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EFFECT OF HYDROGENATED VEGETABLE OIL AND GREASE ON STABILITY OF BITUMEN MIX

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Abstract: *Bitumen (asphalt) is a petroleum grounded substantial which is used as binder in flexible pavement. In Literatures, there are several trials which have been carried out by partially substituting bitumen with waste motor oil and vegetable oil. The outcomes gained by laboratory examination show most important gain in strength with considerable saving in cost. This paper presents the outcomes from a laboratory study in which the effect of hydrogenated vegetable oil (HVO) and grease on stability of bitumen mixture was assessed. The grease contains metals like lithium, copper and aluminium, which can cause adverse effects on the atmosphere. Whereas Hydrogenated vegetable oil may cause serious health problems to human being. To deal with this problem, this study includes to check the effect of usage of Hydrogenated vegetable oil and grease as a partial replacement of bitumen. The laboratory test comprises of Marshall stability test on bitumen mix with partial replacement of HVO and grease. It gives good stability and flow value result for partial replacement of HVO and grease as 0.5 % and 0.4% respectively.*

Keywords: HVO, Grease, Marshall Stability, Flow value Analysis

1. INTRODUCTION

Bitumen (asphalt) is a petroleum grounded substantial which is used as binder in flexible pavement in addition asphalt has severe adverse effects on atmosphere as well as on living being. Due to the restriction of petroleum, increased price and the adverse effects on the environment, study is going on to find an resourceful, cost effective and eco-friendly substitute binder to substitute the bitumen. The possible materials that can be used as an substitute binder where maximum of them are bio-based material and waste materials like bio-oil, plastic, polymer, waste cooking oil, waste tire rubber etc. Researchers have found some helpful outcome with these materials.

It is necessary to adopt bituminous material with good stability and flow. Marshall stability test is linked to the resistance of bituminous constituents to distortion, displacement, rutting and shearing resistance. The stability is resultant of the inner friction and cohesion. Marshall stability measures the maximum load sustained by the bituminous material at a loading rate of 50.8mm/minutes. Trial is used to fix optimum binder content for the form of aggregate mixture and traffic intensity.

Unsaturated vegetable oils can be changed through partial or whole "hydrogenation" into oils of higher melting point. The hydrogenation procedure includes "sparging" the oil at high temperature and pressure with hydrogen in the presence of a catalyst, naturally a powdered nickel compound. The Hydrogenated vegetable oil (HVOs) are key sources of trans fatty acids (TFAs), which are of attention due to their effects on type 2 diabetes mellitus (T2DM). The TFAs spoiled β cells and worsened the insulin resistance in cell and animal studies, cardiovascular diseases, systemic irritation, dyslipidaemia, endothelial dysfunction, and more newly hepatic and neurodegenerative diseases. Due to these adverse effects of hydrogenate vegetable oil it is decided to use as partial replacement of bitumen binder.

A grease comprises of an oil and or added fluid lubricant that is mixed with a thickener, naturally a soap, to get a solid or semisolid. Greases are a kind of shear-thinning or pseudo-plastic fluid, which means that the viscosity of the fluid is reduced under shear. The nature of the soaps effects the temperature resistance (relating to the viscosity), water resistance, and chemical stability of the resulting grease.

2. Objective of work

1. To check properties of aggregate and bitumen.
2. To check stability of conventional bitumen mix.
3. To check stability of bitumen mix with various proportions of Hydrogenated Vegetable Oil.
4. To check stability of bitumen mix with various proportions of Grease.
5. To compare stability of bitumen mix with hydrogenated vegetable oil and bitumen mix with grease.

3. Scope

1. A trial section of a flexible pavement can be prepared and examined by using the optimum percentage replacement values of several additives (hydrogenated vegetable oil and grease) obtained in the work. This experimental section can be assessed for the performance characteristics both in terms of structural evaluation as well as functional evaluation of the roadway.
2. The hydrogenated vegetable oil and grease based bitumen mix can be used for construction of flexible pavements for any type of road. (low traffic, high traffic)
3. This bitumen mix with more stability can be used where additional stability may be needed due to deficiency in the

stability of bitumen mix to carry original design loads. Deficiency may be result of deterioration or effect of water on aggregate – bitumen bonding, or improper construction of flexible pavement.
4. To improve the properties of plane bitumen when used in road construction.

4. METHODOLOGY

Marshall stability test as per ASTM D6927 – 06 is conducted.

