

Upgradation of Marginal Materials using Stabilization Techniques

Maliha Ashraf¹ Dr. P.K.Agarwal² Dinesh Kumar³

^{1,2,3}Department of Civil Engineering

^{1,2,3}MANIT Bhopal (MP) India

Abstract— Construction of a large number of roads in India under various projects requires good quality aggregate. The scarcity, high cost and extraction of these aggregates has led to the investigation of cheaper materials of sufficient strength for the construction of roads. The marginal materials or the locally available materials are thus employed to serve the purpose. The use of the marginal materials having comparatively less strength will affect design, construction and pavement performance. These materials may often cause poor performance thus leading to rutting, shoving, cracking, aggregate abrasion, raveling, low strength, low skid resistance, shortened service life etc. In order to utilize these materials effectively certain modifications or improvement is required which is achieved by stabilizing these materials using various stabilizing agents. Stabilization is a process of improving the properties of the marginal materials to get desired engineering properties. The paper highlights various stabilizing agents such as coarse grained materials as well as lime, cement, fly ash and also mixture of these to stabilize weaker soils/marginal materials. Various tests required to test the suitability of these stabilized materials has also been discussed. Also the issues associated with the use of these stabilizing agents and their possible solutions have been discussed.

Key words: Stabilization Techniques, marginal materials

I. INTRODUCTION

The cost of road construction has increased in the last few years at a very rapid rate. The main reason of this is the non availability of good and economical construction materials. Apart from economical consideration for the sustainable development, now a days it is an important issue for all the authorities related to road construction that marginal materials (Non-Conventional Materials) should be used in road construction.

Geotechnical properties of marginal materials can be improved by various methods such as mechanical and chemical stabilization. Stabilization is thus process of altering and improving the properties of marginal materials in order to get the desired engineering properties. Mechanical stabilization is the mixing of granular material such as gravels, sands or crushed stone in order to alter the gradation properties of marginal materials. Chemical stabilization is the addition of cement, lime, fly ash, bentonite etc. Chemical stabilization is the addition of chemical binding agents to marginal materials to remove moisture and improve the strength properties of materials.

Thus, the present paper is an attempt to analyze and understand application of various stabilization techniques to marginal materials. The objective of the paper is to understand the engineering properties of the marginal materials and understand their usage in stabilizing various local materials. The paper also identifies various problems faced while using the stabilized materials and the possible solution recommended.

II. UPGRADATION OF MARGINAL MATERIALS USING STABILIZATION TECHNIQUES

Since marginal materials sometimes fail the strength criterion, improvement in materials is achieved through stabilization which leads to increase in durability and strength of the marginal materials.

The marginal material needs certain modification in order to comply with the gradation, plasticity characteristics and strength requirements of the conventional aggregate. If the marginal material is too coarse risk related to shear and settlement failure is increased. If the local material is too fine, it fails the strength requirement as there is high risk of deformation. The materials having rounded shape have in general poor inter-particle friction and thus provide lesser stability. The locally available material often leads to distress, thus leading to premature failure and severe shrinkage cracks and fatigue cracks. Hence there is a general loss in stability. The marginal materials may also cause poor performance of the pavement resulting in cracking, rutting, shoving, raveling, aggregate abrasion, low strength, low skid resistance, shortened service life and also combination of these problems. Also, the materials greatly affect the workability therefore modifications may be required.

The cost of excavation of the weak material and replacing it by better material can be avoided using stabilization techniques. When the construction site is located in remote areas and adequate availability of appropriate material is not possible, soil stabilization become the best alternative.

Basically, the available materials i.e. locally available/marginal materials can be stabilized mechanically or chemically to achieve comparable performance at competitive price. The selection of stabilization techniques is generally based on gradation and plasticity of the material to be treated. The various stabilization techniques employed to improve the strength as well as stability of marginal materials have been discussed below:

A. Stabilization using Mechanical method

The stabilization is accomplished by mixing or blending of marginal materials in order to obtain a material that meets the required strength and stability specifications. Generally, if the local material is coarse grained i.e. sandy gravel, requisite quantity of fine grained soil i.e. cohesive soils is added in order to adjust the proportions. Similarly, coarse grained soil is added if the available soil is fine grained. Mostly gravels, crushed stones and natural sands are added to the marginal materials. The natural sand is added mainly to reduce the plasticity whereas the gravels and crushed stones are added to increase the CBR of the marginal materials.

