USE OF NATURAL FIBRE AS SOIL STABILIZING AGENT

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PRESENTATION OUTLINE

- INTRODUCTION
- BACKGROUND
- METHODOLOGY
- RESULTS AND DICUSSION
- CONCLUSION AND RECOMMENDATIONS
- ACKNOWLEDGEMENT

INTRODUCTION

- Stabilization of clayey soils in foundations/subgrades and in mud houses is one of the key mechanisms in utilizing the soil sites where the existing soils are lacking the adequate strength parameters as per the design specifications.
- The use of cementitious materials such as cement, lime, flash etc., are the common methods of soil treatment for improving its mechanical properties.

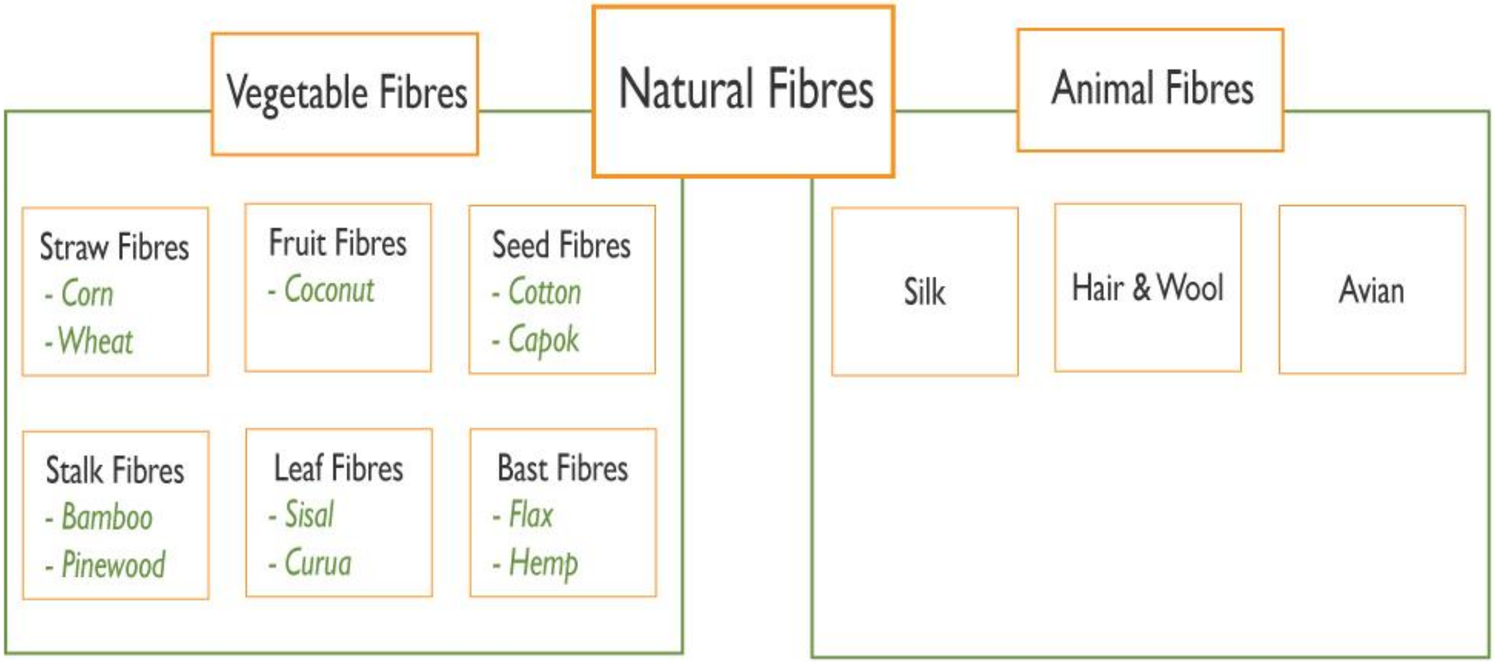
INTRODUCTION

- Recent trends are very much focused on fibre reinforcement, where use of the artificial fibre is very common.
- The use of natural fibres is little addressed in the literature to be used as reinforcing materials.
- Fibers are actually the stalks of the plant. e.g. **straws of wheat, rice, barley**, and other crops including **bamboo** and **grass**. Tree wood is also such a fiber. The most used plant fibers are **cotton, flax and hemp**, although **sisal, jute, kenaf, bamboo and coconut** are also widely used.

INTRODUCTION

- Therefore, this study was focused to investigate effectiveness of wheat straw as soil stabilizing agent.
- The analysis was carried out through experimentation.
- Mechanical behaviour of soil such as its consistency, shrinkage, consolidation, density and compressive strength, etc. were investigated.

