

BHARAT PERMEABLE DRAINAGE(BPD) SYSTEM

Water scarcity in India is an ongoing water crisis in India that affects nearly 600 million people each year. [1] In addition to affecting the huge rural and urban population, the water scarcity in India also extensively affects the ecosystem and agriculture.

India has only 4% of the world's fresh water resources despite a population of over 1.3 billion people. Several large cities of India have experienced water shortages in recent years, with Chennai being the most prominent in 2019. **The shortage of water affected the entire city of 9 million people and resulted in the closure of several hotels, restaurants and businesses.**

Groundwater extraction and irrigation

India is the world's biggest groundwater user, extracting 251 bcm (billion cubic metre, equivalent to 1 cubic kilometre) of groundwater in 2010, compared to 112 bcm of groundwater extracted by the United States.

From 2007 to 2017, the continued exploitation of groundwater caused the groundwater level in India to decrease by 61 percent, according to the Central Ground Water Board (CGWB). The unmonitored and unregulated extraction of groundwater has diminished and contaminated the water resources, and therefore threatens the people who depend on these water sources for their daily needs.

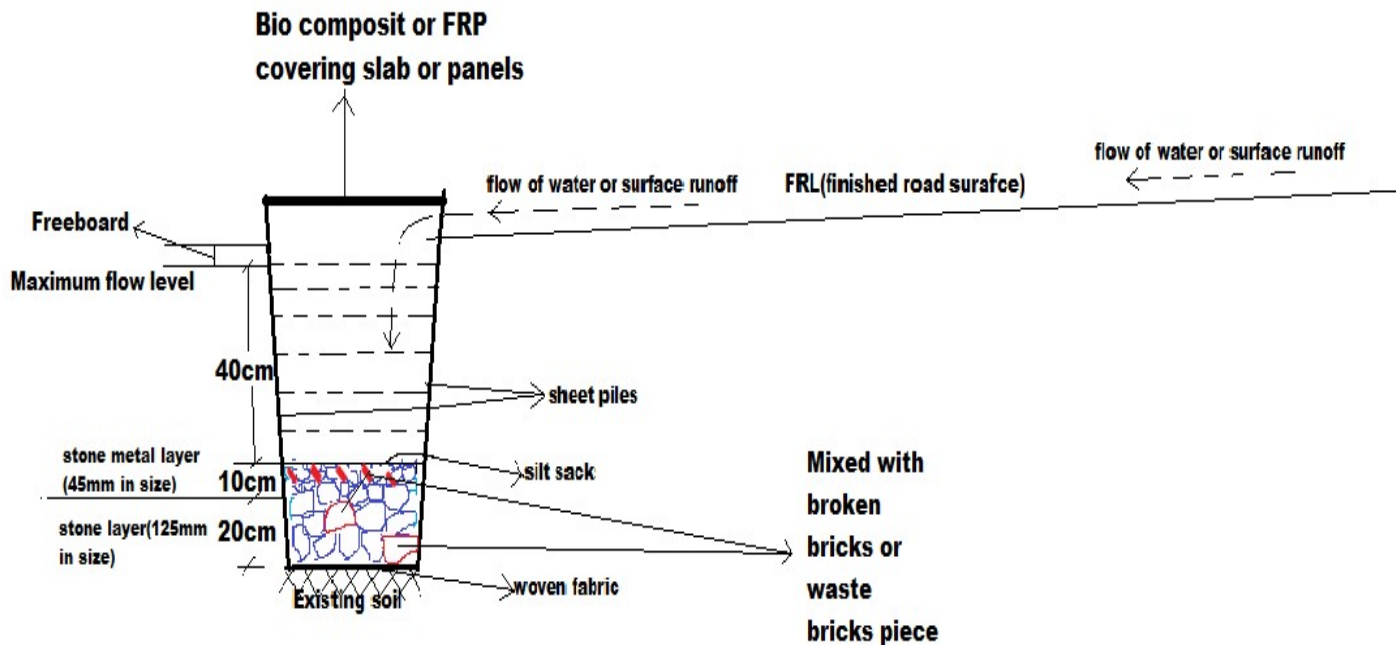
Groundwater meets more than half of the country's need of water supply, and nearly 89% of the groundwater extracted in India is used for irrigation. The traditional techniques of irrigation are also to blame for the water crisis as they result in a majority of water loss and evaporation during the irrigation process.

According to a report by the National Institution for Transforming India (NITI Aayog), at least 21 major Indian cities, including the capital New Delhi will completely run out of groundwater by 2020. **The report also noted that approximately 200,000 people die in India each year due to the lack of access to safe drinking water.(source:- Wikipedia)**

IN ORDER TO COUNTERACT OR SOLVE THE ABOVE PROBLEM OF CONSTANTLY DECREASING OF GROUND WATER TABLE IN OUR COUNTRY AND SOME COUNTRIES OF WORLD, WE DESIGN A INNOVATIVE DRAINAGE

SYSTEM NAMELY BHARAT PERMEABLE DRAINAGE SYSTEM ALSO KNOWN AS BPD SYTEM.

