UNIT – 3

Subject – Engg. Geology

Unit 3 is divided into 3 Parts:

Part 1: Landslides, its Causes and classification, Preventive measures, settlement and subsidence

Part 2: Underground Water sources, Aquifers, Aquiclude, Artesian well, Infiltraton Galleries, Infiltration Well, Underground Water Provinces in India and Building Stones

Part 3: Engineering Properties of rocks, Alkali Aggregate Reaction, Grouting, Pozzolanic Materials, Fly ash

(Lanslides and its classification topic of this unit was covered in previous E-content which was entitled as Landslides)

Topics covered in this content- Underground Water sources, Aquifers, Aquiclude, Artesian well, Infiltraton Galleries, Infiltration Well, Underground Water Provinces in India and Building Stones

Part 2

Introduction to Groundwater

Groundwater is water that gets collected beneath the surface of the earth. The water seeps through the surface and the mud soaks it. Groundwater is procured by drilling or digging a well or by pumping. However, overpumping of groundwater shouldn't be done as it affects the salinity of the soil. It reduces the water level and increases the salinity of the soil.

Groundwater gets recharged by the process of Infiltration. **Groundwater** is the **water** found **underground** in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers.

Groundwater is often cheaper, more convenient and less vulnerable to pollution than surface water. Therefore, it is commonly used for public water supplies.

Underground water sources:

In this category the following sources can be listed:

1. Open Well
2. Tube well
3. Artesian well
4. Infiltration Gallery
5. Infiltration Well

1. Open Wells:

If it is ascertained that sufficient water is entrapped in some water bearing stratum below the ground surface, the entrapped water can be made available for use. A hole is sunk into the ground till it reaches such a depth as to hold sufficient water for use. Water should be available at lesser depth for economic justification.

2. Tube Wells:

If there are water bearing rocks or soil layers alternate to impervious layers or water bearing strata of indefinite extent then a metal tube with suitable perforations may be sunk in the ground to derive the water for use.

3. Artesian Wells:

When a permeable stratum is confined between impervious strata at the top and bottom artesian condition exists. The outcrop of the permeable stratum should be at a height enough to produce sufficient hydrostatic pressure on the water at lower points.

Then if a bore is drilled at proper position through the upper impermeable strata the water under pressure will rise in the bore. When the pressure is more water even overflows at the surface and can be utilized. Figure 1.4 shows the typical situation where artesian well is adopted.

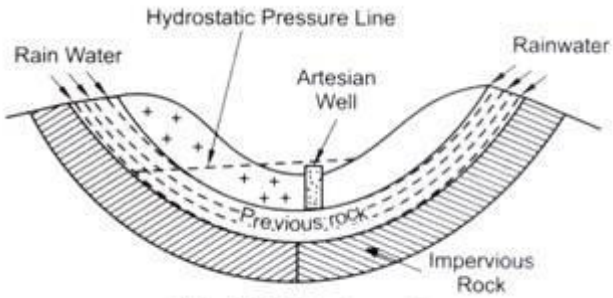

Fig. 1.4. Artesian well

4. Infiltration Gallery:

When water can be obtained within a reasonable distance below ground level, for example, below the river bed, horizontal porous pipes with open joints can be laid under the ground. It is apparent that a very large proportion of the groundwater will be intercepted by galleries than by a vertical well.

The intercepted water can be collected at suitable points in vertical collecting wells and can be used. Inverted filter surrounding the pipes can be provided to prevent clogging of pipes. Horizontal galleries laid at a depth more than 8 metres are uneconomical. Figure 1.5 shows cross-section and longitudinal section of the infiltration gallery.

