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Research Paper

Engineering

KEYWORDS : Rut Test, Fatiuge Beam test etc

Evaluation of Flexible Pavement with Intrusion of Geogride Material Under Fatigue & Rut Test

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ABSTRACT

It consists of glass fiber strands arranged in a grid structure and covered with a polymer coating. The full range of Geogrid has been specially developed for asphalt reinforcement. It adds to the strength of road, it is designed to turn crack stresses horizontally and dissipate the stress. It helps to reduce reflective cracking for years to coming on Flexible pavement, As reinforcement, it increase the tensile strength characteristics of asphalt concrete. Geogride for pavement rehabilitation provide the functions such as waterproofing, stress absorption and reinforcement between the old and new asphalt concrete overlay. There are a number of different Geogride materials, and with the similarity of many of the names, as well as much similar sounding trade names. The greatest future benefit of Geogride materials is likely to be realized in pavement structures as well as a clearer valuation of immediate and life-cycle cost and benefits. A Geogride material when used with asphalt concrete has shown a serviceable life equivalent to that of an overlay. In this Paper Presentation deals the fatigue test and rut test using with Geogride material. During My Research 2 Types PMB, 3 Types of Geogride Materials used for Direct Tensile strength test & Wheel Tracking test & Fatiuge Beam test carried out. After all test result, I found that Geogride material have more Tensile Strength, Economical and improve pavement life as compare to PMB material used.

1. INTRODUCTION

Maintenance of pavements involves two stages viz. routine maintenance and periodic maintenance. If the routine maintenance is delayed, there are chances of development of cracks. Movements concentrated around pre-existing cracks are unable to withstand shear and tensile stresses which create the crack. This movement may be due to the traffic loading which causes differential deflections at cracks in the underlying pavement layers, expansion or contraction of subgrade soils and, of the pavement itself due to changes in temperature, or combination of these phenomena. When these stresses become greater than the shear or tensile strength of the HMA, cracks develop in the new overlay. This propagation of an existing cracking pattern from the old pavement into and through a new overlay is known as reflective cracking. The full range of Geogride has been specially developed for asphalt reinforcement. It adds to the strength of road, it is designed to turn crack stresses horizontally and dissipate the stress. As reinforcement, it increases the tensile strength characteristics of asphalt concrete. Geogride for pavement rehabilitation provide the functions such as waterproofing, stress absorption and reinforcement between the old and new asphalt concrete overlay. This report deals with the use of different Geogride material and comparing their strength parameters viz, rutting, fatigue life

1.1Scope of work

In my work I have tested various types of Geogride material and carried out fatigue and rut test using with different types of Geogride material. In fatigue test a beams were prepared using with different types of material, tested and Geogride finding a fatigue life. In rut test slabs were prepared and tested on rut testing machine for a 20, 000 cycles or 20 mm rut depth which is earlier.

1.2Methdology

The overall methodology involves following steps;

1. The Initial step of methodology was Literature review which contains propagation and mechanism of reflective cracking and measures to retard it including information regarding Geogride material.
2. The second step was studying the physical properties of aggregates, bitumen and Geogride material. Further test like indirect tensile strength, fatigue test and rutting test were carried out.
3. The third step was Marshall Mix design. Later Geogride material was tested and fatigue and rut tests were conducted.
4. The fourth step was evaluation of cost-economics include consideration.

The last step was conclusion that, which Geogride material was best for road construction

2. LITERATURE REVIEW

2.1Defects in bituminous surfacing

The defects in bituminous surfacing may be grouped into four categories as per C.Venkettappa (Transportation Engg.)

(i) Surface defects which include fatty surface, smooth surface, streaking & hungry/dry surface.
(ii) Cracks viz. Block cracking, Fatigue cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks and Reflective cracks.
(iii) Deformation defects which include slippage, rutting,corrugation, shoving, shallow depressions and settlements.
(iv) Disintegration defects which includes stripping, loss of aggregates, raveling, pot-holes and edge breaking.

2.2 Mechanism Of Fatigue Crack Propagation

Fatigue is the general phenomenon of material failure due to the growth of microscopic flaws as a result of repeated loading. These micro-cracks become more visible as the stress concentrations at the tip of the crack increases and causes further crack propagation. Paris' Law, as provided in equation

$Dc/dN = A (\Delta K)^n$----- (2.1)

Where
C = crack length
N = number of load application
Dc / dN = rate of crack growth {or "crack speed "}
ΔK = change of stress intensity factor during loading
A, n = fracture parameters for the asphalt mixture

In 1921, Griffith provided a criterion, which stated, "Crack propagation would occur if the energy released upon crack growth is sufficient to provide all of the energy that is required for crack growth".

