Volume 2, Issue 6, June – 2017 International Journal of Innovative Science and Research Technology

ISSN No: - 2456 - 2165

Enhancement of Soil Index Properties by Adding Stone Dust Mix

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Abstract— **Index properties & strength of murum/Gravel soil is less and does not fulfill the requirement for its uses as a road pavement material such as GSB. These property is likely improved by adding a suitable admixture of stone dust/river sand. Therefore a detailed experimental study is proposed by adding & mixing combination of quarry soil (i. e. murum/Gravel soil) with stone dust in assorted percentage, to find suitable proportion of local murum/Gravel soil that will suit parameter for granular Sub-base material for low traffic volume roads in rural area.**

Aim of this study to find out solution for use of local gravel soil/murum in construction of road pavement layers by adding suitable percentage of stone dust/river sand. To improve its properties and to make it suitable material for road pavement material like Granular sub-base. Following objects are taken in to consideration while study.

Keyword-*Index property, adding stone dust, soil index improvement, strength of murum/gravel, liquid limit, plastic limit, sieve analysis.*

I. INTRODUCTION

As per the scope of this investigation in most of the developing Countries like India, there is major scope for development of rural construction. Since only by providing a better infrastructure facilities like fast, easy, and economical conveyance and connectivity of rural areas with district and tehsil places the overall social and economic development of villages can be possible. For the rural development government had launched many schemes like "*Prandhan Mantri Gram Sadak Yojana and Mukhaya Mantri Gram Sadak Yojana*" for construction of rural roads and link roads. Still there is large numbers of village roads and link roads which is remain unnoticed and proposed for construction in upcoming Government schemes of rural development.

Regarding the construction of such type of village roads and link roads there are two big deal, which are taken in to consideration. One is major use of local resources so that local employment and economy may increase; and two is the maintain economical construction cost. Maximum village roads are of short length and disconnected on different locations, the progress of work to be executed is also small and scattered in different locations. To execute small work in disconnected location by good quality material from a long distant approve quarry is not economic and difficult in transportation. Hence keeping in view the economy of work, not easy in movement of heavy machine, inaccessibility of good material and for optimal usage of natural resources, there is a tuff requirement of this study and there is better scope of advantages in construction of rural roads with help of this study.

II. SCOPE OF STUDY

Scope of this investigation in most of the developing Countries like India, there is major scope for development of rural construction. Since only by providing a better infrastructure facilities like fast, easy, and economical conveyance and connectivity of rural portion with mainly district and tehsile area the overall development of villages can be possible. For the rural development government had sanctioned many schemes like "*Prandhan Mantri Gram Sadak Yojana and Mukhaya Mantri Gram Sadak Yojana*" for construction development of rural roads and link roads. Still there is maximum numbers of village roads and link roads which is untouched and proposed for construction in incoming Government schemes of rural development.

As in the construction of such type of village roads and link roads there are two major concepts, which are taken in to consideration. One is large use of local resources so that local employment may increase; and second is to balance economical work cost as well as easy construction method. Since large no. of village roads are short length and not connected, the number of work to be perform is also low and disconnected in various locations. To execute small work in scattered area by transport good quality material from a long distance approve quarry is uneconomical and not easy in operation. That's why the economy of work is not easy in movement of heavy equipment, unavailability of good material and for optimal usage of natural resources, there is a tuff requirement of this study and there is better scope of get advantages in improving infrastructure of rural area with the help of this study.

To find the solution of reprocess the garbage obtained from dismantled material of road pavements with the help of these study. Waste obtained from dismantling of road pavements is a problem for that area & land. Recycle of this material will economical for construction & save our ecosystem also.

III. FIELD AREA SURVEY & PROPERTY OF GRAVEL SOIL/MURUM

Available materials for the build of earthen embankments, the sub grade were fine sand loamy, gravels, clay and rocks. Different mixtures of the loamy sand and gravels could be easily used for embankment construction and sub grade work, while the basaltic rocks is good material for provide strength to slope. Gravel is good for the construction of an embankment. Strength of gravel are satisfactory, but gravel lacks the requisite function of water tightness, as it contains 35 to 40 percent of pore space. Stone dust, on the other hand, while less porous than gravel, is much low stable in compaction.

