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Comparative study of Use Of Flexible Bituminous Geomembrane Sheets & Concrete Lining For Pench Left Bank Canal of Nagpur region

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Abstract: Today Geomembranes are a long term solution for canal leakage problems and are one of the most important materials to cope with problematic soils. The necessity of Geomembranes performance is more obvious nowadays regard to the scarcity of fresh water for irrigation. There are evidences that hard linings which use to reduce irrigation canals leakage don't have the expected performance. In most cases the drainage problems exacerbated due to leakage wastes.

In this study the canal network of Pench project was taken into account which is the life line of Nagpur – Bhandara district. In this project conventional concrete lining with use of BGM was studied. Canal behavior with concrete lining as well as canal behavior with BGM behavior was studied. The installation of BGM was observed and studied in detail.

Keywords: Geomembrane, prefabricated bituminous geomembrane, canal lining, seepage loss

1. INTRODUCTION

Over the years, there have been incidences of breaches in Pench project canal, affecting water supply to Nagpur city as well as water for irrigation in rural areas of district. Water Resources Department (WRD) has studied in detail the reasons behind breaches and has drawn up a plan involving an huge expenditure to take up long-term repairs of the canal, which has breached 43 times in the past nine years. Pench project's main dam is at Totladoh in Nagpur district, on river Pench in Wainganga sub-basin of Godavari basin. Pench project is the lifeline of Nagpur and Bhandara District. The dam at Navegaon Khairi and Khindsi reservoir also are parts of the Pench project. Water from the project irrigates total 1,04,476 hectares of agricultural land including 83,076 in Nagpur district and 21,400 hectares in Bhandara district. The project also is main supplier of drinking water to Nagpur City with population of about 30 Lakhs and water supply to Koradi and Khaparkheda Thermal Power Stations. The canal network of Pench project is very long with total length of about 1763.90 km. This huge network comprises 84.05 km of main canal, 158.66 km of branch canals, 367.92 km of distributaries, and 1,153.27 km of minor canals. As the canal was constructed 37 years ago using the technology and techniques available at that time, it required attention as far as timely strengthening, repair and maintenance works were concerned. There has always been instances of canal breach during water flows, sloughing of bank & collapse of slopes during fluctuation or depleting supply Depths thus creating Emergency situation.

2. PROJECT LOCATION

Thesite is about 3.4 km from National Highway 44 and is on state highway 249. The project is 1km from Gundhari Village. At proposed locations of canal lining, canal flows from North to South direction

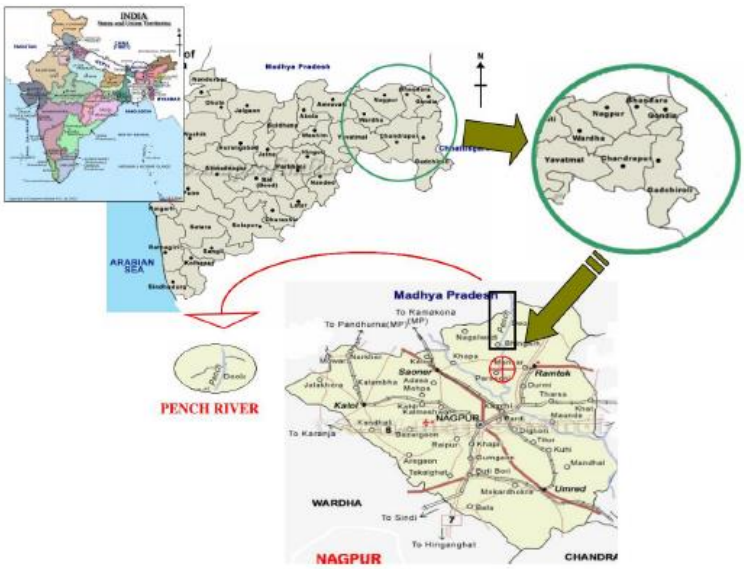

Figure 1: Project Location Map of Pench Canal

CANAL SALIENT FEATURES

Table1: Salient features of Pench L B Canal

i	Total Length	32	KM
ii	Length (Pilot Study)	800	m
iii	Bed width	13	m
iv	Full Supply Depth	3.8	m
v	Design Discharge	90	Cumecs
vi	Mean Velocity	2	m/s
vii	Bed Slope	1 (V):7000 (H)	
viii	Side slopes	1(V):1.5 (H)	

