Soil Friability its Effect on Soil Aggregate Stability

P Anand[1] Dr.Guruprasad Hugar[2] Md.Khaja Moniuddin[3] S B Jagdish[4]
[1,4]P.G. Student [2,3]Assistant Professor
[1,3,4]Department of Civil Engineering
[1,2]B.K.I.T. College Bhalki, District Bidar [4]Government Sri Krishnarajendra Silver Jubilee Technological Institute, K. R. Circle, Bangalore 560001

Abstract— In many parts of the world the shrink-swell characteristics of fine-grained material is of considerable importance and of potential economic significance. Expansive soils cause significant damage to structures and roadways by cyclically shrinking and swelling within the active zone, which is defined as the depth in a soil to which periodic changes of moisture occurs. The term ‘soil friability’ has been defined as the tendency of a mass of unconfined soil in bulk to crumble and break down under applied stress into smaller fragments, aggregates and individual soil particles. There is a general concern that low soil organic carbon (SOC) contents may deteriorate soil physical properties. This study has been conducted to illustrate the effect of SOC on soils shrinkage limit (Ws) and friability index (FI) upon four of the arid soils namely black cotton, red, marshy and mountainous soils obtained from organic farms of the study area. Wastes like humus, pressmud, bagasseash and flyash were used as a source of SOC to amend with the soils. SOC inputs were made volumetrically up to 70% in the increments of 10% of the soil columns; there was also a control column without any external addition of SOC. The relation between SOC, shrinkage limits and friability index was analyzed by series of experiments carried in triplicate in three different phases based on the mode of application of SOC. Natural soil was amended with humus, bagasseash, flyash, pressmud to the percentage of 0 to 40 for first phase, 0 to 70 for second phase and laying of amended materials on the natural soil for the third phase. Which are test for 0, 7, 14, 21 and 28 days respectively. The friability index (FI) was tested for black cotton soil whose value increases from 0.20% to 6.32% at 40% pressmud amended with a natural soil where by the values increase from 1.59% to 16.81% at 40% pressmud for the red soil and also the values increase from 0.73%to 13.77% at 70% pressmud amended with natural soil.

Key words: Soil Friability, Soil Aggregate

I. Introduction

Organic composed soil is arable which is widely known. This kind of soil always causes deterioration of soil structure. In recent days the use of mixing of natural soil with organic composed soil that is known as organic amendments which is becoming most burning issue now days. Organic matter (OM) helps to change the physical and chemical properties as well as mechanical properties of the soil like water content, plasticity, durability shrinkage properties porosity, permeability etc. The soil organic content will increase by adding an organic fertilizer which indirectly helps the soil resist the deformation and compatibility of the soil. If the aggregates lose their structural stability the dispersed clay particles would clog up the pores thus denying the infiltration of the rainwater into the soil, later on they completely seal the soil surface leading to crust formation. These crusts promote erosion especially through surface run-off. However, this does not mean that aggregates should always be stronger; they should also be weak enough for the penetration of roots inside them. Thus optimizing the statement of soil aggregation implying strong enough to resist structural damage along with facilitating the root penetration. Aggregate stability is the ability of aggregates to resist disruptive forces to abate soil erosion. This is why aggregate stability is studied comprehensively since early 1900s. In the study of aggregate stability, diverse opinions have come from researchers regarding the poor performance of certain types of organic material, or regarding the consistent effects of certain soil factors on aggregate stability. However soil aggregate stability can be summarized into three statements:

1) Difficulty in measuring the aggregate stability
2) Difficulty in determining the relative importance of several aggregate stability factors and
3) Difficulty in dealing with the diverse nature of the soil constituents that affect aggregate stability.

Although most researchers are aware of these three problems, so far no study have come which could discuss these three problems together with respect to aggregate stability.

Influencing factor for aggregate stability are many hence it very difficult to measure aggregate stability by directly are else adequately. The indices however doesn’t represent the aggregate stability individually it not a feasible task however the individually indices only represents the aggregate stability up to a certain aspects hence the indices that index is not suitable for all circumstances thus few of the researchers recommend the use of several indices simultaneously with the intention that each index measures the respective aspects of aggregate stability that are not measured by the other indices. Thus multi indices give raise to ambiguity of selecting the number of indices and in particular any of the indices to stress on. As well as there is no guarantee that selected indices have thoroughly measured aggregate stability. It is very difficult to determine the importance of relationship between soil factor and aggregate stability however changes are recorded with variation of aggregate stability. Causality can only be inferred from control experiments have major disadvantages.

They can overestimate the effect of a factor because other important factors of aggregate stability are controlled but correlation studies (for measuring associations) may measure the effect of a factor more realistically because all factors are considered simultaneously. Some of the engineer properties like practical size distribution, specific gravity, compressive parameters are extensively studied because organic matter constitutes important aggregate stability

The aggregate model C-P-OM (clay-polyvalent cations-organic matter), for example, shows that organic matter needs both clay and cations to form and stabilize aggregates. Nevertheless, an often neglected area of study is to determine how the aggregate sizes affect aggregate stability. The most of researchers measure aggregate stability of whole soils, and then attempt to determine how aggregate stability relates to the constituents or properties of whole soils. Aggregate stability of individual aggregate size fractions, especially aggregates smaller than 250 micron, are often neglected. The size of the aggregates should not be neglected because the chemical and physical properties of aggregates vary with their sizes, and are different from whole soils. Why this is so is related to the aggregation process. For all soils, there exists some sort of aggregate hierarchy, where larger aggregates are assemblages of smaller aggregates or particles. And because of this aggregate hierarchy, certain aggregate size fractions have their own distinct physical and chemical properties. For example, the distribution of some soil constituents' especially organic matter decreases in amount with decreasing aggregate size. Moreover aggregate stability of aggregate size fractions may be different from one another because the mechanism of aggregate stability varies with the aggregate sizes.

II. Objectives of the Study

- To utilize waste as a source in benefiting soil properties.
- To validate the role of organic carbon in the soil structural stability (friability).
- To verify the role of type of waste on soil friability & shrinkage.
- To test the time dependent influence in the effect of organic carbon on soil aggregate.
- Determine the role of organic carbon in minimizing soil swell-shrink.
- To validate whether SOC was the only dominant parameter in improving soil properties.

III. Literature review

A. Aggregate Stability and Size Distribution: (Kemper and Rosenau, 1986):

The high aggregate stability values to measure aggregate stability in soils such as the use of water-stable aggregates (WSA) In this WSA,40g of<4.75mm air-dried soils were put in the topmost of a nest of four sieves of 2.00,1.00, 0.50, and 0.25mm mesh size and pre-soaked for 30 min in deionized water. Thereafter, the nest of sieves and its content were oscillated vertically in water 20 times using 4cm amplitude at the rate of one oscillation /sec after wet sieving the resistance soil material on each sieve on and the unstable aggregate were transferred into beakers, dried in the oven at 60oc until studied wait was achieved the % ratio of the aggregate in each sieve represents water stable aggregates.

