EXPERIENCE ON USE OF COIR IN RURAL ROADS

by

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Coir Fibre

- India contributes nearly 70% of the world production of coir
- Overall production in southern region of India – 2,50,000 tonnes/annum
- Advantageous than any other type of natural fibre, due to its prime properties like strength, durability and hairy surface
- The high lignin content of coir fibre (to an extent of 46%) differentiates it from other natural fibres which contributes to an overall life more than 2-3 years
- Degradation of coir is hardly 25% in 6 months
- Longlasting infield service life of 4-10 years in case of geotechnical applications

Coir Geotextiles

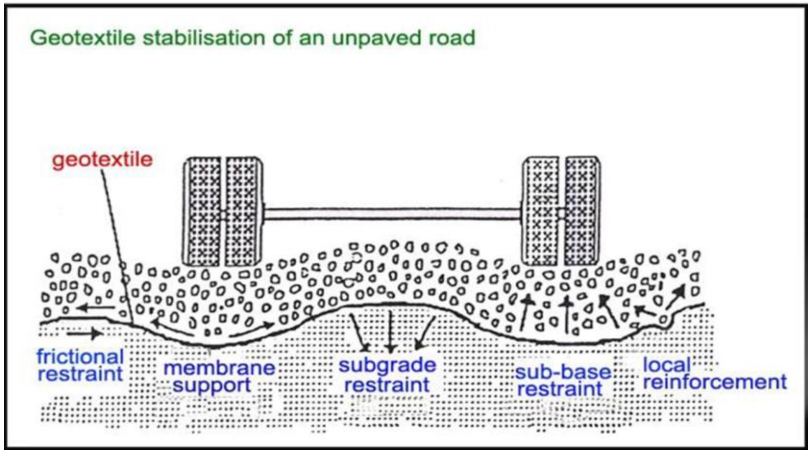
Grade I – 400 gsm

Grade II – 700 gsm

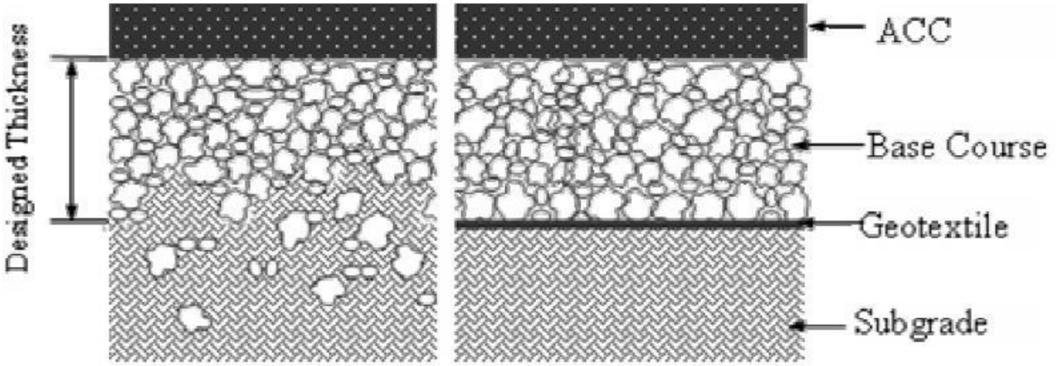
Grade III – 900 gsm

Functions of Coir Geotextile

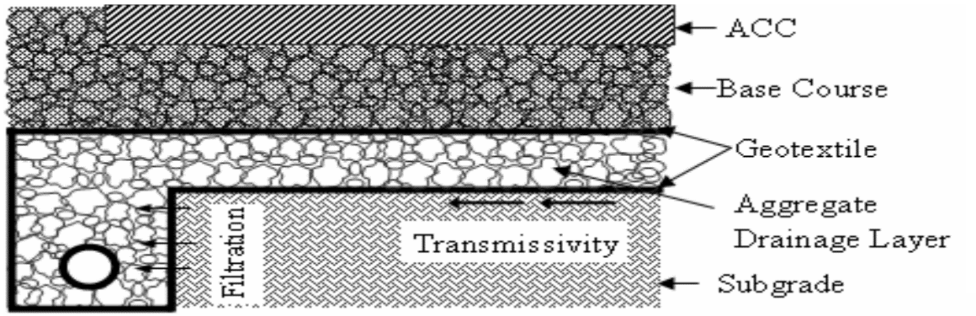
Reinforcement



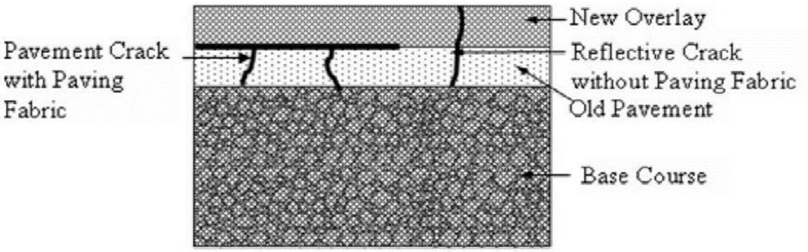
Separation



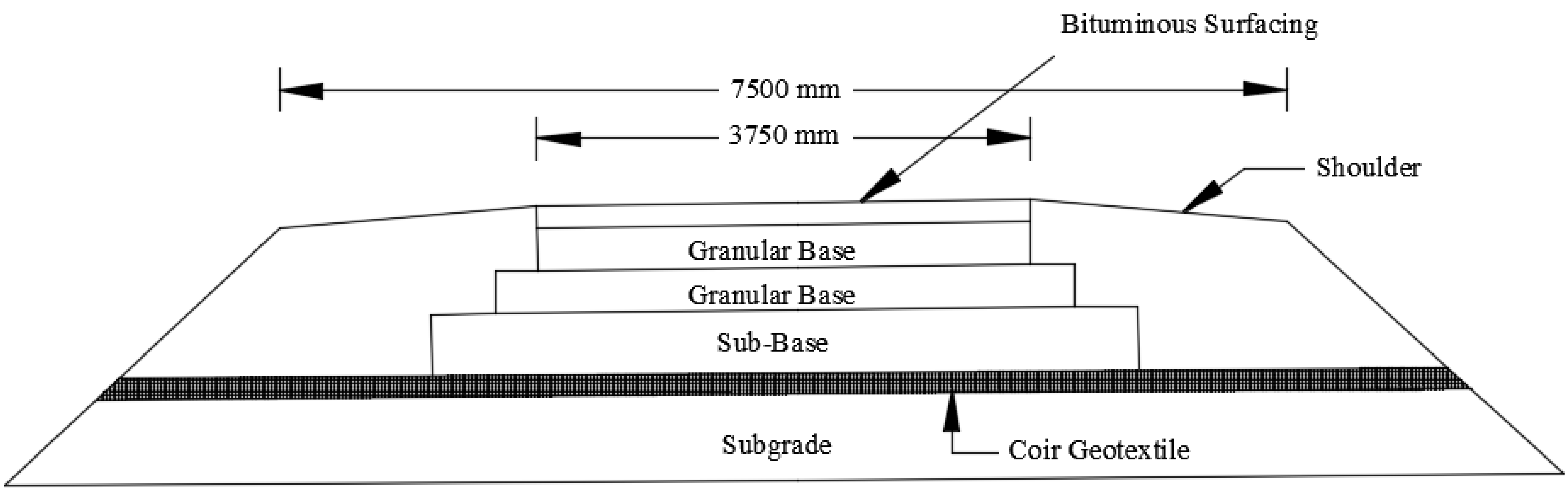
Filtration, Drainage (Transmissivity)