A. Material selection

1) Bitumen: In this study 30/40-penetration grade bitumen was used as binder as it is commonly used for high traffic roads. The physical properties of bitumen are specified in table-2.

2) Aggregate: The test on aggregates conforming to IS: 2386 (part 1 to part 5) Was taken. Physical properties of aggregate are specified in table 3.

B. Proportion of Aggregates

The aggregates are weighed as per blending percentage and shifted to mixing pan.

TABLE 1. SELECT AGGREGATE GRADING TO BE USED.

Sieve size	Specification (% Retained)	Aggregate Type		% Retained	Total sample Weight (gm)	Weight (grams)
19	0	Coarse	65	0	780	0
13.2	10			10		120
9.5	20			20		240
4.75	35			35		420
2.36	11	Fine	32	11	384	132
1.18	9			9		108
0.3	6			6		72
0.75	6			6		72
pan	3	Filler	3	3	36	36

TABLE 2: PHYSICAL PROPERTIES OF BITUMEN

Sr. No	Test name	Permissible Value	Results Obtained
1	Penetration	175-200 mm	186.00
2	Ductility	40 cm minimum	57 cm
3	Specific gravity	0.99 minimum	1.12

TABLE 3. PHYSICAL PROPERTIES OF AGGREGATE

Sr. No	Test name	Permissible value	Results obtained
1	Crushing test	< 10 (exceptionally strong). > 35 (weak)	1.60
2	Abrasion test	35 % maximum	21.2 %
3	Impact test	35% maximum	6.83
4	Specific gravity	2.5 to 2.9	Coarse Aggregate – 2.869 Fine Aggregate - 2.631
5	Water absorption	0.1% TO 2.0%	0.38 %
6	Stripping value	5 % maximum	4.33%

C. Preparation of Specimen

Nearly 1200g aggregates are required for casting a single specimen. The aggregates are taken as per mix design. Bitumen is taken as given % and percent of bitumen partially replaced by hydrogenated vegetable oil by entire weight of bitumen. Bitumen is added to the aggregate by percent of whole weight and mix carefully at 160-170ºc temperature. Afterwards the mix is filled into Marshall Mould and compacted by giving 75 blows on both sides in Marshall Compactor. After compaction the mould is cooled for 24 hrs at atmospheric temperature. The sample is extracted from Marshall Mould after cooling.

D. Curing of Specimen

The specimen is weighed and kept in water bath for 30 minutes at 60ºC. Constant temperature must be maintained for complete period of 30 min as the weakest state for bitumen is attained by keeping and maintaining 60ºC temperatures in water bath.

E. Testing in Marshall Apparatus

The sample is then placed in Marshall testing machine. The stability is measured in terms of strength and resistance to plastic deformation of cylindrical specimen is measured in mm on dial gauge when it is loaded at rate of 50.8 mm per min.

F. Various Parameters of Marshall method

The properties that are of interest include the theoretical specific gravity Gt, the bulk specific gravity of the mix Gm, percent air voids Vv, percent volume of bitumen Vb, percent void in mixed aggregate VMA and percent voids filled with bitumen VFB. These calculations are discussed in table-4.

5. Result and Discussion

TABLE 4. STABILITY OF NORMAL MIX SAMPLE PREPARED WITH DIFFERENT PERCENTAGE OF BITUMEN

Sr. No	% bitumen	Marshall stability value (MSV)	Flow value	Bulk density (gm)	% air voids (vv)	% vol. Of bitumen (vb)	VMA	VFB
1	3.5	408.167	4.15	2.47	4.63	7.46	12.09	61.70
2	4.0	442.81	4.17	2.46	4.28	8.45	12.73	66.38
3	4.5	415.70	3.38	2.47	3.14	9.50	12.64	75.16
4	5.0	372.90	2.83	2.48	2.36	10.54	12.90	81.71
5	5.5	353.65	3.53	2.47	1.98	11.50	13.48	85.31
6	6.0	348.00	4.13	2.48	1.20	12.53	13.73	91.26

