A REVIEW ON DIFFERENT HIGHWAY DRAINAGE METHODS BY ITS COMPARATIVE STUDY

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Abstract— This paper reviews the effects and importance of drainage on highway pavement by reviewing various research works carried out by various researchers. The top most reason of the failure of the roads is rain water. At the time of rainfall, some amount of water flows on the road and some amount of it percolates through ground soil mass and reaches to ground water. Thus, this water or moisture content in pavement causes the premature weakening, modulus reduction and reduction in SBC. These scathing effects can be reduced by preventing water from entering into pavement by providing the adequate drainage system. These can be done by various water resisting materials like waste plastic, used or burnt oil, zycosil etc.

Index Terms— Drainage, rain water, highway, water resisting material, SBC

I. INTRODUCTION

India's road development is largely dependent upon research capabilities in the Country both at the chain of national laboratories under Council of Scientific and Industrial Research and State laboratories. Highways are built to make travelling convenient. Hence, highways should be smooth to travel. But water is one of the factor which prevents the convenience sometimes. Because highway pavements are very sensitive to the damaging effects of water which enters the pavement through cracks, pavement infiltration, joints and ground water.

Highway drainage involves the removal of surplus water within the Highway limits and satisfactory disposal of it. The drainage water reaches the roadway mainly due to the precipitation of rain and snow, surface runoff from adjacent areas or it may be due to moisture rising by capillarity from the water-table underneath the roadbed.

Due to the improper or bad or unavailability of proper damage system in the pavement can cause different effects like;

1) Reduction in strength of pavement.
2) Differential swelling.
3) Stripping of asphalt in flexible pavement.

Table 1 Classification of 50% drainage

Quality of drainage	**Time to drain**
Excellent	2 Hours
Good	1 day
Fair	7 day
Poor	1 month
Very poor	Does not drain

Drainage system is to be used in highway pavement to fulfil various requirements. These requirements are as follows;

1) Prevent reduction in strength of paving material.
2) Prevent subgrade failure.
3) Decrease volume changes.
4) Prevent frost action.
5) Prevent slope failures.

Thus drainage is one of the important fundamental factor governing the stability, load carrying capacity and life of roadway. Highway drainage is an important aspect because water reaching the sub grade has a tendency to weaken the pavement and there is structural damage which is very costly to repair. So adequate drainage is a primary requirement for maintaining the structural soundness and functional efficiency of a road. Pavement structure including subgrade must be protected from entrance of water, otherwise over a period of time it may weaken the subgrade by saturating it and cause distress in pavement structure. Because of this, quick removal of water from the surface and subsurface is a basic requiring condition in highway pavement design. And also due to proper drainage there are very less chances of skidding of vehicle because of surface water.

II. LITERATURE SEARCH

Tejas D. Khediya (2016) studied on Surface and Sub Surface Highway Drainage System.as per him drainage of the highway is the process of removing and controlling surplus water on the surface and sub soil water in sub surface with in the right way. During Rainfall, Part of water flows on ground surface and part of it percolates through soil mass until it reaches the ground water below water table. Due to percolation of water in highway pavement moisture content of soil increases which reduce the bearing capacity of the soil. Thus stability of

highway is reduced [1].

Avula Vamshi (2013) studied on Use of waste plastic in construction of bituminous road. In this paper she suggested that bottles, containers and packing strips etc. is increasing day by day. As a result amount of waste plastic also increases. Many of the wastes produced today will remain in the environment for many years leading to various environmental concerns. Therefore it is necessary to utilize the wastes effectively with technical development in each field. Many by-products are being produced using the plastic wastes. Plastic waste, consisting of carry bags, cups and other utilized plastic can be used as a coating over aggregate and this coated stone can be used for road construction. The mix polymer coated aggregate and tyre modified bitumen have shown higher strength. Use of this mix for road construction helps to use plastics waste. [2]

Sundaram & Rojasay (2008) studied the Effective blending technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests. [3]