Bharat Permeable Drain(BPD) system:- Permeable means infiltration of water and bharat permeable drainage(BPD) is that type of system, where storm water or rainfall water runoff in the surface of road and other impermeable surfaces is caught by drain and some part infiltrate into the soil and the large part or excess strom or rain water automatically dispose into the injection well and inject into the aquifer after filtration of silt particles,solid sediments etc. The x-section of BPD system as shown in figure below;



X-section of BPD (Bharat permeable drain)

The bharat permeable drainage (BPD) system is divided into four parts as discuss below;

(A) PERMEABLE DRAIN

1. Woven fabrics.
2. Stone-bricks layers (size 125 mm & 45 mm) two layers.
3. Silt sacks.
4. Flexible sheet piles
5. Stone metal layers(SML) retainer

(B) INJECTION WELL

1. Filtration pit
2. percolation perforated pipe

(C) SOAK PIT

(D) COVERING WITH RECYCLED BIO COMPOSIT OR FRP(Fibre reinforced polymers) SLAB /PANELS

The above divided parts of bharat permeable drainage (BPD) system is briefly explained below;

(A) PERMEABLE DRAIN

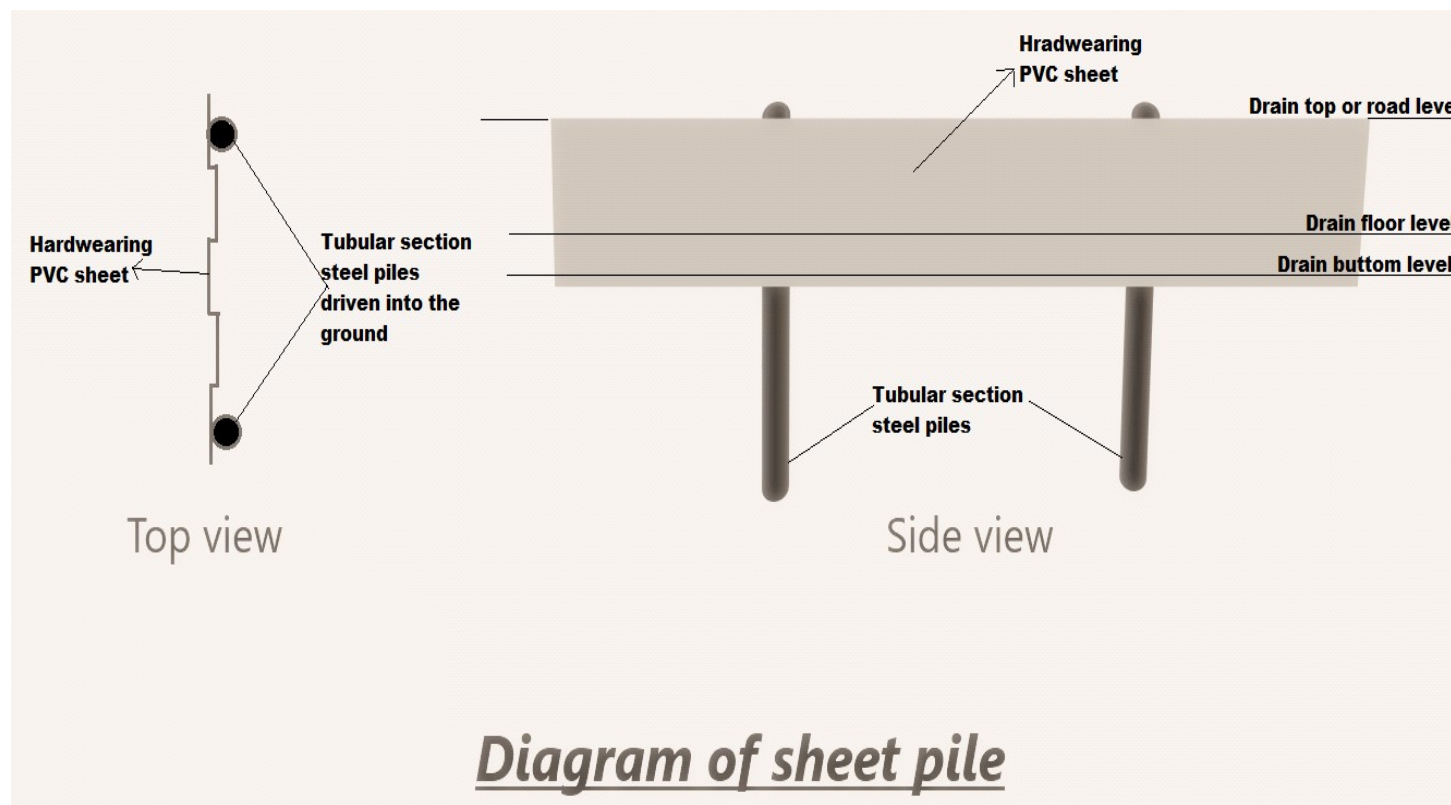
As we explained earlier, this system is used to infiltrate some part of rainfall or storm water and the remaining excess water is flow into the drain like traditional type and automatically dispose in the injection well.