BACKGROUND

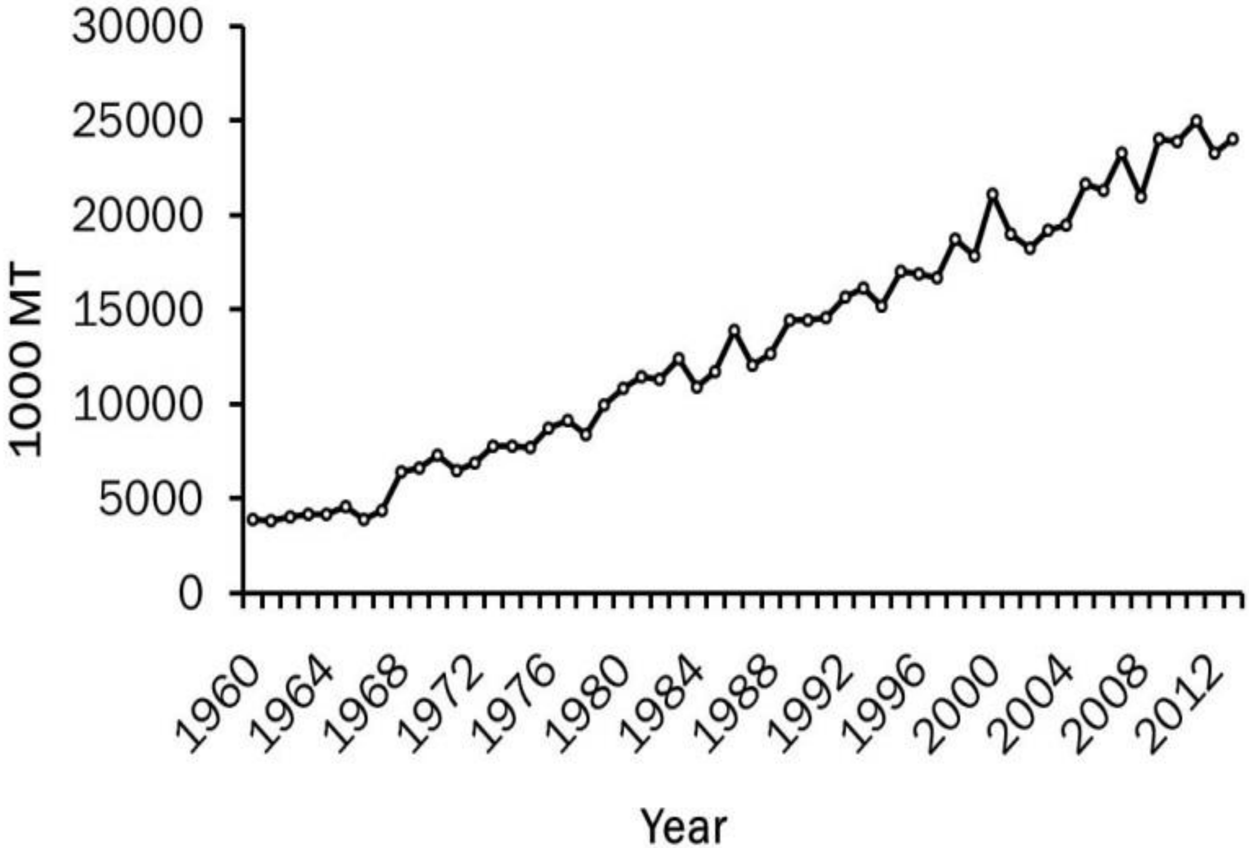


Natural Fibres
Vegetable Fibres
Animal Fibres
Straw Fibres
- Corn
- Wheat
Fruit Fibres
- Coconut
Seed Fibres
- Cotton
- Capok
Stalk Fibres
- Bamboo
- Pinewood
Leaf Fibres
- Sisal
- Curua
Bast Fibres
- Flax
- Hemp
Silk
Hair & Wool
Avian

BACKGROUND

- It has been long recognized that natural fibre is abundance as a raw material and there has been little utilization of it as an engineering material to be used as reinforcing materials.
- the production of wheat straw or rice husk in Pakistan has a continuous rising trend through decades. Pakistan wheat production by year is shown in Figure.

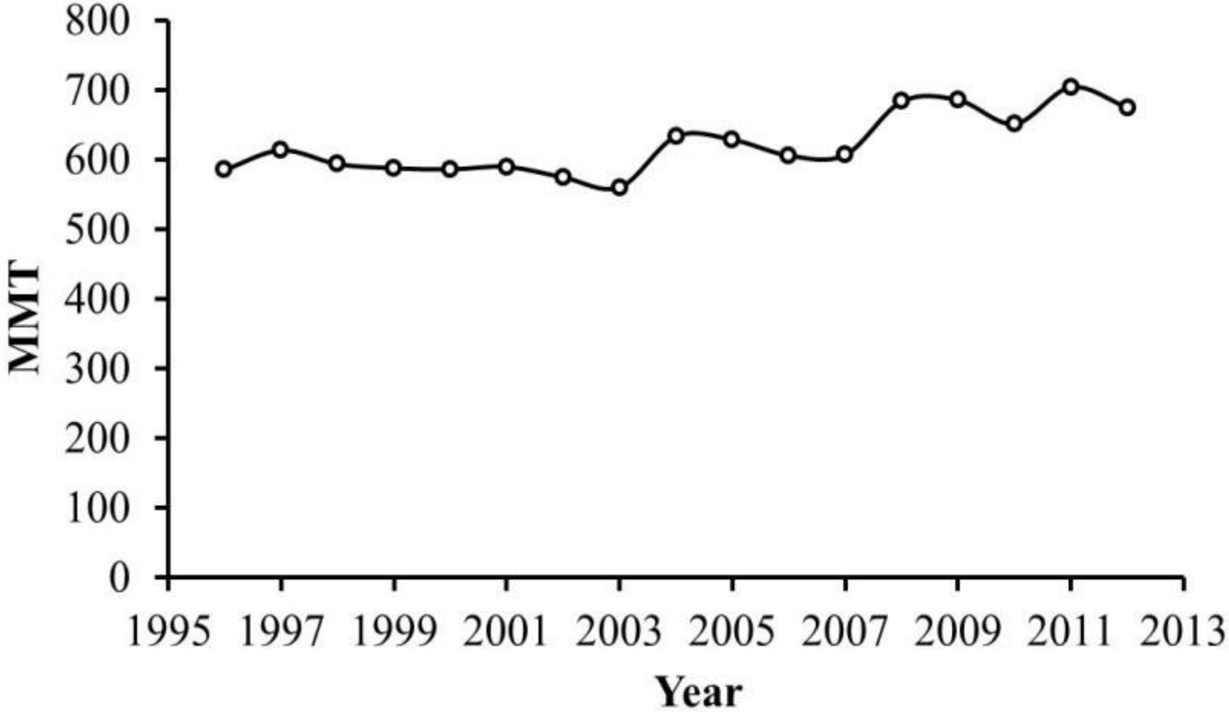
BACKGROUND



30000
25000
20000
15000
10000
5000
0
1000 MT
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
2012
Year

BACKGROUND

World wheat production by year is shown in Figure



MECHANICAL PROPERTIES OF CLAY

- Consistency
- Shrinkage
- Density
- Consolidation
- Compressive strength, etc.

EFFECT OF CLAY CONSISTENCY

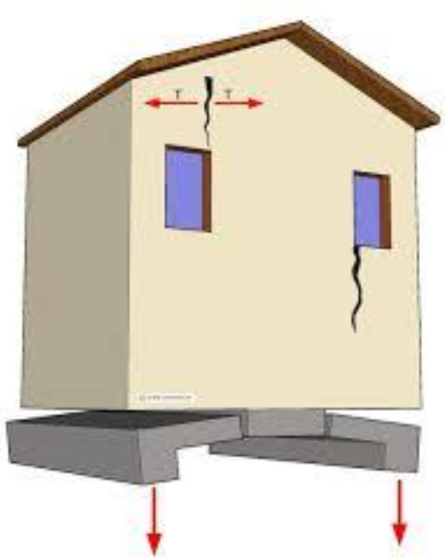
The stability of adobe (mud) houses mainly depends on clay consistency and compressive strength

DESIRABLE TEXTURE OF ADOBE HOUSES

The most desirable soil texture for producing the mud of adobe is 15% clay, 10-30% silt and 55-75% fine sand.[14] Another source quotes 15-25% clay and the remainder sand and coarser particles up to cobbles 2-10 inches with no deleterious effect. Modern adobe is stabilized with either emulsified asphalt or Portland cement up to 10% by weight.

EFFECT OF SHRINKAGE

EFFECT OF CONSOLIDATION



Effect of consolidation and soil saturation is obvious on buildings and subgrades

EFFECT OF DENSITY/STABILITY

The performance of highways significantly depends on the stability/compressive strength of subgrades

METHODOLOGY

Materials	• Clay • Wheat Straw
Experimental Setups	• Consistency Limit Test • Shrinkage Limit Test • Compaction Test • Compressive strength Test • Consolidation Test
Testing Procedure	• Detail is on next Slide

CLAY STOCK

Fine clay of breaking the lumps

Clay stock

WHEAT STRAW

Wheat straw before threshing

Threshing of wheat straw

Threshed wheat straw

COMPOSITE MATERIALS

Threshed wheat straw

Clay mixed with fibre (dry mixing)

Clay mixed with fibre and water at OMC

Clay mixed with fibre and water at WP

EXPERIMENTAL SETUPS

TESTING PROCEDURE

- Unit weight
- Average specific gravity
- Volume of solids
- Void ratio
- Constant compaction efforts
- Targeted unit weight
- Targeted relative density

UNIT WEIGHT

$$\gamma = \frac{M_{total}}{V}$$

$$M_{soil} = \left(\frac{100}{100 + C + F}\right) M_{total}$$

$$M_{cement} = \left(\frac{C}{100+C+F}\right) M_{total}$$

$$M_{Fibre} = \left(\frac{F}{100 + C + F}\right) M_{total}$$

AVERAGE SPECIFIC GRAVITY

$$G_{av} = \frac{100 - C - F}{100} \times G_{soil} + \frac{C}{100} \times G_{cement} + \frac{F}{100} \times G_{Fibre}$$

