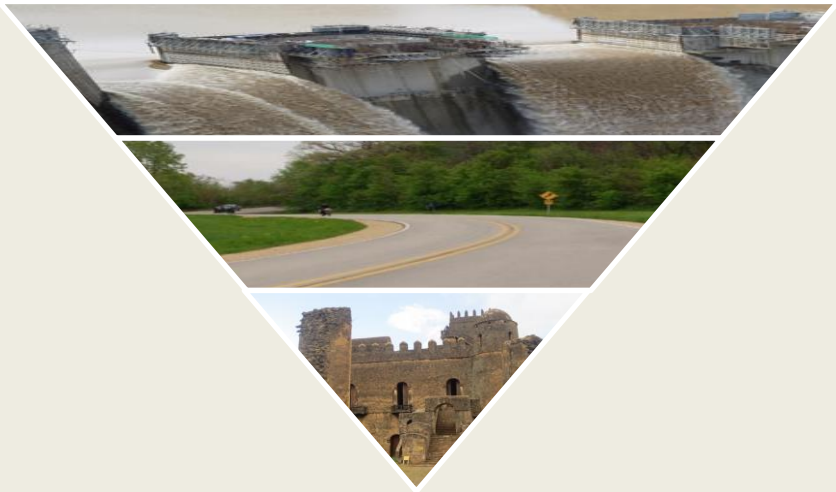
DAM, ROAD, BUILDING, AND WATER

ENGINNERING IMPORTANT TERMS



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MAY, 2020 G.C

This short Pdf softcopy is prepared to students whom are mostly in University studying Hydraulics, Civil, Water, Irrigation, and Supply Engineering that contains Dam, Water, and Road Parts. It's also useful for those graduated and working for further knowledge and in site. I have tried my best to correct and figure out mistakes…if there is any mistakes that I didn't sort out…Pardon me! Comment, I'll try to fix the problem for future.

I have graduated from Haramaya University by BSc Hydraulics and Water Resource Engineering and currently on some work.

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Good Luck!

Dedication

With appreciation and love, I dedicate this Pdf softcopy to, my mother Workinesh Choforo, Whole family, and friends: 4Doc_4Engin and 3AF.

Contents

Contents Pages

ENGINEERING IMPORTANT TERMS ONE----------1

Road and Water Part

ENGINEERING IMPORTANT TERMS TWO----------14

Hydropower and River Part

ENGINEERING IMPORTANT TERMS THREE----------27

Water Supply and Treatment Parts one

ENGINEERING IMPORTANT TERMS FOUR----------40

Water Supply and Treatment Part Two

ENGINEERING IMPORTANT TERMS FIVE----------53

Building Works Part by Amharic Language

SOURCES----------63

ENGINEERING IMPORTANT TERMS ONE

Transportation is all about moving goods and people from one place to another, It is also Safe, efficient, reliable, and sustainable movement of persons and goods over time and space

Transportation engineering is a type of civil engineering which focuses on the infrastructure of transportation: all the elements which support the movement of goods and people.

Transportation engineering can be broadly consisting of the four major parts:

1. *Transportation Planning 2. Geometric Design 3. Pavement Design 4. Traffic Engineering*

Geometric design is the process where by the layout of the road in the terrain is designed to meet the needs of the road users.

Design speed for a highway may be considered as "the maximum safe speed that can be maintained over a specified section of a highway when conditions are so favorable that the design features govern".

There are three different sight distances that are of interest in geometric design: *-Stopping sight distance; -Meeting sight distance; -Passing sight distance*.

Stopping sight distance (SSD) is the total distance traveled by a given vehicle before stopping during three time intervals

Sight Distance is the distance visible to the driver of a vehicle ahead of him

For highway safety, the designer must provide sight distances of sufficient length so that drivers can control the operation of their vehicles.

Passing Sight Distance- Minimum distance required to safely complete passing maneuver on 2-lane two way highway. Allows time for driver to avoid collision with approaching vehicle and not cut off passed vehicle when upon return to lane

TERIAN CLASSIFICATION

The geometric design elements of a road depend on the transverse terrain through which the road passes. Transverse terrain properties are categorized into four classes as follows:

FLAT: Flat or gently rolling country, which offers few obstacles to the construction of a road, having continuously unrestricted horizontal and vertical alignment (transverse terrain slope up to 5 percent).

ROLLING: Rolling, hilly or foothill country where the slopes generally rise and fall moderately and where occasional steep slopes are encountered, resulting in some restrictions in alignment (transverse terrain slope from 5 percent to 25 percent).

MOUNTAINOUS: Rugged, hilly and mountainous country and river gorges. This class of terrain imposes definite restrictions on the standard of alignment obtainable and often involves long steep grades and limited sight distance (transverse terrain slope from 25 percent to 50 percent).

ESCARPMENT: In addition to the terrain classes given above, a fourth class is added to cater to those situations whereby the standards associated with each of the above terrain types cannot be met. We refer to escarpment situations inclusive of switchback roadway sections, or side hill transverse sections where earthwork quantities are considerable, with transverse terrain slope in excess of 50 percent).

The aim of alignment selection process is to find a location for the new road that will result in the lowest total construction, land, traffic, and environmental costs.

The methods that must be included in selecting the alignment and locating the route. These are:

-Reconnaissance survey -Preliminary location survey -Final location survey

The functional classification in Ethiopia includes five functional classes.

Trunk Roads (Class I) Centers of international importance and roads terminating at international boundaries are linked with Addis Ababa by trunk roads. They are numbered with an "A" prefix: an example is the Addis-Gondar Road (A3). Trunk roads have a present AADT □1000, although they can have volumes as low as 100 AADT.

II. Link Roads (Class II) Centers of national or international importance, such as principal towns and urban centers, must be linked between each other by link roads (see Table A-2). A typical link road has over 400 - 1000 first year AADT, although values can range between 50-10,000 AADT. They are numbered with a "B" prefix. An example of a typical link road is the Woldiya- Debre Tabor- Woreta Road (B22), which links, for instance, Woldiya on Road A2 with Bahir Dar of Road A3.

III. Main Access Roads (Class III) Centers of provincial importance must be linked between each other by main access roads. First year AADTs are between 30-1,000. They are numbered with a "C" prefix.

IV. Collector Roads (Class IV) Roads linking locally important centers to each other, to a more important center, or to higher class roads must be linked by a collector road. First year AADTs are between 25-400. They are numbered with a "D" prefix.

V. Feeder Roads (Class V) Any road link to a minor center such as market and local locations is served by a feeder road. First year AADTs are between 0-100. They are numbered with an "E" prefix and are presented in Appendix A.

Roads of the highest classes, trunk and link roads have, as their major function to provide mobility, while the primary function of lower class roads is to provide access. The roads of intermediate classes have, for all practical purposes, to provide both mobility and access.

Average Annual Daily Traffic (AADT):-Total yearly traffic volume in both directions divided by the number of days in the year.

Average Daily Traffic (ADT):-Total traffic volume during a given time period in whole days greater than one day and less than one year divided by the number of days in that time period.

Axel load:-Association to find a Method to estimate pavement design loads such as:-

Bridge is a structure providing passage over an obstacle, The obstacle may be a river, a valley, a road or a railway line. The passage may be for a highway, railway traffic, pedestrian, a canal or pipe line. According to the form or type of superstructure as *slab, girder, truss, arch, cable stayed or suspension*

Centerline:-Axis along the middle of the road.

Circular Curve:-Usual curve configuration used for horizontal curves.

Crest:-Peak formed by the junction of two gradients.

Crest Curve:-Convex vertical curve with the intersection point of z tangents above z road level

Cross-Section:-Vertical section is showing the elevation of the existing ground, ground data and recommended works, usually at right angles to the centerline.

Culvert is a cross drainage work whose length (total length between the inner faces of abutments or extreme vent-way boundaries when measured at right angles to the axis of vent-way) is less than 6 meters. Four types such as **pipe culvert, box culvert, arch culvert and slab culvert**.

Design Capacity:-Maximum number of vehicles that can pass over a lane or a roadway during a given time period without operating conditions falling below a pre-selected design level.

Design Speed:-Design speed is used as an index which links road function, traffic flow and terrain to the design parameters of sight distance and curvature to ensure that a driver is presented with a reasonably consistent speed environment

Design Traffic Volume:-Number of vehicles or persons that pass over a given section of a lane or road way during a time period of one.

Design Volume:-Volume determined for use in design, representing traffic expected to use the road.

Equivalent Axle Load Factor (EALF) In many design methods, the total estimated or projected magnitude and occurrence of the various traffic loadings are converted to the total number of passes of the equivalent standard axle loadings, defined as the standard 80 KN(18-kips)equivalent single-axle load(ESAL).

ESAL: - the total number of equivalent 18 kip (80 KN) single axel loads expected on the pavement for the design period.

Embankment:-That portion of the road prism composed of approved fill material, which lies above the original ground and is bounded by the side slopes, extending downwards and outwards From the outer shoulder breakpoints and on which the pavement is constructed.

Escarpment (Terrain):-Steep country inclusive of switchback sections and side hill traverses; transverse terrain slope > 75 percent.

Excavated material is usually classified as: Common excavation, Loose rock, or Solid rock.

EWL- Equivalent wheel load

Flexible pavements: - a multi layered structure; the external load is largely transmitted to the sub grade by lateral distribution with increasing depth

Fill:-Material which is used for the construction of embankments.

Flat (terrain):-flat terrain with largely unrestricted horizontal and vertical alignment; transverse terrain slope up to 5 percent.

Free Haul:-Maximum distance through which excavated material may be transported without added cost above the unit bid price.

Gradient is the rate of rise or fall along the length of the road with respect to the horizontal.

Geometric (Design) Standards:-Guidelines for limiting values of road alignment and cross-section design.

Mountainous (terrain):-Terrain that is rugged and very hilly with substantial restrictions in both horizontal and vertical alignment; transverse terrain slope 25-75 percent.

Pavements: - are structures over the sub grade soil in order that vehicles may have smooth and comfortable ride in addition to distributing stresses imposed evenly horizontal withstand loads from the flexural strength or beam strength Alignment of the pavement and serves as the foundation of the pavement structure

Remote sensing is the science of gathering information from a location that is distant from the data source. Image analysis is the science of interpreting specific criteria from a remotely sensed image. *"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."*

Rigid pavement: - a structure constructed from cement concrete and drives its capacity

Road Bed:-The natural in-situ material on which the embankment or capping layers are to be constructed.

Road Functional Classification:-Classification of roads according to service provided in terms of the road hierarchy.

Rolling (Terrain):-Terrain with low hills introducing moderate levels of rise and fall with some restrictions on vertical alignment; traverse terrain slope 5-25 percent.

Sag Curve;-Concave vertical curve with the intersection point of the tangents below the road level.

Interactions with the Atmosphere, Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of *scattering and absorption*.

Scattering occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path.

There are three (3) types of scattering which take place.

Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules.

Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapor are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering.

Nonselective scattering. This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering.

Speed:-Rate of movement of vehicular traffic or of specified components of traffic, expressed in kilo meters per hour (km/h).

Absorption is the other main mechanism at work when electromagnetic radiation interacts with the atmosphere. In contrast to scattering, this phenomenon causes molecules in the atmosphere to

absorb energy at various wavelengths. Ozone, carbon dioxide, and water vapor are the three main atmospheric constituents which absorb radiation.

Shoulder is the portion of the roadway contiguous to the carriageway for the accommodation of stopped vehicles; traditional and intermediate non-motorized traffic, animals, and pedestrians; emergency use; the recovery of errant vehicles; and lateral support of the pavement courses.

Camber (Normal cross fall, Surface drainage or, crown) should be sufficient to provide adequate surface drainage whilst not being so great as to make steering difficult. The ability of a surface to shed water varies with its smoothness and integrity. 2%

Super elevation- Is raising of outer edge with respect to inner edge, to counteract the centrifugal force. 7%

Sight Distance:-Distance visible to the driver of a passenger car measured along the normal travel path of a roadway to the roadway surface or to a specified height above the roadway surface when the view is unobstructed by traffic

Stopping Sight Distance: - Distance required by a driver of a vehicle travelling at a given speed, to bring his vehicle to a stop after an object on the roadway becomes visible. It includes the distance travelled during the perception and reaction times and the vehicle braking distance.

Tangent:-Portion of a horizontal alignment of straight geometrics.

Traffic:-Vehicles, pedestrians and animals travelling along a route.

Traffic Capacity:-Maximum number of vehicles which has a reasonable expectation of passing over a given section of a lane or a roadway in one direction or in both directions for a two-lane single roadway road, during a given time period under prevailing road and traffic conditions.

Traffic Flow:-Number of vehicles or persons that pass a specific point in a stated time, in both directions unless otherwise stated.

Typical Cross-Section:-Cross-section of a road showing standard dimensional details and features of construction.

Vertical Alignment:-Direction of the centerline of a road in profile.

Vertical Curve:-Curve on the longitudinal profile of a road, normally parabolic.

Surface/wearing course: - The layer in contact with traffic loads. Bituminous pavement, Cement concrete pavement

Base course: - the layer immediately beneath the surface course

WBM (Water Bound Macadam) - Red soil + Aggregate

WMM (Wet Mix Macadam) – Stone dust + Aggregate + Gypsum

Sub base course: - the layer between the base course and sub grade.

40mm size of aggregate (Drainage layer)

Sub grade: - it is usually the natural material located along the horizontal Alignment of the pavement. Red or Morrum

Rainwater: Cause erosion on surface or may seep downward, damage pavement (surface drains)

Groundwater: May rise by capillary action and damage pavement (sub-surface damage)

Water body: May cross a road (river/stream) and may damage road (cross drainage words)

Borrow- material not obtained from roadway excavation but secured by widening cuts, flattening back slopes, excavating from sources adjacent to the road within the right-of-way, or from selected borrow pits as may be noted on the plans

Waste:-Material excavated from roadway cuts but not required for making the embankments. It must be pointed out that this material is not necessarily wasted as the word implies, but can be used in widening embankments, flattening slopes, or filling ditches or depressions for erosion control.

Free Haul (FH)- the maximum distance through which excavated material may be transported without the added cost above the unit bid price. Must be less than 1KM distance. Economical distance of transportation 500m

Overhaul- excavated material transported to a distance beyond the free haul distance

Economic Limit of Haul (ELH)- distance through which it is more economical to haul excavated material than to waste and borrow.

$$E.L.H. = F.H.\ distance + \frac{\text{Unit Price of Borrow}}{\text{Unit Price of Overhaul}}$$

The steps involved in the computation of earthwork quantities: 1- *End area calculations, 2- Earthwork calculations, 3- Preparation of mass haul diagram, 4- Balancing earthworks using the mass haul diagram*

End area calculations are usually made by one of the following methods:

1. **Plan meter Method** - The original ground line and template section (cross section) must be plotted on grid paper. Centerline profile grade must first be calculated for each cross section station to determine the centerline reference of each template plot.

Areas of cut and fill quantities are calculated using a plan meter, converted to square meters, and tabulated for each section.

2**. Electronic Computer Method** - This method is widely used due to its versatility and speed of calculations. The end area calculation on modern computer programs is an integral part of the alignment design program and shown on output listings along with the geometric of each section.

Chain data recording- for Road 20m and Hydraulic structure 10-15m

The **plasticity index of road** construction is **6%**

Minimum road width 3.75m and *Maximum car width 2.44m*

Pavement unevenness for developed 80cm/km and non- developed 200cm/km

Median 0.5-2.6m allowable(10cm height)

For forest area 3.75m of road width. Every 5KM there should be horizontal curve on state highway & Every 15KM there should be horizontal curve on nation highway

More than 200mm of rock or stones are not used in fill system of road or to construct embankment.

Cost of operation considered in construction *Fuel coast, Driver coast and Time*

HEC-RAS- Hydrological Engineering Center-River Analysis System

UTM- Universal Transfer measures, **DEM**- Digital Elevation Model

BIM- Building Information Modeling ex. Revit, ArchiCAD and Excel

GCS-Geographic coordinate system in degree and **PSC**- Projected CS in meter. 1^0=111KM

Period of removal (Minimum)

Vertical formwork of columns, walls and beams	16 hrs
Soffit formwork to slab	21 days
Props to cantilever slab	14 days
Soffit formwork to beams	21 days
Props to cantilever beams	14 days

Azimuth-An angles measures always from north, Clockwise

Bearing- An angle measures from South or North Clockwise and Anti-clockwise

WATER SUPPLY AND TREATMENT

Artesian spring - Water held b/n two impervious strata of soil and released through an opening .