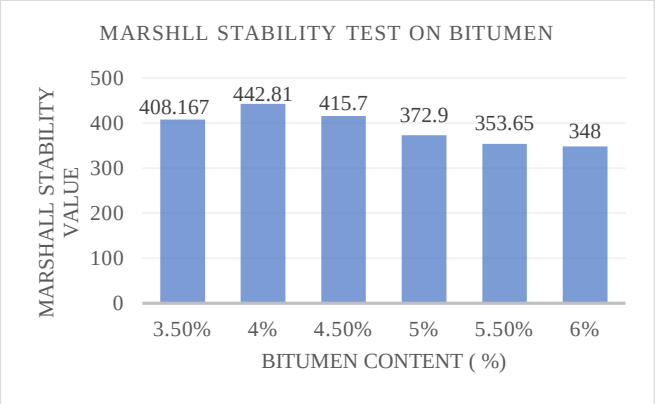

Figure 1 Variation of Marshall Stability with Bitumen Content

The above Graph represents, the 4 % bitumen content gives maximum Marshall stability value and as % of bitumen content is increases then stability value decreases.

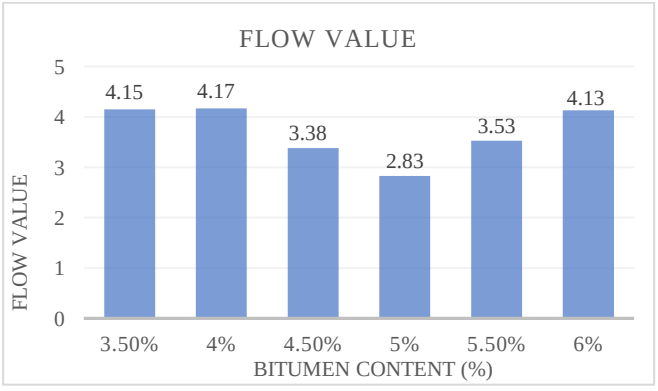

Figure 2 Variation of Marshall Flow with Bitumen Content

The above Graph represents, the 4 % bitumen content gives maximum flow value and 5 % bitumen content gives minimum flow value.

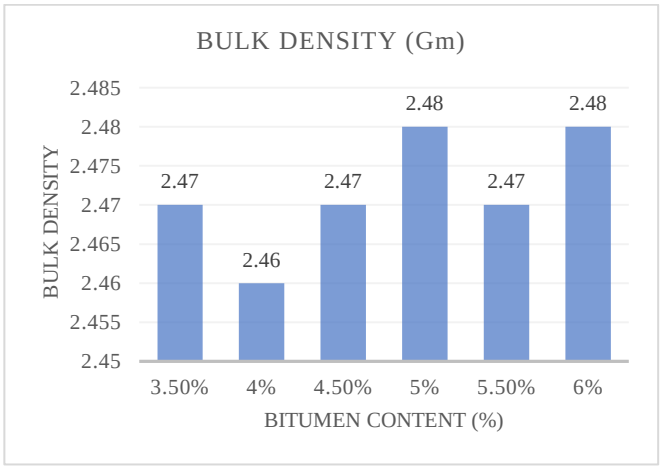

Figure 3 Variation of Bulk density with Bitumen Content

The above Graph represents, the 5 % and 6% bitumen content gives maximum bulk density and 4% bitumen content gives minimum bulk density.

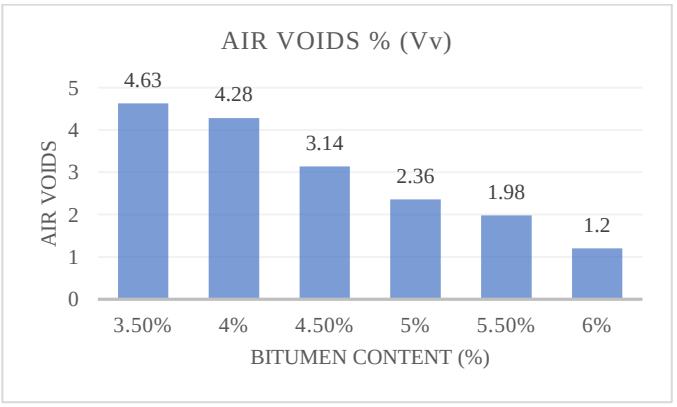

Figure 4 Variation of Air voids with Bitumen Content

The above Graph represents, the 3.5 % bitumen content gives maximum Air void percentage and as % of bitumen content is increases then air voids percentage decreases.

