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**Publisher’s version / Version de l'éditeur:**
https://doi.org/10.1520/JTE101228
*Journal of Testing and Evaluation, 36, January 1, pp. 34-40, 2008-01-01*

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**NRCC-50440**

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A version of this document is published in / Une version de ce document se trouve dans:
Journal of Testing and Evaluation, v. 36, no. 1, Jan. 2008, pp. 34-40 doi:
10.1520/JTE101228

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# Moisture Buffering Capacities of Five North American Building Materials

**Abstract:**

The moisture buffering capacities of five building materials which are widely used in North America was investigated experimentally. An experiment to quantify the moisture buffering capacity of building materials was developed. Hygrothermal properties of these building materials, reported in this paper, include the density, thermal conductivity, equilibrium moisture content, water vapor permeability, water absorption coefficient and air permeability. Moisture buffering test results showed that among these materials the fiberboard product has the best moisture buffering capacity, whereas plywood has insignificant capacity to adjust to indoor relative humidity level.

**Keywords:** moisture buffering capacity, hygrothermal material property, North American, building material

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# Moisture Buffering Capacities of Five North American Building Materials

## Introduction

Indoor air humility level is one of the most important factors that determine the indoor air quality for occupants (Fang et al. 2000). It has significant diurnal variation due to the activities of the occupants. Also seasonal change of indoor environmental conditions can be found because of the outdoor weather. From the study of hygrothermal properties of the hygroscopic building materials, it can be concluded that some building materials can effectively reduce the peaks of indoor humidity level and sequentially improve the indoor air quality (Padfield 1998). The use of hygroscopic building material to adjust indoor humidity condition is effective and is achieved without any external energy input. Hence, there has been an increasing interest in this topic recently. The ability of a building material within indoors to moderate humidity level can be represented by its moisture buffering capacity (MBC).

Earlier research showed the potential of using building materials to moderate indoor relative humidity (Padfield 1998, Salonvaara et al. 2004). One of the researchers experimentally investigated the role of absorbent material in moderating the change of relative humidity (Padfield, 1998). In his work, the moisture buffering capacity was measured for wood, brick, cellular concrete and unfired clay. It is found that wood end grain panels showed the best buffering capacity due to rapid diffusion and high moisture capacity of wood. Some others studied the moisture buffering capacity of building materials by small scale laboratory, full scale single room tests and numerical calculations (Salonvaara et al. 2004). A review (Rode et al.

2004) was carried out for moisture buffering in interior spaces, and the authors indicated that there is a need to quantify the moisture buffering capacity of building materials. Recently, a workshop was held in Europe of which the main purpose was to standardize a test method for MBC (Rode 2003). Later, in 2005, a Nordtest standard defining the moisture buffering effect and test method was presented as a result of a Nordic collaboration project (Rode et al. 2005). In North America, a series of tests on moisture buffering capacity of plywood products had been performed (Osanyintola 2005). However, there is no test standard available for MBC of building materials in North America. In addition, the shortage of moisture buffering value data of most building materials will delay further research in using absorptive material to improve indoor environmental conditions. This paper reports the measurement results of moisture buffering capacities of five building materials that are commonly used in North American, which include:

1. gypsum board
2. OSB
3. plywood
4. wood fiberboard
5. cement stucco

## Basic Principles of Moisture Buffering Capacity

MBC can be defined as the ability of building material within indoor to moderate humidity level. The term, Moisture buffering Value (MBV), quantifies the moisture buffering capacity of building material, and it indicates the amount of moisture uptake or release by a material when it is exposed to repeated daily variations in relative humidity between two given levels. Research has found that besides hygrothermal properties of building material, MBV depends on air flow velocity, area, and thickness of the test specimen (Rode et al. 2005).

The experimental principle is based on an environmental chamber test, where the test specimen is exposed under a square wave relative humidity change in daily cycles. During the test the changes in mass of specimen are recorded. The change in mass since the beginning of test is calculated as,

$$\Delta m = \frac{m - m_i}{A} \tag{1}$$

where $m$ (kg) is the mass of test specimen at a specific time, $m_i$ (kg) is the mass of the test specimen when the experiment started (i.e. the initial conditions) and $A$ ($m^2$) is the exposed surface area of the test specimen.

The MBV can be calculated as the rate between specimen mass change during absorption or desorption of a relative humidity cycle and relative humidity difference, which is shown in Equation 2.

$$MBV = \frac{\Delta m_p}{\Delta RH} \tag{2}$$

$$\Delta m_p = \frac{m_{final} - m_{start}}{A} \tag{3}$$

where $\Delta m_p$ (kg) is the mass change during each relative humidity cycle, $m_{final}$ (kg) is the mass of the test specimen measured at the end of an adsorption or desorption phase and $m_{start}$ (kg) is the mass of the test specimen when the adsorption or desorption phase started.

## Materials

*Basic Material Characteristics*

The building products under testing were gypsum board, plywood, OSB, wood fiberboard, and cement stucco. The specimens were cut into approximately 140 mm x 140 mm rectangular sheet. The gypsum board is made by BPB, and its product name is "ProPoc Regular Gypsum Board" which conformed to CAN/CSA-A82.27. The plywood product conforms to CSA O121M Douglas Fir Plywood, the quality is assured by Canadian Plywood Association (CANPLY), and the Brand is Tolko. The OSB is made by Louisiana Pacific, and it is certified as conforming to CSA 0325 1R24/2F16. The wood fiberboard is coated with asphalt on its both sides, the brand is EMCO, and it conforms to CAN/ULC-S706 Type II, Category 3. The stucco used was pre-mixed by manufacture; the brand marked on the product package is Mélange à crépissage Bomix., and it conforms to CAN/CSA-A5 "Portland Cement", Lime. The stucco specimens were prepared and allowed to dry for more than 28 days as suggested by the manufacturer, and they were embedded on metallic lath.

The edges and one major surface of each specimen were sealed with molten wax, therefore there was only one major surface exposed to the air. By this way, it simulated the situation in practice. Before test, all the specimens were conditioned in the climate chamber where the indoor temperature and relative humidity was 22°C and 50 %RH for a month until the equilibrium condition was reached (i.e. mass change of the specimen is less than 0.1% for two weeks). The basic information on experimental material is listed in Table 1. In Table 1, the term, initial moisture content, represents the moisture content of the pre-conditioned specimen.

