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USING RICE STRAW TO REINFORCE RIGID FOAM

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ABSTRACT

At the present time, the environmental problems include all civilized societies and in Egypt, it became a huge problem. The common problem is associated with agricultural residues accumulated in the field and their disposal by wrong unsuitable ways, causing many problems to environmental balance. So, the agricultural residues disposal and how to use it in useful applications became the most important subject which takes the first place between different countries. Recently, there is a high level of interest towards agricultural residues utilization in useful ways that will help keeping healthy and friendly environment. This research was carried out to seek the possibility of using Rice straw to reinforced rigid foam, in order to increasing the foam resistance for breaking and improved its properties. This work was carried out of Agricultural Engineering Department, Faculty of Agriculture, Al- Azhar University, Cairo Egypt. Urethane foam was producted between and around the rice straw bundles by placing a 50-50 blend of prepolymer and activator in the bottom of the mold immediately after mixing. After about 30 min, the reinforced foam was removed form mold give beams (5 cm × 5 cm ×30 cm) for testing. Four kinds specimens were made, unreinforced, reinforced by one rice straw bundle, reinforced by three rice straw bundles, and reinforced by five rice straw bundles. Every bundle have five rice straw stalks.

The results of this study indicate that, the minimum value of shear stress was 2.39 kPa at unreinforced (0%) and the maximum was 3.58kPa at (35%). The minimum and maximum values of compression were 2.62, 3.27 kPa at 0% and 35%, respectively. The minimum and maximum values of acoustic insulation were 15.3, 20.9 at 0% and 35%, the minimum and maximum values of acoustic insulation were 15.3, 20.9 at 0% and 35%, respectively. Every one cubic meter of the foam, costs about 300 L.E, but after the reinforcement by 7%, 21%, 35% rice straw,

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the costs were 279,237 and 195 L.E respectively. The Rice straw could be used for reinforced foam, and improved its properties. In Arab Lybian, all farmers used foam plats for classify the breeding area in poultry buildings.

INTRODUCTION

Basically agricultural plant products are not waste materials, but the great importance placed on the edible part of the plant overshadows use of the remaining plant product. Here in Egypt, the rice are planted extensively. After harvest, the rice straw is burned in many areas. Air pollution regulations are prohibiting this burning; specific use of the rice straw for making materials is becoming more fesible. K.S. Kumar and R.P. Lottman (1972) show that the straw tillers have good tensile strength and are good examples of natural fibers, their tensile strength are around 6000 psi in alignment. The tensile strength of foam is around 35psi. Foam is lightweight, about 0.91 to 1.36 kg and the inclusion of straw would maintain this lightweight advantage.

The foam is a good insulator and also could protect the straw from rot. Koniger (1953) studied the principle of cutting plant material and stated that the mechanical separation occurred at a predetermined and well – define location in the material in contrast to crushing where several failure plans usually developed randomly. The cutting process, in all case, was initiated when the edge of the knife first made contact with the material. During the continued motion of the knife, the contact forced and stresses increased and a stress pattern was built up inside the stalk until failure conditions were reached, either over the entire section at the same time or gradually beginning in one point of the section and continuing until complete separation has been achieved. Person (1987) stated that during the continued motion of the knife, the contact forces and stresses increased and a stress pattern was built up inside the material until failure conditions were reached, either over the entire section at the same time or gradually, beginning at one point of the section and continuing until complete separation has occurred. Chancellor (1988) stated that the biological materials commonly subjected to cutting can be classified in two general categories:

1. Non- fibrous materials having uniform properties in all directions at the time of cutting, the cells of these materials being usually turgid with liguid cell materials.
2. Fibrous materials with high tensile strength fibers oriented in a common direction and with comparatively low strength materials bonding the fibers together.