B. The Relationship between Soil Structural Stability and Erodibility of the Soils: (Le Bissonnais, 1996):

They all observed that soils with weak aggregate stability erode faster than those with high aggregate stability values. Soil structure is a very important soil property, which influences many processes in the soil. There are many methods for aggregate stability measurement varying in the energy applied in the treatment. The aim of this paper is to compare two aggregate stability measurement methods on a set of reclaimed dumpsite soils. Method proposed by Le Bissonnias (1996) which allow distinguishing the particular aggregate breakdown mechanisms.

C. Soil aggregate stability: its evaluation and relation to organic matter constituents and other soil properties: (Christopher Teh Boon Sung, 1996):

The purpose of this study was. To compare the aggregate stability of individual aggregate size fractions. To determine the interrelationship and efficiency of several aggregate stability indices, and to determine the relationship and importance of organic matter and other soil constituents on aggregate stability. To compare the aggregate stability of individual aggregate size fractions, a mathematical model was developed to estimate the breakdown of individual aggregate size fractions in the wet-sieving (using nested sieves) method. This model was validated and calibrated by comparing the estimation values to the actual aggregate breakdown values by paired sample t-test, linear regression and prediction error sum of squares. The average percentage of stable aggregates for all aggregate size fractions were represented in an index called average intact aggregates (AlA). To determine the relationship between aggregate stability and soil constituents, whole soils as well as individual aggregate size fractions were analysed. For analysis of whole soils, nine soil samples were analysed for organic matter and its constituents, texture, free iron oxides, aggregation, bulk density, cation exchange capacity and exchangeable cations. Aggregate stability of whole soils was measured with the same eight indices used in the factor analysis study. For analysis of individual aggregate size fractions, four soils were selected. Each soil was separated into six aggregate size fractions: 1 000-2000) lm, 500- 1 000) lm, 250-500) lm, 1 50- 250) lm, 53-ISO) lm, and <53) lm. Each aggregate size fraction was analysed as done in the analysis of whole soils. However, additional analysis included free aluminium oxides and the carboxyl (COOH) and phenolic hydroxyl (OR) functional groups in humic acid (HA) and fulvic acid (FA). Aggregate stability was measured using WDCS (water dispersible clay) and silt, WDC (water-dispersible clay) and TP (turbidity percentage) indices.

D. Aggregate stability is used as an indicator of soil structure: (Six et al, 2000):

Soil aggregation therefore results from there arrangement of particles, flocculation and cementation Soil disturbance from tillage is a major cause of organic matter depletion and reduction in the number and stability of soil aggregates when native ecosystems are converted to agriculture. No-till (NT) cropping systems usually exhibit increased aggregation and soil organic matter relative to conventional tillage (CT). However, the extent of soil organic matter changes in response to NT management varies between soils and the mechanisms of organic matter stabilization in NT systems are unclear. We evaluated a conceptual model which links the turnover of aggregates to soil organic matter dynamics in NT and CT systems; we argue that the rate of macro aggregate formation and degradation (i.e. aggregate turnover) is reduced under NT compared to CT and leads to a formation of stable micro aggregates in which carbon is stabilized and sequestered in the long term.

E. Aggregate stability as an indicator of soil susceptibility to runoff and erosion; validation at several levels: (Bernard barthes, Ericroose, 2001):

The evaluation of soil susceptibility to runoff and water erosion in the field is often expensive or time-consuming. Several author have reported that susceptibility is linked to aggregate stability, whose determine is far easier. However, this susceptibility has general been dand field-assessed susceptibility to runoff and erosion.

Susceptibility to runoff and erosion was determined at several levels first, on southern French regosol, through measurements of runoff and soil loss from1-m2micro plots under simulated rainfall. Second from 100-800-m2runoff plots on a nit sol in benin a ferralsol in Cameroon and to erosion was determined through semi-quantitative assessment of the frequency of erosion features on vineyard hillsides in southern france. Aggregate stability was determined by immersion in water and wet-sieving of 2-mm sieved, air 0to 10cm soil samples, which actually tests aggregate resistance to slaking.

IV. Materials and Methodology

A preliminary survey was carried out in different locations in and around Raichur, India to select the soil samples for the present study. Raichur, a city and district head quarter in the Indian state of Karnataka. Raichur located between Krishna and Tungabhadra rivers. Located at 16.2°N 77.37°E. It has an average elevation of 407 meters (1335 ft). Four classes of soils namely Black Cotton Soil, Marshy Soil, Red Soil and Mountainous Soil were taken from different locations by removing the top 5cm soil and collecting samples from each location(fig.3.1:bird view of soil sampling location). then the collected samples are analyzed in its natural form for particle size distribution by Sieve analyzing as per IS: 460-1962 and grouped accordingly in soil class, determined field density by the cores taken from the field, also analyzed for SOC and field moisture content, and then analyzed for organic carbon walkley-black, (1934) and moisture content. Soil amendments like Flyash (obtained from RTPS) Raichur thermal power station and Bagasseash, Pressmud (Obtained from Sugar Industry) and Humus (Agri. University) were used in the study as the source of SOC (soil organic carbon).

The collected soil samples were then tested in laboratory for:

Constituents	Flyash %	Bagasse ash %	Constituents	Humus %	Constituents	Pressmud % (Except pH)
Sio2	61.1	78.34	Water soluble fraction	7	pH	4.95
Al203	28	8.35	Hemicellulose	18.52	Total solids	27.87
Ti02	1.3	1.07	Cellulose	11.44	Volatile Solids	84.00
Fe203	4.2	3.61	Lignin	47.64	C.O.D	117.6
Mgo	0.8	-	Protein	10.06	B.O.D	22.2
Cao	1.7	2.15	Ether-soluble fraction	5.34	OM	84.12
K20	0.18	3.46	pH	5.6	N	1.75
Na20	0.18	0.12	SOM	0.83	pH	0.65
LoI	2.4	7.42	SOC	0.28	K	0.28
SOC	0.89	0.85			Na	0.18
SOM	0.3	0.29			Ca	2.7
					SOM	0.71
					SOC	0.24

Table 5: Composition of amendments

1) Particle size distribution
2) Organic Carbon and organic matter Content
3) Density
4) Specific gravity

V. Experimental Investigations

- Sieve Analysis
- Carbon Content In Soils and amendments (Walkley-Black Method)
- Moisture content (Pycnometer and Oven Drying)

The collected soil samples were then tested in laboratory for:

1) Particle size distribution
2) Organic Carbon and organic matter Content
3) Density
4) Specific gravity

A. Particle Size Analysis of Soils and Amendments

Sieve analysis was performed for all the collected soil samples as per IS: 460-1962 and grouped accordingly in soil class. BC soil was clayey sand with high plasticity, having 38%sand and 62% silt & clay. Red soil was clayey sand with intermediate plasticity, having 41%sand and 59% silt & clay. Mountainous soil was silty sand with low plasticity, having 42%sand and 58% silt & clay.

