भारतीय मानक
Indian Standard

IS 14961 : 2024

पहाड़ी क्षेत्रों में सतही जल प्रबंधन (वर्षा जल संचयन सहित) — दिशानिर्देश

(पहला पुनरीक्षण)

Surface Water Management in Hilly Areas (Including Rainwater Harvesting) — Guidelines

(First Revision)

ICS 13.060.10; 13.060.20

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

June 2024 **Price Group 11**

Hill Area Development Engineering Sectional Committee, CED 56

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hill Area Development Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

Surface water management in hilly areas refers to the process of developing, implementing, and maintaining methods that are designed to efficiently control and utilisation of surface water resources. Erosion, sedimentation, flooding and landslide are just some of the problems that can arise in hilly regions because of their steep slopes and intricate hydrological systems. Hilly regions present their own set of unusual challenges. There are a variety of strategies that are necessary for effective surface water management in these regions. These practices include watershed management, erosion control measures, and the construction of retention ponds and check dams, and the creation of flood control infrastructure such as levees and channels. In addition, the implementation of sustainable land use techniques and the management of vegetation are crucial components in the reduction of soil erosion and the improvement of water retention. The objective of surface water management in hilly regions is to strike a balance between the requirements of human communities and those of natural ecosystems. This is accomplished by ensuring the availability of clean water for drinking, agriculture, and other uses, while also protecting the environment and lowering the risk of natural disasters. In hilly regions, water harvesting is one of the most prevalent and effective surface water management technique.

The term ‘water harvesting’ implies collection and storage of rainwater and also other activities aimed at harvesting surface water, prevention of losses through evaporation and seepage, and all other hydrological studies and engineering interventions aimed at conservation and efficient utilization of limited water endowment of a physiographic unit such as a watershed or a geomorphic basin. Roof top rainwater harvesting is one of the appropriate options for augmenting ground water recharge/storage in urban areas where natural recharge is considerably reduced due to increased urban activities and not much land is available for implementing any other artificial recharge measure. Roof top rainwater harvesting can supplement the domestic requirements in rural areas as well. A roof water collection system is recommended as the first option for hill areas

This standard was first published in 2001. This revision has been brought out to incorporate the modification based on the experience gained in the use of this standard since its publication. Significant changes incorporated in this revision are as follows:

a) Name of this Indian Standard has been changed from ‘Guidelines for rain water harvesting in hilly areas by roof water collection system’ to ‘Surface water management in hilly areas (including rainwater harvesting) — Guidelines’ for wider utilization;

b) The detail description of surface water management in hilly areas through water conservation structures has been included with respect to the slope distribution;

c) Components used in the rainwater harvesting system by roof water collection system has been elaborated;

d) Detailed description has been given for the first flush system and filtration unit used for the rainwater harvesting;

e) The comparative study for tanks and cisterns is provided;

f) Design consideration for the rainwater harvesting system has been introduced;

g) Formula for estimating the quantity of harvestable water is included;

h) Exhaustive list of materials has been provided for all component of rainwater harvesting system; and

j) Do’s and don’ts for rainwater harvesting has been included.

(*Continued on third cover*)

Indian Standard

SURFACE WATER MANAGEMENT IN HILLY AREAS (INCLUDING RAINWATER HARVESTING) — GUIDELINES

(First Revision)

1 SCOPE

This standard provides guidelines for surface water management in hilly areas, with a focus on sustainable practices and the integration of rainwater harvesting techniques.

2 REFERENCES

The standards listed in Annex A contain provisions, which through references in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards.

3 SURFACE WATER MANAGEMENT

Surface water management in hilly areas refers to the process of developing, implementing, and maintaining methods that are designed to efficiently control and utilisation of surface water resources. Erosion, sedimentation, flooding and landslide are the problems that can arise in hilly regions because of their steep slopes and intricate hydrological systems. There are a variety of strategies that are necessary for effective surface water management in these regions. These strategies may include watershed management, erosion control measures, and the construction of retention ponds and check dams, and the creation of flood control infrastructure such as levees and channels. In addition, the implementation of sustainable land use techniques and the management of vegetation are crucial components in the reduction of soil erosion and the improvement of water retention. The objective of surface water management in hilly regions is to strike a balance between the requirements of human communities and those of natural ecosystems. This is accomplished by ensuring the availability of clean water for drinking, agriculture, and other uses, while also protecting the environment and lowering the risk of natural disasters such as landslides and flash floods. In hilly areas, the distribution of water conservation structures varies according to the slope gradient, as different slopes present distinct challenges and opportunities for surface water management. A suggestive list of water conservation structures with respect to ground surface slope in percent is given in Table 1.

These structures are practiced for water conservation either for surface storage or for underground recharge as well as soil moisture enhancement. Detail of these structures are as given below.

3.1 Recharge Pits

Recharge pits are closed well like structure, which is covered by filling the stones, after digging the pit. It allows the rainwater to recharge the groundwater. The pit, if aimed for recharging the bore well, must be constructed near the bore well, as close as possible. In another case, the selection of the site is the most important step in the construction of recharge pit. In these structures, most of the infiltration occurs laterally through the walls of the pit. Abandoned gravel quarry pits or brick kiln quarry pits in alluvial areas and abandoned quarries in basaltic areas can also be used as recharge pits wherever they are underlain by permeable horizons. The groundwater recharge by constructing recharge pit is best practice to be followed in alluvial areas. Schematic drawing of a typical recharge pit is shown in Fig. 1. The site is well suited if:

a) It has a sufficiently clean and large catchment area;

b) The location permits fast infiltration and percolation of water; and

c) In a more ideal situation, it is in the valley of the surface layout.

The infiltration offered by the selected location further depends upon:

a) The depth of groundwater — the lower the better;

b) Soil surface; and

c) Underlying soil type — offering high percolation rate.

Table 1 Suggestive List of Water Conservation Structures with Respect to Ground Surface Slope in Percent

(*Clause* 3)

Sl No.	**Ground Surface Slope,** percent	**Suitable Structure**
(1)	(2)	(3)
i)	< 2	Recharge pit Injection well Percolation tank Recharge basin Anicut
ii)	2 to 5	Recharge pit Injection well Percolation tank Recharge basin Recharge shaft *Nallah* bund Contour bund Gravity head recharge well Check dam
iii)	5 to 10	Stonewall terrace Loose stone check dam
iv)	10 to 15	Injection well Recharge shaft Percolation tank
v)	15 to 30	Gravity head recharge well Bench terracing Staggered contour trench Continuous contour trench Gully plug

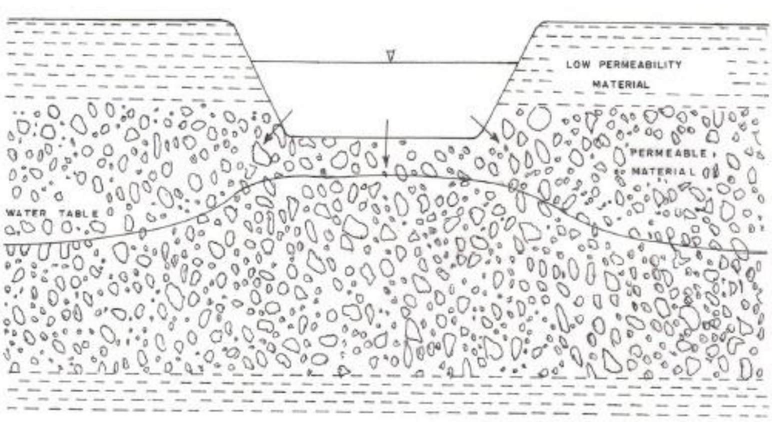


FIG. 1 SCHEMATIC DRAWING OF A TYPICAL RECHARGE PIT

3.2 Injection Wells

Injection wells are structures similar to bore wells or tube wells and are constructed for augmenting the groundwater storage in deeper aquifers through supply of water either under gravity or under pressure. The aquifer to be replenished is generally one with considerable desaturation due to overexploitation of groundwater. Artificial recharge of aquifers by injection wells can also be done in coastal regions to restrict the ingress of seawater and to combat problems of land subsidence in areas where confined aquifers are heavily pumped. In alluvial areas, injection wells, for recharging a single aquifer or multiple aquifers, can be constructed similar to normal gravel packed pumping wells. However, in case of recharge wells, cement sealing of the upper section of the wells is done to prevent the injection pressure from causing leakage of water through the annular space of the borehole and the well assembly. In hard rock areas, injection wells may not require casing pipes and screens and an injection pipe with an opening against the fractures to be recharged may be sufficient. However, properly designed injection wells with slotted pipes against the zones to be recharged may be required for recharging multiple aquifer zones separated by impervious rocks. The effectiveness of recharge through injection wells is limited by the physical characteristics of the aquifers. Schematic drawing of a typical injection well is shown in Fig. 2.

3.3 Percolation Tanks

Percolation tank is an artificially created small surface water body submerging a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 million cubic meters (MCM). It is necessary to design the tank to provide a ponded water column generally, 3.0 m to 4.5 m. The percolation tanks are mostly earthen dams with masonry structure only for spillway. Schematic drawing of a typical percolation tank is shown in Fig. 3.

a) Percolation tanks should normally be constructed in a terrain with highly fractured and weathered rock for speedy recharge. Also, it should be constructed preferably on 2nd to 3rd order steams, located on highly fractured and weathered rocks, which have lateral continuity downstream;

b) The aquifer to be recharged should have sufficient thickness (about 3 m) of permeable vadose zone to accommodate recharge;

c) The recharge area downstream should have sufficient number of wells and cultivable land to benefit from the augmented ground water;

d) The size of percolation tank should be governed by percolation capacity of strata in the tank bed; and

e) To minimize the silting at the bottom of the tank, soils in the catchment area should preferably be of light sandy type.

