Standards Design for Some Pile Fabrics Used as Curtains to Achieve a Comfortable Properties

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Abstract: The quality of any product including textile products determined by the suitability of its actual properties for the function which was produced for it, and that's where the functional appropriate of product measured according to rigorous studies of the conditions of the end-use. Therefore, multiple studies was to develop a scientific basis for the design and production of textile products with specifications suitable for many end use functions imposed by the circumstances of modern life that we live. From here, the idea of this research, that relied on producing a total of eighteen face-to-face (double woven) warp pile fabrics which used as curtains, in order to study the effect of their different factors of textile structural (pile yarn material, pile height, and weave structure for pile)on their comfort properties (thermal insulation- sound absorption). All test methods are explained and results discussed. All samples have achieved the expected results and more results were reached, for examples, samples produced with 100% Acrylic fibers have recorded the highest rates of thermal insulation and sound absorption, As well samples produced with high pile have recorded the highest rates, whereas samples produced with weave structure for pile (w) have recorded the lowest rates. It was stressed that all the construction parameters under study were significantly affected in characteristics of thermal insulation and sound absorption.
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Key words:- pile fabric construction, pile height, pile thickness, air permeability, thermal insulation coefficient, Tog, sound absorption coefficient.

1-Introduction:

The textile industry of the oldest and most prestigious industries since the beginning of creation to the present, it is one of the pillars upon which the economy of many countries, including Egypt, scientific advances massive and rapid play an important role in the development of this industry and passing successive stages including the makings of high-performance career in many fields such as medicine, engineering, agriculture and other fields, where the industry of textile products are no longer interested only in the form and design but extended attention to include the efficient of its functionality performance. Pile fabrics is one of the finest textiles, which is characterized by the appearance lavish and comfortable soft surface of the fingers and eyes, it is one of the fabrics that are associated with art and technology significantly, in addition, it gives of great economic return, Therefore it is used in many areas which require working on the support and development it in order to increase its marketing and remain on the throne of textile. Pile fabrics manufacturing method has evolved even became there is a way of producing pile from warp on face to face machines (pile double woven), a style characterized by several characteristics, including:

-Reduce the mechanical effort.
-Double output.
-The high quality of the product.

With the increased demand for pile double woven there is a need for increased attention to improving the their quality and study the various factors affecting the efficiency of its functionality in order to enhance these fabrics in the areas of multi-use. In this paper we focus on the use of pile fabrics in the field of interval curtain fabrics to suit the use on the rooms windows, the rooms separators, on the openings which have exposed to the outside noise, and this in hospitals, schools, offices, theaters, radio and television studios, reception of hotels, residences and other places, In spite of the importance of shape and design of pile fabrics used in this field, but it's the most important characteristics that must be met in these fabrics is to provide a sense of comfort in places that are using where. And comfort properties required of curtain fabrics associate with the properties of air permeability, heat insulation and sound absorption.

Researchers agreed that the factors of structural composition of fabrics affecting the properties feeling comfortable, and Welfers searched at the porosity parts in the fabrics, as well as the geometry of the texture and pore size and the amount of air trapped and its impact on the physical properties of the fabrics[(1)].

From here, the idea of this research was to study the effect of different factors of pile fabrics structure which used as curtains on the properties of comfort (air permeability, sound absorption and thermal insulation), in an attempt to lay scientific foundations and produce a type of pile fabrics suitable for using as curtains to achieve the properties of comfort.

2-Theoretical studies:-

2-1- Face to face warp pile fabrics (double fabrics):-

In this kind of double pile fabric textile structures consisting of overlapping three systems of yarns are:

1- Group of pile warp yarns .

2- Group of ground warp yarns (stuffing warp + chain warp)

3- Group of weft yarns[2].

As the basic idea is dependent on the movement of pile warp yarns in the distance between the two layers of fabrics where they are separated by a knife moving with horizontal reciprocating movement linked with the movement of the tambourine, on the bar is installed on width of the machine.

Pile warp yarns form by overlapping with the weft yarns of two fabrics layers one forms of the following three letters (V,W,U), this after separated the two fabrics from each other as shown in Figure (1). And this is expressed in digital formats, where the pile V is called (V- 1/2), pile U is called (U- 2/4) and pile W is called (W- 3/6) [2].

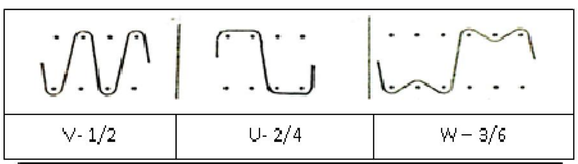

Figure (1): The weave structures for pile at face to face warp pile fabrics.

Notes that the distance between two layers of fabric represents twice the height of the pile for the two layers, and this distance can be organized between the two layers by controlling adjust the height of the distance between the two rulers (upper and lower).

This distance between the two layers of fabric achieved by adjusting the tensile affecting on the two groups of warp yarns on the one hand and between the two fabrics after their separation from each other and wrap each in opposite directions from the other hand, where the tensile forces the top fabric in contact with the bottom surface of the upper ruler, and the bottom fabric in contact with the upper surface of the lower ruler[3].

To ensure that the stability of the height in the distance between the two layers of fabrics, which can be changed as a result of differing tensile affecting on warp yarns or on the two layers of fabrics after separated from each other using metal strips called (Lancette) placed in the distance between the two layers of warp[3].

Based on all of the above it is clear that the structural factors which affect the physical properties of the pile fabrics multiple, these physical properties depend on the material type of the three groups of yarns involved in the installation (warp pile - warp ground - wefts) or on the textile installation of the pile or on the pile height on the surface.

2-2- Property of sound absorption:-

2-2-1- The sound:-

The sound is any compressive disturbance moving in material so that causes the movement of the eardrum and leads to the sense of hearing[4].

Sound consists of waves transmitted through the air at a speed of 1100 ft / s, and is transmitted in other materials, such as liquids, gases and solids, and the speed of transmission depends on the degree of their flexibility[5].

2-2-2- The noise pollution:

Noise pollution is one of physical contaminants, which means the existence of sound waves between waves transmitted by air to human in a degree effect on him organically and psychologically[6].

The noise is an environmental problem caused by industrial activities and means of transport, and its intensity are increasing day by day due to the increased construction activity and the associated increase in noise from transport, especially in big cities[7].

The noise is different from other factors of pollution in it's local to a large extent, which means that we do not feel it except only next to its source and does not spread its effects from one place to another as in the case of water pollution or air pollution which may be transmitted from one area to another or from one state to the other, as the impact of the noise cease as soon as stopping its source, does not leave any obvious impact on the environment, and thus the effect of noise specified expires after interruption its source[8].

2-2-3- The noise Standards:

Because of the impact of harmful noise on human life mental and neurological and organic, so the matter requires the need to establish standards for noise levels of human exposure, as well as the time duration allowable incurred by human, has been general agreement on the noise of less than 75 decibels be safe to extent large, and will not be exposed the human to the effects of the noise harmful[8].

2-2-3- Effects of the noise:

Noise pollution is the most dangerous types of contamination for humans and the pattern of his life, where it is possible for a person to protect himself easily against other types of pollution, and noise cause many diseases, where some scientific studies confirmed the presence of a strong relationship between the noise and the prevalence of heart disease, deafness, poor digestion and the high pressure, insomnia and the lack of sleep, it's also affecting much on the population of the big cities by fatigue as well as psychiatric illnesses, but the vast majority of people are not fully aware of the damage resulting from the continued exposure noise and the loud sounds, human has feared for his health from water pollution, may feel by air pollution , but do not shed the attention to the hype and noise surrounding him[8].

From here, the phenomenon of the spread of sound, noise and its effect on indoor spaces, one of the factors that lead to the lack of a sense of comfort.

2-2-4- How to control the noise:

Control the noise using multiple ways and means to start by measuring the level of noise in the place, where it can be controlled via[9] :

1-To reduce noise at the source (source).

2- To reduce noise while passing in the middle (middle).

3 - To protect the sense of hearing per receiver from the noise (receiver).

2-2-5- Sound insulation:

To Protect the sense of hearing per receiver from noise there are several ways of which what depends on sound insulation, using a variety of means including the use of soundproof materials such as the walls livery and the floors coverings [10].

Modern construction technology has helped on control the noise level and inconvenience in houses and enclosed places, and this by covering the walls using the sound insulations which is working to reduce the frequency coefficient with increasing sound absorption coefficient [9].

The sound absorption coefficient that it is defined as the ratio between the amount of absorbed sound energy and the amount of Fallen sound energy, and its value ranges between 0.01 to 1[11].

2-2-6- Use of textiles in the field of sound insulation:

Textiles possesses many of the physical properties which depend on the textile structures and properties of raw materials involved in their installation, which calls for the importance of the use of these textiles in the field of sound insulation.

Where some studies have indicated that the noise absorption and its transmission through textile raw materials such as cotton and acrylic may give positive results, Where possible, the use of these materials as insulation for sound much better than other insulation materials such as rock wool, and this because the textile raw materials it is characterized by a decrease of both cost and weight[12], [13].

Well as one study indicated that the fabric made from acrylic fibers with air gaps give better results for sound insulation when compared to samples made of rock wool at the rate of low frequencies at least 1000 Hertz[13].

Choosing textile compositions few intersections in the unit of measurement leads to an increase in the amount of air stored in samples which would lead to increase its ability to absorb sound[14].

Studies have proved that whenever the density of the pile increases, its ability to absorb sound are increasing, regardless of the type of pile (cut pile or loop pile) in the tufted carpet samples, This is in addition to the degree of absorption of tufted carpets with loop pile slightly lower for their counterparts with cut pile[15].

Studies have proved that the non-woven backing improved the ability to absorb sound for tufted carpet at medium frequencies (500 Hz), and the cotton backing a little better than acrylic backing in the case of one layer at frequencies ranging between (500-1000 Hz) [16].

2-3- Property of thermal insulation:-

The amount of heat transmitted into anybody leads to an increase in the internal energy of the molecules of this body as much as the amount of heat transmitted to him, and that seems in the form of a rise in body temperature[17].

