BEHAVIOUR OF C & Φ OF BLACK COTTON SOIL WITH GLASS FIBER INCLUSION: AN EXPERIMENTAL STUDY

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Abstract:

Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. In this way, using natural fibers to reinforce soil is an old and ancient idea. Consequently, randomly distributed fiber reinforcedsoils have recently attracted increasing attention in geotechnical engineering for the secondtime. The main objective of this investigation had been focused on the strength behavior of the soil reinforced with randomly included glass fiber. The reinforced soil samples were subjected to compaction and triaxial compression tests. The results of these tests have clearly shown a significant improvement in the failure deviator stress, Shear strength parameters (*C* and ϕ of the studied soil. It can be concluded that glass fiber can be considered as a good earth reinforcement material.

Keywords: Glass fiber, reinforcement, soil, cohesion, Friction.

Introduction:

The soil- strengthening concept is a prehistoric method and demonstrated plentifully by the nature in the action of tree roots. This thought is used for the enhancement of definite desired properties of soil like bearing capacity, shear strength, permeability characteristics etc. This thought and theory was first developed by Vidal (1969) by which he established that the introduction of reinforcing elements in a soil mass increases the shear resistance of the medium. Presently soil strengthening performance is well established and is used in variety of applications like enhancement of bearing capacity, drainage control etc. Conventional methods of strengthening consists of continuous inclusions of strips, fabrics, and grids into a soil mass. The random insertion of usual fibers like coir, sisal, sun hemp and glass fibers etc. Is also considered as a soil strengthening technique. These fibers act to interconnect particles and group of particles in unitary coherent matrix. This work investigates the use of glass fiber as soil strengthening material.

1.1 **Fiber Reinforced Soil**

Reinforced soil with arbitrarily spread discrete fibers resembles the conservative soil strengthening in many of its properties. The preparation is fairly similar to that of stabilization of soil using admixtures like lime, cement, etc. Generally the discrete fibers are simply added and mixed with the soil, much the similar as cement, lime or any other additives.One of the main compensation of arbitrarily spread fibers is the protection of strength isotropy and lack of possible failure plane that can expand equivalent to the slanting strengthening (Chakra borty, 1996). Very limited information has been reported on the use of arbitrarily spread discrete natural fibers for soil strengthening. (Mandal et al. 1989)

1.2 Fibers as Earth Strengthening Material

The fibers have been tried strengthing in the soil strengthening (Mandal et al. 1989), due to their realistic cost, strength, ecological, less biodegradability gracious natural history and bulk availability. Besides the above advantages it has some practical drawbacks, such as spreading and lack of reproducibility. Of these the difficulty of spreading can be effectively overcome by applying small length say 1 or 1.5cm of fibers using polymer compounds (Khazanchi 1990). This is an established explanation for biodegradability of natural fibers. Though there are abundance of natural materials available for being used as soil strengthening material to improve certain engineering properties of soil such as jute, coir, glass fibers, bamboo, wood, palm leaf, coconut leaf etc. Research workers are concentrating with limited varieties of materials like bamboo, jute, and coir and other materials are presently not considered in the field of soil reinforcement. Out of these materials, glass fiber has got a gorgeous scene of being used as a natural material for soil strengthening in the form of a) simple fibers, b) geotextile, and c) geosynthetics (after being given chemical and thermal treatment).

2. Objectives of the study:

The purpose of the study is to evaluate the usefulness of glass fibers as soil strengthening material. The analysis has been partial to the following studies,

1. To study The achievement of glass fibers addition in weak soil on compaction performance.
2. To study the optimum percentage of fiber content on strength and deformation characteristics of soil
3. To study the influence of glass fibers addition on cohesion (c) and angle of internal friction (φ).

In order to achieve the above objective the strength behavior of black cotton soils arbitrarily reinforced with glass fibers has been considered. These the suitability of glass fiber as a strengthening material caused assessed. A cycle of experiments are carried out on black cotton soil sample with different percentages of fiber addition. Undrained triaxial shear tests are performed on glass fiber reinforced soil to evaluate the stress-strain behavior of the innovative material. Other significant engineering properties like specific gravity and compaction behavior are also studied besides the triaxial tests. In addition to the above mentioned tests, compaction tests, direct shear tests also carried out to assess the suitability of reinforcement soil. As a reference test for making evaluation, the above stated tests are also carried out for unreinforced soil sample.

