IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

TECHNO-ECONOMICAL DESIGN OF FLEXIBLE PAVEMENT BASED ON THE STABILIZATION OF SOIL USING STONE DUST AS ADDITIVE

[1]DOMMARAJU SOMESH ,[2] K V ASHOK KUMAR,[3] T SURESH BABU

[1]M.Tech Student,[2] Asst Professor,[3] Professor

[1]Civil Engineering,

[1]Visvodaya Engineering College, Kavali,Nellore,Andhra Pradesh, India

Abstract: Due to rapid urbanization, industrialization and growth of population there is tremendous increase in construction activities, has led to scarcity of land with good bearing capacities thus forcing the construction over sites deemed unsuitable for such activities. To improve the geotechnical properties of soil of such sites soil stabilization methods are adopted. The cities and villages are coming closer there is fast growth of vehicles running on roads. There is shortage of land for construction of buildings, roads, highways and airfields. The land available may or may not be suitable for construction activities. The existing site conditions may or may not be sufficiently strong enough to withstand the load coming on it. In order to overcome these problems, ground improvement technique such as soil stabilization, soil reinforcement etc. are evolved. Stabilization is an effective alternative for improving soil properties, the engineering properties derived from stabilization vary widely due to heterogeneity in soil composition. The mechanical stabilization of soil proves to be cost effective and reliable. As the property of expansive soil proves to be suitable for mechanical stabilization, the cohesive natured clayey soil were chosen and checked for their geotechnical properties with other general soil characteristics by varying the content of stone dust. This thesis mainly presents the economics of the soil stabilization stone dust as additive at different percentages. The economics is calculated based on the present market rate prevailing at Hyderabad.

***Index Terms* –urbanization, Stabilization, additive, soil reinforcement.**

CHAPTER - 1

1.1 INTRODUCTION

The Greater Hyderabad Municipal Corporation (GHMC) was created in 2007 to oversee the civic infrastructure of the 18 "circles" of the city. This increased the area of Hyderabad from 175 square kilometers to 650 square kilometers, and the population grew by 87%. The GHMC has a population of 10 million, which makes it the 6th most populous urban agglomeration in India. GHMC's population has grown from 7.7 million in 2011, showing substantial growth. Hyderabad has an estimated population of 8.7 million with a population density of 18,480 people per square kilometer (47,000/sq mi).

Over the years engineers have tried different methods to stabilize soils that are subject to fluctuations in strength and stiffness properties as a function of fluctuation in moisture content. Stabilization can be derived from thermal, electrical, mechanical or chemical means. The first two options are rarely used. Mechanical stabilization, or compaction, is the densification of soil by application of mechanical energy.

CHAPTER - 2

2.0 LITERATURE REVIEW

The literatures were reviewed and found that various authors, used various materials to stabilize the weak soils to improve the strength of the soils. Their study indicates the improved CBR's.

Orekanti Eshwara Reddy et.al. (1) studied the effect of quarry dust on compaction properties of clay. For the study, they used the clayey soil and quarry dust collected from Madepalli, which is located in Krishnagiri district of Tamilnadu. The soil was replaced by quarry dust in the proportion of 10,20,30,40 and 50% based on the study they found that 30% replacement of soil by quarry dust is an optimum mix and is recommended for use in construction.

A.K. Sabot et.al. (2) Have carried out experimentation on effect of crusher dust lime and compaction properties of expansive soil. They have replaced expansive soil upto 70% (with increment of 10%) i.e. 10%, 20%, 30%, 40%, 50%, 60%, 70% and quarry dust is added to soil samples for finding the properties of mixes. Based on the results they have observed that when crusher dust added to expansive soil liquid limit, plastic limit decreases. For experimental work they have collected expansive soil and stone dust from Bhubaneswar.

CHAPTER - 3

3.0 TRAFFIC AND PAVEMENT CHARACTERIZATION

3.1STABILIZATION OF SOIL

Guide lines for soil stabilization: Stabilization projects are site specific and require integration of standard test methods, analysis procedures and design steps to develop acceptable solutions. Many variables should be considered in soil treatment, especially if the treatment is performed with the intent of providing a long-term effect on soil properties. Soil-stabilizer interactions vary with soil type and so does the extent of improvement in soil properties. Hence developing a common procedure applicable for all types of stabilizers is not practical. Instead, a generalized, flowchart-based approach, which provides the steps that should be followed in stabilizer selection, is presented in Figure 3.1.

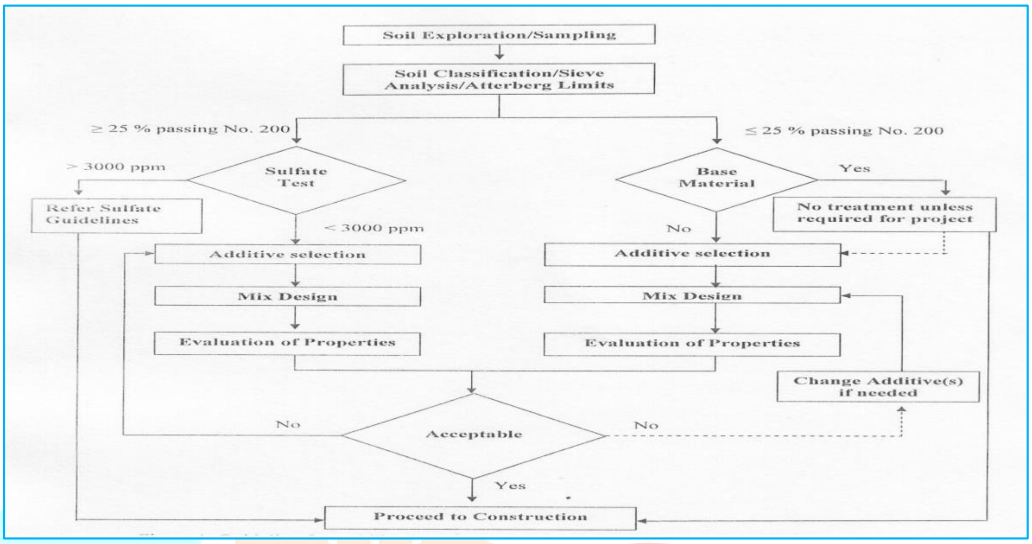


Figure 3.1 Guide line for stabilization of soils (source AASHTO)

Soil stabilization aims at improving soil strength and increasing resistance to softening by water to bonding the oil particulars together, water proofing the particles or the combination of two.