2.3 Measures to Control Reflective -Cracking

Over the past several decades, extensive research work was carried out to reduce the problem of reflection cracking. Some of the measures attempted are discussed here briefly.

2.3.1 Use of Polymer Modified Bitumen

EVA (Ethyl Vinyl Acetate) and SBS (Styrene Butadiene Styrene) polymer modified bitumen were successfully used as overlay binders in the construction of bituminous overlays placed over concrete carriageways said by S.K. Patil. ADOT placed their first stress absorbing membrane interlayer (SAMI), an interlayer designed to reduce reflective cracking in an overlay. Both the SAM and SAMI were designed to utilize the enhanced elastic properties of the rubber – modified binder in the rehabilitation of a cracked pavement and their applications showed great promise in reducing reflective cracking

2.3.2. Use of Geogrid.

It consists of glass fiber strands arranged in a grid structure

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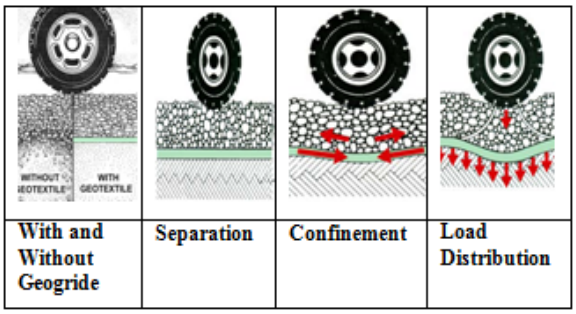
and covered with a polymer coating. The full range of Geogrid has been specially developed for asphalt reinforcement. it adds to the strength of road, as it is designed to turn crack stresses horizontally and dissipate the stress. It helps to reduce reflective cracking for years to come, As reinforcement, it increase the tensile strength characteristics of asphalt concrete.

Benefits Of Geogrid

1. High tensile strength
2. Low elongation
3. No long-term creep.
4. Thermal stability.
5. Durability
6. Asphalt compatibility.
7. Easy installation.

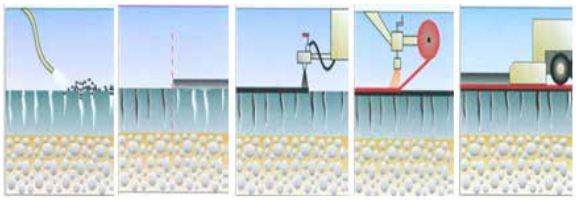
2.4 The Main Geogride Characteristics

The Main Geogride Characteristics as per Geosynthetic, British Columbia (Ministry of agriculture and lands),



(Figure 2.1 : Main Geogride characteristics.)

2.5 Hot mix overlay Standard paving operations should closely follow fabric layout. All areas in which paving fabric has been placed should be paved during the same day. If the fabric becomes wet, it must be allowed to dry completely before paving. A minimum compacted asphalt thickness of 1" to 1.5" Is required depending on roadway volume.



1. Cleaning 2. Filling of 3.Applying 4.Sprying 5.Laying of Cracks Tack-coat Geogride Bitumen (Photograph 2.1: installation guidelines)

3. LABORATORY TEST

3.1 Physical Properties of the Aggregates

The aggregates in the obtained Mix were tested for various physical properties such as stripping value, water absorption, impact value, flakiness and elongation indices and the results were obtained from the site and the sample was collected and tested as per IS-2386 & IS:6241 Codes.

3.2 Physical Properties Of Bitumen

The bitumen used for the mix was also tested for the required properties i.e. Penetration Test (IS 1203-1978), Softening Point (IS 1205-1978), Specific Gravity and Ductility (IS 1208-1978)by IS Codes.

