DEVELOPMENT OF TEXTILE STRUCTURE FOR MOISTURE RETENTION PROPERTY

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BONIFIED CERTIFICATE

Certified that this project report titled “DEVELOPMENT OF TEXTILE STRUCTURE FOR MOISTURE RETENTION PROPERTY” is the bonafide work of Mr. S.Prem kumar who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

Samrat Mukherjee 13 06/05

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ABSTRACT

The work aimed at studying the effect of textile structures on the water retentivity. In this regards different grams per meter square of Non-woven and woven structures were analysed for its water retentivity and drying rate at 35°C, 40°C, 45°C. Among the result observed Non-woven structure finds 2.5 times more water retaining than woven under any condition of test. The retaining capacity of Non-woven increased due to irregular arrangement of fibres and water remains held by surface tension in capillary space between the fibres.

In civil engineering, concrete should always be in moist and worm condition for hydration process, called curing. Hydration, it is the reaction between cement and water to produce hard mass, called concrete. For curing of vertical column and slopes woven gunny bags are wrapped over the concrete and water is sprayed. Water retained by this fabric is lower and gets dried quickly. Moreover the drying is not uniform. So it results in crack formation and reduction in strength of concrete.

As this project is of practical application, investigation have been carried out on compressive strength of concrete wrapped with varying GSM of Non-woven and woven structure and cured for 7 days and tested for its strength, it resulted in concrete wrapped with Non-woven fabric gave strength improvement of 2.5 N/mm^2 higher than woven of same gram per meter square, but the compressive strength are same within Non-woven wrapped concrete. So alternate days curing is done. The Non-woven wrapped with 1500 GSM fabric has shown 2 N/mm^2 higher compressive strength, it is because of higher retentive when compared with 370 GSM of woven fabric. The reason for lower strength of 370 GSM woven is, fabric gets dried quickly within a day and stops the curing process.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1

INTRODUCTION

Textiles are finding applications in many areas, the use of absorbent product are of great demand in medical, industrial, and so on. New products are developed for specific end use requirement. Textile fabrics are used in civil engineering for curing of vertical columns and slopes.

Cement is a composition of lime, silicate, aluminate & iron. When cement is mixed with sand, aggregate & water, it forms a hard mass called concrete. Curing is the process of keeping the concrete moist & warm enough for hydration. The strength of concrete depends on curing reaction & time of curing. There should be continuous supply & uniform distribution of moisture throughout the curing process. In absence of curing, heat generated inside the concrete cause stress & result in crack formation.

There are different methods of curing, one of which is wet covering [using gunny bags]. The gunny bags are wrapped over the concrete and water is sprayed. The problem with this is water evaporates quickly from the gunny bags. So again water spraying has to be done. If a textile structure, which can hold more amount of moisture, can replace conventional gunny bags, an improved structure would be generated with minimum crack formation.

CHAPTER-2

REVIEW OF LITERATURE

2.1 COMPOSITION OF CEMENT

Pulverizing clinker formed by [8] calcium raw material primarily consisting of lime, silicate, aluminate & iron to obtain cement. Cement, when mixed with water forms a paste, which hardens & binds the aggregates (sand, gravel, & crushed rocks) together to form a hard durable mass called concrete. A mixture of sand, cement & small stones is called concrete mixer. When water is added to this mixer, cement reacts with water (chemical reaction) to form a gel like substance & hardens the structure (Kulkarni.P.D. et al I998).

According to Neville (1997), curing is the process, which maintain the [10] proper internal moisture level in concrete. The one significant variable, which directly effect permeability, quality and the ultimate strength property of concrete, is curing. Prolonged and through moist curing is the most significant factor in producing waterproof and watertight, high quality, high strength concrete. One form of prolonged moist curing is to apply moist burlap to the concrete surface continually keeping it moist for a period of 28days.

2.2 LAW OF HYDRATION

According to Neville A.M. (1997), Cement contains [10] disilicate calcium; trisilicate calcium which are active compounds & react with water. The reaction is

Disilicate calcium+Water ⟶ Hydrated calcium silicate +calcium hydroxide.

The above reaction contains 20% to 30% of calcium hydroxide, which is crystalline. These crystalline products are surrounded by the hydrated calcium silicate & aluminates, which are colloidal in nature. The entire composition of calcium hydroxide &

the hydrated calcium silicate is called “cement gel” When this gel sets & hardens; it gives the strength to the cement paste. From Fig 2.1, it is seen during setting of cement heat liberation takes place, it gradually raises and reaches its peak after 7 hr and slowly reduces. During the process of curing 120 calories of heat is generated from one gram of cement.

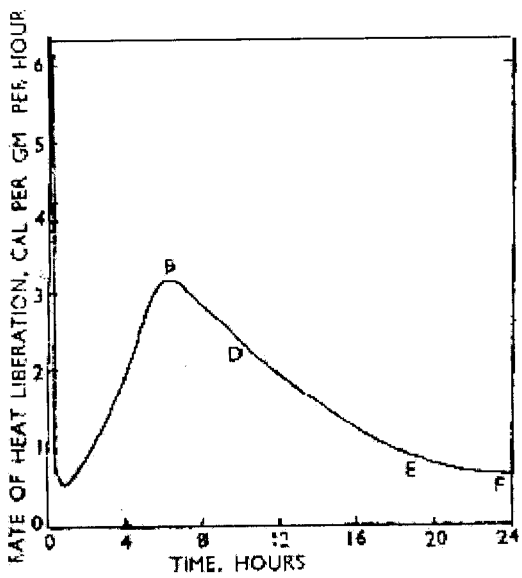


Fig- 2.1 Heat liberation from setting of cement.

Absence of curing results in reduction of hydration process & uneven curing occurs in concrete & develops stress giving to crack formation. To avoid crack formation

- The water should not be evaporated from concrete, which is used during curing process.
- After vertical concrete formation, water needs to be sprayed and retained.

According to Kulkarni.P.D (1998), the cement gel & pores [8] are filled with water. Hydration takes place as long as the capillary pores are filled with water. In case, the water evaporates, the pores in concrete will be filled with air & it is not possible to replace it with water again. So this leads to strength loss in concrete.

From Fig 2.2, it is clear that compressive strength of concrete decreases with increase in temperature. It is due to evaporation of water at high temperature &

reduction in hydration reaction. Age of concrete also plays an important role. For the 1st day the concrete strength increases with temperature, this is due to huge amount of water present in concrete.

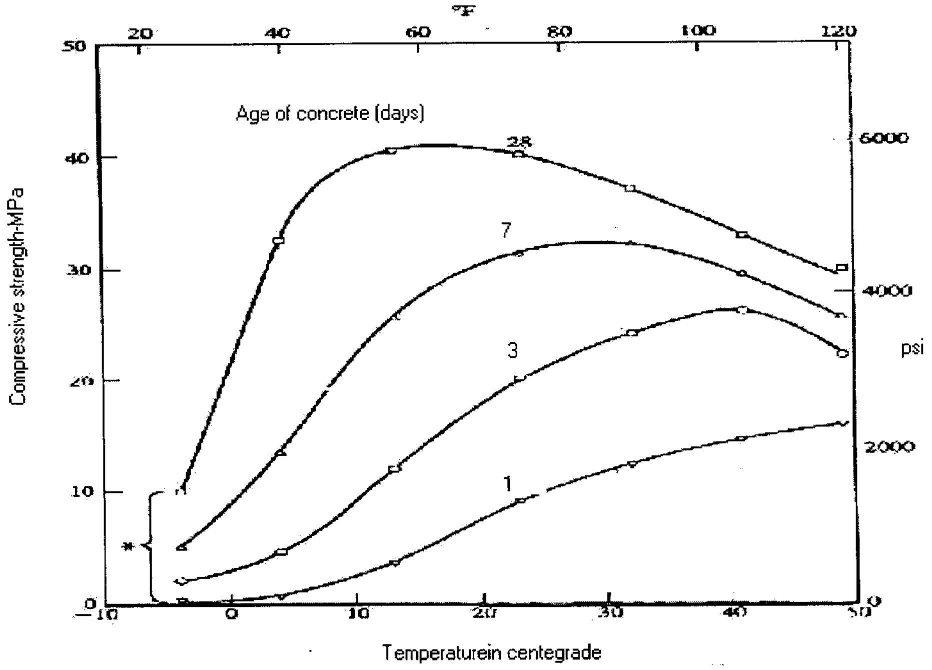


Fig-2.2 Influence of temperature on strength of concrete cured at the temperature indicated.