3 Material and experimental program:

The broad objective of the present investigation is to study the strength criterion of black cotton soils mixed with glass fibers in random manner. Hence a series of experiment are conducted in the laboratory on soil reinforced and also on unrein forced soil. The details of investigation are as follows.

3.1 Materials Used

With inclusion of glass fiber in soil it improves effectiveness in the peak shear strength. Glass fiber slightly increases. the value of shear parameter and slightly reduces the brittleness. The glass Fiber in soil reinforcement provides: Preventing the formation of the tensile crack, increasing hydraulic conductivity and liquefaction strength, reducing the term conductivity and weight of the building material, restraining the swelling tendency of expensive soil. Glass fibers are used to enhance the soil strength properties and reduce the shrinkage properties and to overcome chemical and biological degradation Settee and Rao carried out tensile strength test on black cotton soil reinforced with glass fiber. The test result illustrated that soil showed a significant increases in the cohesion intercept and slight decreases in the angle of internal friction with increase in fiber content.

Table 3.1 Properties of glass fiber

S.no.	Strength	Value
1.	Tensile strength (kg/cm^2)	930.1
2.	Modulus of elasticity (mpsi)	1.18
3.	Flexure strength (Kg/cm^2)	1908.97
4.	Modulus of plasticity (mpsi)	0.96
5.	Diameter of fiber	7 to 35 micron

3.1(a)Advantages of glass fiber

- The strength of glass fiber is stronger twice of steel yet its weight is 60% lighter than the steel.
- Glass fibers have very low co –efficient of linear expansion and are insensitive to temperature variations.
- It repel water and readily dries, as their shape is non-cellular as well as cylindrical.
- Glass fiber do not degrade or deteriorate, dur to that insects and rodents cannot attack them.
- Glass fiber come in different types of sizes enabling to combine with many synthetic resins as well as mineral matrices like cement plaster etc.
- Being mineral materials, Glass fiber is neither combustible nor support combustion. When exposed to heat, It neither emit smoke nor toxic gases.
- When treated with suitable binder material it has ability to mould excellently to close dimensional tolerances.

3.1.1 Soil

The black cotton soil used for the study was collected from the location of Dabra Madhya Pradesh. The Soil sample was collected in polythene bags and then air dried. Engineering properties of this soil listed in Table 3.2 Engineering properties of soil used in this study

SL.no	Soil properties	Values
1.	Specific gravity	2.64
2.	Grain size analysis	

	Gravel	0.0
	Sand	2.48
	Silt	18.45
	Clay	81.09
3.	Consistency limit	
	Liquid limit	46.30
	Plastic limit	31.0
	Plasticity index	15.03
4.	I.S Classification	CH
5.	Compaction study	-
	Optimum moisture content	18%
	Maximum dry density	1.67gm/cc
6.	Shear parameters	
	Cohesion	69.12 KN/m2
	Angle of shearing resistance	3°

s.no.	Test	Soil	Fiber content (%)					Fiber length	Water content
			0.125	0.250	0.375	0.500	0.625		
1	Compaction	B.C.	Sample I	Sample II	Sample III	Sample IV	Sample V	15mm	OMC
2	Triaxial	B.C	Sample I	Sample II	Sample III	Sample IV	Sample V	15mm	OMC

