g) All underground service lines have to be well coordinated and stacked appropriately in the design stage to avoid overlaps and marked with indicators above the ground for ease in maintenance and servicing. Underground service stacks should be generally aligned in soft areas with no tree plantation, this would facilitate easy maintenance without disrupting the hard surface.

h) Designed façade for service structures that are above the ground in external areas is advisable so as to assist in developing aesthetically pleasing exterior environment. Such structures should be designed in a modular way so that it would be part of the street furniture.

10 ROOF LANDSCAPE

10.1 Green roof design include the following:

a) Understanding the structural stability and load bearing capacity (dead and imposed loads) of roof. The structural loading is a combination of dead loads; all permanently placed parts of the roof, including hardscape, plants, growing medium, features, etc; and the imposed loads, such as people and temporary components.

b) Waterproofing of the structure and the green areas.

c) Arrangement of surface and subsurface drainage of the roof.

d) Soil fill, and planting with limited root zone.

e) Location and planting of trees.

f) Location and design of pavements, walls, landscape features and structures.

10.2 Design Guidelines

The guidelines given below shall be followed for the design of green roofs (*see* Fig. 1)

a) *Screed* — A concrete layer shall be laid on the roof slab to provide slopes for subsurface drainage of vegetated areas, drains. Where there is a large green area on the roof, perforated pipes laid in screed shall be used to channelize subsurface water to the adjoining drainage chambers.

b) *Waterproofing membrane* — A protective layer shall be laid on the sloped concrete surface to protect the building's structure and the waterproofing membrane on the building slab.

c) *Drainage* — Drainage shall comprise of surface drainage and subsurface drainage. Subsurface drainage layer shall be very porous to permit water to pass easily through it. It should be permanent and continuous over the entire roof surface and strong enough to support the weight of the plant materials and hardscape above it. This layer shall be kept free of any materials that could prevent the free flow of water to the drains. Drainage cells may be used to increase soil depth. Surface drainage shall allow for easy flow of water from the roof surface to the drainage chambers on grade. It shall comprise of drains, catch basins. They shall be carefully designed to avoid expansion joints on the roof.

d) *Filter membrane* — Helps in containing the roots and the growing medium, while allowing for water penetration and prevents clogging of the drainage layer and roof drains.

e) *Soil* — Shall be as described in **8.1.2**. The depth of soil shall depend on type of planting, screed thickness and structural allowance for fill above slab.

f) *Vegetation* — Shall be grass, shrubs, ground covers, trees. Type of vegetation shall depend on the structural allowance for fill above slab.

g) *Irrigation* — Shall be adequately provided. The thin depth and well-drained soil used in green roof construction cannot provide the plantings with the subsurface water normally available to ground level plantings. Care shall be exercised to prevent the soil mass from drying out and causing damage to the plant materials.

h) *Services/Utilities* — As described in **9.1** shall be integrated with the landscape

j) *Hardscape* — Includes paving, street furniture and water features, walls, fences, screens, pergolas, kerbs, fire paths, roads. The landscape elements shall be considered in relationship to the structural limitations of the roof and its supports below. The street furniture, including lighting fixtures shall be carefully anchored on rooftops.

11 PROTECTION OF LANDS[illegible] CONSTRUCTION

refer for topsoil preservation & site measures

Development projects involve [illegible] existing soil conditions, removal o[illegible] overall change in the microclimate and drainage pattern. Measures to minimize hazardous effects should be put into effect as explained below.

11.1 Pre-Construction Measures

Measures for the prevention of soil erosion, sediment control and management of stormwater shall be implemented as given in **11.1.1** to **11.1.5**.