According to Neville.P.G (1997), curing is the process of keeping the concrete moist & warm [10] enough for hydration to take place. From the Fig 2.3, by maintaining 20°c during curing process the strength of concrete reaches it's maximum. It is normal practice to maintain 18°c to 20°c.

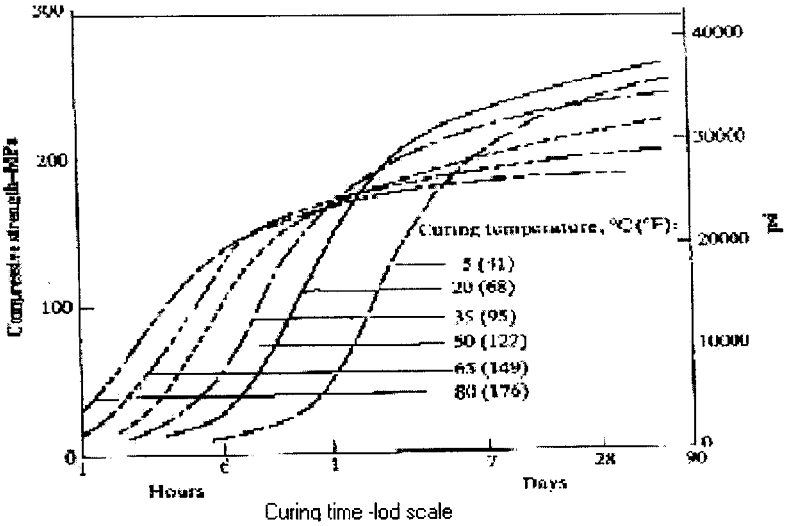


Fig-2.3 Relation between compressive strength and curing time of concrete at different curing temperature.

2.3 METHODS OF CURING

The curing method can be broadly divided into Normal and self curing as given in the classification below

CURING

Normal curing

A) Water curing
  1) Immersion
  2) Ponding
  3) Spraying
  4) Wet covering
    [Gunny bags]

Self-curing

[When water/cement ratio > 0.5]
  1) Membrane curing.
  2) Steam curing.
  3) IR Radiation
  4) Electrical curing.
  5) Spray curing.

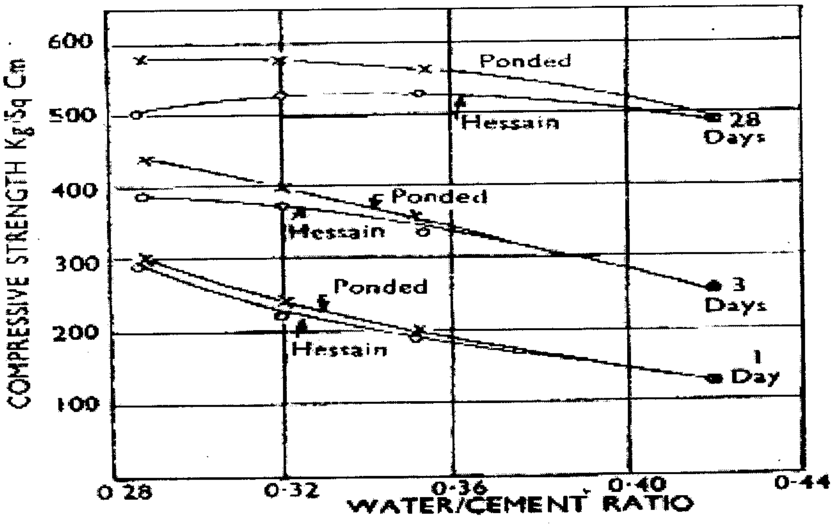


Fig 2.4 Influence of curing condition on strength of concrete.

- In water curing process, water is sprayed on concrete. For vertical concrete there is no provision to hold water, so huge amount of water is required.
- Membrane curing uses water storage area [10] for curing. Here polyester film & waterproof paper are used for moisture retention. Here, wet curing method is done for 1 or 2 days & then the membrane curing is done, too have better curing.
- Steam curing is used in the manufacturing prefabricated concrete. The required strength is achieved with in 3 days. This concept was tried at work place, but did not give the required strength.
- Infra red rays curing are used in cold climate. It is mainly used in the manufacturing of hollow blocks.
- In electrical curing alternating current is passed through concrete between two electrodes. Here care must be taken to prevent the moisture going outside.
- Spray curing uses synthetic hydrocarbon resins in high voltage. It is a costly process.

A summary of different curing procedures is given in Table 2.1.

Table-2.1 Different methods of curing.

METHOD	ADVANTAGE	DISADVANTAGE
Sprinkling with water or covering with Burlap	Excellent result if kept constantly	Likelihood of drying between sprinkling; difficult on vertical walls.
Straw	Insulation in Winter	Can dry out, blow away, or burn
Moist Earth	Cheap but messy	Stains concrete; can dry out; removal problem
Pending on flat surface	Excellent result, maintains uniform temperature	Require considerable labour; undesirable in freezing weather.
Curing compounds	Easy to apply and inexpensive	Sprayer needed; inadequate coverage allows drying out; film can be broken or tracked off before curing is completed; unless pigmented, can allow concrete to get too hot.
Waterproof paper	Excellent protection, prevents drying	Heavy cost can be excessive; storage and handling problem
Plastic film	Absolutely watertight, excellent protection. Light and easy to handle	Should be pigmented for heat protection; requires reasonable care and tears must be patched; must be weighed down to prevent blowing away.

2.4 WATER CEMENT RATIO

It is the ratio of weight of the water divided by the weight of cement. According to Shetty.M.S (2001), Strength of concrete [14] primarily depends upon the strength of cement paste. The strength of cement paste depends upon the dilution of paste.

The Abrams law states that

$$S=A/B^{x}$$

Where, S is strength of concrete, x is Water/cement ratio by volume & for 28 days results constants A & B are 14,000 lbs/sq & 7 days respectively. This law implies that strength of concrete depends upon water/cement ratio provided the mix is workable.

Fig 2.5 stats that;

- If the water cement ratio [2] is 0.2, water is inadequate for full hydration.
- If the water cement ratio is 0.4, water available is sufficient for full hydration & cement gel occupies all space without any air pores.
- If the water cement ratio is 0.6, water available is more that required quantity full hydration takes place & the free water occupies a certain space in the cement evaporation. This reduces the strength.

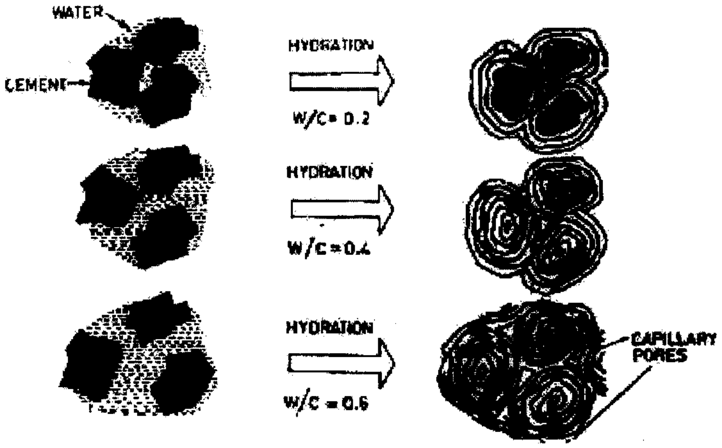


Fig 2.5 Hydration of cement with insufficient (w/C=0.2), sufficient (W/C=0.4), and excess (W/C=0.6).

According to A.M. Neville (1997), the strength of concrete [10] depends on two factors

1) Water/cement ratio
2) Degree of compaction.

In case of fully compacted cement, the strength is taken to be inversely proportional to water/cement ratio. This relation is preceded by a law called Abram's law.

$$Fc= k_1/k_2^{w/c}$$

Where Fc = strength of concrete, w/c = water/cement ratio, k_1 & k_2 = empirical constant.

According to Feret's rule

$$Fc=k[c/(c+w+a)]^2$$

Where Fc = strength of concrete, c, w, a, are absolute volumetric proportions of cement, water & air respectively & k is a constant.

Water/cement ratio is the largest single factor in the strength of fully compacted concrete, aggregate, and water is influenced by the

- Ratio of cement to mixing water
- Ratio of cement to aggregate
- Grading, surface texture, shape, strength, and stiffness of aggregate particles
- Maximum size of the aggregate.

