"دراسة تأثير المساحيق البوليمرية على بعض الخواص الميكانيكية للايبوكسي"

"Studying The Effect of Polymer Powders on some Mechanical Properties of Epoxy"

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Abstract

To determine the possibility of using polymer powders as reinforcing materials in the thermoset polymer matrix composite , epoxy as the matrix and carboxy methyl cellulose (CMC) and polyethylene glycol (PEG 4000) as the reinforcing powders were used to prepare a particle reinforced composite. In the sample preparation, seven weight fractions of each powder (0.02, 0.04, 0.06, 0.08, 0.1, 0.12, 0.14) wt% were designed to determine the mechanical properties of composites that represented by hardness and compression strength. The results of this research were: for epoxy reinforced with CMC, the hardness increases with increasing the weight fractions reaching to (78.2) at 0.1 wt % and decreases in other weight fractions while maximum compressive load (7.324kN) was obtained at 0.12wt %, for epoxy reinforced with PEG4000 the hardness increases with increasing the weight fractions reaching to (71.1) at 0.06wt % and decreases in other weight fractions while maximum compressive load (10.449 kN) was obtained at 0.08wt%

الخلاصة :

لحساب امكانية استخدام المساحيق البوليمرية كمواد للتقوية في المادة المركبة ذات الارضية البوليمرية المتصلدة بالحرارة تم تحضير مادة مركبة مقواة بالجسيمات تتالف من ارضية من الايبوكسي و مساحيق التقوية المتمثلة بكاربوكسي مثيل سليلوز و بولي اثيلين كلايكول. عند تحضير العينات تم تصميم سبع نسب وزنية من كل مسحوق و هي wt%(0.02, 0.04, 0.06,0.08,0.1,0.12,0.14) لحساب الخواص الميكانيكية للمواد المركبة و المتمثلة بالصلادة و مقاومة الانضغاط. كانت نتائج هذا البحث بالنسبة للأيبوكسي المقوى بكاربوكسي مثيل سليلوز، تزداد الصلادة مع زيادة النسب الوزنية وصولا الى(78.2)عند (0.1 wt%) ويتناقص عند النسب الوزنية الاخرى بينما اقصى حمل عند الانضغاط (7.324 kN)تم الحصول عليها عند (0.12wt%) اما بالنسبة الى الايبوكسي المقوى بالبولي اثيلين كلايكول فتزداد الصلادة مع زيادة النسب الوزنية وصولا الى (71.1)عند (0.06wt%)ويتناقص عند النسب الوزنية الاخرى بينما اقصى قوة عند الانضغاط (10.449kN)تم الحصول عليها عند (0.08wt%).

Introduction:

Epoxy resin represents some of the highest performance resin due to the mechanical properties and resistance to environmental degradation, which leads to their exclusive use in aircraft components. Epoxy resins are the most commonly used thermoset plastic in polymer matrix composites and do not give off reaction products when they cure and so have low cure shrinkage. They also have high thermo stability, high abrasion resistance, and high impact strength.(Chow2007&Singla 2010)

Because of the need to materials that are non- toxic to the human body and have appropriate characteristics for specific purposes is ever increasing due to the lack of resources and increasing levels of environmental pollution, in these days various synthetic polymers are being prepared combined with various reinforcing particles in order to improve the mechanical properties and to obtain the characteristics demanded in actual application. (Premalal 2002)

These natural particles are especially being sought since the production of composites using natural substances as reinforcing materials is not only inexpensive but also able to minimize the environmental pollution caused by the characteristic biodegradability, decreasing the wear of the machinery part, making the final product light ,so these composites will play an important role in resolving future environmental problems.(Yang 2004)