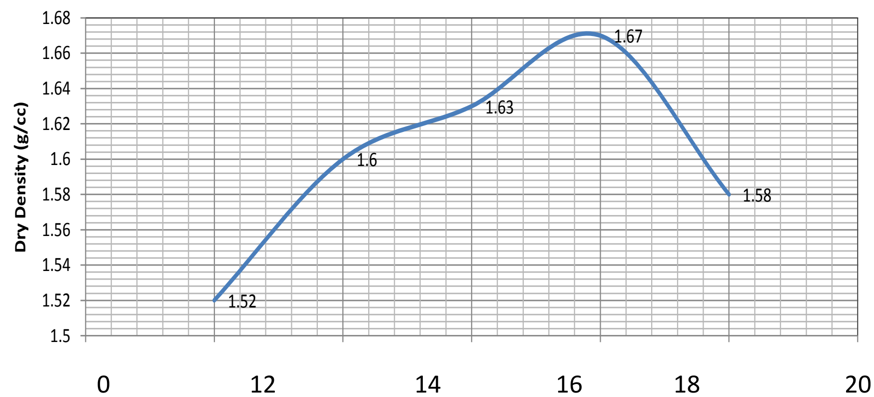
3.3 Brief Test Procedures

Preparation of fiber mixed soil sample is as follows

1. The raw soil sample is air dried
2. It is pulverized,, and required quantity of sample is weighed.
3. Air dry fibers in selected proportion by weight of raw soil are taken
4. The fibers are added to the soil in a tray randomly and mixed thoroughly so as to have a coherent mass.
5. Desired quantity of water is added as per the requirement of the tests. The samples for compaction test and triaxial test are prepared at the respective OMC and MDD.
6. The brief procedures for the conduction of deferent tests such as triaxial tests, and compaction test, are described below.

3.3.1 Compaction Test

Compaction test was carried out adopting IS light compaction method as specified in IS 2720 (Part VIII) – 1980. which determine the optimum moisture content and maximum dry density of a soil.Compaction of soil increases density but reduces void ratio and porosity. The moisture content at which the soil gives maximum density known as optimum moisture content and that maximum density is called maximum dry density. The graph is plotted between dry density and water content. The results of this test are useful in the stability analysis of soil. From the figure 3.3.1 it is observed that the dry density initially increase with an increase in water content till a maximum value of dry density is achieved. With further increase in water content then dry density decreases.



Water content (%) Compaction with Black Cotton Soil

Fig 3.3.1

3.3.2 Triaxial Compression Test

The conventional undrained triaxial compression test was performed at a strain rate of 1.27mm per minute under the confining pressures (σ_3) of 0.70 kg/Cm^2 and 2.10 kg/Cm^2. The remolded soil specimens with and without reinforcement were prepared in standard mould at the respective optimum moisture content with maximum dry density using IS light compaction. confining pressure play the significant role in changing the behavior of soil. Deep foundations observe the confining pressure of very high magnitude. Triaxial shear test is only test to simulate this confining pressure. Triaxial tests are superior where confining stress is to be applied and the plane of shear failure is not predetermined. The shear parameters, namely the cohesion (c) and angle of shearing resistance ($\emptyset$) can be easily determined from this test. The Cylindrical shaped triaxial test specimens were obtained by driving sample extruder and specimens were ejected out and trimmed off so that the finished dimensions of the specimen being 38mm in diameter and 76mm in length. These specimens were tested in triaxial testing machine under undrained condition. Failure of specimens reinforced with fiber is presented

4. Result and discussion:

Soil testing is an integral part of analysis and design of substructures in civil engineering. A proper collection of soil samples and determination of relevant soil properties simulate on field-loading condition are important parameter of the foundation engineering. To obtain the information about the index and engineering properties of the soil collected from various locations, a series of Atterberg limits, sieve analysis, compaction and triaxial shear tests are conducted on soils, with varying content of fiber 0.125%, 0.250%, 0.375%, 0.500% and 0.625%. In judging the utility of fiber in soil at locations, fiber plays an important role in compaction as well as shear strength behavior of soil. Fiber content widely affects index and engineering parameters of a soil.

For this study, types of soil samples are collected from locations like Dabra (M.P.) and the index and engineering properties of the same and mixed with fibers varying from 0.125% to 0.625% by weight are determined in soil mechanics laboratory as per IS codes. The same are discussed in detail in subsequent sections.