According to Power.T.C (1949), the influence of the water/cement ratio [11] on strength does not truly constitute a law because the water/cement ratio rule does not include many qualifications necessary for its validity. In particular, strength at any water/cement ratio depends on the degree of hydration of cement and its chemical and physical property; the temperature at which hydration takes place; the air content of the concrete; and also the change in the effective water/cement ratio and the formation of crack due to bleeding.

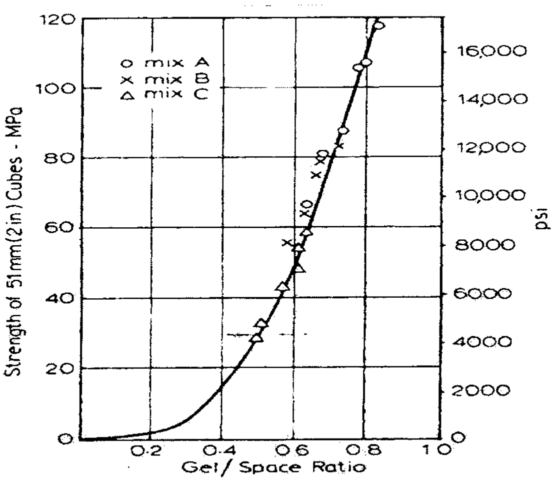


Fig-2.6, Relationship between the compressive strength of mortar and gel/space ratio.

According to Krokosky.E.M (1970), the strength of concrete [7] is fundamentally a function of the volume of void in it. The relation between strength and the total volume of void is not a unique property of concrete but is found also in other brittle material in which water leaves behind pores.

According to Binsheng Zhang, the water in concrete can be classified as [3] capillary water, gel water & chemical combined water. Capillary water is readily evaporable water & exists not only in capillary pores of cement paste but also in aggregate pores & at interfaces. Gel water exists in the gel pores of cement paste.

It is generally described as adsorbed water or physically bonded water & does not evaporate easily. However it can be driven out when the ambient temperature is high, so it is regarded as conditionally evaporable water. Chemically combined water, also called non evaporable water, is part of the cement hydrate compounds & can only be released from concrete when the chemical paste & aggregates occurs at very high temperature.

As the heating is applied the moisture reduces & brittleness of concrete lowers. This is due to the strength & stiffness of concrete decreases, but the toughness increases with increasing heating temperature, exposure time & thermal cycle.

According to Kim & C.S.Lee (1998), the nonuniform moisture distribution [6] in concrete causes the differential drying shrinkage. From this tensile stress occurs on concrete & results in crack formation. The creep of concrete significantly affects this residual stress. An analysis method was suggested in which the creep of concrete was also considered. Differential drying measured using embedded strain gauge. In the concrete, structure exposed to environmental condition, water movement occurs by moisture diffusion in concrete. Thus the moisture content in concrete varies in both space & time the moisture distribution of a cross section of concrete is non-uniform.

2.5 ROLE OF TEXTILE STRUCTURE

The textile structure has great influence on the water molecule holding capacity & distribution of water molecule. A non-woven fabric can hold more amount of water molecule than a woven because of its 3-dimensional structure & high pore volume. In woven fabric, by varying the weave pattern & using multi layer of fabric water molecule holding capacity can be improved.

According to E.P.G.Ghol & L.D.Vilensky, fibre with hygroscopic nature [5] has high moisture content property. This hygroscopic nature is directly related to polarity of its polymers & the ratio of its amorphous & crystalline region. A hygroscopic polymer has predominantly amorphous polymer system consisting of polar groups. These attack water molecules, while the amorphous nature allows entry of the water molecule into the polymer system. Highly crystalline polymer system does not permit ready entry of water molecule even if the polymers are distinctly polar.

2.6 PHENOMENA OF WETTING & WICKING

According to Saville.B.P (1999), absence of external force [13] the transport of liquid into fibrous assembly is driven by capillary force that arises from the wetting of fibre surface. In order for wicking to take place spontaneously the balance of energy has to be such that energy is gained as the liquid advances into the material.

Increase in density of material [15] gives good capillary rise.

A) Open weave has low adhesive force to pull the water droplet from needle.
B) In open weave surface tension is lower then the water drop from needle coming out.

According to Dr.T.Ramachamdran & N.Kesavaraja (2004), for moisture evaporation [12] capillary path of fibre plays an important role. Chemical treatment influence wetting & wicking behavior. Softener treated material does not show difference in wicking compared to untreated material, due to pore in fabric structure are not changed. The combination of cellulose & pectinase shows better improvement in wetting property than individual enzymes treatment. This is due to the change in contact angle between fibre & water molecule. Lipase enzyme on polyester fabrics improves the wettability & water retention property. This is by means of reduction in contact angle between the water molecules & fabric surface.

The NaOcl (Sodium hypochlorite) bleached material has improvement in wettability where as H_2O_2 (hydrogen peroxide) shows decrease in wettability behavior in cotton material. This is due to the reduction in contact angle between fabric & water molecule by NaOcl. Diffusion & wicking are two ways by which the moisture is transferred to the atmosphere. Above two are governed by fibre type & fabric structure. The wicking takes place only in the wetted fabrics. So the hydrophilic & staple fibers yarn has good wicking characteristics. The structure with high cover factor gives the good wicking character; it is due to surface tension of fabric being higher than the water surface tension.

The wicking takes place only in the wetted fabrics. The wicking depends upon the contact angle. It is the angle between the fabric surface and the water molecules. The contact angle is less in case of fabric having higher wicking behaviour and the water contact angle is higher for the water repellent fibre and fabrics. Wicking will not take place in the man made fibre like polyester but the transport of liquid will takes place.

Wetting means, the contact angle between a liquid and a solid is zero or so close to zero that the liquid spreads easily along the solid surface. Three interface are involved in the contact of liquid with a solid, and the behaviour of the liquid is determined by the energy per unit area of the interface. The energies are;

γ_{LA} for the liquid- air interface
γ_{SA} for the solid- air interface
γ_{LS} for the liquid –solid interface

The control relationship for the case of a finite contact angle situation is the Young Dupre equation:

$$\cos\theta = (\gamma_{SA} - \gamma_{LS}) / \gamma_{LA}$$

Qualitatively speaking, then for good wetting and spreading, $\cos\theta$ approaching 1 or θ approaching zero, γ_{LS} and γ_{LA} should be as small as possible.

2.6.1 Capillary action phenomenon

For wetting of fibrous assembly such as non-woven, more than just the contact angle is involved in the basic mechanism of the action. The phenomenon is related to that of the capillary rise, where the driving force is that of the pressure difference. For a bundle of average radius r, from the Lap lace equation

$$\triangle P = 2\,\gamma_{LA}\cos\theta / r$$

Depending on the value of θ, $\triangle P$ is the pressure required to force entry of the liquid or to restrain its entry.

For wetting liquid, $\cos\theta = 1$

$$\triangle P = 2\,\gamma_{LA}/r$$

In addition to $\triangle P$ being larger, for promoting capillary penetration it is also desirable that the rate of liquid entry is large. If the contact angle is greater than 90^0 the liquid will tend not to penetrate between the fibres, whereas if the contact angle is less than 90^0, the liquid will pass through easily.

2.7 STUDY OF MOISTURE TRANSFER IN FABRIC

According to Billie J. collier (1999), three ways [2] by which water pass through textile layers are diffusion, sorption, and wicking. Water can also be removed from surface of a textile fabric by evaporation.

Moisture can diffuse through the air space between fibres or yarn; this depends on yarn structure and fabric count. Diffusion is more likely to occure in fabric that has large interstices or open space within the structure. Pores that can be effective in diffusion include fabric interstices between yarn and yarn interstices that are space between fibres within a yarn. The number and size of fabric interstices in a given area of fabric depends on fabric count, yarn linear density, and yarn twist.

Sorption includes adsorption, absorption, and desorption. Adsorption is the process of taking up water and holding it near the surface. In absorption, molecular moisture diffuses through the material. The desorption is release of moisture, either adsorbed or absorbed from the material. Absorption, and desorption are involved in the transport of moisture through a textile materials moisture is adsorbed by fibres near the fabric surface, then transported through the fibres, and desorbed on the other side of the fabric. This process is closely related to the inherent moisture regain of fibres that involves absorption.