Sealing Function

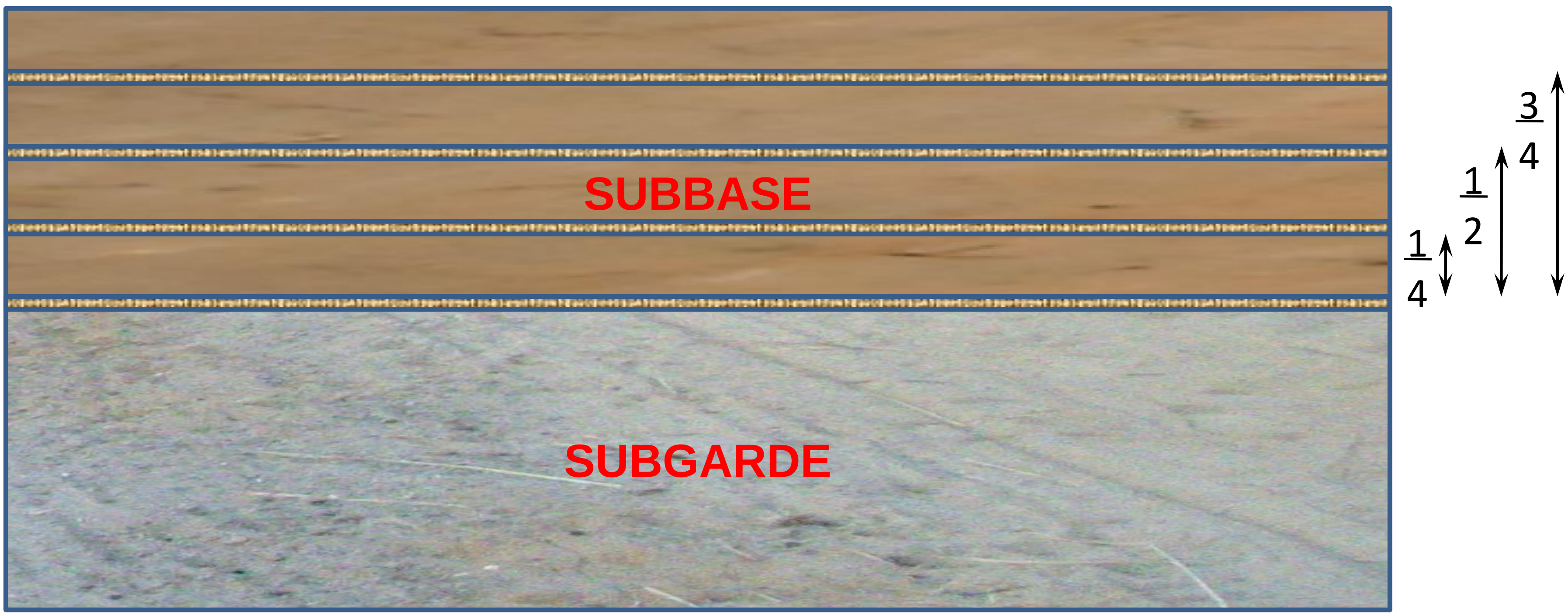


Schematic Diagram of a Typical Coir Geotextile Reinforced Road

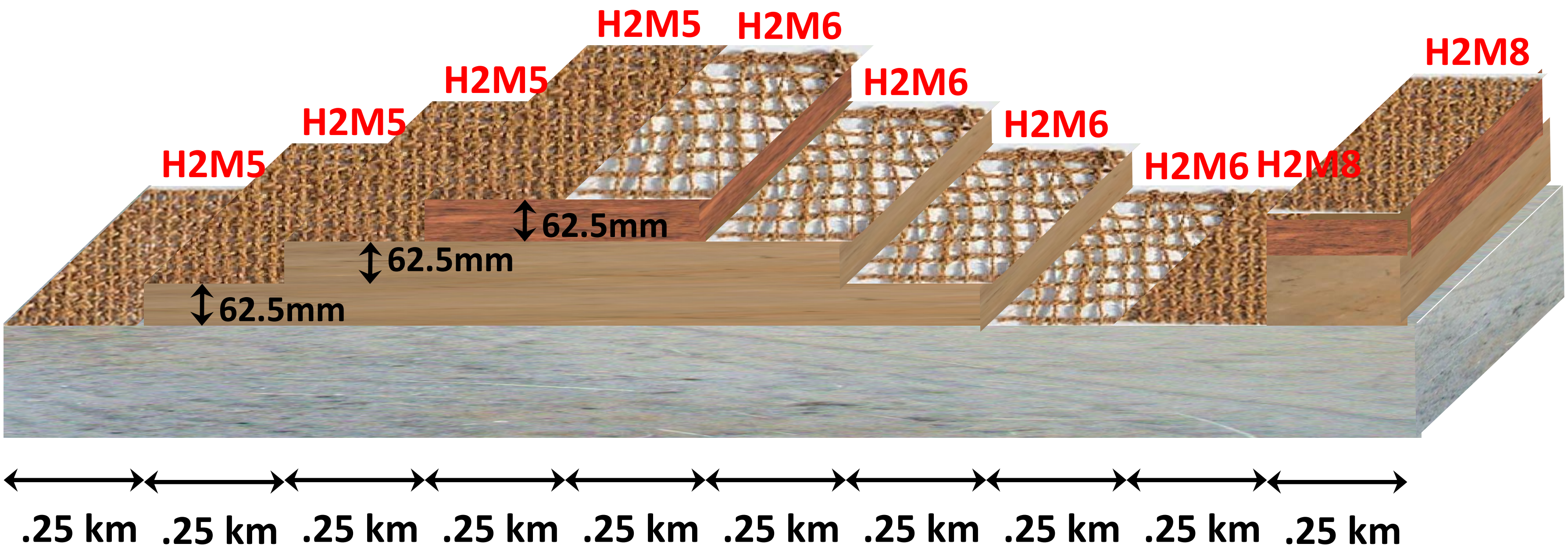


Position of Coir Geotextile

- Above Subgrade
- 1/4th of Sub-base thickness
- 1/2nd of Sub-base thickness
- 3/4th of Sub-base thickness