Bagasseash particles were uniform non-granular and average particle sizes ranged between 7μ m to 12 μ m; Flyash had 1% clay, 12% of silt and 87% of sand content. Pressmud was coarser than rest of the amendments with its particle size ranging from 0.1μ to 1mm (20%), 1mm to 10mm (80%). Humus had 38% of fine sand fraction, 35% silt sized fraction and 27%clay sized fraction

Phase I: Soil-amendment combinations were made by replacing 0 to 40% mixed in 50% of soil volumes with amendments by blending it with the top 15cm soil of the column. The best performed soil amendment combinations with amendments by blending it with the complete soil of the column.

Phase II: Soil-amendment combinations were made by 0 to 70% mixed in complete volume of soil with amendments by blending it with the 30cm soil of the column

Phase III: This phase was similar to phase II with the only difference that amendments were just stacked at top without blending with soil.

B. Test Procedure:

Soil columns 10 cm diameter and 30 cm length were fabricated by acrylic tubes and were then packed with the collected soil samples to their respective densities. Soil columns were saturated once and were kept in unsaturated condition. The study was carried out in three phases based on the mode of application of SOC to soil as explained below.

VI. RESULTS AND DISCUSSION

A. Organic Carbon and Organic Matter Present In the Soil Samples (Walkley-Black Method)

The collected soils were tested for their soil organic carbon and soil organic matter

	Soil	SOC in %	SOM in %
1	Red soil	0.27%	0.80%
2	Marshy soil	0.285%	0.845%
3	Black cotton soil	0.30%	0.880%
4	Mountainous soil	0.322%	0.948%

Table 6.1: SOC & SOM in soil samples

B. Organic Carbon and Organic Matter Present in the Amendments

The collected amendments were tested for their soil organic carbon and soil organic matter

Sl.No.	Amendments	SOC in %	SOM in %
1	Humus	0.277%	0.83%
2	Bagasseash	0.285%	0.845%
3	Flyash	0.30%	0.889%
4	Press mud	0.24%	0.711%

Table 6.2: SOC & SOM in soil samples

Sl. No	Sieve Size	Mass of Soil Retained On Each Sieve (Gm)	% Retained	Cumulative % Retained C	% Finer (100-C)
1	4.75	317.64	31.76	31.76	68.24
2	4.00	4.61	0.46	32.23	67.78
3	3.35	37.53	3.75	35.98	64.02
4	2.80	20.80	2.08	38.06	61.94
5	2.36	47.93	4.79	42.85	57.15
6	2.00	47.72	4.77	47.62	52.38
7	1.70	38.61	3.86	51.48	48.52
8	1.40	46.88	4.69	56.17	43.83
9	1.18	47.97	4.80	60.97	39.03
10	1.00	59.06	5.91	66.88	33.13
11	8.50E-04	46.94	4.69	71.57	28.43
12	7.70E-04	5.98	0.60	72.17	27.83
13	6.00E-04	33.76	3.38	75.54	24.46
14	5.00E-04	70.12	7.01	82.56	17.45
15	4.25E-04	52.69	5.27	87.82	12.18
16	3.55E-04	0.12	0.01	87.84	12.16
17	3.00E-04	19.08	1.91	89.74	10.26
18	2.50E-04	44.85	4.49	94.23	5.77
19	2.12E-04	19.98	2.00	96.23	3.77
20	1.80E-04	0.71	0.07	96.30	3.70
21	1.50E-04	11.27	1.13	97.43	2.57
22	7.50E-04	17.37	1.74	99.16	0.84
23	0	6.56	0.66	99.82	0.18
TOTAL	=	998.18			

Table 6.3: Particle Size Distribution in Black Cotton Soilv

Sieve analysis was performed for all the collected soil sample as per IS: 460-1962 and grouped accordingly in soil class. BC soil was clayey sand with high plasticity, having 38%sand and 62% silt & clay.

1) Mountainous Soil:

Soil samples were sieved to determine the particle size distribution it can determine the percentage of finer for individual grain sizes lies between 4.75mm to 75 micron and a pan which differentiate the coarse, fine, silt and clay percentage of the soil retained.

SL. NO	Sieve Size	Mass of Soil Retained on Each Sieve (Gm)	% Retained	Cumulative % Retained C	% Finer (100-C)
1	4.75	133.00	13.30	13.30	86.70
2	4.00	6.23	0.62	13.92	86.08
3	3.35	22.20	2.22	16.14	83.86
4	2.80	14.52	1.45	17.59	82.41
5	2.36	36.92	3.69	21.29	78.71
6	2.00	58.60	5.86	27.15	72.85
7	1.70	51.75	5.18	32.32	67.68

8	1.40	105.50	10.55	42.87	57.13
9	1.18	80.00	8.00	50.87	49.13
10	1.00	89.00	8.90	59.77	40.23
11	8.50E-04	75.00	7.50	67.27	32.73
12	7.70E-04	4.00	0.40	67.67	32.33
13	6.00E-04	36.60	3.66	71.33	28.67
14	5.00E-04	85.50	8.55	79.88	20.12
15	4.25E-04	38.20	3.82	83.70	16.30
16	3.55E-04	6.00	0.60	84.30	15.70
17	3.00E-04	21.50	2.15	86.45	13.55
18	2.50E-04	45.00	4.50	90.95	9.05
19	2.12E-04	25.00	2.50	93.45	6.55
20	1.80E-04	1.20	0.12	93.57	6.43
21	1.50E-04	13.30	1.33	94.90	5.10
22	7.50E-04	31.30	3.13	98.03	1.97
23	0	15.13	1.51	99.54	0.46
Total	=	995.45			

Table 6.4: Particle Size Distribution in Mountainous Soil.

Sieve analysis was performed for all the collected soil sample as per IS: 460-1962 and grouped accordingly in soil class. Mountainous soil was silty sand with low plasticity, having 42%sand and 58% silt & clay.

2) Marshy Soil:

Soil samples were sieved to determine the particle size distribution it can determine the percentage of finer for individual grain sizes lies between 4.75mm to 75 micron and a pan which differentiate the coarse, fine, silt and clay percentage of the soil retained.

Sl. No	**Sieve Size**	**Mass of Soil Retained on Each Sieve (gm)**	**% Retained**	**Cumulative % Retained C**	**% Finer (100-C)**
1	4.75	51.13	5.11	5.11	94.89
2	4.00	1.04	0.10	5.22	94.78
3	3.35	70.30	7.03	12.25	87.75
4	2.80	1.69	0.17	12.42	87.58
5	2.36	7.59	0.76	13.18	86.83
6	2.00	6.22	0.62	13.80	86.20
7	1.70	5.38	0.54	14.34	85.67
8	1.40	6.58	0.66	14.99	85.01
9	1.18	6.38	0.64	15.63	84.37
10	1.00	15.37	1.54	17.17	82.83
11	8.50E-04	22.32	2.23	19.40	80.60
12	7.70E-04	4.85	0.49	19.89	80.12
13	6.00E-04	33.25	3.33	23.21	76.79
14	5.00E-04	132.05	13.21	36.42	63.59
15	4.25E-04	170.47	17.05	53.46	46.54
16	3.55E-04	0.35	0.04	53.50	46.50
17	3.00E-04	77.50	7.75	61.25	38.75
18	2.50E-04	257.40	25.74	86.99	13.01
19	2.12E-04	23.35	2.34	89.32	10.68
20	1.80E-04	3.76	0.38	89.70	10.30
21	1.50E-04	43.19	4.32	94.02	5.98
22	7.50E-04	32.94	3.29	97.31	2.69
23	0	4.29	0.43	97.74	2.26
TOTAL	=	977.40			

Table 6.5: Particle Size Distribution in Marshy Soil

Sieve analysis was performed for all the collected soil sample as per IS: 460-1962 and grouped accordingly in soil class. It bears no plasticit

3) Red Soil:

Soil samples were sieved to determine the particle size distribution it can determine the percentage of finer for individual grain sizes lies between 4.75mm to 75 micron and a pan which differentiate the coarse, fine, silt and clay percentage of the soil retained.