Wicking is the transfer of liquid water through the capillary interstices of the yarn. Wicking depends on wettability of fibre surface, as well as the structure of the yarn and fabric. In contrast to diffusion of water vapour, wicking increases as moisture regain decreases, because the fibre does not absorb the water.

Moisture movement and air movement through a textile fabric are sometime considered together under the topic of fluid flow. Airflow is similar to diffusion of moisture vapour through a textile fabric. The air permeability of a textile fabric is the degree to which the material is penetrable by air. Flow through a fabric occurs when the air pressure is different on the two sides of the fabric. Air permeability is the rate of airflow through the fabric when there is a different air pressure on either surface of the fabric. It is closely related to convection heat transfer and to moisture transport via diffusion. As fabric interstices increases in number and size, air permeability increases. The porosity of a fabric is the total volume of void space within a specified area of the fabric.

According to Bhupender S. Gupta (1992), **Absorbent capacity©** (g/g) given by [1] the total mass of fluid absorbed by the mass of the sample.

2.8 MOISTURE TRANSPORT

According to Saville P.B (1999), moisture is transmitted [13] through the fabric in two ways

a. By diffusion of water vapour through the fabric
b. By wicking of liquid water by capillary transport. This depends on surface property of fibre, total surface area. The size & number of capillary path are also important.

2.9 MECHANICAL PROPERTIES OF CELLULOSE FIBRES

Table-2.2 Moisture content of different fibres.

Fibre	**Diameter (micrometer)**	**Density (g/cm cube)**	**Moisture content**
Cotton		1.5	7-8
Jute	200	1.45	12
Coir	100-450	1.15	10-12

From the above Table 2.2 it could be seen that jute & coir has good moisture content.

CHAPTER- 3

OBJECTIVE

The objectives of the project are:

1) To investigate the effect of **fabric structure** and **GSM** on water retention property under different atmospheric conditions, when placed vertically
2) Investigate the effect of varying GSM and structured (woven and Non-woven structure) textile substrate for concrete curing applications in terms of their **compressive strength and failure characteristics**.

CHAPTER - 4

METHODOLOGY

Selection of fibres

↓

Selection of weave pattern & bonding technique in Non-wovens

↓

Testing of fabric for water retention property [varying Temp and RH]

- **Liquid retention test,**
- **Water holding capacity.**

↓

Implementation of fabric on concrete

↓

Curing of concrete for different cycles

↓

Testing the compressive strength of concrete

↓

Analysis of crack propagation in fractured specimens

CHAPTER – 5

MATERIALS AND METHODS

5.1 MATERIALS USED

Jute wovens, (plain weave of varying grams per square meter) and Non-wovens of (varying grams per square meter) are used. Table-5.1, 5.2 below gives the particulars of Jute woven and Jute Non-woven material. Jute fabric was woven on a plain hand loom and the nonwoven jute fabric was Needle punched in a DILO machine with the following machine particulars

- Machine type –OD- 2 /6.
- In feed – 0.25 m/min.
- Draw off speed - .25 m/min.
- Stroke frequency – 120 stroke / min.
- Depth of penetration - 10 mm.
- Thickness between two plates – 25 mm.
- Needle board – 600 needles / board.
- Needle gauge – 5 needles / square inch.
- Down stroking needles.

Table 5.1 Particulars of Jute woven fabric.

S.No	Weave	GSM	Sample weight in gms (10×10 cm)	Warp count (Nju)	Weft count (Nju)	EPI	PPI
1	Plain	370	3.70	10.0	10.0	12.0	12.0
2	Plain	400	4.00	8.7	9.0	12.0	11.0
3	Plain	650	6.50	7.0	21.2	24.0	9.0
4	Plain	700	7.00	9.8	11.5	22.0	9.0

Where, Nju= Number in jute system, EPI= Ends per inch, PPI= Picks per inch.

(Nju, is a direct system of numbering where 14,400 yards of yarn, weighed in pounds gives the count of yarn)

Table 5.2 Particulars of Non-woven sample.

S.No	Specification	GSM	Sample weight (10x10cm)	Thickness of Material (mm)	Type of Web laying	Type of bonding
1	Non-woven	370	3.70	3.0	Parallel laying	Needle punching
3	Non-woven [with back woven]	440	4.40	4.0	Parallel laying	Needle punching
4	Non-woven [with back polythene]	1000	10.0	6.0	Cross laying	Needle punching
5	Non-woven	1500	15.0	7.0	Cross laying	Needle punching

5.2 DESIGN OF APPARATUS

In the design concept, wooden cuboids Fig 5.1 of length 30 centimeter are embedded in the bottom platform to make it stand straight. At one face of each wooden cuboids piece a stripe attachment is given with a set of bolt and nut. The distance between the two nuts is 20 centimeter. The combination of strip and wooden piece act as a jaw to hold the fabric. Similar way one more jaw is prepared. These two jaws are placed side by side and fabric is clamped.

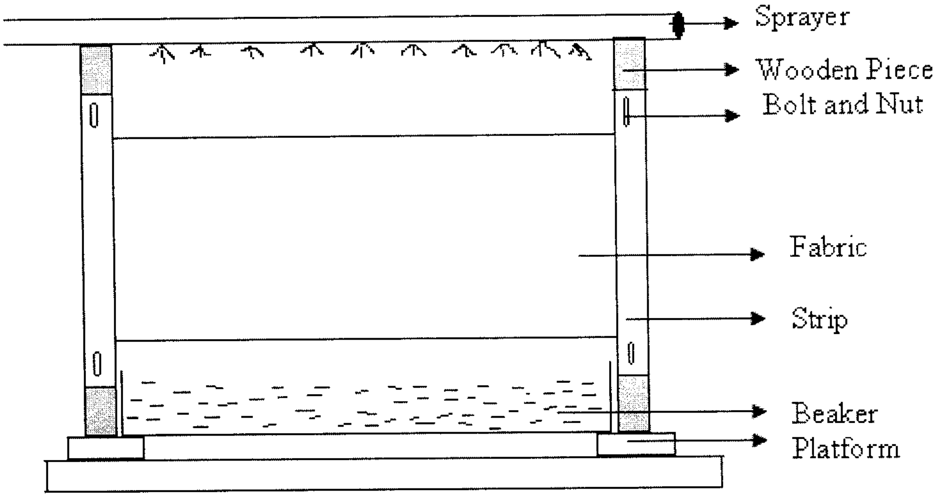


Figure 5.1 Water retentivity capacity tester (Fabric clamped by its sides).

5.3 EXPERIMENTAL PLAN

Design of Apparatus for testing vertical water retention

Jute fabric of size 10×10 cm is weighed and made to clamp by its sides in the jaws of water retentive capacity tester in vertical position. The Fig 5.2 shows the view of fabric held by its sides. During testing with side clamping fabric some problems are generated which are as,

- Water leaks out from its sides.
- Water leaks out from protruding fibres.
- Time gap has to be allowed for vertical pouring of water.

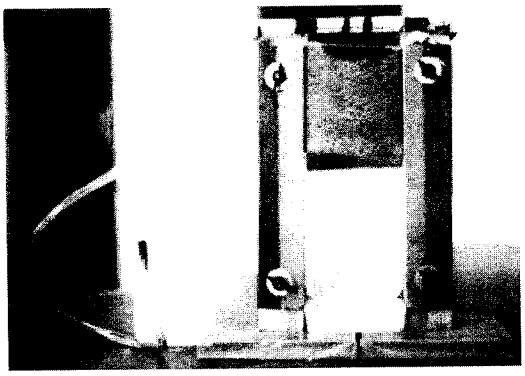


Figure 5.2 Water retentivity capacity tester (Fabric clamped by its sides).

Fabric of 10×10 centimeter Fig 5.3 is placed on a horizontal plane and 10 milliliter of water (W_1) is sprayed for prewetting. Now, the fabric is clamped by its top two corners and made to hang vertically. Bottom of fabric a beaker is kept to collect excess water oozing out from the fabric. A measured quantity of water is sprayed on top of the fabric through sprayer till first drop of water falls down from bottom of fabric.

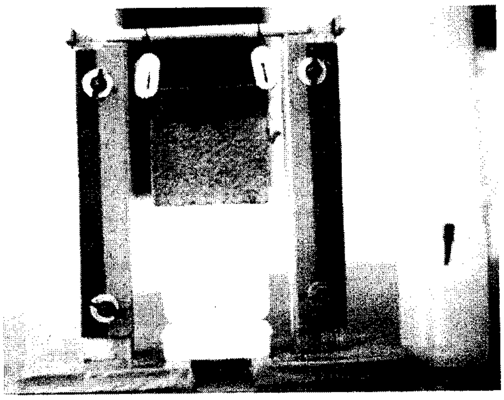


Figure 5.3 Water retentivity capacity tester (Fabric clamped by its top two corners).

