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Digital Image Processing for Soil Characteristics

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Abstract—**This research helps inside the improvement of digital image analysis method for estimation of physical properties of soil in lieu of laboratory technique. The conventional laboratory approach a few drawbacks which include a number of guide involvements, time taking unsure prediction and constantly invasive in nature, because of this to reduce above stated drawbacks, this studied work is undertaken to increase a correlation amongst soil photograph function specially Fractal Dimension (FD) and physical properties of soil especially Water Content (Ww), Specific Gravity (Gs), Coefficient of Curvature (Cc), Uniformity coefficient (Cu), Liquid Limit (W_L), Plastic Limit (Wp), Shrinkage Limit (Ws) and field density. And this investigation also useful figuring out the cracking & shrinkage percent variation with addition of Polypropylene fibers as 0.2%, 0.4%, 0.6% and 0.8%. The prevailing studies**

offers accumulating soil samples for path pits at precise as per IS code approach. The digital image database is ready for the collected soil sample inside the laboratory and index properties (Y) are decided. The digital image analysis is adopted to estimate the image feature namely Fractal dimension (X). Correlation is advanced between Y and X with the aid of becoming suitable polynomial equation with the use of regression fashions. The final outcomes of this research will make contribution to make soil bodily homes estimation automatic to a structural engineers, emphasizes that there may be extremely good ability in the use of fractal measurement foe estimating physical properties by using digital image analysis, with minimum human mistakes.

I. INTRODUCTION

A. General

Expansive soil are notably sensitive to moisture content material and temperature and commonly undergo huge extent adjustments whilst uncovered to them. They swell whilst water content and temperature of soil will increase and shrinks when the reduction water content and temperature occurs. Regular clayey soil and Black cotton soils with a high content of expansive mineral like montmorillonite indicates the most dramatic cut back-swell behavior.

Cracks and shrinkage depend upon such a lot of factors like percentage of clay within the soil, type of clay minerals, degree of weathering, initial moisture content material, temperature and unique surface area of clay debris, particle association and thickness of deposition.

Cracks and shrinkage in soil affects it's geotechnical properties in diverse methods. Permeability of soil changes due to cracks in clay boundaries which lead to development of preferential float paths for transportation of conminants. Improvement of cracks can also cause decrease in bearing ability of soil as a result of which non-uniform and differential settlement of basis take place. Alignment of embedded pipes may be changed due to the surface shrinkage. This paper affords a singular methodology for the quantification of surface cracks and shrinkage with the aid of taking digital photographs of the specimen after which the use of software program Image-J for photo processing and Microsoft Excel for the calculation of cracks and shrinkage region.

Artificial soil organized through blending polypropylene fiber content inside the blend changed into varied from 0%, 0.2%, 0.4%, 0.6% and 0.8% of soil used for enhancing adhesion belongings of PP fibers. Specimen tested for experiments have been organized at 1.5 cm thickness.

II. MATERIALS AND METHODS

A. Introduction

Normal clayey soil & Black Cotton Soil are highly expansive soils and is very much prone to large volume changes (swelling and shrinkage) that are directly related to change in water content. This experimental set-up makes it possible for us to quantify cracks and shrinkage in Normal clayey soil& Black Cotton Soil and to study the impact of some of the parameters that affect the intensity and density of cracks. These cracks and shrinkage were reduced by increasing the PP FIBERS content in the mix and by reducing the moisture content.

Extraction of meaningful statistics from digital pix clicked with the aid of virtual digital by means of photograph processing is called Image analysis. It is carried out in simple steps. The first step include the photograph processing in which photo is prepared in numerous levels for in addition evaluation. This consist of the conversion of RGB photograph to a grey gray scale photo, and then to a binary (Black & White) picture obtained via thresholding the gray scale photograph. The second step includes the analysis of the processed picture obtained from step one to calculate the parameters that characterize the crack and shrinkage pattern like overall place of cracks, cracka average width, Length of crack & Shrinkage area.Several operation has to carried out to perform those operation.

