Sl. No. (1)	Dimensions (2)	Designation (3)	5 m Platform (m, *Min*) (4)	7.5 m Platform (m, *Min*) (5)	10m Platform (m, *Min*) (6)
i)	Length		6.0	6.0	6.0
ii)	Width		1.5	1.5	1.5
iii)	From plummet: back to pool wall	A	1.5	1.5	1.8
iv)	Back to platform directly below		-	1.5	1.5
v)	From plummet to pool wall at side	B	3.9	4.5	5.2
vi)	From plummet to adjacent plummet	C	-	-	3.6
vii)	From plummet to pool wall ahead	D	10.5	11.0	13.7
viii)	On plummet from board to ceiling overhead	E	3.6	3.6	3.6
ix)	Clear overhead behind and each side plummet	F	2.7	3.0	5.0
x)	Clear overhead ahead of plummet	G	5.0	5.0	5.0
xi)	Depth of water at plummet	H	4.3	4.5	5.2
xii)	Bottom distance ahead of plummet	J	6.0	8.0	12.2
xiii)	Bottom depth ahead of plummet	K	3.3	4.0	4.5
xiv)	Bottom distance each side of plummet	L	3.6	4.0	4.3
xv)	Bottom depth each side of plummet	M	4.3	4.5	5.2

Starting Platforms

Starting Platforms may be from 0.50 m to 0.75 m above the surface of water. The maximum height of the platform above the water shall be 0.75 m where the water depth is 1.2 m or greater and 0.50 m when the water depth is less than 1.2 m. The surface area of each platform shall be 0.5 m x 0.5 m with a maximum slope of not more than 10^{o}. Surface of each block shall be covered with non-slip material and with back stroke hand grip facility.

Walkways and Deck Areas

Pools shall be completely surrounded by a deck that is at least 1.2 m in width and extends completely around and adjacent to the pool. There shall be no obstructions or interruptions of the pool deck within the 1.2 m adjacent to the pool other than necessary structural supports, or appurtenances such as diving boards, slides, perimeter overflow systems, or handrails. A clear, unobstructed walkway at least 1.1 m in width shall be maintained at such obstructions or interruptions.

Structural supports located within the minimum required deck width or within 1.2 m of the swimming pool shall be no closer than 3 m apart measured parallel to the adjacent perimeter of the pool, with the dimension of any single support in a plane parallel to the adjacent pool perimeter no greater than 1 m and the sum of all such support dimensions no greater than 10 percent of the pool perimeter.

The deck between two adjacent swimming pools shall be at least 2.5 m wide. All decks and walkways shall have an unobstructed overhead clearance of at least 2 m.

Synthetic material which meets the following criteria may be installed for deck coverings:

a) Non-fibrous and allows drainage such that it will not remain wet or retain moisture;
b) Inert and will not support bacterial or fungal growth;
c) Durable;
d) Cleanable; and
e) Provides a slip-resistant finish.

The decks and walkways shall have a paved surface. The surface of the pool deck, and other surfaces used for foot contact, such as gratings of perimeter overflow systems, shall be slip-resistant.
The outer perimeter of the deck for outdoor pools shall be at least 10 cm higher than the surrounding ground surface except where access is provided to adjacent turf areas.

Recirculation System - Each swimming pool shall be provided with a recirculation system which will convey, clarify, chemically balance and disinfect the swimming pool water. The recirculation system shall include pumps, piping, filters, chemical feed equipment, and associated controls and monitoring devices. A swimming pool recirculation system shall be capable of processing one pool volume of water in six hours or less. A wading pool recirculation system shall be capable of processing one pool volume of water in two hours or less.

Electrical Installation – Lighting
Artificial lighting shall be provided at all indoor pools and at all outdoor pools that are open for use after sunset in accordance with one of the following:

i) Underwater lighting of at least 8.35 lumens or 5.5 watts per square metre of pool water surface area, located to provide illumination of the entire pool floor; plus area lighting of at least 10 lumens or 6.6 watts per square metre of deck area.
ii) If underwater lights are not provided, at least 33.5 lumens or 2.2 watts per square metre of pool water surface area and deck area.

Where portable electric vacuum cleaning equipment is used, electrical receptacles with ground-fault circuit interrupter protection shall be provided. Separation between receptacles shall be a maximum of 30 m. All receptacles installed in the swimming pool area shall have waterproof covers and ground-fault circuit interrupter protection.Lighting controls should not be accessible to the public.

Ventilation
Adequate ventilation shall be provided in facilities to prevent objectionable odour.

Shower and bathroom

Separate shower, dressing booth and sanitary facilities shall be provided for each gender. This may not be applicable for schools and other institutional use where a pool may be open to one gender at a time. The rooms should be well lit, drained, ventilated, and of good construction, using impervious materials. They should be developed and planned to ensure maintenance of good sanitation throughout the building at all times. Floors should have a slip-resistant surface and sufficiently smooth to ensure ease in cleaning.

SWIMMING POOL WATER TREATMENT SYSTEM

Water supplied to a public swimming pool and all related plumbing fixtures, including drinking fountains, lavatories and showers, shall at all times meet the quality standards. A water treatment system shall be provided to filter, chemically balance and disinfect the swimming pool water. The system shall be so designed for the recirculation flow rate that turnover period shall not exceed 8 h in case of diving pool, 2 h for wading pool, and 6 h for other pools.

Hair and Lint Strainer

A hair and lint strainer shall be installed on the suction side of the pump except on vacuum filter systems. The strainer basket shall be easily removable. Valves shall be installed to allow the flow to be shut off during cleaning, switching baskets, or inspection.

Inlets

Inlets for filtered water shall be located and directed suitably to produce uniform circulation of water to facilitate the maintenance of a uniform disinfectant residual throughout the entire pool without the existence of dead spots, and to produce surface flow patterns that effectively assist skimming.

Outlets

Pools shall be provided with a main drain at the deepest point. The main drain shall be connected to the recirculation system. Openings must be covered by grating which cannot be removed without the use of tools. Openings of the grating shall be at least four times the area of the main drain pipe or have an open area. The maximum width of grate openings shall be 3.5 cm. Main drains and all other suction outlets installed in the pool shall be designed to prevent bather entrapment.

Make-up Water

Make-up water shall be added through a fixed air gap of at least 15 cm to the pool, surge tank, vacuum filter tank, or other receptacle. When make-up water is added directly to the pool, the fill-spout should be located under a low diving board or immediately adjacent to a ladder rail, grab rail, or fixed lifeguard chair.

Filtration

The design filtration rate in the particular application in which the filter is utilized shall not exceed the maximum design filtration rate for which the filter was installed.

Wash or backwash water from diatomaceous earth filters shall be passed through a separation tank designed for removal of suspended diatomaceous earth and solids, prior to disposal.

Disinfection

The pool water shall be continuously disinfected by suitable disinfecting agent that imparts easily measured residual. Gaseous chlorine, chlorine compounds, bromine compounds or other bactericidal agents should be used to maintain the quality parameters of water as specified in clause 8 of the standard.

Depth Markers

The depth of water shall be marked at or above the water surface on the wall of the pool and on the edge of the deck next to the pool so as to be readable by persons entering or in the pool. Depth markings shall be provided at the shallow and deep ends of the pool, the transition point, and the point of maximum depth, and shall be spaced at not more than 7.5 m intervals measured peripherally, except that depth markings are not required at a zero-depth edge.

Depth markers shall indicate pool depth in metric system, and shall be of a color that contrasts with the background. Numerals indicating depth shall be a minimum of 10 cm high.

In shallow areas, "no diving" markers or symbols at least 10 cm high must be located at not more than 7.5 m intervals around the pool perimeter except at a zero-depth edge.

Disinfectant Residual

- Where chlorine is used as a disinfectant, the chlorine residual shall be maintained between 1.0 and 4.0 ppm. as free chlorine residual. A free chlorine residual of at least 2.0 ppm shall be maintained when the pool water temperature exceeds 30oC.
- Where bromine is used as a disinfectant, a bromine residual shall be maintained between 2.0 and 8.0 ppm. as total bromine. A bromine residual of at least 4.0 ppm. shall be maintained when the pool water temperature exceeds 30oC.
- Where chlorinated cyanurates are used, the cyanuric acid concentration shall not exceed 100 ppm.
- Where silver/copper or copper ion generators are used, the concentration of copper shall not exceed 1.3 ppm. and the concentration of silver shall not exceed 0.05 ppm. Where ozone is used, the ambient air ozone concentration shall be less than 0.1 ppm at all times either in the vicinity of the ozonator or at the pool water surface.

For all other physical, chemical and bacteriological parameters the quality of water used in swimming pools in continuous circulation type shall conform to IS 3328.

OPERATION AND MAINTENANCE

Pool and Pool Area : The swimming pool shall be maintained free from sediment, lint, dirt and hair. The walls, ceilings, floors, equipment and the pool area shall be properly maintained so that they are protected from deterioration. Cracks and other defects in the pool, if appear, should be repaired. All equipment shall be maintained in proper condition, with all required components in place.

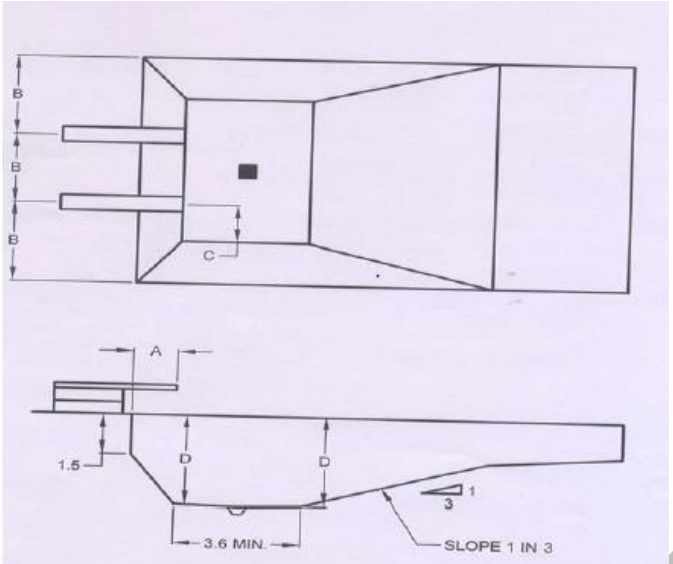
Indoor pool decks shall be disinfected at least weekly. No furniture, plants or other furnishings shall be placed within 1.2 m of the pool. This area should be kept free of obstructions. Starting blocks should be securely anchored when in use but removed or prohibited from use when not being used in conjunction with competitive swimming or training.

Perimeter Overflow and Skimmers : The perimeter overflow systems or automatic surface skimmers should be kept clean The flow through each skimmer shall be adjusted as often as necessary to maintain a vigorous skimming action which will remove all floating matter from the surface of the water. The pool water should be maintained at an elevation such that effective surface skimming is accomplished. For pools with perimeter overflow systems, adequate surge storage capacity should be maintained so that flooding of the perimeter overflow system does not occur during periods of peak usage.

Inlet Fittings : Inlets should be checked frequently so that the rate of flow through each inlet establishes a uniform distribution pattern. Inlets in pools with surface skimmers shall be adjusted as necessary to provide vigorous skimming.

Security: Doors or gates in the swimming pool enclosure shall be kept closed and locked when the swimming pool is closed.