Woven Fabrics:- Woven fabric is any textile formed by weaving woven fabric often created on loom and made of many threads on a wrap and weft. Technically a woven fabric is any fabric made by interlacing two or more threads at right angles to one another. Woven fabrics have the ability to block soil particles entering into the coarse aggregates layer.

Stone-bricks layer:- Stone-bricks layer is a layer which is used to permit water retention of storm water or rainfall water runoff and infiltration through soil into the Aquifer.

Silt sack:- Silt Sack is a sediment control sheet type used to prevent silt and sediment from entering into the permeable drainage system. The sack catches the silt and sediment while allowing excess water to pass through freely in the drain.

Recycled PVC sheet piles:- We can use the recycled hardwearing PVC sheet piles. Sheet piles are structural sections that can interconnected to form a continuous sheet pile wall. Sheet piles rely on their structural stiffness to resist lateral forces due to earth, water, or other loads. These interconnected piles also use to counteract the horizontal thrust of the vehicle and helpful in retaining the soil of the road shoulders or berm. After laying of sheet piles then the tubular section steel piles should be driven through the vertical holes in sheets into the ground . As shown in figure below;



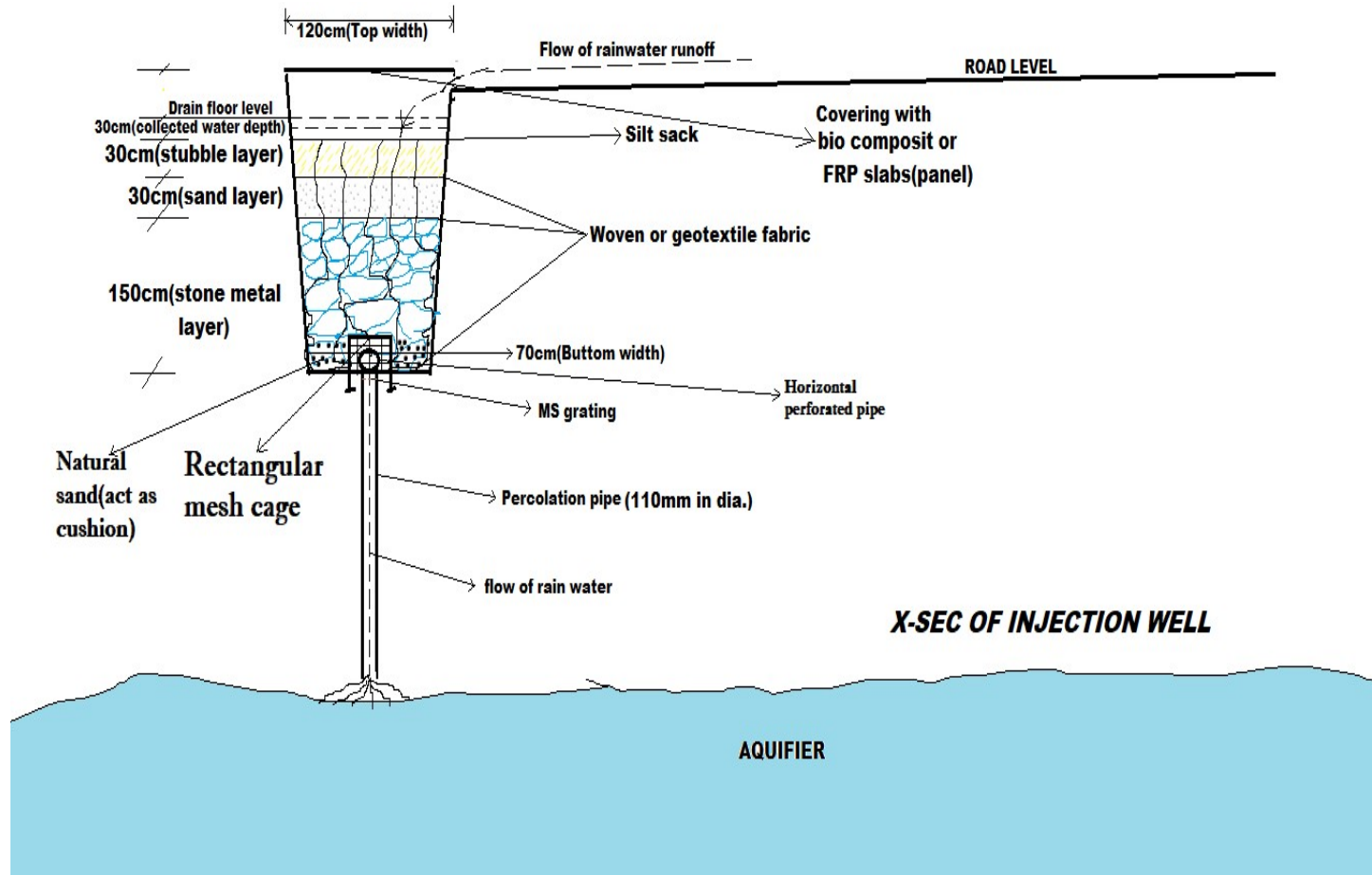
Stone metal layer(SML) retainer:- SML retainer is like a steel sheet of 2mm to 5mm thickness(According to the flow velocity of rain water in a permeable drain)

