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Effect of Sodium Chloride on Properties of Bitumen

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Abstract- Nowadays a lot of modifications are taking place throughout the world to develop the existing highway materials to fulfill the demand of increased vehicles. People are at the trend to innovate something new that can do better than it was. Some material produce a good effect and enhance the strength as well as qualities of bitumen. On the other hand, some are responsible for the adverse on the bitumen. In saline areas like coastal regions, the salts play a significant role in the bituminous pavements. Water of sea nearly contains 3% sodium chloride, and evaporation of intake bodies of water has produced huge and extensive deposits of it. We can be economically benefited if salt is used as an admixture to bitumen. But we do not even know the impact, good or bad of the mixing of salt with bitumen. The objective of this paper to find out whether it is desirable or not taking various proportion salt with bitumen and doing the specified test of bitumen. It is observed from the laboratory test that the penetration and ductility values are gradually increased with increase of salt content. The flash point, fire point, and softening point value are stepwise reduced as a percentage of salt content increased. Moreover, it reduces the stability of roads. Mixing of salt to bitumen upgrades workability and it is beneficial in the economical point of view. Finally, moisture effect test on the bituminous mix with the inclusion of salts shows the degradation of strength due to moisture movement.

Keywords: *sodium chloride, bitumen, bituminous mix, flash fire point, stability.*

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I. Introduction

Bituminous mixes are most commonly used all over the world in pavement construction. Under normal circumstances, conventional bituminous materials if designed and executed properly perform satisfactory. But for applications like roundabouts or where traffic is extremely heavy, stiffer mixes are required which can have large fatigue life and more resistance permanent deformation. Most publications ascribe moisture damage to variables like bitumen properties, aggregate characteristics, hot mix processing, bituminous mixture characteristics, quality control during construction, nature of water at the interface, dynamic effect of traffic loading, type, and properties of anti-stripping additives, and others. The great diversity of variables and differences in earlier research results reported make a prediction of moisture sensitivity difficult. Most mechanistic design methods for bituminous pavements mainly base on fatigue and rutting as the primary design criteria. However, SHRP's mechanistic/analytical approach to pavement design proposed the need to consider resistance to moisture damage as a factor in selection and proportioning of binders and aggregates (McGennis et al., 1995).

The Coastal area, pavement often come across with saline water. In this area, the salts particularly sodium chloride plays an important role in the stability as well as durability of roads. In this situation, the effect of salts on properties of bitumen is important for design and maintenance of the pavements. The present status of literature, indicate that a little work has been conducted to determine the behavioral changes in the bituminous pavements in the present of salts. In this paper, an attempt has been undertaken to study the effect of salts on varies properties of bitumen.

II. The Objective of Study

In recent years, a significant achievement has been made the study in the different field of engineering Also various causes have been determined to take appropriate measures against the determination and detrimental effect. In general, the presence of alkalis and salts produce a harmful on the behavioral aspects of binding materials. In these studies, an attempt has been made to quantify the adverse effects in term of some specific standard tests. The objective of this studies are

- To the effect of salts on the properties of bitumen.
- To determine the variation of strength with the inclusion of salts.
- To observe the effect of water on the strength of bituminous mixes with the inclusion of salts in bitumen.
- To carefully examine the use of salts in the bitumen regarding various properties such as penetration, solubility, ductility, etc.

III. Tested on Bitumen

To determine its behavior and its suitability a variety of tests have been specified by institutions like ASTM, I.S.I, Asphalt Institute, And B.S.I. The various tests of bitumen are followed:

- *Penetration test:* The penetration tests determine the hardness or softness of bitumen by measuring the depth in one-tenth in millimeter to which a standard loaded needle will penetrate vertically in five seconds.

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Figure 1: Penetration test apparatus

- *Softening point test:* The softening point test is the temperature at which the substance attains a particular degree of softening under specified condition test .The softening point of bitumen is usually determined by ring and ball test.