Poly (ethylene glycol) (PEG) hydrogel based polymers are among the most widely used synthetic materials for biomedical applications. Because of their biocompatibility, and ease of fabrication, hydrogels are highly suitable for use as constructs to engineer tissues as well as for cell transplantation. A critical parameter of importance for PEG hydrogels is their mechanical properties which are highly dependent on the environmental conditions. Properties of PEG-based hydrogels can be engineered to resemble scaffolds composed of extracellular matrix molecules, which provide structural support, adhesive sites and mechanical as well as biomechanical signals to most cells. The molecular structure of PEG 4000 is HO-CH2-(CH2-O-CH2-)n-CH2-OH (Drira,2006)

Carboxy methyl cellulose, or CMC, is a cellulose derivative with carboxymethyl groups (-CH2-COOH) bound to some of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone as shown in Fig.1. Carboxy methylcellulose is a derivative of cellulose formed by its reaction with alkali and chloroacetic acid.(wikipedia,2010)

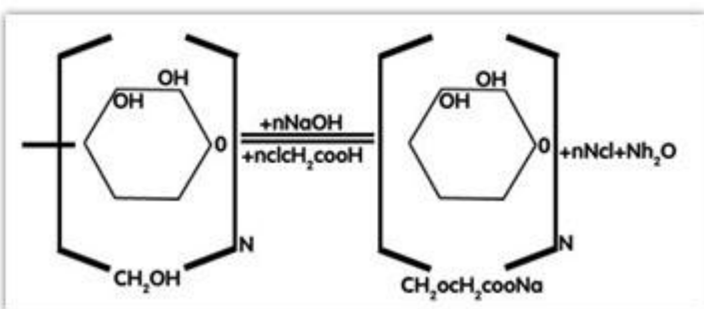

Fig.(1):chemical composition of CMC. .(wikipedia,2010)

Goyanes S. and Rubiolo G. (2003) studied the influence of the filler content on the mechanical properties of an epoxy resin composite filled with aluminum powder was investigated. Compressive tests were performed at room temperature and at different strain rates. The response of the composites was also studied by positron annihilation lifetime spectroscopy. The results were discussed in terms of a proposed model that takes into account the contribution of the filler powder. To this purpose information from positron spectroscopy is important since it allow to evaluate correctly the internal stresses introduced in the composite epoxy lattice by the metal filler.

Yang (2004) studied the effect of reinforcing polypropylene with lignocellulosic fillers on the physical, mechanical and morphological properties where four levels of filler loading (10, 20, 30 and 40 wt.%) were designed. Tensile strengths of the composites slightly decreased as the filler loading increased. Tensile modulus improved with increasing filler loading. Notched and unnotched Izod impact strengths were lowered by the addition of filler .

Hamza (2009) studied the flexural characteristics of the composite beam made from epoxy reinforced by Al and Cu particles with volume fractions (3, 6, 9,12and 15 wt%). The results were showed that the modulus of elasticity ,the flexural strength and maximum shear stress increased with increasing the volume fraction of the reinforced particles of Al and Cu, while the deflection decreases with the increasing the volume fraction.

From the above point of view, the present work is a comparative study for epoxy matrix reinforcing with PEG4000 and CMC to determine the compression strength and hardness of these composites .PEG and CMC could be utilized as a biodegradable powders to minimize environmental pollution and to improve the mechanical properties.

EXPERIMENTAL PART :

A: Sample Preparation:-

A matrix material was epoxy (Quickmast 105) from DCP company (Don Construction Product Ltd.). The hardener type was (Quickmast 105) from company DCP with ratio (3:1) as (for each 3gm from epoxy mixed with 1 gm of hardener).

Seven specimens for compression test according to ASTM-D695 for each type of reinforcement in the weight fractions (0.02, 0.04, 0.06, 0.08, 0.1, 0.12, 0.14) wt% and one specimen from epoxy only.

Seven specimens for hardness test (30mm*10mm) for each type of reinforcement in the weight fractions (0.02, 0.04, 0.06, 0.08, 0.1,0. 12, 0.14) wt% and one specimen from epoxy only.

B: Mechanical Testing:-

Compression tests were conducted according to ASTM-D695 with a General Hydraulic Tests Machine by gunt HAMBROG. Hardness tests were conducted by Shore A hardness Tester TH200 .All tests were carried out at room temperature.