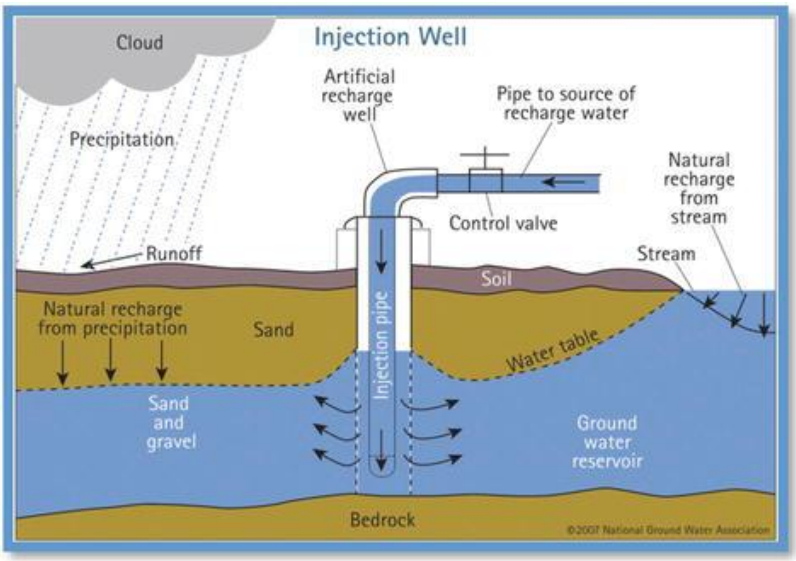


FIG. 2 SCHEMATIC DRAWING OF A TYPICAL INJECTION WELL

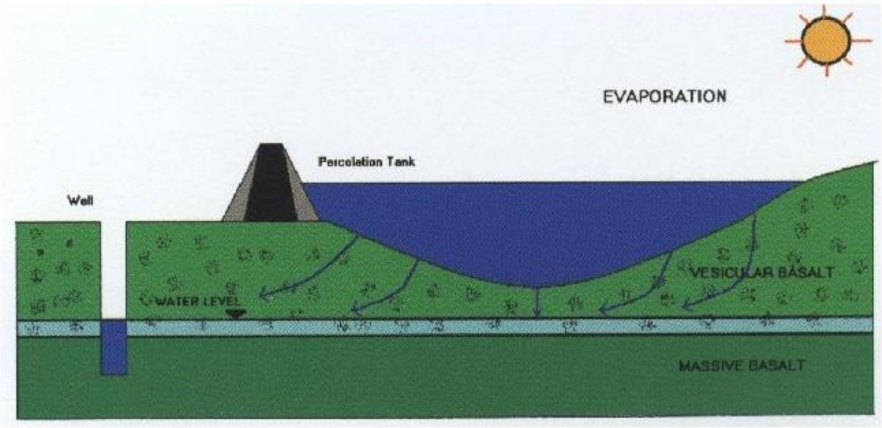


FIG. 3 SCHEMATIC DRAWING OF A TYPICAL PERCOLATION TANK

3.4 Recharge Basin

Recharge basins temporarily store runoff but release at least a portion of that runoff by infiltrating the water into the ground. The recharge volume is stored and allowed to infiltrate into the underlying soils over a period of time following a storm event. The storage volume above this level may be released by an outlet structure designed to bypass all excess flows. Recharge basins must be carefully designed to infiltrate the soil on a given site at a rate that will not cause flooding. Photographic view of a typical recharge basin is shown in Fig. 4.

FIG. 4 PHOTOGRAPHIC VIEW OF A TYPICAL RECHARGE BASIN

3.5 Anicuts

These structures are used to harvest rainwater for supplemental irrigation. An anicut is a small dam or weir type of structure built across a small river to store water behind it. The anicut keeps the level of water high enough and also used to feed the canal even in dry periods, while excess water is allowed to spill over and continue downstream during the rainy periods. An anicut system is dominant in the wet zone of the country. The water stored behind an anicut can be used for irrigation of crops or drinking water for humans and livestock. They are also used to increase the residence of water to recharge the groundwater, especially for wells located in the downstream. Anicuts are also used in wildlife sanctuaries to provide sufficient water for fauna. Photographic view of a typical anicut is shown in Fig. 5.

FIG. 5 PHOTOGRAPHIC VIEW OF A TYPICAL ANICUT

3.6 Recharge Shafts

Recharge Shafts are similar to recharge pits but are constructed to augment recharge into phreatic aquifers where water levels are much deeper and the aquifer zones are overlain by strata of low permeability. Further, these are much smaller in cross sectional area when compared to recharge pits. This is most efficient and cost effective techniques to recharge unconfined aquifer overlain by poorly permeable strata. Recharge shaft may be dug manually if the strata is of non-caving nature. The diameter of the shaft is normally more than 2 m. The shaft should end in more permeable strata below the tip of impermeable strata. It may not touch water table. The unlined shaft should be backfilled, initially with boulders/cobbles followed by gravel and coarse sand. In case of lined shaft, the recharge water may be fed through a smaller conductor pipe reaching up to filter pack. By constructing recharge shaft in tanks, the surplus water is recharged to groundwater. Recharge shaft of 0.5 m to 3 m. diameter and 10 m to 15 m, deep are constructed depending upon the availability of quantum of water. The top of the shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand. In upper portion of 1 m to 2 m depth, the brick masonry work is carried out for the stability of the structure. Schematic drawing of a recharge shaft is shown in Fig. 6.

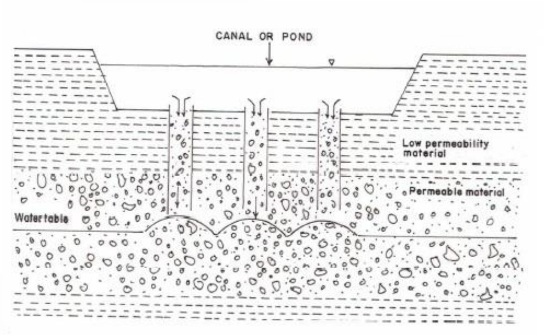


FIG. 6 SCHEMATIC DRAWING OF A RECHARGE SHAFT

3.7 *Nallah* Bunds

Nallah bunding means construction of bunds of suitable dimensions across a *nallah* or gully with additional arrangement at suitable intervals. It is constructed across gullies, *nallahs* or streams to check the flow of surface water in the stream channel and to retain water for longer durations in the pervious soil or rock surface. *Nallah* bunds are constructed across bigger streams and in areas having gentler slopes. *Nallah* bunds are useful in arid and semi-arid regions with low rainfall. Bunds should be provided from top of the catchment to the valley at regular intervals.

Nallah bunds may be temporary structures such as brush wood dams, earthen *nallah* dams, and woven wire dams constructed with locally available material or permanent structures constructed using stones, brick and cement. Competent civil and agro-engineering techniques are to be used in the design, layout and construction of permanent check dams to ensure proper storage and adequate outflow of surplus water to avoid scours on the downstream side for long-term stability of the dam. Photographic view of a typical *nallah* bund is shown in Fig. 7.

FIG. 7 PHOTOGRAPHIC VIEW OF A TYPICAL *NALLAH* BUND

3.8 Contour Bunds

Contour bunds are a series of mechanical barriers across the land slope on a contour to break the slope length, so that the long slope is cut into a series of smaller ones and each contour bund acts as a barrier to the flow of water, at the same time impounding water against it for increasing soil moisture. Contour bunds divide the length of the slope, reduce the volume of runoff water, and thus minimize the soil erosion. This technique is generally, adopted in low rainfall areas (normally less than 800 mm) where gently sloping agricultural lands with very long slope lengths are available and the soils are permeable.

Contour bunding involves construction of narrow-based trapezoidal embankments (bunds) along contours to impound water behind them, which infiltrates into the soil and ultimately augment ground water recharge. Elevation contours, preferably of 0.3 m interval are then drawn, leaving out areas not requiring bunding such as habitations, drainage, etc. The alignment of bunds should then be marked on the map. The important design aspects of contour bunds are:

a) Spacing;
b) Cross section; and
c) Deviation freedom to go higher or lower than the contour bund elevation for better alignment on undulating land.

Schematic and photographic view of a typical contour bunds are shown in Fig. 8.

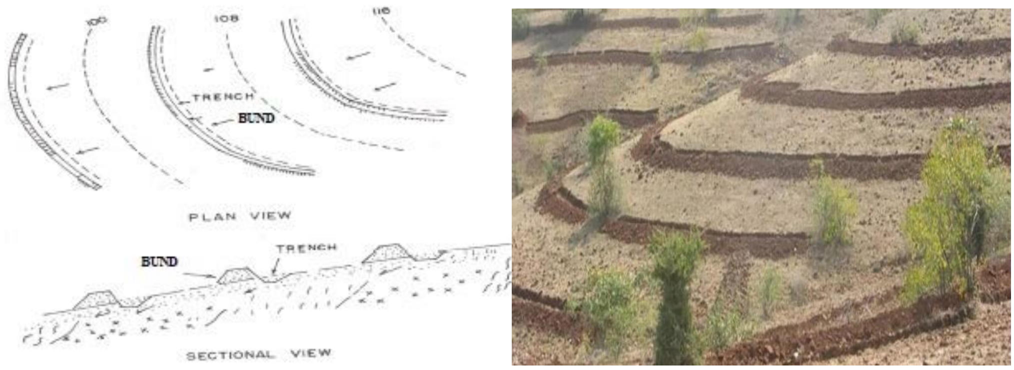


FIG. 8 SCHEMATIC AND PHOTOGRAPHIC VIEW OF A TYPICAL CONTOUR BUNDS

3.9 Gravity Head Recharge Well

Gravity head recharge well is also known as bore well/tube wells. In areas where considerable desaturation of aquifers has already taken place due to over-exploitation of ground water resources resulting in the drying up of dug wells or lowering of piezometric heads in bore/tube wells, structures provide a cost-effective mechanism for artificial recharge of the phreatic or deeper aquifers. It is the most suitable structure when groundwater level is much deep, land availability is limited, and the aquifer is deep overlain by impermeable strata. The rainwater flows down into the well from rooftops and recharges groundwater under gravity flow condition. This well can also be used for pumping. Schematic drawing of a typical gravity head recharge well is shown in Fig. 9.

3.10 Check Dams

Check dams are constructed on 1st and 2nd order streams along the foot hill zones. Check dams are constructed across gullies, *nallahs* or streams to check the flow of surface water in the stream channel and to retain water for longer durations in the pervious soil. Providing a stable channel for runoff is the fundamental step of gully control. The function of the check dams is to flatten the steep gradient of the gully by constructing a series of checks. The check dams convert the longitudinal gradient into a series of steps with low risers and long flat treads.

The site selected for check dam should have sufficient thickness of permeable soils or weathered material to facilitate recharge of stored water within a short span of time. The water stored in these structures is mostly confined to the stream course and the height is normally less than 2 m. These are designed based on the stream width and excess water is allowed to flow over the wall. In order to avoid scouring from excess runoff, water cushions are provided on the downstream side. To harness maximum runoff in the stream, a series of such check dams are constructed to have recharge on a regional scale.

Check dams are normally 10 m to 15 m long, 1 m to 3 m wide and 2 m to 3 m high, generally constructed in a trapezoidal form. For construction of the check dam, a trench, about 0.6 m wide in hard rock and 1.2 m wide in soft impervious rock is dug for the foundation of core wall. A core brick cement wall, 0.6 m wide and raised at least 2.5 m above the streambed is erected and the remaining portion of trench back filled on upstream side by impervious clay. The core wall is buttressed on both sides by a bund made up of local clays and stone pitching is done on the upstream face. If the bedrock is highly fractured, cement grouting is done to make the foundation leakage free. Photographic view of a typical check dam is shown in Fig. 10.

3.11 Stonewall Terrace

These structures are used for moisture conservation in the valley areas. Terracing is common in hilly and mountainous regions that are subjected to substantial population pressure. Terraces are built along contour lines to increase the arable surface area and conserve water and soil on hill slopes. Terraced fields can be of different shapes and sizes, and consist of a flat section and a near vertical riser, protected by a wall of dry stones, soil, grass, or trees. The height of the riser or wall can be from several decimetres to a few meters, with a continuous or intermittent structure comprised of a single wall or a complex series of walls. The flat surface created by terracing is generally used for cultivation.