Figure 2: Softening point test apparatus

- *Flash and Fire point test:* Flash and fire point tests is conducted on bitumen to know the safe mixing and application temperature values of particular bitumen grade.
  The flash point of a material is the lowest temperature at which the vapour of a substance momentarily takes fire in the form of a flash under specified condition of test.
  The fire point is the lowest temperature at which the material gets ignited and burns under specified conditions of test.

Figure 3: Flash and Fire point test

- *Ductility test:* The flexible pavement construction at where the bitumen binders are used, it is of significant importance that binders from the ductile thin film around the aggregates. This serves as a satisfactory binder in improving physical interlocking of the aggregates. The binder material which does not possess sufficient ductility would crack and thus provide previous pavement surface. It has been started by some agencies that the penetration and ductility properties go together, but depending upon the chemical composition and the type of crude source of the bitumen, sometimes it has been observed that the above statement is incorrect. It may hence be mentioned that the bitumen may satisfy the penetration value, but may fail to satisfy the ductility requirements. Bitumen paving engineer would however want that both test requirements be satisfied in field jobs. Penetration or ductility can not in any case replace each other. The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread cracks. The test is conducted at 27 ± 0.5 ° Cand a rate of pull of 50 ± 2.5 mm per minute. The test has been standardized by the ISI.

Figure 4: Ductility test

- *Specific Gravity test:* The density of a bituminous binder is a fundamental property frequently used as an aid in classifying used in paving jobs. In most applications, the bitumen is weighted, but finally, in use with the aggregate system, the bitumen content is converted in volume basis. Thus an accurate density value is required for conversion of weight to volume. The specific gravity is greatly influenced by the chemical composition of the binder. Increased amounts of aromatic type compounds caused an increase in the specific gravity. The test procedure has been standardized by the ISI.

IV. Materials Used for Specimen

1. Bitumen
2. Sodium chloride.

V. Effect of Water on Bituminous Mixes

One of the complex problems in the field of highway engineering, existing since bitumen paving technology came into existence is stripping. The term stripping, as employed by highway engineers, denotes the occurrence of adhesion failure or weakening of the cohesive bonds within the aggregate asphalt system.It isconsidered as great economic loss and engineering failure regarding proper mixture design.

Majidzadeh.k (1969) stated that the factors affecting the adhesion failure phenomenon are innumerable. They include the material characteristics, construction techniques, and diversified environmental conditions. They are displacement, film rupture, and detachment and pore pressure theories. Of course, it is obvious that owing to the complexities of material composition and diversity of environmental conditions, no single mechanism may be adequate to explain the stripping phenomenon in bituminous mixtures. The concepts of the theories are briefly summarized as follows:

- *Displacement Concept:* According to this theory the binder aggregate function in the presence of water becomes thermodynamically unstable and reacts to more stable position [Lee,A.R] 1954. It is generally believed that, to displacement phenomena to be initiated in a mixture, the binder aggregate interface should become exposed to the water phase. That is well, the coated aggregate may not exhibit any binder displacement unless the continuity of aggregate coating is destroyed.
- *Detachment Concept:* The theory attributes the adhesion to a thermodynamic replacement of the bitumen by a thin film of water that may come from either outside or from within the aggregate while from the bitumen coating remains intact [Hughes, A.R]I 1960). The characteristics of the interface are believed to be very important in the detachment process. The water reaching the interface become intimately associated with the lattice of the mineral surface.
- *Pore Pressure Concept:* It has been postulated that the buildup of pore pressure in the mixture of high void content may result in stripping phenomena [Halberg, S] 1950. That is, on a wet surface of bituminous pavement additional forces due to traffic also act and these greatly exceed the thermodynamic forces. In a saturated pavement under dynamic load, water is pressed into the pavement in front of the moving load and sucked out behind the wheel contributing to the stripping phenomena. Among these four concepts, the displacement and detachment theories can be classified as the primary causes of stripping and pore pressure, film rupture concepts in fact only contributing to the phenomena.