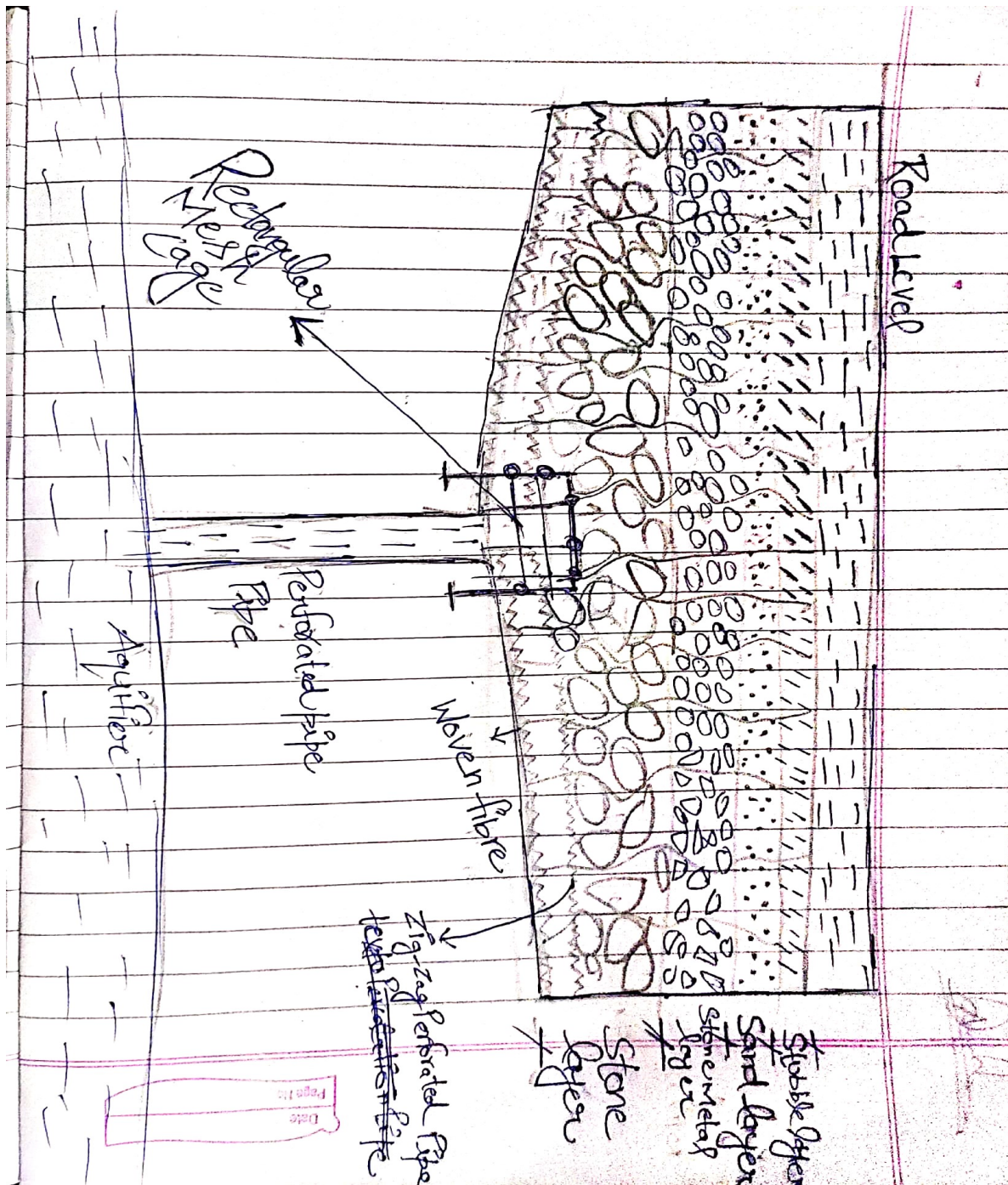
SML retainer is used to retain the stone metal layers in a fixed position. During high intensity of rainfall when the runoff of rainfall or storm water is high then the flow of storm or rainfall water in permeable drain is also very high. High flow in permeable drain directly impact on the stone metal layers results in displacement of the stone metal layers which affect in a slope of permeable drain. SML retainer is like a steel sheet of 2mm to 5mm thickness(According to the flow velocity of rain water in a permeable drain)

To counteract this we fixed a SML retainer vertically perpendicular to sheet piles after every 10mtr length of permeable drain.

