EFFICACY OF CEMENT ON STABILIZATION OF GRAVEL SOILS AS ROAD CONSTRUCTION MATERIAL

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Abstract - *The vehicle load transfer mechanism can be efficiently managed by the inter-connecting layers and their characteristics. The top layers should be strong enough to take care of vehicle stresses; one such is Base- course. Usually Base-course materials are natural soils like gravels, sands, stone particles, etc. Gravel soils in large quantity can be popularly used as Sub Base, Base-course materials in the construction of pavements. When the gravel soil possess considerable amount of fines (silt and clay), they take moisture and deform under loading. To reduce the excess deformations of the gravel soils under saturation and to increase the strength and durability, stabilization is one of the techniques to be adopted and cement can be chosen as stabilizer. Different percentages of cement (OPC 53 grade) were added to gravel soils and tests were conducted to assess compaction and strength characteristics. By addition of cement, compaction characteristics are improved thereby improving the California Bearing Ratio (CBR) values. Hence by addition of 2-3% cement to gravel soils makes them suitable to meet the requirements of Ministry of Road Transport and Highways (MORTH) specifications as Base- course material.*

Key Words: ***Base- course, Deform under loading, Stabilization, Strength, Durability, Compaction, Addition of cement. MORTH***

1.INTRODUCTION

Gravel soils are frequently used in road construction as Sub-Base layers fill material in Embankments and low-lying areas of several projects. By the nature the composition of gravel soil varying their particles in the range from 75 mm to 2µ. Presence of wider ranges of particles makes the Gravel soil Dense/Compacted which achieves higher strength under shearing. Sometimes the presence of plastic fines like silt and clay particles takes excess moisture and makes these gravel soils to shear. To arrest these plastic deformations, stabilization techniques can be proposed. In this an attempt is made to stabilize gravel soils by reducing the plasticity and improving strength characteristics by adding cement as a stabilizer. Various percentages of cement added to Gravel soils of various degree of plasticity characteristics verifies to suit pavement layers.

2. METHODOLOGY:

2.1 MATERIAL USED:

The materials used in this investigation are:

- Gravel Soil
- Cement(53 grade)

2.2 LABORATORY TESTING:

2.2.1. Properties of Material:

The following tests were conducted on the soil. The index and engineering properties of soil were determined.

1. Grain size analysis confirming (IS: 2720-part 4, 1985)
2. Consistency limits or Atterberg's Limits using Uppals method confirming (IS: 2720-part 5, 1985)
3. Compaction test confirming (IS: 2720- Part 8: 1983)
4. California bearing ratio test confirming (IS: 2720-Part 16: 1987)

3. Results

To study the performance of gravel-cement stabilized materials at various percentages of cement (1%,2%,3%,4%&5%)and exposed for curing periods has been tested to know compaction and strength characteristics.

3.1 MATERIALS:

Two gravel samples designated as G_1, G_2 were collected from quarries and tested for various geotechnical characteristics such as Gradation, consistency, compaction and strength etc.

3.1.1 Geotechnical Properties of Gravels:

Table 3.1 Geotechnical properties of Gravel 1(G_1), Gravel 2(G_2)

Gravel 1(G_1), Gravel 2(G_2)		
Property	**Values G_1**	**Values G_2**
Gradation Properties		
Gravel (%)	58	50
Sand (%)	24	30
Fines (%)	18	20
Index Properties		
Liquid Limit (%)	23	29
Plastic Limit (%)	18	19
Plasticity Index (I_P)	5	10
IS Classification	GM-GC	GC

Compaction Characteristics		
Optimum moisture content (OMC) (%)	7	8
Maximum dry density (MDD) (g/cc)	2.12	2.08
Strength Characteristics		
California bearing ratio (%) (CBR Soaked)	33	26

