Compaction Experiments on Different E-glass Fabric Preforms in the Vacuum Infusion Process

by

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This is to certify that I have examined this copy of a master's thesis by

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and have found that it is complete and satisfactory in all respects,

and that any and all revisions required by the final

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ABSTRACT

An experimental procedure was designed to realistically characterize the compaction behavior of e-glass fabric preforms during all stages of Vacuum Infusion (VI). To mimic VI, the loading (compaction) was done on a dry preform, and the unloading (decompaction) was done after the preform was saturated with the resin. When fabrics were wetted at constant full compaction pressure, a significant decrease in thickness was observed for the random type fabric, but not for the woven and biaxial fabrics and polypropylene distribution medium. The rate of change of thickness $\partial h / \partial t$ had different signs and order of magnitudes when various constant compaction pressures were applied during fiber relaxation stage. Thus, previous coupled compaction-mold filling models based on static relationship between thickness and compaction pressure do not appropriately simulate the compaction physics of VI. The time-dependent database output from this study is a useful and straightforward tool to model VI.

ÖZET

Bu deneysel prosedür, Vakum İnfüzyon (VI) usulünde kullanılan cam elyaf dokumaların sıkıştırma davranışlarını gerçekçi biçimde tanımlamak için tasarlandı. VI üretim usulündeki davranışa tamamen benzetmek için, yükleme işlemi kuru elyaf dokuma üstünde, boşaltma işlemi ise elyaf dokuma reçine ile doymuş hale geldikten sonra yapılmıştır. Elyaf dokuma sabit tam sıkıştırma basıncı altında ıslatıldığında, keçe elyaf tabakanın kalınlığında önemli ölçüde azalma gözlemlenirken, örgülü, çift-eksenli dokumalarda ve polipropilen dolgu katmanının kalınlığında belirgin bir değişim gözlemlenmemiştir. Boşaltma sonunda uygulanan çeşitli sabit sıkıştırma basınçlarında, kalınlıktaki değişim oranının, $\partial h / \partial t$, farklı işaret ve büyüklük değerlerine sahip olduğu belirlenmiştir. Bu nedenle, kalınlık ve sıkıştırma basıncı arasındaki statik ilişkiye bağlı önceki etkileşimli ve kalıp dolum modelleri, VI imalat usulünü doğru şekilde temsil etmemektedir. Bu çalışmadan elde edilen zamana bağlı veri tabanı, VI usulünün modellenmesinde faydalı ve kullanımı kolay bir araçtır.

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NOMENCLATURE

$Ø$	Porosity of the fabric
$\partial h / \partial t$	The rate of change of thickness [m/s]
ρ_{sup}	Superficial (surface) density of fabric per layer [kg/m^2]
ρ_{sup}	Superficial (surface) density of glass fibers [kg/m^2]
σ	Standard deviation of thickness in each configuration set [m]
dP/dt	The rate of change of compaction pressure [Pa/s]
$D_{contact}$	Diameter of the contact surface [m]
D_{hole}	Diameter of the resin hole [m]
F	Compaction force on fabric [N]
h	Thickness of the fabric perform [m]
$h_{average}$	Average thickness of the fabric perform [m]
h_i	Initial thickness of the fabric perform [m]
$h_{settled}$	Thickness at the end of the settling time [m]
Δh	Change in the perform thickness until the gelation [m]
$\Delta h_{relaxation}$	Change in thickness during relaxation stage [m]
$\Delta h_{unloading}$	Change in thickness during unloading stage [m]
$\Delta h_{wetting}$	Change in thickness during wetting stage [m]
Δv_f	Change in fiber volume fraction
P	Resin pressure [Pa]
P_0	Initial compaction pressure [Pa]
P_{atm}	Atmospheric pressure [Pa]
P_c	Compaction pressure on fabric [Pa]
$P_{c,final}$	Final compaction pressure on fabric [Pa]
$P_{c,relaxation}$	Relaxation pressure [Pa]
N	Number of experiments
t	Time [s]
v_f	Fiber volume fraction
$v_{f,fiberwet}$	Fiber volume fraction after the wetting stage

Chapter 1

INTRODUCTION

This study focuses of compaction/decompaction characterization of glass fabric preforms during Vacuum Infusion (VI) process. This characterization of reinforcing materials determines the dimensions and thus the mechanical properties of the final part.

In this chapter; the introduction to composites, VI process, and previous studies in the literature are discussed.

1.1. Composite Materials

Composites are the heterogeneous combination of reinforcing fabric and polymer fabric. Recently, composite material usage has been increased because of their advance properties such as high specific strength and stiffness, high corrosion resistance and low electrical and thermal conductivities. Considering the properties mentioned above, composite materials are used in military applications, marine industry, energy, sporting goods and transportation vehicles.

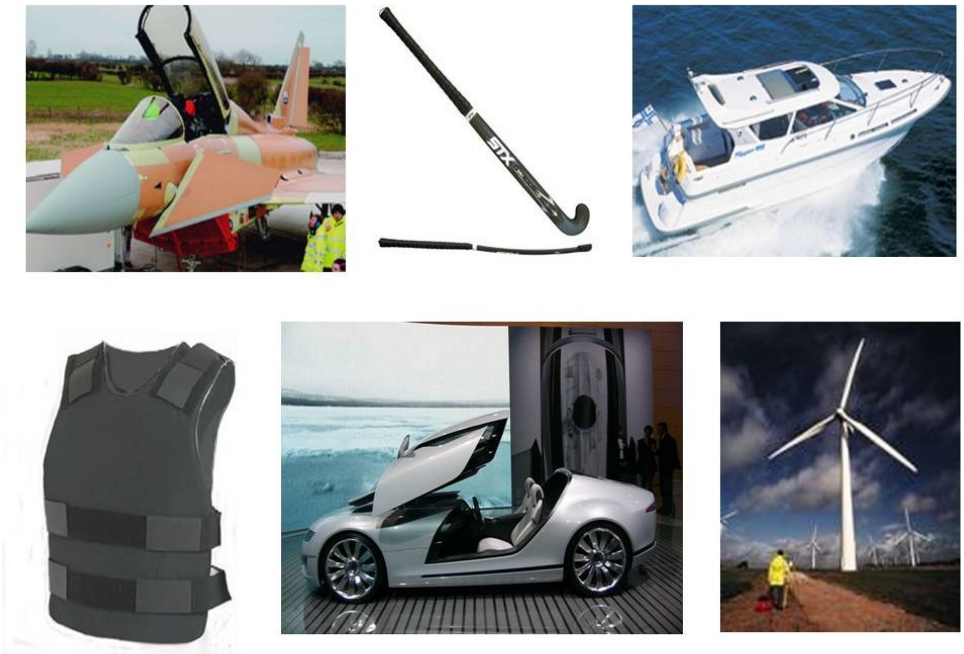


Figure 1.1 Use of composite materials in different industries [1-6]

1.2. Fabric

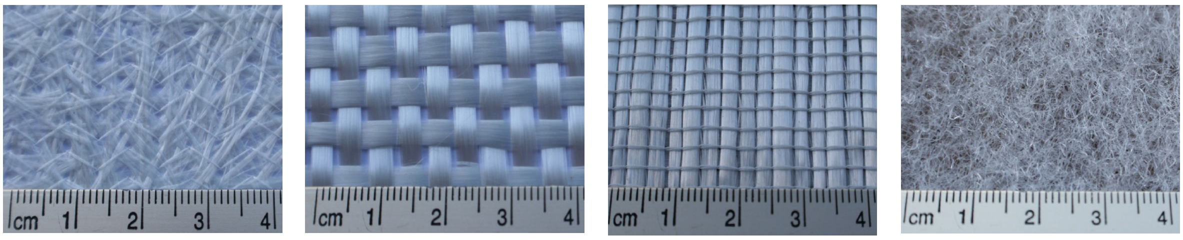
In advance composite applications, fabric preforms are used for reinforcement purpose by weaving fibers (filaments) or similar processes. Major fraction of the structural loads are carried by the fabric. Depending on the application, different fabric types are used. Fabric type and its structure affect the mechanical properties of the material. Fabrics used in composite material manufacturing, are generally made of glass, carbon or aramid fibers. Some mechanical properties of different fabric types are given on Table 1.1.

Table 1.1 Modulus of elasticity and ultimate tensile strength for different materials [7].

Material	Modulus of Elasticity, E [GPa]	Ultimate Tensile Strength, UTS [MPa]
Aluminum	69 - 79	90 - 600
Steel	190 - 200	415 - 1750
Thermoplastic polymer	1.4 - 3.4	20 - 120
Thermoplastic polymer (reinforced with short fibers)	2 - 50	20 - 120
Thermoset polymer	3.5 - 17	35 - 170
Glass fiber (unidirectional)	73 - 85	3500 - 4600
Carbon fiber	275 - 415	2000 - 3000
Kevlar (Aramid)	62 - 117	2800

Fiber volume fraction ($Vf = 1 - \phi$, where ϕ is the porosity) is the ratio of fiber volume to the total volume. As Vf of the part increases, the strength of the part increases. However, during resin injection, impregnation of the fabric with higher fiber volume fraction is more difficult due to its resistance to flow.

In this study, different E-glass fabric structures are used in the experiments (see Figure 1.2.)



(R)
Random (stitched) fabric
Fibroteks
500 g/m^2

(W)
Woven (plain) fabric
Fibroteks F50
Warp/Weft ratio = 18/24
500 g/m^2

(B)
Biaxial (stitched) fabric
90^o/0^o
Metyx LT850 E10D
860 g/m^2

(C)
Distribution medium
Polypropylene core
Metyx Meticore 250 PP
250 g/m^2

Figure 1.2. E-glass fabric types (R: random, W: woven, and B: biaxial) and distribution media (C: polypropylene core) used in this study.

1.3. Resin

Resin is a polymer with the cure agents added in it during injection stage. It saturates the fabric and keeps fibers in shape after it solidifies. Moreover, protection of fabric against the environmental conditions and transmitting the external load to the fabric are provided by resin.

Two types of polymer are commonly used in the composite material manufacturing: thermosets and thermoplastics. Thermosets are liquid, and they have low viscosity at room temperature. By heating or adding cure agent chemicals, molecules structure three dimensional network by cross-linking. This phenomenon is known as curing. Thermosets are usually stronger than thermoplastics due to covalent bond. Since the curing process is irreversible, the product cannot be reshaped or melted.

Thermoplastics are generally in solid phase and have higher viscosity at room temperature. To inject the thermoplastics into the mold cavity, external heating and heat induced by friction are necessary. As thermoplastics are heated, weak secondary bonds are broken, and the fluid is injected in a mold, or extruded through a die. During cooling the thermoplastics, bonds are regenerated between the molecules. Therefore, polymerization of thermoplastics is reversible.

In this study, Poliya Polipol™ 336-RTM Polyester [8] with curing agents Cobalt %1 and Butanox M60 solution is used. The density and the viscosity of the polyester are 1.04 g / cm^3 and 0.3 Pa.s, respectively. The effect of curing agent fractions on the resin gelation time of polyester is shown in the Table 1.2 [9].

Table 1.2 Gellation time of the Poliya Polipol™ 336-RTM polyester [8] for two different fractions of curing agents at the room temperature ($\cong 20°C$).

Polyester	1000 ml	1000 ml
Butanox M 60	5 ml	5 ml
Cobalt (% 1)	5 ml	3 ml
Gellation time (min.)	≈ 20	≈ 35

1.4. Vacuum Infusion Process and Its Issues

Vacuum Infusion (VI) is one of the Liquid Composite Molding (LCM) processes used to manufacture large composite parts, particularly in the automotive and marine industries. A reinforcing fabric preform, typically made of continuous glass or carbon fibers, is draped on a one-sided mold surface. A resin distribution medium, peel-ply and vacuum bag are stacked on the preform. The mold cavity is sealed using tacky tape between the mold wall and the vacuum bag. A vacuum is drawn for two reasons: first, to compact the preform; and, secondly to drive thermoset resin from the reservoir to the mold cavity to fill the empty spaces between the fibers of the preform. The resin system is usually designed so that the gelation time (pot life) is slightly longer than the mold filling time to ensure the complete mold filling. The part is demolded after green strength and rigidity are achieved in the part during the curing stage.

Mold design (i.e., deciding the dimensions and locations of the distribution medium, resin inlets and exits) is critical to achieve complete mold filling and thus eliminating micro-level and macro-level voids (dry spots) in the part. A distribution medium has higher porosity and permeability than the preform used. The resin flows mainly through this medium in in-plane directions first, and then flows in the adjacent preform with a lag. The distribution medium can be either disposable (a.k.a. flow mesh) or embedded (a.k.a. core). The disposable distribution medium is placed between the peel-ply and the vacuum bag; the embedded distribution medium is sandwiched between the fabric layers and thus it becomes a part of the finished part. The embedded distribution medium increases the thickness and moment of inertia of the part's cross-section, however it reduces the overall fiber volume fraction and mechanical strength.

The major issues in the generic VI process are (1) low fiber content due to the limited compaction of the preform since the compaction pressure cannot be higher than atmospheric pressure; (2) high surface roughness of the part on the peel ply/vacuum bag side, and (3) variation in the part thickness due to (i) the change in the compaction pressure as resin pressure changes during the resin infusion, and (ii) fiber relaxation with time even at constant compaction pressure. In this study, the item (3) was investigated for commonly used e-glass fabric types, and a compaction/decompaction database was constructed to be used in the process models such as [10,11].

1.5. Previous Compaction Experiments

Chen and Ye [12,13] and Chen and Chou [14,15] studied compaction behavior of fabric preforms with their micromechanical analytic models based on the beam theory. These analytical studies were for single [12,14] and multi [13,15] layer plain woven fabric preforms. As the number of layers increased in a stack of fabrics, the thickness reduction per layer increased [13]. Chen et al. [16] conducted compaction experiments on multi layer preforms made of various fabric types, such as continuous strand mats, plain woven fabric and unidirectional knitted materials.

Considering the difficulty in the analytical study of a wide variety of fabric structures, some empirical models were used to represent the compaction behavior of the fabrics [17-20]. Robitaille and Gauvin [17-19] used empirical equations to relate the fiber volume fraction, V_f to the compaction pressure, F with a power law: $V_f = AP^B$ where the coefficients *A* and *B* are determined from the experimental data by curve fitting. To model the time-varying compaction pressure at fixed fiber volume fraction due to fiber relaxation, they used another empirical relation, $P = P_0\left(1 - Ct^{1/D}\right)$ where P_0 is the initial compaction pressure, *C* and *D* are determined from the experimental data. To investigate the effect of process parameters on their empirical model and compaction behavior, Robitaille and Gauvin varied the following parameters: the number of layers, compaction rate, maximum compaction pressure, holding time before the relaxation, the number of cycles, and saturation of the fabric. In Somashekar et al.'s compaction/decompaction experiments [21] on dry continuous filament random mat, plain woven fabric and biaxial stitched fabric specimens, first the thickness is reduced until a particular value. It is kept at that thickness for a while, and then the compaction pressure is unloaded to a minor value (0.12 kPa) rapidly. The recovery after the unloading step was divided into the following two stages, which behaved differently: "elastic" and "time-dependent". Elastic recovery was due to the spring-back which took place immediately after the unloading. Following the elastic recovery, nonlinear time-dependent recovery occurred. The part thickness did not reach the original undisturbed value, and a permanent deformation, $h_{undisturbed} - h_{final}$ remained. Somashekar et al. also investigated the effect of the following parameters on the compaction: cycling loading type (single and multiple cycles, and different hold times between the cycle steps), holding time, compaction speed, and the number of layers. As observed in their experiments, the major part of the time-dependent recovery occurred in 25 minutes, and the complete recovery took a long time in the order of days. For example, the time-dependent recovery was 5.2 % at t = 25 minutes, and it increased to 6.2 % (corresponding to 0.29 mm change in h) at t = 68.5 hours for a continuous filament random mat. However, the dry loading/dry unloading experimental procedure does not resemble the compaction of preforms in the actual VI process due to the absence of the lubrication effect which takes place during both unloading and relaxation stages. For this reason, some experiments were designed to include the wetting process. However, the wetting procedure of these studies [18,19,22,23] was done at the beginning of the compaction experiments, not between the loading and unloading stages. However in the actual VI process, a dry preform is compacted during the initial vacuuming, and then decompaction takes place after being wetted with resin. Thus, it is much more appropriate to model the VI process by wetting the preform between the loading and unloading stages, as done for the experiments of this study. Robitaille and Gauvin saturated the specimens with either distilled water [18] or a mixture of distilled water and silicon oil [19] at the beginning of the experiments.

Grimsley et al. [22], and Buntain and Bickerton [23] used actual thermoset resin for saturation.

Some cycling loading studies were done to obtain higher fiber volume fractions [17-19,21]. Robitaille and Gauvin [19] indicated that, the organization of the fiber structure become nearly stable after ten cycles of compaction/decompaction.

In the most of the mentioned experimental studies, compaction pressure was measured (as the dependent variable) while controlling the thickness (as the independent variable). As it will be discussed in the following section, the opposite approach will be used in this study to mimic the actual VI process more accurately. Also, in the majority of these previous studies, the specimens were compacted up to high fiber volume fractions that could be achieved in the Resin Transfer Molding (RTM) process only, thus the measured maximum compaction pressures were in the order of MPa. The fiber relaxation was investigated afterwards in terms of measuring the decrease in the compaction pressure at fixed thicknesses. This approach is ideal to calculate the maximum compaction force that must be applied to close the mold initially, and then its variation with time, as it was done in [23]. However, this is applicable only in the RTM in which the part thickness is constant, but the compaction pressure is changing with time; whereas the VI process has different features due to the non-rigid upper mold part used, which is a vacuum bag.

1.6. Objectives

In this study, the following were achieved:

- Compared to the previous characterization experimental approaches, a more realistic compaction experimental procedure was designed for the VI process. During all stages of the experiment, the compaction pressure, P_c is controlled as the independent variable; and the part thickness, h, which is the dependent variable of the actual VI process, is measured. Briefly, the stages of the experiment are shown on Figure 1.3.

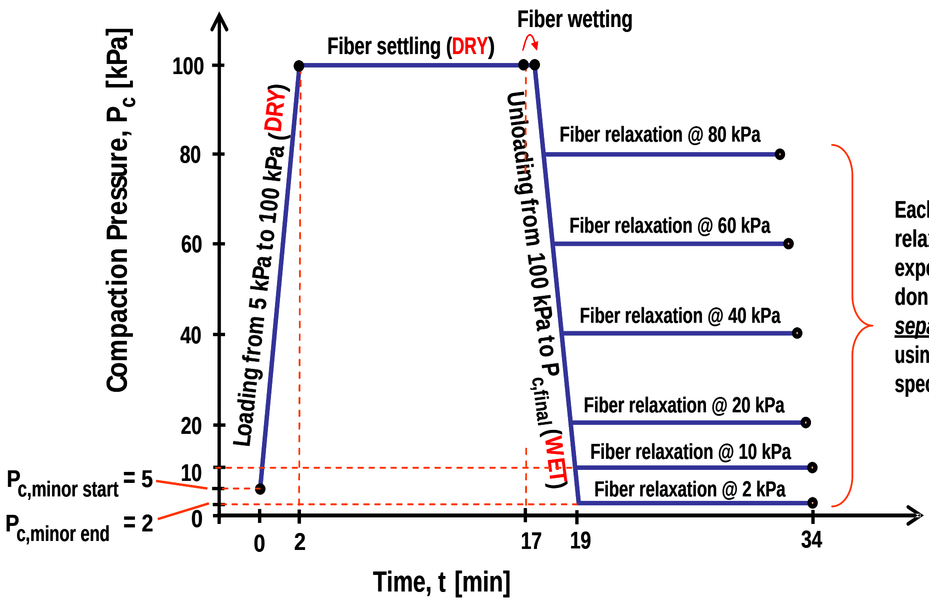


Figure 1.3. The stages of a compaction characterization experiment. Compaction pressure, Pc is the independent variable of the experiment, and the specimen thickness, h is measured which is dependent on Pc.

- (i) dry loading (compaction) from a minor compaction pressure of P_c = 5 kPa to 100 kPa; (ii) fiber settling at P_c = 100 kPa to resemble the pre-injection vacuuming condition; (iii) quick fiber wetting with actual resin; (iv) wet unloading (de-compaction) up to P_c = 2 kPa; (v) fiber relaxation at P_c = 2 kPa to resemble the post-injection condition.

- The compaction experimental setup used in [24] was modified in this study, such that the fiber wetting could be done while the specimen stays inside the setup under constant compaction pressure.

- Three different types of e-glass fabric (random, woven and biaxial) were tested in different layup configurations.

- The fiber relaxation was investigated at different levels of compaction pressure besides 2 kPa by measuring $h(t)$ and thus calculating the rate of change of thickness, $\partial h / \partial t$. This part of the constructed database is important to realistically simulate the preform decompaction, particularly during the late stages of the process. This was demonstrated in [10] by comparing the results of actual VI experiments and the coupled compaction/flow model in which the database constructed in this study was used.

To model the VI process appropriately, one needs to know how the fabric preform's thickness changes during the compaction and decompaction stages of the process. Thus, a carefully designed characterization test is proposed here to mimic the process step by step. (i) During the loading and fiber settling stages, the fabric should be dry and the compaction pressure should be increased up to a maximum value of one bar; (ii) the fabric must be wetted to resemble the resin arrival in VI; and (iii) the wetted fabric should be unloaded up to a compaction pressure reached at the end of the VI process at the interested location in the fabric. In the previous studies, the compaction characterization of fabrics was done on either dry or wet specimens from the beginning to the end of the experiment except [Senan thesis,Yenilmez,Senan,Sozer] in which the fabric is wetted between the loading and unloading stages, as also done here. In the previous studies, the thickness was changed and the corresponding compaction pressure was measured (similar to the universal compaction test). However, this is not suitable to characterize the actual VI process, but valid for the RTM process only. Thus, in this study to mimic the VI process appropriately, the compaction pressure was controlled: (i) from a minor pressure of 5 kPa to a maximum pressure of 100 kPa during the compaction stage; and (ii) from 100 kPa to 2 kPa during the decompaction stage. Also, the fiber settling was investigated at Pc = 100 kPa for 15 minutes, and fiber relaxation was investigated at Pc = 80, 60, 40, 20, 10 and 2 kPa for 15 minutes. In each stage, the part thickness was measured as the dependent variable. Each fabric configuration was tested using ten separate specimens; and each relaxation test was performed on ten separate specimens. The average and standard deviations were tabulated.

In this study, the main contribution was to create a very realistic experimental procedure to characterize the compaction/decompaction behavior of different fabric types and configurations. The constructed database is going to be a useful tool for prospective researchers during modeling the VI process in which the compaction and flow modules are coupled.

Chapter 2

EXPERIMENTAL SETUP AND PROCEDURE

2.1. Experimental Setup

The experimental setup is schematically shown in Figure 2.1. It stays on a horizontal table. The compaction cylinder and the base cup were machined so precisely that the compaction cylinder can slide in the base cup with no resistance, and yet no significant tilt occurs.

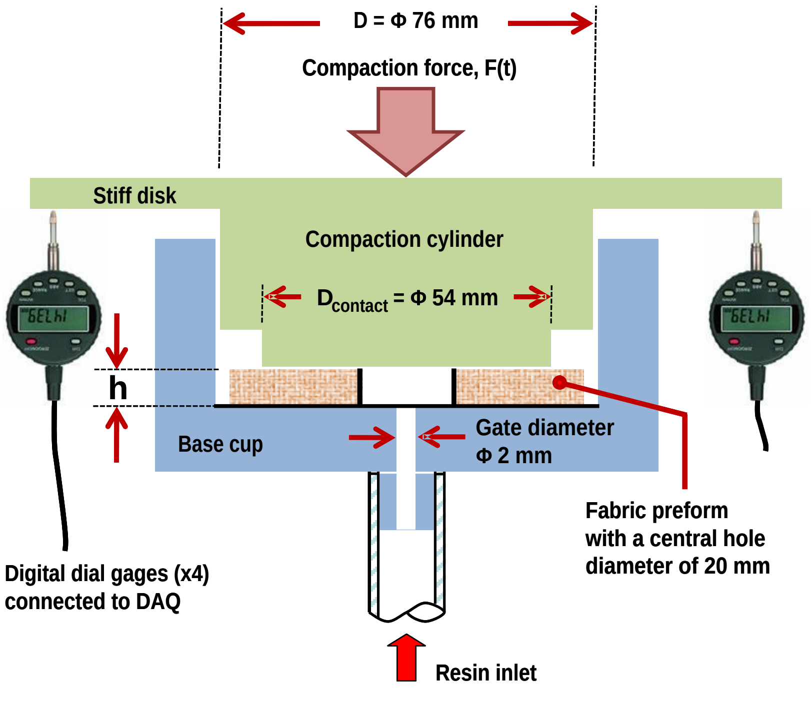


Figure 2.1 Experimental setup for compaction characterization

2.2. Experimental Procedure

The experimental procedure is detailed below:

(1) ***Preparation of specimens***: Each circular fabric and core layer is cut with an outer diameter of 60 mm and an inner hole diameter of 20 mm. Sharp punches are used so that a minimum deformation occurs on the fabrics or core. The layers are stacked to construct the preform specimens. They are stored on a shelf for at least 24 hours so that complete (or almost complete) fiber relaxation is allowed, thus a permanent fiber structure and thickness of the specimen is restored.

(2) ***Zeroing dial-gages***: After the compaction cylinder is placed in the clean and empty base cup, the average of the four dial gages' readings is recorded by the DAQ system to set the zero-thickness reference.

(3) ***Placement of specimen***: A specimen is centered in the base cup.

(4) ***Loading (compaction)***: This step of the procedure mimics the early stage of vacuuming in the VI process. The compaction force, $F(t)$ is increased by filling a light-weight water barrel on the compaction cylinder with a water pump. The compaction pressure, $P_c = F(t) / \left[\pi \left(D_{contact}^2 - D_{hole}^2 \right) / 4 \right]$ is initially 5 kPa when the minor load (the weights of the compaction cylinder, the stiff disk and the barrel) is applied. The rate of change of the compaction pressure is set to a constant

approximate value of $dP_c/dt = 0.8$ kPa/s by keeping the water flow rate constant. Thus, the loading stage takes approximately two minutes for P_c to reach 100 kPa.

(5) ***Fiber settling***: At this maximum compaction pressure, $P_c = 100$ kPa, the change in the specimen thickness is recorded for 15 minutes to see the effect of fiber settling due to nesting. This step is conducted to mimic the last stages of vacuuming in the VI process before resin infusion is begun, in which the compaction pressure reaches a steady value, but the preform thickness may still decrease with time due to fiber nesting.

(6) ***Fiber wetting***: This step of the experiment resembles the arrival of the resin flow front to a specific location of the preform in VI where the compaction behavior is being studied. The specimen is saturated with thermoset polyester resin, Poliya Polipol^{TM} 336-RTM. The resin is injected from the central hole (see Figure 2.1) at a low flow rate so that the maximum resin pressure is insignificant, relative to the compaction pressure of 100 kPa. The preliminary case studies revealed that this undisturbed condition is obtained if the flow rate is in the order of 1 cc/s or less for the fabric types used in this study. Thus, the wetting stage takes approximately 10 seconds for thin specimens (four fabric layers plus one layer of embedded core), and approximately 20 seconds for thick specimens (eight fabric layers plus two layers of embedded core).

(7) ***Unloading (decompaction)***: This step of the procedure mimics the thickening of the preform during mold filling as the resin pressure, P builds up (and thus compaction pressure, $P_c = P_{atm} - P$, decreases) while the flow front continues to propagate away from the point of interest in the preform. In a similar (but reverse) way to the loading step, the compaction force, $F(t)$ is decreased by emptying the water barrel using the water pump. The rate of change of the compaction pressure is set to dP_c/dt = - 0.8 kPa/s until P_c becomes 5 kPa when the water barrel is empty. During this stage, the readings of the digital gages are recorded with a frequency of 10 Hz. The compaction pressure is further decreased from 5 to 2 kPa in one single step simply by removing the water barrel from the top of the compaction cylinder. This part of the experiment is done with care to ensure that the removal is done 4 seconds after P_c reaches 5 kPa so that dP_c/dt is kept almost uniform during the entire experiment.

(8) ***Fiber relaxation at 2 kPa***: At a fixed compaction pressure of P_c = 2 kPa, the change in the specimen thickness is recorded for 15 minutes to observe the fiber relaxation due to "spring-back" and "time-dependent deformation" [21]. This step resembles the last stages of the mold filling and extra time until the gelation of the resin. Even though the resin pressure (and thus the compaction pressure) does not significantly change with time, the part thickness may change due to the fiber relaxation.

2.3. Fiber Relaxation Experiments at Different Compaction Pressures

The experimental procedure mentioned above can be useful to study the decompaction characterization of fabric preforms which undergoes an unloading up to P_c = 2 kPa during the actual VI process. This is the only case when the resin pressure reaches P = 98 kPa for the preform sections near the resin inlets. Away from the inlets, P decreases hence P_c increases. Thus, for a complete and more realistic model of the VI process, further experiments should be conducted in which the unloading stage ends at different levels; and the relaxation cycle is continued afterwards at that final compaction pressure value. As schematically illustrated in Figure 1, different sets of characterization experiments are done exactly the same way as described in the previous section, except that Step (7) is performed until P_c is either 80, 60, 40, 20 or 10 kPa, and Step (8) is continued for 15 minutes at that particular compaction pressure. The constructed database is assumed to be enough to extend it to the entire compaction pressure range by interpolating the data in 2-80 kPa range, and extrapolating it in 0-2 and 80-100 kPa ranges. Particularly, extrapolating the data in 0-2 kPa range should be done with caution as the unloading and fiber relaxation characteristics become very nonlinear at and near that range

2.4. Fabrics and Layup Configurations

Three types of e-glass fabrics (random (R), woven (W) and biaxial (B)) and one type of embedded distribution medium (polypropylene core (C)) were tested in this study. The photographs, brand names, and superficial densities are shown in Figure 1.2. The compaction characterization experiments were conducted on the following configurations: C, C_2, F_4, F_2CF_2 and $F_2CF_4CF_2$ (or in a different representation, 1C, 2C, 4F, 2F/1C/2F, and 2F/1C/4F/1C/2F) where F stands for e-glass fabric layer (R, W or B) and C stands for the core material. In each configuration layup, the fabric orientations were kept the same; that is, the individual layers were all stacked in the roll direction.

Chapter 3

RESULTS OF THE EXPERIMENTS

Considering (i) the non-uniformity in the fiber structure of fabric rolls and (ii) inaccuracy in the specimen preparation (such as different nesting during fabric stacking), each set of the experiment was conducted on ten separate specimens. In this study, the results will be represented as $h_{average} \pm \sigma$ where $\sigma = \left(\frac{1}{N-1} \sum_{i=1}^{N} \left(h_i - h_{average} \right)^2 \right)^{1/2}$ is the standard deviation of those ten experiments (N = 10) in each configuration set.

Two typical experimental data are shown in Figures 3.1 and 3.2 for random preform, 2R/1C/4R/1C/2R and woven preform, 2W/1C/4W/1C/2W, respectively.