4.1 Effect of Fiber Content on Maximum Dry Density

The results of compaction tests conducted on different soil-fiber mixture shows a regular pattern. The graph is plotted between maximum dry density in g/cc as an abscissa and fiber content as an ordinate. It observed that the maximum dry density initially increases with an increase in fiber content till a maximum value achieved. With further increase in fiber content shows reduction of dry density (γ_d). Fig. 4.1

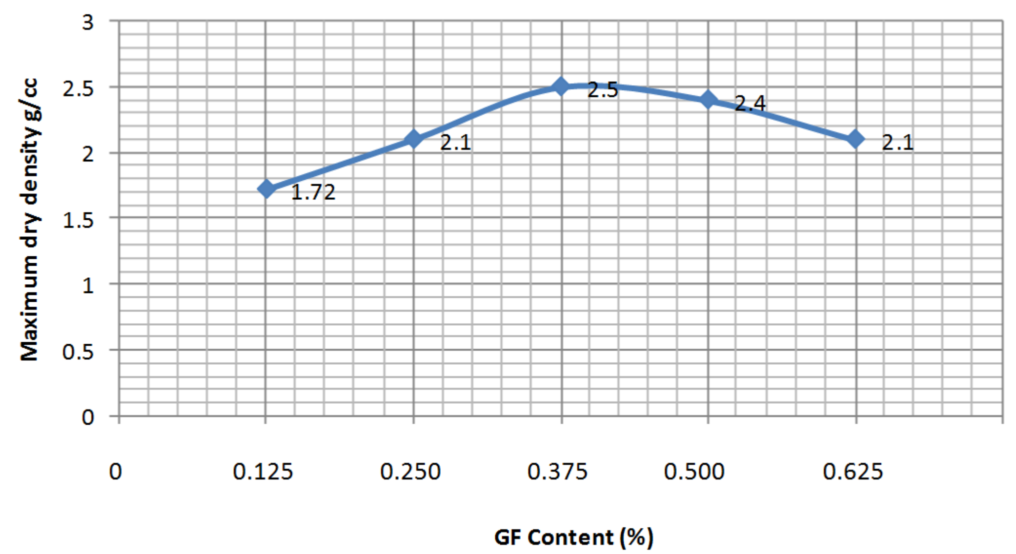


Fig 4.1

4.2 Effect of Fiber Content on optimum Moisture Content

Figure 4.2 shows the variation of optimum moisture content with respect to fiber content. The graph is plotted between optimum moisture on Y axis and fiber content on X – axis. It can be easily observed from these graphs that increase in fiber content, optimum moisture content shift towards downward i.e. optimum moisture content deceases with increase in fiber content

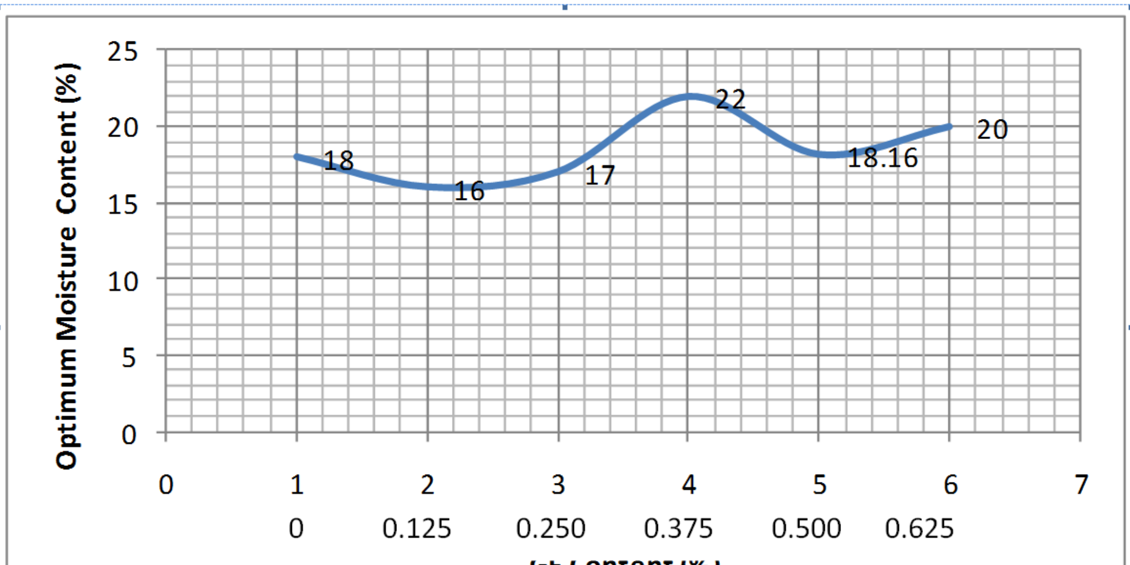


Fig 4.2

4.3 Effect of Fiber Content on cohesion

The graph is plotted between cohesion (KN/m²) Y- axis and fiber content (%) on X-

axis. From the figure 4.4 it observed that the maximum value of cohesion initially increases with an increase ;in fiber content till amaximum value achieved at optimum fiber content (fiber gives maximum cohesion value at 0.250%) with further increase in fiber content shown decrement of cohesion for water content 22%. But cohesion shows a linear variation for water content 22%.

