Ground Water Drainage Techniques for Highways with Relatively High Water Table

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Abstract: In this study, various subsurface drainage systems for pavement structures have been reviewed and an overview their potential benefits to the performance of the pavement have been presented. The selection of subsurface drainage technique is based on different criterion such as traffic loading, depth of the ground water table and subgrade soil types, strength and potential drainage conditions. When the groundwater is close to the pavement, it could affect the performance and will need a subsurface drainage or dewatering system to mitigate against the effects of water. Subsoil drainage techniques such as longitudinal drains, transverse and horizontal drains, drainage blankets, interceptor drains and well systems have been discussed in detail.

1. Introduction:

Many paved and unpaved roadways in the United States are subjected to problems associated with excess water within the foundation structure of the roadway (Christopher and McGuffey, 1997). This excess water originates from water infiltrating along the roadway surface or along the shoulders, groundwater seeping in from upslope areas, high water in roadway ditches, groundwater rising up from beneath the roadway, or from thawing ice lenses formed during periods of extreme cold. The excessive wetness of the roadway foundation leads to a weakening of the roadway foundation and, eventually, failure of the surface, whether it is paved or unpaved. The national economic cost of pavement damage as a result of excess water is estimated in tens of millions of dollars annually. While surface drainage practices do help to alleviate some of the problems associated with excess water conditions, the principal way of handling the problem is to use subsurface drainage (Caleb et al, 2009).

Subsurface drainage is the process through which artificial underground water drains, which may be piped or pipe less, are used for the purpose of removing excess water. The primary goal of this type of drainage is to improve properties of the subsoil and base materials for improved performance of supported structures, such as highway or airfield pavements.

As the result of over 50 years of research on subsurface drainage for roadways, many products have been made available for construction and installation of subsurface drainage systems and guidelines have been developed for system design, construction, and maintenance. Some aspects of subsurface drainage system design include a preliminary assessment of whether or not subsurface drainage is necessary at a given location, determination of the source of excess water if it exists at all, determination of the type of drain to install, longitudinal or transverse or both, determination of the required capacity of the drainage system to reduce the excess water conditions, design of the filter material to prevent subsurface erosion of roadway foundation material, and design of the drain outlets. Sets of procedures have been developed for performing the required quantitative analysis associated with these design aspects. The calculations are conducted using charts, tables, and nomographs, and, in some cases, with publicly available computer modeling software.

Objective: The objective of the study was to investigate various subsurface drainage systems for pavements with relatively high-water table.

3. Subsurface Drainage

Purpose: The key factors that determine the need for subsurface drainage may be categorized as (i) traffic loads, which include volume and weight (axle), (ii) factors influencing the amount of free water entering the pavement system which include climatic factors, ground water, roadway geometry, pavement type and surrounding condition, (iii) factors that increase potential for moisture-related pavement damage, such as subgrade degradation, and condition, types of pavement material used, pavement thickness and shoulder design. (ERES, 1999)

(i)Traffic Loads: The total traffic volume and weight is an important factor in the life and performance of a pavement. The volume and weight of traffic expected on the pavement is a key factor in pavement structural design as well as assessment of pavement subsurface drainage needs. Many of the moisture related pavement distresses can be accelerated by high volumes of heavy traffic loads.

(ii) Sources of Moisture: An important component of design and installation of an effective pavement subsurface drainage system is the knowledge and understanding of the sources of moisture reaching the subsurface layers of the pavement structure. The moisture in the pavement subgrade may come from many sources, as is illustrated in Figure 1.