3.2PURPOSE OF STABILIZATION

a) To improve the strength of sub-bases, bases and in the case of low cost roads.
b) To bring above economy in the cost of roads.
c) To control dust
d) To improve permeability characteristics
e) To reduce frost susceptibility
f) To reduce compressibility and thereby settlements
g) To facilitate compaction and increase load bearing capacity
h) To make use of locally available soils

3.3 TYPE OF STABILIZATION TECHNIQUES

A completely consistent classification of soil stabilization techniques is difficult. The method used for stabilization surface deposits are:

a) Mechanical stabilization
b) Stabilization with special stabilizers
c) Complex stabilization with more than one stabilizer

3.2.1 Mechanical stabilization

It is the cheapest and simplest method. Commonly used for the construction of sub-bases, bases and surfacing of roads and also improving the sub grade soils of low bearing capacity. It is based on the principal of controlled grading and proper compaction of soil. Mechanical stability means the property of resistance to deformation and displacement under applied loads. Mechanical stability depends on the mechanical strength of the aggregate, mineral composition of the minerals, grading of the mixer, plasticity characteristics of the binder soil and the compaction.

3.2.2 Stabilization with special stabilizers

a) Cement stabilization

Portland cement is one of the most widely used additives for soil stabilization. Soil cement is an intimate mix of soil, cement and water which is well compacted to for a strong base course. Cement treated or cement modified soils refer to the compacted mix when cement is used in small portions to impart small strength or modify the property of the soil.

b) Lime stabilization

Lime is produced from natural lime stone. Hydrated lime called slaked lime is commonly used for stabilization. Lime is also used in the following admixtures of soil stabilization, viz., lime, fly ash, lime Portland cement, lime bitumen. The two chemical reactions that occur when lime is added to wet soil:

i. Attraction nature of the absorbed soil
ii. Cementing action - lime generally increases the placidity index of the low plasticity of the soil and in the cases of highly plastic soils it increases the OMC and decreases the plasticity

c) Bitumen stabilization

Basic principles in bitumen stabilization are water proofing and binding. By water proofing inherent strength can be retained. Binding action is important in the case of cohesion less soils. In granular soils the coarse grain may be individually coated bind together by non-plastic and less water sensitive or non-expensive and converts the clay clots into aggregates.

d) Fly ash stabilization

Fly ash is also generally considered as a traditional stabilizer. While lime and Portland cement are manufactured materials, fly ash is a by-product from burning coal during power generation. These by-products can broadly be classified into class C (self-cementing) and class F (non-self-cementing) fly ash based on AASHTO M 295 (ASTM C 618). Class C fly ash contains a substantial amount of lime, Cao, but almost all of it is combined with glassy silicates and aluminates..

3.2.3 Complex stabilization

It is a term used for treatment of soil with more than one stabilizer. Difficult soils such as organic soils, highly plastic fat clays with easy soluble salts require more than one stabilizer for their effective treatment. The following different type of combinations used are:

- Cement, Calcium chloride & Lime
- Cement & bituminous emulsion
- Cut back & Lime or Calcium chloride
- Cement , Naphtha soap

3.4 METHOD OF DEEP SOIL STABILIZATION

a) Electrical method
b) Grouting method
c) By heating and freezing method

3.5 FACTORS AFFECTING SOIL BITUMEN:

- Soil type
- Types of bituminous material
- Amount of bitumen
- Mixing
- Compacting

Asphalts and tars have been used for soil stabilization. This method is better suited to granular soils and in dry climates.

3.6 TRAFFIC VOLUME

The traffic volume is defined as the number of vehicles crossing a particular cross section per unit time. It is measured as vehicle per minute or vehicle per hour or vehicle per day. In order to express the traffic flow on a road per unit time, it is important to convert the different vehicle type in to a uniform standard unit called as passenger car unit. The traffic volume is dynamic and varies during the 24 houres of the day There are three important cyclical variations:

- Hourly pattern
- Daily Pattern:
- Monthly and yearly pattern

3.7 FLOW

Flow or volume is counting the number of vehicles on a particular stretch of a road. This is defined as the number of vehicle that pass a point on a high way or a given lane of given stretch of road or direction of a highway during the specific time interval. The measurement is carried out by counting the number of vehicles 'n' passing a particular point in one lane in a defined period't'. Then the flow 'q' is expressed in vehicles/hour is given by F=n/t.

3.7.1 Variation of volume or flow

The Variation of flow or volume with time, i.e., season to season, month to month, week to week, day to day, hour to hour and also within hour is important for calculations. Volume will be above average in a pleasant motoring in summer, but will be pronounced in rural than in urban. Weekdays, Saturdays and Sundays will also face difference in pattern. When compared day – day pattern for routes of similar nature often show similarity, which is useful for predictions to be made

3.7.2 Types of volume measurements

Since there is considerable variation in the volume of traffic, several types of measurements of volume are commonly adopted which will average these variations into a single volume count to be used in many design purposes.

a. Average Annual Daily Traffic (AADT
b. Average Annual Weekly Traffic (AAWT)
c. Average Daily Traffic (ADT)
d. Average Weekday Traffic (AWT)