Position of Coir Geotextile



The test track was designed as per IRC SP 72: 2015

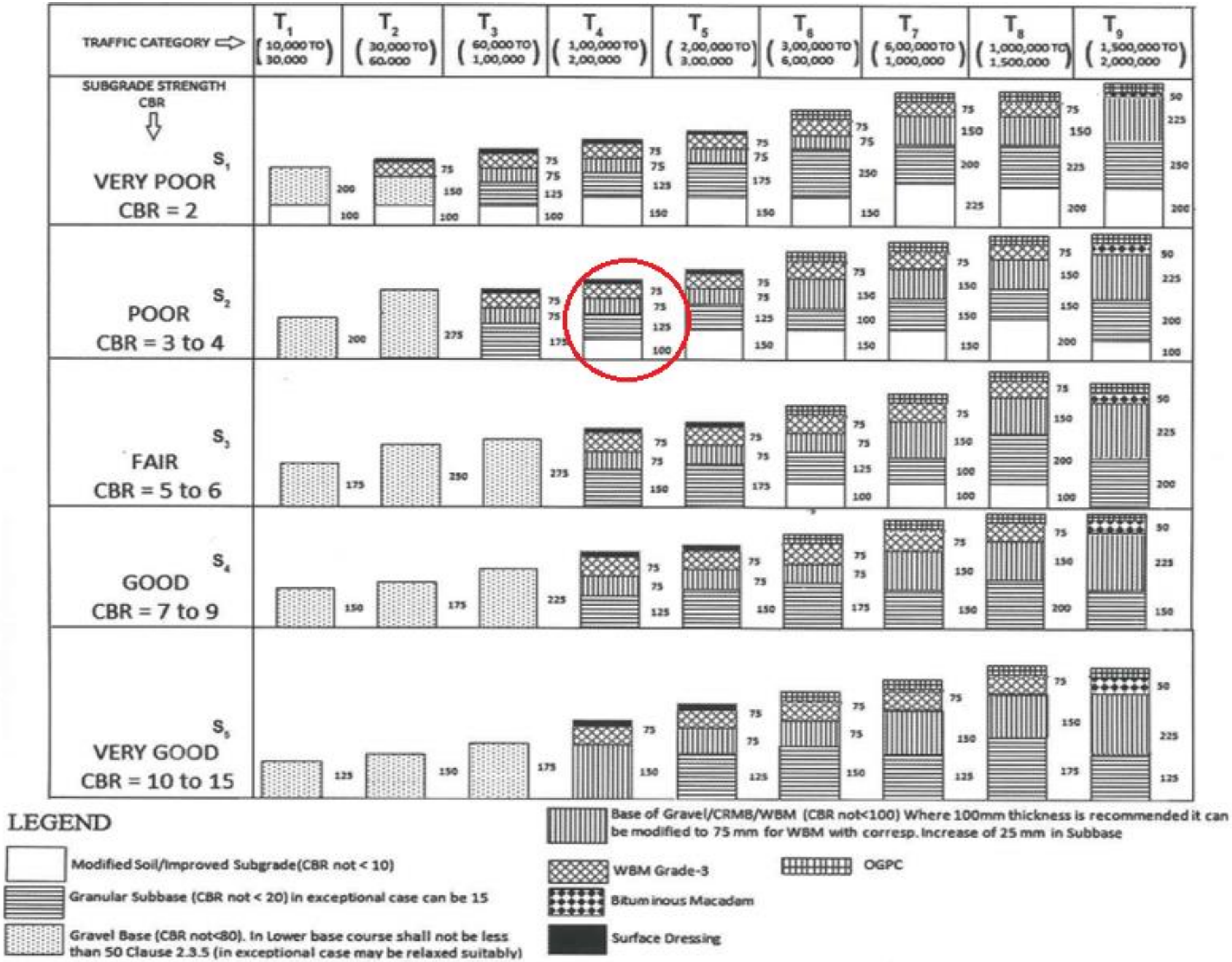
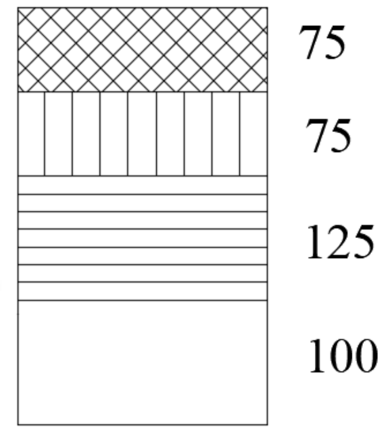
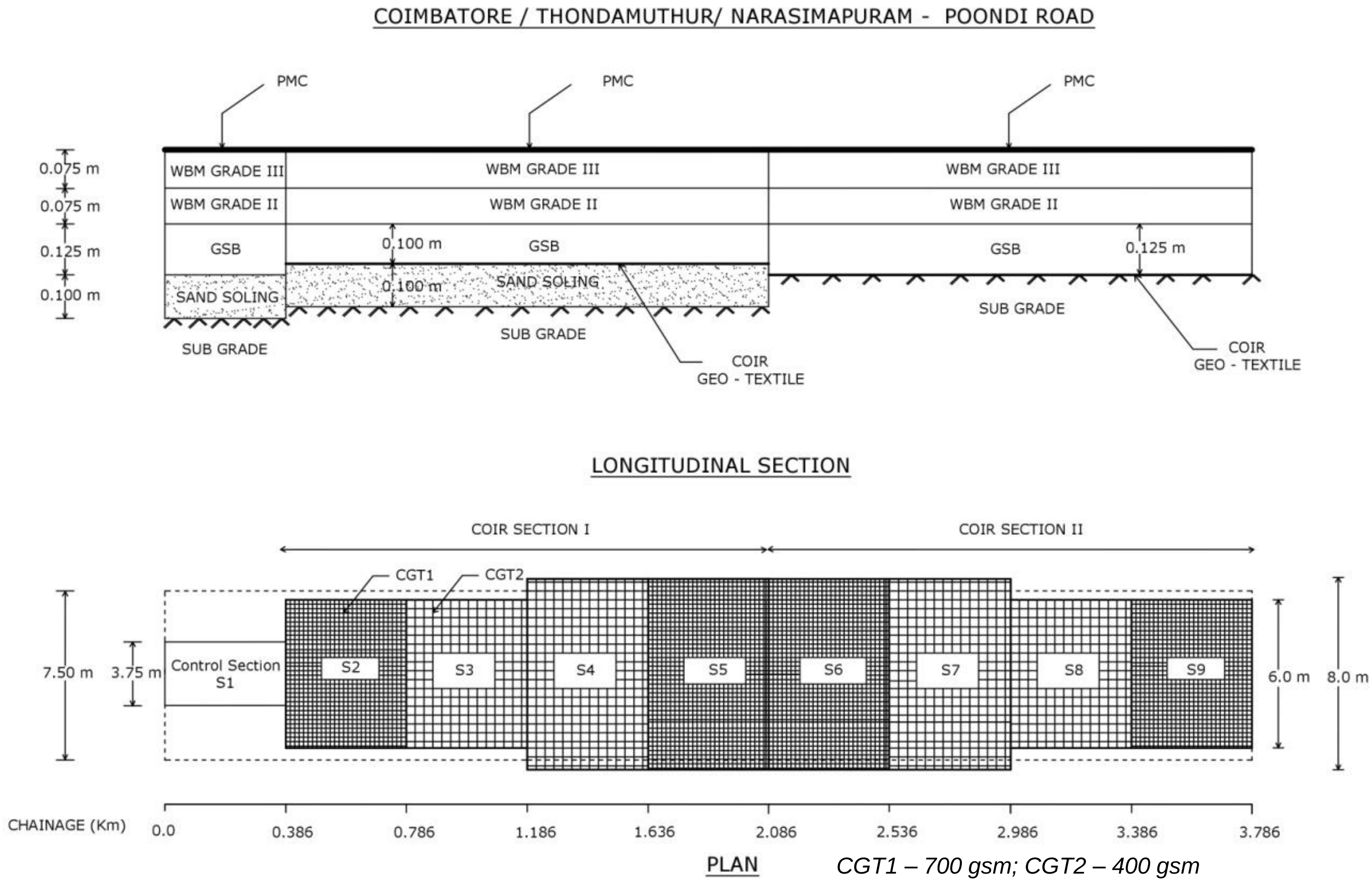


