International Journal of Scientific Engineering and Technology ISSN :2277-1581
Volume No.4 Issue No.10, pp: 490-493 01 Oct. 2015

A Review Study of Urban Landfill Pavement Drainage System in Madhya Pradesh

Tapas Dasgupta, Amit Vishwakarma

Abstract: Urban Land fill pavement drainage is one of the key components which need to be considered along with other parameters for urban land fill pavement management system. In which various issues related with integrating the urban land fill pavement roadway drainage with Land fill pavement Management System. It highlights the major ingress and egress routes of water in land fill pavement structure, methods to measure moisture and approaches to control the water entry. This paper reviews different software's for designing the drainage system and techniques for modeling the drainage conditions in land fill pavement deterioration models. The effect of poor surface and subsurface drainage on land fill pavement performance and its life-cycle are also discussed. The measures to manage the poor land fill pavement roadway drainage conditions are also presented. The need for a detailed field and laboratory studies related to land fill pavements drainage systems has been demonstrated.

INTRODUCTION

Pavement structure on poor soil subgrade show early distress causin premature failure of the pavement. Clayey soil show undesirable engineering behavior such as low bearing capacity, high shrinkage and swell characteristics and high moisture susceptibility. the long term performance of any construction facility depends on the soundness of underlying strata. Unstable soil can create significant problems for pavement and structures.

The drainage system should be well planned for urban areas where there are more underground utilities and scarcity of land for expansion. Poor drainage results into losses - direct and indirect in the form of damaged roads and reduced serviceability. Excessive water content in the land fill pavement base, sub-base and sub-grade soils can cause early distress and lead to a structural or functional failure of land fill pavement, if counter measures are not undertaken. In spite of this, adequate priority for drainage system is rarely accorded, whether it is in the matter of planning, organization, fund allocation or monitoring, funds allocations or monitoring. Funds required for a proper design and planning of drainage system are less as compared to that, used for infrastructural development.

Water-related damage can cause one or more of the following forms of deteriorations: a) Reduction of sub-grade and base/sub-base strength, b) Differential swelling in expansive sub-grade soils, c) Stripping of asphalt in flexible land fill pavements, d) Frost heave and reduction of strength during frost melt, and e) Movement of fine particles into base or sub-base course materials resulting in a reduction of the hydraulic conductivity considerably (Huang 2004). Removal of water from the land fill pavement is done through surface and subsurface drainage. Effective surface water drainage of highway land fill pavements is essential for maintaining a desirable level of service and traffic safety. Poor surface drainage contributes to accidents resulted from hydroplaning and loss of visibility from splash and spray. In addition to surface drainage, land fill pavement must be designed to allow adequate subsurface drainage. Long-term accumulation of water inside the land fill pavement reduces the strength of unbounded granular materials and sub-grade soils, and causes pumping of fine materials with subsequent land fill pavement repaid deterioration.

When a land fill pavement is saturated with water, heavy vehicle loads causes severe impact leading to pumping, disintegration of cement-treated bases, stripping of asphalt and overstressing of weakened sub-grade. Water is also responsible for a large number of non-load related distresses such as: D-cracking in concrete land fill pavements and accelerated aging and oxidation in asphalt land fill pavements. . Therefore, land fill pavement drainage design should be at the forefront of land fill pavement design and not an afterthought.

This is an effort made to describe various issues related to land fill pavement drainage in urban areas. The researches done so far related to surface and sub-surface drainage, methods for controlling and measuring the water movement in the land fill pavements, software's available for drainage modeling and the prevailing design standards for drainage system are reviewed.

