BENDING BEHAVIOR OF NATURAL COMPOSITES SIMPLY SUPPORTED RECTANGULAR BEAMS

Awatif Mustafa Ali
Mechanical .Eng. Dep.
AL-Mustansiriya University

ABSTRACT
The central deflection of the composite simply supported beams is investigated in this research. Fiber glass as a synthetic fiber , jute as a natural fiber as well as the egg shell ,starch as a powder, and coarse corn and tiny corn as a grains with polyester as a matrix are used to study the difference between the behavior of each type . In addition to, the effect of the moisture absorption is considered, so that the test specimens are immersed in distilled water and H_2SO_4 for seven days .The results show that H_2SO_4 has a significant effect on the flexural behavior(increase the deflection) of the beam .This is due to the chemical reaction between the polyester and H_2SO_4. Also, the variation of the central deflection with time under constant load is investigated. Finally, from the load deflection relations the stiffness of each material is calculated as well as the modulus of elasticity are evaluated experimentally.

KEYWORDS: Composite plates, Bending, Moisture absorption.

دراسه سلوك الانحناء لصفائح المواد المركبة الطبيعية

عواطف مصطفى علي
مدرس مساعد / كلية الهندسة / الجامعة المستنصرية

الموجز
في هذا البحث تم اختبار الانحناء لصفائح مصنوعة من البولستر المدعم بألياف الزجاج كألياف صناعية وألياف الجوت كألياف طبيعيه و قشور البيض والنشا كمسحوق إضافة إلى شعيرات الذرة الخشنة والناعمة استخدمت لدراسة اختلاف سلوك الانحناء لكل نوع .اخذ بنظر الاعتبار تأثير عدة عوامل على انحناء الصفائح مثل نسبة امتصاص الرطوبة وتأثير الحوامض لذلك تم نقع العينات بالماء المقطر وحامض الكبريتيك لمدة أسبوع بينت النتائج أن النقع لمدة أسبوع بحامض الكبريتك له تأثير كبير على زيادة سلوك الانحناء بسبب التفاعل الكيماوي بين الحامض والبوليستر. كما درس تغيير مقدار التشوه المركزي مع الزمن تحت تاثير حمل ثابت. ثم تم حساب معامل المرونه والنعومة لكل ماده عمليا.

INTRODCTION

Fiber reinforced polymer composites (FRP) have been widely used to replace metal and wood because of their high specific tensile strength, good fatigue resistant, low density, reduced tool wear, enhanced energy recovery,

Good biodegradability and corrosion resistance, (**Varelidis, 1998**). Recently, there is the tendency of replacing synthetic fiber such as glass fiber with natural fiber for polymer composites. The reasons are mainly due to the low cost, sustainability and environmental issues (**Bradly, 1995**). However, one of the main concerns of using natural fiber reinforced polymer composites is their susceptibility to moisture absorption which can affect the physical, mechanical and thermal properties (**Espert, 2002**).

The push for aerospace dominance that began in the 1950's and really picked up speed in the 1960's was a new impetus for composite development. Richard Young of the W. M. Kellogg Company began using filament winding for making small rocket motors. This technology was purchased by Hercules and was the basis for the large-scale rocket motor business which was at the heart of the space race. By 1962 the need for highly accurate filament winding machine was improved and even more applications in aerospace were introduced. (**Crawford, 1998**)

Generally natural fibers are classified into three categories; animal, vegetable and mineral fibers, as shown in **Figure A.1**

Among which mineral fibers are no longer or very rarely used due to their carcinogenic effect All vegetable fibers such as ,cotton, flax ,jute, hempetc contains (**Michael, 2002**) .Mainly cellulose and protein .These are the base of fibers with animal origin such as .Hair, silk and wool. Vegetable fibers are further classified into bast, leaf, or seed fibers According to their origin. The bast and leaf lend mechanical Support to the plants s stem or leaf respectively; examples for these kinds of fibers include flax, hemp, jute and ramie. The surface of natural fibers are uneven and rough provides good adhesive to the matrix in a composites material .the specific mechanical properties of natural fibers have high significance for their utilizations in composites (**Michael, 2002**).

Environmental factors such as humidity and temperature can limit the applications of sandwich structure composites by deteriorating the mechanical properties over a period of time. When a fiber-reinforced composite sandwich structure is exposed to a hydrothermal environment and mechanical loads, changes in material properties are expected. These changes in material properties are connected to irreversible material strength degradation. Exposure to water ambience induces environmental effects into both the core and the face sheet of sandwich structure (**Strength, 2010**).

Ecological concern has resulted in a renewed interest in natural materials for their recyclables, light weight and non pollution. Important issues such as recyclables and environmental safety need to be addressed when new materials and products are introduced. Lignocelluloses natural fibers such as flax, hemp, sisal and jute are an interesting, environmentally friendly alternative to the use of glass fibers as reinforcement in engineering composites Because of the benefits that these fibers provide over conventional reinforcement materials and the development of natural fiber composites has been a subject of interest for the past few years (**Liu, 2007**).

Simply Supported Beams

A beam is horizontal structural member that supported a vertical load. Its length is much larger than its cross sectional area. For atypical beam ,the slender ratio SR ,is defined as the ratio of length(L) to the radius of gyration (r).(SR=L/r) ; $r= \sqrt{I/A}$ where (I) :moment of inertia and(A) beam cross section can be rectangular or a built section. Beam are fabricated of steel, Aluminum, concrete, wood and composite materials. They are used in buildings, bridges, aircraft, machinery, and other types of structures. A simple beam rests on 2 or fewer supports .A lentils place across the space between two columns is an example of a simple beam [8].

2. Bending Testing Apparatus

The bending testing apparatus used in this work is shown in **FigureB.1**
Below

The Materials Used

Different types of natural and synthetic materials are used such that
1. Fiber glass
2. Tiny crushed corn
3. Corn case
4. Egg shell powder
5. Jute fibers
6. crushed grain (coarse and tiny)
7. Starch of corn

These materials are used as the reinforcements with the polyester as the matrix to manufacture the composite plates.

The steps of sample preparation

Manufacturing process for composite material preparing involves many techniques such as hand lay up, press molding, vacuum, etc.

The step of preparation sample shown as the flow chart **Figure B.3** in this work we use first method (hand layup).

$$W_c = W_f + W_m \tag{1}$$

$$\varphi = \frac{W_f}{W_c} \tag{2}$$

$$V_f = 1 + \frac{1 - \varphi \rho_f}{\varphi . \rho_m} \tag{3}$$

$where$:-W_f, W_m, W_c

Weight of the fiber, matrix and composite material respectively.

V_f: Volume fraction of the fiber

V_m: Volume fraction of the matrix

V: volume fraction of the composite material

ρ_f, ρ_m: Density of the fiber and matrix.

Ψ: Weight fraction.

RESLTS DISCSSION AND CONCLSIONS

The experimental results of the beam bending tests for many types of composites materials are carried out .To investigate the effect of the type of the reinforcement on the central displacement of the simply supported beam, different type of composite materials are used, such as

A- Jute and corn bast (as natural fibers).

B- Fiber glass as synthetic fibers.

C-starch and egg shell powder as powder.

D- Corn grain (coarse and tiny).

All these type of reinforcement mixed with the polyester as matrix with volume fraction 50% **Figure 1 to Figure 7** show that :-

1- The fiber glass polyester is sustained higher load (31.5kg) before fracture while the jute polyester and the coarse corn polyester sustained lower load(5kg,3.5kg) respectively .It can be conclude that the synthetic fibers is more stronger than the natural fibers.