VI. Effect of Mixture Density on Stripping

There are primarily three perquisites for the occurrence of stripping phenomena in bituminous mixtures: the presence of water in a pavement, repeated load application and the physiochemical nature of the bituminous aggregate system. To eliminate or reduce the chances of stripping, one should attempt at least one of these factors. From the pavement design point of view, the water present in the pavement can be reduced by decreasing the void content of the bituminous mixtures. This approach could be considered as one of the preventive measures in the construction of bituminous paving using the physio-chemically unstable bituminous aggregate system.111

VII. Preparation of Compressive Strength test Specimen

The mix proportion of cement fine aggregate and coarse aggregate is 1:2:4.The water-cement ratio is 0.50. Test for compressive strength is carried out on a cube. American Society for Testing Materials ASTM C39/C39M provides Standard Test. For cube test the types of specimen each cube 10cm X 10 cm x 10 cm is used. After 24 hours these molds are removed, and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. These specimens are tested by compression testing machine after three days, seven days curing or 28 days curing. Load at the failure divided by area of specimen gives the compressive strength of concrete.

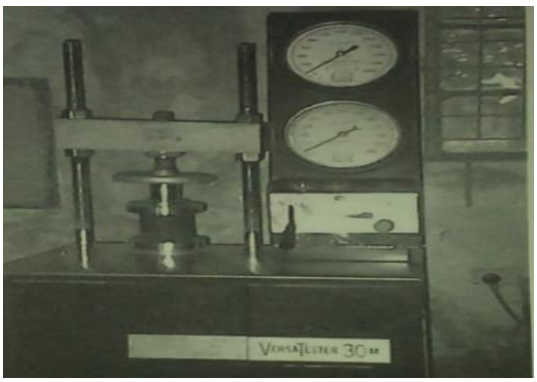


Figure 5: Experimental setup of compressive strength

VIII. Marshall Test Specimen

The coarse aggregates, fine aggregates and mineral should be proportioned and mixed specified gradation of mineral aggregates and bitumen binder as per IRG.29-1968. Approximately 1200g of aggregates and filler are taken and heated to a temperature of 170˚

C to 190 ° C. The compaction molds assembly, rammer, cleaned and kept pre-heated to temperature of 100 ° C to 145 ° C. The mixing temperature for 80/100 grade bitumen may be around 154 ° C that for 60/70 grade bitumen 160 ° C. The weight of aggregate taken may be suitably alerted a thickness of 63.5±3.0 mm

IX. Results and Discussions

a) *Effect of Salt on Properties of Bitumen*

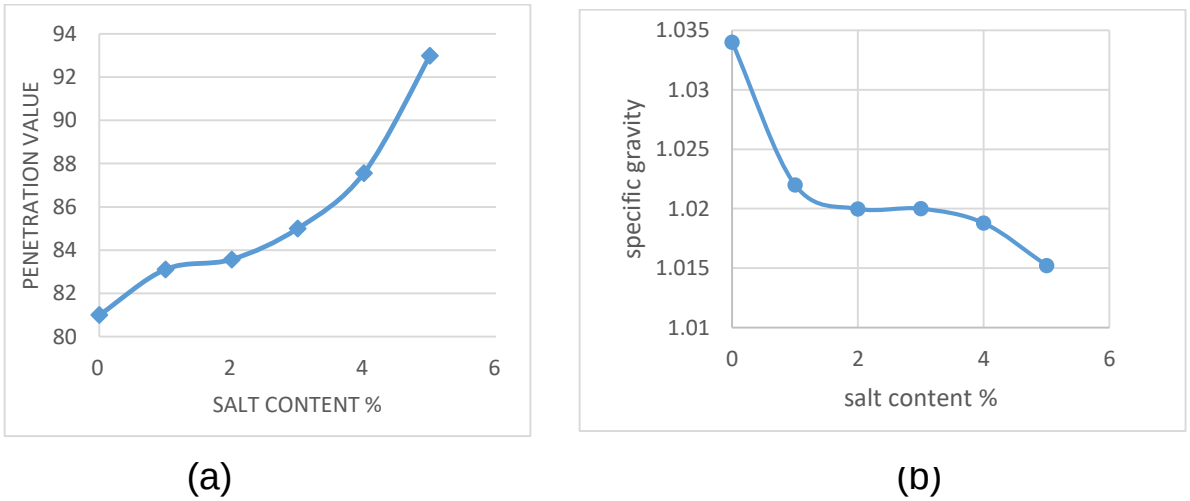


Figure 6: (a) variation of penetration value and (b) specific gravity concerning salt content.