James lux (1997) said that, this straw appears small and light, and most people do not know how really weighty it is. If people knew the true value of this straw, a human revolution could occur, which would become powerful enongh to move the country and the world. Allen (1999) said that foamed concrete is also known as Autocalaved Aerated (AAC). It was invented in Sweden in 1914 and is just starting to be available in North America, distributed by Hebel USA. In concrete, the coarse aggregate is made with lime, water, and finely ground sand. If a luminum powder is added then ëfoamed concrete is created to harden in a mold and then cured in an autoctave (a pressurized steam chamber). The benefits of this method are that it gas a lesser density, but a higher insulating capacity. Therefore less concrete material is reguired, reducing mining impacts. As well, the higher insulating capacity reduces heat and energy loss by creating a more efficient building envelope. Cutenll and Johnson (1995) showed that the decibel (dB) is a measurement unit encountered frequently in connection with stereo systems, the decibel is used extensively on specification sheets to describe the performance characteristics of receivers, the intensity level β (expressed in decibels) is defined as follows:

$$\beta \text{ (In decibels)} = 10 \log (I/I_0) \ldots\ldots \text{(1)}$$

Where:

I_0 : is the intensity of the reference level to which (I) is being compared is often the threshold of hearing, $I_0 = 1.00 \times 10^{-12}$ W/m^2

Kennedy and Wanek (2002) said that the straw is available at a cheap price wherever grain is grow and stacked like giant bricks to from a thick wall. Straw bales offer super insulation from the nois outside.

This study aims to improve the fracture toughnes of the foam and still maintain its rigidity and other properties an advantage for semi –

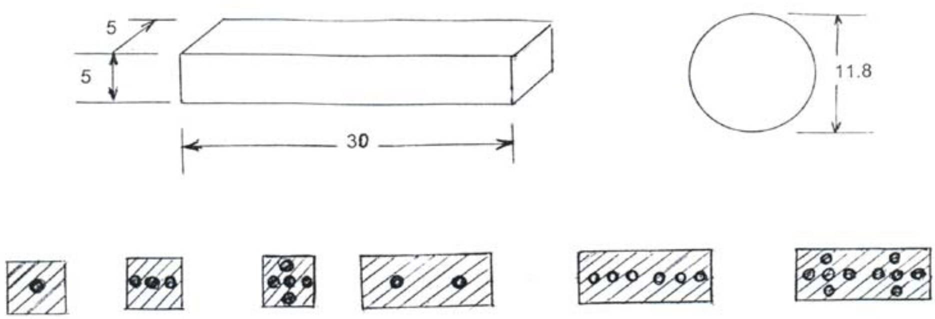
structural application, like, for classify the breeding area in poultry buildings.

MATERIALS AND METHODS

The present study was conducted in Agricultural Engineering Department, AL-Azhar University, Cairo Egypt. The study was under taken together some basic on formation regarding quasi – static force requirement for reinforced rigid foam by using rice straw. The parameters determined were modules of elasticity in shear, compression, a coustic insulation, and cost account.

Expendable rectangular molds lined with pluminum foil were used to prepare test specimens. Rice straw was arranged in bundles and placed vertically in the mold. Urethane foam was produced between and around the rice straw bundles by placing a 50-50 blend of prepolymer and activator in the bottom of the mold immediately after mixing. After about 30 min, the reinforced foam was removed from mold and give beams (5cm× 5cm × 30cm) for testing. Four kind's specimens, unreinforced, reinforced by one rice straw bundle, reinforced by three rice straw bundles, and reinforced by five rice straw bundles. Every bundle have five rice straw, Fig.(1).

The quasi – static testes were conducted using to determine shear and compressive resistance of foam beams. A digital force gauge with accuracy of 0.2%.



- Number of bundles Dim.in.cm.

Fig (1): Schematic for specimens and placement of bundles.

a: the long of specimen (30 cm)

b: a cubic foam with specimen to record a sound level (11.8 cm)

Digital sound level meter:

To study the effect of using foam reinforced by rice straw bundles on acoustic insulation percentage "Ai" (%), the sound level meter was used to measure the level of sound by decibel "dB" fig (2), the specification of digital sound level meter are as follow (according to manufactured catalogue):

Model: SL 130. Rang: low (from 35 to 1oo) and high (From 65 to 130) dB.

