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Economic Evaluation of Pavement: Using Coconut Coir

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Abstract — *Development of roads plays an important role in development of a nation. Flexible pavement often faces problems like cracking and rutting due to frequent traffic loads. Therefore these problems are to be tackled in order to improve the performance and serviceability of road pavements. Our main focus is on the studies and suitability of coconut coir which is a naturally available material in abundance as waste of coconut and can be used as reinforcement material on surface mixes.*

Marshall Method of mix design was adopted for the mixes and the optimum bitumen content, fibre content and fibre length are determined for coir fibre reinforced bituminous mixes and their performance is analyzed. An Optimum Bitumen content 5.25%, Optimum Fibre content 0.6% and Fibre Length 16.25 mm is obtained after analysis. On studying the Marshall parameters, it is found that the addition of Coir Fibre to Bituminous Coarse contributes significantly in improving the performance of the mix.

Keywords: *Bitumen, Coir Fibre, Marshall Mix Design, Bituminous Coarse, Stability and Flow.*

I. INTRODUCTION

A pavement structure can be designed either as a flexible pavement or a rigid pavement based on its structural behavior, with flexible pavements being widely preferred in India due to its advantages over rigid pavements and economy. Flexible pavements have low or negligible flexural strength and are rather flexible in their structural action under the loads. These pavements are layered structures with the following component layers. The layered pavement structure transmits vertical or compressive stresses to the lower layers by grain to grain transfer through the points of contact in the granular structure with strong graded aggregates and should transfer the compressive stresses to a wider area. In light of the above factors, it can be learnt that bituminous mix is one of the best flexible pavement layer materials. Bituminous mix is generally used as a surface course and wearing course in flexible pavements since it is necessary that the wearing course must provide a smooth riding surface that is dense and at the same time take up wear and tear due to traffic.

II. OBJECTIVE

- Determine property of Coconut Coir.
- To determine various mix proportions of coconut coir with bitumen.
- To compare the properties of bituminous mix specimen with the properties of coated aggregates.
- Determine Benefit Cost Ratio.

III. MATERIAL, ITS PROPERTIES & CHARACTERISTICS

3.1 BITUMEN:

A black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation. It is used for road surfacing and roofing.

3.1.1 Characteristics

Adhesion, Resistance to water, Hardness, Viscosity and Flow, Softening Point and Ductility.

Fig. 1 Bitumen

3.2 AGGREGATE:

A material or structure formed from a mass of Fragments or particles loosely compacted together.

Fig. 2 Aggregate

3.2.1 Characteristics

Composition, Size & Shape, Surface Texture, Bulk Density, Bulking of Sand, Fineness Modulus, Surface Index, Crushing Value, Impact Value, Abrasion Value of Aggregate.

3.3 COCONUT COIR:

Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. The individual fibre cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls. Each cell is about 1 mm (0.04 in) long and 10 to 20 µm (0.0004 to 0.0008 in) in diameter fibre are typically 10 to 30 cm (4 to 12 in) long.

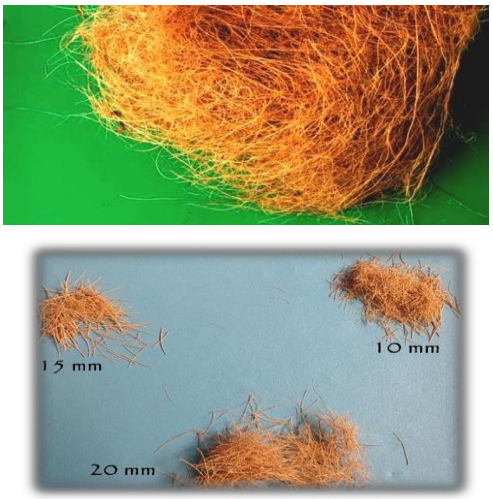

Fig. 3 Coconut Coir

3.3.1 Characteristics

The coir fibre is relatively waterproof, and is one of the few natural fibre resistant to damage by saltwater. Fresh water is used to process brown coir, while seawater and fresh water are both used in the production of white coir

3.3.2 Types of Coconut Fibre

When coconut fibre is extracted from matured coconuts. They are naturally brown in colour having a strong and thick nature and good abrasion resistance. This fibre is called **Brown Fibre**.
When coconut fibre is extracted from immature coconuts. They are naturally white in colour having smooth and fine soft touch properties and it is also weaker than the brown fibre. This fibre is called **White Fibre**.