Table 1 The basic material characteristics of tested building materials

| Test material | Area ($cm^2$) | Thickness (mm) | Dry density ($kg/m^3$) | Initial Moisture Content (kg/kg) |
|---|---|---|---|---|
| Gypsum board | 148.5 | 12.5 | 569 | 53.7 |
| Plywood | 148.8 | 12.7 | 428 | 134.6 |
| OSB | 148.7 | 11.4 | 634 | 71.5 |
| Fiberboard | 148.4 | 10.9 | 270 | 71.5 |
| Stucco | 99.9 | 19.5 | 1353 | 124.6 |

*Heat, Air and Moisture Transfer Properties of Materials*

To characterize the hygrothermal properties of the tested building materials, the heat, air and moisture transfer properties were experimentally measured, which include:

1. thermal conductivity
2. equilibrium moisture content
3. water vapor permeability
4. water absorption coefficient and
5. air permeability

In this investigation, ASTM Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus (ASTM, 1998) was used to measure the thermal conductivities of dry materials. The uncertainty in the thermal conductivities derived from these measurements may be as high as 5%. The measured thermal conductivities of those materials are shown in Table 2.

Table 2 Measured thermal conductivities of the products investigated

| Products | Thermal Conductivities ($Wm^{-1}K^{-1}$) |
|---|---|
| Gypsum board | $0.146 \pm 0.002$ |

| | |
|---|---|
| Plywood | 0.085 ± 0.003 |
| OSB | 0.089 ± 0.002 |
| Fiberboard | 0.047 ± 0.001 |
| Stucco | 0.328 ± 0.008 |

ASTM Standard Test Method for Hygroscopic Sorption Isotherms of Building Materials C1498 (ASTM, 2001) was used for determination of sorption isotherm for building products in hygroscopic range. Temperature-humidity chambers were used for sorption isotherm measurement. The weights of specimens were determined by an electronic analytical balance with the resolution of 0.001g. The results from there measurement are listed in Table 3.

Table 3. Equilibrium moisture content at various relative humidities, RH

| | Moisture Content (kg $kg^{-1}$) | | | | |
|---|---|---|---|---|---|
| RH (%) | Gypsum | Plywood | OSB | Fiberboard | Stucco |
| 100(saturation) | 1.32±0.10 | 1.29±0.05 | 1.38±0.05 | 3.61±0.03 | 0.21±0.01 |
| 95(desorption) | 0.13±0.02 | 0.27±0.01 | 0.25±0.01 | 0.30±0.01 | 0.058±0.001 |
| 90(desorption) | 0.028±0.0003 | 0.20±0.001 | 0.19±0.002 | 0.19±0.002 | 0.055±0.002 |
| 70(desorption) | 0.024±0.0005 | 0.14±0.001 | 0.12±0.002 | 0.12±0.001 | 0.033±0.0004 |
| 50(desorption) | 0.020±0.0004 | 0.095±0.002 | 0.084±0.001 | 0.083±0.001 | 0.022±0.0003 |
| 30(desorption) | 0.019±0.0002 | 0.063±0.001 | 0.053±0.001 | 0.055±0.001 | NA |
| 30(sorption) | 0.0036±0.0001 | 0.066±0.0003 | 0.047±0.001 | 0.045±0.001 | NA |
| 50(sorption) | 0.0048±0.0001 | 0.095±0.0003 | 0.062±0.0003 | 0.059±0.0004 | 0.013±0.0003 |
| 70(sorption) | 0.0083±0.0001 | 0.14±0.002 | 0.11±0.002 | 0.10±0.001 | 0.024±0.004 |
| 90(sorption) | 0.014±0.0002 | 0.20±0.005 | 0.16±0.02 | 0.15±0.001 | 0.049±0.001 |
| 95(sorption) | 0.027±0.007 | 0.27±0.03 | 0.25±0.02 | 0.23±0.02 | 0.059±0.001 |

The water absorption by partial immersion is determined by measuring the change in mass of the test specimen, the bottom of which is in contact with water. This testing method is explained in the European standard for thermal performance of building components- Determination of Water Absorption Coefficient CEN/TC 89/WG10 N95 (CEN 1994). The results from these measurements are listed in Table 4.

Table 4. Water absorption coefficient

| Products | Water Absorption Coefficient ($Kg/m^2 \cdot s^{1/2}$) |
|---|---|
| Interior Gypsum Board | 1.6E-01 ± 4.2E-02 |
| Plywood | 2.0E-03 ± 1.3E-03 |
| Oriented Strand Board | 1.8E-04 ± 2.2E-04 |
| Wood fiber Board | 1.2E-03 ± 9.2E-04 |
| Stucco | 8.8E-02 ± 2.2E-02 |

Dry cup and wet cup methods were used to determine the water vapor permeability of building materials (Kumaran 1998a, 1998b). The experimental procedure is based on an extension (Kumaran 1998b) of the cup methods described by ASTM standard E96 (ASTM 2000). The derived water vapor permeabilities of building materials are listed in Table 5. The measurement uncertainty from these tests can be less than 1%, however, the derived values from derivation can be from 5% to 30%. The permeability from stucco product has the greatest uncertainty because of its in-homogeneity (Kumaran et al. 2006).

Table 5. The dependence of water vapor permeability on RH for building materials

| | Water Vapor Permeability ($kg\ m^{-1}\ s^{-1}\ Pa^{-1}$) | | | | |
|---|---|---|---|---|---|
| RH (%) | Gypsum | Plywood | OSB | Fiberboard | Stucco |
| 10 | 3.00E-11 | 1.01E-13 | 2.95E-13 | 1.82E-11 | 1.27E-11 |
| 20 | 3.17E-11 | 1.80E-13 | 4.05E-13 | 1.85E-11 | 1.37E-11 |

| | | | | | |
|---|---|---|---|---|---|
| 30 | 3.34E-11 | 3.22E-13 | 5.58E-13 | 1.86E-11 | 1.47E-11 |
| 40 | 3.53E-11 | 5.77E-13 | 7.67E-13 | 1.87E-11 | 1.58E-11 |
| 50 | 3.73E-11 | 1.03E-12 | 1.06E-12 | 1.88E-11 | 1.7E-11 |
| 60 | 3.94E-11 | 1.86E-12 | 1.46E-12 | 1.88E-11 | 1.83E-11 |
| 70 | 4.17E-11 | 3.37E-12 | 2.01E-12 | 1.89E-11 | 1.97E-11 |
| 80 | 4.42E-11 | 6.18E-12 | 2.78E-12 | 1.89E-11 | 2.12E-11 |
| 90 | 4.68E-11 | 1.16E-11 | 3.85E-12 | 1.89E-11 | 2.29E-11 |
| 100 | 4.96E-11 | 2.26E-11 | 5.35E-12 | 1.89E-11 | 2.47E-11 |

For measuring the air permeability, ASTM standard C 522-97, Standard Test Method for Airflow Resistance of Acoustical Materials is widely used (ASTM 1997). In this investigation, an extended method (Bomberg and Kumaran 1986) was used to measure the air permeability of building materials. The specimens used for these measurements are the same as those in the water vapor permeability tests. The results are listed in Table 6.