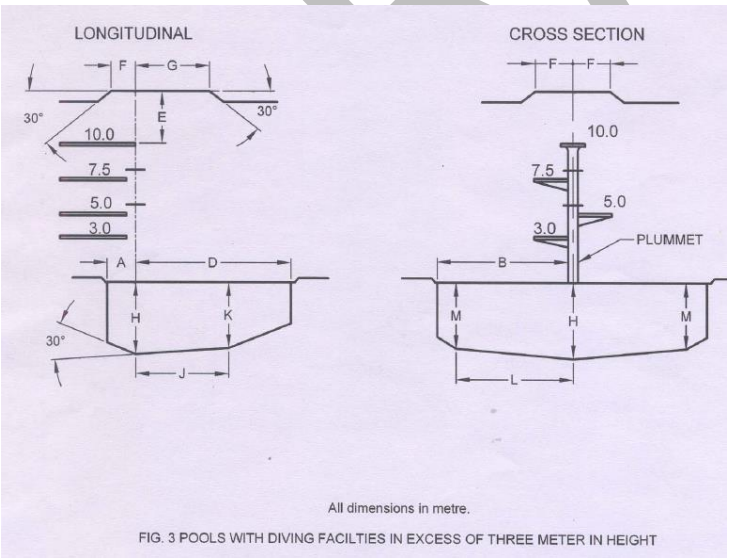
Diving Equipment: Diving equipment for swimming pool with diving facility shall be maintained in a safe condition, be securely anchored, and have a slip-resistant surface.



All dimensions in metre.

FIG. 2 GENERAL POOL WITH DIVING AREA DIMENSIONS

Minimum distance indicated	≤ 0.5	1	3
A – End wall to Tip of Board	1	1.5	1.5
B – Center of board to sidewall or adjacent board	3	3	3.6
C – Center of board laterally to point of required depth	1.2	1.2	1.8
D – Depth at end of board and for beyond 3.6 m,	2.8	3	3.6



All dimensions in metre.

FIG. 3 POOLS WITH DIVING FACILTIES IN EXCESS OF THREE METER IN HEIGHT

RAINWATER HARVESTING

In some of the developed countries, the shortage of water even for drinking purpose is a perpetual phenomenon throughout the world, especially, in developing and underdeveloped countries. Countries like Slovakia, Israel, use water about 4-5 times before disposing off, however, in India it is used only once before being disposed. This is certainly not a very encouraging situation. Water stored in streams, Lakes, and soil evaporates while water stored in plants transpires to form clouds, which store the water in the atmosphere. The never-ending exchange of water from the atmosphere to the oceans and back again is known as the hydrologic cycle. This cycle is the source of all forms of precipitation (hail, rain, sleet and snow), and thus of all water. Making the most efficient use of this limited and precious resource is essential. This includes using appliances and plumbing fixtures that conserve water, not wasting water and taking advantage of alternative water sources such as grey water reuse and rain water harvesting.

Rain water harvesting and conservation, is the activity of direct collection of rainwater. The conservation of rainwater so collected can be stored for direct use or can be re-charged into the ground water. The main goal is to minimize flow of rainwater through drains/ nallas to the rivers without making any use of the same. It is a known fact that the ground water level is depleting and going down and down in the last decades. Thus rainwater harvesting and conservation aims at optimum utilization of the natural resource, that is, rain Water, which is the first form of water that we know in the hydrological cycle and hence is a primary source of water for us. The rivers, lakes and ground water are the secondary sources of water. In present times, in absence of rain water harvesting and conservation, we depend entirely on such secondary sources of water and in the process it is forgotten that rain is the ultimate source that feeds to these secondary sources.

Rain Water Harvesting & Conservation means to understand the value of rain and to make optimum use of Rain Water at the place where it falls.

In Artificial recharge techniques normally address to following issues:

(i) To enhance the sustainable yield in areas where over development has depleted the aquifer.

(ii) To utilize the rainfall runoff which is going to sewer or storm water drain.

(iii) Conservation and storage of excess surface water for future requirements, since the requirements often change within a season or a period.

(iv) Surface water is inadequate to meet our demand and we have to depend on ground water.

(v) Due to rapid urbanization, infiltration of rainwater into the sub soil has decreased drastically and recharge of ground water has diminished.

(vi) To arrest seawater ingress.

(vii) To improve the vegetation cover and reduce flood hazard

(viii) To raise the water levels in wells and bore wells that are drying up. To remove bacteriological and other impurities from sewage and waste water so that water is suitable for reuse.

(ix) To improve the quality of existing Ground Water through dilution.

(x) To reduce power consumption.

The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development.

There are two main techniques of rainwater harvesting:

(i) Storage of rain water on surface for future use

(ii) Recharge to ground water

Collecting, storing and putting to use rooftop rainwater from houses or any construction is rooftop rainwater harvesting. Rainwater harvesting can also be collecting, filtering and recharging Ground Water through percolation pits, open wells or bore wells. Rain Water Harvesting can be defined as activity of direct collection and storage of Rain Water as well as other activities aimed at harvesting and conserving surface and Ground Water and prevention of loss through evaporation and seepage.

ROOF TOP RAIN WATER HARVESTING

Roof top Rain Water harvesting is the technique through which Rain Water is captured from roof catchments and stored in tanks/ reservoirs/Ground Water aquifers. It consists of conservation of roof top Rain Water in urban areas and utilizing it to augment Ground Water storage by artificial recharge. It requires connecting the outlet pipe from root top to divert collected water to existing well/tube well/bore well or a specially designed well.

Roof Top Rain Water Harvesting & Conserving Systems, both small and large are comprised of six basic components as described below:

(i) Catchment Area/Roof: Surface upon which rain falls

(ii) Gutters and Downspouts: transport channels from catchment surface to storage

(iii) Leaf Screens and Roof Washers: Systems that remove contamination and debris.

(iv) Cisterns or Storage Tanks: where collected Rain Water is stored

(v) Conveying: the delivery system for treated Rain Water, either by gravity or pump

(vi) Water Treatment: filters and equipment and additives to settle, filter and disinfect.

The system involves collecting water that falls on zinc, asbestos or tiles roof of a house during rain storms, and conveying it by an Aluminium, PVC wood or plastic drain or collector to a nearby covered storage unit or cistern. Rain Water yield varies with the

size and texture of the catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity.

SIZING OF RAIN WATER PIPES FOR ROOF DRAINAGE

S.No.	Diameter of pipe (mm)	Average rate of Rain Fall (mm per hour)					
		50	75	100	125	150	200
		Roof Area (Sqm)					
(i)	50	13.4	8.9	6.6	5.3	4.4	3.3
(ii)	65	24.1	16.0	12.0	9.6	8.0	6.0
(iii)	75	40.8	27.0	20.4	16.3	13.6	10.2
(iv)	100	85.4	57.0	42.7	34.2	28.5	21.3
(v)	125	-	-	80.5	64.3	53.5	40.0
(vi)	150	-	-	-	-	83.6	62.7

(Extract from SP-35)

This Table will help in determining the number of pipes of particular diameter required for given roof surface area and average of rate of rain fall in millimeter per hour for that area.

Storage Tanks

The quantity of water stored in a water harvesting system depends on size of the catchment area and the size of the storage tanks. The storage tanks have to be designed according to the water requirements, rain fall and catchment availability.

Settlement tank

Settlement tanks are used to remove silt and other floating impurities from rain water. Settlement tank is like an ordinary container having provision for in flow, out flow and over flow. Settlement tank can have an unpaved bottom surface to allow standing water to percolate into the soil. Apart from removing silt from water the desilting chamber acts like a buffer in the system.

For designing the optimum capacity of the tank, following aspects have to be considered:

(i) Size of catchment
(ii) Intensity of rainfall
(iii) Rate of recharge

Since the desilting tank also acts as buffer tank, it is designed such that it can retain a certain amount of rainfall, since the rate of recharge may not be comparable with the rate of runoff. The capacity of tank should be enough to retain the run off occurring from conditions of peak rain fall intensity.

Any container with adequate capacity of storage can be used as a settlement tank. Generally masonry or concrete underground tanks are preferred since they do not occupy any surface area. For over ground tanks pre-fabricated PVC or ferro cement tanks can be used and prefabricated tanks are easier to install so it should be preferred.

Recharge structures

The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development and usage. Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and type of recharge structures. In particular, the features parameters and data to be considered are: geological boundaries, hydrological boundaries, inflow and outflow of water, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of aquifer, tectonic boundaries. The aquifers best suited for artificial recharge are those aquifers which absorb large quantity of water and do not release the same too quickly.

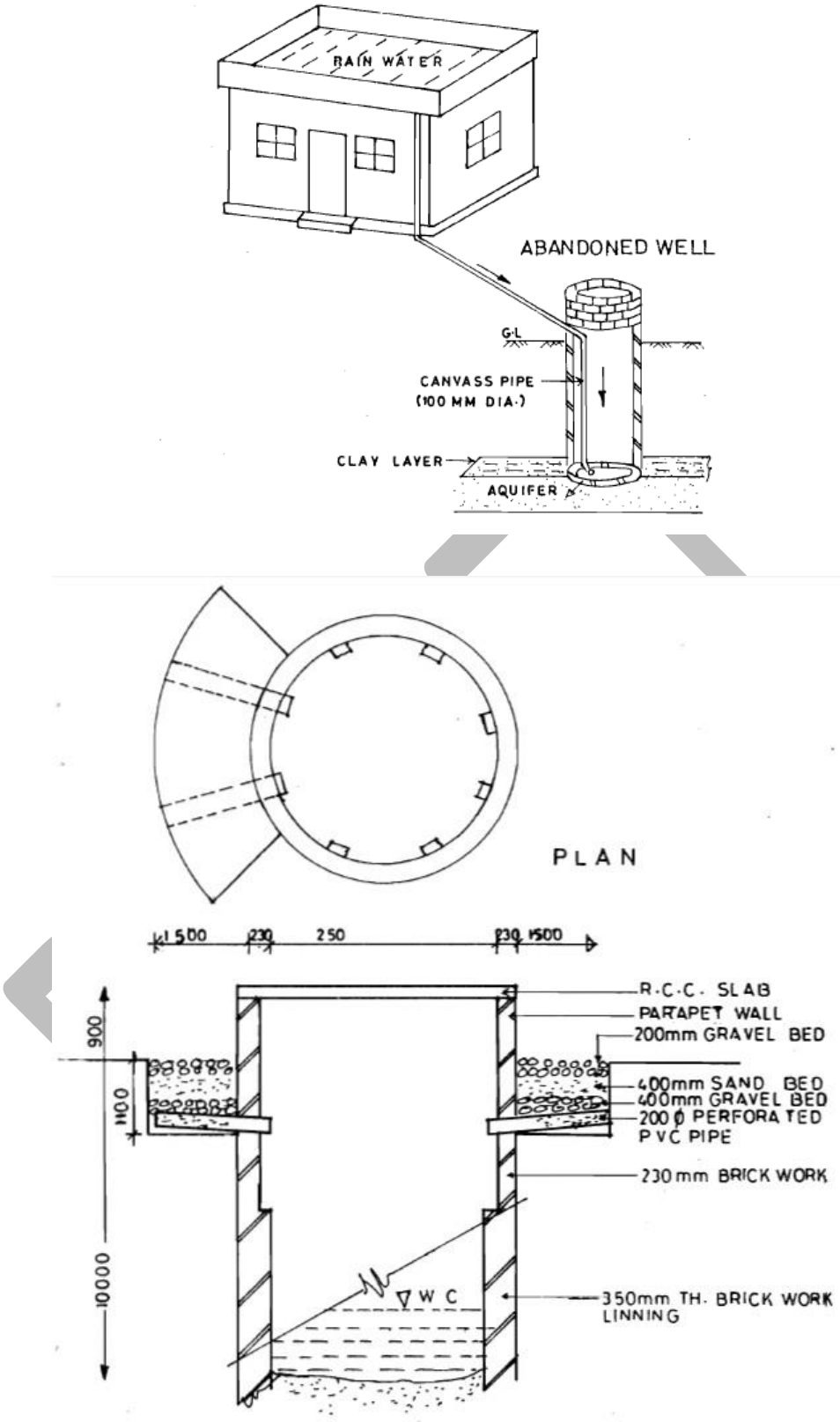
The various type of recharge structures are:

(i) Recharge through Abandoned Dug Well
(ii) Recharge through Hand Pump
(iii) Recharge pit
(iv) Recharge through Trench
(v) Gravity Head Recharge Tube Well
(vi) Recharge Shaft

Design guidelines: In general the recharge structures are designed with total volume as twice peak discharge as detailed below:

Abandoned Dug Well

(i) A dry/unused dug well can be used as a recharge structure
(ii) The recharge water is guided through a pipe to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.
(iii) Before using the dug well as recharge structure, its bottom should be cleaned and all the fine deposits should be removed
(iv) Recharge water should be silt free as far as possible.
(v) It should be cleaned annually preferably.
(vi) It is suitable for large building having the roof area more than 1000 Sqm
(vii)The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.