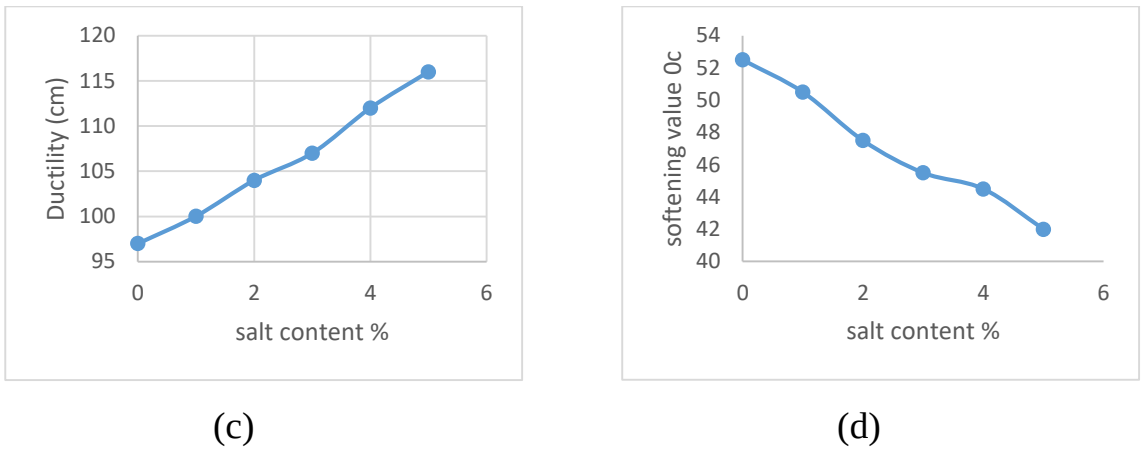
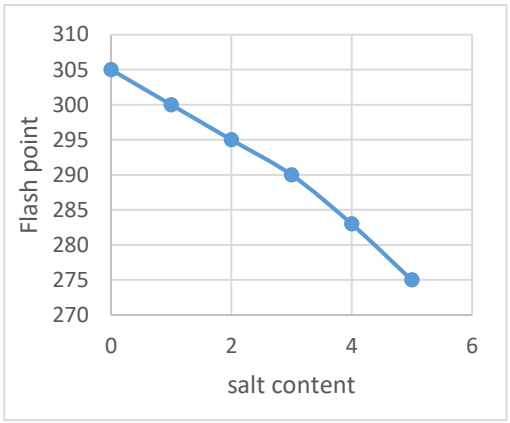
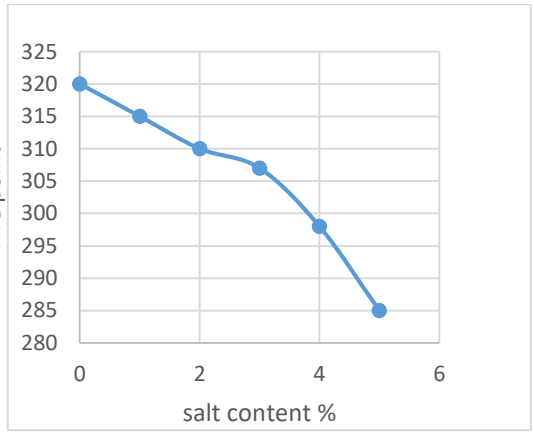


Figure 7: (c) variation of ductility and (d) softening value concerning salt content.