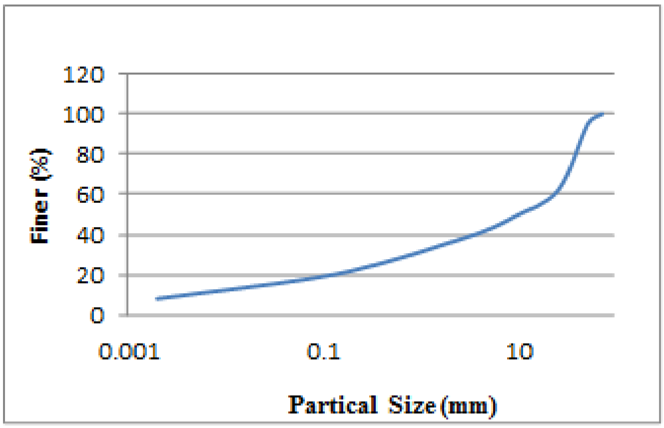

Fig 3.1 Gradation curve for Gravel-1

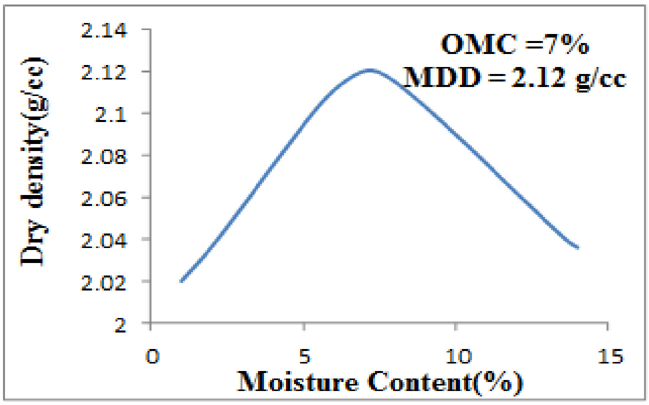

Fig 3.2 Compaction Curve of Gravel-1

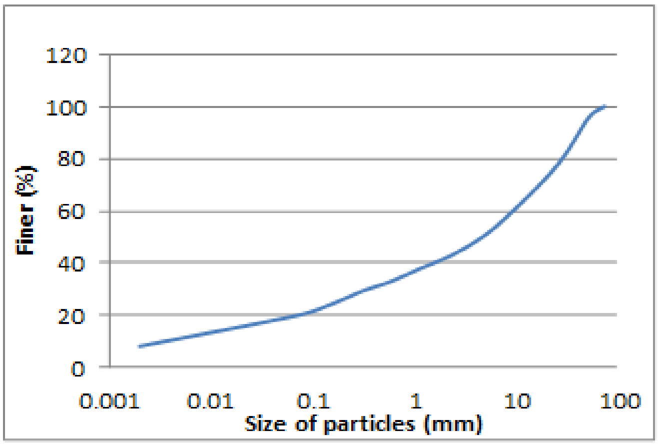

Fig 3.3 Gradation curve of Gravel-2

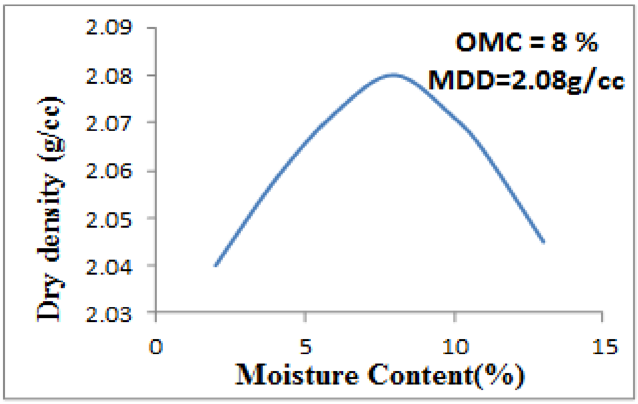

Fig 3.4 Compaction Curve of Gravel -2

From the test results it is identified that the gravel soils are varying from high plasticity (Ip>15) to medium plasticity (7<Ip<15) characteristics and I_p <7 for low plasticity characteristics. The fines of these soils exhibited low to intermediate compressibility characteristics and presence of fines makes the soil attain low maximum dry densities with high moisture contents. At these basic characteristics these gravel soils have high variations in CBR values. It is also identified that when gravel soils having low plasticity index (less than 7) it attained high maximum dry densities at low optimum moisture content and exhibited high CBR values. Hence gravel soils having low plasticity characteristics with CBR (greater than 30) can be used as Sub-Base course material where as gravel soils having high plasticity characteristics require stabilization to improve its strength characteristics to suite as Sub Base course material and with CBR values greater than 60 can be used as Base-course materials.