Sl. No	Sieve Size	Mass of Soil Retained on Each Sieve (gm)	% Retained	Cumulative % Retained C	% Finer (100-C)
1	4.75	227.94	22.79	22.79	77.21

2	4.00	1.42	0.14	22.94	77.06
3	3.35	25.94	2.59	25.53	74.47
4	2.80	12.88	1.29	26.82	73.18
5	2.36	38.85	3.89	30.70	69.30
6	2.00	49.88	4.99	35.69	64.31
7	1.70	42.52	4.25	39.94	60.06
8	1.40	70.05	7.01	46.95	53.05
9	1.18	75.63	7.56	54.51	45.49
10	1.00	60.90	6.09	60.60	39.40
11	8.50E-04	53.14	5.31	65.92	34.09
12	7.70E-04	4.08	0.41	66.32	33.68
13	6.00E-04	34.05	3.41	69.73	30.27
14	5.00E-04	59.27	5.93	75.66	24.35
15	4.25E-04	47.74	4.77	80.43	19.57
16	3.55E-04	0.52	0.05	80.48	19.52
17	3.00E-04	21.80	2.18	82.66	17.34
18	2.50E-04	45.65	4.57	87.23	12.77
19	2.12E-04	27.07	2.71	89.93	10.07
20	1.80E-04	1.36	0.14	90.07	9.93
21	1.50E-04	18.56	1.86	91.93	8.07
22	7.50E-04	34.28	3.43	95.35	4.65
23	0	22.44	2.24	97.60	2.40
TOTAL	=	975.97			

Table 6.6: Particle Size Distribution in Red Soil

Sieve analysis was performed for all the collected soil sample as per IS: 460-1962 and grouped accordingly in soil class. Red soil was clayey sand with intermediate plasticity, having 41% sand and 59% silt and clay.

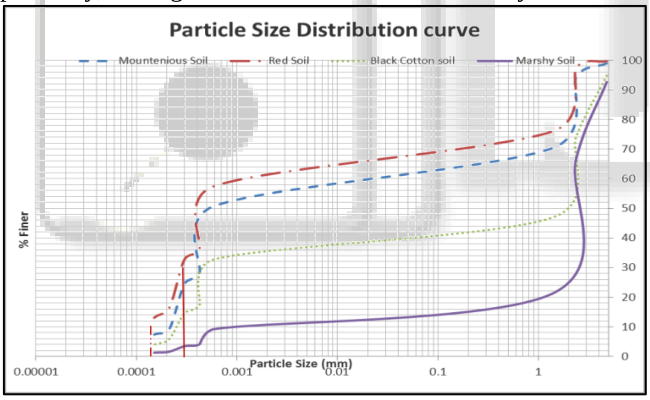

Fig 6.1: Particle Size Distribution Curve

C. Short Term Effect of SOC on Soil Stability Property

Soil stability property was analyzed for its short term effect by continuing the study for 28 days and observing the variations in the factors once every week. Soil aggregates strength tests were also conducted in parallel. This chapter presents the assessment for the property of soil stability carried for the short term along with the aggregate stability.

Soil organic carbon in arable soils in several parts of the world is diminishing which is probable to cause weakening of soil structure and workability. In recent years, the use of organic amendment has become popular for the improvement of SOM (soil organic matter). Organic matter can bring the change in soil physical and mechanical properties. These include compatibility, soil strength, water content and soil physical quality in general. The increased content of OM results in improved soil physical properties. Additions of organic fertilizers result in increased SOC. Previous investigations have consistently found increase in SOC whereas reduces soil BD by incorporating farm yard manure (FYM). The soil consistence (or consistency) refers to the resistance offered by the soil against the force that tends to deform it at a range of water contents. Soil consistence is therefore described at different water states as dry or hard, semi-solid or friable, moist, plastic, wet and viscous. Soil consistency in relation to water content (WC), expressed in terms of different Atterberg's limits (shrinkage limit (W_S), plastic limit (W_P) and liquid limit (W_L), has important implications to agricultural, engineering, and industrial uses of the soil. At the W_L, the soil is saturated and it flows like a liquid. Therefore viscosity, which is the property of a liquid to resist motion of elemental particles with respect to one another, is a good indicator of the W_L. In contrast, the W_P occurs at the plastic-solid phase where the material is at considerably lower WC. In this state, the clay particles are much closer together and the capillary forces originating at the air–water interfaces are very high. The W_P and W_L are also defined as the WCs at which the average value of undrained shear strength is around 170 and 1.7 kPa, respectively. W_P and W_L are the direct measures of soil mechanical behavior and represent properties like particle size distribution, OM, clay mineralogy, and physic-chemical properties. These limits are used to estimate the shear strength, compressibility of soils, and to predict the transition in soil mechanical behavior in the field. Stated that the W_L was related better to soil compressibility than plastic limit. The optimum and workable WC range for tillage operations without undue effort and with minimum risk of structural damage could be determined with the help of consistency limits. Found maximum production of small aggregates when tillage of a sandy loam (with 0.17 kg /kg clay) was done at 0.90WP. Atterberg's limits are affected by similar factors that affect the thickness and dynamics of the diffused double layer they include clay, sand, and OM content. Soil consistency is significantly affected by SOC because of high absorptive capacity of organic materials for water and their interactions with soil minerals affecting bond strength and surface tension properties of soil. Found that biomass incorporations significantly increased the soil consistency limits. found that both W_L and W_P increased with increasing OM. reported that the long-term application of the farm yard manure(FYM) increases lignin and lignin-like products in the soil organic matter whereas compost manure increases protein and protein-like, as well as carbohydrates content of soil organic matter. Soil friability is the tendency of a mass of unconfined soil in bulk to crumble and break down under applied stress into smaller fragments with ease, without powdering. The trepidation for deteriorating soil structure calls for better understanding of SOM (soil organic matter) interaction with soil. Smaller fragments, which originally comprised the larger clods, have relatively greater strength than the larger clods, otherwise, the soil mass could break down into dust. Found that larger the aggregates, the smaller the mean tensile strength. The present study thus aims to investigate the short term effect of SOC (soil organic carbon) in different application modes on soil shrinkage and friability.