B. Stabilization using Lime

The clayey soils, moorum or soils met with alluvial plains can be effectively treated with lime. The lime stabilization is recommended to reduce plasticity, increase workability and

increase the strength of the local material. In order to increase the effectiveness of stabilization, 15 percent of the soil fraction should pass through 425micron sieve and should have a plasticity index of at least 10 percent. It is also desirable that percentage of soil that is retained on 425micron sieve should be well graded with uniformity coefficient of at least 5. The clay minerals should be ilitic, montmorillonite or kaolinite. The local soil having high kaolinite as the basic clay mineral generally have a fairly low plasticity index and a high liquid limit can be stabilized effectively using lime. The organic matter present in the marginal material should not be more than 2 percent and also the sulphate content should not be greater than 0.2 percent. The purity of lime i.e. amount of calcium oxide present in lime will affect the strength of the stabilized soil. Therefore, the lime should have a purity of at least 50 percent. For effective stabilization, uniform mixing is a must and fineness of the lime is a measure of the degree of mixing achieved.

C. Stabilization using Cement

The granular materials having low concentration of organic matter are generally stabilized using cement. The marginal material to be stabilized using cement should not have a percentage fraction passing through 75 micron sieve greater than 60 percent. The uniformity coefficient of the materials should be exceed 5 preferably 10. The materials having high mica content are not suitable for stabilization using cement. The local materials having organic content greater than 2 percent and sulphate and carbonate concentration exceeding 0.2 percent cannot be stabilized using cement.

D. Stabilization using Lime Fly Ash

Lime and fly ash combination can be used to stabilize granular material. The fly ash contains silica and aluminum compound which when fixed with lime and water forms a hard cementitious mass having high compressive strength. The coarse grained materials having less or no fine can be stabilized by using lime fly ash stabilization technique The marginal materials having plasticity index between 5 and 20 can be stabilized using lime and fly ash combination.

E. Stabilization using Lime, cement and fly Ash

Cement is sometimes used in combination with lime and fly ash to improve the strength and durability of the stabilized materials. Generally, this technique is applied to heavy clays. In the first stage, lime is added to reduce the plasticity and also to facilitate pulverization. In the second stage, the resulting soil is stabilized with cement and fly ash.

F. Stabilization using Bitumen

Clean graded sands stabilized using this technique as bitumen binds the soil particle.

G. Test Requirements of Stabilized Materials

Normally, two tests i.e. Unconfined compressive strength test and durability tests are carried out in order to test the suitability of the stabilized marginal material. The significance of the tests carried out to test the suitability of the stabilized materials has been discussed in Table 1.

Tests required	Significance	Key points considered
Unified Compressive strength test (UCS)	Measures the strength of the stabilized marginal material	The material to be tested is mixed at a fixed moisture content The ratio of maximum particle size and the dimension of the mould should be kept as small as possible.
Durability test	Measures the durability of the stabilized material i.e. a measure of weight losses, swelling, shrinkage and moisture changes	The loss in weight in durability test for base of pavement should not exceed 20 percent, for sub base and shoulder the loss should be less than 30 percent

Table 1: Significance of test carried out to test the suitability of the stabilized materials

III. CHALLENGES ASSOCIATED WITH STABILIZATION

There are two major problems namely cracking and long term durability of the materials which arise while using stabilized

materials in road construction. The problems, their contributing factors, the further problems associated and the possible solution have been discussed in detail in Table 2.