According to **V.S. Punith**, (2001), some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics such as plastic bottles, polythene bags etc. on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction. [4]

The study by **Rokade et al.** (2012) was on the drainage performance of flexible highway pavements. They suggested that the Water in the pavement system can lead to moisture damage, modulus reduction, and loss of strength. Pavement service life can be increased by 50% if infiltrated water can be drained without delay. Full saturation of pavement systems can occur only under very specific circumstances, when positive total heads are present (e.g., surface ponding, etc.) and distributed in such a manner that saturation of the pavement system is reached. These detrimental effects can be reduced by preventing water from entering the pavement, providing adequate drainage to remove infiltration, or building the pavement strong enough to resist the combined effect of load and water. Pavement service life can be increased by 50% if infiltrated water can be drained without delay [5].

Dipanjan Mukherjee (2014) reported that proper drainage is a very important consideration in design of a highway. He researches on the highway surface drainage system & problems of water logging in road section. Water that drains from roads and footpaths flows into public drainage systems. This is known as highway drainage [6].

Apurva J Chavan (2013) studied on the use of plastic waste in flexible pavement. She reported that disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. The aggregate mix is heated and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The use of the innovative technology will not only strengthen the road construction but also increase the road life as well as will help to improve the environment. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. [7]

A study by **K.V. Priya** et al. (2015) is on the nanotechnology for advancement in transportation engineering. They studied that the applications, innovations, developments in the field of nanotechnology in various applied fields is receiving widespread attention. It is essential to note that these applications are improving general well-being of the public. The development of nanotechnology and its significance in civil engineering practice is illustrated in this paper for enhancing the vision of nanotechnology in the field of road pavements. Although good pavements can be constructed using existing techniques and available materials, there are a number of areas where the judicious application of nanotechnology techniques should be able to improve the longevity and performance of the service provided by the pavement facility. [8]

Devangi G Hattimare (2016) reported that Construction and subsequent maintenance of pavements in good condition has become quite problematic especially in areas where soft bitumen is met with. During Rainy season the natural bitumen become failure and pose serious problem. To the movement of vehicular traffic, treatment and strengthening of bitumen appear to be the only solution for keeping the pavement of surfaces serviceable. The pavements even when constructed according to the conventional methods are failing due to the bitumen undergoing deformations during monsoon and become unserviceable. Treatment of the bitumen with Zycosoil has used recently to obtain the desired strength. In view of the present investigation, an attempt is made to conduct different types of experiments on bitumen mix with Zycosoil and to study the changes in the engineering properties of the bitumen. Penetration, ductility, specific gravity , flashpoint, Marshall mix Tests were conducted on the bitumen mixed with Zycosoil with different percentages such as 0.1%, 0.2%, 0.3% and 0.4%. [9]

III. GENERAL

There are two sources of water on the pavement;

i) Rain water
ii) Ground water table rising due to capillary action.

There are main three types of drainage.

1. Surface drainage
2. Subsurface drainage
3. Cross drainage

SURFACE WATER DRAINAGE

Removal of the surface water from the roadway is termed as surface drainage. In this system, water is first collected in longitudinal drain and then disposed off at the nearest stream, water course or valley. Or in other words, when a system in which surface water is collected and

disposed within right-of-way of a road, then it is called surface drainage.

This system prevent the surface water to flow from the pavement surface to the shoulders and in the subgrade or any other layer of the road pavement.