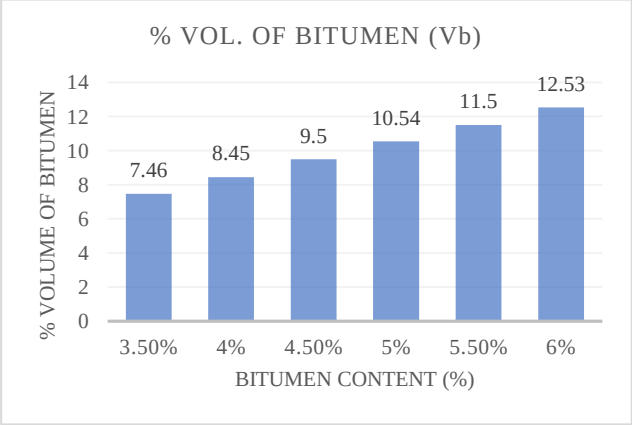

Figure 5 Variation of Vb with Bitumen content

The above Graph represents, as the % of bitumen content is increases the % volume of bitumen also increases.

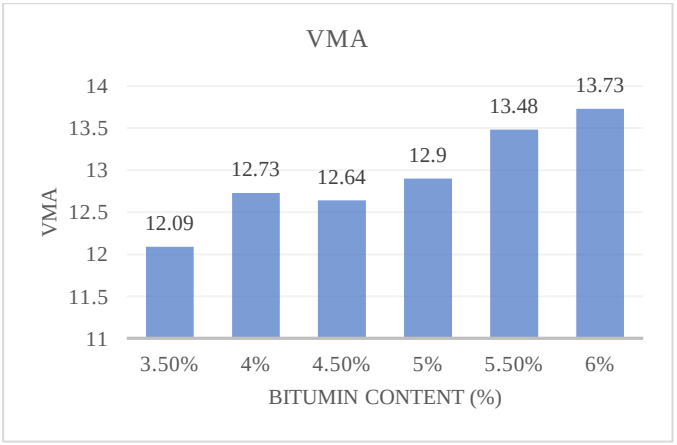

Figure 6 Variation of VMA with Bitumen content

The above Graph represents, the 6% bitumen content gives maximum VMA value and 3.5 % of bitumen content gives minimum VMA value.

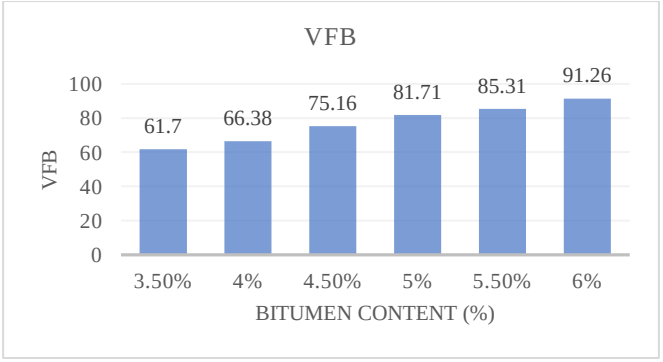

Figure 7 Variation of VFB with Bitumen Content

The above Graph represents, as the % of bitumen content is increased then VFB values increases.

Determination of optimum bitumen content -

Fix the optimum binder content for the mix design by taking average value of the following two bitumen contents found form the graphs obtained in the previous step.
1. Binder content corresponding to maximum stability
2. Binder content corresponding to maximum flow value

Binder content corresponding to maximum stability = 4.00% Binder content corresponding to maximum flow value = 4.00%

OPTIMUM BINDER CONTENT = (4.00+4.00)/2

= 4.00%

***G.* Results of stability of Bituminous mix with partial replacement of hydrogenated vegetable oil (HVO)–**

The HVO were used in the bituminous mix of VG 30 Grade. Marshall Method of bituminous mix design is used to find out stability and flow characteristics of the mix. The optimum binder content (OBC) of 4.0% was partially replaced with 0.4%, 0.5%, 0.6%, 0.7%, and 1.0% of HVO and specimens are prepared for given percentage. The results are shown in following Table and Figures.