Augur - Large screw shaped blade on a shaft driven manually by rotating a handle at top to bore into the soil.

Ambient air - Surrounding air at a point.

Aeration - Process of gas transfer between water and air.

Biological test - Test for the presence and identification of microorganism.

Back wash - Cleaning of filter bed by reverse flow of water.

Catchment - Area from which rainwater is received by a river.

Chlorination - Mixing of chlorine in water to kill bacteria

Plain chlorination - Application of normal dose of chlorine after filtration.

Super chlorination - Application of excess dose of chlorine .

Break point chlorination-Dosage of chlorine beyond which is all free chlorine only.

Dechlorination - Removal of excess chlorine.

Pre-chlorination - Chlorine applied prior to regimentation and filtration process.

Post-chlorination - Chlorine applied after filtration process.

Re-chlorination - Application of chlorine again in the distribution system.

Colloids - Suspended matter of size less than one micron in water.

Conservancy system - Removal of human wastes manually and disposals without any treatment

Comparator- Instrument to compare the color of sample against standard solution or color dyes.

Coagulation - Process of charge neutralization or destabilization of colloids with chemicals.

Conventional treatment - Treatment processes normally adopted like sedimentation, filtration and chlorination.

Carcinogen - Cancer - causing substance.

Chloramine - Compound resulting from the reaction of chlorine with ammonia in water.

Circular or ring system - Water mains laid around the area of supply through sub mains and branches to the center of the area.

Communication pipe - Pipe from the ferrule the stop-cock.

Coliforms - Bacteria of intestinal origin.

Disinfection - Process of killing of infective bacteria in water

Deep well - Well that penetrates one or more impermeable layers of soil.

Dug well - large open well with steining.

Driven well - Tube well made by penetration of a pointed end by series of blows.

Demand - Requirement of water for particular use

Design period - Number of years the scheme s supposed to serve.

Detention time - time taken by water to travel between the inlet and outlet of tank.

Dead-end system - system of layout in which any point on the distribution system receive water from one direction only.

Delivery head - height to which water is pumped above the pump level

Distribution pipe - supply pipe in building from which connections to fixtures take off

Down take supply system - system of supply to building from an overhead tank through down-take pipes for floors below.

Epidemic - sudden incidence of disease among large population.

Evapotranspiration - Escape of moisture through leaves of plants.

EDTA- Ethyiene Diamine Tetraacetic Acid.

Effective size - 90% of the grains are larger than this size.

Flushing -cleaning with force of water.

Fluorosis - Disease caused by excess fluorides intake affecting the bones

Dental fluorosis - excess fluorides affecting the teeth

Skeletal fluorosis - Excess fluorides affecting the bone system.

Flocculation- Process of floc formation by aggregation of chemical precipitate and colloids.

Ferrule -A valve fixture screwed on the street main and connecting the communication pipe.

Filtration - removal of turbidity etc. By passing water through a bed of soil layer.

Foot valve - Valve at the bottom end of the suction pipe to hold priming water.

Geological formation - Layers of earth's crust formed over a period of millions of years by lava and other agencies.

Grid-ron system - Layout of the distribution system by a network of inter-connected pipes with water flowing in any direction of least resistance to flow.

Hydropneumatic system - system of pumping water by compressed air to fixtures in a building.

Hydrological cycle - Movement of water through soil, ocean and air in cyclic form.

Hydrograph - graph plotted between time and discharge.

Head of water - equivalent height of water column that balances any pressure (pressure head) or velocity (velocity head)

Heavy metals - cations of higher valency more than 2 like Fe, Cr, Sr, Hg.

Hydraulic conductivity*:* ratio of velocity to hydraulic gradient, indicating permeability of porous media.

Hydraulic gradient (dh/dx*):* the slope of the piezometric surface or water table line in m/m. the magnitude of the head determines the pressure on the groundwater to move and its velocity.

Industrial effluent - Waste water flowing out of the industries

Intake - structure that enables drawl of water from a source.

Intermittent system - System of supply of water for few hours a day or on alternate days.

Incrustation- Formation of hard coating by salt deposition .

Incubation - Growth under controlled temperature in a cubicle

Impeller - Curved valves fitted between two discs revolving – part of the centrifugal pump.

Jet pump - Pumping device utilizing the section created by a venturi- jet to lift water up to the impeller level

L.P.C.D - Liter's per capita per day - a unit of supply,

Loss of head - Reduction of energy water - it may be due to frictional resistance, bends, contractions, tees, valves etc.

Lift - Distance from the water surface (in water tank) to the center of the pump

Manholes: are provided at suitable intervals along the pipe line, so as to serve for inspection and maintenance. Most of the fixtures in the water supply system are also place inside a manhole to protect them from damage. Manholes are made of concrete, brick or stone masonry. A thin sheet metal or cast-in situ concrete may be used as cover.

Mortality rate - The number of deaths per 1000 population in a year

Morbidity rate- Number of cases of disease incidence & prevalence per 1000 pop'n in a year.

Microorganism - Organisms like bacteria that can not be seen by naked eye.

MPN - Most probable Number. A statistical indicator of probability of presence of coliform organisms in water.

Monitoring - To assess the quality at intervals.

N.T.U. - Nephello Turbidity unit - units of Turbidity.

Potable water - Water that is fit for drinking, safe and agreeable.

Pollution - Introduction of substances that came undesirable change in quality of water.

Pathogens - Disease causing organisms like bacteria, virus etc.

Prophylactic - Preventive of Disease as a temporary measure.

Peak demand - Maximum rate of Demand. Express as a multiple of average demand.

Precipitation - Separation of dissolved constituent by chemical reaction into solids and settlings.

Plate count - Count of colonies of microorganisms in a culture plate.

Pressure filter - Sand filter in which filtration is carried and under high pressure.

P.C.C - Pre-Stressed cement concrete. .

PVC - Poly Vimye Chloride

Porosity: ratio of volume of voids to total volume

Priming - Filling of section pipe and casing of pump completely water.

Plumbing - Laying and joining of pipes in a building for fixtures.

Over flow rate - Quantity of water applied in cute meters per square meter area of sedimentation tank or filter per day or per hour.

Run off - Rain water flowing on the surface of land.

Residual chlorine - Amount chlorine per liter left after killing of bacteria.

Raw, water - Quality of water before treatment.

Rapid sand filter - Sand filter whose rate of filtration under gravity is faster.

Recarboration - Application of carbon-dioxide to reduce the

Reflux valve - Also called non-return valve -valve that allows flour of water in one direction only towards higher elevation.

Sanitation - Clean liners of inside and surroundings of homes.

Saline water - Water containing excess of dissolved salts.

Suspended matter - Particles of impurities that have not settled.

Shallow well - Well that doesn't cut through impervious layer.

Steining - Brick or stone masonry or concrete wall on the inside of well to retain earth.

Strainer - Fitted in suction pipe-perforated pipe or wire mesh to exclude for soil particles from entering the suction pipe.

Sanitary block - Unit in a building, housing toilets, urinals, baths etc.

Sewer - pipe carrying domestic wastewater from toilets, kitchen etc.

Sterilizations - Destruction of all organisms in water.

Service reservoir - Storage of water after treatment per supply.

Sedimentation - Setting of suspended matter by gravitational force only.

Softening - Process of removal of hardness in water.

Short-circuiting - Part of liquid travelling faster towards outlet than the rest.

Sludge-Is the semisolids of organic & inorganic matter settled at the bottom of the settling tanks.

Slow sand filter - Sand filter whose rate of filtration is slow and their filters do not have providing for back washing.

Service pipe - Part of house connection for the street main that is under the control of the owner of the premises.

Specific yield: the amount of aquifer water expressed as a percentage that is free to drain under the influence of gravity. By definition it is less than the porosity since some water is not free to drain due to attractive and bonding forces such as surface tension.

Storage coefficient (S): volume of water that an aquifer releases from or takes into storage per unit surface area per unit change in piezometric head. For confined aquifers S = 0.00005-0.001 and for unconfined aquifers S = 0.01-0.35.

Transmissivity*:* measure of how easily water in a confined aquifer can flow through the porous media.

Turbidity - Degree of obstruction to passage of light.

Treatment - Process of removing impurities in water.

Terminal velocity - Constant velocity of decent of particles in water.

Under drainage- System of pipes per collective filtered water at the bottom of sand bed of filter.

Uniformity coefficient - A ratio indicative of degree of variation of size of grains of sand.

Weir - A low dam across a river or stream over which water flows

Wholesome water - Water that is not inqurious to health

Water carriage system - System of river pipes to remove domestic waste water.

Zeolite - Silicates of aluminum and sodium compounds, which exchange calcium and magnesium ions per sodium ions.

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ENGINEERING IMPORTANT TERMS TWO

Energy- There are two types of energy -- stored (potential) energy and working (kinetic) energy. These sources are divided into two groups -- renewable and nonrenewable. Renewable and nonrenewable energy sources can be used to produce secondary energy sources including electricity and hydrogen.

Renewable energy an energy source that can be replenished in a short period of time. sources include solar energy from sun, Wind, geothermal energy from inside the earth, biomass from plants, and hydropower and ocean energy from water are also renewable energy sources.

Non-renewable energy an energy source that we are using up and cannot recreate in a short period of time energy sources, which include the fossil fuels -- oil, natural gas, and coal.

There are two main sources of energy.

i) **Conventional sources of energy**:-The energy resources which were used during 1950 -1975 are called conventional energy resources and are classified as coal, oil, natural gas and nuclear fuel. These resources are accumulated in nature and cannot be easily replenished once exhausted.

ii) **Non conventional sources of energy**:-The energy consumption of the world has been increasing with industrial growth. Eg. Hydropower, Tidal, Wind, Solar, Biomass, Geothermal These resources are accumulated in nature and can be easily replenished. To overcome the shortage and ecological problem we need to take over the alternative energy resources for use, known as non conventional energy.

Hydroelectricity is one of the most mature forms of renewable energy, providing more than 19% of the world's electricity consumption from both large and small power plants.

A dam is built to trap water, usually in a valley where there is an existing lake. Water is allowed to flow through tunnels in the dam, to turn turbines and thus drive generators.

Small hydropower is a local energy resource, which can be usefully harnessed for rural energy demands from rivers, where there is a gradient of a few meters and the flow rate is more than a few liters per second. Local definitions can range in size from a few kilowatts to 50 megawatts or more.

Projects in the 100 kW to 1 MW range sometimes referred to as "mini" hydro, projects less than 100 kW referred to as "micro" hydro and projects less than 5 kW are named as Pico hydro.

Components of small hydro can broadly be classified into two

1.**Civil work**: Intake, Canal, Silting basin, Forebay, Support and anchor blocks, Power house

2.**Electro-Mechanical equipment**: Trash rack, Penstock and gates, Turbine, Generator, Load controller

The *main civil works of a small hydro* development are: *1. The diversion dam or weir, 2. The water passages and, 3. The powerhouse*

The diversion dam or weir directs the water into a canal, tunnel, penstock or turbine inlet.

The water then passes through the turbine, spinning it with enough force to create electricity in a generator. The water then flows back into the river via a tailrace

The powerhouse contains the turbine or turbines and most of the mechanical and electrical equipment

Power output depends on the *available water (flow)* and *head (drop in elevation*). The amount of energy that can be generated depends on the quantity of water available and the variability of flow throughout the year.

Types of small hydro developments: 1. Run-of-river developments 2. Water storage (reservoir) developments

Storage at a small hydro plant, if any, is generally limited to small volumes of water in a new head pond or existing lake upstream of an existing dam.

Pondage is the term used to describe small volumes of water storage.

Pumped storage- water is "recycled" between downstream and upstream storage reservoirs. Water is passed through turbines to generate power during peak periods and pumped back to the upper reservoir during off-peak periods.

Objective of a hydropower Scheme- To convert the potential energy of a mass of water, flowing in a stream with a certain fall (termed the .head.), into electric energy at the lower end of the scheme, where the powerhouse is located.

Classification of small scale hydropower scheme classification ***based on head***

High head: 100m and above, Medium head: 30 - 100 m, Low head: 2 - 30 m

Other classifications: Run-of-river schemes, Schemes with the powerhouse located at the base of a dam & Schemes integrated on irrigation canal or in a water supply pipe.

The flow duration curve (FDC) is a graphical tool which gives an idea about the temporal variability of water flow in a very simplistic manner.

Available gross head at a power development site is the fall from the pond or the reservoir level at the dam to the water level in the river at the tail race.

The net available head is calculated as the difference between the gross head and the sum of all losses between the pond and the turbine runner.

Firm power also called *primary power*, is the power which always ensured to a consumer at any hour of the day and is thus completely dependable power. Such a power corresponds to the minimum stream flow and is available all times. Firm power can be increased by use of pondage (storage).

Secondary power is the power which is produced above the minimum steam flow of the river. Storage is required to get secondary power.

Load factor is the ratio of average load to the peak load and is expressed as daily, weakly, monthly or yearly value. The area under a load curve is the total energy (KWh) production during the period and it can be plotted to obtain energy consumption curve. Maximum load determines plant capacity.

Capacity factor is also called *plant use factor or plant factor*. The net capacity factor of a power plant is the ratio of the actual output of a power plant over a period of time and its output if it had operated at full nameplate capacity the entire time.

Dams and weirs are primarily intended to divert the river flow into the water conveyance system leading to the powerhouse. Dams also produce additional head and provide storage capacity. The choice of dam type depends largely on local topographical and geotechnical conditions.

Embankment Dams

Homogeneous dams: These dams are used for low embankments (<4m) and often as secondary dams. For dam safety reasons, some type of drainage is almost always provided.

Zoned embankment dams: These are used for dam heights from 4m and up. Constructions are extremely sensitive to the engineering design and construction, and it is therefore vital to engage highly skilled consultants and contractors require experienced site-supervision engineers. Critical components of these dams are the core, the transition zones (filters) surrounding the core and drainage capacity of the dam toe.

Embankments dams with membrane: The membranes can be of different types and be located either at the upstream front of the embankment or vertically in the center of the embankment. Membranes can be made from concrete, asphalt or in the form of a geo membrane on the upstream slope.

Concrete dams are categorized according to how they function statically, and fall into one of the following groups.

Gravity dams: These are dependent on their own mass for stability. Their cross-section is basically triangular in order to provide adequate stability and stress distribution across the foundation plane. The upper part is normally rectangular in order to provide adequate crest width for installation and transportation.

Design issues include stability analysis (sliding and overturning), stress control, temperature control during construction to avoid cracking, control of uplift pressures under the dam, etc.

Buttress dams: These dams consist of a continuous upstream face that is supported by buttresses at regular intervals. The upstream face is normally divided into vertical sections by dilatation joints, each section being supported by a buttress. Cross-sections are similar to those of gravitation dams. In colder climates, the upstream face can be susceptible to freezing of the water contained in the concrete, damaging the concrete. For this reason buttress dams in such locations are often covered along the downstream contour of the buttresses in order to provide climate control.

Arch and Cupola dams

These dams function structurally as horizontally laid out arches that transfer the water pressure on the upstream face into the abutments rather than into the foundation. Arch dams can be designed with a constant radius over the dam height, or with varying radii (Cupola dams). Arch dams with a constant radius have a vertical and "straight" cross-section. These dams will be subject to considerable vertical strain forces since the deformation of the dam will tend to be greatest in the vertical center of the dam.

The **Cupola dam** is designed to have only compression forces for all directions and at all sections. This requires the radius of the curvature to vary over the dam height, which produces a curved vertical cross-section.

Spillways. Able to safely accommodate high floods that can exceed normal flow conditions in the river by orders of magnitude. For this reason carefully designed overflow passages are incorporated in dams or weirs as part of the structure. Often divided into ungated and gated spillways,

Weir. The large majority of small hydro schemes are of the run-of-river type, where electricity is generated from discharges larger than the minimum required to operate the turbine. In these

schemes a low diversion structure is built on the streambed to divert the required flow whilst the rest of the water continues to flow over it. Weirs role is not to store the water but to increase the level of the water surface so the flow can enter into the intake.