Slope management by terracing has been found to be one of the most effective engineering measures, provided that terraces are well-designed correctly built, and appropriately maintained. Terraces are formed by cut and fill areas. By filling areas, the arable land can be expanded, thus making it possible to grow crops on a large scale in hilly areas. The ridges or embankments play an important role in the interception of runoff and field water. The walls are constructed with locally available rocks. The terraces are located in steep terrain under low (and erratic) rainfall regimes. The terrace walls are 1.0 m to 2.5 m high and the level beds 3.0 m to 25.0 m wide, depending on the slope. These terraces are usually found near settlements. Construction is very labour intensive, considering how little land is effectively protected from erosion and brought into cultivation. Photographic view of a typical stonewall terrace is shown in Fig. 11.

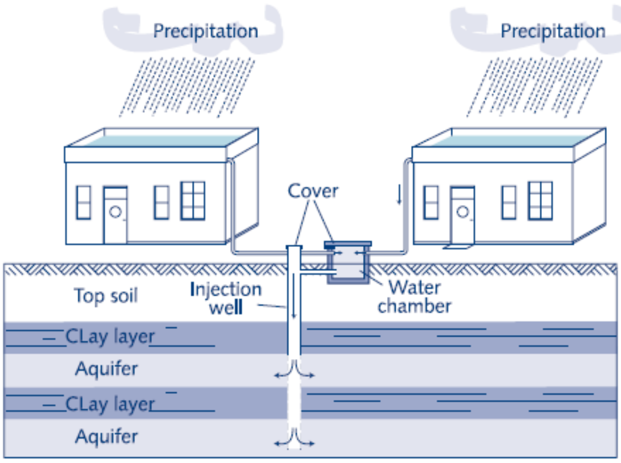


FIG. 9 SCHEMATIC DRAWING OF A TYPICAL GRAVITY HEAD RECHARGE WELL

FIG. 10 PHOTOGRAPHIC VIEW OF A TYPICAL CHECK DAM

FIG. 11 PHOTOGRAPHIC VIEW OF A TYPICAL STONEWALL TERRACE

3.12 Loose Stone Check Dams

These structures are used for in-situ moisture conservation. Loose stone check dams made of relatively small rocks/pieces are placed across the gully. The main objectives for these dams are to control channel erosion along the gully bed and to stop waterfall erosion by stabilizing gully heads. Loose stone check dams are used to stabilize the incipient and small gullies and the branch gullies of a continuous gully or gully network. The length of the gully channel is not more than 100 m and the gully catchment area is two hectare or less. The maximum effective height of the dam is 1.0 m and its foundation depth is at least 0.5 m. The thickness of the dam at spillway level is 0.5 m to 0.7 m and the inclination of its downstream face is 20 percent; the thickness of the base is computed accordingly. The upstream face of the dam is generally vertical. The foundation of the dam is dug so that the length of the foundation will be more than the length of the spillway. The foundation of the wings should be dug in such a manner that the wings will enter at least 50 cm into each side of the gully. The crest and middle part must be constructed with bigger rocks than the rest of the dam. Schematic and photographic view of a loose stone check dam is shown in Fig. 12.

3.13 Bench Terracing

Bench terraces are a series of level or virtually level strips running across the slope at vertical intervals, supported by steep banks or risers. Bench terraces are basically the platform like construction, which are constructed along the contours of the sloping land. This type of terraces is generally constructed on the land slope ranging from 6 percent to 33 percent. Bench terraces are classified into following three types based on the purpose of their construction:

a) Hill type bench terraces;

b) Irrigated type bench terraces; and

c) Orchard type bench terraces.

Hill type bench terraces are generally, constructed in those hilly areas which have reverse land slope towards the hill. Irrigated type bench terraces are also known as level bench terrace, and are generally, constructed in irrigated conditions. Orchard type bench terraces are constructed in the form of narrow strips, which are widely used for orchard plantations. Schematic drawing of a bench terrace is shown in Fig. 13.

The main objectives of bench terracing are:

a) To reduce run-off or its velocity and to minimize soil erosion;

b) To conserve soil moisture and fertility and to facilitate modem cropping operations that is, mechanization, irrigation and transportation on sloping land; and

c) To promote intensive land use and permanent agriculture on slopes and reduce shifting cultivation.

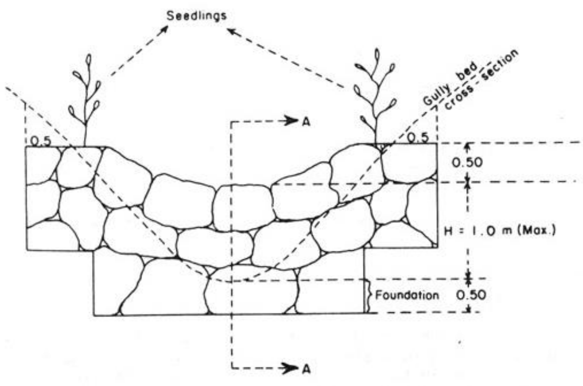


FIG. 12 SCHEMATIC AND PICTURE OF A LOOSE STONE CHECK DAM

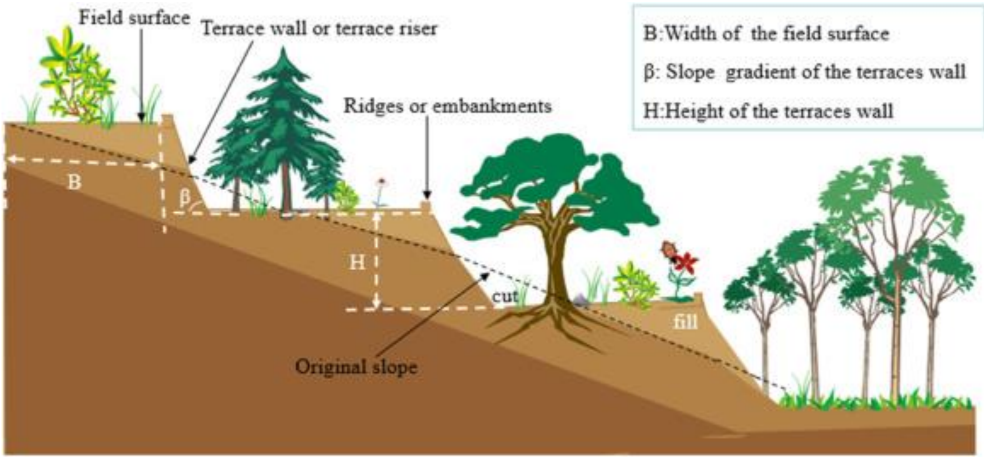


FIG. 13 SCHEMATIC DRAWING OF A BENCH TERRACE

3.14 Staggered Contour Trenches

These structures are used for in-situ moisture conservation. The staggered trenching involves the excavation of trenches of shorter length in a row along the contour with interspace between them. These trenches are arranged in straight line (staggered form). Suitable vertical intervals between the rows are restricted to impound the runoff without overflow. In the alternate row, the trenches are located directly below one another. The trenches in successive rows are thus staggered, with the trenches in the upper row and the interspace in the lower row being directly below each other. The length of the trench and the interspace between the trenches in the same row should be designed in such a way that no long unprotected or uninterrupted slope remains to cause unexpected runoff or erosion. As the trenches are not continuous, no vertical disposal drain is excavated. The cross-sectional area of these trenches should be designed to collect the runoff expected from intense storms at recurrence intervals of 5 to 10 years. Staggered contour trench technique is useful in slowing surface water run-off and soil erosion from sloping land, and in re-vegetating degraded land. This is especially useful in areas with high rainfall, steep slopes, and thin soils which should use slightly graded bunds/terraces/trenches to allow some drainage. Schematic and photographic view of a staggered contour trench is shown in Fig. 14. Important features of staggered contour trenches are:

a) These trenches are short (3 m to 5 m long) and arranged in row along the contour with inter-space between them;

b) The vertical interval between two successive trenches is decided on the basis of expected runoff from the area, above without overflow;

c) In staggered sequenced, the alternate rows of trench are located directly below one another;

d) The length of row and slope between them is fixed based on the concept that there should not be greater length of unprotected or uninterrupted slope to cause unexpected runoff and erosion; and

e) The cross-sectional area of these trenches is designed to collect the runoff from an intense storm during 5 to 10 year's return period.

3.15 Continuous Contour Trenches

These structures are used for in-situ moisture conservation. Continuous contour trenches are dug at a right angle to the slope and are planned along the contour lines. Doing so stops the water flowing downhill in its tracks by the trenches, and water percolation into the soil below is facilitated. Between two trenches, crops can be planted during the growing season (when there is less rain) from the subsoil water. Photographic view of a typical contour trench is shown in Fig. 15. Advantages of this structure are as follows:

a) The rainwater does not immediately run off the hill;

b) These trenches help control the water from flooding downstream farm areas, which helps in saving water and channelling it in the right direction;

c) The water that percolates into these trenches after a rainfall, keeps the soil moisture intact for a long time that may even extend up the following dry season. The same water can be directly pumped out for irrigation or extracted from shallow wells in the area; and

d) Without trenches, a lot of soil erosion happens which increases the salt build-up in the water downstream. This becomes unfavourable for groundwater quality as well as for crops. Also, the roots and foliage of the vegetation trap sediment that would otherwise overflow from the trench during heavy rainfall.

3.16 Gully Plug

A gully plug is a small, temporary, or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows for a certain design range of storm events and to conserve soil moisture. Gully plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season. The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

The principle is to capture runoff from a broad catchment area, thus transferring low rainfall into utilizable soil moisture, and to prevent soil erosion. Slowing the velocity of flowing water helps in settling down organically rich soil. A well-maintained gully plug creates a flat, fertile and moist field, where high value crops and trees can be grown. Photographic view of typical gully plugs are shown in Fig. 16.