3.8 PAVEMENT COMPOSITION

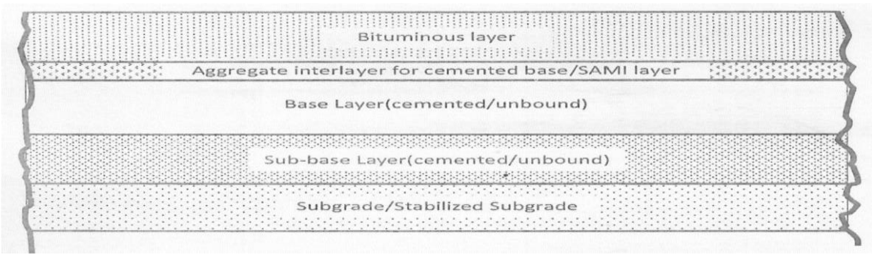


Figure 3.2: Typical pavement composition (source IRC 37)

3.8.1 Sub-grade

The subgrade is the top 500 mm of the embankment immediately below the bottom of the pavement, and is made up of in-situ material, select soil, or stabilized soil that forms the foundation of a pavement. It should be well compacted to limit the scope of rutting in pavement due to additional densification during the service life of pavement

CBR (%)	Maximum Variation in CBR value
5	± 1
5 – 10	± 2
11 – 30	± 3
31 and above	± 5

3.8.2Sub base layer

Specifications of granular sub-base (GSB) materials conforming to MORTH Specifications for Road and Bridge Works are recommended for use. These specification suggest close and coarse graded granular sub-base materials and specify that the materials passing 425 micron sieve when tested in accordance with IS:2720 (Part 5) should have liquid Limit and plasticity index of not more than 25 and 6 respectively.. Filter and drainage layers can be designed as per IRC: SP: 42-1994 (33) and IRC: SP: 50-1 999(34).

The relevant design parameter for granular sub-base is resilient modulus (MR), which is given by the following equation: $M_{R\ gsb} = 0.2h^{0.45} * M_{R\ subgrade}$

Where h = thickness of sub-base layer in mm

M_R value of the sub-base is dependent upon the M_R value of the sub grade since weaker sub grade does not permit higher modulus of the upper layer because of deformation under loads.

3.8.3 Base layer

The base layer may consist of wet mix macadam, water bound macadam, crusher run macadam, reclaimed concrete etc. Relevant specifications of IRC/MORTH are to be adopted for the construction. When both sub-base and the base layers are made up of unbound granular layers, the composite resilient modulus of the granular sub-base and the base is given as $M_{R\ granular} = 0.2h^{0.45} * M_{R\ subgrade}$

Where h = thickness of granular sub-base and base, mm

Poisson's ratio of granular bases and sub-bases is recommended as 0.35.

3.8.4 Bituminous layer

The recommended resilient modulus values of the bituminous materials with different binders are given in Table 7.1. These are based on extensive laboratory testing modern testing equipment following ASTM Test procedures. The tests carried out were "Indirect "Tensile Test" (ASTM: D7369-09) (12) and "Standard Test Method for Determining Fatigue Failure of Compacted Asphalt Concrete Subjected to Repeated Flexural Bending"(ASTM: D7460-10) (13), a 'Four Point Bending Test' at 10 Hz frequency in constant strain mode.

The Poisson's ratio of bituminous layer depend upon the pavement temperature and a value of 0.35 is recommended for temperature up to 35°C and value of 0.50 for higher temperatures. It is noted that the bituminous mixes harden with time and modulus may increase to higher values in upper layers due to ageing than what is given in the Table 7.1. Deterioration also occurs due to heavily loaded vehicles. Hence field performance is to be periodically recorded or future guidance. Table 2.2 gives various considerations for the selection of binders and mixes in the light of Indian and international experience.

Table 3.2: Resilient Modulus of Bituminous Mixes, MPa

Mix type	Temperature °C				
	20	25	30	35	40
BC and DBM for VG10 Bitumen	2300	2000	1450	1000	800
BC and DBM for VG30 Bitumen	3500	3000	2500	1700	1250
BC and DBM for VG40 Bitumen	6000	5000	4000	3000	2000
BC and DBM for modified Bitumen (IRC SP 53 2010)	5700	3800	2400	1650	1300
BM with VG10 Bitumen	500 MPa at 35 °C				
BM with VG30 Bitumen	700 MPa at 35 °C				
WMM/ RAP treated with 3% bitumen emulsion/ foamed bitumen (2% residual bitumen and 1% cementatious material)	600 MPa at °C (laboratory values vary from 700 to 1200 MPa for water saturated samples)				

CHAPTER - 4

4.0 METHODOLOGY

4.1 GENERAL

4.2 SPECIFIC GRAVITY

Specific gravity of solid is an important parameter to determine the void ratio and particle size. The specific gravity of a soil mass is the indication of its average value of all the solid particles present in the soil mass. The SG of solid particle (G) is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water at 4 °C.

Thus the specific gravity is given by the following equation

$$G = \frac{(w_2 - w_1)}{(w_2 - w_1) - (w_3 - w_4)} x\ 100$$

Where

W_1 – Weight of density bottle and stopper

W2 – Weight of oven dried soil sample including bottle

W3 – Weight of density bottle &Stopper

W4 – Weight of density bottle filled with water

4.3 LIQUID LIMIT

The Liquid limit (LL) of a soil is the moisture content at which the soil changes from liquid state to plastic state. The device used to determine LL is “Casagrande’s apparatus” which consists of Grooving tool, Balance of capacity 500 grams and sensitivity 0.01gram, Thermostatically controlled oven with capacity up to 2500 C, Porcelain evaporating dish about 12 to 15cm in diameter, Spatula flexible with blade about 8cm long and 2cm wide, Palette knives with the blade about 20cm long and 3cm wide, Wash bottle or beaker containing distilled water, Containers airtight and non- corrodible for determination of moisture content. Figure 4.1 shows “Casagrande” apparatus required for determining the liquid limit