2- The jute polyester and the corn bast beam have the higher displacement than the other t**yp**es in which the maximum deflection at the fracture is (4.5mm) and (4mm) respectively, whereas the maximum deflection for the fiber glass is (2.6mm).That is the natural fibers is more elastic than the synthetic fibers.

3- Starch_ polyester has lower displacements (0.55mm) because in this case the properties of the polyester is dominate .i.e. the starch_ polyester material is brittle.

4- The tiny corn is best than the coarse corn since, (is sustained higher load before fracture) otherwise the maximum deflection is inverse. Considering the tiny corn specimens is more homogenous than the coarse corn specimen.

5- from **Figure 6** it can be shown that the egg shell powder sustain higher load for the same deflection compare with coarse corn .This is due to the homogeneous of the egg shell .
Figure 8 shows that the comparison of bending behavior deferent type of test material .It can be seen that the fiber glass_ polyester is more stiffness than the other.

Effect of moisture on the deflection test
In order to investigate the effect of moisture absorption .The test specimens are immersed in water and H_2SO_4 acid for 7 days and under 80% of the fracture load for each type of test materials The results show that the water and H_2SO_4 have evident effect on the central deflection of the beam.
Figure 9 show that the treat with water and without has the same effect on the fiber glass whereas **Figure 10** shows that the central deflection of the jute specimens is larger than the specimen with out treatment .This is may be due to that the moisture decreases the strength of the fiber, which is predominant in the beam specimen.
Figure 11 shows that the effect of water and acid on starch specimens. The water has a stronger effect on the specimens' .because of the water effect the bond of starch that effect leads to fracture after one minute. **Figure 12** shows that the effect of the water and acid on the first has same then water has greater effect on eggshell powder specimens
Figure 13 show that the water has stronger effect than H_2SO_4 on the central deflection on the coarse corn .It can be seen that the water has hard coarse corn effect on corn. **Figure 14** shows that the water and acid are significant effect on the central deflection on the tiny corn .while **Figure 15** show that the acid and water have appositive effect on the corn blast composite and this is unexpected behavior may be due to inhomogeneous deflection increase with time specimen.

REFERENCES
[1]Bradly WL, Grant TS.1995,"The effect of the moisture absorption on the interfacial strength of polymeric matrix composites".

[2]Espert A, Vilaplana F, Karlsson S.2002, "Comparison of water absorption in natural cellulosic fibres from wood and one-year crops in polypropylene composites and its influence on their mechanical properties" Compos Part A

[3]Michael K. Bannister 2002,"3D *FIBRES RIENFORCED POLYMER COMPOSITES*", L.TONG 3D Fiber Reinforced Polymer Composites.

[4]R.J.Crawford,BSc, PhD, DSc, FEng, FIMechE, FIM Department of Mechanical, Aeronautical and Manufacturing Engineering The Queen's University of Belfast 1998, PLASTICS ENGINEERING Third Edition.

[5]Strength degradation of glass fiber reinforced polymer sandwich composites under hygrothermal loading conditions 2010.

[6]Varelidis PC, Kominos NP, and Papaspyrides 1998, CD. Polyamide coated glass fabric in polyester resin: interlaminar shear strength versus moisture absorption studies. Composites.

[7]X. Y. Liu*, G. C. Dai 2007, Surface modification and micromechanical properties of Jute fiber mat reinforced polypropylene composites.

[8]Zaid Rassim Mohammed Al-Ani, Beam Flexural Analysis of Composite Laminated Simply Supported Rectangular

SAMPLE OF CALCLATION

$$\delta = \frac{WL^3}{48EI} \quad \text{(a)}$$

$$E=\frac{W}{\delta}\times\frac{L^3}{48I} \quad \text{(b)}$$

$$E=K\times\frac{L^3}{48I} \quad \text{(c)}$$

$K=\frac{(3-2)\times 9.81}{(250-150)\times 10^2}$

$I=\frac{bh^3}{12}=15\times\frac{4^3}{12}=80\,mm^4$

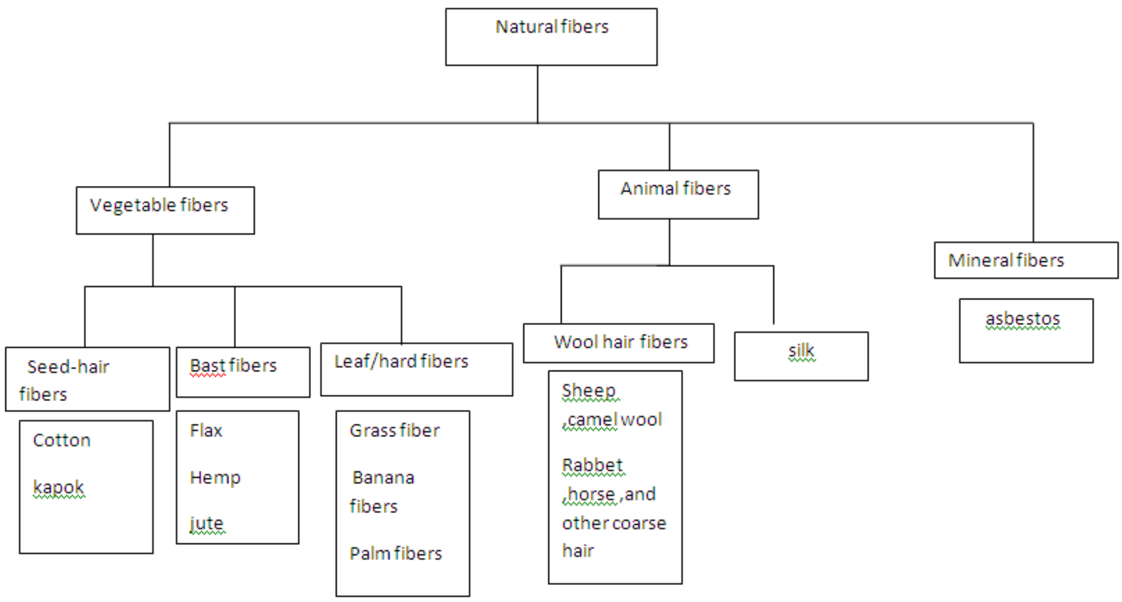
L=16h=16$\times$4 =64mm

$E=9.81\times\frac{64^3}{48\times 80}$ =6.69Mpa

Where k=stiffness (N/mm)
E=Modulus of elasticity (Mpa)
L=length of the sample (mm)
h = height of the sample (mm)
I=moment of inertia (mm^4).