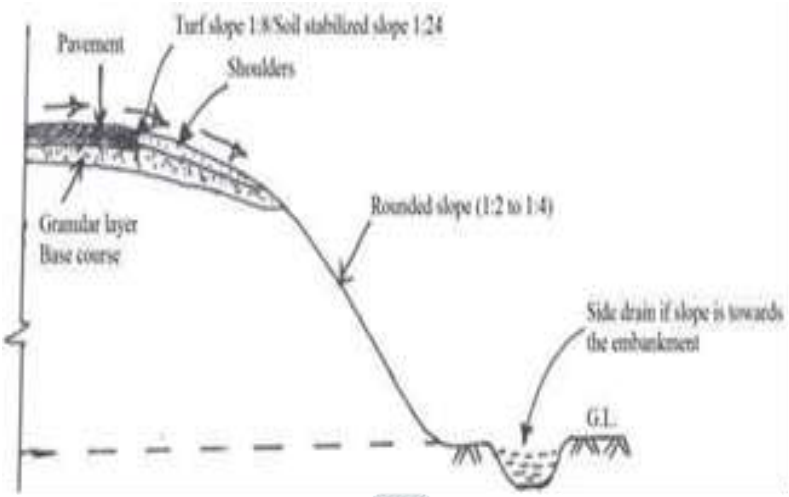

Fig-1 Surface drainage in Road embankment

Different water resisting materials are like waste plastic (PET), Zycosil, Used oil, Geotextile etc. There has been much studies done regarding these different water resisting material. Waste plastic is being used in the surface layer/bituminous concrete layer for the restriction of water passes through it. [5] As well as zycosil also used in the surface layer for the same reason as waste plastic. These techniques are being used in surface drainage of the highway pavement. [6]

SUBSURFACE WATER DRAINAGE

When a system by which sub-soil water from underside of the road pavement is collected and removed then it is called subsurface drainage. Subsurface drainage is specially used to control the moisture content of the road subgrade. In other words, diversion or removal of excess of soil water from the subgrade is termed as subsurface drainage. Changes in moisture content of the sub-grade are caused by fluctuations in ground water.