3.1.2 Properties of Cement

Cement was collected from local available markets that is OPC 53 grade and tested for various properties.

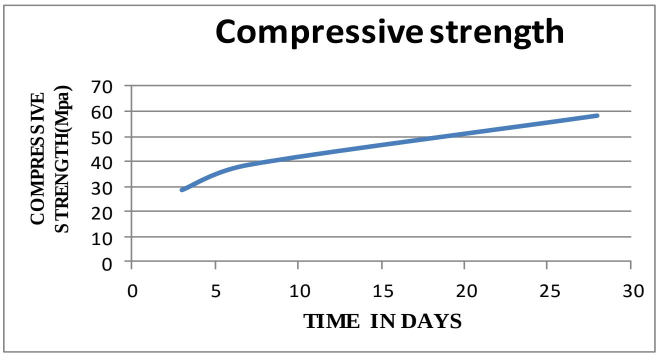

Fig 3.5 Compressive Strength of Cement with Respect to Time

3.2 GRAVEL-CEMENT MIXES

To use Gravel soils as sub base and base course materials, cement can be selected as an additive to achieve high CBR values. Therefore various percentages of cement of 53 grade was added to gravel soils and subjected to compaction and strength characteristics. To obtain CBR values the Gravel-cement samples were compacted at their maximum dry densities and cured for seven days (control curing). After required curing period, samples were tested for compressive strength values