2-3-1- Effects of temperature on human:

Climate (temperature of its components) is one of the most natural factors impact on the life and activity of organisms (human - animal - plant), and here Matorologi science or science of medical climate has become one of the main branches of science in the modern era[1].

High temperature leads to an increase of activities vital to the human body until it reaches a maximum at the optimum temperature when the man feels comfortable and this when the availability of the terms of air stillness and saturated with moisture. And the effect of the heat is reflected at the skip of optimum temperature where activities vital to humans begin to decline until it stops at a specific temperature known as the low temperature because it means the end to this man[18].

2-3-2- Thermal Insulation:

Is the use of substances that have the properties of thermal insulation so help reduce leakage and heat transfer from inside to outside the building in the summer, and inside to outside in the winter. The heat that penetrates the building, and which is supposed to overcome it by using air-conditioners to maintain the proper temperature can be divided into three types[19], [20].

- Heat that penetrates the walls and ceilings.
- Heat that penetrates the windows.

- Heat that is transmitted through natural ventilation openings.

Heat that penetrates the walls and ceilings in the days of summer are estimated at 60-70% of the heat , which can be overcome by using air conditioning.

The rest comes from windows and vents, which can be overcome by using textile curtains (the subject of this research).

2-3-3-Advantages of using thermal insulation:

-Keep building with the appropriate temperature for a long time without the need to run air conditioners.

- Rationalization in the consumption of electric power, where scientific experiments proved that the application of the use of thermal insulation in residential buildings, government facilities, commercial and industrial reduces the electric power at rates up to 40%.

- Reduces the use of air conditioners, which reduces the impact on the psychological and healthy human because of the noise resulting from the operation of those devices.

- Raise the level of comfort to the users of these buildings.

3-Experimental work:-

3-1- Fabric samples produced under research:-

In this study, a total of eighteen face-to-face (double woven) warp pile fabrics which using as curtains were produced, in order to study the effect of their different factors of textile structural on their comfort properties, Table (1) shows the specifications of the machine used for producing samples under study.

Table (1) the specifications of the machine used for producing samples under study:-

No.	Property	Specification
1	Machine	Face-to-face. Double rapier.
2	Machine type	GÜSKEN Veloromat GMV-80
3	Shedding system for moving the warp pile yarns and the warp yarns used for the ground of the fabrics	Dobby
4	Dobby type	Stàubli 1230 de 92
5	Reed used(dents / cm)	6 dents /cm

The material of yarns (warp and weft) used for the ground of the fabrics was 100% polyester, and their count was 30/2, table (2) shows the specifications of all samples under study.

Table (2) the specifications of all samples under study:-

S. No.	Warp Pile material	Warp Pile yarn count	weave structure for pile	Pile height mm	pile density /cm
1	Fibro 100%	24/2	V	2	17
2	Fibro 100%	24/2	V	4	17
3	Fibro 100%	24/2	V	6	17
4	Fibro 100%	24/2	U	2	17
5	Fibro 100%	24/2	U	4	17
6	Fibro 100%	24/2	U	6	17
7	Fibro 100%	24/2	W	2	17
8	Fibro 100%	24/2	W	4	17
9	Fibro 100%	24/2	W	6	17
10	Acrylic 100%	24/2	V	2	17
11	Acrylic 100%	24/2	V	4	17
12	Acrylic 100%	24/2	V	6	17
13	Acrylic 100%	24/2	U	2	17
14	Acrylic 100%	24/2	U	4	17
15	Acrylic 100%	24/2	U	6	17
16	Acrylic 100%	24/2	W	2	17
17	Acrylic 100%	24/2	W	4	17
18	Acrylic 100%	24/2	W	6	17

3-2- Laboratory Testing:-

In this paper we used the existing methods to measure the change in the comfort properties of warp pile fabrics by changing their textile structural factors.

3-2-1- Determination of fabric weight:-

This test was carried out by using Metter PI 200 according to the American Standard specifications of (ASTM-D3776-85)[21].The average of 3 readings for each sample was used .

3-2-2- Determination of fabric thickness:

This test was carried out by using Helios Tester according to the American Standard specifications of (ASTM-D1777-64)[22]. The average of 5 readings for each sample was used.

3-2-3- Determination the ability of fabrics to air permeability:

This test was carried out by using Air flow tester FX3300,S/N 483 according to the American Standard specifications of (ASTM-D. 737-75)[23], the idea of the used device that to calculate the amount of air measured by cm^3, passing through cm^2 of the tested fabric sample in a time of 1 minute under a pressure of 125 Pa (Pascale). The average of 5 readings for each sample was used.

3-2-4- Determination the ability of fabrics to thermal insulation:

This test was carried out by using standard test method for thermal transmittance of textile materials according to the American Standard specifications of (ASTM-D1518)[24]. The average of 3 readings for each sample was used.

3-2-5- Determination the sound absorption coefficient of fabrics:

In this section, the sound absorption coefficient of different materials is measured in impedance tube, using two-microphone transfer-function method according to ISO 10534-2 and ASTM E1050-98 international standards. The experimental apparatus include: B&K BZ 5050 & 5051 software, B&K3550 analyzer, B&K4260 impedance tube, 1/4inch B&K4187 condenser microphones cartridge with B&K 2670 preamplifier, and B&K 2706 power amplifier. [25]. The sound (noise)absorption values (%)of samples under study were measured at successive frequencies, 100, 125, 160, 200,250,315,400,500,630,800,1000,1250, and 1600Hz.

4-Results and Discussion-:

Results of experimental tests carried out on the produced samples were statistically analyzed and presented in the following tables and graphs.

Table (3) results of all tests applied to samples under study:-

S . No.	Total weight g/m2	Thickness (mm)	Air permeability (cm3/ cm2/sec)	Coefficient of thermal insulation (Tog)
1	627	3.00	10.5	1.30
2	649	3.35	10.3	1.44
3	670	3.75	9.8	1.64
4	408	2.12	22.6	1.29
5	436	2.43	21.2	1.39
6	488	3.28	19.3	1.51
7	352	1.53	29.3	1.24
8	355	1.90	28.5	1.34
9	374	2.62	27.9	1.36
10	626	3.01	9.8	1.87
11	660	3.38	9.6	1.92
12	681	4.54	9.2	2.01
13	410	2.19	21.6	1.45
14	445	2.64	19.4	1.59
15	510	3.62	18.8	1.71
16	365	1.82	28.3	1.40
17	371	1.98	27.2	1.50
18	387	3.18	26.6	1.57

4-1- **Effect of research variables on weight property:-**

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, pile height, and weave structure for pile on fabric weight are set out in table (4).

Table (4): Regression equation and correlation coefficient for fabric weight by the effect of pile yarn material, pile height, and weave structure for pile:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 605.6667 + 10.75 X	0.99991
Fibro 100%	U	Y = 364 + 20 X	0.985329
Fibro 100%	W	Y = 338.3333 + 5.5 X	0.922018
Acrylic 100%	V	Y = 600.6667 + 13.75 X	0.990817
Acrylic 100%	U	Y = 355 + 25 X	0.985329
Acrylic 100%	W	Y = 352.3333 + 5.5 X	0.967247

Y = Fabric weight (g/m2) , **X** = Pile height (mm)

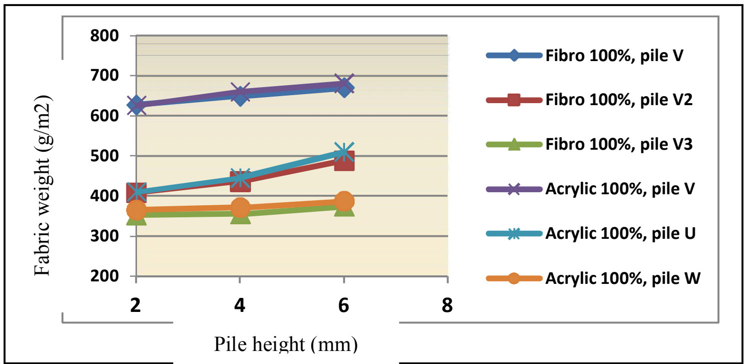

Figure (2): Effect of pile yarn material, pile height, and weave structure for pile on fabric weight(g/m^2).

4-1-1- Effect of pile yarn material type on fabric weight:-

Figure (2) shows the interactive effect of pile material type on fabric weight (g/m^2).
It is clear from this figure and **table (4)** that there is a highly significant effect of pile material type on fabric weight.

It is clear that all samples made of acrylic have recorded the highest rates of weight compared to the samples made of fibro.

4-1-2- Effect of pile height on fabric weight:-

Figure (2) shows the interactive effect of pile height on fabric weight (g/m^2).
It is clear from this figure and **table (4)** that there is a highly significant effect of pile height on fabric weight.
It is clear that the pile height increases, the weight was increased, this means that there is direct relationship between pile height and fabric weight. I can report that the increase in pile height allows to the surface of fabric to store more length of yarns causing an increase of pile density, and thereby increase the weight of fabric.

4-1-3- Effect of weave structure for pile on fabric weight:-

Figure (2) shows the interactive effect of weave structure for pile on fabric weight (g/m^2).

It is clear from this figure and **table (4)** that there is a highly significant effect of weave structure for pile on fabric weight.
It is clear that all samples made of pile shape (V) had recorded the highest rates of weight, whereas samples made of pile shape (W) have recorded the lowest rates.
This is most probably due to the structure of these piles. That the structure of pile shape (V) produced from 2 picks, whereas the structure of pile shape (U) produced from 4 picks, and the structure of pile shape (W) produced from 6 picks, as shown in figure (1).. And as a result the less number of picks per unit the more pile density, so the weight of the samples made of pile shape (V) had increased which had recorded the highest rates of weight compared to the samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the lowest rates.

4-2- Effect of research variables on thickness property:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, pile height, and weave structure for pile on fabric thickness are set out in table (5).