Murum is mainly known as laterite soil can be formed by a deep weather layer from which silica has been striped. There is collection of alluminium and iron oxides and hydroxides. The similarly red or reddish colour of these soils is reveal by the iron colonial. Murum are residual soils and are made by erosion of basaltic rock at places, where monsoon is grave. They form mix of erosion rocks pieces in different sizes,(like clay, sand, silt). They are good material for road work.

Perfect material passing 75 micron shall not exceed 10%. Liquid limit is not more than 20% & Plasticity index is not more than 6%, most of the gravel quarries, murum obtained from disintegration of rock consist fine aggregate, clay soil, clayey sand and percentage of coarse aggregate in fraction, such materials are of high plasticity index, High plasticity modulus and low strength/CBR value.

Mainly this standard, the definitions given in IS: 2809-1972 'Glossary of terms and symbols relating to soil engineering (first revision) and the following shall apply.

Clay – these are finely grained particle of size less than0.002.these are cohesion plastic. It is plastic a moderate to wide range of water content.

Silt –It is granular material of a size between sand & clay. Silt particle range between 0.002mm to 0.063mm.It isfine-grained soil with little or no plasticity.

Sand and Gravel – sand is granular material composed of rock & mineral particle, size of soil is between 0.063mm to 2mm. It is cohesion less aggregates of angular, sub-angular.

IV. DIVISION & IDENTIFICATION

Division - Soils are mainly divided into three divisions as given below:-

Coarse-Grained Soils – It is more than half the total material by weight & larger than 75-micron.

Fine-Grained Soils – It is more than half of the total material by weight is smaller than 75-micron.

Organic Soils and Different Miscellaneous Soil Materials - These soil consist maximum percentages of fibrous organic material, and particles of disintegrate vegetation. In addition, some soils contains shells, concretions, cinders, and other non-soil materials.

Subdivision - First two divisions are divided as given.

Coarse-Grained Soils - The coarse grained soils are explained by two subdivisions, namely:

Gravels – It is more than half the coarse divided (+75 micron) is larger than 4.75-mm IS Sieve size. This subdivisions insist gravel soils.

Sands – It is more than half the coarse divided (+75 micron) is smaller than 4.75-mm IS Sieve size. This subdivisions include sands soils.

Fine-Grained Soils - Fine-grained soils are explained by three subdivisions on the basis of the following randomly values of liquid limit:

Silts and clay of low compressibility – having a liquid limit less than 35 (represented by symbol L),

Silt and clays of medium compressibility -having a liquid limit greater than 35 and less than 50 (represented by symbol I), and

Silts and clays of high compressibility – having a liquid limit greater than 50 (represented by symbol H).

Groups –

The coarse-grained soils shall be further divided into eight basic soil groups. The fine-grained soils shall be further divided into nine basic soil groups.

Highly organic soils and other miscellaneous soil materials shall be placed in one group. The groups shall be designated by symbols. As per SP 36 table 1 and 2

Field Identification and Classification Procedure

The field method is used mainly in the field to identify and classify soils. Optical observance is required in place of accurate laboratory tests to explain the basic soil properties. The method is, in fact, a process of elimination start on the left side of the classify chart and work to the right yet to the proper group name is not obtained. The group name should be affix by elaborated word descriptions, including the description of the in-place terms for soils is to be used in place as foundations. A given sample of the soil is selected which is rub palm of the hand or open on a flat surface. All particles are larger than 75 mm are throw from the sample. Only the part of the sample smaller than 75 mm is described. The sample is classified as coarse grained or fine-grained by calculating the percentage by weight of separate particles which is seen by the unused eye. Soils consisting more than 50 percent transparent particles are coarse-grained soils, soils containing less than 50 percent transparent particles are fine-grained soils. If it is calculated by the soil is coarse grained,' it is next identified by calculating and recording the percentage of: (a) gravel sized particle, size between from75 mm to 4.75-mm IS Sieve size; (b) sand size particles, size between from 4.75 to 75-micron IS Sieve size; and (c) silt and clay size particles, size between smaller than 75-micron IS Sieve.

IV. EXPERIMENTAL WORK

Materials availability for the construction of earthen embankments and sub grade are fine sand loamy, gravel, clay and basaltic rock. The different mixtures of the sandy loam and gravel could be used for embankment construction, while the basaltic rocks formed good material for providing strength to slope. Gravel is used for the work of an embankment and Sub grade work. The weight and stability of gravel are both suitable, but gravel lacks the requisite function of water tightness as it often consists as much as from 35 to 40 percent of pore space.