Fixed storage structures, such as weirs and ungated spillways have the advantage of security, simplicity, easy maintenance, and are cost effective.

Mobile storage structures such as gated spillways can regulate the water level such that it stays more or less constant for most incoming flow conditions.

Water intake structure must be able to divert the required amount of water into the power canal or into the penstock without producing a negative impact on the local environment and with the minimum possible head loss.

The power intake is a variant of the conventional intake, usually located at the end of a power canal, although sometimes it can replace it. Because it has to supply water to a pressure conduit, the penstock- its hydraulic requirements are more stringent that those of a conveyance intake.

Penstock- Conveying water from the intake to the powerhouse.

Powerhouse is to protect the electromechanical equipment that convert the potential energy of water into electricity, from the weather hardships. The number, type and power of the turbo-generators, their configuration, the scheme head and the geomorphology of the site determine the shape and size of the building. Which includes *Inlet gate or valve, Turbine, speed increaser, control system, condenser switch gear, generator, protection system, DC emergency supply and power and current transformer.*

Hydraulic turbine is to transform the water potential energy to mechanical rotational energy. It is appropriate to provide a few criteria to guide the choice of the right turbine for a particular application and even to provide appropriate formulae to determine its main dimensions.

The water pressure can apply a force on the face of the runner blades, which decreases as it proceeds through the turbine, called reaction turbines. The turbine casing, with the runner fully immersed in water, must be strong enough to withstand the operating pressure. Ex. Francis and **Kaplan turbines**.

The water pressure is converted into kinetic energy before entering the runner. The kinetic energy is in the form of a high-speed jet that strikes the buckets, mounted on the periphery of the runner, called impulse turbines. Ex. Pelton and Turgo turbine. They’re only used for high heads from 60 m to more than 1000m.

Turgo turbine can operate under a head in the range of 50-250 m. Like the Pelton, it is an impulse turbine, however its buckets are shaped differently and the jet of water strikes the plane of its runner at an angle of 20º

Cross-flow turbines

This impulse turbine, also known as *Banki-Michell* is used for a wide range of heads overlapping those of Kaplan, Francis and Pelton. It can operate with heads between 5 and 200 m.

It have low efficiency compared to other turbines and the important loss of head due to the clearance between the runner and the downstream level should be taken into consideration when dealing with low and medium heads.

Francis turbines are reaction turbines, with fixed runner blades and adjustable guide vanes, used for medium heads. In this turbine the admission is always radial but the outlet is axial. Their usual field of application is from 25 to 350 m head.

Kaplan and propeller turbines are axial-flow reaction turbines; generally used for low heads from 2 to 40 m. The Kaplan turbine has adjustable runner blades and may or may not have adjustable guide- vanes. Fixed runner blade Kaplan turbines are called propeller turbines. They are used when both flow and head remain practically constant, which is a characteristic that makes them unusual in small hydropower schemes.

The type, geometry and dimensions of the turbine will be fundamentally conditioned by the following criteria:

• *Net head* • *Range of discharges through the turbine*

• *Rotational speed* • *Cavitations problems* • *Cost*

Net head

The **gross head** is well defined, as the vertical distance between the upstream water surface level at the intake and the downstream water level for reaction turbines or the nozzle axis level for impulse turbines.

Discharge- A single value of the flow has no significance. It is necessary to know the flow regime, commonly represented by the Flow Duration Curve (FDC).

Cavitation- When the hydrodynamic pressure in a liquid flow falls below the vapor pressure of the liquid, there is a formation of the vapor phase. This phenomenon induces the formation of small individual bubbles that are carried out of the low-pressure region by the flow and collapse in regions of higher pressure.

River engineering is the process of planned human intervention in the course, characteristics or flow of a river with the intention of producing some defined benefit.

Rivers can be classified based on different criteria, e.g., discharge, platform, location, catchment area, sediment discharge etc.

a) Based on variation of discharge in river,

i. **Perennial rivers:** Rivers which Carry significant flow throughout the year

ii. **Non-perennial rivers:** Seasonal rivers which get their flow in the rainy season

iii. **Flashy rivers:** rivers in which their stage rises and falls in a very short period of a day or two due to the steep flood hydrograph. A small flow may, however, continue for some time.

iv. **Virgin rivers:** Rivers which become completely dry much before they join another river or sea due to evaporation and percolation

b) Based on stability of river,

i. **Stable rivers:** River slope, and river regime are relatively stable and show little variation from year to year except that the river may migrate within its permanent banks.

ii. **Aggrading Rivers:** When the sediment load entering a river reach is greater than the sediment load leaving a river reach, the river in that reach becomes an aggrading river due to deposition of excess sediment.

iii. **Degrading Rivers:** When the sediment load entering a river reach is less than that leaving the river reach, the river in that reach becomes a degrading river due to erosion of the bed and bank material.

Based on the location of reach of river

i. Mountainous Rivers: Rivers in mountainous reaches are further divided into ***incised rivers*** and ***boulder Rivers***. Incised rivers have a steep bed slope and high velocity of flow. The bed and the banks of these rivers are made up of rocks and very large boulders which are, usually, highly resistant to erosion. The sediment transported by an incised river is often different from that of the river bed and comes from the catchment due to soil erosion.

ii. Rivers in Flood Plains: After the boulder stage, a river enters the alluvial plains. The bed and banks are now made up of sand and silt. The bed slope and the velocity of flow in the river are much smaller than those of Boulder Rivers. The cross-section of the river is decided by the sediment load and the erodibility of the bed and banks of the river. The sediment transported by such rivers is predominantly of the same type as the material forming the channel bed. During

high floods, these rivers inundate very large areas and cause considerable damage to life, property, and crops. Such rivers are also called *alluvial rivers.*

iii. Tidal Rivers: All rivers ultimately meet the sea. In the reach of a river just upstream of the sea, there would occur periodic changes in water levels due to tides. This reach of the river is called tidal river and receives sea water during flood tides and raises its level. During ebb tides, the river water level is lowered. The length of the river reach affected by tidal effects depends on the river slope, the tidal range, discharge, river configuration etc.

iv. Delta Rivers: A river, before becoming a tidal river, may split into number of branches due to very flat bed slopes resulting in shoal formation and braiding of the channel. This part of the river reach is called *Delta River*. The delta river indicates a stage, rather than a type of river.

Based on the plan-form of river

i. Straight Rivers: In the straight reaches of a river, its section has the shape of a trough and maximum velocity of flow occurs in the middle of the section. It is very difficult to find the straight reach of an alluvial river over large lengths. Alluvial rivers seldom run straight through a distance greater than ten times the river width (1). Even in the apparent straight reaches, the line of maximum depth - commonly known as ***Thalweg*** – moves back and forth from one permanent bank to another.

ii. Meandering Rivers: On account of the slight asymmetry of flow in alluvial rivers, there is a tendency for such rivers to vary their plan-forms into bends which eventually result in a meandering pattern. Rivers having such meandering patterns are known as meandering rivers which, in plan, comprise a series of bends of alternate curvature. The successive curves are connected through straight reaches of the river called 'crossing'. Meandering increases the length of river and decreases its slope.

Causes of meandering: The latest and widely accepted theory behind meandering is based upon the e*xtra turbulence generated by the excess of river sediment during floods*.

There are four variables, which govern the meandering process. They are:

(i) Valley slope, (ii) Silt grade and silt charge,

(iii) Discharge, (iv) Bed and side materials and their susceptibility to erosion.

Meander parameters **Meander Length (ML).** It is the axial length of one meander, i.e. the tangential distance between the corresponding points of a meander.

Meander Belt (MB). It is the distance between the outer edges of clockwise and anti-clockwise loops of the meander.

Meander Ratio. It is the ratio of meander belt to meander length, i.e. MB/ML

Tortuosity. It is the ratio of the length along the channel to the direct axial length of the river reach.

Crossings or Cross-overs. The short straight reaches of the river, connecting two consecutive clockwise and anti-clockwise loops, are called ***crossings or cross-overs***.

Braided River: When a river flows in two or more channels around alluvial islands, it is called a braided river. The braided patterns in a river develop after local deposition of coarser material which cannot be transported under prevailing conditions of flow and which subsequently grows into an island consisting of coarse as well as fine material.

Braided channels occurs in rivers with high slope when, ***threshold level*** of ***sediment load*** *or* ***slope is reached***, any slope over this ***threshold creates a braided stream***. This occurs due to ***rapid evaporation & infiltration*** after period of heavy rainfall, it can lead to deposition of sediment load. ***Braiding is caused by fluctuations in discharge levels, low river velocity and also by the stream or river losing. Furthermore,*** braided streams occur in areas where the transported load contains a high amount of coarse material such as sands and stones

There are 3 major processes that are taking place in a river. These are:

- **Erosion:** wearing away of material. Involves four major processes.
- **Abrasion:** is the grinding of rock fragments carried by the river against the bed and banks of the river. This action causes the channel to widen and deepen. This grinding is most powerful in flood time when large fragments of rock are carried along in the river bed.
- **Attrition:** Attrition is the collision of rock fragments in the water against one another. The rock particles are broken into smaller pieces and become smoother the longer the process continues.
- **Solution:** Solution (corrosion) is the process by which river water reacts chemically with soluble minerals in the rocks and dissolves them.
- **Hydraulic action:** The sheer force of the water as the turbulent current hits banks and pushes water into cracks. The air in cracks compressed, pressure increased and in time bank will collapse. When water from a fast moving stream enters minute cracks in a rock, the pressure exerted weakens and eventually breaks up the rock.

Transportation: movement of the eroded material. There four major transportation processes. These are:

 Saltation: when pebbles, sand and gravel (bed load) are lifted up by current and bounced along the bed in a hopping motion.

 Traction: Is where **boulders** or **stones** are rolled along the stream bed by the force of the water.

Suspension: Fine particles such as clay, silt and fine sand are carried along in the river.

 Solution: Dissolved materials containing minerals like calcium and sodium are carried in the water and are invisible to the naked eye.

Deposition: when velocity begins to fall, it has less energy and no longer had competence and capacity to carry all its load so largest particles, materials begins to be deposited. Deposition my occurs when:

 Low discharge during period of low precipitation Less velocity when river enter sea or lake.

 Shallow water occurs on inside of a meander. The load suddenly increase (debris from landslide)

 River overflow its bank so velocity outside channel is reduced. (resulting in floodplain)

Sediment transport for ***cohesive*** and ***non-cohesive*** materials are different. Most non-cohesive sediment transport formulas were developed for sediment transport in ***clear water*** under ***equilibrium conditions***.

The following definitions are commonly used to describe the particle size:

 The nominal diameter refers to the diameter of a sphere of the same volume as the particle usually measured by the displaced volume of a submerged particle,

 The sieve diameter is the minimum length of the square sieve opening through which a particle will fall,

 The fall diameter is the diameter of an equivalent sphere of specific gravity G = 2.65 having the same terminal settling velocity in water at 24◦C.

Sieve analysis- Sieving is considered as semi-direct method of particle size measurement because it does not measure the particle size precisely for at least four reasons:

i. Because of irregularities in shape, particles larger (e.g. cylindrical) than the spherical equivalent diameter may pass through the sieve openings; ii. Inaccuracies in size and shape of

the sieve openings; iii. the sieving operation is for a finite duration and therefore some particles may not have an opportunity to pass a given sieve opening; and

iv. Small particles may cling to large ones, thereby changing the percentage of material reaching the sieves with smaller openings.

Porosity is a measure of the volume of void to per total volume.

Stable channel is an unlined earth channel : (a) which carries water, (b) the banks and bed of which are not scoured objectionably by moving water, and (c) in which objectionable deposits of sediment do not occur''.

Irrigation canals can be divided into three categories that can be described as follows:

 Canals with a rigid boundary: Canals with an erodible boundary and carrying clean water:

 Canals with an erodible boundary and carrying water with sediment

The design of stable canals:

i. The regime method; ii. The tractive force method;

iii. The permissible velocity method; iv. The rational method.

Bed Load Samples are usually collected at, or slightly below, the bed surface to determine the particle size distribution and density of sediment particles available for transport.

Samplers for obtaining bed material are generally one of the following types:

 Drag bucket or scoop; Grab bucket or clamshell Vertical pipe or core; Piston core; and Rotating bucket.

Water sampler used to measure wash load concentrations is a heavy device in which a bottle, closed by a rubber stopper, can be placed. The sampler is suspended by a line, then lowered to the required depth, and the rubber stopper pulled off by means of the thin line fixed to it.

River training, in its wider aspects, covers all those engineering works which are constructed on a river, so as to guide and confine the flow to the river channel, and to control and regulate the river bed configuration, thus ensuring safe and effective disposal of floods and sediment loads. Stabilizing and training the river along a certain alignment with a suitable waterway is, therefore, the first and foremost aim of river training.

River training measures aim at achieving one or more of the following objectives:

(*i) Flood Protection (ii) Navigation (iii) Sediment Control (Mean water training or Training for sediment) (iv) Guiding the Flow*

Depending upon the purpose for which a ***river training programme is undertaken***, the river training works may be classified into the following *three* categories:

 High water training or Training for discharge. *Low water training or Training for depth.*

 Mean water training or Training for sediment.

Levees (also known as an embankment, bund, marginal bunds or dike) is an embankment running parallel (or nearly so) to the river and is constructed to protect the area on either side of it from flooding.

Spurs (also known as groynes, spur dikes, or transverse dikes) are structures constructed in a river transverse to the river flow, extending from the bank into the river. Spurs guide the river flow, promote scour and deposition of the sediment where desired, and trap the sediment load to build up new river banks.

Guide Banks while selecting a site for bridge on an alluvial river, certain site requirements are always kept in mind. These requirements include *straight reach* of the river and *small width of the river* at the bridge site. The crossing reach between two successive bends of a meandering site is suitable from these considerations. Earthen embankments are provided on one or both sides of the river at the bridge site. These embankments are known as ***guide banks (or guide bunds).***

Launching Apron heavy scour of the river bed at the curved heads and shanks of guide banks can cause undermining of the stone pitching thereby resulting in failure of the guide banks. Such failure of guide banks can be prevented by providing launching aprons (consisting of stones) beyond the toe of the guide banks

Bank protection measures provide a shield against erosion of bank material and maintain the alignment of banks. These can be of either direct or indirect type. Indirect bank protection measures, such as spurs are not constructed directly on the bank. But, direct bank protection measures, such as revetment, riprap, etc. are constructed on the bank itself.

Gabions: Gabions are patented rectangular wire boxes (or baskets) filled with relatively small-size stone, usually less than 8 in. in diameter. Where flow velocities are such that small stone would not be stable if used in a riprap blanket, the wire boxes provide an effective restraint.

A culvert is a conduit which conveys stream flow through a roadway embankment. Most culverts are constructed of concrete, corrugated aluminum, corrugated steel, and sometimes

corrugated plastics. Culvert shapes vary from circular to rectangular, and elliptical, pipe arch, arch and metal box sections are commonly used.

Two basic types of flow control are recognized depending on the location of the control section: *Inlet control or outlet control*. The characterization of pressure, as well as subcritical and supercritical flow regimes play an important role in determining the location of the control section.

Inlet control occurs when the culvert barrel is capable of carrying more flow than the inlet will accept. Critical flow depth is located at the inlet and the flow is supercritical in the barrel.

Outlet control flow occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept. Under outlet control conditions, either subcritical or pressure flow exists in the culvert barrel.

Bridge Scour is lowering of the river bed by water erosion such that there is a tendency to expose the foundation of a bride. The amount of this reduction below an assumed natural level (generally the level of the river bed prior to the commencement of scour is termed as depth of scour.

The types of scour that can occur at bridge crossings are typically refereed as:

a) General scour **b)** Contraction scour and **c)** Local scour. **d)** Total scour

Vortex reduction - Streamlining the piers can reduce scour depth by ***l0 to 20 percent***. Another method of reducing the vortex strength at the pier is to construct barriers upstream of bridge piers, for instance, with a cluster of piles. While the piles are subjected to scour, failure of these piles is not damaging to the bridge.

Bed protection - Riprap piled up around the base of the pier is a common method of local scour protection. The region of the bed beyond the riprap pile scours and as the scour hole is formed, the riprap slides down into the scour hole, eventually armoring the side of the scour hole adjacent to the pier.