RESULTS AND DISSCOUSION:

Fig (2) shows the relationship between Shore A hardness and the weight fractions of reinforcing particles represented by CMC and PEG 4000. The hardness increases with increasing the weight fractions of CMC reaching to 78.2 at 0.1wt % and to 71.1 at 0.06 wt % for PEG because the interstitial of an adding material among the polymer particles and consequently increasing the physical bonding among them which leads to increase the hardness of composite material but decreasing the values of hardness at the other weight fractions belonging to that high weight fractions of the reinforced material decreases the density of crosslinking in epoxy.

Figs.(3&4) are showing the relationship between the load(kN)-distance(mm) from compression test. The maximum compressive load occurs at unreinforced epoxy is 7.44 kN where in epoxy reinforced with CMC the compressive load is near to the compressive load of unreinforced epoxy. The compressive load decreases to 6.445 kN at the specimen of epoxy reinforced with 0.1wt % CMC because it has highest hardness and consequently it is brittle and in the other two specimens the hardness increases through the same range.

Figs.(5&6) are showing the shape of brittle failure under compressive load such as concrete. All these specimens were suffered from shear fracture on the planes of 45̊ with the axis as well as many splitting and cracking.

It is clear from Figs.(7&8) that the compressive loads are increasing gradually starting from the unreinforced epoxy specimen reaching to the epoxy reinforced with 0.08wt % PEG where the ultimate value of compressive load is equal to 10.449 kN , then the compressive loads are decreasing and increasing to 8.75 kN at the epoxy reinforced with 0.14wt % PEG where the ductility and toughness are improving compared with small hardness of these specimens.

Fig.(9) represents the shape of ductile failure in compression test where friction is usually highest at the edges and severe barreling caused by friction may cause the side walls to fold up and the friction at ends prevents spreading of material which results in barreling. Cracks may occur on the barreled surface either at 45̊ to the compression axis or perpendicular to the hoop direction.

Conclusions

1. The reinforcement with poly ethylene glycol (PEG4000) powder improves the toughness and ductility of the epoxy at the expense of hardness.

2. The addition of Carboxy methyl cellulose (CMC) powder to the epoxy makes it more hard and brittle.

3.The maximum hardness reaches to 78.2 at 0.1wt % of Carboxy methyl cellulose (CMC) in epoxy.

4.The maximum compressive load is obtaining from epoxy specimen reinforced with 0.08wt % poly ethylene glycol (PEG) and equal to 10.449kN.

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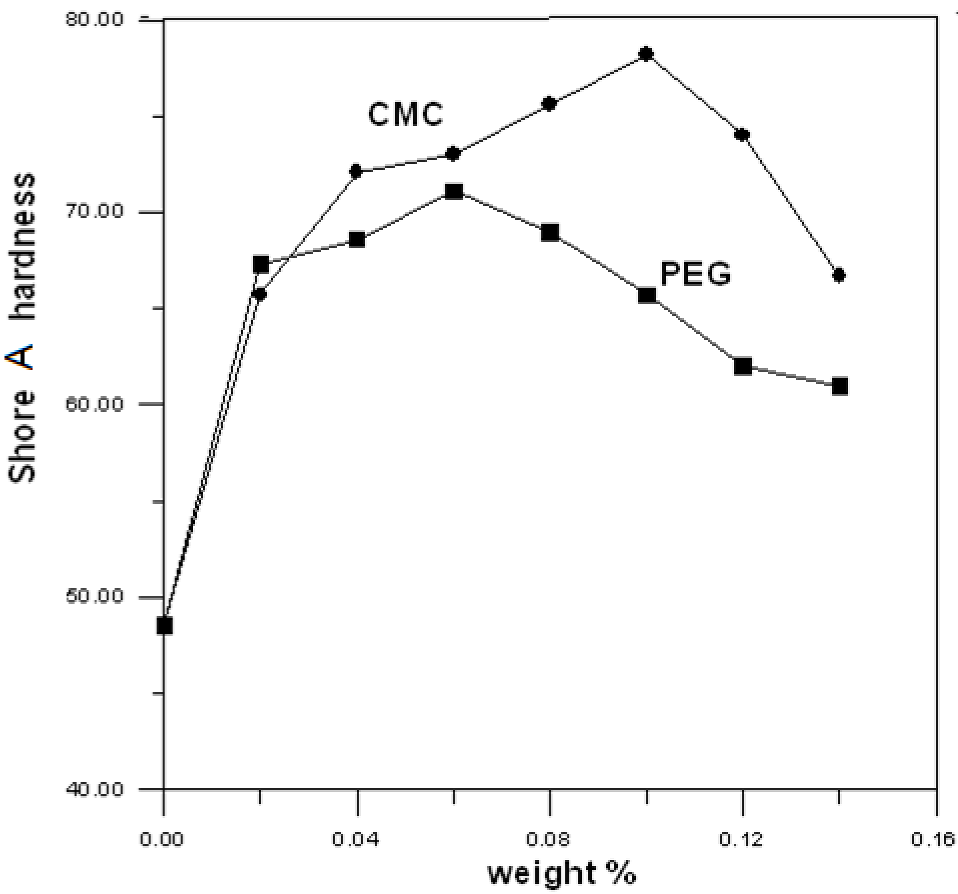