A coustic insulation:

In the beginning, to measure acoustic insulation percentage "Ai" (%) the source of sound (constant tone) must be adjusted at a constant level first. This by placing the source of sound in the opened side of cubic foam and the other opened side was closed by foam disk. The microphone of digital sound level meter was placed in a foam disk hole then the sound level meter and the source of sound were turned on. To record a sound level with a high constant level of sound, the sound volume bottom was controlled. After the source of sound was adjusted at a constant sound level which was about 115 dB, the measuring process began by removing the foam disk. The thickness of specimen was measured and recorded by a digital vernier placed in the middle distance between the two sides inside the cubic foam, after that the specimen's side was closed by a foam disk and the microphone of the sound level meter was placed in a foam hole.

The source of sound and the sound level meter were turned on again at a selected sound volume which was 115 dB, then the sound level meter recorded the sound level reading behind the specimen and by subtraction 115dB from that reading (after the sample was placed) the resultant was divided by 115 dB and multiplied by 100 to give the acoustic insulation percentage "Ai" (%) and so on for all specimens. Fig. (3). (EL - Bessoumy,R.R.,2005.).

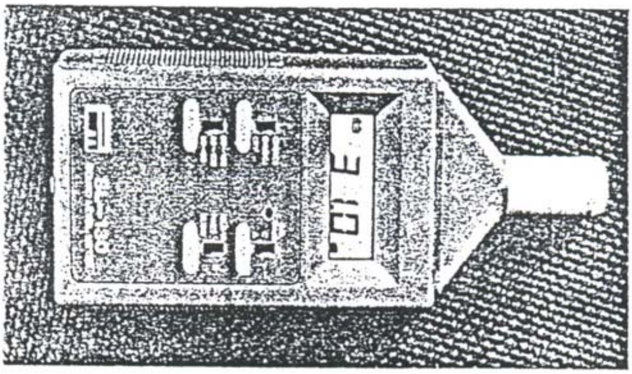
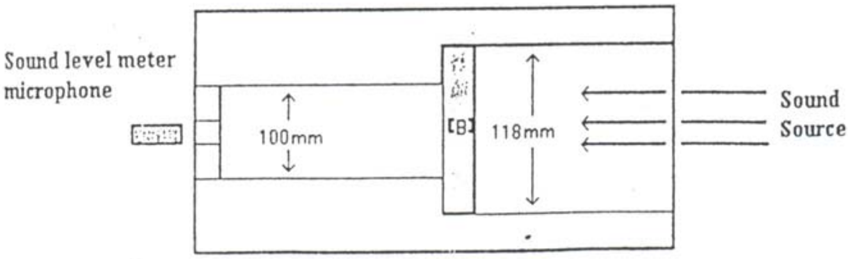


Fig (2):The digital sound level meter.



Fig(3)A cubic foam with sample(B).

2. Theoretical consideration:

2.1 Determination of mechanical properties:

The properties which influence the cutting process are the elastic behavior of the material in shear, and compression (P.S Chattopadhyay, and K.P. Pandey, 1999).

2.1.1. Shear:

The shearing behavior of the material is maximum shear strength (δ_s**)**.
The maximum shear strength is expressed by:

δ_s = F max/ A……………………………………………….… (2).

Where: δ_s**:** is the maximum shear strength.

F max: is the maximum shear force.

A: is the cross – sectional area of material at the plane of shear.

2.1.2. Compression:

The compression behavior of material is the modulus of elasticity in compression which is given by:

$\delta_c = \{F_c / A\} / \Delta L / d = F_c\, d / A\, \Delta L$…………………………… (3).

Where:

δ_c: is the modulus of elasticity in compression.
F_c: is the compressive force.
Δ L: is the transverse deformation due to compressive.
A: is the cross – sectional area of material at the plan of compression.
d: is diameter of the material at the point of compression.

Experimental procedure:

The quasi – static tests were conducted using the digital force gauge to determine shear and compressive resistance of foam beams. All tests were conducted on four specimens.

-Unreinforced foam.
- 7 percent volume rice straw (1 bundle) in specimen.
- 21 percent volume rice straw (3 bundles) in specimen.
- 35 percent volume rice straw (5 bundles) in specimen.

Shear test:

The fabricated fixture was fixed rigidly on the base platform of the test machine under the cross head.

Compression test:

The specimen foam of 30 cm length was placed on the base platform perpendicularly below the digital force guage.