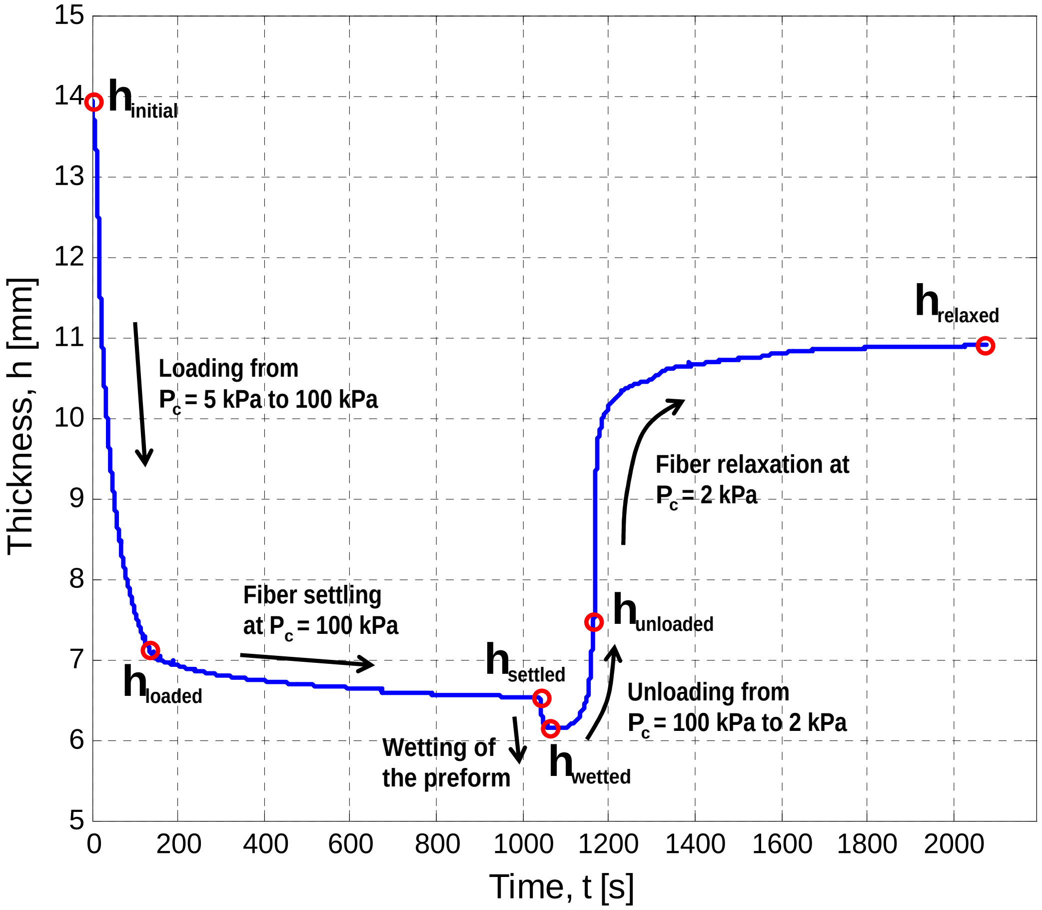


Figure 3.1. The change in specimen thickness during a typical compaction characterization experiment for 2R/1C/4R/1C/2R preform.

During the short wetting stage (from the end of the fiber settling to the beginning of the unloading), the thickness decreases significantly. This phenomenon is not as significant for the other fabric types (woven and biaxial) as this random type. Note that the thickness increases with very high rate when the compaction pressure is relatively low (2 kPa in this case) at the end of the unloading stage. This explains why the part thickness increases with time at sections near the injection port, even when the compaction pressure is not changing significantly with time at those sections.

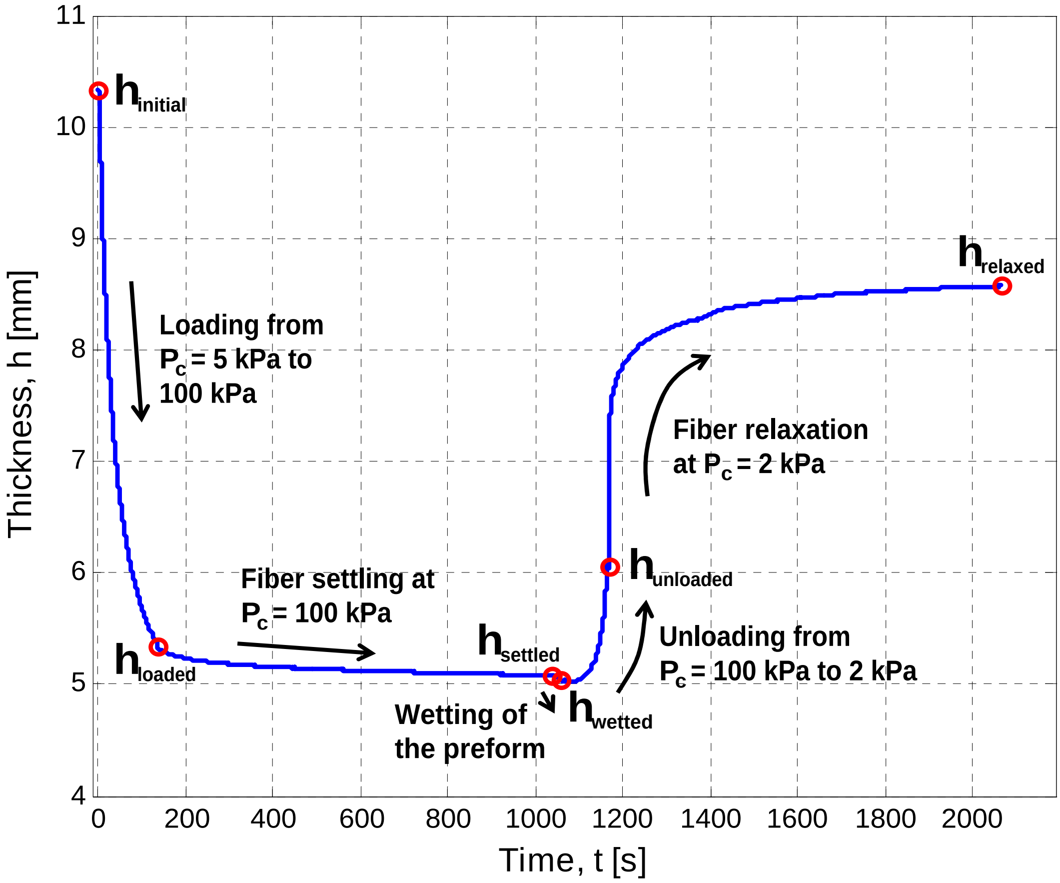


Figure 3.2. The change in specimen thickness during a typical compaction characterization experiment for 2W/1C/4W/1C/2W preform.

This woven preform, 2W/1C/4W/1C/2W has a different compaction characteristics than random preform (compare this figure with Figure 3.1 during their wetting stages).

Some of the qualitative similarities are as follows: (1) at the end of the loading stage (i.e., at full compaction pressure of P_c = 100kPa), h is reduced to approximately half of the initial thickness corresponding to the minor pressure of 5 kPa. (2) The thickness recovery during the 2-minute unloading stage (approximately 1.4 and 1.0 mm for the random and woven preforms, respectively) is less than the thickness reduction during the 2-minute loading stage (approximately 7 and 5 mm for the random and woven preforms, respectively). The average values of the ten experiments are tabulated in Table 3.1. (3) Both fabric types have very steep thickness recovery $\partial h / \partial t$ in the early part of the fiber relaxation at P_c = 2 kPa, and then the recovery becomes rather slow afterwards. (4) Both fiber settling at 100 kPa and fiber relaxation at 2 kPa do not converge to steady values in 15 minutes. This is important from the view point of the control and/or modeling of the VI process, since the part thickness keeps changing with time, even if the compaction pressure is set to a constant value during the initial vacuuming and gelation stages of the VI process. The major difference between the random and woven fabrics' compaction characteristics is their response upon being wetted. When the specimens are saturated with resin, the random preform has an average thickness reduction, $\Delta h_{wetting}$ of 0.28 mm (minimum of 0.22 mm, maximum of 0.38 mm, and a standard deviation of ± 0.05 mm). On the other hand, the

PREFORM	$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
1C	4.04 ± 0.29	1.72 ± 0.09	1.59 ± 0.08	1.58 ± 0.07	2.01 ± 0.12	3.07 ± 0.18	-2.33 ± 0.25	-0.13 ± 0.02	0.00 ± 0.00	0.42 ± 0.06	1.06 ± 0.12
2C	7.04 ± 0.53	2.95 ± 0.18	2.72 ± 0.16	2.71 ± 0.16	3.47 ± 0.32	5.30 ± 0.36	-4.09 ± 0.47	-0.23 ± 0.04	-0.01 ± 0.01	0.77 ± 0.24	1.83 ± 0.18
4R	3.14 ± 0.18	1.94 ± 0.10	1.78 ± 0.10	1.61 ± 0.09	1.82 ± 0.08	2.25 ± 0.16	-1.20 ± 0.18	-0.17 ± 0.02	-0.16 ± 0.05	0.20 ± 0.06	0.43 ± 0.10
2R/1C/2R	6.91 ± 0.39	3.53 ± 0.30	3.22 ± 0.27	3.04 ± 0.25	3.84 ± 0.29	5.40 ± 0.34	-3.38 ± 0.21	-0.31 ± 0.04	-0.18 ± 0.03	0.81 ± 0.08	1.55 ± 0.10
2R/1C/4R/1C/2R	13.18 ± 1.04	6.97 ± 0.63	6.40 ± 0.61	6.12 ± 0.58	7.61 ± 0.78	10.47 ± 0.96	-6.21 ± 0.75	-0.57 ± 0.05	-0.28 ± 0.05	1.48 ± 0.24	2.87 ± 0.27
4W	1.99 ± 0.06	1.54 ± 0.05	1.51 ± 0.05	1.49 ± 0.05	1.58 ± 0.04	1.79 ± 0.10	-0.44 ± 0.05	-0.04 ± 0.01	-0.02 ± 0.02	0.09 ± 0.04	0.21 ± 0.07
2W/1C/2W	5.03 ± 0.25	2.74 ± 0.11	2.61 ± 0.11	2.60 ± 0.11	3.08 ± 0.11	4.31 ± 0.16	-2.29 ± 0.17	-0.13 ± 0.02	-0.01 ± 0.00	0.48 ± 0.05	1.23 ± 0.10
2W/1C/4W/1C/2W	10.37 ± 0.52	5.38 ± 0.31	5.12 ± 0.29	5.09 ± 0.29	6.03 ± 0.29	8.35 ± 0.37	-4.99 ± 0.37	-0.26 ± 0.04	-0.03 ± 0.01	0.95 ± 0.11	2.32 ± 0.26
4B	3.68 ± 0.07	2.73 ± 0.08	2.65 ± 0.08	2.54 ± 0.08	2.80 ± 0.07	3.30 ± 0.05	-0.95 ± 0.07	-0.08 ± 0.01	-0.11 ± 0.02	0.27 ± 0.02	0.49 ± 0.05
2B/1C/2B	7.11 ± 0.49	4.32 ± 0.19	4.12 ± 0.16	4.06 ± 0.16	4.73 ± 0.24	6.01 ± 0.34	-2.80 ± 0.40	-0.20 ± 0.04	-0.06 ± 0.01	0.67 ± 0.09	1.28 ± 0.12
2B/1C/4B/1C/2B	14.56 ± 0.50	8.71 ± 0.27	8.32 ± 0.26	8.18 ± 0.28	9.41 ± 0.37	11.88 ± 0.78	-5.85 ± 0.47	-0.38 ± 0.06	-0.15 ± 0.04	1.23 ± 0.31	2.47 ± 0.53

Table 3.1 Part thickness, *h* and its change during different stages of compaction characterization tests for different fabrics and configurations. In each set, ten experiments were conducted using ten separate specimens. All the thickness values are in [mm].

woven preform has an insignificant average thickness reduction, $\Delta h_{wetting}$ of 0.03 mm only (minimum of 0.02 mm, maximum of 0.04 mm, and a standard deviation of ± 0.01 mm). As tabulated in Table 3.1, the biaxial preform, 2B/1C/4B/1C/2B has $\Delta h_{wetting}$ = 0.15 mm in average (minimum of 0.10 mm, maximum of 0.20 mm, and a standard deviation of ± 0.04 mm), which is not as insignificant as in the woven fabric, but smaller than the random fabric.

The comparison of Figure 3.1 (for $P_{c,relaxation}$ = 2 kPa) and Figure 3.3 (for $P_{c,relaxation}$ = 40 kPa) indicates very different unloading and relaxation behaviors of the preforms. When the unloading stage is terminated at a compaction pressure of 40 kPa, not only $\Delta h_{unloading}$, but also $\Delta h_{relaxation}$ are insignificant as shown in Figure 3.3 for the random preform, 2R/1C/4R/1C/2R. The two other types of the fabrics (woven and biaxial) also exhibited the same qualitative behaviors at relatively high compaction pressures (80, 60 and 40 kPa).

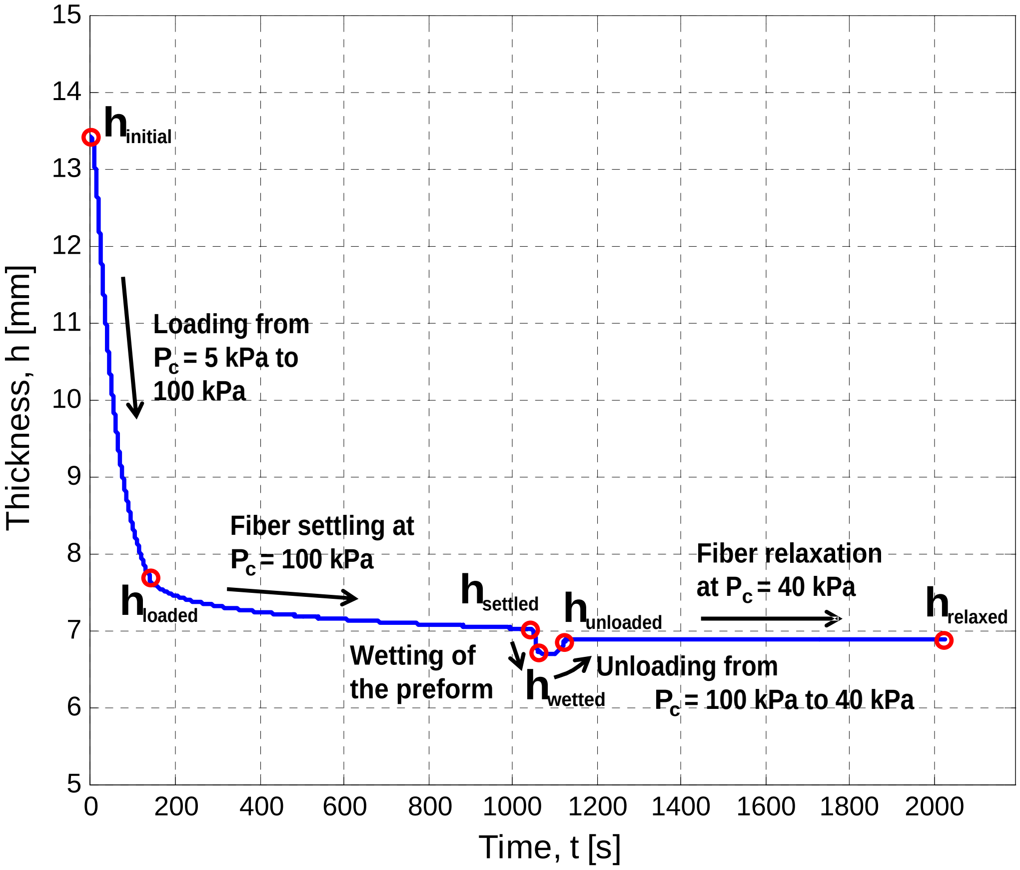


Figure 3.3. A typical compaction characterization experiment in which the compaction pressure is P_c = 40 kPa during the relaxation stage (which takes place after the unloading stage).

Experimental results are plotted in the following figures: 1C and 2C in Figure 3.4, 4F in Figure 8, 2F/1C/2F in Figure 3.6, and 2F/1C/4F/1C/2F in Figure 3.7, where F represents fabric types (R, W and B) and C represents the core distribution medium. For each case, the four characterization stages were plotted: h vs. P_c during loading; h vs. t during fiber settling at 100 kPa; h vs. P_c during unloading; and h vs. t during fiber relaxation at 2 kPa. Percentage fiber volume fraction, $V_f = 100\, n\left(\rho_{\mathrm{sup}} / \rho_{fiber}\right)(1/h)$ was used on the right-hand vertical axis in each graph. Here, n is the number of fabric layers in the preform, ρ_{sup} and ρ_{fiber} are the superficial (surface) density of the fabric per layer and density of glass fibers, respectively. ρ_{sup} values are tabulated in Figure 1.2 and ρ_{fiber} is taken as 2540 kg/m^3. h, V_f, Δh and ΔV_f values corresponding to different stages of the compaction experiments are tabulated for each fabric configuration in Tables 3.1 and 3.2.

PREFORM	$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
1C	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2C	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4R	25.16 ± 1.40	40.60 ± 2.00	44.42 ± 2.44	48.92 ± 2.78	43.35 ± 1.78	35.09 ± 2.32	15.44 ± 2.15	3.82 ± 0.65	4.50 ± 1.24	-5.57 ± 1.71	-8.26 ± 1.34
2R/1C/2R	11.43 ± 0.69	22.47 ± 1.93	24.61 ± 2.06	26.08 ± 2.14	20.59 ± 1.55	14.64 ± 0.94	11.04 ± 1.37	2.14 ± 0.18	1.47 ± 0.19	-5.49 ± 0.71	-5.95 ± 0.69
2R/1C/4R/1C/2R	12.02 ± 0.95	22.75 ± 2.02	24.79 ± 2.29	25.91 ± 2.38	20.89 ± 2.09	15.15 ± 1.42	10.73 ± 1.57	2.04 ± 0.32	1.13 ± 0.20	-5.02 ± 0.56	-5.74 ± 0.77
4W	39.68 ± 1.25	51.06 ± 1.50	52.29 ± 1.61	52.90 ± 1.85	49.72 ± 1.32	44.01 ± 2.56	11.38 ± 1.26	1.23 ± 0.29	0.61 ± 0.82	-3.18 ± 1.36	-5.72 ± 1.62
2W/1C/2W	15.69 ± 0.78	28.76 ± 1.24	30.18 ± 1.27	30.34 ± 1.28	25.57 ± 0.95	18.30 ± 0.67	13.07 ± 0.80	1.42 ± 0.16	0.16 ± 0.05	-4.77 ± 0.58	-7.28 ± 0.63
2W/1C/4W/1C/2W	15.22 ± 0.76	29.36 ± 1.61	30.85 ± 1.65	31.05 ± 1.67	26.16 ± 1.20	18.89 ± 0.82	14.14 ± 1.19	1.49 ± 0.17	0.20 ± 0.06	-4.89 ± 0.73	-7.26 ± 0.85
4B	36.83 ± 0.66	49.70 ± 1.45	51.21 ± 1.55	53.42 ± 1.63	48.33 ± 1.17	41.08 ± 0.67	12.87 ± 1.24	1.50 ± 0.17	2.21 ± 0.47	-5.09 ± 0.65	-7.25 ± 0.85
2B/1C/2B	19.12 ± 1.32	31.42 ± 1.42	32.96 ± 1.29	33.42 ± 1.32	28.71 ± 1.48	22.59 ± 1.31	12.31 ± 1.15	1.53 ± 0.24	0.46 ± 0.11	-4.70 ± 0.39	-6.12 ± 0.36
2B/1C/4B/1C/2B	18.62 ± 0.65	31.14 ± 0.98	32.58 ± 1.03	33.17 ± 1.14	28.84 ± 1.10	22.90 ± 1.60	12.52 ± 0.95	1.44 ± 0.20	0.59 ± 0.17	-4.33 ± 1.01	-5.94 ± 0.98

Table 3.2 Fiber volume fraction, V_f and its change for the experiments tabulated in Table 1.
All V_f values are in [%]. The averages and the standard deviations were calculated using the ten values in each experimental set, not using $h_{average} \pm \sigma$.

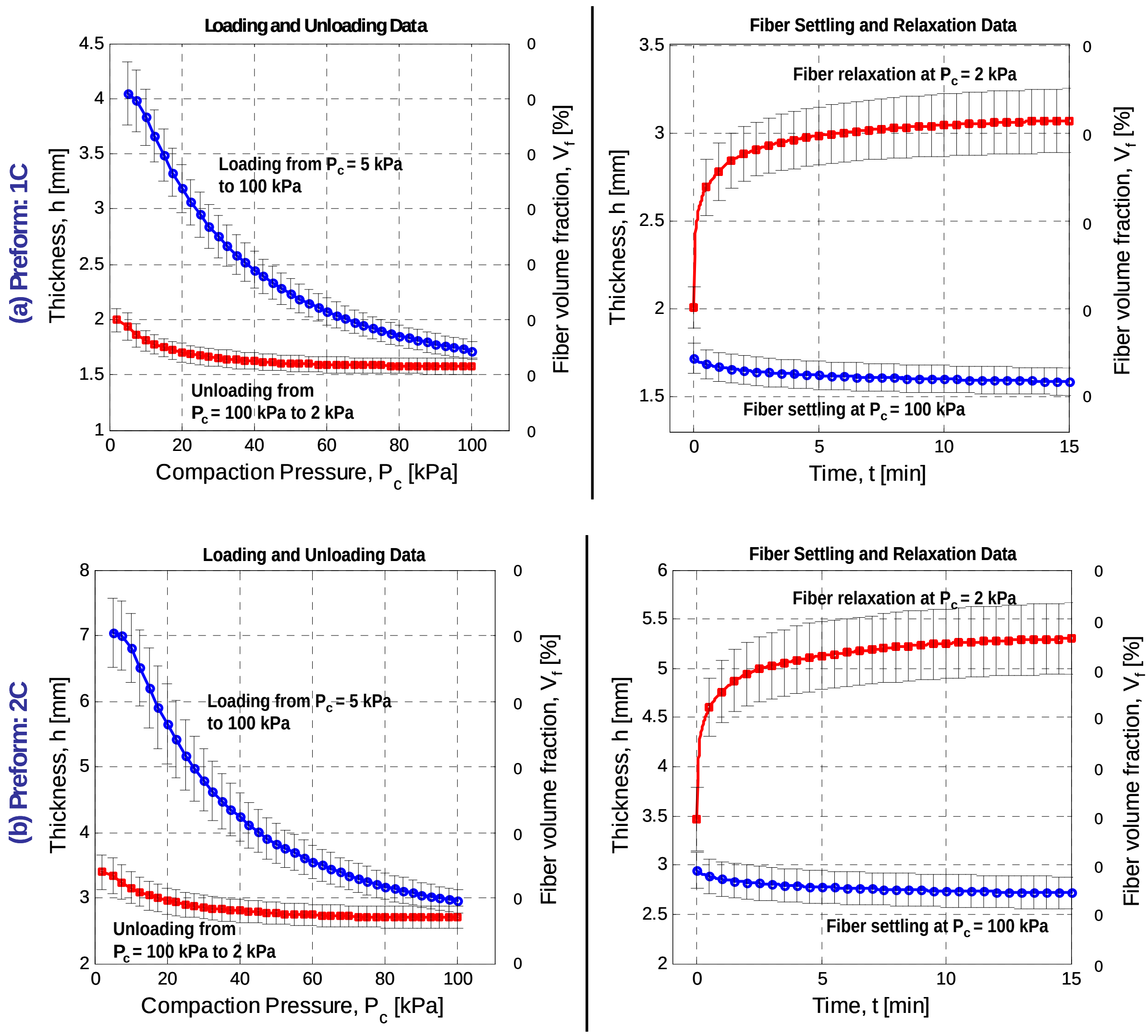


Figure 3.4. Compaction characterization test results for CORE only: (a) one layer core, 1C, and (b) two layers of core, 2C. In each case, one experiment was done on each of the ten separate specimens. The averages are shown with solid lines and the standard deviations of the experiments are shown with error bars.

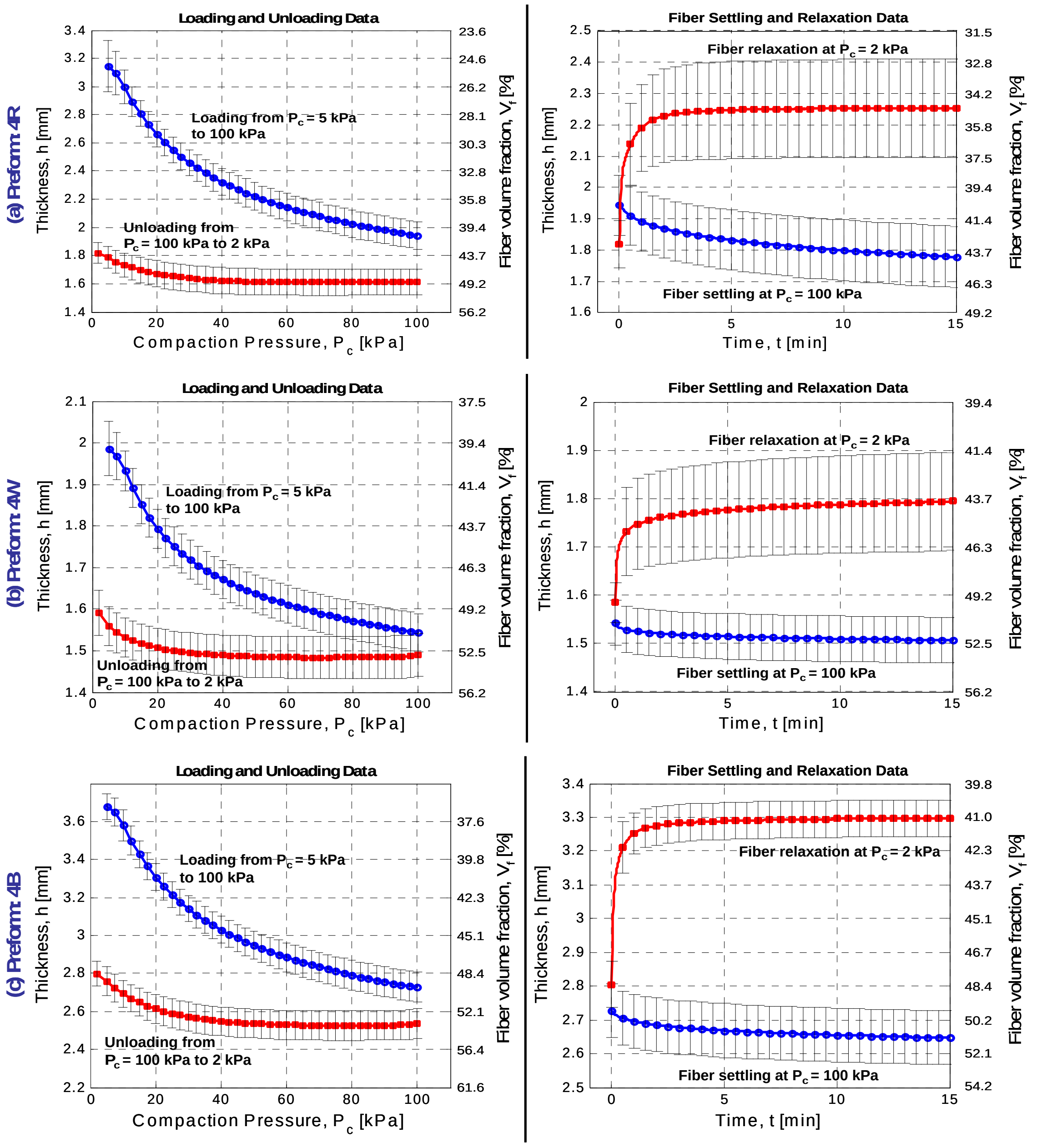


Figure 3.5. Compaction characterization test results for four layers of FABRICS only: (a) 4R, (b) 4W, and (c) 4B.

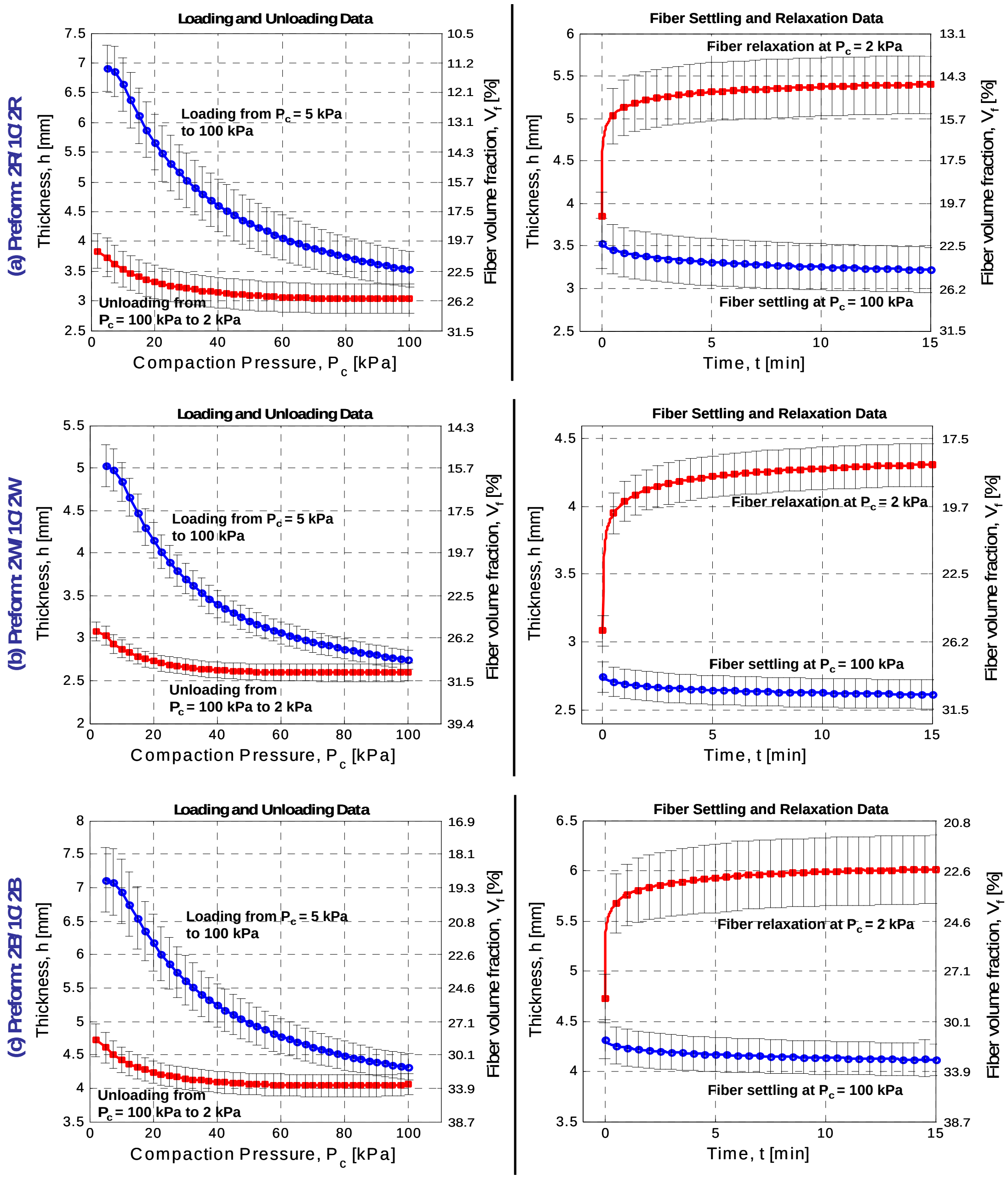


Figure 3.6. Compaction characterization test results for one layer of core embedded in four layers of FABRICS: (a) 2R/1C/2R, (b) 2W/1C/2W, and (c) 2B/1C/2B.