IV. TEST RESULTS

4.1 BITUMINOUS TEST RESULTS

Property	Value
Penetration (mm)	76.1
Specific Gravity (kg/m3)	1.02
Softening Point (°C)	45
Ductility (mm)	>100

Table 1. Bituminous Test Results

4.2 AGGREGATE TEST RESULTS

Property	20mm	10mm	Stone Dust
Specific Gravity kg/m3	2.73	2.97	2.9
Impact Value	5.22 (Exceptional Strong)	4.39 (Exceptional Strong)	-

Table 2. Aggregate Test Results

4.3 GRADATION OF PROPORTIONED BITUMINOUS MIX BC-I GRADE

IS sieve in mm	Percentage Passing					
	20 mm	10 mm	Dust (mm)	Proportioned Value	Required Value	Acceptable Range
26.5	100	100	100	100	100	100
19	76.89	100	100	97.5	95	90 - 100
13.2	15.04	100	100	74	69	59 - 79
9.5	0.58	55.2	100	67	62	52 - 72
4.75	0	1.2	99.86	50	45	35 - 55
2.36	0	0.65	96.44	40	36	28 - 44
1.18	0	0.64	55.26	30.5	27	20 - 34
0.6	0	0.64	33.92	24	21	15 - 27
0.3	0	0.02	27.69	17.5	15	20 – 10
0.15	0	0.06	13.93	11	9	13 – 5
0.075	0	0.05	8.08	6.5	5	2 – 8
Proportion (%)	**0.33**	**0.22**	**0.45**			