After a minute, when water stops falling down, the water retaining capacity of fabric (W_4) is calculated by

$W_4=W_1+W_2-W_3$

Where

W_1- Prewetting water

W_2 – Water poured on the fabric

W_3- Water in beaker

The fabric is weighed and dried at required temperature for evaporation of water. During drying, the fabric is weighed every 15 minutes to find the rate of drying. The drying of samples is carried in Humidity chamber.

5.4 CONCRETE PREPARATION AND TESTING

5.4.1 Preparation of concrete mould and samples

Concrete of size 100 ×100 × 100 centimetre cube is prepared with mix proportion of 1:1.5:3 (Cement: fine aggregate: course aggregate) and water cement ratio of 0.5. Steel moulds with flat internal faces [tolerance of ± 0.025 mm] and interior angles between internal faces maintained at 90±0.5°C are taken for preparing the concrete. A base plate with machined plane surface, large enough to prevent leakage of cement slurry during filling of the mould is provided. Spring clips or screws are supplied to assist in holding the mould the mould on the base plate.

Cement is mixed with sand and spread over the stone aggregate. Dry materials are mixed by turning over 4-5 times with a shovel until the mix appears uniform. Water of 27.5 litres is abed per bag of cement for M20 concrete.

5.4.2 Curing of specimens

Specimens are removed from the moulds after 24 hours and wrapped with woven and nonwoven of same GSM. The wrapped concrete is immersed in water for 10 minutes and kept in room temperature. This process is continued for 7 days and compressive strength of concrete is tested. In another set, concrete wrapped with 370

GSM woven and 370 GSM non-woven are immersed in water alternate days for 6 days and subsequently tested.

5.4.3 Testing of concrete

The specimen is centrally placed in the compressive testing machine and load is applied continuously, uniformly and without shock. The rate of loading is 14 N / mm^2 / minute. The load is increased until the specimen fails. The load is recorded at first crack and load at ultimate failure. The tests are carried out according to IS 516-1978.

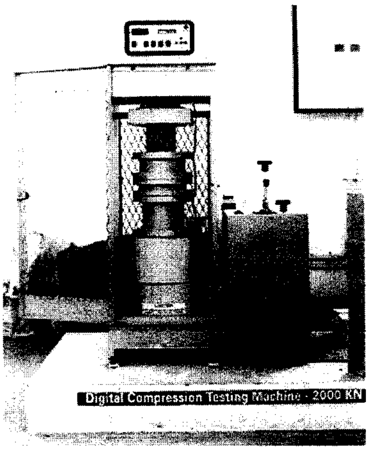


Figure 5.4 Compression testing machine.

CHAPTER – 6

RESULTS AND DISCUSSION

6.1 WATER RETENTIVITY AND DRYING TIME OF DIFFERENT FABRIC

Table-6.1, 6.2 shows the retentivity and drying time of different fabric. it can be seen that nonwoven samples of GSM similar to wovens, retain higher amount of water under different conditions of temperature and relative humidity.

Table 6.1 Drying time of woven sample tested at varying condition.

S.No	GSM	Sample weight (10×10 cm)	Maximum Water holding (ml)	Maximum absorption capacity (%)	Drying time in minutes		
					Temp 35°C and RH=50%	Temp 40°C and RH=60%	Temp 45°C and RH=70%
1	370	3.7	11	197	32 min	17 min	17 min
2	400	4.00	12	200	60 min	30 min	18 min
3	650	6.50	22	238	123 min	90 min	73 min
4	700	7.00	25	257	150 min	94 min	75 min

It can be seen from the Tables 6.1 and 6.2 that non-woven structures have overall retained higher amounts of water when compared with same GSM woven. Non-wovens, which can be manufactured to higher GSM material could retain water for much higher time [480 minutes being the highest for 1500 GSM non-wovens]. The absorption capacity, calculated on the weight of the parent material, was also consistently higher for the Nonwoven structures. Non-woven with back woven (440 GSM) had lower absorption capacity due to the woven part contribution.

Table 6.2 Drying time of Non-woven sample tested at varying condition.

S.No	GSM	Sample weight (10×10 cm)	Maximum water holding capacity (ml)	Maximum absorption capacity (%)	Drying time in minutes		
					Temp 35°C and RH=50%	Temp 40°C and RH=60%	Temp 45°C and RH=70%
1	370	3.70	20.0	440	151 min	135 min	90 min
2	440	4.40	17.0	286	123 min	110 min	63 min
3	1000	10.0	30.0	200	303 min	241 min	210 min
4	1500	15.0	70.0	366	480 min	450 min	420 min

From Figure 6.1 it is observed that 370 GSM nonwoven at 35°C and RH 50% has retained water up to 2.5 hours when compared to woven which under similar wetting, temperature and RH conditions, dried up in 0.5 hours.

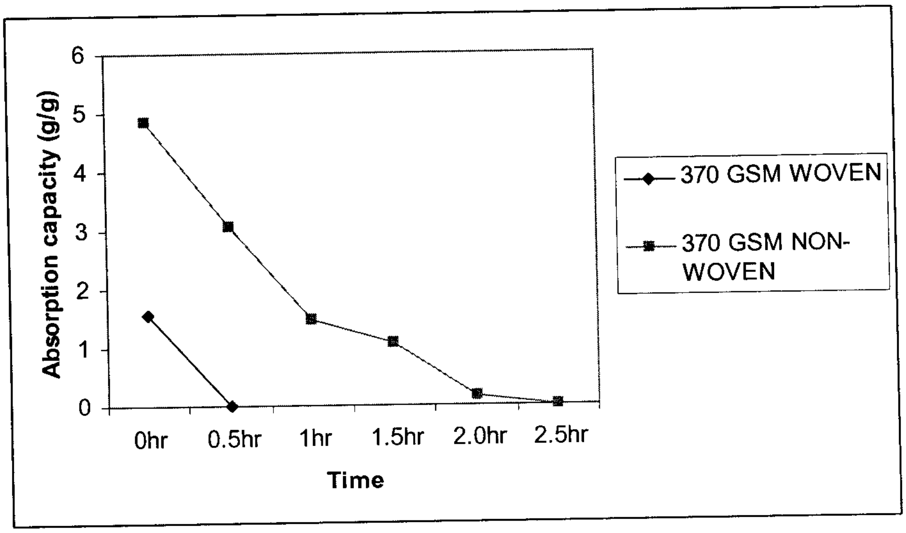


Figure 6.1 Drying rate of Woven and Non-woven sample of 370 GSM tested at 35°C and RH=50%.

Drying characteristics of woven samples:

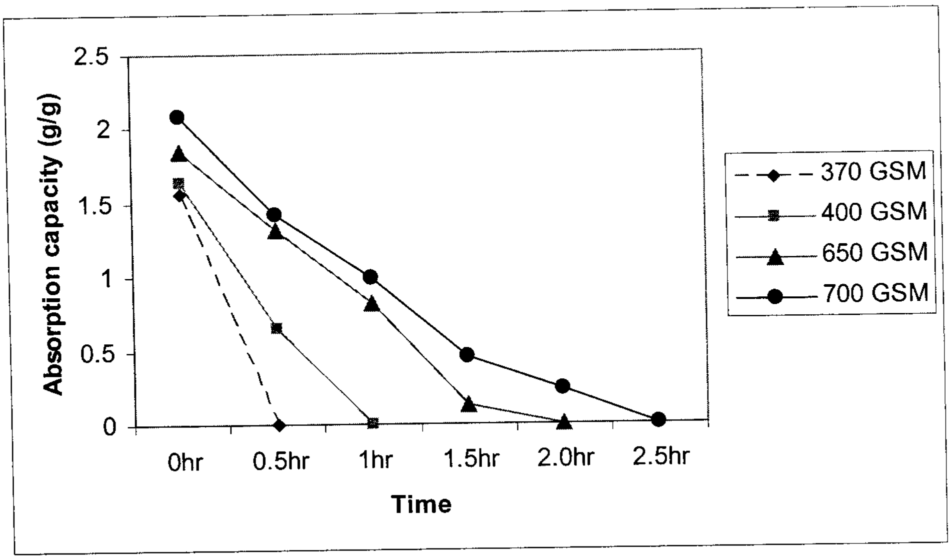


Figure- 6.2 Drying rate of Woven sample tested at 35°C and RH = 50%.

