

THE Major Project on
**“COMPARATIVE STUDY OF STABILIZATION OF EXPANSIVE SOIL USING
MICROSILICA AND RICE HUSK ASH”**

Submitted in Partial Fulfillment for the Award of the Degree of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With Specialization in

GEOTECHNICAL ENGINEERING

By

Rohit Ralli

(Roll No. 2K12/GTE/14)

Under The Guidance of

PROF. A.K GUPTA

Civil Engineering Department

Delhi College Of Engineering, Delhi



Department of Civil Engineering

Delhi Technological University, Delhi 2014



DELHI TECHNOLOGICAL UNIVERSITY

CERTIFICATE

This is to certify that the project report entitled “COMPARATIVE STUDY OF STABILIZATION OF EXPANSIVE SOIL USING MICROSILICA AND RICE HUSK ASH” is a bonafide record of work carried out by Rohit Ralli (2K12/GTE/14) under my guidance and supervision, during the session 2014 in partial fulfillment of the requirement for the degree of Master of Technology (Geotechnical Engineering) from Delhi Technological University, Delhi.

This is to certify that the above statement made by candidate is correct to the best of my knowledge.

PROF.A.K. GUPTA
PROFESSOR

DR. RAJU SARKAR
ASSISTANT PROFESSOR

Department of Civil Engineering
Delhi Technological University
Delhi-110042



DELHI TECHNOLOGICAL UNIVERSITY

DECLARATION

I Rohit Ralli hereby certify that the work which is presented in the Major Project entitled “COMPARATIVE STUDY OF STABILIZATION OF EXPANSIVE SOIL USING MICROSILICA AND RICE HUSK ASH” is submitted in the partial fulfillment of the requirement for the award of degree of “MASTER OF TECHNOLOGY” with specialization in “GEOTECHNICAL ENGINEERING” at Delhi Technological University is an authentic record of my own work carried under the Supervision of **Prof. A.K. Gupta**. I have not submitted the matter embodied in this major project for the award of any degree or diploma also it has not been directly copied from any source without giving its proper reference.

ROHIT RALLI

ACKNOWLEDGEMENT

I would like to express my deepest sense of gratitude and indebtedness to **Prof. A.K. Gupta and Dr. Raju Sarkar**. For his gaudiness and Consistent encouragement and support during the course of my work in the last two year. I truly appreciate and value his esteemed gaudiness and encouragement from the beginning to the end of the thesis, his knowledge and company at the time of cries remembered lifelong.

I sincerely thank to our **Prof. A Trivedi**, Present Head of the Civil Engineering Department, for their maintained academic curriculum and providing necessary facility for my work. I am also thankful to **Prof. A.K Sahu**, Associate Professor in Civil Engineering Department as a Co-ordinator and advisor, **Dr. Amit Shrivastav**, Associate Prof.in Civil Engineering Department and all professor of the Civil Engineering Department, especially of Geotechnical engineering group who have directly or indirectly helped me during the project

I am also thankful to all the staff member of Geotechnical Engineering Laboratory, Transportation Laboratory and Nano Tech. Laboratory for their assistance and Co-operation during the course of experimentation

I also thank all my batch mates specially **Deepak Dhiman** who have directly or indirectly helped me in my project work and shared the moments of joy and sorrow throughout the period of my project work.

Finally yet importantly, I would like thank my Parents, gaudiness, brothers and sisters, who taught me the value of hard work by their own example. I would like to share this moment of happiness with my parents. They rendered me enormous support and blessing during whole tenure of my stay in the Delhi Technological University.

At last but not the least, I thank to all those who directly or indirectly help me for the completion of project.

ABSTRACT

The engineering properties of expansive soils may need to be improved to make them suitable for construction using some sort of stabilization methods. Stabilization of pavement subgrade having expansive soils has traditionally relied on treatment with lime, cement, or waste materials such as microsilica. Most transportation agencies, however, are hesitant to specify these non-traditional stabilizers without reliable data to support vendor claims of product effectiveness. The main objective of this study is to investigate the effect of the engineering properties of expansive soils when blended with microsilica and Rice husk ash. Utilizing some of these materials as alternative materials for the construction in no doubt is a best solution. Hence an attempt is made to justify the use of microsilica and RHA for stabilization of expansive soil. This paper highlights the effectiveness of using these materials in the treatment of soil. Laboratory test results presents the influence of different mix proportions of microsilica and rice husk ash on compaction, strength and swelling nature properties of soil.