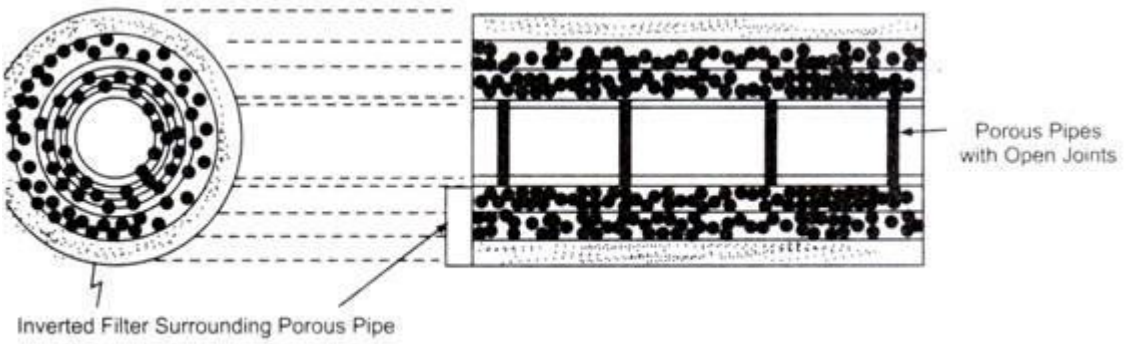

Fig. 1.5. Infiltration gallery

5. Infiltration Wells:

Sometimes water can be made available by sinking infiltration wells in the porous soil, for example, in the dry bed of a river. The infiltration well can be joined to vertical collecting wells or jack wells sunk on the bank of the river by means of horizontal underground porous pipeline. It intercepts water also and is called Infiltration gallery. Thus it can be recognized that infiltration wells and galleries supplement each other. Figure 1.6 shows the cross-sectional elevation and plan of an infiltration well.

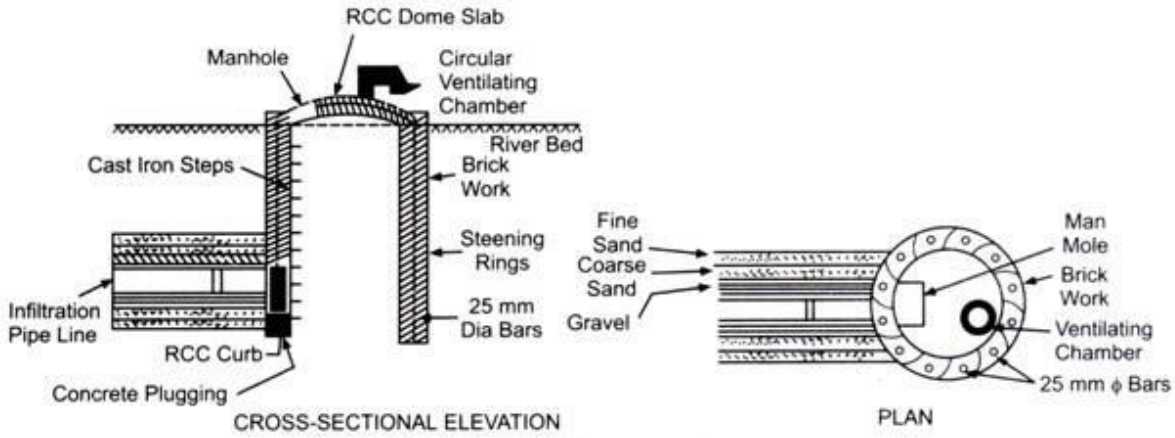

Fig. 1.6. Infiltration well

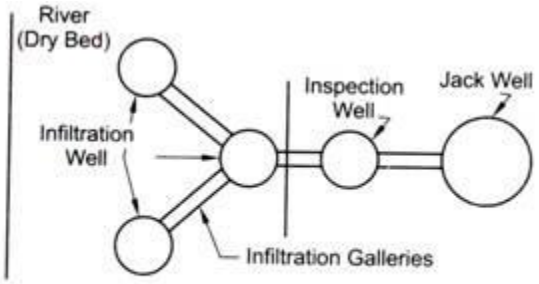

Fig. 1.7. Plan showing arrangement of wells and galleries

Aquifer

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well. It is a porous substrate. When water can flow directly between the surface and the saturated zone of an aquifer, the aquifer is unconfined. The deeper parts of unconfined aquifers are usually more saturated since gravity causes water to flow downward.

Aquiclude

An *aquiclude* is a substrate with porosity that is so low it is virtually impermeable to groundwater. Basically aquiclude is a geological formation which is impermeable to flow of water. It contains a large amount of water in it but does not permit water through it and also does not yield water.

GROUND WATER PROVINCES OF INDIA

The ground water provinces occurring in India have been classified into 8 as follows

1. The Precambrian Crystalline province
2. Precambrian Sedimentary province
3. Gondwana Sedimentary province
4. Deccan Trap province
5. Cenozoic Sedimentary province
6. Cenozoic Fault Basin province
7. Indo-Gangetic Alluvial province
8. Himalayan High Land province

Precambrian Crystalline Province

The province underlain by igneous and metamorphic rocks of Precambrian age extends from Kanyakumari in the south to Delhi in the north, these rocks are weathered up to 30 m and ground water occurs under water table conditions. Ground water occurs under semi-confined to confined condition depending upon the depth and nature of the fracture.