Details of Recharge Dug well

ABANDONED I RUNNING HANO PUMP

(i) An abandoned/running hand pump can be used for recharge

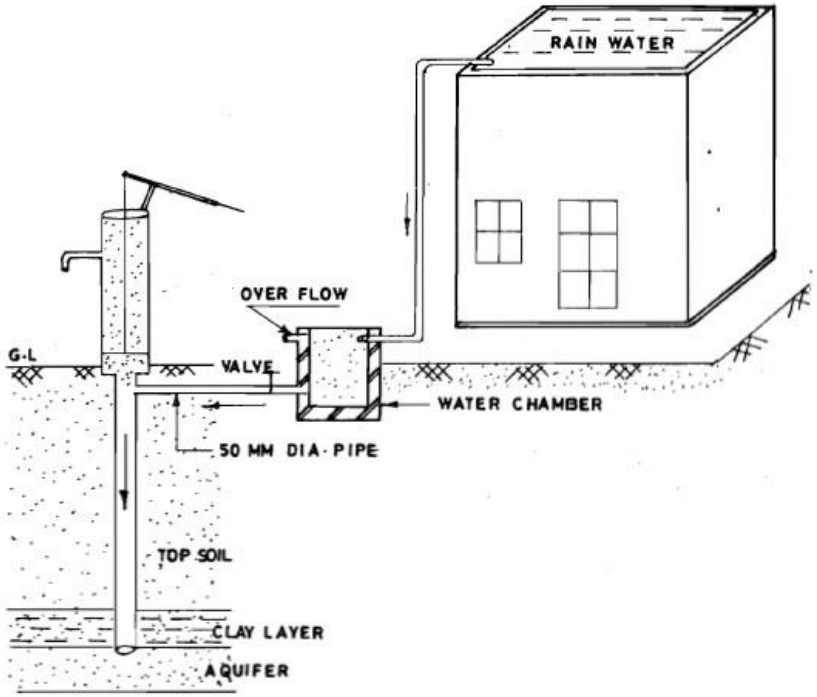
(ii) The structures are suitable for the small building having the roof area upto 150 Sqm

(iii) Water is diverted from rooftop to the hand pump through pipe of 50 to 100 mm diameter

(iv) For running hand pump a closing valve is fitted in conveyance system near hand pump to avoid entry of air in suction pipe

(v) Recharge water should be silt free

(vi) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.



Recharge through Hand pump

Recharge Pit

(i) Recharge pits are constructed for recharging the shallow aquifer.

(ii) These are constructed generally 1 to 2 m wide and 2 to 3 m deep

(iii) After excavation, the pits are refilled with pebbles and boulders

(iv) Water to be recharged should be silt free as far as possible.

(v) Cleaning of the pit should be done annually preferably.

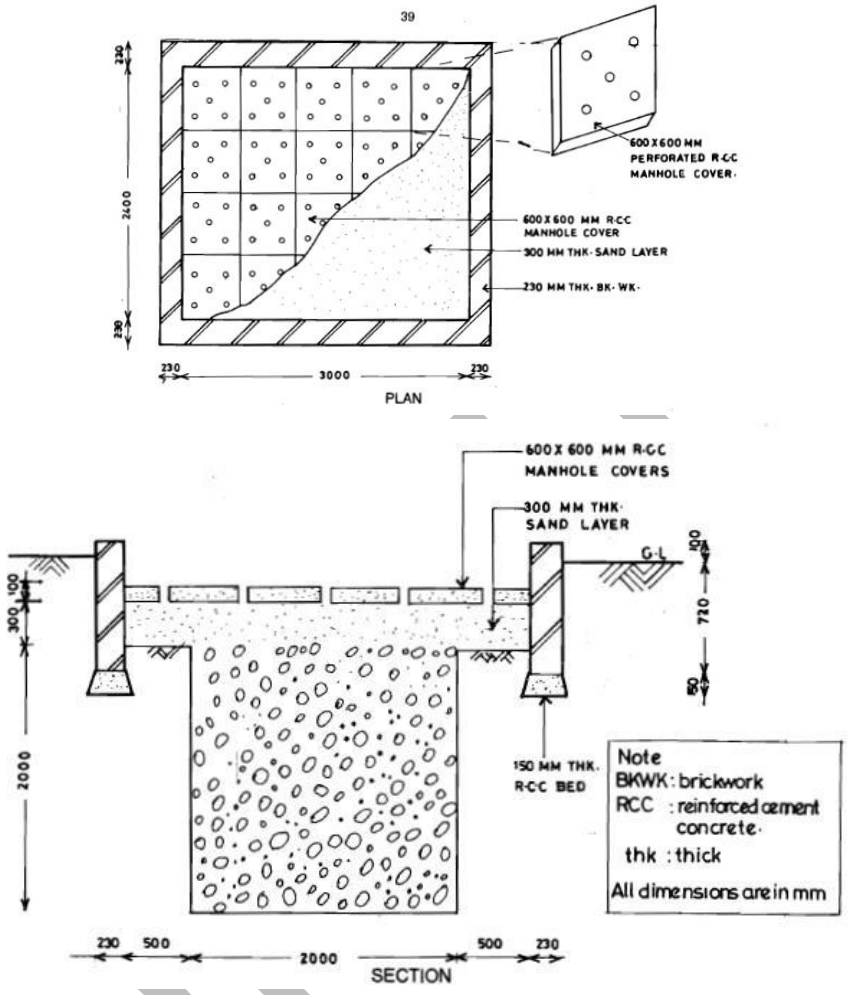
(vi) It is suitable for small buildings having the roof top area upto 100 Sqm

(vi) Recharge pit may be of any shape i.e. circular, square or rectangular.

(vii) The run off of 1st rain should not be allowed to go percolate to the rain

water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

(ix)If the pit is of trapezoidal shape, the side slopes should be steep enough to avoid silt deposition.



Details of Recharge Pit

Recharge Trench (Ref Drawing N0.13& 14)

(i)It is constructed when permeable strata of adequate thickness is available at shallow depth

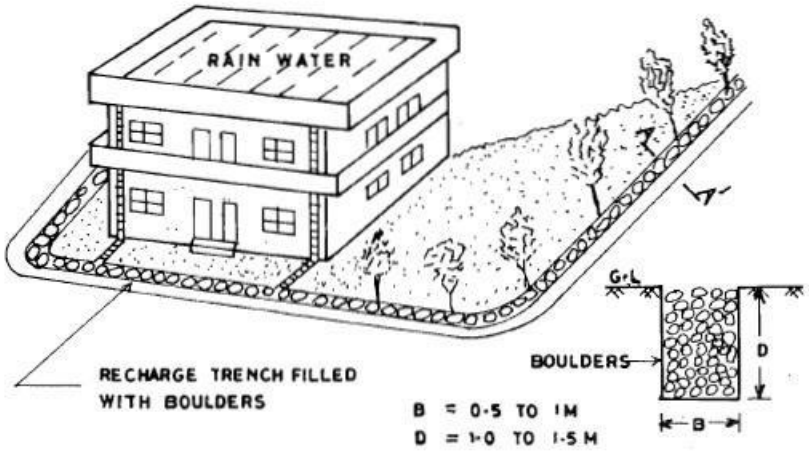
(ii) It is a trench of shallow depth filled with pebbles and boulders

(iii) These are constructed across the land slope

(iv) The trench may be 0.5 to 1 m wide 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of land and roof top area

(v) It is suitable for the buildings having the roof area of 200 to 300 Sqm

(vi) Cleaning of trench should be done periodically.



Recharge through Trench

Gravity Head Recharge Well (Ref Drawing No15 To 19)

(i) Bore wells/tube wells can be used as recharge structure

(ii) This technique is suitable where

(a) Land availability is limited

(b) When aquifer is deep and over laid by impermeable strata (clay)

(iii)The roof top Rain Water is channelised to the well and recharges under gravity flow condition.

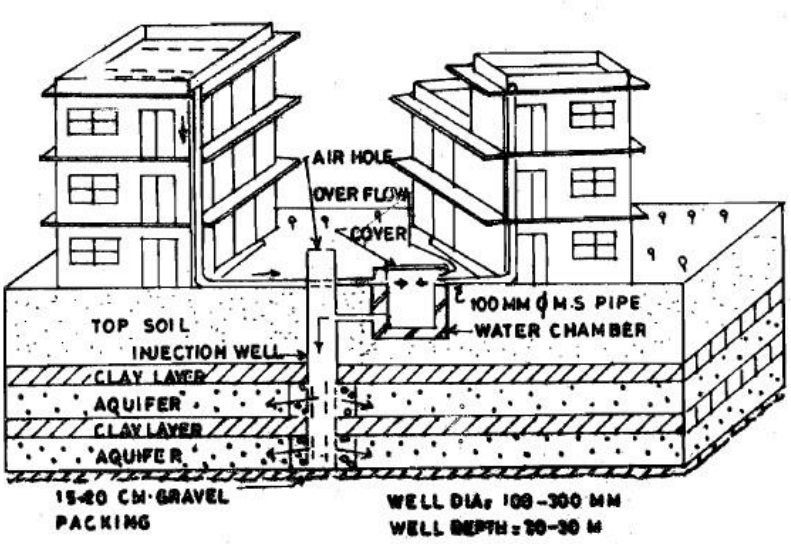
(iv)Recharge water should be silt free as far as possible.

