Banana Drains

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Abstract: Banana drains (BD) are particular type of band shaped fibre drains prepared by simulating banana plant stem. They are composite type having two/three parts made mainly with woven, nonwoven and netting materials prepared with jute, coir, caddis and non-retted, non-spum jute ribbon. They are degradable but their design life time can be extended to 1-10 years by modifications. They have greater consolidation effect than other types of fibre drains on soft clayey soil. Moreover, it is presumed that hydrogen bonds present in lignocellulosic materials play a vital role in determining the permeability of BD when applied in clayey soil.

1 Introduction

Vertical drains (VD) are commonly used to solve the consolidation problems in soft clayey soil. BD as VD have been found to be more efficient, effective and economical than similar types of VD. Sand drain (SD) is the best-known type of drain in geotechnical engineering, but prefabricated drains are also in use since 1937. Kjellman cardboard wick, Geodrain, Castleboard, Bidim, Colboard, Alidrain, Wickdrain (WD) are the common types of drains generally available in the market. (Hansbo, 1979, Hughes et al., 1972, Lee et al., 1987, Davies, et al., 1931). But most of the presently used prefabricated drains are of synthetic origin though natural fibres are also used. VD are often used but horizontal drains or drains with different pose angles can be applied for the purpose of consolidation.

Characteristics for ideal drains (Hughes, et al., 1972): (1) Permeability of the drains should be greater than that of the ground to be treated. (2) Flexibility/stiffness of the drains should be similar to that of soil. (3) Should be continuous and good hydraulic connection with the bed. (4) Should be useful up to the expected period of design time of consolidation. (5) Should be clean, porous and in good capillary condition so that it is not clotted by surrounding soil.

2 Materials for fibre drains

Application of geotextile (GT) in different forms for solving various geotechnical problems is recently getting prominence and uses of cotton, cotton waste, Jute, Kenaf, coir, banana fibres etc. are also known. Application of GT for drainage (D) of soil water is not a new one. Basic properties of fibrous materials that might be used for making of drains may be mentioned as water permeability, air permeability, capillarity, flexibility, strength, and durability in the application media.

3 What is BD

BD is a new type of fibre drain acting like a WD prepared mainly with jute fibre but coir, banana fibre and synthetic fibres may also be used. It is a composite type of product where

two/three types of woven, nonwoven and netting materials are used where the innermost netted part is enveloped by nonwoven and or woven parts respectively. The woven outer part is made with specially blended cloth with jute, coir and jute cuttings. (Abdullah et al., 1987). The nonwoven middle part is made with a mixture of jute caddis, coir, masticated garment waste in specific proportions. The innermost part is made with special type of yarn made by non-retted, non-spun jute ribbon in the vertical ribs connected with horizontal light ribs at definite angles without interconnection simulating the natural banana plant stem. All the parts are modified with higher hydrophobicity and less biodegradability which are depicted in Figs 1-4.

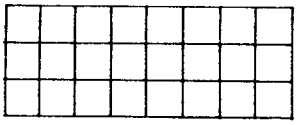

Fig.1 Woven Jute Fabric

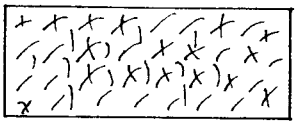

Fig.2 Non woven jute fabric

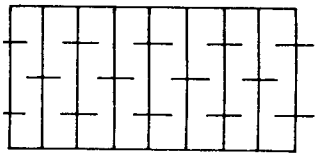

Fig.3 Netted core of Jute Ribbon / Cord.

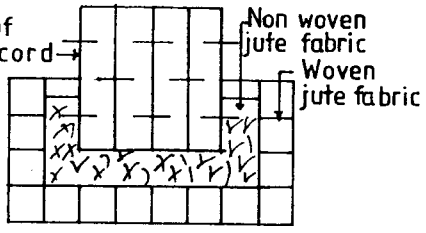

Fig. 4 Banana Drain

4 Jute as GT material

Considering the requirement necessary to be used as GT material, jute comply with all the properties except durability particularly where longer durability is necessary. Thus jute has been used as a GT material like topsoil stabilizers, nursery sheets, fibre drain (FD), WD, SD etc. Jute being quick biodegradable, normal jute products degrade within 3-5 months. Obviously considering the Bangladesh condition untreated normal jute products available in the market should not be treated as jute GT until these have improved hydrophobicity and less biodegradability.

Jute is a lignocellulosic bast fibre and its Physico-chemical properties are the resultant properties of its individual components and various inter and intra molecular chemical, physical and hydrogen bonds present in them. Capillarity and moisture holding capacity of jute products are mainly dependent on the hydroxyl groups and oxygen containing groups among jute constituents and hydrogen bonds present in them. (Abdullah et al., 1992).