Table 3. Gradation of Proportioned Bituminous Mix BC-I Grade

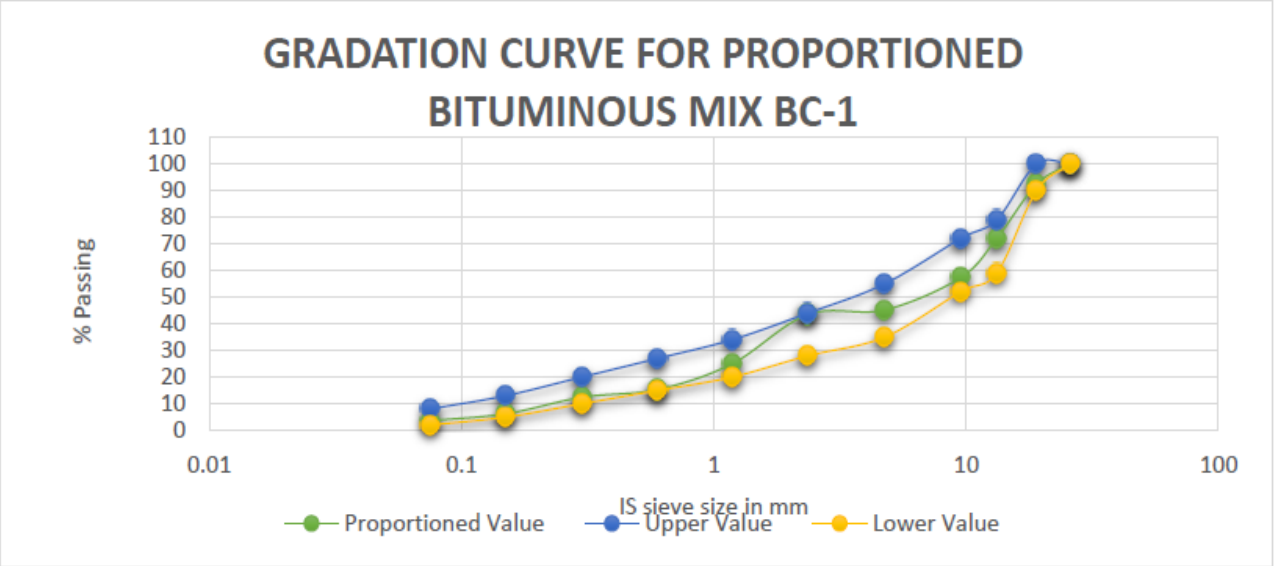

Fig. 4 GRAPH: Gradation Curve for Proportioned Bituminous Mix BC-I

4.4 BITUMEN MIXES TEST RESULTS

Sr. No.	20 mm	10 mm	Stone Dust	% Bitumen	Wt. of Bitumen (g)	Total Mix (g)	Bulk Spec. Gravity	Theoretical Spec. Gravity	P. Load	P. Displacement	Av	VFB
1	396	264	540	5	60	1260	2.37	2.63	**5.5**	4.2	9.78	33.82
2	396	264	540	5	60	1260	2.61		**6.39**	2.72		
3	396	264	540	5	60	1260	2.43		**7.42**	3.15		
4	396	264	540	5.5	66	1266	2.47	2.61	**11.31**	6.43	5.3	50.89
5	396	264	540	5.5	66	1266	2.47		**11.06**	5.79		
6	396	264	540	5.5	66	1266	2.47		**11.4**	5.96		
7	396	264	540	6	72	1272	2.46	2.59	**11.55**	6.27	4.94	54.81
8	396	264	540	6	72	1272	2.48		**14.13**	3.54		
9	396	264	540	6	72	1272	2.47		**13.86**	3.43		
10	396	264	540	6.5	78	1278	2.5	2.57	**12.5**	5.28	2.83	69.65
11	396	264	540	6.5	78	1278	2.51		**14.08**	5.77		
12	396	264	540	6.5	78	1278	2.51		**14.2**	5.81		

Table 4. Bitumen Mixes Test Results

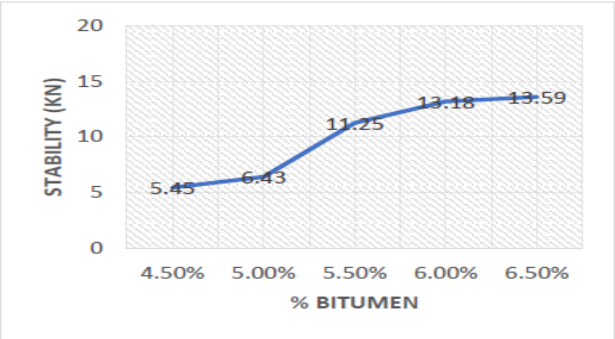

Fig. 5 GRAPH: Stability of Bitumen Mixes

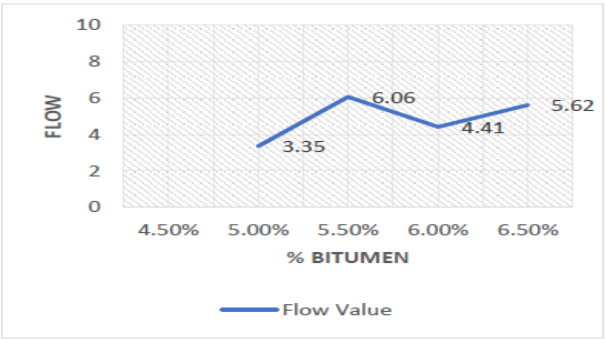

Fig. 6 GRAPH: Flow Value of Bitumen

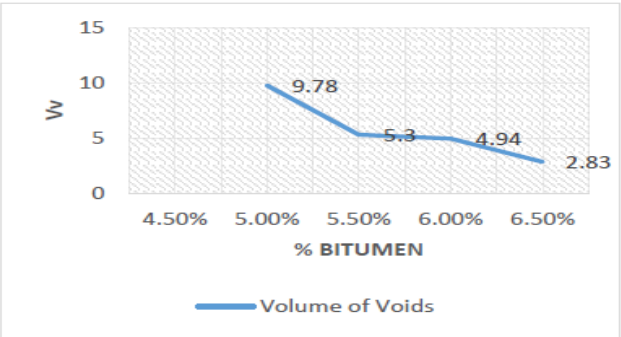

Fig. 7 GRAPH: Volume of Voids

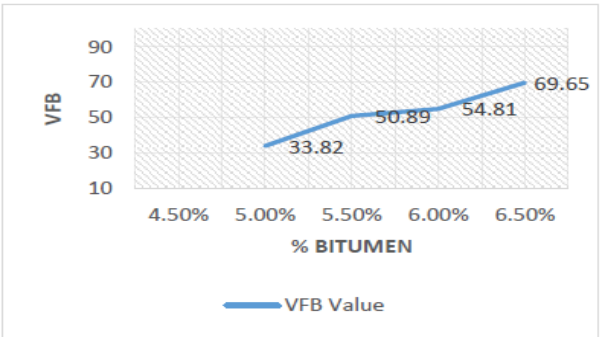

Fig. 8 GRAPH: Voids in Mineral Aggregate

4.5 OPTIMUM BITUMEN CONTENT

Parameter	Value	Corresponding Bitumen Content (%)
Max. Stability	13.59 KN	6.5
Min. Flow	3.43 mm	5
Av	5.3	5.5
Mean VFB	52.29	5.5
OBC		**5.625**