(v) The well can also be used for pumping

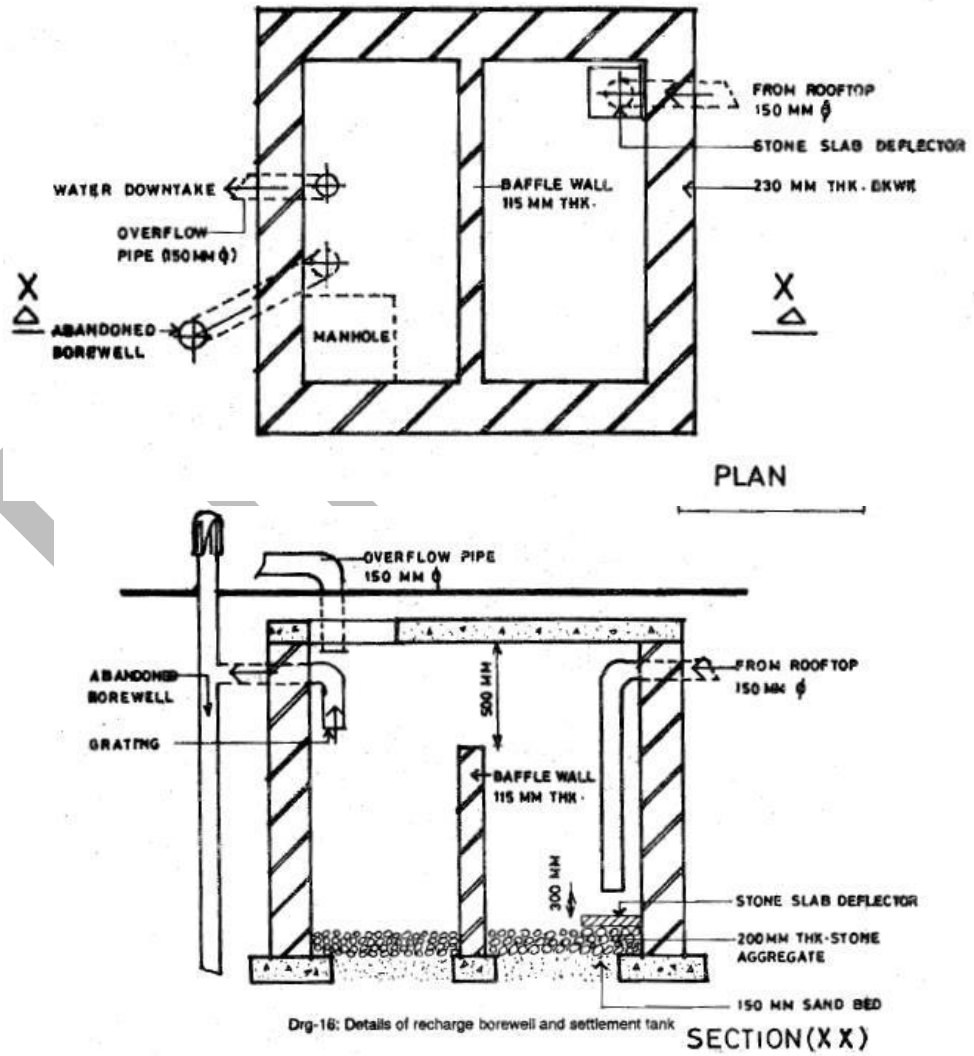
(vi) Most suitable for the areas where Ground Water levels are deep

(vii)The number of recharging structures can be determined in limited area around the buildings depending upon roof top area and aquifer characteristics.

(viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

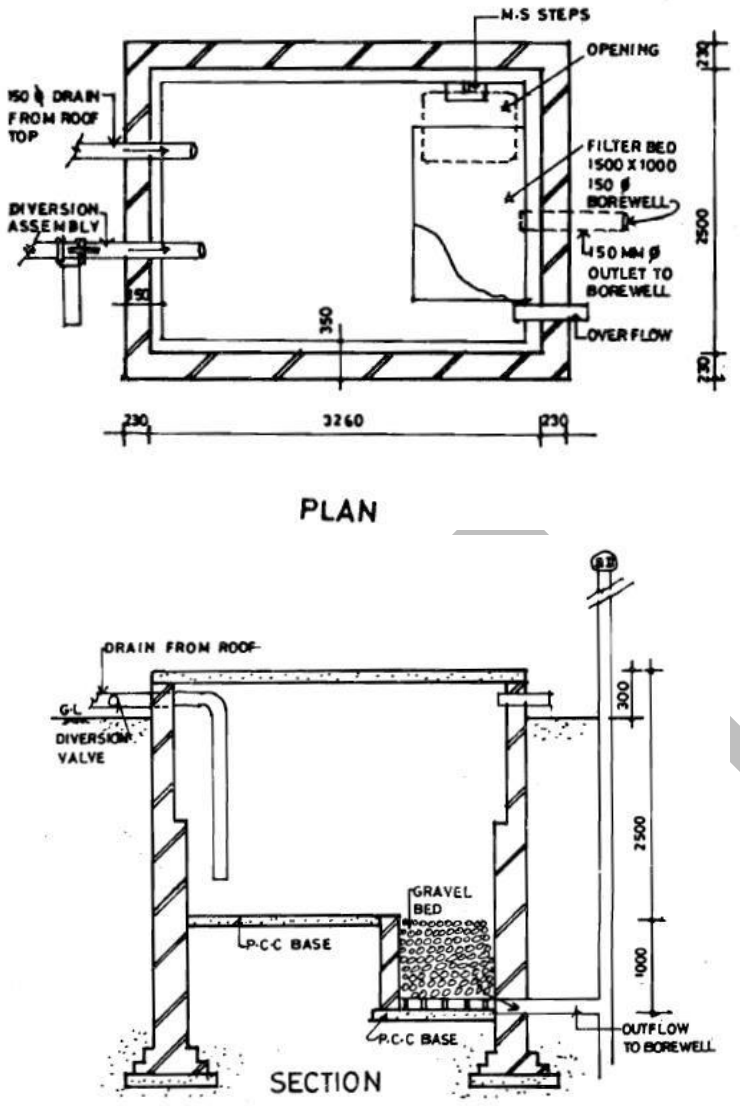


Gravity head recharge Tube Well



Drg-16: Details of recharge borewell and settlement tank

Details of Recharge Borewell and Settlement Tank



Details of Recharge Borewell and Filtration Tank

Recharge Shaft (Ref Drawing No.20 To 22)

(i)A recharge shaft is dug manually or drilled by the reverse/direct rotary method

(ii)Diameter of recharge shaft varies from 0.5, to 3 m depending upon the availability of water to be recharged.

(iii) It is constructed where the shallow aquifer is located below clayey surface.

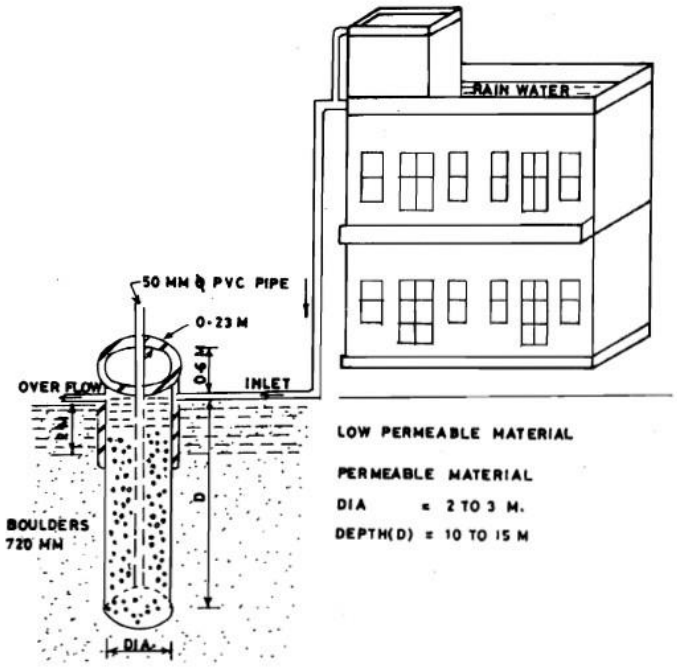
(iv) Recharge shaft is back filled with boulders, gravels and coarse sand

(v) It should end in more permeable strata (sand)

(vi) Depth of recharge shaft varies from 10 - 15 m below ground level

(vii)Recharge shaft should be constructed 10 to 15 m away from buildings for the safety of building

(viii)It should be cleaned annually preferably by scraping the top layer of sand and re-filling it accordingly.



Recharge Shaft

Maintenance of recharge structure

Roof Top Rain Water Harvesting for Ground Water recharge involves injection of rain water in to the aquifer through recharge trench cum tube wells under gravity flow. The surface water although treated through the filter bed may cause clogging after comparatively short periods of injection. In this case through the precaution is taken, there is a probability of silt being injected into the recharge wells and may cause clogging. Short periods of pumping quickly remove the clogging particles and improve the recharge capacity. Annual redevelopment of recharge wells by air compressor is recommended for improving the recharge capacity of trench cum recharge wells. Moreover silt deposited on sand bed also reduces the recharge rate. This also needs periodic removal of the finer material by scraping.

Guidelines for action plan for artificial recharge project

(i) Collect basic data on topography, rainfall pattern of that area, hydro-geology aquifer situation, land-source water availability. Identify the methods which is most suitable

(ii) With reference to the local conditions of the area, further identify the most appropriate techniques of artificial recharge suitable at various sites/ locations on the basis of total available volume of rainwater which can be harvested and the location of available

aquifer, whether it is at shallow depths i.e. 6 to 8 meters from ground level or at sufficient depths i.e. more than 8 meters from ground level.

(iii) Determine the number of each type of artificial recharge structure needed to achieve the quantitative targets. The recharge structure should be designed with volume of water it may store for equivalent of 24hours rainfall and surface area of run-off for which the recharge structure has been considered, without giving any allowance for percolation during this period of 24 hours.

(iv) For individual structure at different locations ,finalise the design specifications from the details given in case studies. If required ,the necessary advice from local Geological Department or Central Ground Water Board may be obtained.

(v) Finalise the design of the conveyance system required to bring the source water to the recharge structure site and the treatment required in the form of settlement tanks.

(vi) Plan the required monitoring system to evaluate the efficiency of recharge scheme and ensure regular maintenance of recharge structures before onset of monsoon every year.

In a given plot, attempt should be made to keep the maximum plot area as katcha area which allows rain water for percolation to ground water. The rain water from seasons first rain should normally not be used for percolation to recharge structure because it contains pollutants from the air and catchment surface. For such water suitable arrangement for by-pass in pipe system should be introduced. A suitable provision should be made if possible to allow rain water to percolate to ground water after passing it through settlement tank because such rain water contains silt which is deposited on sand bed and reduces the percolation rates. The recharge structure should be made on a plot at the places of lower levels I elevations so that rain water may flow towards it under normal gravitation flow .

On a vast and sloppy land patch, the contour bunds preferably of mud with height varying from 15 cm to 30 cm should be made to store run off temporarily over the katcha land area, thus allowing more time for percolation of water to the ground water and arresting the flow of run off to the drains I sewers. For recharge of runoff from roads suitable arrangements in the foot path by introducing some katcha area should be made. In large residential and office complexes the drive ways, pucca path and areas should had some katcha area which may facilitate rain water to percolate to ground water.

Artificial recharge techniques are adopted where:

(i) Adequate space for surface storage is not available specially in urban areas.

(ii) Water level is deep enough (more than 8 mtr) and adequate sub- surface storage is available.

(iii) Permeable strata is available at shallow/moderate depth upto 10 to 15 m.

(iv) Where adequate quality of surface water is available for recharge to ground water
(v) Ground water quality is bad and our aim is to improve it
(vi) Where there is possibility of intrusion of saline water especially in coastal area.
(vii) Where the evaporation rate is very high from surface water bodies.

The decision, whether to store or recharge rain water, depends on the rain fall pattern of a particular region.

(i) If the rain fall period between two spells of the rain is short i.e. two to tour months, in such situation a small domestic size water tank for storing rain water for drinking and cooking purpose can be used.
(ii) In other regions, where total annual rain fall occurs only during 3 to 4 months of monsoon and the period between two such spells is very large i.e. 7 to 8 months, so it is feasible to use rain water to percolate to the ground water aquifers rather than for storage which means that huge volumes of storage container are required.