Now a days probe deals with the mechanical stabilization of murum with mixture of stone dust/sand. The work presented in dissertation include results of index properties of (liquid limit & plastic limit), compaction characteristics (optimum moisture content and maximum dry density) and shear strength parameters (cohesion and angle of shearing resistance) for the murum liquidizer with differ percentages of stone dust/sand.

Sample formulation (As per IS 2720-I): - Soil sample, as picked from the field, are dried in the air or in sun. In wet weather condition, a drying apparatus is used in that case the temperature of the sample should not be more than 60°C. The lumps may be broken with a wooden-beetle to hasten drying. The organic matter, like tree bark , roots, stems should be removed from the sample. Similarly, matter other than soil, like shells should also be removed from the main soil mass. A noting are made of such removals & their percentage of the total soil sample noted. When samples are to be taken for estimation of organic matter, lime content, etc, total sample should be taken for calculation without separating shells, roots. etc.

Drying of the sample - Amount of drying depends upon the proposed test to be conducted on the specific sample. The type, temperature & duration of drying of specific soil samples for various tests are given in Table I. When oven is used for drying, the temperature in the oven shall not exceed by 110°C.

Degree of pulverization - The big lumps may be broken with the help of wooden beetle. Further pulverization may be done in pounder and mortar. The pulverized soil shall be passed through the specified sieve for the particular test and the soil retained on that sieve shall be again pulverized for sieving. This procedure should be repeated again when the further attempts at pulverizing very low soil passes through the specified sieve. It should be taken care not to break the individual soil particles. Quantity of soil sample should be given in table of IS 2720 part –4 .

Grain size analysis (As per IS 2720 Part - IV): - The portion of the soil sample hold back on 4*75-mm IS Sieve, selected as given in 3.2, shall be weighed and the mass calculated as the mass of the sample wrong for hygroscopic moisture. The amount of the soil sample taken shall depend on the large particle size contained in the soil. The sample shall be isolate into various fractions by sieving through the Indian Standard Sieves specified. Different sieves may be present between the sieves depending upon the added information that may be desired to be taken from the analysis. While sieving through each sieve, the sieve shall be tossing so that the sample rolls in non uniform motion over the Sieve. Particles may be tested to see if they will fall through but they shall not be pushed through. The mixture from the sieve are rubbed, if need, with the rubber pounder in the mortar taking care to see that particular soil particles are not broken and re-sieved to make sure that only particular particles are holdback. The amount taken every time for sieving on each sieve shall be such that the most weight of material retained on every sieve at the completion of sieving does not exceed the values given in Note 2 of IS 2720 part - IV. The weight of the material holdback on each sieve shall be recorded. If the sample appears to contain over 5 percent moisture, the water content of the material shall be calculated in accordance with 5 IS m: 2720 (Part 4) – 1985 IS: 2720 (Part 2)-1973" and the masses accurate accordingly. When the sample consists less than 5 percent moisture it is not require to determine the water content for dry weight computations and all the calculations may be made on the basis of wet weight only. If the soil consists more than 20 percent gravel particles & the fines are very cohesive with considerable quantity adhering to the gravel after removing, the gravel shall be washed on 4.75-mm IS Sieve . For further analysis a fresh Area of the fraction passing 4.75-mm IS Sieve are taken,

Calculations - The percentage of soil holdback on every sieve shall be calculated on the basis of the total mass of soil sample take out from the results the percentage passing through all of the sieves shall be calculated.

Atterberg Limit test (Liquid limits and Plastic limit As per IS 2720 PART –V): -

Test for the determination of liquid limit by Cone penetration method –

Soil Sample – After receiving soil sample weighing about 150g it is dried in air or in oven from thoroughly mixed portion of the soil passing 425 micron IS Sieve obtained in accordance to IS : 2720 (Part 1)-1983.if clods are in sample then it is broken with the help of wooden mallet.