Table 5. Optimum Bitumen Content

4.6 BITUMINOUS MIXES WITH COIR FIBRE TEST RESULTS

Sr. No.	Total Aggregate	% Bitumen	Wt. of Bitumen (gram)	% Coir	Wt. of Coir (gram)	Length of Fibre (mm)	Total Mix (gram)	Bulk Specific Gravity	Theoretical Specific Gravity	P. Load	P. Displacement	AV	VFB
1	1200	5	60	0.3	3.87	10	1263.87	2.3864	2.6171	14.75	4.92	8.8147	36.1931
2	1200	5	60		3.87	10	1263.87	2.3522	2.6171	15.05	4.92	10.1203	33.0680
3	1200	6	72		3.816	10	1275.82	2.2903	2.5793	14.26	3.8	11.2032	34.8771
4	1200	6	72		3.816	10	1275.82	2.4081	2.5793	15.8	4.96	6.6357	47.4844
5	1200	5	60		3.87	15	1263.87	2.4257	2.6171	16.18	5.71	7.3126	40.6086
6	1200	5	60		3.87	15	1263.87	2.3666	2.6171	17.11	4.93	9.5723	34.3114
7	1200	6	72		3.816	15	1275.82	2.4023	2.5793	17.16	5.31	6.8622	46.6483
8	1200	6	72		3.816	15	1275.82	2.4007	2.5793	15.19	4.25	6.9223	46.4313
9	1200	5	60		3.87	20	1263.87	2.4089	2.6171	16.51	4.13	7.9556	38.5931
10	1200	5	60		3.87	20	1263.87	2.3974	2.6171	17.38	4.54	8.3918	37.3360
11	1200	6	72		3.816	20	1275.82	2.3976	2.5793	18.02	3.22	7.0420	46.0051
12	1200	6	72		3.816	20	1275.82	2.4094	2.5793	16.56	3.45	6.5843	47.6781
13	1200	5	60	0.5	6.3	10	1266.3	2.3980	2.6087	16.51	3.96	8.0763	38.2368
14	1200	5	60		6.3	10	1266.3	2.3982	2.6087	17.16	3.78	8.0688	38.2589
15	1200	6	72		6.36	10	1278.36	2.4057	2.5709	15.19	5.87	6.4245	48.2916
16	1200	6	72		6.36	10	1278.36	2.4156	2.5709	9.28	5.26	6.0394	49.8362
17	1200	5	60		6.3	15	1266.3	2.3892	2.6087	17.29	4.15	8.4159	37.2691
18	1200	5	60		6.3	15	1266.3	2.3967	2.6087	18	3.69	8.1281	38.0862
19	1200	6	72		6.36	15	1278.36	2.4119	2.5709	18.02	3.15	6.1835	49.2467
20	1200	6	72		6.36	15	1278.36	2.4090	2.5709	18.6	3.92	6.2964	48.7947
21	1200	5	60		6.3	20	1266.3	2.3986	2.6087	18.9	3.26	8.0541	38.3021
22	1200	5	60		6.3	20	1266.3	2.4031	2.6087	17.26	3.12	7.8834	38.8094
23	1200	6	72		6.36	20	1278.36	2.4133	2.5709	15.31	4.28	6.1303	49.4625
24	1200	6	72		6.36	20	1278.36	2.4003	2.5709	16.12	4.05	6.6350	47.4870