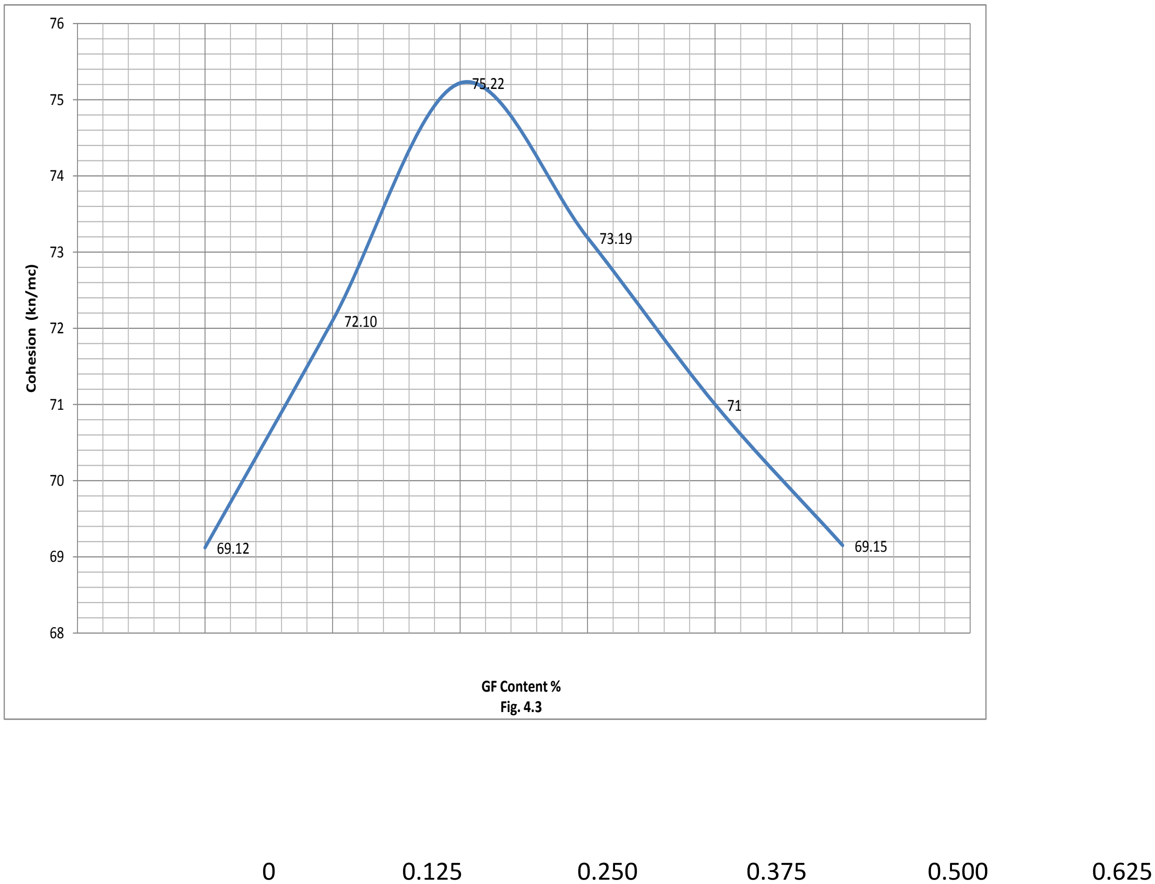


Fig. 4.3

4.4 Effect of Fiber Content of Angle of internal Friction

A graph is plotted between angle of internal friction (ϕ) Y- axis and fiber content (%) on X axis. It observed that the maximum value of angle of internal friction initially increases with an increase in fiber content till a maximum value achieved at optimum fiber content (fiber gives maximum angle of internal friction at 0.125%) with further increase in fiber content shown in fig. 4.4 decrement of angle of internal friction for water content 22%. But angle of internal friction shows a linear variation for water content 22%