Ground water development is largely by open dug wells and large diameter wells. Well yielding 20 cum to 200 cum / day are common. Ground water movement is mainly along joints. Quartzites and marble devoid of primary porosity, opening is not numerous. Generally these are considered to be

poor aquifers. In case of lime stone characterized by solution cavities can be expected to give higher yield.

Precambrian Sedimentary Basin

This province comprise of Limestone, Shale, Sandstone, Quartzites and local conglomerate belonging to Precambrian to early Paleozoic age. These province is found in I) Cuddapah basin ii) Raipur basin iii) Vindhyan basin iv) Western Rajasthan basin. Because of compaction and cementation process, the rocks mostly devoid of primary porosity, but the introduction of structural features, the secondary porosity developed and karstification of calcareous rocks have yielded copious supply of ground water. Weathering varies from up to 200 m. Ground water occurrence is largely limited to 150 m, Yield characters ranges from 5 to 200 cum / day for small drawdown.

Gondwana Sedimentary Province

This province occurring as disconnected patches mainly fluviatile or Locustrine sediments of sandstone, shale and with little amount of limestone. These rock formations are classified into lower and upper formations. Total thickness of the formation range from 6 to 7 km. Lower Gondwana is compact and it is devoid of water because source rock is compact shale. Upper Gondwana sediments form very good aquifers, because those are more arenaceous. Water table lies generally within 30 m. dug wells in productive sand tone yielded maximum water.

Deccan Trap Province

Deccan trap province comprising Basalt flows includes hard, massive traps, Vesicular traps, Tuffs, Breccias, Ash and Intertrappeans. Age ranging from late cretaceous to early Eocene. The flows are flat but dip of 5 o to 15 o is also seen in some places. The traps have been divided into three groups viz., upper, middle and lower Gondwana, which are 450, 1200, and 1500 m thick.

The occurrence of "red boles", which is reddish brown clayey material, water bearing causes problems during drilling. Ground water occurs under water table conditions in weathered and jointed traps. Bore well drilled in traps have given higher yield mostly trapping 2 or more flows. At places the contact between the traps and the basement rock have yielded considerable quantity of water.

Cenozoic Sedimentary Province

This province comprise of narrow coastal plains along the Kerala and Tamil Nadu coast, coastal fringes of Saurashtra and Kutch peninsula. In the east coast, the seaward dipping strata contain several artesian aquifers. This province characterized by sand stone and shale. Shale is more compact, impervious and yield little water. Where as sand stone and conglomerates are highly permeable and yield about 150 cum, example Cuddalore sand stone. In Cambay basin, the sediments of deltaic estuarine and lagoonal alternate with Marine sediments, which are generally saline. Springs are also developed in hilly tracts.

Cenozoic Fault Basin

These discrete fault basin are included viz, the Narmada, Purna and Tapti valleys. They contain quaternary valley fill deposits consisting of sand and gravel intermixed with silt and clay, affected by faults. Thickness ranging from 50m to 150m. These lenses are of sand and gravel, which form moderately, yielding aquifers.

The Ganga – Brahmaputra Alluvial Province

It is the next most extensive province covering almost northern Indian planes, after Precambrian Crystalline province, deposited in fore deep or crustal buckle; the thickness increases from south to north. The basement is hard rock under the alluvial sloping at an average of 1 o to 3o. In alluvium, ground water occurs in three-distinct physic-graphic and hydrological belts such as Bhabhar consist of talus material from the hill slope, which is highly permeable unsorted boulder, grave sand with little clay. The belt merges with Terai consisting of permeable water bearing gravel, sand, and pebble intermingle with silt and clay. The axial belt, which comprises of stratified fine gravel, silt and clay deposited by the river system.

Water table in this area is less then 10 mbgl. Wells have recorded free flow of 100 – 300 cum/hr. Ground water have been developed by dug, dug cum bore wells, casing wells and tube wells yielding up to 300 cum/hr for 6 to 109 m of drawdown.

Himalayan High Land Province

This province includes a group of highly folded and faulted sedimentary rock ranging in age from

Paleozoic to Cenozoic. These sedimentary rocks are mainly comprising of limestone, sandstone and shale, and their metamorphic equivalents traversed by deep gorges and intermundane valley filled with alluvium this acts as conduits and transmits large quantities of water which recharges Ganga Bhramputra province. Whenever the alluvium is thick dug well for domestic purpose yield 100 – 200 cum/hr. with ion dissolved solid content.