Figure-6.2 shows that drying time of woven structures increased as a function of their GSM. The nature of change in absorption capacity (the slope of the curves) has however been different. Higher GSM fabrics have lost water at a slower rate or in other words, the decrease in their absorption capacity was less intense when compared to lower GSM wovens. 700 GSM woven fabric could retain water upto 2.5 hr which was improvement of 2 hrs over the lower GSM material.

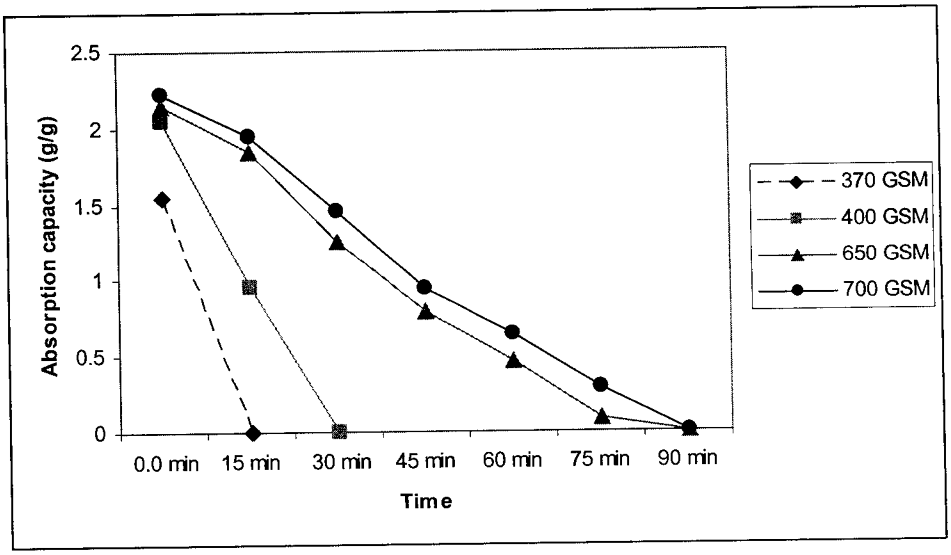


Figure 6.3 Drying rate of Woven sample tested at 40°C and RH = 60%.

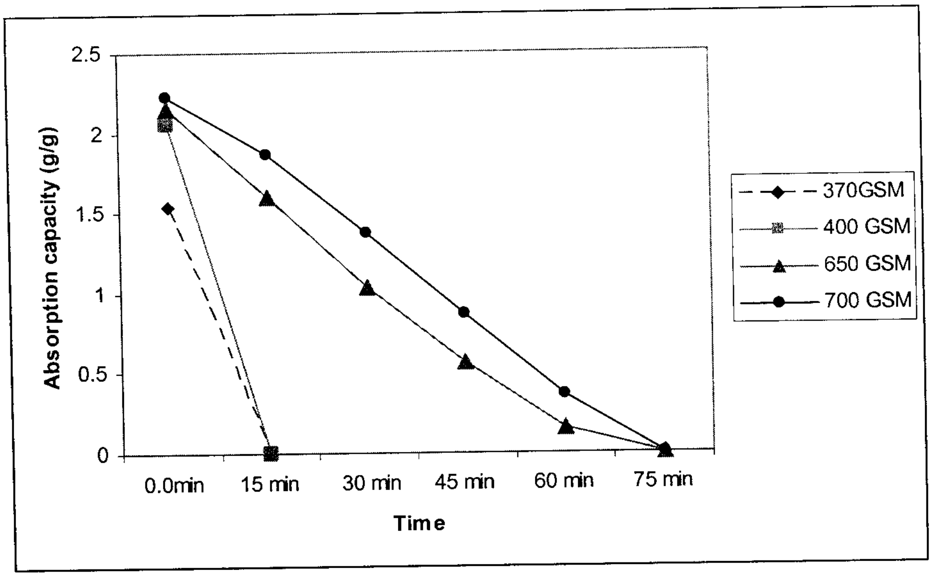


Figure 6.4 Drying rate of Woven sample tested at 45°C and RH = 70%.

From Fig 6.3, 6.4 the time of drying reduces with increase in temperature, but higher GSM fabric takes longer time to dry than lower GSM fabric under any condition of test.

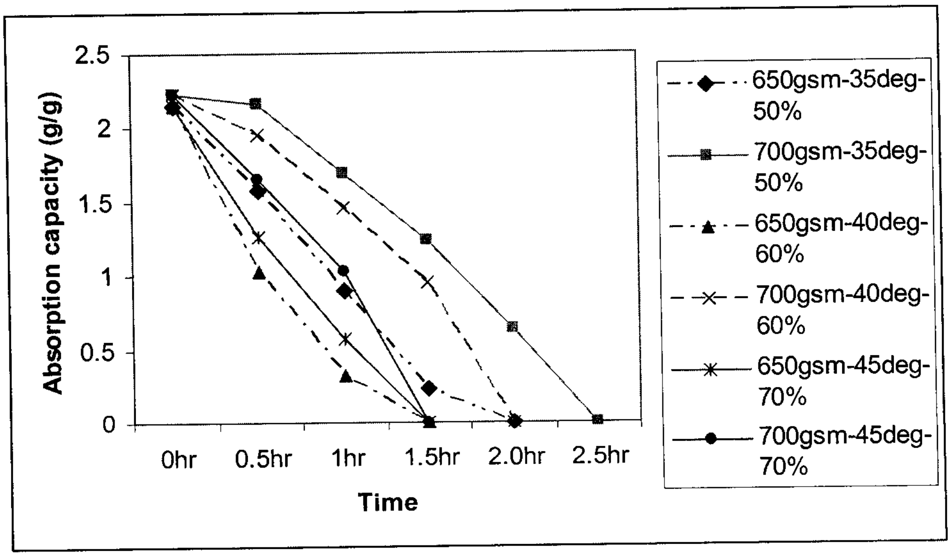


Figure 6.5 Comparison of 650 GSM and 700 GSM woven sample tested at different Temperature and RH.

From Fig 6.5, samples tested with different 370 and 1500 GSM have shown marginal changes in drying time with temperature and RH difference of 5°C and 10%.

Drying characteristics of Non-woven samples:

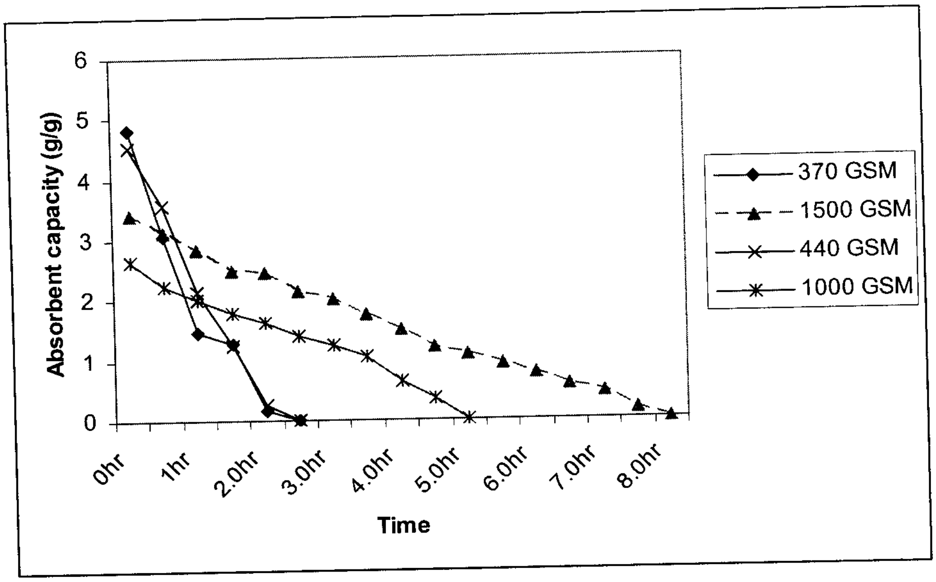


FIGURE 6.6 Drying rate of Non-woven sample tested at 35°C and RH = 50 %.