Fig. 4 Pavement Design Catalogues for Gravel/Granular Bases and Sub-bases

Selected section



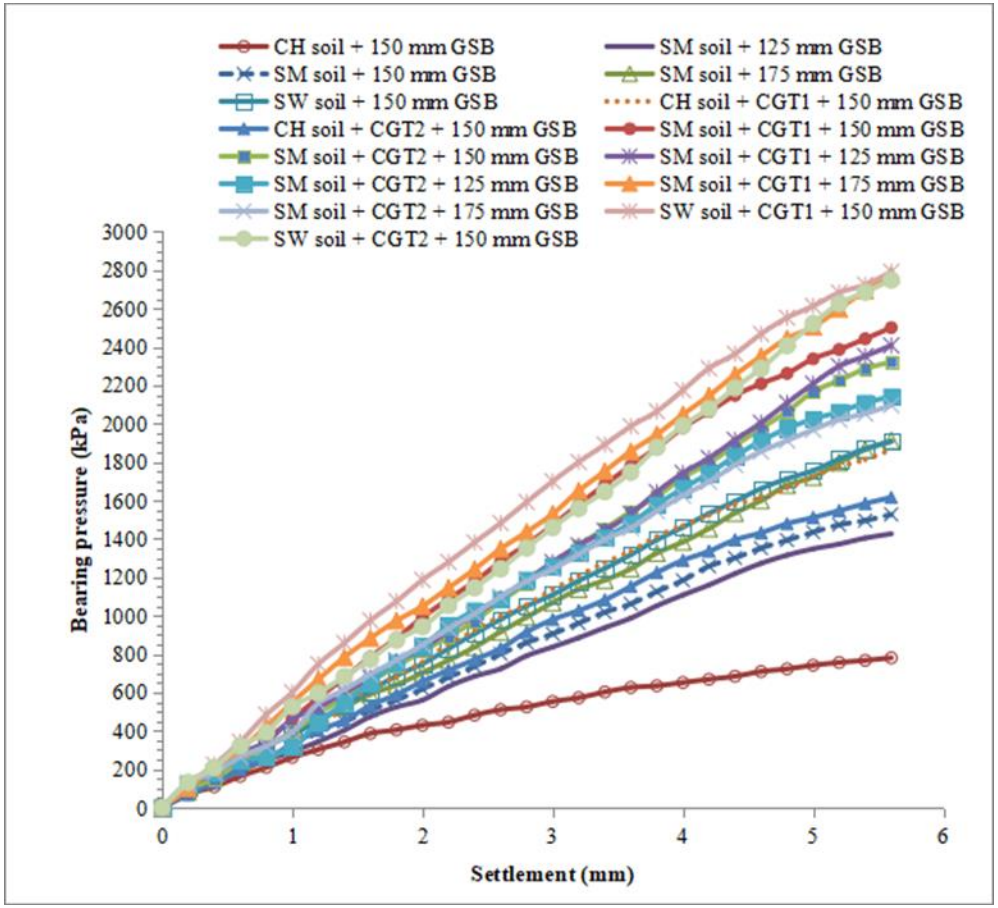
Test Track



CGT1 – 700 gsm; CGT2 – 400 gsm

Laboratory Studies

Laboratory plate load test setup



Bearing pressure – settlement curves for different test configurations

Field Test Conducted

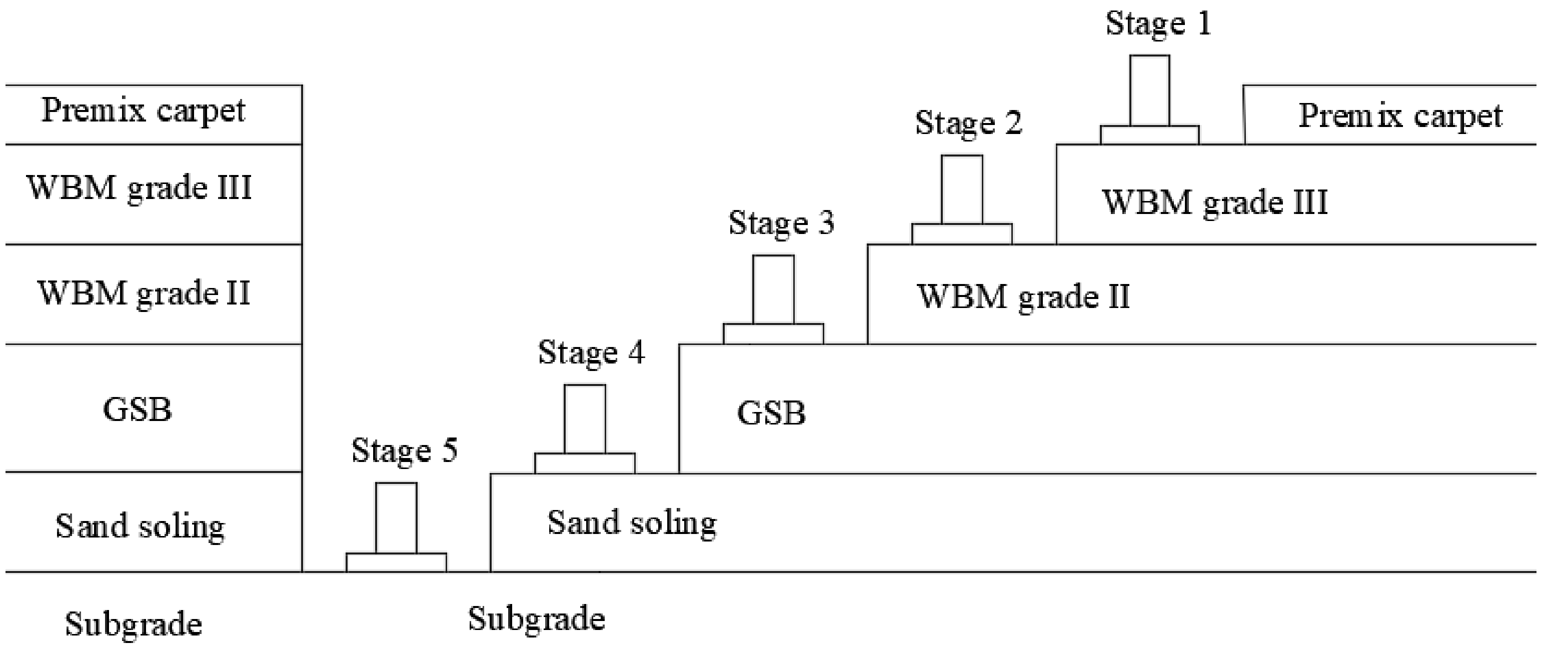
Geogauge

Static Load Plate Test

CBR test

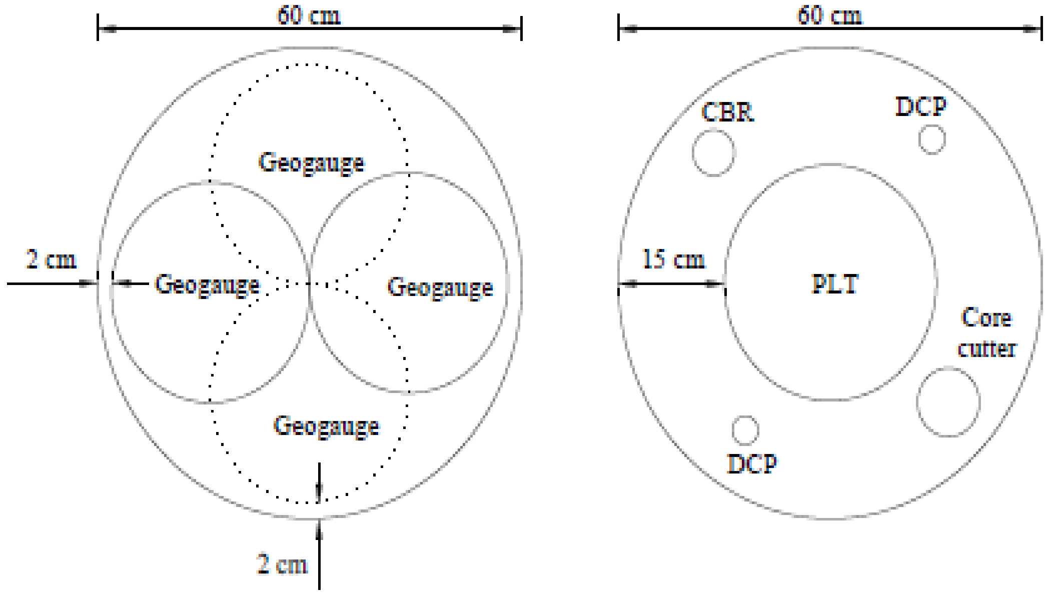
DCP test

Experimental Setup and Testing for Determination of Elastic Modulus



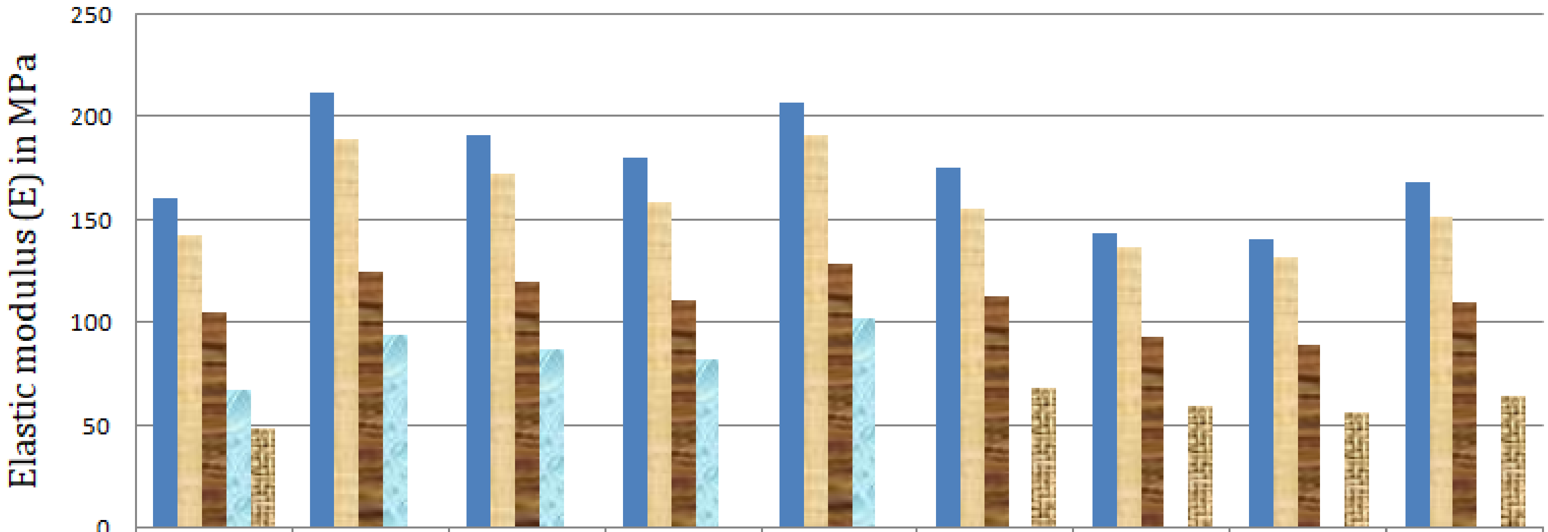
Schematic illustration of test procedure in the control section

Test Sequence



Layout of test measurements

Elastic Modulus using Geogauge

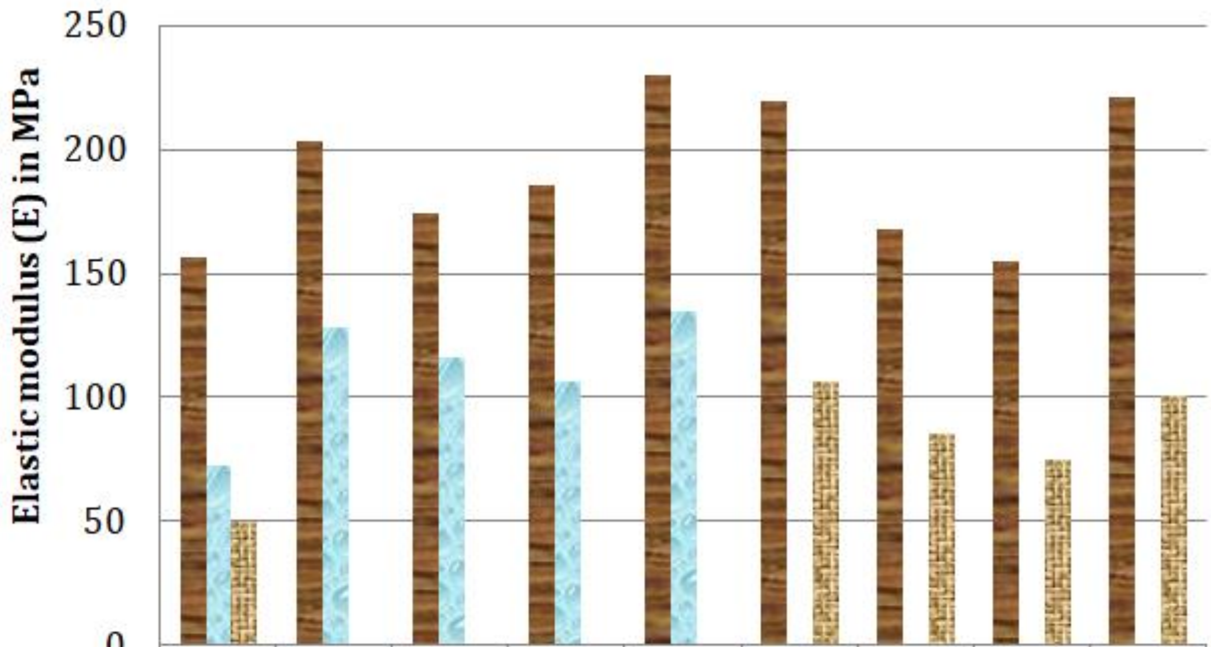


	S1	S2	S3	S4	S5	S6	S7	S8	S9
WBM gr III	161	212	192	180	208	175	143	141	169
WBM gr II	142	189	173	158	191	156	137	131	152
GSB	105	125	120	111	129	113	93	89	110
Sand soling	67	94	87	82	102	--	--	--	--
Subgrade	49	--	--	--	--	68	59	57	65