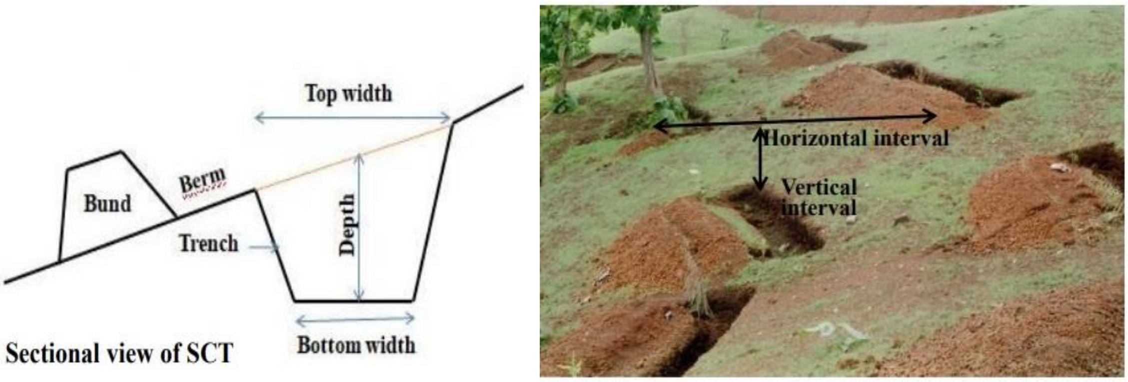


FIG. 14 SCHEMATIC AND PICTURE OF A STAGGERED CONTOUR TRENCH

FIG. 15 PHOTOGRAPHIC VIEW OF A TYPICAL CONTINUOUS CONTOUR TRENCH

FIG. 16 PHOTOGRAPHIC VIEW OF TYPICAL GULLY PLUGS

4 WATER HARVESTING

The term ‘water harvesting’ implies collection and storage of rainwater and also other activities aimed at harvesting surface water, prevention of losses through evaporation and seepage, and all other hydrological studies and engineering interventions aimed at conservation and efficient utilization of limited water endowment of a physiographic unit such as a watershed or a geomorphic basin.

The water harvesting is effected by:

a) In-situ harvesting;
b) Artificial recharge — methods and structures; and
c) Treatment of catchments for augmenting surface run-off.

In-situ harvesting system is necessary in areas, where:

a) rainfall is scanty; and
b) water bearing geological formations are not available.

In-situ harvesting is effected through natural and artificial sources.

Rainwater harvesting is one of the effective tool for surface water management in hilly areas, it is the process of collection and storing rainwater, instead allowing it to run off. In the rainwater harvesting system, rainwater is collected from smaller surface areas as well as rooftops and collected either in surface storage structures, or into a pit or borehole for underground recharge and storage. The water collected through rainwater harvesting may be utilized for domestic needs with proper treatment, livestock, watering gardens, and irrigation. The harvested water can also be committed to longer-term storage or groundwater recharge.

In hilly areas, rainwater is harvested mainly for two purposes:

a) Domestic use; and
b) Agricultural use which is mostly for irrigation purpose or enhancing soil moisture.

Rainwater harvesting for domestic needs is generally, done using rooftop rainwater harvesting system near the building in a tank or to recharge groundwater for future use. Sometimes, community tanks are also constructed to store rainwater for meeting the demands of domestic or cattle needs. For the agricultural needs, various structures are practiced for water conservation either for surface storage or for underground recharge as well as soil moisture enhancement. These structures largely depend on the slope condition of the ground surface, which may very form site to site a brief detail about these structure is given in 3.

5 ROOF TOP WATER HARVESTING SYSTEM

Roof top rainwater harvesting system is the technique through which rainwater is captured from the roof catchments and stored either in storage structures or in sub-surface ground water reservoirs. Rainwater may be harvested in areas, having rainfall of considerable intensity, spread over the larger part of the year, for example, in the hilly areas. Roof top water collection is considered as an ideal solution for water problem where there is inadequate ground water supply and surface sources are either lacking or insignificant.

Roof top rainwater harvesting is one of the appropriate options for augmenting ground water recharge/storage in urban areas where natural recharge is considerably reduced due to increased urban activities and not much land is available for implementing any other artificial recharge measure. Roof top rainwater harvesting can supplement the domestic requirements in rural areas as well. A roof top water collection system is recommended as the first option for hill areas

5.1 Principle

The principle of rainwater harvesting from the roof top is to collect and store whatever amount of rainwater that could be stored and divert the rest for recharging the groundwater. In this system, rooftop forms the catchment. Whether to store or recharge water depends on rainfall pattern of the region. Where the rainfall is throughout the year barring a few dry spells, a small domestic size tank can be used for storing water, for the short time spells between two rainfalls. However, if the total rainfall occurs in a span of three to four months or monsoon, the volume of available water is extremely large which requiring huge structures, it is better to use the water for recharge. The aquifer to be recharged should have sufficient thickness of permeable zone to accommodate the recharge. The total volume of rainwater available for rainwater harvesting of a given roof top area and particular rainfall may be taken from IS 15797.

5.2 Components

The important components of the roof top water harvesting systems include roof catchment, coarse mesh, gutters, downpipes, first flush device, filtration unit and storage tank.

5.2.1 *Catchment*

The catchment of a roof top water harvesting system is the roof surface which directly receives the rainfall and provides water to the system. The style, construction and material of the roof determine its suitability as a catchment.

5.2.2 *Coarse Mesh*

It is provided at the roof to prevent the passage of debris to storage tank (Fig. 17). The approximate size of course mesh is 850 microns (20 mesh). The minimum size of mesh should be 100 microns for proper filtration of water.

5.2.3 *Gutters*

These are channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank. Gutters can be a semi-circular or rectangular gutter (Fig. 18 and Fig. 19). They are provided with an end cap.

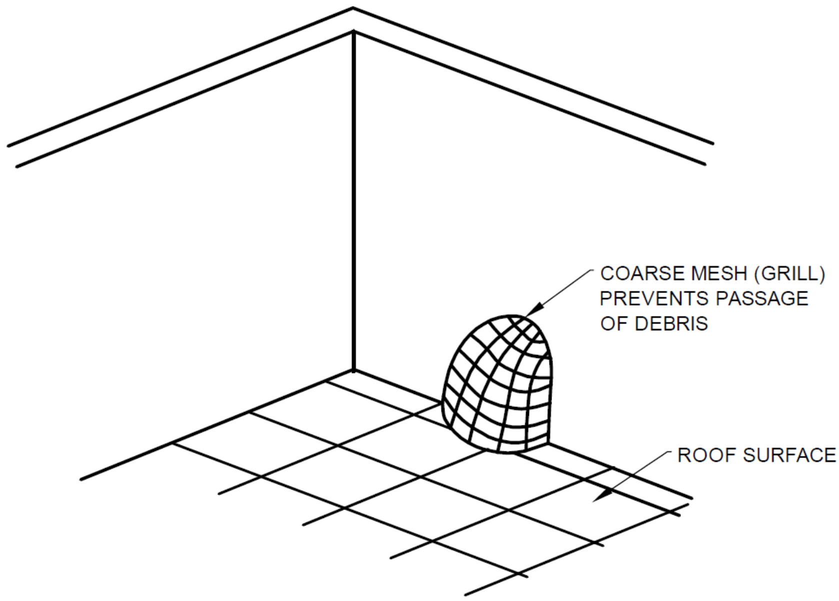


FIG. 17 TYPICAL COARSE MESH DETAILS

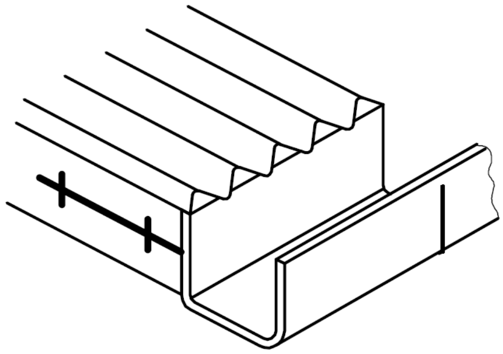


FIG. 18 TYPICAL DIAGRAM OF RECTANGULAR GUTTER

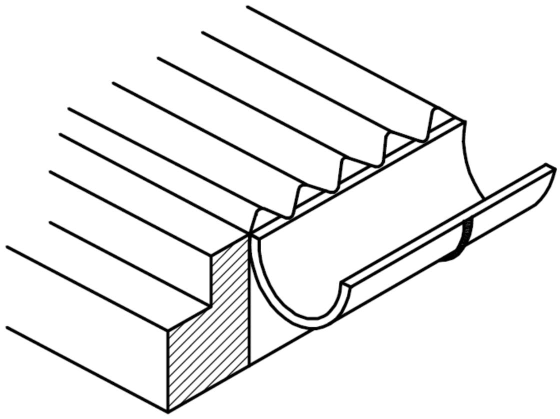


FIG. 19 TYPICAL DIAGRAM OF SEMI-CIRCULAR GUTTER

5.2.4 *Down Pipes* (*Drain Pipes*)

Down pipe is the pipe that carries the rainwater from the gutters to the storage tank. Down pipe is joined with the gutters at one end, whereas the other end is connected to the filter unit of the storage tank.

5.2.5 *First Flush*

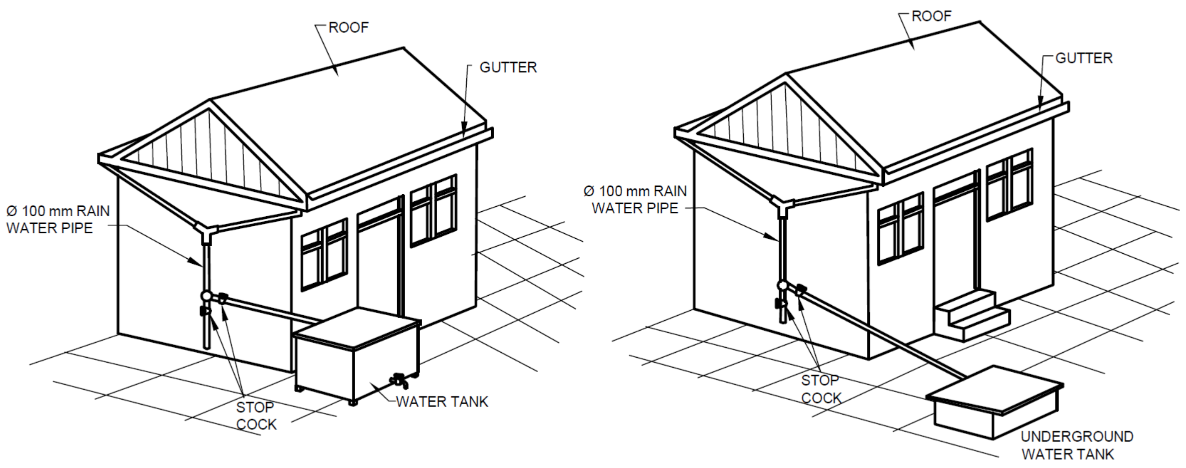
Debris, dirt, dust and droppings get collected on the roof of a building or other collection area. When the first rains arrive, this unwanted matter will be washed into the tank, causing contamination of the water and reducing its quality. Many rainwater harvesting systems therefore incorporate a system for diverting this 'first flush' water to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof so that it does not enter the storage tank.

5.2.6 *Filtration Unit*

To keep water clean, prevent clogging and sediment buildup, basic filtration is needed. The type and number of filtering components on a system depend on the amount of roof debris. There are a wide variety of systems available for treating water before, during, and after storage. The level of sophistication varies from extremely high-tech to very rudimentary. The simple trash rack has been used in some systems but this type of filter has a number of associated problems. Firstly, it only removes large debris; and secondly the rack can become clogged easily and requires regular cleaning. Settling tanks and partitions can be used to remove silt and other suspended solids from the water. These are usually effective, but add significant additional cost if elaborate techniques are used. Many systems found in the field rely simply on a piece of cloth or fine mosquito mesh to act as the filter (and to prevent mosquitoes entering the tank).