B. Materials Used

1. *Normal clayey soil (NC)*

The normal clayey soil obtaining from yard in front of GTE lab – CWIT, Pune 01. This soil is typically garden type soil having good fertility. This Soil is organic in nature having specific gravity (G) is less than 2.

TABLE 1. INDEX PROPERTIES OF NC SOIL

Specific Gravity (G)	2.04
Unit mass (γ_{dry})KN/m^3	2.26
Liquid limit(L_L)	77.36
Plastic Limit(L_P)	33.24
C_u & C_C	7.75&0.59

2. *Black Cotton Soil I (BC1)*

The soil samples or specimens used in test are obtained from different places. BC1which is comparatively dry and having finer size obtained from Farm at Nadhenagarnear Kalewadi.

TABLE 2. INDEX PROPERTIES OF BC1

Specific Gravity (G)	1.8
Unit mass (γ_{dry}) KN/m^3	1.51
Liquid limit(L_L)	79.28
Plastic Limit(L_P)	51.79
C_u & C_C	4.6&0.96

3. Black Cotton Soil II (BC2)

BC2 which is more saturated soil having boulder like size obtaining from Farm at Mundhwa- Pune.

TABLE 3.INDEX PROPERTIES OF BC1:-

Specific Gravity (G)	2.1
Unit mass (γ_{dry}) KN/m^3	1.86
Liquid limit(L_L)	81.07
Plastic Limit(L_P)	59.98
C_u & C_C	5.3&1.16

4. PP FIBERS

Here, in this project, soil stabilization has been done with the help of randomly distributed "Polypropylene (PP) fibers" obtained from waste materials with 4%lime for make good bonding between fibers and soil. The change in the cracking % which can be calculated from image processing.

TABLE 4. PROPERTIES OF POLYPROPYLENE

Parameters or property	Values
Fiber types	Single
Unit weight	0.91 gm/cm^3
Average diameter	0.034mm
Average length	12mm
Breacking tensile strength	350MPa
Modulus of elasicity	3500MPa
Fusion point	165^o C
Burning point	590^{o}C

METHODOLOGY

1.Preparation of raw images.

The Photograph taken by way of camera is an uncentred RGB (Red Green Blue) image. In Image J software circular crop is used to crop any circular area. Preparation of image consist of selecting thevinner circular area of plate and cropping the outer area to get a centred RGB image with white background. This photo is then converted to 8-bit grey-scale image by selecting the option in Image J window Image-type-8bit. A grey -scale image is the image in which the only colour are shades of grey. Three intensities had to specify every pixel in full colour image. A grey colour is the one in which the red, green and blue components all have equal intensity in the RGB space and so it is only necessary to specify a single intensity for each pixel.

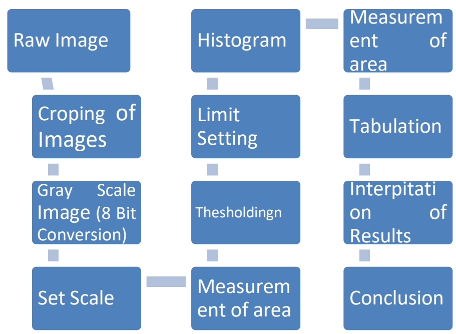

FIG 1 .FLOWCHART OF PROCEDURE FOR CALCULATION OF SHRINKAGE & CRACK AREA BY USING IMAGE-J SOFTWARE.

2.Grey- Scale Processing

The images taken with the help of camera should not have any illumination on specimen surface otherwise it will affect the results.For its corrections and details of interest grey scale processing was performed. In is done in simple two steps 1) Subtract background area that removes smooth continuous backgrounds 2) Un-sharpen the area that affect and enhances and sharpens the edges of images by subtracting a blurred version of the image.

3.Image Segmentation

Image segmentation is done to separate the crack and shrinkage area from the soil. It is done by thresholding the grey scale image with a fixed threshold value. In ImageJ it can done by clicking to the option Image-Adjust-Threshold. It can be done manually if whole data is not there. It can divides the total image in multiple regions. Cracked and shrinkage area is having darker pixels as the light does not enter in them, while the surface area of intact soil is lighter pixel value as sufficient light falls on its surface. By thresholding all the pixels in images changed to 0 as a Black and 255 as a white pixel by threshold value. A pixel having value less than threshold value become black and those pixels have more value than threshold value will become white.