The sections reinforced with 700 gsm (S2 in CS – I & S6 in CS - II) have higher mean stiffness and elastic modulus

The increased modulus is attributed to the accelerated in-plane drainage due to the presence of the coir geotextile

Elastic Modulus using DCP

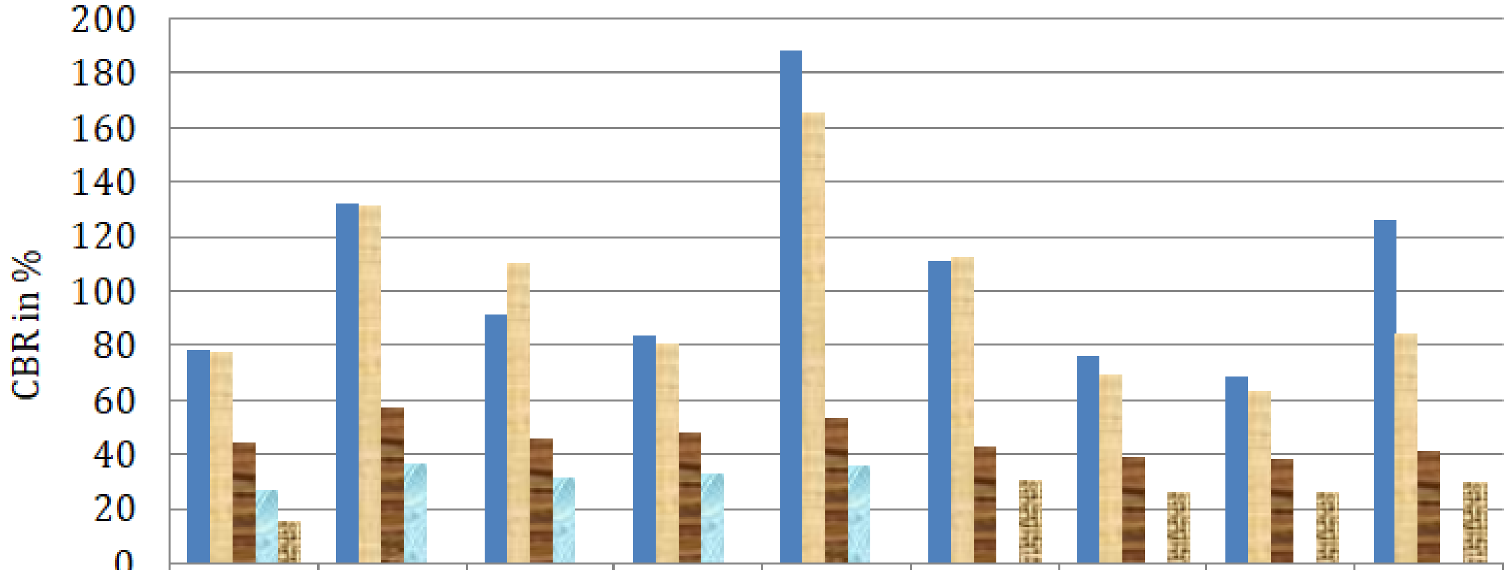


	S1	S2	S3	S4	S5	S6	S7	S8	S9
GSB	156	204	174	185	230	220	168	155	221
Sand soling	72	128	115	106	134	--	--	--	--
Subgrade	50	--	--	--	--	106	85	75	100

Reasonable increment in CBR and modulus values of the GSB compared to the control section

Pattern followed by the sections with similar layer thicknesses and varying geotextile widths is the same as that obtained from the geogauge results

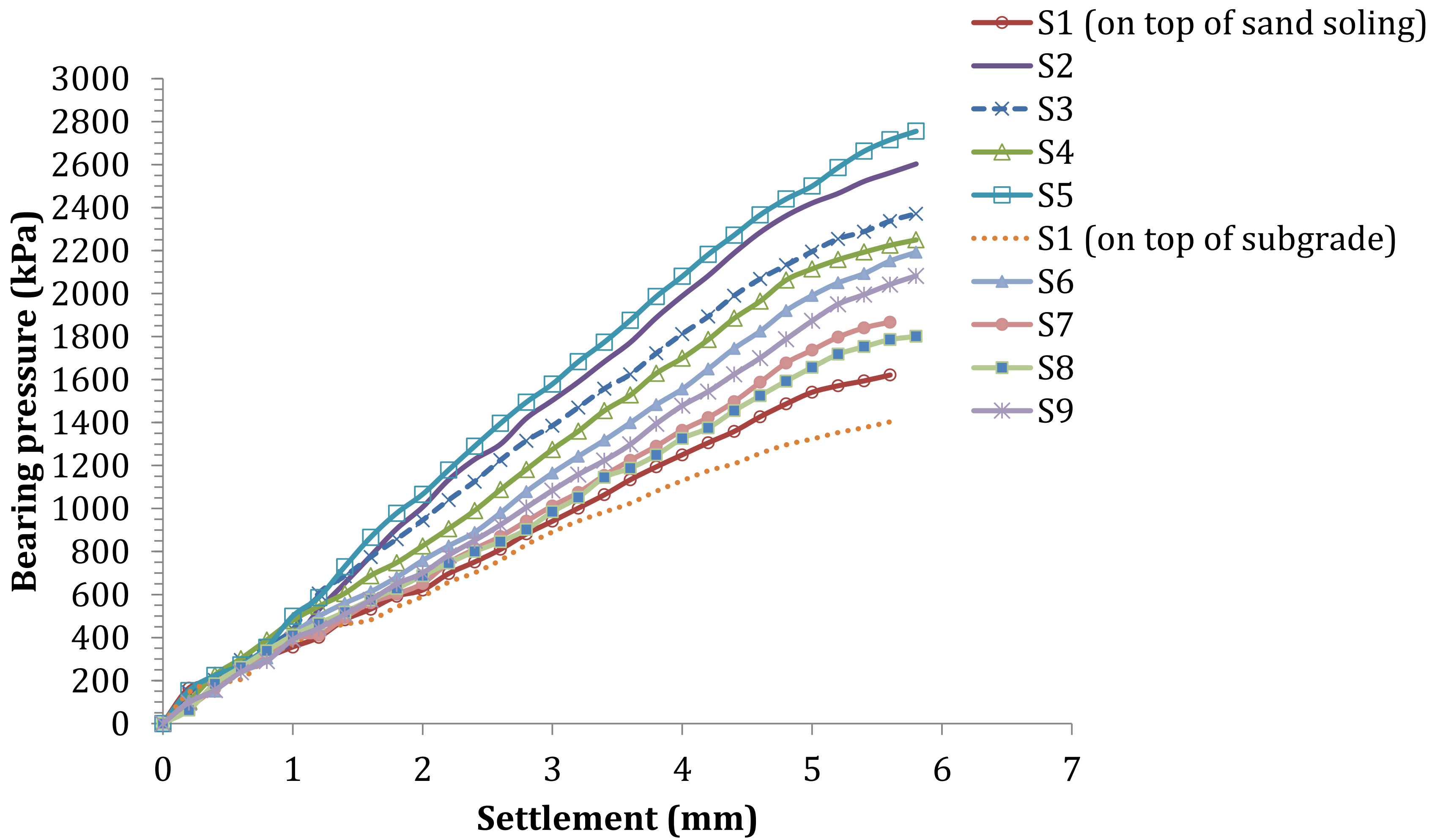
Field CBR Test Results



	S1	S2	S3	S4	S5	S6	S7	S8	S9
WBM gr III	78	133	91	84	188	111	76	69	126
WBM gr II	77	131	110	81	166	112	70	63	84
GSB	44	57	46	48	53	43	39	38	41
Sand soling	27	37	32	33	36	--	--	--	--
Subgrade	15	--	--	--	--	31	26	26	30

