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STABILIZATION OF SANDY SOIL WITH USE OF BITUMEN EMULSION

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Abstract: *Soil is considered to be most basic construction material that has good shear strength due to the cohesion and internal friction among the soil solid particles. But due to much heavy loads coming from bridges, building etc, even soil having good shear strength can fail resulting in subsequent failure of the structures due to differential settlement. The most important and effective part of a road pavement is subgrade soil, its strength and stability. If strength of soil is poor, then stabilization is normally needed. In the present study, an attempt has been made to improve the properties of the soil by adding bitumen emulsion with sand, the use of the emulsion is for improving the strength of soil expressed in terms of Marshall Stability values which may prove to be economical and give better results. The main objective is to study the behavior and effect of bitumen emulsion on sand by Marshall Stability of mix design. The specimen was prepared with different grading of sand such as coarse, medium and fine sand with bituminous emulsion.*

In the present investigation the Marshall properties of bituminous mix using bitumen emulsion have been studied and compared with sand emulsion mix whose desirable value are mentioned in MORTH recommendation specification. The various specimens were made with varying percentages of bitumen emulsion as 8%, 9%, and 10% with sand and evaluate the Marshall Stability load value or flow value. In the present investigation the Marshall properties of coarse sand and medium sand are studied and result are obtained which are compared with MORTH recommendation specification.

Key Words: Stabilization, Sandy Soil, Emulsion, Marshall Stability

1. Introduction

A commonly used pavement structure in India is the flexible pavement type, whereby a bituminous mix or surface treatment is placed over a base course made of granular materials. Other flexible pavement types being used consist of base courses made of bituminous mixes or penetration macadam [Ministry of Works, 1999]. Sand mix with bitumen emulsion is used as base coarse construction, as filler in various courses and as a seal coat in surface dressing. The Bituminous mixes used in the construction of the surfacing and base course layers are hot-mixed, hot laid and compacted and are normally referred to as "Hot-Mixes", or Bituminous concrete, or Asphalt Concrete. [9]

The processes involved in producing the hot mixes consume enormous energy such as electricity, fuel oils and or firewood. This is one of the causes of high construction costs on one hand, and on the other hand the heating processes cause some environmental pollution in form of dust and poisonous fumes, and sometimes fire accidents occur to workmen and the surroundings. One possible approach to overcome the disadvantages associated with bituminous hot mixes is to use Bitumen Emulsion cold-mixes (BEMIX).

The main object and scope of the study is

1. To prepare and test specimen of sand and emulsion mix to evaluate the Marshall Stability load value and flow value.
2. Comparing the Marshall properties of sand emulsion mix and semi dense bituminous concrete mix.

Bitumen Emulsion-cold Mixes can be produced and constructed without application of heat, and therefore are economical. Environmental pollution in form of poisonous fumes and dust, and risk of fire accidents to workmen and surrounding are eliminated, as no heating process is involved.

The main ingredients of Bitumen Emulsion Cold paving mixtures are Bitumen emulsion binder and mineral aggregates, which are mixed without application of heat, either as plant-mix or as mixed-in-place.

2. Material

2.1 Granular material: Sand is naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.

The composition of sand varies, depending on the local rock sources and condition, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example, aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish for example, it is the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.

Granular material used in this experimental study is obtained from the Narmada river of Jabalpur region which is well graded sand found out by sieve analysis which is extracted from the Colon ghat near Shahpura dist. Jabalpur

In the current study, three types of sand (course grained, medium grained and fine grained), and locally blended bitumen emulsions of Grade SS-2 were used to make mix designs as follows:

i) Course grained sand

This consisted of coarse grained soil which is mixed with bitumen emulsion of Grade SS-2 with its different percentages. This mixture was proposed for use in base course construction.

ii) Medium grained sand

This consisted of Medium grained soil which is mixed with bitumen emulsion of Grade SS-2 with its different percentages. This mixture had been proposed for use as filler in various courses.

iii) Fine grained sand

This consisted of Fine grained soil which is mixed with bitumen emulsion of Grade SS-2 with its different percentages. This mixture had been proposed for use in surface course or used as a seal coat in surface dressing.

2.2 Bitumen emulsion: Bitumen emulsion is a two-phase system consisting of bitumen, water and one or more additives which assist in its formation, stabilization and in modifying its properties. The bitumen is dispersed throughout the water phase in the form of discrete globules, typically 0.1 to 50 pm in diameter which are held in suspension by electro-static charge stabilized by an emulsifier. Depending on the composition of raw materials, which go into bitumen emulsion, these may include bitumen, water, emulsifier, acid or caustic, polymers, salts, solvents, additives, and emulsion stabilizers.

