Feasibility Study on Cement Treated Base and Sub Base layers of Service Roads - A Case Study on Khed Sinnar NH 50 Project

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Abstract – *It is a case study to know feasibility of cement treaded base roads in India for low cost development of roads. In India, due to massive infrastructure construction activities are taking place both in rural and urban area have caused scarcity of construction materials.. The pavement industry looks for ways of improving lower quality materials that are readily available for use in roadway construction. Cement/ lime treatment has become an accepted method for increasing the strength and durability of soils and marginal aggregates, reducing quantity of aggregates. Indian Roads Congress (IRC) developed a Special Publication (SP) for mix design of lime/cement treated base/subgrade. No pavement design guideline is presently available for cement/lime treated base. To overcome this problem, the objective of the present research work is to develop a pavement design chart using cement and lime stabilized base for rural roads with light to Medium traffic (Traffic level up to 5 million standard axles). Cement stabilized layers was used in service roads of NH 50. Service road of 22.6 Km was constructed using Cement treated base and sub-base layers. It not only saved money but also help to increase life cycle of road.*

***Key Words*: Cement Treated Base (CTB), Cement treated Sub base (CTSB), Pavement, Thickness, Cost, Stabilization.**

1. INTRODUCTION

Today, mostly existing rural roads in India are unpaved/low volume roads. Heavy rainfall and floods affect almost all these roads frequently. The roads are severely damaged due to flood, currents and wave action. This situation needs maintenance of these roads every year/frequently. These adverse effects together with inadequate compaction significantly impair the durability of these roads. The ultimate effect is comparatively low subgrade strength and eventually higher pavement thickness if paved roads are to be constructed. On the basis of this context, some treatment of locally available materials has become necessary for satisfactory and economic construction of roads in these regions.

Cement stabilized bases or lime stabilized sub-bases may be provided for the construction of rural roads for low volume/ light traffic. An increasing emphasis has been placed on the use of stabilized pavement materials in recent years. Through the use of stabilizing agents, low-quality materials can be economically upgraded to the extent that these may be effectively utilized in the pavement structure. Stabilized pavement materials are generally incorporated into the pavement structure as base courses and sub-bases. In a layered system of elastic materials, where the overlying layers have higher moduli of elasticity than underlying layers, tensile stresses are developed at the interfaces between the layered materials. This layered system analysis is commonly resumed to be applicable to a pavement where the stiffer materials are used in the upper layers. Since many stabilized materials are relatively weak in tension, any type of rational design procedure must take their tensile strength into account.

Indian Roads Congress prepared a Special Publication (IRC: SP-89-2010): Guidelines for Soil, Material Stabilization Using Cement, Lime and Fly Ash is useful for selecting proper stabilized materials based on available local soil.

Some control over the grading can be achieved by limiting the coefficient of uniformity to a minimum value of 5; however, it should preferably be more than 10. If the coefficient of uniformity lies below 5, the cost of stabilization will be high, and the maintenance of cracks in the finished roads would be expensive. If the plasticity of soil is high, there are usually sufficient clay minerals which can be readily stabilized with lime. Cement is more difficult to mix intimately with plastic materials, but this problem can be alleviated by pretreating the soil with approximately 2 percent lime. Tables 1 to Table 4 are the guidelines for selection of Stabilized materials for subgrade, sub-base and base course (IRC: SP: 89-2010).

1.1 NEED

Present service roads are less durable due to its less elasticity modulus, so by use of cement treated base it can be increased. Granular bases can carry less tonnage of loads but can withstand more tonnage of loads. As Design tonnage increases cost increases in Granular bases but not in the case of cement treated bases. When traffic is diverted from main Carriageway to Service road due to maintenance, cement treated bases can withstand more traffic load as compared to granular bases. CTB can handle leakage of water from other sources due to its good drainage properties. Improved Performance in Rutting and Fatigue Cracking compared to unstabilized granular base to cement treated base. It resists cyclic freezing, rain, and spring-weather damage, when compared with granular base of service road. Cement-treated base continues to gain strength with age even under traffic, when compared.

1.2 OBJECTIVE AND SCOPE

It is necessary to study the characteristics of properties of the material, testing its feasibility, the test on various parameters of material, strength etc. It will help to design the cement treated base and sub base layers for service road, to improve the strength properties of layers with addition of cement. The objective of the present study is to develop Comprehensive guidelines for pavement design for rural roads using CTB/CTSB.

Table -1: Gradation Requirement for Stabilized Materials

Sieve Size	Passing(%)			
	Grading I	Grading II	Grading III	Grading IV
75mm		100		
53mm	80	80-100	100	
45mm	95-100			
37.5mm				95-100
26.5mm		55-90	70-100	55-75
22.4mm	60-80			
11.2mm	40-60			
9.5mm		35-65	50-80	
4.75mm	25-40	25-55	40-65	10-30
2.36mm	15-30	20-40	30-50	
0.6 micron				
0.425 micron	8-22	10-35	15-25	
0.3 micron				
0.075 micron	0-8	3-10	3-10	0-10
7 Days UCS(Mpa)	6	4.5	1.5	0.75

Table -2: Material characteristics for Cement Modified Materials

Property	Specified Value
Liquid Limit (L.L)	<45%
Plasticity index(P.I)	<20%
Organic Content	2%
SO4 Content	0.20%
Water Absorption	<2%
10% Fine Value	>=50KN

2. METHODOLOGY

This section mainly depicts the flow process of the project and mix design process. The system of methods followed in a particular discipline is sketched below.