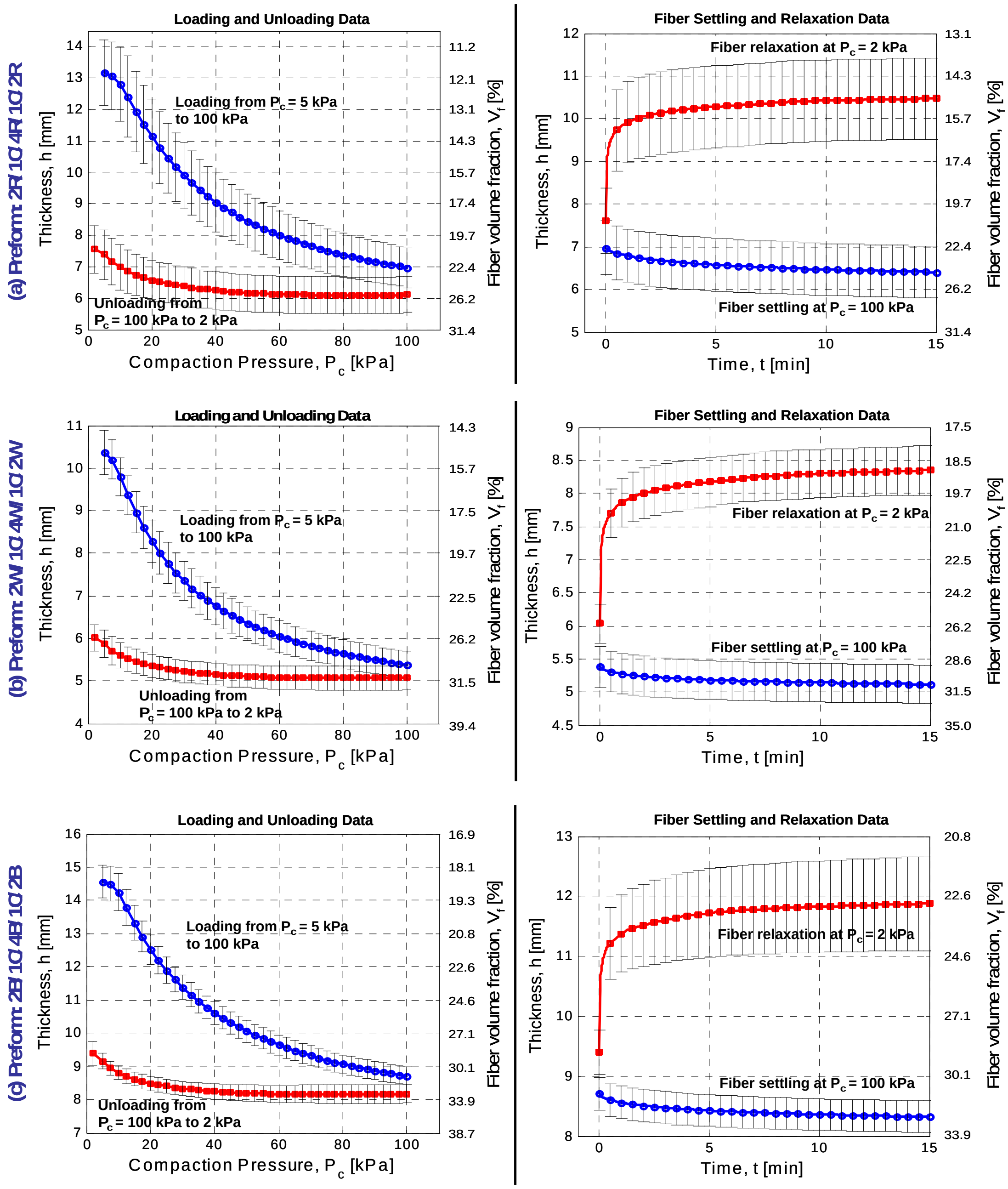


Figure 3.7. Compaction characterization test results for two layers of core embedded in eight layers of FABRICS: (a) 2R/1C/4R/1C/2R, (b) 2W/1C/4W/1C/2W,and (c) 2B/1C/4B/1C/2B.

Since the core polypropylene distribution medium does not contribute to the reinforcing of a composite part, V_f is zero in 1C and 2C experiments as shown in Figure 3.4; and this embedded core is the cause why 2F/1C/2F and 2F/1C/4F/1C/2F preforms have much lower V_f than 4F preforms. The maximum V_f is $V_{f,fiberwet}$ which is achieved after the fiber wetting stage. The average $V_{f,fiberwet}$ is 48.9, 52.9 and 53.4 % for 4R, 4W and 4B preforms, respectively. When one layer of core is embedded in these four layers of fabrics (2F/1C/2F), $V_{f,fiberwet}$ can become only 26.1, 30.3 and 33.4 % for random, woven and biaxial preforms, respectively. When two layers of core are embedded in eight layers of fabrics (2F/1C/4F/1C/2F), $V_{f,fiberwet}$ can become 25.9, 31.5 and 33.2 % for random, woven and biaxial preforms, respectively, which are approximately equal to the corresponding values in the 2F/1C/2F cases.

The following compaction characterization data of Table 3.1 essentially affect the results of a coupled compaction/flow modeling of the VI process such as [10,11]: (1) $h_{settlec} \pm \sigma_{settled}$ which determines the thickness distribution in the dry preform just before the resin infusion is begun. (2) The change in the preform thickness until the gelation is $\Delta h = \Delta h_{wetting} + \Delta h_{unloading} + \Delta h_{relaxation}$. These values are applicable only if the pre-infusion vacuuming is done for 15 minutes, and the pot life (gelation time) of the resin is adjusted to 17 minutes (corresponding to 2 minutes of the unloading + 15 minutes of the fiber relaxation of the characterization experiments). If these stages last shorter than the durations mentioned above, then the user of the database should refer to Figures 3.4-3.7 instead of the values in Table 3.1.

The relaxation experiments were conducted as explained earlier in Figure 1.3. The results at $P_{c,final}$ = 80, 60, 40, 20, 10 and 2 kPa are shown in Figures 3.8-3.10 for the random, woven and biaxial fabric preforms with a configuration of 2F/1C/4F/1C/2F. Although the fabric types have different quantitative thickness and fiber volume fraction values during the relaxation stage, there are some qualitative similarities. At the high compaction pressure of P_c = 80 kPa, no fiber relaxation is observed. Indeed, the fiber settling continues as shown in part (a) of Figures 3.7-3.10 where the part thickness decreases with time. At the other compaction pressures (60, 40, 20, 10 and 2 kPa), thickness increases with time, however with different rates of change of thickness, $\partial h / \partial t$. At both P_c = 60 and 40 kPa, there is an initial immediate increase in h, which was explained as "spring-back" in [21,22] for suddenly unloaded specimens, and $\partial h / \partial t$ is insignificant afterwards. When the compaction pressure is 20 kPa or less, the immediate "spring-back" causes different order of magnitude in Δh, and h does not reach a steady value in 15 minutes. This slow response was also observed in the "time-dependent" deformation range in [23].

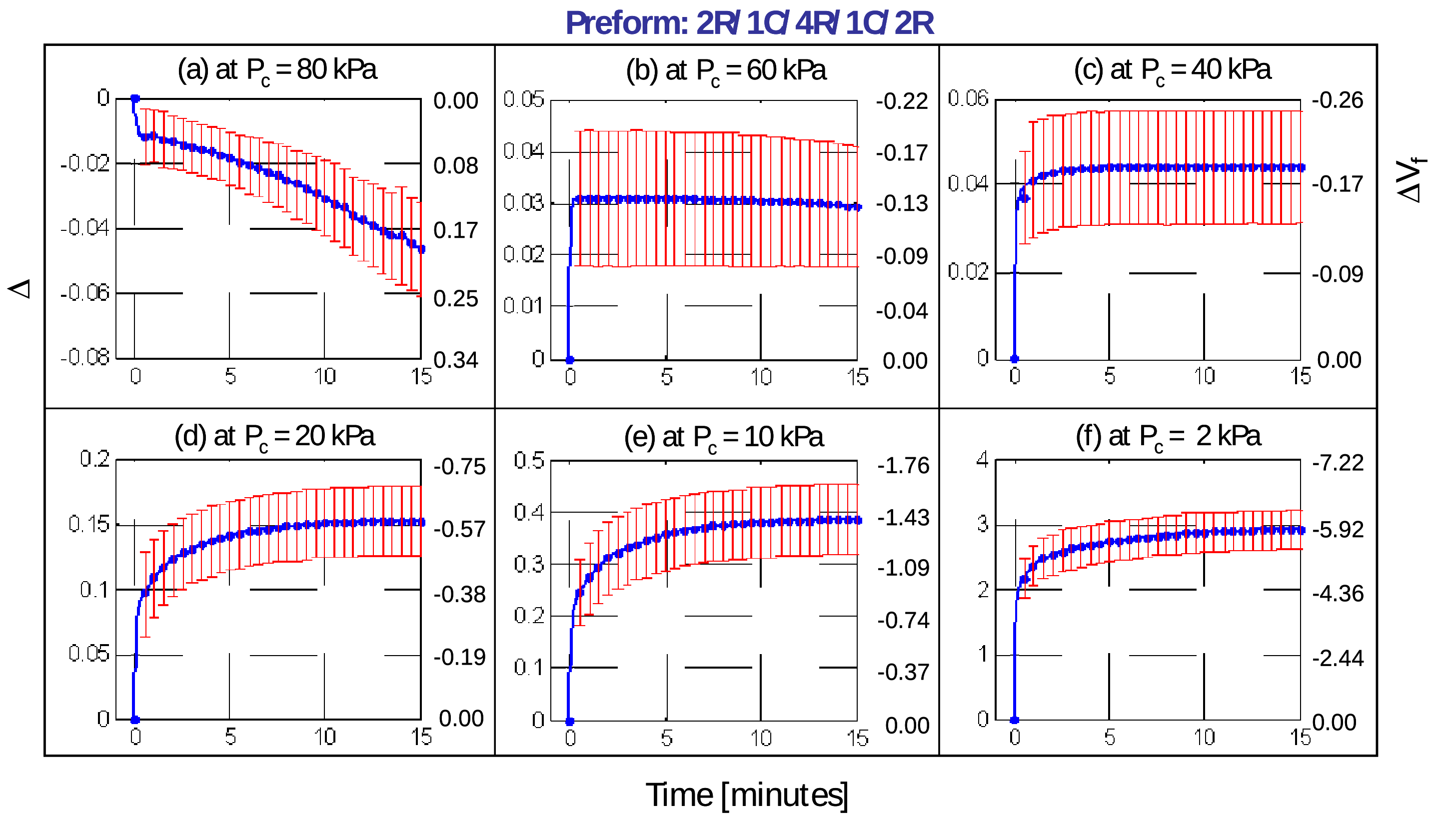


Figure 3.8. Fiber relaxation during compaction characterization tests for two layers of core embedded in eight layers of RANDOM FABRIC: 2R/1C/4R/1C/2R. Ten different relaxation experiments were carried out at each different compaction pressure: (a) Pc = 80 kPa, (b) Pc = 60 kPa, ... , (e) Pc = 2 kPa.

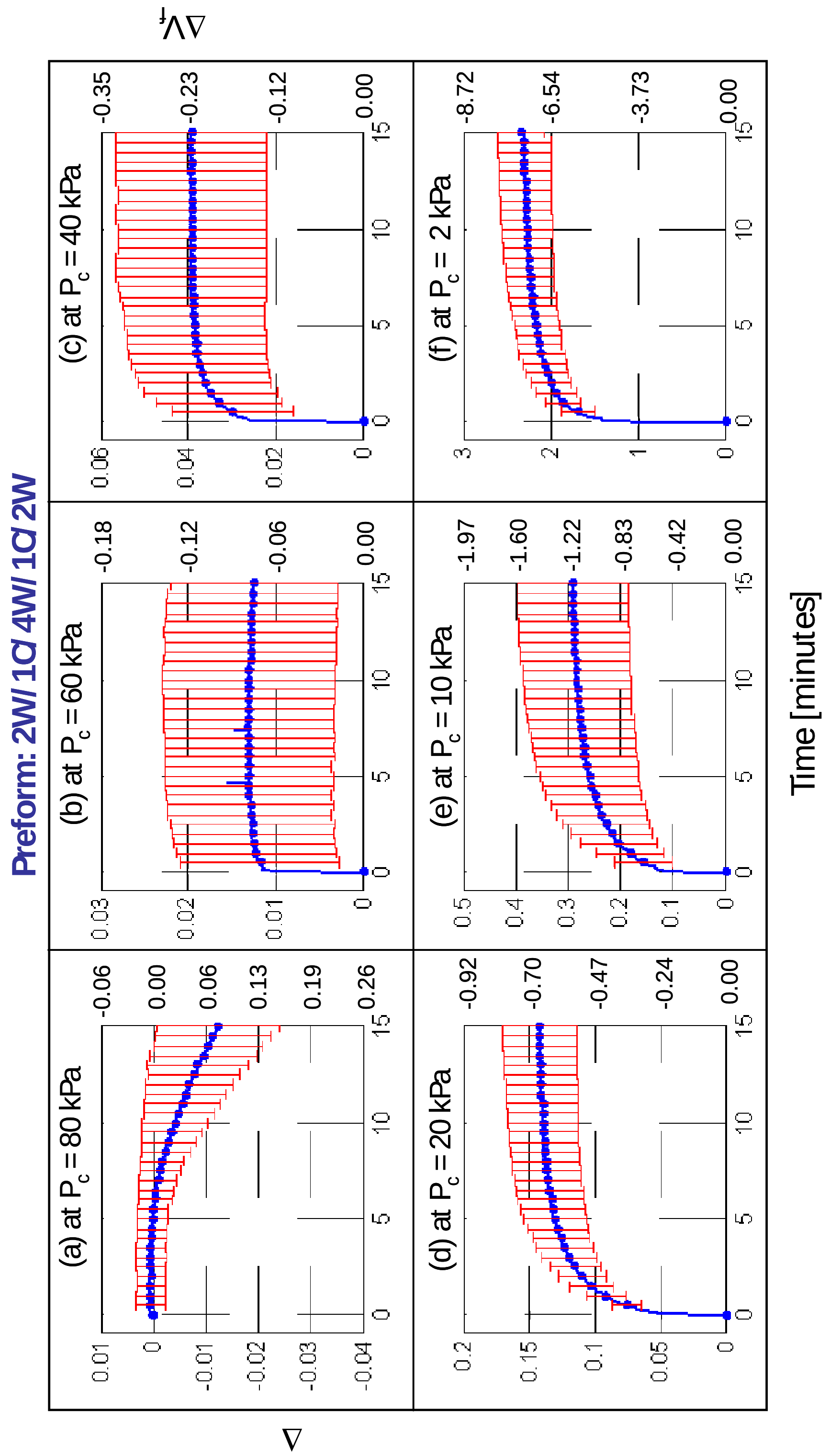


Figure 3.9. Fiber relaxation during compaction characterization tests for two layers of core

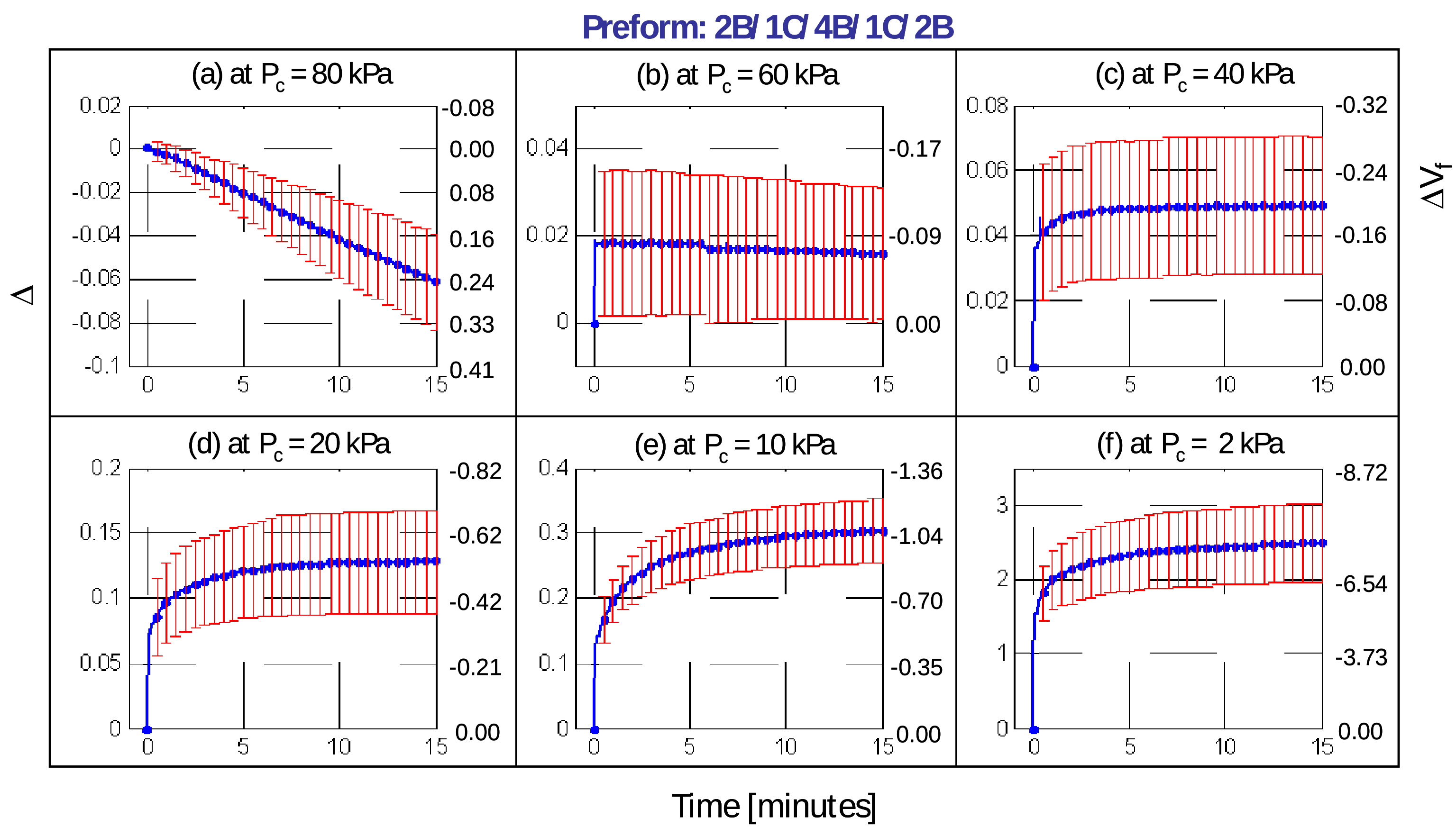


Figure 3.10. Fiber relaxation during compaction characterization tests for two layers of core embedded in eight layers of BIAXIAL FABRIC: 2B/ 1C/ 4B/ 1C/ 2B. Ten different relaxation experiments were carried out at each different compaction pressure: (a) Pc = 80 kPa, (b) Pc = 60 kPa, ... , (e) Pc = 2 kPa.

Chapter 4

SUMMARY AND CONCLUSION

An experimental procedure was designed to characterize the compaction of e-glass fabrics during the following stages: (1) loading (compaction from 5 kPa to 100 kPa), (2) fiber settling (for 15 minutes at constant compaction pressure of 100 kPa), (3) saturation of the preform (with actual thermoset polyester resin at 100 kPa), (4) unloading (decompaction from 100 kPa to $P_{c,final}$), and (5) fiber relaxation at $P_{c,final}$ for 15 minutes. These stages resemble different stages of the VI process: (1,2) vacuuming before the resin infusion, (3) arrival of the resin to a particular preform location of interest, (4) thickening of the preform due to the change in the local resin pressure, (5) thickening of the preform due to time-dependent fiber relaxation.

Just upon being wetted at constant full compaction pressure, significant decrease in the thickness was observed for the random fabric; and this is in agreement with the observations in [24]. However this characteristic is not valid for the woven and biaxial fabrics and the polypropylene distribution medium. The early stage of the unloading yielded a very insignificant change in the thicknesses of all fabric types used; the thickness increased notably only when the compaction pressure was half a bar or less.

To cover the major domain of compaction pressures at which the preforms may undergo relaxation stages, the relaxation experiments were performed at $P_{c,final}$ = 80, 60, 40, 20, 10 and 2 kPa. Very different relaxation behaviors at different $P_{c,final}$ indicate that coupled compaction-mold filling models based on a static relationship between thickness and compaction pressure do not appropriately simulate the actual compaction/decompaction physics of VI. Thus, a time-dependent relationship should be used to realistically model the process.

The experimental procedure designed in this study enables to realistically characterize the compaction/decompaction of fabric preforms in the VI process. The approach is different from the previous studies due to the following items: (i) the compaction pressure is the independent variable, and the part thickness is the dependent variable which is measured during the test; (ii) the test has the following stages: loading, fiber settling, wetting, unloading and fiber relaxation. The first two stages are performed on a dry specimen, and then it is saturated with resin afterwards. The database constructed in this study shows that, different fabric types have different compaction and relaxation behavior, therefore the process model should have the database for the fabric type and configuration used in the actual VI process instead of a generic fabric type. The two sandwich configurations (2F/1C/2F and 2F/1C/4F/1C/2F) suggest that the thickness is almost linearly proportional with the number of layers used (or, fiber volume fractions are almost the same). For the three fabric types used here, single sandwich configuration may be sufficient to estimate the behavior of multilayer configurations assuming that the fabric preform is manufactured symmetrically. Using core material significantly decreases the effective fiber volume fraction, thus the mechanical properties are expected to be influenced. Since the relaxation is not linearly dependent on the compaction pressure, the relaxation behavior at different relaxation pressures should be carefully investigated as done in this study, and used in the process model.

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VITA

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APPENDIX A

COMPACTION EXPERIMENTS:

1C	1 layer core
2C	2 layer score
4R	4 layers random
4W	4 layers woven
4B	4 layers biaxial
2R/1C/2R	2 layers random, 1 layer core and 2 layers random
2W/1C/2W	2 layers woven, 1 layer core and 2 layers woven
2B/1C/2B	2 layers biaxial, 1 layer core and 2 layers biaxial
2R/1C/4R/1C/2R	2 layers random, 1 layer core, 4 layers random, 1 layer core and 2 layers random
2W/1C/4W/1C/2W	2 layers woven, 1 layer core, 4 layers woven, 1 layer core and 2 layers woven
2B/1C/4B/1C/2B	2 layers biaxial, 1 layer core, 4 layers biaxial, 1 layer core and 2 layers biaxial

All h values are in [mm].

1C

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	156	4.23	1.62	1.49	1.49	1.83	3.11	-2.61	-0.13	-0.00	0.34	1.28
Exp.	157	4.23	1.81	1.67	1.67	2.17	3.31	-2.42	-0.15	-0.00	0.50	1.15
Exp.	159	4.60	1.87	1.70	1.70	2.22	3.38	-2.73	-0.16	-0.00	0.52	1.16
Exp.	160	3.98	1.73	1.57	1.57	2.02	2.95	-2.25	-0.16	-0.00	0.45	0.93
Exp.	195	4.13	1.78	1.66	1.65	2.03	3.21	-2.34	-0.13	-0.01	0.38	1.17
Exp.	197	4.08	1.73	1.59	1.59	2.05	3.08	-2.35	-0.14	-0.00	0.46	1.03
Exp.	198	3.81	1.59	1.46	1.46	1.87	2.91	-2.22	-0.13	-0.00	0.41	1.04
Exp.	216	4.06	1.65	1.54	1.55	1.98	2.96	-2.41	-0.11	0.01	0.43	0.98
Exp.	219	3.73	1.69	1.57	1.57	1.94	2.83	-2.04	-0.13	-0.00	0.37	0.90
Exp.	324	3.60	1.71	1.59	1.59	1.95	2.94	-1.88	-0.12	-0.00	0.36	0.99
Exp.	0	4.04	1.72	1.59	1.58	2.01	3.07	-2.33	-0.13	-0.00	0.42	1.06
AVERAGES for h:												
Exp.	0	4.04	1.72	1.59	1.58	2.01	3.07	-2.33	-0.13	-0.00	0.42	1.06
STANDARD DEVIATIONS for h:												
Exp.	0	0.29	0.09	0.08	0.07	0.12	0.18	0.25	0.02	0.00	0.06	0.12

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	156	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	157	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	159	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	160	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	195	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	197	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	219	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	324	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGES for Vf:												
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2C

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	138	7.13	2.91	2.68	2.67	3.91	5.57	-4.22	-0.23	-0.01	1.24	1.65
Exp.	140	6.81	2.70	2.49	2.48	3.17	4.92	-4.11	-0.21	-0.01	0.69	1.76
Exp.	141	7.45	2.81	2.53	2.52	3.05	5.03	-4.64	-0.28	-0.00	0.53	1.98
Exp.	142	7.06	3.02	2.77	2.75	3.81	5.57	-4.05	-0.25	-0.02	1.06	1.76
Exp.	143	7.27	3.02	2.73	2.72	3.37	5.34	-4.25	-0.29	-0.01	0.65	1.97
Exp.	144	7.29	2.95	2.72	2.71	3.45	5.60	-4.34	-0.23	-0.01	0.74	2.15
Exp.	147	7.58	3.37	3.10	3.09	3.94	5.83	-4.21	-0.27	-0.01	0.85	1.89
Exp.	148	7.54	3.01	2.77	2.74	3.57	5.47	-4.53	-0.24	-0.03	0.83	1.90
Exp.	325	6.18	2.89	2.71	2.71	3.25	4.95	-3.29	-0.18	-0.01	0.55	1.69
Exp.	326	6.07	2.84	2.69	2.68	3.21	4.75	-3.23	-0.15	-0.00	0.52	1.55
Exp.	0	7.04	2.95	2.72	2.71	3.47	5.30	-4.09	-0.23	-0.01	0.77	1.83
AVERAGES for h:												
Exp.	0	7.04	2.95	2.72	2.71	3.47	5.30	-4.09	-0.23	-0.01	0.77	1.83
STANDARD DEVIATIONS for h:												
Exp.	0	0.53	0.18	0.16	0.16	0.32	0.36	0.47	0.04	0.01	0.24	0.18

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	138	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	142	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	144	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	147	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	148	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	325	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	326	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGES for Vf:												
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4R

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	71	2.94	2.07	1.90	1.65	1.83	2.27	-0.87	-0.17	-0.25	0.18	0.44
Exp.	91	3.04	1.95	1.84	1.76	1.83	2.10	-1.08	-0.12	-0.08	0.08	0.27
Exp.	110	3.47	2.09	1.90	1.73	1.92	2.54	-1.38	-0.20	-0.17	0.19	0.62
Exp.	118	2.97	1.83	1.67	1.52	1.78	2.16	-1.14	-0.16	-0.15	0.26	0.38
Exp.	128	3.16	2.01	1.85	1.69	1.94	2.50	-1.15	-0.16	-0.16	0.26	0.56
Exp.	130	3.43	1.86	1.68	1.56	1.79	2.23	-1.57	-0.18	-0.11	0.22	0.45
Exp.	151	3.14	1.98	1.84	1.63	1.79	2.27	-1.16	-0.15	-0.21	0.17	0.48
Exp.	153	3.04	1.89	1.72	1.53	1.73	2.16	-1.15	-0.17	-0.19	0.20	0.43
Exp.	154	3.18	1.94	1.75	1.61	1.88	2.22	-1.24	-0.18	-0.15	0.27	0.35
Exp.	155	3.02	1.81	1.64	1.48	1.71	2.07	-1.21	-0.17	-0.16	0.23	0.36
Exp.	0	3.14	1.94	1.78	1.61	1.82	2.25	-1.20	-0.17	-0.16	0.20	0.43
AVERAGES for h:												
Exp.	0	3.14	1.94	1.78	1.61	1.82	2.25	-1.20	-0.17	-0.16	0.20	0.43
STANDARD DEVIATIONS for h:												
Exp.	0	0.18	0.10	0.10	0.09	0.08	0.16	0.18	0.02	0.05	0.06	0.10

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	71	26.75	38.04	41.52	47.78	43.14	34.75	11.30	3.48	6.26	-4.64	-8.39
Exp.	91	25.94	40.31	42.88	44.87	43.00	37.43	14.37	2.57	1.99	-1.87	-5.57
Exp.	110	22.68	37.61	41.47	45.57	41.01	30.97	14.93	3.86	4.10	-4.56	-10.04
Exp.	118	26.52	42.95	47.14	51.81	44.33	36.45	16.43	4.20	4.67	-7.48	-7.88
Exp.	128	24.94	39.24	42.65	46.70	40.54	31.46	14.31	3.41	4.05	-6.16	-9.08
Exp.	130	22.94	42.38	47.00	50.43	44.08	35.29	19.45	4.61	3.43	-6.34	-8.79
Exp.	151	25.09	39.71	42.89	48.40	43.94	34.66	14.62	3.18	5.51	-4.46	-9.28
Exp.	153	25.88	41.58	45.81	51.42	45.49	36.44	15.70	4.23	5.61	-5.93	-9.05
Exp.	154	24.80	40.66	44.87	48.99	41.99	35.40	15.86	4.21	4.12	-7.00	-6.59
Exp.	155	26.05	43.48	47.97	53.23	45.96	38.05	17.43	4.49	5.25	-7.27	-7.91
Exp.	0	25.08	40.51	44.30	48.78	43.28	34.94	15.42	3.79	4.48	-5.50	-8.34
AVERAGES for Vf:												
Exp.	0	25.16	40.60	44.42	48.92	43.35	35.09	15.44	3.82	4.50	-5.57	-8.26
STANDARD DEVIATIONS for Vf:												
Exp.	0	1.40	2.00	2.44	2.78	1.78	2.32	2.15	0.65	1.24	1.71	1.34

4W

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	292	1.91	1.50	1.46	1.47	1.59	1.84	-0.42	-0.03	0.01	0.11	0.25
Exp.	293	1.98	1.51	1.48	1.48	1.64	1.87	-0.47	-0.03	0.00	0.16	0.24
Exp.	294	2.00	1.55	1.51	1.48	1.53	1.58	-0.45	-0.05	-0.03	0.05	0.06
Exp.	295	1.98	1.54	1.51	1.50	1.60	1.80	-0.44	-0.04	-0.01	0.10	0.20
Exp.	296	1.92	1.49	1.45	1.40	1.54	1.76	-0.43	-0.05	-0.05	0.14	0.23
Exp.	297	2.02	1.58	1.54	1.54	1.64	1.86	-0.44	-0.04	0.01	0.09	0.22
Exp.	298	2.00	1.64	1.60	1.58	1.64	1.95	-0.36	-0.04	-0.02	0.05	0.32
Exp.	299	2.14	1.57	1.53	1.47	1.54	1.71	-0.58	-0.03	-0.06	0.07	0.17
Exp.	300	1.96	1.55	1.54	1.53	1.58	1.76	-0.41	-0.02	-0.01	0.05	0.18
Exp.	311	1.94	1.50	1.46	1.44	1.56	1.80	-0.44	-0.04	-0.02	0.12	0.23
Exp.	0	1.99	1.54	1.51	1.49	1.58	1.79	-0.44	-0.04	-0.02	0.09	0.21
AVERAGES for h:												
Exp.	0	1.99	1.54	1.51	1.49	1.58	1.79	-0.44	-0.04	-0.02	0.09	0.21
STANDARD DEVIATIONS for h:												
Exp.	0	0.06	0.05	0.05	0.05	0.04	0.10	0.05	0.01	0.02	0.04	0.07

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	292	41.16	52.60	53.78	53.41	49.61	42.79	11.44	1.18	-0.36	-3.80	-6.82
Exp.	293	39.71	52.09	53.30	53.23	48.09	42.03	12.37	1.22	-0.07	-5.14	-6.06
Exp.	294	39.38	50.69	52.23	53.16	51.51	49.70	11.32	1.54	0.93	-1.64	-1.81
Exp.	295	39.77	51.01	52.25	52.53	49.20	43.79	11.25	1.24	0.28	-3.33	-5.41
Exp.	296	40.99	52.83	54.48	56.29	51.27	44.62	11.83	1.65	1.81	-5.02	-6.65
Exp.	297	38.99	49.88	51.19	51.01	48.12	42.41	10.88	1.31	-0.18	-2.88	-5.71
Exp.	298	39.33	48.02	49.15	49.75	48.16	40.28	8.69	1.13	0.60	-1.59	-7.88
Exp.	299	36.78	50.28	51.42	53.51	51.00	45.95	13.50	1.14	2.09	-2.51	-5.05
Exp.	300	40.16	50.72	51.27	51.52	49.88	44.67	10.55	0.55	0.25	-1.65	-5.21
Exp.	311	40.55	52.52	53.87	54.63	50.37	43.82	11.97	1.35	0.77	-4.26	-6.55
Exp.	0	39.65	51.02	52.25	52.85	49.69	43.88	11.38	1.23	0.60	-3.16	-5.81
AVERAGES for Vf:												
Exp.	0	39.68	51.06	52.29	52.90	49.72	44.01	11.38	1.23	0.61	-3.18	-5.72
STANDARD DEVIATIONS for Vf:												
Exp.	0	1.25	1.50	1.61	1.85	1.32	2.56	1.26	0.29	0.82	1.36	1.62