LIST OF FIGURES

Figure No	Name of the figure	Page No
1	Soil types in Madhya Pradesh	2
2	Expansive soil at the site	2
3	Schematic diagram of Microsilica production	5
4	Thermal decomposition of Rice husk ash	6
5	Reaction Mechanism of stabilization on Clay Soils	12
6	DELKM microsilica bag	25
7	Photo of RHA sample	25
8	Plasticity chart (IS: 1498-1970)	28
9	Principle of EDS (Wikipedia)	30
10	Plasticity chart	35
11	Hydrometer analysis of soil	36
12	Liquid limit of soil	37
13	Electronic Dispersive Spectrum of Soil	38
14	Electronic Dispersive Spectrum of Microsilica	39
15	Electronic Dispersive Spectrum of RHA	40
16	SEM for Soil at 10.0um Scale	41
17	SEM for Microsilica at 5.0um Scale	42
18	SEM for RHA at 2.0um Scale	42
19	Variation of Dry Density with Water Content of soil	43
20	Variation of compressive strength with axial strain of soil at different days of curing	44
21	Variation of Load with Penetration of soil	45
22	Variation of Shearing stress with horizontal displacement of soil at different normal stresses	46
23	Variation of Shearing stress with Normal stress of soil	46
24	Variation of dry density with water content of soil blended with different percentage of microsilica	47
25	Variation of optimum moisture content with microsilica in different percentage	48
26	Sample prepared in standard proctor test	49

27	Variation of maximum dry density with microsilica in different percentage	49
28	UCS sample	50
29	Installation of UCS sample	50
30	Failure of UCS sample	50
31	Variation of compressive strength with axial strain of soil blended with different percentage of microsilica at one day curing	50
32	Variation of compressive strength with axial strain of soil blended with different percentage of microsilica at seven days curing	51
33	Variation of compressive strength with axial strain of soil blended with different percentage of microsilica at Fourteen days curing	51
34	Unconfined Compressive Strength with microsilica in different percentage at different days in curing	52
35	Sample prepared in CBR mould	54
36	Testing of CBR sample	54
37	Variation of load with penetration of soil blended with different percentage of microsilica	55
38	Variation of CBR(%) with microsilica in different percentage	55
39	Variation of Free swell index with microsilica in different percentage	57
40	Sample of direct shear test	58
41	Failed sample after testing	58
42	Variation of Shearing Stress with horizontal displacement at different percentage of microsilica at 50kN/m^2	58
43	Variation of Shearing Stress with horizontal displacement at different percentage of microsilica at 100kN/m^2	59
44	Variation of Shearing Stress with horizontal displacement at different percentage of microsilica at 150kN/m^2	60
45	Variation of Shearing stress with horizontal displacement of soil blended with microsilica at five percent at different normal stress	60
46	Variation of Shearing stress with horizontal displacement of soil blended with microsilica at seven percent at different normal stress	61
47	Variation of Shearing stress with horizontal displacement of soil blended with microsilica at nine percent at different normal stress	61
48	Variation of Shearing stress with horizontal displacement of soil	62

	blended with microsilica at eleven percent at different normal stress	
49	Variation of Shearing stress with horizontal displacement of soil blended with microsilica at thirteen percent at different normal stress	63
50	Variation of Shearing stress with horizontal displacement of soil blended with microsilica at fifteen percent at different normal stress	63
51	Variation of shear stress with normal stress to calculate the shear parameters i.e. cohesion and angle of internal friction	65
52	Variation of cohesion with microsilica at different percentage	66
53	Variation of angle of internal friction with microsilica at different percentage	66
54	Variation of dry density with water content of soil blended with different percentage of RHA	67
55	Variation of OMC with RHA in different percentage	68
56	Variation of MDD with RHA in different percentage	69
57	Variation of compressive strength with axial strain of soil blended with different percentage of RHA at one day curing	70
58	Variation of compressive strength with axial strain of soil blended with different percentage of RHA at seven days curing	70
59	Variation of compressive strength with axial strain of soil blended with different percentage of RHA at fourteen days curing	71
60	Unconfined Compressive Strength with RHA in different percentage at different days of curing period	72
61	Variation of Load with penetration of soil with different percentage of RHA content	75
62	Variation of CBR with RHA in different percentage	75
63	Variation of Free swell index with RHA in different percentage	77
64	Variation of Shearing Stress with horizontal displacement at different percentages of RHA at normal stress 50KN/m ²	78
65	Variation of Shearing Stress with horizontal displacement at different percentages of RHA at normal stress 100KN/m ²	79
66	Variation of Shearing Stress with horizontal displacement at different percentages of RHA at normal stress 150KN/m ²	80
67	Variation of Shearing stress with horizontal displacement of soil blended with RHA at five percent at different normal stress	80