Table (5): Regression equation and correlation coefficient for fabric thickness (mm) by the effect of pile yarn material, pile height, and weave structure for pile:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 2.616667 + 0.1875 X	0.99926
Fibro 100%	U	Y = 1.45 + 0.29 X	0.965728
Fibro 100%	W	Y = 0.926667 + 0.2725 X	0.983246
Acrylic 100%	V	Y = 2.113333 + 0.3825 X	0.958324
Acrylic 100%	U	Y = 1.386667 + 0.3575 X	0.977863
Acrylic 100%	W	Y = 0.966667 + 0.34 X	0.914807

Y = fabric thickness (mm) , **X** = Pile height (mm)

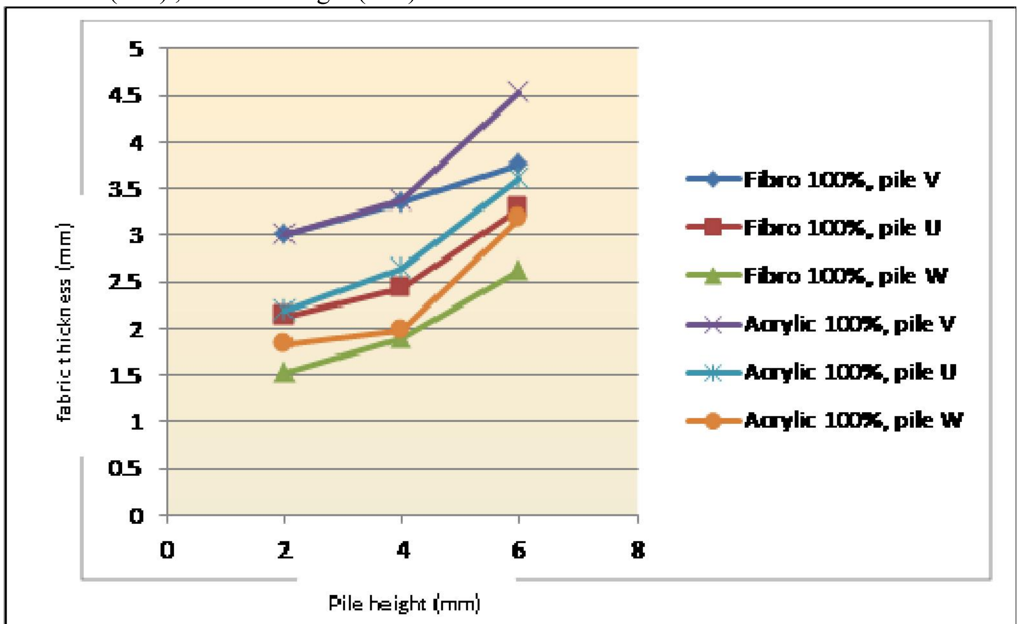

Figure (3): Effect of pile yarn material, pile height, and weave structure for pile on fabric thickness (mm).

4-2-1- Effect of pile yarn material type on fabric thickness:-

Figure (3) shows the interactive effect of pile material type on fabric thickness (mm).

It is clear from this figure and **table (5)** that there is a highly significant effect of pile material type on fabric thickness.

It is clear that all samples made of acrylic have recorded the highest rates of thickness compared to the samples made of fibro. This is because the acrylic fibers be overgrown.

4-2-2- Effect of pile height on fabric thickness:-

Figure (3) shows the interactive effect of pile height on fabric thickness (mm).

It is clear from this figure and **table (5)** that there is a highly significant effect of pile height on fabric thickness.

It is clear that the more pile height the more thickness, this means that there is direct relationship between pile height and fabric thickness. I can report that the increase in pile height allows to the surface of fabric to store more length of yarns causing an increase of pile density, and thereby increase the thickness of fabric.

4-2-3- Effect of weave structure for pile on fabric thickness:-

Figure (3) shows the interactive effect of weave structure for pile on fabric thickness (mm).

It is clear from this figure and **table (5)** that there is a highly significant effect of weave structure for pile on fabric thickness.

It is clear that all samples made of pile shape (V) had recorded the highest rates of thickness, whereas samples made of pile shape (W) have recorded the lowest rates.

This is most probably due to the structure of these piles. That the structure of pile shape (V) produced from 2 picks, whereas the structure of pile shape (U) produced from 4 picks, and the structure of pile shape (W) produced from 6 picks, as shown in figure (1).. And as a result the less number of picks per unit the more pile density, so the thickness of samples made of pile shape (V) had increased which had recorded the highest rates of thickness compared to samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the lowest rates.

4-3- Effect of research variables on property of air permeability:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, weave structure for pile, and pile height on the ability of fabric to air permeability are set out in table (6).

Table (6): Regression equation and correlation coefficient for the fabric air permeability (cm^3/ cm^2/sec) by the effect of pile yarn material, weave structure for pile, and pile height:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 10.9 - 0.175 X	-0.97073
Fibro 100%	U	Y = 24.3333 - 0.825 X	-0.9962
Fibro 100%	W	Y = 29.966667 - 0.35 X	-0.99662
Acrylic 100%	V	Y = 10.13333 - 0.15 X	-0.98198
Acrylic 100%	U	Y = 22.73333 - 0.7 X	-0.94965
Acrylic 100%	W	Y = 29.06667 - 0.425 X	-0.98589

Y = fabric air permeability (cm^3/ cm^2/sec), **X** = Pile height (mm)

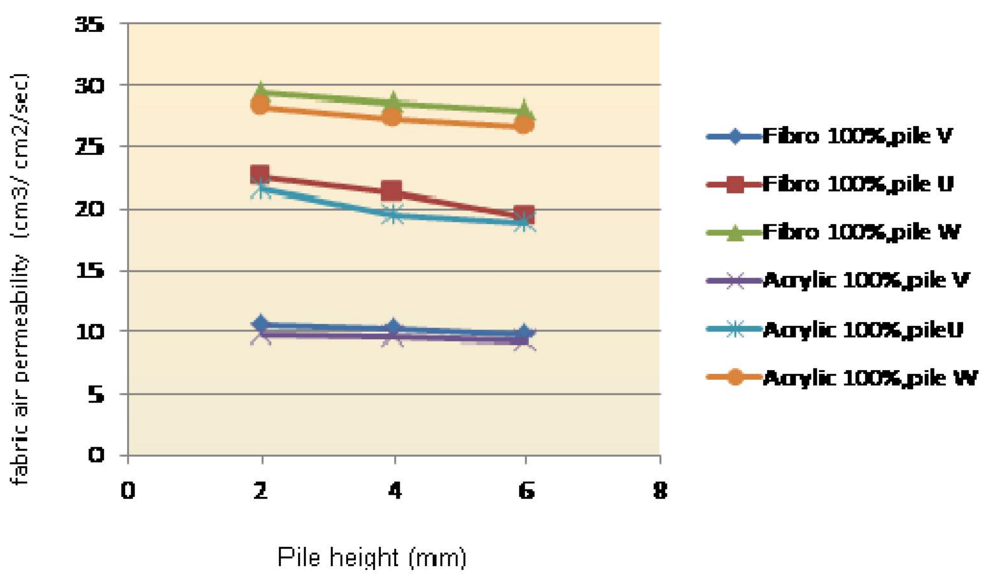

Figure (4): Effect of pile yarn material, weave structure for pile, and pile height on fabric air permeability (cm^3/ cm^2/sec).

4-3-1- Effect of pile yarn material type on the ability of fabrics to air permeability:-

Figures (4), (5),(6) show the effect of pile material type on the ability of fabrics to air permeability (cm^3/ cm^2/sec).

It is clear from these figures and **tables (6), (7), (8)** that there is a highly significant effect of pile material type on fabric air permeability.

It is clear from these figures that all samples made of fibro had recorded the highest rates of the ability of fabrics to air permeability compared to the samples made of acrylic which have recorded the lowest rates. This is due to the acrylic fibers are overgrown which allows it to contain stagnant air that impedes air permeability

4-3-2- Effect of weave structure for pile on the ability of fabrics to air permeability:-

Figures (4), (5), (6) show the interactive effect of weave structure for pile on the ability of fabric to air permeability (cm^3/ cm^2/sec).

It is clear from these figures and **tables (6), (7), (8)** that there is a highly significant effect of weave structure for pile on fabric air permeability (cm^3/ cm^2/sec).

It is clear that all samples made of pile shape (W) had recorded the highest rates of fabrics air permeability, whereas samples made of pile shape (V) have recorded the lowest rates.

This is most probably due to the structure of these piles. That the structure of pile shape (V) produced from 2 picks, whereas the structure of pile shape (U) produced from 4 picks, and the structure of pile shape (W) produced from 6 picks, as shown in figure (1). Accordingly the less number of picks per unit the more pile density, causing an increase in the amount of the stagnant air trapped between the piles and each other, besides free spaces between piles and each other have decreased, and thus the ability of the fabric to air permeability decreased which consistent with the study of Brody, H. [26], and the result the samples made of pile shape (V) had recorded the lowest rates of fabric air permeability compared to the samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the highest rates.

4-3-3- Effect of pile height on the ability of fabric to air permeability:-

Figure (4) shows the interactive effect of pile height on the ability of fabric to air permeability (cm^3/ cm^2/sec).

It is clear from this figure and **table (6)** that there is a highly significant effect of pile height on fabric air permeability.

It is clear that the more pile height the less fabric air permeability, this means that there is inverse relationship between pile height and the ability of the fabric to air permeability . I can report that the increase in pile height allows to the surface of fabric to store more length of yarns causing an increase of pile density on the surface of the fabric, causing an increase in the amount of the stagnant air trapped between the piles and each other, besides free spaces between piles and each other have decreased, and thus the ability of the fabric to air permeability decreased which consistent with the study of Brody, H. [26].

4-3-4- Effect of fabric weight on the ability of fabrics to air permeability:-

Regression equation and correlation coefficient for the effect fabric weight on its ability to air permeability are set out in table (7).