TABLE 5. STABILITY OF BITUMINOUS MIX SAMPLE PREPARED WITH DIFFERENT PERCENTAGE OF HYDROGNETED VEGETABLE OIL

Sr. No	% bitumen	% vegetable oil	Marshall stability value	Flow value	Bulk density (gm)
1	3.6	0.4	351.93	2.50	2.51
2	3.5	0.5	344.93	2.43	2.51
3	3.4	0.6	329.90	2.18	2.52
4	3.3	0.7	305.4	2.01	2.54
5	3.0	1.0	218.60	1.89	2.58

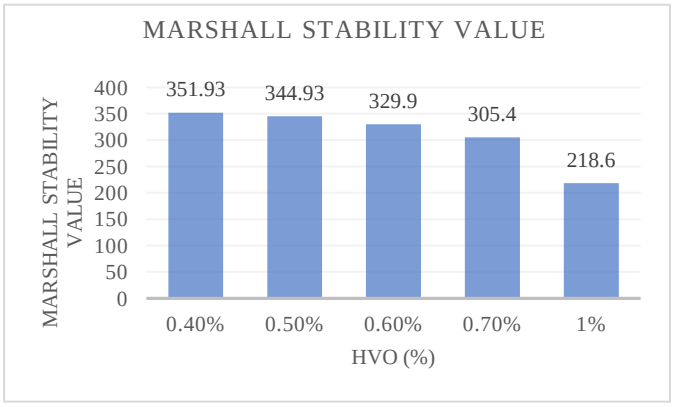

Figure 8 Variation of Marshall stability with partial replacement % of HVO

From above Graph it is observed that, 0.4 % HVO content gives maximum Marshall stability value and as % of HVO content is increased then stability value decreases.

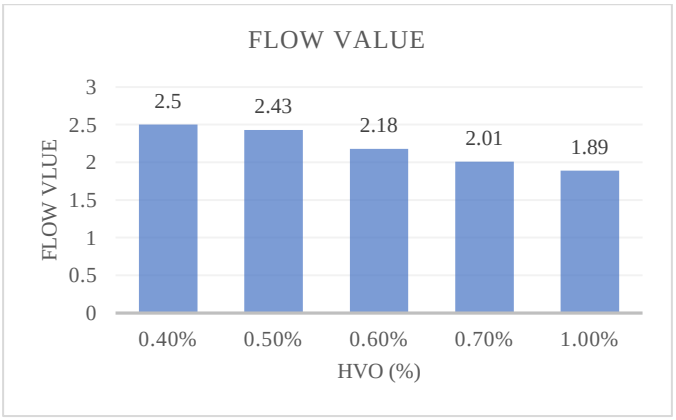

Figure 9 Variation of Marshall flow with partial replacement % of HVO

From above Graph it is observed that, the 0.4 % HVO content gives maximum flow value and as % of HVO content is increased then flow value decreases.

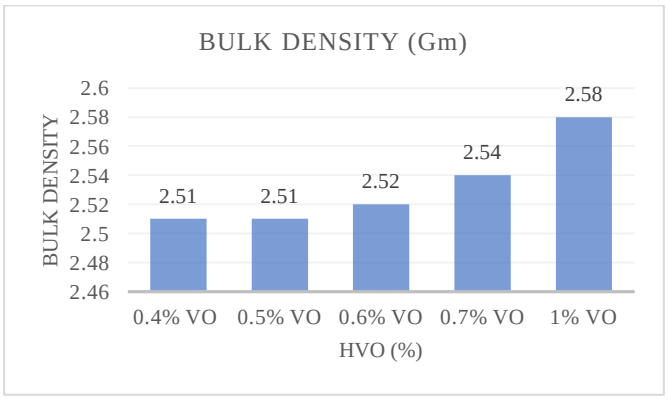

Figure 10 Variation of bulk density with partial replacement % of HVO

From above Graph it is observed that, the 1.0% HVO content gives maximum bulk density and as % of HVO content is increased then bulk density increases.

H. Results of stability of Bituminous mix with partial replacement of Grease –

The Grease were used in the bituminous mix of VG 30 Grade. Marshall Method of bituminous mix design is used to find out stability and flow characteristics of the mix. The optimum binder content (OBC) of 4.0% was partially replaced with 0.4%, 0.5%, 0.6%, 0.7%, and 1.0% of Grease and specimens are prepared for given percentage. The results are shown in following Table and Figures.