5.2.7 *Storage Tank*

These are provided to store the harvested water. There are an almost unlimited number of options for storing water. Common vessels used for very small-scale water storage include plastic bowls and buckets, jerry cans, clay or ceramic jars, cement jars, old oil drums, empty food containers, etc. For storing larger quantities of water, the system will require a storage structure which could be over ground or underground (*see* Fig. 20). Tank is an above-ground storage vessel while cistern is a below-ground storage vessel. Multiple tanks can be connected together to increase the storage capacity. They can be linked at the top or the bottom. Both tanks and cisterns have their advantages and disadvantages. A comparison of the two is shown in Table 2.



20A OVER-GROUND STRUCTURE

20B UNDER-GROUND STRUCTURE

FIG. 20 TYPICAL ROOF WATER COLLECTION STRUCTURE

Table 2 Comparison of Tank and Cistern

(*Clause* 5.2.7)

Sl No.	Tank	Cisterns
(1)	(2)	(3)
i)	Inspection for leakage is easy	Inspection for leakage is difficult
ii)	Space requirement is more	Require little or no space above ground
iii)	Generally more expensive	Generally less expensive
iv)	Can be more easily damaged	Chances of damage are less
v)	Possible damage by tree roots are less	Can be damaged by tree roots
vi)	No possibility of contamination from groundwater	Possibility of contamination from groundwater
vii)	Relatively less risky for children and small animals	If uncovered, it may be dangerous to children and small animals
viii)	Water extraction is easy and can be by gravity in many cases	Water extraction may be problematic, often requiring a pump
ix)	More prone to attack from weather	Less prone to attack from weather

The storage tanks can vary in size from a cubic metre up to hundreds of cubic metres for large projects, depending upon the requirement. The typical maximum size for a domestic system is 20 or 30 cubic metres. The size of the tank depends upon factors like daily demand, duration of dry spell, catchment area and rainfall. It will also depend upon a number of technical and economic considerations such as space availability, options available locally, local traditions for water storage, cost of purchasing new tank, cost of materials, labour for construction, materials and skills available locally, ground conditions and use of rainwater harvesting.

Storage tanks are also provided with pipe fixtures at appropriate places for drawing water, cleaning the tank and for disposal of excess water. They are called tap or outlet, drain pipe and over flow pipe respectively.

A typical roof water harvesting system is shown in Fig. 21.

5.3 Design Considerations

5.3.1 *Catchment Suitability*

Roofs made of corrugated iron sheet, asbestos sheet, tiles or concrete can be utilized as catchments for harvesting rainwater. Thatched roofs, on the other hand, are not suitable, as pieces of roof material may be carried by water and may also impart some colour to water. The slope and shape of the roof are also important in planning a roof top rainwater harvesting system. Water flows with high velocity on steep-sloped roofs, causing overflow or wastage of water from gutters and filters. Gentle slopes in the range of 10° to 30° are most suitable for the smooth flow of water into the storage tank. Roofs having slopes more than 30° are to be avoided wherever possible.

5.3.2 *Estimating Quantity of Harvestable Water*

The total amount of water received by an area through rainfall is called the rainwater endowment of that area. The amount that can be effectively harvested from the certain area is called the rainwater harvesting potential of that area. It depends upon the collection efficiency (also called runoff coefficient) of the surface which in turn depends upon the type of roof surface. The runoff coefficient generally lies between 0.7 to 0.9 (Table 3). If the value is not known, a value of 0.85 is assumed. However, not 100 percent of the rainwater harvesting potential is harvested. The effectively harvested water further depends upon the evaporation, spillage and first flush wastage. Generally, the effectively harvested water is considered to be 80 percent of the rainwater harvesting potential.

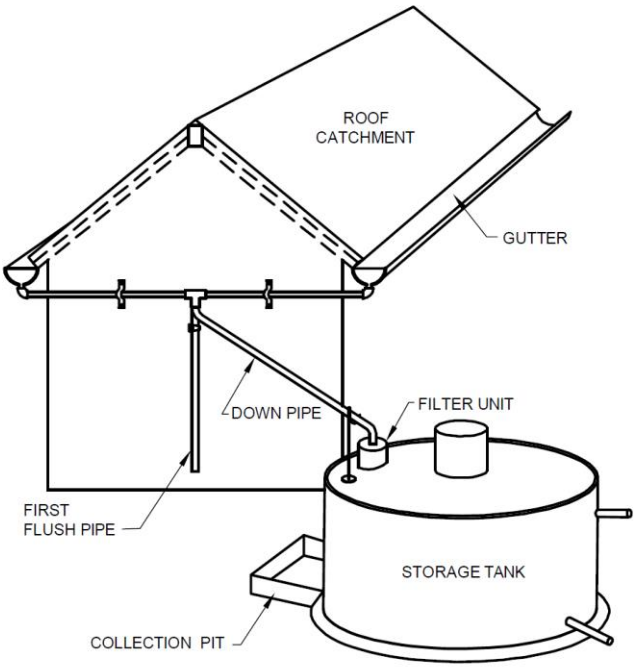


FIG. 21 A TYPICAL ROOF WATER HARVESTING SYSTEM

Table 3 Runoff Coefficient for Various Roof Surfaces

(*Clause* 5.3.2)

Sl No.	Diameter of Pipe mm	Roof Area, in m^2 for Average Rate of Rainfall in, mm/h					
		50	75	100	125	150	200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	50	29.70	19.80	14.85	11.88	9.90	7.42
ii)	65	57.23	38.15	28.61	22.89	19.08	14.31
iii)	75	81.84	54.56	40.92	32.74	27.28	20.46
iv)	100	168.00	112.00	84.00	67.20	56.00	42.00
v)	125	293.48	195.66	146.74	117.39	97.83	73.37
vi)	150	462.95	308.64	231.48	185.18	154.32	115.34

NOTE — For rainwater pipes of other materials, the roof area shall be multiplied by (0.013/coefficient of roughness of surface of that material). For example, for rainwater pipes of PVC (coefficient of roughness – 0.009), the above values of roof area shall be multiplied by 0.013/0.009 = 1.44.

Following calculations can be made to estimate the quantity of effectively harvested water:

a) Rainwater endowment of a rooftop area (m^3):

$$= \text{Area of roof top } (m^2) \times \text{ annual rainfall } (m)$$

b) Rainwater harvesting potential of a roof area (m^3):

$$= \text{Rainwater endowment of that area } (m^3) \times \text{ collection efficiency } (\%)$$

c) Effectively harvested water (m^3):

$$= 0.8 \times \text{ rainwater harvesting potential of a roof area } (m^3)$$

5.3.3 *Gutter*

Gutters need to be supported so they do not sag or fall off when loaded with water. The way in which gutters are fixed depends on the construction of the house. It is possible to fix iron or timber brackets into the walls, but for houses having wider eaves, proper design is required.

Size and slope of gutter should be proper. The size of the gutter should be according to the flow during the highest intensity rain. It is advisable to make them 10 percent to 15 percent oversize. For slope, the rule of thumb is 6 mm of slope per 3 000 mm of gutter.

5.3.4 *Down Pipes* (*Drain Pipes*)

PVC or GI pipes of 50 mm to 150 mm diameter are commonly used for down pipe. In the case of RCC buildings, drain pipes themselves serve as down pipes. The drain pipes of suitable size, made of PVC/GI/CI/HDPE are provided in RCC buildings to drain off the roof top water to the storm drains. They have to be connected to a pipe to carry water to the storage tank. The joining of down pipe and first flush pipe can be easy if both are of same material (Fig. 22 and Fig. 23).

The suggested diameters of rainwater pipes for different magnitudes of average rainfall are presented in Table 4.

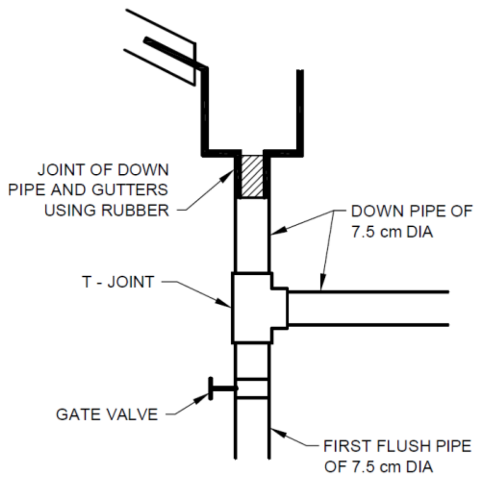


FIG. 22 A DOWN PIPE

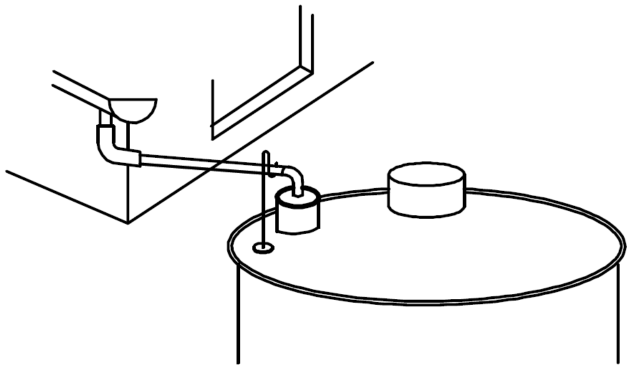


FIG. 23 MOST COMMON ARRANGEMENT OF DOWN PIPE

Table 4 Sizing of Rainwater Pipes for Roof Drainage

(*Clause* 5.3.4)

Sl No.	Diameter of Pipe mm	Roof Area in Square m for Average Rainfall in, mm/h					
		50	75	100	125	150	200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	50	13.4	8.7	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

5.3.5 *First Flush*

The simplest form of first flush arrangement is a manually operated arrangement whereby the inlet pipe is moved away from the tank inlet, and then replaced again once the initial first flush has been diverted. This method has obvious drawbacks because there has to be a person present who will remember to move the pipe.

In another semi-automatic system, a separate vertical pipe is fixed to the down pipe with a valve provided below the 'T' junction (Fig. 24).

Some systems use tipping gutters as first flush device (Fig. 25). This system uses a bucket which accepts the first flush and the weight of this water off-balances a tipping gutter which then diverts the water back into the tank. The bucket then empties slowly through a small-bore pipe and automatically resets. The process will repeat itself from time to time if the rain continues to fall, which can be a problem where water is really at a premium. In this case a tap can be fitted to the bucket which can be operated manually. The quantity of water that is flushed depends on the force required to lift the guttering. This can be adjusted to suit the needs of the user.