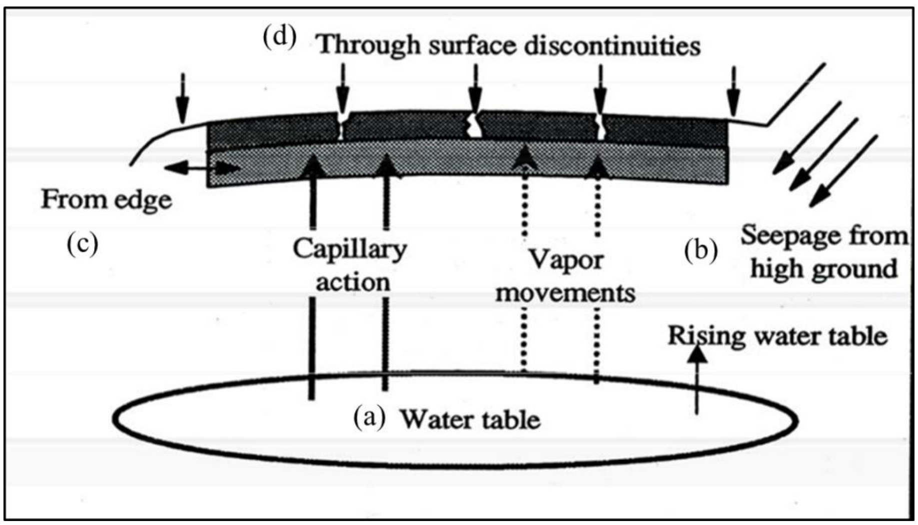
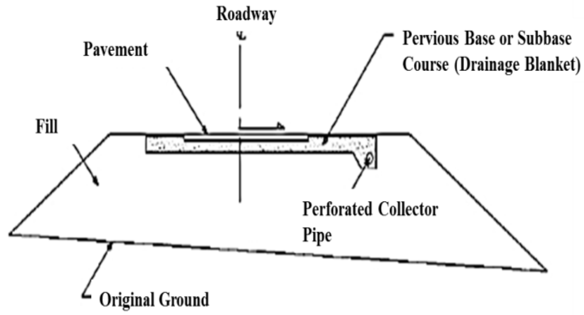


Figure 1: Sources of moisture reaching subsurface of pavement system.

(iii) Subgrade type, strength, and permeability are important factors influencing the decision on the need for subsurface drainage because support provided to pavement by the subgrade is critical to the pavement's performance. The fundamental material properties are an important aid to classifying materials and helping to predict how they will perform, particularly with respect to their ability to transmit the flow of water. The index properties of subgrade materials are those which help in identifying and classifying the material, which may also be important indicators of material performance.

Types of Subsurface Drainage Systems (Caleb et al, 2009):

(i)Longitudinal Drains: Longitudinal drains are normally located parallel to the roadway centerline, with both horizontal and vertical alignments. This type of drainage usually includes a trench of substantial depth, a collector pipe, and a protective filter of some kind, or it may be less elaborate. Examples of types of longitudinal drains are shown below (Fig. 2(a) & 2(b)).



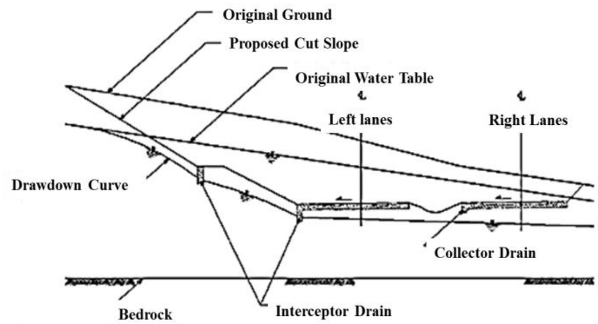
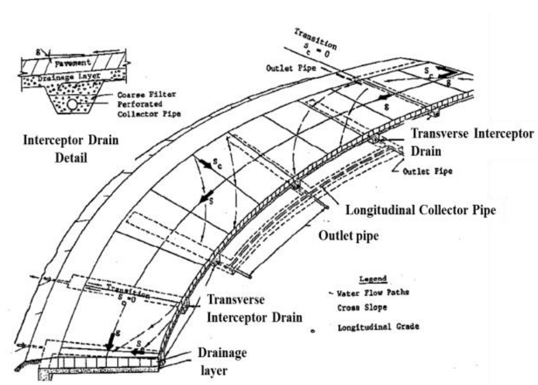


Figure 2(a):Longitudinal collector drain used to seeping into pavement structural section.

Figure 2(b): Multiple, multipurpose longitudinal water drain installation.

(ii) Transverse and Horizontal Drains

Transverse drains are a class of subsurface drains that run laterally beneath the roadway. The common placement of these drains is at right angles to the roadway centerline, although they may be skewed in some cases, creating what is often referred to as the "herringbone" pattern. This type of drainage system is often used at avement joints to drain infiltration and groundwater which may be in the bases and subbases (Fig. 3).