CANAL BEHAVIOUR WITH CONCRETE LINING

During the site inspection of left bank pench canal it is observed that concrete lining of canal is severely damaged. Root causes behind the cracking of concrete lining of canal can be summarised as below:

i) Concrete lining has joints at regular interval of 2-3m, through which seepagewas taking place across the banks of the canal. General soil type along the canal alignment is Expansive soil which is popularly known as "Black cotton soil". Expansive soil exert pressure on the concrete lining due to volume expansion. As concrete is weak in tension, the expansion joint crack become wider and also sometimes new cracks develops in concrete lining. Flowing water cause internal erosion below the lining of canal when water enters in these cracks.

ii) During drawdown condition, situation becomes even worse when uplift force due to pore water pressure along with the swell pressure exerted by bank soil cause cracking of lining and sometime sliding of the whole soil mass along with the lining into the canal.

iii) A distinct disadvantage of CC is its lack of extensibility. Main issues with the concrete lining are frequent cracks due to contraction taking place from temperature change, drying and shrinkage and settlement of sub-grade. Cement concrete (CC) lining without reinforcement may be damaged due to excessive external water pressure. The reinforced concrete lining can withstand the external water pressure but at a very high cost. When unexpected water pressures are encountered, un-reinforced lining will crack more easily than the reinforced lining and will relieve the pressure thereby reducing the area of damage. Sometimes reinforcement is required to increase the resistance against cracks and shrinkage cracks. The reduction in the cracks results in less seepage losses. This reinforcement adds 10 to 15 percent to the cost and for this reason steel reinforcement is usually omitted except for very particular situations. Further it is observed that even reinforced lining is bound to crack in extreme conditions ad is not 100% seepage resistant and therefore cannot prevent breaches completely.

Following are some pictures showing the heavy seepage from canal outer face in the same zone of Canal before BGM lining. This seepage has also lead to progressive erosion and has lead to bank breach failure as well as canal inline structures such as Culverts/Aqueduct failure

Figure 2: Canal outer face Seepage in same stretch before BGM lining.

CANAL BEHAVIOUR WITH BGM LINING

The installation of BGM layer forms an impermeable barrier all around the inner surface of canal upto half FB and into the embankment upto 0.5 m embankment top width and the BGM at the end. This layer prevents the seepage of canal water to enter into the embankment fill and at the same time during rains, the rainwater is also prevented to percolate into the half of the embankment top. Thus, the moisture variation almost ceases to take place in the canal

embankment and hence no excess pore pressure develops during drawdown condition. Also, the provision of BGM layer rules out any possibility of soil erosion by flowing water. This shows that the major failure causing factors are ruled out due to provision of BGM layer in the canal. Thus it can be seen that the critical failure surface is on the slope of embankment opposite to the canal side. But in actual practice, there is no seepage or failure anywhere at the site on outside slope of canal. Hence the system is completely safe with BGM layer.Following are some of the pictures of outside face of canal after BGM lining installation where no seepage can be seen at site even under full flow condition.

Figure 3: Canal outer face & Culvert condition in same stretch after B G Mlining.