3.3 Testing of Geogride

Geogride is to be tested for many properties before using in roads as an inter/ intra layer. Placing of Geogride material like TGU-40, TGU-80, TGU100, which acts as a stress absorbing membrane? Following test were carried out on Geogride are explained in the following sequence:-

3.3.1 Asphalt retention.

As per ASTM: D 6140-97, Standard Method to Determine Asphalt Retention of Paving Fabrics Used in Asphalt Paving for Full-Width Applications

3.3.2 Melting point.

This test was conducted as per AASHTO M 288-92, Standard Specifications for Geogride Specification for Highway Application. The Geogride was placed in the oven at 165 deg. for 24 hrs.

3.3.3 Tensile Strength.

Tensile strength is the most important parameter, as it will define the Geogride able to act as a stress absorbing membrane. The tensile strength is measured on tensile strength measuring instrument. A sample of Geogride is adjusted in the jaws of the machine such that the length between the two jaws is about 20 cm. The reading is taken until the reading decreases in the dial gauge.

3.3.4 Stripping Of Geogride

This test was conducted as per G. Dondi, Laboratory Test on Bituminous Mixes Reinforced by Geogrides, Rilem-199 the stripping of the asphalt coated Geogride sample was determined to know the susceptibility of Geogride towards water. The Geogride coated with bitumen as per the asphalt retention procedure, then the Geogride was placed in water at 40 deg for 24 hrs. After that through visual inspection the stripping is determined. The stripping should be minimal possible

3.4 Evaluation Of Properties Of The Bituminous Mix

In the present study various tests were performed in the laboratory as per MORT&H, Nov-2000, Base & Surface course (Bituminous), Sec-500 and to examine the extent of segregation in the mixes and its effect on the properties. Initially the mix was tested for the binder content and then it's grading was obtained by sieve analysis. Then the mix was tested for various Marshall Strength parameters like density, stability, VFB, percent air voids and flow.

3.4.1 Gradation of the Mix

The various sieves used for the Sieve Analysis and their corresponding permissible percent passing as specified by the MOST are listed in the given table 3.1

Sieve size (mm)	Percentage passing
26.5	100
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
600 micron	26-38

Table 3.1 Specified Aggregate Gradation for (BC)

3.4.2 Marshall method of Bituminous Mix Design.

Bituminous mix design was carried out as per Highway Engineering by L.R. Kadyali. And MS-2, Mix Design Methods for Asphalt Concrete and Hot Mix Type.

Thickness of Compacted Layer, mm		40
Marshall Method Design Criteria		
I	Number of blows on each face	75
Ii	Marshall Stability, minimum (kg)	900
Iii	Marshall Flow, mm	2-4
Iv	Voids in Compacted Mix, Va %	3-5
V	Voids Filled with Bitumen VFB,	65-75
Vi	Voids in Mineral aggregate VMA,	10-12 %

Table 3.2: Design criteria for the various Marshall Strength Parameters

3.5 Fatigue Test by Repetitive Loading

This test was conducted as per Beam fatigue equipment manual. The WFI Beam Fatigue Apparatus comprises cradle with pneumatic lateral positioning and servo-motor controlled vertical clamping. In this, the stand- alone version, the cradle has a digital servo-controlled pneumatic actuator built into the beam.

3.5.1 The Beam Cradle



The beam cradle has been designed to subject an asphalt beam specimen to 4 point bending with free rotation and horizontal & translation of all load and reaction points as shown in photograph. 3.10. The spacing between loading points can be either 300 mm or 355.5

3.1:Fatigue beam apparatus





3.2 Compaction of beam 3.3. Fatiuge bam

3.5.2 Operator Control

These controls are used to locate & clamp the specimen and position the actuator ram prior to starting a test and releasing the specimen at the completion of the test.





3.4 Beam in testing position **3.5 Crack after testing beam**

3.6WHEEL TRACKING TEST.

This test was done as per Wheel tracking equipment manual.

3.6.1Equipment and Procedure

Rutting potential is key factor for design of various wearing bituminous surfaces. Rutting characteristics of BC, SDBC and SMA mixes were investigated using Wheel Tracking (Dry Type) equipment (HWTD). The Wheel tracker is capable of carrying out tests in accordance with British standard BS 598-part 10: 1998. The distance of travel (230+/- 5mm), rate of tracking (42 passes per minute) and wheel/tyre specifications are as detailed in BS 598. A typical view of test in progress

The specimen (slabs) were prepared and placed in the testing assembly at 45ºC. The test was started after placing the specimen in closed cabinet as per test requirement. Each sample is subjected to reciprocating load (525±5 N) repetitions for 20,000 passes or until 20 mm rut impressions on the slab surface whichever is earlier



Photograph 3.5: Wheel Tracking Test in Progress.