Table (7): Regression equation and correlation coefficient for fabric air permeability (cm^3/ cm^2/sec) by the effect of fabric weight:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 20.72271 - 0.01622 X	-0.96741
Fibro 100%	U	Y = 39.0843 - 0.04066 X	-0.99645
Fibro 100%	W	Y = 47.38501 - 0.05222 X	-0.88707
Acrylic 100%	V	Y = 16.37088 - 0.01043 X	-0.94741
Acrylic 100%	U	Y = 31.59547 - 0.02563 X	-0.88225
Acrylic 100%	W	Y = 53.22268 - 0.06907 X	-0.9111

Y= fabric air permeability (cm^3/ cm^2/sec), **X** = fabric weight (g/m^2)

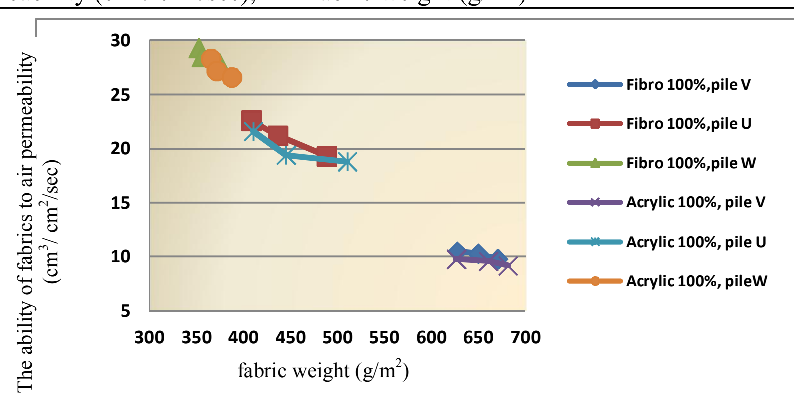

Figure (5): Effect of pile yarn material, weave structure for pile, and fabric weight on fabric air permeability (cm^3/ cm^2/sec).

Figure (5) shows the interactive effect of fabric weight on its ability to air permeability (cm^3/ cm^2/sec).

It is clear from this figure and **table (7)** that there is a highly significant effect of fabric weight on fabric air permeability.

It is clear that the more fabric weight the less fabric air permeability, this means that there is inverse relationship between fabric weight and the ability of the fabric to air permeability . I can report that the increase in fabric weight allows to the surface of fabric to have more pile yarns, and allows to the ground of fabric to have more yarns, causing the fabric to become more compact, and thereby free spaces between piles and each other had decreased, and thus the ability of the fabric to air permeability have decreased which consistent with the study of Brody, H. [26].

4-3-5- Effect of fabric thickness on the ability of fabric to air permeability:-

Regression equation and correlation coefficient for the effect fabric thickness on its ability to air permeability are set out in table (8).

Table (8): Regression equation and correlation coefficient for the ability of fabric to air permeability ($cm^3/cm^2/sec$) by the effect of fabric thickness:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 13.36746 - 0.94083 X	-0.97925
Fibro 100%	U	Y = 28.12093 – 2.71555 X	-0.98467
Fibro 100%	W	Y = 31.03253 – 1.22274 X	-0.96494
Acrylic 100%	V	Y = 10.92076 - 0.38081 X	-0.99504
Acrylic 100%	U	Y = 24.83471 – 1.74013 X	-0.86307
Acrylic 100%	W	Y = 29.6181 - 0.96766 X	-0.83428

Y= fabric air permeability ($cm^3/cm^2/sec$), **X** = fabric thickness (mm)

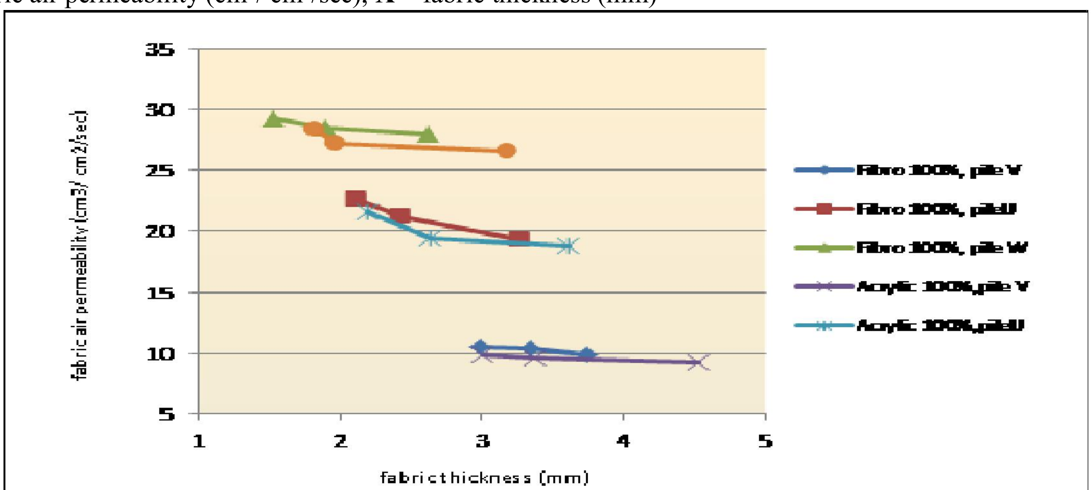

Figure (6): Effect of pile yarn material, weave structure for pile, and fabric thickness on the ability of fabric to air permeability ($cm^3/cm^2/sec$).

Figure (6) shows the interactive effect of fabric thickness on the ability of fabric to air permeability ($cm^3/cm^2/sec$).

It is clear from this figure and **table (8)** that there is a highly significant effect of fabric thickness on its ability to air permeability.

It is clear that the more fabric thickness the less ability to air permeability, this means that there is inverse relationship between fabric thickness and its ability to air permeability . I can report that the increase in fabric thickness allows to the surface of fabric to have more pile yarns causing an increase of pile density on the surface of the fabric,, causing the fabric to become more compact, and thereby free spaces between piles and each other had decreased, and thus the ability of the fabric to air permeability have decreased which consistent with the study of Brody, H. [26].

4-4- Effect of research variables on thermal insulation property:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of pile yarn material, weave structure for pile, and pile height on the ability of fabric to thermal insulation are set out in table (9).

Table (9): Regression equation and correlation coefficient for the ability of fabrics to thermal insulation (thermal insulation coefficient (Tog)) by the effect of pile yarn material, weave structure for pile, and pile height:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 1.12 + 0.085 X	0.99485
Fibro 100%	U	Y = 1.176667 + 0.055 X	0.998625
Fibro 100%	W	Y = 1.193333 + 0.03 X	0.933257
Acrylic 100%	V	Y = 1.793333 + 0.035 X	0.986666
Acrylic 100%	U	Y = 1.323333 + 0.065 X	0.999015
Acrylic 100%	W	Y = 1.32 + 0.0425 X	0.99485

Y = Thermal insulation coefficient (Tog), **X** = Pile height (mm)

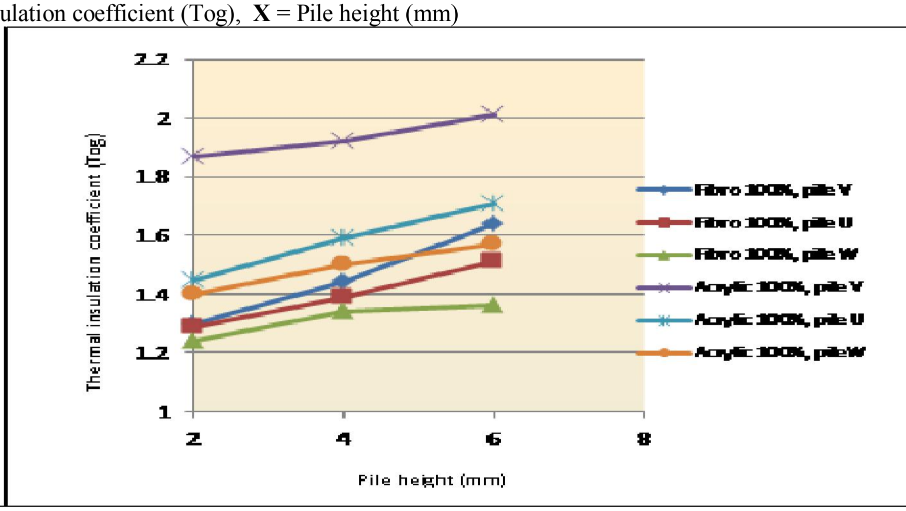

Figure (7): Effect of pile yarn material, weave structure for pile, and pile height on the coefficient of thermal insulation of fabric (Tog)

4-4-1- Effect of pile yarn material type on thermal insulation coefficient of fabric:-

Figures (7), (8),(9),(10) show the effect of pile material type on the coefficient of thermal insulation of fabric (Tog).

It is clear from these figures and **tables (9), (10), (11), (12)** that there is a highly significant effect of pile material type on thermal insulation coefficient of fabric.

It is clear from these figures that all samples made of fibro acrylic had recorded the highest rates of the coefficient of thermal insulation of fabric compared to the samples made of fibro which have recorded the lowest rates, this due to the ability of acrylic fibers to book stagnant air inside the anatomical structure of its fibers and therefore its ability to the thermal insulation increases.

4-4-2- Effect of weave structure for pile on thermal insulation coefficient of fabric:-

Figures (7), (8),(9),(10) show the interactive effect of weave structure for pile on thermal insulation coefficient of fabric (Tog).

It is clear from these figures and **tables (9), (10), (11), (12)** that there is a highly significant effect of weave structure for pile on the coefficient of thermal insulation of fabric.

It is clear that all samples made of pile shape (V) had recorded the highest rates of the coefficient of thermal insulation, whereas samples made of pile shape (W) have recorded the lowest rates.

This is most probably due to the structure of these piles. That the structure of pile shape (V) produced from 2 picks, whereas the structure of pile shape (U) produced from 4 picks, and the structure of pile shape (W) produced from 6 picks, as shown in figure (1). Accordingly the less number of picks per unit the more pile density on surface, causing an increase in the amount of the stagnant air trapped between the piles and each other, besides free spaces between piles and each other have decreased, and thus the ability of the fabric to loss heat decreased, and the result the thermal insulation coefficient of these samples increases, therefore the samples made of pile shape (V) had recorded the highest rates of the coefficient of thermal insulation compared to the samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the lowest rates.

4-4-3- Effect of pile height on thermal insulation coefficient of fabric:-

Figure (7) shows the interactive effect of pile height on thermal insulation coefficient of fabric (Tog).

It is clear from this figure and **table (9)** that there is a highly significant effect of pile height on thermal insulation coefficient.