ENGINEERING IMPORTANT TERMS THREE

Water is available in various forms such as rivers, lake, streams. Water is the most abundant compound in nature. It covers 75% of the earth surface. About 97.3% of is contained in the great oceans that are saline &2.14% is held in icecaps glaciers in the poles, which are also not useful.

Protected water supply means the supply of water that is treated to remove the impurities and made safe to public health. Water may be polluted by physical and bacterial agents

While designing the water supply scheme for a town or city, it is necessary to determine the total quantity of a water required for various purposes by the city.

Following are the various types of water demands of a city or town:

i. Domestic water demand ii. Industrial demand iii. Institution and commercial demand

iv. Demand for public use v. Five demand vi. Loses and wastes

PER CAPITA DEMAND- If 'Q' is the total quantity of water required by various purposes by a town per year and 'p' is population of town, then per capita demand will be

Per capita demand = Q/ P x 365 litres/day

Per capita demand of the town depends on various factors like standard of living, no. and type of commercial places in a town etc.

The following are the main factors affecting for capita demand of the city or town. *a) Climatic conditions b) Size of community c) Living standard of the people d) Industrial and commercial activities e) Pressure in the distribution system f) System of sanitation* g) *Cost of water*

VARIATIONS IN DEMAND. The per capita demand of town is the average consumption of water for a year. In practice it has been seen that this demand does not remain uniform throughout the year but it various from season to season, even hour to hour.

SEASONAL VARIATIONS. The water demand varies from season to season. In summer the water demand is maximum, because the people will use more water in bathing, cooling, lawn watering and street sprinkling. This demand will becomes minimum in winter because less water will be used in bathing and there will be no lawn watering. The variations may be up to 15% of the average demand of the year.

DAILY VARIATIONS. This variation depends on the general habits of people, climatic conditions and character of city as industrial, commercial or residential. More water demand will be on Sundays and holidays due to more comfortable bathing, washing etc as compared to other

working days. The maximum daily consumption is usually taken as 180% of the average consumption.

HOURLY VARIATIONS- On Sundays & other holidays the peak hours may be about 8 A.M. due to late awakening where as it may be 6 A.M. to 10 A.M. and 4 P.M. to 8 P.M. and minimum flow may be between 12P.M. to 4P.M. when most of the people are sleeping. But in highly industrial city where both day & night shifts are working, the consumption in night may be more.

DESIGN PERIOD- The complete water supply project includes huge and costly constructions such as dams, reservoirs, treatment works and network of distribution pipelines.

Design period of *a) Distribution system – 30 years b) Treatment units , pumps, service reservoirs – 15 years c) Impounding reservoir and dam – 50 years*

The following are the standard methods by which the forecasting population is done.

i. Arithmetical increase method Pn = P+ n x c, where P- population at present n -No. of decades c- Constant determined by the average of increase of 'n' decades

ii. Geometrical increase method Pn = P(1 + r)n. Pn = P(1+IG/100)

where P- population at present C → average percentage of growth of 'n' decades

iii. Incremental increase method Pn = P + n . c + n (n+1).b / 2.

iv. Simple graph method v. Decrease rate of growth method

vi. Comparative graph method vii. The master plan method

Absolutely pure water is never found in nature and contains number of impurities in varying amounts. The rainwater which is originally pure, also absorbs various gases, dust and other impurities while falling. This water when moves on the ground further carries salt, organic and inorganic impurities.

CHARACTERISTICS OF WATER- For the purpose of classification, the impurities present in water may be divided into the following three categories.

PHYSICAL CHARACTERISTICS- The following are the physical characteristics

1. Turbidity 2. Color and temperature 3. Taste and odor

TURBIDITY is caused due to presence of suspended and colloidal matter in the water. The character and amount of turbidity depends upon the type of soil over which the water has moved ground waters are less turbid than the surface water.

Turbidity is a measure of resistance of water to the passage of light through it.

Turbidity is expressed as NTU (**Nephelometric Turbidity Units)** or PPM (parts per million) or Milligrams per liter (mg/l). Turbidity is measured by *1) Turbidity rod or Tape 2) Jacksons Turbidimeter 3) Bali's Turbidimeter*

Color in water is usually due to organic matter in colloidal condition but sometimes it is also due to mineral and dissolved organic impurities. The color produced by one milligram of platinum in a liter of water has been fixed as Temperature of water is measured by means of ordinary thermometers. The temperature of surface water is generally at atmospheric temperature, while that of ground water may be more or less than atmospheric temperature.

CHEMICAL CHARACTERISTICS- In the chemical analysis of water, these tests are done that will reveal the sanitary quality of the water. Chemical tests involve the determination of total solids, PH value, Hardness of water, Chloride content etc.

Total solids includes the solids in *suspension colloidal & in dissolved* form. The quantity of suspended solids is determined by filtering the sample of water through fine filter, drying & weighing.

PH VALUE OF WATER- PH value denotes the concentration of hydrogen ions in the water and it is a measure of acidity or alkanity of a substance.

$$PH = - \log 10[H+] \text{ or } 1 / \log 10[H+]$$

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Acidity ← Neutral→ Alkalinity

Depending upon the nature of dissolved salts and minerals, the PH value ranges from 0 to 14. For pure water, PH value is 7 and 0 to 7 acidic and 7 to 14 alkaline range. For public water supply PH value may be 6.5 to 8.5. The lower value may cause tubercolation and corrosion, where as high value may produce incrustation, sediment deposits and other bad effects.

PH value of water is generally determined by PH papers or by using PH meter.

PH can read directly on scale or by digital display using PH meter.

HARDNESS OF WATER- It is a property of water, which prevents the lathering of the soap. Hardness is of two types.

1. Temporary hardness: It is caused due to the presence of carbonates and Sulphates of calcium and magnesium. It is removed by boiling.

2. Permanent hardness: It is caused due to the presence of chlorides and nitrates of calcium and magnesium. It is removed by zeolite method.

Hardness is usually expressed in gm/liter or p.p.m. of calcium carbonate in water. Hardness of water is determined by EDTA method. For potable water hardness ranges from 5 to 8 degrees. When s**oftening** is practices when hardness exceed 300mg/lit. Water hardness more than 600 mg/lit have to rejected for drinking purpose.

METHODS OF REMOVAL OF HARDNESS

1. Boiling 2. Freezing 3. Lime addition 4. Lime soda process 5. Excess Lime treatment 6. Caustic soda process 7. Zeolite process 8. Demineralization or exchange process.

Methods 1,2 and 3 are suitable for removal of temporary hardness and 4 to 8 for both temporary and permanent hardness.

Zeolite process- This is also known as the base-exchange or Ion exchange process. The hardness may be completely removed by this process. Zeolites are compounds (silicates of aluminum and sodium) which replace sodium Ions with calcium and magnesium Ions when hard water is passes through a bed of zeolites.

Water treatment includes many operations like Aeration, Flocculation, Sedimentation, Filtration, Softening, Chlorination and demineralization.

SCREENING- Screens are fixed in the intake works or at the entrance of treatment plant so as to remove the floating matters as leaves, dead animals etc.

SEDIMENTATION- It is the process in which the suspended solids are made to settle by gravity under still water conditions is called plain sedimentation.

COAGULATION- When water contains fine clay and colloidal impurities which are electrically charged are continually in motion and never settle down due to gravitational force. Certain chemicals are added to the water so as to remove such impurities which are not removed by plain sedimentation. The chemical form insoluble, gelatinous, flocculent precipitate absorbs and entangle very fine suspended matter and colloidal impurities during its formation and descent through water. These coagulants further have an advantage of removing color, odor and taste from the water.

FILTRATION- The process of passing the water through beds of sand or other granular materials is known as filtration. For removing bacteria, color, taste, odors and producing clear and sparkling water, filters are used by sand filtration 95 to 98% suspended impurities are removed.

THEORY OF FILTRATION

The following are the mechanisms of filtration

1. **Mechanical straining** – Mechanical straining of suspended particles in the sand pores.

2. **Sedimentation** – Absorption of colloidal and dissolved inorganic matter in the surface of sand grains in a thin film

3. **Electrolytic action** – The electrolytic charges on the surface of the sand particles, which opposite to that of charges of the impurities are responsible for binding them to sand particles.

4. **Biological Action** – Biological action due to the development of a film of microorganisms layer on the top of filter media, which absorb organic impurities.

Filtration is carries out in three types of filters

1. Slow sand filter & 2. Rapid sand filter are called Gravity filters *3. Pressure filter*

DISINFECTION OF WATER- The process of killing the infective bacteria from the water and making it safe to the user is called disinfection. The water which comes out from the filter may contain some disease – causing bacteria in addition to the useful bacteria. Before the water is supplied to the public it is utmost necessary to kill all the disease causing bacteria. The chemicals or substances which are used for killing the bacteria are known as disinfectants.

REQUIREMENTS OF GOOD DISINFECTANTS

1. They should destroy all the harmful pathogens and make it safe for use 2. They should not take more time in killing bacteria 3. They should be economical and easily available 4. They should not require high skill for their application 5. After treatment the water should not become toxic and objectionable to the user.

6. The concentration should be determined by simply and quickly.

METHODS OF DISINFECTION by different physical and chemical methods

I. PHYSICAL METHODS

1. BOILING: Boil the water for 15 to 20 minutes and kills the disease causing bacteria.

This process is applicable for individual homes.

2. ULTRA-VIOLET RAYS: Water is allowed to pass about 10cm thickness by ultraviolet rays.

This process is very costly and not used at water works. Suitable for institutions.

3. ULTRASONIC RAYS: Suitable for institutions.

II. CHEMICAL METHODS

1. CHLORINATION: Using chlorine gas or chlorine compounds.

2. BROMINE AND IODINE: It is expensive and leaves taste and odor.

3. POTASSIUM PERMANGANATE: This method is used for disinfection of dug well water, pond water or private source of water.

4. OZONE : Very expensive process, leaves no taste, odor or residual.

5. EXCESS LIME TREATMENT: Needs long detension time for time interval and large lime sludges to be treated.

Chlorination is the addition of chlorine to kill the bacteria Chlorination is very widely adopted in all developing countries for treatment of water for public supply.

Chlorine is available in gas, liquid or solid form (bleaching powder).

Defluoridation is process of removal of excess fluoride present in the water. The excess fluoride in the water causes dental abnormalities, hypertension, peptic ulcer, Skin infections, defective vision, coronary thrombosis etc. The permissible level of fluoride in the water is 1mg/litre.

F**our different systems of water distribution** which are used. They are: *1. Dead End or Tree system 2. Grid Iron system 3. Circular or Ring system 4. Radial system*

DEAD END OR TREE SYSTEM: This system is suitable for irregular developed towns or cities. In this system water flows in one direction only into sub mains and branches. The diameter of pipe decreases at every tree branch.

GRID IRON SYSTEM- From the mains water enters the branches at all Junctions in either directions into sub mains of equal diameters. At any point in the line the pressure is balanced from two directions because of interconnected network of pipes.

CIRCULAR OR RING SYSTEM- Supply to the inner pipes is from the mains around the boundary. It has the same advantages as the grid-Iron system. Smaller diameter pipes are needed.

RADIAL SYSTEM: This is a zoned system. Water is pumped to the distribution reservoirs and from the reservoirs it flows by gravity to the tree system of pipes. The pressure calculations are easy in this system. Layout of roads need to be radial to eliminate loss of head in bends.

This is most economical system also if combined pumping and gravity flow is adopted.

Depending upon the methods of distribution, the distribution system is classified as the follows: *1. Gravity system 2. Pumping system 3. Dual system or combined gravity and pumping system*

GRAVITY SYSTEM: When some ground sufficiently high above the city area is available , this can be best utilized for distribution system in maintaining pressure in water mains . This method is also much suitable when the source of supply such as lake, river or impounding reservoir is at sufficiently higher than city.

PUMPING SYSTEM: Constant pressure can be maintained in the system by direct pumping into mains. Rate of flow cannot be varied easily according to demand unless number of pumps are operated in addition to stand by ones. Supply can be effected during power failure & breakdown of pumps. Hence diesel pumps also in addition to electrical pumps as stand by to be maintained. During fires, the water can be pumped in required quantity by the stand by units.

COMBINED PUMPING AND GRAVITY SYSTEM: This is also known as dual system. The pump is connected to the mains as well as elevated reservoir. In the beginning when demand is small the water is stored in the elevated reservoir, but when demand increases the rate of pumping , the flow in the distribution system comes from the both the pumping station as well as elevated reservoir. As in this system water comes from two sources one from reservoir and second from pumping station, it is called dual system. This system is more reliable and economical, because it requires uniform rate of pumping but meets low as well as maximum demand. The water stored in the elevated reservoir meets the requirements of demand during breakdown of pumps and for fire fighting.

The water may be supplied to the consumers by either of the two systems.

1. CONTINUOUS SYSTEM- This is the best system and water is supplied for all 24 hours. This system is possible when there is adequate quantity of water for supply. In this system sample of water is always available for fire fighting and due to continuous circulation water always remains fresh. In this system less diameter of pipes are required and rusting of pipes will be less. Losses will be more if there are leakages in the system.

2. INTERMITTENT SYSTEM- If plenty of water is not available, the supply of water is divided into zones and each zone is supplied with water for fixed hours in a day or on alternate days. As the water is supplied after intervals, it is called intermittent system.

PUMPS- The function of pump is to left the water or any fluid to higher elevation or at higher pressure. Pumps are driven by electricity, diesel or steam power. They are helpful in pumping water from the sources, that is from intake to the treatment plant and from treatment plant to the distribution system or service reservoir.

Type of Pump: Displacement pumps- This type of pumps are suitable for moderate heads and small discharges suitable for fire protection, water supply of individual houses. Ex. Reciprocating pumps. Rotary, chain, gear wheel, pump and wind mills.

Velocity pumps- This type of pumps are used widely in water supply schemes containing sand, silt etc. Ex. Centrifugal pumps, deep well, turbine pumps, jet pumps

Buoyancy pumps- Airlifting pumps are generally adopted for pumping of water from deep wells to a lift of about 60m containing mud, silt, debris etc. Ex. Airlifting pumps

Impulse pumps- Used for Small water supply projects to left the water for a height of about 30m or so. Ex. Hydraulic Ram

There are various types of pumps, but the two types generally encounter, are:

1. Rota-dynamic pumps; and 2. Displacement pumps.

A **Rota-dynamic pump** has a wheel or a rotating element which rotates the water in a casing, and thus, imparting energy to the water. Such a pump may be of the following two types:

A) Centrifugal pump; and B) Axial-flow pump.

COMPONENT PARTS OF CENTRIFUGAL PUMP

Centrifugal force is made use of in lifting water . Electrical energy is converted to potential or pressure energy of water.

1. CASING: The impellor is enclosed in the casing, which is so designed that kinetic energy of the liquid is converted into pressure energy before it leaves the casing. *2. Delivery pipe 3. Delivery valve 4. Impeller 5. Prime mover 6. Suction pipe* ***7.*** *Strainer and foot valve*

Pipes convey raw water from the source to the treatment plants in the distribution system. Water is under pressure always and hence the pipe material and the fixture should withstand stresses due to the internal pressure, vacuum pressure, when the pipes are empty, water hammer when the values are closed and temperature stresses.

The following are the different types of pipes

1. Cast Iron 2. Steel 3. Prestressed concrete 4. R.C.C 5. A.C. Pipes

6. Galvanized Iron (G.I) 7. P.V.C and plastic pipes

Pipelines carrying water are laid 0.6m to 1m below the ground surface. Just before covering the trench with the earth, the pipe joints are to be tested for leakage. Joints are inspected visually during the test and relied wherever required.

PIPE CORROSION – CAUSES AND PREVENTION

The term pipe corrosion is used to indicate the loss of pipe material due to action of water (Internal pipe corrosion) and action of water logged soil above the pipe surface (external pipe

corrosion) by the results of corrosion, troublesome to both the water authority and consumers. The various factors contributing to the pipe corrosion are

1. **ACIDITY:** The water having low PH value due to the presence of carbonic acid or other acids may cause corrosion
2. **ALKANITY:** The water possessing sufficient calcium bicarbonate alkanilinity is anti-corrosive in nature
3. **BIOLOGICAL ACTION:** The growth of iron-bacteria, and Sulphur bacteria may develop aerobic and anaerobic corrosion respectively.
4. **CHLORINATION:** The presence of free chlorine or chloramines makes the water corrosive
5. **ELECTRICAL CURRENTS:** Corrosion canals also be developed by the union of dissimilar metals or by the earthing of electrical system to water pipes.
6. **MINERAL AND ORGANIC CONSTITUENTS:** The presence of high total solids in water accelerates the process of corrosion.
7. **OXYGEN:** the presence of oxygen is found in both the corrosive and non-corrosive waters. The aeration in fact is employed in some cases for prevention of corrosion.