VOLUME OF SOLIDS

$$\gamma_s = \frac{M_s}{V_s}$$

$$G_s = \frac{\gamma_s}{\gamma_w}$$

$$V_s = \frac{M_s}{G_s \gamma_w}$$

VOID RATIO

$$V_t = \frac{\pi}{4} D^2 H$$

$$V_v = V_t - V_s$$

$$e = \frac{V_v}{V_s}$$

TARGETED RELATIVE DENSITY

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}}$$

$$\eta = \frac{e}{1 + e}$$

$$\eta = \frac{V_v}{V_t}$$

$$V_s = V_t - V_v$$

$$M_s = V_s G_s \gamma_w$$

DIFFICULTIES IN SAMPLE PREPARATION

DIFFICULTIES IN SAMPLE PREPARATION


Provision of collar


Controlled compaction efforts

SAMPLE PREPARATION

(a) (b)

(a) (b)

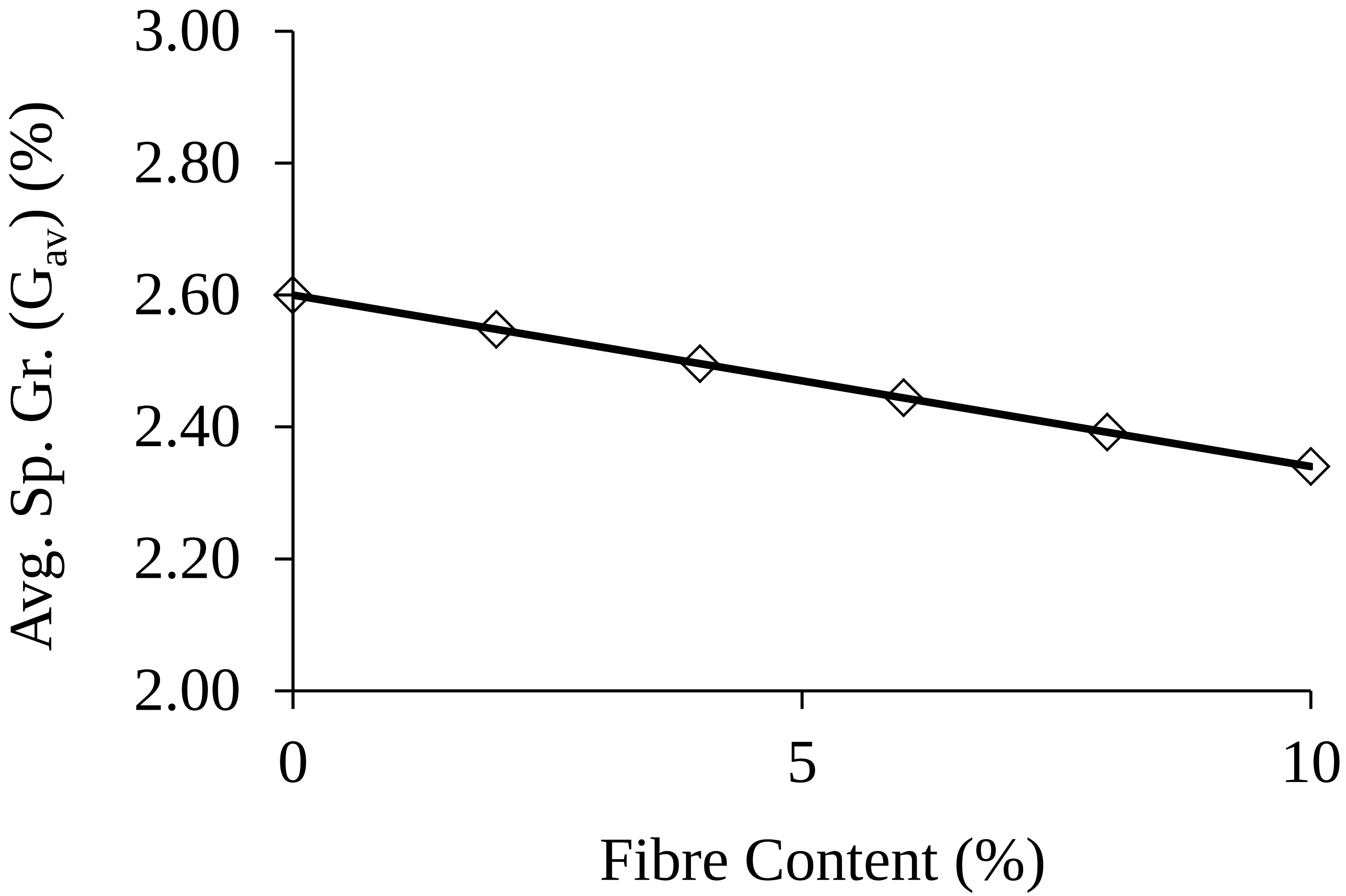
(a) Sample prepared mould without collar (b)Sample prepared mould with collar.

RESULTS AND DISCUSSION

Average Specific Gravity

% WS	G_{soil}	G_{ws}	G_{av}
0	2.6	0.36	2.6
2	2.6	0.36	2.548
4	2.6	0.36	2.496
6	2.6	0.36	2.444
8	2.6	0.36	2.392
10	2.6	0.36	2.34