Common Building Stones in India

There are 12 Commonly Used Building Stones in India. These stones are listed below with their Properties and Uses:

1. Granite
2. Basalt and trap
3. Serpentine
4. Limestone
5. Chalk
6. Sandstone
7. Caliche
8. Marble
9. Slate
10. Quartzite
11. Laterite
12. Gneiss

1. Granite

Granite is an igneous rock which is formed by the solidification of magma at a considerable depth from the earth's surface. It is hard and durable. It is available in different colors. The color of granite varies according to the amount of feldspar in it. It can be polished nicely.

The compressive strength of granite is about 75 to 130 MPa. Its specific gravity lies between 2.63 to 2.75. Its density is about 26 to 27 KN/m^3.

Uses

Granite is used for large engineering projects such as the construction of bridge abutments, dams, offshore structures, etc. It is also used for constructing steps, walls, flooring, etc.

Fig 1: Granite Tiles

2. Basalt and trap

Basalt and trap are also igneous rocks. These stones are also called as green stones or white stones or blue basalt. They are hard and tough. It is difficult to work with this kind of rocks. The specific gravity of basalt and trap varies from 2.6 to 3.0. They are having a high compressive strength of 150 to 190 MPa.

Uses

Basalt and trap used as railway ballast, aggregate in concrete, pavement material, etc. Yellow and red-colored basalt and trap are used to construct decorative features in structures.

Fig 2: Basalt and Trap as Railway Ballast

3. Syenite

Syenite is also an igneous rock which is hard and durable like granite. The structure of syenite is coarse-grained and its crushing strength varies from 90 to 150 MPa. It is available in different colors but typically they are light in color.

Uses

Crushed syenite is commonly used as aggregate in pavement construction and concrete making. It is also used for external facings of building walls etc.

Fig 3: Syenite

4. Limestone

Limestone belongs to sedimentary rocks which are formed by the deposition of particles of weathering. It contains calcium carbonate in huge proportion. It is soft and easily workable. The compressive strength of limestone is about 55 MPa and specific gravity lies between 2.0 to 2.75.

Uses

Limestone is used to manufacture lime and cement. It is also used for flooring, roofing, etc.

Fig 4: Limestone Blocks

5. Chalk

Chalk is a sedimentary rock and it contains pure lime in it. It is very soft and easily can be converted into powdered form. It is generally white in color and contains a porous structure.

Uses

powdered chalk is used for manufacturing lime putty and also used as a pigment in Portland cement.

Fig 5: Chalk Rocks

6. Sandstone

Sandstone is a sedimentary rock and consists of different minerals like quartz, feldspar, silica, etc. in it. The hardness of sandstone depends upon the proportion of minerals in it. However, it is easily workable and also available in different colors. The specific gravity of sandstone lies between 2.65 and 2.95. Its compressive strength is about 65 MPa and with a density of 20 to 22 KN/m^3.

Uses

It is used as material for roofing, paving, columns, facing works and ornamental carvings, etc.

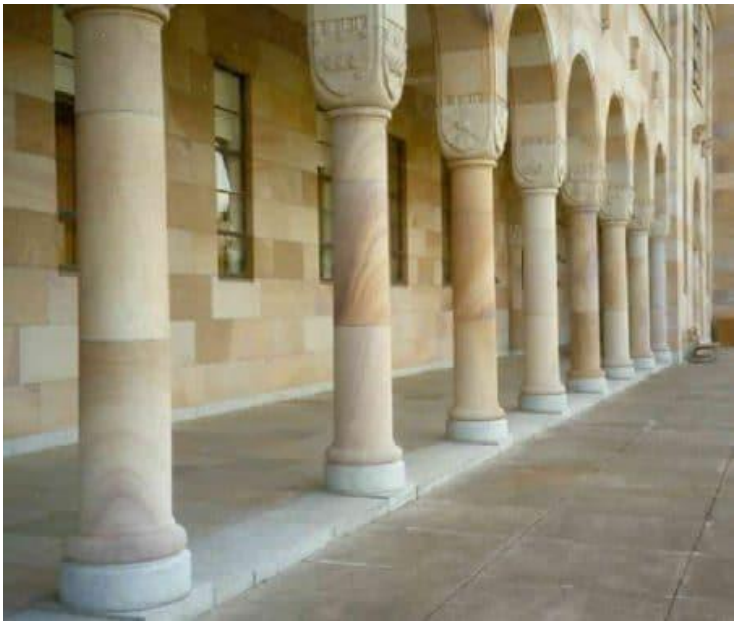

Fig 6: Sandstone Columns

7. Caliche

Caliche also called as Kankar falls under the sedimentary category of rocks. It is the impure form of limestone. It is porous in structure and irregular in shape. Its hardness varies from soft to hard.