Fig. (2): relationship between Shore A hardness and the weight fractions of CMC and PEG4000.

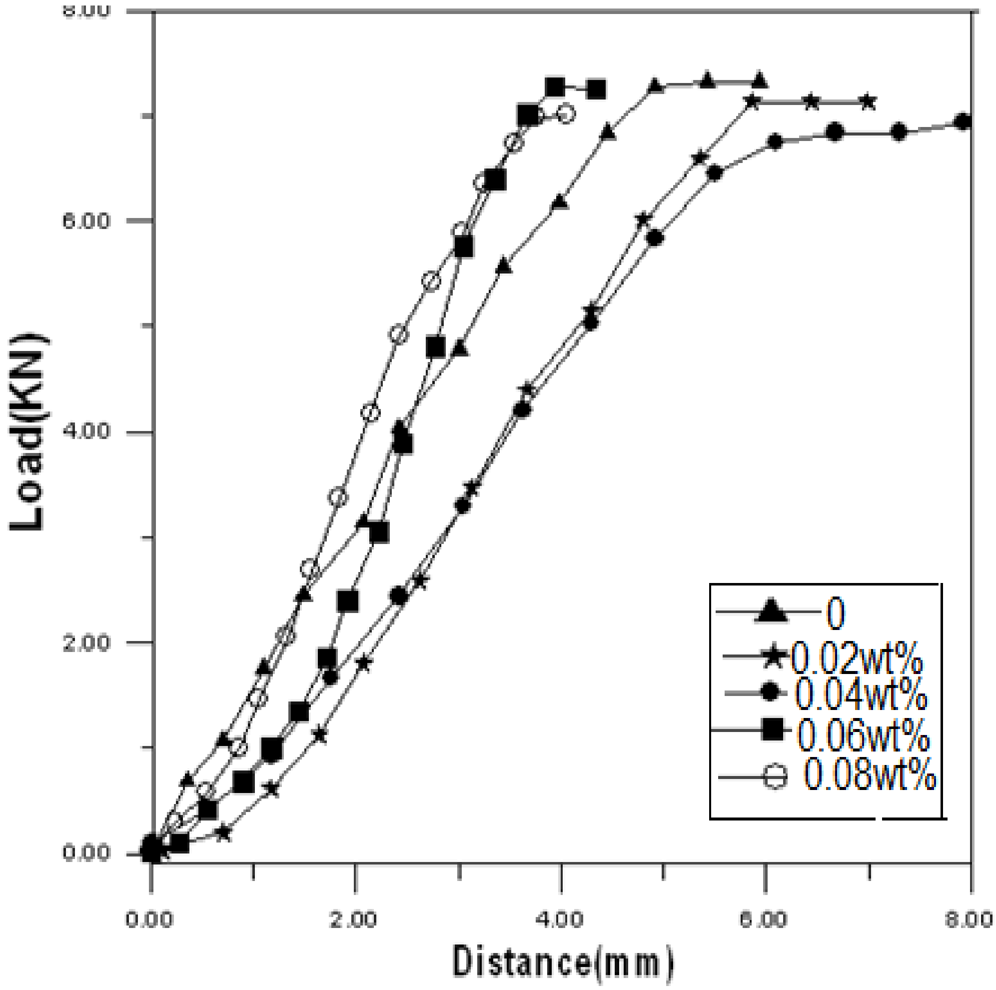

Fig.(3): data of compression test for epoxy