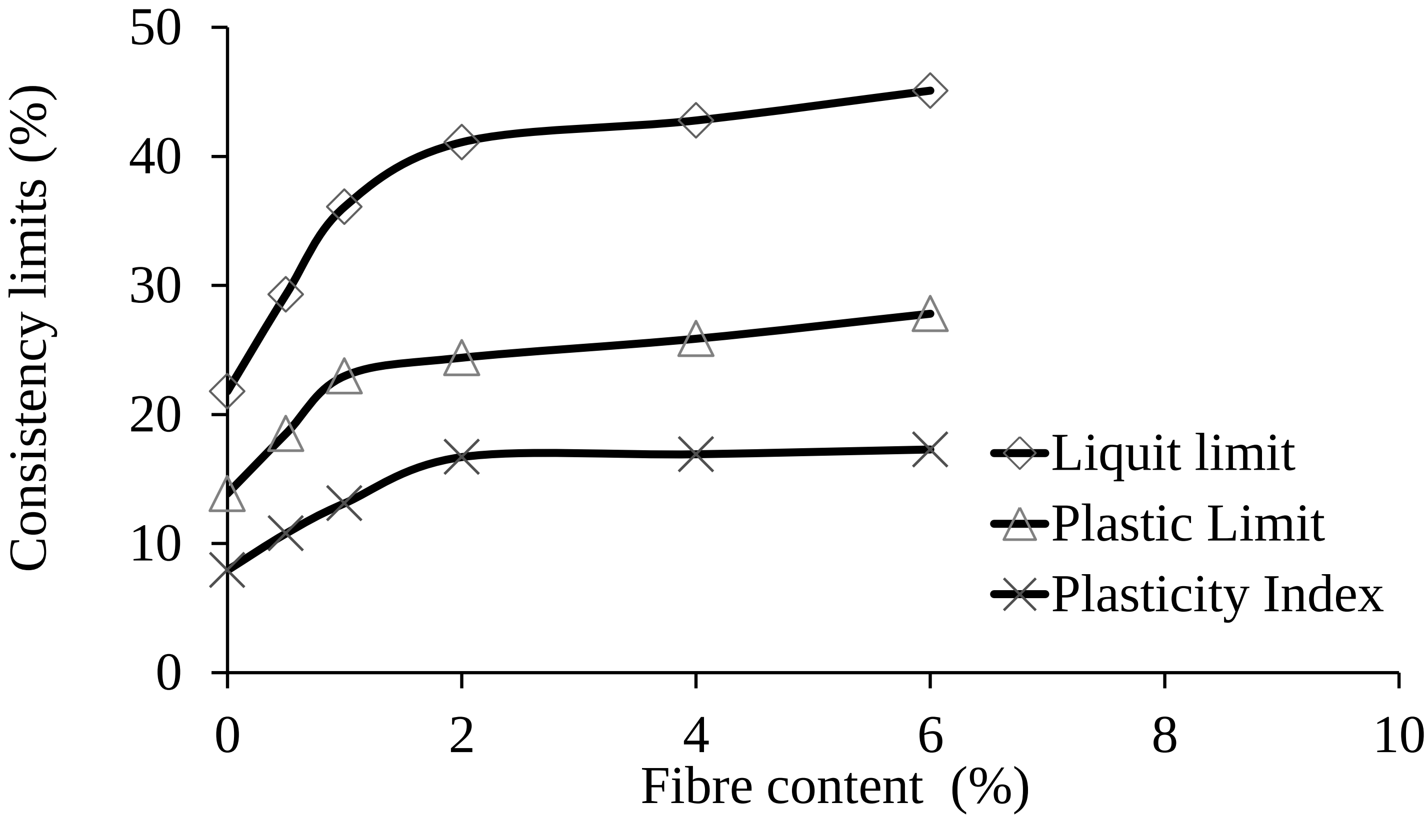
EFFECT OF % AGE OF WS ON THE G_{av}



CONSISTENCY LIMITS

Fibre content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	21.8	13.87	7.93
0.5	29.3	18.52	10.78
1	36.1	22.98	13.12
2	41.1	24.4	16.7
4	42.79	25.87	16.92
6	45.1	27.81	17.29

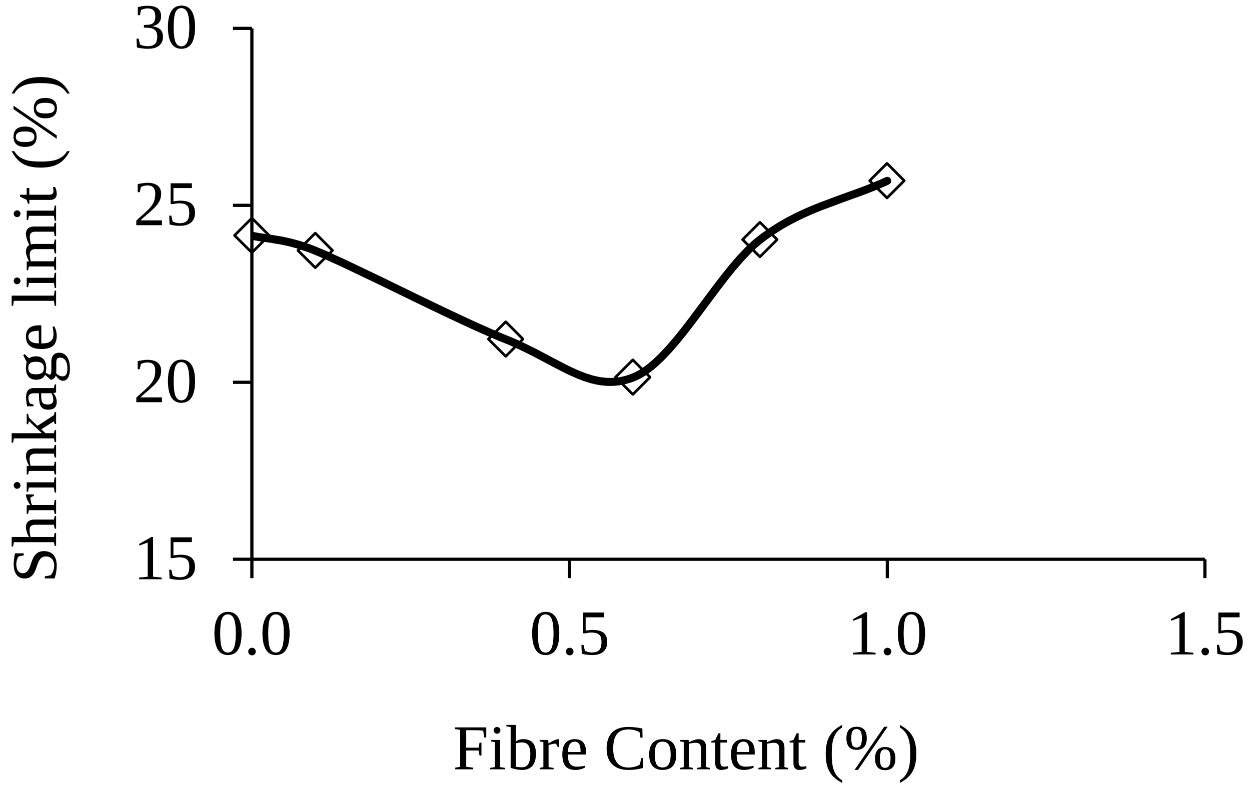
CONSISTENCY CHARACTERISTICS



SHRINKAGE LIMIT

Fibre Content (%)	Shrinkage Limit (%)
0	24.15
0.1	23.715
0.4	21.21
0.6	20.135
0.8	24.03
1.0	25.69