Photograph 3.6 : Mould of Rutting Slab



Photograph 3.7: Rutting Slab



Photograph 3.8 A Position of Beam after rutting test

4. LABORATORY INVESTIGATION & RESULTS

4.1 Physical properties of Aggregates & Bitumen

In this chapter the results of various tests conducted in the laboratory are listed. The various properties of course aggregates and Bitumen

Sr. No.	Name of the property	Value in %
1	Aggregate Impact Value	14
2	Flakiness Elongation Index	20
3	Water absorption	1.1
4	Soundness test	4%
5	Loss Angeles abrasion test	19%

Table 4.1: Physical properties of Aggregate.

Sr. No	Bitumen Sample	Specific Gravity	Softening point ˚C	Ductility cm	Pene traction
1	60/70	1.01	47.7	74	65
2	PMB 40	1.02	67	>70	42
3	PMB 70	1.03	60	>90	70

Table 4.2: Various properties of the Binder

The specific gravity of coarse aggregate 20 mm, 13.2 mm, stone dust and lime are 2.67, 2.67, 2.69 and 2.80 respectively. Specific gravity of bitumen has been taken as 1.02

4.2 Gradation of aggregate

For the different sizes of aggregates, individual aggregates gradation has been done .To get the specified gradation of BC mix, aggregates of different sizes were blended with different proportion and many trials were made.

Sieve size (mm)	% Passing 12.5 mm	% Passing 6 mm	% Passing Stone dust	% Passing Lime	A: B: C: D - 28:32:37:3
	(A)	(B)	(C)	(D)	
19	100	100	100	100	100
13.2	89.1	100	100	100	97
9.5	38.5	100	100	100	82.8
4.75	6.33	66.3	99.7	100	62.9

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2.36	2.78	32.7	92.9	100	48.6
1.18	0	11.56	84.7	100	38
600 µ	0	4.59	66.5	100	29.1
300 µ	0	2.07	48.7	100	21.7
150 µ	0	0	31.8	98.9	15
75 µ	0	0	10.4	80.3	6.3

Table 4.3: Prescribed limits as per MOST specifications

Four different types' Geogride samples were purchased from the market for use

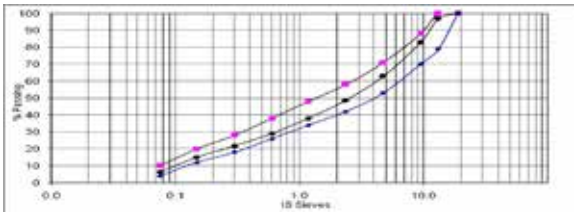

Table 4.4 Identification of Geogride Material TGU 40 - Techfeb Geogrid having 40 (kn/m) Strength.

TGU 60 - Techfeb Geogrid having 40 (kn/m) Strength
TGU-100 - Techfeb Geogrid having 100 (kn/m) Strength.
4.4 Beam Fatigue Test

Beam fatigue test was done to find out fatigue life cycles of beams In this test constant strain method is use. As per standard the no. of cycle is more compared to other beam. With using every material 3 sample S1, S2, S3 taken.

Fabric Type	Thick -ness (mm)	Asphalt Retention (kg/Sq. m)	Tensile strength (kg)	Melting Point Deg. Cel.	Mass per Area Gm/ Sq. M
		-0.6	36	165	140
Sample M1 TGU40	2.2	1.5	64	>900	185
Sample M 2 TGU60	2.5	1.6	105	>900	205
Sample M 3 TGU100	3.1	1.6	146	>165	245