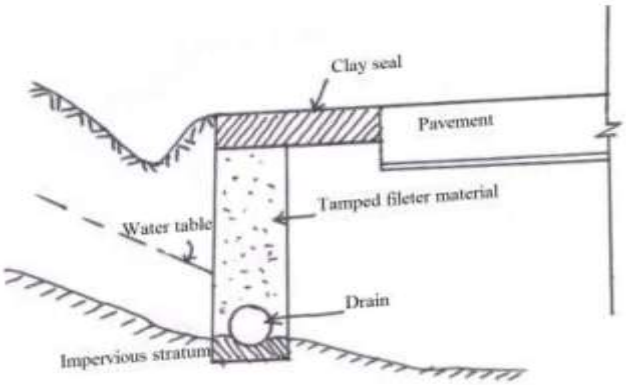

Fig-2 Intercepting Drains

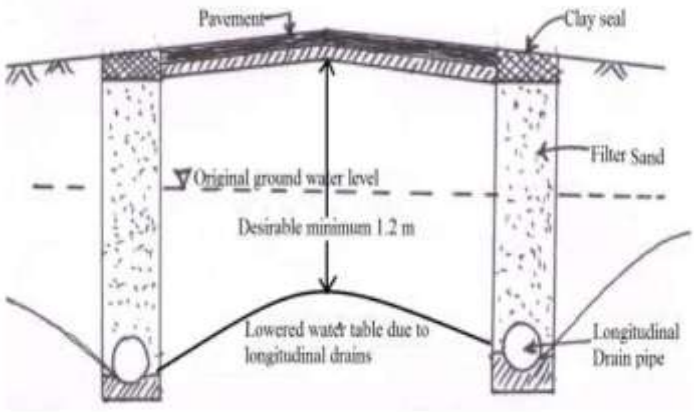

Fig-3 Lowering high water table in permeable soils

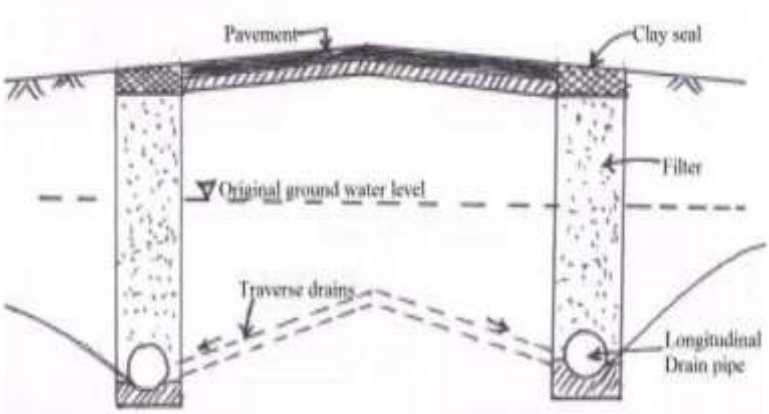

Fig-4 Sub-surface drainage system with Transverse drains

For sub surface drainage, there are main two methods for the drainage. First one is control of sub soil flow and another one is control of high water table. These are done by the using the drain pipes as intercepting drain and by deep drain. In other method of sub-surface drainage

there are two methods, one is by lowering high water table in permeable soils and other one is by transverse drains.

CROSS DRAINAGE

Cross drainage works is a structure constructed when there is a crossing of canal and natural drain, to prevent the drain water from mixing into canal water.

Whenever highway crosses a river or stream, cross drainage works have to be provided. Sometimes water from side drains also is diverted away from the road through cross drains. On highways generally, culverts and bridges are used as cross water way of about 6 meters, then the cross drainage structure is known as culverts. For higher discharge and greater linear way of the structure is known as a bridge.

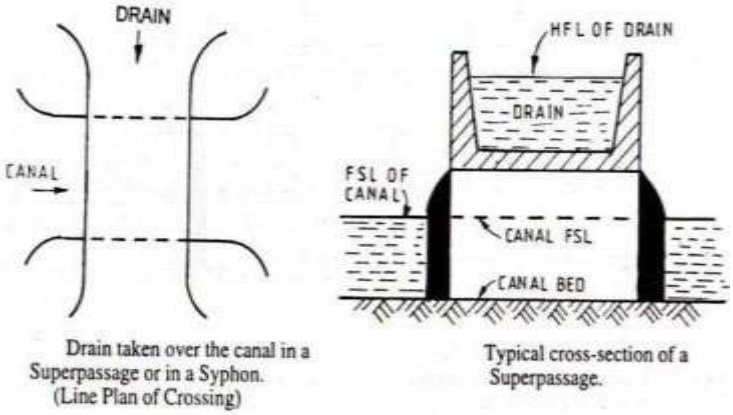

Fig-5 Cross drainage work

In all of these different types of drainage methods, there are various sub methods that has been used nowadays. In these methods, different water resisting materials are being used to restrict the water passes through the surface layer of the pavement.

Different water resisting materials are like waste plastic (PET), Zycosil, Used oil, Geotextile etc. There has been much studies done regarding these different water resisting material. Waste plastic is being used in the surface layer/bituminous concrete layer for the restriction of water passes through it [5]. As well as zycosil also used in the surface layer for the same reason as waste plastic. These techniques are being used in surface drainage of the highway pavement [6].

SURFACE DRAINAGE BY WASTE PLASTIC

Usually waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, rag pickers, waste buyers at Rs 5-6 per kg. Household plastic was also collected for the project work, like empty milk bags, used plastic bags etc. The collected Plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process. It is to be cleaned by de-dusting or washing if required. Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36 mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°c.The mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170°c. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests i.e. Penetration test, Ductility test, Stripping test, Ring and ball test and Marshall Stability value test for the results.

- *OUTCOME*

As per the principle and laboratory investigation the increase in percentage of polymer decreased the penetration value. This shows that the addition of polymer increases the hardness of the bitumen. The penetration values of the blends are decreasing depending upon the percentage of polymers and the type of polymer added. The ductility decreased by the addition of plastic waste to bitumen. The decrease in the ductility value may be due to interlocking of polymer molecules with bitumen. Flash and fire point increased with the increase in the percentage of polymer .The polymer bitumen blend road surfaces are less affected by fire hazards. This shows that the blend has better resistance towards water. This may be due to better binding property of the polymer bitumen blend. The softening point increased by the addition of plastic waste to the bitumen. Higher the percentage of plastic waste added, higher is the softening point. The influence over the softening point may be due to the chemical nature of polymers added. The increase in the softening point shows that there will be less bleeding during summer.

