HARYANA CANAL LINING - COST BENEFIT ANALYSIS OF GEOCOMPOSITE SYSTEM ADOPTED FOR MULTIPLE FUNCTIONS - A CASE STUDY

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ABSTRACT

Asian countries have a strong history of being closely linked to agriculture and farming related occupation. Canal irrigation is one of the principal methods used for irrigating the crop fields. Generally, irrigation canals are lined or unlined. Lining helps in minimizing seepage losses and protecting the banks and bed of canal from erosion. Smooth lining also helps in improving the efficiency of canal by increasing discharge and velocity. Reports indicate that unlined canals can lose between 35% and 50% of water they carry, depending upon the overall length of the canal, soil characteristics of the region they traverse, and the hydraulic and discharge parameters. When dry, the canals in water logged areas are subject to reverse seepage flow of water from adjacent land to canal body. In such conditions, this reverse water flow exerts uplift pressure on canal lining and hence suitable measures are needed to relieve this pressure. Traditionally, gravel filter and drainage layers are provided under the lining along with pressure release valves to release the back water into the canal. However, the aggregates used for filter and drainage layers is becoming scarce commodity in India and an alternate material is essential to replace the increasing need of aggregates for such infrastructure projects. With advancement of technology in the field of construction, 'Geosynthetics' has become a simple and effective replacement to various conventional solutions respecting the safety, technical and functional requirements of structure. Drainage composites are special type of geocomposites that enable rapid drainage of excess water while preventing soil particle migration. This paper presents case study of an irrigation canal in the state of Haryana, India. A three layer drainage composite comprising of non-woven geotextile filter, drainage net and geomembrane was successfully adopted as an alternative to conventional gravel filter layers. The project was executed in year 2009-2010 and it is successfully functioning for the past two years. With the successful performance of three layered drainage composite solution, apprehensions about technical aspects, functionality and commercial benefits were put to rest. The three layered drainage composite combines three distinct functions of filtration, drainage and impermeability to enhance the life of lining overlying it. Through this paper, an attempt is made to highlight the successful implementation of Drainage Geocomposite for multiple functions in canal lining project. Due to their distinct advantages of light weight, higher drainage capacity, quality consistency and ease of installation over conventional system, drainage composites are very promising cost effective alternatives to conventional solutions and shall be increasingly used in infrastructure projects.

Keyword: Lining, geosynthetics, drainage composite

INTRODUCTION

With continuous development in civil engineering, canal irrigation has transformed into one of the widely used irrigation system from all the available methods of irrigation. Generally irrigation canals are lined or unlined. With unlined canals, the issues like loss of water due to seepage, soil erosion and failures of side slopes are of major concern. This has led the engineers to consider constructing lined canals. In dry conditions, the canals in water logged areas may be subjected to reverse seepage flow of water from adjacent land towards the canal body (Fig. 1).

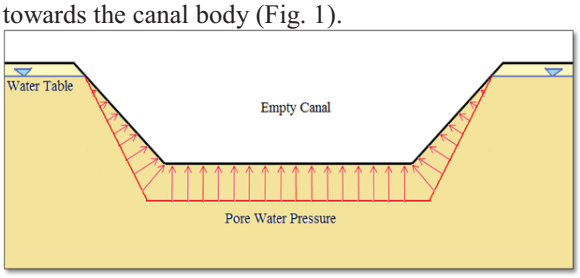

Fig. 1 Empty canal subjected to pore water pressure from surround soil mass

Under this situation, the reverse water flow exerts uplift pressure on canal lining and it is very essential to adopt appropriate measures to relieve this pressure.

Thus, the need for an efficient drainage system arises which can govern and increase the life of the canal lining and the canal itself.