3. Methodology:

In this study the natural sand were used for testing under various types like coarse sand size ranges from 4.75mm to 2mm, Medium sand size ranges from 2mm to 0.425mm and Fine sand size from 0.425mm to 0.075mm. The bituminous emulsions are used for preparing the specimen is slow setting type 2(SS-2). The sand was tested for specific gravity, sieve size analysis and Marshall Stability.

3.1 Mix design procedure

- The dry sand of weight 1200g is taken and mixed with different percentage of bitumen emulsion (8%, 9%, and 10%).
- The sample was then mixed thoroughly and left for 10-15min. at room temperature.
- After mixing the sample the mould was prepared in a Marshall mould.
- Each side of the mould specimen was compacted with 75 blows by Marshall Compaction hammer.
- After 3 days the Marshall Stability properties of the sample is determined.

4. Specification of Bitumen Emulsion

Table-1: Specification of bitumen emulsion of Grade SS-2 as per IS 8887: 2004

Characteristics	Grade of Bitumen Emulsion, SS-2
Residue on 600 micron IS sieve % by mass	0.05 % Max
Viscosity @ 50 °C (Say bolt), sec	30-150
Storage stability after 24 hours, % Max	Less than 2
Binder – Residue by evaporation % Min	60%
Setting time	> 60 minutes

5. Characterization of Soil

Table-2: Specific gravity of soil which was determined in laboratory

Type of Soil	Specific gravity
Coarse grained soil	2.63
Medium grained soil	2.84
Fine grained soil	2.96

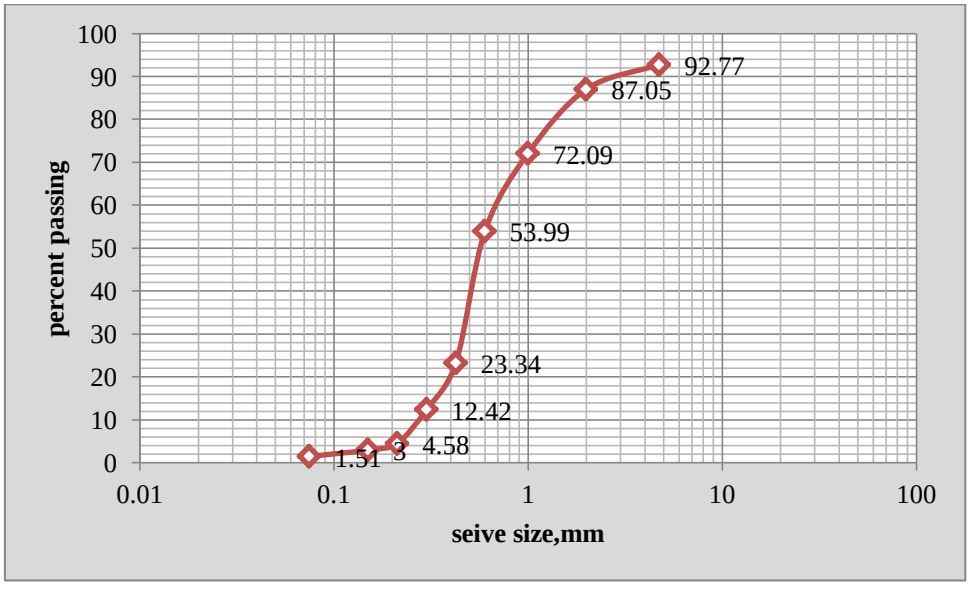
Table-3: Requirements for sand asphalt base course as per MoRTH (Table 500-15)

Parameter	Requirement
Minimum stability (KN at 60°C)	2.0
Minimum flow (mm)	2
Compaction level (Number of blows)	2×75
Percent air voids	3-5
Percent voids in mineral aggregate (VMA)	16 min.
Percent voids filled with bitumen (VFB)	65-75

6. Grain Size Distribution (Sieve Analysis)

Table- 3: Sieve analysis of soil sample with Grain size distribution graph

Sieve Size mm	Weight Of Fine Aggregate Retained				Percentage Retained	Cumulative Percentage Retained	Percent Passing
	Determination Number						
	1	2	3	Avg			
4.75	86.4	59.32	71.14	72.29	7.229	7.229	**92.77**
2	65.12	52.93	53.55	57.2	5.72	12.949	**87.05**
1	161.32	137	150.3	149.54	14.954	27.903	**72.09**
0.6	173.12	181.65	186.55	180.44	18.044	45.947	**53.99**
0.425	285.52	319.52	314.43	306.49	30.649	76.596	**23.34**
0.3	104.32	116.54	106.54	109.13	10.913	87.509	**12.42**
0.212	76.13	83.52	75.4	78.35	7.835	95.344	**4.58**
0.15	15	15.95	14.42	15.12	1.512	96.856	**3**
0.075	14.13	16.98	13.8	14.97	1.497	98.353	**1.51**
PAN	12.10	13.56	11.59	12.42	1.242	99.595	**0.405**