25	1200	5	60	0.7	8.82	10	1268.82	2.3908	2.6001	13.56	5.1	8.0522	38.3074
26	1200	5	60		8.82	10	1268.82	2.3826	2.6001	14.2	4.52	8.3665	37.4068
27	1200	6	72		8.904	10	1280.9	2.3840	2.5627	14.1	4.2	6.9721	46.2528
28	1200	6	72		8.904	10	1280.9	2.3810	2.5627	13.4	4.8	7.0887	45.8408
29	1200	5	60		8.82	15	1268.82	2.3936	2.6001	12.1	4.98	7.9417	38.6346
30	1200	5	60		8.82	15	1268.82	2.4032	2.6001	12.56	4.56	7.5727	39.7684
31	1200	6	72		8.904	15	1280.9	2.3904	2.5627	12.4	5.2	6.7206	47.1674
32	1200	6	72		8.904	15	1280.9	2.3810	2.5627	13.15	4.12	7.0887	45.8408
33	1200	5	60		8.82	20	1268.82	2.3885	2.6001	11.8	6.05	8.1402	38.0509
34	1200	5	60		8.82	20	1268.82	2.3913	2.6001	10.3	5.55	8.0298	38.3734
35	1200	6	72		8.904	20	1280.9	2.3791	2.5627	12.53	5.34	7.1622	45.5832
36	1200	6	72		8.904	20	1280.9	2.3969	2.5627	14.29	6.2	6.4681	48.1225

Table 6. Optimum Bitumen Content according to % of Coir

4.7 OPTIMUM FIBRE CONTENT

Sr. No.	Coir (%)	OBC	Stability (KN)	Flow (mm)	Vv	VFB
1	0.3	5.5	17.29	3.33	8.11	42.24
2	0.5	5.75	18.31	3.19	7.19	43.5
3	0.7	5.5	13.88	4.5	7.46	42.44