DRAINAGE STUDIES

Studies Related to Water Ingress/Egress in Land fill pavements

Elsayed and Lindly (1996) noted that until the study by Ridgeway (1982), high water table and capillary water were thought to be the primary causes of excess water in land fill pavements. Recently, crack and shoulders infiltration and to some extent sub-grade capillary action, were considered to be the major routes of water entry to the land fill pavement The significance of infiltration was shown by an immediate increase in edge drain outflow following a precipitation event. Van Sambeek (1989) reported that surface water infiltration can account for as much as 90 to 95 percent of the total moisture in a land fill pavement system. also identified transverse and longitudinal joints as major routes of ingress. Similarly, field studies by showed that land fill pavement-shoulder joints were a major source of surface infiltration. For routes of egress, noted that the lateral or median drain is the most significant route except when a highly conductive under drain (sub-grade unsaturated hydraulic conductivity > 0.1 cm/s) is provided.

Groundwater conditions may affect the moisture in land fill pavement systems and may be the major factor influencing sub-grade water content if the ground water table is within approximately 6.09 m (20 feet). Capillary water and water vapor may migrate towards ground surface, and increases the moisture content especially in sub-grades. Development of a perched water table may also increase the head build-up in sub-base layers (Ahmed et al. 1993).

Birgisson and Roberson (2000) presented an approach for measuring real-time moisture content in land fill pavement bases during and after rain events. Conceptual models were formed for water flow through land fill pavement sections, and an evaluation of the drainage performance of typical edge drain configurations is provided. It was summarized that the factors affecting the performance of land fill pavement drainage systems include level of compaction around and on top of the drainage pipe, the layering of the land fill pavement, and the connection between the edge drain and the shoulder.

Ksaibati et al. (2002) reported that lowering groundwater table depth results in lowering moisture content in base and sub-base layers. Water is always present in soil and in granular land fill pavement material in some forms, but free water, capillary water, bound moisture, and water vapour are the most concerns to land fill pavement engineers.

Knowledge of the movement of water in roads is important for several reasons. Initially, there is a need to be able to predict maximum flows in order to design sub-base drains. The presence of water in the sub-base affects the mechanical performance of the land fill pavement and its long-term durability. The movement of water can also leach contaminants from the sub-base materials. This is particularly important where alternative materials, which may contain significant concentrations of contaminants such as metals, are used in an unbound granular sub-base. With increasing pressure to use greater amounts of alternative materials instead of natural aggregates, in accordance with policies on sustainable development, it is important to address this issue.

Studies on Sub-Surface Drainage

Sharma et al. (2005) carried out trials on gradation of drainage layers and its impact on permeability values. The results showed variations in permeability values with change in gradation. The most significant factors affecting coefficient of permeability are the effective grain size D10, percentage passing 200 sieve and dry density.

Stormont and Zhou (2001) carried out a study on improving land fill pavement sub-surface drainage systems by considering unsaturated water flow using a computer simulation program. Conventional drainage is predicted on saturated conditions; however, most water movement near the surface occurs under saturated conditions.

Grover & Veeraragavan (2010) Quantified the benefits in terms of Vehicle Operating Cost (VOC) of providing good drainage over the service life of the land fill pavement. The performance in terms of deflection, roughness, cracking and raveling were predicted for do-nothing and after maintenance intervention. The comparison was made for sections with good and poor sub-surface drainage based on the permeability of GSB layers.

Veeraragavan & Grover (2010) investigated the reasons for premature failure of a section of national highway land fill pavement due to poor sub-surface drainage. Benkelman beam deflection and dynamic cone penetration test data were used in the analysis and resilient modulus was calculated for each land fill pavement layers. Using MICHPAVE (Michigan Flexible Land fill pavement Design System) computer program the stresses and strain were calculated and used to predict the performance of the land fill pavement section in terms of cracking and rutting. Remedial measures to repair the land fill pavement section and improve the sub-surface drainage were also presented.