Table 1 show (E, K) for the sample test

Test sample	Modulus of Elasticity (E) (MPa)	Stiffness value (K) (N/mm).
Fiber glass	44.63	78.1
jute	6.68	9.81
Starch	51.5	91.56
Corn blast	22.83	40.59
Tiny corn	20.99	40.875
Coarse corn	13.79	24.52
Egg-shell	93.52	166.27



FigureA.1 Classification of natural fibers [3]

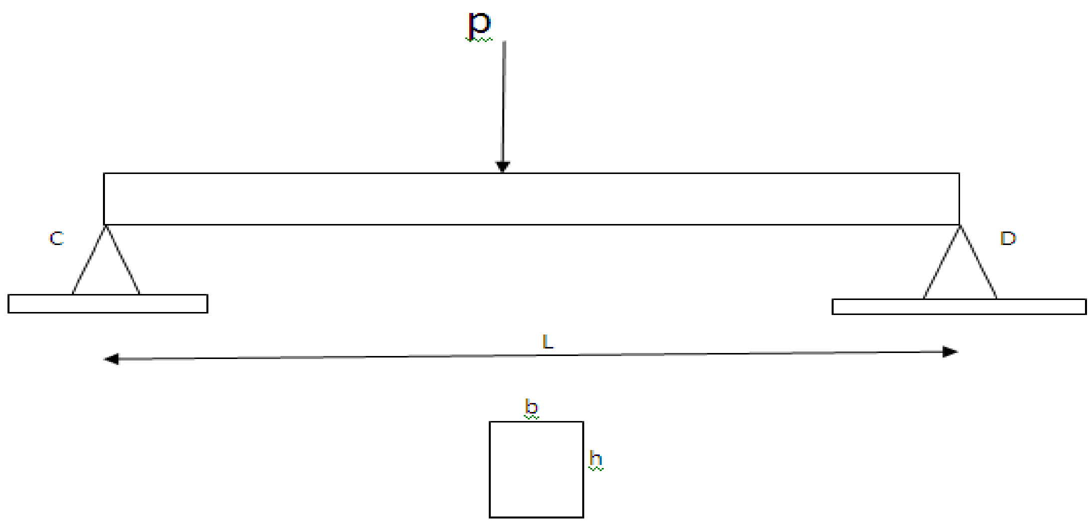
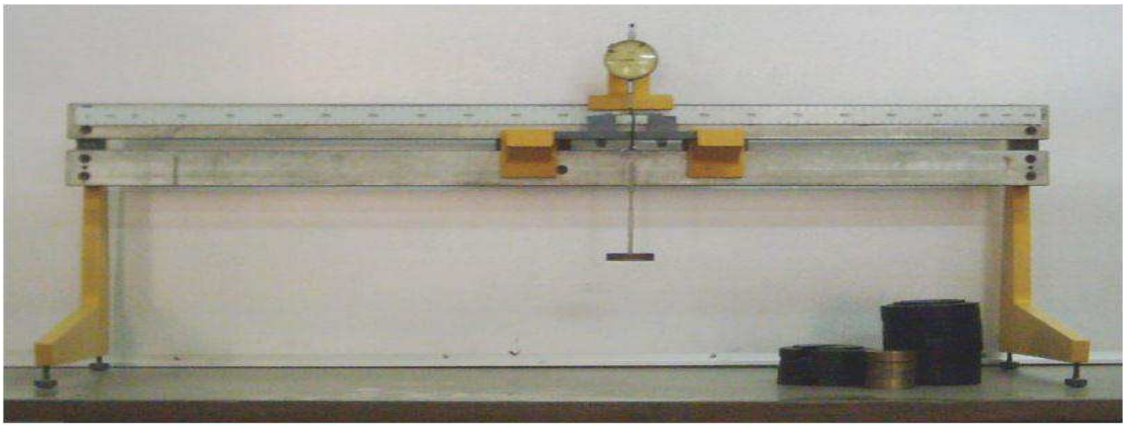
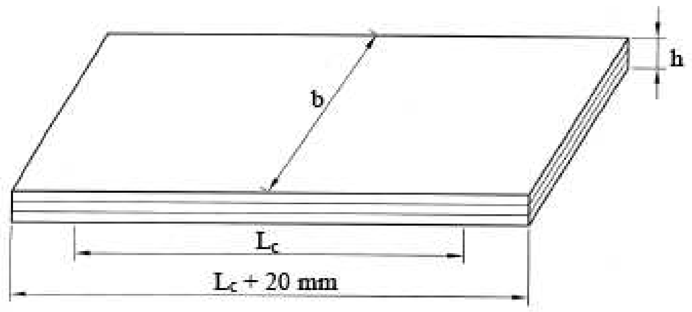


Figure A.2 Show the simply supported beam with concentrated load



FigureB.1 bending test apparatus



where

$L_c = (15 - 17)$ h.

b = 15 mm ± 0.5 mm for h < 10 mm

In this study, L_c = 16 h for al bending specimens.

Figure B.2 Bending specimen's dimension [8]