Challenges	Factors contributing	Problems caused	Possible solutions
Cracking in Stabilized Layer	The tensile strength, Shrinkage characteristics, Stiffness, Creep of the stabilized materials. The restraint offered by the subgrade. Temperature and moisture variations leading to change in volume. External loadings caused by traffic etc.	Loss of interlock and eventual failure. Ingress of water in cracks may lead to weathering, de-bonding between pavement layers.	Immediate closure of these developed cracks using approved curing compound
Primary Cracking	Shrinkage Temperature fluctuations	Wide cracks further leads to lateral reflective cracks.	In order to prevent the propagation of lateral cracks, greater thickness of material is required. Laying should be performed when the weather is

	Thermal shrinkage due to higher temperature while the material is laid. Greater variation in day and night temperature.		less hot. The stabilizing material should have low early strength and high long term strength to provide good mechanical interlock
Traffic-associated cracks	Stabilized materials have low strength of lesser thickness than required.	Leads to map cracking causing the stabilized material to deteriorate in small slabs thereby poor load transfer. Pumping of finer materials from the underlying surface	Proper design strategy should be followed to take account of the traffic that is to be encountered during the design life of the road.
Durability of the stabilized material	Deficiency in the amount and quality of stabilizer. Deficient compaction and curing	Peeling off the surface dressings from the stabilized layers.	Standard preliminary testing should be done Quality control should be maintained.

Table 2: Challenges and possible solutions while performing stabilization.

IV. CONCLUSIONS

The following conclusions have been drawn from the above study:

- Upgrading of the marginal materials through beneficiation techniques i.e. mechanical and chemical stabilization appears feasible and many a times very economical.
- The addition of stabilizing agent to the marginal materials improves the physical and mechanical properties and also reduces the liquid limit and plasticity index.
- Fly ash, lime and bentonite are very cheap materials therefore can be used to effectively stabilize soft soils in rural areas where cost of construction is of primary importance.
- The lime and cement stabilization are better options when strength is of prime importance
- Cement and bitumen are well suited for on-plastic and granular soils whereas lime performs best in cohesive soil.

REFERENCES

- [1] Agarwal P. K., Ashraf M., Yadav R.K., Singh A., "Application of Marginal Materials for the construction of PMGSY roads in the state of Madhya Pradesh".
- [2] Arulrajah A., Ali M.M.Y, et al., "Geotechnical Properties of Waste Excavation Rockin Pavement Subbase Applications." J. Mater. Civ. Eng, Vol. 24, Issue 7, 2016, pp 924-932.
- [3] Brennan G E., "Marginal Materials for Sealed Roads: A Newzealand Experience", ARRB Proceedings, Volume 12, Issue 3, 1984.
- [4] Cook J R., Bishop E C., Gourley C S and Elsworth N E, "Promoting the use of marginal materials", Published by TRL Limited, 2001.
- [5] Cook J R., Gourley CS., "A Framework for the Appropriate Use of Marginal Materials" World Road Association (PIARC)-Technical Committee C12 Seminar in Mongolia, June 2002.
- [6] Gautam B., Yuan D., Abdalla I. and Nazarian S., "Guidelines for Using Local Materials for Roadway Base And Subbase", Research report conducted for Texas Department of Transportation in Cooperation, The University of Texas at El Paso, 2009.
- [7] Little D.N., and Graves R., "Upgrading Marginal Aggregate Bases and High-Fines Bases With Low Levels of Stabilizers", Texas Transportation Institute, Texas A&M University and Vulcan Materials Company, 1999.
- [8] Mishra B., Mishra R.S., "A Study on Use of Industrial Wastes in Rural Road Construction", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 11, November 2015.
- [9] Rollings R.S., "Marginal Materials for Pavement Construction", Final Report, Department of the Army Waterways Experiment Station Corps of Engineers, US. Vicksburg Mississippi, 1988.
- [10] Satyakumar M., R. Anil, Chandran S.R., "Subgrade Stabilization Using Additives for Rural Road: A Case Study" A National Conference On Fifteen Years of PMGSY (FYPMGSY) ,Civil Engineering Department, Indian Institute Of Technology Roorkee, Roorkee-247667 (Uttarakhand) August 6-7, 2016
- [11] Zumrawi M., "A Study on Mechanical Stabilization to improve Marginal Base Materials in Khartoum" International Journal of Science and Research (IJSR), Vol. 3 Issue 6, June 2014, pp 1716-1721.