Table 6. Air permeabilities of building materials

| Products | Air Permeability (kg $m^{-1}$ $Pa^{-1}$ $s^{-1}$) |
|---|---|
| Interior Gypsum Board | 5.2E-08 |
| Plywood | 1.3E-09 |
| Oriented Strand Board | 5.1E-09 |
| Wood fiber Board | 2.2E-07 |
| Stucco | 1.2E-09 |

**Experimental Settings**

A test protocol for experimental determination of moisture buffering values of building materials was recently defined by NORDTEST project (Rode et al. 2005). In current investigation the experimental procedure followed this protocol.

*Experimental Facilities*

Envirotronics standard temperature/humidity chamber SH16 was used in this test. The temperature range is - 30°C to + 177°C with accuracy of ±0.3°C, and it can change relative humidity from 10% to 98% within ±2%. The workspace of the chamber is 76.2mm (width) × 76.2mm (depth) × 76.2mm (height). The picture of chamber is shown in figure 1. The climate change inside the chamber is controlled by Envirotronics System Plus Programmer/Controller. This controller also functions as a data logger, which can store the information about the chamber into a diskette or transfer running data to a data acquisition system. An electronic analytical balance with the resolution of 0.001g was used for recording the mass change of the specimen exposed to the dynamic climate condition. A Vaisala temperature/humidity probe with uncertainty of 2% was placed in the test chamber to monitor the RH and temperature. The air velocity in the test chamber was measured using TSI Velocicalc plus Air Velocity Meter.

Figure 1. Envirotronics standard temperature/humidity chamber at IRC-NRC

*Experimental Conditions*

The specimens in the test chamber were periodically weighed. The change in mass of the specimens within the humidity cycle represents the moisture accumulated by building products. Test condition can be seen in Table 7. The high RH lasted for 8 hours and low RH for 16 hours, and those RH set points were same with the requirement in Nordtest standard (Rode et al. 2005).

Table 7. Test conditions for moisture buffering test

| Temperature (°C) | Low RH (%) | High RH (%) |
|---|---|---|
| 23 ± 0.3 | 33 ± 2 | 75 ± 2 |

Figure 2 presents the temperature and relative humidity measured using the temperature-humidity sensor located in the test chamber during a typical MBC test. The RH and temperature profile in Figure 2 was recorded every 5 minutes for 4 repeated cycles. Some scattered points can be found in RH reading. It was the result from opening the chamber when the specimen was weighted at one hour interval. The measured average air velocity inside the chamber during test is 1.3 m/s.

Figure 2. Measured relative humidity and temperature of the air entering the test chamber during a typical MBC test

**Results and Discussions**

This section presents the experimental data from the facilities mentioned above. The moisture accumulation data are used to determine the MBV of five building products. The initial and boundary conditions of the tests were also recorded. Three test specimens, 140 mm × 140 mm, were used for each material except stucco in these measurements. All the stucco specimens were cut into 100 mm × 100 mm square sheet.

The experimental data for uncoated gypsum board are presented in Figure 3. It shows the mass changes of 3 uncoated gypsum board specimens for four 24-hour cycles. The mass change $\Delta m$ since the beginning of the test is calculated using Equation 1.

Figure 3. Mass changes of gypsum board over four 24-hour cycles for 3 specimens

It can be seen that the mass changes of three gypsum specimens under stepwise relative humidity circles followed a similar pattern of moisture absorption and desorption. During the first three cycles, the average mass change of three gypsum board specimens for the absorption process, $\Delta m_{ads}$, is 23.31 ± 0.33 g/m$^2$, and for the desorption process $\Delta m_{des}$, is 23.15 ± 0.48 g/m$^2$. The average mass change, $\Delta m_{avg}$, during three humidity cycles is 23.23 ± 0.32 g/m$^2$, which will be used later to quantify the MBC of building materials. The measured mass changes of plywood, OSB, fiberboard and stucco products for four 24-hour cycles are plotted in Figure 4 to 7 respectively.

Figure 4 Mass changes of plywood over four 24-hour cycles for 3 specimens

Figure 5 Mass changes of OSB over four 24-hour cycles for 3 specimens

Figure 6 Mass changes of fiberboard over four 24-hour cycles for 3 specimens

Figure 7 Mass changes of stucco over four 24-hour cycles for 3 specimens

It can be seen from Figure 4 to Figure 7 that the mass changes in all the tested building products follow similar patterns of moisture uptake and release. The quantities of mass changes of the tested building products under absorption and desorption processes during three RH cycles are summarized in Table 8. The differences in moisture uptake and release were due to the hysteresis effect, however, this difference decreased in this three RH cycles. At the third cycle, the percentage differences between moisture uptake and release are less than 2% for all building products. The mass changes listed in Table 8 were based on the average value from 3 test specimens under the same test condition.

Table 8. The measured mass changes of the tested building products under MBC test

| Materials | | 1st Cycle Mass Change (g/m$^2$) | 2nd Cycle Mass Change (g/m$^2$) | 3rd Cycle Mass Change (g/m$^2$) | Average Mass Change (g/m$^2$) |
|---|---|---|---|---|---|
| Gypsum | Adsorption | 22.6 ± 0.1 | 23.2 ± 0.1 | 23.6 ± 0.3 | 23.2 ± 0.5 |
| | Desorption | 23.1 ± 0.4 | 23.5 ± 0.4 | 23.3 ± 0.1 | 23.3 ± 0.3 |
| Plywood | Adsorption | 11.5 ± 0.6 | 12.4 ± 0.9 | 12.8 ± 1.0 | 12.2 ± 0.9 |
| | Desorption | 12.6 ± 0.7 | 12.9 ± 0.3 | 13.0 ± 0.4 | 12.8 ± 0.5 |
| OSB | Adsorption | 21.0 ± 2.6 | 22.5 ± 3.3 | 22.8 ± 3.6 | 22.1 ± 2.9 |
| | Desorption | 23.1 ± 4.7 | 23.2 ± 4.0 | 23.3 ± 4.2 | 23.2 ± 3.7 |
| Fiberboard | Adsorption | 60.1 ± 3.1 | 63.2 ± 3.0 | 63.5 ± 3.1 | 62.9 ± 2.7 |
| | Desorption | 61.3 ± 2.4 | 61.1 ± 2.8 | 62.2 ± 2.9 | 61.5 ± 2.4 |
| Stucco | Adsorption | 37.8 ± 0.5 | 37.3 ± 1.2 | 37.6 ± 1.7 | 37.3 ± 1.1 |
| | Desorption | 40.0 ± 2.2 | 37.6 ± 1.0 | 36.7 ± 0.5 | 38.2 ± 2.0 |

The amount of moisture uptakes and releases under RH cycles for building products depends on materials. MBV of all the tested materials were calculated based on Equation 2. The comparison of the MBV for different building products is shown in Figure 8 and Table 9. The MBVs shown in Figure 9 are the average of MBV value and its standard deviation for 3 specimens at the third RH cycle.