EFFECTS OF PIPE CORROSION

1. Pipe corrosion may lead to the tuberculation (formation of small projections on the inside surface of pipe) which decreases carrying capacity of water
2. The pipe corrosion leads to the disintegration of pipeline and it demands heavy repairs
3. The pipe corrosion imparts color, taste and odor to the flowing water
4. The pipe connections are seriously affected by pipe corrosion
5. The pipe corrosion may make the water dangerous for drinking and other purposes.

PREVENTION OF PIPE CORROSION- Pipe corrosion is not possible to completely eliminate but we can minimize by the following methods.

1. **Cathodic protection:** By connecting the pipe line to the negative pole of D.C. generator or to the anode metals like magnesium so that the entire pipe acts as cathode. This cathodic treatment is most effective. It is expensive and involves many practical problems
2. **Proper pipe material:** The alloys of Iron or steel with chromium, copper or nickel are found to be more resistance
3. **Protective Linings:** The pipe surface should be coated with asphalt, bitumen, cement mortar, paints, resins, tar, zinc etc.

4. **Treatment of water:** By proper treatment and adjustment of PH value, control of calcium carbonate, removal dissolved oxygen and carbon dioxide, addition of sodium silicate etc. prevent the pipe corrosion.

The various devices fixed along the water distribution system are known as ***appurtenances***.

They're used a) To control the rate of flow b) To release or admit air into pipe line

c) To draw water for fire fighting d) Ultimately to improve efficiency of the distribution system

The following are the some of the fixtures used in the water distribution system.

(i) Valves (ii) Fire hydrants and (iii)Water meter

TYPES OF VALVES- In water works practice, to control the flow of water, to regulate pressure, to release or to admit air, prevent flow of water in opposite direction valves are required. The following are the various types of valves named to suit their function

1. Sluice valves 2. Check valves or reflex valves 3. Air valves= 1. Air inlet valves & 2. Air relief valves 4. Drain valves or Blow off valves= wash out valves 5. Scour valve

Sluice valves or gate valve is used to control the flow of water.

Check or reflex valve is used to allow water to flow in one direction only

Air inlet valves-opens automatically & allow air to enter into the pipeline to avoid -ve pressures

Air-relief valve – are fixed at summit of pipeline to remove accumulated air to avoid air lock

Drawn valve or blow off valve or wash out valve provided at all dead ends and depressions of pipeline to drawn out the wash water.

Scour valve is similar to blow off valve is located at the depressions and dead ends to remove the accumulated silt and sand

FIRE HYDRANTS- A hydrant is an outlet provided in water pipe for tapping water mainly in case of fire. They are located at 100 to 150 m a part along the roads and also at junction roads. They are of two types namely.

1. **Flush Hydrants**. is kept in under ground chamber flush with footpath covered by C.I. cover carrying a sign board "F-H".

2. **Post Hydrants**- The post hydrant remain projected 60 to 90cm above ground level.

They have long stem with screw and nut to regulate the flow. In case of fire accident, the fire fighting squad connect their hose to the hydrant and draw the water and spray it on fire.

A good fire hydrant: *1. Should be cheap 2. Easy to connect with hose*

3. Easily detachable and reliable 4. Should draw large quantity of water

WATER METER- These are the devices which are installed on the pipes to measure the quantity of water flowing at a particular point along the pipe. The readings obtained from the meters help in working out the quantity of water supplied and thus the consumers can be charged accordingly. The water meters are usually installed to supply water to industries, hotels, big institutions etc. metering prevents the wastage of purified water.

Terms relating to plumbing, principles and the common practices used in the house plumbing

1. ***Water main:*** A water supply pipe vests in the administrative authority for the use of public or community

2. ***Ferrule***: It is gunmetal or bronze screwed into the hole drilled in CI pipe mains. Communication pipe takes off from the ferrule. The pressure in the domestic supply and equal distribution among the house connection are effected by adjusting the ferrule opening. Normally the ferrule opening is equal in area to the area of flow in communication pipe.

3. ***Saddle***: it is used in place of ferrule for mains of AC or PVC pipes

4. ***Communication pipes***: It is a pipe taking off from the ferrule for the house connection. It is owned and managed by the water supply authority. Communication pipe terminates at the boundary of the consumers premises.

5. ***Service pipe*** : it is the part of the house connection beyond the stop cock. It is owned and maintained by the consumer . No pumps shall be installed on this pipe.

6. ***Water meter:*** It is installed to measure the flow. It is an integrating meter that it records the total flow up to the time of measurement. Generally 12.5 mm to 18.75mm rotary water meters are installed either at the beginning or at the middle of the service pipe. A masonry pit is constructed around it. It has facility of sealing by the water supply authority

7. ***Residual pressure***: It is generally measured at the ferrule & should be about 7m head of water

8. ***Goose Nech***: It is the short bent pipe and allow for small changes in length due to expansion and movement of pipes due to soil settlements

STOP COCKS: It is a valve fitted at the end of communication pipe and it is under the control of water supply authority. The purpose of stop cock is to stop the supply of water. Temporary disconnections are made at the stopcock while permanent disconnections are made at ferrule.

WATER TAPS OR BIB COCKS

These are the water taps which are attached at the end of water pipes and from which the consumers obtained water. It is operated from a handle, the water comes out from the opening. The bibcock's may also be of push type and they operate automatic.

PIPE FITTINGS In addition to the pipes, valves, tapes, various types of pipe fittings such as unions, caps, plugs, flanges, nipples, crosses, tees, elbows, bends etc. are used during laying of distribution pipes.

STORAGE OF WATER IN BUILDINGS- In the buildings, the storage of water is required for the following purposes 1. For supplying the water to the consumers during non-supply hours 2. For reducing the maximum rate of demand on the water mains 3. For storage of watering during interruption to damage repair etc, of the water mains. 4. When the available head is insufficient to supply the water in each stores in multi stores of buildings

The storage of water in buildings are constructed of cast Iron, wrought iron, galvanized mild steel plates or R.C.C. storage tanks. Storage tanks may be kept on the roof of the building or on the ground and should be water-tight . The storage tank should be placed in such a position so that the discharge of water can be readily seen. The tank should be provided with overflow pipe and drain pipe near the bottom to clean the tank. The storage tanks are provided with outlet pipes to draw the water.

ESTIMATING STORAGE CAPACITY- The quantity of water to be stored depends on the following factors. *a) Rate of supply of water from water works b) Type of building such as residential, public or industrial c) Whether water supply is continuous or intermittent d) Frequency replenishment of overhead tanks, during the 24 hours*

OVERHEAD STORAGE TANK- When water is to be distributed at very high pressure elevated tanks may be constructed with steel (R.C.C) R.C.C elevated tanks are very popular because *1. Long life 2. Little maintenance 3. Decent appearance*

UNDER GROUND STORAGE RESERVOIR

These reservoirs are used for storing and distributing clear water. These reservoirs are constructed on high natural grounds and are usually made of stones, bricks, plain or reinforced cement concrete. The side walls are designed to take up the pressure of the water, when the reservoir is full and the earth pressure when it is empty.

In down take water supply water from the street mains collected in aground level sump and then pumped up to overhead tanks on top of the building. All the overhead tank and distribution pipes.

TYPES OF TANKS a) R.C.C TANKS: R.C.C tanks are very popular because 1) They have long life 2) Very little maintenance 3) decent appearance

b) G.I. TANKS: G.I. tanks are generally in rectangular or square in shape. Now a days G.I. tanks are not preferring because 1) Life of the tank is short 2) Corrosion of metal 3) maintenance cost may be more

c) HDPE TANKS: Now a days HDPE tanks are very popular for storing less quantity of water and hence useful for residential purpose.

HYDRAULICS May be defined as the branch of engineering which deals with water at rest or in motion. When a liquid is contained in a vessel, it exerts force at all points on the sides and bottom of the container. This force per unit area is called ***Intensity of pressure***.

If 'p' is the total force acting on the cross sectional area 'a' then intensity of pressure p = P/a. The direction of this pressure is always at right angles to the surface, with which the fluid at rest, comes in contact.

The vertical height of the free surface above any point in a liquid at rest is known as ***Pressure head.*** H = p / w_____ P = wh where w → Sp. wt of water h → depth of water

This equation shows that the intensity of pressure at any point in a liquid is proportional to its depth from the liquid surface.

The pressure may be expressed as 1. Force per unit area _____ N/m2 2. Height of the equivalent liquid column --- cm or m

UNITS The pressure is expressed in Pascal (pa) 1 Pascal = 1 N/m2_ 1 M pa = 1 M N/mm2

BERNOULLI'S THEOREM- It states that in a steady, irrotational flow of an incompressible fluid, the total energy at any point is constant. The above statement is based on the assumption that there are no losses due to friction in pipe Mathematically $Z + V^{2/}$ 2g+P/W = constant Where Z = Potential energy, V2 / 2g = Velocity energy, P/w = Pressure energy

LOSSES OF HEAD IN PIPES- When a liquid is flowing in pipe , it loses energy or head due to friction of wall , change of cross section or obstruction in the flow . All such losses are expressed in terms of velocity head. The following are losses which occur in a flowing fluid.

1. Loss of head due to friction 2. Loss of head due to sudden enlargement

3. Loss of head due to sudden contraction 4. Loss of head due to bends

5. Loss of head at entrance 6. Loss of head at exit.

ENGINEERING IMPORTANT TERMS FOUR

Dams are constructed across rivers and streams to create reservoir behind them. The area of land draining to the dam site is called a catchment or watershed. Conscientious planning, design and operation of dams and reservoirs are necessary to minimize the overall cost of the project.

The following investigations are required for reservoir planning:

Topographic surveying- to produce a top map which will be used as a base for

- *o preparing water surface area vs. elevation curve*
- *o plotting storage volume vs. elevation*
- *o indicating man-made and natural features that may be affected*

 ***Geologic investigations*-** required to give detailed information about the following items

- *o Water tightness of the reservoir basin*
- *o Suitability of foundations for the dam*
- *o Geological and structural features, such as faults, fissures, etc.*
- *o Type and depth of overburden*
- *o Location of permeable and soluble rocks if any*
- *o Ground water conditions in the region*
- *o Location and quantity of materials for the dam construction*

 Hydrological investigations- involve determination of rainfall, runoff, seepage, and evaporation in the reservoir catchment from long years of data. These information are essential for estimating the reservoir capacity and design of spill way.

Criteria for selection of reservoir sites

 Catchment geology- minimum percolation losses and high runoff potential

 Dam site- strong foundation with minimum seepage loss under the dam

 Narrow valley- sites that resulting lesser dam length

 Topography- should be such that large area and valuable properties are not submerged

 Site that creates deep reservoirs- this has the advantages of minimizing the evaporation loss and submerged area when compared to shallow reservoirs

 Sites that ensure good water quality- avoid sites that are downstream of waste discharges and tributaries with high silt loads

Volume of reservoirs- Reservoirs should have a storage capacity such that the safe yield exceeds the maximum day demand. *Yield* is the amount of water that can be supplied from a

reservoir in a specified interval of time (e.g. day, month or year). *Safe yield* or *firm yield* represents the maximum quantity of water that can be guarantied during a critical dry period. The storage capacity of reservoirs can be determined using two methods- mass curve method and analytical method.

Mass curve method- In this method reservoir capacity is determined from accumulated mass inflow and accumulated demand curves. The inflow represents net flows into the reservoir and can be obtained by subtracting outflows (e.g. evaporation, seepage loss, and downstream flow requirements) from total inflows (e.g rainfall, and stream flow).

Some of the commonly used impoundments include embankment dams and concrete dams.

 Embankment dam- a dam constructed from natural materials excavated or obtained nearby. The natural fill materials are placed and compacted without the addition of any binding agent. Two types- *Earth fill dam (*if compacted soil constitutes over 50% of the dam volume) and *Rock fill dam* (over 50% of the material is coarse-grained material or crushed rock with impervious membrane).

Some advantages of embankment dams include: o Suitability to sites in wide valleys and relatively steep-sided gorges alike o Adaptability to a broad range of foundation conditions o Use of locally available natural materials

The major disadvantages of embankment dam are

o Its susceptibility to damage or destruction by overflow, with a consequent need to ensure adequate flood relief o Vulnerability to leakage and internal erosion

Concrete dams- type include gravity dam, arch dam, buttress dam, etc.

Gravity dam- Dependent upon its own mass for stability. All external pressures (e.g. water pressure, wave pressure, silt pressure, uplift pressure, etc.) are counterbalanced by the weight of the dam

- Particularly, suitable across gorges with very steep side slopes
- Masonry can also be an alternative construction material
- Shape: straight or curved - Dam height: can be very high if sound foundation is obtained

Arch dam - Functions structurally as a horizontal arch, transmitting the major portion of the water load to the abutments or valley sides rather than to the floor of the valley.

- It is structurally more efficient and requires less concrete volume

Buttress dam- consists of a continuous upstream face supported at regular intervals by downstream buttresses.

Geologic formations that are considered to be good aquifers include sand, gravel, and sandstones. Limestone and shale that have caverns, fissures or faults can also be considered as good aquifers. Although clay is highly porous, its ability to transmit water is very poor due to the very small particle sizes (< 0.0004 mm).

Hydrology is the science, which deals with the increment of the water on the ground, under the ground, evaporation from the land and water surface and transportation from the vegetation and going back into atmosphere where it precipitates.

Hydrological cycle of water. The water which goes in atmosphere by evaporation and transpiration again comes back in the form of precipitation under favorable climatic conditions.

PRECIPITATION. The evaporated water from the surfaces of streams, rivers, sea, ponds, wet surfaces, trees and plants again returned to the earth surface by the condensation in the form of rain, hails, dew, sleet.

The water of precipitation further goes off in the following ways.

i. **RUN-OFF:** After precipitation a portion of its water flows over the ground in the form of rivers and streams and some water flows towards lakes and ponds and collected there.

ii. **INFILTRATION:** A portion of precipitation, percolates in the ground and it is stored in the form of sub-soil or ground water.

iii. **EVAPORATION:** some portion of the precipitation is also evaporated from the lakes, rivers, reservoirs and wet surfaces in the form of vapor due to sun's heat is known as evaporation.

iv. **EVAPO-TRANSPIRATION:** The roots of the trees sucks water from the ground and some portion of it evaporates in the atmosphere through leaves in the form of transpiration.

SURFACE SOURCES- All the sources of water can be broadly divided into

1. Surfaces sources and 2. Sub surface sources

The surface sources further divided into

i. Streams ii. Rivers iii. Ponds iv. Lakes v. Impounding reservoirs etc.

SUBSURFACE SOURCES- These are further divided into

(i) Infiltration galleries (ii) Infiltration wells (iii) Springs

SPRINGS: Sometimes ground water reappears at the ground surface in the form of springs. Springs generally supply small springs.

Types of springs:

1. Gravity Springs: When the surface of the earth drops sharply the water bearing stratum is exposed to atmosphere and gravity springs are formed.

2. Surface Spring: This is formed when an impervious stratum which is supporting the ground water reservoir becomes out crops.

3. Artesian Spring: When the ground water rises through a fissure in the upper impervious stratum. When the water-bearing stratum has too much hydraulic gradient and is closed between two imperious stratum, the formation of Artesian spring from deep seated spring.

Ground water is one of the most abundant resources in the world. It is also one of the most neglected, polluted and wasted. With the rapid urbanization and growing demands on water supply, the ground water resources are depleting on one hand and getting polluted on the others. The quality of groundwater is uniform and is free from turbidity and color.

The following are the reasons for ground water depletion

1. Increasing demand 2. With drawing more than recharge

3. Reducing of recharge area due to buildings, paved paths and roads

4. Diminishing surface water bodies 5. Uncertain rainfall

Artificial recharge is to augment the natural infiltration of rain water or surface runoff into underground formation by artificial method is known as rainwater harvesting. The methods suggested are water spreading, recharge through pits, trenches, wells, shafts and directly diverting runoff water into the existing wells.