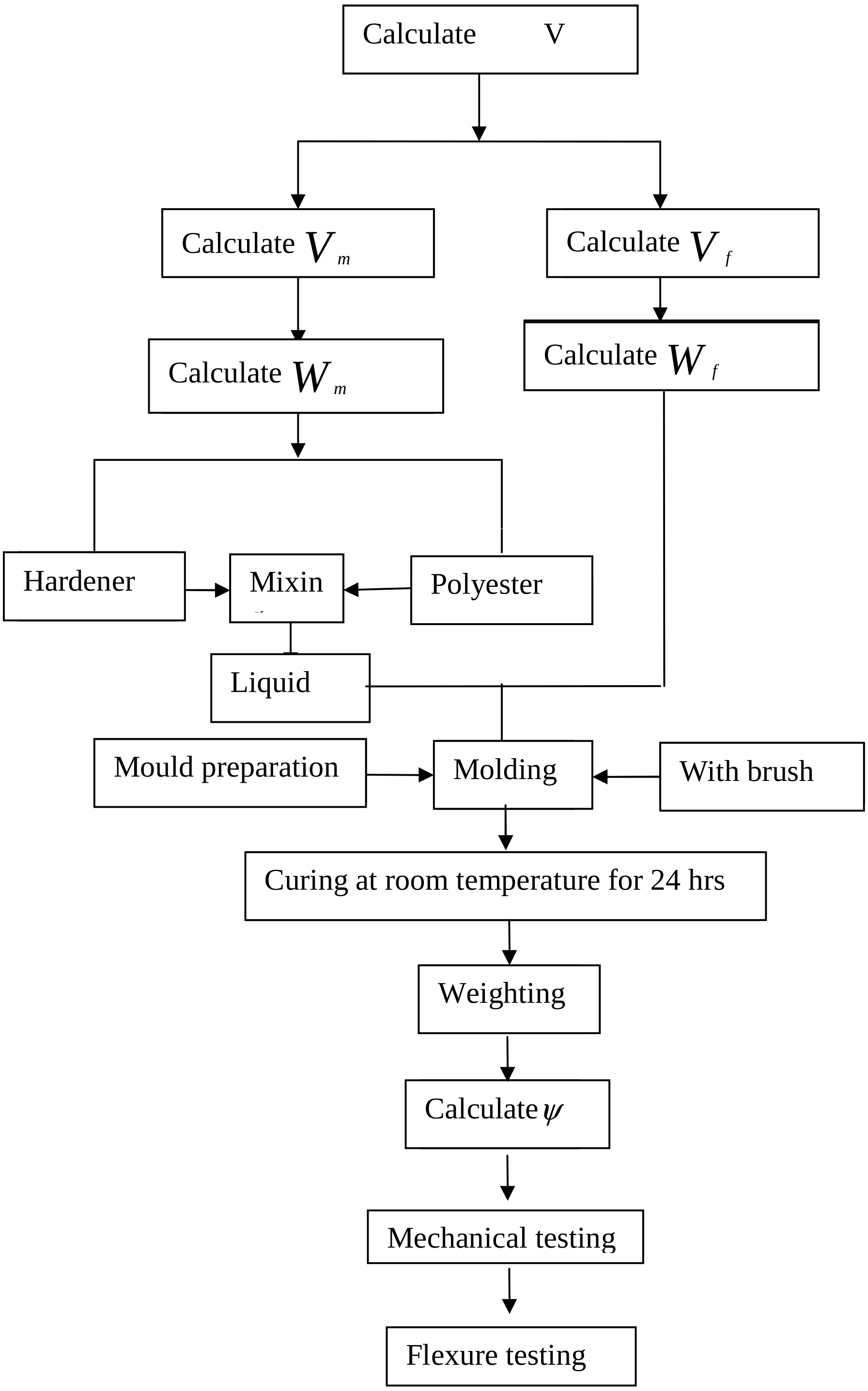


Figure B.3 show the flow chart of the steps of the sample preparation

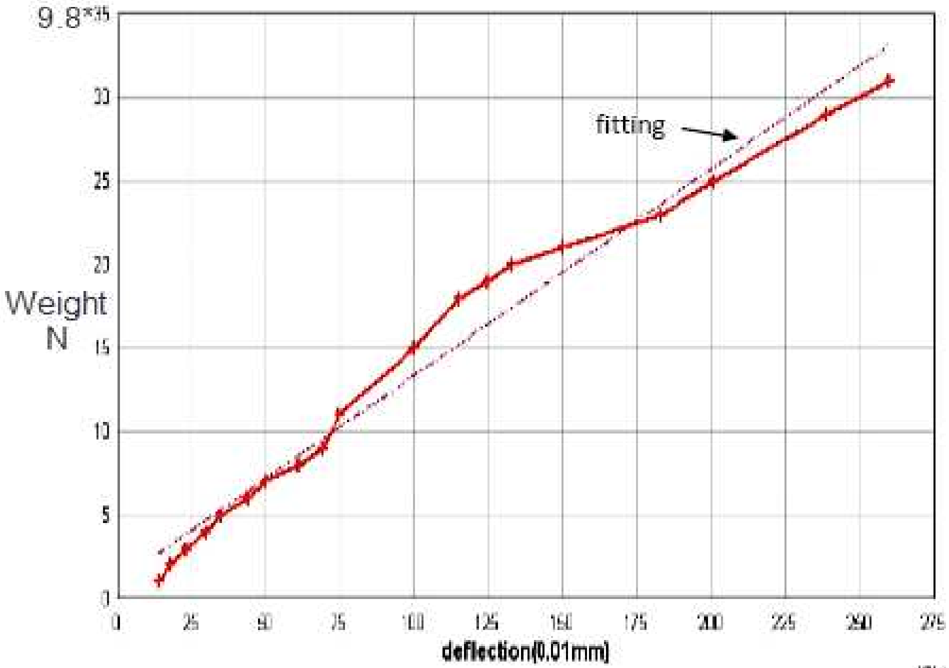


Figure 1 the variations of the central displacements with load for fiber glass composite beam

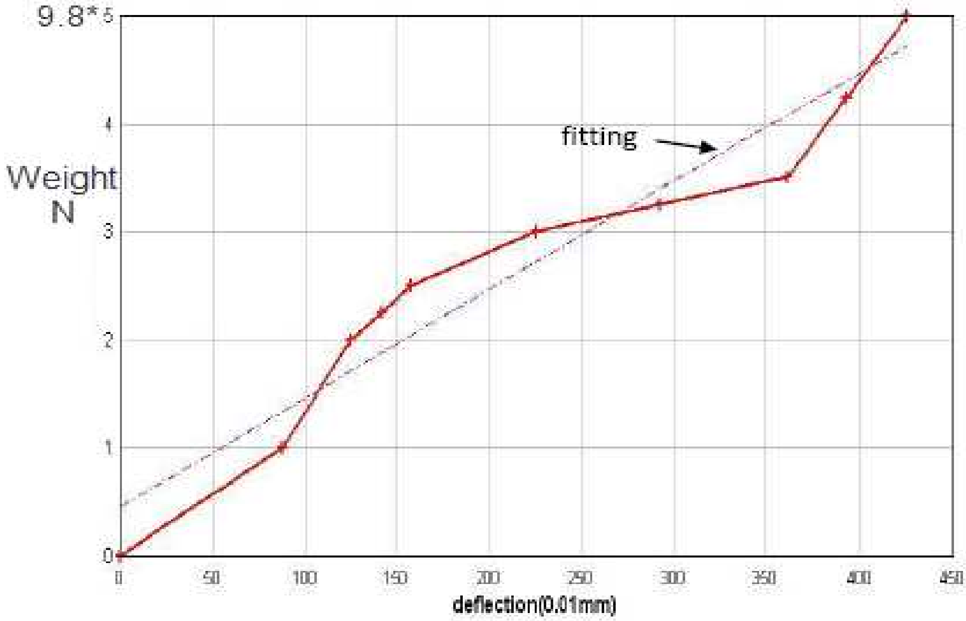


Figure 2 the variations of the central displacements with load for jute composite beam.

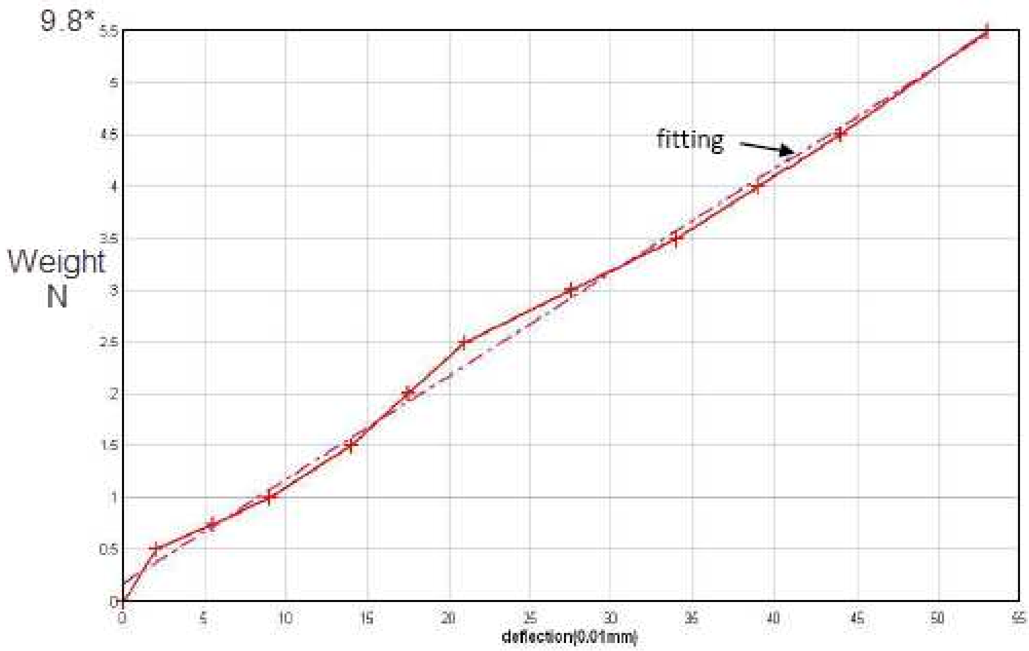


Figure 3 the variations of the central displacements with load for starch composite beam.