D. Effect of Soil Organic Carbon on Soil Shrinkage Limit and Friability Index

Since the study outcomes of were irregular and to know the time based effect on FI this study was carried. Effect of SOC was analyzed on soil shrinkage limit and friability index for each soil amendment combination for 28 days with the observations made once every 7 days.

For BC soil all the amendments brought down the shrinkage limit (W_s) week by week indicating the aggregation of fines. However FI Values of all the soil amendment combinations were less than the control (8.37) indicating reduction in period (time duration between the first watering at the time of sowing and the last watering before harvesting the crop). Aggregate strength increased (as observed during soil crushing before sieve analyzing) from week to week indicating the increased bondage within the soil aggregate.

For Red soil, as witnessed in the above soil amendment combinations, W_s reduced week by week indicating the aggregation of fines this was again proved by reduced W_L. FI values of all the above combinations increased (subjected to phase and time) in comparison with the control (1.10) this increment was remarkably noticeable in bagasseash and flyash amendments where the FI value increased as high as 11.51 and 11.33 respectively. Increments in FI values indicate increment in period when cultivation is feasible and soil conditions are optimal for tillage. Hence amending red soil not only gains the strengths but also increase the period which is the added advantage for agriculture along with soil conservation.

Like soil amendment combinations observed for BC and red soil, W_s in mountainous soil also reduced week by week.FI (friability index) values of all the combinations increased (subjected to phase and time) in comparison with the control (3.58). Except flyash amendment rest increased FI in comparison with the control. Noticeable Increment in FI was seen in Pressmud amended soil where the FI value increased to 4.82. Hence amending mountainous soil with the above is of immense importance both in agriculture along with soil conservation.

Effect of OC was analyzed on soil shrinkage limit and friability index for each soil amendment combination for 28 days with the observations made once every 7 days

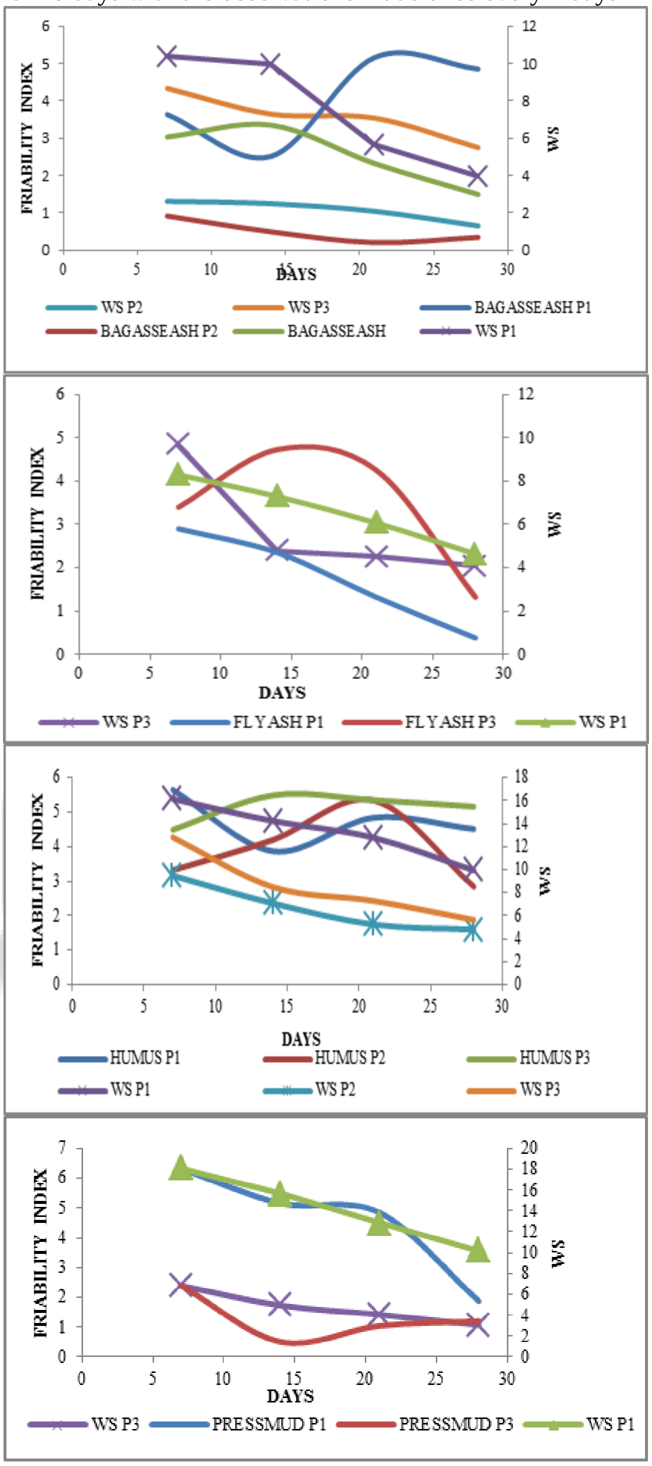

Fig. 6.2: Short term effect of OC on soil shrinkage limit and friability index on BC soil

All the amendments brought down the shrinkage limit (Ws) week by week indicating the aggregation of fines. However FI (friability index) Values of all the soil amendment combinations were less than the control (8.37) indicating reduction in period (time duration between the first watering at the time of sowing and the last watering before harvesting the crop). Aggregate strength increased (as observed during soil crushing before sieve analyzing) from week to week indicating the increased bondage within the soil aggregate.