Figure 8 The Moisture Buffering Values (MBV) as an average value for all the measurements (3 specimens at the third RH cycles with moisture uptake and release). The thin vertical line-bars indicate standard deviations

Table 9 The Moisture Buffering Values (MBV) as an average value for all the measurements (3 specimens at the third RH cycles with moisture uptake and release). Standard deviation is calculated for the same data.

| Materials | MBV (g/m$^2$%RH) | | |
|---|---|---|---|
| | Average | Standard Deviation | % Deviation |
| Gypsum | 0.56 | 0.00 | 0.3 |
| Plywood | 0.31 | 0.02 | 5.3 |
| OSB | 0.55 | 0.09 | 16.9 |
| Fiberboard | 1.50 | 0.07 | 4.7 |
| Stucco | 0.88 | 0.03 | 2.9 |

From the statistics shown in Table 9, it can be seen that for most tested building products except OSB and Stucco the standard deviation of measured MBVs are within 5%. The highest standard deviation can be found in OSB product because of its heterogeneous property. Moreover, experimental studies found that fiberboard product has the best moisture buffering capacity whereas plywood has insignificant capacity to adjust indoor relative humidity level.

The sorption and desorption processes vary from material to material, but the majority of building materials follow a general sharp curvature. Since during the moisture buffering test building materials uptake and release water with the change of relative humidity, the processes are possibly described by the sorption and desorption characteristics of them. Gypsum board products shown in Figure 3 have a distinctive sorption and desorption curve. At the first four hours, its moisture content changed very fast, after that the curvature tended to be flatter. This reflects that gypsum board has a faster moisture response.

All the moisture buffering test data are available for the comparison of numerical simulation results. The simulation of the dynamic moisture transport for those tested building materials subjected to the boundary relative humidity changes are conducted by using computer model, hygIRC 1-D. It is developed at IRC NRC, which has been evolving for past fifteen years. hygIRC 1-D is the one dimensional version of hygIRC. It comprises of the recently benchmarked hygIRC solver, a climate database containing 30 to 40 years of hourly weather data for 19 Canadian and 6 US cities, a material database containing the hygrothermal properties of more than 100 common construction materials as measured at NRC IRC (Kumaran 1996, Kumaran et al 2002), and models to derive interior temperature and relative humidity conditions. The material properties measured in this work have been imported in the model as material property input, which includes air permeability, thermal conductivity, density, sorption isotherm, and vapor permeability data. During the simulation, the initial moisture content is set as the measured value. The moisture transfer coefficient can be calculated based on air flow velocity near the surface of test specimen by the well known approximation, Lewis equation. The measured air velocity is 1.3 m/s, and then through the calculation the moisture transfer coefficient near the specimen surface is determined as $7\times10^{-8}$ s/m, which has been used in the simulations.

Results showed that overall agreement between the experimental and numerical data is acceptable for gypsum board, OSB and fiberboard. The simulated weight changes of plywood and stucco are higher than the measured value. The difference between simulation and measurement of the stucco is more obvious than that for the plywood. These differences could be the resultant of the variation in material properties of these building products, and the inaccurate measurement of the air velocity in the test chamber.

To determine the sensitivity of the simulated moisture transfer to changes in the material properties used in the model, parametric analysis was carried out. Fiberboard was chosen because this material showed the best agreement between experimental data and simulation. It has been found that moisture transfer coefficient has the greatest effect in the numerical simulation of moisture transfer within fiberboard, and the sorption isotherm also gives significant influence. However, the liquid diffusivity has almost no effect.

## Concluding Remarks

In this paper the moisture buffering capacities of five building materials which are widely used in North America were experimentally investigated. An experiment to quantify the moisture buffering capacity of building materials was developed based on Nordtest standard. The heat, air and moisture transfer properties of these tested building materials were also measured. The experiments show that although the hysteresis effects have influence on moisture response under the dynamic humidity conditions, the resultant differences in the third RH cycle are less than 2% for all tested materials.

These five building materials have distinctive hygrothermal properties, which lead to their different moisture buffering response. Fiberboard product has the best moisture buffering capacity whereas plywood has insignificant capacity to adjust indoor relative humidity level.

Further experimental and numerical studies are required to understand the moisture buffering capacity for other building materials. Studies for different building materials under more test conditions are needed to determine the material that is best suited to adjust the indoor humidity level in a building.