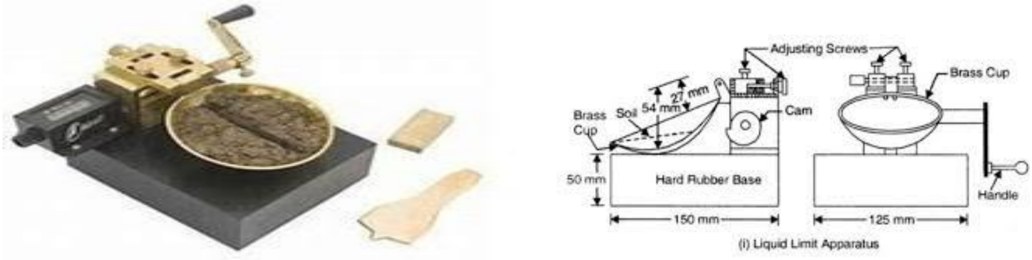


Figure 4.1 Casagrande’s Apparatus to determine the Liquid Limit

4.4 PLASTIC LIMIT

The plastic limit is defined as the moisture content, in percentage, at which the soil crumbles when rolled into threads of 3mm in diameter. The plastic limit is the lower stage of soil. The apparatus are Porcelain evaporating dish about 12cm in diameter, Flat glass plate 10mm thick and about 45cm square or longer, Spatula flexible with the blade about 8cm long and 2cm in wide, Ground glass plate 20 x 15 cm, Airtight containers, Balance of capacity 500grams and sensitivity 0. 01gram, thermostatically controlled oven with capacity up to 250 °C, Rod 3mm in diameter and about 10cm long. Figure 3.2 shows” apparatus required for determining the plastic limit

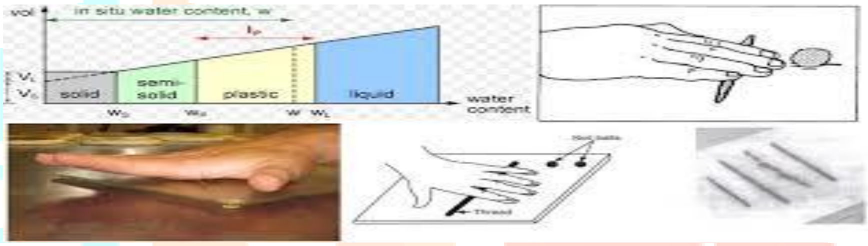


Figure 4.2 Apparatus for determining the plastic limit

4.5 PLASTIC INDEX

The plasticity Index is defined as the numerical difference between its Liquid Limit and Plastic Limit. Plasticity Index = Liquid Limit - Plastic Limit.

4.6 SIEVE ANALYSIS

The sieve analysis consists of sieve shaker, set of sieves, oven, weigh balance. The sample of soil so collected from the site is prepared as per IS 2720 part 1. Take 400 grams of sample. The set of sieves are stacked in descending order viz. 4.75mm on top and below 2.36mm, 1.18mm, 600 micron, 300 micron, 150 micron, 75 micron. The soil sample is placed on top sieve of size 4.75mm and by sieve shaker the sieves are shaken. After the sieve is shaken the mass in each sieve is determined. The test procedure is conducted as per IS 2720 part 2. The procedure is followed for all the samples viz. soil, soil and various proportions of stone dust added to the soil. Figure 4.3 are the typical set of standard sieves used for performing sieve analysis.

Figure 4.3 Set of Standard Sieves

4.7 STANDARD PROCTOR TEST

The fundamentals of compaction were first time presented by RR. Proctor in 1933, in his honor. The standard laboratory compaction test which is developed is commonly called the Standard Proctor Test. Compaction is a type of mechanical stabilization where the soil mass is densified with the application of mechanical energy also known as compactive effort. The mechanical energy may be produced by the dynamic load, static load, vibration, or by tamping. The test procedure is conducted as per ASTM D-698, AASHTO T-99, BS 1377. The procedure is followed for all the samples viz. soil, soil and various proportions of stone dust added to the soil.

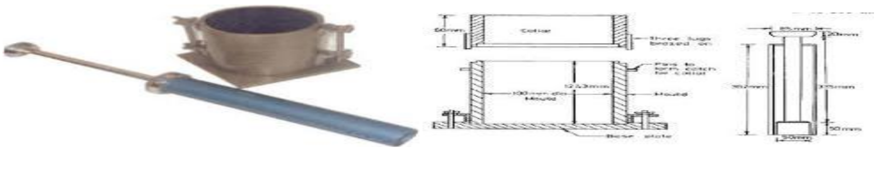


Figure 4.4 Standard Proctor test Apparatus

4.8 CALIFORNIA BEARING RATIO TEST

The California Bearing Ratio(CBR) test is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. It was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR test may be conducted in remoulded or undisturbed sample. Test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value.

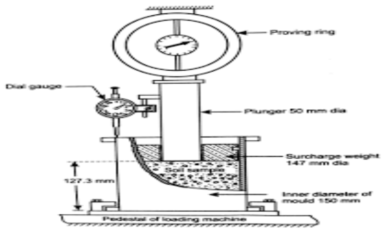


Figure 4.5 California bearing ratio test apparatus

4.9 DESIGN TRAFFIC

The method considers traffic in terms of the cumulative number of standard axles (8160 kg) to be carried by the pavement during the design life.

Initial traffic in terms of CVPD
Traffic Growth rate during the design life
Design life in number of years
Vehicle damage factor (VDF)
Distribution of commercial traffic over the carriageway.