68	Variation of Shearing stress with horizontal displacement of soil blended with RHA at seven percent at different normal stress	81
69	Variation of Shearing stress with horizontal displacement of soil blended with RHA at nine percent at different normal stress	81
70	Variation of Shearing stress with horizontal displacement of soil blended with RHA at eleven percent at different normal stress	82
71	Variation of Shearing stress with horizontal displacement of soil blended with RHA at thirteen percent at different normal stress	83
72	Variation of Shearing stress with horizontal displacement of soil blended with RHA at fifteen percent at different normal stress	83
73	Variation of shear stress with normal stress of soil blended with RHA at different percentage	85
74	Variation of cohesion with RHA in different percentage	86
75	Variation of angle of internal friction with RHA in different percentage	87
76	Variation of OMC with additives in different percentage	88
77	Variation of MDD with additives in different percentage	88
78	Variation of UCS with additives in different percentage at one day in curing period	89
79	Variation of UCS with additives in different percentage at seven days in curing period	89
80	Variation of UCS with additives in different percentage at fourteen days in curing period	90
81	Variation of CBR with additives in different percentage	90
82	Variation of free swell index with additives in different percentage	91
83	Variation of shear stress with additive in percentage for a normal stress of 50kN/m ²	91
84	Variation of shear stress with additive in percentage for a normal stress of 100 kN/m ²	92
85	Variation of shear stress with additives in different percentage for a normal stress of 150 kN/m ²	92
86	Variation of cohesion with additive in different percentages in soil	93
87	Variation of angle of internal friction with additive in different percentages in soil	93

LIST OF TABLES

Table No	Name of Table	Page no
1	Microsilica properties and specifications provided by DELKEM	24
2	Rice husk ash properties and specifications provided by NK ENTERPRISES	24
3	Test program for stabilization of expansive soil using Microsilica and RHA	26
4	Representation of group symbol in Plasticity chart: (IS:1498-1970)	28
5	Free swell index V/s Degree of Expansiveness (IS: 2720 (part XL) (1977))	29
6	Standard Load for CBR Test	33
7	Mineralogical Characteristics of Soil	39
8	Mineralogical Characteristics of Microsilica	40
9	Mineralogical Characteristics of RHA	41
10	Shearing stress Vs Normal stress of soil	45
11	Variation of MDD and OMC with different percentage of microsilica content	48
12	Unconfined Compressive Strength at different percentage of microsilica at different curing period	53
13	CBR value at different percentage of microsilica	56
14	Free swell index at different value of microsilica	57
15	Shearing stress & Normal stress at different percentage of microsilica	64
16	Equation of slope & intercept of line at different percentage of microsilica	65
17	Variation of MDD and OMC with different percentage of RHA content	68
18	Unconfined Compressive Strength at different percentages of RHA content at different curing period	73
19	CBR value at different percentages of RHA	76
20	Free swell index at different percentages of RHA	77
21	Shearing stress & Normal stress at different percentage of RHA content	84
22	Equation of line, slope & intercept of line at different percentage of RHA	86

LIST OF ABBREVIATION & SYMBOL

The principal symbol used in this thesis is presented for easy reference. A symbol is used for different meaning depending on the context and defined in the text as they occur.