4.Binary Processing

Binary operations is used for correction if after segmentation if any error remains in the image like 'salt in pepper' in the cracks and shrinkage area or 'pepper in the salt' in the intact soil. For Binary operation go to Process- Binary-Make Binary in ImageJ to perform further binary processing to the image . Erode replaces each pixels with the minimum value in a 3 by 3 neighborhood. It is effectiveness in removing pixels to the of black objects.

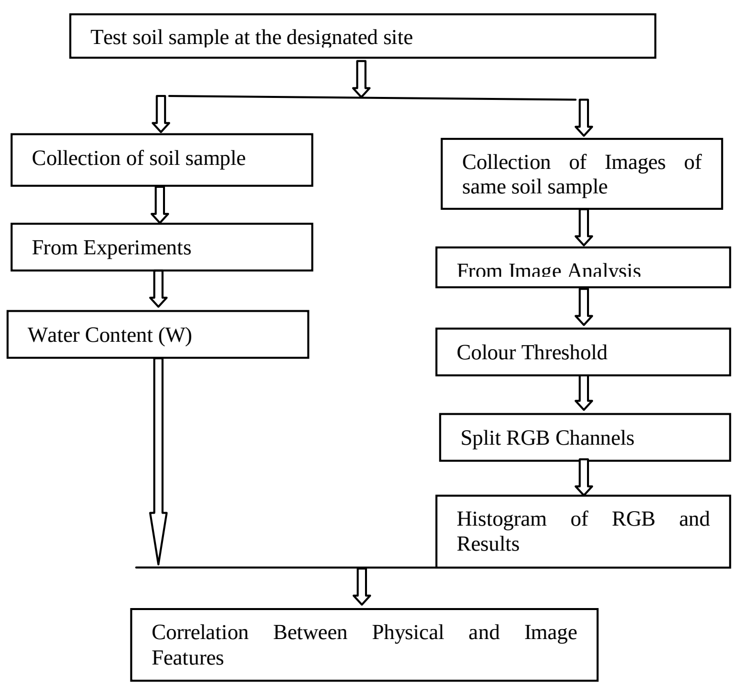

FIG 2. FLOW CHART OF METHODOLOGY ADOPTED FOR WATER CONTENT DISTRIBUTION IN THIS WORK

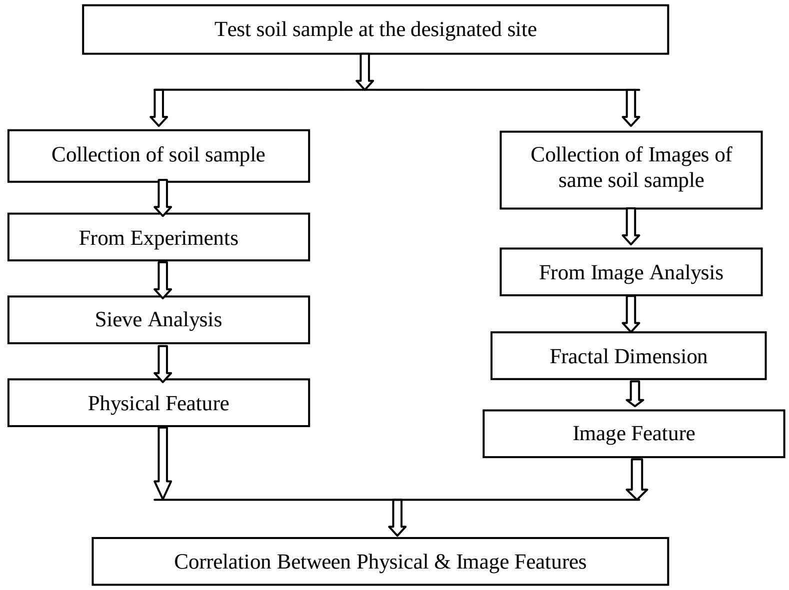

FIG 3. FLOW CHART OF METHODOLOGY ADOPTED FOR GRAIN SIZE DISTRIBUTION IN THIS WORK

III. EXPERIMENTAL RESULTS

Tables gives the physical soil properties obtained as per IS code provisions in geotechnical laboratory, Civil Engineering Dept Cusrow Wadia Institute of Technology, Pune ,Maharashtra, India.