Studies on Surface Drainage

Anderson et al. (1998) studies on improving surface drainage to reduce the tendency for hydroplaning. Three general techniques were identified for reducing the water film thickness: controlling the land fill pavement geometry, the use of textured surfaces to include porous asphalt surfaces and grooved surfaces, and the more effective use of drainage appurtenances. Various laboratory and field studies were conducted and the results were integrated into an interactive computer program, PAVDRN. The program can predict the water film thickness along the line of maximum flow and determines the hydroplaning potential along the flow paths. If the predicted hydroplaning speed is less than the design speed, the designer is prompted to choose from alternative designs that reduce the thickness of the water film.

Hydroplaning can occur at speeds of 89 km/hr with a water depth of 2 mm. The AASHTO Model Drainage Manual provides guidance in calculating when it can occur. It also reports that the driver is responsible for using caution and good judgment when driving in wet conditions similar as when driving in ice and snow (AASHTO 1999).

Studies on Effect of Drainage on Life-Cycle of Land fill pavements

Markow (1982) developed a predictive model of land fill pavement performance that included the effect of moisture on land fill pavement layer properties and the quality of the sub-surface drainage. It was found that good and fair drained sections performed about equally well for the assumed climactic conditions, but the poorly drained land fill pavement didn't performed significantly well. In economic terms. the added value of including adequate land fill pavement drainage was about $200,000 (Rs. 80.26 lakh).

Forsyth et al. (1987) reported the use of edge drains to improve the durability of rigid and flexible land fill pavements and results indicated that drained sections experienced a reduction of about 20% in the deflection level compared to an un-drained section. The cost per square yard from construction to first rehabilitation for both drained and un-drained land fill pavements were also estimated which is narrated in Table 1.

Table 1 : Estimated Costs for Land fill pavement Sections

Land fill pavement Type	**Drained Sections**		**Un-drained Sections**	
	Cost	**Life**	**Cost**	**Life**
	S/sq.yd/yr (Rs./m^2/yr)	**Yrs.**	**S/sq.yd/yr (Rs./m^2/yr)**	**Yrs.**
Rigid	0.87 (57.95)	30	1.47 (97.92)	20
Flexible	1.67 (111.23)	20	2.12 (141.21)	16

(Source : Forsyth et al. 1987)

Christopher and MeGuffey (1997) prepared a synthesis of practice related to land fill pavement sub-surface drainage and concluded that land fill pavements that are drained and maintained last up to twice as long as land fill pavements that are not drained. Cedergen (1998) estimated that a flooded un-drained land fill pavement experiences 10 to 70,000 times the damage from a load event compared to a drained land fill pavement. As a conservative single value, he suggested that an un-drained land fill pavement experiences 15 times the damage compared to a well drained land fill pavement. Cedergen predicted that un-drained land fill pavements have a life cycle of the order of 33% of un-drained land fill pavements, which translates into an annual cost for the US of $15 billion in 1990 (Rs. 60,195 crores).

Zaghloul et al. (2004) determined the effect of the higher moisture content on the land fill pavement life-cycle cost. The analyses showed that an increase in base course moisture content from 16% of 45% resulted in the reduction of land fill pavement service life from 13 to 7 years. For a 40-year period, this translates to a three-fold increase in life-cycle cost for 76.2 m (250 ft) long land fill pavement section. Reducing moisture retention through various means, thereby improving the subsurface drainage quality of flexible land fill pavement systems, can achieve substantial long-term savings was the major conclusion of this research.

Grover and Veeraragavan (2010) quantified the benefit per unit agency cost per km for land fill pavement section with good drainage for constant traffic growth rate as 7% more than that of land fill pavement section with poor drainage.

Studies in Evaluation of Existing Drainage System

AASTHO 1993 recommended a procedure based on calculation of time-to-drain for assessing the quality of existing drainage for permeable base. For a land fill pavement to have good drainability characteristics according to AASTHO, the structural section of the land fill pavement should not be filled with excess water and it should not carry heavy wheel loads during period when there is excess moisture under the land fill pavement. For this, the water should be able to flow out of the land fill pavement faster than it enters. Table 2 presents the drainage level for land fill pavement structures based on time required to drain out the water, 50% drainage.