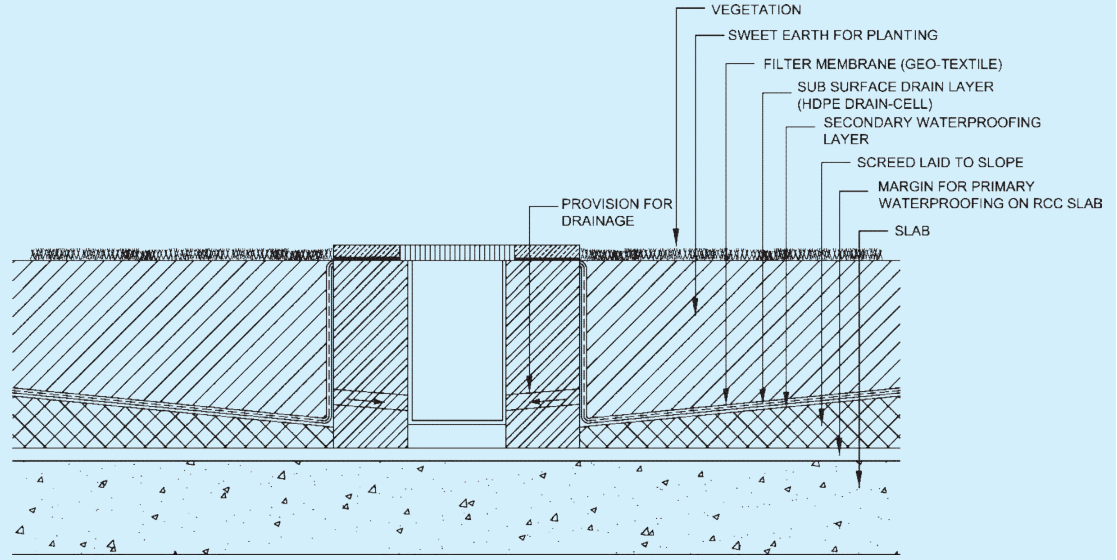

FIG. 1 TYPICAL DETAILS OF GREEN ROOF

11.1.1 *Timing of Construction*

Construction work and erosion control applications shall be scheduled and sequenced during dry weather periods when the potential for erosion is the lowest. Slope protection techniques to control erosion shall be used when construction during wet season is unavoidable. Sedimentation collection systems, drainage systems, and runoff diversion devices shall be installed before construction activity. The landscape architect/engineer-in-charge shall monitor the site conditions and progress of work and schedule appropriate timing and sequencing of construction.

11.1.2 *Preservation of Existing Vegetation*

11.1.2.1 Protection of existing vegetation (including trees, shrubs, grasses and other plants) where possible, by preventing disturbance or damage to specified areas during construction is recommended. This practice minimizes the amount of bare soil exposed to erosive forces. All existing vegetation shall be marked on a site survey plan. A tree survey in prescribed format shall be carried out as indicated in Table 3.

Table 3 Plant Material Schedule for Tree Survey

(*Clause* 11.1.2.1)

Sl No.	Tree No.	Botanical Name	Common Name	Girth mm	Height mm	Spread mm	Condition
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

The landscape plan should indicate trees, which have been preserved, and also those, which had to be transplanted or removed clearly differentiating between these three categories.

11.1.2.2 Trees retained on the project site shall be protected during the construction period by following measures:

a) Damage to roots shall be prevented during trenching, placing backfill, driving or parking heavy equipment, dumping of trash, oil, paint, and other materials detrimental to plant health by restricting these activities to outside the area of the canopy of the tree.

b) Trees shall not be used for support; their trunks shall not be damaged by cutting and carving or by nailing posters, advertisements or other material.

c) Lighting of fires or carrying out heat or gas emitting construction activity within the ground, covered by canopy of the tree shall not be permitted.

d) Young trees or saplings identified for preservation (height less than 2.00 m, 0.10 m trunk girth at 1.00 m height from finish ground, 2.00 m crown diameter) within the construction site have to be protected using tree guards of approved specification.

e) Existing drainage patterns through or into any preservation area shall not be modified unless specifically directed by the landscape architect/engineer-in-charge.

f) Existing grades shall be maintained around existing vegetation and lowering or raising the

levels around the vegetation is not allowed unless specifically directed by the landscape architect/engineer-in-charge.

g) Maintenance activities shall be performed as needed to ensure that the vegetation remains healthy.

h) The preserved vegetated area shall be inspected by the landscape architect/engineer-in-charge at regular intervals so that they remain undisturbed. The date of inspection, type of maintenance or restorative action followed shall be recorded in the logbook.