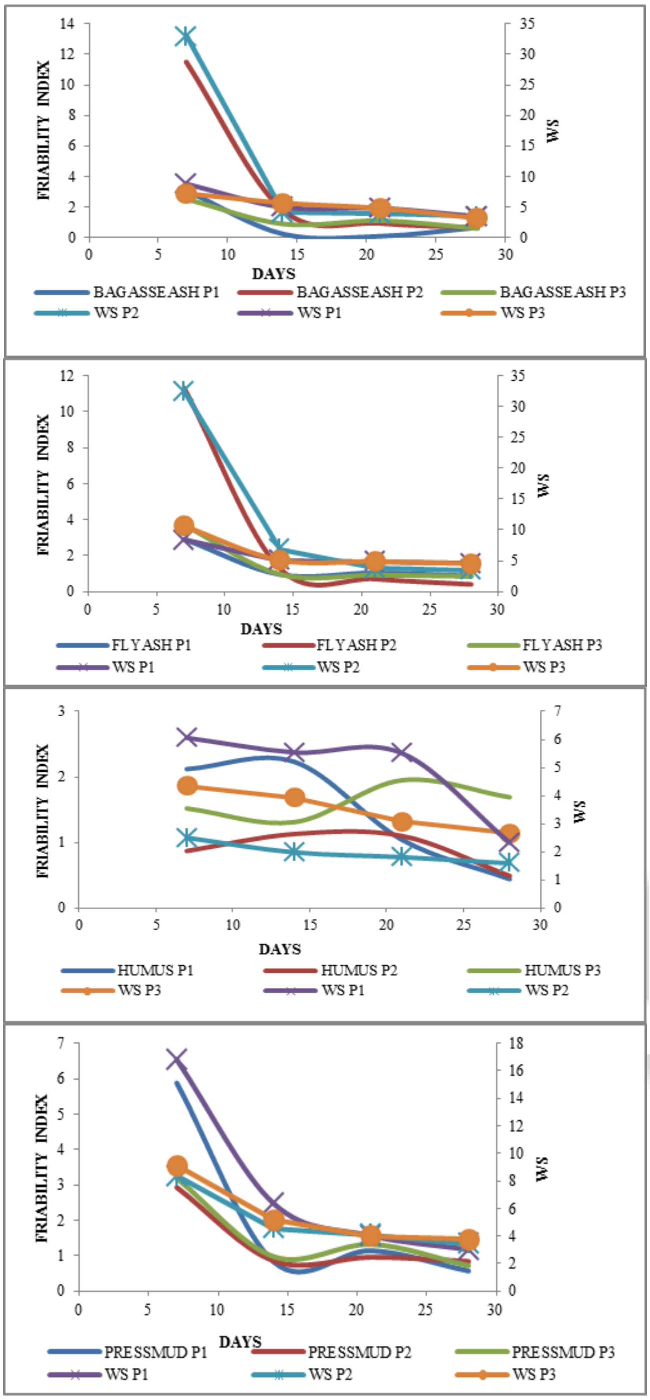

Fig 6.3: Short term effect of OC on soil shrinkage limit and friability index on Red soil

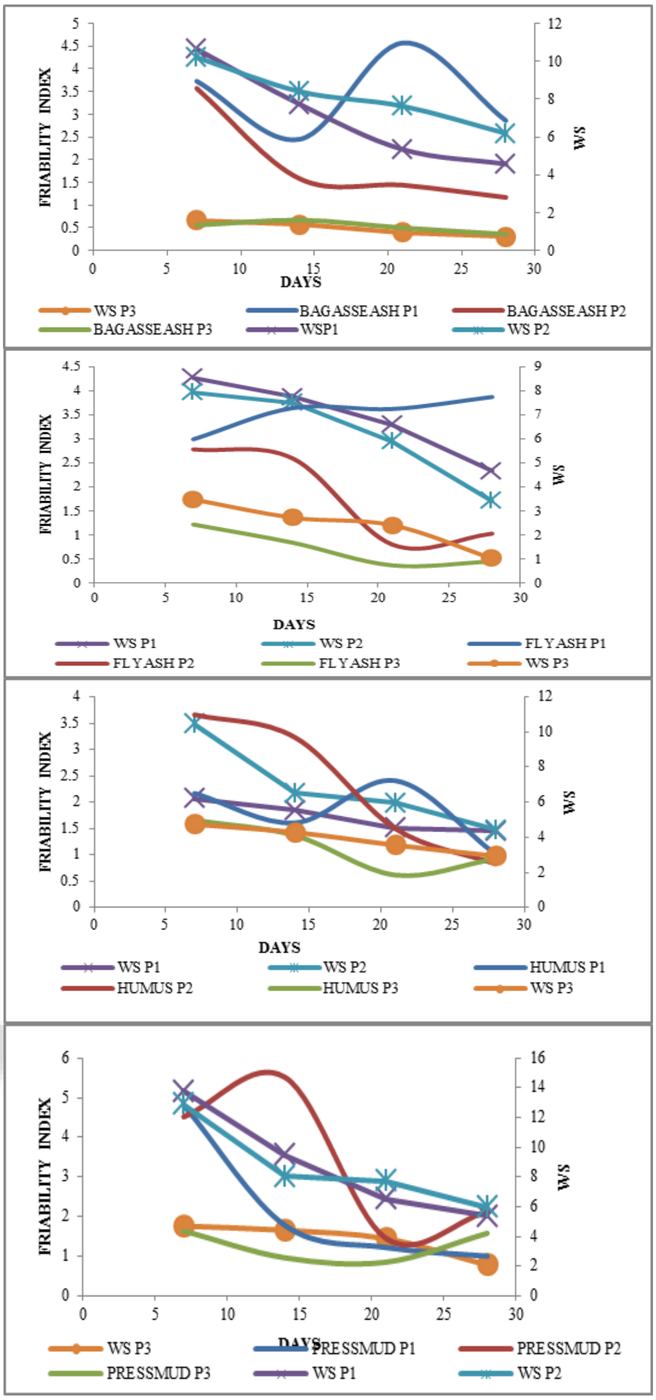

Fig 6.4: Short term effect of OC on soil shrinkage limit and friability index on Mountainous soil

As witnessed in the above soil amendment combinations, shrinkage limit (Ws) reduced week by week indicating the aggregation of fines this was again proved by reduced liquid limit (WL). FI values of all the above combinations increased (subjected to phase and time) in comparison with the control (1.10) this increment was remarkably noticeable in bagasseash and flyash amendments where the FI value increased as high as11.51 and 11.33 respectively. Increments in FI values indicate increment in period when cultivation is feasible and soil conditions are optimal for tillage (Tivy, 1990). Hence amending red soil with the above soil aggregate not only gain the strengths but also increase the period which is the added advantage for agriculture along with soil conservation.

E. Effect of Soil Organic Carbon on Soil Aggregate Stability

Effect of SOC was analyzed on soil aggregate stability for each soil amendment combination for 28 days with the observations made once every 7 days. Soil aggregate stability of initially air-dry aggregates is carried out by abrupt submergence followed by wet sieving as explained in Section. Soil aggregate stability tests were conducted for BC soil to assess the effect of SOC on soil aggregation. Soil samples were collected from the soil columns amended with Humus, Bagasseash, Pressmud and Flyash with respect to the phases of amending. Table 6.7 shows the short term effect on soil aggregate stability phase wise.

Da	amendme	Aggregate	amendme	Aggregate	amendm	Aggregate	amendme	Aggregate

ys	nt and phase	Stability (%)	nt and phase	Stability (%)	ent and phase	Stability (%)	nt and phase	Stability (%)
	Control	34.26	Control	34.26	Control	34.26	Control	34.26
7	Bagassea sh P1	40.44	Flyash P1	39.13	Humus P1	34.9	Pressmud P1	41.75
14		44.06		44.06		45.71		47.37
21		44.06		40.77		45.71		40.77
28		50.7		50.62		50.7		42.41
7	Bagassea sh P2	35.88	Flyash P2	36.43	Humus P2	40.77	Pressmud P2	45.71
14		45.71		42.41		39.13		45.71
21		42.41		42.41		44.06		42.41
28		45.71		44.06		47.33		45.71
7	Bagassea sh P3	39.78	Flyash P3	37.5	Humus P3	39.13	Pressmud P3	40.77
14		42.41		40.77		40.77		47.37
21		44.06		40.77		39.13		47.37
28		49.03		42.41		49.03		52.38

Table 6.7: Effect of SOC on aggregate stability for BC soil

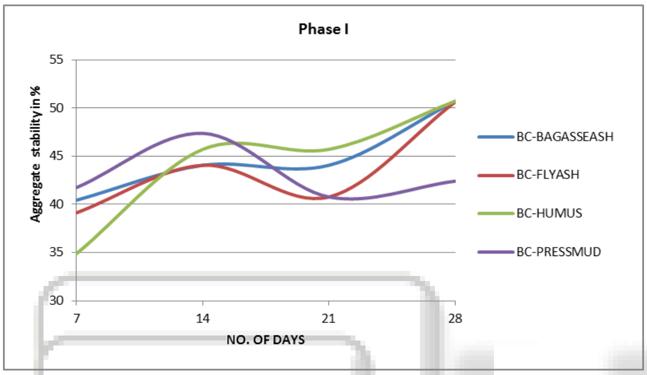

Fig 6.5: Effect of SOC on aggregate stability for BC soil in I phase

Natural soil amended with humus/bagasseash tested for aggregate stability whose peak value increase from 34.26 at 0% humus to 50.70% at 40% humus/ bagasseash amended with natural soil.