(e)



(f)

Figure 8: (e) variation of flash point value and (f) fire point value concerning salt content

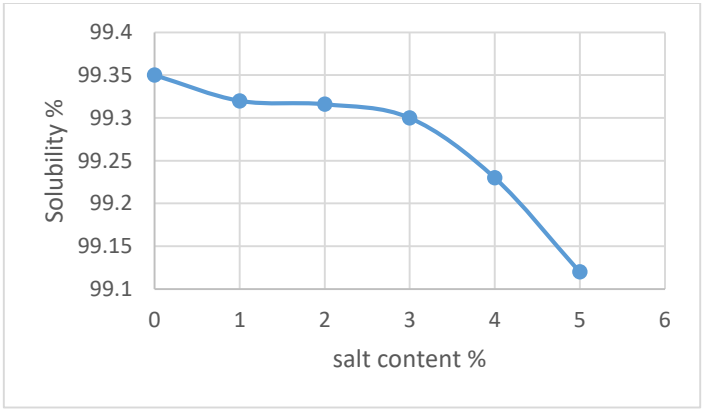
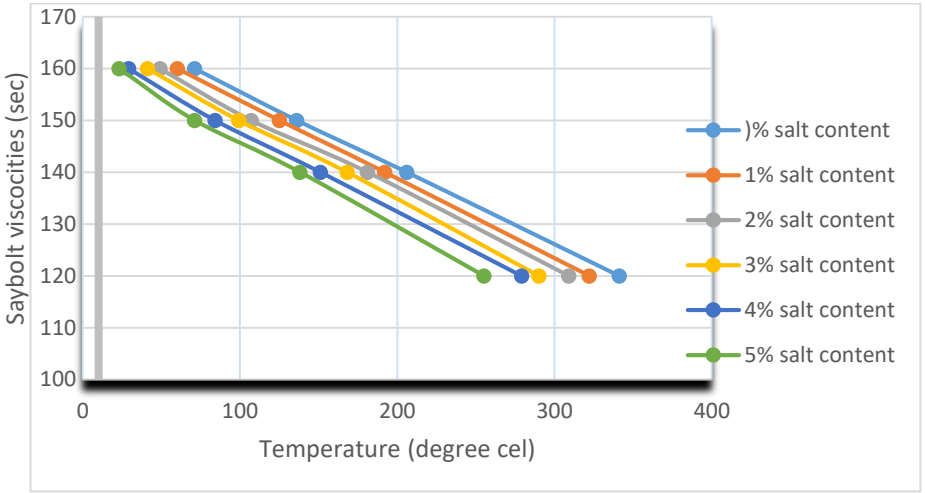
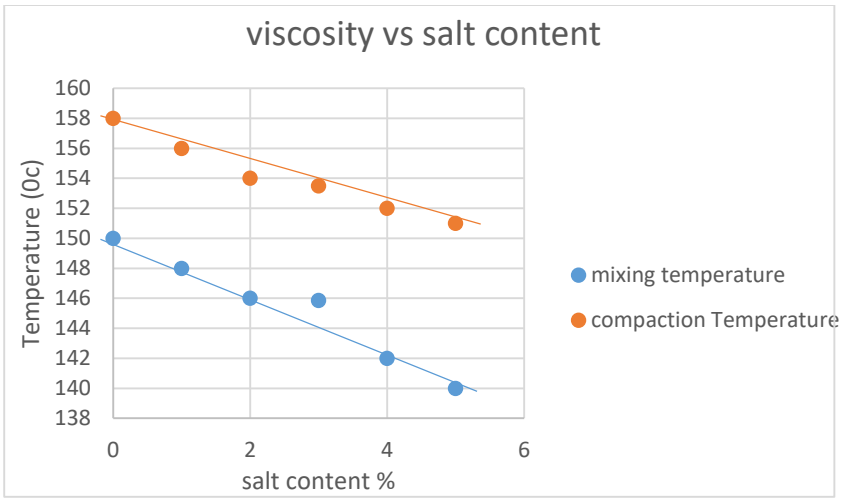