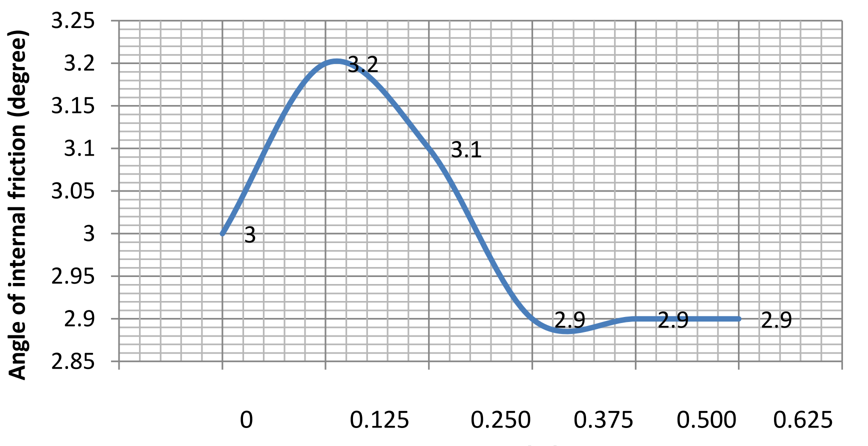


Fig. 4.4

S. No.	Water Content (%)	Dry Density g/cc	Fiber Content (%)	Cohesion kn/m^2	Angle
1.	18	1.67	-	69.12	3^0
2.	16	1.72	0.125	72.10	3.2^0
3.	17	2.1	0.250	75.22	3.1^0
4.	22	2.5	0.375	73.19	2.9^0
5.	18	2.2	0.500	71.13	2.9^0
6.	20	2.1	0.625	69.15	2.9^0

5. Conclusion

In regions where black cotton soil is encounters, construction of building and other civil engineering structure is highly risky on geotechnical grounds as the soil is highly compressible posses low shear strength and is susceptible for volumetric instability. Many investigators have attempted to improve the engineering properties of this soil by mixing non cohesive materials. Chemicals like lime and cement etc. fibers both natural and synthetic have also been mixed to small quantities to enhance the strength and reduce the swelling and shrinkage characteristics.

In the present work the glass fiber was randomly included in to the soil at five different percentages of fiber content viz 0.125%, 0.250% 0.375, 0.500%, and 0.625%, by weight of soil and length of fibers ware 15mm and a series of experiments conducted on fiber mixed soil as Proctor compaction test, Traixial shear test and shear test.

Based on the experiments conducted to study the influence of glass fiber inclusion on the strength behavior of expensive soil under various tests the following conclusions can be drawn :

1. When the glass fibers are added to the expensive soil, it initially increases the dry density of the soil up to a certain limit and then reduces the dry density of the soil. Addition of fiber in to the soil causes the decrease ;in OMC and further increase in fiber content brings the OMC down.

2. Shear stress of fiber reinforced soil is improved due to the addition of the glass fiber. The shear stress is increased with increase in length of fiber up to a certain limit beyond which increase in fiber content reduces the shear stress. The increase in the fiber fails to interlock the soil particles properly due to which soil fiber particles do not act as a single coherent medium.

3. The value of cohesion is increased due to the inclusion of glass fiber. Between 0.250% to 0.375of fiber content, the increase in fiber increases the value of cohesion and this variation is linear.