12. QUALITY CONTROL

Quality control is the techniques/ tests for controlling quality and quality assurance is defined as the process to ensure the product is fit for the purpose for which it was intended. The basic idea of quality control/ quality assurance is that the contractor has to perform the necessary tests and inspection to ensure that all the works in road construction meet the specification. The contractor is responsible for the work from the beginning till the final acceptance of all the works and the expiry of any defects liability period.

Quality is required at all stages of the project whether it is buildings, bridges, small culverts, roads, etc. Quality materials and workmanship are required at all stages. All works shall comply with the requirements of the contract and be in accordance with specification and relevant clauses of the latest edition of the MoRTH specification for roads and bridge works and other such guidelines.

The contractor will carry out the works in a responsible and orderly fashion with least disruption to the public and in accordance with the safety, environmental and social requirements of the contract. Adequate provision in accordance with the contract requirements shall be provided for the safe movement of traffic and people through the worksite. The contractor shall arrange and pay for tests carried out at the frequencies specified. Test results must accompany relevant bill to verify that work completed complies with the requirements of the contract. Tests shall be carried out at laboratories approved by the engineer which have calibrated equipment and skilled personnel capable of carrying out the desired test in accordance with the relevant IS codes.

List of typical equipment that needs to be checked/ calibrated for road/ bridge works

Item	What needs to be checked
Level	Line of collimation
Measuring tapes	Accuracy against standard
Rollers	Drums are smooth and round
PTR rollers	Tyre pressure is correct
Graders	Blades are straight
Pavers	Boards are flat segments are aligned and angle of attack correct hydraulics smooth
Trucks	Mechanically sound, tyres at correct pressure
Thermometers	Checked against standard
Weigh-Scales	Calibrated with standard weights
Laboratory equipment	Must all be checked against standards (see IRC codes)

Requirements of Materials for Earth Work

The material used for embankment/ subgrade construction can be from roadway excavation or from borrow pits.

The essential physical requirements of embankment/ subgrade materials are;

(a) Size of coarse material: max 75 mm for embankment and max 50mm for subgrade

(b) Liquid limit: max 70%

(c) Free swelling index: max 50%

(d) Plasticity index: max 45%

(e) Maximum dry density(MDD):minimum 1.52 gm/cc

(f) CBR value: minimum 5% for embankment and 8%minimum for subgrade

(g) Thickness of each compacted layer should not be more than 200 mm.

(h) Field density: 95% of MDD for embankment layers and 97% of MDD for subgrade layers.

Requirements of Materials for Sub-Base

The material to be used for sub-base work shall be natural sand, moorum, gravel, crushed stone or combinations thereof depending upon the grading requirement. The physical requirements of the materials for sub-base are

(a) 10 per cent fines value in soaked condition: min 50 KN

(b) Water absorption: max 2%.

Requirements of Materials for Base Course

Physical Requirements of Aggregates for WBM

The requirements for aggregates used are

(a) Los Angeles abrasion value: max 40%

(b)Aggregate impact value: max 30%

(c) Combined Flakiness and Elongation index: max 30%.

Grading requirement of the aggregate

Grading No	Sieve range	Sieve size (mm)	% by weight passing
1	90-45	125 90 63 45 22.4	100 90-100 25-60 0-15 0-5

2	63-45	90 63 53 45 22.4	100 90-100 25-75 0-15 0-5
3	53-22.4	63 53 45 22.4 11.2	100 95-100 65-90 0-10 0-5

The screenings used to fill the voids have to satisfy gradation given below. When gravel is used the liquid limit should be less than 20 and the plasticity index less than 6%. Percent passing 75-micron sieve should not be more than10%.

Grade classification	Size of screening(mm)	Sieve size (mm)	% By weight passing
A	13.2	13.2 11.2 5.6 180mc	100 95-100 15-35 0-10
B	11.2	11.2 5.6 180mc	100 90-100 15-35

Requirements of Materials for Bituminous Macadam

The physical requirements of aggregate used for bituminous macadam are,

(a)Los Angeles abrasion value: max 40%

(b) Aggregate impact value: max 30%

(c) Flakiness and elongation (total): max 30%

(d) Water absorption: max 2%

(e) Soundness: max loss of weight 12% for sodium sulphate and 18% for magnesium sulphate.

Grading requirement

IS sieve designation	Percent by weight passing sieve	
	Grading-1	Grading-2
45.0 mm	100	

26.5 mm	75-100	100
22.4 mm	60-95	75-100
11.2 mm	30-55	50-85
5.6 mm	15-35	20-40
2.8 mm	5-20	5-20
90 microns	0-5	0-5

Bitumen content for pre mixing shall be 3 to 3.5 per cent by weight of total mix. The maximum compacted layer thickness shall be 100 mm. Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity.

Temperature

For binder at the time of mixing : 150-163 Degrees

For aggregate at the time of mixing : 155-163 Degrees

For mix at the plant : 130-160 Degrees

For laying at site : 120-160 Degrees

Rolling operation shall be completed before temperature of mix falls below 100 degrees.

Requirements of Materials for Bituminous Penetration Macadam

The physical requirements of aggregates shall be the same as that of bituminous macadam. Quantities of materials required for 10 sq.m area for bituminous penetration macadam is given below.

Compacted thickness	**Binder**	**Coarse aggregate**	**Key aggregate**
	Straight run bitumen		
50 mm	50 kg	0.60 cu.m	0.15 cu.m
75 mm	68 kg	0.90 cu.m	0.18 cu.m

Grading requirement

IS Sieve Designation	**Per cent by weight passing sieve**			
	For 50 mm compacted thickness		**For 75mm compacted thickness**	
	Coarse aggregate	**Key aggregate**	**Coarse aggregate**	**Key aggregate**
63 mm			100	
53 mm				
45 mm	100		58-82	

26.5 mm	37-72			100
22.4 mm		100	5-27	50-75
13.2 mm	2-20	50-75		
11.2 mm				5-25
5.6 mm		5-25		
2.8 mm	0-5	0-5	0-5	0-5

Dry and clean coarse aggregate shall be spread uniformly and evenly at the rate specified by the above table. After the coarse aggregate has been rolled and checked, the bituminous binder shall be applied at specified temperature, the rate of application given in the above table.

Immediately after the first penetration of bitumen, key aggregate in a clean and dry state shall be spread uniformly over the surface by means of an approved mechanical spreader at the rate specified in the above table and rolled in accordance with the specification.

Requirements of Materials for Seal Coat

Seal coat of two types (see MORT&H clause 513)

(a) Type-A- Chip Sealing seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

(b) Type-B- Premixed seal coat comprising of thin application fine aggregate premixed with bituminous binder.

Physical requirement of aggregate

Type-A- the aggregate shall satisfy all the physical requirements of aggregate for bituminous macadam except for water absorption which shall be less than 1%. Stone chippings shall be of 6.7 mm size defined as 100% passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09cum/10sq.m.

NOTE : The contractor is responsible to ensure that the surface seal coat does not strip, ravel, flush or bleed. Spray rates for bitumen & spread rates for aggregate chips must be adjusted to allow for the effects of traffic and size and quality of aggregate chip etc.

Type-B- The aggregate shall pass through 2.36 mm sieve and be retained on 180-micron sieve. The quantity used for premixing shall be 0.06 cum/10sq.m.

The spray rate of bitumen for bituminous works is detailed below

a) For Tack Coat

Normal bituminous surface: 2 to 2.5 kg/10 sq.m

Dry/hungry surface: 3.5 to 4 kg/10 sq.m

Note : There is no need for tack coat on freshly laid bituminous surfaces if overlaid on same day without opening to traffic.

b) Requirement of sprayed bituminous chip sealing for surface dressing

Spray rates for bitumen and spread rates for aggregate chips depends on traffic, aggregate chip size, bitumen temperature, and penetration etc and shall be checked with the Engineer before sprayed chip sealing is attempted

Requirements of Materials for Built Up Spray Grout (See IRC47)

Requirements of Materials for Built Up Spray Grout grading requirement is given below are percentage by weight passing the sieve.

IS Sieve (mm)	Coarse Aggregate (mm)	Key aggregate (mm)
53	100	
26.5	40-75	
22.4		100
13.2	0-20	40-75
5.6		0-20
2.8	0-5	0-5

Requirement of bitumen

First : 15 kg/10sq.m

Second: 15 kg/10sq.m

Coarse aggregate is spread uniformly at the rate of 0.5-cum/10sq.m areas over a tack coat and binder is applied at 15kg/10sq.m area. Immediately after key aggregate is spread uniformly at 0.13 cum/ 10sq.m area and rolled whenever required for uniformity. Then the final surface has to be provided without delay .If there is delay, a seal coat should be provided as an intermediate step.

Requirements of Materials for Semi-Dense Bituminous Carpet (MORT&H Clause 508)

Aggregate water absorption: 1% (max)

Binder content: Minimum 4% of mix by weight.

Grading requirements

Grading	1	2
Nominal aggregate size	13mm	10mm
Layer Thickness	35 – 40mm	25 -30mm
IS Sieve + (mm)	Cumulative % by weight of total aggregate passing	
19	100	
13.2	90 – 100	100
9.5	70 – 90	90 - 100
4.75	35 – 51	35 - 51
2.36	24 – 39	24 - 39

1.18	15 – 30	15 - 30
0.3	9 – 19	9 – 19
0.075	3 – 8	3 - 8
Bitumen content % by mass of total Mix #	Min. 4.5	Min 5.0
Bitumen grade	65*	65*

Requirement of mix

Marshall stability : 8.2 KN (samples compacted with 75 blows)

Marshall flow : 2 to 4 mm

Percent air voids in mix : 3 to 5

Percent air voids in aggregates : 13 to 15 (minimum) (13.2 mm max size)

Percent voids in mineral aggregate Filled with bitumen (VFB) : 65 to 78

Binder content : 4% minimum

Temperature of mix at laying : 120 to 160 degree C

Minimum temperature for rolling : 90 o C

Compressive strength of the concrete

Compressive strength of the concrete shall be tested in accordance with IS 516. Three test specimens of 150mm cubes (cubes shall be prepared as per IS 1199) shall be made, cured and tested at the age of 28 days for compressive strength in each samples. The minimum frequency of sampling of concrete of each grade shall be as per the following table.

Quantity of concrete in Work, M3	No. of Samples	Acceptance Criteria
1 - 5	1	The mean strength determined from any group of four consecutive samples should exceed the specified Characteristic compressive strength. Strength of any sample is not less than the specified characteristic compressive strength minus 3 Mpa.

FIELD TESTS

Field Tests for Bituminous works

No bituminous work shall be carried out when the atmospheric temperature is less than 16 degree and when the base or the construction materials are damp. The thickness of the layer can be checked at frequent intervals after compaction by using pre decided depth

blocks. Rolling should continue till the roller marks are eliminated. Rolling temperature should not fall below 100 degree.

It is necessary to conduct tests at frequent intervals during the work to find out whether the prescribed bitumen quantity is being used in the work. For this a simple field solubility test can be conducted (for field control) as follows.

About 1 kg of the mix is collected and weighted accurately. The sample is immersed and flushed in either carbon di-sulphide or carbon tetra chloride liquids (both chemicals are highly toxic and should only be used in a fully vented fume cupboard). Kerosene can also be used for the purpose. Since the bitumen is completely soluble in these solvents except for negligible quantities of impurities like carbon, salts, etc. the weight of aggregates without the bitumen can be obtained to arrive at the difference in weight, which represents the weight of bitumen used in the mix.