5 Preparation of BD

(1) Jute cloth of different construction and designs varying from 0.3-1.0 kg/m^2 are prepared according to application conditions with blended yarn of jute, coir and jute cuttings with specific permeability. (2) Above fabrics were then modified for higher hydrophobicity and specifically designed biodegradability. (3) Non-woven lap with various thickness is made according to need with jute caddis, coir, banana fibre, waste rayon, masticated garment waste etc. (4) Core netted part of BD is made with special type of modified cords/ribs made of non-retted, non-spun jute ribbons in the rib of vertical direction and modified yarn in the horizontal direction. (5) The core part of the BD is enveloped by part-II and part-I respectively as is shown Figs 1-4. All the parts are then sewn with specially modified jute thread. Properties of BD are shown in Table 1.

6 Laboratory test

Consolidation effect of the above differently treated BD were studied with those normal SD and WD made with jute materials by a method developed in BJRI (Bangladesh Jute Research Institute) Laboratory with Dhaka soil having 50% water content, 50% consolidation time was measured by the equation:

$$c = t - t_1$$

where c is the consolidation time, t_1 is the time of evaporation of normal water and t is the time of evap-oration and D through the above drains in identical conditions. After 50% con-solidation time, the bursting strength of the drains were measured. The results are shown in Table II.

Table 1. Material properties of banana drain (BD)

Materials	Fabrics	Yarn	Ribbon	Other Parameters
Jute fibre, Jute ribbon, jute cuttings, caddis, coir, banana fibre, rayon, masticated garment wastes	(a) Plain, twill, untreated and treated woven structure jute fabric. (b) Untreated and treated non-woven lap of different proportions of coir, caddis, coir, banana fibre, masticated garment wastes	Two ply (258.2 Tex) treated jute yarn	Non-retted, non spun modified jute ribbon (5-7 mm diameter)	Type: Composite Parts: 2/3 parts, Width: 100-200mm Thickness: 5-15mm Weight: 0.3-1.0 kg/m^2 Tensile strength: warp: 1-8 kN/m weft: 0.8-4.5 kN/m Permeability: Vertical :0.0008 m/s Horizontal: 0.0005 m/s at σ=300 kPa Durability: 1-10 years Elongation: 15%-20% in warp and weft directions.

Table 2. Consolidation time and loss of strength of different types of BD

Type of Drain	Consolidation time (days)		Loss in bursting strength (%)	
	Untreated	Treated	Untreated	Treated
One Jacketed Banana drain (non-woven and net core	140	123	biomass	3
One jacketed (woven & net core)	138	126	biomass	3
Two jacketed (woven + non-woven + net core)	120	100	structure is deformed but not converted into biomass	2
WD	135	130	biomass	4
SD	142	133	biomass	7

7 Application of BD

Application of BD is altogether different from those of the WD or SD. They are generally applied after civil construction by boring holes by mechanical/ electrical means. But BD are be applied at the construction time of civil works with special design as follows: Time of consolidation of vertical BD in clayey soil and design spacing can be calculated using the equation (Prodhan, 1984, Prodhan et al., 1984).

$$t=\lambda z.\frac{D^2}{8c_r}\left[\ln\left[\frac{D}{d_d}\right]-0.75\right]\left[\ln\frac{1}{(1-\tilde{U}r)}\right]$$

where t=time of consolidation

$$\lambda z=\frac{t_{B.D}}{t_{W.D}}<1$$

$t_{B.D}$=time for BD

$t_{W.D}$=time for Band-shaped wick Drain.

D=Influence diameter of vertical drains

d_d=Equivalent diameter of drain.

$\tilde{U}r$=Average degree of consolidation due to radial drainage;

C_r=Co-efficient of radial consolidation.

$d_d=\frac{2(a+b)}{\pi}$ a= Width of drain. b=thickness of drain.

Here λz shows the drainage characteristic of BD which is more effective than any type of Band-shaped drain.

8 Conclusion

Jute has similar properties as wood and cotton. It is hydrophillic and quick degradable. Thus it is not suitable for using as GT material where life span is necessary for more than 120-150 days. Design time for consolidation of soft clayey soil may require more than 360 days. BD are special types of fibre drains where jute fibre with higher content of lignin have been used as lignin is more resistant to biodegradation. Moreover, nonbiodegradability and hydrophobic characters of these products are improved by modifications. Structure of BD is simulated from the stem of banana plant. In the D system, soil pore pressure is reduced by removing water through the drain by the formation of hydraulic connection by the D system either by wick or sand media by gravataional precess. In the BD innermost hydrophobic and less biodegradable network act similarly. One jacketed woven or nonwoven BD has similar property like those of WD and SD. But two jacketed BD works better as both capillary and hydraulic properties function simultaneously. All the treated drains are better than untreated ones as shown in Table II. Moreover, due to higher hydrophobicity the permeability of BD is increased. Before completion of total consolidation, they become biomass and restrict further consolidation. But treated ones can function up to the designed time. As loss of strength is very insignificant during consolidation, the BD work as reinforced type of jute GT due to its composite nature. In BD consolidation process seems to be governed by hydrogen bonds and capillary system of the media (Abdullah, et al., In the press). It may be stated that better consolidation effect can be achieved by BD as compared to other drains.

In Bangladesh conditions, BD are supposed to be more economic than those of synthetics and other types of fibre drains.

9 Acknowledgement

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