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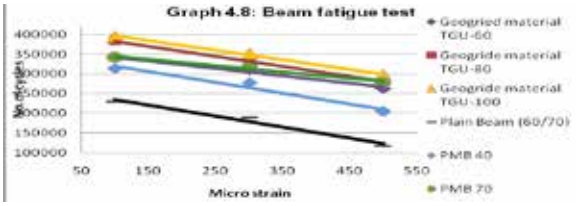
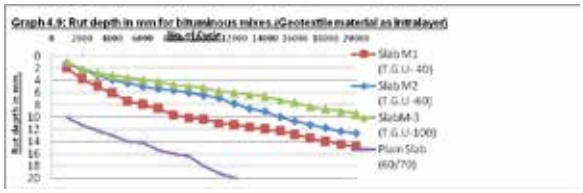
Beam Details	No. of Cycles		
	100µ Strain	300µ Strain	500µ Strain
M1-S1 (60/70)	339700	-	-
M1-S2 (60/70)	-	310900	-
M1-S3 (60/70)	-	-	264000
M2-S1 (60/70)	383000	-	-
M2-S2 (60/70)	-	331800	-
M2-S3 (60/70)	-	-	281500
M3-S1 (60/70)	394500	-	-
M3-S2 (60/70)	-	351500	-
M3-S3 (60/70)	-	-	297000
Plain 1 (60/70)	229400	-	-
Plain 2 (60/70)	-	188700	-
Plain 3 (60/70)	-	-	117100
Plain 1 (PMB 40)	314400	-	-
Plain 2 (PMB 40)	-	277300	-
Plain 3 (PMB 40)	-	-	204200
Plain 1 (PMB 70)	341900	-	-
Plain 2 (PMB 70)	-	319000	-
Plain 3 (PMB 70)	-	-	277800

Table 4.5 Beam fatigue test Result



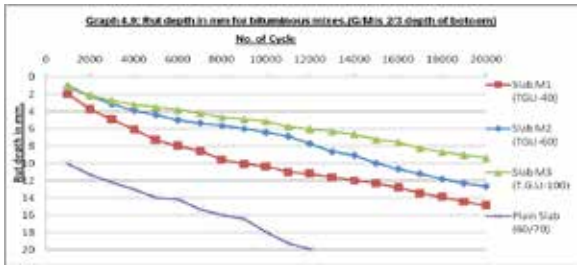
4.6 Wheel tracking test

This test is done to determine the rutting resistance of bituminous mixes. Wheel tracking tests were conducted on beam specimen prepared of bituminous mixes with asphalt coated Geotextile as an intralayer as well as 2/3 distance to the bottom face. The test has been done for 20000 passes Or 20 mm rutting, whichever earlier, and the rut depth was measured at interval of 2 hours.



Cycle	Slab M1 (TGU-40)	Slab M2 (TGU-60)	Slab M3 (TGU-100)	Plain Slab (60/70)
1000	2.19	1.63	1.09	11.05
2000	4.42	2.6	2.05	12.8
3000	5.81	3.49	2.84	13.26
4000	6.9	4.07	3.59	13.94
5000	8.02	4.57	4.15	14.19
6000	8.74	5.18	4.85	14.78
7000	9.23	5.55	5.04	15.44
8000	10.21	5.97	5.23	16.51
9000	10.41	6.02	5.41	17.4
10000	10.93	6.83	5.45	18.4
11000	11.32	6.99	6.02	19.15
12000	11.63	7.59	6.14	19.81
13000	11.98	7.96	6.71	20.46
14000	12.52	8.19	6.99	
15000	13.11	8.83	7.31	
16000	13.98	9.42	7.65	
17000	15.03	10.89	8.39	
18000	15.56	11.51	9.09	
19000	15.97	12.67	9.71	
20000	16.34	13.92	10.8	

Table 4.6 Rut depth of Bituminous mixes. (G.M. as intra-layer)



Cycle	Slab M1 (T.G.U- 40)	Slab M2 (T.G.U -60)	Slab M3 (T.G.U -100)	Plain Slab (60/70)
1000	1.98	1.17	0.99	10.05
2000	3.76	2.21	2.14	11.3
3000	4.95	3.15	2.74	12.2
4000	6.05	3.89	3.2	13.01
5000	7.3	4.4	3.51	13.969
6000	7.99	5.01	3.82	14.18
7000	8.55	5.35	4.19	15.34
8000	9.61	5.63	4.66	15.99
9000	10.1	6	4.9	16.4
10000	10.33	6.44	5.15	17.95
11000	11	6.87	5.76	19.19
12000	11.21	7.75	6.02	19.96
13000	11.62	8.61	6.31	20.53
14000	11.97	9.07	6.64	
15000	12.27	9.98	7.21	
16000	12.81	10.67	7.55	
17000	13.44	11.22	8.25	
18000	13.91	11.78	8.67	
19000	14.4	12.31	9.01	
20000	14.87	12.65	9.37	

Table 4.7Rut depth of Bituminous mixes. (G.M. 2/3 depth of bottom)