Figure 9: Variation of solubility concerning salt conten

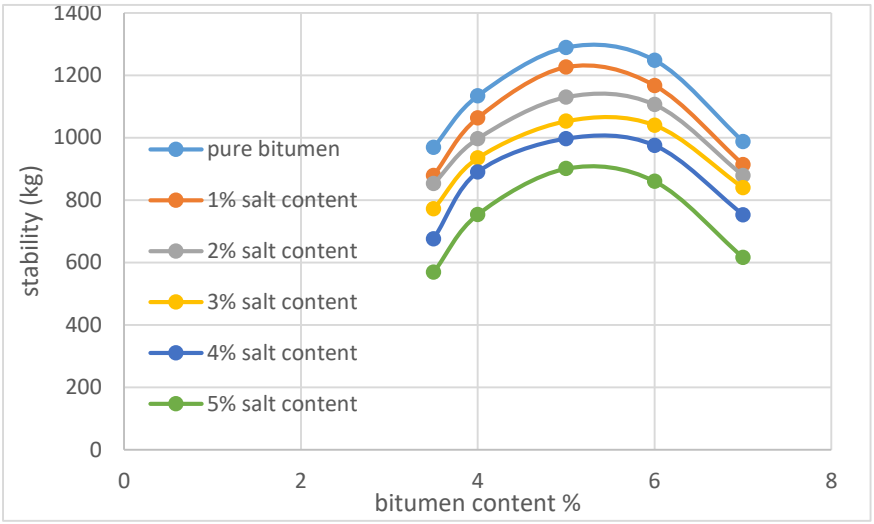
A Result of say bolt viscosities test of Bitumen



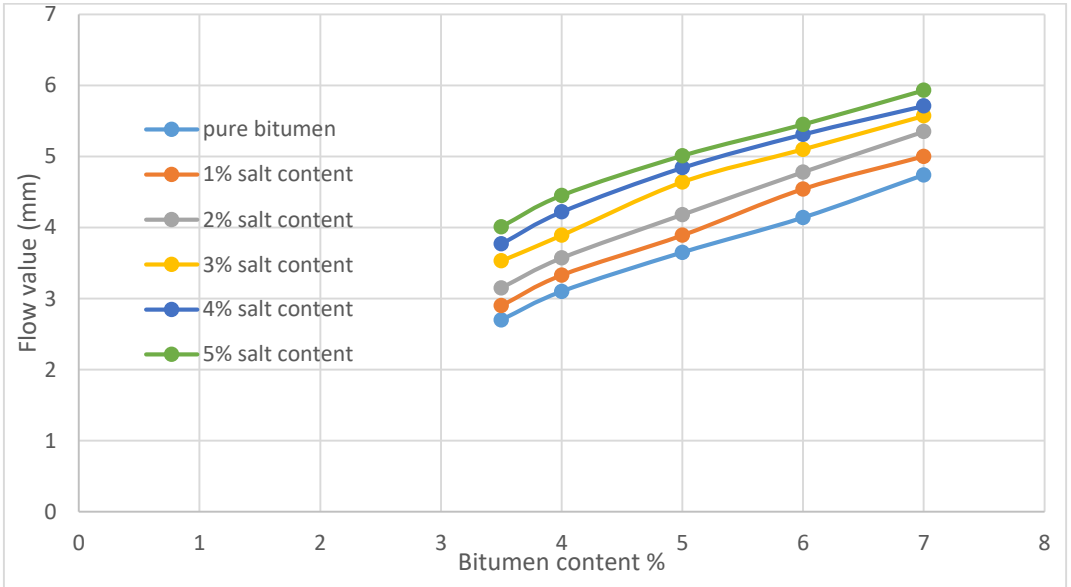
Viscosity of mixing and compaction temperature with salt content in binder bituminous mix