- *SIGNIFICANCES*

The blend of polymer bitumen is a better binder compared to plain bitumen. The blend has increased Softening Point and decreased Penetration Value with a suitable ductility. When used for road construction it can withstand higher temperature. Hence it is suitable for tropical regions. It has decreased Penetration Value. Hence its load carrying capacity is increased. The blend with aggregate has no Stripping Value. So it can resist the effect of water. The Marshall Stability Value is high. The bitumen required can be reduced depending upon the % of polymer added. It is a good saving too. No toxic gas is produced. Disposal of waste plastic will no longer be a problem. The binding properties of polymer also improve the strength of mastic flooring. The use of waste plastics on the road has helps to provide better place for burying the plastic waste without causing disposal problem. At the same time, a better road is also constructed. It also helps to avoid the general disposal technique of waste plastics namely land-filling.

Table 2 Test results of VG 30 Bitumen with and without mixing Plastic

Sr. no.	Test	Test Results	
		Plain Bitumen	Modified Bitumen with Plastic
1	Penetration	65 mm	55 mm

2	Ductility	83 mm	52 mm
3	Softening point	53 ^{o}C	61.5 ^{o}C

SURFACE DRAINAGE BY ZYCOSOIL

Another water resisting material Zycosoil nanotechnology leads to permanent anti-stripping of aggregate surfaces. It also acts as a binding agent with asphalt. The most important development of asphalt industry in the last 50 years, lead to an improvement of the quality of roads and lowering of the costs of maintenance of the highway pavement.

Content of zycosoil varies between 0.05% to 0.15 by weight of asphalt binder. The specific gravity of zycosoil is 1.05. In case accurate weighting balance is unavailable usage of 1 ml instead of 1 gm zycosoil is be acceptable.

Various benefits of the use of zycosoil are;

1) Quick setting time
2) Increasing in amount of filler and decrease air void in asphalt mixture.
3) Improve Marshall Stability and maintaining flow value.

Apart from these zycosoil makes the permanent water repellent layer on all types of soil, aggregates and other road construction materials. This technology addresses the critical subsurface drainage problem in road making and repairs. And zycosoil's reactive bonding ability with the aggregates and asphalt helps to eliminate stripping of aggregate at great extent.

Table 3 Test results of VG 30 Bitumen with and without mixing Zycosoil

Sr. no.	**Test**	**Test Results**	
		Plain Bitumen	**Modified Bitumen with Zycosoil**
1	Penetration	65 mm	62.3 mm
2	Ductility	83 mm	80 mm
3	Softening point	54 ^{o}C	53 ^{o}C

IV. CONCLUSION

We can conclude that, using plastic waste in mix will help reduction in need of bitumen by around 10%, increase the strength and performance of road, avoid use of anti-stripping agent, avoid disposal of plastic waste by incineration and land filling and ultimately develop a technology, which is ecofriendly. Following are the general conclusion for the use of plastic mixed bituminous concrete;

1) The optimum content of waste plastic to be used is between the ranges of 5% to 10%.
2) The problems like bleeding are reduce in hot temperature region.
3) The addition of waste plastic modifies the properties of bitumen.
4) The modified bitumen shows good result when compared to standard results

Same way for zycosoil, the conclusion was drawn that Zycosoil has a potential for minimizing water damage occurring in asphalt mixtures and could be used as an effective anti-stripping agent capable of improving the resistance of asphalt mixtures to water damage. It is however recommend that quantitative binder and mixture tests be performed in the near future to draw a stronger conclusion of the effectiveness and suitable use of Zycosoil as an anti-striping agent.

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