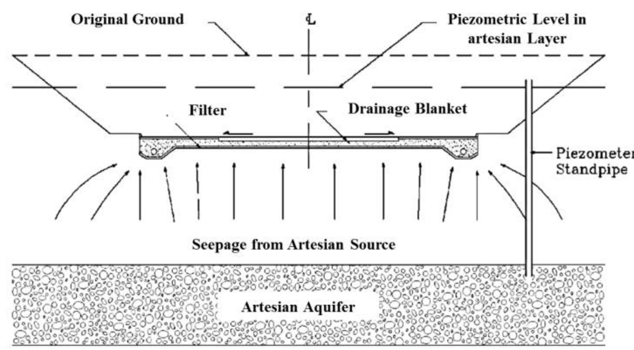


Figure 3:Transverse drains on super elevated blankets.

Figure 4: Applications of horizontal drainage curve

(iii) Drainage Blankets

Drainage blanket is a term generally applied to a very permeable layer whose width and length in flow direction is large relative to its thickness. These drainage systems, if properly designed, can be used for effective control of both groundwater and infiltration (Moulton, 1980). The horizontal drainage blanket can be placed beneath or serve as an integral part of a pavement structure to remove infiltrated water or to remove groundwater from both gravity and artesian sources (Fig. 4).

(iv) Interceptor Drainage

In many instances hillslopes along the side of roadways can have ground water seeping from higher ground, which leads to instability of the hillslope in many instances. This ground water is also a source of water for the pavement foundation. An illustration of a field situation near a pavement section with hillslope seepage is shown on Figure 5. Placing an interceptor drain up gradient from the ditch, or beneath the ditch itself, can help to control the hillslope seepage and decrease or even eliminate the flow beneath the roadway, thus removing the source of water from entering into the pavement foundation (Fig. 5).

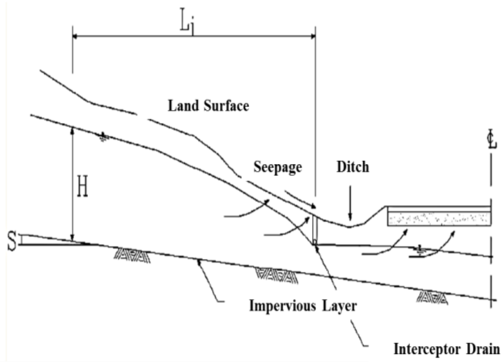


Figure 5:Inceptor Drainage illustration.

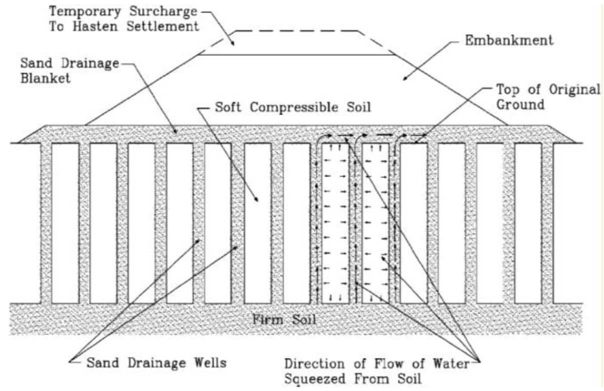


Figure 6: A Typical sand drainage well installation

(v) Well Systems

Under certain conditions, such as potentially troublesome highway slopes, systems of vertical wells can be used to control the flow of groundwater and relieve pore water pressures. When necessary, these systems are pumped for temporal lowering of the water table during construction, or may otherwise be allowed to overflow for the relief of artesian pressures. A common practice is to provide them with some collection system, such as tunnels, drilled-in pipe outlets, or horizontal drains, so they can be drained freely at the bottom (Fig. 6).

5. Conclusion

The selection of sub surface drainage system is dependent on amount free water entering the pavements, factors related to moisture related damage and traffic loads. Longitudinal drains, Transverse drains, drainage blankets, interceptor drains and drainage are various systems discussed for sub surface drainage.

6. Acknowledgements

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7. References

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