It is clear that the more pile height the more thermal insulation coefficient of fabric, this means that there is direct relationship between pile height and the ability of fabrics to thermal insulation. I can report that the increase in pile height allows to the surface of fabric to store more length of yarns causing an increase of pile density on the surface of the fabric, which increased the degree of coverage of the pile to fabric ground, causing an increase in the amount of the stagnant air trapped between the piles and each other, besides the free spaces between piles and each other had decreased, and thus the ability of the fabric to loss heat have decreased, and the result of this the thermal insulation coefficient of these samples increased.

4-4-4- Effect of fabric weight on the thermal insulation coefficient of fabric:-

Regression equation and correlation coefficient for the effect fabric weight on the coefficient of thermal insulation of fabric are set out in table (10).

Table (10): Regression equation and correlation coefficient for the thermal insulation coefficient by the effect of fabric weight:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -3.66105 + 0.007895 X	0.993399
Fibro 100%	U	Y = 0.200453 + 0.002694 X	0.99292
Fibro 100%	W	Y = -0.08749 + 0.003888 X	0.721412
Acrylic 100%	V	Y = 0.331759 + 0.002443 X	0.955599
Acrylic 100%	U	Y = 0.443625 + 0.002505 X	0.976787
Acrylic 100%	W	Y = -1.14384 + 0.007036 X	0.936537

Y= thermal insulation coefficient (Tog), **X** = fabric weight (g/m^2)

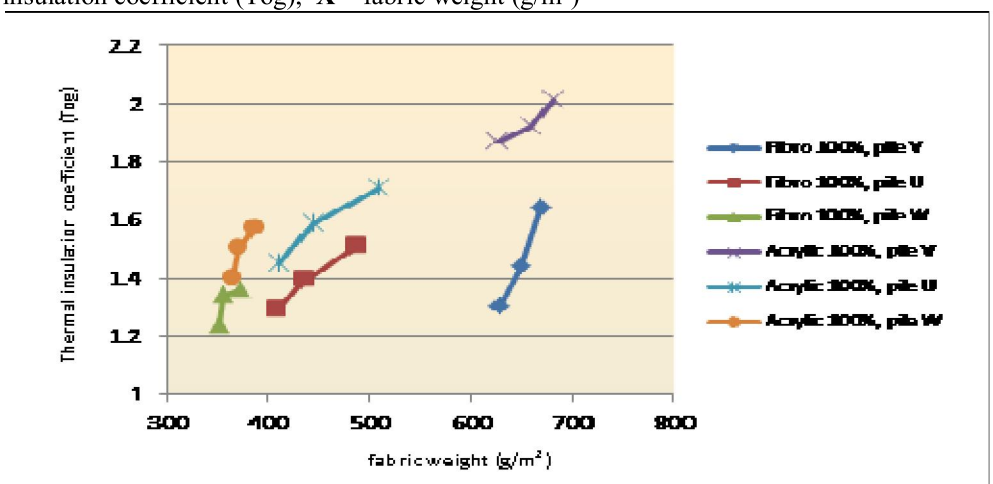

Figure (8): Effect of pile yarn material, weave structure for pile, and fabric weight on the thermal insulation coefficient of fabric (Tog)

Figure (8) shows the interactive effect of fabric weight on the thermal insulation coefficient (Tog).

It is clear from this figure and **table (10)** that there is a highly significant effect of fabric weight on the thermal insulation coefficient.

It is clear that the more fabric weight the more thermal insulation coefficient, this means that there is direct relationship between fabric weight and the ability of fabrics to thermal insulation . I can report that the increase in fabric weight allows to the surface of fabric to have more pile yarns, and allows to the ground of fabric to have more yarns, causing the fabric to become more compact, and thereby free spaces between piles and each other had decreased, and thus the ability of the fabric to loss heat have decreased, and the result of this the coefficient of thermal insulation of these samples increased.

4-4-5- Effect of fabric thickness on thermal insulation coefficient:-

Regression equation and correlation coefficient for the effect fabric thickness on the thermal insulation coefficient are set out in table (11).

Table (11): Regression equation and correlation coefficient for thermal insulation coefficient (Tog) by the effect of fabric thickness:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -0.06994 + 0.454438 X	0.998012
Fibro 100%	U	Y = 0.928502 + 0.179373 X	0.978005
Fibro 100%	W	Y = 1.114008 + 0.098839 X	0.852144
Acrylic 100%	V	Y = 1.612109 + 0.088168 X	0.992043
Acrylic 100%	U	Y = 1.098289 + 0.172205 X	0.967616
Acrylic 100%	W	Y = 1.257558 + 0.099903 X	0.869157

Y=The thermal insulation coefficient (Tog), **X** = fabric thickness (mm)

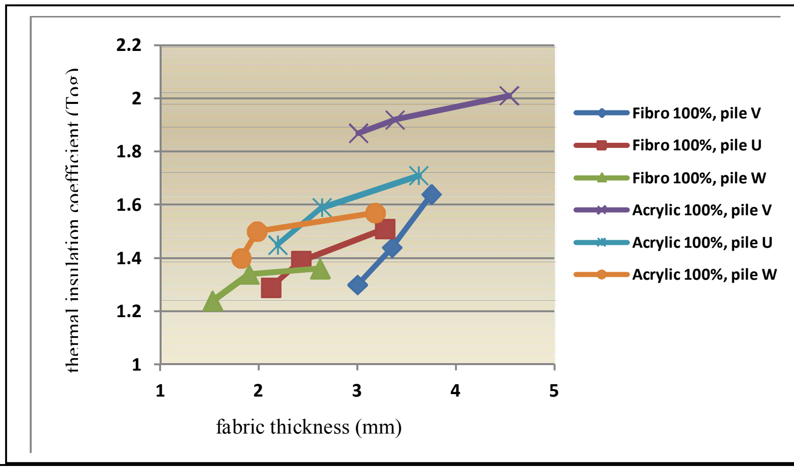

Figure (9): Effect of pile yarn material, weave structure for pile, and fabric thickness on thermal insulation coefficient of fabric

Figure (9) shows the interactive effect of fabric thickness on thermal insulation coefficient (Tog).

It is clear from this figure and **table (11)** that there is a highly significant effect of fabric thickness on thermal insulation coefficient of fabric.

It is clear that the more fabric thickness the more thermal insulation coefficient, this means that there is direct relationship between fabric thickness and its ability to thermal insulation . I can report that the increase in fabric thickness allows to the surface of fabric to have more pile yarns, and allows to the ground of fabric to have more yarns, causing the fabric to become more compact, and thereby free spaces between piles and each other had decreased, and thus the ability of the fabric to loss heat have decreased, and the result of this the thermal insulation coefficient of these samples increased.

4-4-6- Effect of fabric air permeability on the thermal insulation coefficient of fabric:-

Regression equation and correlation coefficient for the effect the ability of fabrics to air permeability on thermal insulation coefficient are set out in table (12).

Table (12): Regression equation and correlation coefficient for the thermal insulation coefficient (Tog) by the effect of fabric air permeability:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 6.246154 - 0.46923 X	- 0.99007
Fibro 100%	U	Y = 2.794629 – 0.06646 X	-0.99939
Fibro 100%	W	Y = 3.822568 – 0.95963 X	-0.95963
Acrylic 100%	V	Y = 4.146429 – 0.23214 X	-0.99965
Acrylic 100%	U	Y = 3.277055 – 0.08497 X	-0.96262
Acrylic 100%	W	Y = 4.195987 – 0.09888 X	-0.99778

Y= thermal insulation coefficient (Tog), **X** = Fabric air permeability (cm3/ cm2/sec)

It is clear from this figure and **table (12)** that there is a highly significant effect of fabric air permeability on thermal insulation coefficient of fabric.

It is clear that the more fabric air permeability the less thermal insulation coefficient, this means that there is inverse relationship between fabric air permeability and its ability to thermal insulation. I can report that the increase in the ability of fabric to air permeability resulted in a decrease in the amount of the stagnant air trapped between the piles and each other that increases the ability of the fabric to loss heat , and the result of this the thermal insulation coefficient of these samples decreased.

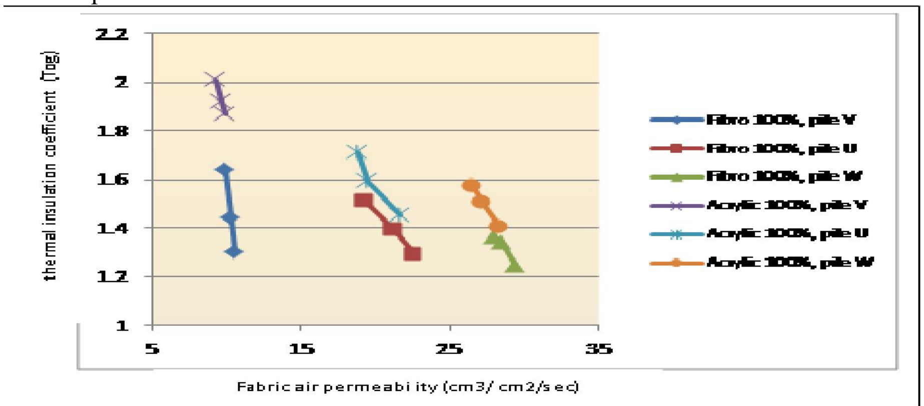

Figure (10): Effect Fabric air permeability on thermal insulation coefficient

Figure (10). Interactive effect of the ability of fabrics to air permeability on thermal insulation coefficient (Tog).

4-5- Sound absorption test:-

4-5-1- Results of sound absorption coefficient test at successive frequencies:-

Normal incidence absorption coefficients of curtains were measured according to the standard ISO 10534-2, using a Bruel & Kjaer two-microphone impedance tube of type 4206. The tube had a diameter of 10 cm allowing measurements in the range from 100Hz to 1.65 kHz.

Through the experiment researches on acoustic curtains, it can be derived that the expanding rate, the space and the area density can influence the absorption properties of the curtain. With a larger space, the sound absorption performance of the curtain can be improved. There is a very significant increase, especially in low frequency.

The larger the area density of the curtain, the better absorption of the full band can be achieved, especially in the high frequency but there is an optimal area density.