PROJECT DESCRIPTION

The irrigation department of Haryana state, India, had planned canal works with concrete lining. The total length of canal to be constructed was approximately 65km out of which a portion of 30km was in cutting (Fig. 2). The ground water table in the cutting portion was high. It was thus apparent that, this portion of canal lining in cutting would be subjected to high pore-water pressures from the surrounding soil. The expected uplift pressure on concrete lining necessitated the provision of a drainage arrangement underneath the lining. The initial proposal for drainage beneath the canal lining comprised of conventional granular gravel layer and arrangement of a network of perforated pipes. Haryana Irrigation Department was seeking alternatives to replace this complex drainage arrangement with a solution that would be superior on technical grounds as well as cost effective.

Fig. 2 Canal surface to be lined

With advancement of technology in the field of construction, 'Geosynthetics' has become a simple and cost effective replacement to various conventional solutions. 'Drainage Composite' (Fig. 3) is a subset under the family of 'Geosynthetics' which can effectively replace the conventional drainage of graded gravel layer by performing the functions of drainage, filtration and also barrier as per requirement.

The 'Drainage Composite' normally consists of a light weight, three dimensional rigid polymeric core which has high compressive strength and discharge capacity. As indicated in the following figure the core may be ribbed, netted, nubbed, columned or dimpled. This core is sandwiched between layers of heat bonded non-woven geotextile acting as a filter and separator on one or either sides of the core. The geotextile on one side may be replaced with an impermeable layer of geomembrane based on requirement.

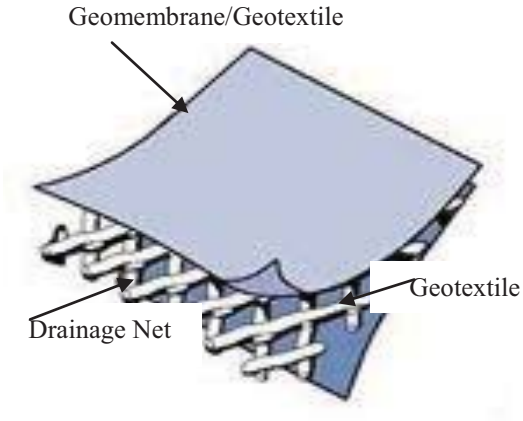

Fig. 3 View of three layered drainage composite

For Haryana Canal, the type of drainage composite adopted was Mac Drain N-105M. This product particularly combines three layers: 1. Drainage net or polymeric core 2. Heat bonded non-woven geotextile and 3. Layer of impermeable geomembrane

This three layer combination was provided considering the requirements at site and function of each component: Non-woven geotextile was designed to function as filter media which will allow the subgrade water to enter into the core portion and also retain the subgrade soil. The water travelling through core may drain out into main canal through pressure release valves. The impermeable layer of geomembrane will act as additional sealing layer apart from concrete lining reducing seepage loss from canal (Figs. 4, 5 and 6).