11.1.3 *Staging Areas*

Measures shall be followed for collecting runoff from construction areas and material storage sites; diverting water flow away from such polluted areas, so that pollutants do not mix with stormwater runoff from undisturbed areas.

Temporary drainage channels, perimeter dike/swale, etc, shall be constructed to carry the pollutant-laden water directly to treatment device or facility. The plan shall indicate how the above is accomplished on site, well in advance of the commencing of the construction activity.

11.1.4 *Preservation of Topsoil*

Topsoil removal and preservation shall be mandatory for development projects larger than 1.00 hectare. Topsoil shall be stripped to a depth of 200 mm from areas proposed to be occupied by buildings, roads, paved areas and external services. Topsoil is rich in organic content and is essential to establish new vegetation. It shall be stockpiled to a height of 400 mm in designated areas and shall be reapplied to site during plantation of the proposed vegetation. Topsoil shall be separated from subsoil debris and stones larger than 50 mm diameter. The stored topsoil may be used as finished grade for planting areas.

11.1.5 *Spill Prevention and Control*

Spill prevention and control plans shall be made, clearly stating measures to stop the source of the spill, to contain the spill, to dispose the contaminated material and hazardous wastes, and stating designation of personnel trained to prevent and control spills. Hazardous wastes include pesticides, paints, cleaners, petroleum products, fertilizers and solvents.

11.2 Measures During Construction

During construction soil becomes unconsolidated due to removal of stabilizing material such as vegetation and disturbance of stabilized existing grade resulting in loss of topsoil and also deposition in undesirable places. A soil erosion and sedimentation control plan to be prepared prior to construction. The soil erosion, sediment control and stormwater practices should be considered whilst construction is proceeding, in accordance with **11.2.1** to **11.2.4**.

11.2.1 *Sedimentation Basin*

A temporary dam or basin at the lowest point of the site has to be constructed for collecting, trapping and storing sediment produced by the construction activities, together with a flow detention facility for reducing peak runoff rates. This would allow most of the sediments to settle before the runoff is directed towards the outfall.

11.2.2 *Contour Trenching*

Contour trenching is an earth embankment or ridge-and-channel arrangement constructed parallel to the contours along the face of the slope at regular intervals on long and steep slopes (in sloping areas with slopes greater than 10 percent) (*see* Fig. 2). They are used for reducing runoff velocity, increasing the distance of overland runoff flow, and to hold moisture and minimize sediment loading of surface runoff. Vegetative cover of tree and native grasses in the channels may be planted to stabilize the slopes and reduce erosion.

11.2.3 *Mulching*

Mulching shall be used with seeding and planting in steep slope areas (slopes greater than 33 percent) that are prone to heavy erosion. Netting or anchoring shall be used to hold it in place. Other surface runoff control measures like contour terracing to break up concentrated flows shall be installed prior to seeding and mulching. Materials such as straw, grass, grass hay and compost shall be placed on or incorporated into