Depending on the actual needs of different function halls, people can use acoustic curtains expanding rate to adjust the reverberation time [(27),(28),(29)].

Our samples were placed directly at the tube end (samples placed directly on the rigid end of the tube without packing air-space), so the sound absorption coefficient appears small especially in low frequency range as appear in Figures from (11) to (16) which show the sound absorption coefficient of samples under study at successive frequencies, 100,125,160,200,250,315,400, 500, 630 ,800 ,1000,1250, and 1600 Hz.

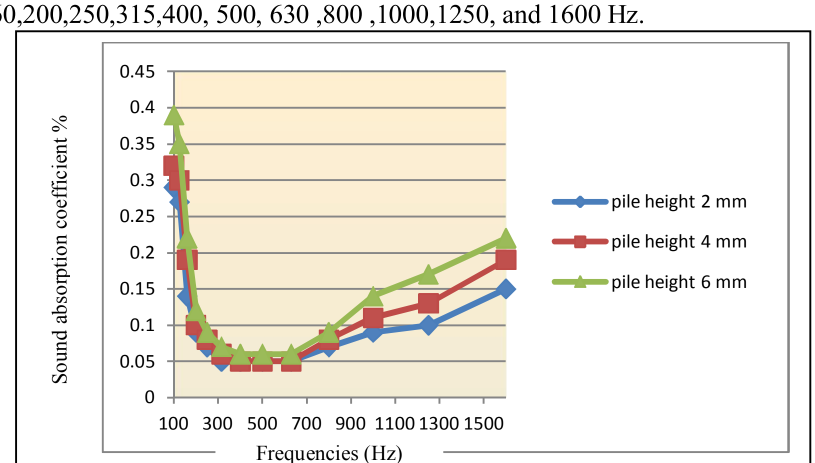

Figure (11): Sound absorption coefficient of samples made of fibro material 100% and weave structure for pile V

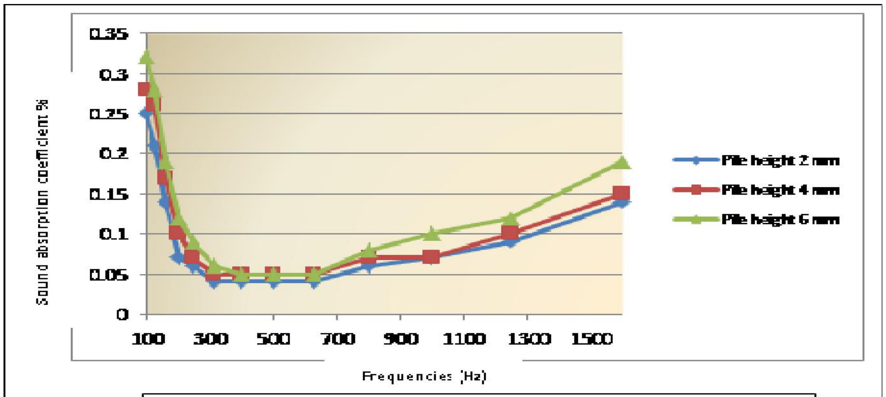

Figure (12): Sound absorption coefficient of samples made of fibro material 100% and weave structure for pile U

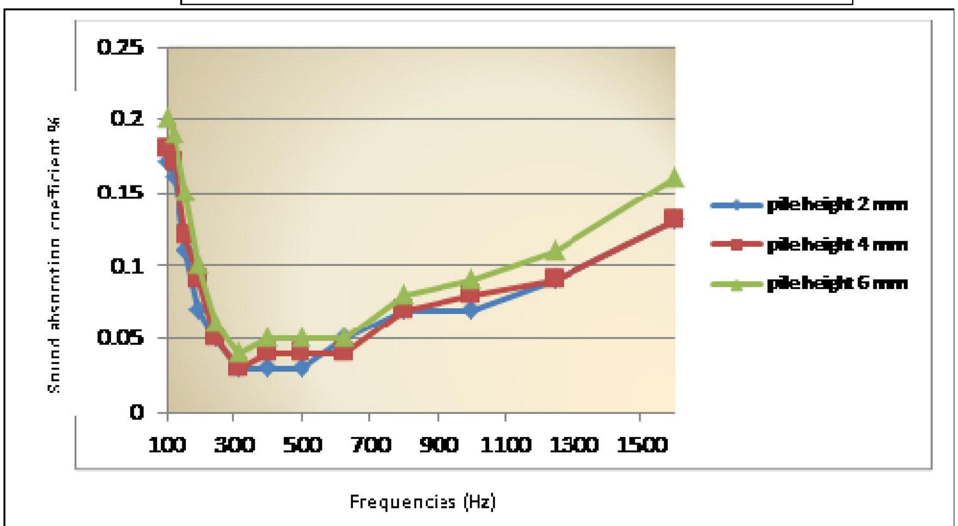

Figure (13): Sound absorption coefficient of samples made of fibro material 100% and weave structure for pile W

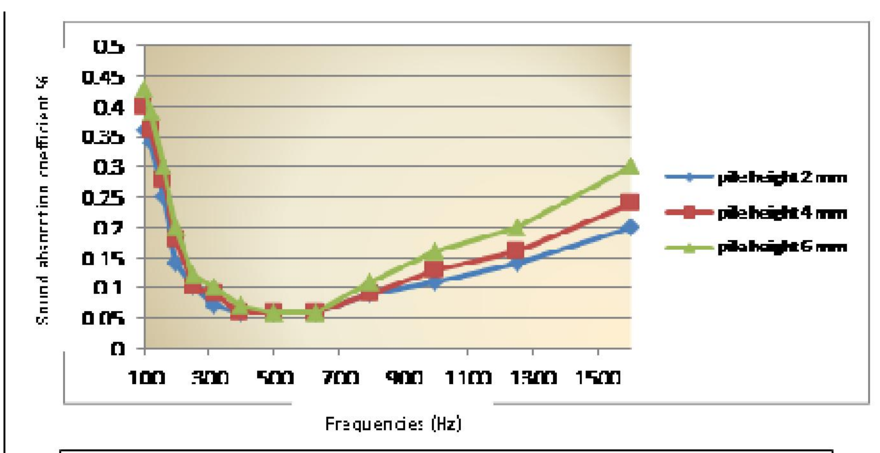

Figure (14): Sound absorption coefficient of samples made of Acrylic material 100% and weave structure for pile V

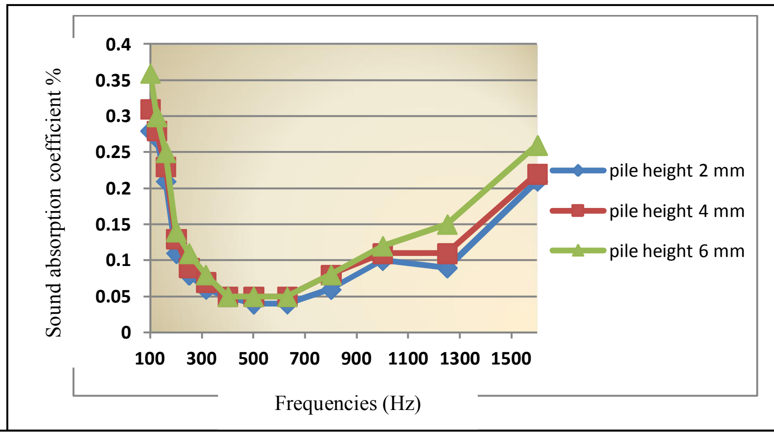

Figure (15): Sound absorption coefficient of samples made of Acrylic material 100% and weave structure for pile U

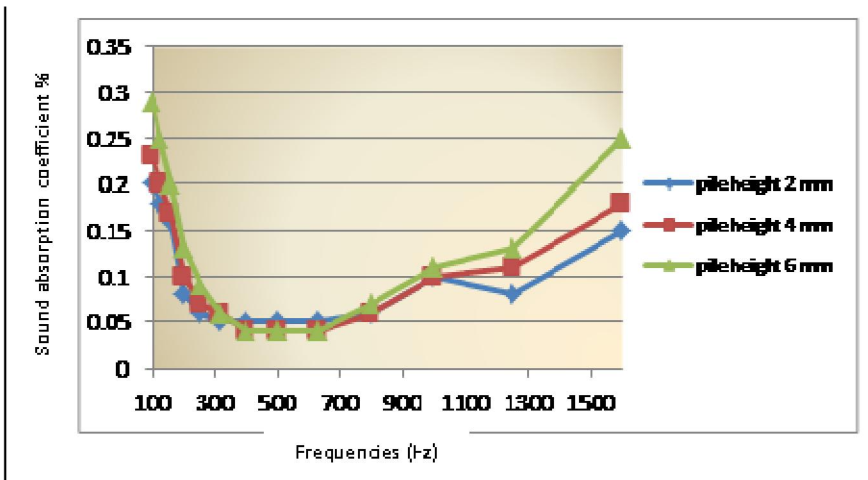

Figure (16): Sound absorption coefficient of samples made of Acrylic material 100% and weave structure for pile W

4-5-2- Effect of research variables on sound absorption properties:-:-

Statistical analysis of the data were made with relationships between variables. Regression equation and correlation coefficient for the effect of research variables on the ability of fabric to sound absorption are tabulated in tables (13) to (20).