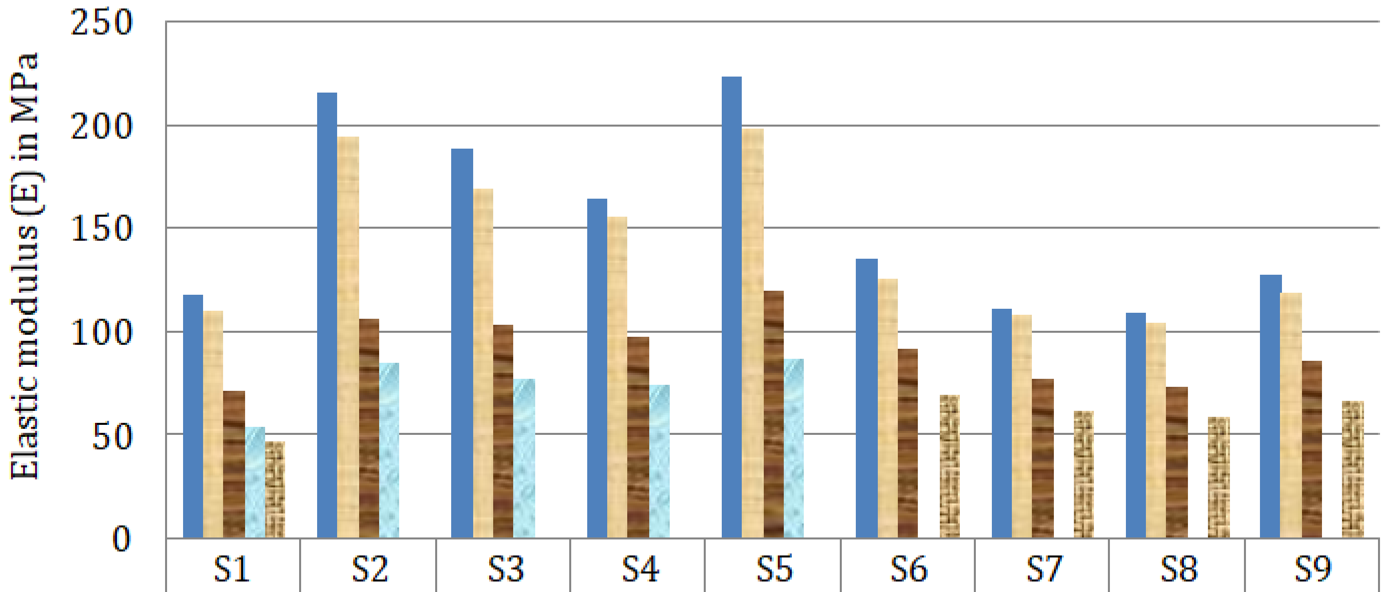
The increment in the CBR due to the subgrade stabilization is reflected in all the layers of the pavement

Field Plate Load Test Results



Bearing pressure Vs. Settlement

Elastic Modulus using Static Load Plate Test



	S1	S2	S3	S4	S5	S6	S7	S8	S9
WBM gr III	118	217	189	165	224	136	112	109	128
WBM gr II	110	194	169	156	198	126	108	104	119
GSB	72	107	103	97	120	92	77	74	86
Sand soling	55	85	78	75	87	--	--	--	--
Subgrade	47	--	--	--	--	70	62	59	66

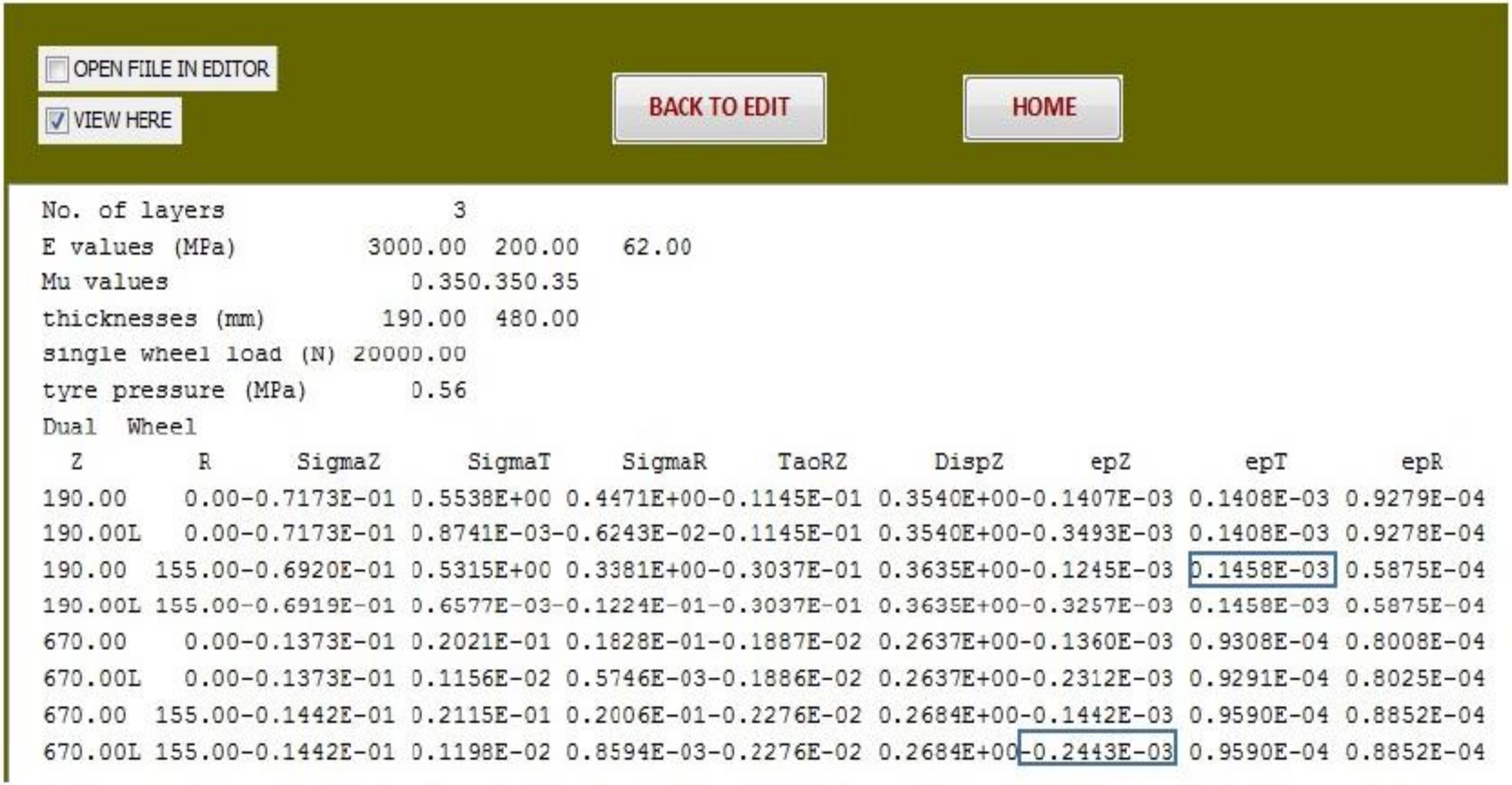
Subgrade of all the coir geotextile reinforced sections resulted in higher elastic modulus than the control section

Same trend is reflected for all the other structural layers of all the reinforced sections, except the 400 gsm reinforced sections of CS II

Multilayer Analysis by IITPAVE

- Linear elastic analysis was carried out
- Average contact pressure - 560 kPa
- A multilayer pavement section was modeled and analysed using a circular loaded area
- The structure was subjected to load from single axle with dual tyre of a truck of 40 kN distributed over a circular area of radius 0.15 m
- Poisson’s ratio of 0.35 for all the layers
- Centre to centre spacing of the dual wheels along the Y-axis - 31 cm

Analysis using IITPAVE (contd.)




```
No. of layers                  3
E values (MPa)           3000.00  200.00   62.00
Mu values                   0.350.350.35
thicknesses (mm)          190.00  480.00
single wheel load (N) 20000.00
tyre pressure (MPa)         0.56
Dual  Wheel
```