Graph 1: - Percentage Passing and Sieve Size

7. Result and Discussion

The obtained results of Marshall Parameters are shown in tables 4 & 5 and graphs 1to 8.

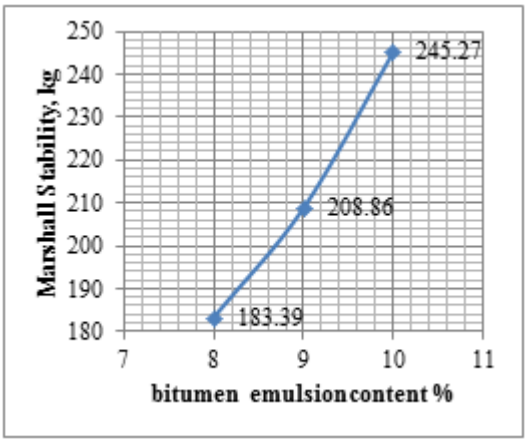
Table4: Medium Grain size Sand

MARSHAL STABILITY METHOD FOR THE DETERMINATION OF STABILITY AND FLOW VALUE			
Mixing temperature, ºC=25	Grade of bitumen emulsion SS-2		
Number of blow on either side=75	Compacting temperature, ºC=25		
FLOW VALUE DIAL, 1 DIVISION=.01	proving ring calibration factor=6.289		
Specific gravity of medium sand =2.84	Specific gravity of emulsion=1.1		
Properties of the design mix	**Bitumen emulsion content, %**		
	8%	**9%**	**10%**
➢ Stability Value , KG	183.39	208.86	245.27
➢ Flow Value ,mm	2	2.8	3
➢ Theoretical specific gravity , G_t	2.54	2.51	2.48
➢ Bulk specific gravity , G_m	1.94	1.96	1.99
➢ Air Voids percentage , V_v	22.83	21.91	19.75
➢ Percent volume in bitumen , V_b	13.83	15.58	17.54
➢ Voids in mineral aggregate , VMA	36.66	37.49	37.76
➢ Voids filled with bitumen , VFB	37.72	41.58	47.04

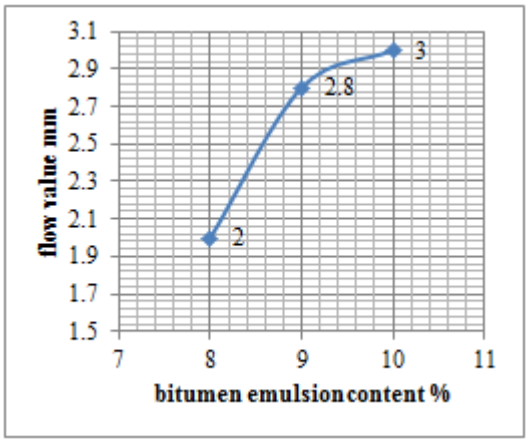
Table 5: Coarse Grain size Sand

MARSHAL STABILITY METHOD FOR THE DETERMINATION OF STABILITY AND FLOW VALUE			
Mixing Temperature, ºc=25	Grade Of Bitumen Emulsion SS-2		
Number Of Blow On Either Side=75	Compacting Temperature, ºc=25		
Flow Value Dial, 1 Division=.01	Proving Ring Calibration Factor=6.289		
Specific Gravity Of Coarse Sand =2.63	Specific Gravity Of Emulsion=1.1		
Properties	**Bitumen emulsion content, %**		
	8%	**9%**	**10%**
➢ Stability Value , KG	331.12	306.59	284.53
➢ Flow Value ,mm	4.35	5.30	7.4
➢ Theoretical specific gravity , G_t	2.38	2.36	2.33
➢ Bulk specific gravity , G_m	2.04	2.06	2.07
➢ Air Voids percentage , V_v	14.28	12.71	11.16
➢ Percent volume in bitumen , V_b	14.38	16.15	17.96
➢ Voids in mineral aggregate , VMA	28.66	28.86	29.12
➢ Voids filled with bitumen , VFB	50.17	55.96	61.67