TABLE 1. EXPERIMENTAL RESULTS OF **NORMAL SOIL** SAMPLE

Physical Properties	Trail Number				
	1	2	3	4	5
Water Content (%)	7.08	7.10	7.14	5.58	7.10
Specific Gravity	2.04	2.05	2.04	1.91	1.98
Sieve Analysis					
Coefficient of Curvature (C_c)	7.75	7.75	7.75	7.75	7.75
Coefficient of uniformity (C_u)	0.59	0.59	0.59	0.59	0.59
Liquid Limit (W_L)	66.39	75.25	83.28	84.54	-
Plastic Limit (W_p)	36.27	37.04	34.22	38.1	20.5

TABLE 2. EXPERIMENTAL RESULTS OF **BLACK COTTON SOIL 1**

Physical Properties	Trail Number				
	1	2	3	4	5
Water Content (%)	9.92	5.54	9.03	4.16	9.14
Specific Gravity	1.55	2.08	2.15	1.85	1.95
Sieve Analysis					
Coefficient of Curvature (C_c)	4.61	4.61	4.61	4.61	4.61
Coefficient of uniformity (C_u)	0.59	0.59	0.59	0.59	0.59
Liquid Limit (W_L)	60.14	76.27	92.20	86.26	-
Plastic Limit (W_p)	44.90	48.2	51.34	55.28	59.54

TABLE 3. EXPERIMENTAL RESULTS OF **BLACK COTTON SOIL 2**

Physical Properties	Trail Number				
	1	2	3	4	5
Water Content (%)	33.15	25.06	24.86	23.49	21.89
Specific Gravity	2.14	2.08	2.35	1.88	1.98
Sieve Analysis					
Coefficient of Curvature (C_c)	4.30	4.30	4.30	4.30	4.30
Coefficient of uniformity (C_u)	1.16	1.16	1.16	1.16	1.16
Liquid Limit (W_L)	62.25	78.52	85.20	88.53	-
Plastic Limit (W_p)	52.30	49.50	53.25	58.65	58.65

A. Water Content

TABLE 4. DETERMINATION OF WATER CONTENT BY IMAGE J

Mode	Water Content
41	20
56	25
40	30
37	35

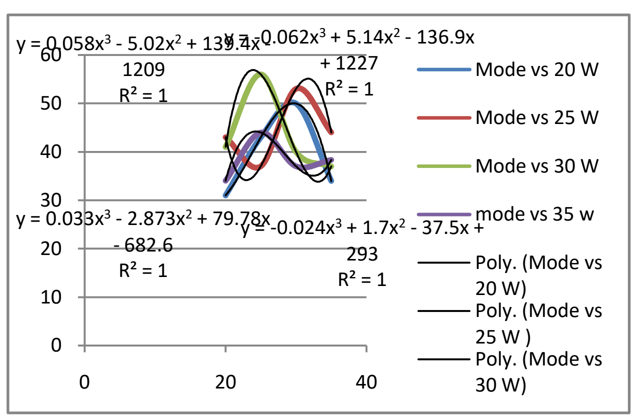

FIG 1. CORRELATION OF WATER CONTENT BETWEEN EXPERIMENTAL AND IMAGE J

B .Grain Size Distribution

TABLE 5. DETERMINATION OF FRACTAL DIMENSION FOR NORMAL SOIL

Fractal Dimension	Sieve Size
1.616	4.75
1.382	2.36
1.178	1.18
1.986	0.6
1.037	0.3
1.600	0.15
1.646	0.075