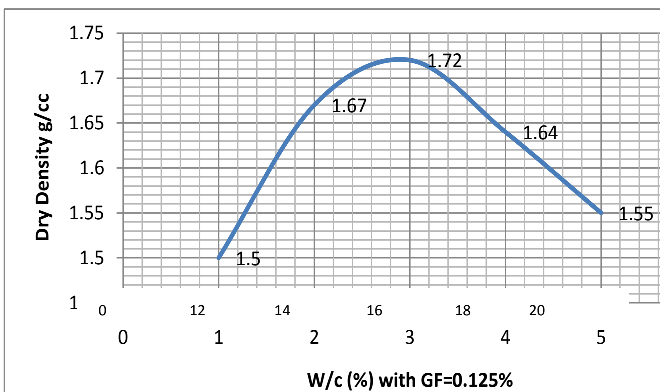
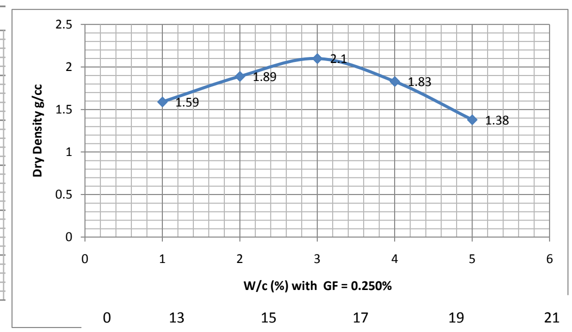


Fig. 4.1 a



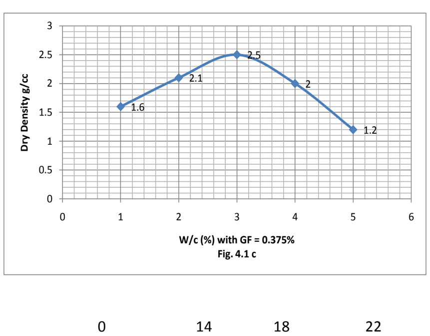


Fig. 4.1 c

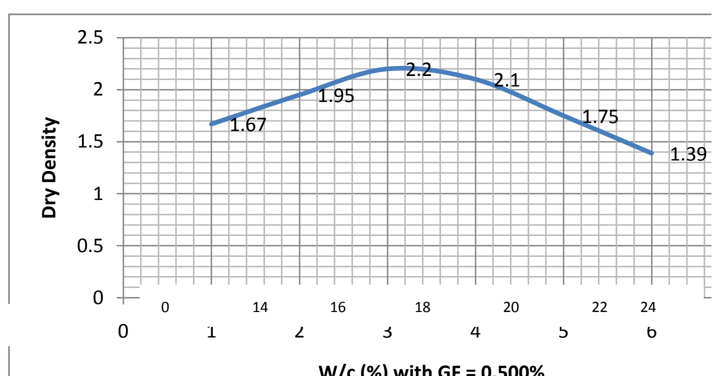
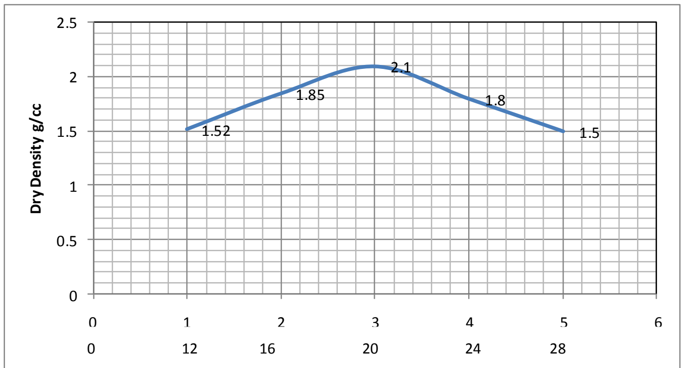
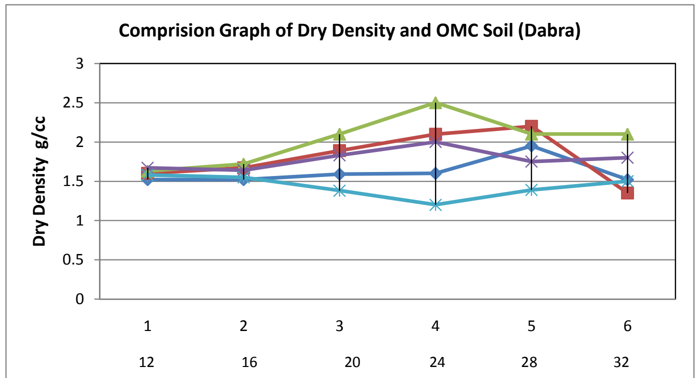


Fig. 4.1 d



W/c (%) with GF = 0.625% Fig. 4.1 e



Water Content % Fig. 4.1 f

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