3.2.1 Variation of Compaction and Strength Characteristics of G_1 with Cement ($I_p = 5$)

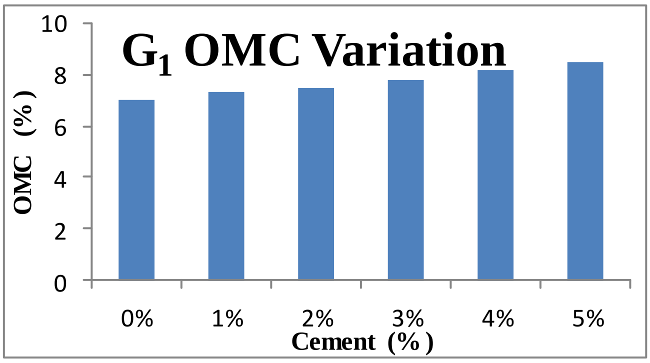

Fig 3.6 Variation of OMC with percentage of cement of G_1

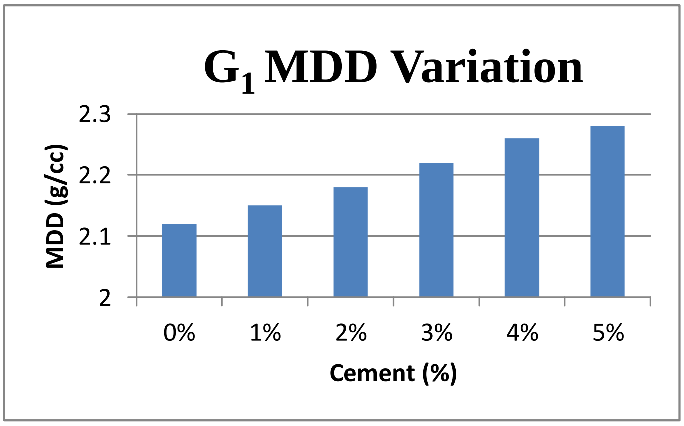

Fig 3.7 Variation of MDD with percentage of cement of G_1

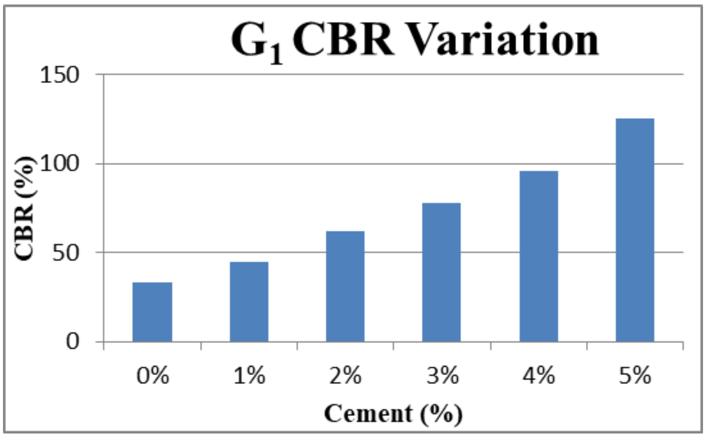

Fig 3.8 Variation of CBR with percentage of cement of G_1

From the test results it is identified that as percentage of cement is increasing OMC, MDD and CBR values are increasing. Maximum dry densities increased from 2.12 to 2.28 and CBR increased from 33 to 125%. Addition of cement to low plastic gravels utilizes its cement content for the development of bond between cement and gravel soil particles and generates high strength values. Addition of 2 % cement to the low plastic gravel generated a CBR value of 62 can be used as Base-course material (CBR>60%) with respect to MORTH specifications.