4B

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	240	3.68	2.72	2.64	2.50	2.75	3.25	-0.95	-0.08	-0.14	0.25	0.50
Exp.	241	3.66	2.60	2.51	2.40	2.72	3.26	-1.06	-0.08	-0.11	0.32	0.54
Exp.	242	3.61	2.64	2.57	2.49	2.76	3.24	-0.97	-0.07	-0.08	0.27	0.49
Exp.	243	3.77	2.70	2.61	2.49	2.76	3.33	-1.08	-0.09	-0.12	0.26	0.58
Exp.	244	3.76	2.79	2.71	2.61	2.85	3.39	-0.96	-0.08	-0.11	0.25	0.53
Exp.	245	3.60	2.67	2.58	2.49	2.75	3.23	-0.94	-0.08	-0.09	0.25	0.48
Exp.	246	3.62	2.76	2.67	2.56	2.80	3.32	-0.87	-0.09	-0.11	0.24	0.52
Exp.	247	3.74	2.83	2.75	2.60	2.88	3.34	-0.91	-0.07	-0.15	0.28	0.46
Exp.	248	3.62	2.74	2.67	2.56	2.85	3.27	-0.88	-0.07	-0.11	0.30	0.42
Exp.	249	3.73	2.84	2.75	2.67	2.92	3.35	-0.89	-0.08	-0.08	0.25	0.43
Exp.	0	3.68	2.73	2.65	2.54	2.80	3.30	-0.95	-0.08	-0.11	0.27	0.49
AVERAGES for h:												
Exp.	0	3.68	2.73	2.65	2.54	2.80	3.30	-0.95	-0.08	-0.11	0.27	0.49
STANDARD DEVIATIONS for h:												
Exp.	0	0.07	0.08	0.08	0.08	0.07	0.05	0.07	0.01	0.02	0.02	0.05

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	240	36.83	49.71	51.22	54.16	49.23	41.69	12.88	1.51	2.93	-4.92	-7.55
Exp.	241	37.04	52.16	53.92	56.35	49.76	41.49	15.12	1.76	2.43	-6.59	-8.27
Exp.	242	37.52	51.32	52.67	54.43	49.14	41.76	13.80	1.35	1.76	-5.29	-7.38
Exp.	243	35.89	50.22	51.94	54.35	49.15	40.66	14.34	1.72	2.41	-5.20	-8.49
Exp.	244	36.06	48.49	49.92	51.94	47.45	39.99	12.43	1.43	2.03	-4.50	-7.45
Exp.	245	37.60	50.81	52.47	54.34	49.30	41.99	13.22	1.65	1.87	-5.03	-7.31
Exp.	246	37.37	49.12	50.69	52.92	48.37	40.83	11.76	1.56	2.23	-4.55	-7.54
Exp.	247	36.25	47.94	49.22	52.06	47.04	40.52	11.69	1.28	2.84	-5.02	-6.52
Exp.	248	37.46	49.50	50.82	53.00	47.48	41.40	12.04	1.32	2.18	-5.52	-6.08
Exp.	249	36.33	47.76	49.22	50.64	46.34	40.44	11.43	1.45	1.43	-4.30	-5.90
Exp.	0	36.82	49.67	51.17	53.37	48.30	41.07	12.84	1.50	2.21	-5.07	-7.23
AVERAGES for Vf:												
Exp.	0	36.83	49.70	51.21	53.42	48.33	41.08	12.87	1.50	2.21	-5.09	-7.25
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.66	1.45	1.55	1.63	1.17	0.67	1.24	0.17	0.47	0.65	0.85

2R/1C/2R

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	331	6.76	3.28	2.98	2.79	3.58	5.16	-3.49	-0.30	-0.18	0.79	1.58
Exp.	338	7.10	3.70	3.37	3.21	4.01	5.74	-3.40	-0.33	-0.16	0.80	1.73
Exp.	398	6.86	3.38	3.10	2.93	3.71	5.22	-3.48	-0.29	-0.17	0.78	1.51
Exp.	399	6.97	3.35	3.04	2.88	3.66	5.19	-3.62	-0.31	-0.16	0.78	1.54
Exp.	403	7.33	3.65	3.35	3.19	4.06	5.74	-3.68	-0.30	-0.16	0.87	1.68
Exp.	404	6.07	3.06	2.81	2.66	3.42	4.86	-3.01	-0.25	-0.15	0.76	1.44
Exp.	405	7.31	3.81	3.49	3.25	3.92	5.57	-3.51	-0.32	-0.24	0.67	1.64
Exp.	406	6.48	3.26	2.99	2.83	3.61	5.04	-3.22	-0.27	-0.16	0.78	1.43
Exp.	407	7.08	3.83	3.47	3.25	4.15	5.64	-3.25	-0.36	-0.22	0.90	1.49
Exp.	408	7.15	3.95	3.59	3.38	4.33	5.82	-3.20	-0.36	-0.22	0.95	1.49
Exp.	0	6.91	3.53	3.22	3.04	3.84	5.40	-3.38	-0.31	-0.18	0.81	1.55
AVERAGES for h:												
Exp.	0	6.91	3.53	3.22	3.04	3.84	5.40	-3.38	-0.31	-0.18	0.81	1.55
STANDARD DEVIATIONS for h:												
Exp.	0	0.39	0.30	0.27	0.25	0.29	0.34	0.21	0.04	0.03	0.08	0.10

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	331	11.64	24.02	26.46	28.19	21.97	15.25	12.38	2.44	1.73	-6.21	-6.72
Exp.	338	11.10	21.29	23.35	24.51	19.62	13.71	10.19	2.07	1.16	-4.89	-5.91
Exp.	398	11.48	23.26	25.42	26.87	21.22	15.09	11.79	2.16	1.45	-5.65	-6.14
Exp.	399	11.30	23.52	25.88	27.34	21.53	15.16	12.21	2.36	1.46	-5.81	-6.36
Exp.	403	10.74	21.56	23.51	24.67	19.41	13.71	10.82	1.95	1.16	-5.26	-5.70
Exp.	404	12.98	25.75	28.02	29.63	23.03	16.19	12.77	2.27	1.61	-6.60	-6.84
Exp.	405	10.76	20.68	22.56	24.23	20.07	14.14	9.91	1.88	1.67	-4.16	-5.93
Exp.	406	12.15	24.16	26.33	27.84	21.84	15.63	12.02	2.17	1.51	-6.00	-6.21
Exp.	407	11.12	20.55	22.69	24.21	18.98	13.95	9.43	2.14	1.52	-5.23	-5.02
Exp.	408	11.01	19.92	21.92	23.33	18.19	13.53	8.91	2.00	1.41	-5.14	-4.67
Exp.	0	11.39	22.32	24.46	25.93	20.48	14.58	10.93	2.14	1.47	-5.45	-5.90
AVERAGES for Vf:												
Exp.	0	11.43	22.47	24.61	26.08	20.59	14.64	11.04	2.14	1.47	-5.49	-5.95
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.69	1.93	2.06	2.14	1.55	0.94	1.37	0.18	0.19	0.71	0.69

2W/1C/2W

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	301	4.72	2.48	2.38	2.37	2.87	4.08	-2.24	-0.10	-0.01	0.50	1.21
Exp.	302	5.22	2.74	2.62	2.61	3.05	4.39	-2.48	-0.12	-0.01	0.44	1.34
Exp.	303	4.74	2.72	2.60	2.59	3.05	4.16	-2.02	-0.12	-0.01	0.45	1.12
Exp.	304	5.15	2.78	2.62	2.60	3.12	4.37	-2.38	-0.16	-0.02	0.52	1.25
Exp.	305	5.43	2.87	2.73	2.72	3.25	4.48	-2.55	-0.14	-0.02	0.53	1.23
Exp.	308	5.26	2.85	2.74	2.72	3.12	4.22	-2.41	-0.11	-0.02	0.40	1.10
Exp.	309	4.75	2.66	2.53	2.51	3.02	4.16	-2.09	-0.13	-0.02	0.51	1.14
Exp.	310	5.03	2.74	2.60	2.59	3.05	4.22	-2.29	-0.13	-0.01	0.46	1.17
Exp.	327	5.13	2.84	2.71	2.70	3.27	4.53	-2.29	-0.13	-0.01	0.57	1.26
Exp.	328	4.86	2.74	2.60	2.59	3.04	4.48	-2.12	-0.14	-0.01	0.45	1.44
Exp.	0	5.03	2.74	2.61	2.60	3.08	4.31	-2.29	-0.13	-0.01	0.48	1.23
AVERAGES for h:												
Exp.	0	5.03	2.74	2.61	2.60	3.08	4.31	-2.29	-0.13	-0.01	0.48	1.23
STANDARD DEVIATIONS for h:												
Exp.	0	0.25	0.11	0.11	0.11	0.11	0.16	0.17	0.02	0.00	0.05	0.10

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	301	16.68	31.70	33.06	33.26	27.42	19.29	15.02	1.36	0.20	-5.84	-8.13
Exp.	302	15.09	28.76	30.10	30.23	25.84	17.96	13.67	1.34	0.13	-4.39	-7.89
Exp.	303	16.60	28.90	30.27	30.37	25.85	18.92	12.30	1.38	0.10	-4.52	-6.93
Exp.	304	15.28	28.35	30.10	30.34	25.24	18.00	13.07	1.75	0.24	-5.10	-7.23
Exp.	305	14.51	27.42	28.81	28.98	24.24	17.59	12.91	1.39	0.17	-4.74	-6.65
Exp.	308	14.96	27.62	28.75	28.94	25.22	18.65	12.65	1.14	0.19	-3.72	-6.57
Exp.	309	16.58	29.65	31.16	31.38	26.09	18.93	13.07	1.51	0.22	-5.29	-7.16
Exp.	310	15.66	28.76	30.24	30.38	25.82	18.67	13.11	1.47	0.14	-4.55	-7.15
Exp.	327	15.35	27.71	29.06	29.15	24.10	17.38	12.37	1.34	0.10	-5.06	-6.72
Exp.	328	16.21	28.75	30.27	30.42	25.92	17.60	12.54	1.53	0.15	-4.50	-8.32
Exp.	0	15.66	28.72	30.14	30.30	25.54	18.28	13.06	1.42	0.16	-4.76	-7.27
AVERAGES for Vf:												
Exp.	0	15.69	28.76	30.18	30.34	25.57	18.30	13.07	1.42	0.16	-4.77	-7.28
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.78	1.24	1.27	1.28	0.95	0.67	0.80	0.16	0.05	0.58	0.63

2B/1C/2B

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	214	7.08	4.32	4.07	4.02	4.78	5.99	-2.76	-0.25	-0.05	0.76	1.21
Exp.	215	7.83	4.53	4.31	4.27	5.08	6.53	-3.30	-0.22	-0.04	0.80	1.45
Exp.	218	7.73	4.17	4.00	3.95	4.58	5.86	-3.55	-0.18	-0.05	0.63	1.29
Exp.	220	6.60	4.03	3.87	3.82	4.41	5.43	-2.57	-0.16	-0.05	0.59	1.02
Exp.	221	7.43	4.43	4.18	4.12	4.78	6.16	-3.00	-0.25	-0.06	0.66	1.38
Exp.	250	6.61	4.12	3.97	3.90	4.40	5.62	-2.49	-0.15	-0.07	0.50	1.22
Exp.	251	6.35	4.13	3.99	3.94	4.51	5.78	-2.23	-0.14	-0.05	0.57	1.27
Exp.	252	7.08	4.37	4.14	4.07	4.80	6.11	-2.72	-0.22	-0.08	0.73	1.31
Exp.	253	7.11	4.56	4.32	4.27	5.00	6.34	-2.54	-0.24	-0.05	0.73	1.34
Exp.	254	7.34	4.52	4.30	4.22	4.94	6.30	-2.81	-0.23	-0.07	0.72	1.36
Exp.	0	7.11	4.32	4.12	4.06	4.73	6.01	-2.80	-0.20	-0.06	0.67	1.28
AVERAGES for h:												
Exp.	0	7.11	4.32	4.12	4.06	4.73	6.01	-2.80	-0.20	-0.06	0.67	1.28
STANDARD DEVIATIONS for h:												
Exp.	0	0.49	0.19	0.16	0.16	0.24	0.34	0.40	0.04	0.01	0.09	0.12

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	214	19.13	31.33	33.25	33.68	28.34	22.60	12.20	1.92	0.42	-5.34	-5.74
Exp.	215	17.29	29.91	31.42	31.68	26.68	20.75	12.62	1.51	0.26	-5.00	-5.93
Exp.	218	17.53	32.44	33.87	34.29	29.59	23.10	14.91	1.43	0.42	-4.70	-6.49
Exp.	220	20.52	33.62	35.04	35.46	30.69	24.92	13.10	1.41	0.42	-4.77	-5.77
Exp.	221	18.23	30.59	32.40	32.89	28.33	21.98	12.35	1.81	0.49	-4.57	-6.34
Exp.	250	20.50	32.87	34.13	34.74	30.78	24.11	12.37	1.26	0.61	-3.96	-6.68
Exp.	251	21.31	32.81	33.93	34.36	30.01	23.44	11.50	1.12	0.43	-4.35	-6.57
Exp.	252	19.12	31.02	32.68	33.29	28.20	22.15	11.90	1.66	0.61	-5.09	-6.05
Exp.	253	19.06	29.68	31.32	31.68	27.09	21.36	10.62	1.64	0.36	-4.59	-5.73
Exp.	254	18.46	29.95	31.52	32.08	27.42	21.51	11.49	1.57	0.56	-4.66	-5.91
Exp.	0	19.04	31.36	32.91	33.37	28.64	22.52	12.33	1.55	0.46	-4.72	-6.12
AVERAGES for Vf:												
Exp.	0	19.12	31.42	32.96	33.42	28.71	22.59	12.31	1.53	0.46	-4.70	-6.12
STANDARD DEVIATIONS for Vf:												
Exp.	0	1.32	1.42	1.29	1.32	1.48	1.31	1.15	0.24	0.11	0.39	0.36

2R/1C/4R/1C/2R

	$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp. 181	13.93	7.12	6.53	6.15	7.77	10.90	-6.81	-0.59	-0.38	1.62	3.13
Exp. 223	13.26	7.17	6.53	6.29	7.88	10.90	-6.09	-0.64	-0.24	1.59	3.02
Exp. 224	14.57	8.00	7.43	7.13	9.04	11.97	-6.57	-0.57	-0.30	1.91	2.93
Exp. 225	14.69	7.86	7.22	6.88	8.48	11.41	-6.83	-0.64	-0.34	1.59	2.93
Exp. 226	13.44	6.73	6.14	5.91	7.51	10.69	-6.71	-0.59	-0.23	1.59	3.18
Exp. 227	11.75	6.30	5.78	5.57	6.74	9.56	-5.45	-0.52	-0.22	1.17	2.82
Exp. 228	11.90	7.32	6.77	6.47	7.89	10.92	-4.58	-0.55	-0.30	1.41	3.03
Exp. 229	12.10	6.35	5.88	5.64	6.74	9.29	-5.75	-0.47	-0.24	1.10	2.55
Exp. 230	13.13	6.20	5.61	5.34	6.68	9.01	-6.93	-0.59	-0.27	1.34	2.33
Exp. 231	13.01	6.68	6.14	5.86	7.36	10.08	-6.33	-0.54	-0.28	1.50	2.72
Exp. 0	13.18	6.97	6.40	6.12	7.61	10.47	-6.21	-0.57	-0.28	1.48	2.87
AVERAGES for h:											
Exp. 0	13.18	6.97	6.40	6.12	7.61	10.47	-6.21	-0.57	-0.28	1.48	2.87
STANDARD DEVIATIONS for h:											
Exp. 0	1.04	0.63	0.61	0.58	0.78	0.96	0.75	0.05	0.05	0.24	0.27

	$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp. 181	11.31	22.13	24.12	25.60	20.28	14.45	10.83	1.99	1.48	-5.33	-5.82
Exp. 223	11.88	21.98	24.12	25.05	19.98	14.44	10.10	2.14	0.93	-5.07	-5.54
Exp. 224	10.81	19.69	21.19	22.08	17.42	13.16	8.88	1.50	0.89	-4.66	-4.26
Exp. 225	10.72	20.03	21.81	22.88	18.58	13.81	9.31	1.78	1.07	-4.30	-4.78
Exp. 226	11.72	23.38	25.64	26.62	20.97	14.73	11.67	2.26	0.98	-5.65	-6.24
Exp. 227	13.40	24.98	27.23	28.29	23.38	16.47	11.58	2.25	1.07	-4.91	-6.91
Exp. 228	13.24	21.52	23.26	24.33	19.97	14.42	8.28	1.75	1.07	-4.36	-5.55
Exp. 229	13.01	24.81	26.80	27.94	23.37	16.95	11.79	2.00	1.13	-4.57	-6.42
Exp. 230	12.00	25.41	28.07	29.48	23.56	17.47	13.41	2.66	1.41	-5.92	-6.09
Exp. 231	12.11	23.58	25.64	26.86	21.38	15.62	11.47	2.06	1.22	-5.48	-5.76
Exp. 0	11.95	22.59	24.59	25.71	20.70	15.04	10.64	2.01	1.12	-5.01	-5.66
AVERAGES for Vf:											
Exp. 0	12.02	22.75	24.79	25.91	20.89	15.15	10.73	2.04	1.13	-5.02	-5.74
STANDARD DEVIATIONS for Vf:											
Exp. 0	0.95	2.02	2.29	2.38	2.09	1.42	1.57	0.32	0.20	0.56	0.77

2W/1C/4W/1C/2W

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	312	10.33	5.53	5.29	5.25	5.95	8.68	-4.80	-0.24	-0.04	0.70	2.73
Exp.	313	9.95	5.20	4.94	4.90	5.83	7.89	-4.75	-0.25	-0.04	0.93	2.06
Exp.	314	9.51	5.18	4.97	4.93	5.84	8.07	-4.33	-0.21	-0.04	0.91	2.22
Exp.	316	10.35	5.34	5.08	5.05	6.06	8.57	-5.01	-0.26	-0.04	1.02	2.51
Exp.	317	9.92	5.08	4.83	4.80	5.74	8.35	-4.84	-0.25	-0.03	0.94	2.61
Exp.	319	10.63	5.19	4.92	4.89	6.01	8.34	-5.44	-0.27	-0.04	1.13	2.33
Exp.	320	10.47	5.41	5.11	5.09	6.08	8.03	-5.06	-0.30	-0.02	0.99	1.96
Exp.	321	11.30	5.67	5.43	5.41	6.36	8.41	-5.63	-0.24	-0.02	0.95	2.05
Exp.	322	10.26	5.11	4.87	4.84	5.77	8.04	-5.15	-0.24	-0.02	0.93	2.27
Exp.	341	10.96	6.09	5.73	5.70	6.68	9.12	-4.87	-0.35	-0.03	0.98	2.44
Exp.	0	10.37	5.38	5.12	5.09	6.03	8.35	-4.99	-0.26	-0.03	0.95	2.32
AVERAGES for h:												
Exp.	0	10.37	5.38	5.12	5.09	6.03	8.35	-4.99	-0.26	-0.03	0.95	2.32
STANDARD DEVIATIONS for h:												
Exp.	0	0.52	0.31	0.29	0.29	0.29	0.37	0.37	0.04	0.01	0.11	0.26

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	312	15.24	28.46	29.76	29.98	26.47	18.15	13.21	1.30	0.22	-3.52	-8.32
Exp.	313	15.83	30.31	31.85	32.13	27.01	19.97	14.49	1.54	0.28	-5.12	-7.04
Exp.	314	16.56	30.40	31.67	31.93	26.95	19.52	13.84	1.27	0.26	-4.98	-7.43
Exp.	316	15.21	29.48	30.98	31.20	25.98	18.37	14.27	1.50	0.22	-5.23	-7.61
Exp.	317	15.87	31.01	32.63	32.81	27.43	18.86	15.14	1.62	0.18	-5.37	-8.57
Exp.	319	14.82	30.33	31.99	32.22	26.19	18.88	15.52	1.66	0.23	-6.03	-7.31
Exp.	320	15.04	29.12	30.81	30.96	25.92	19.61	14.07	1.69	0.15	-5.03	-6.31
Exp.	321	13.94	27.79	29.00	29.11	24.75	18.72	13.85	1.21	0.10	-4.36	-6.02
Exp.	322	15.35	30.83	32.36	32.51	27.29	19.59	15.48	1.53	0.15	-5.22	-7.70
Exp.	341	14.37	25.88	27.47	27.63	23.58	17.27	11.51	1.59	0.16	-4.04	-6.31
Exp.	0	15.19	29.28	30.77	30.96	26.10	18.86	14.09	1.49	0.19	-4.86	-7.24
AVERAGES for Vf:												
Exp.	0	15.22	29.36	30.85	31.05	26.16	18.89	14.14	1.49	0.20	-4.89	-7.26
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.76	1.61	1.65	1.67	1.20	0.82	1.19	0.17	0.06	0.73	0.85

2B/1C/4B/1C/2B

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	279	14.84	8.74	8.49	8.34	9.41	12.45	-6.10	-0.25	-0.15	1.07	3.05
Exp.	280	14.81	8.89	8.48	8.38	10.19	12.70	-5.91	-0.42	-0.10	1.81	2.52
Exp.	281	14.42	8.90	8.53	8.38	9.45	12.29	-5.52	-0.36	-0.15	1.07	2.83
Exp.	282	14.09	8.30	7.91	7.71	9.05	11.47	-5.79	-0.39	-0.20	1.34	2.42
Exp.	283	15.11	9.11	8.64	8.50	9.57	12.48	-6.00	-0.47	-0.14	1.07	2.91
Exp.	284	14.60	8.96	8.55	8.38	9.03	10.31	-5.64	-0.41	-0.17	0.65	1.27
Exp.	286	14.31	8.75	8.34	8.24	9.66	12.04	-5.56	-0.42	-0.10	1.42	2.39
Exp.	287	14.69	8.61	8.24	8.06	9.52	12.42	-6.07	-0.38	-0.18	1.46	2.91
Exp.	289	15.22	8.35	7.97	7.79	8.95	10.91	-6.87	-0.38	-0.18	1.16	1.96
Exp.	290	13.54	8.44	8.08	7.97	9.23	11.69	-5.09	-0.36	-0.11	1.27	2.46
Exp.	0	14.56	8.71	8.32	8.18	9.41	11.88	-5.85	-0.38	-0.15	1.23	2.47
AVERAGES for h:												
Exp.	0	14.56	8.71	8.32	8.18	9.41	11.88	-5.85	-0.38	-0.15	1.23	2.47
STANDARD DEVIATIONS for h:												
Exp.	0	0.50	0.27	0.26	0.28	0.37	0.78	0.47	0.06	0.04	0.31	0.53

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	279	18.26	31.00	31.91	32.49	28.80	21.75	12.74	0.92	0.58	-3.69	-7.04
Exp.	280	18.29	30.45	31.95	32.33	26.59	21.33	12.16	1.49	0.38	-5.74	-5.27
Exp.	281	18.79	30.44	31.74	32.31	28.66	22.04	11.65	1.30	0.57	-3.66	-6.61
Exp.	282	19.23	32.64	34.25	35.14	29.93	23.61	13.42	1.61	0.88	-5.21	-6.32
Exp.	283	17.93	29.74	31.35	31.86	28.30	21.71	11.81	1.61	0.51	-3.56	-6.59
Exp.	284	18.56	30.23	31.68	32.32	29.98	26.27	11.67	1.46	0.63	-2.34	-3.71
Exp.	286	18.93	30.94	32.49	32.87	28.05	22.49	12.02	1.55	0.38	-4.82	-5.56
Exp.	287	18.44	31.44	32.88	33.60	28.46	21.80	13.00	1.44	0.72	-5.14	-6.66
Exp.	289	17.80	32.43	33.96	34.76	30.26	24.83	14.63	1.54	0.79	-4.49	-5.43
Exp.	290	20.01	32.09	33.53	34.00	29.34	23.17	12.08	1.44	0.47	-4.66	-6.17
Exp.	0	18.60	31.11	32.55	33.13	28.80	22.81	12.51	1.43	0.59	-4.33	-5.99
AVERAGES for Vf:												
Exp.	0	18.62	31.14	32.58	33.17	28.84	22.90	12.52	1.44	0.59	-4.33	-5.94
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.65	0.98	1.03	1.14	1.10	1.60	0.95	0.20	0.17	1.01	0.98

APPENDIX B

RELAXATION EXPERIMENTS:

2R/1C/4R/1C/2R @ Pc = 80 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	345	13.28	7.43	6.82	6.46	6.42	6.38	-5.85	-0.61	-0.37	-0.04	-0.04
Exp.	346	12.97	6.70	6.16	5.93	5.90	5.85	-6.27	-0.54	-0.23	-0.03	-0.05
Exp.	347	13.03	6.58	6.02	5.85	5.84	5.80	-6.45	-0.56	-0.17	-0.02	-0.04
Exp.	348	13.70	7.53	6.92	6.58	6.55	6.49	-6.17	-0.62	-0.34	-0.03	-0.06
Exp.	349	12.95	7.31	6.80	6.45	6.43	6.40	-5.64	-0.51	-0.35	-0.02	-0.04
Exp.	350	12.50	6.94	6.50	6.28	6.24	6.18	-5.56	-0.44	-0.22	-0.05	-0.06
Exp.	351	13.44	7.37	6.76	6.49	6.44	6.37	-6.07	-0.61	-0.27	-0.06	-0.07
Exp.	352	12.81	6.60	6.12	5.84	5.78	5.74	-6.21	-0.48	-0.28	-0.06	-0.04
Exp.	353	12.53	6.83	6.22	5.94	5.90	5.88	-5.70	-0.60	-0.29	-0.04	-0.02
Exp.	354	13.14	6.92	6.48	6.14	6.12	6.07	-6.23	-0.44	-0.34	-0.02	-0.04
Exp.	0	13.04	7.02	6.48	6.20	6.16	6.11	-6.01	-0.54	-0.29	-0.04	-0.05
AVERAGES for h:												
Exp.	0	13.04	7.02	6.48	6.20	6.16	6.11	-6.01	-0.54	-0.29	-0.04	-0.05
STANDARD DEVIATIONS for h:												
Exp.	0	0.38	0.36	0.33	0.29	0.29	0.28	0.30	0.07	0.06	0.02	0.01

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	345	11.86	21.19	23.08	24.39	24.54	24.68	9.33	1.89	1.31	0.16	0.14
Exp.	346	12.14	23.51	25.57	26.57	26.69	26.92	11.37	2.07	0.99	0.12	0.23
Exp.	347	12.09	23.93	26.15	26.92	26.99	27.17	11.84	2.21	0.77	0.07	0.18
Exp.	348	11.49	20.91	22.77	23.94	24.05	24.28	9.42	1.86	1.17	0.11	0.23
Exp.	349	12.16	21.55	23.16	24.41	24.48	24.62	9.39	1.60	1.25	0.07	0.14
Exp.	350	12.59	22.69	24.22	25.06	25.25	25.49	10.10	1.53	0.84	0.19	0.24
Exp.	351	11.72	21.36	23.29	24.25	24.46	24.73	9.64	1.93	0.96	0.21	0.27
Exp.	352	12.29	23.85	25.73	26.97	27.25	27.46	11.56	1.88	1.24	0.28	0.21
Exp.	353	12.57	23.06	25.30	26.53	26.69	26.80	10.49	2.24	1.23	0.16	0.10
Exp.	354	11.98	22.77	24.30	25.65	25.75	25.93	10.79	1.53	1.35	0.10	0.18
Exp.	0	12.08	22.43	24.30	25.42	25.56	25.76	10.35	1.87	1.12	0.15	0.19
AVERAGES for Vf:												
Exp.	0	12.09	22.48	24.36	25.47	25.62	25.81	10.39	1.87	1.11	0.15	0.19
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.35	1.14	1.26	1.20	1.21	1.21	0.96	0.26	0.20	0.07	0.05

2R/1C/4R/1C/2R @ Pc = 60 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	356	13.07	6.76	6.15	5.80	5.85	5.90	-6.31	-0.62	-0.35	0.05	0.04
Exp.	357	13.51	6.71	6.09	5.85	5.84	5.90	-6.80	-0.62	-0.24	-0.00	0.05
Exp.	358	13.02	6.64	5.92	5.71	5.74	5.77	-6.38	-0.72	-0.21	0.03	0.03
Exp.	359	14.28	7.46	6.83	6.34	6.33	6.34	-6.82	-0.63	-0.48	-0.02	0.01
Exp.	360	12.97	6.90	6.25	5.85	5.85	5.88	-6.07	-0.65	-0.40	-0.00	0.03
Exp.	361	12.88	7.43	6.74	6.39	6.36	6.39	-5.45	-0.69	-0.36	-0.03	0.03
Exp.	362	13.33	7.43	6.75	6.56	6.55	6.57	-5.90	-0.67	-0.20	-0.00	0.02
Exp.	363	13.10	6.49	5.89	5.81	5.82	5.85	-6.61	-0.59	-0.09	0.02	0.03
Exp.	366	13.06	6.60	6.02	5.79	5.80	5.82	-6.46	-0.57	-0.23	0.00	0.03
Exp.	367	12.95	6.99	6.46	6.08	6.10	6.13	-5.96	-0.53	-0.38	0.02	0.03
Exp.	0	13.22	6.94	6.31	6.02	6.02	6.05	-6.28	-0.63	-0.29	0.01	0.03
AVERAGES for h:												
Exp.	0	13.22	6.94	6.31	6.02	6.02	6.05	-6.28	-0.63	-0.29	0.01	0.03
STANDARD DEVIATIONS for h:												
Exp.	0	0.42	0.37	0.36	0.30	0.29	0.28	0.43	0.06	0.12	0.02	0.01

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	356	12.05	23.28	25.61	27.16	26.91	26.70	11.23	2.33	1.54	-0.25	-0.20
Exp.	357	11.65	23.46	25.86	26.94	26.95	26.71	11.80	2.40	1.08	0.01	-0.24
Exp.	358	12.09	23.72	26.60	27.59	27.42	27.28	11.62	2.88	0.99	-0.16	-0.14
Exp.	359	11.03	21.12	23.07	24.83	24.89	24.84	10.09	1.94	1.76	0.07	-0.05
Exp.	360	12.14	22.83	25.19	26.90	26.91	26.79	10.69	2.36	1.72	0.01	-0.12
Exp.	361	12.23	21.19	23.35	24.65	24.76	24.65	8.96	2.16	1.30	0.10	-0.10
Exp.	362	11.81	21.20	23.31	24.02	24.04	23.97	9.39	2.11	0.71	0.02	-0.07
Exp.	363	12.02	24.28	26.73	27.12	27.05	26.93	12.26	2.45	0.40	-0.07	-0.12
Exp.	366	12.06	23.87	26.15	27.18	27.17	27.06	11.82	2.28	1.03	-0.01	-0.12
Exp.	367	12.16	22.53	24.36	25.89	25.81	25.68	10.37	1.83	1.53	-0.08	-0.13
Exp.	0	11.91	22.69	24.95	26.17	26.14	26.01	10.78	2.26	1.22	-0.03	-0.13
AVERAGES for Vf:												
Exp.	0	11.93	22.75	25.02	26.23	26.19	26.06	10.82	2.28	1.20	-0.04	-0.13
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.36	1.19	1.40	1.28	1.22	1.18	1.11	0.29	0.45	0.11	0.06