Table (13): Regression equation and correlation coefficient for the ability of fabric to sound absorption (sound absorption coefficient) at the frequency 100 (Hz) by the effect of pile yarn material, weave structure for pile, and pile height:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 0.233333 + 0.025 X	0.974355
Fibro 100%	U	Y = 0.213333 + 0.0175 X	0.996616
Fibro 100%	W	Y = 0.153333 + 0.0075 X	0.981981
Acrylic 100%	V	Y = 0.326667 + 0.0175 X	0.996615
Acrylic 100%	U	Y = 0.236667 + 0.02 X	0.989743
Acrylic 100%	W	Y = 0.15 + 0.0225 X	0.981982

Y = Sound absorption coefficient at frequency 100 Hz, **X** = Pile height (mm)

Table (14): Regression equation and correlation coefficient for the ability of fabric to sound absorption (sound absorption coefficient) at the frequency 1600 (Hz) by the effect of pile yarn material, weave structure for pile, and pile height:-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 0.116667 + 0.0175 X	0.996616
Fibro 100%	U	Y = 0.11 + 0.0125 X	0.944911
Fibro 100%	W	Y = 0.113333 + 0.0075 X	0.981981
Acrylic 100%	V	Y = 0.146667 + 0.025 X	0.993399
Acrylic 100%	U	Y = 0.18 + 0.0125 X	0.944911
Acrylic 100%	W	Y = 0.093333 + 0.025 X	0.974355

Y = Sound absorption coefficient at frequency 1600 Hz, **X** = Pile height (mm)

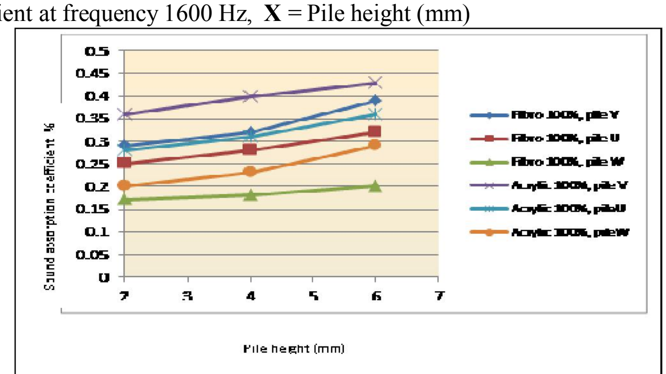

Figure (17): Effect of pile yarn material, weave structure for pile, and pile height on the sound absorption coefficient of fabric at the frequency 100 Hz

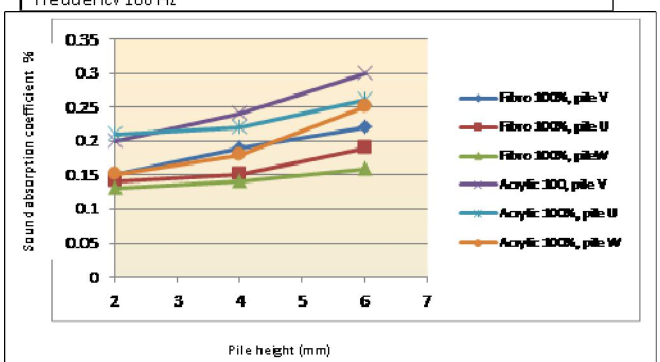

Figure (18): Effect of pile yarn material, weave structure for pile, and pile height on the sound absorption coefficient of fabric at the frequency 1600 Hz

4-5-2-1- Effect of pile yarn material type on the sound absorption coefficient of fabric:-

Figures from (11) to (24) show the effect of pile material type on the sound absorption coefficient of fabric.

It is clear from these figures and **tables (13) to (20)** that there is a highly significant effect of pile material type on the sound absorption coefficient.

It is clear from these figures that all samples made of acrylic had recorded the highest rates of sound absorption coefficient compared to the samples made of fibro which have recorded the lowest rates. This is most probably due to the structure of the Acrylic fibers. This structure would have air inside its lumen which increases the air volume in the fabric and, in turn, increases its ability to absorb sound waves rather than reflecting it.

4-5-2-2- Effect of weave structure for pile on the sound absorption coefficient of fabric:-

Figures from (11) to (24) show the interactive effect of weave structure for pile on the sound absorption coefficient of fabric.

It is clear from these figures and **tables from (13) to (20)** that there is a highly significant effect of weave structure for pile on the sound absorption coefficient.

It is clear that all samples made of pile shape (V) had recorded the highest rates of the sound absorption coefficient, whereas samples made of pile shape (W) have recorded the lowest rates at both low and high frequencies. This is most probably due to the structure of these piles. That the structure of pile shape (V) produced from 2 picks, whereas the structure of pile shape (U) produced from 4 picks, and the structure of pile shape (W) produced from 6 picks, as shown in figure (1). And as a result the pile density on the surface of the fabric had increased with the decreasing of picks number per unit area and also the fabric volume had increased, accordingly the amount of the stagnant air trapped between the piles and each other increased which absorb the sound waves rather than reflecting it, that means the efficiency will be increased, therefore the samples with pile structure (V) had recorded the highest rates of the sound absorption coefficient compared to the samples with pile structure (U) and other samples with pile structure (W) which have recorded the lowest rates.

4-5-2-3- Effect of pile height on the sound absorption coefficient of fabric:-

Figures from (11) to (18) show the interactive effect of pile height on the sound absorption coefficient of fabric.

It is clear from these figures and **tables (13),(14)** that there is a highly significant effect of pile height on the sound absorption coefficient.

It is clear that the more pile height the more sound absorption coefficient at both low and high frequencies, this means that there is direct relationship between pile height and the ability of fabrics to sound absorption. We can concluded that the increase in pile height allows to the surface of fabric to store more length of yarns causing an increase in the amount of the stagnant air trapped between the piles and each other, which absorb the sound waves rather than reflecting it, and thus the ability of the fabric to absorb the sound increases, and the result of this the sound absorption coefficient increases.

4-5-2-4- Effect of fabric weight on its sound absorption coefficient:-

Regression equation and correlation coefficient for the effect of fabric weight on its sound absorption coefficient are set out in tables (15), (16).

Table (15): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of fabric weight at the frequency 100 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -1.17025 + 0.002318 X	0.971246
Fibro 100%	U	Y = - 0.09924 + 0.000862 X	0.996023
Fibro 100%	W	Y = -0.26814 + 0.001253 X	0.978568
Acrylic 100%	V	Y = -0.43178 + 0.001264 X	0.998578
Acrylic 100%	U	Y = -0.4557 + 0.000796 X	0.999604
Acrylic 100%	W	Y = -1.126505 + 0.004021 X	0.997788

Y= Sound absorption coefficient (%) at frequency 100 (Hz), **X** = fabric weight (g/m^2)

Table (16): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of fabric weight at the frequency 1600 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -0.87028 + 0.001629 X	0.99763
Fibro 100%	U	Y = - 0.12558 + 0.000643 X	0.986912
Fibro 100%	W	Y = -0.30814 + 0.001253 X	0.978568
Acrylic 100%	V	Y = -0.90522 + 0.001757 X	0.968767
Acrylic 100%	U	Y = -0.00413 + 0.000515 X	0.986912
Acrylic 100%	W	Y = -1.49503 + 0.00451 X	0.999559

Y= Sound absorption coefficient (%) at frequency 1600 (Hz), **X** = fabric weight (g/m^2)

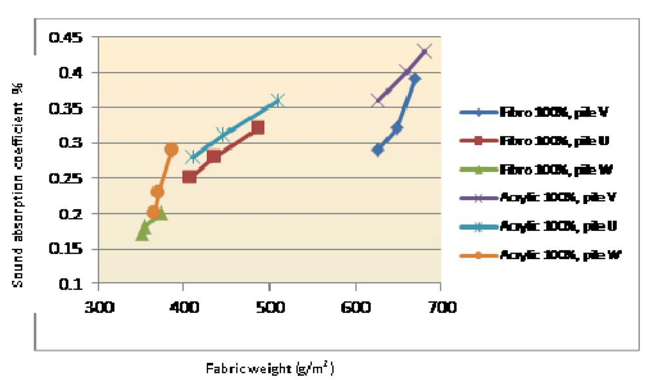

Figure (19): Effect of pile yarn material, weave structure for pile, and fabric weight on sound absorption coefficient (%) at frequency 100 (Hz)

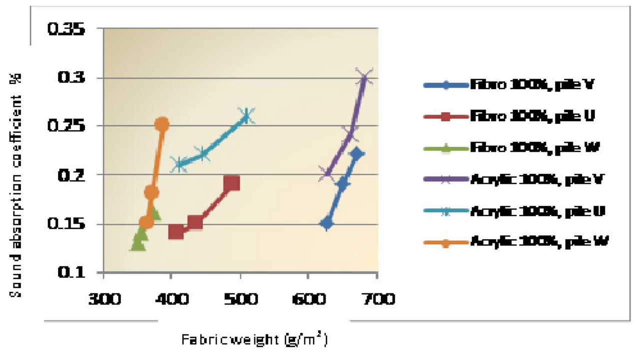

Figure (20): Effect of pile yarn material, weave structure for pile, and fabric weight on sound absorption coefficient (%) at frequency 1600 (Hz)

Figures (19),(20) show the interactive effect of fabric weight on its sound absorption coefficient.

It is clear from these figures and **tables (15),(16)** that there is a highly significant effect of fabric weight on its sound absorption coefficient.

It is clear that the more fabric weight the more sound absorption coefficient at both low and high frequencies, this means that there is direct relationship between fabric weight and the ability of fabric to sound absorption . We can concluded that the increase in fabric weight allows to the surface of fabric to have more pile yarns causing an increase in the amount of the stagnant air trapped between the piles and each other which improves the sound waves absorption efficiency rather than reflecting it, and the result of this the sound absorption coefficient increases.

4-5-2-5- Effect of fabric thickness (mm) on its sound absorption coefficient:-

Regression equation and correlation coefficient for the effect fabric thickness on its sound absorption coefficient are set out in tables (17), (18).