3.2.2 Variation of Compaction and Strength Characteristics of Gravel 2 with Cement ($I_p = 10$):

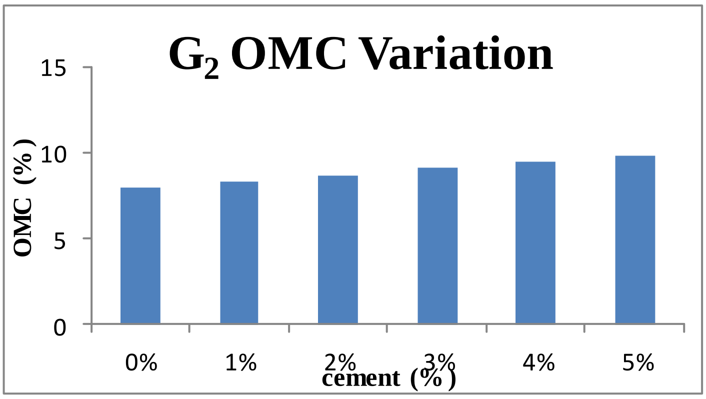

Fig 3.9 Variation of OMC with percentage of cement of G_2

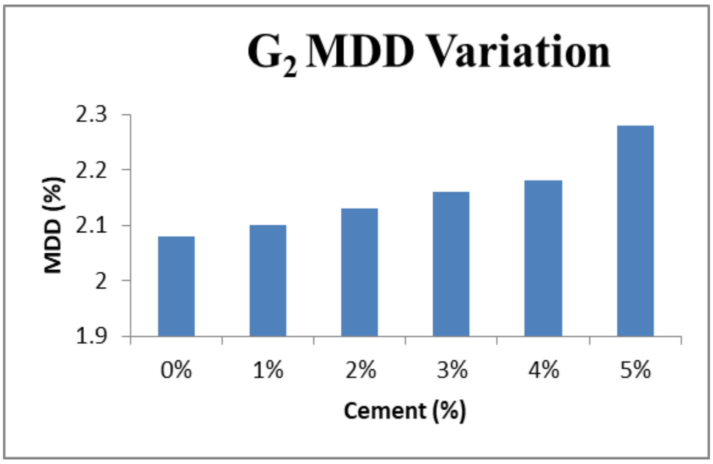

Fig 3.10 Variation of MDD with percentage of cement of G_2

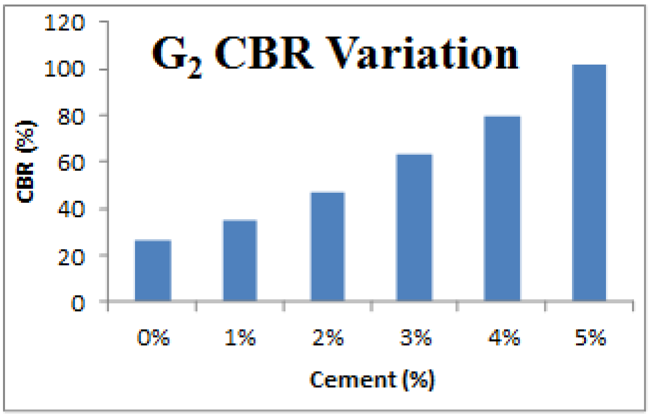

Fig 3.11 Variation of CBR with percentage of cement of G_2

From the test results it is identified that as percentage of cement is increasing OMC, MDD and CBR values are increasing. Maximum dry densities increased from 2.08 to 2.20 and CBR increased from 26 to 102%. Addition of cement to medium plastic gravels utilizes a part of cement content for the reduction of plasticity and remaining cement for generation of bond between cement and gravel soils particles and generates high strength values. Addition of 1% of cement to medium plastic gravels attained CBR value of 35% can be used as Sub-Base course (CBR>30%). Addition of 3% cement to the medium plastic gravel generated a CBR value of 63 can be used as Base-course material (CBR>60%) with respect to MORTH specifications.

3.3 VARIATION OF MDD FOR DIFFERENT PLASTICITY INDEX GRAVELS WITH RESPECT TO CEMENT

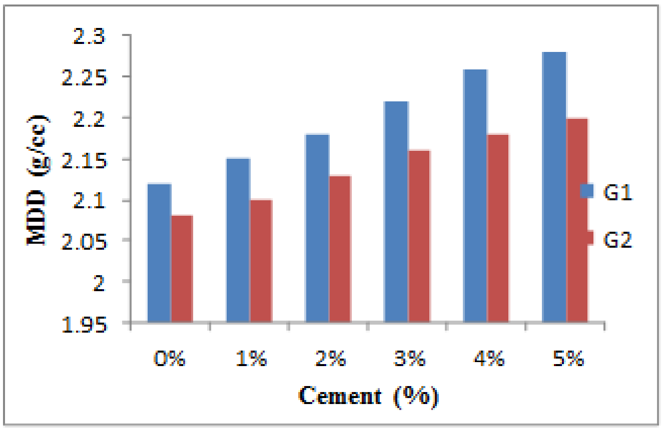

Fig 3.12 Variation of MDD for different plasticity index gravels with respect to cement

3.4 VARIATION OF OMC FOR DIFFERENT PLASTICITY INDEX GRAVELS WITH RESPECT TO CEMENT

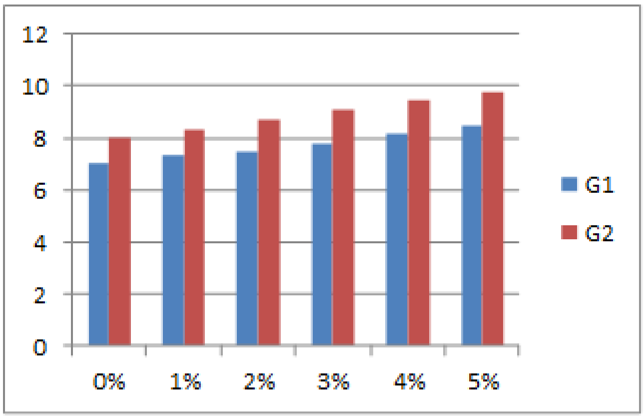

Fig 3.13 Variation of OMC for different plasticity index gravels with respect to cement