Z	R	SigmaZ	SigmaT	SigmaR	TaoRZ	DispZ	epZ	epT	epR
190.00	0.00	-0.7173E-01	0.5538E+00	0.4471E+00	-0.1145E-01	0.3540E+00	-0.1407E-03	0.1408E-03	0.9279E-04
190.00L	0.00	-0.7173E-01	0.8741E-03	-0.6243E-02	-0.1145E-01	0.3540E+00	-0.3493E-03	0.1408E-03	0.9278E-04
190.00	155.00	-0.6920E-01	0.5315E+00	0.3381E+00	-0.3037E-01	0.3635E+00	-0.1245E-03	0.1458E-03	0.5875E-04
190.00L	155.00	-0.6919E-01	0.6577E-03	-0.1224E-01	-0.3037E-01	0.3635E+00	-0.3257E-03	0.1458E-03	0.5875E-04
670.00	0.00	-0.1373E-01	0.2021E-01	0.1828E-01	-0.1887E-02	0.2637E+00	-0.1360E-03	0.9308E-04	0.8008E-04
670.00L	0.00	-0.1373E-01	0.1156E-02	0.5746E-03	-0.1886E-02	0.2637E+00	-0.2312E-03	0.9291E-04	0.8025E-04
670.00	155.00	-0.1442E-01	0.2115E-01	0.2006E-01	-0.2276E-02	0.2684E+00	-0.1442E-03	0.9590E-04	0.8852E-04
670.00L	155.00	-0.1442E-01	0.1198E-02	0.8594E-03	-0.2276E-02	0.2684E+00	-0.2443E-03	0.9590E-04	0.8852E-04

Results of Field Tests

Test section		Subgrade Elastic Modulus E (Mpa)			Modulus Improvement Factor (MIF)		
		Geogauge	DCP	Plate load test	Geogauge	DCP	Plate load test
Control section		48.5	49.9	46.9	--	--	--
Subgrade reinforced with	CGT1	68.5	106.0	69.8	1.41	2.00	1.41
		71.8	100.5	66.0	1.48	2.12	1.49
	CGT2	59.0	85.0	61.5	1.22	1.50	1.25
		61.0	74.9	58.7	1.26	1.70	1.31

Design Example

Step 1: Subgrade CBR = 3%

Step 2: Design traffic = 0.06 – 0.1 msa

Step 3: Conventional pavement section for 3-4% CBR as per IRC: SP: 72-2015

GSB = 175 mm; WBM = 75 mm; WBM gr III = 75 mm

Step 4: Elastic modulus for different layers of conventional section

Subgrade = 30 MPa (as per IRC 37:2018, E = CBR*10)

GSB = 61.3 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)^{0.45}*E_{Support}$)

Base = 116.87 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)^{0.45}*E_{Support}$)

Step 5: Determination of modulus improvement factor (MIF)

$$E_{Reinforced\ Subgrade} = MIF*E_{Unreinforced\ Subgrade}$$

As per Geogauge test results, MIF = 1.41-1.48 (CGT1); 1.22-1.26 (CGT2)

As per Plate load test results, MIF = 1.41-1.49 (CGT1); 1.25-1.31 (CGT2)

As per DCP results, MIF = 2.0-2.12 (CGT1); 1.5-1.7 (CGT2)

For safer side, adopting the least MIF obtained from Geogauge test results,

MIF for subgrade reinforced with 700 gsm mass density = 1.41

MIF for subgrade reinforced with 400 gsm mass density = 1.22

Design Example

Step 6: Elastic modulus for different layers of coir geotextile reinforced section

For CGT1 geotextile reinforced section,

Subgrade = MIF * 30 MPa = 42.3 MPa

GSB = 86.44 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)0.45*E_{Support}$)

Base = 164.82 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)0.45*E_{Support}$)

For CGT2 geotextile reinforced section,

Subgrade = MIF * 30 MPa = 36.6 MPa

GSB = 74.79 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)0.45*E_{Support}$)

Base = 142.61 MPa (as per IRC 37:2018, $E_{Granular\ layer} = 0.2*(h)0.45*E_{Support}$)

Design Example

Step 7: Determination of design thickness of different layers of reinforced section using IITPAVE

Using the Elastic modulus values computed above for conventional section and Poisson's ratio = 0.35,

The maximum vertical compressive strain at the top of subgrade is ε_v = 0.00238;

Design for CGT1 geotextile reinforced section:

Using the Elastic modulus values computed for 700 gsm geotextile reinforced section and Poisson's ratio = 0.35,

For same section adopted for conventional design as per IRC: SP:72-2015,

i.e. Base = 150 mm and GSB = 175 mm,

ε_{v1} = 0.00169 ; Since $\varepsilon_{v1} < \varepsilon_v$ the section is safe.

Design Example

For 25 mm reduction in GSB in the conventional design as per IRC: SP:72-2015,

i.e. Base = 150 mm and GSB = 150 mm,

$$\varepsilon_{v2} = 0.00192$$

Since $\varepsilon_{v2} < \varepsilon_v$ the section is safe.

For 50 mm reduction in GSB in the conventional design as per IRC: SP:72-2015,

i.e. Base = 150 mm and GSB = 125 mm,

$$\varepsilon_{v3} = 0.00223$$

Since $\varepsilon_{v3} < \varepsilon_v$ the section is safe.

For 75 mm reduction in GSB in the conventional design as per IRC: SP:72-2015,

i.e. Base = 150 mm and GSB = 100 mm,

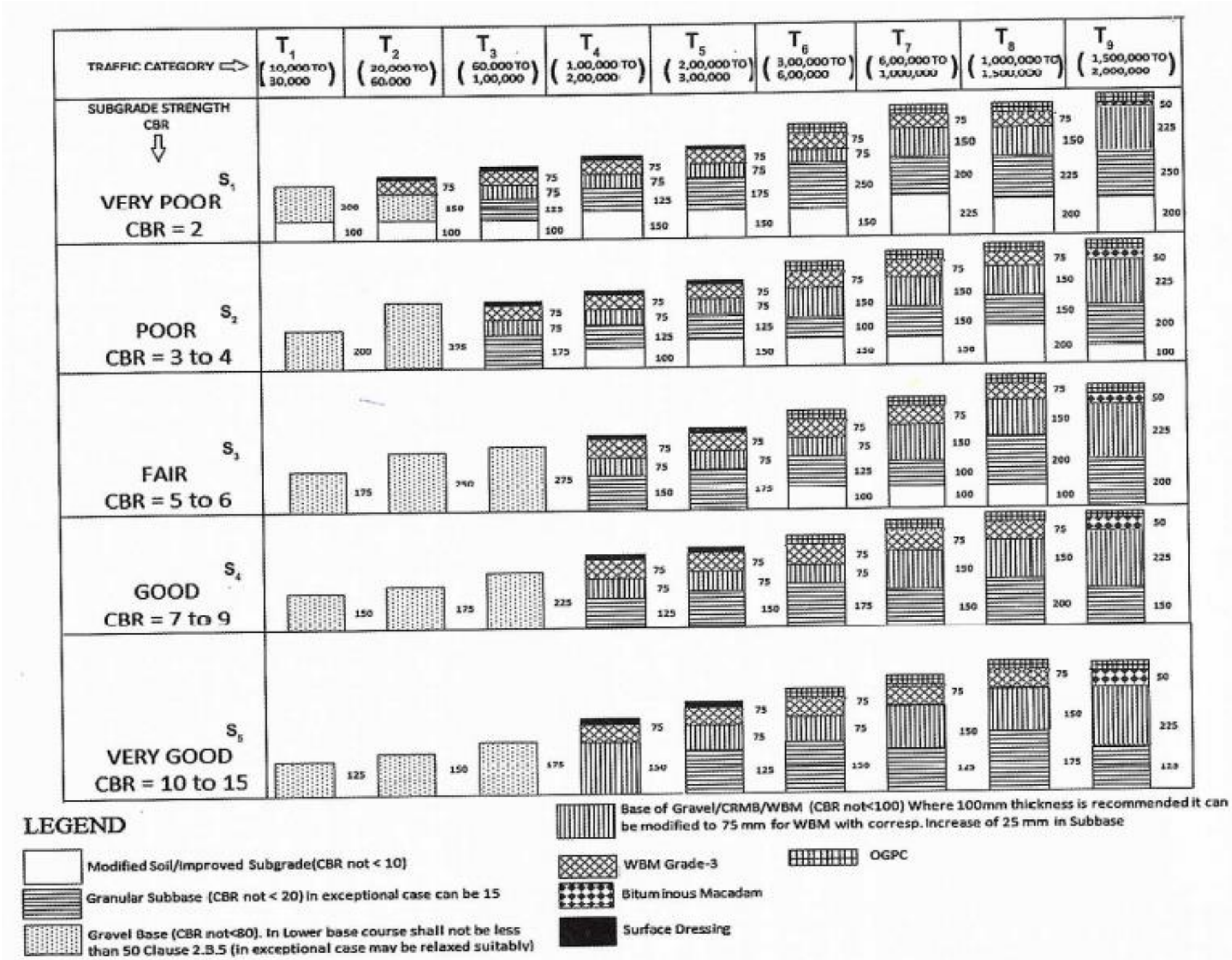
$$\varepsilon_{v4} = 0.00254$$

Since $\varepsilon_{v4} > \varepsilon_v$ the section is not safe.