MATERIALS

Bitumen: Bitumen is used on the purpose to coalesce and unite the clay particles. The properties of bitumen (penetration 100/150 at 25∘C, 100g, 5sec; softening point 39–47∘C; flash point 230∘C).
Waste clay :- Grain-size distribution of CW consists of 1.74% sand, 20.76% silt, and 77.5% clay and the determined soil class is high plasticity clay (CH).
Bentonite : Bentonite is generally used in improvement of impermeable compacted clay layers in landfills due to its high swelling potential and low hydraulic conductivity.
Fibre glass and Nonwoven polyester :- Two different reinforcement materials were used, fiberglass tissue also known as glass fleece (CT) and nonwoven polyester (PK), and both were obtained from a geomembrane production plant.
Waste tire : The particle size of the adopted waste tire samples was less than 1.18mm. The steel free waste tire (<1.18mm) was adopted from a tire recycling plant.

PROPERTIES OF BITUMINOUS GEOMEMBRANE (BGM) LINING

A BGM is a composite material with several constituents to attain the desired overall material properties. They typically consist of non-woven geotextile and glass fleece layers impregnated with and encapsulated in elastomeric bitumen, with a sanded surface on one side for enhanced friction and an anti-root layer on the other. The geotextiles dictate the mechanical properties of the BGM, while the elastomeric bitumen provides waterproofing, chemical resistance and protection from ageing. The glass fleece is used for manufacturing purposes. It ensures stability of the geomembrane during impregnation of the geotextile with hot bitumen.

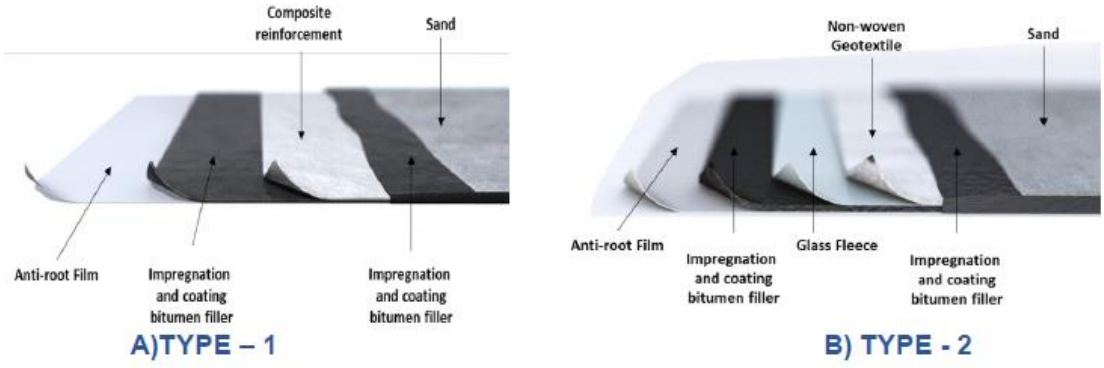

Figure 4: typical cross section of a BGM

The geotextile is then temporarily too soft to support the weight of the bitumen without large deformation. It will be seen below that, although, the glass fleece is used for manufacturing purposes, it has an impact on the properties of the bitumen geomembrane.

Typical thicknesses are from 2mm to 5.6mm. The BGM is supplied in rolls from 4.0m to 5.0m wide, typically up to 90m long.

Key points relating to issues relevant to the BGM application are listed below:

- **Water permeability** – Permeability of 4 x 10-14 m/s.
- **Temperature resistance** – Softening point approximately 120°. Can be increased to 145° as special order.
- **Design Life of BGM**- 30-40 Years

- **Material Life Span** – Chosen by the Atomic Energy Commission in France for a design life of a minimum of 300 years (Reference – Bituminous Geomembrane Cover for a low to Medium Level Radioactive Waste Disposal Site). Chosen by the Nuclear Safety Agency in the USA with a design life of 1,000 years. Based on current knowledge, it is the geomembrane with the longest service life.