3.5 VARIATION OF CBR VALUES FOR DIFFERENT GRAVELS WITH RESPECT TO CEMENT

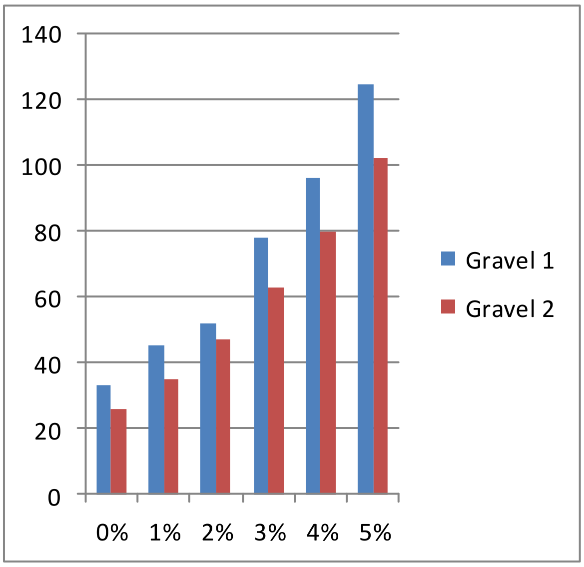

Fig 3.14 Variation of CBR values for different gravels with respect to cement

Hence from the test results it is identified that as the percentage of cement is increasing both maximum dry density and optimum moisture content values are also increasing. Increase in optimum moisture contents are due to requirement of more water to coat the particles and attained effective arrangement under a given compactive energy. This results occupation of more solids in given volume is responsible in attaining high dry densities. The presence of fines and their plasticity characteristics are responsible in varying their quantity of maximum dry densities and optimum moisture contents. High plasticity index gravels attained less maximum dry densities and less CBR values comparatively gravel soils of low plasticity characteristics. Low plastic gravel soils (Ip<5) require 2% of cement CBR values greater than 60 can be used as base course material, gravel soils of medium plasticity soils (Ip=7 to 15) require 1to2 % of cement to suit as sub base course material(CBR>30) and 3 to 4 % of cement as base course material (CBR>60) where as high plastic gravel soils Ip>15 require 3% of cement as sub base material and 5% as base course material.

3.6 SUMMARY:

From the test results it is observed that gravel soils have variation in their degree of plasticity range from 5 to 20%. The greatest variations in plasticity characteristics are responsible for variations in density and CBR values. High plasticity gravel with I_p>15% attained low CBR value 15% and low plasticity gravel with I_p < 5% attained high CBR(33) value. MORTH specifications say that material suited as Sub Base material should have CBR > 30% and Base course material CBR > 60%. From the results of gravel cement mixes, high plastic gravel with I_p = 20% the percentage of cement required is 3%, I_p = 15% the percentage of cement required is 2%, I_p = 10% the percentage of cement required is 1% and I_p = 5% no cement is required to suit as a Sub-Base course material. I_p = 20% the percentage of cement required is 5%, I_p = 15% the percentage of cement required is 4%, I_p = 10% the percentage of cement required is 3% and I_p = 5% the percentage of cement required is 2% to suit as a Base course material.

4. CONCLUSIONS

From the study of the performance of cement on Gravel soils the following conclusions are drawn.

1. Four gravels classified as high plasticity (I_p > 15%) to low plasticity (Ip < 7%) gravels, that is G_1 as low plastic, G_2,G_3 as medium plastic and G_4 as high plastic. High plasticity gravel attained low maximum dry densities as 2.00g/c with high OMC 10.5% and CBR 15% where as low plasticity gravel attained OMC as 7%, high MDD as 2.12 g/cc and CBR as 33%. Plasticity increases OMC, reduces density and strength values.

2. MDD increases from 2.00 g/cc to 2.12 g/cc and CBR increased from 15% to 30%.

3. As the percentage of cement is increasing characteristics like optimum moisture content, maximum dry densities and CBR are also increasing.

4. High plasticity gravels require 3% cement, medium plasticity gravels require 1-2% and for low plasticity gravels no cement is required to suit as Sub-Base course material.

5. High plasticity gravels require 5% cement, medium plasticity gravels require 3-4% and low plasticity gravels require 2% cement to suit as a Base course material.

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