(B) INJECTION WELL

Injection well is used for recharging the excess rainfall water storm water i.e flow into the bharat permeable drainage system. The excess storm water is disposed into the injection well and infiltrate into the aquifers. **The diagram of injection well is shown in figure below;**





ELEVATION OF INJECTION WELL

Injection well consist of two parts.

i. Filteration pit:- The filteration pit is that type of pit in which the excess storm water or rainfall water in permeable drain is automatically disposed into it . Because this pit is directly connects with the permeable drain .This may be rectangular in shape. The dimensions of filteration pit consists of a **10.0 x 1.20** and **3m in depth** from the top surface of road level.(Dimension of filteration pit should be vary according to discharge capacity or dimensions of permeable drain)

Filteration pit is also Consists of different size of layer of stones,Aggregates and Sand.

1. First of all, we have to laid the woven fibre mesh horizontally, after laying the woven fibre we have to laid the horizontal zig-zag perforated pipe of 300mm diameter with rectangular cage fixed upon the top end of vertical perforated pipe as shown in figure below.

1. The buttom first layer is of maximum size of stones with broken pieces of bricks i.e from 125mm in sizes . <Contain arround 40% voids>.

2. The second layer consists of small size of stones with respect to buttom layer its size varies from 45mm <Contain arround 40% voids>.

3. After previous layer . The woven fiber is laids at the top of the 2nd layer of stones aggregates . Woven fibre is used to prevent the sanel particles of top layer entering into the 2nd layer of stones aggregates.

4. After laying of woven fibre then its time to laid down the sand or fine aggregates at the top of the woven fibre.

5. After laying of sands or fine aggregates again we have to laid a piece of woven fibre as shown in figure above and laying of stubble(from agricultural field waste) layer on woven fibre.

6. In the last we have to cover the whole dia of filteration pit with silt sack to prevent the soil particles and suspended solids in storm water entering into the filteration pit.

ii.Percolation perforated Pipe(vertical):- Percolation perforated pipe is a pipe used for percolation of the storm or rainfall water through filteration pit and directly percolates into the aquifier .The top of the percolation perforated pipe is directly and vertically connects with buttom of filteration pit.

Grating Mesh:- Grating mesh is a Sandwich b/w the top of percolation perforated pipe and the bottom of filtration pit. This Mesh is commonly used to prevent the stones or pebbles of layer of filtration pit entering into the percolation perforated pipe which choked the percolation perforated pipe and the discharge capacity of recharge of storm water is low or very low and require more maintenance.

(C) SOAK PIT

A soak pit is a pit used in areas of severe or maximum rainfall conditions because in severe or maximum rainfall intensity areas generate heavier runoff and heavier discharge of rainfall or stormwater. This pit is usually constructed in every 100 meters of centre to centre distance and dimensions of this pit is **1.00mx1.50mx2.0m** (The centre to centre distance of soak pit should be vary according to site conditions i.e infiltration capacity of soil and intensity of rainfall in that area.)

(D) COVERING WITH RECYCLED BIO COMPOSIT OR FRP(fibre reinforced polymers) SLAB/ PANELS

A recycled plastic slabs or panels is used to cover the top opening BPD system i.e permeable drain, soak-pit, injection well which is is further also used as footpath for public and society.

Three types of components used in recycled plastic slab or panels are;

1. Recycled plastic sheets or panels:- A recycled Bio composit or FRP(Fibre reinforced polymer) panel is used to cover the top opening of BPD system. A bio composit or FRP panel is laid at the top of sheet piles and joint(flexible joint) with top of tubular steel pile(which we are driven into the ground) and this tubular steel pile work as a column and transfer all the dead load, live load and distribute into the ground.

2. I-section MS beams:- The I beam consists of two horizontal planes, known as flanges, connected by one vertical component, or the web. The shape of the flanges and the web create an "I" or an "H" cross-section. This beam is provided at every 2.40m c/c distance and joint with the recycled plastic sheet.

Benefits of MS I-sec beams are;

Comes in Various Dimensions

I beams are universal beams and used globally for most steel construction project. It comes in a variety of weights, section depths, web thickness, flange widths, and other specifications for different purposes. Depending on the structure of the I beam, it is used for different purposes.

Bears Higher Loads

The design of an I beam makes it capable of bending under high stress instead of buckling. As the beam receives the load, the force is transmitted perpendicularly, thus supporting other members of the beams. I beams are mostly made of steel, therefore ensuring structural integrity with relentless strength and support. I beam strength is less formidable in the transverse direction and also adept at carrying torsion. Steel has properties that allow withstanding hefty loads of the structures. The strength of the steel and the shape of the beam both can reduce the need to include numerous support structures, saving time and money and making the structure more stable.