S.No	Notation	Description
1	SF	Mirosilica
2	RHA	Rice husk ash
3	G	Specific gravity
4	LL	Liquid limit
5	PL	Plastic limit
6	PI	Plasticity index
7	C_u	Coefficient of curvature
8	C_c	Coefficient of uniformity
9	OMC	Optimum Moisture Content ,%
10	MDD	Maximum Dry Density, gm/cc
11	UCS	Unconfined Compressive strength,KN/m ²
12	CBR	California Bearing Ratio Test
13	DST	Direct Shear test
14	C	Unit Cohesion, KN/m ²
15	AR	Aspect Ratio
16	ϕ	Angle of Internal Friction
17	BCS	Expansive Soil
18	XRD	X-Ray Diffraction
19	SEM	Scanning Electron Microscope
20	M.C	Moisture Content
21	c	Intercept
22	M.C	Moisture Content

CONTENTS

	Page No.
Title	i
Certificate	ii
Declaration	iii
Acknowledgement	iv
Abstract	v
List of figures	vi-ix
List of tables	x
Abbreviation & Symbol	xi
 CHAPTER 1: INTRODUCTION	
1.1 Introduction	1
1.2 Soil stabilization: An overview	3
1.2.1 Principles of Soil Stabilization	3
1.2.2 Needs & Advantages	3
1.2.3 Methods of soil stabilization	4
1.3 Microsilica: An overview	4
1.3.1 Uses of microsilica	5
1.4 Rice husk ash: An overview	5
1.4.1 Uses of Rice husk ash	7
1.5 Issues for the millennium	8
1.6 Need for the research	8
1.7 Objective	9
1.8 Scope of thesis	9
 CHAPTER 2: LITERATURE REVIEW	
2.1 Introduction	10
2.2 Expansive Soil	10
2.2 Stabilization of soil with microsilica	13

2.3	Stabilization of soil with rice husk ash	17
-----	--	----

CHAPTER 3: EXPERIMENTAL WORK AND METHODOLOGY

3.1	Introduction	23
3.2	Material used	23
3.2.1	Expansive soil	23
3.2.2	Microsilica	23
3.3.3	Rice husk ash	24
3.3	Sample preparation and experimental program	25
3.4	Determination of particle size distribution	26
3.4.1	Sieve analysis	26
3.4.2	Hydrometer analysis	26
3.5	Determination of Index Property of soil	27
3.5.1	Specific gravity	27
3.5.2	Liquid Limit	27
3.5.3	Plastic Limit	27
3.5.4	Plasticity Index	28
3.5.5	Free Swell Index	29
3.5.6	Energy dispersive X-ray spectrometry	29
3.5.7	Scanning electron microscope	30
3.6	Determination of engineering property of the soil	31
3.6.1	Proctor compaction test	31
3.6.2	Unconfined Compressive strength test	32
3.6.3	California bearing ratio test	32
3.6.4	Direct shear test	34

CHAPTER 4: RESULT AND DISCUSSION

4.1	Physical property of the Expansive Soil	35
4.1.1	Grain Size distribution	35
4.1.2	Specific gravity	36
4.1.3	Liquid Limit	37
4.1.4	Plastic Limit	37
4.1.5	Plasticity Index	37
4.1.6	Free swell Index	38
4.1.7	Energy dispersive X-ray spectrometry	38
4.1.7.1	EDX of soil sample	38
4.1.7.2	EDX of microsilica	39
4.1.7.3	EDX of RHA	40
4.1.8	Scanning electron microscope	41
4.1.9	Proctor Compaction test	43
4.1.10	Unconfined compressive Strength	43
4.1.11	California bearing ratio test	44
4.1.12	Direct shear test	45
4.2	Soil blended with microsilica	47
4.2.1	Proctor compaction test	47
4.2.2	Unconfined compressive strength	50
4.2.3	California bearing ratio test	54
4.2.4	Free swell index	56
4.2.5	Direct shear test	58
4.3	Soil blended with rice husk ash	67
4.3.1	Proctor Compaction test	67
4.3.2	Unconfined compressive strength	69
4.3.3	California bearing ratio test	74
4.3.4	Free swell index	76

4.3.5	Direct shear test	78
-------	-------------------	----

CHAPTER 5: COMPARISON OF RESULTS

5.1	Compaction test	88
5.2	Unconfined compressive strength	89
5.3	CBR test	90
5.4	Free swell index	91
5.5	Direct Shear test	91

CHAPTER 6: CONCLUSION

6.1	Conclusion	94
6.2	Scope of future work	95

REFERENCES		96
-------------------	--	-----------