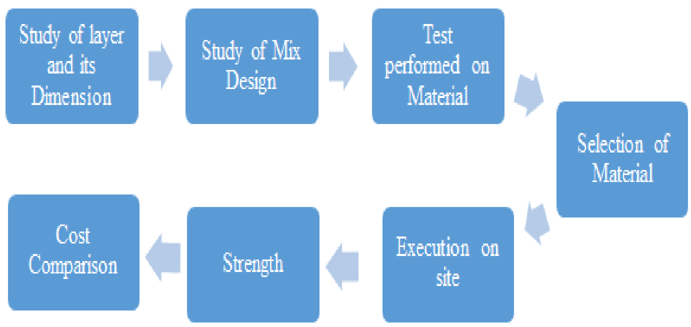

Fig -1: Methodology

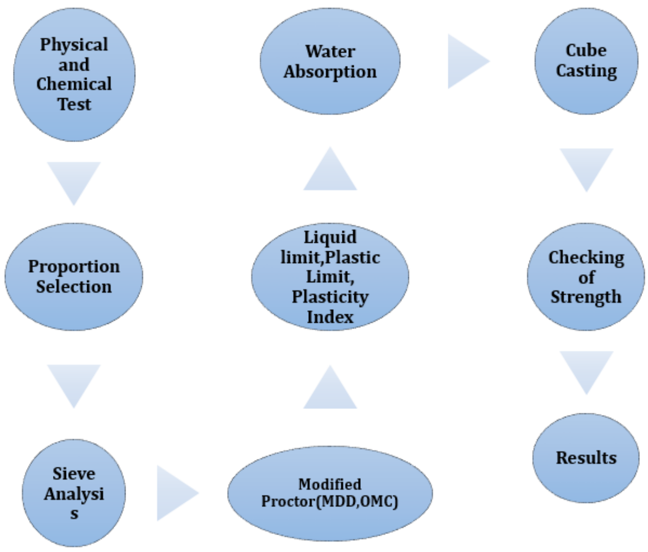

Fig -2: Process Cycle for CTB and CTSB

3. Tests on Materials

Table -3: Cement treated Sub Base

Sr no.	List of Experiments	Code Referred
1	Gradation of soil for Stabilisation with cement for cement treated sub base(Selection of Proportion)	MORTH -Table 400-4
2	Gradation of soil for Stabilisation with cement for cement treated sub base(Sieve Analysis)	MORTH -Table 400-5
Physical Properties		
3	Modified Proctor(M.D.D)	IS 2720(Part 8)
4	Modified Proctor(O.M.C)	IS 2720(Part 8)
5	Plasticity Index	IS 2720(Part 5)
6	Plasticity Modulus	IS 2720(Part 5)
7	Plasticity Product	IS 2720(Part 5)
8	Uniformity Coefficient	IRC 84 page 12, clause 3.1.2
9	10% Fines Value	IS 2386 (Part 4)
10	Water absorption(20mm)	IS 2386(Part 3)
11	Water absorption(10mm)	IS 2386(Part 3)
12	Soundness After 5 Cycles	ASTM D 559
13	Water absorption(C dust)	IS 2386(Part 3)
14	7 Day UCS	IRC SP 89-2010

Table -5: Cement treated base

Sr. no.	List of Experiments	Code Referred
1	Gradation of soil for Stabilisation with cement for cement treated sub base(Selection of Proportion)	MORTH -Table 400-4
2	Gradation of soil for Stabilisation with cement for cement treated sub base(Sieve Analysis)	MORTH -Table 400-5
Physical Properties		
3	Modified Proctor(Max. dry density)	IS 2720(Part 8)
4	Modified Proctor(Optimum Moisture Content)	IS 2720(Part 8)
5	Plasticity Index	IS 2720(Part 5)
6	Plasticity Modulus	IS 2720(Part 5)
7	Plasticity Product	IS 2720(Part 5)
8	Uniformity Coefficient	IRC 84 page 12,clause 3.1.2
9	Water absorption(20mm)	IS 2386(Part 3)
10	Water absorption(10mm)	IS 2386(Part 3)
11	Water absorption(Crushed dust)	IS 2386(Part 3)
12	Compressive Strength(Cement 4% by wt. of mix)	IS 516

Table -4: Cement

Sr. No.	Name of Experiments	Codes Referred
1	Fineness of Cement	IS 4031 Part 1
2	Normal Consistency of Cement	IS 4031 Part 4
3	Initial and Final Setting Time of Cement	IS 4031 Part 5
4	Compressive Strength of Cement Mortar Cubes	IS 4031 Part 7