5 . COST-ECONOMICS

The cost comparison per Km for 75 mm BC Mix using with using Geogride M1(T.G.U-40),M2(T.G.U-60),M3(TGU-100) respectively is shown below;

Assume,
Road length =1 km
Road width = 7 m. B.C. laying having thick =7.5 cm

- Total volume of bituminous Mix = 1000 × 7 × 0.075= =525 M^3
  Co Cost of bitumen = 40 Rs/ liter t of bitumen = 40
- Average assuming CDM = 2420 kg/ M^3
  So, Total weight of mix/ km = 2420 × 525=12, 70, 500 kg.
- Total loose weight of mix / km = 16, 51, 650 kg.
- Cost of bitumen per km = 16,51,650*4.45*40/100 = 29, 39, 937 Rs/ Km Cost of road per km = 29,39,937 * 2.2 = 64, 67, 861 Rs/ Km ------(1)

Area of road = 1000*7 = 7000 Sq.m

- If use Geogrid M1 (TGU-40), then cost is 60 Rs./ Sq. m in cluding installation charges. Cost of Geogrid = 4, 20, 000 Rs. ------(2)
- If use Geogrid M1 (TGU-60), then cost is 90 Rs./ Sq. m including installation charges.Cost of Geogrid = 6, 30, 000 Rs. -------(3)
- If use Geogrid no-6 (TGU-100), then cost is 125 Rs./ Sq. m including installation charges. Cost of Geogrid = 8, 75, 000 Rs. -------(4)
- Apply a tack coat at the rate of 0.3 Kg / Sq. m
  Quantity of tack coat = 7000*0.3 = 2100 Kg.
- Cost of tack coat including charges = 50 Rs.
  Cost of tack coat per Km. = 2100*50 = 1, 05, 000 Rs.-- (5)
- If use of Geogrid M1 (TGU-40) in construction of road, the cost will be summation of (1),(2) and (5); which is Rs.69,92,861 RS.
- If use of Geogrid M2 (TGU-60) in construction of road, the cost will be summation of (1),(3) and (5); which is Rs.72,02,861 RS.
- If use of Geogrid M3 (TGU-100) in construction of road, the cost will be summation of (1), (4) and (5); which is 74, 47,861 Rs.
- Increase a cost 5, 25, 00 Rs,7,35,00 Rs & 11, 27, 000 Rs. If use Geogrid M1(TGU-40),M2(TGU-60)M3(TGU-100) Respectively, with reference of plain Bituminous concrete road.
- But, past experiment says if use Geogrid material then life of road will be increase up to 70 % means maintenance period increase.

6 .CONCLUSION

The following conclusions were drawn based on Geogrid material in bituminous concrete mix to retard reflective cracking in bituminous overlays.

- GeogriedM1(TGU-40),M2(TGU-60)&M3(TGU100)has adequate tensile strength 64,105&146 kgs respectively.
- In beam fatigue test a no. of cycle required for particular strain value, Geogrid material of M1(TGU-40), M2 (TGU-60) & M3 (TGU-100) with 60/70 grade of bitumen is almost same of PMB-40 and PMB-70, so that if use of Geogrid material is beneficial in terms of economy.
- The no. of cycle for required strain value is high i.e. 2, 64,000& 2,81,500 & 2, 97, 000 for Geogride material M1(TGU-40) & M2(TGU-60) & M3(TGU-100),when use Geogrid material as compared to plain beam i.e. 1,17,000.
- Geogrid material if placed at 2/3rd height from the bottom also increases the fatigue life but it may not be beneficial as it lies in the compression face of the beam.
- When Geogrid material M1(TGU-40) & M2(TGU-60) & M3(TGU-100) is provided at intralayer, rutting depth is decrease 11.92 mm,7.96 mm and 6.71 mm respectively as compared to plain slab.
- WhenGeogridM1(TGU-40)&M2(TGU-60)&M3(TGU-100) is provided at 2/3 depth to bottom, rutting depth is decrease 11.62 mm ,8.61 and 6.31 mm respectively as compared to plain slab.
- The rutting of the bituminous overlay improves when the Geogrid material is placed nearer to the bottom surface.
- Finally it is concluded that it is more economical and feasible to use Geogrid material M1(TGU-40)&M2(TGU-60) & M3(TGU-100) as an intralayer.

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