International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 7 July 2022, pp: 1360-1363 www.ijaem.net ISSN: 2395-5252

Combating the frost action in flexible pavement and an approach for designing the frost resistant flexible pavement

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Submitted: 10-07-2022 Revised: 18-07-2022 Accepted: 23-07-2022

ABSTRACT: The pavement performance is very much affected by the variation in moisture and the frost. This is mainly because of variation in stability and the volume of the subgrade soil due to these two effects. Variation in temperature generally effects the pavement materials like bitumen mixes and this variation leads to a phenomenon called frost action. Frost is a decisive factor influencing pavement performance in cold areas of Himalayas, Kashmir, European countries, etc. Three conditions are required for frost occurrence:

1. Soil which is susceptible to frost formation.
2. Temperature in soil should be below freezing point of water.
3. Moisture in the soil.

The distress caused to road pavements due to freezing and thawing of water which is trapped within the subgrade soil immediately is called frost action. In cold region frost may penetrate to large depths below the surface of pavements, resulting in the formation and growth of subsurface ice lenses. Such frost action is accompanied by volume expansion that forcefully and unevenly displaces lower pavement boundaries.

KEYWORDS: Frost action ·Frost as an action of capillary ·Thaw weakening · Test results· Design of Model.

I. INTRODUCTION

The various action of forces causes the failure of highway pavement, particularly the action of the water movement causes several issues in the highway structure. The first focus of our study is to recognize the challenges and problems mainly due to Frost action that we aspect and to find some possible solutions while constructing and maintenance of roads in cold regions.

In the cold resigns like Kashmir, Nepal, Himachal Pradesh the action of water will deteriorate the highway pavement the mechanism is named as “FROST ACTION”. Frost action is the process through which moisture in soils and other materials alternately freezes and thaws. Frost heave and frost boil are the two crucial frost processes in the soil. When the water molecules in the pores freeze during colder temperatures, the process known as "frost heave" occurs, which causes the soil to expand. When frozen soil begins to thaw, a phenomenon known as a frost boil causes the soil to become loose. After the process of frost heave, frost boil occurs. When the ambient temperature falls below the freezing point, the water molecules freeze and ice is generated. In frost heave, the water molecules are mostly travelling from the bottom of the water table to the higher section of the soil. Because the conversion of water to ice increases volume by 9%, the formation of ice in soil pores causes an increase in soil volume. This is because every pore heaves as a result of the volume increase. The soil at ground level lifts up as a result of frost heave. This is one of the main problems in building small structures above the earth.

Silts and fine sands are the types of soil that are susceptible to frost heave action. Once the frost heave has taken place, a drop in temperature causes the ice to melt. As a result, the top levels of the system release free water. The thawing process begins at the upper layers and progresses downward over time. In this manner, the soil in the higher levels is loosened and softened while the dirt in the lower layers is frozen. The effects of frost boil have an impact on the ground-based constructions. The

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main problem with highway pavements is that when vehicle weights operate on soft soil and water, a hole is created. If the situation is extreme, the pavement may collapse and the subsoil may be exposed. The majority of silty soils are those that are susceptible to frost boil.

The alternate freezing and thawing of moisture in soils and other materials is known as frost action. Frost action can cause damage to plants, structures and roads so it is important to maintain proper drainage

When water penetrates through the top surface of the pavement and reaches in the subsequent layers and due to decrease in the temperature (below freezing point) the water gets converted into ice lenses, which results in lifting of pavement and thus results in cracks on top surface.

II. OBJECTIVES AND METHODOLOGY

OBJECTIVES

a. To analyse factors influencing frost heave.

b. To design and fabricate frost resistance flexible pavement model.

METHODOLOGY

Location Details

The methodology adopted helps us to know the effect of frost action on highway pavements and mechanism of frost action on highway pavements.

1. Collection of soil from **"SOPORE (Baramulla 193201) 34.2868° N, 74.4624° E 50 km away from Srinagar"**

Fig.1 Location of sample collected

2. Analysing general properties of that soil such as particle size distribution, consistency limits, shear strength based on that the model is design.