Table 2 : Classification of 50%

Drainage (AASHTO, 1993)

Quality of Drainage	**Water Removed within**
Excellent	2 hours
Good	1 day
Fair	7 days
Poor	1 month
Very Poor	Water will not drain

Mahboub and Allen (2003) analysed different scenarios of land fill pavement sub-surface drainage using finite element analyses. The finite element models were designed to evaluated the (i) effect of a broken and seated concrete layer with or without a superpave asphalt layer (ii) effect if central collection pipe, (iii) effect of superpave HMA surface, (iv) effect of land fill pavement geometry and land fill pavement types, (v) effect of cracks on land fill pavement surface, (vi) effect of slope on drainage blanket. The analyses were done using the SEEP/W routine of the GEOSLOPE computer program.

AI-Qadi et al. (2004) quantified the benefits of a specially designed geo-composite membrane [a low modulus polyvinyl chloride (PVC) layer sandwiched between two nonwoven geo-textile] to act as a moisture barrier in flexible land fill pavement systems and quantitatively measured the moisture content of unbound granular materials non-destructively using GPR. The study recommended the use of an impermeable interface underneath drainage layers, given that the water table is low, to ensure effective water drainage of land fill pavements.

CONCLUSION

Based on the review of literature done on the studies related to land fill pavement drainage systems, the following conclusions can be made:

- Infiltration through cracks and joints is thought to be the major ingress route and engineered drainage is believed to be the major egress route.
- The water thickness on the land fill pavement surface can be reduced by optimizing the geometric parameters and maximizing the surface texture, thereby reducing the hydroplaning and increasing the safety.
- The three approaches to control the damage due to moisture distresses are (i) prevent moisture from entering the land fill pavement system (ii) use materials and design features that are insensitive to the effects of moisture (iii) quickly remove moisture that enters the land fill pavements system.
- Suitable software can be selected to model the water movements in the land fill pavements and study the effect on land fill pavement performance.
- The effects of subsurface drainage on the performance of bituminous land fill pavements should be studied by construction of test tracks in the experimental design having both drained and untrained sections of the same base type.
- Improving the sub-surface drainage results in reducing the rehabilitation cost and increases the land fill pavement service life.
- Based on above studies there is a need to develop new improved specifications for design of flexible land fill pavements which take into account the effect of different base type, change of sub-grade modulus due to variation of moisture in sub-base, variability of permeability due to minor variation in gradation, etc. Hence, looking into the complexity/intricacy of drainage problem, criteria of material, and plasticity characteristics of sub-grade deserves to be reviewed.

REFERENCES :

i. *Caterpillar. 1984. Caterpillar Performance Handbook, No. 14. Peoria, Illinois.*

ii. *Cook, M.J. and J.G. King,1983. Construction cost and erosion control effectiveness of filter windrows on fill slopes. USDA Forest Service, Research Note INT-335, November 1983.*

iii. *Dietz, P., W. Knigge and H. Loeffler. 1984. Walderschliessung. Verlag Paul Parey, Hamburg and Berlin, Germany.*

iv. *Haber, D. and T. Koch. 1983. Costs of erosion control construction measures used on a forest road in the Silver Creek watershed in Idaho. U.S. Forest Service, Region 1 and University of Idaho, Moscow, Idaho.*

v. *Nagygyor, S.A. 1984. Construction of environmentally sound forest roads in the Pacific Northwest. In (ed Corcoran and Gill) C.O.F.E./U.F.R.O. Proceedings, University of Maine, Orono, and University of New Brunswick, Fredericton, April 1984, p.143 - 147.*

vi. *Oregon State University. 1983. Road construction on woodland properties. Or. St. Univ. Ext. Cir. 1135. Corvallis, Oregon. 24 p.*

vii. *Pearce, J. K. 1960. Forest Engineering Handbook. US Dept. of Interior. Bureau of Land Management. 220 p*