Procedure - About 150 gm. of air dried soil from thoroughly mixed portion of material passing 425 micron IS sieve is obtained. Distilled water is mixed to the soil thus obtained in a mixing disc to form a uniform paste. Then the wet soil paste is transferred to the cylindrical cup of cone penetrometer apparatus, ensuring that no air is trapped in this process. Finally the wet soil is leveled up to the top of the cup and placed on the base of the cone penetrometer apparatus. The

ISSN No: - 2456 - 2165

penetrometer is so adjusted that the cone point just touches the surface of the soil paste in the cup and the initial ready is to be taken. The vertical clamp is then released allowing the cone to penetrate into soil paste under its own weight for 5 seconds. After 5 seconds the penetration of the cone is noted to the nearest millimeter. The test is repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. The exact moisture content of each trial is determined

Determination of Liquid Limit - A graph presenting water content on the y-axis and the cone penetration on the x-axis are drawn the best fitting straight line is. The moisture content corresponding to cone penetration of 20 mm shall be taken as the liquid limit of the soil and shall be expressed to the nearest first decimal place.

Plastic Limit:- Soil Sample - A sample weighing about 20 g mixed portion of the material passing 425-micron IS Sieve, obtained in accordance with-IS : 2720 (Part 1)-1983" shall be taken. When both the liquid limit and the plastic limit of a soil are to be determined, amount of soil is sufficient for both the tests shall be taken for preparation of the soil. At a stage in the process of mixing of soil and water the mass becomes plastic enough to be easily shaped into a ball.

Procedure - Mix the soil with distilled water in an evaporating dish and leave the soil mass for naturing. This period may be upto 24hrs. Take about 8g of the soil and roll it with fingers on a glass plate. The rate of rolling should be between 80 to 90 strokes per minute to form a 3mm dia. If the dia. of the threads can be reduced to less than 3mm, without any cracks appearing, it means that the water content is more than its plastic limit. Knead the soil to reduce the water content and roll it into a thread again. Repeat the process of alternate rolling and kneading until the thread crumbles. Collect and keep the pieces of crumbled soil thread in the container used to determine the moisture content. Repeat the process at least twice more with fresh samples of plastic soil each time. The pieces of crumbled soil thread shall be collected in an air-tight container and the moisture content determined as described in IS: 2720 (Part 2)-1973

Plasticity Index: - The plasticity index is calculated as the difference between its liquid limit & plastic limit:

Plasticity index (Ip) = liquid limit (wl) - plastic limit (wp).

Experiments on the material used (Gravel soil / murum): - From the upper parametric study of murum of four sources, I have resulted that the most suitable murum is Hanotia Alam quarry. Because of its better engineering properties than other quarries murum, it is more economical to increase its property. That's why I have chosen Hanotia alam quarry murum for research. Hanotia alam is located on 11km far from vidhya nagar town of Bhopal. Following test is conducted on soil sample obtained from quarry Hanotia Alam;

Name of test – Sieve analysis of murum

Table 1 . Gradation of natural murum

Weight of sample (gm.)		4000		Name of quarry	Hanotia Alam	
S. No.	**IS sieve in mm**	**Weight retained gms**	**Cumulative Wt. Rt. gms**	**Cum. Wt. Retain. %**	**% Passing**	**Limit %**
1	75	0	0	0	100	100
2	26.4	1670	1670	41	57	55-75
3	4.75	1950	3640	90	9	10-30
4	0.075	200	3840	95	4	0-10
	Sieve Size	**Upper Limit**	**Achieved**	**Lower Limit**		
	75	100	100.00	100		
	26.5	75	58.00	55		
	4.75	30	9.00	10		
	0.075	10	4.00	0		

V. ANALYSIS OF TEST RESULT

The analysis of results obtained from experiments conducted on murum mixture with stone dust of different percentage are as below.

Properties of basic materials:- The characteristics of natural material murum and stone dust is as below;

Table 2 . Summary of results for Natural murum and stone dust as individual ingredient of admix

S. No.	Properties	Natural Murum	Stone dust
1	Liquid limit	30.90%	0
2	Plastic Limit	23.21%	0
3	Plasticity Index	7.63%	0
4	Optimum Moisture content	11.00%	7.72%
5	Maximum Dry Density	1.68 gm/cc	2.16gm/cc
6	Soaked CBR Value	14.34%	63.02%
7	Un soaked CBR Value	20.83%	---

Index Properties of Murum Mixtures: -The liquid limit and plastic limit tests are conducted on the murum mixtures for this investigation and the obtained results are presented in the table. The plasticity index is obtained by deducting plastic limit from liquid limit.