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Figure 1

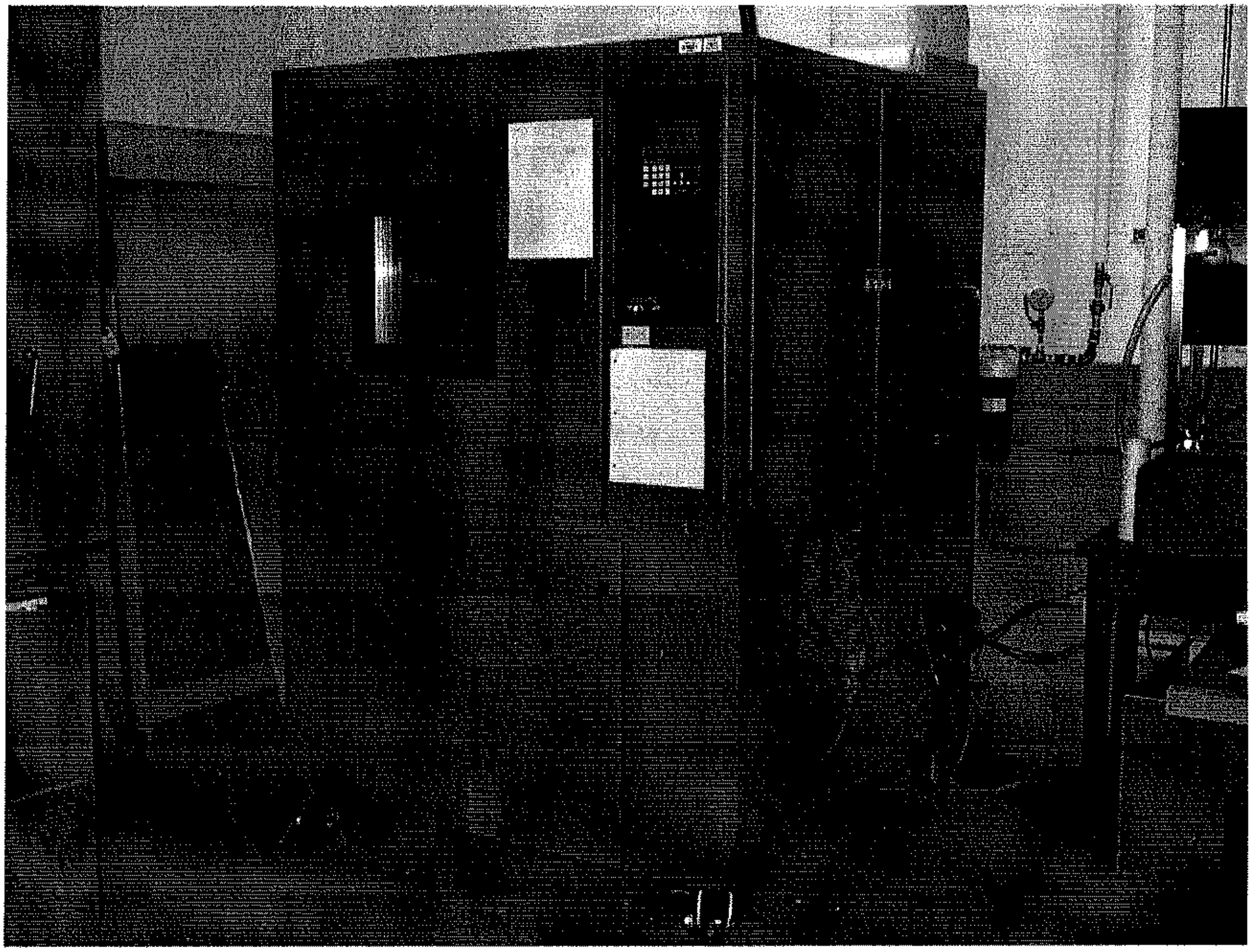


Figure 2

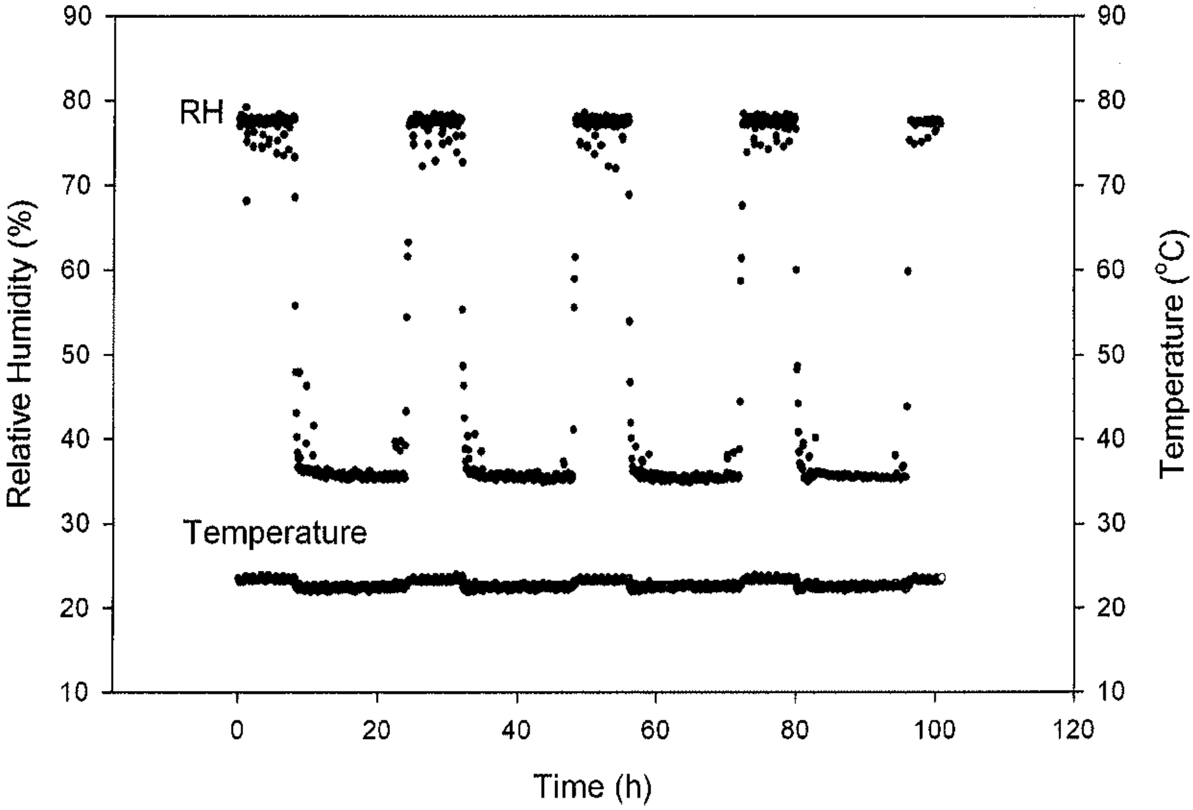
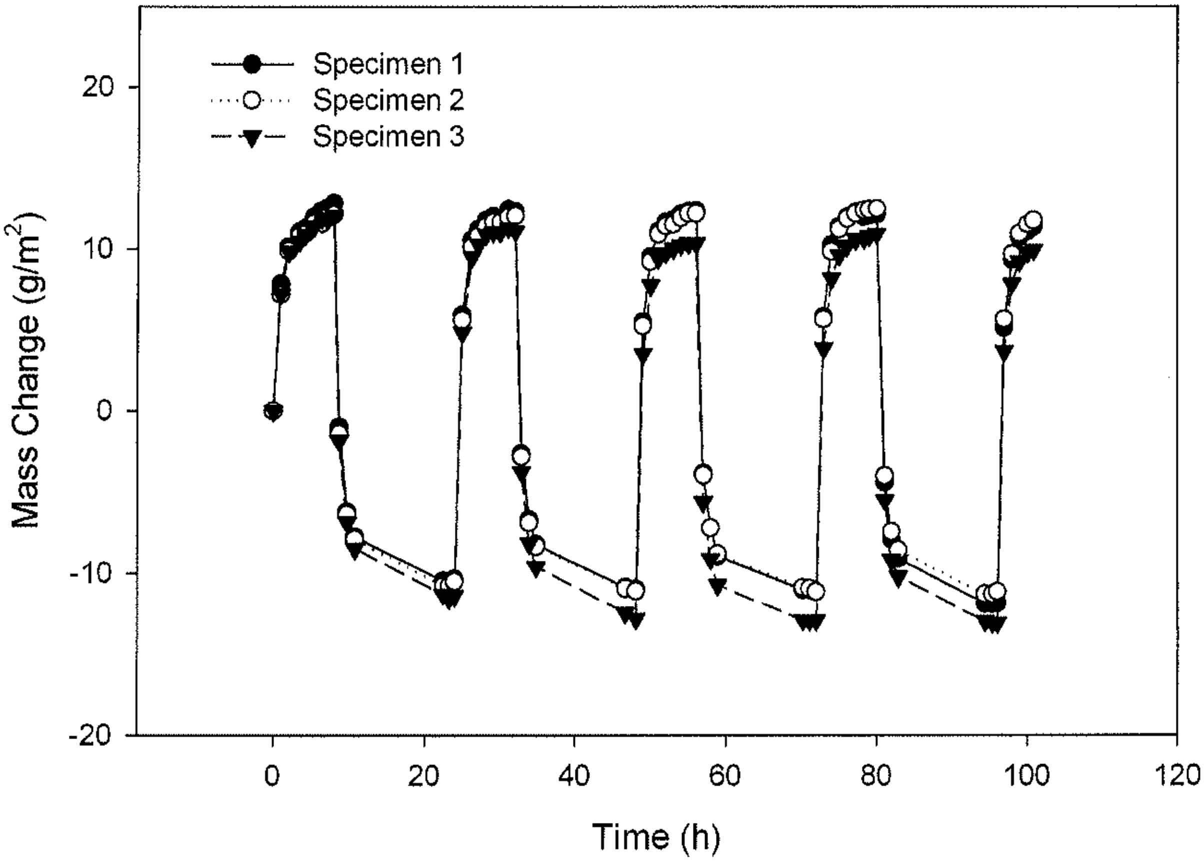
