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Rainwater Harvesting Through Subsurface Dyke *(Groundwater Recharging Structure)*

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Abstract: *Water is a natural resource which is most important to every human being on the earth. As rise in water scarcity due to increase in population day by day demand for water is also increasing and change in climatic condition, deforestation, overuse which creates serious problem throughout the world for all community. Industrial development, and Agricultural field development and production has resulted in overuse of groundwater and surface water resources and hence reduces the quality of water. Therefore the conventional water resources like well, rivers and reservoirs, etc are inadequate to fulfill the water demand.*
Hence preservation of water is the only way to store and utilize for the future use. Rainwater is the main source to implement this method for groundwater recharging usually in monsoon. Our main objective is to increase the ground water table by obstructing the base flow of water in river sand bed and this water will be percolated and joined to the groundwater, this groundwater should be properly utilized for the future use.
Keywords: *Subsurface dyke, Percolation, Groundwater, Recharge, Conservation, Clay, PVC sheet*

I. Introduction

Sub-surface dyke is a sub-surface barrier/hidden check dam across a stream or river which retards the natural subsurface/ground water flow of the system and stores water below ground surface to meet the demand during the period of need. The main purpose of groundwater dam is to arrest the base flow and it helps to maintain groundwater level in the sub-basin. This underground structure arrest or minimize the base flow of water in the sand bed near the valley portion so as to build-up the ground water storage in the upstream side of the subsurface dyke.

Ground water has become the most important source of domestic, industrial and irrigation supply in many regions. Although the total amount of water on earth is generally assumed to have remained virtually constant, the rapid growth in population, development in agriculture and industries putting more stress on the quality and quantity aspects of natural system. The most suitable location for a sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow outlet having limited thickness of loose soil or porous rock on the top with massive or impervious rock below.

II. Advantages & Disadvantages:

Advantages:

I. The basic principle of the subsurface dyke is this: instead of storing the water in the surface reservoirs, water can be injected and stored in underground. It is composed of a cut-off wall by which the base flow is dammed (or intrusion of the seawater is prevented),
II. And facilitates (like wells, intake, shaft and infiltration wells) that yield good water which is stored in sand bed.
III. Water storage in subsurface dyke offers as a major advantage that evaporation losses are much less for water stored underground.
IV. Since the subsurface dyke suffers virtually no loss of stored water from evaporation, it is more advantageous than the surface dam in dry regions.
V. Further, risk of contamination of the stored water from the surface is reduced because parasites cannot breed in underground water. Contamination of the water by insects and animals cannot take place because the water is not visible on the sand surface. Health hazards such as mosquito breeding are avoided.
VI. The technology is preferred by the community for several reasons: it increases the capacity of traditional wells, it is simple and less expensive to construct, replicable and easily maintainable by the community.
VII. Even unskilled workers also can take-up this work.

Disadvantages:

I. Since the utilization of stored groundwater in a subsurface dam requires pumping, operating costs are higher than those of a surface dam.
II. The size of the voids between the solids of sand determines the capacity of the basin and base flow. When the particle size is small, the water stored in the sand bed will be reduced,
III. Survey and design require trained persons to avoid possible failures.

III. Materials And Methodology:

Materials:

The materials required to construct the sub-surface dyke are cement, clay, PVC sheets etc.

Cement: (Figure.1)

Cement is a binding material or a substance which is used for the construction that sets, hardens and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate and water produces mortar and if cement mixed with sand, water and gravel, it produces concrete.

Figure 1

Grades of cement:

I. 33 Grade Ordinary Portland Cement

This cement is used in widely in the world. It is more suitable cement for masonry and general concrete works where the members are not taken to very high stresses. It is not suitable where Sulphate is in the soil or in the ground water

II. 43 Grade Ordinary Portland Cement

This cement is used where high early strength in 1 to 28 days range is required. These days the Structural Engineers propose these cements mainly for RCC works, where a member takes high tensile stress.