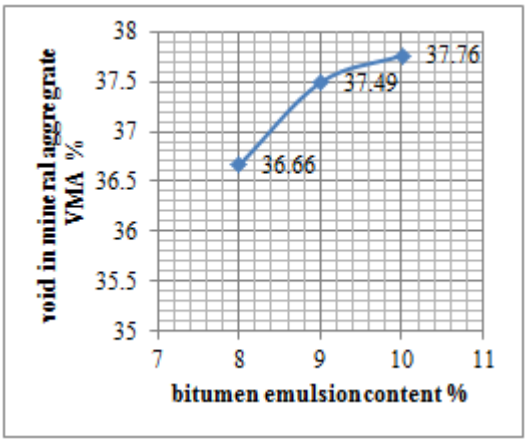
Variations of Marshall Parameters for fine grain size sandy soil are shown in Graph 2, 3, 4 and 5.



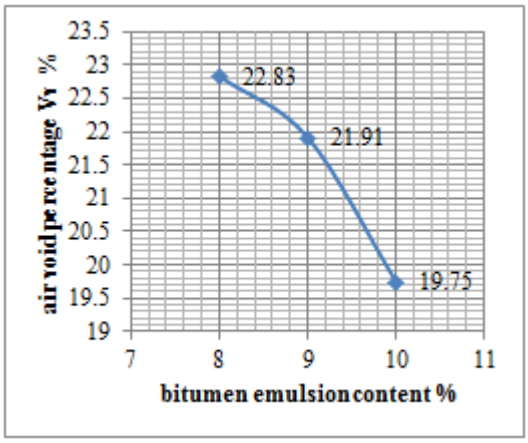
Graph:-2 Marshall Stability value and Bitumen Emulsion Content %



Graph:-3 flow value And Bitumen Emulsion Content%

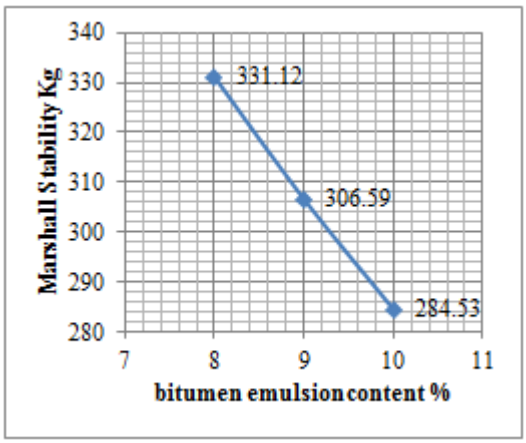


Graph:-4 VMA% and Bitumen Emulsion Content%

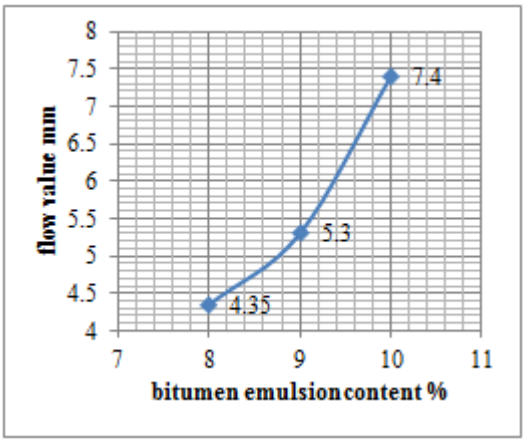


Graph:-5 Air Voids% and Bitumen Emulsion Content%

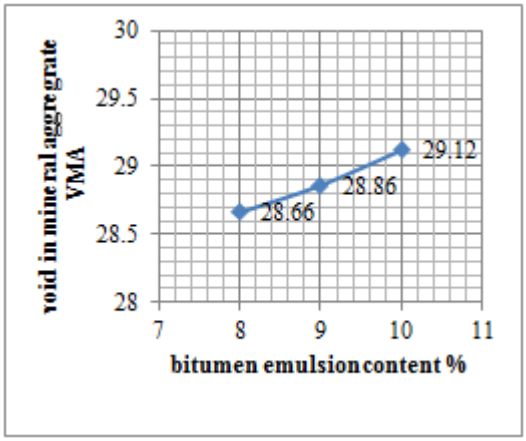
Variations of Marshall Parameters for Medium grain size sandy soil are shown in Graph 6, 7, 8 and 9.