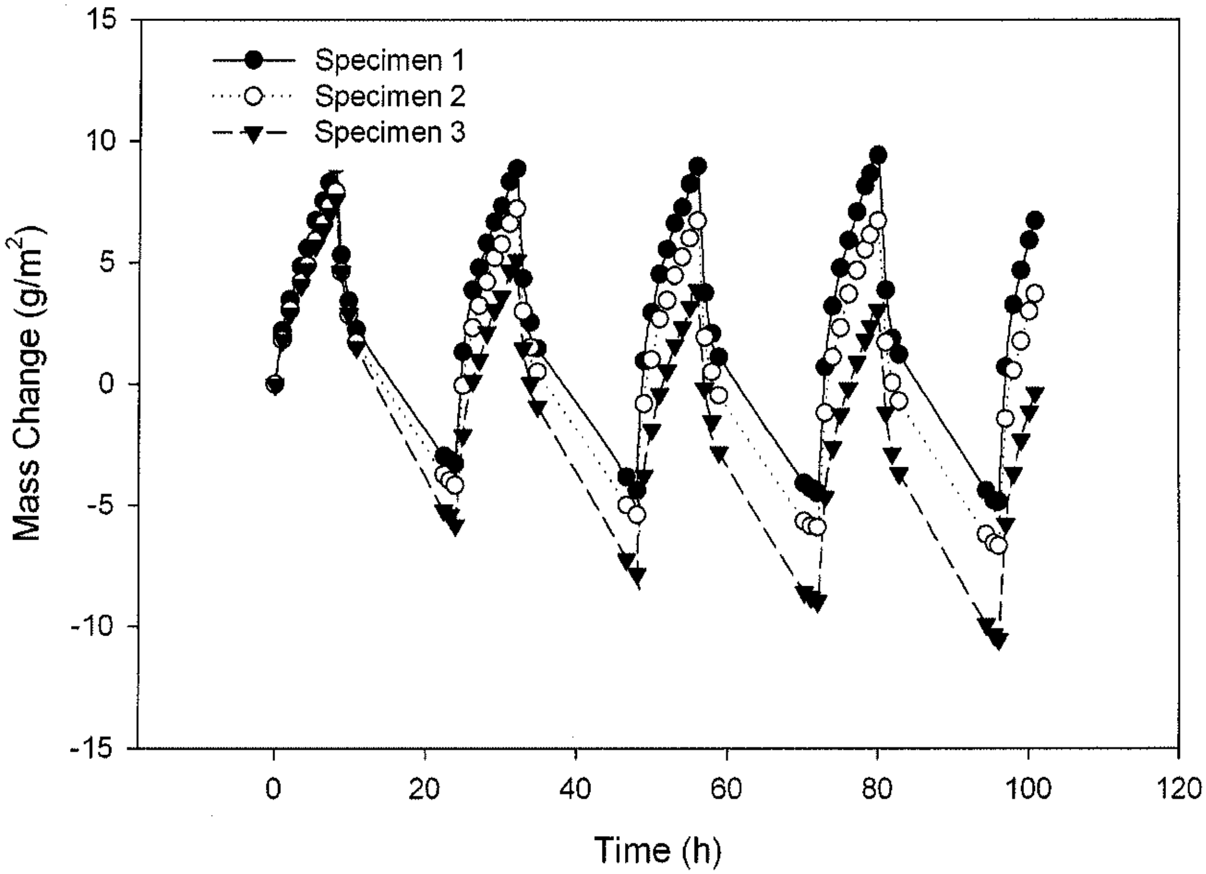

RH
Temperature
Relative Humidity (%)
Temperature (°C)
Time (h)
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120