TABLE 6. STABILITY OF BITUMINOUS MIX SAMPLE PREPARED WITH DIFFERENT PERCENTAGE OF GREASE

Sr. No	% BITUMEN	% GREASE	MARSHALL STABILITY VALUE	FLOW VALUE	BULK DENSITY (Gm)
1	3.6	0.4	398.7	2.12	2.49
2	3.5	0.5	255.11	2.39	2.49
3	3.4	0.6	247.16	2.83	2.48
4	3.3	0.7	241.67	2.90	2.47
5	3.0	1.0	187.13	4.51	2.46

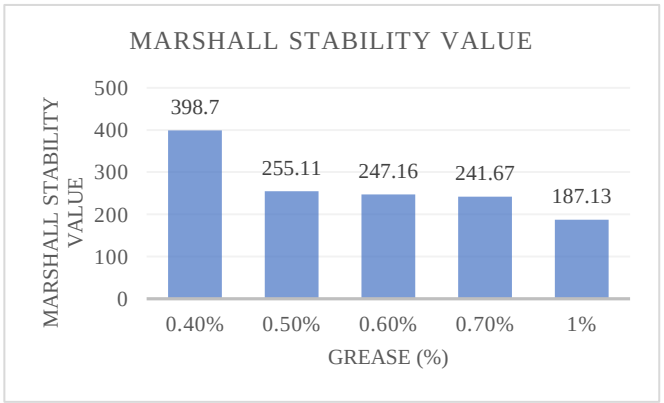

Figure 11 Variation of Marshall stability with partial replacement % of Grease

From above Graph it is observed that, the 0.4 % grease content gives maximum Marshall stability value and as % of grease content is increased then stability value decreases.

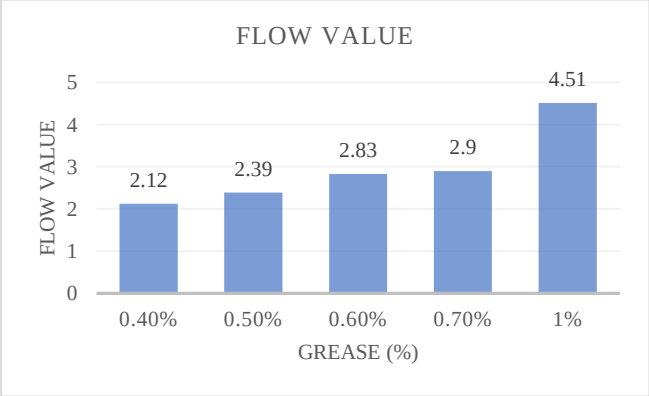

Figure 12 Variation of Marshall flow with partial replacement % of Grease

From above Graph it is observed that, the 1.0% grease content gives maximum flow value and 0.4 % bitumen content gives minimum flow value.

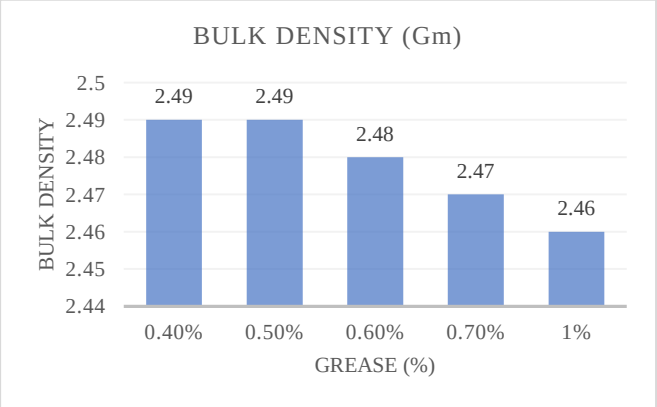

Figure 13 Variation of Bulk density with partial replacement % of Grease

From above Graph it is observed that, the 0.4 % and 0.5% grease content gives maximum bulk density and 1.0% bitumen content gives minimum bulk density.

Comparison between MSV of Bitumen mix with partial replacement of hydrogenated vegetable oil and grease

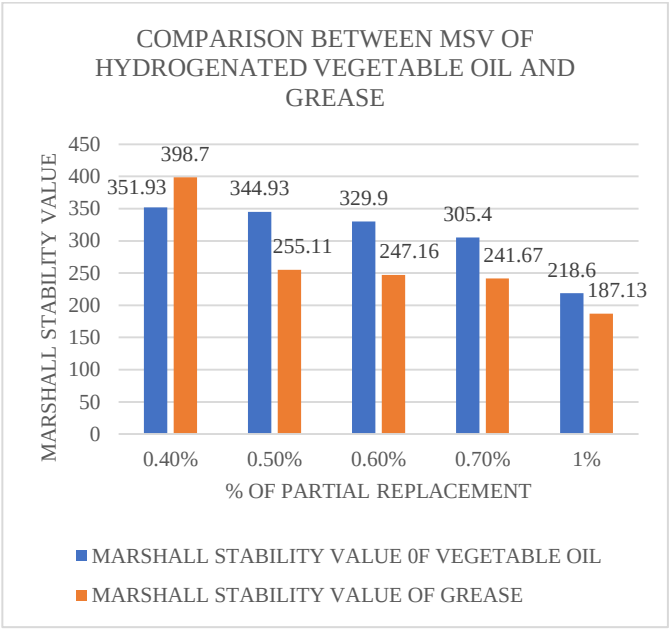

Figure 14. Representation of % of partial replacement of HVO and grease versus corrected Marshall stability values.