Marshall Stability Test

The Marshall Stability test shall be used to determine bituminous concrete mix proportions and to test the product delivered to the job. Mix shall be approved by the Engineer prior to use in the works.

Other Control Measures

The camber of the laid surface should be checked by means of camber board and spirit level. Triangular wedges may be used for finding out depressions under a 3 metre straight edge. Maximum allowable depression is 6mm. Templates may also be prepared to check the cambers at different locations. The longitudinal alignment should be checked by a straight edge and triangular wedge. Traffic on the fresh surface should not be allowed until the mix has become cool enough to prevent wheel-marking by traffic.

Standards of surface evenness

The surface unevenness should be controlled during construction so that both longitudinal and cross profiles are simultaneously satisfied. The maximum number of undulations permitted in any stretch of 300 meters length is 30 and in the cross profile, it is 6 only. Surface level evenness shall be in accordance with table 900-1 of MORT&H Specification for Roads and Bridges. Surface evenness may be measured by 3m straight edge and wedges or by other acceptable means approved by the Engineer

Road Maintenance works

Depending on the standards of original construction, change in traffic intensity, climatic conditions etc., maintenance of roads presents problems of different nature. A systematic approach involving sequential operations is necessary.

The different items of maintenance works being carried out, fall under three headings

- Routine maintenance: including filling up potholes, patches, repairs to side berms, improving surface drainage, cleaning choked culverts, painting sign boards etc.

- Periodical maintenance: including surface renewals (ie re-gravelling) and strengthening by way of providing overlays and
- Rectification/ upgradation: including widening of roads, improvement of CD works, improved drainage measures, providing new sign boards etc.

1. Routine Maintenance

Potholes : The occurrence of potholes is the most common phenomenon observed especially after rains. These can be the result of but not limited to:

(a) Ingress of water into the pavement through cracks,

(b) Ingress of water by surface ponding because of insufficient surface camber or superelevation.

(c) Lack of bond between the surfacing and the base course and

(d) Use of insufficient bitumen in the surfacing etc

Patching of these potholes has to be executed with care to make it successful. The potholes should be cut as nearly as possible to the shape of a rectangle, sides being vertical. All loose material shall be cleaned out. If there are deep pot holes as a result of improper drainage or existence of soft pocket in the subgrade, these should be dug out down to solid subgrade, and made good with well-graded aggregate. In WBM roads, the potholes should be filled with aggregates and screenings as specified for WBM and compacted with heavy hand rammers. In asphalt roads, the bottom and sides of the potholes duly trimmed to a rectangular shape should be coated with bitumen emulsion (using a sprayer or by brushing) and filled with premix. The premix should be compacted in layers of 25mm at a time, the hand rammers being dipped in water often so that the coated metal may not stick to it. The finished surface should be compacted level with (not below, but in any case no more than 5mm above) the surrounding road surface.

Shoulder Grading : Shoulders must be graded to slope away from the carriageway such that water can flow across the shoulder and not run along the pavement adjacent to the carriageway.

Grass Cutting-Jungle Clearance : Grass shall be cut at regular intervals and debris shall be removed from the site.

2. Periodic Maintenance

Periodic maintenance such as BT overlays or Bitumen Chip Sealing surface dressing, or re-gravelling shall be carried out.

Profile Corrective Courses : Where the maximum profile corrective course thickness works out to not more than 40 mm, it shall be done as an integral part of the average course. In other cases, the profile corrective courses shall be provided as a separate layer. Potholes have to be filled before profile corrective course is laid. Profile corrective course shall be measured as volume compacted in position.

BT Carpet : BT Carpeting shall be in accordance with the specification and must be manufactured at 150º C and laid in accordance with clauses B9 to B13.

Bituminous Testing:

The control tests to be conducted on bituminous works are listed below for ready reference.

1. SDBC:
   a) Quality of binder
   b) Aggregate impact value
   c) Flakiness and elongation index
   d) Stability of mix – Marshall test for stability, flow value, Density and void content
   e) Binder content
   f) Temperature
2. BUSG/Bituminous penetration macadam
   a) Quality of binder
   b) Aggregate impact value
   c) Flakiness and elongation index
   d) Aggregate grading
   e) Binder content
   f) Temperature
3. Tack Coat/Prime Coat:
   a) Quality of binder
   b) Rate of spread
   c) Temperature
4. Seal coat:
   a) Quality of binder
   b) Aggregate impact value
   c) Flakiness and elongation indices
   d) Grading of aggregates
   e)Average Least Dimension of Chips
   f) Rate of spread
   g) Temperature
5. Bitumimous Macadam:

a) Quality of binder

b) Aggregate impact value

c) Flakiness and elongation index

d) Stability of mix – Marshall test for stability, flow value, Density and void content

e) Binder content

f) Temperature

g) Stripping value

h) Rate of spread of mixed material

i) Water absorption

k) Grading of aggregate

For all these following tests are also required

a) Temperature to be measured at regular intervals.

b) Depths of bituminous layers measured at regular intervals.

c) Tests to determine the bitumen content in a mix at regular intervals.

d) Check on camber and profile.

Acceptance : The Contractor is responsible for the sample collection, testing and submission of the test result to the Engineer along with each relevant bill. After the submission of test result the Engineer may authorise the payment of the work if it satisfies the specification requirement. If the test results do not satisfy the specification requirement the Contractor shall propose a method of corrective action for approval by the Engineer and provide conforming work at his own cost.

Field Tests for Concrete Works

Aggregate

a) Coarse aggregate : For plain and reinforced cement concrete works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel or a suitable combination thereof or other approved inert materials.

For every new source the following tests are to be conducted.

a) Aggregate impact value (max 30%)

b) Water absorption (max 2%)

c) Los Angels Abrasion Value (max 40%)

d) Grading of aggregate

e) Flakiness and Elongation index (max35%)

Grading requirement of coarse aggregate

IS Sieve Size	Per cent by weight passing the sieve		
	40 mm	**20 mm**	**12.5 mm**
63 mm	100		
40 mm	95-100	100	
20 mm	30-70	95-100	100
12.5 mm			90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

b) Fine aggregate : The fineness modulus of fine aggregate shall neither be than 2.0 nor greater than 3.5.

Grading requirement of fine aggregate

IS Sieve Size	Per cent by weight passing sieve		
	Zone-1	**Zone-2**	**Zone-3**
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

Cement

Cement to be used in works shall be any of the following

a) Ordinary Portland cement, 33 grades confirming to IS 269

b) Ordinary Portland cement, 43 grade confirming to IS 8112

c) Ordinary Portland cement, 53 grade confirming to IS 12269

The manufacture's test certificate can be accepted.

Steel

The steel used for structural work shall confirm to Table 1000-3 of MORT&H specifications. The manufacture's test certificate can be accepted.

Concrete mix design and sampling : Prior to construction, the contractor shall prepare a design mix in the case of 'Design Mix Concrete' or prepare a nominal mix in the case of 'Nominal Mix Concrete' and obtain approval from the Engineer before use. For PCC and small RCC works nominal mix design can be adopted, but for major RCC works and for the concreting of load bearing structures a design mix must be followed based on the criteria in clause 1704 of MORT&H Roads and Bridges Specifications. For the testing and characteristic strength refer Table1700 MORT&H specification.

Formwork : All formwork and the reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing concrete.

Mixing, Transporting and Placing of Concrete : Concrete shall be mixed either in a concrete mixer or in batching plant as mentioned in the contract or approved by the Engineer. Hand mixing shall not be permitted. The mixer or plant shall be at an approved location considering the properties of the mixers and transportation arrangement available with contractor. Concrete shall not be freely dropped in to place from a height exceeding 1.5 m. Concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm and vibrated to eliminate honeycomb.

Curing : Exposed surfaces of concrete shall be kept continuously in a damp or wet condition or by covering a layer of sacks, canvas, hessian or similar materials and shall be kept constantly wet for a period not less than 14 days from the date of placing of concrete.

Finishing : Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete and resulting holes filled with cement mortar.

Acceptance : The Contractor is responsible for the sample collection, testing and submission of test result to the Engineer with each relevant bill. After the submission of test result the Engineer can authorize the payment for the work if it satisfies the specification requirement. If the test results do not satisfy the specification requirement the Contractor shall propose a method of corrective action for approval by the Engineer, rectify the non-conformance, and provide conforming work at no extra charge.

SECTION- 13

13. SAFETY MEASURES

This chapter details the safety measures to be followed in various construction and maintenance operations. The aim is to provide and maintain a working environment that is safe and effectively minimises risks to the health of its employees, contractor, equipments and members of the general public.

The Department shall ensure safety by;

- Placing the health and safety of all people ahead of the provisions of service.
- Taking corrective action for every incident with the potential to cause harm, whether such harm eventuates or not, and also in the case of every accident.

- Insisting on arrangements for the safe use, handling, storage and transport of equipment and substances.
- Insisting on adequate facilities and protective clothing & equipment to protect the health and safety of all employees

The practice of safety involves shared responsibilities and a team approach by all employees. Everyone associated with the department shall be responsible for their own health and safety, and the safety of others affected by the actions of their work. Necessary provisions for safety shall be foreseen and incorporated in the estimates during project preparation stage itself.

The department shall insist on provision of protective clothing and equipment where hazards cannot otherwise be prevented or suitably controlled, and when complete protection is essential. First Aid facilities shall be made available at all offices and worksites, for the treatment of employees (including contractors) and visitors who are injured or become ill.

Accidents

Working in the construction industry can sometimes be dangerous. Work-related accidents can cause serious injuries, while most of these accidents are preventable. Accidents are mainly classified into 4 types, viz. fatal accident, grievous injury accidents, minor injury accidents and non-injury accidents. The following procedure shall be adopted in case of accidents.

Major Accident:

An accident will be considered a major one, if it involves loss of life (fatality), serious injury to any person(grievous injury), non-injury accidents involving loss of property likely to cost Rs. 50 lakh or more or would cause serious disruption of normal life in the area affected, such as by interruption to main lines of communication etc. In case a major accident involving structures under construction or under maintenance by the department. occurs, the following procedure shall be followed.

i. The Overseer or Subordinate under the control shall inform the Assistant Engineer, Assistant Executive Engineer and Executive Engineer of the accidents by the quickest possible means. The Police Inspector having jurisdiction over the area shall also be informed in cases of death or serious injury to person and where criminal activity is suspected.
ii. The Assistant Engineer and Assistant Executive Engineer concerned shall, on receipt of such information proceed to the spot within the shortest time possible and organise or assist in rescue operations. The Assistant Executive Engineer or in his absence the Assistant Engineer shall immediately inform through suitable means (telegram/ fax/ email) for official recording the Executive Engineer, the Collector of the District, the Superintending Engineer and Chief Engineer briefly giving details of the accident. Where the accident involves electrocution, the Electrical Inspector shall also be informed.

iii. The Executive Engineer on receipt of such information shall send an email or fax message to the Chief Engineer Administration and who shall report to Secretary to Government, giving brief details of the accident. He shall also proceed to the spot within 24 hour, of the accident or in as short a time as possible and hold a preliminary enquiry on the cause of the accident etc. and submit a detailed report to the Superintending Engineer and the Chief Engineer within 3 days of the completion of the enquiry. This enquiry shall be independent of any Police enquiry in the matter.

iv. The Superintending Engineer shall, on receipt of information, inspect the site within 3 days or as short a time as possible and ascertain by personal enquiry the causes of the accident, the adequacy of relief measures, and also find out best means of restoring normal activities in the affected area. His report shall be sent to Chief Engineer independently of the Executive Engineer's report within 3 days after his inspection.

v. The Chief Engineer shall inspect the site within a week of the occurrence of fatal accidents or as early as possible and make such personal enquiries as he feels necessary in order to furnish a full report of the accident to the Chief Engineer and he in turn submit report to Government, detailing the causes, the action taken thereafter and action to be taken to restore normalcy in the area. In addition, this report shall contain information as to whether there is prima facie negligence or dereliction of duty on the part of any Government servant and if so, make recommendations regarding disciplinary proceedings to be taken against the delinquents.