4.10 COMPUTATION OF DESIGN TRAFFIC

As per IRC 37 – Cumulative number of standard axles to be catered for in the design

$$N = \frac{365 * \{(1+r)^n - 1\}}{r} * A * D * F$$

Where

N - Cumulative number of standard vehicles
A - Initial traffic in the year of completion of construction in terms of the number of commercial vehicles
D - Lane distribution factor (as per IRC 3.3.5.1 (ii))
F - Vehicle damage factor
n – Design life in years
r - Annual growth rate of commercial vehicles (for 7.5% r = 0.075)

As per IRC 37 - The traffic in a year of completion is estimated using the formula

$$A = P * (1+r)^x$$

Where

A – Initial traffic in the year of completion of construction in terms of number of commercial vehicles per day
P – Number of commercial vehicles as pet last count
r – Annual growth rate of commercial vehicles (for 7.5% r = 0.075)
x – Number of years between last count and year of completion of construction

CHAPTER - 5

5.0 RESULTS AND DISCUSSIONS

To study the effect of utilization of stone dust on properties of soil and to make them suitable for highway construction, the soil samples and stone dust were collected and designated as "S" for existing soil, "SD10" 10% stone dust, "SD20" 20& stone dust, and so on to "SD60" 60% stone dust. The purpose of adding stone dust to expansive soil is to improve its geotechnical properties, increase in load carrying capacity, reduce settlements, lateral deformation and give good supporting layer for structure. The different test conducted is grain size analysis, consistency limit, specific gravity, standard proctor test and C.B.R. test.

Table 5.1 Geotechnical properties of expansive soils

Sl. No.	Properties of soil sample	Soil
1	Grain size distribution	
	Sand size (0.075 – 4.75mm) %	21
	Silt size (0.002 – 0.075mm) %	-
	Clay size (<.002mm) %	79
2	Consistency limits	
	Liquid Limit %	59
	Plastic Limit %	31
	Plasticity Index %	28
3	Specific gravity	2.62
4	Compaction characteristics	
	MDD gms/cm^3	1.47
	OMC %	26.10
5	Soaked CBR value %	3.27

Table 5.2Geotechnical properties of stone dust

Sl. No.	Properties of soil sample	Stone dust
1	Grain size distribution	
	Coarse particle size (2.0–4.75mm)%	9
	Medium particle size (0.425–2.0mm)%	37
	Fine particles (0.075 – 0.425mm) %	42
	Silt size (0.002 – 0.075mm) %	12
	Clay size (<.002mm) %	-
2	Specific gravity	2.79
3	Compaction characteristics	
	MDD gms/cm^3	1.95
	OMC %	10.9
4	Soaked CBR value %	22.67

The results are shown in the following Figures / Graphs for the sieve analysis conducted for only soil, stone dust and different % of stone dust blended with soil

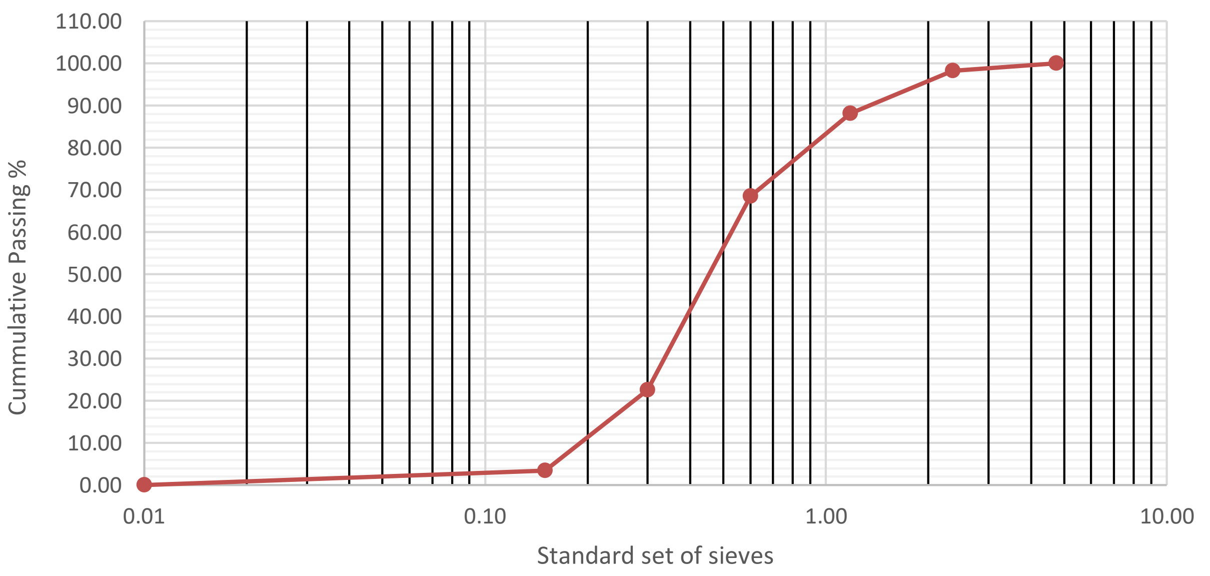


Figure 5.2 : Seive analysis of stone dust.

Table 5.3 Effect of stone dust on Atterberg's limit for soil.

Sl. No.	Proportion of stone dust to soil	Soil (S), Stone Dust (SD)						
		S	SD10	SD20	SD30	SD40	SD50	SD60
		100:0	90:10	80:20	70:30	60:40	50:50	40:60
1	L L %	59	53	43	36	30	27	23
2	P L %	31	28	24	19	16	14	Non plastic
3	P I %	28	25	21	17	14	13	Non plastic