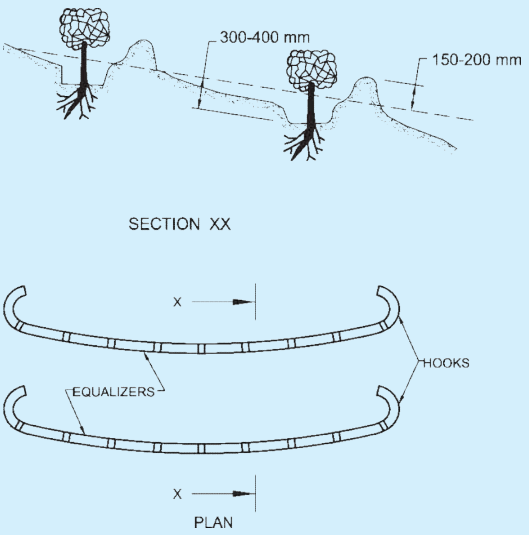

FIG. 2 TYPICAL CONTOUR TRENCHES

the soil surface. In addition to stabilizing soils, mulching will reduce the stormwater runoff over an area. Together with seeding or planting, mulching aids plant growth by holding the seed, fertilizers and topsoil in place. It retains moisture and insulates the soil against extreme temperatures.

11.2.4 *Geo-Grids*

A deformed or non-deformed netlike polymeric material used with foundation, soil, rock, earth or any other geo-technical engineering-related material as an integral part of the human made project structure or system, called geo-grids may be used as control measure. On filling with lightly compacted soil or fine aggregate, a monolithic structure is created providing an effective means of confinement for unconsolidated materials within the cells and preventing their movement even on steep slopes. If required the area can then be seeded to maintain 'green' environment. The junctions have a central opening through which water can permeate ensuring that organic material receives moisture for rapid growth.

12 SOIL AND WATER CONSERVATION

The soil conservation, sediment control and stormwater management practices as given under **12.1** to **12.3** shall be followed after construction is completed.

12.1 Vegetative Measures

The vegetative measures shall include the following.

12.1.1 *Topsoil Laying*

This includes the placement of topsoil or other suitable plant material over disturbed lands to provide suitable soil medium for vegetative growth. Topsoil laying shall involve replacing fertile topsoil that were stripped and stockpiled during earlier site development activities; the laid soil shall be stabilized before the next monsoon by planting grass, shrubs and trees.

The following guidelines shall apply to the placement of topsoil:

a) Existing or established grade of subsoil should be maintained.

b) A *p*H of 6.0 to 7.5 and organic content of not less than 1.5 percent by mass is recommended for topsoil. Where *p*H is less than 6.0, lime shall be applied to adjust *p*H to 6.5 or higher up to 7.5. Any soils having soluble salt content greater than 500 parts per million shall not be used.

c) Prior to spreading the topsoil, the sub-grade shall be loosened to a depth of 50 mm to permit bonding. Topsoil shall be spread uniformly at a minimum compacted depth of on grade of 1:3 or steeper slopes; a minimum depth of 100 mm on shallower slopes is essential. A depth of 300 mm is preferred on relatively flatter land.

12.1.2 *Planting/Vegetation Cover*

The most effective way to prevent soil erosion, sedimentation and to stabilize disturbed and undisturbed land is through the provision of vegetative cover by effective planting practices. The foliage and roots of plants provide dust control and a reduction in erosion potential by increasing the infiltration, trapping sediment, stabilizing soil, and dissipating the energy of hard rain. Temporary seeding shall be used in areas disturbed after rough grading to provide soil protection until final cover is established. Permanent seeding/ planting is used in buffer areas, vegetated swales and steep slopes. The vegetative cover also increases the percolation of rainwater thereby increasing the ground water recharge.

12.2 Stormwater Management and Filtration Techniques

The surface water flow is increased in urban areas due to predominance of hard surfaces. Stormwater management techniques assure conservation of water thereby increasing the ground water recharge. Filters facilitate draining pollutants out from surface water runoff through straining before discharge into the drainage way. Rain water harvesting and sullage recycle systems need to be implemented on all new constructions over 1 000 m^2 in urban areas. *See also* Part 9 'Plumbing Services, Section 2 Drainage and Sanitation' and **7.2** of Part 11 'Approach to Sustainability' of the Code.

12.2.1 *Rain Water Harvesting Structures in Urban Environment*

12.2.1.1 Water harvesting refers to the collection and storage of rainwater and also harvesting surface and ground water, prevention of loss through evaporation and seepage, and other hydrological and engineering interventions aimed at conserving water.