III. RESULTS AND DISCUSSION

SI NO.	TESTS CONDUCTED	RESULTS
1.	WATER CONTENT	29.5%
2.	SPECIFIC GRAVITY	2.5
3.	HYDROMETER TEST % Clay Fineness content (ref. NIT Srinagar)	 30% >75%
4.	ATTERBERG'S LIMIT Liquid limit Plastic limit Plasticity index	 35% 29.15% 17.95%
5.	COMPACTION Standard proctor test MDD OMC	 1.67 g/cc 20.6%
6.	SHEAR STRENGTH Direct shear test Cohesion (c) Angle of internal friction (Φ)	 38 KN/m2 24.15
7.	CALIFORNIA BEARING RATIO TEST (CBR)	4%

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DESIGN AND FABRICATION FROST RESISTING PAVEMENT MODEL

From the result of California bearing ratio test we adopted the CBR value of 4% for designing our model.

DESIGN OF PAVEMENT AS PER IRC 37-2012

I. **Granular Sub-base:** it is a layer in the flexible pavement just above compacted sub-grade layer. It is mixture of sand and gravels, crushed stones &broken rocks.

II. **Granular Base Course:** This layer consists of soil particles ranging in size from coarse to fine. It provides drainage for the pavement structure and protects the structure from frost. Aggregates structures and protects the structure from frost. Aggregates used consists of sand and gravel, quarry rock, slag etc.

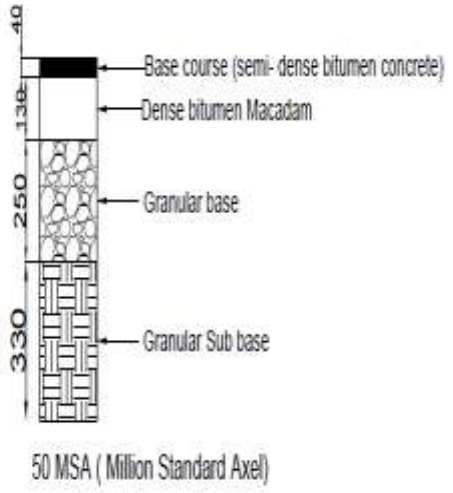

Fig 2.6 pavement layer thickness as per IRC 37: 2012

III. **Dense Bitumen Macadam (DBM):** It is a binder course that lies above the base course and is utilized on roads where there are more heavy commercial vehicles and close-graded premix material with a void percentage of 5–10%. The DBM is composed of filler material, coarse and fine aggregates, and the necessary amount of binder.

IV. **Semi-dense Bitumen Concrete:** It is a top wearing course on which the wheel load acts upon. And it is laid after the BM course to obtain smoother finish on road surfaces.

- It consists of coarse aggregates, fine aggregates mineral filler and bitumen.
- This layer is used to distribute the wheel load safely to the layers beneath it.

PROPOSED MODEL AS PER IRC 37-2012

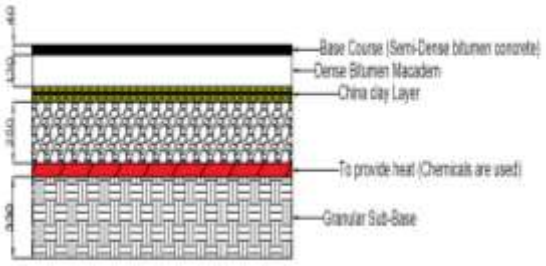

Fig.2 Cross section of the pavement

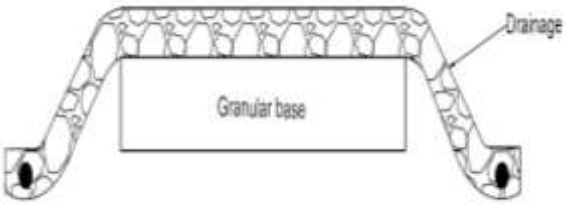

Fig.3 Cross-section of drainage system (Line drain)

Fig.4 frost resistant flexible pavement model

IV.CONCLUSIONS

- Frost action is a common issue in cold region like Kashmir where heavy snowfall can be observed. Due to this frost action the outer layer of pavement deteriorates and causes many issues like ruts, slip, skid and penetration of water into the lower layer etc.
- The main reason for frost action is due to percolation of water into soil and the condensation of this percolated water in the lower layer.
- The result of OMC, MDD, Cc, Cu etc. gives the strength and basic properties of the soil.

- Based on the above results we can conclude that the soil has high moisture content, small grain size distribution & less strength against water pressure.
- To avoid this a small approach has been made, where we are using **china clay** as a water barrier.
- It reduces almost 80% of infiltration of water into soil.
- We can also use CaCo3 as a chemical layer below the subbase. By doing so we can prevent the storage of water at lower level and also the chemical reaction between water & the chemical reduces the formation of ice crystals.

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