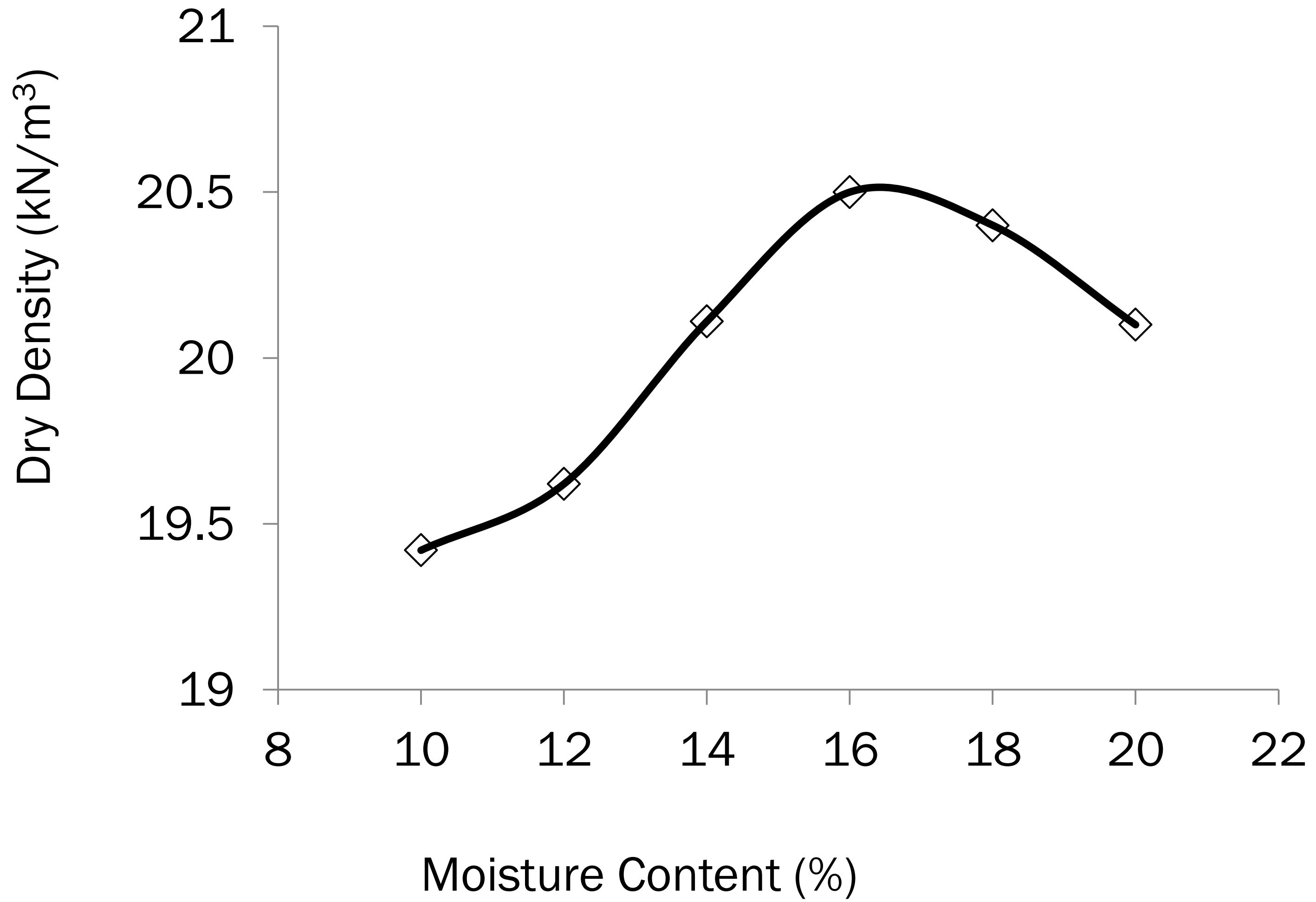
SHRINKAGE TEST



OPTIMUM MOISTURE CONTENT

Water Content (%)	Dry Unit Weight (kN/m^3)
10	19.42
12	19.62
14	20.11
16	20.5
18	20.4
20	20.1

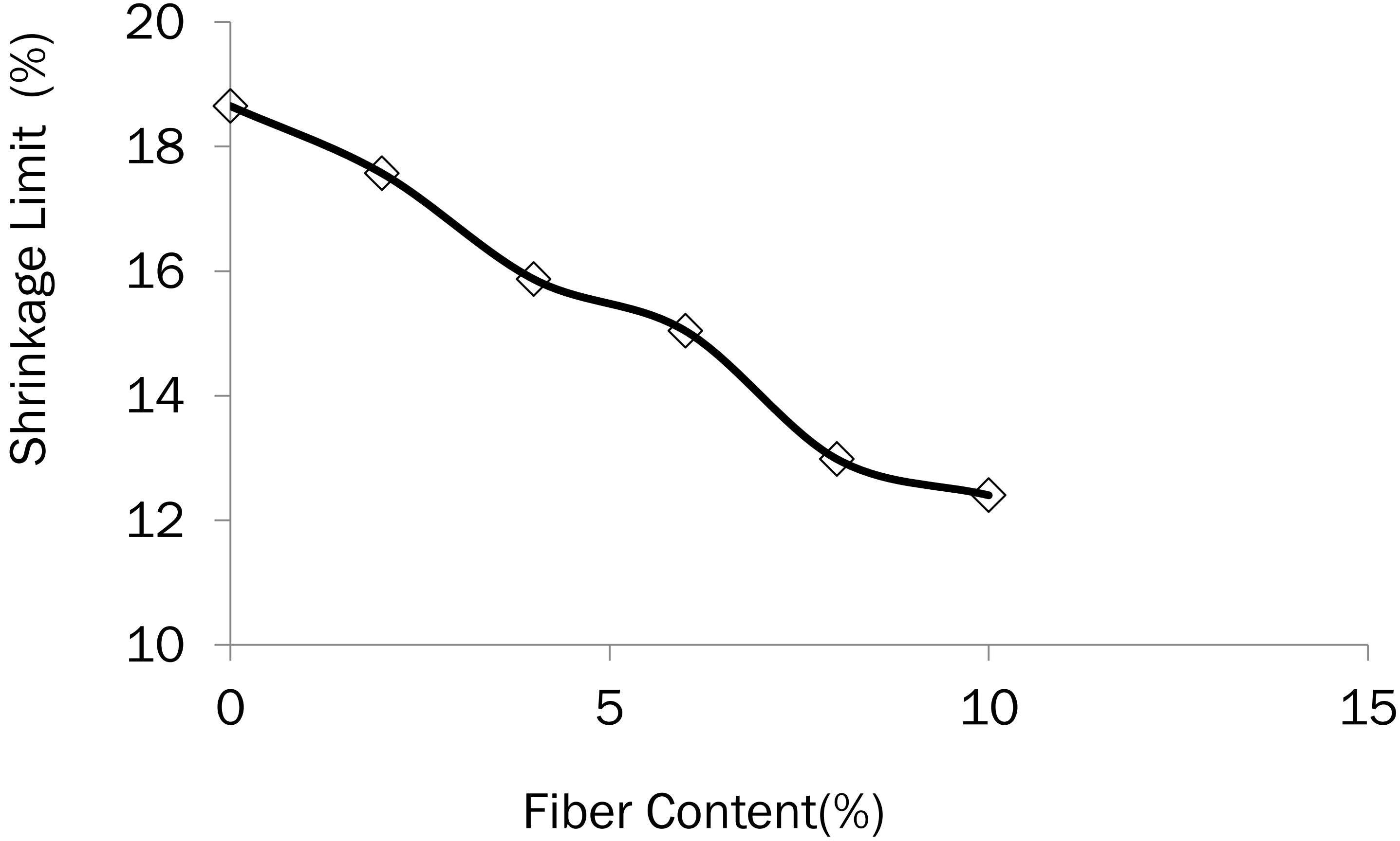
OPTIMUM MOISTURE CONTENT



OPTIMUM FIBRE CONTENT

Fibre Content (%)	Dry Unit Weight (kN/m^3)
0	18.65
2	17.57
4	15.87
6	15.04
8	12.98
10	12.40