Figure 3



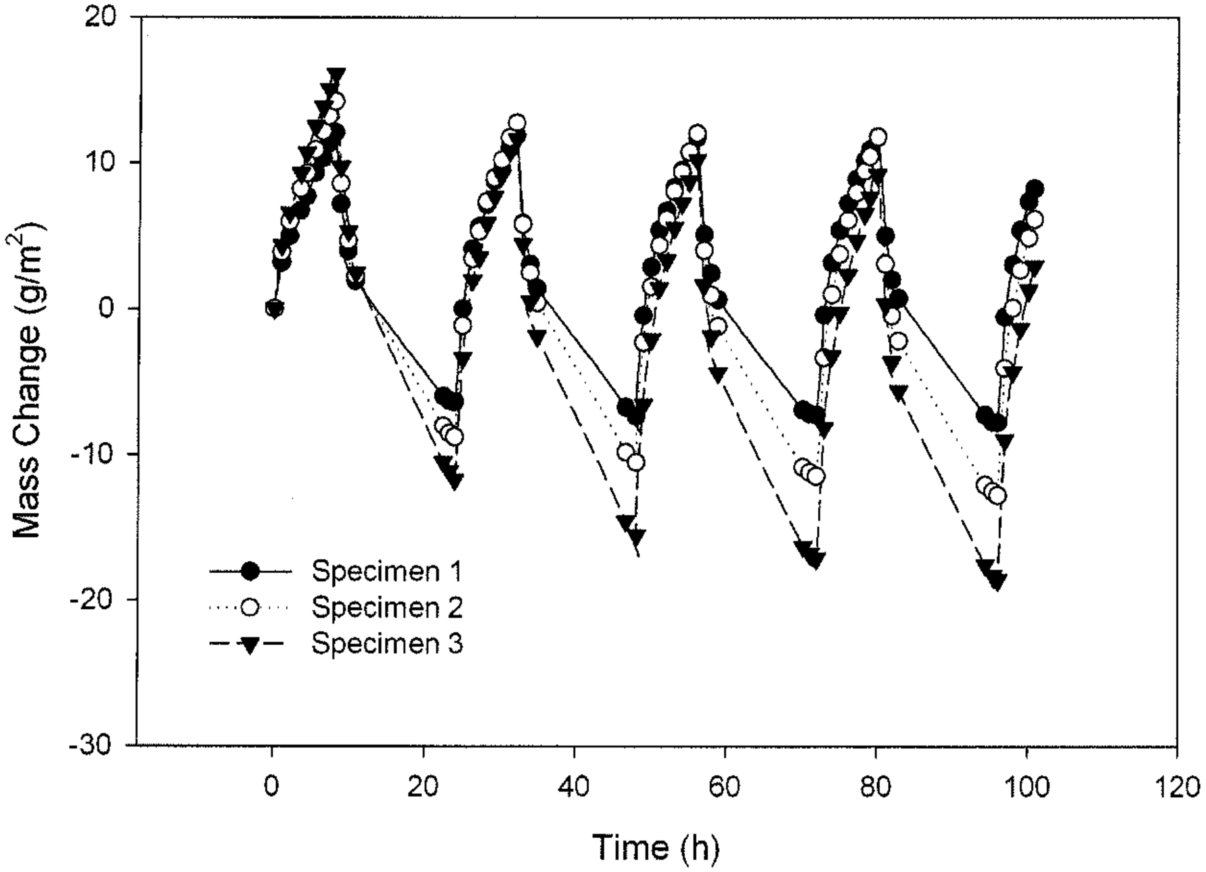
Specimen 1
Specimen 2
Specimen 3
20
10
0
-10
-20
Mass Change (g/m$^2$)
0
20
40
60
80
100
120
Time (h)

Figure 4



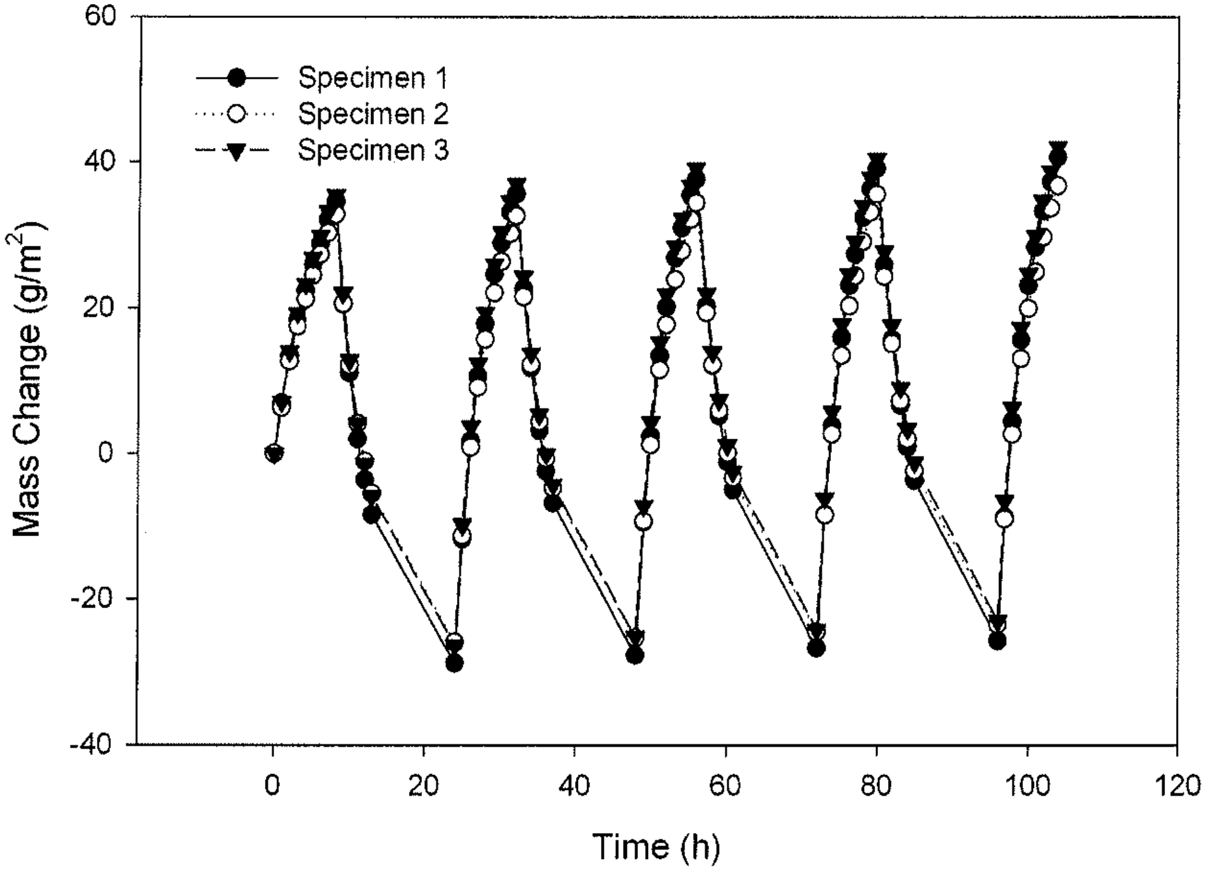
Specimen 1
Specimen 2
Specimen 3
15
10
5
0
-5
-10
-15
Mass Change (g/m^2)
0
20
40
60
80
100
120
Time (h)