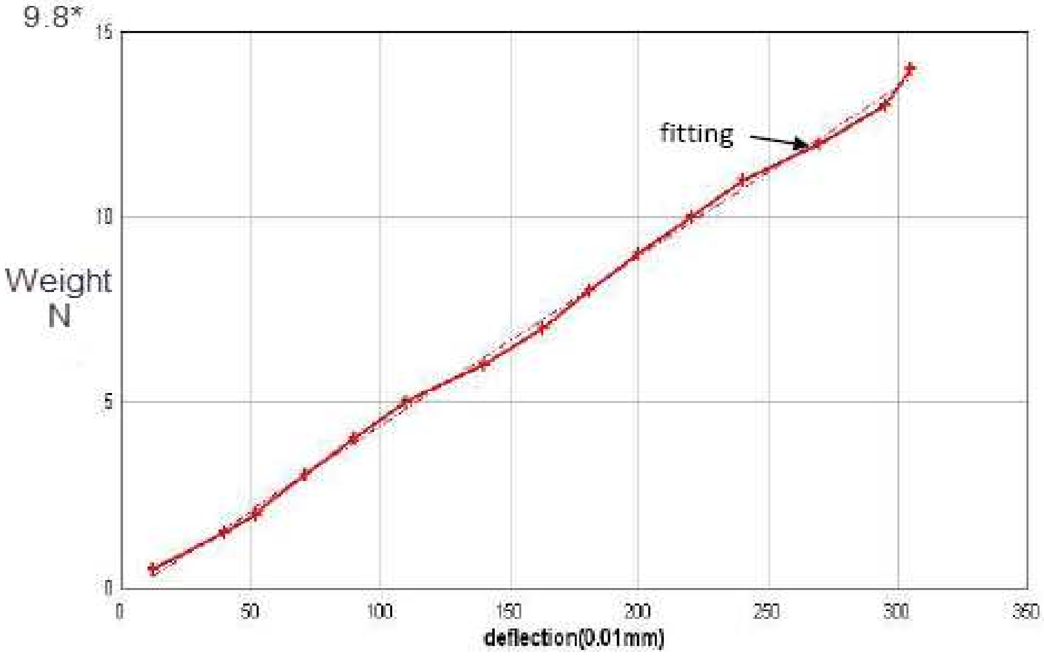


Figure 4 the variations of the central displacements with load for tiny corn composite beam.

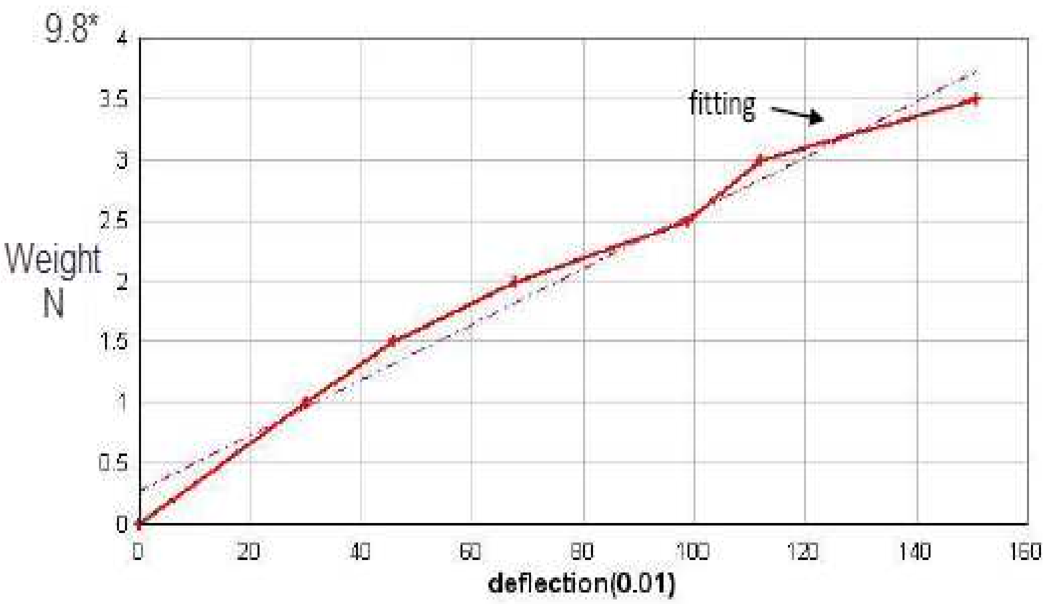


Figure 5 the variations of the central displacements with load for coarse corn composite beam.

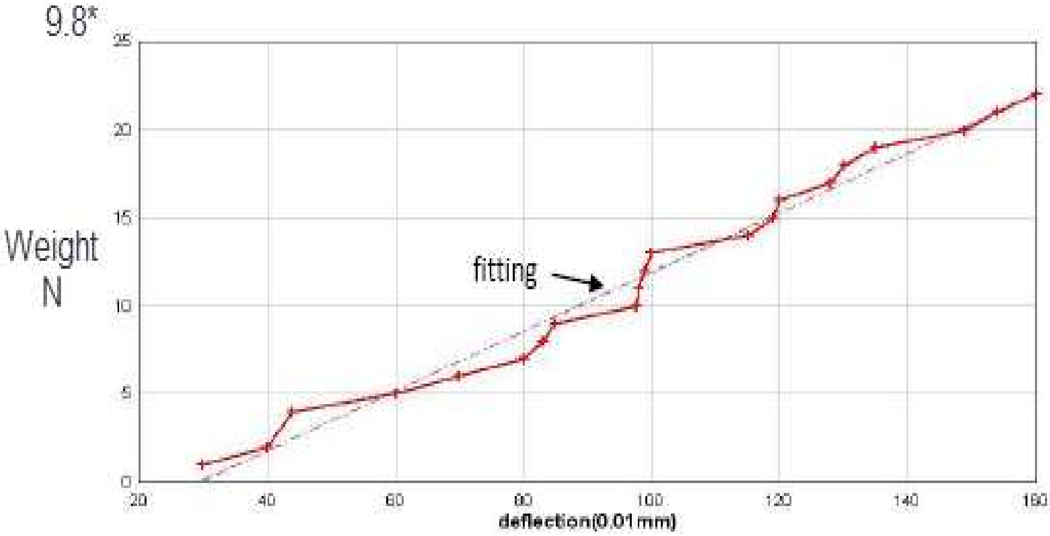


Figure 6 the variations of the central displacements with load for egg shell powder composite beam.