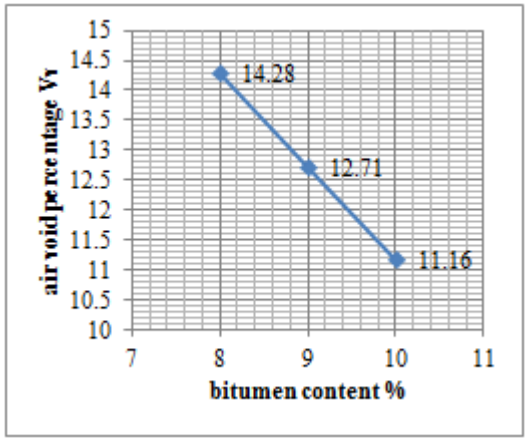
Graph:-6 Marshall Stability value and Bitumen Emulsion Content %



Graph:-7 flow value and Bitumen Emulsion Content%



Graph:-8 VMA% and Bitumen Emulsion Content%



Graph:-9 air voids% and Bitumen Emulsion Content%

8. Discussion

A.MEDIUM GRAINED SOIL

- Marshal stability value (kg) at 8% is found to be 183.39kg which increases to 245.27kg at 10% which is maximum.
- Flow value (mm) at 8% is 2mm and is increases to 3mm at 10% bitumen emulsion.
- Voids in mineral aggregate (VMA) is 36.66 at 8% bitumen emulsion which get increases to 37.76 at 10% bitumen emulsion.
- The percentage of air voids are maximum at 8% which is 22.83 and is reduces to 19.75 at 10% bitumen emulsion.
- Theoretical specific gravity, G_t at 8% bitumen emulsion is 2.54 which reduce to 2.48 at 10% bitumen emulsion.
- Bulk specific gravity, Gm is 1.94 at 8% bitumen emulsion and is increases to 1.99 at 10% bitumen emulsion.

B.COARSE GRAINED SOIL

- Marshal stability value (kg) at 8% is found to be 331.12kg which reduces to 284.53kg at 10% bitumen emulsion.
- Flow value (mm) at 8% is 4.35mm and is increases to 7.4mm at 10% bitumen emulsion.
- Voids in mineral aggregate (VMA) is 28.66 at 8% bitumen emulsion which get increases to 29.12 at 10% bitumen emulsion.

9. Conclusion:

From the above study following conclusions are drawn based on performance of the bituminous emulsion mix:

From the limited study it is observed that initial stability of the mix is dependent on optimum total liquid content (OTLC) of the compacted of roads with very qualified pavements and improved longevity and pavement performance. The study on the use of sands mix with emulsion, after obtaining optimum Bitumen Emulsion Content of the mix has also increased stability and durability when compared with SS2. By using different type of mixes of sands increased the stability of roads thus the road can be withstand heavy traffic load and shows better service life. Use of good quality materials in road construction is becoming increasingly expensive in India due to its high demand & scarcity in nature.

On the following of test results it was concluded that the sand materials may be effectively used with bituminous emulsion.

- Effect on Marshall value: As per MORTH specification the Marshall stability value is 200kg which is minimum and the obtained Marshall stability value in coarse grained sand at 8% bitumen emulsion found to be 331.12kg which gradually reduces to 284.53 at 10% bitumen emulsion. In Medium grained sand the Marshall Stability value obtained at 10% is 245.27kg which is higher than 8% bitumen emulsion.
- Air void percentage:-As per MORTH specification the percent air voids is 3-5% and the obtained air void percentage is minimum in coarse grained soil as compared to Medium grained soil. At 8% bitumen emulsion in coarse grained sand air voids is found to be 14.28% which reduces to 11.16% at 10% bitumen emulsion. In Medium grained sand

the air void percentage is 22.83% at 8% bitumen emulsion which decreases to 19.75% at 10% bitumen emulsion.

- Voids in mineral aggregate:-As per MORTH specification the minimum percent void in mineral aggregate is 16%. In coarse grained sand at different percentage (8%, 9%, 10%) the percentage of mineral aggregate values is reduced when compared with Medium grained sand at same percentage.

- Voids filled with bitumen:As per MORTH specification the percent void filled with bitumen is 65-75%.In coarse grained sand the voids filled with bitumen at different percentage (8%, 9%, 10%) is increased when compared with Medium grained sand at same percentage.

- Flow value: As per MORTH specification the minimum flow value is 2mm.In coarse grained sand the flow value is 4.35mm at 8% emulsion which increases to 7.4mm at 10% bitumen emulsion. In Medium grained sand the flow value at 8% bitumen emulsion is 2mm which increases to 3mm at 10%bitumen emulsion.

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