Table 3 . Relation in between Atterberg limit and % of stone dust

S.No.	Description of mix	LL	PL	PI
1	Natural Murum	30.90	23.21	7.63
2	N.M. + 10% stone dust	29	22.92	6.05
3	N.M. + 15% stone dust	28	22.32	5.63
4	N.M. + 20% stone dust	26.5	21.34	5.14
5	N.M. + 25% stone dust	24	20.13	3.85

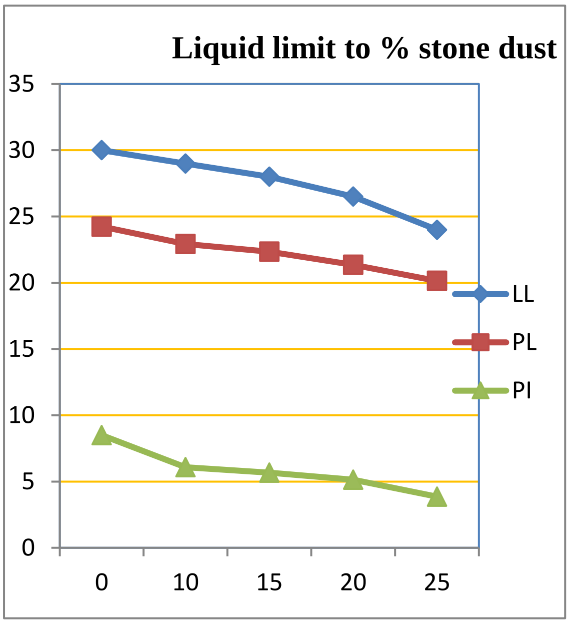


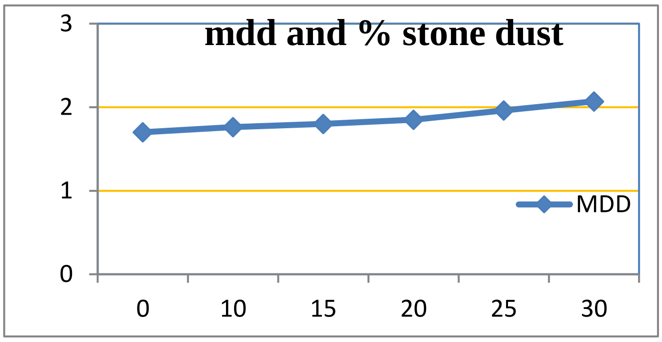
Figure 1 . Graph showing relationship of LL, PL, PI with % of stone dust

It is observed from the table 3 and fig.1, the liquid limit and plastic limit values of murum-dust mix decrease with increase in percentage of stone dust. The plasticity of the mixes is reduced due to increase in stone dust particles which impart non-plasticity to the mix.

Compaction characteristics of Murum Mixtures: -Heavy compaction tests were conducted on the murum mixtures considered for this investigation to determine the maximum dry density (mdd) values and optimum moisture content (omc) values and the results are shown in table 4

Table 4 . Relation in between omc and mdd AND % of stone dust

S.No.	Description of mix	Mdd	omc
1	Natural Murrum	1.71gm/cc	11.04%
2	N.M. + 10% stone dust	1.74rm/cc	10.85%
3	N.M. + 15% stone dust	1.6gm/cc	9.95%
4	N.M. + 20% stone dust	1.84gm/cc	8.84%
5	N.M. + 25% stone dust	1.95gm/cc	8.3%
6	N.M. + 30% stone dust	2.06gm/cc	7.94%



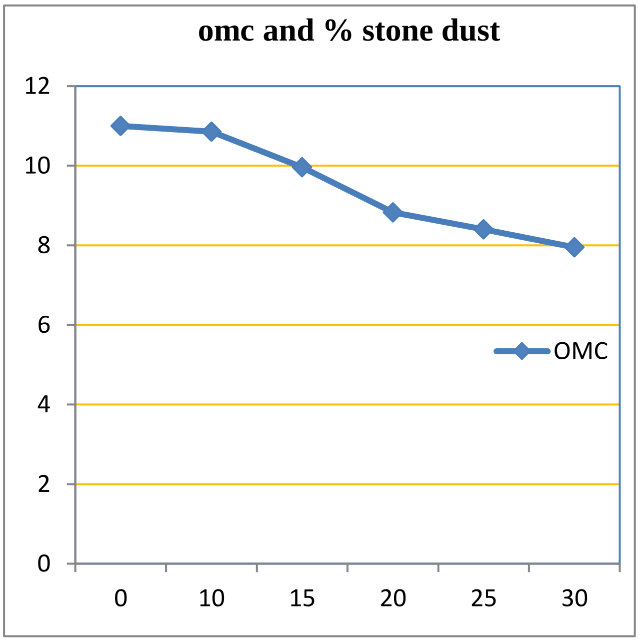


Figure 3 . Graph showing relationship of omc and mdd with % of stone dust

The variation of maximum dry densities and the optimum moisture contents for varying percentages of additive are shown in Fig. 4.4. The mdd values are improving and omc values are decreasing with increasing percentages of stone dust adding to murum. Because the fact that stone dust particles fill the void gap of the coarse grained particles of murum.