2R/1C/4R/1C/2R @ Pc = 40 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	365	12.98	6.80	6.16	5.94	6.11	6.18	-6.18	-0.64	-0.22	0.17	0.07
Exp.	370	12.17	6.71	6.17	6.01	6.18	6.23	-5.46	-0.54	-0.16	0.16	0.05
Exp.	371	12.34	6.62	6.10	5.84	5.98	6.02	-5.72	-0.52	-0.26	0.14	0.04
Exp.	372	12.00	6.53	5.99	5.77	5.89	5.92	-5.47	-0.54	-0.22	0.12	0.04
Exp.	375	12.59	6.66	6.18	5.92	5.98	6.02	-5.94	-0.47	-0.26	0.05	0.04
Exp.	376	12.58	6.45	6.04	5.73	5.86	5.88	-6.14	-0.41	-0.31	0.13	0.03
Exp.	377	12.44	6.47	6.04	5.77	5.94	5.99	-5.96	-0.43	-0.27	0.17	0.05
Exp.	378	12.92	7.11	6.52	6.23	6.27	6.30	-5.81	-0.59	-0.29	0.05	0.03
Exp.	379	12.37	6.66	6.10	5.85	6.02	6.07	-5.71	-0.56	-0.24	0.17	0.05
Exp.	390	12.97	6.74	6.23	5.92	6.05	6.10	-6.24	-0.51	-0.30	0.13	0.05
Exp.	0	12.54	6.67	6.15	5.90	6.03	6.07	-5.86	-0.52	-0.25	0.13	0.04
AVERAGES for h:												
Exp.	0	12.54	6.67	6.15	5.90	6.03	6.07	-5.86	-0.52	-0.25	0.13	0.04
STANDARD DEVIATIONS for h:												
Exp.	0	0.34	0.19	0.15	0.15	0.13	0.13	0.28	0.07	0.05	0.05	0.01

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	365	12.13	23.17	25.57	26.52	25.78	25.48	11.04	2.40	0.96	-0.74	-0.30
Exp.	370	12.94	23.47	25.52	26.19	25.50	25.28	10.53	2.04	0.67	-0.69	-0.22
Exp.	371	12.76	23.77	25.80	26.96	26.34	26.17	11.01	2.03	1.16	-0.62	-0.17
Exp.	372	13.12	24.12	26.28	27.29	26.75	26.58	11.00	2.16	1.01	-0.54	-0.17
Exp.	375	12.50	23.65	25.47	26.59	26.36	26.17	11.15	1.81	1.13	-0.24	-0.19
Exp.	376	12.52	24.43	26.07	27.48	26.89	26.77	11.91	1.64	1.41	-0.59	-0.12
Exp.	377	12.66	24.32	26.06	27.28	26.50	26.29	11.66	1.73	1.23	-0.78	-0.21
Exp.	378	12.19	22.16	24.16	25.29	25.10	24.98	9.97	2.00	1.13	-0.19	-0.12
Exp.	379	12.73	23.65	25.84	26.91	26.16	25.96	10.92	2.19	1.08	-0.76	-0.20
Exp.	390	12.14	23.38	25.29	26.59	26.03	25.83	11.24	1.92	1.29	-0.55	-0.20
Exp.	0	12.56	23.60	25.59	26.70	26.13	25.94	11.03	2.00	1.11	-0.57	-0.19
AVERAGES for Vf:												
Exp.	0	12.57	23.61	25.60	26.71	26.14	25.95	11.04	1.99	1.11	-0.57	-0.19
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.34	0.65	0.60	0.64	0.56	0.57	0.54	0.23	0.20	0.21	0.05

2R/1C/4R/1C/2R @ Pc = 20 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	380	12.34	6.51	5.94	5.66	6.22	6.37	-5.82	-0.57	-0.28	0.56	0.15
Exp.	381	12.77	6.77	6.17	5.98	6.32	6.52	-6.00	-0.60	-0.20	0.35	0.20
Exp.	382	12.76	6.73	6.16	5.80	6.10	6.24	-6.03	-0.57	-0.36	0.30	0.14
Exp.	383	12.79	6.94	6.43	6.12	6.65	6.80	-5.85	-0.51	-0.31	0.53	0.15
Exp.	384	12.22	6.22	5.89	5.87	6.37	6.57	-6.01	-0.33	-0.02	0.50	0.20
Exp.	385	12.69	6.33	5.80	5.57	6.12	6.25	-6.36	-0.53	-0.23	0.55	0.14
Exp.	386	12.21	6.32	5.97	5.94	6.52	6.66	-5.89	-0.35	-0.03	0.58	0.14
Exp.	387	12.77	6.42	5.95	5.86	6.47	6.64	-6.35	-0.47	-0.09	0.61	0.17
Exp.	388	12.62	6.61	6.05	5.83	6.41	6.54	-6.01	-0.56	-0.22	0.58	0.13
Exp.	389	12.55	6.98	6.35	6.11	6.65	6.77	-5.57	-0.63	-0.24	0.54	0.13
Exp.	0	12.57	6.58	6.07	5.87	6.38	6.54	-5.99	-0.51	-0.20	0.51	0.15
AVERAGES for h:												
Exp.	0	12.57	6.58	6.07	5.87	6.38	6.54	-5.99	-0.51	-0.20	0.51	0.15
STANDARD DEVIATIONS for h:												
Exp.	0	0.23	0.27	0.20	0.17	0.20	0.20	0.24	0.10	0.12	0.10	0.03

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	380	12.77	24.19	26.51	27.80	25.31	24.73	11.42	2.32	1.30	-2.50	-0.58
Exp.	381	12.33	23.26	25.51	26.35	24.91	24.16	10.93	2.25	0.84	-1.45	-0.75
Exp.	382	12.34	23.39	25.57	27.17	25.82	25.25	11.05	2.18	1.60	-1.35	-0.56
Exp.	383	12.31	22.68	24.49	25.73	23.66	23.15	10.37	1.81	1.23	-2.06	-0.51
Exp.	384	12.88	25.33	26.75	26.81	24.72	23.96	12.44	1.42	0.07	-2.10	-0.75
Exp.	385	12.41	24.88	27.14	28.26	25.74	25.18	12.46	2.26	1.12	-2.52	-0.56
Exp.	386	12.90	24.90	26.36	26.50	24.16	23.65	12.00	1.47	0.13	-2.34	-0.50
Exp.	387	12.33	24.53	26.47	26.87	24.35	23.73	12.19	1.94	0.40	-2.53	-0.62
Exp.	388	12.48	23.83	26.02	27.01	24.56	24.07	11.34	2.20	0.98	-2.45	-0.48
Exp.	389	12.54	22.56	24.80	25.77	23.68	23.25	10.01	2.25	0.96	-2.08	-0.44
Exp.	0	12.53	23.92	25.94	26.81	24.67	24.09	11.39	2.02	0.87	-2.14	-0.57
AVERAGES for Vf:												
Exp.	0	12.53	23.95	25.96	26.83	24.69	24.11	11.42	2.01	0.86	-2.14	-0.58
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.23	0.97	0.85	0.80	0.77	0.74	0.85	0.34	0.51	0.43	0.11

2R/1C/4R/1C/2R @ Pc = 10 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	505	12.32	5.95	5.35	5.12	5.82	6.29	-6.37	-0.60	-0.23	0.70	0.48
Exp.	506	11.75	5.84	5.46	5.45	6.25	6.57	-5.92	-0.38	-0.01	0.81	0.31
Exp.	507	12.45	6.38	5.75	5.68	6.54	6.87	-6.06	-0.63	-0.08	0.87	0.33
Exp.	508	12.73	6.04	5.58	5.55	6.43	6.72	-6.69	-0.46	-0.03	0.88	0.28
Exp.	509	12.26	6.94	6.31	6.00	6.62	6.97	-5.32	-0.63	-0.31	0.62	0.35
Exp.	510	12.11	6.55	5.93	5.65	6.44	6.83	-5.56	-0.61	-0.28	0.79	0.39
Exp.	511	12.63	6.79	6.35	6.05	6.71	7.17	-5.85	-0.43	-0.30	0.66	0.46
Exp.	512	11.42	6.67	6.09	5.90	6.82	7.28	-4.75	-0.58	-0.19	0.92	0.45
Exp.	513	11.38	6.38	5.84	5.75	6.47	6.91	-5.01	-0.53	-0.09	0.72	0.44
Exp.	514	12.51	5.98	5.52	5.45	6.27	6.63	-6.53	-0.46	-0.07	0.82	0.36
Exp.	0	12.16	6.35	5.82	5.66	6.44	6.82	-5.80	-0.53	-0.16	0.78	0.39
AVERAGES for h:												
Exp.	0	12.16	6.35	5.82	5.66	6.44	6.82	-5.80	-0.53	-0.16	0.78	0.39
STANDARD DEVIATIONS for h:												
Exp.	0	0.48	0.38	0.35	0.28	0.28	0.29	0.64	0.09	0.12	0.10	0.07

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	505	12.79	26.47	29.44	30.75	27.07	25.02	13.68	2.97	1.31	-3.68	-2.04
Exp.	506	13.40	26.98	28.84	28.91	25.18	23.98	13.58	1.86	0.07	-3.73	-1.21
Exp.	507	12.65	24.67	27.37	27.75	24.07	22.93	12.01	2.70	0.38	-3.67	-1.14
Exp.	508	12.37	26.06	28.22	28.36	24.48	23.45	13.69	2.16	0.14	-3.88	-1.04
Exp.	509	12.84	22.69	24.96	26.25	23.78	22.58	9.85	2.27	1.29	-2.48	-1.20
Exp.	510	13.01	24.05	26.55	27.88	24.47	23.05	11.05	2.49	1.34	-3.42	-1.41
Exp.	511	12.47	23.21	24.79	26.03	23.48	21.97	10.74	1.58	1.25	-2.55	-1.51
Exp.	512	13.79	23.62	25.86	26.68	23.08	21.64	9.83	2.24	0.81	-3.60	-1.43
Exp.	513	13.84	24.70	26.96	27.40	24.34	22.78	10.86	2.26	0.44	-3.06	-1.56
Exp.	514	12.59	26.32	28.53	28.88	25.12	23.74	13.73	2.21	0.35	-3.76	-1.38
Exp.	0	12.95	24.79	27.06	27.82	24.46	23.08	11.84	2.27	0.76	-3.36	-1.39
AVERAGES for Vf:												
Exp.	0	12.97	24.88	27.15	27.89	24.51	23.11	11.90	2.27	0.74	-3.38	-1.39
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.53	1.50	1.62	1.42	1.12	0.99	1.64	0.39	0.52	0.51	0.28

2R/1C/4R/1C/2R @ Pc = 2 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	181	13.93	7.12	6.53	6.15	7.64	10.90	-6.81	-0.59	-0.38	1.49	3.25
Exp.	223	13.26	7.17	6.53	6.29	7.84	10.90	-6.09	-0.64	-0.24	1.55	3.06
Exp.	224	14.57	8.00	7.43	7.13	8.96	11.97	-6.57	-0.57	-0.30	1.83	3.01
Exp.	225	14.69	7.86	7.22	6.88	8.41	11.41	-6.83	-0.64	-0.34	1.53	2.99
Exp.	226	13.44	6.73	6.14	5.91	7.42	10.69	-6.71	-0.59	-0.23	1.50	3.28
Exp.	227	11.75	6.30	5.78	5.57	6.69	9.56	-5.45	-0.52	-0.22	1.13	2.87
Exp.	228	11.90	7.32	6.77	6.47	7.86	10.92	-4.58	-0.55	-0.30	1.38	3.06
Exp.	229	12.10	6.35	5.88	5.64	6.73	9.29	-5.75	-0.47	-0.24	1.09	2.57
Exp.	230	13.13	6.20	5.61	5.34	6.67	9.01	-6.93	-0.59	-0.27	1.33	2.34
Exp.	231	13.01	6.68	6.14	5.86	7.34	10.08	-6.33	-0.54	-0.28	1.47	2.74
Exp.	0	13.18	6.97	6.40	6.12	7.56	10.47	-6.21	-0.57	-0.28	1.43	2.92
AVERAGES for h:												
Exp.	0	13.18	6.97	6.40	6.12	7.56	10.47	-6.21	-0.57	-0.28	1.43	2.92
STANDARD DEVIATIONS for h:												
Exp.	0	1.04	0.63	0.61	0.58	0.76	0.96	0.75	0.05	0.05	0.22	0.29

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	181	11.31	22.13	24.12	25.60	20.61	14.45	10.83	1.99	1.48	-4.99	-6.15
Exp.	223	11.88	21.98	24.12	25.05	20.08	14.44	10.10	2.14	0.93	-4.97	-5.64
Exp.	224	10.81	19.69	21.19	22.08	17.57	13.16	8.88	1.50	0.89	-4.51	-4.41
Exp.	225	10.72	20.03	21.81	22.88	18.72	13.81	9.31	1.78	1.07	-4.16	-4.91
Exp.	226	11.72	23.38	25.64	26.62	21.23	14.73	11.67	2.26	0.98	-5.39	-6.50
Exp.	227	13.40	24.98	27.23	28.29	23.53	16.47	11.58	2.25	1.07	-4.76	-7.06
Exp.	228	13.24	21.52	23.26	24.33	20.05	14.42	8.28	1.75	1.07	-4.29	-5.62
Exp.	229	13.01	24.81	26.80	27.94	23.41	16.95	11.79	2.00	1.13	-4.52	-6.46
Exp.	230	12.00	25.41	28.07	29.48	23.61	17.47	13.41	2.66	1.41	-5.87	-6.14
Exp.	231	12.11	23.58	25.64	26.86	21.47	15.62	11.47	2.06	1.22	-5.39	-5.85
Exp.	0	11.95	22.59	24.59	25.71	20.84	15.04	10.64	2.01	1.12	-4.87	-5.81
AVERAGES for Vf:												
Exp.	0	12.02	22.75	24.79	25.91	21.03	15.15	10.73	2.04	1.13	-4.89	-5.88
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.95	2.02	2.29	2.38	2.06	1.42	1.57	0.32	0.20	0.54	0.78

2W/1C/4W/1C/2W @ Pc = 80 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	483	10.23	5.58	5.25	5.23	5.23	5.20	-4.65	-0.32	-0.02	-0.00	-0.03
Exp.	484	10.68	5.59	5.31	5.30	5.29	5.29	-5.10	-0.28	-0.01	-0.00	-0.00
Exp.	485	10.44	5.47	5.18	5.17	5.16	5.13	-4.97	-0.29	-0.01	-0.00	-0.03
Exp.	486	11.18	5.51	5.23	5.22	5.22	5.20	-5.67	-0.27	-0.01	-0.00	-0.01
Exp.	487	9.59	4.78	4.57	4.55	4.55	4.54	-4.81	-0.21	-0.01	-0.00	-0.01
Exp.	488	10.16	5.58	5.25	5.24	5.23	5.23	-4.58	-0.33	-0.01	-0.01	-0.00
Exp.	489	9.97	5.06	4.77	4.76	4.76	4.75	-4.91	-0.29	-0.01	-0.01	-0.01
Exp.	490	10.29	5.07	4.88	4.87	4.86	4.85	-5.22	-0.19	-0.01	-0.00	-0.01
Exp.	491	9.93	5.05	4.77	4.76	4.76	4.76	-4.88	-0.28	-0.01	-0.00	0.00
Exp.	492	9.79	4.90	4.64	4.63	4.63	4.62	-4.90	-0.25	-0.01	-0.01	-0.01
Exp.	0	10.23	5.26	4.99	4.97	4.97	4.96	-4.97	-0.27	-0.01	-0.00	-0.01
AVERAGES for h:												
Exp.	0	10.23	5.26	4.99	4.97	4.97	4.96	-4.97	-0.27	-0.01	-0.00	-0.01
STANDARD DEVIATIONS for h:												
Exp.	0	0.46	0.32	0.29	0.29	0.29	0.28	0.31	0.04	0.00	0.00	0.01

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	483	15.39	28.24	29.98	30.09	30.12	30.30	12.85	1.74	0.12	0.02	0.19
Exp.	484	14.74	28.19	29.66	29.73	29.75	29.77	13.45	1.47	0.07	0.02	0.01
Exp.	485	15.09	28.80	30.40	30.49	30.51	30.71	13.71	1.60	0.09	0.02	0.20
Exp.	486	14.09	28.60	30.10	30.15	30.18	30.27	14.52	1.49	0.06	0.03	0.08
Exp.	487	16.42	32.94	34.48	34.57	34.61	34.69	16.52	1.55	0.09	0.03	0.09
Exp.	488	15.50	28.23	30.01	30.06	30.10	30.11	12.73	1.78	0.05	0.04	0.02
Exp.	489	15.80	31.13	32.99	33.06	33.10	33.18	15.33	1.86	0.07	0.04	0.08
Exp.	490	15.30	31.06	32.30	32.36	32.39	32.46	15.76	1.24	0.07	0.02	0.07
Exp.	491	15.87	31.21	33.02	33.07	33.08	33.07	15.34	1.82	0.05	0.00	-0.01
Exp.	492	16.08	32.17	33.93	34.00	34.04	34.08	16.09	1.76	0.07	0.04	0.04
Exp.	0	15.40	29.96	31.59	31.66	31.69	31.77	14.56	1.63	0.07	0.03	0.08
AVERAGES for Vf:												
Exp.	0	15.43	30.06	31.69	31.76	31.79	31.86	14.63	1.63	0.07	0.03	0.08
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.68	1.83	1.85	1.85	1.85	1.83	1.38	0.19	0.02	0.01	0.07

2W/1C/4W/1C/2W @ Pc = 60 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	473	10.92	5.68	5.33	5.28	5.29	5.32	-5.24	-0.35	-0.04	0.00	0.04
Exp.	474	10.32	5.57	5.24	5.20	5.20	5.21	-4.75	-0.33	-0.04	0.01	0.01
Exp.	475	10.65	5.50	5.23	5.21	5.21	5.22	-5.15	-0.27	-0.02	0.01	0.01
Exp.	476	10.11	5.27	4.99	4.98	5.03	5.05	-4.84	-0.28	-0.01	0.05	0.01
Exp.	477	11.07	5.61	5.32	5.30	5.31	5.31	-5.46	-0.29	-0.02	0.01	0.00
Exp.	478	10.44	5.40	5.08	5.07	5.07	5.07	-5.04	-0.31	-0.01	-0.00	0.01
Exp.	479	10.83	4.95	4.62	4.60	4.61	4.62	-5.88	-0.33	-0.02	0.01	0.01
Exp.	480	11.24	5.75	5.42	5.39	5.45	5.47	-5.49	-0.34	-0.02	0.05	0.02
Exp.	481	10.41	5.20	4.90	4.89	4.91	4.92	-5.21	-0.30	-0.01	0.02	0.01
Exp.	482	10.43	5.19	4.91	4.89	4.96	4.96	-5.24	-0.28	-0.02	0.07	0.01
Exp.	0	10.64	5.41	5.10	5.08	5.10	5.12	-5.23	-0.31	-0.02	0.02	0.01
AVERAGES for h:												
Exp.	0	10.64	5.41	5.10	5.08	5.10	5.12	-5.23	-0.31	-0.02	0.02	0.01
STANDARD DEVIATIONS for h:												
Exp.	0	0.36	0.26	0.25	0.24	0.24	0.25	0.33	0.03	0.01	0.03	0.01

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	473	14.42	27.72	29.55	29.80	29.78	29.58	13.30	1.83	0.25	-0.02	-0.20
Exp.	474	15.26	28.27	30.05	30.29	30.26	30.22	13.01	1.78	0.24	-0.04	-0.03
Exp.	475	14.79	28.65	30.12	30.25	30.20	30.14	13.87	1.46	0.14	-0.05	-0.06
Exp.	476	15.58	29.89	31.55	31.62	31.29	31.21	14.31	1.66	0.07	-0.33	-0.08
Exp.	477	14.23	28.06	29.58	29.69	29.66	29.63	13.83	1.52	0.10	-0.03	-0.03
Exp.	478	15.09	29.18	30.98	31.04	31.07	31.04	14.09	1.80	0.07	0.03	-0.03
Exp.	479	14.55	31.84	34.08	34.23	34.14	34.09	17.30	2.24	0.15	-0.09	-0.05
Exp.	480	14.01	27.39	29.08	29.19	28.91	28.80	13.38	1.70	0.11	-0.29	-0.11
Exp.	481	15.13	30.31	32.14	32.19	32.08	32.00	15.18	1.83	0.05	-0.11	-0.08
Exp.	482	15.10	30.36	32.09	32.21	31.77	31.72	15.26	1.74	0.12	-0.44	-0.06
Exp.	0	14.80	29.11	30.86	30.99	30.85	30.78	14.31	1.75	0.13	-0.14	-0.07
AVERAGES for Vf:												
Exp.	0	14.81	29.17	30.92	31.05	30.92	30.84	14.35	1.76	0.13	-0.14	-0.07
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.50	1.41	1.55	1.53	1.51	1.53	1.27	0.21	0.07	0.16	0.05

2W/1C/4W/1C/2W @ Pc = 40 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	463	10.58	5.17	4.87	4.83	4.86	4.88	-5.41	-0.30	-0.04	0.03	0.01
Exp.	464	10.57	5.01	4.82	4.80	4.90	4.92	-5.55	-0.20	-0.02	0.10	0.02
Exp.	465	10.60	5.53	5.26	5.23	5.34	5.39	-5.07	-0.27	-0.04	0.12	0.05
Exp.	466	10.45	5.40	5.08	5.06	5.18	5.25	-5.05	-0.32	-0.03	0.12	0.07
Exp.	468	10.57	5.59	5.25	5.24	5.33	5.35	-4.98	-0.34	-0.01	0.09	0.03
Exp.	469	10.75	5.65	5.30	5.28	5.39	5.42	-5.10	-0.35	-0.01	0.11	0.03
Exp.	470	11.09	5.03	4.74	4.72	4.80	4.84	-6.05	-0.29	-0.03	0.08	0.04
Exp.	471	11.10	6.06	5.66	5.65	5.73	5.78	-5.04	-0.40	-0.01	0.08	0.05
Exp.	472	9.53	5.25	5.02	4.99	5.10	5.16	-4.29	-0.23	-0.03	0.11	0.06
Exp.	493	10.45	5.44	5.09	5.07	5.13	5.16	-5.02	-0.35	-0.01	0.05	0.03
Exp.	0	10.57	5.41	5.11	5.09	5.18	5.22	-5.16	-0.30	-0.02	0.09	0.04
AVERAGES for h:												
Exp.	0	10.57	5.41	5.11	5.09	5.18	5.22	-5.16	-0.30	-0.02	0.09	0.04
STANDARD DEVIATIONS for h:												
Exp.	0	0.43	0.32	0.27	0.28	0.28	0.29	0.45	0.06	0.01	0.03	0.02

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	463	14.89	30.46	32.33	32.57	32.38	32.30	15.57	1.87	0.24	-0.20	-0.08
Exp.	464	14.90	31.40	32.68	32.79	32.13	31.98	16.50	1.27	0.12	-0.66	-0.16
Exp.	465	14.85	28.47	29.93	30.14	29.48	29.20	13.62	1.46	0.20	-0.65	-0.29
Exp.	466	15.07	29.15	30.98	31.13	30.40	30.01	14.09	1.82	0.15	-0.73	-0.38
Exp.	468	14.90	28.16	29.98	30.06	29.57	29.42	13.27	1.82	0.08	-0.49	-0.15
Exp.	469	14.65	27.87	29.73	29.80	29.19	29.03	13.22	1.86	0.07	-0.61	-0.16
Exp.	470	14.21	31.28	33.20	33.39	32.81	32.55	17.08	1.92	0.19	-0.57	-0.27
Exp.	471	14.19	25.99	27.82	27.89	27.49	27.25	11.80	1.84	0.07	-0.40	-0.24
Exp.	472	16.52	30.02	31.37	31.54	30.86	30.52	13.50	1.35	0.17	-0.67	-0.34
Exp.	493	15.07	28.98	30.95	31.03	30.70	30.50	13.91	1.98	0.08	-0.33	-0.20
Exp.	0	14.90	29.09	30.82	30.95	30.42	30.19	14.19	1.73	0.13	-0.53	-0.23
AVERAGES for Vf:												
Exp.	0	14.92	29.18	30.90	31.03	30.50	30.28	14.26	1.72	0.14	-0.53	-0.23
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.64	1.67	1.61	1.65	1.65	1.66	1.63	0.26	0.06	0.17	0.10

2W/1C/4W/1C/2W @ Pc = 20 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	452	10.43	6.19	6.04	6.04	6.32	6.45	-4.24	-0.15	0.00	0.28	0.13
Exp.	455	10.44	5.55	5.28	5.26	5.57	5.71	-4.89	-0.27	-0.02	0.31	0.13
Exp.	456	11.54	5.80	5.47	5.42	5.67	5.79	-5.74	-0.33	-0.05	0.25	0.12
Exp.	457	11.92	5.58	5.30	5.26	5.63	5.81	-6.34	-0.28	-0.04	0.37	0.18
Exp.	458	11.60	5.97	5.59	5.55	5.97	6.13	-5.63	-0.37	-0.04	0.41	0.16
Exp.	459	10.29	5.93	5.59	5.56	5.88	6.05	-4.36	-0.34	-0.03	0.32	0.17
Exp.	460	10.91	5.73	5.32	5.28	5.51	5.62	-5.17	-0.42	-0.04	0.23	0.11
Exp.	461	12.07	6.03	5.58	5.56	5.74	5.87	-6.04	-0.44	-0.02	0.18	0.13
Exp.	462	10.43	5.37	5.03	5.02	5.29	5.40	-5.07	-0.33	-0.02	0.27	0.11
Exp.	467	11.26	5.81	5.50	5.47	5.91	6.09	-5.44	-0.32	-0.02	0.43	0.18
Exp.	0	11.09	5.80	5.47	5.44	5.75	5.89	-5.29	-0.33	-0.03	0.31	0.14
AVERAGES for h:												
Exp.	0	11.09	5.80	5.47	5.44	5.75	5.89	-5.29	-0.33	-0.03	0.31	0.14
STANDARD DEVIATIONS for h:												
Exp.	0	0.67	0.25	0.27	0.27	0.28	0.30	0.68	0.08	0.01	0.08	0.03

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	452	15.10	25.42	26.07	26.07	24.93	24.43	10.33	0.65	-0.00	-1.14	-0.50
Exp.	455	15.08	28.37	29.82	29.91	28.25	27.59	13.29	1.45	0.09	-1.66	-0.67
Exp.	456	13.65	27.16	28.79	29.04	27.77	27.18	13.51	1.63	0.25	-1.27	-0.58
Exp.	457	13.21	28.20	29.71	29.91	27.95	27.09	15.00	1.51	0.20	-1.96	-0.86
Exp.	458	13.58	26.39	28.16	28.37	26.40	25.71	12.81	1.77	0.21	-1.97	-0.69
Exp.	459	15.30	26.55	28.18	28.35	26.79	26.04	11.25	1.63	0.16	-1.56	-0.75
Exp.	460	14.44	27.47	29.63	29.83	28.58	28.00	13.03	2.16	0.20	-1.25	-0.58
Exp.	461	13.05	26.13	28.20	28.30	27.42	26.84	13.08	2.07	0.10	-0.88	-0.58
Exp.	462	15.09	29.34	31.28	31.39	29.77	29.19	14.25	1.93	0.11	-1.62	-0.58
Exp.	467	13.99	27.08	28.64	28.76	26.67	25.87	13.09	1.56	0.12	-2.10	-0.80
Exp.	0	14.20	27.17	28.79	28.93	27.39	26.73	12.97	1.62	0.14	-1.54	-0.66
AVERAGES for Vf:												
Exp.	0	14.25	27.21	28.85	28.99	27.45	26.79	12.96	1.64	0.14	-1.54	-0.66
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.86	1.18	1.39	1.42	1.34	1.34	1.34	0.42	0.07	0.40	0.11

2W/1C/4W/1C/2W @ Pc = 10 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	515	10.95	5.55	5.24	5.22	6.02	6.29	-5.40	-0.31	-0.02	0.80	0.28
Exp.	516	11.18	5.98	5.62	5.59	6.22	6.56	-5.20	-0.36	-0.02	0.63	0.33
Exp.	517	11.06	5.54	5.28	5.27	6.00	6.19	-5.52	-0.27	-0.01	0.73	0.20
Exp.	518	12.13	6.16	5.80	5.79	6.64	6.95	-5.97	-0.36	-0.01	0.85	0.31
Exp.	519	11.16	5.12	4.70	4.69	5.38	5.64	-6.04	-0.42	-0.01	0.69	0.26
Exp.	521	10.00	5.82	5.52	5.50	6.06	6.51	-4.18	-0.30	-0.02	0.56	0.44
Exp.	523	9.63	5.94	5.55	5.54	6.21	6.51	-3.69	-0.38	-0.02	0.67	0.29
Exp.	524	11.04	6.35	6.01	5.99	6.72	7.18	-4.69	-0.34	-0.02	0.73	0.46
Exp.	526	10.72	5.22	5.00	4.97	5.54	5.76	-5.51	-0.21	-0.03	0.57	0.22
Exp.	527	11.47	5.84	5.48	5.46	6.00	6.10	-5.63	-0.37	-0.02	0.54	0.10
Exp.	0	10.93	5.75	5.42	5.40	6.08	6.37	-5.18	-0.33	-0.02	0.68	0.29
AVERAGES for h:												
Exp.	0	10.93	5.75	5.42	5.40	6.08	6.37	-5.18	-0.33	-0.02	0.68	0.29
STANDARD DEVIATIONS for h:												
Exp.	0	0.70	0.39	0.38	0.38	0.42	0.48	0.76	0.06	0.01	0.10	0.11

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	515	14.38	28.36	30.05	30.19	26.18	25.03	13.98	1.69	0.13	-4.01	-1.15
Exp.	516	14.08	26.33	28.04	28.16	25.30	24.01	12.25	1.71	0.12	-2.86	-1.29
Exp.	517	14.24	28.40	29.84	29.90	26.27	25.43	14.17	1.44	0.06	-3.64	-0.84
Exp.	518	12.98	25.57	27.14	27.20	23.73	22.67	12.58	1.57	0.06	-3.47	-1.06
Exp.	519	14.11	30.75	33.53	33.60	29.27	27.90	16.63	2.78	0.07	-4.32	-1.37
Exp.	521	15.74	27.04	28.51	28.63	25.98	24.20	11.30	1.47	0.12	-2.65	-1.77
Exp.	523	16.35	26.53	28.35	28.44	25.35	24.20	10.18	1.82	0.08	-3.09	-1.15
Exp.	524	14.26	24.80	26.20	26.28	23.42	21.93	10.54	1.40	0.08	-2.86	-1.48
Exp.	526	14.69	30.19	31.48	31.69	28.44	27.34	15.51	1.29	0.21	-3.25	-1.10
Exp.	527	13.73	26.95	28.76	28.87	26.27	25.82	13.22	1.81	0.11	-2.60	-0.44
Exp.	0	14.40	27.38	29.06	29.16	25.91	24.73	12.97	1.68	0.10	-3.25	-1.18
AVERAGES for Vf:												
Exp.	0	14.46	27.49	29.19	29.30	26.02	24.85	13.04	1.70	0.11	-3.28	-1.17
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.96	1.92	2.14	2.15	1.81	1.87	2.09	0.42	0.05	0.58	0.36