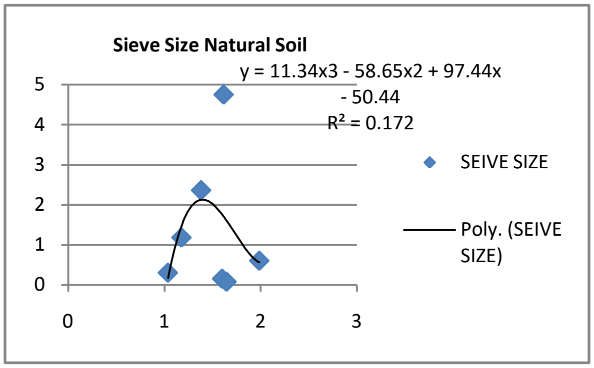

FIG 2. CORRELATION OF SIEVE SIZE EXPERIMENTAL AND FRACTAL DIMENSION IMAGE J FOR NORMAL SOIL.

TABLE 6. DETERMINATION OF FRACTAL DIMENSION FOR BLACK COTTON SOIL 1

Fractal Dimension	Sieve Size
1.862	4.75
1.403	1.18
1.268	0.6
1.984	0.3
1.235	0.15
1.440	0.075

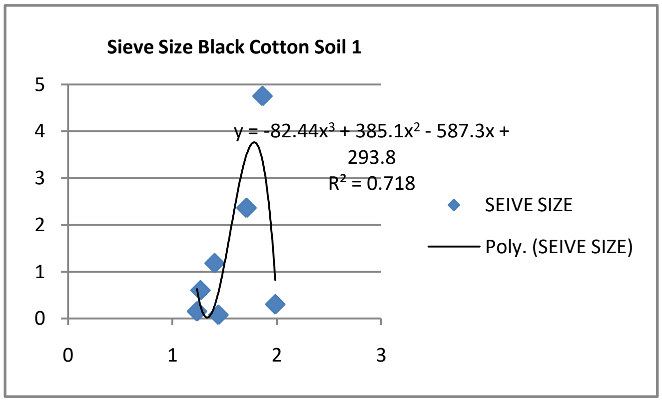

FIG 3. CORRELATION OF SIEVE SIZE EXPERIMENTAL AND FRACTAL DIMENSION IMAGE J FOR BLACK COTTON SOIL

TABLE 7. DETERMINATION OF FRACTAL DIMENSION FOR BLACK COTTON SOIL 2

Fractal Dimension	Sieve Size
1.795	4.75
1.579	2.36
1.328	1.18
1.274	0.6
0.989	0.3
0.938	0.15
1.745	0.075

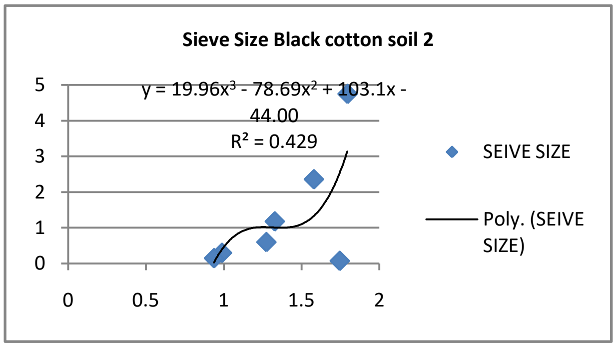

FIG 4.CORRELATION OF SIEVE SIZE EXPERIMENTAL AND FRACTAL DIMENSION IMAGE J FOR BLACK COTTON SOIL .

C. Determination of Cracking and Shrinkage behavior

a) NC

i) Determination of Cracking %

Fiber Content= 0%

TABLE 8. WATER CONTENT VS CRACKING PERCENTAGE FOR NS

Water Content (%)	Cracking %
20	6.881558413
25	37.9572479
30	12.54079668
35	1.259269617