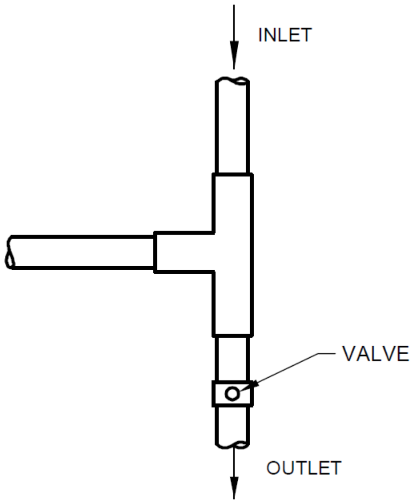


FIG. 24 FIRST FLUSH ARRANGEMENT WITH VALVE

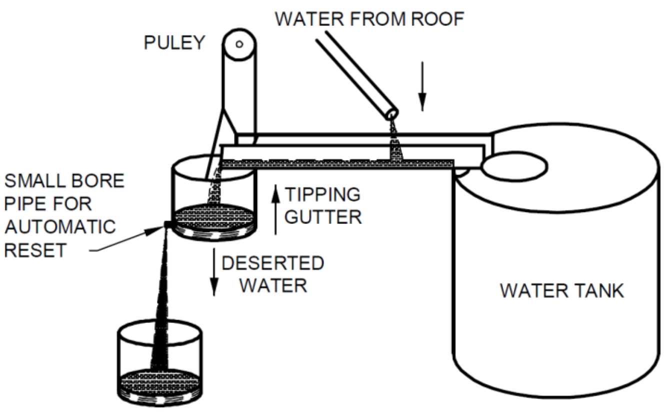


FIG. 25 TIPPING GUTTER TYPE FLUSH DEVICE

Another system is the floating ball device in which the ball forms a seal once sufficient water has been diverted (Fig. 26). The seal is made as the ball rises into the apex of an inverted cone. The ball seals the top of the 'waste' water chamber and the diverted water is slowly released, as with the bucket system above, through a small bore pipe. Again, the alternative is to use a tap.

First flush diverters are usually not needed unless water quality is especially poor (that is, significant bird droppings on collection surface). Also, although more sophisticated methods provide a much more elegant means of rejecting the first flush water, it is generally recommended that, easily maintained systems to be used.

If provision for the first flush device is made, it should be located at outlet of each drainpipe.

5.3.6 *Filtration Unit*

Sand gravel filter, charcoal and sponge are the most commonly used filtration units.

5.3.6.1 *Sand gravel filter*

These filters are constructed by brick masonry and filled with pebbles, gravel and sand (Fig. 27). Each layer is separated by a wire mesh. For effective filtration, the criteria for selecting the filtration media is given in IS 8419 and IS 17955. The detailed guidelines for designed, construction and operation are given in [*see* IS 11401 (Part 1) and (Part 2)].

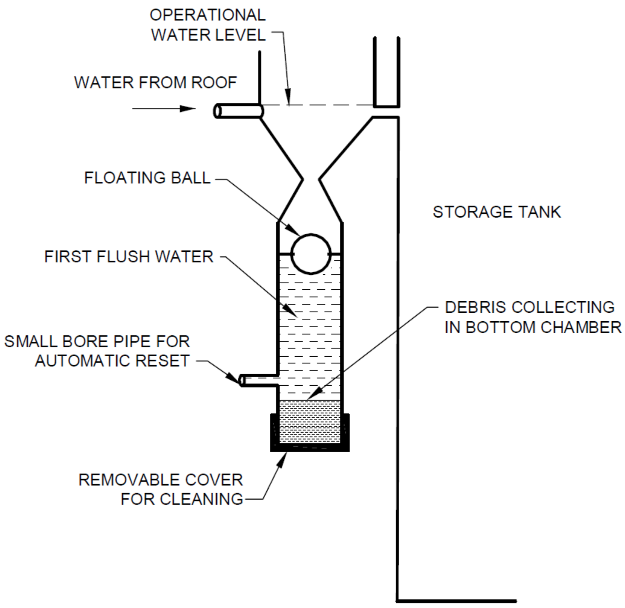


FIG. 26 FLOATING BALL TYPE DEVICE

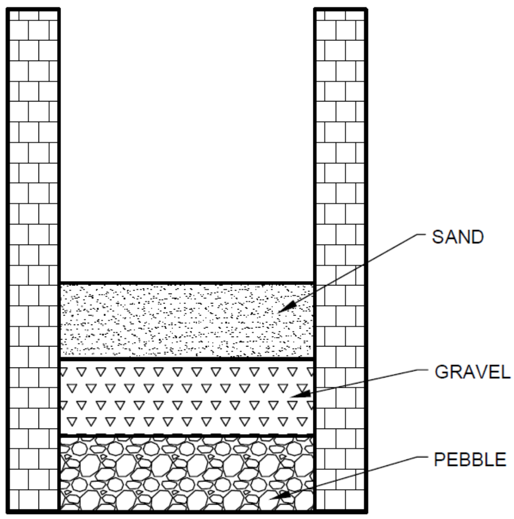


FIG. 27 SAND GRAVEL FILTER

5.3.6.2 *Charcoal filter*

It is one of the best filtration unit, which adsorbs even the diluted pollutants in water including particulates and bird fecal matter. It can be made in-situ or in a drum. The drum or the chamber is filled with pebbles, gravels, sand and charcoal in alternate layers as shown in Fig. 28. Each layer is separated by a wire mesh. This type of filter is only suitable, where the inflow is slow to moderate. The guidelines for the selection of material and construction are given in [IS 8419, IS 17955, IS 2752 and IS 11401 (Part 1) and (Part 2)]. The filter material must be cleaned periodically before the monsoon season.

5.3.6.3 *Piped filtration unit*

A filtration device that uses a bed of media to remove organic and inorganic particles from the incoming irrigation water. Each media filter is contained within a pressure vessel(s) or tank(s) having service openings (*see* Fig. 29), inlet, outlet and backflush connections that contains underlying drains (for example, PVC plastic, stainless steel, or ceramic materials) with or without a gravel bed to facilitate the backwashing procedure. Media filter is sometimes referred to as a depth filter. The guidelines for selection of material and construction are given in IS 14606.

5.3.6.4 *Sponge filter*

It is simple, easiest and cheapest form filter made from PVC drum. It has a layer of sponge in the middle of the drum (Fig. 30). It is suitable for residential units.

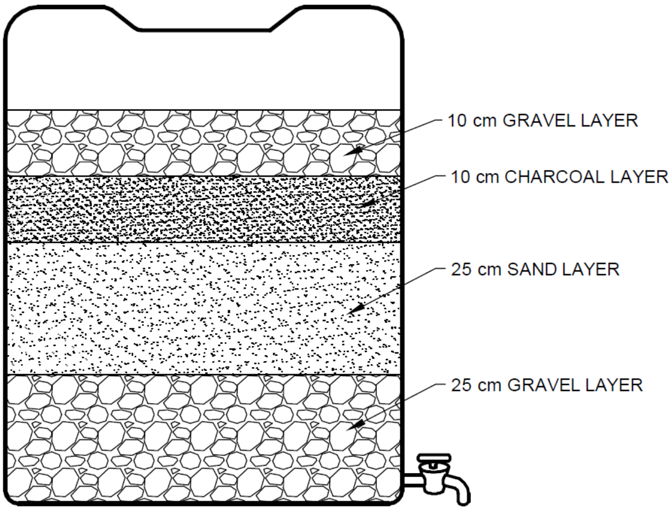


FIG. 28 CHARCOAL FILTER

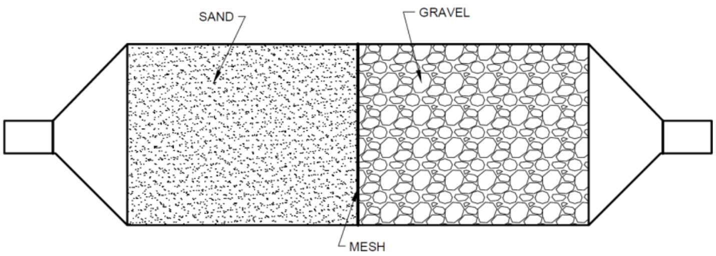


FIG. 29 PVC PIPE FILTER

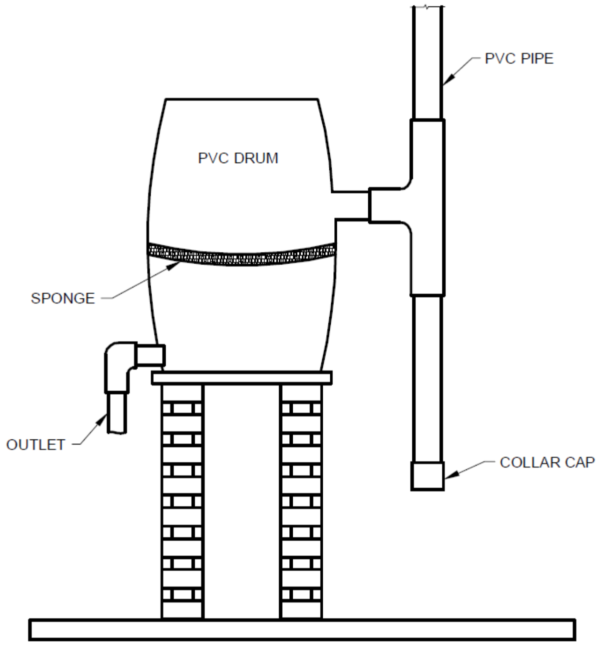


FIG. 30 SPONGE FILTER

5.3.7 *Storage Tank*

The water storage tank usually represents the biggest capital investment element of a domestic rainwater harvesting (RWH) system. It, therefore, requires careful design to provide optimal storage capacity while keeping the cost as low as possible. The storage tank should be located on slope, which is structurally stable. In case the slope is in the distress, adequate safety measures shall be taken as per [IS 14243 (Part 1) and (Part 2)] before installation of the tank.

The storage tanks should be provided with inlet for rainwater to enter and outlet to access water. There should be an overflow pipe, which should be as large as inlet pipe. The tank should also have an air vent for air to escape while the tank is filling. The overflow pipe can also serve as an air vent.

The required volume of the storage tank may be found by examining monthly rainwater collection potential or supply (based on average monthly rainfall) against the demand. The cumulative shortfall in the dry months has to be met. The tank capacity can be designed based the volume of harvestable water as discussed earlier.

Another approach for acquiring rough estimates of tank size is the demand based approach. It is a very simple method to calculate the largest storage requirement based on the consumption rates and occupancy of the building. It is suitable for areas where roof catchment and rainfall are sufficient. The storage capacity can be estimated using the formula:

$$S = C.n.D$$

where

S = storage capacity (litres);

C = consumption per capita per day (litres);

n = numbre of people per household; and

D = longest average dry period (days).