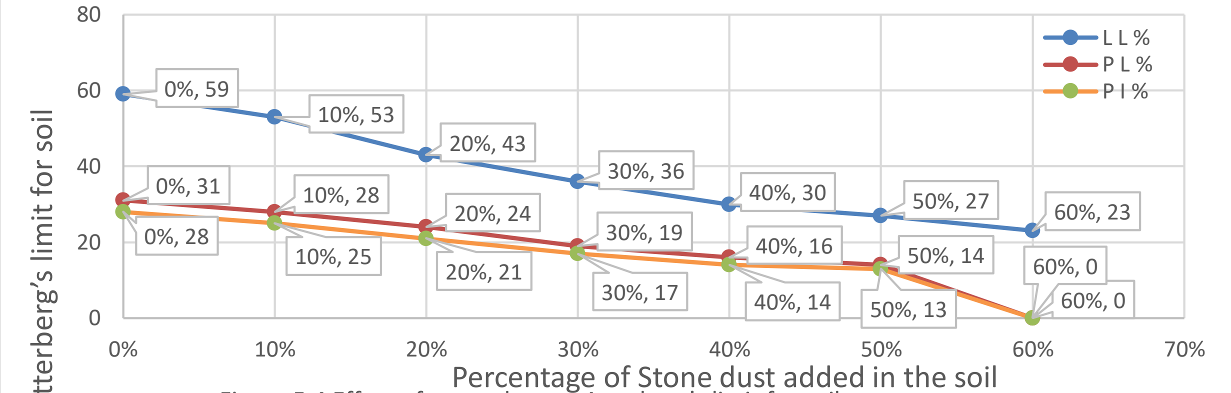


Figure 5.4 Effect of stone dust on Atterberg's limit for soil

From Table 5.3 and Figure5.4 it is seen that the liquid limits, plastic limit, plasticity index of original soil are 56%, 27% and 29% respectively. After adding 10%, 20%, 30%, 40%, 50% and 60% of stone dust, the liquid limit & Plastic Limit of modified soils are found to be reducing. The Liquid limit varies from 53% to 23%, the plastic limit varies from 28 % to non-plastic, and Plastic index varies from 25% to non-plastic. The probable reason for reduction of liquid limit and plastic limit of modified soil may be due to mechanical stabilization and addition of non-plastic material.

Table 5.4 Effect of stone dust on soil and stabilized soil.

Sl. No.	Proportion of stone dust to soil	Soil (S), Stone Dust (SD)						
		S	SD10	SD20	SD30	SD40	SD50	SD60
		100:0	90:10	80:20	70:30	60:40	50:50	40:60
1	MDD	1.47	1.55	1.60	1.64	1.67	1.70	1.73
2	OMC	26.10	24.90	23.70	22.70	21.30	20.20	19.10
3	CBR	3.27	4.21	5.01	6.12	7.08	8.51	9.78

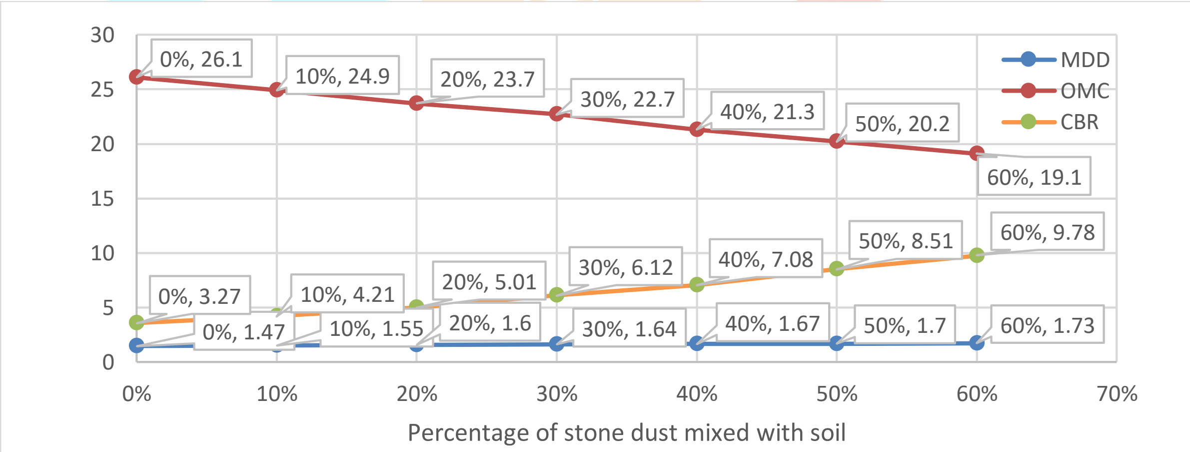


Figure 5.5: Variation of MDD, OMC, CBR corresponding to percentage of stone dust

From Table 5.4 and Figure 5.5, it is found that, as the percentage of stone dust is increased the value of maximum dry density is also increased. The maximum dry density of soil without modification is 1.47 gm/cc and varies from 1.55 to 1.73 as the percentage of stone dust is increased. The probable reason for increase in maximum dry density is due to proper rearrangement of soil particles and addition of non-plastic material, which improves the binding capacity.

5.1 Computation of Traffic Design (Technical)

The following are the data collected for calculating the msa of that particular road stretch as per IRC 37.

Particulars	Symbol	Value	Unit
Length of the road		5.00	Km
No of lanes of the road		2.00	
Average number of vehicles in both lanes	P	1600.00	CVPD
Annual growth rate of commercial vehicles	r	7.50%	
Total period of construction	x	4.00	Months
Design period of the road	n	10.00	Years
Vehicle damage factor (table 1 of IRC 37 2001)	F	4.50	VDF
Lane distribution factor (3.3.5.1 (ii)) IRC 37	D	75.00%	LDF

As per IRC 37 – Cumulative number of standard axles to be catered for in the design

$$N = \frac{365 * \{(1+r)^n - 1\}}{r} * A * D * F$$

Where

N - Cumulative number of standard vehicles

A - Initial traffic in the year of completion of construction in terms of the number of commercial vehicles

D - Lane distribution factor (as per IRC 3.3.5.1 (ii))

F - Vehicle damage factor

n – Design life in years

r - Annual growth rate of commercial vehicles (for 7.5% r = 0.075)

As per IRC 37 - The traffic in a year of completion is estimated using the formula

$$A = P * (1 + r)^x$$

Where

A – Initial traffic in the year of completion of construction in terms of number of commercial vehicles per day