4. MIX DESIGN

4.1 Mix Design of Cement Treated Base (CTB)

1. Physical and chemical testing of aggregate, cement, water.
2. Selection of Proportion of Material like 20mm, 10mm, dust and cement (% weight) to form CTB is done with the help of MORTH table 400-4.
3. Sieve Analysis of final CTB is done and compared with MORTH table 400-4.
4. Then, Modified Proctor test is done to determine Max. Dry Density (MDD) and Optimum Moisture Content with min cement percentage of CTB according to IS 2720 (Part 8).
5. Find Liquid Limit, Plastic Limit and Plasticity Index according to IS 2720 (part 5).
6. Plasticity Modulus and Product are determined according to IS 2720 (part 5).
7. Find Uniformity Coefficient as specified.
8. Water absorption of 20mm,10mm and dust is find out according to IS 2386 (part 3).
9. Then cubes are casted with the help of Vibro Hammer.
10. It is cured for 7 days and its strength is measured with the help of Compressive Testing Machine.
11. If all Results are found within limits as specified, then Design of CTB material is finalized.

4.2 Mix Design of Cement Treated Sub Base (CTB)

1. Physical and chemical testing of aggregate, cement, water.
2. Selection of Proportion of Material like GSB, dust and cement (% weight) to form CTSB is done with the help of MORTH table 400-4.
3. Sieve Analysis of final CTSB is done and compared with MORTH table 400-4.
4. Then, Modified Proctor test is done to determine Max. Dry Density (MDD) and Optimum Moisture Content of CTSB with min. cement content according to IS 2720 (Part 8).
5. Find Liquid Limit, Plastic Limit and Plasticity Index according to IS 2720 (part 5).
6. Plasticity Modulus and Product are determined according to IS 2720 (part 5).
7. Find Uniformity Coefficient as specified.
8. 10% Fines value is determined according to IS 2386 (Part 4)
9. Water absorption of material larger and less than 10mm in size is found out according to IS 2386 (part 3).
10. Then cubes are casted with the help of Vibro Hammer.
11. Cubes are cured for 7 days and its 7 days Unconfined Compressive Strength (UCS) is measured with the help of Compressive Testing Machine.
12. Two extra cubes are casted for Soundness Test. It is subjected to 12 cycles of wetting and drying consisting of immersion in water for 5 hours followed by drying at 71degree Celsius. After each cycle specimens are brushed with scratch wire brush (18-20 strokes on the sides and 4 strokes at each end). The loss in weight of brushed specimen is determined. Parallel test of volume and moisture changes of specimens after each cycle is recorded.
13. If all Results are found within limits as specified, then Design of CTSB material is finalized.

7. COST COMPARISON

Table -6: Width and Thickness Comparison

Conventional Service Road			Cement treated Road		
Layer	**Thickness**	**Width**	**Thickness**	**Width**	**Layer**
SDBC	30 mm	5.5 m	30 mm	5.5 m	SDBC
DBM	50 mm	5.5 m	100 mm	5.5 m	Aggregate layer
Wet mix macadam	250 mm	6.5 m	60 mm	6.5 m	Cement Treated Base
Granular Sub base	200 mm	7 m	200 mm	6.5 m	Cement Treated Sub Base

Table -7: BOQ Rates

LAYERS	RATES
Granular Sub Base (GSB)	1136 ₹ per Cum.
Wet Mix Macadam (WMM)	1296 ₹ per Cum.
Dense Bituminous Macadam (DBM)	9469 ₹ per Cum.
Semi Dense Bituminous Course (SDBC)	11010 ₹ per Cum.
Cement Treated Sub Base Course (CTSB)	1663 ₹ per Cum.
Cement Treated Base (CTB)	1736 ₹ per Cum.
Aggregate Layer (AG)	1296 ₹ per Cum.

Table -7: Comparison

Service Road with CTB				
Layers	**Thickness (mm)**	**Rates (₹)**	**Quantity in 1 Cum**	**Cost**
SDBC	30	11010	165	1816650
AG	100	1296	550	712800
CTB	60	1736	390	677040
CTSB	250	1663	1625	2702375
Total				₹ 5908865

Conventional Service Road				
Layers	**Thickness (mm)**	**Rates (Rs)**	**Quantity 1 Cum**	**Cost**
SDBC	30	11010	165	1816650
DBM	50	9469	275	2603975
WMM	125	1296	812.5	1053000
GSB	250	1136	1750	1988000
Total				₹ 7461625

Difference ₹ 7461625 – ₹ 5908865 = ₹ 1552760

6. CONCLUSIONS

1. Longer Life of pavements.
2. Speed of the Project Completion is accelerated.
3. Reduced Use of Aggregates.
4. Less local construction traffic due to fast construction.
5. Transportation/haulage is reduced.
6. Reduced Project Cost (approx. 15 lakhs per KM)
7. Reduced thickness of pavement.
8. Reduction of bitumen consumption due to strong Sub Base.
9. Aggregate consumption is less for the case of stabilized base compared to that of the conventional method.
10. Uniform distribution of Load in Cement treated service road as compared to conventional road.
11. Resistance against cracking and fatigue cracking.
12. Best option in low lying water clogged area.

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