Has a High Moment of Inertia

The section at the centre of the beam, or the neutral axis, does not resist bending due to the uniform distribution of the weight across the beam. Due to the distance between the flange and the axis, I beams have a high moment of inertia. The larger the moment of inertia, the lesser the beam will bend to resist the bending moments. I beams can be rolled, welded, extruded, and riveted as well because of this property.

Helps in Fabrication

Metal fabrication involves the cutting, bending, and shaping of structural steel. I beams are very versatile and can be used in any steel construction projects. I beam steel fabrication is fast, efficient, and affordable to fulfil the orders and meet the demands of the project. With the right amount of knowledge, experience, hard work, and the use of specialised tools, it is easier to use I beam during custom welding processes and metal fabrication for all types of construction.

Reduces, Reuses, and Recycles

The production of I beams means minimum waste during construction. There are green practices in different countries making I beam affordable. Almost half of the world's steel is produced in electric plants to generate no CO2 emissions. Steel products can be recycled over and over again without compromising on their strength. Since I beams are mostly made of steel, they can be recycled and reused in many ways and also reduce costs. Recycling steel saves the equivalent energy to power about millions of households for a year.

Prevents Vibration

One of the major challenges while constructing a building is to create a structure with less floor vibration. Floor vibrations in the steel buildings can be created with a variety of direct and indirect sources of vibration. But the three main categories can be:

- Human activity (jumping, walking, and running)

- Machinery and equipment

- External force (traffic on street or underground, or wind)

Since I beams are stiffer and bear higher loads, they are used to reduce the vibration of the floor by supporting the structure. With steel I beam, the vibration is damped quickly before it can travel very far.

3. Nuts & Bolts (Flexible joints):- Nuts and bolts or flexible joints is used to join the recycled plastic sheet with the I- beams and tubular steel columns. This flexible joint is very helpful during internal maintenance like removal of silt deposit in silt sack (either by suction pump or by labour) of BPD system.

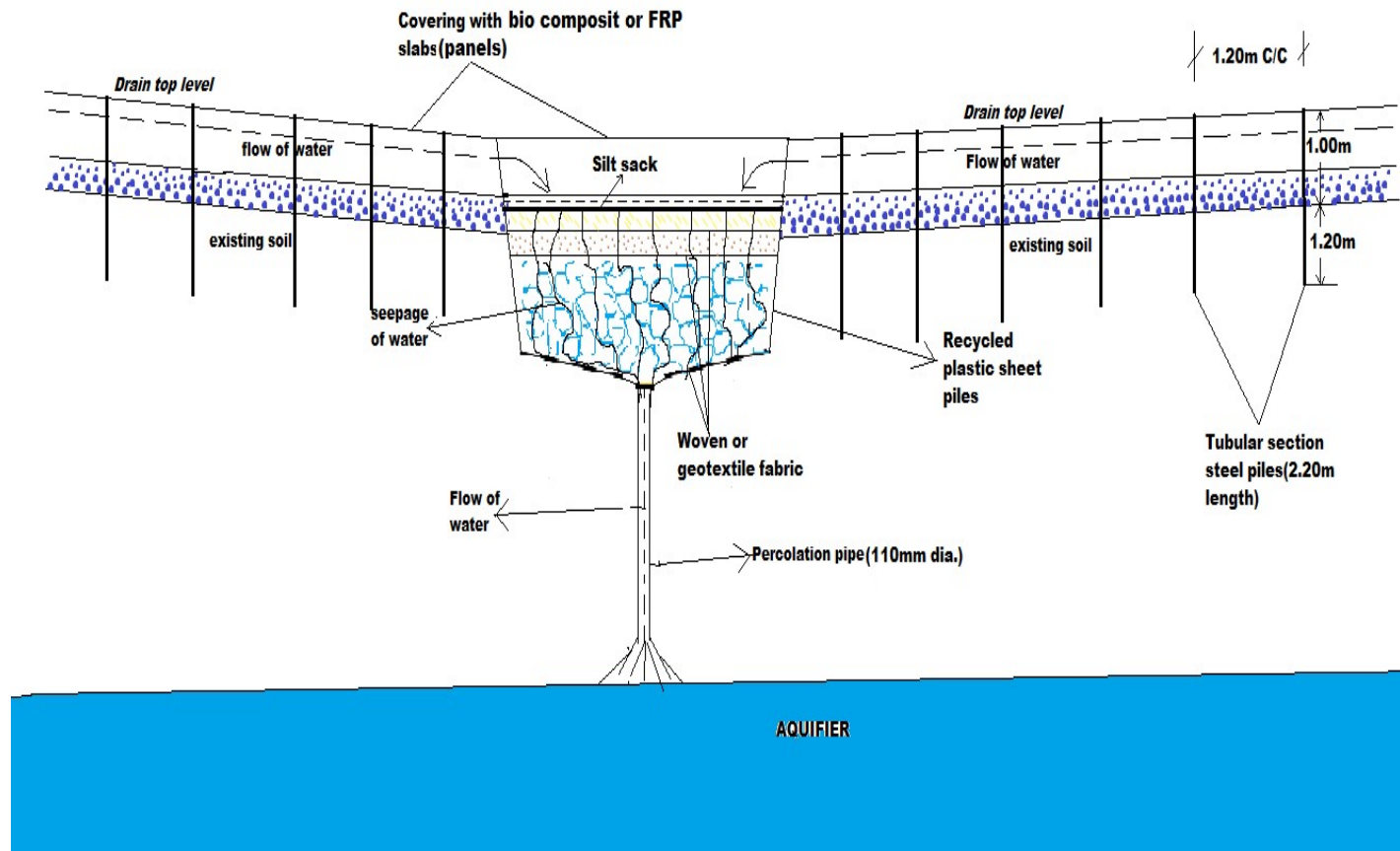
ELEVATION OF BHARAT PERMEABLE DRAINAGE(BPD) SYSTEM