Surface waters also provide ground water recharge under certain conditions. When surface water loses water to the adjacent aquifer, the stream is called a ***losing stream***. When the opposite occurs and water flows from the ground water to the stream, it is called a ***gaining stream.***

Ground water occurs in many types of geologic formations known as *aquifers*. **An aquifer** is a formation that contains sufficient quantities of saturated permeable material to yield significant quantities of water. Groundwater system includes wells, springs, and infiltration galleries.

The advantages of ground water are:

 It is likely to be free of pathogenic bacteria; Generally, it may be used without further treatment; In many instances it can be found in the close vicinity of rural communities;

 It is often most practical and economical to obtain and distribute;

 The water-bearing stratum from which it is drawn usually provides a natural storage at the point of intake.

The disadvantages are: Ground water is often high in mineral content; It usually requires pumping; The drilling work requires skilled labor and expensive equipment.

WELLS: A well is defined as an artificial hole or pit made in the ground for the purpose of tapping water.

The three factors which form the basis of theory of wells are

1. Geological conditions of the earth's surface 2. Porosity of various layers

3. Quantity of water, which is absorbed and stored in different layers.

The following are different types of wells

1. Shallow wells 2. Deep wells 3. Tube wells 4. Artesian wells

INTAKES FOR COLLECTING SURFACE WATER:

The main function of the intakes works is to collect water from the surface source and then discharge water so collected, by means of pumps or directly to the treatment water.

Types of Intake structures:

Depending upon the source of water the intake works are classified as following

1. Lake Intake 2. Reservoir Intake 3. River Intake 4. Canal Intake

Aquifers are classified as unconfined and confined aquifers. An unconfined aquifer does not have confining unit and is defined by water-table. Confined aquifer is overlain by a confining unit that has a lower hydraulic conductivity.

The velocity of groundwater flow can be estimated from Darcy's Law. Darcy law states that the flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path. When water is pumped out the water-table or piezometric surface declines and forms a cone of depression or drawdown curve.

The water yield capacity of aquifers depends on different parameters that include particle size, porosity, specific yield, storage coefficient, hydraulic gradient, hydraulic conductivity, and transmissivity. Definitions of these terms are presented below.

Porosity: ratio of volume of voids to total volume

Specific yield: the amount of aquifer water expressed as a percentage that is free to drain under the influence of gravity. By definition it is less than the porosity since some water is not free to drain due to attractive and bonding forces such as surface tension.

Storage coefficient (S*):* volume of water that an aquifer releases from or takes into storage per unit surface area per unit change in piezometric head. For confined aquifers S = 0.00005-0.001 and for unconfined aquifers S = 0.01-0.35.

Hydraulic gradient (dh/dx*):* the slope of the piezometric surface or water table line in m/m. the magnitude of the head determines the pressure on the groundwater to move and its velocity.

Hydraulic conductivity*:* ratio of velocity to hydraulic gradient, indicating permeability of porous media.

Transmissivity*:* measure of how easily water in a confined aquifer can flow through the porous media.

Shallow well construction- Shallow wells are less than 30 m deep and are constructed by digging, boring, driving, or jetting methods. They all are used in unconsolidated formations.

Dug wells are generally excavated by hand and are vertical wells in the ground that intersect the water table. Generally they have diameter > 0.5 m and depth < 15 m. lining and casing materials are usually concrete or brick.

Driven wells consist of a series of pipe lengths driven vertically downward by repeated impacts into the ground. Water enters the wells through a drive point at the lower end, which consists of a screened, cylindrical section, protected by a steel cone. Driven wells usually have diameters 25 – 75 mm and length generally below 15 m.

Bored wells are constructed with hand-operated or power-driven augers. Diameters of 25 to 900 mm and depths up to 30 m, under favorable conditions, can be attained.

Jetted wells are constructed with a high-velocity stream of water directed vertically downward, while the casing that is lowered into the hole conducts the water and cuttings to the surface. Small-diameter holes, up to 10 cm, with depths up to 15 m, can be installed in unconsolidated formations.

Deep well construction- Deep and extensive aquifers with adequate yield can be tapped by constructing deep wells by *percussion (cable tool) drilling* or *rotary drilling methods.* Percussion drilling is accomplished by regular lifting and dropping of a string of tools, with a sharp bit on the lower end to break rock by impact. The method is most useful for consolidated rock materials to depths of 600 m.

Sewage is the liquid waste from a community and generally conveyed by a sewer. Sewage again is differently classified depending on its nature and sources.

 Domestic sewage is that which originates in the sanitary conveniences of a dwelling, business house or institutions.

 Industrial waste is the liquid waste produced from industrial processes, as dying, brewing, papermaking etc.

 S*anitary sewage* is a combination what is produced by domestic sewage together with industrial waste.

 Storm water is the liquid flowing in sewers during or following a period of rainfall and resulting there from. Some underground water may find its way through joints into sewerage system is termed as ***infiltration***.

Sewer is a pipe or conduit, generally closed but normally not flowing full, used for carrying sewage. Types of sewer can be enumerated as follows.

Sanitary sewer is one, which carries sanitary sewage & excludes storm sewage as far as possible.

Storm sewer carries storm water only, including surface runoff and street wash.

Combined sewer is designed to carry all types of sewage, such as domestic sewage, industrial wastes, and storm water.

Sewerage System: - is the system of sewers including all appurtenances required for sewage disposal. A sewerage system will consist of mainly:

(i) collection work (ii) Treatment works if any (iii) Disposal works.

Different types of sewers needed are house connections or sewer from individual house to public sewers, laterals, and the sewer receives the house connections. ***Laterals*** will be single sewer and it will not receive sewage from any other sewer excepting house connections. Two or more laterals will form a ***sub main.*** More than one sub mains meeting together will form the main sewer. When more than one main meet and form ultimately a single sewer directed to the treatment unit is known as ***trunk sewer***.

Sewage disposal applies to the act of disposing of sewage by any method may be to a body of ***water*** or on ***land***. It may be done with or without any previous treatment of the sewage. The last stretch of trunk sewer carrying sewage to the disposal point is known as ***outfall sewer***.

Invert: is the lowest point of the inside surface of the sewer or drain at any cross section.

Refuse*:* includes all kinds of dry wastes produced from a community. It may consist of house sweepings, garbage, dead animals etc.

Garbage*:* It includes all sorts of semi solid and solid wastes out of food products such as vegetables, peeling of fruits, waste meat etc.

Rubbish*:* is any sun-dried solid waste as paper rags, broken pottery, cans and other materials comparatively inert in chemical action.

System of sanitation is classified on the basis of collection and conveyance of waste produced in a community. This is mainly related to excreta disposal. The methods of collection adopted are mainly following two types*: (a) Dry or conservancy system (b) Water carriage system*.

Dry or Conservancy system- This is adopted where no sewerage system exists. Conservancy system is also known as ***scavenger system***. In this system all sorts of refuse from a community is collected first in dust bins or garbage vats, which are located at suitable points inside the township. From these dustbins the refuse is collected and carried by trucks or carts to the point of disposal. Disposal of refuse is done by means of land filling, incineration, composting or dumping in the sea.

Water Carriage System- This system of sanitation is modern one. Here no human agency is directly employed for collection and conveyance of night soil. Spent up water for domestic use which otherwise goes to waste is employed carrying night soil, hence the name is given as water carriage system.

Sewerage system- Nature of sewers provided for carrying different types of liquid wastes will indicate the sewerage system. There are three systems of sewerage adopted in practice. They are combined, separate and partially separate systems.

1. ***Combined system*****: -** In combined system one single set of sewers are laid for carrying liquid wastes from a community. Both sanitary sewage and storm water is allowed to enter the sewerage system for disposal.

2. ***Separate System:*** **-** In separate system two separate sets of sewers are laid. One set will carry sanitary sewage and the second set will carry storm water. As storm water is carried separately, it is not foul in nature and normally disposed of to natural watercourses without treatment. Whereas the sanitary sewage is taken to treatment plant separately and after required treatment it is disposed of.

3. Partially Separate System**: -**This is also termed as partially combined system. The sewers are designed as sanitary sewer but sufficient excess capacities are provided to carry a part of storm

discharge also. In this type, the initial washings from drainage area i.e. a part of the storm water are included in the sewers.

Planning a Sewerage Project

Prior to planning and designing a sewerage project certain survey and investigation works need to be conducted. On the basis of the findings decision has to be taken, whether sewerage scheme is required, if required what system is to be adopted, nature and extent of treatment to be provided etc. The following data dare to be collected in preparing a scheme.

(a) Population (b) Quantity of water. (c) Industries.

(d) Rainfall data. (e) Surveying (f) Scope of expansion. (g) Economy.

Sewer layouts- For collections and disposal of sewage a net work of sewers to be laid. The pattern of sewer layout system depends on the following factors.

(a) Type of sewerage system whether combined, separate or partially separate system

(b) The topography of area (c) Location of disposal point (d) The hydrological feature of area

Various patterns of layout are given below.

1. Perpendicular Pattern: in this pattern number of sewers are laid in such a way that each reaches to the respective outfall point through the shortest route. The sewers are useful for carrying storm water in separate system; otherwise the river will get polluted in several points.

2. Interceptor Pattern: in this system a number of main sewers are laid serving different zones. Again the mains at their outfall ends are connected by a large size-intercepting sewer, which leads the sewage to pump house or treatment plant. Intercepting sewer at the junctions of main sewers may be provided with over flows that will carry the excess and less polluted storm water to the river.

3. Zone patterns: This pattern is used where different zones with respect to different elevations exist. Here several intercepting sewers are laid according to elevations of the zone. Storm overflows are made to make direct discharge to river but sewage is brought to a common point for treatment. This type of system is useful in combined flow.

4. Fan pattern: Here all the sewers are directed to one point i.e. towards the outfall sewer after covering the entire area with branches laterals etc. This type of system is used where natural topography is lower towards outfall point and having a short of valley formation along more or less central line. This system is used for combined or partially combined sewers.

5. Radial Pattern: This pattern is used for sanitary sewage in a place where central part of area is high and going down all round towards the outskirts. This type of layout pattern can only be used where several disposal points are available.

Types of sewage- The components that make up the wastewater flow from a community depend on the type of collection system used and may include the following:

1. **Domestic (also called sanitary) sewage**: wastewater discharged from residences and from commercial, institutional, and similar facilities.
2. **Industrial sewage (Non-domestic):** wastewater in which industrial wastes predominate.
3. **Storm water**: Runoff resulting from rainfall and snowmelt.
4. **Infiltration /Inflow**: water that enters the sewer system through indirect and direct means. Infiltration is extraneous water that enters the sewer system through leaking joints, cracks & breaks, or porous walls. Inflow is storm water that enters the sewer system from storm drain connections (catch basins),roof leaders, foundation & basement drains, or through manhole covers.

Infiltration/Inflow- Extraneous flows in sewers, described as infiltration and inflow.

Infiltration: Water entering a sewer system including sewer service connections, from the ground through such means as defective pipes, pipe joints, connections, or manhole walls.

Steady inflow: water discharged from cellular and foundation drains, cooling water discharges, and drains from springs and swampy areas. This type of inflow is steady and is identified and measured along with infiltration.

Direct inflow: those types of inflow that have a direct storm water runoff connection to the sanitary sewer and cause an almost immediate increase in wastewater flows. Possible sources are roof leaders, yard and areaway drains, manhole covers, cross connections from storm drains and catch basins, and combined sewers.

Total inflow: The sum of the direct inflow at any point in the system plus any flow discharged from the system upstream through overflows, pumping station bypasses, and the like.

Delayed inflow: storm water that may require several days or more to drain through the sewer system. This category can include the discharge of sump pumps from cellular drainage as well as the slowed entry of surface water through manholes in ponded areas.

The rate and quantity of infiltration depend on the length of sewers, the area served, the soil and topographic conditions, and to a certain extent the population density (which affects the number and total length of house connection).

Different materials are available to be used for sewer construction. Sewer materials may be either pre-cast or cast-in-situ. Pre-cast sewer materials include vitrified clay, plain concrete sewer, reinforced concrete sewer, asbestos cement pipe, plastic truss pipe etc.

Other sewer materials

Bituminized fibre pipe is manufactured in small sizes and is primarily used for house sewers.

Solid wall plastic pipes made of PVC are also available in different sizes. Solid wall plastic pipe may be used alone, in conjunction with plastic truss pipe, and in vacuum and pressurized collection systems. Like plastic truss pipe, the cemented joints tend to be virtually water tight.

Cast or ductile iron is used in force mains and small outfall lines. It may also be employed where sewers are constructed above the ground surface and in inverted siphons. Lines within sewage treatment plants are often constructed of iron. Joints are made in the same fashion as in water distribution systems.

Corrugated metal pipe is sometimes used for storm sewers. It may be galvanized, coated with bituminous material, or coated with asbestos. Corrugated metal pipe sections are available in many thicknesses and cross-sections. Their primary use is roadway drainage.

Forces Acting on Sewer pipes

The structural design of sewer pipes should be such that to enable them to withstand the various forces likely to come on them. The following forces acts on sewer pipes.

1. Internal pressure (Due to sewage) 2. pressure due to external loads

3. Temperature stresses 4. Flexural stresses

Sewer systems require a variety of appurtenances to ensure proper operation. These include manholes, inlets, catch basins, traps, inverted siphons, sewer crossings, and pumping stations.

Manholes are used as a means of access for inspection and cleaning. They are placed at intervals of 90 to 150m and at points where there is a change in direction, change in pipe size, or considerable change in grade.

Inlet is an opening into a storm or combined sewer for entrance of storm runoff. Inlets are placed at the gutters, usually at street intersections but occasionally at midpoints of the blocks, if they are more than 150m long.

Catch basins- This is an inlet with a basin, which allows debris to settle out. The outlet pipe is usually trapped in order to prevent escape of odors from the sewer, a provision that also causes retention of floating matter.

Sand, Grease, and Oil traps- The sewage from kitchens of hotels and restaurants contains grease, which tends to accumulate on sewer walls and cause clogging. Some cities, therefore, require grease traps in the waste lines from the sinks of such kitchens. Sewage from garages, particularly from the floor drains and wash racks, contains oil, mud, and sand.

Inverted siphons- In sewerage works the term inverted siphon is applied to a portion of a sewer which dips below the hydraulic grade line to avoid such an obstruction as a railway cut, a subway, or a stream. Maximum velocity should be maintained in siphon design with 0.9m/s minimum. Inverted siphons are constructed of cast-iron, concrete, or tile pipe, depending upon the construction conditions that are encountered.

Storm water collection

In urban areas, storm water runoff generally occurs as sheet flow to the streets, conveyed as gutter flow along the streets to drain inlets; collected by storm sewers in buried conduits; and discharged into streams, lakes, or ponds. The storm water collection system is a combination of streets and storm sewers. The lots are graded so that the runoff flows toward the street, and the street conveys the runoff to the storm sewer drain inlets.

The time of concentration (tc) is the time required for water to flow from the most hydraulically remote point in the drainage area to the point of design. *tc* can also be defined as the time for the runoff from the drainage area to reach equilibrium under a steady rainfall rate.

Efficiency is the ratio between the output and input powers the input power given to the pump is the power delivered by the driver units which is called the break horsepower, B.H.P. the output of the pump is the work done which is the weight of the liquid pumped in a certain time multiplied by the head developed by the pump. The power output is the water horsepower W.H.P

WATER HAMMER- When the water flowing in a long pipe is suddenly brought to rest by closing the valve or by any similar cause, there will be a sudden rise in pressure due to momentum of the moving water being destroyed. This cause a wave of high pressure transmitted along the pipe, which creates noise known as knocking. This phenomenon of sudden rise of pressure in the pipe is known as WATER HAMMER or HAMMER BLOW.

CAVITATION is phenomena of vapor bubble formation and collapse of it. This phenomenon is happen when the absolute pressure in a liquid reaches the vapor pressure of the liquid at operating temperature.

The harmful effects of cavitations are:- Pitting and erosion of the surface due to continuous hammering action of the collapsing bubble Sudden drop in head, efficiency and power delivered to the fluid Noise and vibration produced by the collapse of vapor bubbles.