- **Friction angle** – approximately 20-25° on root barrier side, 30-35° on sanded side, but is dependent on the subgrade and over liner material utilised. A High Friction Angle BGM product with sand on both sides is available if required. However, the polyester root-barrier film is considered an important consideration in canal/lake application.
  - **Seepage chemical resistance** – no issues with expected pH, metals
  - **Cover leachate chemical resistance** – not affected by leachate waters.
  - **Fuel & oil chemical resistance** – Low. Diesel will soften the bitumen. Nevertheless, BGM has been used

under highways and in roadside ditches to protect an underlying critical aquifer (Coppinger, J., et. al. 2002). Note though that the root barrier is polyester and will not dissolve.

- It is an electrical insulator so it can be electrically surveyed for leaks.
- Tear resistance is high due to the presence of the nonwoven geotextile in the middle of the bituminous geomembrane.
- Considerable extensibility of upto 50% strain at peak tensile strength as against the extensibility of 10-12% in HDPE at similar tensile strength.
- **Puncture resistance** – Enhanced by an internal 300-400g/m2 geotextile. BGM will require protection from mechanical puncture by rocks. The subgrade typically is required to have pore sizes of less than 25mm. Due to the fact that bituminous geomembranes have limited extensibility, they are susceptible to puncture by protruding stones under high loads (which is not the case in a cover).
- **Bioturbation resistance** – Excellent resistance to animals including rats, termites, beetles, cockroaches. Anti-root barrier resists root penetration, except possibly at welds where the anti-root film is discontinuous

3. COMPARISON OF CC LINING AND BGM LINING

Table2: *Comparison between parameters of BGM & Cement Concrete Lining*

1.	**CNS Requirement**	No CNS layer required. Can be normal soil.	CNS layer (30cm to 100 cm) is required as subgrade.
2.	**Waiting Period**	BGM can be installed immediately after subgrade preparation.	Waiting period of atleast one season/one year after CNS filling before concrete lining can be done.
3.	**Construction rate**	Very fast Installation @3000 sq. m length/day/gang	Slower installation @ 800 to 1000 sq.m per unit (1 paver and 2 TM)
4.	**UV exposure**	Highly resistant to oxidation and UV.	The UV light breaks down polymers and other bond chains within the concrete itself, weakening them over time.

5.	**Weather Resistant**	BGM is thicker and heavier making it more resistant to wind lifting. The same has been tested in Kharif season in PLBC of Pench Project	Concrete placed during the hot months is subject to conditions that can adversely affect the properties and serviceability of the concrete, such as increas drying shrinkage cracking.
6.	**Expansivity**	BGM is flexible and can absorb soil pressure of the expansive soil.	Poor expansivity. Not suitable for site conditions having expansive soil and leads to
7.	**Water Permeability**	10-14 m/sec	Approx. 10-7m/sec
8.	**Manning's**	0.012	0.018 to 0.020
9.	**Coefficient of Thermal**	0/°C	10 x 10-6/°C
10.	**Contraction, Expansion**	No special joint is required as BGM is flexible and no construction joint is required.	Expansion and Contractions joints are required which become vulnerable spots for deterioration
11.	**Cost Economics**	Rs 1100 per sq.m including dressing of Slopes	Rs 1300 per sq,m including excavation for CNS and CNS

4. CONCLUSION

1) General soil in the command area of Pench Project is Black cotton/ Expansive soil and therefore great care is to be taking while filling the CNS and compacting it properly to required density. Despite the care, after laying of CC concrete, any micro movement in sub grade due to settlement of canal section or drawdown caused due to water level fluctuations in canal may lead to cracking of lining.

2) The BGM was installed in Km 8 of LBC of Pench Project and about 27000 sq. m of BGM was installed in 15 days. Further BGM was also applied on the joints on U/S and D/s of Aqueduct, HR of Gundri Minor and over the Slab Culvert. During kharif about 75 cumecs of water was released in the LBC and seepages were observed and it was found that there was absolutely no seepage through the Earthwork, Aqueduct, Slab Culvert ad Head Regulator. This was confirmed from the flow of adjacent nallas which were having very negligible flows.

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