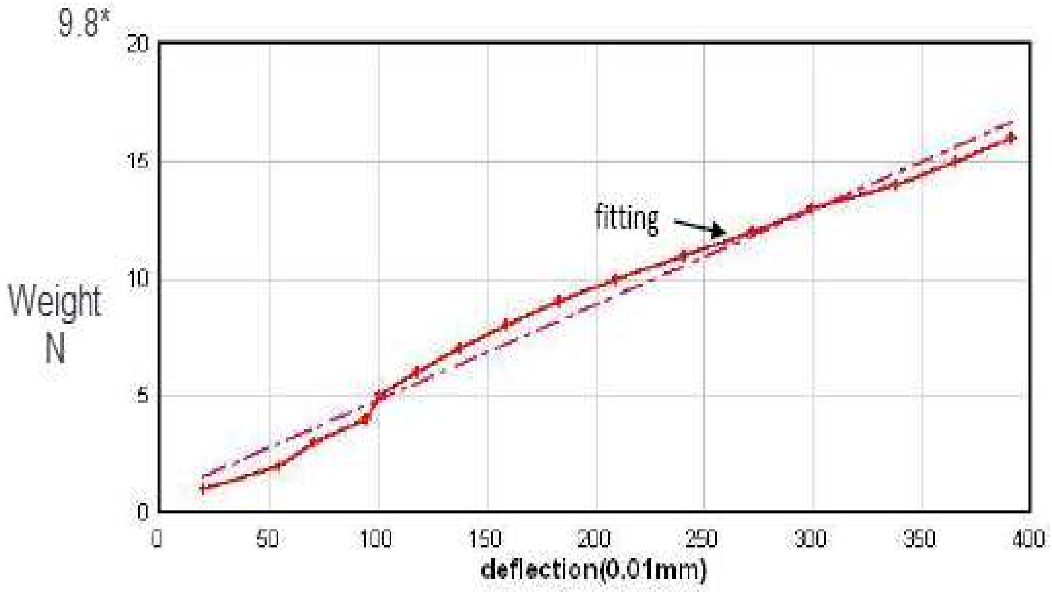


Figure 7 the variations of the central displacements with load for corn bast composite beam.

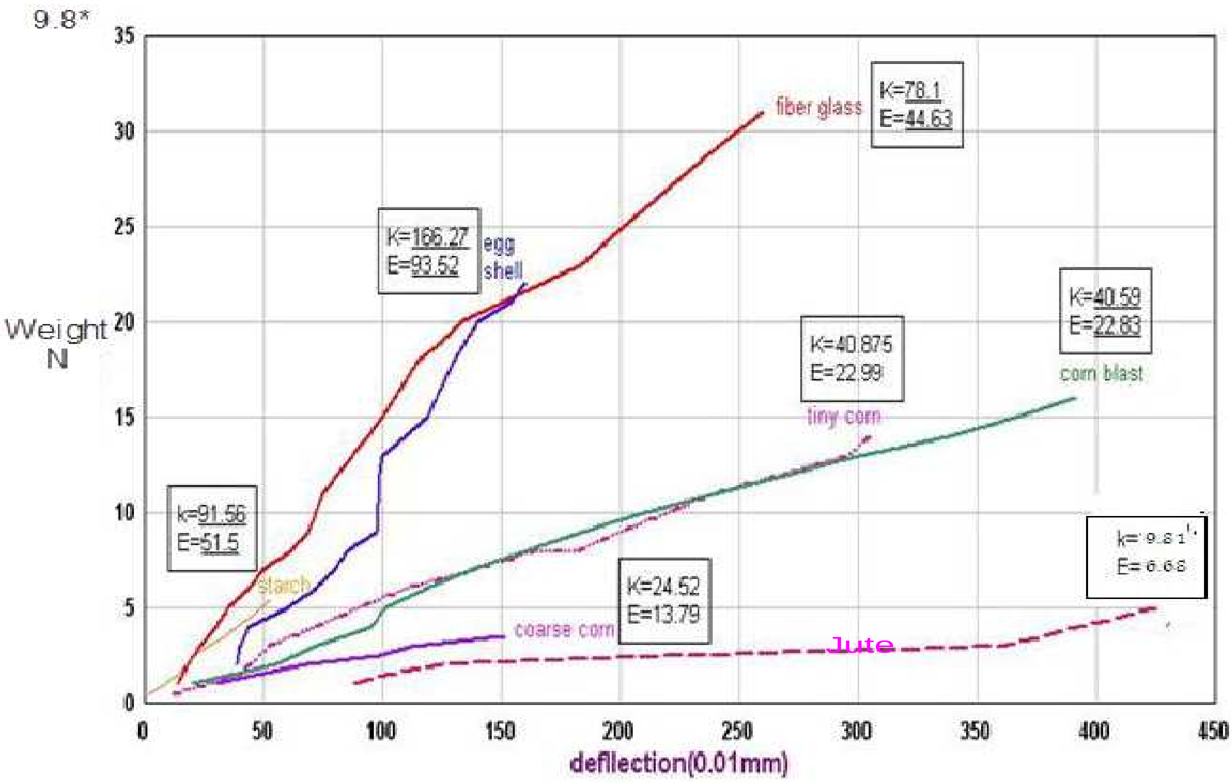


Figure 8 the comparison of bending behavior for many types of composites materials and their modulus of Elasticity (E) (MPa) and stiffness value (K) (N/mm).

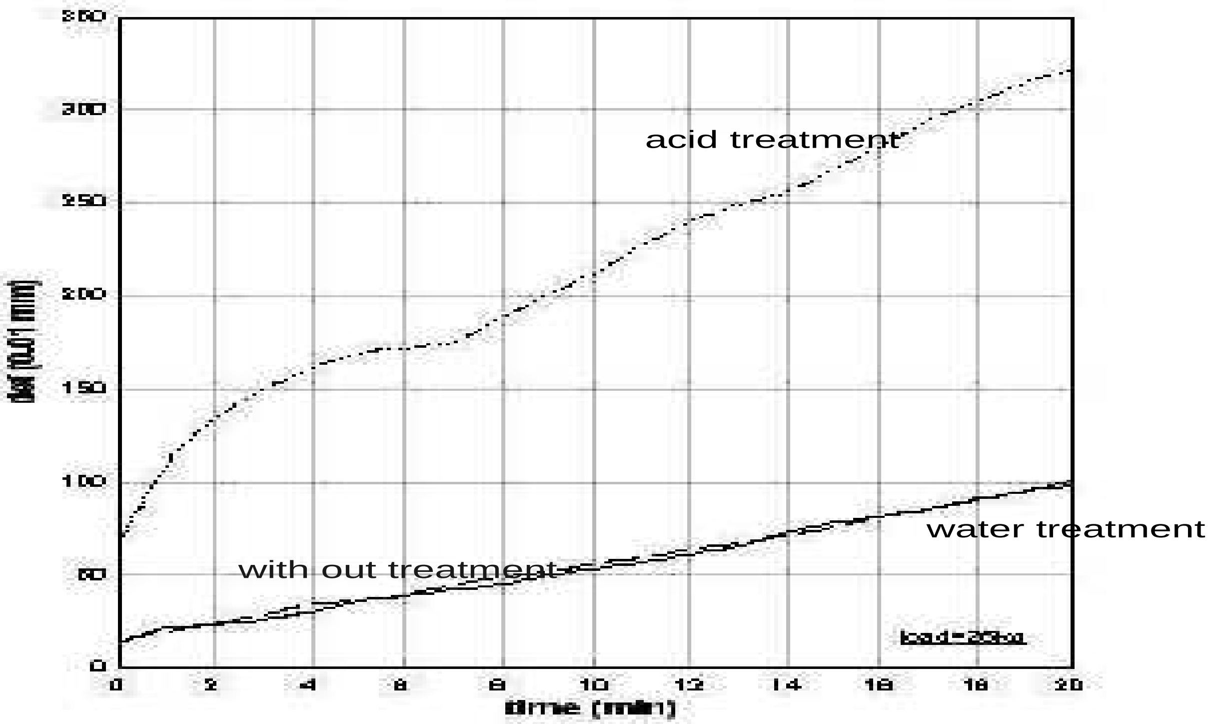


Figure 9 the variation central deflection with time for fiber glass composites the variation