5.3.8 *Other Design Considerations*

a) Underground storage tanks should be suitably lined with water proofing material and preferably have a hand pump installed for withdrawal of water. Their top shall remain at least 300 mm above the ground;

b) The bottom of surface tank should be placed little higher than the ground level on a raised platform. An outlet pipe should be fixed at the bottom of the tank to facilitate cleaning of the tank. A tap should be provided for withdrawing water;

c) The tank shall have a manhole of 600 mm × 600 mm square or 600 mm diameter with cover, a vent pipe/overflow pipe (with screen) of 100 mm diameter, and a drain pipe at the bottom;

d) The sand being used for filter in rainwater harvesting systems should be free from clay, loam, vegetable matter, organic impurities, etc and should also be uniform in nature and grain size. In place of sand, 'anthrafilt', made from anthracite (stonecoal) can also be used as filter medium. This material is found to possess many advantages such as low cost, high rate of infiltration and better efficiency. However, as sand is readily available almost everywhere, the usual practice is to use it as filter medium;

e) The capacity of storage tank, which reflects the total household water requirement during the period of water scarcity, need to be checked with the amount of water available from house roof top during rains. If the amount of water available from roof is less than the required capacity of storage tank, then the household shall use the water available from roof only for a part of the water scarcity period;

f) The roof should be away from big trees to avoid accumulation of leaf litter and bird droppings;

g) Among all the components of rainwater harvesting systems, storage tank is the component occupying most space, and hence the space required for the system depends on the size of the storage tank. For a typical 10 000 litres tank, the minimum space required is 3.0 m × 3.0 m. Therefore, assessment of availability of space adjacent to the house shall be done giving due importance to the preferences of the household. Storage tanks located near the roof reduce the cost of down pipes. The site should be clean, hygienic and away from cattle sheds to avoid contamination of stored water;

j) Light promotes algae growth. Dark colored tanks are preferable to light color tanks as they do a better job of keeping out light;

k) A storage tank should not be located close to a source of contamination, such as a septic tank, etc;

m) A storage tank must be located on a lower level than the roof to ensure that it fills completely; and

n) A rainwater harvesting system must include installation of an overflow pipe, which empties into a non-flooding area. Excess water may also be used for recharging the aquifer through dug well or abandoned hand pump or tube well, etc.

5.4 Material

Although suitable locally available materials of non-corroding, non-rusting, and non-absorbent nature are permissible, for longer life, materials indicated below are recommended.

5.4.1 *Roofing*

Corrugated iron sheet, asbestos sheet, galvanized iron sheet, asbestos cement sheets, aluminum sheet, concrete clay tiles, are the most commonly used roofing material for rainwater harvesting. A detail list of roofing material that can be utilized for making the roof for rainwater harvesting is given below:

a) Galvanized steel strips and sheets as per IS 277;

b) Corrugated and semi — Corrugated asbestos cement sheets as per IS 459;

c) Corrugated aluminium sheet as per IS 1254;

d) Asbestos cement flat sheets as per IS 2096;

e) Hollow clay tiles as per [*see* IS 3951 (Part 1) and (Part 2)];

f) Roofing slate tiles as per IS 6250;

g) Corrugated coir wood wool cement roofing sheets as per IS 10388;

h) Corrugated bitumen roofing sheets as per IS 12583;

j) Silica-asbestos-cement flat sheets as per IS 13000;

k) Shallow corrugated asbestos cement sheets as per IS 13008;

m) Clay roofing country tiles, half round and flat tiles as per IS 13317;

n) Continuously pre-painted galvanized steel sheets and strips as per IS 14246;

p) Fibre cement flat sheets as per IS 14862; and

q) Fibre reinforced cement sheets as per IS 14871.

Thatched roofs, on the other hand, are not suitable as pieces of roof material may be carried by water and may also impart some colour to water. Thatched roof may be used provided it is covered by water proof sheeting like polyethylene films. If the roof is painted, only non-toxic paints be used for painting the roof. Water collected from roofs painted with toxic paints should not be used for drinking purposes

5.4.2 *Gutter* (*Drain*)

Galvanized iron sheets as per IS 277, asbestos cement gutters as per [*see* IS 1626 (Part 2)], wood, bamboo or reinforced cement concrete can be used to make gutters. Semi-circular or rectangular shaped channels can be made using GI sheet. Bamboo or betel trunks cut vertically in half or cut PVC pipes can also be used. These channels are fixed to the roof by using mild steel supports. IS 2527 gives the guidelines for fixing rainwater gutters and downpipes for roof drainage.

V-shaped gutters from galvanized steel sheet can also be made simply by cutting and folding flat galvanized steel sheet. The better the grade of steel sheet that is used, the more durable the product. However, fitting a downpipe to V-shaped guttering can be problematic. Plastic pipes can also be cut into half to make gutters (*see* Fig. 31). This requires only a saw and some clamps to fix the half-pipes to roofs. It may be made quickly and cheaply in areas where plastic pipes are available. Use of locally available materials is preferred as it reduces the overall cost of the system.

5.4.3 *Down Pipe* (*Drain Pipe*)

PVC or GI pipes are commonly used for down pipe. Galvanized mild steel pipe, cast iron pipe, high-density polyethylene pipe can also be used. In the case of RCC buildings, drain pipes themselves serve as down pipes. Pipes of diameter 20 mm to 25 mm are generally used for the purpose for drain pipes and over flow pipe. Multiple option is available for selection of drain pipe on the basis of material, shape and size. A list of specification that can be utilized for drain pipe is given below:

a) Steel tubes, tubulars and other wrought steel fittings as per IS 1239;

b) Centrifugally cast (spun) iron pressure pipes and pipe fittings as per IS 1536;

c) Asbestos cement building pipes as per IS 1626;

d) Sand cast iron spigot and socket pipes, fittings and accessories as per IS 1729;

e) Centrifugally cast (spun) iron spigot and socket pipes, fittings and accessories as per IS 3989;

f) Polyethylene pipes for water supply as per IS 4984;

g) Unplasticized PVC pipes for water supplies as per IS 4985;

h) Glass — Fibre reinforced plastic (GRP) pipes joints and fittings as per IS 12709;

j) Unplasticized polyvinyl chloride (PVC-U) pipes as per IS 13592;

k) Unplasticized polyvinyl chloride (UPVC) injection moulded pipe as per IS 14735;

m) Chlorinated polyvinyl chloride (CPVC) pipes as per IS 15778; and

n) Oriented unplasticized polyvinyl chloride (PVC-O) pipes as per IS 16647.

5.4.4 *Storage Tank*

Multiple options are available for the construction of storage tanks with respect to the shape (cylindrical, rectangular and square), the size (capacity from 1 000 litres to 15 000 litres or even higher) and the material of construction (brick, stone, cement bricks, ferrocement, concrete and reinforced cement concrete). Factory manufactured storage tanks are most suitable in the range of 4 000 litres to 15 000 litres. On site construction storage tank like brick, stone or cement brick may be used for capacities ranging between 15 000 litres to 50 000 litres. Cement concrete and reinforced cement concrete are used for tank capacities exceeding 50 000 litres. The preferred material for underground storage tanks are masonry, reinforced cement concrete, high density polyethylene and for over ground the preferred material are galvanized iron sheet, reinforced cement concrete, plastic/high density polyethylene, ferrocement sheet. A list of storage tank specifications for rainwater harvesting is given in below:

a) Rectangular pressed steel tanks as per IS 804;

b) Rotational moulded polyethylene water storage tanks as per IS 12701;

c) Precast ferrocement water tanks as per IS 13356; and

d) Glass fibre reinforced polyester resin (GRP) water storage tanks as per IS 14399.

FIG. 31 HALF CUT PLASTIC PIPE GUTTER

5.5 Recharge Structures

When roof water harvesting is done for recharging the ground water, suitable recharge structure is required. For selecting the site and type of recharge structures knowledge of hydrological and geological features of the area (aquifers) is required. The aquifers best suited for the purpose are those which absorb large quantity of water but do not release the same quickly. The various recharge structures are:

a) Abandoned dug well;

b) Hand pump/bore well;

c) Recharge pit;

d) Recharge trench;

e) Gravity head recharge tube well; and

f) Recharge shaft.

5.6 Operation and Maintenance

a) Before the tank is put into use it should be thoroughly cleaned and disinfected with a suitable disinfectant such as chlorine, bleaching powder, potassium permanganate;

b) Since the water shall remain stored for quite a long time, periodical disinfection of stored water is essential to prevent growth of pathogenic bacteria;

c) In order to avoid any instability to slopes, excess and after use water should be drained to the nearest *nullah* or any natural drains or disposed through a properly designed outlet system;

d) As bacteriological contamination cannot be detected by the naked eye, it is necessary to analyze the quality of water in laboratories by collecting few water samples from storage tank. These tests help in verifying the presence of pathogenic bacteria;

e) For disinfecting using bleaching powder, the general dosage recommended is 10 milligrams of bleaching powder containing 25 percent of free chlorine per litre of water. This meets the required standard of 2.5 milligrams of chlorine per litre of water;

f) After adding the bleaching power, the water shall be stirred thoroughly for even distribution of the disinfectant. The water should be kept for about 30 min after adding bleaching powder before it is ready for use. The quantity of bleaching powder to be added for different water depths in the storage tank is shown in Table 5;

g) Roof or terraces used for harvesting should be clean, free from dust, algal plants, etc. They should not be painted since most paints contain toxic substances and may peel off;

h) Do not store chemicals, rusting iron, manure or detergent on the roof;

j) Nesting of birds on the roof should be prevented;

k) Terraces should not be used for toilets either by human beings or by pets;

m) Do not use polluted water to recharge ground water. Ground water should only be recharged by rainwater;

n) Filter media should be cleaned before every monsoon season;

p) During rainy season, the whole system (roof catchment, pipes, screens, first flush, filters, tanks) should be checked before and after each rain and preferably cleaned after every dry period exceeding a month;

q) At the end of the dry season and just before the first shower of rain is anticipated, the storage tank should be scrubbed and flushed off all sediments and debris;

r) Cover tank openings to prevent evaporation and exclude light; and

s) Frequency for different activity related to rainwater harvesting is given in Table 6.

5.7 Do's and Don'ts for Harvesting Rainwater

5.7.1 *Do's for Harvesting Rainwater*

a) Clean roof every two weeks to remove debris and leaves that could contaminate the rainwater;

b) Empty the first rain separator either right after or just before every rainfall;

c) Clean water tanks once every six months and keep tank firmly closed at all times to prevent debris from slipping inside;

d) Double-check the pipes leading to any possible containment system and make sure they're in good working order;

e) When setting up any rainwater harvesting system, keep rainwater harvesting and sanitation lines separate to avoid cross-contamination;

f) On the top of rainwater tank, make sure to have a lid that fits tightly to prevent entry of sunlight to get in and prevent algae growth;

g) Reuse water as much as possible; and

h) Participation in water conservation programmes.