2W/1C/4W/1C/2W @ Pc = 2 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	312	10.33	5.53	5.29	5.25	5.92	8.68	-4.80	-0.24	-0.04	0.67	2.75
Exp.	313	9.95	5.20	4.94	4.90	5.83	7.89	-4.75	-0.25	-0.04	0.93	2.06
Exp.	314	9.51	5.18	4.97	4.93	5.84	8.07	-4.33	-0.21	-0.04	0.91	2.22
Exp.	316	10.35	5.34	5.08	5.05	6.05	8.57	-5.01	-0.26	-0.04	1.00	2.52
Exp.	317	9.92	5.08	4.83	4.80	5.69	8.35	-4.84	-0.25	-0.03	0.89	2.66
Exp.	319	10.63	5.19	4.92	4.89	5.99	8.34	-5.44	-0.27	-0.04	1.10	2.36
Exp.	320	10.47	5.41	5.11	5.09	6.05	8.03	-5.06	-0.30	-0.02	0.96	1.98
Exp.	321	11.32	5.67	5.43	5.41	6.36	8.41	-5.65	-0.24	-0.02	0.95	2.05
Exp.	322	10.26	5.11	4.87	4.84	5.73	8.04	-5.15	-0.24	-0.02	0.89	2.31
Exp.	341	10.96	6.09	5.73	5.70	6.68	9.12	-4.87	-0.35	-0.03	0.98	2.44
Exp.	0	10.37	5.38	5.12	5.09	6.01	8.35	-4.99	-0.26	-0.03	0.93	2.34
AVERAGES for h:												
Exp.	0	10.37	5.38	5.12	5.09	6.01	8.35	-4.99	-0.26	-0.03	0.93	2.34
STANDARD DEVIATIONS for h:												
Exp.	0	0.52	0.31	0.29	0.29	0.30	0.37	0.37	0.04	0.01	0.11	0.26

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	312	15.24	28.46	29.76	29.98	26.60	18.15	13.21	1.30	0.22	-3.39	-8.45
Exp.	313	15.83	30.31	31.85	32.13	27.01	19.97	14.49	1.54	0.28	-5.12	-7.04
Exp.	314	16.56	30.40	31.67	31.93	26.95	19.52	13.84	1.27	0.26	-4.98	-7.43
Exp.	316	15.21	29.48	30.98	31.20	26.03	18.37	14.27	1.50	0.22	-5.17	-7.66
Exp.	317	15.87	31.01	32.63	32.81	27.69	18.86	15.14	1.62	0.18	-5.12	-8.83
Exp.	319	14.82	30.33	31.99	32.22	26.31	18.88	15.52	1.66	0.23	-5.92	-7.43
Exp.	320	15.04	29.12	30.81	30.96	26.04	19.61	14.07	1.69	0.15	-4.91	-6.43
Exp.	321	13.91	27.79	29.00	29.11	24.75	18.72	13.87	1.21	0.10	-4.36	-6.02
Exp.	322	15.35	30.83	32.36	32.51	27.48	19.59	15.48	1.53	0.15	-5.03	-7.89
Exp.	341	14.37	25.88	27.47	27.63	23.58	17.27	11.51	1.59	0.16	-4.04	-6.31
Exp.	0	15.19	29.28	30.77	30.96	26.19	18.86	14.09	1.49	0.19	-4.77	-7.33
AVERAGES for Vf:												
Exp.	0	15.22	29.36	30.85	31.05	26.24	18.89	14.14	1.49	0.20	-4.80	-7.35
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.76	1.61	1.65	1.67	1.26	0.82	1.19	0.17	0.06	0.70	0.92

2B/1C/4B/1C/2B @ Pc = 80 kPa

	$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp. 411	14.95	8.60	8.21	8.10	8.08	8.04	-6.35	-0.39	-0.11	-0.01	-0.05
Exp. 412	13.74	9.01	8.57	8.50	8.47	8.38	-4.74	-0.43	-0.08	-0.03	-0.09
Exp. 413	14.38	8.54	8.10	7.98	7.97	7.91	-5.85	-0.44	-0.12	-0.00	-0.07
Exp. 414	13.58	8.54	8.11	8.01	8.00	7.96	-5.05	-0.42	-0.10	-0.01	-0.04
Exp. 415	14.04	8.71	8.28	8.23	8.23	8.21	-5.33	-0.43	-0.05	-0.00	-0.02
Exp. 416	13.85	9.02	8.59	8.48	8.47	8.38	-4.83	-0.44	-0.11	-0.01	-0.09
Exp. 417	14.63	8.71	8.29	8.20	8.19	8.12	-5.93	-0.42	-0.09	-0.01	-0.07
Exp. 419	14.65	8.62	8.17	8.09	8.07	7.99	-6.03	-0.45	-0.09	-0.02	-0.07
Exp. 420	13.17	8.79	8.41	8.34	8.33	8.28	-4.38	-0.39	-0.07	-0.01	-0.05
Exp. 421	13.92	8.52	8.16	8.08	8.07	8.00	-5.39	-0.36	-0.08	-0.01	-0.07
Exp. 0	14.09	8.71	8.29	8.20	8.19	8.13	-5.39	-0.42	-0.09	-0.01	-0.06
AVERAGES for h:											
Exp. 0	14.09	8.71	8.29	8.20	8.19	8.13	-5.39	-0.42	-0.09	-0.01	-0.06
STANDARD DEVIATIONS for h:											
Exp. 0	0.55	0.19	0.18	0.19	0.18	0.18	0.64	0.03	0.02	0.01	0.02

	$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp. 411	18.12	31.49	32.99	33.44	33.50	33.70	13.37	1.50	0.45	0.06	0.20
Exp. 412	19.71	30.07	31.60	31.88	31.98	32.31	10.36	1.52	0.29	0.10	0.33
Exp. 413	18.83	31.72	33.45	33.96	33.97	34.26	12.89	1.73	0.50	0.01	0.29
Exp. 414	19.94	31.73	33.39	33.82	33.86	34.03	11.79	1.66	0.43	0.04	0.18
Exp. 415	19.29	31.09	32.71	32.90	32.92	32.98	11.80	1.62	0.19	0.02	0.06
Exp. 416	19.56	30.02	31.54	31.94	31.98	32.32	10.46	1.52	0.40	0.04	0.33
Exp. 417	18.51	31.11	32.69	33.03	33.08	33.34	12.60	1.58	0.34	0.04	0.27
Exp. 419	18.48	31.41	33.14	33.50	33.57	33.88	12.93	1.73	0.36	0.07	0.31
Exp. 420	20.57	30.81	32.22	32.48	32.52	32.73	10.24	1.42	0.26	0.04	0.21
Exp. 421	19.47	31.79	33.20	33.51	33.56	33.86	12.32	1.41	0.31	0.05	0.30
Exp. 0	19.22	31.11	32.68	33.03	33.08	33.33	11.89	1.57	0.35	0.05	0.25
AVERAGES for Vf:											
Exp. 0	19.25	31.12	32.69	33.05	33.09	33.34	11.88	1.57	0.35	0.05	0.25
STANDARD DEVIATIONS for Vf:											
Exp. 0	0.76	0.65	0.70	0.74	0.73	0.72	1.16	0.11	0.10	0.02	0.09

2B/1C/4B/1C/2B @ Pc = 60 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	442	13.68	8.23	7.82	7.80	7.82	7.84	-5.45	-0.41	-0.02	0.02	0.01
Exp.	443	13.98	8.06	7.64	7.58	7.57	7.57	-5.92	-0.42	-0.06	-0.01	0.00
Exp.	444	13.75	7.89	7.57	7.49	7.49	7.50	-5.86	-0.32	-0.08	-0.00	0.01
Exp.	445	13.93	8.16	7.73	7.71	7.76	7.78	-5.77	-0.43	-0.01	0.05	0.02
Exp.	446	12.84	8.17	7.79	7.73	7.72	7.75	-4.67	-0.38	-0.07	-0.01	0.03
Exp.	447	14.08	8.52	8.11	7.92	7.92	7.95	-5.56	-0.41	-0.19	-0.01	0.04
Exp.	448	14.19	8.65	8.27	8.14	8.12	8.12	-5.54	-0.38	-0.13	-0.02	-0.00
Exp.	449	13.60	8.75	8.28	8.22	8.21	8.20	-4.85	-0.47	-0.05	-0.01	-0.01
Exp.	450	10.96	8.61	8.13	7.96	7.96	7.97	-2.35	-0.48	-0.17	-0.01	0.01
Exp.	451	14.22	8.72	8.21	8.04	8.04	8.07	-5.49	-0.51	-0.17	-0.00	0.03
Exp.	0	13.52	8.38	7.96	7.86	7.86	7.88	-5.15	-0.42	-0.09	0.00	0.02
AVERAGES for h:												
Exp.	0	13.52	8.38	7.96	7.86	7.86	7.88	-5.15	-0.42	-0.09	0.00	0.02
STANDARD DEVIATIONS for h:												
Exp.	0	0.99	0.31	0.27	0.24	0.23	0.23	1.06	0.05	0.06	0.02	0.02

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	442	19.80	32.92	34.63	34.71	34.62	34.55	13.12	1.71	0.08	-0.09	-0.07
Exp.	443	19.37	33.61	35.46	35.74	35.79	35.78	14.24	1.85	0.27	0.05	-0.00
Exp.	444	19.70	34.31	35.78	36.16	36.18	36.13	14.61	1.47	0.38	0.02	-0.06
Exp.	445	19.44	33.20	35.06	35.12	34.90	34.81	13.75	1.86	0.06	-0.22	-0.09
Exp.	446	21.09	33.13	34.75	35.05	35.09	34.94	12.04	1.61	0.30	0.04	-0.16
Exp.	447	19.24	31.80	33.39	34.18	34.21	34.05	12.56	1.59	0.79	0.03	-0.15
Exp.	448	19.09	31.31	32.76	33.29	33.35	33.36	12.23	1.45	0.52	0.07	0.00
Exp.	449	19.91	30.96	32.72	32.94	32.99	33.02	11.05	1.76	0.22	0.05	0.03
Exp.	450	24.72	31.46	33.31	34.02	34.05	33.98	6.74	1.85	0.71	0.03	-0.06
Exp.	451	19.05	31.05	32.98	33.67	33.68	33.55	12.00	1.94	0.69	0.01	-0.13
Exp.	0	20.03	32.34	34.05	34.46	34.46	34.39	12.31	1.71	0.41	-0.00	-0.07
AVERAGES for Vf:												
Exp.	0	20.14	32.38	34.09	34.49	34.49	34.42	12.23	1.71	0.40	-0.00	-0.07
STANDARD DEVIATIONS for Vf:												
Exp.	0	1.71	1.20	1.17	1.05	1.03	1.02	2.22	0.17	0.26	0.09	0.07

2B/1C/4B/1C/2B @ Pc = 40 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	433	15.06	8.88	8.46	8.35	8.49	8.58	-6.18	-0.42	-0.11	0.14	0.09
Exp.	434	14.60	8.65	8.21	8.17	8.28	8.34	-5.95	-0.44	-0.04	0.11	0.06
Exp.	435	13.37	8.28	7.85	7.80	7.89	7.92	-5.09	-0.44	-0.04	0.09	0.03
Exp.	436	14.28	8.69	8.32	8.28	8.36	8.41	-5.59	-0.38	-0.04	0.08	0.05
Exp.	437	13.97	8.95	8.60	8.50	8.62	8.67	-5.02	-0.36	-0.10	0.13	0.05
Exp.	438	13.57	8.80	8.27	8.25	8.29	8.32	-4.76	-0.54	-0.02	0.04	0.03
Exp.	439	13.48	8.01	7.65	7.62	7.72	7.76	-5.47	-0.36	-0.04	0.10	0.04
Exp.	440	13.37	8.23	7.87	7.80	7.83	7.86	-5.14	-0.36	-0.08	0.04	0.03
Exp.	441	13.84	8.72	8.27	8.19	8.27	8.31	-5.13	-0.45	-0.08	0.08	0.05
Exp.	494	13.44	8.00	7.62	7.61	7.78	7.85	-5.44	-0.38	-0.01	0.18	0.07
Exp.	0	13.90	8.52	8.11	8.06	8.15	8.20	-5.38	-0.41	-0.06	0.10	0.05
AVERAGES for h:												
Exp.	0	13.90	8.52	8.11	8.06	8.15	8.20	-5.38	-0.41	-0.06	0.10	0.05
STANDARD DEVIATIONS for h:												
Exp.	0	0.58	0.36	0.34	0.32	0.32	0.33	0.44	0.06	0.03	0.04	0.02

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	433	17.99	30.52	32.02	32.45	31.91	31.56	12.53	1.50	0.43	-0.54	-0.35
Exp.	434	18.56	31.32	32.99	33.16	32.72	32.48	12.77	1.66	0.18	-0.45	-0.24
Exp.	435	20.26	32.70	34.52	34.71	34.34	34.21	12.44	1.82	0.19	-0.38	-0.12
Exp.	436	18.97	31.16	32.57	32.72	32.40	32.21	12.19	1.41	0.15	-0.32	-0.19
Exp.	437	19.39	30.25	31.51	31.88	31.41	31.24	10.87	1.26	0.36	-0.47	-0.17
Exp.	438	19.97	30.77	32.76	32.84	32.68	32.57	10.80	1.99	0.08	-0.17	-0.11
Exp.	439	20.09	33.82	35.39	35.55	35.09	34.89	13.73	1.57	0.16	-0.46	-0.20
Exp.	440	20.25	32.91	34.41	34.75	34.59	34.47	12.66	1.50	0.34	-0.16	-0.12
Exp.	441	19.57	31.07	32.77	33.08	32.77	32.59	11.51	1.69	0.32	-0.31	-0.18
Exp.	494	20.15	33.86	35.55	35.60	34.80	34.49	13.71	1.69	0.04	-0.80	-0.31
Exp.	0	19.49	31.79	33.40	33.63	33.22	33.02	12.30	1.61	0.23	-0.40	-0.20
AVERAGES for Vf:												
Exp.	0	19.52	31.84	33.45	33.67	33.27	33.07	12.32	1.61	0.23	-0.41	-0.20
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.79	1.36	1.41	1.35	1.31	1.33	1.02	0.21	0.13	0.19	0.08

2B/1C/4B/1C/2B @ Pc = 20 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	422	13.20	7.61	7.27	7.17	7.40	7.53	-5.58	-0.35	-0.09	0.22	0.13
Exp.	423	13.79	7.97	7.64	7.50	7.87	7.95	-5.82	-0.32	-0.14	0.36	0.08
Exp.	424	13.81	7.91	7.58	7.48	7.79	7.87	-5.91	-0.33	-0.09	0.31	0.07
Exp.	425	14.03	8.15	7.75	7.74	8.13	8.25	-5.88	-0.39	-0.01	0.39	0.11
Exp.	426	13.70	8.20	7.73	7.70	8.00	8.11	-5.50	-0.46	-0.04	0.30	0.12
Exp.	427	13.27	7.97	7.65	7.63	7.82	7.91	-5.30	-0.32	-0.02	0.19	0.09
Exp.	429	13.90	8.63	8.21	8.08	8.42	8.57	-5.26	-0.42	-0.13	0.34	0.15
Exp.	430	14.23	8.62	8.25	8.07	8.40	8.58	-5.61	-0.37	-0.18	0.33	0.18
Exp.	431	13.96	8.32	7.92	7.82	8.29	8.47	-5.65	-0.39	-0.10	0.47	0.19
Exp.	432	13.04	8.18	7.63	7.60	8.02	8.17	-4.86	-0.55	-0.03	0.42	0.16
Exp.	0	13.69	8.15	7.76	7.68	8.01	8.14	-5.54	-0.39	-0.08	0.33	0.13
AVERAGES for h:												
Exp.	0	13.69	8.15	7.76	7.68	8.01	8.14	-5.54	-0.39	-0.08	0.33	0.13
STANDARD DEVIATIONS for h:												
Exp.	0	0.39	0.32	0.30	0.27	0.31	0.34	0.32	0.07	0.06	0.09	0.04

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	422	20.53	35.58	37.27	37.76	36.62	35.98	15.05	1.69	0.49	-1.15	-0.64
Exp.	423	19.65	34.00	35.45	36.10	34.43	34.07	14.35	1.44	0.65	-1.67	-0.36
Exp.	424	19.61	34.26	35.75	36.19	34.76	34.43	14.65	1.49	0.44	-1.43	-0.33
Exp.	425	19.31	33.25	34.95	34.98	33.30	32.85	13.94	1.69	0.04	-1.68	-0.45
Exp.	426	19.77	33.05	35.02	35.19	33.87	33.38	13.28	1.97	0.18	-1.32	-0.49
Exp.	427	20.41	33.98	35.40	35.48	34.64	34.24	13.57	1.42	0.08	-0.84	-0.40
Exp.	429	19.49	31.38	32.99	33.53	32.18	31.62	11.89	1.61	0.53	-1.35	-0.56
Exp.	430	19.03	31.42	32.84	33.56	32.24	31.56	12.38	1.42	0.73	-1.32	-0.68
Exp.	431	19.40	32.57	34.19	34.63	32.68	31.97	13.17	1.62	0.44	-1.95	-0.71
Exp.	432	20.77	33.13	35.52	35.66	33.78	33.14	12.35	2.39	0.14	-1.88	-0.64
Exp.	0	19.78	33.22	34.89	35.27	33.80	33.27	13.43	1.68	0.38	-1.47	-0.53
AVERAGES for Vf:												
Exp.	0	19.80	33.26	34.94	35.31	33.85	33.32	13.46	1.68	0.37	-1.46	-0.53
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.58	1.29	1.32	1.26	1.35	1.41	1.05	0.30	0.25	0.34	0.14

2B/1C/4B/1C/2B @ Pc = 10 kPa

	$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp. 495	13.78	8.38	7.88	7.86	8.58	8.93	-5.39	-0.51	-0.01	0.72	0.35
Exp. 496	14.25	8.38	7.95	7.94	8.53	8.83	-5.87	-0.43	-0.01	0.59	0.31
Exp. 497	14.73	8.52	8.07	8.06	8.91	9.17	-6.21	-0.45	-0.01	0.85	0.26
Exp. 498	14.79	8.61	8.19	8.15	8.98	9.33	-6.18	-0.42	-0.03	0.83	0.35
Exp. 499	14.62	8.23	7.81	7.79	8.55	8.88	-6.39	-0.42	-0.02	0.76	0.34
Exp. 500	14.14	8.46	7.95	7.93	8.84	9.20	-5.69	-0.50	-0.03	0.91	0.36
Exp. 501	14.66	8.72	8.27	8.24	8.81	9.10	-5.95	-0.45	-0.02	0.57	0.29
Exp. 502	14.39	8.81	8.21	8.17	8.75	8.95	-5.58	-0.60	-0.04	0.58	0.20
Exp. 503	14.08	8.26	7.83	7.82	8.52	8.80	-5.82	-0.43	-0.01	0.69	0.28
Exp. 504	14.60	8.83	8.16	8.12	8.66	8.95	-5.77	-0.68	-0.04	0.54	0.30
Exp. 0	14.40	8.52	8.03	8.01	8.71	9.02	-5.88	-0.49	-0.02	0.70	0.30
AVERAGES for h:											
Exp. 0	14.40	8.52	8.03	8.01	8.71	9.02	-5.88	-0.49	-0.02	0.70	0.30
STANDARD DEVIATIONS for h:											
Exp. 0	0.33	0.22	0.17	0.16	0.17	0.18	0.31	0.09	0.01	0.13	0.05

	$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp. 495	19.66	32.31	34.39	34.45	31.56	30.33	12.65	2.08	0.06	-2.89	-1.23
Exp. 496	19.01	32.32	34.06	34.11	31.77	30.67	13.32	1.74	0.05	-2.34	-1.10
Exp. 497	18.39	31.79	33.57	33.62	30.41	29.55	13.40	1.78	0.05	-3.21	-0.86
Exp. 498	18.32	31.47	33.09	33.22	30.16	29.04	13.16	1.61	0.13	-3.06	-1.12
Exp. 499	18.53	32.92	34.69	34.77	31.70	30.50	14.39	1.77	0.08	-3.07	-1.20
Exp. 500	19.15	32.02	34.05	34.17	30.64	29.43	12.87	2.03	0.12	-3.53	-1.20
Exp. 501	18.47	31.08	32.77	32.86	30.73	29.75	12.60	1.69	0.09	-2.13	-0.98
Exp. 502	18.82	30.75	32.98	33.14	30.95	30.26	11.92	2.23	0.17	-2.19	-0.69
Exp. 503	19.24	32.79	34.58	34.62	31.81	30.78	13.55	1.79	0.04	-2.81	-1.02
Exp. 504	18.55	30.66	33.21	33.37	31.29	30.25	12.11	2.55	0.16	-2.08	-1.04
Exp. 0	18.81	31.79	33.72	33.82	31.09	30.05	12.99	1.93	0.10	-2.73	-1.05
AVERAGES for Vf:											
Exp. 0	18.81	31.81	33.74	33.83	31.10	30.06	13.00	1.93	0.10	-2.73	-1.05
STANDARD DEVIATIONS for Vf:											
Exp. 0	0.44	0.81	0.71	0.68	0.60	0.58	0.73	0.29	0.05	0.51	0.17

2B/1C/4B/1C/2B @ Pc = 2 kPa

		$h_{initial}$	h_{loaded}	$h_{settled}$	$h_{fiberwet}$	$h_{unloaded}$	h_{final}	$\Delta h_{loading}$	$\Delta h_{settling}$	$\Delta h_{wetting}$	$\Delta h_{unloading}$	$\Delta h_{relaxation}$
Exp.	279	14.84	8.74	8.49	8.34	9.42	12.45	-6.10	-0.25	-0.15	1.08	3.03
Exp.	280	14.81	8.89	8.48	8.38	10.13	12.70	-5.91	-0.42	-0.10	1.75	2.57
Exp.	281	14.42	8.90	8.53	8.38	9.43	12.29	-5.52	-0.36	-0.15	1.05	2.85
Exp.	282	14.09	8.30	7.91	7.71	9.04	11.47	-5.79	-0.39	-0.20	1.33	2.43
Exp.	283	15.11	9.11	8.64	8.50	9.55	12.48	-6.00	-0.47	-0.14	1.04	2.93
Exp.	284	14.58	8.96	8.55	8.38	9.02	10.31	-5.62	-0.41	-0.17	0.64	1.29
Exp.	286	14.31	8.75	8.34	8.24	9.61	12.04	-5.56	-0.42	-0.10	1.37	2.43
Exp.	287	14.69	8.61	8.24	8.06	9.52	12.42	-6.07	-0.38	-0.18	1.46	2.91
Exp.	289	15.22	8.35	7.97	7.79	8.92	10.91	-6.87	-0.38	-0.18	1.13	1.99
Exp.	290	13.54	8.44	8.08	7.97	9.22	11.69	-5.09	-0.36	-0.11	1.25	2.47
Exp.	0	14.56	8.71	8.32	8.18	9.39	11.88	-5.85	-0.38	-0.15	1.21	2.49
AVERAGES for h:												
Exp.	0	14.56	8.71	8.32	8.18	9.39	11.88	-5.85	-0.38	-0.15	1.21	2.49
STANDARD DEVIATIONS for h:												
Exp.	0	0.50	0.27	0.26	0.28	0.36	0.78	0.47	0.06	0.04	0.30	0.53

		$V_{f,initial}$	$V_{f,loaded}$	$V_{f,settled}$	$V_{f,fiberwet}$	$V_{f,unloaded}$	$V_{f,final}$	$\Delta V_{f,loading}$	$\Delta V_{f,settling}$	$\Delta V_{f,wetting}$	$\Delta V_{f,unloading}$	$\Delta V_{f,relaxation}$
Exp.	279	18.26	31.00	31.91	32.49	28.75	21.75	12.74	0.92	0.58	-3.74	-7.00
Exp.	280	18.29	30.45	31.95	32.33	26.74	21.33	12.16	1.49	0.38	-5.59	-5.41
Exp.	281	18.79	30.44	31.74	32.31	28.71	22.04	11.65	1.30	0.57	-3.60	-6.67
Exp.	282	19.23	32.64	34.25	35.14	29.96	23.61	13.42	1.61	0.88	-5.17	-6.35
Exp.	283	17.93	29.74	31.35	31.86	28.37	21.71	11.81	1.61	0.51	-3.49	-6.66
Exp.	284	18.57	30.23	31.68	32.32	30.02	26.27	11.66	1.46	0.63	-2.30	-3.74
Exp.	286	18.93	30.94	32.49	32.87	28.18	22.49	12.02	1.55	0.38	-4.69	-5.69
Exp.	287	18.44	31.44	32.88	33.60	28.46	21.80	13.00	1.44	0.72	-5.14	-6.66
Exp.	289	17.80	32.43	33.96	34.76	30.37	24.83	14.63	1.54	0.79	-4.39	-5.54
Exp.	290	20.01	32.09	33.53	34.00	29.38	23.17	12.08	1.44	0.47	-4.61	-6.21
Exp.	0	18.60	31.11	32.55	33.13	28.86	22.81	12.51	1.43	0.59	-4.27	-6.05
AVERAGES for Vf:												
Exp.	0	18.62	31.14	32.58	33.17	28.90	22.90	12.52	1.44	0.59	-4.27	-5.99
STANDARD DEVIATIONS for Vf:												
Exp.	0	0.65	0.98	1.03	1.14	1.08	1.60	0.95	0.20	0.17	0.99	0.96

APPENDIX C

ANALYSIS OF SAMPLE EXPERIMENTS:

Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
324	136,06	106,93	3,60	1,71	1,59	1,59	1,95	2,94	-1,88	-0,12	0,00	0,36	0,99

Fabric type = 1 layers of Core Material (METYX, 250 g/m^2)

Exp # = 324

Date = 09/07/08, 16:24

Done by = Barış

Fabric weight = 0.8 g

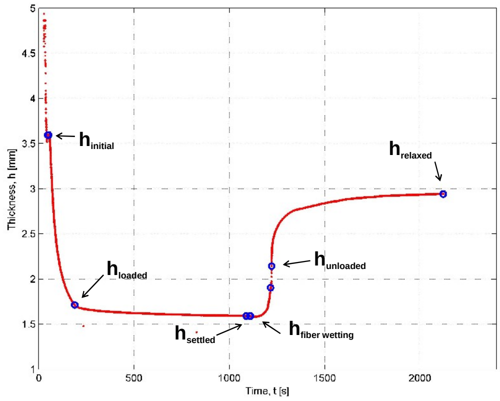
Note = NA

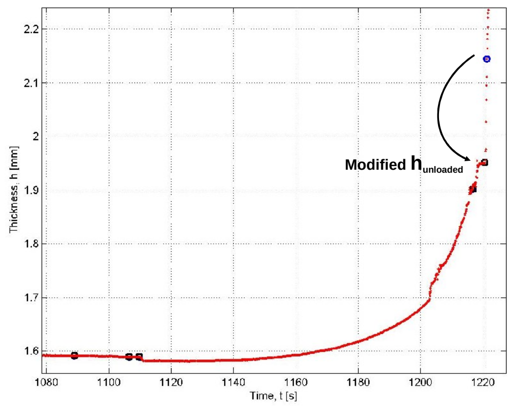
$h_{fiberwet}$ = 1.59 mm

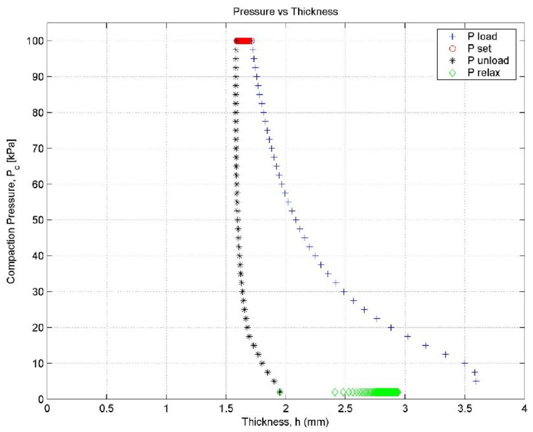
Modified $h_{fiberwet}$ = NA

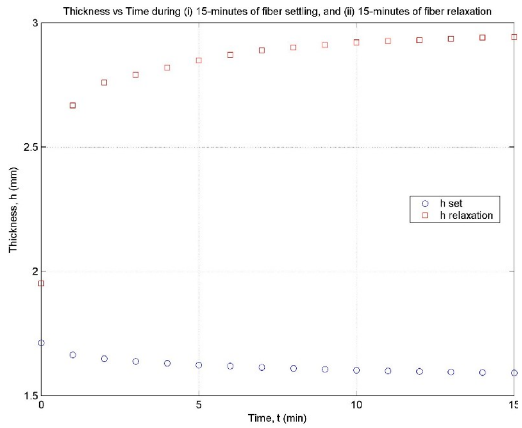
$h_{unloaded}$ = 2.14 mm

Modified $h_{unloaded}$ = 1.95 mm





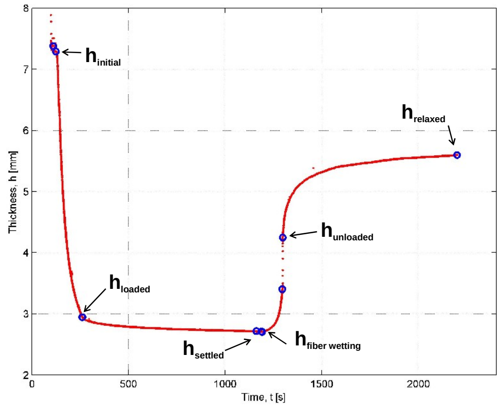


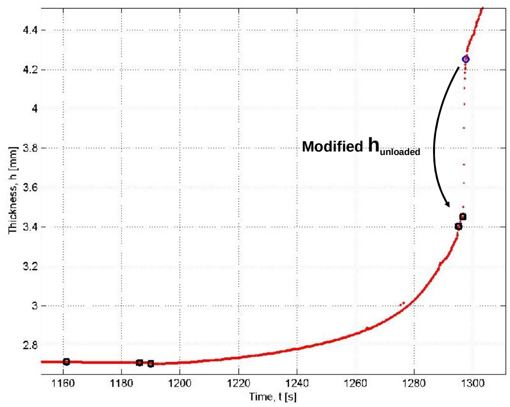


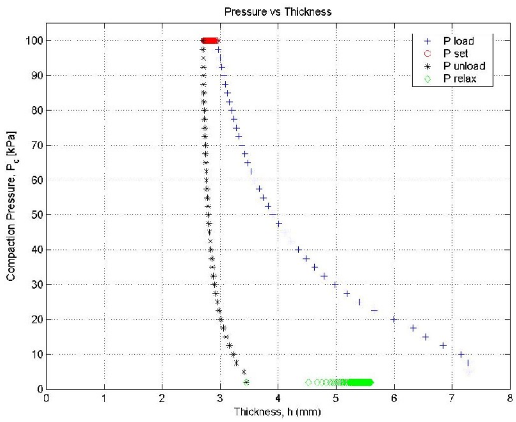
Compaction experiment # 324 – 1 C

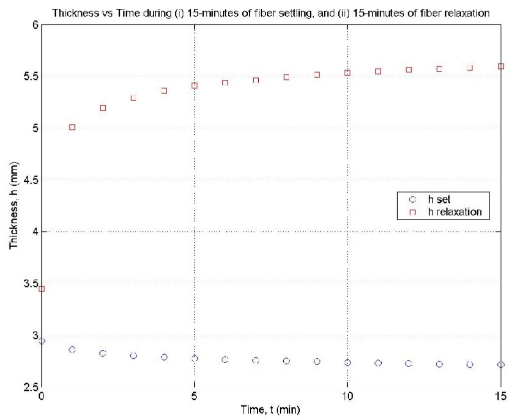
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
144	135,97	105,30	7,29	2,95	2,72	2,71	3,45	5,60	-4,34	-0,23	-0,01	0,74	2,15

Fabric type = 2 layers of Core Material (METYX, 250 g/m²)
Exp # = 144
Date = 12/06/08, 11:56
Done by = Onur and Talha
Fabric weight = 1.6 g
Note = NA
$h_{fiberwet}$ = 2.71 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 4.25 mm
Modified $h_{unloaded}$ = 3.45 mm