Acoustic insulation:

To determine the acoustic insulation "A" (%). The value of sound source was recorder first by a digital sound level it was 115 dB. The specimen was put in the middle distance inside cubic foam. The value of sound behind the specimen was recorded. By subtraction 115 dB from the reading, after the specimen was placed, the resultant was divided by 115 dB (decibel).

The resultant was multiplied by 100 to give the acoustic insulation percentage "Ai" % and so on for all specimens.

This study conducted to test the reinforced foam by compared with:

1-Shear test by equation (2).
2-Compression by equation (3).
3-Acoustic insulation by equation (1).
4-Cost account:

The cost determined for every cubic meter foam after reinforcement.

RESULTS AND DISCUSSIONS

The main purpose of this study was to determine the general natural of variation of strength of reinforced foam beams in shear and compression. In the present study, the mechanical strength have been calculated on the basis of actual sectional area of the foam beam which is know as bulk strength and includes the cavities inside the foam beam.

1- Shear test:

Table (1) and Fig.(4) illustrated the relationship between shear stress and percent volume of reinforcement.

The obtained data revealed that the shear stress in reinforced foam increases with increasing volume of rice straw bundles. The minimum value of shear stress was 2.39 kPa at unreinforced (0%), the maximum value was 3.58 kPa at five bundles (35%).

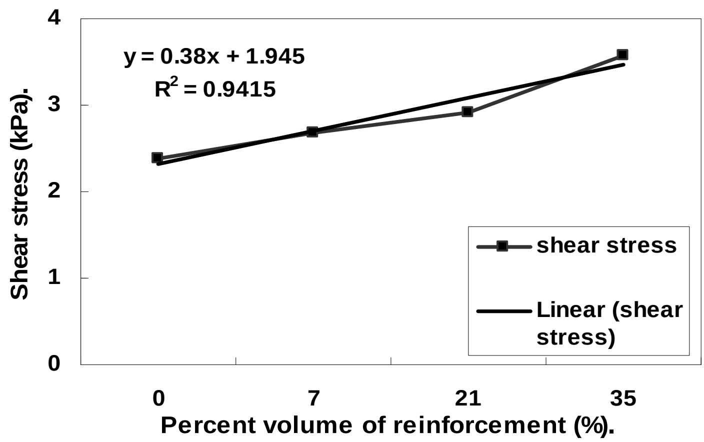


Fig.(4): Increase of shear stress in reinforced foam with increasing volume of rice straw bundles.

2- Compression test:

Table (1) and Fig.(5) illustrated the relationship between compression and percent volume of reinforcement.

The obtained data showed that the compression in reinforced foam increases with increasing volume of rice straw bundles. The minimum value of compression was 2.62 kPa at unreinforced specimens (0%), the maximum value was 3.27 kPa at five bundles (35%).

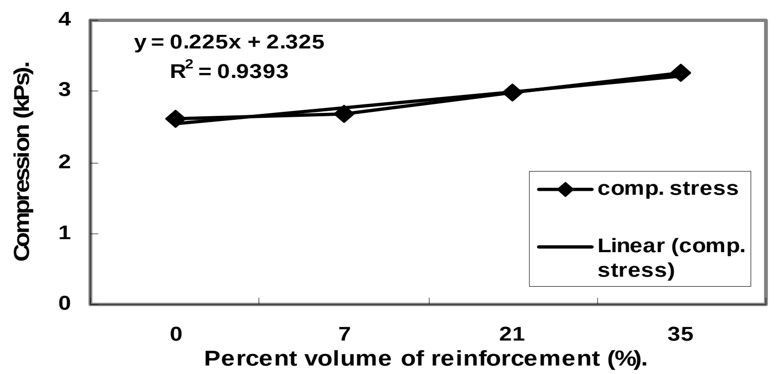


Fig.(5): Increase of compression in reinforced foam with increasing volume of rice straw bundles.

Table (1): The percent volume rice straw from bales, shear stress, comparison and compression stress.

No	Specimens	Percent Volume (%)	Shear stress (kPa)	Comparison stress(kPs)
1	Unreinforced	0	2.39	2.62
2	One bundle	7	2.69	2.68
3	Three bundles	21	2.92	2.98
4	Five bundles	35	3.58	3.27

3- Acoustic insulation:

Table (2) and Fig(6) indicated the relationship between acoustic insulation percentage "Ai" (%) and percent volume of reinforcement.