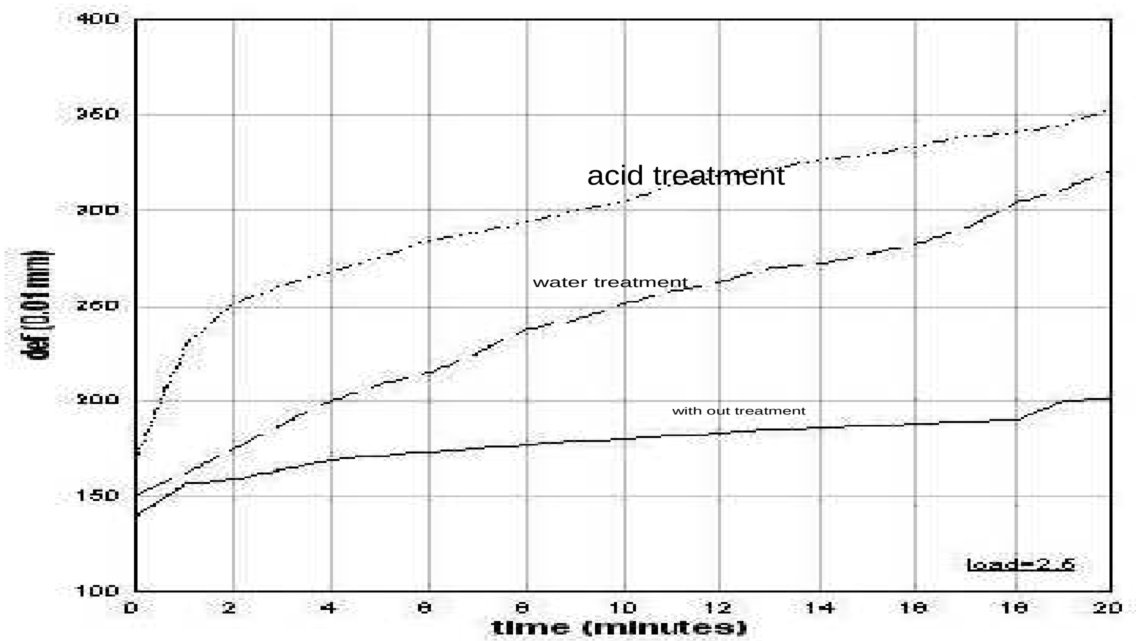


Figure 10 the variation of Central deflection with time for jute composites

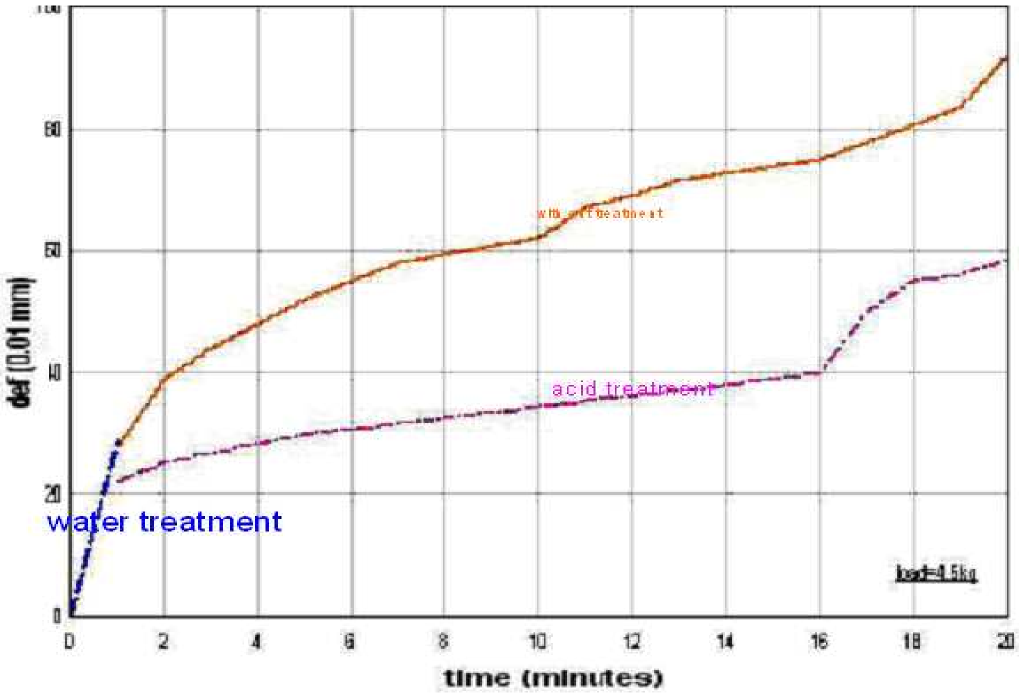


Figure 11 the variation of Central deflection with time for starch composites

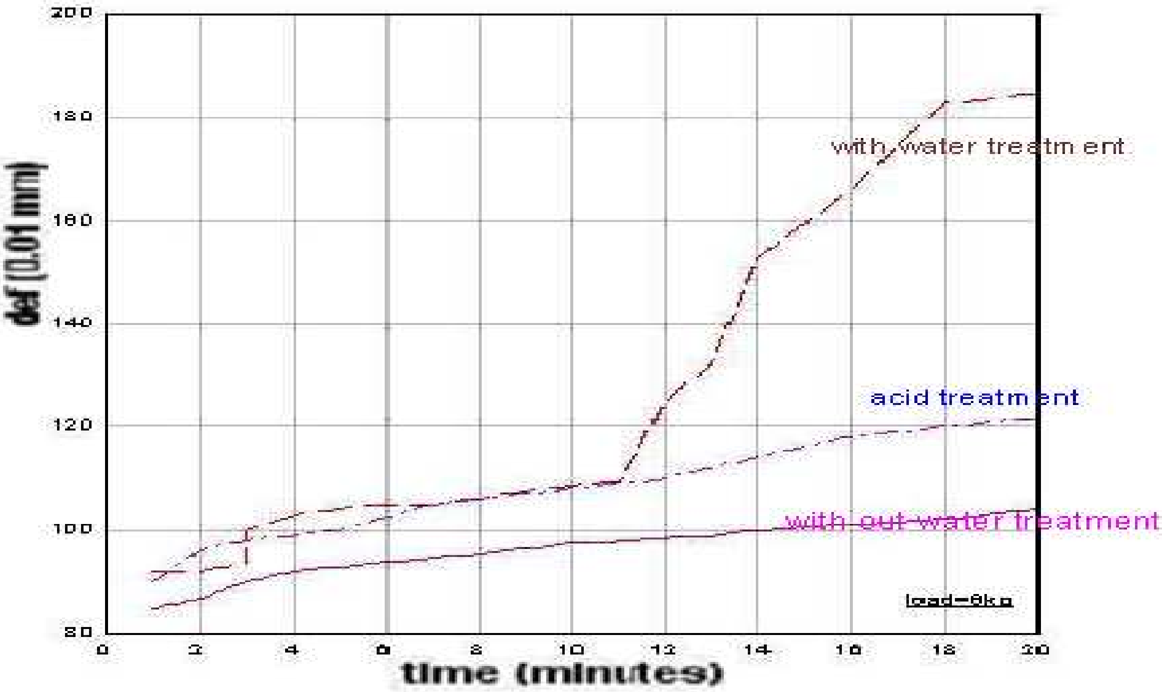


Figure 12 the variation of Central deflection with time for egg shell composites