From Figure 6.6 it is observed that time of drying for 1500 GSM is 8 hrs and reduces with reduction in fabric GSM. It is interesting to note that for nonwoven structures, the initial absorption capacity is higher for lower GSM fabric as evident for 370 GSM and 440 GSM fabric. This happens as a light structure immediately absorb more water but simultaneously looses water at a higher rate which is seen from the higher slope of the curve. On the contrary, a more dense nonwoven structure doesn't allow initial water to get through fast but water absorbed is trapped in the more intense structure and retained for long.

The absorption capacity of 440 GSM fabric is lower than 370 GSM fabric, the reason is 440 GSM fabric having woven plain weave fabric of jute as backing material. Moreover the drying time of 440 GSM is 0.5 hr lower than 370 GSM fabric.

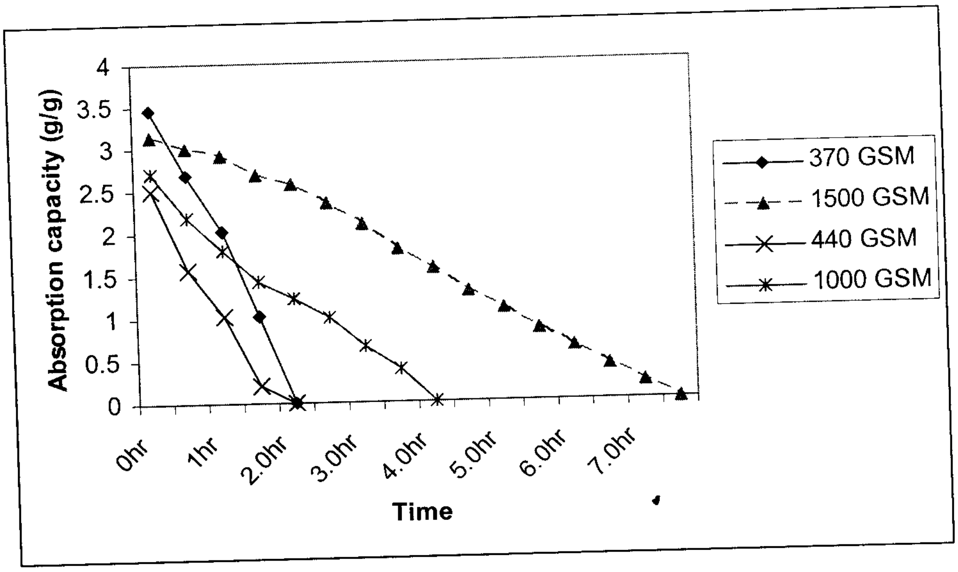


Figure 6.7 Drying rate of Non-woven sample tested at 40°C and RH = 60%.

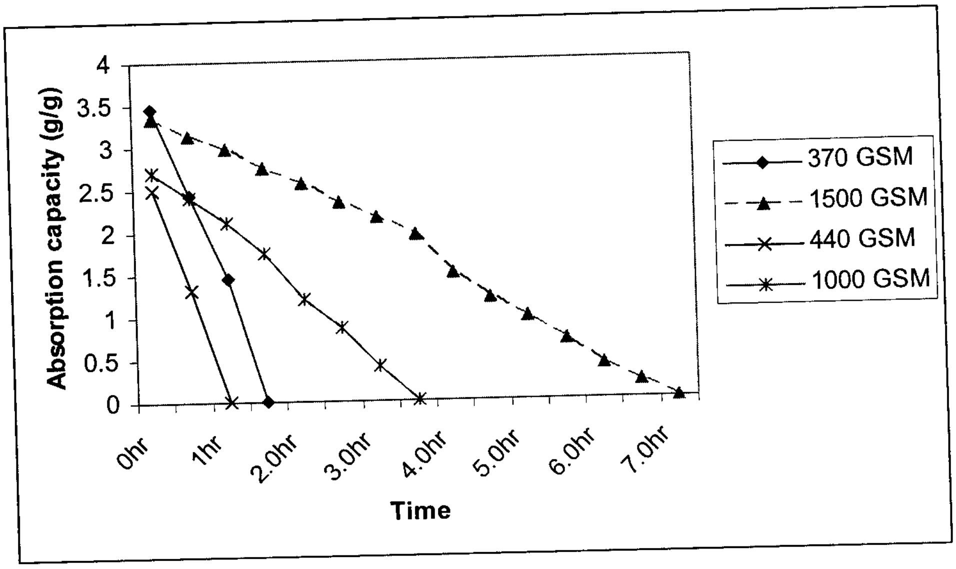


Figure 6.8 Drying rate of Non-woven sample tested at 45°C and RH = 70%.

Similarly, testing under 40°C and 45°C Fig 6.7, 6.8 the rate of drying reduces with increase in temperature. The higher GSM sample takes longer time to dry than lower GSM sample under any condition of test except 440 GSM and 1000 GSM fabric.

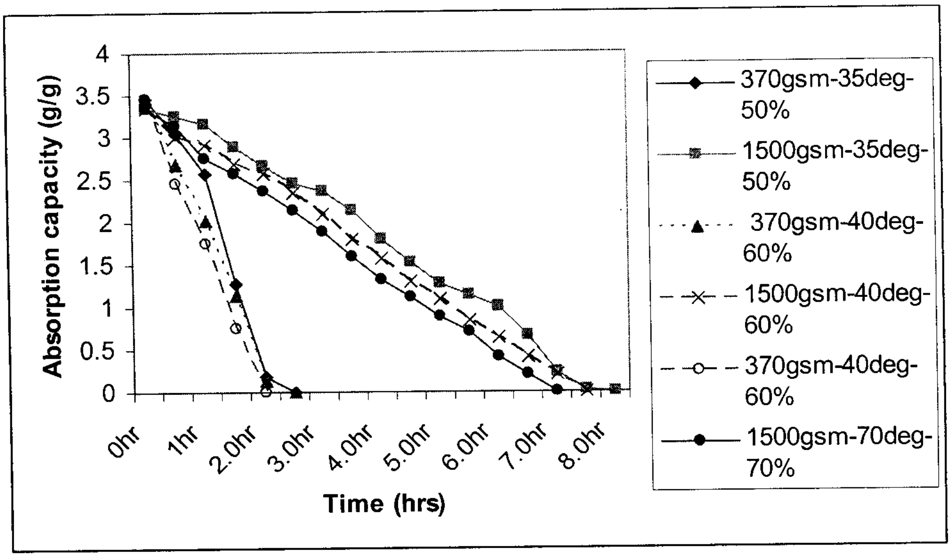


Figure 6.9 Comparison of 370 GSM and 1500 GSM Non-woven tested at different Temperature and RH.

From Fig 6.9, samples tested with different 370 and 1500 GSM have shown marginal changes in drying time with temperature and RH difference of 5°C and 10%.

6.2 INVESTIGATING THE REASONS BEHIND THE HIGHER RETENTIVITY OF NON-WOVENS

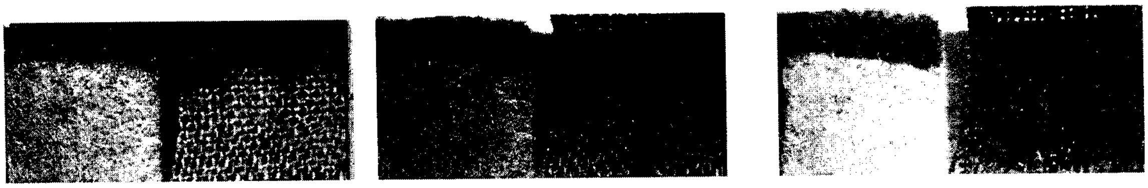
Two reasons seem to work in favor of Non-woven for their higher water retentivity:

1. Woven structures consist of yarn interlacing at right angle to each other. The warp or the weft in the woven structure provides a channel for water to pass and resulted in less retentivity as shown in the Figure 6.10. A Non-woven fabric can hold more amount of water than woven because of its 3-dimensional structure and high pore volume when compared to woven fabrics. In absence of any directed interlacement in nonwoven structure, the water doesn't find a way and gets trapped.

Figure 6.10 Channel formed by water in woven fabric.

2. Woven fabrics have wider holes in their structure. Water droplets, in such structures get a chance to coalesce and become a bigger drop, until their weight exceeds the surface tension of the water-fiber interface and ultimately fall as drops. In a nonwoven structure, wider gaps for such big size water drop formation are not possible and they are retained.