Table (17): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of fabric thickness at the frequency 100 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -0.11888 + 0.13432 X	0.982288
Fibro 100%	U	Y = 0.133188 + 0.057527 X	0.983795
Fibro 100%	W	Y = 0.127758 + 0.027558 X	0.999977
Acrylic 100%	V	Y = 0.247347 + 0.040984 X	0.931597
Acrylic 100%	U	Y = 0.161336 + 0.055147 X	0.997726
Acrylic 100%	W	Y = 0.100198 + 0.060087 X	0.974651

Y= Sound absorption coefficient (%) at frequency 100 (Hz), **X** = fabric thickness (mm)

Table (18): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of fabric thickness at the frequency 1600 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = -0.12609 + 0.92899 X	0.992717
Fibro 100%	U	Y = 0.045311 + 0.043942 X	0.997487
Fibro 100%	W	Y = 0.087758 + 0.027558 X	0.999977
Acrylic 100%	V	Y = 0.020447 + 0.062091 X	0.984768
Acrylic 100%	U	Y = 0.128847 + 0.035912 X	0.992486
Acrylic 100%	W	Y = 0.035565 + 0.067809 X	0.982229

Y= Sound absorption coefficient (%) at frequency 1600 (Hz), **X** = fabric thickness (mm)

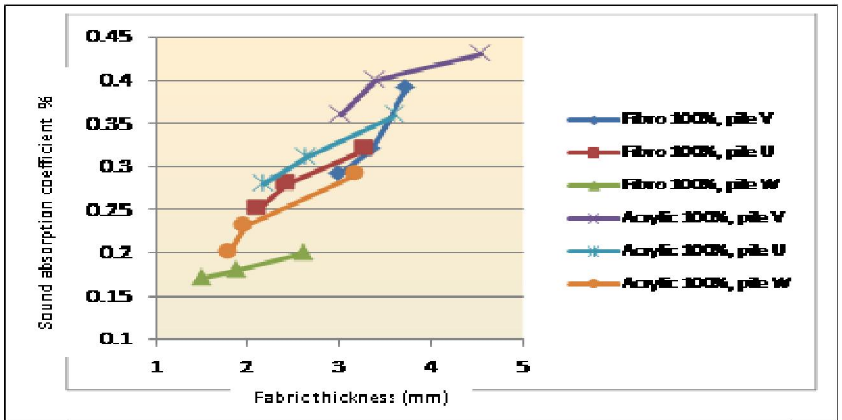

Figure (21): Effect of pile yarn material, weave structure for pile, and fabric thickness on sound absorption coefficient (%) at frequency 100 (Hz)

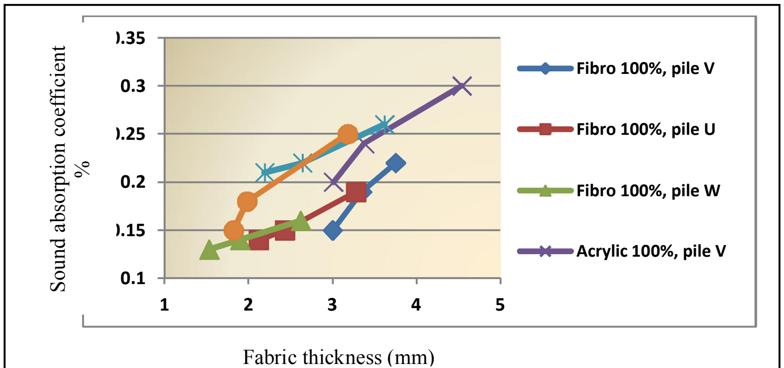

Figure (22): Effect of pile yarn material, weave structure for pile, and fabric thickness on sound absorption coefficient (%) at frequency 1600 (Hz)

Figures (21),(22) show the interactive effect of fabric thickness on its sound absorption coefficient.

It is clear from these figures and **tables (17),(18)** that there is a highly significant effect of fabric thickness on its sound absorption coefficient.

It is clear that the more fabric thickness the more sound absorption at both low and high frequencies, this means that there is direct relationship between fabric thickness and the ability of fabrics to sound absorption . We can concluded that the increase in fabric thickness allows to the surface of fabric to have more pile yarns causing an increase in the amount of the stagnant air trapped between the piles and each other which improves the sound waves absorption rather than reflecting it, and the result of this the sound absorption coefficient increases.

4-5-2-6- Effect of the fabric air permeability (cm^3/ cm^2/sec) on its sound absorption coefficient:-

Regression equation and correlation coefficient for the effect the ability of fabric to air permeability on the sound absorption coefficient are set out in tables (19), (20).

Table (19): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of the ability of fabric to air permeability at the frequency 100 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 1.784872 - 0.14231 X	- 0.99988
Fibro 100%	U	Y = 0.729301 – 0.0212 X	-0.99999
Fibro 100%	W	Y = 0.781689 – 0.02095 X	-0.96312
Acrylic 100%	V	Y = 1.452143 – 0.11071 X	-0.96312
Acrylic 100%	U	Y = 0.805828 – 0.02454 X	-0.89515
Acrylic 100%	W	Y = 1.602197 – 0.04978 X	-0.93648

Y= Sound absorption coefficient (%) at frequency 100 (Hz), **X** = the ability of fabrics to air permeability (cm3/ cm2/sec)

Table (20): Regression equation and correlation coefficient for the sound absorption coefficient by the effect of the ability of fabric to air permeability at the frequency 1600 (Hz):-

Pile yarn material	Weave structure for pile	Regression equation	Correlation coefficient
Fibro 100%	V	Y = 1.128205 - 0.09231 X	- 0.9477
Fibro 100%	U	Y = 0.485851 – 0.01549 X	-0.96984
Fibro 100%	W	Y = 0.741689 – 0.02095 X	-0.96312
Acrylic 100%	V	Y = 1.812857 – 0.16429 X	-0.99718
Acrylic 100%	U	Y = 0514325 – 0.79478 X	-0.79478
Acrylic 100%	W	Y = 1.696659 – 0.05493 X	-0.92293

Y= Sound absorption coefficient (%) at frequency 1600 (Hz), **X** = the ability of fabrics to air permeability (cm3/ cm2/sec)

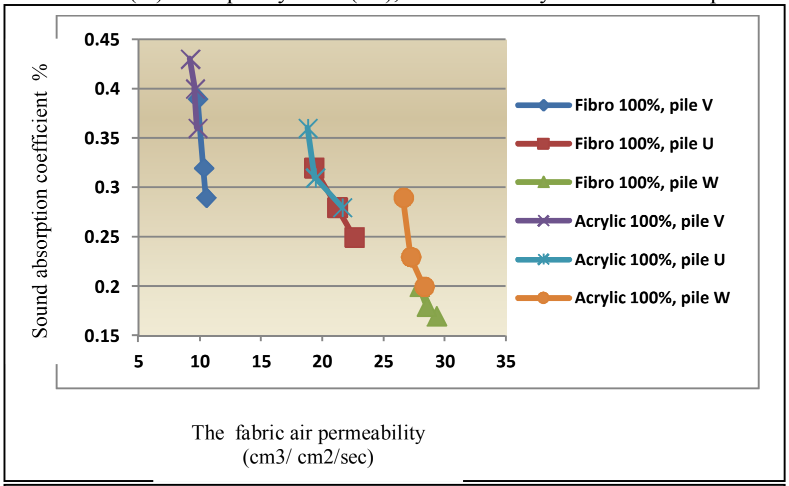

Figure (23): Effect of pile yarn material, weave structure for pile, and the fabric air permeability on the sound absorption coefficient (%) at frequency 100 (Hz).

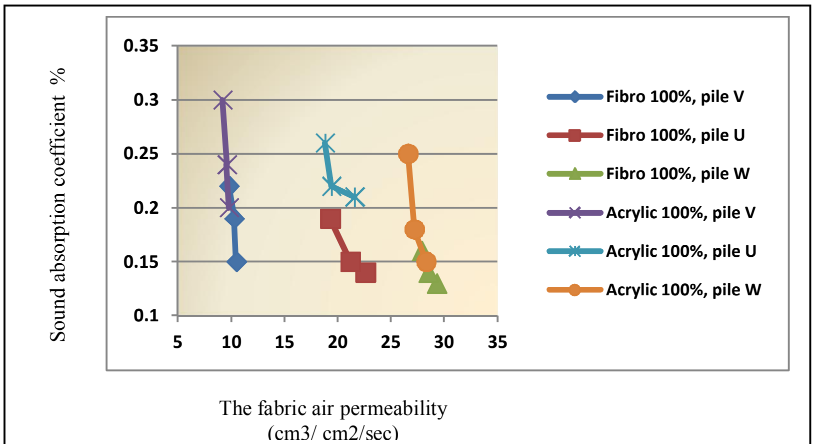

Figure (24): Effect of pile yarn material, weave structure for pile, and the fabric air permeability on the sound absorption coefficient (%) at frequency 1600 (Hz).

Figures (23), (24) show the interactive effect of the ability of fabric to air permeability on its sound absorption coefficient.

It is clear from these figures and **tables (19), (20)** that there is a highly significant effect of the ability of fabrics to air permeability on its sound absorption coefficient.

It is clear that the more fabric air permeability the less sound absorption coefficient at both low and high frequencies, this means that there is inverse relationship between the ability fabric air permeability and its sound absorption properties. We can concluded that the increase in the ability of fabric to air permeability resulted in a decrease in the amount of the stagnant air trapped between the piles and each other which reduces the sound waves absorption efficiency, and the result of this the sound absorption coefficient decreases.

5-Conclusions:-

This research relied on producing a total of eighteen face-to-face (double woven) warp pile fabrics which using as curtains, in order to study the effect of their different factors of textile structural (pile yarn material, pile height, and weave structure for pile)on their comfort properties (thermal insulation- sound absorption).

The following conclusions were drawn based on the present study:-

- All samples made of fibro acrylic had recorded the highest rates of the coefficient of thermal insulation of fabric compared to the samples made of fibro which have recorded the lowest rates.
- All samples made of pile shape (V) had recorded the highest rates of the coefficient of thermal insulation compared to the samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the lowest rates.
- There is direct relationship between pile height and the ability of fabrics to thermal insulation.
- There is a highly significant effect of fabric weight on the thermal insulation coefficient.
- There is direct relationship between fabric thickness and its ability to thermal insulation.
- There is inverse relationship between fabric air permeability and its ability to thermal insulation.
- All samples made of acrylic had recorded the highest rates of sound absorption coefficient compared to the samples made of fibro which have recorded the lowest rates.
- All samples made of pile shape (V) had recorded the highest rates of the coefficient of American Standard specifications for determining compared to the samples made of pile shape (U) and other samples made of pile shape (W) which have recorded the lowest rates.
- There is direct relationship between pile height and the ability of fabric to sound absorption.
- There is direct relationship between fabric weight and the ability of fabric to sound absorption.
- There is direct relationship between fabric thickness and the ability of fabrics to sound absorption'
- There is inverse relationship between the ability fabric air permeability and its sound absorption properties.

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