P – Number of commercial vehicles as pet last count

r – Annual growth rate of commercial vehicles (for 7.5% r = 0.075)

x – Number of years between last count and year of completion of construction

$A = 1600 * (1 + 7.5\%)^4$

A = 2136.75

A = 2140.00 CVPD in both lanes

Commercial vehicles in one lane = $^{2140}/_{2}$ = 1070.00 CVPD

Cumulative number of standard axles

$$N = \frac{365 * \{(1 + 7.5\%)^{10} - 1\}}{7.5\%} * 1070 * 75\% * 4.5$$

N = 18647364.45 standard axles

N = 20.00 msa (million standard axles)

Computation of Pavement Thickness

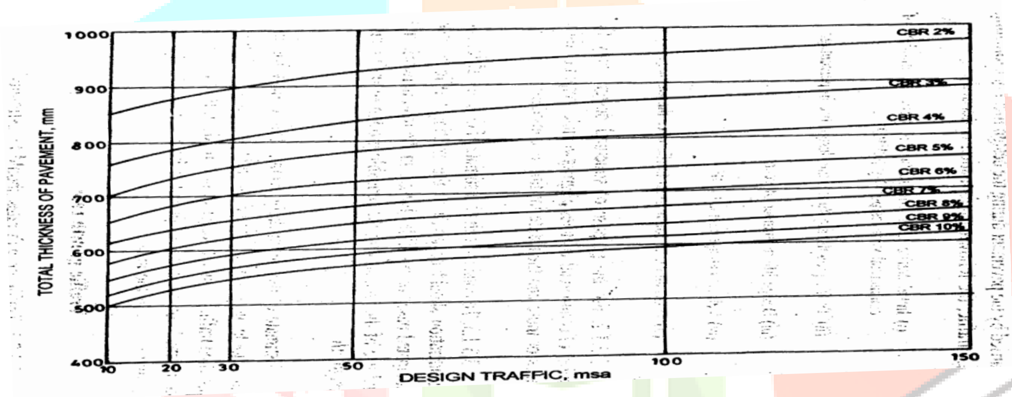


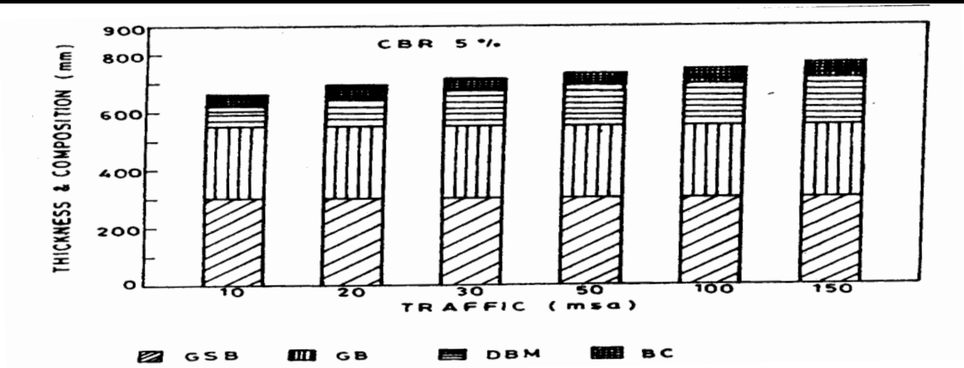
Figure 5.6: Pavement thickness design chart (source IRC 37)

Figure 5.6 shows the pavement thickness design chart for traffic 10 – 150 msa as per IRC 37and the calculated cumulative traffic is 20 msa.

PAVEMENT DESIGN CATALOGUE (source IRC 37)

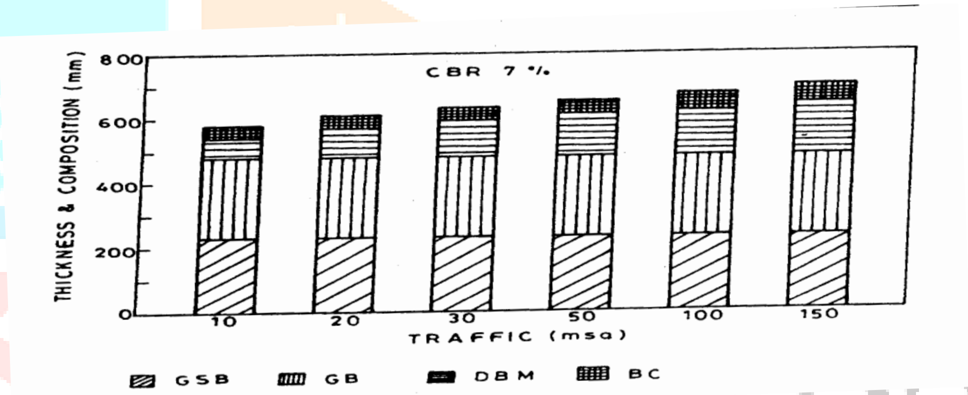
PLATE – 2 RECOMMENDED DESIGNS FOR TRAFFIC RANGE 10 – 150 msa

CBR 5%				
Cumulative Traffic (msa)	**Total Pavement thickness (mm)**	**PAVEMENT COMPOSITION**		
		Bituminous Surfacing		**Granular Base & Sub-base (mm)**
		BC (mm)	**DBM (mm)**	
10	660	40	70	Base = 250 Sub-base = 300
20	690	40	100	
30	710	40	120	
50	730	40	140	
100	750	50	150	
150	770	50	170	