The water retention at different time interval is compared in Fig 6.11. Flow of water through warp or weft is clearly seen. For Non-woven structure with dense 3D structure, the water has not been able to percolate, as evident from Fig 6.11.



(a) (b) (c)

Fig. 6.11 Comparison of water retention of woven vis-à-vis nonwoven fabrics at different time intervals (a) after 10 sec, 10 ml water (b) after 30 sec, 20 ml water (c) after 1 minute, 30 ml water.

6.3 STRENGTH OF CONCRETE

Table 6.3 gives the compressive strength of concrete wrapped with different GSM fabric. The Non-woven wrapped concrete samples were found to have higher strength and bear heavy load before the appearance of first crack. The Non-woven wrapped concrete has compressive strength of 2.5 N/mm^2 higher than woven of same 370 GSM, but the compressive strength are same within Non-woven wrapped concrete. Concrete cured without fabric (NF) has on average compressive strength 1.25 N/mm^2 and 3.5 N/mm^2 lower than concrete cured with fabric of 370 GSM.

Table 6.3 Compressive strength of concrete cured 7 days.

Fabric specification	Trial -1				Trial -2				Average Ultimate compressive strength (N/mm^2)
	Load (KN)		Compressive strength (N/mm^2)		Load (KN)		Compressive strength (N/mm^2)		
	First crack	Ultimate crack	First crack	Ultimate crack	First crack	Ultimate crack	First crack	Ultimate crack	
NF	90	160	9	16.0	81	162	8.1	16.2	**16.1**
WF370 gsm	125	170	12.5	17	140	177	14.0	17.7	**17.4**
Wf 700 gsm	175	195	17.5	19.5	199	198	19.9	19.8	**19.7**
NWF 370 gsm	187	198	18.7	19.8	180	192	18.0	19.2	**19.5**
NWF 1500 gsm	186	199	18.6	19.9	188	196	18.8	19.6	**19.7**
NWFBP 1000 gsm	185	196	18.5	19.6	187	193	18.7	19.3	**19.4**

Where, NF- No fabric, WF- Woven fabric, NWF- Non-woven fabric, NWFBP- Non-woven fabric with back polythene sheeet.

Table 6.4 Compressive strength of concrete cured alternate days.

Fabric specification	Trial -1				Trial -2				Average Ultimate compressive strength (N/mm^2)
	Load (KN)		Compressive strength (N/mm^2)		Load (KN)		Compressive strength (N/mm^2)		
	First crack	Ultimate crack	First crack	Ultimate crack	First crack	Ultimate crack	First crack	Ultimate crack	
WF 370gsm	101	167	10.1	16.7	105	169	10.5	16.9	**16.8**
NWF 370 gsm	178	186	17.8	18.6	177	184	17.7	18.4	**18.5**
NWF 1500 gsm	187	197	18.7	19.7	189	198	18.9	19.8	**19.7**

Tested as per IS 516-1978.

Table 6.4 gives the compressive strength of concrete cured alternate days. The Non-woven of 1500 GSM wrapped concrete has shown higher compressive strength for both type of curing adopted, because of higher water retention. Concrete cured with Woven fabric of 370 GSM has compressive strength of 1.7 N/mm^2 and 2.9 N/mm^2 lower than concrete cured with 370 GSM and 1500 GSM Non-woven fabric. It is due to lower retentive nature of woven fabric leading to drying within a day where the curing process stops after a day's time.

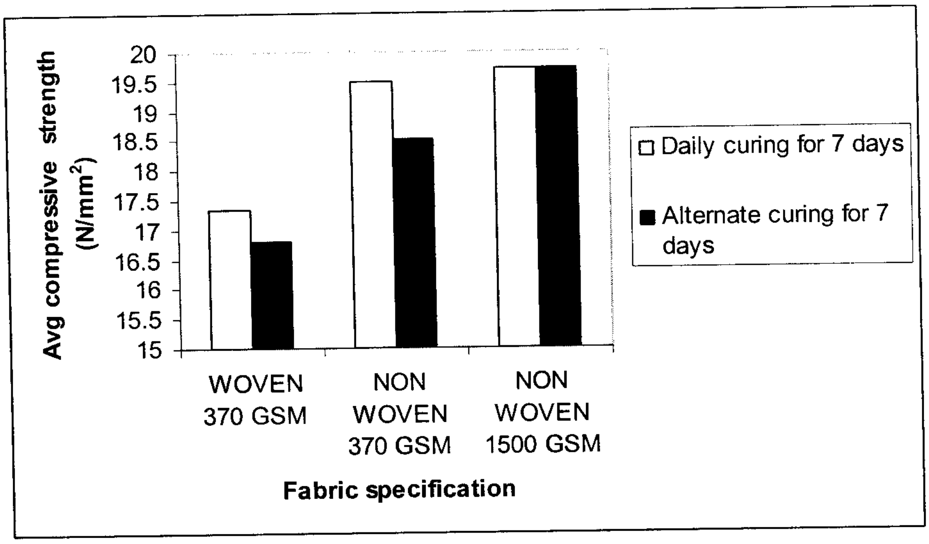


Figure 6.12 Comparison on different cycles of curing.

Fig 6.12 shows the compressive strength reduces for 370 GSM woven and non-woven wrapped concrete in alternate days curing. In both the cases concrete sample wrapped with Non-woven material showed 20% higher compressive strength, when compared to sample wrapped with woven materials of same GSM.

a) b)

Figure 6.13 Comparative crack formation for concrete blocks cured with different fabric of same GSM. a) Non-woven wrapped concrete, b) Woven wrapped concrete.

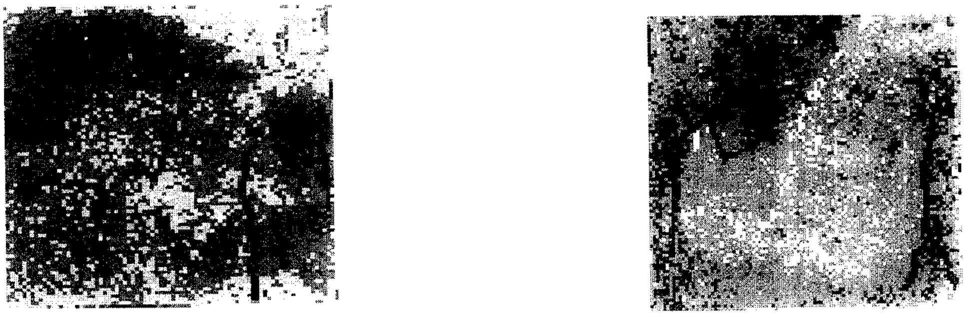
Fig 6.13 shows the comparative crack formation for concrete blocks cured under same conditions with woven and nonwoven of 370 GSM. It is clear that for the nonwoven, the nature of the cracks is vertical which is indicative of better compressive fracture.

For different GSM woven fabric cured samples, multiple cracks occur, with several of them propagating in the horizontal direction Fig 6.14.

a)

b)

Figure 6.14 Concrete blocks cured with woven of 370 and 700 GSM fabric. a) Woven fabric of 370 gsm, b) Woven fabric of 700 gsm.



a)

b)

Figure 6.15 Concrete block cured with Non-woven fabric of 1000 and 1500 GSM. a) Non-woven wrapped concrete of 1000 GSM, b) Non-woven wrapped concrete of 1500 GSM.

On the contrary, as is evident from Fig 6.15, samples cured with Non-woven fabrics had fewer cracks with majorly vertical crack propagation.

CHAPTER - 7

CONCLUSIONS

- Non-woven materials were found to be overall better in terms of retention of water tested under varying conditions of temperature and RH. Non-wovens have on an average retained 20% more water when compared to their similar GSM woven counterpart.

- Non-woven which can be manufactured to very high GSM (1500) had a maximum drying time of 8 hrs (35°C, RH 50%). The maximum value reached for woven is 2.5 hrs which is significantly less. Thus Non-woven can effectively used for slow moisture exchange application.

- The higher retention of water by nonwovens have been used to cure concrete and a comparison made with concrete cured with similar GSM woven fabric. Concrete samples cured with non-woven materials had at least 20% higher compressive strength when compared to woven fabrics of same GSM. This can be ascribed as a direct result of higher water retention of nonwoven structures.

- Alternate day curing is possible with water retentive Non-woven structure which can save water and manpower. Nonwoven jute material can be used for concrete curing applications in places where scarcity of water exists and also for higher strength applications under similar wetting history.

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