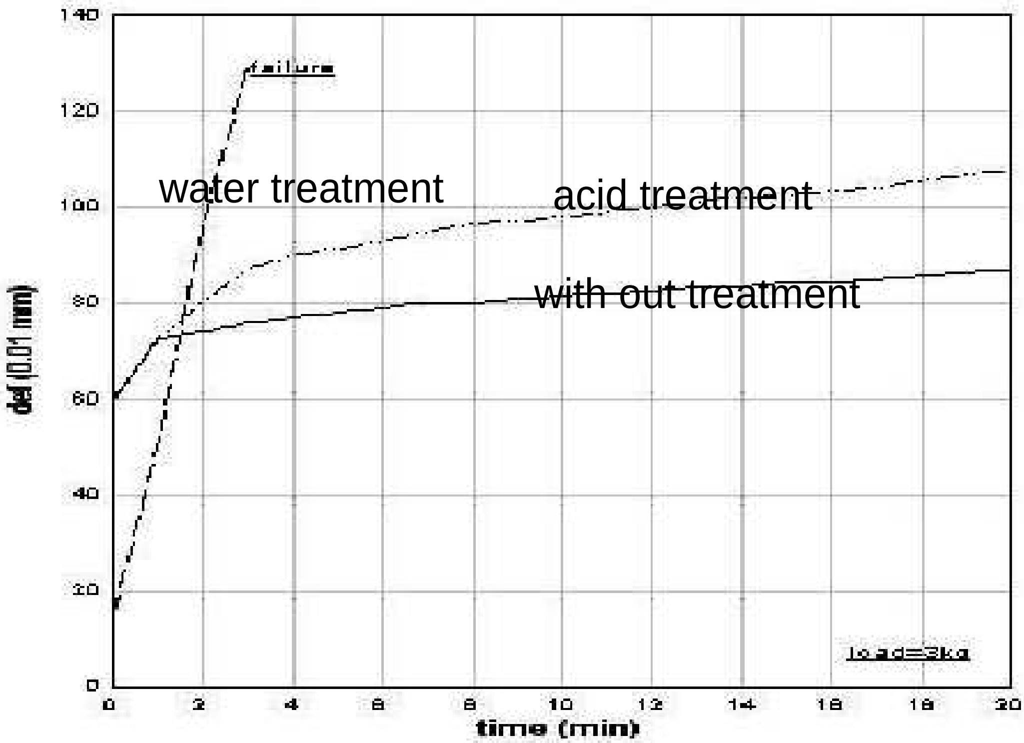


Figure 13 the variation of Central deflection with time for coarse corn composites

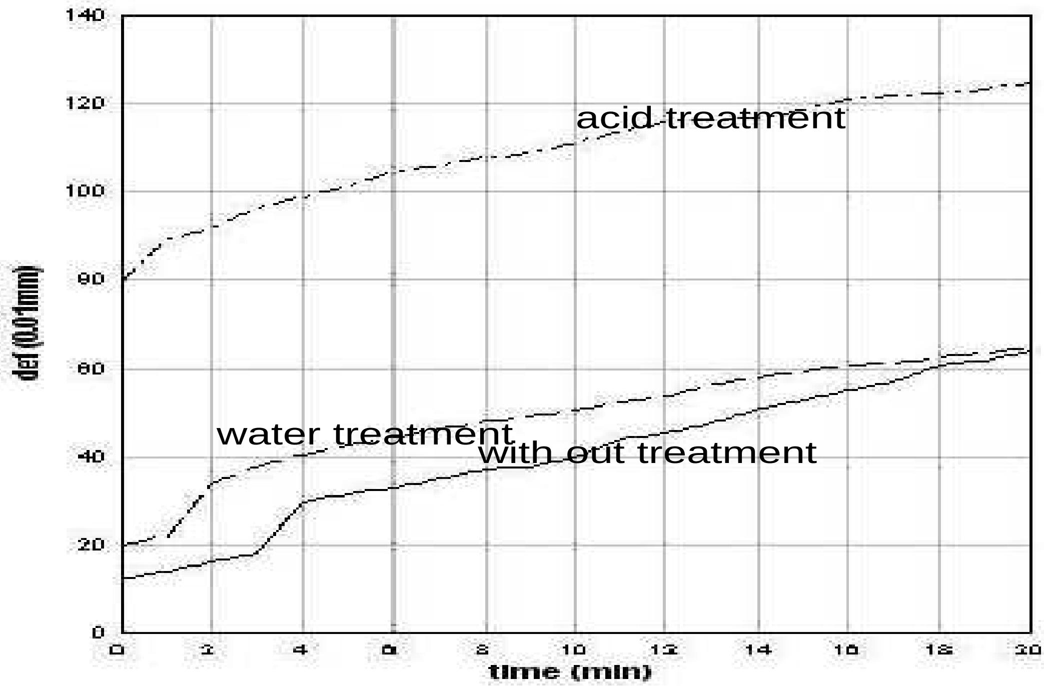


Figure 14 the variation of Central deflection with time for tiny corn composites

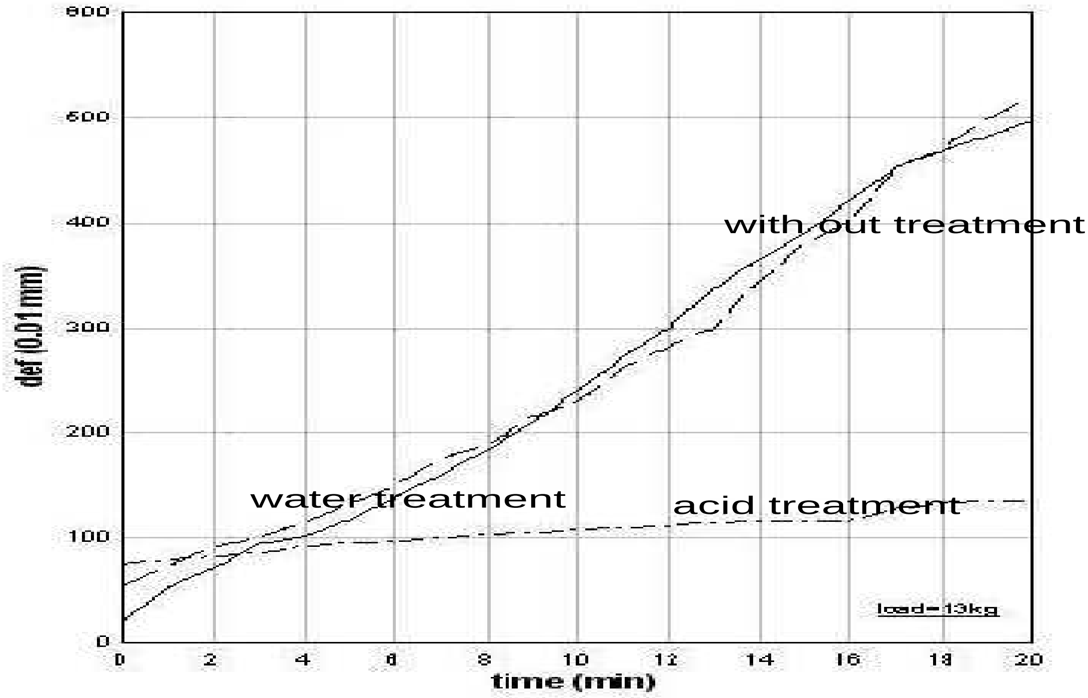


Figure 15 the variation of Central deflection with time for corn blast composites