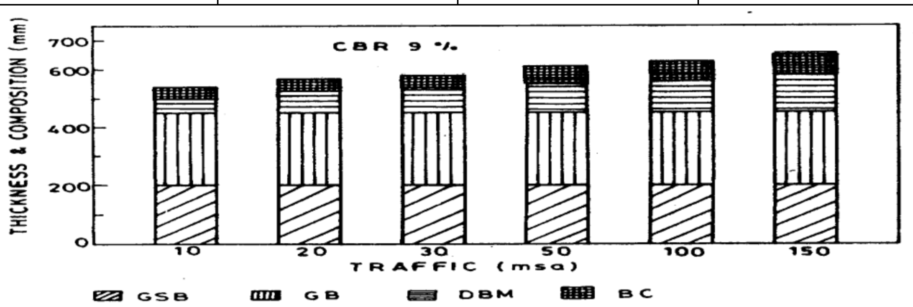
PAVEMENT DESIGN CATALOGUE (source IRC 37)
PLATE – 2 RECOMMENDED DESIGNS FOR TRAFFIC RANGE 10 – 150 msa

CBR 7%				
Cumulative Traffic (msa)	**Total Pavement thickness (mm)**	**PAVEMENT COMPOSITION**		
		Bituminous Surfacing		**Granular Base & Sub-base (mm)**
		BC (mm)	**DBM (mm)**	
10	580	40	60	Base = 250 Sub-base = 230
20	610	40	90	
30	630	40	110	
50	650	40	130	
100	675	50	145	
150	695	50	165	



PAVEMENT DESIGN CATALOGUE (source IRC 37)
PLATE – 2 RECOMMENDED DESIGNS FOR TRAFFIC RANGE 10 – 150 msa

CBR 9%				
Cumulative Traffic (msa)	**Total Pavement thickness (mm)**	**PAVEMENT COMPOSITION**		
		Bituminous Surfacing		**Granular Base & Sub-base (mm)**
		BC (mm)	**DBM (mm)**	
10	540	40	50	Base = 250 Sub-base = 200
20	570	40	80	
30	585	40	95	
50	605	40	115	
100	635	50	135	
150	655	50	155	



PAVEMENT DESIGN CATALOGUE (source IRC 37)
PLATE – 2 RECOMMENDED DESIGNS FOR TRAFFIC RANGE 10 – 150 msa

Table5.5shows the consolidated thickness of pavement at different CBR percentages for different percentages of stone dust added to sub grade soil for 20msa.

Sl. No.	% of addition of Stone dust (SD)	CBR value	Rounded CDR value	Thickness of road (mm)	BC (mm)	DBM (mm)	Base (mm)	Sub base (mm)
1.00	0.00	3.27	3.00	790	40	120	250	380
2.00	10.00	4.22	4.00	730	40	110	250	330
3.00	20.00	5.01	5.00	690	40	100	250	300
4.00	30.00	6.12	6.00	640	40	90	250	260
5.00	40.00	7.08	7.00	610	40	90	250	230
6.00	50.00	8.51	9.00	570	40	80	250	200
7.00	60.00	9.78	10.00	565	40	75	250	200

CHAPTER – 6

6.0 CONCLUSIONS

The main objectives of this study is to improve the Engineering (technical) properties of expansive soil for road construction. This strategy of improving properties of expansive soil is developed by mixing stone dust to expansive soil in different proportions and observing the improvement in properties. The following conclusions may be drawn from the study.

- It is be observed from the study that as the percentage of stone dust is increased, the CBR value is increasing and the OMC is reducing.
- Adding stone dust is effective in decreasing OMC of soils which is advantageous in decreasing quantity of water required during compaction.
- While considering the only the technical properties, the pavement thickness for the existing soil is 790 mm while the thickness of pavement for soil stabilized with 60% stone dustis 565 mm. A significant reduction of thickness is observed and the reduced thickness is 225mm.
- The cost analysis when 60%of stone dust is added to the existing soil works out to be Rs.2,23,45,056.00
- While considering the techno-economical properties the reduction in the design of pavement thickness is 220mm and only when 50% of stone dust is added.
- The cost analysis when 50%of stone dust is added to the existing soil works out to be Rs.2,19,68,783.00
- The 5mm variation observed in the thickness of DBM and 10% of stone dust is the cost additionof Rs.3.83 lakh for 1.0km stretch of two lane road.

REFERENCES

- IS: 1498-1970, “Classification and Identification of soils for general engineering purposes”, Bureau of Indian Standard, New Delhi
- IRC: SP: 89-2010,“Guidelines for Soil and Granular Material Stabilization Using Cement, Lime and Fly ash”, Indian Road Congress, New Delhi.
- IS: 2720 (Part VII)-1980, Methods of Test for Soils, Determination of Water Content-Dry Density Relation Using Light Compaction Method, Bureau of Indian Standards, New Delhi, India.
- IS: 2720 (Part-4)-1985, Grain Size Analysis, A publication of Bureau of Indian Standards, ManakBhawan, New Delhi, India.
- IS:2720 (Part16)-1987, Laboratory Determination of CBR, A publication of Bureau of Indian Standards, ManakBhawan, New Delhi, India.
- IRC: 37-2001, Guidelines For The Design of Flexible Pavements, A publication of Indian Road Congress, New Delhi.
- IRC: 36-1970, Recommended Practice for the Construction of Earth Embankments for Road Construction, A publication of Indian Road Congress, New Delhi.
- American Association of State Highway Transportation Officials (AASHTO). Guide for Design of Pavement Structures. 1993.
- Van Til, C.J., et al. NCHRP Report 1-28: Evaluation of AASHTO Interim Guides for Design of Pavement Structures (AASHTO Design Guide). The American Association of State Highway and Transportation Officials. 444 North Capitol St NW Suite 225, Washington, D. C. 1972.
- White, D. and Vennapusa, P. Optimizing Pavement Base, Subbase, and Subgrade Layers for Cost and Performance of Local Roads. IHRB Project TR-640. Iowa Highway Research Board and Iowa Department of Transportation, Ames, Iowa. 2014.
- Dr.K.V.Krishna Reddy (201, “Correlation between California Bearing Ratio and shear Strength on Artificially Prepared Soils with Varying Plasticity Index”, International Journal of Civil Engineering & Technology (IJCIET), Volume 4, Issue 6, pp. 61 - 66