Table 7. Optimum Bitumen Content according to % of Coir

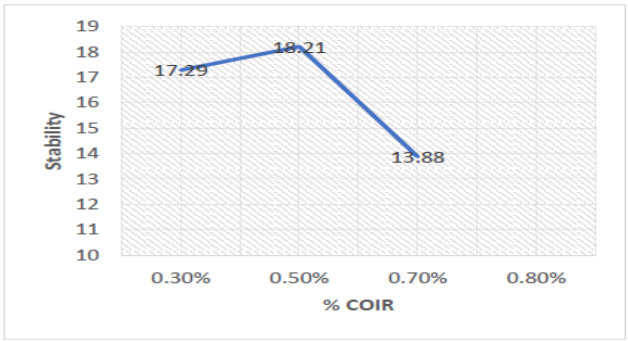

Fig. 9 GRAPH: Stability of Bitumen Coir Mixes

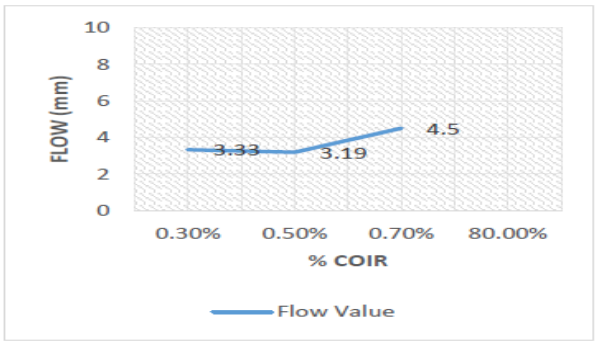

Fig. 10 GRAPH: Flow Value of Bitumen Coir Mixes

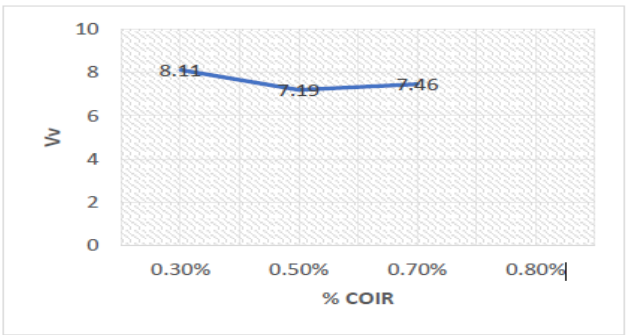

Fig. 11 GRAPH: Volume of Voids

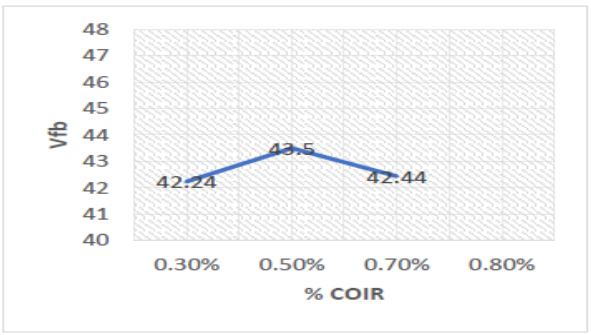

Fig. 12 GRAPH: Voids in Mineral Aggregate

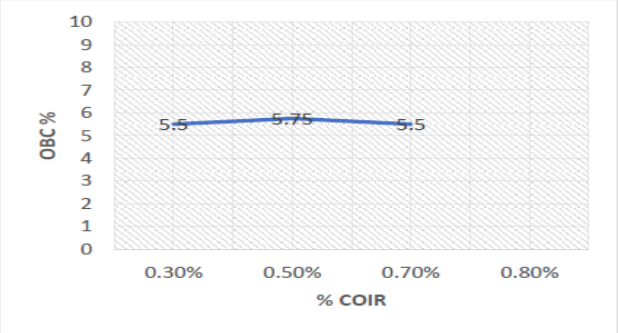

Fig. 13 GRAPH: Optimum Bitumen and Coir Content

4.8 OPTIMUM BITUMEN & COIR CONTENT & LENGTH OF FIBRE

Parameter	Value	Corresponding Bitumen Content (%)	Coir (%)	Coir Length (mm)
Max. Stability	18.31 KN	6	0.5	15
Min. Flow	3.12 mm	5	0.5	20
Av	7.57	5	0.7	15
Mean VFB	39.76	5	0.7	15
OBC		**5.25**	**0.6**	**16.25**

Table 8. Optimum Bitumen Content according to % of Coir

V. ADVANTAGES & DISADVANTAGES

5.1 ADVANTAGES OF COCONUT COIR IN BITUMINOUS MIXES FOR PAVEMENT CONSTRUCTION

- It is a 100% renewable resource
- Coconut coir is light in weight
- It is consistent in high quality
- Coconut coir is completely environmentally friendly
- Coconut coir never shrinks, cracks or produces crust
- Coconut coir is odourless, pleasant to handle, and uniform in composition

5.2 DISADVANTAGES OF BITUMINOUS MIXES

- Difficulty in mixing
- Ensuring attainment of desired stability of mix
- Cracking of bituminous surface
- Ensuring sufficient adhesion with the aggregates in the mix

VI. CONCLUSION

We aspire to get a **Higher Tensile Strength** compared to the normally used Combination of Bitumen & Aggregate. Benefit in cost, due to reduction of Bitumen Content. A Decrement in the **Air Void Ratio** and hence reduction in the **Rutting Effect** due to **Axial Loading**. Decrease in the **Internal Cracks** and **Fracture**.

An Optimum Bitumen content 5.25%, Optimum Fibre content 0.6% of total mix of bitumen and aggregate & Fibre Length of 16.25 mm is obtained after analysis.

As per the references for making an average road of a unit Sq. m which cost around Rupees **2500-3000 /- INR** & will last 2-3 years only. If its NH standard of roads, then it depends on the specifications & may cost on an average 4000 INR+ Sq. m

As per our Project & Calculations, with the utilization of Coconut Fibre, the cost is in the range of **1800-1900 /- INR for** a unit Sq. m, also there is a noticeable good result for tensile strength in comparison with the conventional bituminous mixes. Thus its life span can be also increased.

VII. REFERENCE

- Amit Tiwari, H.K. Mahiyar, Experimental study on stabilization of black cotton soil by fly ash, coconut coir fibre & crushed glass, International Journal of Engineering Technology and Advanced Engineering, Vol 4, Issue -11, 2014.
- R.R. Singh, Er. Shelly Mittal, importance of local subgrade soil for road construction by the use of coconut coir fibre, International journal of research in engineering and technology. Vol 3, Issue-5, 2014.
- Kundan Meshram, S.K. Mittal, P.K. Jain, P.K. Agarwal. Application of coir geotextile in rural roads construction on black cotton soil subgrade, International journal of engineering and innovative technology. Vol 3, Issue-4, 2013.
- Bairwa, R.L., Saxena, A.K. Effect of lime and fly ash on engineering properties of black cotton, International Journal of Emerging Technology and Advanced Engineering ,Vol. 3 Issue-11, 2013.
- V Rama Susheel Kumar , J Vikranth, Application of Coconut Coir and Fly ash in Sub grade strengthening, International Journal of Engineering and Science, Vol 3, Issue-12, December-2014.
- T Subramani, Experimental Investigations On Coir Fibre Reinforced Bituminous Mixes, International Journal of Engineering Research and Applications, Vol. 2, Issue-3, May-Jun 2012.