There are two types of elevations of bharat permeable drainage(BPD) system design which is selected as we discuss earlier according to site conditions i.e infiltration capacity of soil & intensity of rainfall in an area.

(a) Type-1st elevation of BPD system:- Diagram as shown in figure below. This type of elevation design of BPD system is mainly selected or used where;

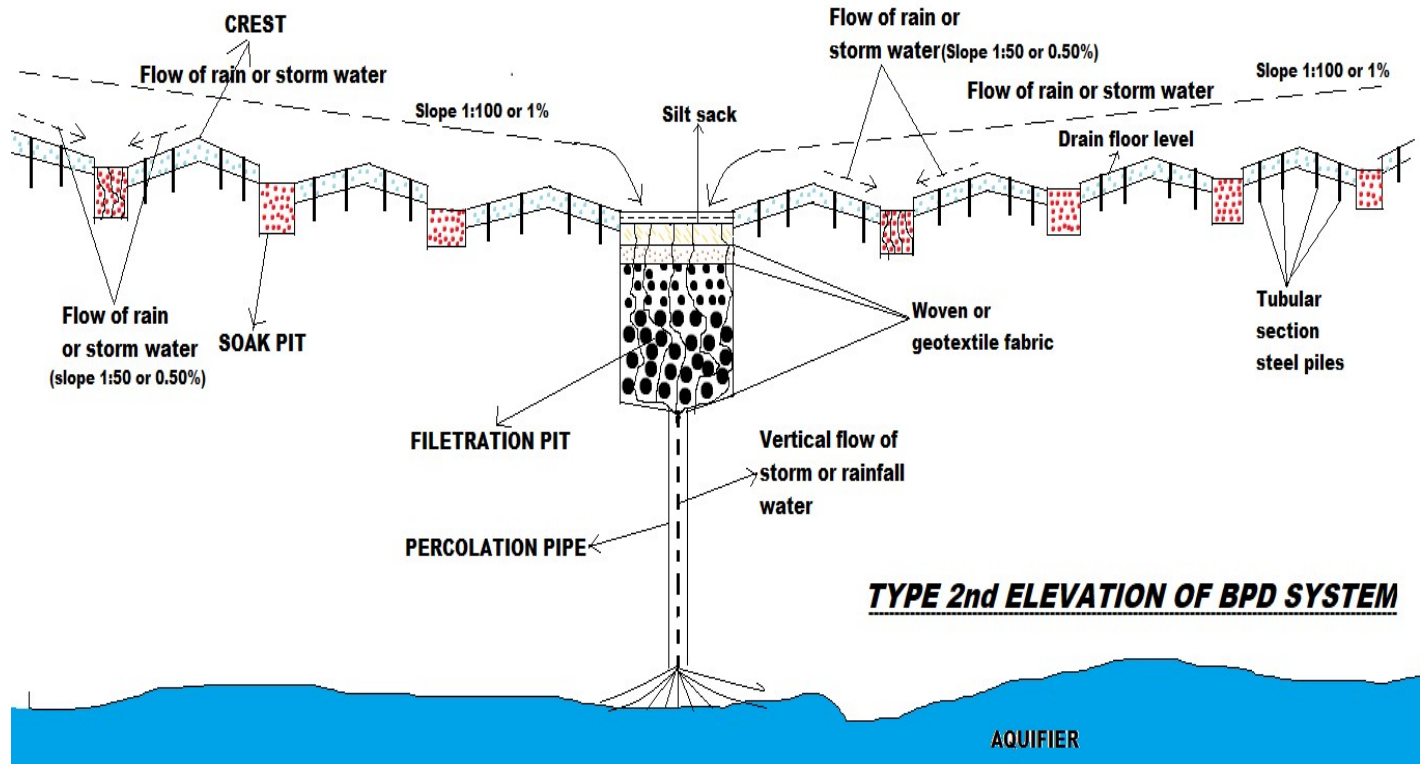
- Infiltration capacity of soil in an area is greater with respect to intensity of rainfall in an area. (Infiltration capacity > Intensity of rainfall)
- Infiltration capacity of soil in an area is equals to the intensity of rainfall in an area. (Infiltration capacity = Intensity of rainfall)