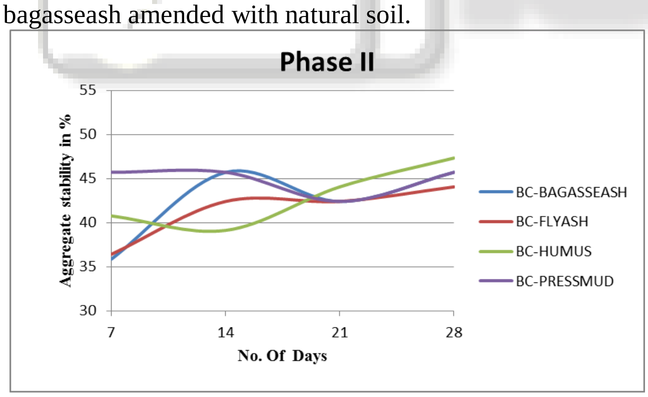

Fig 6.6: Effect of SOC on aggregate stability for BC soil in II phase

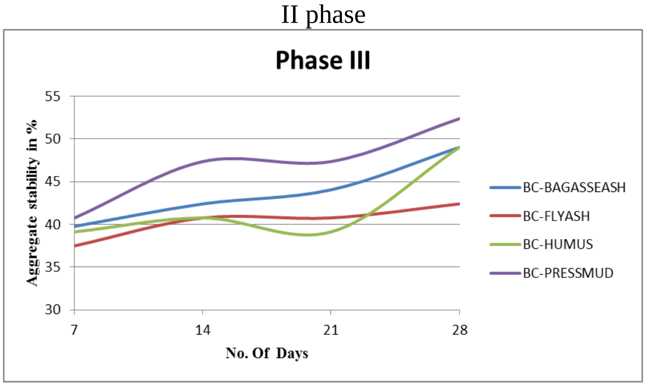

Fig 6.7: Effect of SOC on aggregate stability for BC soil in III phase

Natural soil amended with humus tested for aggregate stability whose peak value increase from 34.26% at 0% humus to 47.33% at 70% humus amended with natural soil due to presence of calcium oxide which acts as a binder with increasing for 28 days.

Natural soil amended with the pressmud for aggregate stability whose peak value increase from 34.26% to 52.38% at normal placing of the pressmud over the black cotton soil for 28 days.

Similarly soil aggregate stability tests were conducted for red soil to assess the effect of SOC on soil aggregation. Table 4.8 shows the short term effect on soil aggregate stability phase wise.

Days	amendment and phase	Aggregate Stability (%)
	Control	40.77
7	Bagasse ash P1	44.72
14		39.13
21		39.13
28		42.41
7	Bagasse ash P2	42.08
14		35.88
21		40.77
28		40.77
7	Bagasse ash P3	45.71
14		37.50
21		42.41
28		52.38
Days	amendment and phase	Aggregate Stability (%)
	Control	40.77
7	Flyash P1	44.72
14		40.77
21		44.06
28		42.41
7	Flyash P2	42.91
14		40.77
21		42.41
28		39.13
7	Flyash P3	50.70
14		39.13
21		40.77
28		40.77
Days	amendment and phase	Aggregate Stability (%)
	Control	40.77

7	HumusP1	42.19
14		37.50
21		39.13
28		42.41
7	HumusP2	55.75
14		44.06
21		42.41
28		49.03
7	HumusP3	49.03
14		42.41
21		44.06
28		40.77
Days	amendment and phase	Aggregate Stability (%)
	Control	40.77
7	Pressmud P1	45.71
14		44.06
21		45.71
28		44.06
7	Pressmud P2	56.43
14		42.41
21		44.06
28		42.41
7	Pressmud P3	49.03
14		39.13
21		42.41
28		44.06

Table 4.8: Effect of SOC on aggregate stability for red soil

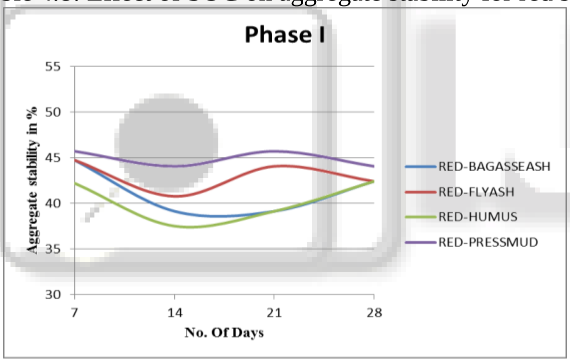

Fig. 6.8: Effect of SOC on aggregate stability for red soil in I phase

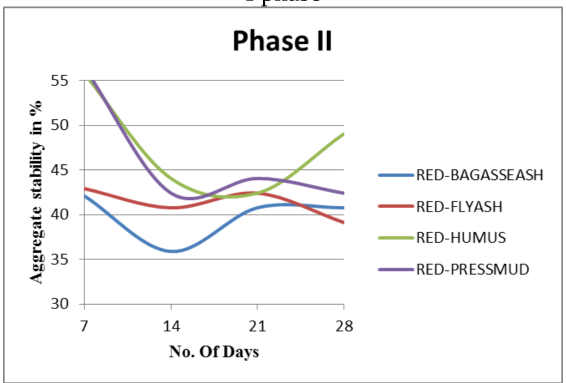

Fig. 6.8: Effect of SOC on aggregate stability for red soil in I phase

Natural soil amended with pressmud tested for aggregate stability whose peak value increase from 40.77 % at 0% pressmud to 45.71% at 40% pressmud amended with natural soil for 28 days.

Natural soil amended with pressmud tested for aggregate stability whose peak value increase from 40.77 % at 0% pressmud to 45.71% at 40% pressmud amended with natural soil for 28 days.