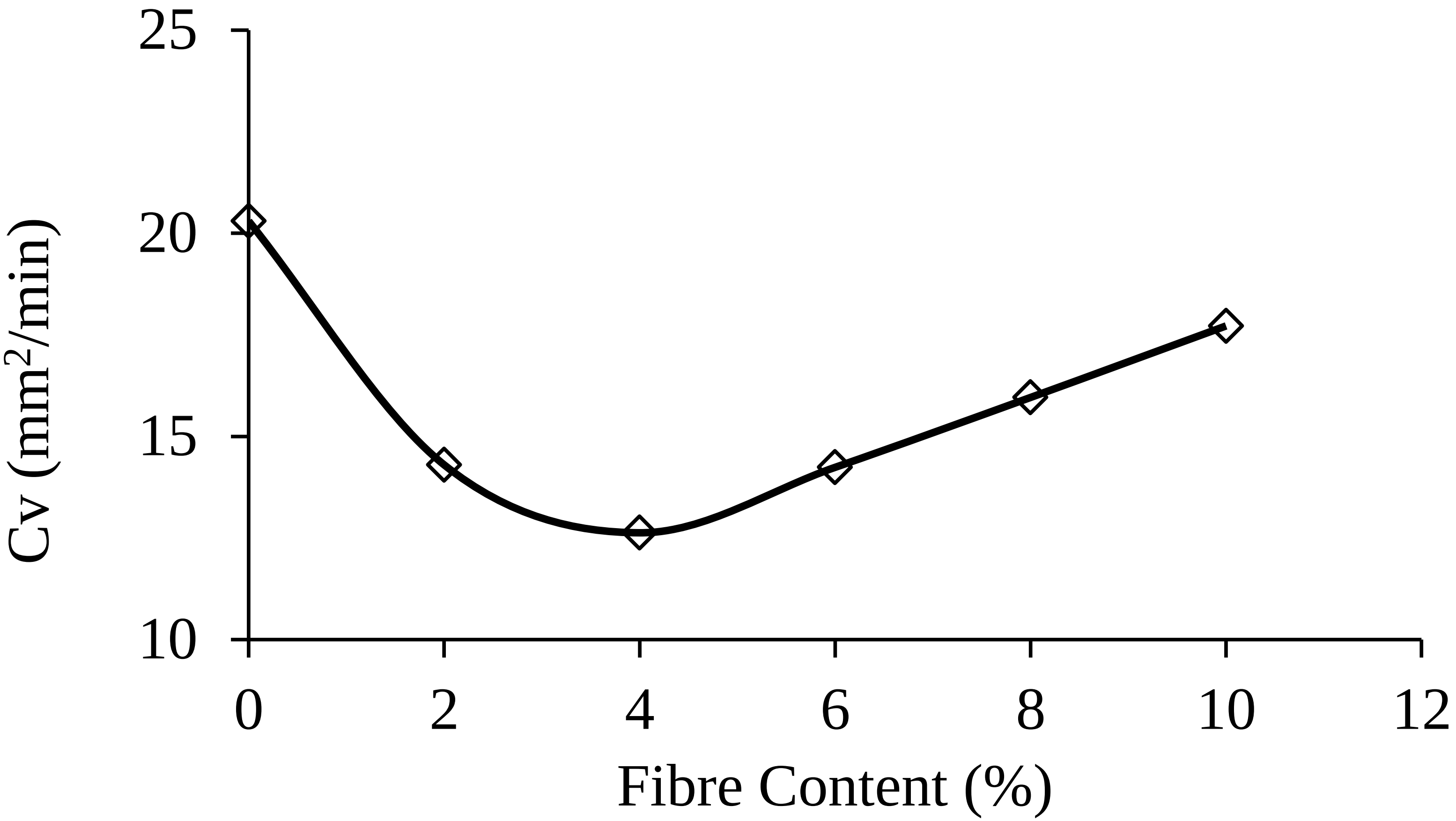
EFFECT OF WHEAT STRAW ON MDD



1-D CONSOLIDATION

Fiber content (%)	t_{90} (minutes)	C_v (mm^2/min)
0	11.088	20.30
2	18.5	14.301
4	29.16	12.63
6	11.90	14.24
8	29.37	15.96
10	23.42	17.72