From above Graph it is observed that, partial replacement of HVO gives the higher Marshall stability values as compared to grease.

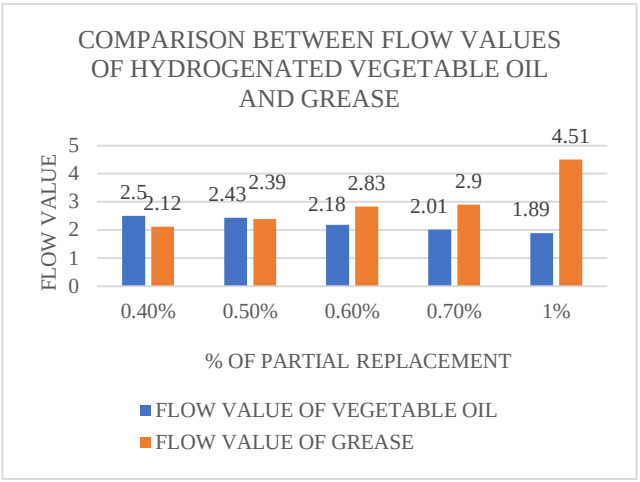

Figure 15. Representation of % of partial replacement of HVO and grease versus Marshall flow

From above Graph it is observed that, as the % of partial replacement of HVO and grease increases, the HVO gives the decrease in flow values and grease gives the increase in flow values.

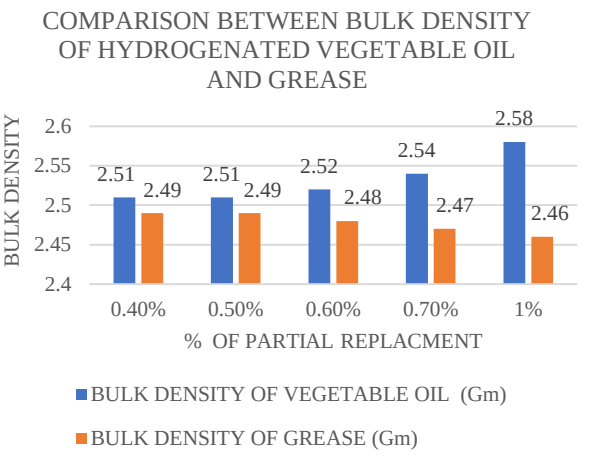

Figure 16. Representation of % of partial replacement of HVO and grease versus bulk density

From above Graph it is observed that, as the % of partial replacement of HVO and grease increases, the HVO gives the increase in bulk density values and grease gives the decrease in bulk density values.

6. CONCLUSIONS

1) The maximum Marshall stability value and flow value for VG-30 grade bitumen is obtained at 4% of bitumen content, which is 30.24% more than minimum permissible value for Marshall stability and 4.25% more than permissible value for Marshall flow.
2) The maximum Marshall stability value and flow value for VG-30 grade bitumen with partial replacement of HVO is obtained at 0.4% of HVO content, which is 3.51% more than minimum permissible value for Marshall stability and 25.00% more than minimum permissible value for Marshall flow.
3) The maximum Marshall stability value and flow value for VG-30 grade bitumen with partial replacement of grease is obtained at 0.4% and 1.00% of grease content respectively, which is 17.26% more than minimum permissible value for Marshall stability and 12.75% more than maximum permissible value for Marshall flow.
4) The maximum/ optimum partial replacement % of HVO in bitumen obtained is 0.5%, which gives Marshall stability value 344.93 and flow value 2.43, which is 1.45% more than minimum permissible value for Marshall stability and 1.50% more than minimum permissible value for Marshall flow.
5) The maximum/ optimum partial replacement % of grease in bitumen obtained is 0.4%, which gives Marshall stability value 398.7 and flow value 2.12, which is 17.26% more than minimum permissible value for Marshall stability and 6% more than minimum permissible value for Marshall flow.

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