Minor Accidents

Minor injury accidents and non-injury accidents involving loss of property likely to cost less than Rs. 50 lakh shall be Minor accidents. First aid shall be provided immediately to affect persons and medical aid sought in case of minor injury accidents. All accidents shall be reported to superior officers. In case of damage to property the value shall be assessed and reported.

Road Safety

An accident is a rare multi-factor event always preceded by a situation in which one or more road users having failed to cope with their environment, resulting in vehicle collision, vehicle to rider or vehicle to property collision. It could be due to road users have failed to cope with their environment. Therefore Engineers can make the road user to cope with, by improving road and travel environments. However, prevention and reduction in accident rate can be achieved only with education and enforcement programmes along with engineering measures.

SAFFTY CODE

1. Suitable scaffolds shall be provided for workmen for all work that cannot safely be done from the ground, or from solid construction except such short period work as can be done safely from ladders. When a ladder is used an extra mazdoor shall be engaged for holding the ladder and if the ladder is used for carrying materials as well, suitable

footholds and hand- holds shall be provided on the ladder and the ladder shall be given an inclination not steeper than ¼ to 1 (¼ horizontal and 1 vertical).

2. Scaffolding or staging more than 3.25 metres above the ground or floor, swung or suspended from an overhead support or erected with stationery support, shall have a guard rail properly attached, bolted, braced and otherwise secured at least 1 meter high above the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structures.
3. Working platform, gangways, and stairways shall be so constructed that they do not sag unduly or unequally, and if height of a platform or gangway or stairway is more than 3.25 meters above ground level or floor level, it shall be closely boarded, have adequate width and be suitably fenced as described in 2 above.
4. Every opening in floor of a building or in a working platform shall be provided with suitable means to prevent fall of person or materials by providing suitable fencing or railing with a minimum height of 1 meter.
5. Safe means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 metres in length. Width between side rails in ,a rung ladder shall in no case be less than 30 cm. for ladders upto and including 3 metres in length. For longer ladders this width shall be increased at least 6 mm. for each additional 30 cm. of length. Uniform step spacing shall not exceed 30 cm.

   Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The contractor shall provide all necessary fencing and lights to protect public from accidents and shall be bound to bear expenses of defense of every suit, action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of the above precautions and to pay any damages and costs which may be awarded in any such suit, action or proceedings to any such person or which may with the consent of the Contractor be paid to compromise any claim by any such person.
6. Excavation and Trenching- All trenches, 1. 5 metres or more in depth shall at all times be supplied with at least one ladder for each 30 metres in length or fraction thereof. Ladder shall be extended from bottom of trench to at least 1 meter above surface of the ground. Sides of a trench which is 1. 5 metres or more in depth shall be stepped back to give suitable slope, or securely held by timber backing, so as to avoid the danger of 1.5 meters of edge of trench or half of depth of trench, whichever is more. Cutting shall be done from top to bottom. Under no circumstances shall undermining or undercutting be done.
7. Demolition -Before any demolition work is commenced and also during the process of the work:-

(a) All roads and open areas adjacent to the work site shall either be closed or suitably protected;

(b) No electric cable or apparatus which is liable to be a source of danger over a cable or apparatus used by operator shall remain clerically charged;

(c) All practical steps shall be taken to prevent danger to persons employed, from risk or fire or explosion, or flooding. No floor roof or other part of a building shall be so overloaded with debris or materials as to render it unsafe.

8. All necessary safety equipment as considered adequate by the Engineer-in-charge shall he available for use of persons employed on the site and maintained in a condition suitable for immediate use; and the Contractor shall take adequate steps to ensure proper use of equipment by those concerned.

When workers are employed in sewers and manholes, which are in use, the Contractor shall ensure that manhole covers are opened and manholes are ventilated at least for an hour before workers are allowed to get into them. Manholes so opened shall be cordoned off with suitable railing and provided with warning signals or boards to prevent accident to public.

9. In the case of using hoisting machines, it should be ensured that these shall be of good mechanical construction, sound material and adequate strength and free from patent defects and shall be kept in good repair and in good working order.
10. Motors, gearing, transmission electric wiring and other dangerous parts of hoisting appliance shall be provided with efficient safeguards, hoisting appliances shall be provided with such means as will reduce to the minimum risk of accidental descent of load, adequate precautions shall be taken to reduce to the minimum risk of any part of a suspended load becoming accidentally displaced.

APPENDIX

(1) Codes to be referred for Design of Roads

1	IRC:32-1969	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
2	IRC:38-1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
3	IRC:39-1986	Standards for Road-Rail Level Crossings (First Revision)
4	IRC:41-1997	Type Designs for Check Barriers (First Revision)
5	IRC:54-1974	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic
6	IRC:65-1976	Recommended Practice for Traffic Rotaries
7	IRC:66-1976	Recommended Practice for Sight Distance on Rural Highways
8	IRC:69-1977	Space Standards for Roads in Urban Areas
9	IRC:73-1980	Geometric Design Standards for Rural(Non-Urban Highways)
10	IRC:86-1983	Geometric Design Standards for Urban Roads in Plains
11	IRC:92-1985	Guidelines for the Design of Interchanges in Urban Areas
12	IRC:98-1997	Guidelines on accommodation of Underground Utility Services Along and Across Roads in Urban Areas(First Revision)
13	IRC:99-1988	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads
14	IRC:103-1988	Guidelines for Pedestrian Facilities
15	IRC:SP:12-1973	Tentative Recommendations on the Provision of Parking Spaces for Urban Areas
16	IRC:SP:23-1983	Vertical Curves for Highways
17	IRC:SP:41-1994	Guidelines on Design of At-Grade Intersections in Rural and Urban Areas
18	IRC:58-2002	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways(Second Revision)

Latest Revision of relevant codes shall be followed

(2) Codes to be referred for Design of Bridges

1	IRC: 5-1998	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Seventh Revision)
2	IRC: 6-2000	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision)
3	IRC: 18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)
4	IRC: 21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III – Cement Concrete (Plain and Reinforced) (Third Revision)
5	IRC: 22-1986	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (First Revision)
6	IRC: 24-2001	Standard Specifications and Code of Practice for Road Bridges, Section V – Steel Road Bridges (Second Revision)
7	IRC: 40-2002	Standard Specifications and Code of Practice for Road Bridges, Section IV – Brick, Stone and Block Masonry (Second Revision)
8	IRC: 78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure (Second Revision)
9	IRC: 83-1999	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings (First Revision)
10	IRC: 83-1987 (Part II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
11	IRC: 83-2002 (Part III)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS
12	IRC: 87-1984	Guidelines for the Design and Erection of False work for Road Bridges
13	IRC: 89-1997	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)
14	IRC SP 20	Specifications for Rural Roads
15	IRC: SP: 33- 1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures
16	IS 456-2000	Plain and Reinforced Concrete - Code of Practice

Latest revision of above codes shall be followed.

(3) Codes to be referred for Design of Building

The National Building Code published by the Bureau of Indian Standards and Kerala Municipal Building Rules has to be followed for the purpose of design of Buildings.

1	I.S. 456-2000	Code of practice for plain and reinforced concrete.
2	I.S. 800-1962	Code of practice for use of structural steel in general building construction
3	I.S. 875-1987	Designs load other than (part I to V) earthquake for building design
4	Part-I:	Dead loads
5	Part-II:	Imposed loads
6	Part-III:	Wind loads
7	Part IV:	Snow loads
8	Part V:	Special loads and load combinations
9	I.S. 1080-1965	Code of practice for design and construction of shallow foundation in soils (other than Raft, Ring and shell)
10	I.S: 1642-1988	Fire safety of buildings (General) Detail 3 of construction
11	I.S.: 1643-1988	Code of practice for Fire safety of buildings (General) Exposure Hazard.
12	I.S. 1644-1988	Code of practice for Fire safety of buildings (General) Exit Requirements and personal Hazards
13	I.S. 1888-1972	Methods of load test on soils
14	I.S.: 1893-1984	Criteria for earthquake resistant design of structures
15	I.S: 1904-1986	Code of practice for design & construction of pile foundation in soil structural safety of building foundation.
16	I.S. 2911-1990	Code of practice for design and construction of pile (Part I to IV) foundation
17	I.S. 2950-1981	Code of practice for design and construction of raft foundation
18	I.S. 3370-1965	Code of Practice for water retaining structures
19	I.S. 3414-1987	Code of Practice for Design and Installation of joints in buildings
20	I.S. 4326-1993	Code of practice for earthquake resistant design of structure.
21	I.S. 6403-1981	Code of practice for Determination of bearing pressure of shallow foundation
22	I.S.13920-1993	Code of practice for ductility detailing of reinforced concrete structures subjected to seismic forces

Latest revisions of above code shall be followed.

I.S. Codes are also available for design of special types of structures like folded plate, shell

structures etc. Refer publication list of BIS for the same.

Similarly there are special publications of I.S., which are useful for design of buildings such as.

1	SP-16	Design Aids to I.S.: 456-1978
2	SP-22	Explanation to I.S.: 1893 & I.S.: 4326
3	SP-23	Concrete Mix
4	SP-24	Explanation of I.S. 456-1978
5	SP-25	Cracks in buildings and their repairs
6	SP- 34	Detailing in R.C.C. structures
7	SP-38	Design of steel trusses

For aspects, which are not covered by any other I.S. codes available, relevant International Standard Codes may be referred to. While designing R.C.C. structures, important provisions of I.S. 456 must be borne in mind.