12.2.1.2 The advantages of using rain water harvesting structures in urban areas are as follows:

a) Water harvesting recharges ground water and is an ideal solution to water problems in areas with inadequate water resources.

b) Increase in ground water aquifer level due to methods enhancing infiltration.

c) Mitigation of the effect of drought.

d) Reduction of stormwater runoff into the public drainage system.

e) Reduction of flooding of the roads during monsoons.

f) Removal of pollutants and soil from the stormwater runoff.

g) Reduction of soil erosion.

12.2.1.3 Methods of ground water recharge may be as follows:

a) Recharge pits.

b) Recharge trenches.

c) Reuse of abandoned dug wells.

d) Reuse of abandoned hand pumps.

e) Recharge shafts.

f) Lateral shafts with bore wells.

g) Spreading techniques like percolation ponds, check dams or gabion structures.

12.2.2 *Structures for Rain Water Harvesting and Soil and Water Conservation*

These may be as given in **12.2.2.1** and **12.2.2.2**.

12.2.2.1 *Infiltration techniques*

a) *Infiltration trenches* — An infiltration trench is a rock filled trench that receives stormwater runoff. Stormwater passes through a combination of pre-treatment measures, a grass swale and into the trench to be stored in void spaces and then infiltrates into the soil matrix.

b) *Bio-filtration swale/grass swale* — Bio-filtration swales are vegetated channels with a slope similar to that of standard storm drain channels (less than 0.6 percent), but wider and shallower to maximize flow residence time and promote pollutant removal by filtration through the use of properly selected vegetation. It has to be designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration and reduce the flow velocity of the stormwater runoff. It shall be integrated with stormwater system (*see* Fig. 3).

c) *Sand filter* — Sand filters are devices that filter stormwater runoff through a sand layer into an underground drain system which conveys the water to a detention facility. They are effective in removing total suspended solids. The effectiveness of sand filtration is improved if it is preceded by a grass swale with infiltration trench.

12.2.2.2 *Detention facilities*

a) *Wet ponds* — Wet ponds are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Wet ponds retain the stormwater runoff in a permanent pool and facilitate pollution removal through settling and biological update.

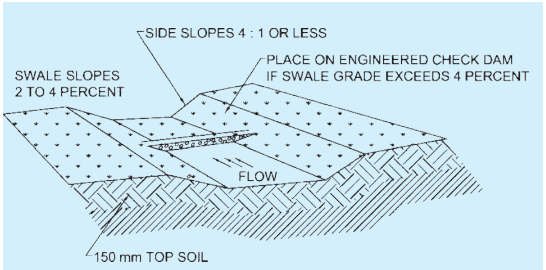

FIG. 3 GRASS SWALE

b) *Stormwater wet lands* — Stormwater wet lands are structures similar to wet ponds that incorporate wetland plants into the design. They have to be designed for treating stormwater runoff, and typically have less biodiversity than natural wetland systems. A distinction should be made between using a constructed wet land for stormwater management and diverting stormwater into natural wetland. The latter is not recommended because it would degrade the resource.

c) *Wet vaults and storage tanks* — Wet vaults and tanks are underground facilities used for the storage of surface water, and typically constructed from reinforced cement concrete (vaults) or corrugated pipes (tanks). The water that is captured in these vaults and tanks may be used later for irrigation.

12.3 Conservation and Reuse of Water for Irrigation

The following measures shall be followed for design of irrigation systems for landscape works:

a) Water conserving irrigation systems should differentiate between systems for different water use zones on the site. Supplementary irrigation sources should be used by means of appropriate water harvesting measures.

b) The irrigation system should be designed considering the prevailing wind direction, slope and proposed grade, type of soil, soil percolation, and the type of vegetation to be watered.

c) Spray irrigation to be designed to provide total head to head cover to avoid dry spots and spray on to paved areas and unplanted surfaces.