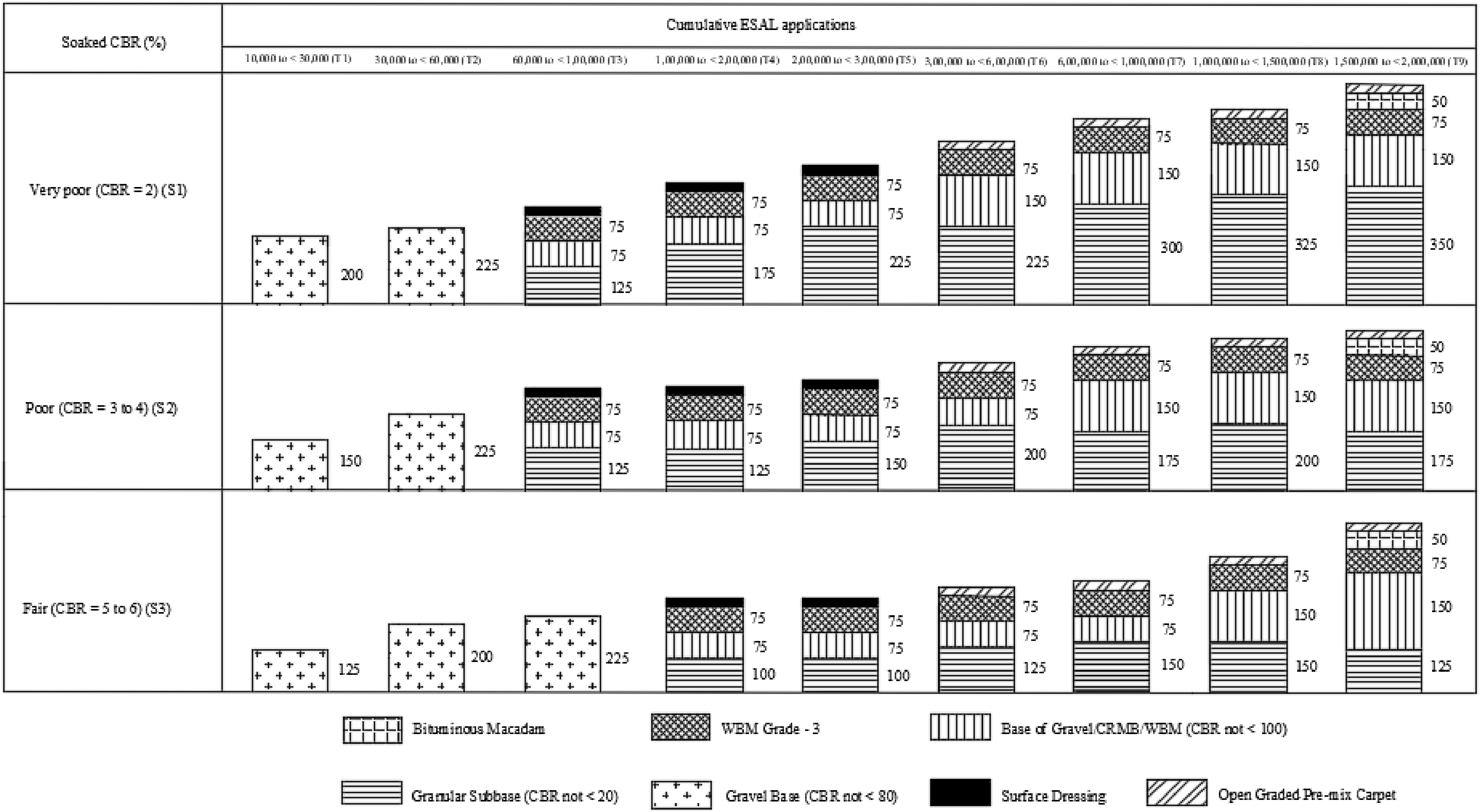
Hence the design thickness is

WBM III = 75 mm, WBM II= 75 mm and GSB = 125 mm

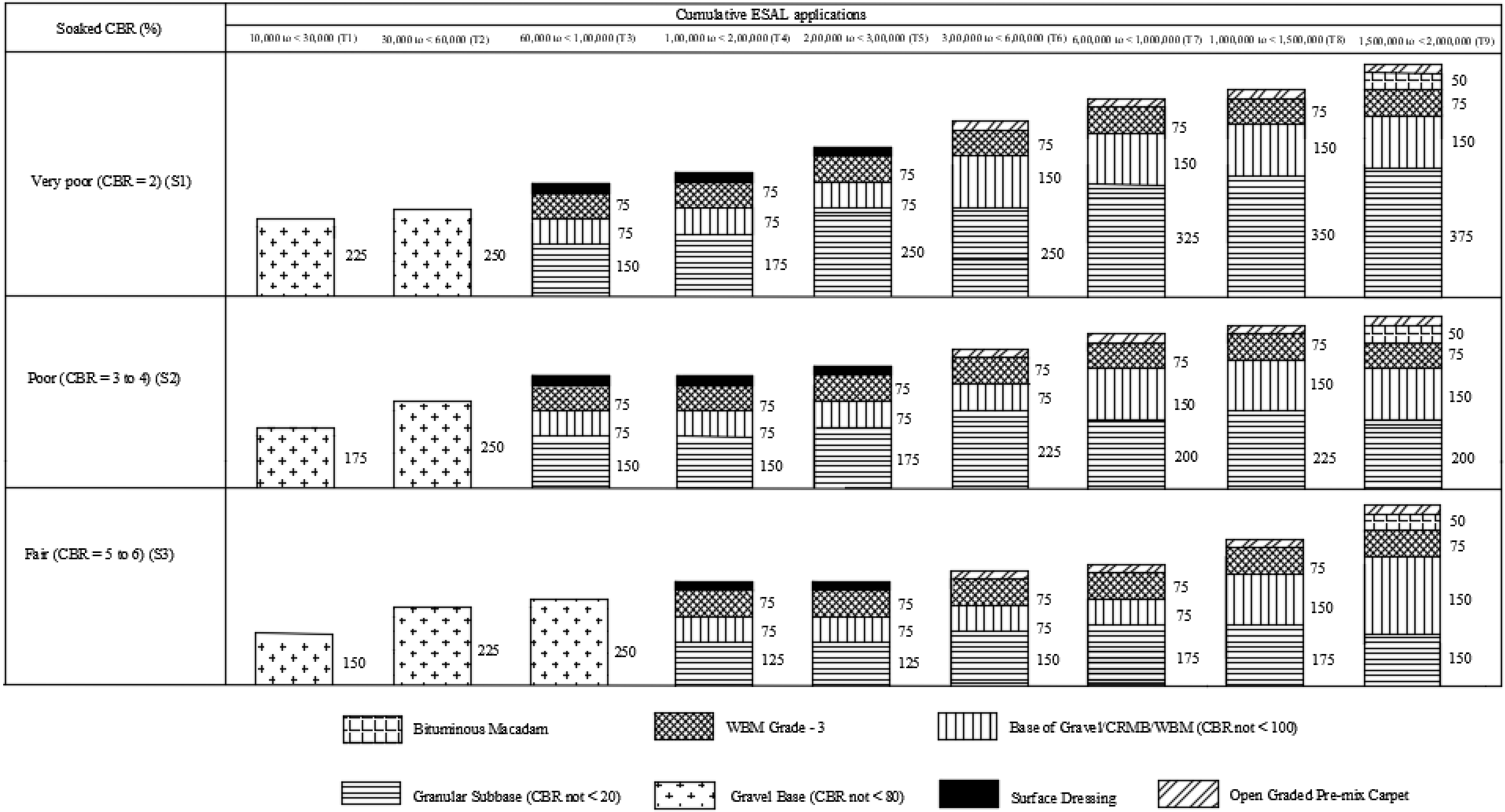
Design Template as per IRC SP: 72 (2015)



Design Template for CGT1 (700 gsm)



Design Template for CGT2 (400 gsm)



Pavement Thickness Reduction for Coir Geotextile Sections

Subgrade CBR = 2 %

Traffic category	Pavement thickness for control section (mm)	Pavement thickness for coir geotextile reinforced section (mm)		Thickness reduction (%)	
		CGT1	CGT2	CGT1	CGT2
T1	300	200	225	33	25
T2	325	225	250	31	23
T3	375	275	300	27	20
T4	425	325	325	24	23
T5	475	375	400	21	16
T6	550	450	475	18	14
T7	650	525	500	19	23
T8	650	550	435	15	12
T9	725	625	650	14	10

Construction of Coir Geotextile Reinforced Roads

Preparation of subgrade

Construction of Coir Geotextile Reinforced Roads

Stiffness Determination

Field Density Determination

Construction of Coir Geotextile Reinforced Roads

Laying of Coir Geotextile

Pinning the edges of geotextile

Construction of Coir Geotextile Reinforced Roads

Laying & Compaction of GSB

Laying & Compaction of Base Layer

Construction of Coir Geotextile Reinforced Roads

Laying of Premix Concrete

Finished Road

Thank You !!