1-D CONSOLIDATION

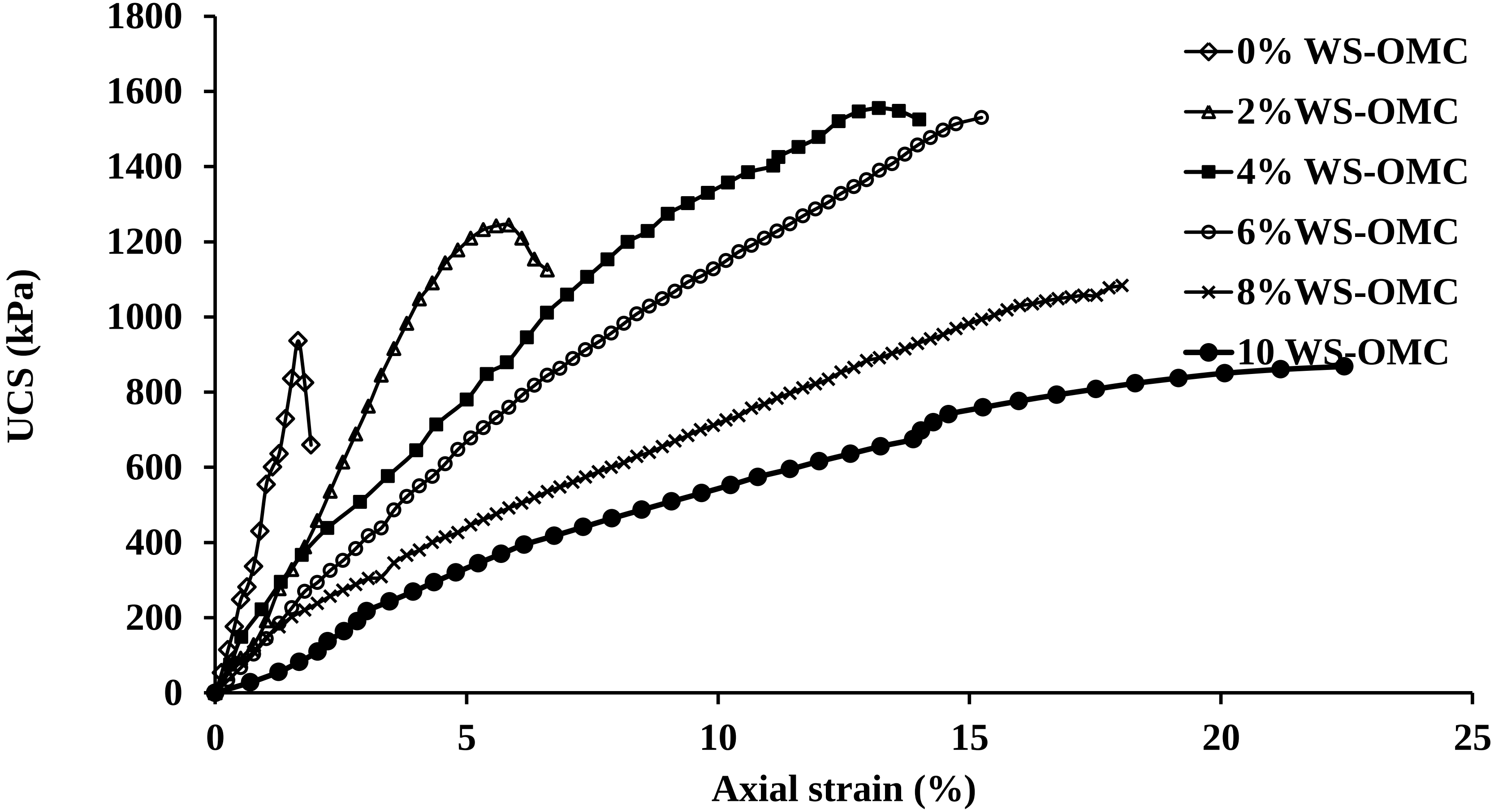


UNIAXIAL COMPRESSIVE STRENGTH

Sample prepared at OMC

Sample prepared at WP

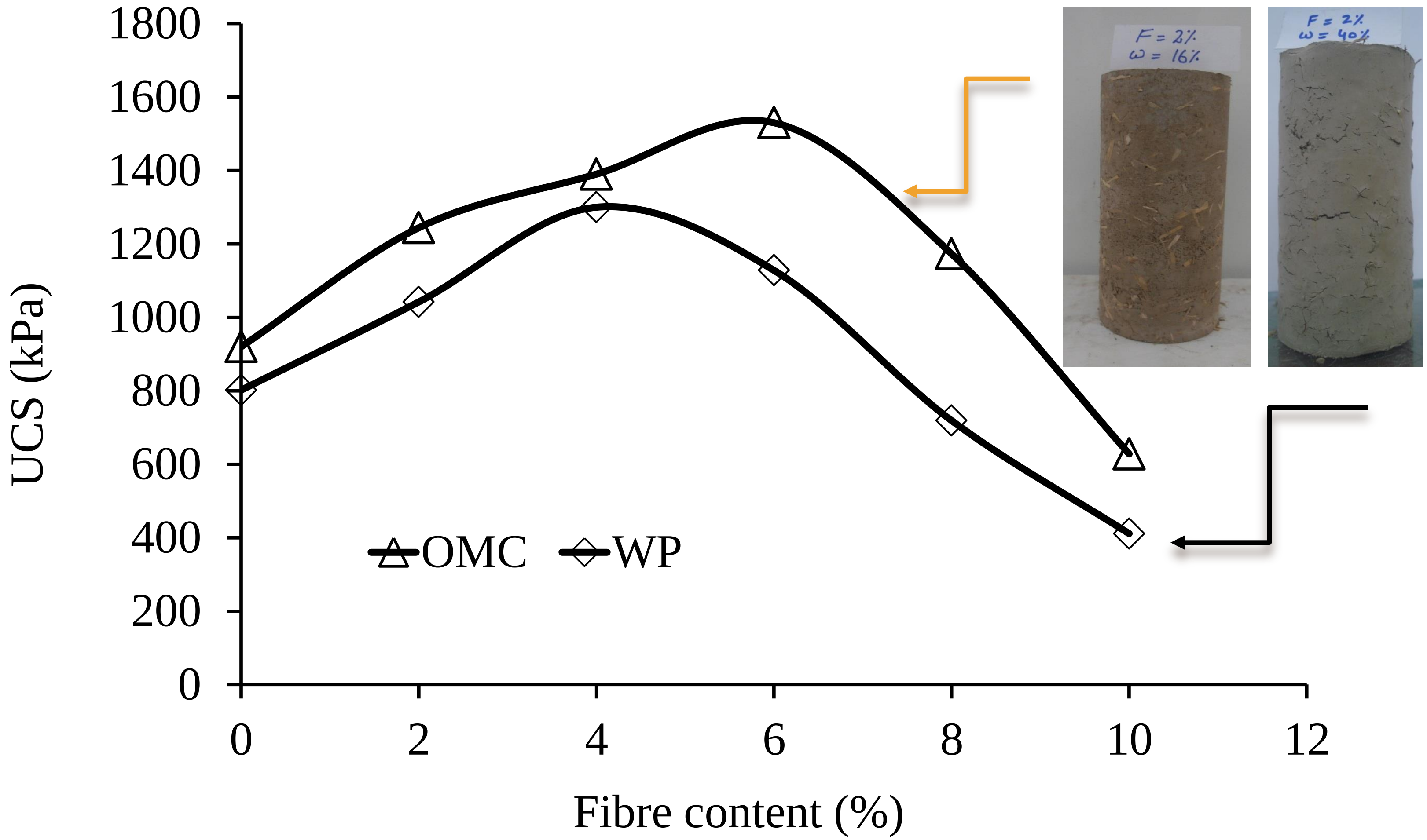
UNIAXIAL COMPRESSIVE STRENGTH



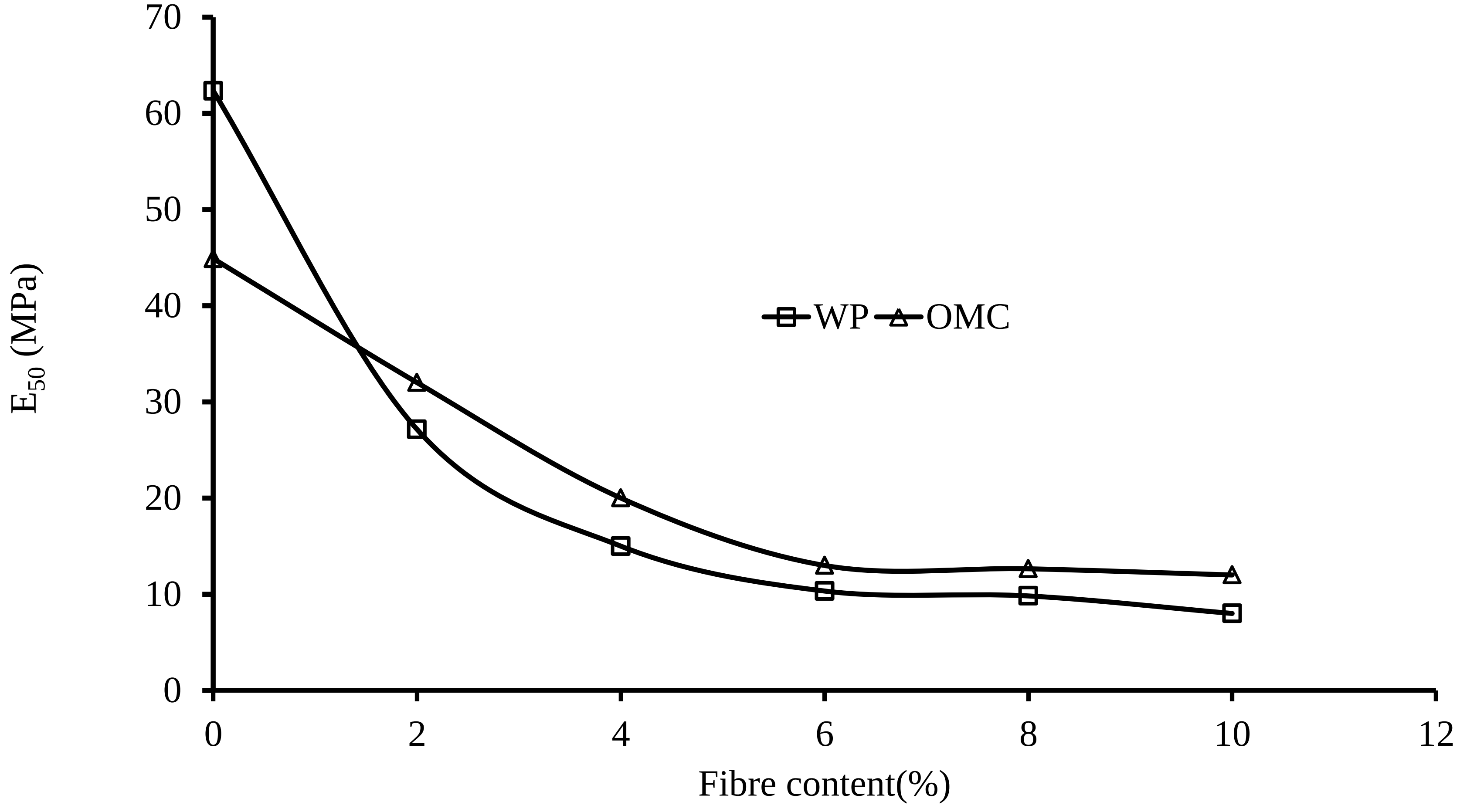
EFFECT OF FIBRE CONTENT ON UCS AT OMC AND WP