SEGREGATION is the "Separation of constituent materials in concrete." In concrete technology, segregation is of three type:-

1. Separation of coarse aggregate from the concrete mixture
2. Separation pf cement pastes from the concrete during its plastic bag
3. Separation of water from the concrete mix (Bleeding in concrete

ENGINEERING IMPORTANT TERMS FIVE

☞የህንፃ ስራ ሂደቶች / Building Works

1. Foundation

*ፋውንዴሽን የሕንፃው በጣም አስፈላጊ ክፍል ነው፡፡

*የግንባታ እንቅስቃሴ የሚጀምረው ለመሠረት መሬትን በመቆፈር እና ከዚያ በመገንባት ነው፡፡

*እሱ የሕንፃው የታችኛው ክፍል ነው።

2. Plinth:- በመሬት ደረጃ እና በመሬቱ ወለል መካከል ያለው የግድግዳ ክፍል ነው፡፡

*Plinth ብዙውን ጊዜ የድንጋይ ንጣፍ ስራ ነው።

*መሠረቱም በእንጨት ላይ ከሆነ ፣ከወለል ወለል በላይ ግድግዳውን ለመደገፍ አንድ ክፈፍ ጣውላ ይጣላል።

*በፕሌይ አናት ላይ እርጥብ ማረጋገጫ ኮርስ ይሰጣል፡፡

*እሱ ብዙውን ጊዜ ከ 75 ሚ.ሜ ውፍረት ያለው የኮንክሪት ኮርስ ነው ፡፡

3. Walls and Columns

*የ wall እና የcolumn ተግባር የመሠረቱን ጭነት ወደ ታች ለማስተላለፍ የህንፃውን ጭነት በአቀባዊ ወደ ታች ማስተላለፍ ነው ፡፡

4. Sill እና lintels የመስኮት ክፈፍ በቀጥታ ከማሸኑ ላይ መቀመጥ የለበትም፡፡

*በመሬቱ ላይ ከ 50 ሚሊ ሜትር እስከ 75 ሚ.ሜ ውፍረት ያለው ተጨባጭ ኮንክሪት ኮርስ ይቀመጣል፡፡

*ይህ ኮርስ እንደ ሰል ይባላል Lintels R.C.C. ሊሆኑ ይችላሉ።

*የበሩ ወይም የመስኮት ክፈፉ ከልክ በላይ ጫና ያልተፈጠረ መሆኑን ለማየት በበሩ እና በመስኮቱ ክፍት ቦታዎች ላይ ጭኖቹን በማስተላለፍ ላይ የተቀረጹ የድንጋይ ንጣፎች ወይም የድንጋይ ንጣፎች።

*ለምሳሌ የአንድ ቤት ርዝመት 3ሜ ሊሆን ይችላል፡የአንድ በር ቁመት 2.10 ከሆነ 90 cm ከበሩ ወደላይ lintel beam ተጠቅመን wall መሥራት እንችላለን፡፡

5. Door & windows

-የበር ተግባር በህንፃው ውስጥ የተለያዩ ክፍሎች እንዲኖሩ እና አስፈላጊ ሆኖ ሲገኝ ተደራሽነትን መካድ ነው፡፡

*በሮች ቁጥር በተቻለ መጠን ዝቅተኛ መሆን አለበት ፡፡ የበሩን ስፋት እንደ በር ሊጠቀም የሚችል ትልቁን ነገር እንቅስቃሴ የሚያመቻች መሆን አለበት ፡፡

6. Floors -ወለሎች የሕንፃ አስፈላጊ አካል ናቸው፡፡

*ለሰራተኞቹ የሥራ / ጠቃሚ አካባቢ ይሰጣሉ የመሬቱ ወለል የተገነባው by filling brick bats, waste stones, gravel and well compacted እና በጥሩ ሁኔታ ከላይኛው ከ ιοο ሚ.ሜ የማይበልጥ የአሸዋ ንብርብር በመሙላት ነው፡፡

*የ 1: 4: 8 ፣ 100 ሚሜ ውፍረት ያለው ተጨባጭ ኮንክሪት እንደ ምሣሌ ማየት ይቻላል፡፡

*በዚህ ላይ እርጥብ ማረጋገጫ ኮርስ ሊሰጥ ይችላል ፡፡

7. Roof

*ከፍታ ለህንፃው የላይኛው ሽፋን የሚሰጥ የህንፃው ከፍተኛ ክፍል ነው፡፡

*እንደ ጣሪያ እና እንደ ኤ.ሲ.ኤል. ወረቀት ያሉ ተንሸራታች ጣራ በቀላሉ የሚፈስ ሽፋን ይሰጣል። ነገር ግን ለተጨማሪ ወለል ግንባታ ዝግጅት አይሰጡም፡፡

*የታጠፈ ጣሪያ ጥሩ የሙቀት መከላከያ ይሰጣል፡፡

*ጠፍጣፋ ጣሪያዎች ለተጨማሪ ወለሎች አቅርቦት ይሰጣሉ ::*terrace የነዋሪዎችን ምቾት ይጨምራል።

*የውሃ ታንኮች በቀላሉ ጠፍጣፋ ጣሪያዎቹ ላይ በቀላሉ ሊቀመጡ ይችላሉ ::

8. Step, Stair, Lift

-ደረጃዎች ከመሬት ወለል እስከ መሬት ወለል ደረጃ ምቹ ተደራሽነት ይሰጣሉ :: በውጭው ግድግዳ ላይ በሮች ያስፈልጋሉ :: ከ 250 እስከ 300 ሚ .ሜ ስፋት እና ከ 150 ሚ.ሜ ከፍታ ለደረጃዎች በጣም ጥሩ መጠን ነው ::

*በምንም ዓይነት ሁኔታ ሁለት ተከታታይ ደረጃዎች መጠኑ የተለየ አይሆንም፡፡

*የሚፈለገው የእርምጃዎች ብዛት በመሬቱ እና በመሬቱ ደረጃዎች ልዩነት ላይ የተመሠረተ ነው።

9. Finishing

-የታችኛው ንጣፍ (ጣሪያ) ፣ ግድግዳዎች እና የወለል ንጣፍ ከፕላስተር ጋር ለስላሳ ማጠናቀሪያ ያስፈልጋቸዋል፡፡

10. የግንባታ አገልግሎቶች የውሃ አቅርቦት ፣ የአካባቢ ጽዳትና የግል ንፅህና ሥራዎች ፣ የኤሌክትሪክ አቅርቦት ሥራ እና የመጠጥ ሰሌዳዎች ግንባታ እና የማሳያ ጉዳዮች ዋና የግንባታ አገልግሎቶች ናቸው፡፡

⚡ኮንክሪት (Concrete) ስሙን ያገኘው ከጥንት ሮማኖች ሲሆን

ቃሉም የመጣው ኮንክሪተስ (Concretus) ከሚለው የሮማኖች ቃል ነው የቃል በቃል ትርጉሙ ተያይዞ ማደግ / አንድ ላይ ማደግ የሚለውን ይወክላል።

*ኮንክሪት በአለም ላይ በብዛት የምንጠቀመው የግንባታ ቁስ ነው።

ኮንክሪት የሲሚንቶ የአሸዋ እና የጠጠሮች ውህድ ነው ። የኮንክሪት የእመቃ ጥንካሬ (Compressive strength) ሚለካው በግሬዱ ነው (Grade)። የተለያዩ የኮንክሪት ግሬዶች አሉ C-5 ፣ C-15 C-25 C-30 ወዘተ የኮንክሪት ግሬድ ማለት ኮንክሪቱ ከሃያ ስምንት ቀን በኋላ የሚኖረው የእመቃ ጥንካሬ (Compressive strength) ማለት ነው ለምሳላ C-25 የሆነ ኮንክሪት ግሬድ ከ28 ቀን በኋላ የሚኖረው የእመቃ ጥንካሬ 25N/mm^2 ይሆናል ማለት ነው የC-30 ግሬድ ደግሞ ጥንካሬው 30N/mm^2 ነው

*ለውሃ ስራዎች ብዙን ግዜ ተመራጩ የኮንክሪት ግሬድ ከ C-30 በላይ ነው

*አንዳንድ ግዜ የኮንክሪት ግሬዶች በተለያዩ መፅሃፎች በተለያየ መልክ ይጠቀሳሉ ለምሳሌ አንዳንድ መፅሃፎች C-30 C-15 የሚለውን አጠቃቀስ ሲጠቀሙ አንዳንዶቹ ደግሞ M-30 M-15 የሚለውን ይጠቀማሉ (ከታች በምስሉ እንደተጠቀሰው) ....በ «C»የሚጠቀሱ የኮንክሪት ግሬዶች በC መጠቀሳቸው የእመቃ ጥንካሬያቸው የተለካው በሲሊንደሪካል ፍተሻ (CYLINDRICAL Test) ስለሆነ ነው በM የሚጠቀሱት ደግሞ ፍተሻው (test) የተደረገው በኪውቢክ ፍተሻ (cubic test) ስለሆነ ነው። በሁለቱ የፍተሻ አይነቶች የሚደረጉ የኮንክሪት ግሬዶች የእመቃ ጥንካሬአቸው ይለያያል። ሲሊንደሪካል ፍተሻ በአንፃራዊነት የኮንክሪትን ትክክለኛ እምቅ ጥንካሬ ይገልፃል ስለዚህ ከኪውቢክ ፍተሻው የተሻለ ነው ማለት ነው።

As you know to determine weight of the bar we use two formulas

1. $W = \frac{D^2}{162} \times$ Length of the bar

2. $W = \frac{D^2}{52.9} \times$ Length of the bar

❋የውሃ ጋኖች (Water Supply Reservoir)

የውሃ ጋኖች ከጥቅማቸው አንፃር ለ ሶስት ይከፈላሉ

1- Collector reservoir
2- Service reservoir
3- Supply reservoir

እያንዳንዱ ጥቅማቸው ምንድነው.....

✓ 1 [Collector reservoir]

ይህ የጋን አይነት ዋና ስራው ውሃው ከሚመነጭበት (የገጸ ምድር ወይም የከርሰ ምድር ውሃ) ቦታ ህክምና ከተደረገለት በኋላ የሚቀመጥበት ጋን ነው፡፡ ጥቅሙ የተሰበሰበውን ውሃ ወደተለያዩ ጋኖች እስኪሰራጭ በጊዜያዊነት እንዲቀመጥና ውሃው ለጋኖቹ እንዲደርስ የሚያደርገውን ጉልበት እንዲያገኝ ይረዳዋል፡፡ ብዙን ጊዜ ውሃው ከሚመነጭበት ቦታ አቅራቢያ ይተከላል፡፡ ውሃ ፈሳሽ እንደመሆኑ ብዙን ግዜ ሚፈልቀው ከፍታቸው ካነሱ ቦታዎች ስለሆነ ከሌሎች ጋኖች ይልቅ የዚህ ጋን ከፍታ (Elevation) ያንሳል፡፡

✓ 2 [Service reservoir]

ይህ የጋን አይነት በቋሚነት ከCollecter reservoir የተቀበለውን ውሃ የሚያርፍበት ነው፡፡ አሰራሩም ከሌሎቹ ጋኖች ለየት ይላል ፡፡ ውሃው የሚያደርስበትን ግፊት ለመቋቋም የሚያስችለውን መካች ጉልበት (Reaction force) በበቂ ሁኔታ እንዲኖረው ይደረጋል፡፡ በቁመትም በመጠንም ትልቅ ነው፡፡ ወጪ ለመቀነስ ከፍ ካለ ቦታ ይተከላል (ውሃ በ3 አይነት መንገድ ይከፋፈላል

ነ-የሞተር ሀይልን በመጠቀም

2-የመሬት የመሳብ ሃይልን (Gravity force) በመጠቀም።

3-የሞተር ሃይልንና የመሬት የስበት ሃይልን በማጣመር በመጠቀም እንዲሰራጭ ይደረጋል፡፡

በአሁን ጊዜ ሶስተኛው አማራጭ በስፋታ አገልግሎት ላይ ይውላል ይህ አማራጭ ከወጪም አንፃር በጣም ተመራጭ ነው ለዚህ ዘዴ ተመራጩ ደግሞ የService reservoir ከፍ ካለ ቦታላይ መተከል ወሳኝነት አለው፡፡)

ከዚህ ጋን ቀጥታ ለስርጭት ቧንቧ አይገጠምም ምክንያቱም ከጋኑ የሚወጣው ውሃ ከፍተኛ ጉልበት ስላለው የማሰራጫ ቱቦዎችን ሊያፈነዳ ይችላል፡፡ ይህን ችግር ለመፍታት ቀጣዩን የጋን አይነት መገንባት አስፈላጊ ነው፡፡

✓ 3. [Supply reservoir]

የዚህ ጋን ዋና ጥቅም ውሃውን ለስርጭት ወደ ስርጭት ቱቦዎች እንዲገባ ማድረግ ነው፡፡ ከላይ እንደጠቀስኩት ከሰርቪስ ጋን ቀጥታ ወደ ስርጭት ቧንቧ ውሃ አይገባም ምክንያቱም ከፍተኛ ሀይል ስላለው የቧንቧዎቹን የመቆየት አቅም ያሳጥራል ብሎም እስከ ማፈንዳት ያደርሳል፡፡ ይህ እንዳይከሰት የሳፕላይ ጋኖች ይገነባሉ፡፡ ይህ ጋን በቱቦዎቹ የሚያልፈውን ውሃ

ግፊት በመቀነስና ፈጥነቱን (velocity) ከ 0.5-2 m/s በማድረግ እና ወደ ቱቦዎቹ የሚገባን ሃይል በመቀነስ (Energy dissipate) ቱቦዎቹ ላይ የሚደርሰውን ጉዳት ያስወግዳል፡፡ ይህ ጋን ከፍ ባለ ቦታ ይተከላል ነገር ግን ከፍታው ከService reservoir ያነሰ ነው።

☞ የአፈርን የመሸከም አቅም (BEARING CAPACITY) እንዴት እንጨምር??...

* ሶስት አይነት የአፈርን የመሸከም አቅም ማስተካከያ ቴክኒኮች አሉ - Mechanical, chemical & other stabilization techniques

A) ሜካኒካል ውስጥ ፦

1. Compaction - አፈሩን ስንጠቀጥቀው Density/ unit weight ይጨምራል ያ ማለት ደግሞ አፈርን የመሸከም አቅም ጨመረ ማለት ነው።

2. Excavation and Replacement – Expansive soil ከሆነ ወይም ሌላ አስቸጋሪ አፈር ከሆነ ይህን መጠቀም እንችላለን

3. Mixing of Different Soils - ሳይታችን ላይ ያለው አፈር Coarse ወይም Fine ብቻ ከሆነ ወይም ደግሞ አፈሩ አንድ አይነት ብቻ ፀባይ ካለው ከተለያዩ አፈሮች ጋር በመደባለቅ የተሻለ የአፈር ፀባይ ማግኘት እንችላለን

B) ኬሚካል ፦

1. Lime stabilization - ይህንን የምንጠቀመው በአብዛኛው ለExpansive soil ነው፡፡ አፈሩን ከ Lime ጋር በመደባለቅ plasticity መቀነስ እንችላለን፡፡ የlime መጠኑ ከሚያስፈልገው በላይ ከበዛ ግን B.C. ይቀንሳል፡፡

2. Cement stabilization - ሲሚንቶን ከአፈር ጋር በመደባለቅ የተሻለ ውጤትን የምናገኝበት መንገድ ነው፡፡ concrete pavement ስር መጠቀም እንችላለን በአብዛኛው ለአየር መንገዶች ፤ ለአውራ ጎዳናዎች ፤ ግድቦችን ከሸርሸራ ለመከላከል ወ.ዘ.ተ. መጠቀም እንችላለን፡፡

3. Asphalt stabilization - አስፓልትን ከአፈር ጋር በመደባለቅ የተሻለ ውጤትን የምናገኝበት ዘዴ ነው በተለይም ለcohesive አፈሮች፡፡ አፈሩን water proof በማድረግና ውሃማነትን በመቀነስ

B. Cን መጨመር እንችላለን፡፡ በአብዛኛው ይህንን ድብልቅ ለመንገዶች እንደ base course መጠቀም እንችላለን፡፡

C) ሌሎች የአፈርን ባህሪ ማስተካከያ መንገዶች፦

1. Drainage-ፓይፖችን አፈር ውስጥ በመቅበር ወይም ጉድጓዶችን በመጠቀም ground water የምንቆጣጠርበት ነው

2. Precompression - ግንባታ ከመጀመራችን በፊት አፈሩ ላይ ሎድ በመጫን ኮምፓክት የምናደርግበት ዘዴ ነው

3. Dynamic Stabilization

ሀ) Blasting - ቦምብ ወደውስጥ በመቅበር በፍንዳታው አፈሩ ይጠቀጠቃል።

ለ) Compaction Piles - ፓይሎችን ወደውስጥ በማስገባት አፈሩ ወደ ጎን እንዲሸሸና እንዲጠቀጠቅ ማድረግ ይቻላል፡፡ ፓይሉን ስናስወጣውም በተቦረቦረው ጉድጓድ ውስጥ የተሻለ አፈር በማስገባት የአፈርን የመሸከም አቅም ማስተካከል እንችላለን፡፡

4. Injection and Grouting - አፈሩን በሲሚንቶ ወይም በተለያዩ chemical ውህዶች በpressure በመምታት ground waterና settlement መቆጣጠር እንችላለን፡፡

የተሻለውን ዘዴ ለመምረጥ የአፈሩንና የአካባቢውን ሁኔታ ፤ ኢኮኖሚ ፤ ሴፍቲና የመሳሰሉትን ነገሮች ማጤን አለብን፡፡

☞BASIC REQUIREMENT OF BUILDING

▸The planning and construction of a building should be aimed at fulfilling the ff requirements.