The obtained data showed that the insulation percentage increases with increasing volume of rice straw bundles.

The maximum acoustic insulation was 20.9% at five bundles (35%), and the minimum acoustic insulation was 15.3% at 0.0 percent volume of rice straw bundles. So the reinforced foam can be use for insulate the sound and noise in the building, by put reinforced foam plats on the walls and ceilings.

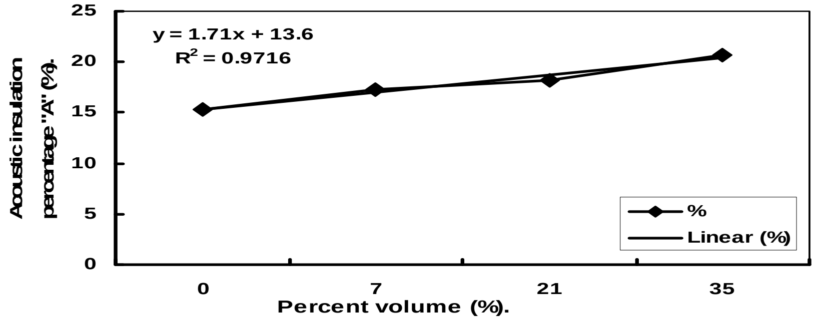


Fig.(6): Effect of percent volume rice straw foam bales on acoustic insulation percentage"A" (%).

Table (2): Acoustic insulation percentage "Ai" (%) for the percent volume rice straw foam bales.

No	Specimens	Percent volume %	Mean	S.D
1	Normal	0	15.3	0.30
2	One bundle	7	17.3	0.49
3	Three bundles	21	18.2	0.31
4	Five bundles	35	20.7	0.67

4- cost account:

Table (3) and Fig (7). Showed the relationship between costs and percent volume of reinforcement.

When increase the ratio of reinforcement of rice straw in specimens, the cost is minimizing for cubic meter foam.

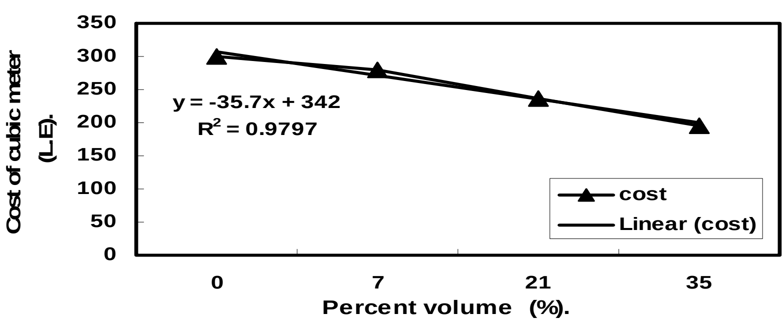


Fig.(7): The relationship between percent volume rice straw reinforcement and costs (L.E).

Table: (3) Percent volume rice straw from specimens and its costs/ (m^3).

No	Specimens	Percent volume %	Cost/m^3 (L.E)
1	Un reinforced	0	300
2	One bundle	7	279
3	Three bundles	21	237
4	Five bundles	35	195

CONCLUSION

1-The minimum value of shear stress was 2.39 kPa at unreinforcement (0%), and the maximum value was 3.58 kPa at five bundles (35%).

2-The minimum value of compression was 2.62kPa at unreinforced specimens (0%), and the maximum value was 3.27 pa at five bundles (35%).

3-The minimum acoustic insulation was 15.3% at (0%) volume of rice straw bundles, and the maximum value was 20.9% at five bindles (35%).

4- The cost of cubic meter of the foam minimizing by increasing the reinforcement of rice straw.