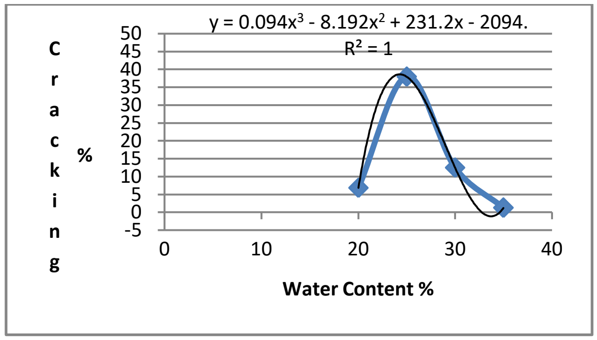

FIG 5.CORRELATION BETWEEN CRACKING % & WATER CONTENT FOR NS

ii) Determination of Shrinkage %:-

Fiber Content=0%

TABLE 9. WATER CONTENT VS SHRINKAGE PERCENTAGE FOR NS

Water Content(%)	Shrink %
20	13.00357034
25	15.79776536
30	19.29716611
35	20.39660242

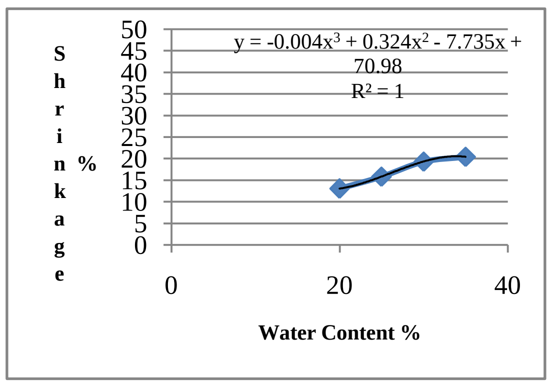

FIG 6. CORRELATION BETWEEN SHRINKAGE % & WATER CONTENT FOR NS

b) **BC 1**

i) Determination of Cracking %:

Fiber Content= 0.6%

TABLE 10. WATER CONTENT VS CRACKING PERCENTAGE FOR BC1

Water Content (%)	Cracking %
20	12.02837619
25	7.156344851
30	6.74725301
35	3.851223797

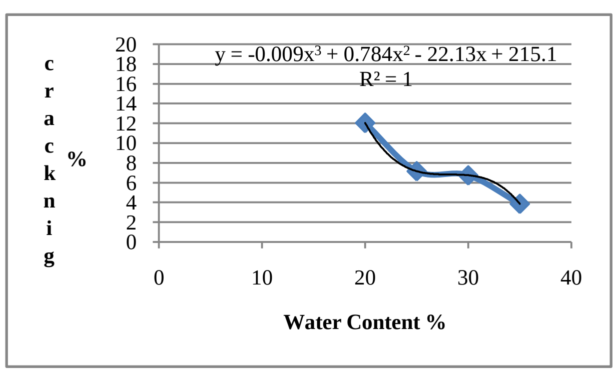

FIG.7 CORRELATION BETWEEN CRACKING % & WATER CONTENT FOR BC1

ii)Determination Of Shrinkage %:

Fiber Content =0.6%

TABLE 11. WATER CONTENT VS SHRINKAGE PERCENTAGE FOR BC1

Water Content (%)	Shrink %
20	1.643390729
25	6.228080213
30	8.259665097
35	14.21961084

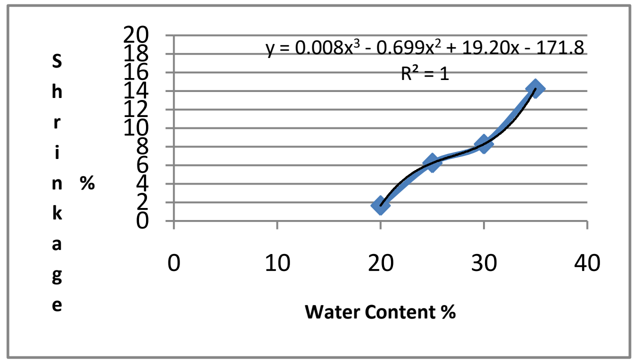

FIG. 8. CORRELATION BETWEEN SHRINKAGE % & WATER CONTENT FOR BC1

c) BC 2

i) Determination of Cracking %:

Fiber Content= 0%

TABLE 12. WATER CONTENT VS CRACKING PERCENTAGE FOR BC2

Water Content (%)	Cracking %
20	42.05435384
25	47.03550439
30	54.70990076
35	60.46318817