Uses

Caliche or kankar is used as aggregate in pavement construction. It is also used to prepare hydraulic lime.

Fig 7: Kankar Bedding Planes

8. Marble

Marble belongs to the metamorphic category of rocks and it is formed when limestone is subjected to excessive heat and pressure. This process of forming is called metamorphism. Marble is hard and compact in nature. It occurs in different colors and also it can take a good polish. Its compressive strength is about 70 Mpa. The specific gravity of marble is about 2.65.

Uses

Marble is used for flooring, facing works, steps, etc. It can be carved into required shape easily hence, it is used for decorative and ornamental works of structures.

Fig 8: Marble Flooring

9. Slate

Slate is a metamorphic rock which is formed by the metamorphic action of shale under low pressure and heat conditions. It is hard and brittle. It consists of foliated texture and generally black in color. It can be split into thin slabs along its natural foliated planes. Its crushing strength ranges from 75 to 210 Mpa with a specific gravity of 2.89.

Uses

Slate is used for floorings, roofing works, partitions, damp proof courses, etc.

Fig 9: Slate Roofing

10. Quartzite

Quartzite also belongs metamorphic category which is formed by the metamorphism of sandstone under high pressure and temperature. It is of crystalline structure with a granular texture. It is hard and brittle. It is not easily workable. Its compressive strength is about 115 MPa.

Uses

Quartzite is used as road aggregate, concrete aggregate, etc. it is also used to construct retaining walls, rubble masonry, stone pitching, etc.

Fig 10: Quartzite Retaining Wall

11. Laterite

Laterite also belongs to the metamorphic category. It is porous and spongy in its structure. It is soft and workable hence quarrying of laterite is easy. It has low crushing strength which is about 1.8 to 3.0 MPa. When it is decomposed it turns into moorum which is widely used for road construction.

Uses

Laterite is used for rough stone masonry works, pavement construction works, etc.

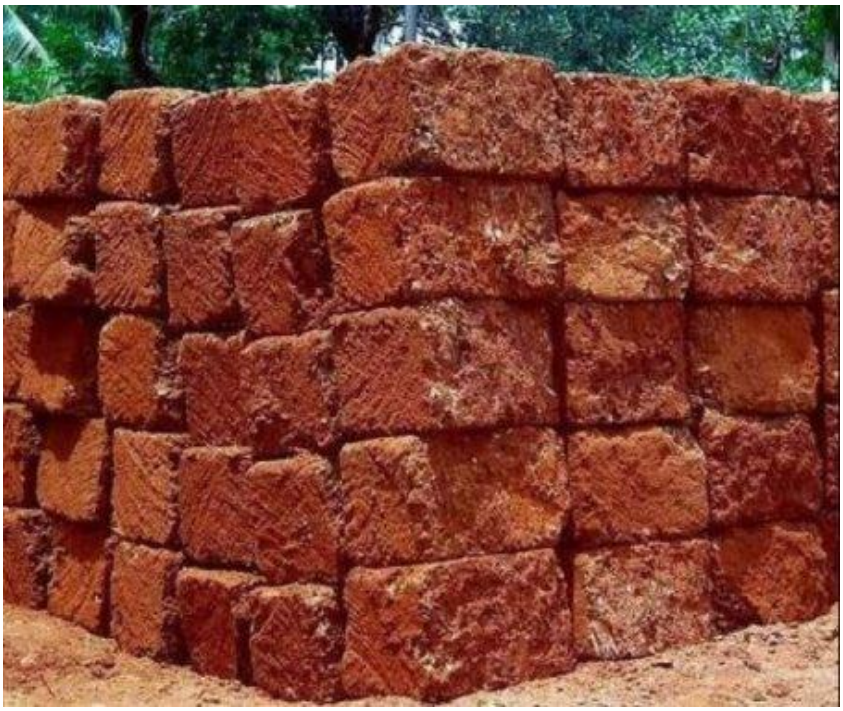

Fig 11: Laterite Masonry Blocks

12. Gneiss

Gneiss is another metamorphic rock formed by the metamorphosis of granite. It consists of foliated structure hence it can be split into thin slabs along its bedding planes. It is strong and durable. Its crushing strength varies from 206 MPa to 370 MPa with a specific gravity of 2.69.

Uses

Crushed gneiss used for pavement construction, rough stone masonry works, stone pitching, etc.

Fig 12: Gneiss Stones