5.7.2 *Don'ts for Harvesting Rainwater*

a) Don't use hazardous substances, chemicals, or paints on your roof because they can chip off and end up in water;

b) Don't leave the filter and the first rain separator valve open at the same time because it'll let debris slip through;

c) Don't leave the tank uncovered during any dry periods because dust will find a way in;

d) Never drink any rainwater collected directly that is not filtered first; and

e) The roof is a catchment area for rainwater, and birds should not be allowed there to nest.

Table 5 Recommended Dosages of Bleaching Powder for Disinfecting Water

[*Clause* 5.6, *Sl No.* (f)]

Sl No.	**Storage Capacity of Tank** (litre)	**Dosage of Bleaching Power in, (g)**			
		Full Tank	Tank Three Fourth (3/4) Full	Tank Half (1/2) Full	Tank One Fourth (1/4) Full
(1)	(2)	(3)	(4)	(5)	(6)
i)	5 000	50	37.5	25	12.5
ii)	6 000	60	45.0	30	15.0
iii)	7 000	70	52.5	35	17.5
iii)	8 000	80	60.0	40	20.0
iv)	9 000	90	67.5	45	22.5
v)	10 000	100	75.0	50	25.0

Table 6 Operation and Maintenance Frequency

[*Clause* 5.6 *Sl No.* (s)]

Sl No.	**Activity**	**Frequency**
(1)	(2)	(3)
i)	Clean the system	1 to 3 times a year
ii)	Clean and disinfect the tank	Every 6 months
iii)	Divert the foul flush	Every storm
iv)	Repair of roof, gutters, pipes, etc	As and when needed

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 277 : 2018	Galvanized steel strips and sheets (plain and corrugated) — Specification (*seventh revision*)
IS 459 : 1992	Corrugated and semi-corrugated asbestos cement sheets — Specification (*third revision*)
IS 804 : 1967	Specification for rectangular pressed steel tanks (*first revision*)
IS 1239 (Part 1) : 2004	Steel tubes, tubulars and other wrought steel fittings — Specification: Part 1 Steel tubes (*sixth revision*)
IS 1254 : 2007	Corrugated aluminium sheet (*fourth revision*)
IS 1536 : 2023	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage — Specification (*fifth revision*)
IS 1626	Asbestos cement building pipes and pipe fittings, gutters and gutter fittings and roofing fittings — Specification:
(Part 1) : 1994	Pipe and pipe fittings (*second revision*)
(Part 2) : 1994	Gutters and gutter fittings (*second revision*)
(Part 3) : 1994	Roofing fittings (*second revision*)
IS 1729 : 2023	Sand cast iron spigot and socket pipes, fittings and accessories — Specification (*third revision*)
IS 2096 : 1992	Asbestos cement flat sheets — Specification (*first revision*)
IS 2527 : 1984	Code of practice for fixing rainwater gutters and downpipes for roof drainage (*first revision*)
IS 2752 : 1995	Activated carbons, granular — Specification (*third revision*)
IS 3951	Hollow clay tiles for floors and roofs — Specification:
(Part 1) : 2023	Filler type (*third revision*)
(Part 2) : 2023	Structural type (*third revision*)
IS 3989 : 2024	Centrifugally cast (spun) iron spigot and socket pipes, fittings and accessories — Specification (*fourth revision*)
IS 4984 : 2016	Polyethylene pipes for water supply — Specification (*fifth revision*)
IS 4985 : 2021	Unplasticized PVC pipes for water supplies — Specification (*fourth revision*)
IS 6250 : 1981	Specification for roofing slate tiles (*first revision*)
IS 8419 : 2023	Underdrainage system of rapid sand gravity filtration equipment — Requirements (*first revision*)
IS 10388 : 1982	Specification for corrugated coir, woodwool, cement roofing sheets
IS 11401	Requirements for slow sand filters:
(Part 1) : 1985	General guidelines
(Part 2) : 1990	Design, construction, operation and maintenance

IS No.	*Title*
IS 12583 : 1988	Specification of corrugated bitumen roofing sheets
IS 12701 : 1996	Rotational moulded polyethylene water storage tanks — Specification (*first revision*)
IS 12709 : 1994	Glass fibre reinforced plastic (GRP) pipes joints and fittings for use for potable water supply — Specification (*first revision*)
IS 13000 : 1990	Silica-asbestos-cement flat sheets — Specification
IS 13008 : 1990	Shallow corrugated asbestos cement sheets — Specification
IS 13317 : 2023	Clay roofing country tiles, half round and flat tiles — Specification (*first revision*)
IS 13356 : 1992	Precast ferrocement water tanks up to 10 000 litres capacity — Specification
IS 13592 : 2013	Unplasticized polyvinyl chloride (PVC-U) pipes for soil and waste discharge system for inside and outside buildings including ventilation and rainwater system — Specification (*first revision*)
IS 14243	Selection and development of site for building in hill areas — Guidelines:
(Part 1) : 1995	Microzonation of urban centres
(Part 2) : 1995	Selection and development
IS 14246 : 2024	Continuously pre-painted galvanized steel sheets and strips — Specification (*second revision*)
IS 14399	Hot press moulded thermosetting glass fibre reinforced polyester resin (GRP) sectional water storage tanks:
(Part 1) : 1996	Specification for panels
(Part 2) : 1996	Guidelines for assembly, installation and testing
IS 14606 : 2022	Irrigation equipment — Granulated media filters — Specification (*first revision*)
IS 14862 : 2000	Fibre cement flat sheets — Specification
IS 14735 : 1999	Unplasticized polyvinyl chloride (UPVC) injection moulded fittings for soil and waste discharge system for inside and outside buildings including ventilation and rainwater system — Specificaion
IS 14871 : 2000	Products in fibre reinforced cement — Long corrugated or asymmetrical section sheets and fittings for roofing and cladding — Specification
IS 15778 : 2007	Chlorinated polyvinyl chloride (CPVC) pipes for potable hot and cold water distribution supplies — Specification
IS 15797 : 2008	Roof top rainwater harvesting — Guidelines
IS 16647 : 2017	Oriented unplasticized polyvinyl chloride (PVC-O) pipes for water supply — Specification
IS 17955 : 2023	Sand and gravel for use as filtration medium — Specification

To access Indian Standards click on the link below:

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/knowyourstandards/Indian_standards/isdetails/

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Hill Area Development Engineering Sectional Committee, CED 56

Organization	*Representative(s)*
In Personal Capacity (*Flat No-802, S4 Tower, Godrej Prime Complex, Shell Colony, Chembur, Mumbai*)	DR R. ANBALAGAN **(*Chairperson*)**
Central Soil & Materials Research Station, New Delhi	DR MANISH GUPTA SHRI HARI DAS (*Alternate*)
Central Water Commission, New Delhi	DIRECTOR HCD SHRI SOMESH KUMAR (*Alternate*)
CSIR - Central Building Research Institute, Roorkee	SHRI AJAY CHAURASIA SHRI NAVEEN NISHANT (*Alternate* I) SHRI M. VINOTH (*Alternate* II)
CSIR - Central Institute of Mining & Fuel Research, Roorkee	DR J. K. MAHNOT DR ASHOK KUMAR SINGH (*Alternate*)
CSIR - Central Road Research Institute, New Delhi	DR PANKAJ GUPTA DR P. S. PRASAD (*Alternate*)
CSIR - National Environmental Engineering Research Institute, Nagpur	DR SHALINI DHYANI
G. B. Pant Institute of Himalayan Environment Development, Almora	SHRI KIREET KUMAR SHRI VAIBHAV EKNATH GOSAVI (*Alternate*)
Geological Survey of India, Kolkata	SHRI AKSHAYA KUMAR MISHRA SHRI DHRUBAJYOTI CHAKRABORTY (*Alternate*)
Indian Institute of Remote Sensing, Dehradun	DR RAJAT S. CHATTERJEE DR SHOVAN L. CHATTORAJ (*Alternate*)
Indian Institute of Technology, Indore	PROF NEELIMA SATYAM
Indian Institute of Technology, Roorkee	DR MAHENDRA SINGH DR N. K. SAMADHIYA (*Alternate* I) PROF AJANTA GOSWAMI (*Alternate* II)
Maccaferri Environmental Solutions Private Limited, Gurugram	SHRIMATI MINIMOL KORULLA SHRI RUDRA BUDHBHATTI (*Alternate*)
National Centre for Seismology, New Delhi	DR O. P. MISHRA DR H. S. MANDAL (*Alternate*)
National Disaster Management Authority, New Delhi	JS (MITIGATION) SHRI SAFI AHSAN RIZVI (*Alternate*)
National Institute of Hydrology, Roorkee	DR SUHAS KHOBRAGADE DR SURJEET SINGH (*Alternate*)

Organization	*Representative(s)*
Rail Vikas Nigam Limited, New Delhi	SHRI SUMIT JAIN
THDC India Limited, Rishikesh	SHRI T. S. ROUTELA SHRI AJAY KUMAR (*Alternate*)
Wadia Institute of Himalayan Geology, Dehradun	DR VIKRAM GUPTA
In Personal Capacity (*Flat No. 4123, Tower 4, ACE Golfshire, Sector - 150, Noida*)	DR R. K. GOEL
BIS Directorate General	SHRI DWAIPAYAN BHADRA, SCIENTIST 'E'/DIRECTOR AND HEAD (CIVIL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
DR MANOJ KUMAR RAJAK
SCIENTIST 'D'/JOINT DIRECTOR
(CIVIL ENGINEERING), BIS

(*Continued from second cover*)

In the formulation of this standard due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by deriving assistance from the following publications:

Best practices of ground water harvesting in different parts of India, central ground water board MOWR.

Advantages and disadvantages of terracing — A comprehensive review. International Soil and Water Conservation Research, Elsevier publication.

Criteria for optimizing check dam location and maintenance requirements. Check dams, morphological adjustments and erosion control in torrential streams, Nova Science Publishers.

This standard contributes to the following Sustainable Development Goal:

a) Goal 6: 'Clean Water and Sanitation';

b) Goal 11: 'Sustainable Cities and Communities' towards making cities and human settlements inclusive, safe, resilient and sustainable; and

c) Goal 13: 'Climate Action'.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding of numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: CED 56 (22531).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
Eastern	: 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091	2367 0012 2320 9474
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019	265 9930
Southern	: C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113	2254 1442 2254 1216
Western	: Manakalya, 4th Floor, NTH Complex (W Sector), F-10, MIDC, Andheri (East), Mumbai 400093	283 25838

Branches : AHMEDABAD, BENGALURU, BHOPAL, BHUBANESHWAR, CHANDIGARH, CHENNAI, COIMBATORE, DEHRADUN, DELHI, FARIDABAD, GHAZIABAD, GUWAHATI, HARYNA, HUBLI, HYDERABAD, JAIPUR, JAMMU & KASHMIR, JAMSHEDPUR, KOCHI, KOLKATA, LUCKNOW, MADURAI, MUMBAI, NAGPUR, NOIDA, PARWANOO, PATNA, PUNE, RAIPUR, RAJKOT, SURAT, VIJAYAWADA.

Published by BIS, New Delhi