Strength parameter of murum mixtures: -From the every murum-stone dusty mix, Six identical soil samples are prepared (Three for stiff CBR and Three for un stiff CBR test) with water particle of optimum moisture contents values of 10.86%, 9.96%, 8.83%, 8.40%, and 7.95% and compacted to corresponding densities of maximum dry densities values of 1.76, 1.80, 1.85, 1.96 and 2.07gm/cc. It was noted from table 4.6 and fig. 4.5, as the percentage of stone dust improves the stiff and un stiff CBR value of murum mixture improves.

Table 5. Relation in between Soaked and Un soaked CBR and % of stone

S.No.	Description of Mix	CBR soaked	CBR Un soaked
1	Natural Murum	14.36%	20.85%
2	N.M. + 10% stone dust	16.21%	22.24%
3	N.M. + 15% stone dust	17.60%	24.10%
4	N.M. + 20% stone dust	20.39%	26.41%
5	N.M. + 25% stone dust	24.09%	30.12%
6	N.M. + 30% stone dust	28.73%	34.76%

Vi. CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

A. Conclusion

Based on the laboratory test results, the following conclusions are drawn;

1. As the percentage of stone dust additive improve from 10% to 25% the plasticity of the murum stone dust mixture decreases from 23.21% to 20.13%.
2. As the percentage of stone dust additive improve from 10% to 30% the mdd values of the murum stone dust mixture increases from 1.71 gm/cc to 2.06 gm/cc and the corresponding omc values decreases from 11.04% to 7.94%.
3. As the percentage of stone dust additive increases the CBR values of the murum stone dust mixture increases from 14.36% to 28.73%.

As the percentage of stone dust additive increases from 10% to 30% the Gradation of the murum stone dust mixture proceeds sides of upper limits of graduation value and at maximum of 30% stone dust it just touches the upper limit of graduation.

It is observed that the mixture of the murum mixed with 25% of stone dust full fill the requirement for granular sub base material recommended by Ministry of rural development (MORD). The values at 30% stone dust are also completed the necessity of granular sub base material but when we are getting our suitability of admixes on lower % of stone dust i. e. 25% then seeing to economy of construction the 25% stone dust is approved as additive.
The details comparison of parameter recommended and of result obtained on 25% stone dust are as sgiven in table 6.

Table 6 . Comparison of recommended parameters with laboratory results

S. No.	Properties	Values Recommended by MORD	Values analyzed on mixture of murrum with 25% stone dust as additive
1	Liquid limit	Not more than 25	23.85 % (less than 25%)
2	Plasticity Index	Not more than 6	3.82% (Less than 6%)
3	MDD	Not less than 1.70 gm/cc	1.93gm/cc (More than 1.70gm/cc)
4	CBR	Not less than 20% after 72 hours soaked condition	24.17% after 72 hour soaked condition (More than 20%)
5	Gradation as per table 400.1	Should lies within prescribed range of table 400.1	Gradation curve lies in between Upper limit and lower limit of required gradation.

Hence we resulted that the 25% stone dust as added by weight of murum is more suited and commended for executing in the work of road pavement as granular sub base material for rural road construction.

B. Recommendation for upcoming future work

Following recommendation are commended for upcoming studies and researches.
1. The similar nature of probe are also commended for finding out usage of existing plastic soil for different road work material like embankment, sub grade and tuff shoulder by added suitable good engineering property material.
2. The similar nature of probe are also commended for finding out good usage of existent plastic soil with additive of aggregate for base course material, soil with lime as additive in soil for embankment/sub grade purpose.
3. The similar natural of probe are also recommended for the garbage obtained from dismantling of absolute existent road or breaked layer of pavement, which can be used as sub grade or base course by adding stone dust/sand as additive or more than

one additive alike stone dust and clay or sand with clay and lime.

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