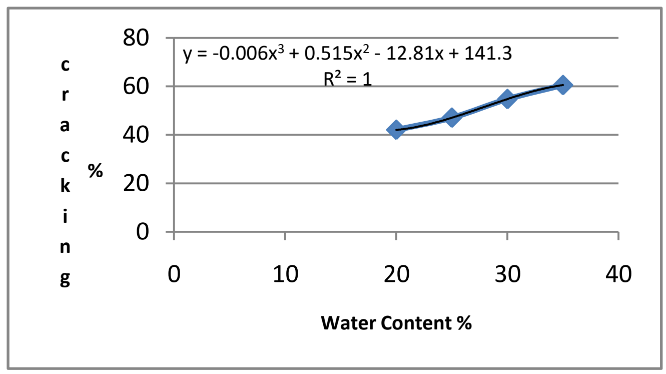

FIG.9 CORRELATION BETWEEN CRACKING % & WATER CONTENT FOR BC1

ii) Determination Of Shrinkage %:

Fiber Content =0%

TABLE 13. WATER CONTENT VS SHRINKAGE PERCENTAGE FOR BC2

Water Content (%)	Shrink %
20	4.660733294
25	11.84462927
30	22.07213028
35	22.4865011

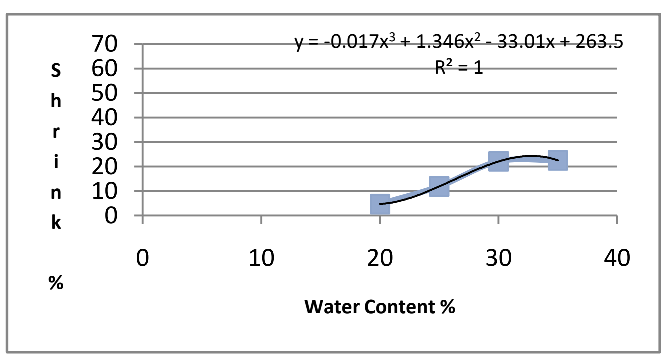

FIG. 10 CORRELATION BETWEEN SHRINKAGE% & WATER CONTENT BC2

IV.CONCLUSION

The laboratory experiments outcomes are acquired with a view to expand relation between fractal dimension and index residences are tabulated in consequences. Additionally Graphs depicts that correlation among fractal dimension and laboratory experiments of soil samples using appropriate curve becoming method which gives the polynomial equation. Following Desk also suggest that there is that percentage of error among conventional laboratory and image analysis technique varies from 1.45% to 13.37% for soil sample image for determination of index properties of soil pattern based totally on correlated equation advanced on this studies paintings. The result of present work emphasizes that there is a great potential in the use of fractal dimension for estimating physical soil properties for practical application, with minimum human error.

6.1 PHYSICAL PROPERTIES FROM LABORATORY TEST AND FROM IMAGE ANALYSIS FOR QUERY SOIL SAMPLE

Physical Properties	From Laboratory Test	From Image Analysis	Absolute Percentage of Error
Water Content(NS)	7.25%	6.58%	13.37%
Water Content (BC1)	8.00%	8.67%	8.37%
Water Content (BC2)	24.85%	25.21%	1.45%

Based on the experimental investigation following conclusion can be made:

A) For Shrinkage:-

1) For Black cotton soil as water content increases shrink percentage increase.

2) For Black cotton soil as fiber percentage increases in the specimen percentage shrink decreases.

3) For Normal clayey soil shrinkage is not remarkable.

B) For Cracking

Quantification of cracking can be very subjective when viewed by naked eye and estimated. The methodology of image processing technique tries to quantify it in a more scientific way. Results indicate that, with percentage of soil cracking with water content and fiber content cracking percentage estimate can be reasonably estimated using digital image processing.

Further, trend line established for varying percentage of water content and cracking percentage with R^2 nearly one, percentage cracking can be estimated for varying water content which can help in selecting appropriate preventive and curative measures from soil structural behavior.

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