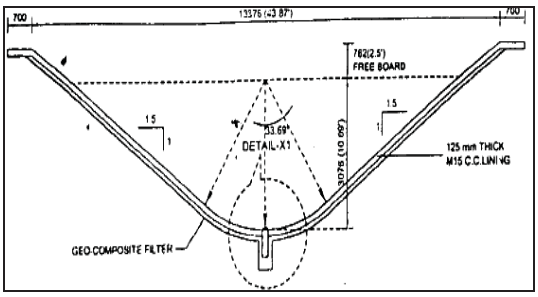

Fig. 4 Typical section of lining works carried out

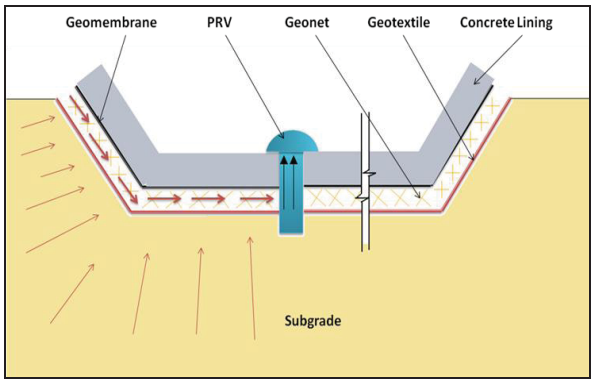

Fig. 5 Schematic arrangement of canal lining with drainage arrangements

BRIEF TECHNICAL SPECIFICATION OF PROPOSED DRAINAGE COMPOSITE

The three layered drainage composite installed in Haryana Canal comprises of core of extruded polyethylene net sandwiched between thermally bonded non-woven geotextile, and geomembrane of low density polyethylene.

Thermally bonded non-woven geotextile has a unique combination of polypropylene and polyethylene. The polypropylene yarns are coated with polyethylene sheath. This unique combination provides excellent chemical resistance and strength to the geotextile. Further, it has excellent filtration characteristics. This fabric structure prevents clogging of geotextile and has very good permeability due to higher range of pore size and at the same time it also prevents loss of fines to a large extent.

Drainage net and geomembrane are made up of polyethylene which has excellent resistance to environmental chemical degradation. As per FHWA – NHI – 00 – 044, polypropylene and polyethylene have excellent chemical resistance. The most important characteristic, i.e. the in-plane flow of drainage composite is of the range 0.66 liter/sec/m under normal pressure of 100 kPa. This is much higher as compared to in-plane flow capacity of conventional graded gravel drain.

TECHNO-COMMERCIAL BENEFITS OF THREE LAYERED DRAINAGE COMPOSITE

The three layered drainage composite has high in-plane flow capacity under pressure as compared to conventional filter. It maintains high flow path for pore water dissipation which helps in maintaining soil stability beneath the canal slopes and canal bed. The tensile strength of drainage composite varies from 7kN/m-23kN/m which can adequately resist soil pressure on slopes and distribute concentrated forces preventing local shear failure. The drainage composite has good puncture resistance due to which it acts as protection layer in addition to drainage function. Robustness of drainage composite prevents the puncturing and tearing during installation

Commercial benefits were experienced under various aspects like, installation under different conditions, reduction in wastage, quality assurance, and increase in canal capacity. Being light in weight and easy to handle, they are quick to install and demonstrate a cost effective replacement to conventional materials in terms of installation expense too.

Direct Cost Benefit Analysis

The commercial effectiveness of the three layered drainage composite was substantiated in Haryana canal project. Typically, drainage composite can be procured and installed at an approximate cost of INR* 500-600 per sqm in Northern part of India, whereas, the cost of equivalent conventional graded filter of 600mm thickness would have a cost in the range INR* 1000 per cum (Delhi CPWD Rates) to Rs 1500 per cum (Rates as per State level SOR). Hence, on an average a considerable cost optimization in the range 30% to 40% was estimated for this project.

Indirect Cost Benefit Analysis

Generally the side slopes of canals are dressed at a slope of 1V:1.5H. Placing the graded gravel filter over slope is a time consuming activity and wastage may be significant. At the same time, factory made material; drainage composite ensures quick and quality installation with minimum wastage. Generally, 600mm thick gravel filter may be provided on either banks and on canal bed. The average thickness of drainage composite is 8mm, this ensures increased discharge carrying capacity as compared to graded filter.

Thus, the three layered drainage composite is much more effective than conventional gravel filter. Use of drainage composite reduces burden on natural resources and offers environment friendly solution. Being factory made material, the quality is assured and it can be maintained for large volume which may be difficult in case of conventional filter.