✴Strength and disability ✴Dimensional and stability

✴Resistance to dampness ✴Resistance to fire

✴Heat insulation ✴ Sound insulation

✴Protection against termite attack ✴Durability

✴Security against burglary ✴Lightning and ventilation

✴Comforts and convenience ✴Economy...etc.

✓A typical building project will include the following

A. Substructure

1. Excavation & Earth work 2. Concrete Work 3. Masonry Work

B. Super structure

1. Concrete work 2. Roofing 3. Masonry works 4.Metal Work

5. Finishing work 6.Glazing 7. Electrical Installation

8. Carpentry & Joinery 9. Sanitary Installation 10. Fence Work

General factors to be considered for determining depth of foundation are:

1. Load applied from structure to the foundation.
2. Bearing capacity of soil.
3. Depth of water level below the ground surface.
4. Types of soil and depth of layers in case of layered soil.
5. Depth of adjacent foundation.

☞BASIC THINGS YOU MUST KNOW AS A CONSTRUCTION ENGINEER

▸Minimum slab thickness is 125mm, but it is advisable to stick to 150mm

▸Always ensure a tolerance of 2mm when casting cubes

▸Minimum number of reinforcements in a square column is 4nos and 6nos for a circular column.

▸Longitudinal reinforcements must not be less than 0.8% and more than 6% of the gross concrete section

▸water absorption of bricks must be kept to a tolerable limit of 15%

▸If bar diameter exceeds 36mm, avoid introducing lap lengths

▸Minimum bar diameter for slab reinforcements is 8mm for high yield steel or 10mm for mild steel, (It is advisable to stick to 12mm).

▸Distribution bars for slab reinforcements must not be less than 8mm (it is advisable to stick to 10mm) and must not exceed 1/8 of slab thickness.

▸Maximum free fall of concretes must not exceed 1.50m

▸Compressive strength of concrete bricks is 3.5N mm^2

▸PH value of the water used for construction must not be less than 6.

➞These are some of the basic things you should know as an engineer. So go to that site and show them what you have got because Knowledge is Power.

☞DIFFERENCE BETWEEN PERT AND CPM

➞PERT and CPM are most commonly used methods for project management. In this article, I will discuss the differences between PERT and CPM.

▸WHAT IS PERT?

*PERT or Program (Project) Evaluation and Review Technique is an event oriented method of network planning. In it, the emphasis is focused on start and completion events rather than on activities. It's appropriate for the project where the time needed to complete different activities are not known. Or the activities taking place between events are not specified.

*In PERT network, the events fall in logical sequence. But the logic of events may be different for different planners. Hence PERT network may vary from planner to planner depending upon their decision as which event to precede or occur concurrently.

*In PERT network the start circle is omitted and only the completed event is recorded. PERT helps in identifying critical area which threatens the completion of the work. It provides the means to determine how resources can be transferred from one job to another job.

▸WHAT IS CPM? CPM or The Critical Path Method is also network comprising events and activities. This network is activity based. The activities are represented by arrowed lines and events by circles. The activities are connected in logical sequence. The time allotted to each activity is related to cost.

➞DIFFERENCE BETWEEN PERT AND CPM:

1. PERT is event oriented whereas CPM is activity oriented. In simple words, in PERT network interest is focused upon start or completion of events and not on activities themselves.
2. In CPM network no allowance is made for uncertainties in the duration of time involved whereas in PERT network uncertainty is considered.
3. In PERT, time is not related to cost whereas in CPM the object is to develop an optimum time cost relationship. However, PERT has since been extended in this direction and the line dividing PERT/CPM is gradually fading out.
4. In CPM duration of activity is estimated with a fair degree of accuracy. In PERT duration of activities are not so accurate and definite.
5. In CPM both time and cost can be controlled during planning. Pert is basically a tool for planning.
6. PERT is used in research and development project, basically for non-repetitive type projects. CPM is widely used in construction projects.

☞ የትኛው ኢኮኖሚካል ነው ?? => Flat Plate, Waffle, Flat with Drop or Solid Slab

በጠቅላላው በፍሎር ደረጃ ኢሄኛው የተሻለ ኢኮኖሚካል ነው አይደለም ለማለት Quantity ካልሰራን ለማወቅ አስቸጋሪ ነው ....

በፓኔል ደረጃ (ስለአንድ እስላብ ብቻ) ካወራን ግን EBCS ሪኮመንድ የሚያረጋቸው የስላብ አይነቶች አሉ ። ሪኮመንዴሽኑ 100 ፐርሰንት ትክክል ነው ማለት አይደለም - ኢኮኖሚካል ነው ለማለት ጂኦሜትሪንና የፈሮ ብዛትን ግምት ውስጥ ማስገባት አለብን - ስለዚህ አሁንም 100 ፐርሰንት እርግጠኛ የምንሆነው ኳንቲቲ በመስራት ብቻ ነው። ነገር ግን ኮዱ ባደረገው ጥናት መሰረት ከኮለን እስከ ኮለን ያለውን ርቀት መሰረት አድርጎ ኢኮኖሚካል ነው ያለውን የስላብ አይነት አስቀምጡዋል።

እነዚህም፡

1. Flat Plate - ሎዱ ቀላል ከሆነና ከኮለን ሴንተር እስከ ኮለን ሴንተር ከ4.5 እስከ 6ሜ ለሆነ ስላብ ኢኮኖሚካል ነው
2. Flat Slab With Drop - ከባድ ሎድ ካለና ከሴንተር - ሴንተር ከ6 እስከ 9ሜ. ለሆነ እስላብ ኢኮኖሚካል ነው።
3. Waffle Slab - ለትልቅ እስፓን ከ7.5–12ሜ

ለትልቅ እስፓን ከmoment ይልቅ vertical load ገቨርን ስለሚያደርግ መሃል ስፓን ላይ ያለውን የስላብ ውፍረት መቀነስ እንችላለን - ዋፍል ስላብ በመጠቀም ማለት ነው።

4. Ribbed Slab -ትልቅ ስፓን ላላቸውና ከቀላል እስከ መካከለኛ የሆነ ተንቀሳቃሽ ሎድ ላላቸው ፓኔሎች ኢኮኖሚካል ነው።

5. Solid Slab - የስፓኑ ርዝመት በጨመረ ቁጥር ኢኮኖሚካል አይደለም። ፍላት ስላቦች ናቸው ኢኮኖሚካል የሚሆኑት ምክንያቱም የፍላት ስላብ ብረት አቀማመጥ በ Strip ስለሆነ የፈሮ ብዛት ይቀንሳል።

➞Center of gravity Vs Centroid

Center of Gravity = አንድ አካል በብዙ ጥቃቅን አካላት የተመሰረተና የእነዚህ አካላት ስብስብ መሆኑ ይታወቃል፡፡ እናም እነዚህ አካላት የየራሳቸው weight ወይም ክብደት አላቸው - weighታቸውንም በአንድ weight መወከል እንችላለን ይህም Resultant ይባላል፡፡ ይህ Resultant act የሚያደርግበት ቦታ Center of Gravity ይባላል፡፡

Center of Mass = ከCenter of Gravity ጋር የሚለያየው በ 'Weight' ቦታ 'Mass' ስናስገባበት Center Of Mass እናገኛለን (W= mg)

Centroid = የአንድ አካል ቅርፅ ላይ (length, width & height) ላይ የሚመሰረት የአካሉ መሃከለኛ ቦታ ነው፡፡ እንዲሁ በተለምዶ የአንድ አካል መሃል ነው የምንለው ነጥብ Centroid ነው፡፡ ለምሳሌ የአራት መአዘን መሀል አሳይ ስትባል የምታሳየው ቦታ

Centroid of a Volume = centroid of ቁመት - ርዝመትና ወርድ ያለው አካል ወይም 3D object

Centroid of an Area = 2D ወይም ስፋትና ርዝመት ብቻ ያለው አካል centroid

Centroid of a Line = ርዝመት ብቻ ያለው አካል centroid

ለምሳሌ ገመድ

Centroid ና Center of Gravity አንድ ነጥብ ላይ የሚሆኑት አካሉ ሙሉ ለሙሉ አንድ ወጥ ከሆነ material ከተሰራ ነው - Density ከተለያየ ሁለቱ ነጥቦች የሚያርፉበት ቦታም ይለያያል፡፡

☞HOW TO CHECK QUALITY OF CEMENT AT SITE

➞Cement is one of the most important materials used in construction. The strength of a structure depends upon several factors, cement quality is one of them. To achieve the desired strength of concrete and to increase the longevity of structure good quality cement should always be used. So it is important to check the quality of cement before using. In our previous article, we have already discussed the different types of cement and their uses in construction. Today we will discuss how to check the quality of cement at site.

To check the quality of cement we need to pass some easy tests which are described below.

1. DATE OF PACKING:

The strength of cement decreases with time. First of all, check the manufacturing date in the bag before using. Generally, cement should be used before 90 days from the manufacturing date. Three months stored cement decreases its strength by 20-30 %, six months stored cement decreases its strength by 30-40% and 12 months stored cement decrease its strength by 40 50%

2. CEMENT COLOR:

The cement should be uniform in color. Good quality cement should have grey color with greenish shade.

3. CHECK FOR LUMPS:

No lumps should be present in the cement. Lumps are formed due to absorption of moisture from the climate.

4. RUBBING TEST:

Cement should feel smooth while rubbing in between fingers. If it gives a rough feeling that means cement is mixed with sand.

5. TEMPERATURE TEST:

Simply insert your hand into the cement bag, it should give cool feeling if its quality is good. Otherwise, you may feel warm because of hydration reaction.

6. FLOAT TEST:

Take some amount of cement and throw it in water. The cement should float for sometimes before it sinks in the water.

7. SETTING TEST: Make a thick cement paste with water and immerse it in water for 24 hours. It should be set and should not develop cracks.

8. STRENGTH TEST:

Prepare a cement block of 25 mm x 25 mm and 200 mm in length. Now submerge it in water for 7 days. Now place it on supports 15 cm apart and load it with 34 kg weight. Block made from good cement will not show any signs of failure.

Type	Unit	Sand	Aggregate	Usage
C-5	1	5	7	Lean concrete
C-15	1	3	5	Totally supported structure element
C-20	1	2	4	Used for slabs
C-25	1	2	5	Commonly used for grade of structure
C-30	1	1	1	For Chemical stores and nuclear

SHEAR WALL

➞SHEAR WALLማለት የአግዳሚ ወይም horizontal load ተፅዕኖዎችን የሚቋቋሙልን ግድግዳዎች ናቸው፡፡

⏩ሺር ዎል የተባሉበትም ምክንያት የመሬት መንቀጥቀጥ በጎን አቅጣጫ ስለሚመጣና ዎሎቹ ላይ የሺር ተፅዕኖ ስለሚያሳድር ነው (ሺር በ Thickness ትይዩ በሆነ አቅጣጫ እንደሚመጣ ልብ ማለት ይገባል፡፡

⏩Horizontal force የሆኑት Earth Quake እና Wind Load በዎሎቹ Thickness ትይዩ በሆነ አቅጣጫ ነው የሚመጡት)፡፡

⏩ሺር ዎሎች በትክክል ዲዛይን ተደርገው ትክክለኛ ቦታቸው ላይ ካልተቀመጡ ከጥቅማቸው ይልቅ ጉዳታቸው እጅግ ብዙ ነው::

ህንጻውን አፍራሽ ግብረ ሃይል ናቸው - ስለዚህ እንዴት ማስቀመጥ እንዳለብን ቀጥለን እንመልከት፡👇

1) አንድ ህንፃ ላይ የሚፈቀደው ትንሹ የሺር ዎል ብዛት ሶስት ነው፡፡ ቢያንስ-ሶስት

2) ሶስት ወይም ከዛ በላይ ሺር ዎሎች ካሉን የዎሎቹ አክሲሶች አንድ ነጥብ ላይ መገናኘት የለባቸውም::

3) ትይዩ እንዲሆኑ የሚፈቀደው ቢበዛ ለሁለት ዎሎች ነው፡፡ ሺር ዎሎች ከኮለንና ቢም ይልቅ የህንፃውን ጥንካሬ ወይም Stiffness ወደ ራሳቸው የመጎተት ከፍተኛ አቅም አላቸው ፤ እንደሚታወቀው የመሬት መንቀጥቀጥ act የሚያደርገው center of Mass ላይ ነው ፤ የመሬት መንቀጥቀጥን በተሻለ ሁኔታ ለመቋቋም ደግሞ የህንፃው ጥንካሬ ወይም Center of Stiffness የሚገኝበት ነጥብና የህንጻው Center of Mass የሚገኝበት ነጥብ በተቻለ መጠን መቀራረብ አለበት ፤ እናም ስናጠቃልለው - በትክክል ያልተቀመጡ ሺር ዎሎች የህንጻውን Center of Stiffness ወይም ጥንካሬ ወደራሳቸው ሲጎትቱት ከ Center of Mass እንዲርቅ ያደርጉታል በመራራቃቸው የተነሳ እሽክርክሪት ፎርስ ወይም Torsion ይፈጠራል፡፡ Torsion ህንፃው እንዲፈርስ ያደርገዋል፡፡

▶የኒውተን ሶስተኛ ህግ ምን ይላል... “The forces of action and reaction between interacting bodies are equal in magnitude, opposite in direction and COLLINEAR” – ሁለት ፎርሶች Collinear force የሚባሉት ደግሞ በአንድ መስመር act ሲያደርጉ ነው፡፡

የመሬት መንቀጥቀጡ CM ላይ Act ሲያደርግ CS ደግሞ በሺር ዎሎቹ ስለተጎተተ ሌላ ቦታ React ያደርጋል፡፡ በዚህ የተነሳ Collinear force አይደሉም ማለት ነው፡፡ ስለዚህ Newton Third Law ውድቅ ሆነ ማለት ነው፡፡ Action እና Reaction በመጠንም ይሁን በአቅጣጫ እኩል ስለማይሆኑ ትርፍ balance ያልተደረገ force ይፈጠራል - Newton First Lawን ታሳቢ በማድረግ ህንፃው Equilibrium ላይ አይሆንም ማለት ነው፡፡ የኒውተን ሁለተኛ ህግስ ማን አለው የሚል ሰው ካለ - በመሬት መንቀጥቀጥ ሳቢያ የሚፈጠረው ፎርስ ማለት የህንፃው ክብደት ሲባዛ በእንቅጥቃጤው የሚፈጠር Acceleration ነው - ይህም Newton Second Law ነው::

⏩ ስናጠቃልለው ከጥፋት ለመዳን ሺር ዎልን ስናስቀምጥ ከላይ ያሉትን ሶስት ነጥቦች ተግባራዊ ማድረግ አለብን፡፡

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THANKS!