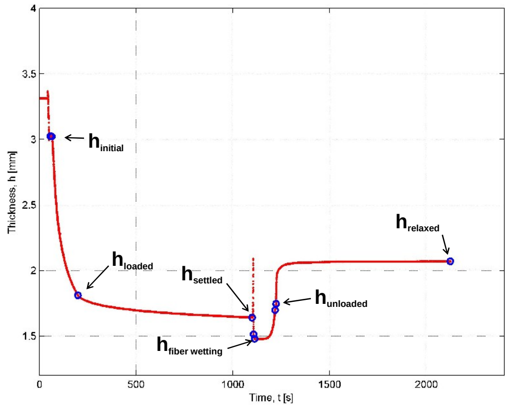


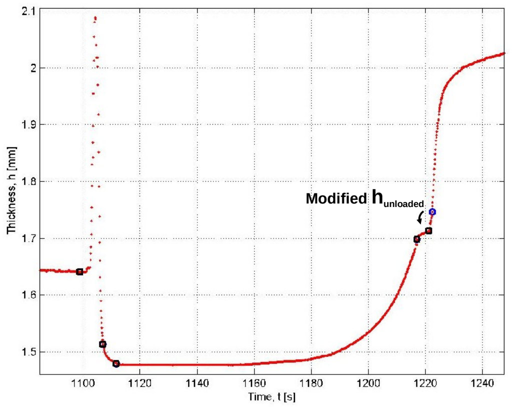


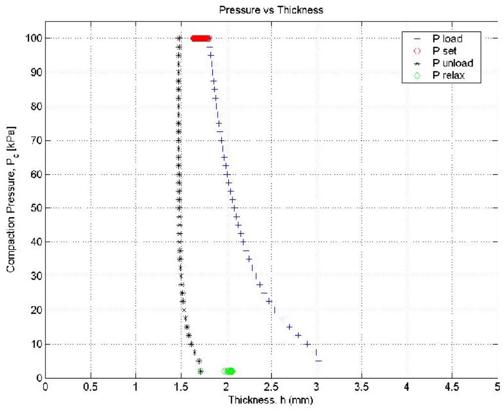
Compaction experiment # 144 – 2C

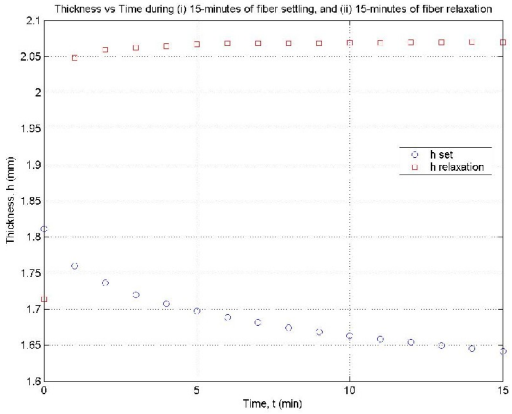
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
155	134,67	105,29	3,02	1,81	1,64	1,48	1,71	2,07	-1,21	-0,17	-0,16	0,23	0,36

Fabric type = 4 layers of Random Fabric (Fibroteks, 500 g/m^2)
Exp # = 155
Date = 16 /06 /08 , 14:42
Done by = Tolga and Talha
Fabric weight = NA
Note = NA
$h_{fiberwet}$ = 1.48 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 1.75 mm
Modified $h_{unloaded}$ = 1.71 mm





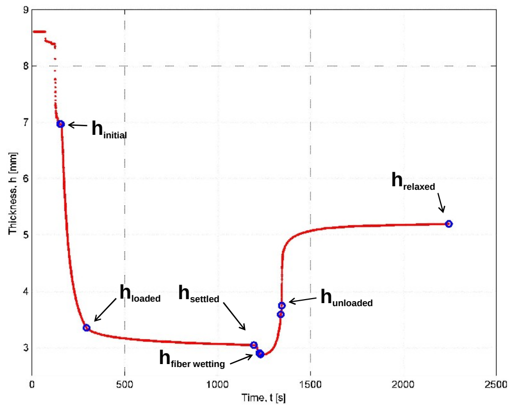


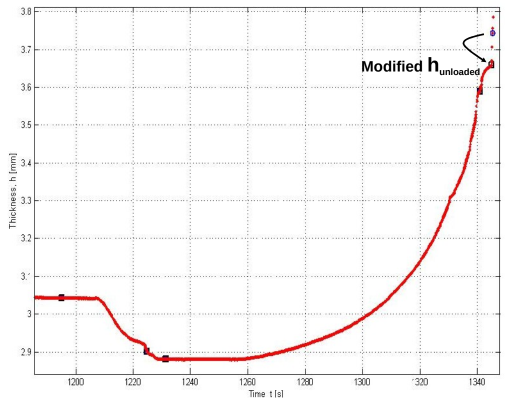


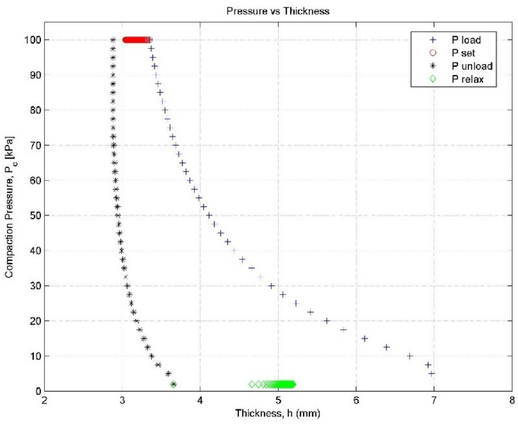
Compaction experiment # 155 – 4R

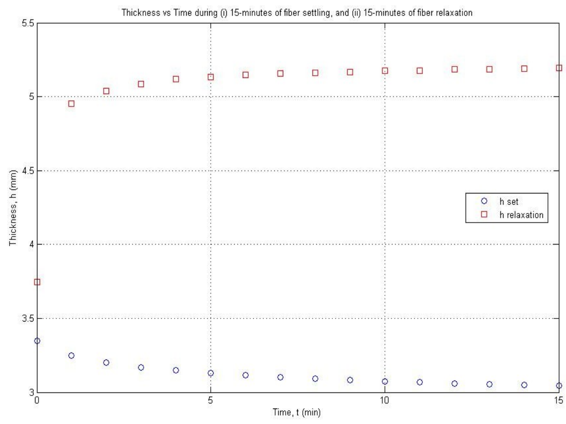
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
399	137,28	109,45	6,97	3,35	3,04	2,88	3,66	5,19	-3,62	-0,31	-0,16	0,78	1,54

Fabric type =[2R+1C+2R],Sandwich R= Random Fabric, (Fibroteks, 500 g/m²) C=Core Material, (METYX, 250 g/m²)
Exp # = 399
Date = 29/07/08,10:43
Done by = Talha
Fabric weight = 10.2 g
Note = NA
$h_{fiberwet}$ = 2.88 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 3.74 mm
Modified $h_{unloaded}$ = 3.66 mm









Compaction experiment # 399 – 2R/ 1C/ 2R

Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
230	134,22	101,82	13,13	6,20	5,61	5,34	6,68	9,01	-6,93	-0,59	-0,27	1,34	2,33

Fabric type =[2R+1C+4R+1C+2R],Sandwich
R= Random Fabric, (Fibroteks, 500 g/m²)
C=Core Material, (METYX, 250 g/m²)

Exp # = 230

Date = 26/06/08, 18:34

Done by = Onur and Barış

Fabric weight = 12.4 g

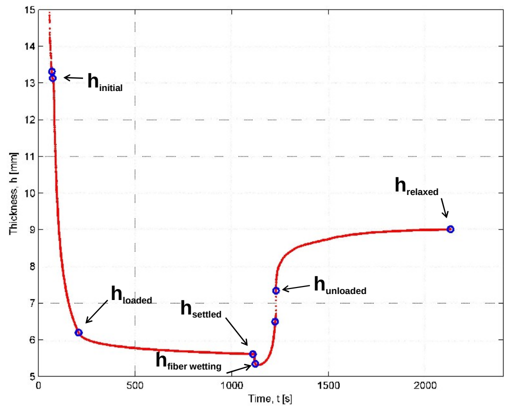
Note = NA

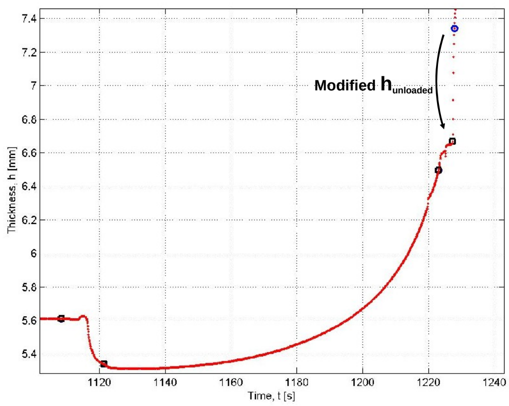
$h_{fiberwet}$ = 5.34 mm

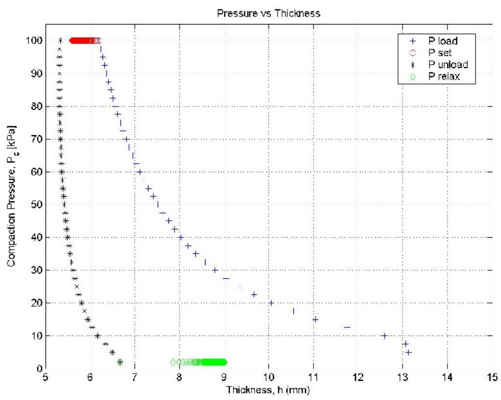
Modified $h_{fiberwet}$ = NA

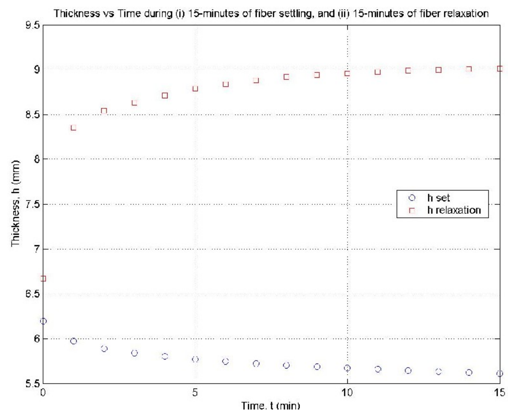
$h_{unloaded}$ = 7.34 mm

Modified $h_{unloaded}$ = 6.68 mm





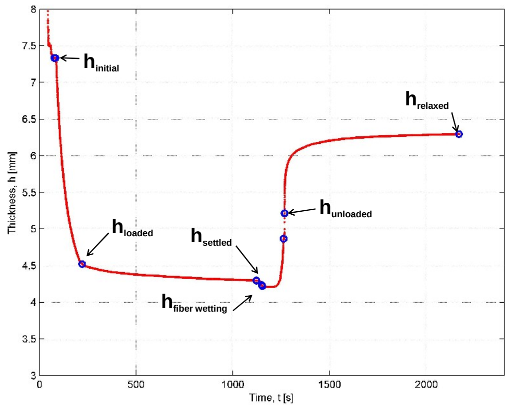


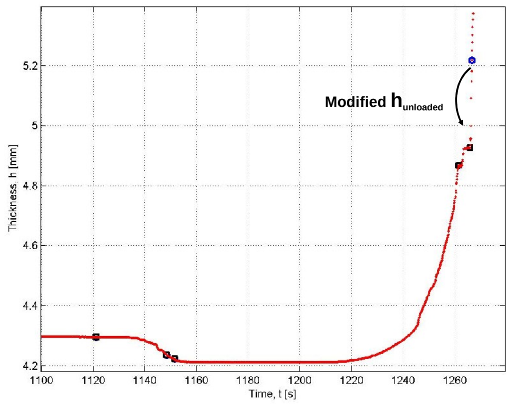


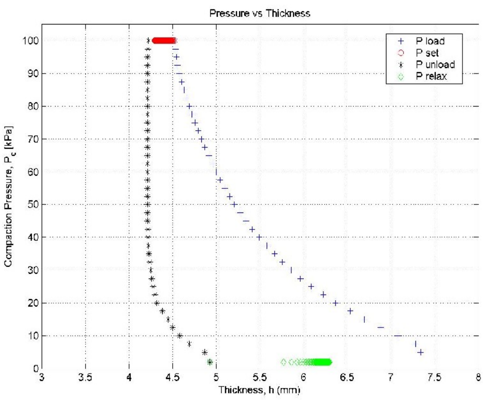
Compaction experiment # 230 – 2R/ 1C/ 4R/ 1C/ 2R

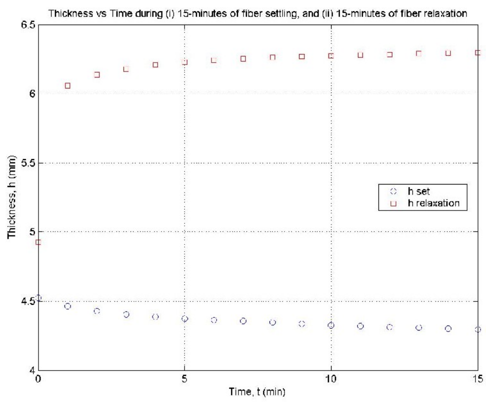
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
254	138,06	110,01	7,34	4,52	4,30	4,22	4,94	6,30	-2,81	-0,23	-0,07	0,72	1,36

Fabric type =[2S+1C+2S],Sandwich S= Stitched Fabric, (METYX, 860 g/m^2) C=Core Material, (METYX, 250 g/m^2)
Exp # = 254
Date = 30/06/08, 21:38
Done by = Tolga
Fabric weight = 11.5 g
Note = NA
$h_{fiberwet}$ = 4.22 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 5.22 mm
Modified $h_{unloaded}$ = 4.94 mm





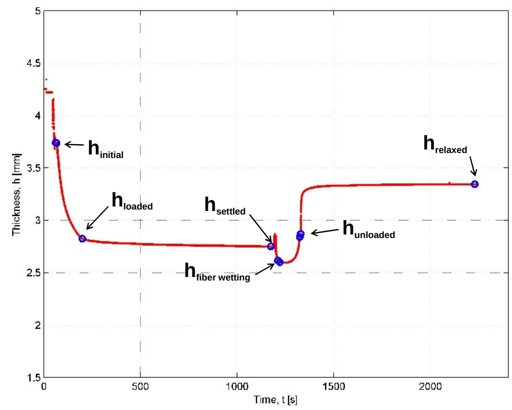


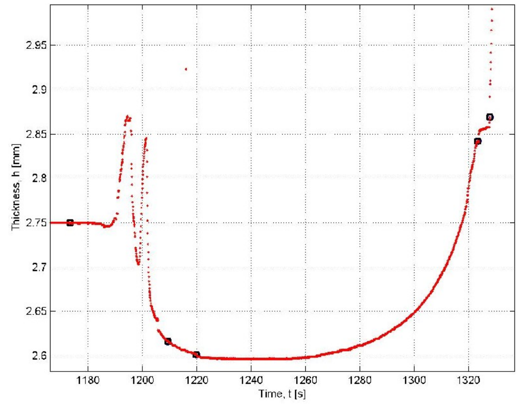


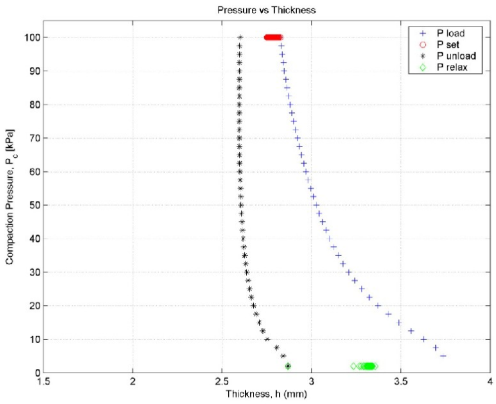
Compaction experiment # 254 – 2B/ 1C/ 2B

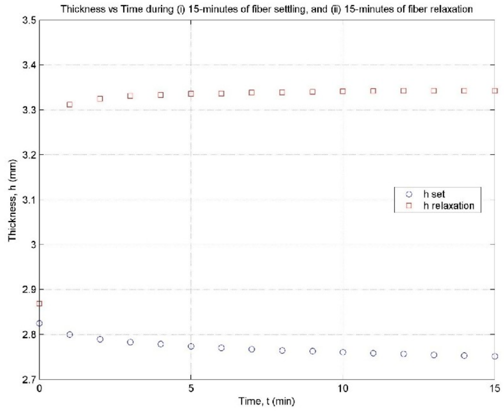
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
247	133,18	103,63	3,74	2,83	2,75	2,60	2,88	3,34	-0,91	-0,07	-0,15	0,28	0,46

Fabric type =[4 Stitched Fabric] S=Stitched Fabric, (METYX, 860 g/m^2)
Exp # = 247
Date = 30/06/08, 16:28
Done by = Onur and Barış
Fabric weight = 10.9 g
Note = NA
$h_{fiberwet}$ = 2.60 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 2.88 mm
Modified $h_{unloaded}$ = NA





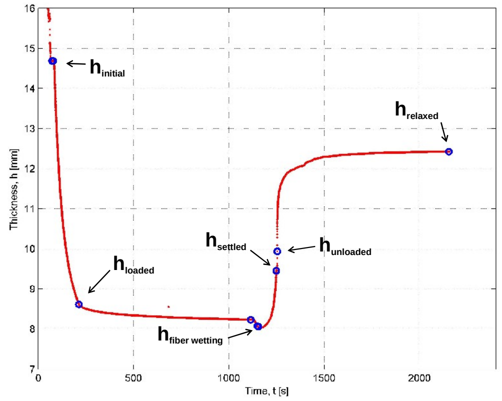


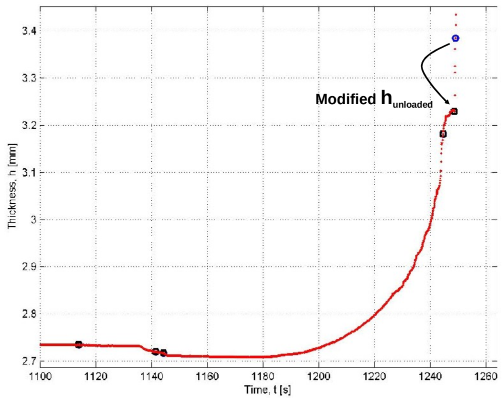


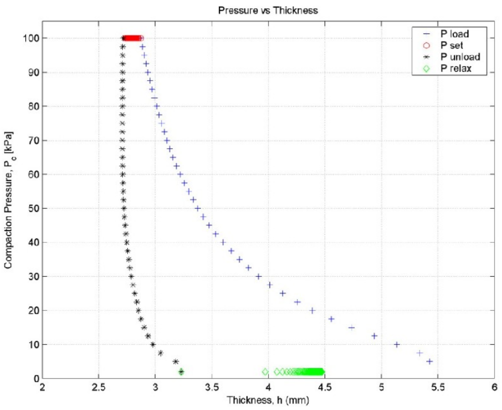
Compaction experiment # 247 – 4 B.

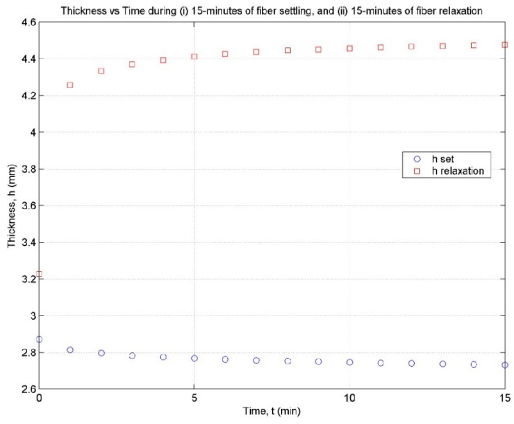
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
287	134,46	94,95	14,69	8,61	8,24	8,06	9,52	12,42	-6,07	-0,38	-0,18	1,46	2,91

Fabric type=[2S+1C+4S+1C+2S],Sandwich S=Stitched Fabric, (METYX, 860 g/m^2) C=Core Material, (METYX, 250 g/m^2)
Exp # = 287
Date = 07/06/08, 16:04
Done by = Barış
Fabric weight = 20.8 g
Note = NA
$h_{fiberwet}$ = 8.06 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 9.94 mm
Modified $h_{unloaded}$ = 9.52 mm





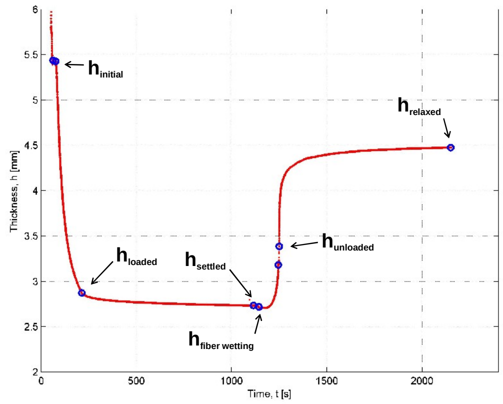


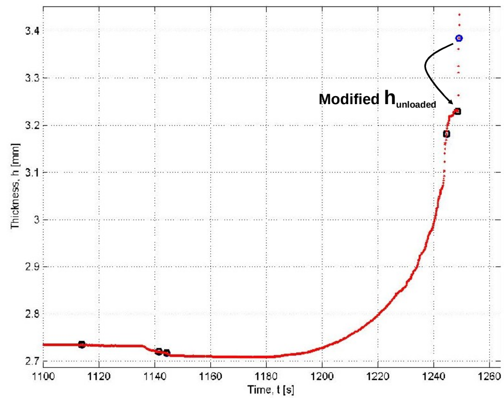


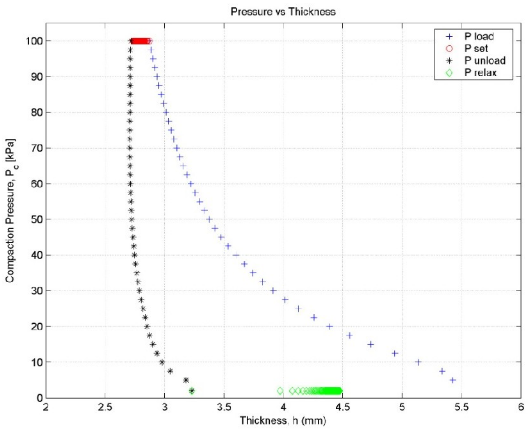
Compaction experiment # 287 – 2 1 4 1 2 Biaxial configuration

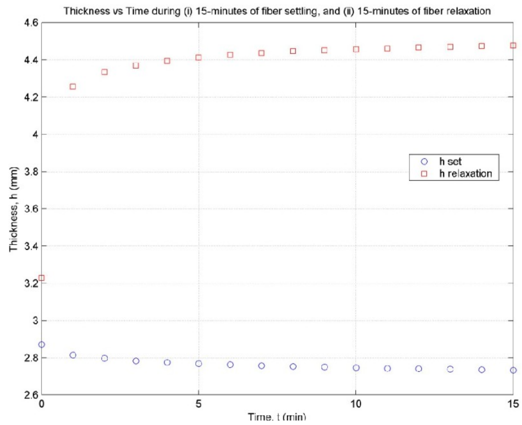
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
305	136,38	100,39	5,43	2,87	2,73	2,72	3,25	4,48	-2,55	-0,14	-0,02	0,53	1,23

Fabric type =[2W + 1C +2W] Sandwich W=Woven Fabric,(METYX, 500 g/m²) C=Core Material,(METYX,250 g/m²)
Exp # = 305
Date = 08/06/08, 16:43
Done by = Barış
Fabric weight = 6.2 g
Note = NA
$h_{fiberwet}$ = 2.72 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 3.38 mm
Modified $h_{unloaded}$ = 3.25 mm





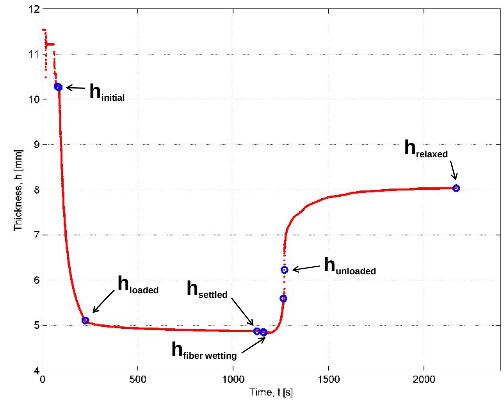


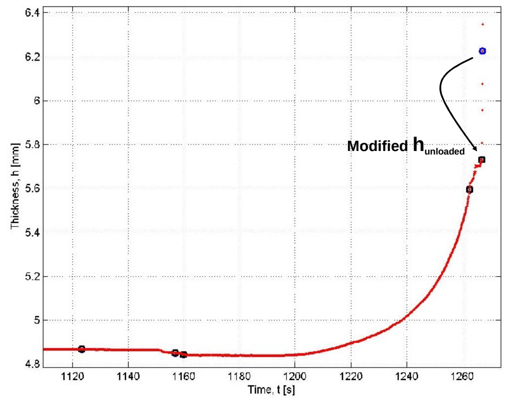


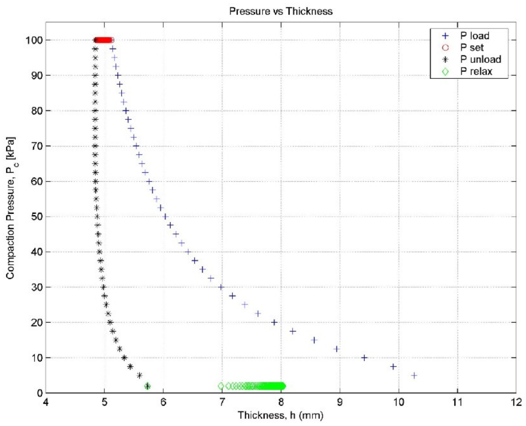
Compaction experiment # 305 – 2W/ 1C/ 2W.

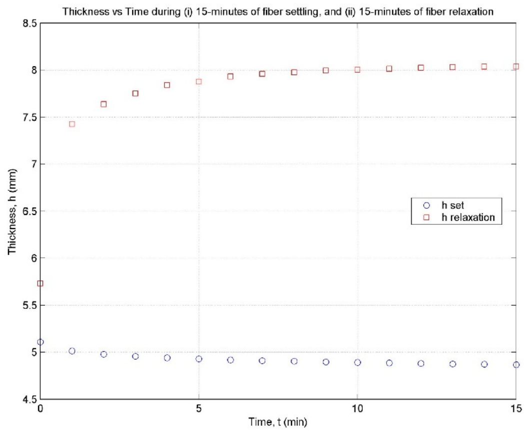
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
322	137,01	102,66	10,26	5,11	4,87	4,84	5,77	8,04	-5,15	-0,24	-0,02	0,93	2,27

Fabric type =[2W + 1C +4W+1C+2W], Sandwich W=Woven Fabric,(METYX, 500 g/m^2) C=Core Material,(METYX,250 g/m^2)
Exp # = 322
Date = 09/06/08,14:38
Done by = Talha
Fabric weight = 11.7 g
Note = NA
$h_{fiberwet}$ = 4.84 mm
Modified $h_{fiberwet}$ = NA
$h_{unloaded}$ = 6.23 mm
Modified $h_{unloaded}$ = 5.77 mm





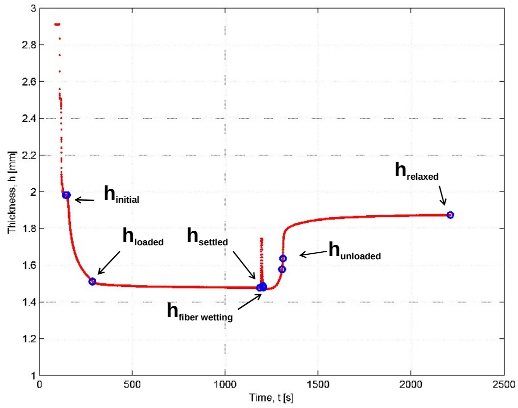


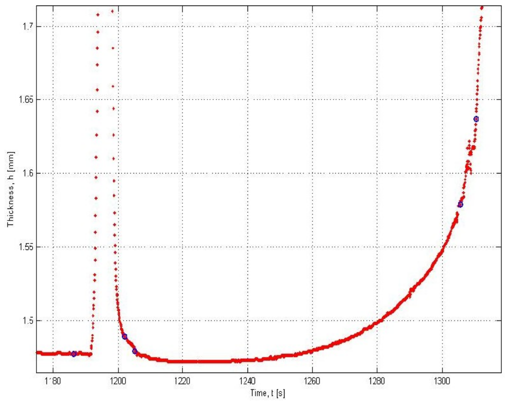


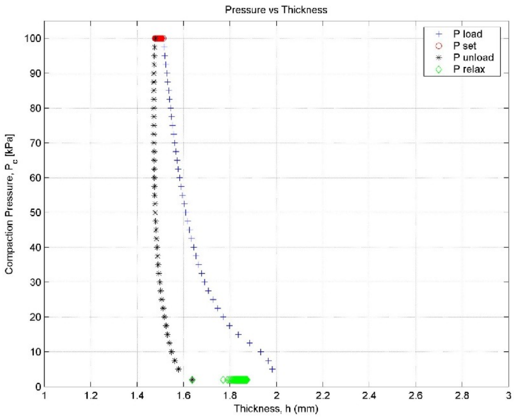
Compaction experiment # 322 – 2W/ 1C/ 4W/ 1C/ 2W.