Figure 5



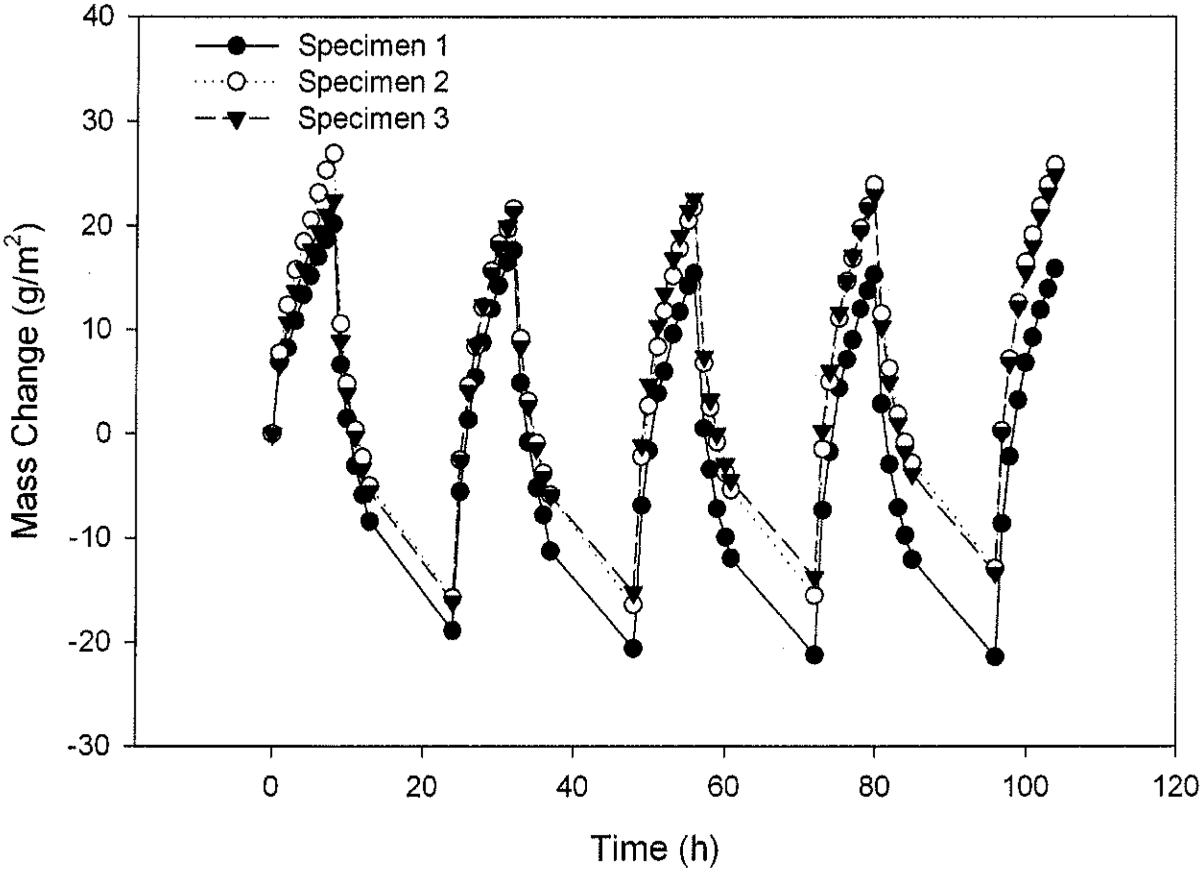
20
10
0
-10
-20
-30
Mass Change (g/m²)
0
20
40
60
80
100
120
Time (h)
Specimen 1
Specimen 2
Specimen 3

Figure 6



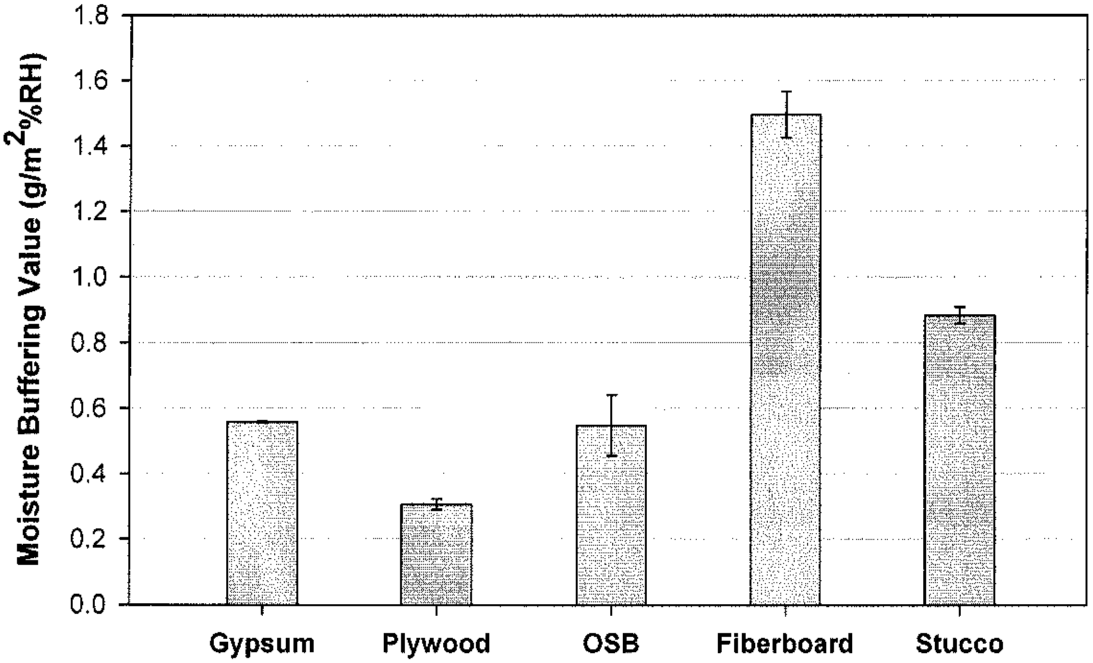
Specimen 1
Specimen 2
Specimen 3
Mass Change (g/m²)
Time (h)
60
40
20
0
-20
-40
0
20
40
60
80
100
120

Figure 7



Specimen 1
Specimen 2
Specimen 3
Mass Change (g/m²)
40
30
20
10
0
-10
-20
-30
0
20
40
60
80
100
120
Time (h)

Figure 8


Moisture Buffering Value (g/m2%RH)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Gypsum
Plywood
OSB
Fiberboard
Stucco