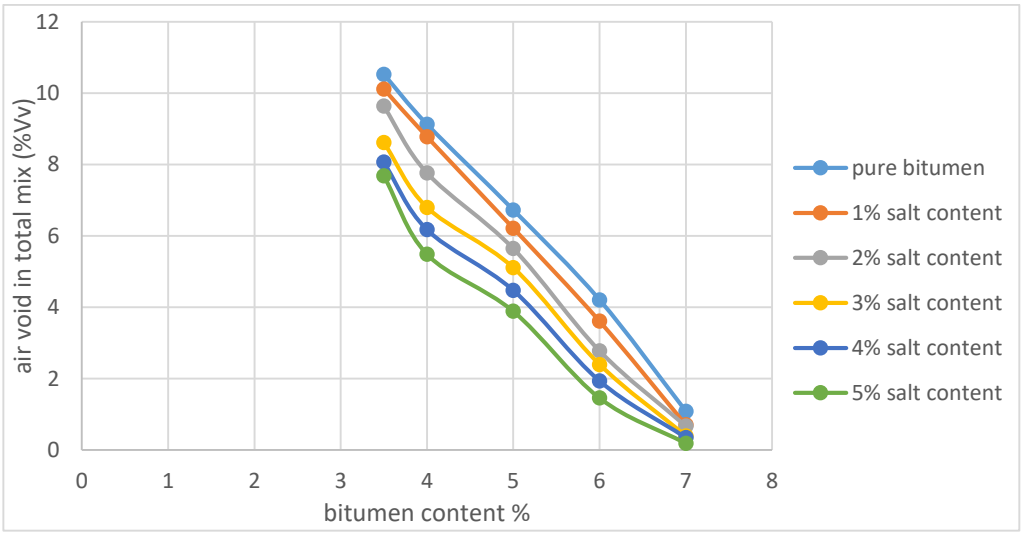
Variation of stability value concerning bitumen content



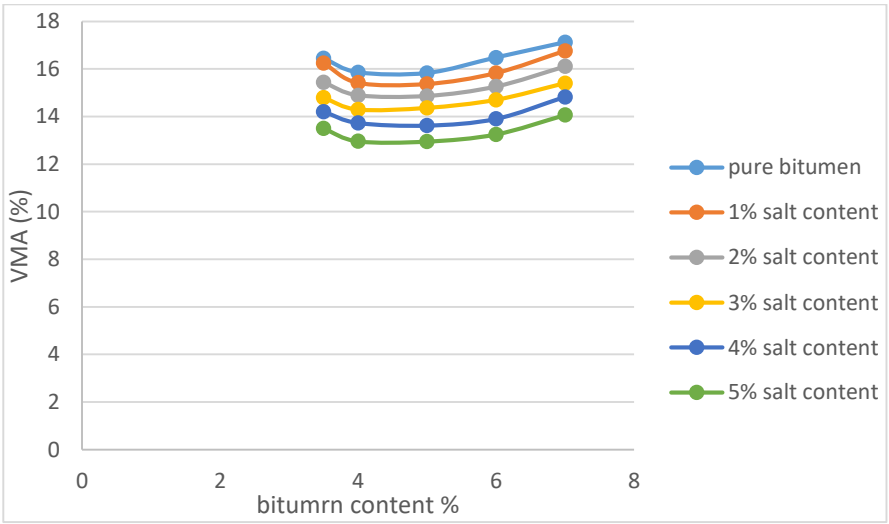
Variation of flow value concerning bitumen content percentage



Variation of percentage of total mix (Vv) concerning bitumen content percentage



Variation of percentage void of mineral aggregate with respect to bitumen content



X. Conclusion

Sodium chloride (Nacl) is a crucial factor for increasing the different properties of bitumen. But sometimes it has negative impacts as reducing the strength of bituminuous mixes. From the test values, it is clearly shown that, the penetration and ductility increases with the increases of salt content (percentage). On the other hand, flash, fire point, solubility decreases with increases of salt content. From the above graph, it is concluded that, tolerable limit of salt varying from 0% to 5%.

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