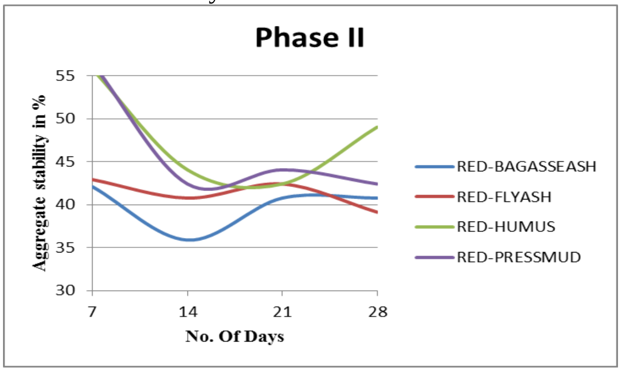

Fig. 6.9: Effect of SOC on aggregate stability for red soil in II phase

Natural soil amended with pressmud tested for aggregate stability whose peak value increase from 40.77% at 0% pressmud to 56.43% at 70% pressmud amended with natural soil for 28 days

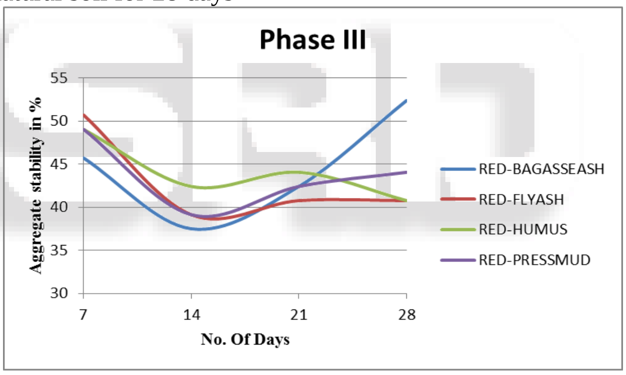

Fig. 6.10: Effect of SOC on aggregate stability for red soil in III phase

Natural soil amended with the pressmud for aggregate stability whose peak value increase from 40.77% to 52.38% at normal placing of the bagasseash over the red soil for 28 days.

Soil aggregate stability tests were conducted for mountainous soil to assess the effect of SOC on soil aggregation. Soil samples were collected from the soil columns amended with Humus, Bagasseash, Pressmud and Flyash with respect to the phases of amending. Table 4.9 shows the short term effect on soil aggregate stability phase wise.

Days	amendment and phase	Aggregate Stability (%)	amendment and phase	Aggregate Stability (%)	amendment and phase	Aggregate Stability (%)	amendment and phase	Aggregate Stability (%)
	Control	39.13	Control	39.13	Control	39.13	Control	39.13
7	Bagasseash P1	50.7	Flyash P1	52.38	Humus P1	50.7	Pressmud P1	50.7
14		49.03		45.71		42.41		45.71
21		45.71		44.06		45.71		45.71
28		50.7		45.71		45.71		55.75

7	Bagasseash P2	42.71	Flyash P2	40.87	Humus P2	57.45	Pressmud P2	55.75
14		42.41		44.06		44.06		49.03
21		42.41		42.41		44.06		44.06
28		49.03		49.03		50.7		52.38
7	Bagasseash P3	54.06	Flyash P3	54.06	Humus P3	52.38	Pressmud P3	52.38
14		44.06		42.41		50.7		52.38
21		47.37		50.7		52.38		47.37
28		54.06		45.71		49.03		47.37

Table 6.9: Effect of SOC on aggregate stability for mountainous soil

Fig 6.11Effect of SOC on aggregate stability for Mountainous soil in I phase

Natural soil amended with humus tested for aggregate stability whose peak value increase from 39.13% at 0% pressmud to 57.45% at 40% humus amended with natural soil for 28 days.

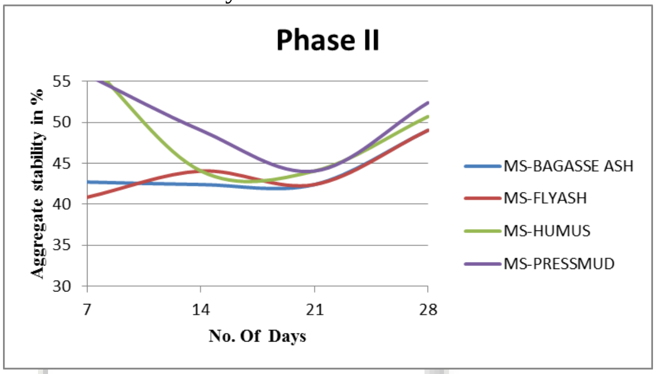

Fig. 6.12: Effect of SOC on aggregate stability for Mountainous soil in II phase

Natural soil amended with flyash tested for aggregate stability whose peak value increase from 40.77at 0% flyash to 54.06% at 70% flyash amended with natural soil for 28 days.

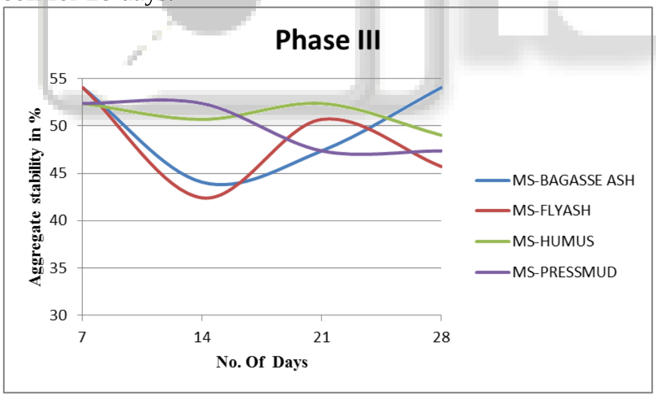

Fig. 6.13: Effect of SOC on aggregate stability for Mountain soil in III phase

Natural soil amended with the bagasseash/flyash for aggregate stability whose peak value increase from 39.13% to 54.06% at normal placing of the bagasseash/flyash over the mountain soil for 28 days.

VII. CONCLUSION

- An aggregate is a group of primary particles that cohere to each other more strongly than to other surrounding soil particles.
- All the soil amendment combinations increased the aggregate stability day by day in comparison with the respective controls as observed in Tables 4.7, 4.8 and 4.9
- Aggregate stability was 34.26%, 40.77% and 39.13% for BC, red and mountainous soils respectively;
- While the mean values of aggregate stability irrespective of phase after amending are bagasseash with combination of bc, red and mountain soils 43.68%, 41.9% and 47.67% .
- In same mean value of aggregate stability of phase amending are flyash with combination of bc, red and mountain soils 41.77%, 42.37% and 46.42%.
- In same value of aggregate stability with combination of humus in bc, red and mountainous soils 43.03%, 44.06% and 48.77%.
- In same value of aggregate stability with combination of pressmud in bc, red and mountainous soils 44.97%, 44.95%, 49.88%.
- Indicating increment in the soil aggregate strength which is a function the cohesive forces between particles that can withstand the applied disruptive force.

Irrespective of phase amending soils with organic carbon is beneficial in aggregating fines and building the time dependent bond within the fines of the soil aggregate.

VIII. SCOPE FOR FUTURE WORK

1) Study can be extended to different soils
2) Study can be extended to different regions
3) Study can be mode using different amendments
4) Study can be extended by addition of different percentage like 0.5%.10%.15% etc. at regular interval

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