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الملخص العربى

إستخـــدام قـــش الأرز فـــي تـــدعيـــم الفــــوم

إبراهيم سيف أحمد السوالي[٢]

ينم الاهتمام بمشاكل البيئة عن مدى تحضر المجتمعات، وفي مصر في الوقت الراهن ساعدت مشكلة تراكم الفضلات الزراعية في الحقول إلى العديد من مشكلات التوازن البيئي. وقد أدى عدم تدبير كيفية استخدام هذه الفضلات بطريقة تطبيقية مفيدة إلى تفاقم المشكلة مما جعلها في صدارة المشكلات البيئية. وحالياً يوجد مستويات عالية لتحويل المخلفات الزراعية بطرق مفيدة للمحافظة على الصحة وبيئة صديقة. وقد وجد فى بعض مزارع الدواجن فى مصر، والغالب الأعم فى الجماهيرية الليبية استخدام ألواح الفوم بسمك ٨ سم فى عملية تقسيم مساحة أرضية التربية للدواجن سواء كانت لانتاج اللحم أو البيض. إلا أنه يعيبه ضعفه وقلة مقاومته للصدمات. وقد يمكن التغلب على هذه الصفة بزيادة تدعيم الألواح بالمخلفات الزراعية مثل القش. مما يجعلها أكثر مقاومة للصدمات.

ولقد أجرى هذا البحث فى قسم الهندسة الزراعية - كلية الزراعة - جامعة الأزهر - القاهرة. لمعرفة مدى إمكانية استخدام قش الأرز في تدعيم القوم كوسيلة مفيدة للاستفادة من المخلفات الزراعية والحصول على منتج من الفوم مدعم قوى مقاوم للكسر وذو صفات أفضل.

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وقد أنتج هذا الفوم عن طريق وضع حزم من القش في قوالب بأطوال ٥×٥×٣٠سم وقد استخدم هذا الحجم حتى يتسنى اجراء التجربة عليه بسهولة واستخدام جهاز قياس قوة الضغط الرقمى ، وإضافة مادة بربوليمر إلى مادة منشطة (كما يطلق عليها فى السوق المصرى) بنسبة ١:١ وذلك بعد خلطهما جيداً، وبعد ٣٠ دقيقة أعطى عينات قابلة للاختبار. وقد تم عمل ٤ نماذج للاختبار، عينة بها حزمة واحدة من القش (٧% حجم قش أرز)، عينة بها ٣ حزم من القش (٢١% حجم قش أرز)، عينة بها ٥ حزم من القش(٣٥% حجم قش أرز)، عينة بدون حزم قش للمقارنة. (حزمة القش بها ٥ عيدان من القش بنفس طول العينة) كما تم عمل عينات على شكل أقراص كما فى شكل (1 – b) لحساب عزل الصوت.

وقد أجريت في هذا البحث ثلاث اختبارات هي:

١. قياس جهد القص.
٢. قياس الضغط على كل عينة.
٣. قياس عزل الصوت. وذلك لكل العينات.
٤. حساب التكاليف للمتر المكعب من الفوم قبل وبعد التدعيم.

وقد أدت النتائج إلى:

- كانت أقل وأعلى قيمة للقص هى ٣٩ و٢ ،٥٨ و٣ ك. بسكال عند عينات بها نسب قش (صفر%، ٣٥%) على الترتيب بزيادة مقدارها حوالي ٨ و٤٩%.
- كانت أعلى وأقل قيمة للضغط هى ٦٢ و٢ ، ٢٧ و٣ ك. بسكال عند عينات (صفر %، ٣٥%) على الترتيب .
- كان أقل وأعلى عزل للصوت (٣ و١٥ ، ٩ و٢٠%) عند عينات (صفر ، ٣٥%) على الترتيب .
- وجد أن التكلفة لثمن متر الفوم المكعب تقل بزيادة نسبة التدعيم بالقش حيث كان ثمن المتر الكعب من الفوم المدعم بنسبة (صفر، ٧، ٢١، ٣٥ %) حوالى ٣٠٠ ، ٢٧٩ ، ٢٣٧ و ١٩٥ جنيه مصرى على الترتيب . والذى يتم تقطيعه على شكل ألواح بسمك ٨ سم لاستخدامه فى أغراض شتى.

ومن خلال هذه االنتائج يمكن استخدام قش الأرز (مخلفات زراعية) فى تدعيم الفوم واستخدامه فى مجال أوسع وتحسين خواصه . ونوصى باستكمال هذه الدراسة واستخدام مخلفات بحجم أكبر (نسب أعلى) وترتيبات مختلفة مستقبلا.