*INR-Indian Rupee

Fig. 6 Drainage composite laid on slope

STUDIES CARRIED OUT

In canal lining, a practice is there to replace conventional graded gravel with a layer of geotextile for function of drainage and separation. For impermeability, a geomembrane layer may also be provided. For Haryana canal lining, an option of two layer drainage system (Geotextile + Geomembrane) was considered. Studies were carried out to compare the in-plane flow capacity of two layered drainage and the three layered drainage system (Drainage Composite. Refer Fig. 3). Apparently, it may seem that two layered structure may serve the drainage function but studies revealed that the required in-plane flow capacity is much higher than the in-plane flow capacity of geotextile. Figure 7 presents the in-plane flow capacity of Geotextile (400 gsm) and Drainage Composite tested at an international renowned and accredited laboratory.

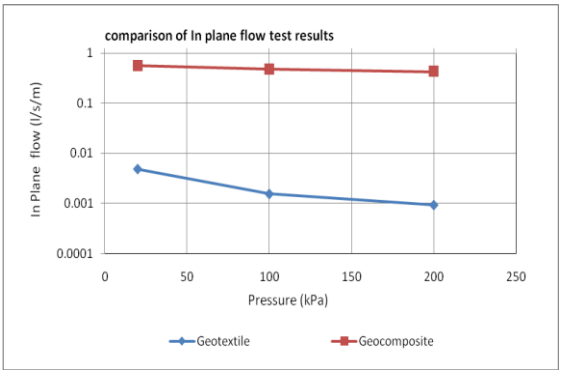

Fig. 7 Results of in plane flow

From Fig. 7 it can be inferred that, the in-plane flow capacity of a three layered drainage composite is about 10^3 times greater than that of a two layered drainage system at 100 kPa pressure. Hence, it can be further reinstated that a three layered drainage composite is a better suited option for replacement of conventional drainage layer. A single layer of geotextile or a two layer geocomposite made of geotextile and geomembrane may not be sufficient to meet the drainage requirements in an irrigation canal.

INSTALLATION BRIEF

The installation methodology in case of three layered drainage composite is much simpler, ensuring good speed and minimum wastage, thereby ensuring efficient installation at minimum cost. The canal bed and side slopes were well trimmed and cleared of any deleterious material. The side slopes were maintained at a stable slope of 1v:1.5h to a vertical height of approximately 4m. The average base width of canal was 4m. On achieving a leveled surface, the three layered drainage composite was laid on the slopes as well as along the bed of canal, with the layer of non woven geotextile of drainage composite in contact with the underlying subsurface and the layer of impermeable geomembrane in contact with concrete lining (Fig. 8).

Fig. 8 Laying of drainage composite in progress

Due care was taken at overlaps and proper sealing with geotextile was ensured at every overlaps. The water collected from drainage composite was designed to be collected in longitudinal drain provided at centre of canal bed. The water collected in longitudinal drain was designed to be discharged into the flowing canal through pressure relief valves that were provided at interval of every 10m along the canal. Pressure Relief Valve is a non return valve which allows water beneath a canal lining to flow inside the canal but does not allow canal water to leak in the subgrade (Fig. 9). These valves thus protect the lining from damage by releasing excessive hydrostatic pressure that may develop behind the concrete lining.

Fig. 9 View of a pressure release valve

After laying of drainage composite over a certain stretch length, the final 125mm thick concrete lining was laid (Fig 10).

Fig. 10 Concrete lining construction

CONCLUSIONS

This paper presents an effective case of usage of three layered drainage composite as alternative to graded filter when ground water table is high. The in-plane flow capacity of a three layered drainage composite is about 10^3 times greater than that of 400 gsm geotextile at 100 kPa pressure. Construction of filter layer beneath the concrete lining is much easier by usage of drainage composite. Use of drainage composite reduces burden on natural resources and offers environment friendly solution. Being factory made material, the quality is assured and it can be maintained for large volume which may be difficult in case of conventional filter. With use of drainage composite the discharge capacity of canal is increased compared to graded filter. Presently, one major hurdle with these engineered materials is the lack of manufacturing facility in many countries. This enforces the system provider to import it at prevailing duties that are on a consistent rise. The problem may be solved by encouraging the setting up of manufacturing plants in potential markets.

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