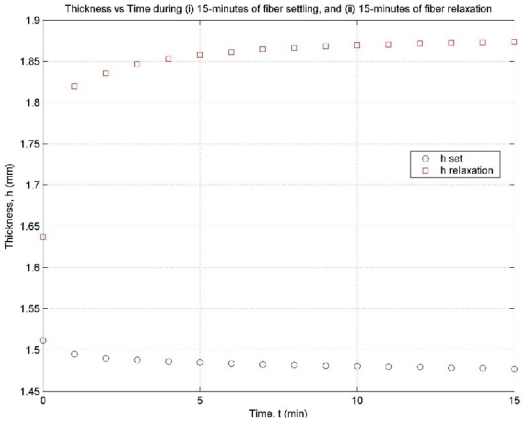
Exp #	$\Delta t_{loading}$ (sec)	$\Delta t_{unloading}$ (sec)	$h_{initial}$ (mm)	h_{loaded} (mm)	$h_{settled}$ (mm)	$h_{fiberwet}$ (mm)	$h_{unloaded}$ (mm)	h_{final} (mm)	$\Delta h_{loading}$ (mm)	$\Delta h_{settling}$ (mm)	$\Delta h_{fiberwet}$ (mm)	$\Delta h_{unloading}$ (mm)	$\Delta h_{relaxation}$ (mm)
293	137,78	100,48	1,98	1,51	1,48	1,48	1,64	1,87	-0,47	-0,03	0,00	0,16	0,24

Fabric type =[4W] W=Woven Fabric,(METYX, 500 g/m²)
Exp # = 293
Date = 07/07/08,18:58
Done by = Barış
Fabric weight = 5.8 g
Note = NA
$\mathbf{h_{fiberwet}}$ = 1.48 mm
Modified $\mathbf{h_{fiberwet}}$ = NA
$\mathbf{h_{unloaded}}$ = 1.64 mm
Modified $\mathbf{h_{unloaded}}$ = NA





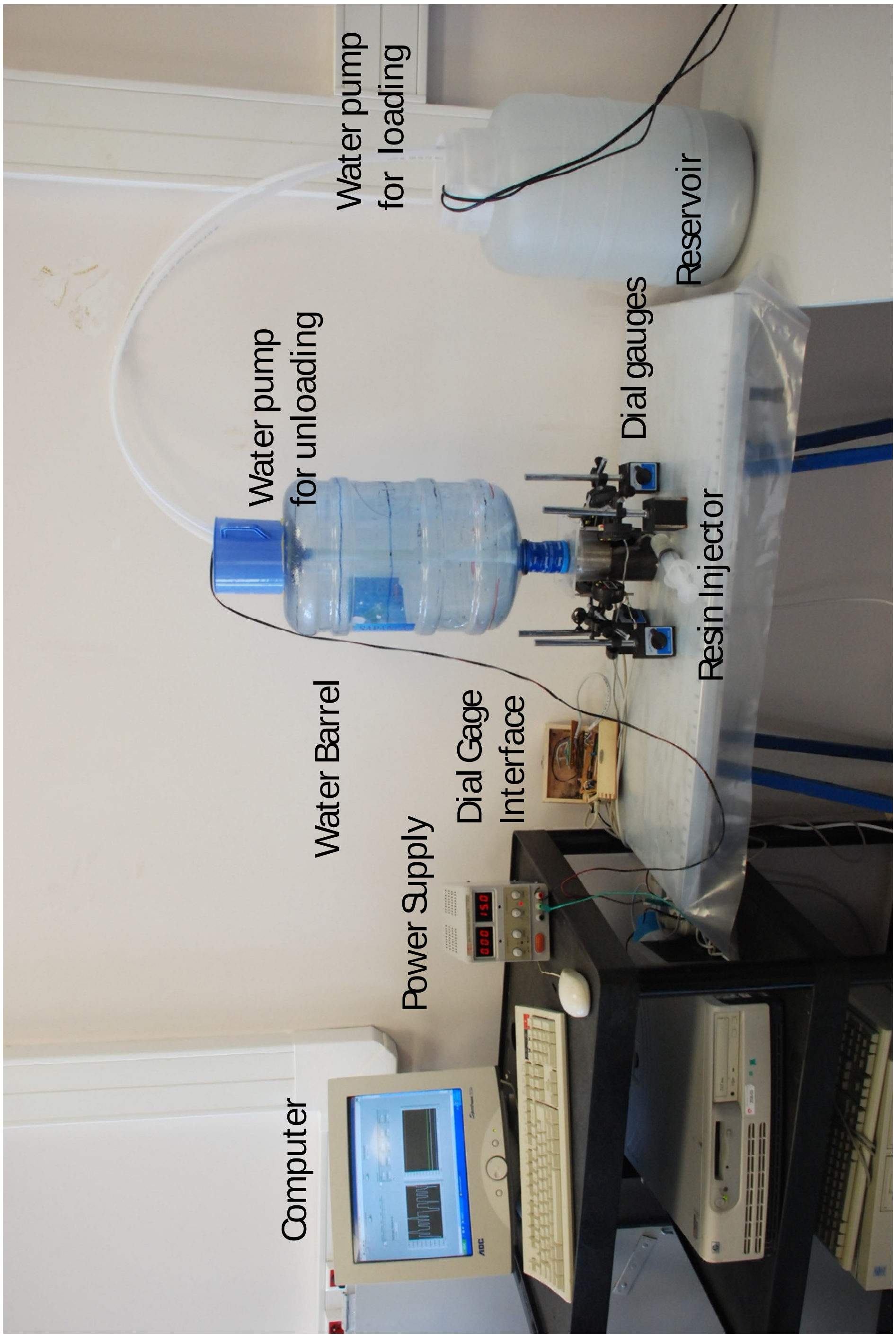




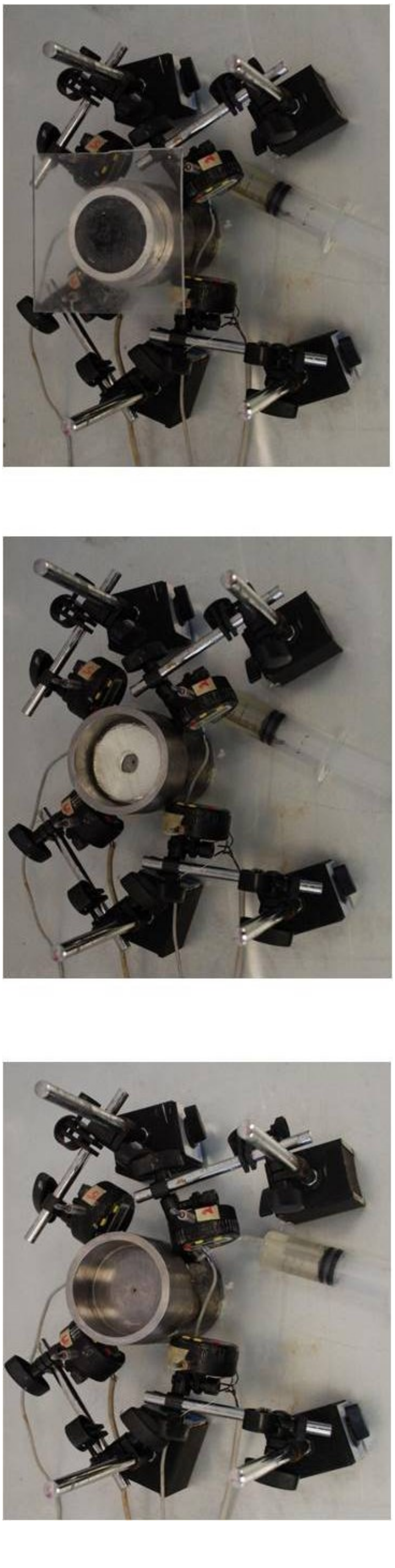
Compaction experiment # 293 – 4 W.

APPENDIX D

EXPERIMENTAL SETUP:

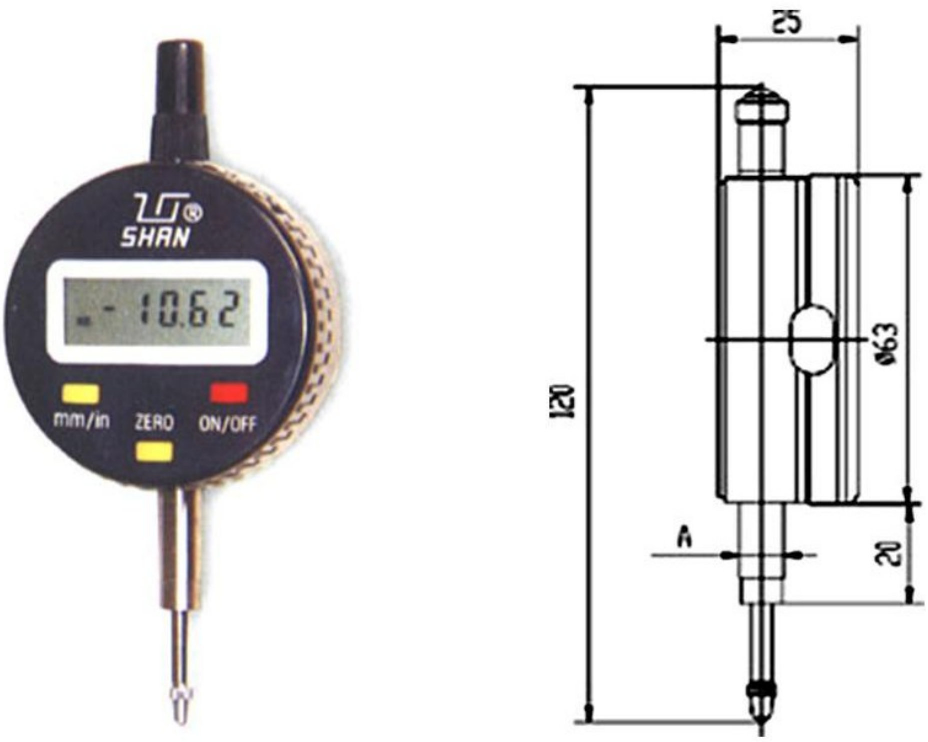


Appendix D.1. Experimental Setup



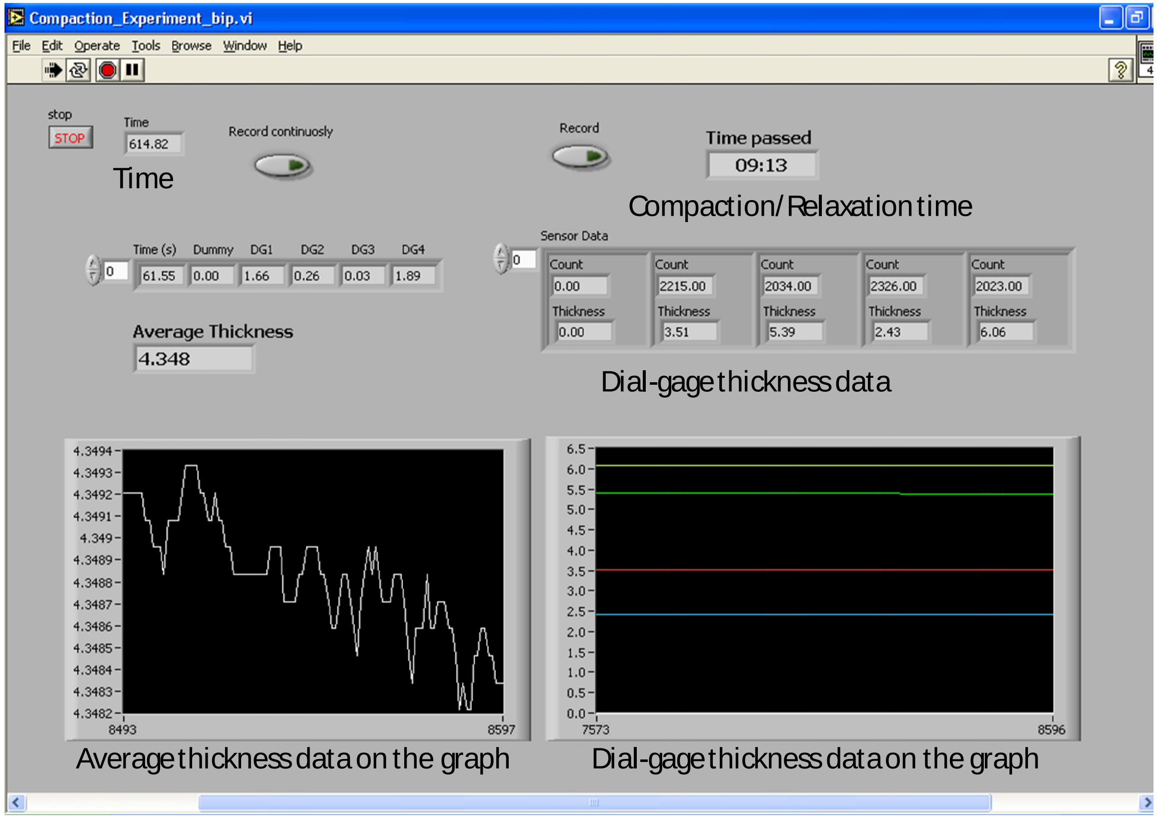
Appendix D.2. Fabric Preform Placement

Appendix D.3. Dial Gage used in Compaction Setup

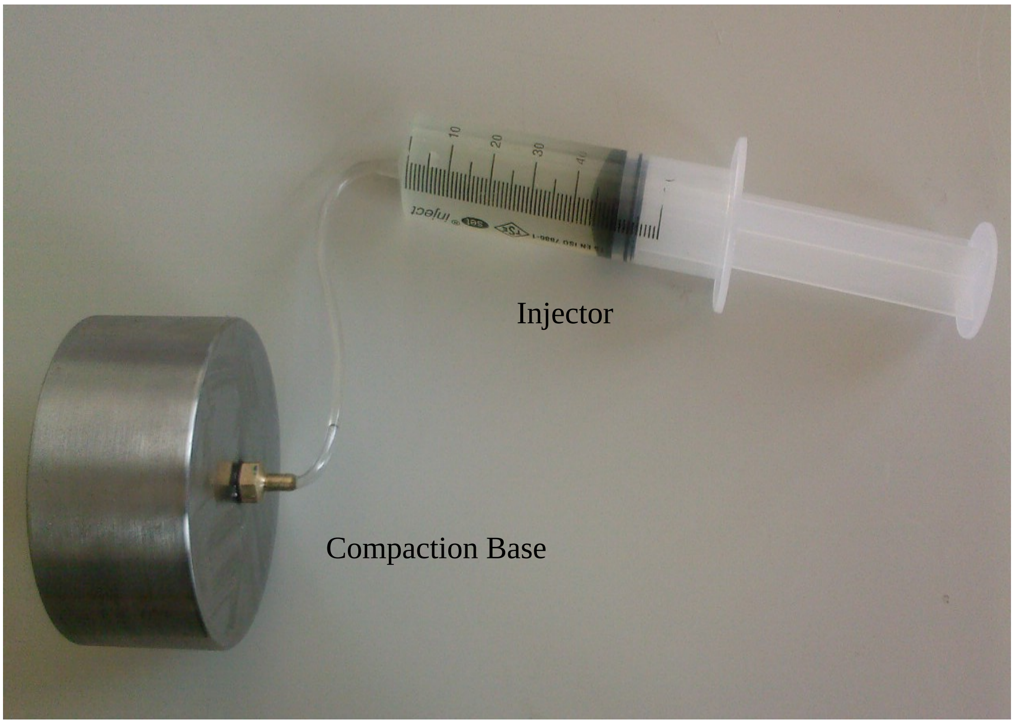


Range (mm)	Resolution (mm)	A (mm)	Dia (mm)	Accuracy (mm)
0 - 10	0.01 / 0.001	8.00	2.50	0.03

Appendix D.4. Labview Interface for Compaction Experiments

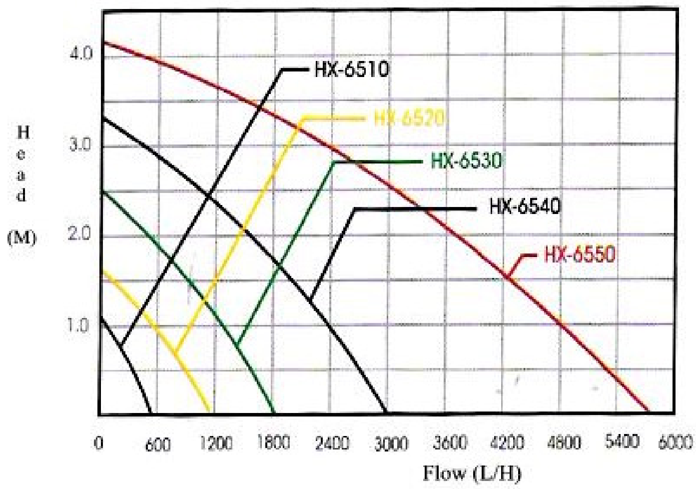


Appendix D.5. The Setup to Saturate Fabric Specimen



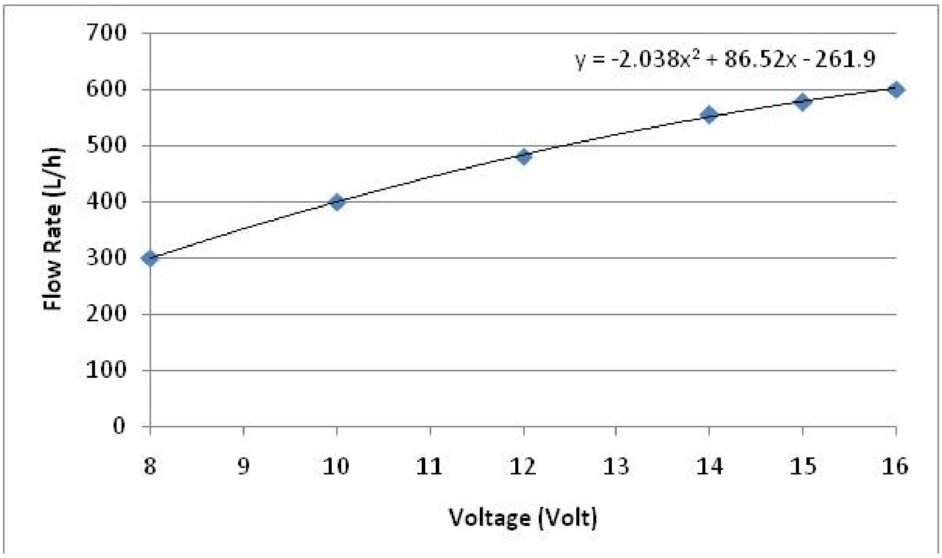
Appendix D.6. Water Pump for Loading the Water Barrel.

Datasheet of the pump.[http://www.coastal-koi.com/index.php]

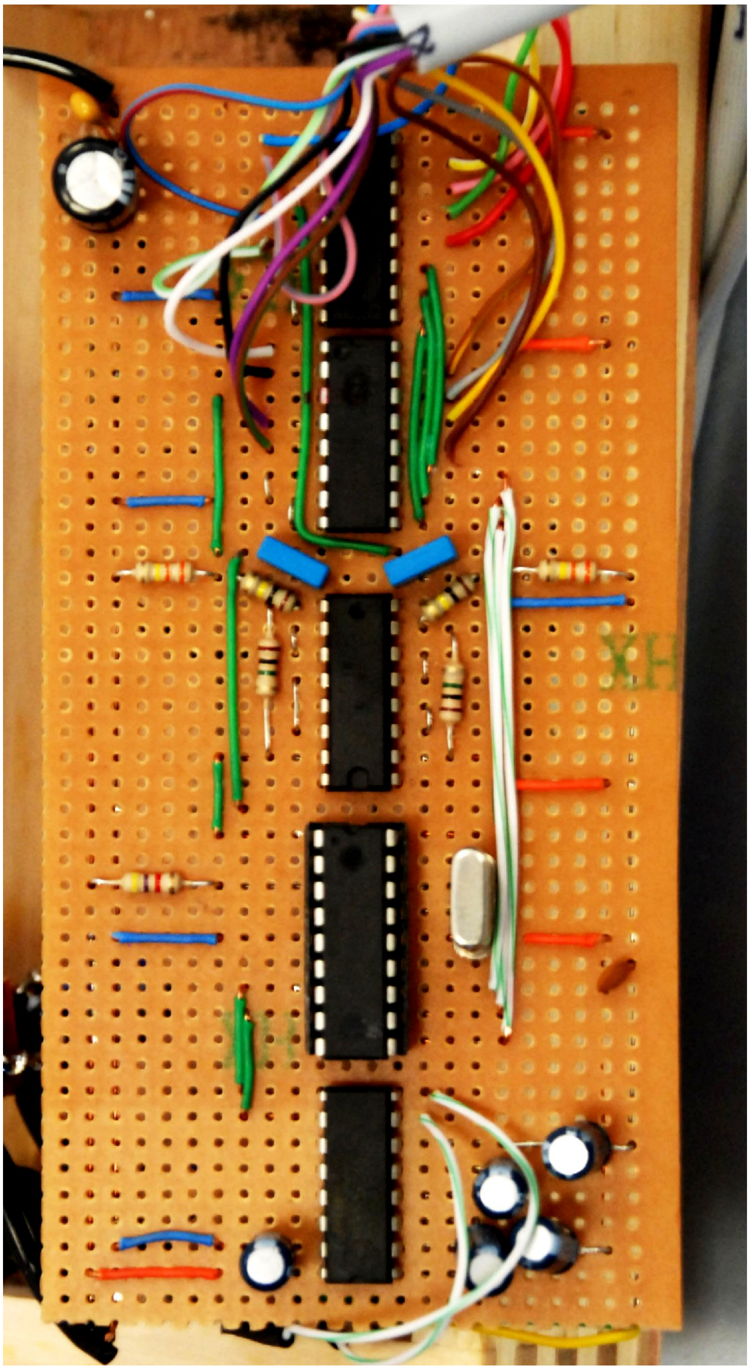


MODEL	VOLTAGE	FREQUENCY	POWER	FLOW	MAX. JET	CALIBRE	WEIGHT	SIZE
HX-6520	220-240 V	50/60 Hz	35 W	1000 L/h	1.6 m	Ø 14.5 mm	1.0 Kg	200x120x120 mm

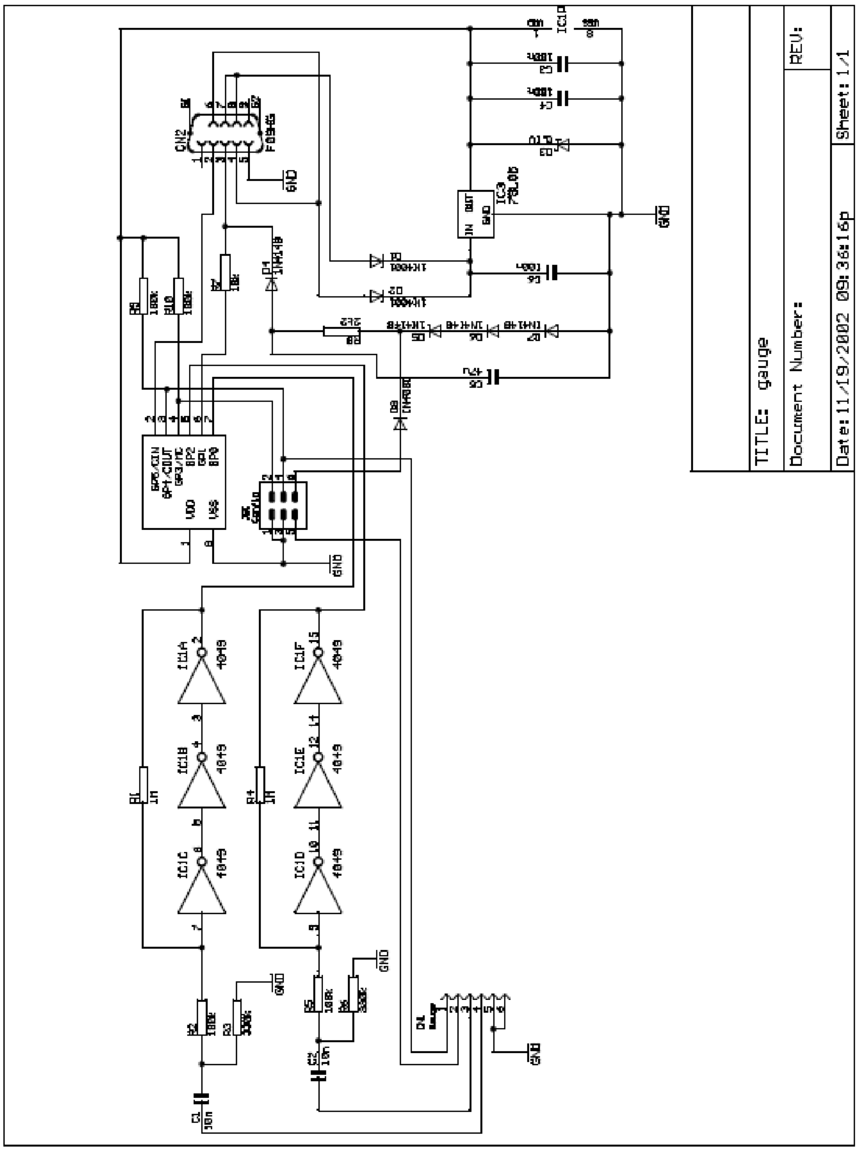
Appendix D.7. Water Pump for Loading the Water Reservoir.



Voltage (V)	Current (A)	FlowRate (l/h)
8	0.65	300
10	0.95	400
12	1.20	480
14	1.40	554
15	1.63	576
16	1.75	600

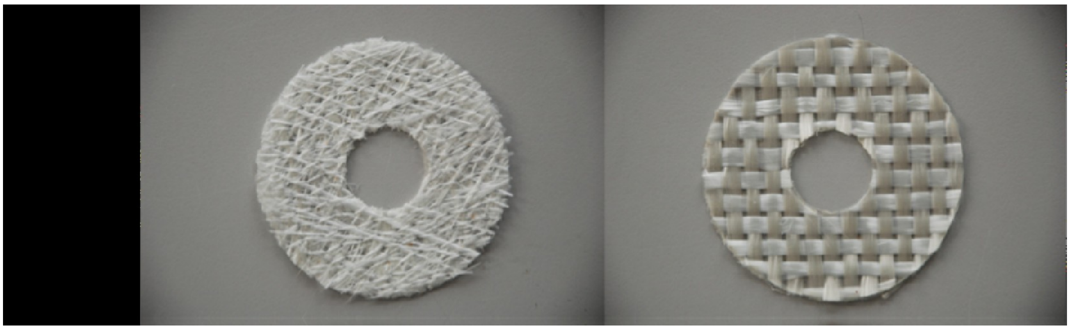


Appendix D.8. Photo of the Dial-Gage Interface.

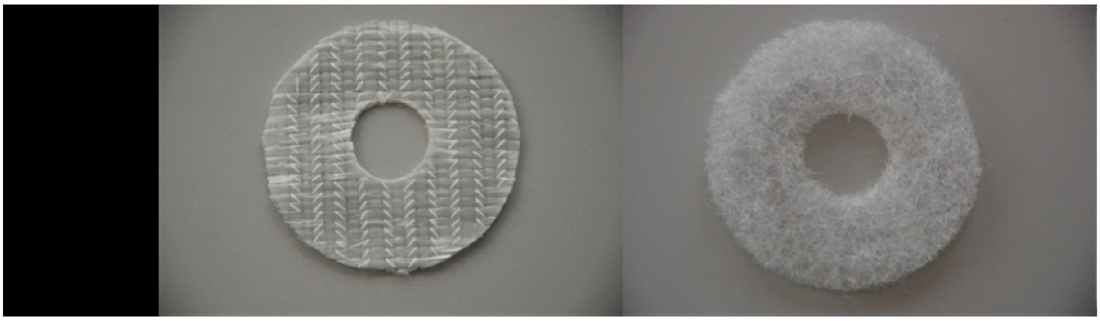


Appendix D.9. Schematic of the Dial-Gage Interface.
[http://www.compendiumarcana.com/caliper/]

Appendix D.10. Samples used in the experiments

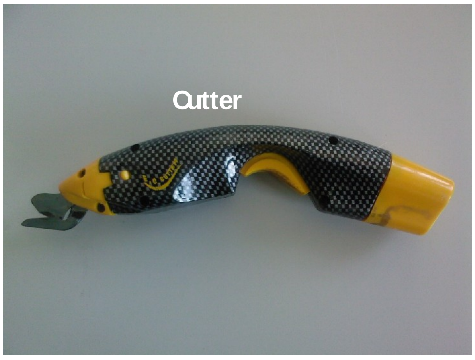


Random and woven fabric

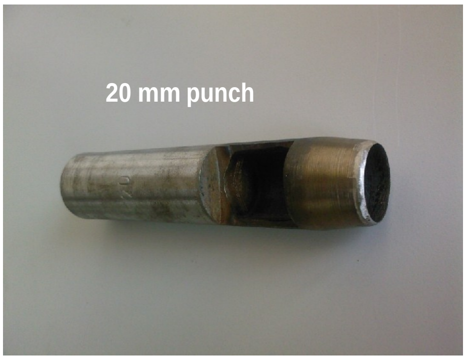


Biaxial and core material

Appendix D.11. Cutting Tools

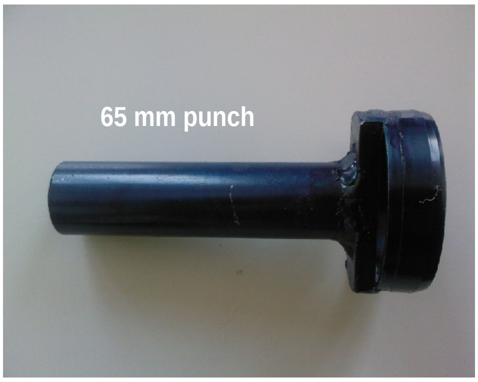


(a) Cutter



(b) 20 mm punch

(c) 65 mm punch



(d) 65 mm punch

Appendix D.12. Resin

Datasheet of the resin. [www.poliya.com.tr]

Polipol™ 336-RTM

SIVI HALDEKİ ÖZELLİKLERİ
PROPERTIES OF LIQUID FORM

TEST TEST	METOD METHOD		DEĞER VALUE
Renk Colour	ISO 2211	-	**max. 100 Hazen**
Yoğunluk Density	ISO 1675	±%5	**1,094 gr/cm^3**
Kırılma Indisi Refraction Index	ISO 0489	±%5	**1,532**
Asit Değeri Acid Value	ISO 2114	±%10	**23 mg KOH/gr**
Viskozite[1] Brookfield® Viscosity Brookfield®	ISO 2555	±%30	**300 cp**
Tiksotropi Thixotropy	-	±%30	**N/A**
Jel Süresi [2] Gel Time	ISO 2535	±%40	**14'**
Monomer Oranı Monomer Content	-	±%12	**37 %**
Parlama Noktası Flash Point	Abel-Pernsky	-	**28 °C**
Raf Omrü Shelf life in months	-	-	**4 ay**

1 **23 °C de, 4 uç, 50 devir ile ölçülmüştür.**
It is measured at 23 °C, 50 rpm with spindle 4.

2 **23 °C de, % 1 ml % 1 lik Co, % 1 ml Mek-p (Butanox M 60) ile ölçülmüştür.**
It is measured at 23 °C added 1 % ml Co (1 % con.) and 1 % ml Mek-p (Butanox M 60).

SERTLEŞME VERİLERİ [3]
CURING DATA

TEST TEST	METOD METHOD		DEĞER VALUE
$t_{65°C \rightarrow 90°C}$ $t_{65°C \rightarrow 90°C}$	ISO 0584	±%10	**6'13"**
$t_{65°C \rightarrow T\,maks}$ $t_{65°C \rightarrow T\,max}$	ISO 0584	±%10	**8'38"**
t_{maks} t_{max}	ISO 0584	±%10	**11'36"**
T_{maks} T_{max}	ISO 0584	±%10	**222 °C**

3 **Reçine 80 °C sıcaklığındaki banyoda, %2 oranında %50 lik Benzoil Peroksit Pasta (Lucidol BT-50,Akzo) ile sertleştirilmiştir.**
Resin cured in 80 °C bath with 2% Benzoyl Peroxide Paste (50% con,Lucidol BT-50,Akzo)

SERTLEŞMİŞ REÇİNENİN ÖZELLİKLERİ [4]
PROPERTIES OF CURED RESIN

TEST TEST	METOD METHOD		DEĞER VALUE
Yük Altında Eğilme Sıcaklığı (HDT) Heat Deflection Temperature (HDT)	ISO 0075-A ISO 0075-B	±%10	77 °C 91 °C
Su Absorbsiyonu Water Absorption	ISO 0062	±%10	0,185 %
Barkol Sertliği (Barcol 934-1) Barcol Hardness (Barcol 934-1)	ASTM-D 2583	±%10	44
Toplam Hacimsel Çekme Total Volume Shrinkage	ISO 2114	±%10	9,04 %

SERTLEŞMİŞ REÇİNENİN MEKANİK ÖZELLİKLERİ [5]
MECHANICAL PROPERTIES OF CURED RESIN

TEST TEST	METOD METHOD		SAF REÇİNE DEĞERİ PURE RESIN VALUE
Eğilme Dayanımı Flexural Strength	ISO 0178	±%10	113 MPa
Elastiklik Modülü Flexural Modulus	ISO 0178	±%10	3110 MPa
Kopmadaki Uzama Elongation at Break	ISO 0178	±%10	4,3 %
Çekme Dayanımı Tensile Strenght	ISO 0527	±%10	64 MPa
Elastiklik Modülü Modulus of Elasticity in Tensile	ISO 0527	±%10	2801 MPa
Kopmadaki Uzama Elongation at Break	ISO 0527	±%10	2,8 %
Izod Darbe Dayanımı Izod Impact Strength	ISO 0180	±%10	9 kj/m^2

4 5 **Sertleşmiş reçinenin testleri için reçine sertleştikten sonra post-kür işlemine tabi tutulmuştur.**
Before the mechanical tests, the cured resin is post-cured.