Fibre content (%)	UCS (kPa) at (OMC)	UCS (kPa) at (WP)
0	920	802
2	1244	1042
4	1390	1300
6	1530	1128
8	1173	719
10	628	411

EFFECT OF FIBRE CONTENT ON UCS AT OMC AND WP



STIFFNESS DEGRADATION



CONCLUSIONS

- From the experimental results it can be concluded that using wheat straw as a soil stabilizing agent there is improvement in the mechanical properties of clay in general.
- However, there is no single fibre content which can improve several mechanical properties.
- For the improvement of each mechanical property, different fibre contents need to be added. Therefore, for the improvement of one of the components there may be adverse effects on some of the other mechanical properties. Thus for the improvement of one of the mechanical properties the adverse effects on other mechanical properties must not be ignored. For instance:

CONCLUSIONS

- For the specimens prepared at optimum moisture content, the maximum uniaxial compressive strength was achieved at an optimum fibre content of 6%,
- For the specimens prepared at plastic state, the maximum uniaxial compressive strength was achieved at an optimum fibre content of 4%.
- The optimum wheat straw content at which maximum decrease in the shrinkage limit noticed was 0.6%.
- Controlled sample preparation is essential for good quality results. (Layering effect, homogeneity, controlled density, etc.)

FACTORS TO BE CONSIDERED

The following factors must be considered:

- Decomposition of wheat straw and factors which can render the decomposition of wheat straw must be investigated. For instance treatment with lime and fly ash.
- Thermal and electrical resistivity characteristics.

FACTORS TO BE CONSIDERED

Compaction rammer for compacting
50 mm diameter samples

Mould with collar


Thank You!

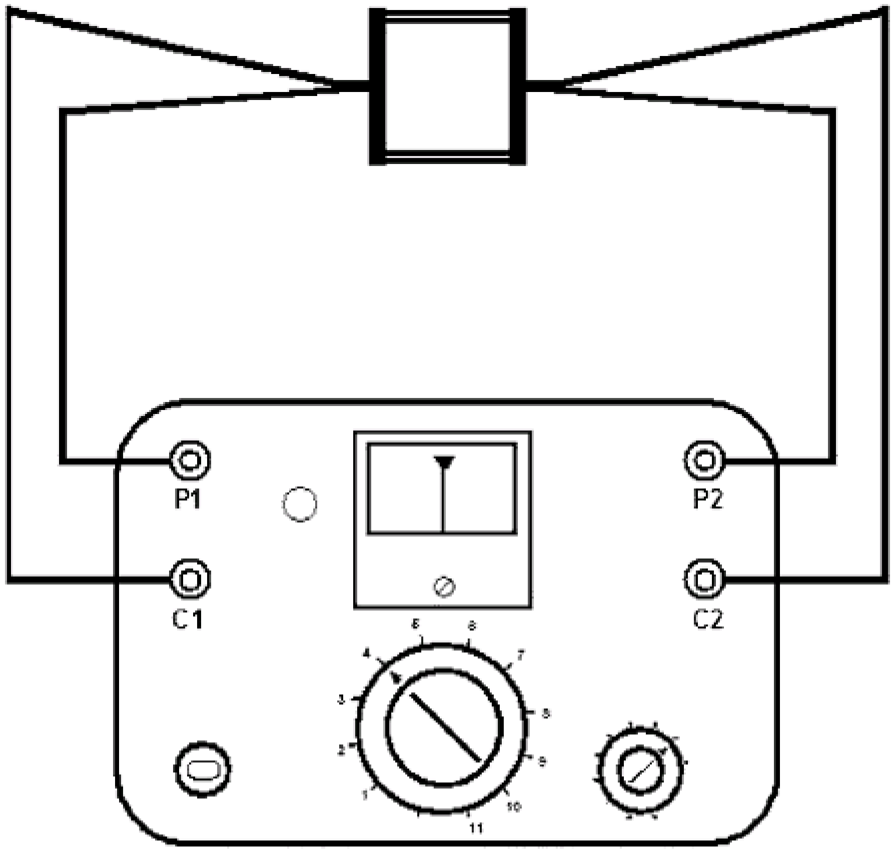
THERMAL RESISTIVITY

Laboratory thermal resistivity measurements of a soil sample.

THERMAL RESISTIVITY

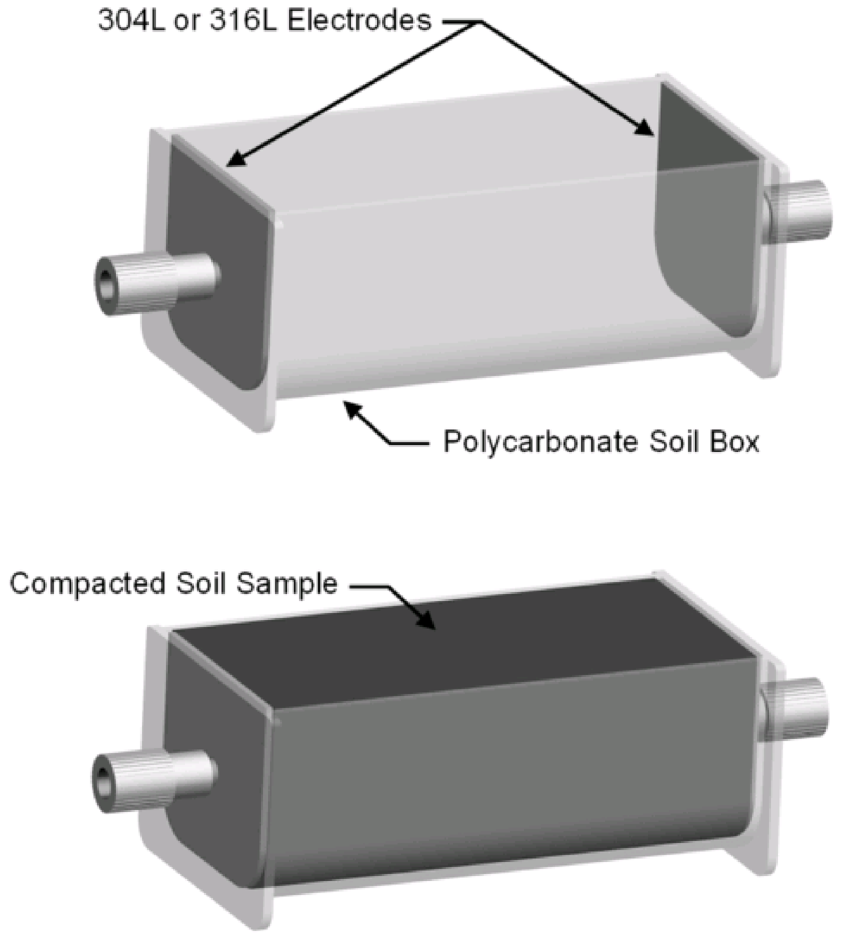
Laboratory thermal resistivity measurements of a rock sample.

ELECTRICAL RESISTIVITY TEST



Typical Connections for Use of Soil Box with Soil Resistance Meter

ELECTRICAL RESISTIVITY TEST



Typical Two-Electrode Soil Box (Empty and Full)