TYPE 1st ELEVATION OF BPD SYSTEM



(b) Type-2nd elevation of BPD system:- Diagram as shown in figure below. This type of elevation of BPD system is mainly selected or used where;

- Infiltration capacity of soil in an area is less than to the intensity of rainfall in an area. (Infiltration capacity < Intensity of rainfall)



DESIGN STEPS OR METHODOLOGY of permeable drain

1. Field test Specification

First of all, there is a strictly need of a field tests i.e infiltration capacity of soil w.r.t intensity of rainfall by engineer in incharge for durability and water logging problem of permeable drain.

2. Earthwork for excavation

Methodology of earthwork should be same as traditional type. But we should be managing these steps:-

Slopes :- In E/W item we should maintain a required amount of slope that the storm water is disposal freely or within the specific amount of time. The

minimum slope in Permeable drain is 1%. The **slope should be vary according to site conditions i.e intensity of rainfall and infiltration capacity of soil**, Geological condition etc.

Two types of slopes maintain during the need of **2nd type elevation**(Areas where intensity of rainfall is high and infiltration capacity is medium or low)

- Slope towards soak pit.
- Crest to crest slope.

As the name suggests, slope towards soak pit is that type of slope which is required to dispose some excess rainfall or storm water into the saok pit.As shown in figure below

While Crest to crest slope is required when the intensity or precipitation of rainfall is high and the infiltration capacity of soil is low or medium. Then the excess available storm water of rainfall should be freely disposed because of crest to crest slope. The excess storm water is early disposed into the nallah or injection well without any water logging in the street or road as shown in fig below

3. After E/W and maintaining of slopes of required amount, woven fibre should be laid horizontally not to put extra pressure or compaction to the surface of Permeable drain.

4. Then it was the time to fix sheet piles. Fix the sheet piles horizontally at the both side of Permeable drain for retaining the shoulder of road and reduce the lateral pressure as well as horizontal thrust of the vehicles. After fixing sheet piles horizontally the tubular section steel piles should be driven through the vertical holes in sheets into the ground **(120cm below the trench level of permeable drain and 100cm above the trench level of permeable drain or 100cm from trench level above to the road level)** for reducing lateral or horizontal pressure built in it. Diagram is shown below;

5. After the sheets piles two types of layers coarse aggregates with mixing of 30% to 50% of broken brick pieces(waste brick pieces) laid over the woven fibre of permeable drain. The first layer s about 20cm thick and the second layer is 10cm thick as shown in figure of x-sec of BPD above. Both the layers may vary according to site conditions i.e hydrological conditions, Geological conditions, Infiltration capacity of soil, Intensity of rainfall etc. **The Voids percentage should be of minimum of 40% of total volume.**

6. After laying of two types of layer, its time to laid the silt sacks at the last or top of stone metal layer and the ends of silt sacks is join with the sheet pile(with the help of glue or bolts) to prevent the storm water enters into the stone metal layers which require more maintenance.

BENEFITS OF PERMEABLE DRAIN OVER TRADITIONAL TYPE

- This drainage system controls the intensity of flood in rivers or streams.
- This drainage system mainly increase the amount or percentage of water in our Aquifiers which directly increase the water table.
- In BPD system, The water is infiltrated into the soil and the natural soil infiltrate this storm water and percolate into the Aquifier.
- This BPD system solves the problem of water scarcity throughout the whole world as compare to traditional type drain.
- This BPD system help re-establish a more natural hydrological balance and reduce runoff volume.
- This drainage system also reduce the water logging problems in low lying areas of the world and also in the cities/towns near the bank of the river. eg's haridawar & kanpur(Ganga river) agra(yamuna river), ahmedabad(sabarmati river), new delhi(yamuna river), dibrugarh(brahmaputra river) etc.

- In BPD system, The cost of construction is almost same as compare to traditional type of drain.
- This system is an important tool for retention of storm water.
- The purpose of this drainage system is to protect the ground water resources which recently decrease in our day to day life.
- This drainage system indirectly help to create a loop to control the **air pollution** and **sound pollution** beacuse use of cement material is almost negligibile in this system as compare to traditional type;

Making cement result in high level of CO2 output and it also increases dust and noise. About 4 to 5% of the worlwide CO2 emissions is caused by cement production and production of 1tonne of cement results in 780kg's of CO2 in our environment.

- In this drainage system, we can use the natural coarse aggregates and sand instead of crushing coarse and fine aggregates which is crushed at crusher plant and as we know that crusher plant is also the reason of sound pollution and air pollution.In the other side we also save our natural resources which is very useful for our future generations.