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Properties of cement:

It is always desirable to use the best cement in construction. Therefore, the properties of good cement must be investigated. Although desirable cement properties may vary depending on the type of construction, generally good cement possesses following properties (which depend upon its chemical composition, thoroughness of burning and fineness of grinding).

- Provides strength to masonry
- Stiffness or hardness early
- Possesses good plasticity
- An excellent building material
- Easily workable
- Good moisture-resistant.

Clay: (Figure.2)

Clay is a naturally occurring aluminum silicate composed primarily of fine grained minerals. Clay deposits are mostly composed of clay minerals, a subtype of phyllosilicate minerals, which impart plasticity and harden when fired or dried: they also may contain variable amounts of water trapped in the mineral structure by polar attraction Organic materials which do not impart plasticity may also be a part of clay deposits.

Clays are plastic due to their water content and become hard, brittle and non–plastic upon drying or firing and the resulting soil is quite sticky since there is not much space between the mineral particles, and it does not drain well at all. This property of clay will not allow water to get pass through it.

Figure 2

PVC SHEETS: (Figure.3)

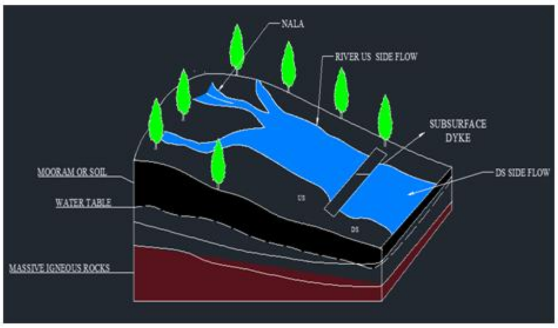
Polyvinyl chloride is one of the most widely used plastics in the world and which is also used to make chemical storage tanks, oil tanks and photographic developing instruments and it is an popular thermoplastic that contains high levels of chlorine which can reach up to 57%. Carbon, which is derived from oil or gas is also used in its fabrication. It is an odorless and solid plastic that is white, brittle and can also be found on the market in the form of pellets or white powder. PVC resin is often supplied in the powder forms and its high resistance to oxidation and degradation make it possible to store the material for long periods.

Figure 3

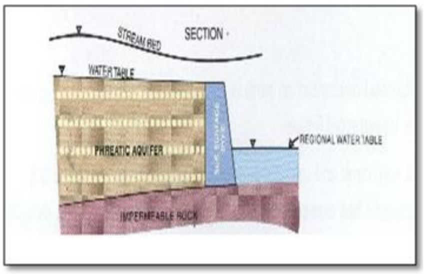
PVC is predominant in the construction industry due to its low production cost, ease to mold and lightweight. It is used as a replacement for metal in many applications where corrosion can compromise functionality and escalate maintenance costs. Many of the world's pipes are made from PVC and these are used in industrial and municipal applications. It is also used to make pipe fitting and pipe conduits. It does not have to be welded and can be connected with the use of joints, solvent cements and special glues--key points that highlight its installation flexibility. The material is also present in the electrical components such as: electrical insulation, wires and cable coatings, etc.

METHOD OF CONSTRUCTION OF SUB-SURFACE DYKES:

Site selection: The guidelines for the selection of sites and design of sub surface dykes are:



SUBSURFACE DYKE



CROSS-SECTION

1. The construction of subsurface dyke should be such that it should conserve more water beneath the ground with suitable recharge conditions and low seepage losses are the main criteria for locating the subsurface dyke.
2. Valley shapes and gradients are considered for identification, and valley should be wide with small outlet or Bottle necked outlet and the valley should be well defined to construct an economical subsurface dyke.
3. The dyke is to be constructed across a relatively narrow ground water valley. Generally it should not exceed 150 meters to 200meters.
4. The thickness of aquifer underlying the site should be adequate (more than 5 m) so that the quantity of ground water stored is commensurate with the effort and investment. Normally, in hard rock watersheds, the drainage courses have a limited thickness of alluvial deposits underlain by a weathered rock or fractured aquifer, which in turn passes into consolidated unaltered aquitard. This forms an ideal situation.
5. The drainage valley across which the subsurface dyke is constructed should carry a seasonal stream, which goes dry in winter and summer and the water table should be located well below the riverbed, preferably throughout the year (The stream should be preferably influent or may be effluent for a very limited period during rainy season). The valley section should preferably have a moderate gradient (less than 1%) so that the benefit spreads sufficiently in the up-gradient direction.
6. A subsurface dyke may potentially deprive the downstream users the benefit of ground water seepage, which they received under a natural flow regime. Care should therefore be taken to see that a large number of users are not located immediately downstream and those affected are duly compensated through sharing of benefits. Care should also be taken to ensure that the water levels in the upstream side of the dyke are deep enough not to cause any water logging as a result of the dyke

IV. Construction Of Subsurface Dyke:

A trench should be dug out across the ground water depression (streambed) from one bank to the other. In case of hilly terrain in hard rocks, the length of the trench generally may be less than 50 meter. In more open terrain, the length may be usually less than 200 m but occasionally even more. It should be wide enough at the bottom to provide space for construction activity.

In case of shallow trenches down to 5 m depth, the width at the bottom should be 2m. For deeper trenches down to 15-20 m, deployment of mechanical equipment may be required. In such cases, width of 5 m at the bottom is recommended. The side slopes within alluvial strata should be 2:1 to make them stable. In case of more consolidated substrata, the slope could be steeper. The width at the surface should be planned accordingly.

CONSTRUCTION OF SUB-SURFACE DYKE

The bottom of the trench should reach the base of the productive aquifer. In case of hard rock terrain, below a limited thickness of alluvial fill, weathered zone and underlying fractured aquifer may occur. The trench should be deep enough to penetrate both highly weathered and fractured strata. In case of more open terrain in consolidated or semi-consolidated strata, the alluvial thickness may be larger and the trench should end below the alluvial fill deposit.

SUB-SURFACE DYKE BEFORE BACKFILLING

In order to minimize or avoid problem of dewatering during construction, the work should be taken up by the end of winter and completed well before the onset of rains, as water table is at lower elevation in this period. The cut-out dyke could be either of stone or brick masonry or an impermeable clay barrier. For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength and 400 to 600 gauges or low-density polyethylene film of 200 gauges is also used to cover the cut out dyke faces.

In the case of relatively shallow trenches within 5 m depth, where good impermeable clay is available within an economic distance (3 km), the cut-out dyke could be entirely be made of clay. In case good impermeable clay is not available, a stone masonry wall of 0.45 meter thickness or a brick wall of 0.25 m thickness may be constructed on a bed of concrete. Cement mortar of 1:5 proportion and cement pointing on both faces is considered adequate.

In the case of very long trenches, for economic considerations, it may be necessary to provide masonry wall only in the central part of dyke and clay dyke suitably augmented by tar felting, PVC sheet etc. on the sides. In the case of clay dyke, the width should be between 1.5 and 2m depending on the quality of clay used.

AFTER CONSTRUCTION BACKFILLED WITH

The construction should be in layers and each fresh layer should be watered and compacted by plain sheet or sheep foot rollers of 1 to 2 ton capacity. In absence of roller, the clay should be manually compacted by hand ramjet. Where the core wall is a masonry structure, the remaining open trench should be back-filled by impermeable clay. The underground structures should be keyed into both the flanks of stream for one meter length to prevent leakage from sides.

V. Conclusion:

1. The site which has broad valley with narrow mouth is suitable for the construction of sub-surface dyke for the groundwater conservation.
2. Sub-surface dykes do not result in wastage of agricultural land and also there will no evaporation loss.
3. Except the construction cost the investment in terms of maintenance cost is nil.
4. In areas of a well defined watershed with a narrow outlet is an efficient system to conserve and utilize the rainfall that is received in a watershed area.
5. The conserved water in the dyke can be utilized through the open well or bore well for the various purposes in the sub-basin area.

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