = 10 to 15 %
- Optimum moisture content = 25 to 30 %

41. Specific gravity of soil is
A. Same for clays and sands
B. Determined by hydrometer
C. Less than 2 for most soil
D. More than 2.5 for most soils

- The specific gravity of the solid substance of most inorganic soils varies between **2.6 and 2.80**
- Laterite soil have a specific gravity of between **2.75 and 3**
- Sand particles composed of quartz (sand) have a specific gravity ranging from **2.65 to 2.67**
- Inorganic clay have specific gravity ranging from **2.7 to 2.8**
- specific gravity of organic soil is **1.5 to 2.0**

42. Which one or more of the following statements is/ are true? **[HPSC 2018]**
A. Presence of organic matter in a soil decreases the bearing capacity of the soil
B. Clays are more porous than sand
C. Aluminous cement is used for foundations in soils with chemical deposits
D. All of these statements are true

These statements are correct
- Presence of organic matter in a soil **decreases the bearing capacity of the soil**
- Clays are more porous than sand
- Aluminous cement is used for foundations in soils with chemical deposits

43. Consider the following statements
1. Each year, black cotton soil appreciably shrinks during dry season and swells during rainy season. This alternate cycle of shrinking and swelling causes severe stresses in structures supported directly by such soil.
2. Black cotton soil contains predominantly a clay mineral called kaolinite, which is responsible for causing appreciable shrinking and swelling
3. Shrinking and swelling of black cotton soil are observed only upto a depth below the ground

Ans
37. C
38. D
39. B
40. A
41. D
42. D
43. D

level. Below that level, there is neither shrinking nor swelling

A. 1,2 and 3 B. 3 only
C. 2 and 3 only D. 1and 3 only

- Black cotton soil contains predominantly a clay mineral called montmorillonite, which is responsible for causing appreciable shrinking and swelling. Clay soils containing other clay minerals do not exhibit the volume change characteristics to the same degree as those containing montmorillonite mineral.

44. Consider the following statement in the context of Aeolian soils

(i) The soil has low density and low compressibility
(ii) The soil is deposited by wind the soil has large permeability
(iii) The soil has large permeability

Which of these statements are correct?

A. (i), (ii) and (iii) B. (ii) and (iii)
C. (i) and (iii) D. (i) and (ii)

Ans

44. B
45. D
46. D
47. D
48. C
49. B
50. A
51. A
52. A

- Due to erosion or wind effect the fine grained particle moves away from hilly or mountaineer area gets deposited in plains in definite volume resulting cleanse, compressible and large coarse particle result large permeability

45. Black cotton soils cover a large part of [JPSC 2013]

A. Northern India B. Rajasthan
C. Central India D. Southern India

- Black cotton soil formed from basalt or trap and contain clay mineral montmorillonite which is responsible for excessive swelling and shrinkage characteristics of the soil.
- Mostly a very big part of southern India known by its famous name as Deccan plateau has majority of black cotton soil. This soil exists in mainly Maharashtra and Karnataka including some parts of Gujarat and Madhya Pradesh.

46. Consider the following statements [ESE 2013]

1. Peat and muck are organic soils
2. Peat is inorganic soil whereas muck is an organic soil
3. Indurated clay is a type of clay which does not soften under prolonged wetting
4. Which of these statements are correct?

A. 1,2 and 3 B. 2 only
C. 3 only D. 1and 3 only

47. Consider the following statements

1. If the soil is not black in colour, it is unlikely to be a swelling soil
2. The swelling pressure of a fine grained soil depends on its initial water content and density
3. The swelling pressure of a fine grained soil depends on the nature of the pore fluid

Which of these statements are correct? [ESE 2013]

A. 1,2 and 3 B. 1 and 2 only
C. 1 and 3 only D. 2 and 3 only

- There are lot of swelling soils which are brown or light coloured, even though most expansive soils are dark in colour
- Swelling pressure of a soil depends on lots of factors such as initial dry density, method of compaction, moisture content, height of specimen, surcharge pressure and nature of pore fluid.

48. Which type of soil is most suitable for construction material

A. Humus B. Bentonite
C. Loam D. Peat

49. Loess is silt deposited by wind and deposits have [OPSC 2019]

A. High density and low compressibility
B. Low density and high compressibility
C. High density and low permeability
D. High bearing capacity and low compressibility

- Loess is silt deposited by wind and deposits have Low density and high compressibility

50. Drilling mud is usually a mixture of [WBPSC 2003]

A. Bentonite clay and water
B. China clay and water
C. Fine silt, fine sand and water
D. Fine silt and water

- Drilling mud is usually a mixture of Bentonite clay and water

51. Select the non-dimensional parameter from the following [UPSC 2012]

A. Specific gravity B. Mannings coefficient
C. Angular velocity D. Specific weight

- Specific gravity of soil solids is the ratio of the weight of a given volume of solids to the weight of an equivalent volume of water at 4°C

52. Gravel and sand belongs to the following category of soils [SSC 2014]

A. Alluvial B. Cohesive
C. Expansive D. Marine

- Alluvial soil are deposited by running water. Marine deposits are mainly confined along an arrow belt near the coast. The marine deposits have very low shearing strength and are highly compressible.