(4) List of relevant codes for painting

1	IS 144: 1950	Ready mixed paint, brushing, petrol resisting, air-drying, for interior painting of tanks and container, red oxide (colour unspecified)
2	IS 145: 1950	Ready mixed paint, slushing, petrol resisting, air-drying for interior painting of tanks and containers, red oxide (colour unspecified)
3	IS 146: 1950	Specification for ready mixed paint, brushing, petrol resisting, stoving, or interior painting of tanks and containers, red oxide
4	IS 147: 1950	Specification for ready mixed paint, slushing, petrol resisting, stoving, for interior painting of tanks and containers, red oxide
5	IS 1200: Part 13: (1994)	Method of measurement of building and civil engineering works: Part 13 Whitewashing, colour washing, distampering and painting of building surfaces
6	IS 1200: Part 15: (1987)	Method of measurement of building and civil engineering works: Part15 painting, polishing, varnishing etc
7	IS 1477: Part I: (2000)	Code of Practice for Painting of Ferrous Metals in Buildings - Part I :Pretreatment
8	IS 1477: Part 2: (1971)	Code of practice for painting of ferrous metals in buildings: Part2 Painting
9	IS 2395: Part 2: (1994)	Code of practice for painting concrete, masonry and plaster surfaces:Part 2 Schedule

10	IS 2524: Part 1: (1968)	Code of practice for painting of nonferrous metals in buildings: Part 1Pretreatment
11	IS 2524: Part 2: (1968)	Code of practice for painting of non-ferrous metals in buildings: Part 2 Painting
12	IS 3140: 1965	Code of practice for painting asbestos cement building products
13	IS 9954: 1981	Pictorial Surface Preparation Standards for Painting of Steel Surfaces
14	IS 14177: 1994	Guidelines for painting system for hydraulic gates and hoists
15	IS 14428: 1997	Guidelines for painting of structures in aggressive chemical environment

Also refer

National Building Code 2005, Part 8 Sections 1	for	Lighting and Ventilation
National Building Code 2005 Part 8 Section 2	for	Electrical and Allied Installations
National Building Code 2005 Part 8 Section 3	for	Heating Ventilation and Air conditioning (HVAC)
National Building Code 2005 Part 8 Section 4	for	Acoustics sound Insulation and Noise control
National Building Code 2005 Part 8 Section 5	for	Lift and Escalators
National Building Code 2005 Part 9 Section 1 clause 4	for	Water supply
National Building Code 2005 Part 9 Section 1 clause 5.5.12	for	Rain Water Harvesting
National Building Code 2005 Part 9 Section 1 clause 5	for	Drainage and Sanitation
National Building Code 2005 Part 9 Section 2	for	Gas Supply
National Building Code 2005 Part 4	for	Fire fighting
National Building Code 2005 Part 10 Section 2	for	Landscaping, Signs and Outdoor Display Structures

Stairs and passages shall be constructed as per the architectural and structural drawings.

(5) Unit Weight of Building Materials

Sl No.	Material	Weight in Kg/m3
1	Broken Stone	1600-1870
2	Broken Brick	1010-1450
3	Brick	1600-1920
4	Cast Iron	7030-7130
5	**Cement**	**1440**
6	Cement Concrete	880-1920
7	RCC	2310-2720
8	Clay	1440-2080
9	**Dry Sand**	**1540-1600**
10	Earth Dry	1410-1840
11	Earth Moist	1600-2000
12	Granite	2400
13	Gravel	1600-1960
14	Lime Slaked	580-640
15	Lime Unslaked	880-1040
16	Lime Mortar	1600-1840
17	Lime Plaster	1760
18	Lime Concrete	1920
19	Laterite	2080-2400
20	Surki	1010
21	Wet Sand	1760-2000
22	Water Fresh	1000
23	Water Sea	1025
24	Timber (common use)	595-850
25	Timber (Teak)	640
26	Std. hardboard 3mm thick 4mm thick 5mm thick	 2.40-3.60 3.20-4.80 4.00-6.00
27	DR Masonry	2080
28	Engg Brick Masonry	2400
29	Common Burnt Clay Brick Masonry	1920
30	Cement Mortar	2080
31	Gravel Loose	1600
32	Gravel Rammed	1920-2160
33	River Sand	1840
34	Wet Sand	1760-2000
35	Diesel Oil	960
36	Petrol	690
37	Fire Wood	400
38	Gold-cast	19250-19330
39	Gold-wrought	19330
40	Copper-cast	8790-8940
41	Copper-wrought	8840-8940
42	Marble	2720
43	Road Tar	1010
44	Bitumen	1040
45	Aggregate	1600-1920

		Weight in kg/m2
46	Lead sheet 1mm thick	11.00
47	Steel Sheet 1mm thick	7.90
48	AC Sheet (a) Corrugated Sheet (b) Semi Corrugated sheet (c) Plain	 12.0-13.30 12.0-13.0 9.16
49	Glass Sheet 2mm thick 3mm thick 4mm thick 5mm thick 5.5mm thick 6.5mm thick	 5.0 7.5 10.0 12.5 13.7 17.0
50	Clay Floor Tiles 12.5 to 25.4mm thick	 10-20
51	Aluminium sheet/mm thick	2.8
52	Copper sheet/mm thick	8.7

(6) Weight, area and perimeter of steel bars

Dia (mm)	**Rounds**			**Square bars**			**Tor steel**		
	Wt (kg)	**Area (cm)**	**Peri (cm)**	**Wt (kg)**	**Area (cm^2)**	**Peri (cm)**	**Wt (kg)**	**Area (cm^2)**	**Peri (cm)**
5	0.154	0.200	1.57	0.20	0.25	2.00			
6	0.22	0.283	1.88	0.28	0.36	2.40			
8	0.39	0.503	2.51	0.50	0.64	3.20	0.395	0.503	2.51
10	0.62	0.785	3.14	0.78	1.00	4.00	0.617	0.785	3.14
12	0.89	1.131	3.77	1.13	1.44	4.80	0.888	1.310	3.77
14	1.21	1.539	4.40	1.54	1.96	5.60	1.208	1.539	4.40
16	1.58	2.010	5.03	2.01	2.56	6.40	1.578	2.011	5.03
18	2.00	2.545	5.65	2.54	3.24	7.20	1.998	2.545	5.65
20	2.47	3.142	6.28	3.14	4.00	8.00	2.466	3.142	6.28
22	2.98	3.801	6.91	3.80	4.84	8.80	2.984	3.801	6.91
25	3.85	4.909	7.85	4.91	6.25	10.00	3.853	4.909	7.85
28	4.83	6.158	8.80	6.15	7.84	11.20	4.834	6.157	8.80
32	6.31	8.042	1.05	8.04	10.24	12.80	6.313	8.042	10.05
36	7.99	10.180	11.31	10.17	12.96	14.40	7.990	10.179	11.31
40	9.86	12.566	12.57	12.56	16.00	16.00	9.865	12.566	12.57
45	12.49	15.904	14.14	15.90	20.25	18.00	12.485	15.904	14.14
50	15.41	19.635	15.71	19.62	25.00	20.00	15.413	19.635	15.71

(7) Safe permissible loads on soils, masonry and concrete

Sl No.	Material	T/m2
1	**Rocks**	
	Hard rock	Above 220
	Ordinary rock	Above 110
	Sand stone	130-220
	Lime stone	100-200
	Soft rock	20-90
	Moorum	20-45
	Clay shale	110
	Marl & firm shale	65
	Hard chalk	45-65
	Soft chalk	17
2	**Cohesive Soils**	
	Very stiff boulder clay	65
	Hard/ stiff clays & sandy clays	30-44
	Firm clays & sandy clays	20
	Ordinary clays	20
	Sand and clay mixed or in layers	20
	Red earth	30
	Black cotton soil	5-10
	Alluvial soil	3-9
	Alluvial loams	9-17
	Made ground (consolidated)	5
	Hoggin (compact)	65
3	**Cohesionless Soils**	
	Compact gravel or sand well cemented	55-80
	Compact gravel or sand and gravel	43-55
	Loose gravel or sand and gravel	30
	Compact coarse sand (confined)	45
	Loose coarse sand	20
	Compact fine sand (confined)	32
	Loose fine sand	10

	Sand with clay	20
	Kanker	32
4	**Stone Masonry**	
	Ashlar in CM 1:3	175
	Ashlar in CM 1:6	90
	Ashlar in lime	80
	Coursed rubble masonry in CM 1:4	110
	Coursed rubble masonry in CM 1:6	55
	Coursed rubble masonry in lime	50
	RR masonry in CM 1:4	90
	RR masonry in CM 1:6	45
	RR masonry in lime	35
	Block masonry in CM 1:3 average crushing strength Of block not less than 35 kg/cm^2 70 kg/cm^2 140 kg/cm^2	 27 65 105
	Solid cement concrete block masonry in CM 1:3	165
5	**Brick Masonry**	
	Brick work in CM 1:3	100
	Brick work in CM 1:4	90
	Brick work in CM 1:6	55
	Brick work in lime	45
	Brick work in mud	27
	Country brick in lime	35
	Country brick in mud	16
	Sun dried brick work	10
	Laterite in lime	25
	Laterite in CM	30
6	**Concrete**	
	Cement Concrete 1:1:2	420
	Cement Concrete 1:1:2	350
	Cement Concrete 1:1:2	310
	Cement Concrete 1:1:2	200
	Cement Concrete 1:1:2	165
	Cement Concrete 1:1:2	110
	Mass cement concrete 1:6	200

	Mass cement concrete 1:8	165
	Mass cement concrete 1:10	110
	Mass cement concrete 1:12	55
	Lime concrete	45
	Brick jelly concrete in lime	20

(8) Maximum safe bearing capacity (IS 1904-1961)

Sl No.	Types of rocks and soils	Maximum safe bearing capacity (tones/ m2)
1	Rock head without laminations and defect (eg. Granite)	330
2	Laminate rocks in deposits of shattered and broken bed rock hard shale cemented material	165
3	Residual deposits of shattered and broken bed rock, hard shale cemented material	90
4	Soft rock	45
5	Gravel or sand and gravel offering high resistance to penetration when excavated by tools	45
6	Coarse sand, compact and dry (ground water level is at a depth not less than the width of the foundation below the base of the foundation)	45
7	Medium sand, compact and dry	45
8	Fine sand silt (dry lumps easily pulverized by the fingers)	15
9	Loose gravel or sand-gravel mixture, loose coarse to medium sand, dry	25
10	Fine sand, loose and dry	10
11	Soft shale, hard or stiff clay in deep bed, dry	45
12	Medium clay, readily indented with a thumb nail	25
13	Most clay and sand clay mixture which can be indented with strong thumb pressure	15
14	Soft clay indented with moderate thumb pressure	10
15	Very soft clay which can be penetrated several inches with the thumb	5
16	Fills or made-up ground	Not generalized

(9) General characteristics of soil (IS 1498:1970)

Soil group	Strength in natural state	Strength when wet and remoulded	Permeability	Dry bulk density g/cc
Gravels or gravel sand mixtures, little or no fine	Very low	-	Pervious	1.84 to 2.00
Gravels or gravel sand mixtures, with clady binder	Medium to high	Slightly plastic	Semi-pervious to pervious	2.08 to 2.29
Silty gravel or gravel-sand -silt mixtures	None to slight	Finer fraction plastic	Semi-pervious to impervious	1.92 to 2.16
Clayey sands or sand-clay mixtures	Slight to medium	Medium to high plasticity	Impervious	1.68 to 2.00
Silt and very fine sand, clayey fine sand with low plasticity	None to slight	Slight plastic but not cohesive	Semi-pervious to impervious	1.52 to 1.92
Inorganic clays of medium plasticity	Medium	Medium plasticity	Impervious	1.28 to 1.60
Inorganic clays of high plasticity	High	High plasticity	Impervious	1.20 to 1.68
Clay and silt with high organic content	Slight to high	Slight to high plasticity	impervious	1.04 to 1.60

(10) Live load on floors (I.S. 875 (Part I) 1987)

1	Houses, Hospitals, Hostels	200 kg/m2
2	Offices	250-400 kg/m2
3	Banks, Reading rooms, Schools	300 kg/m2
4	Shops, Work rooms, restaurants, auditoriums	400 kg/m2
5	Warehouses, Workshops and Factories for light weight loads, dance halls, waiting halls	500 kg/m2
6	Warehouses, Workshops and Factories for medium weight loads	750 kg/m2
7	Warehouses, Workshops and Factories for heavy weight loads, book stalls, libraries	1000 kg/m2
8	Stairs- Balconies not liable to over crowding	300 kg/m2
9	Stairs- Balconies liable to over crowding	500 kg/m2

(11) Live load on roofs

1	Flat, Sloping or curved up to 10^0 (a) Access provided (b) Access not provided	 150 kg/m2 75 kg/m2
2	Sloping roof - slope greater than 10^0	75 kg/m2