specimens reinforced with CMC (0.02-0.08) wt %.

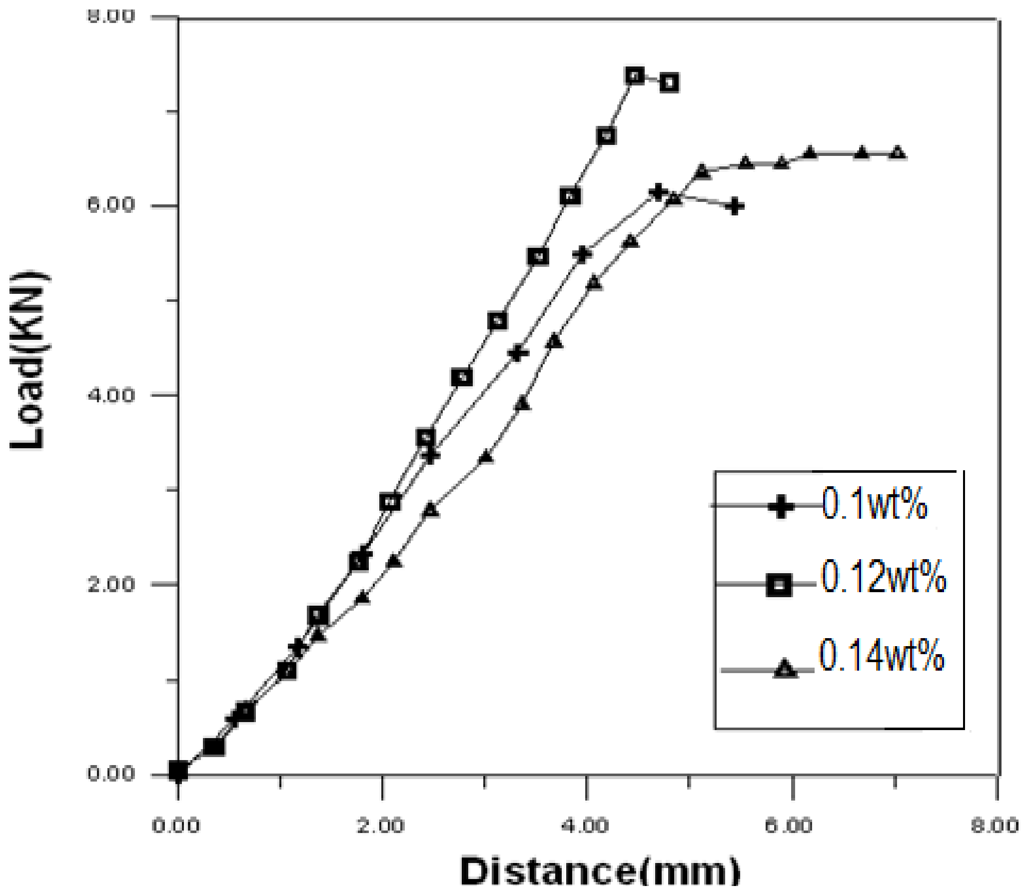

Fig.(4): data of compression for epoxy specimens reinforced with CMC (0.1-0.14) wt %.

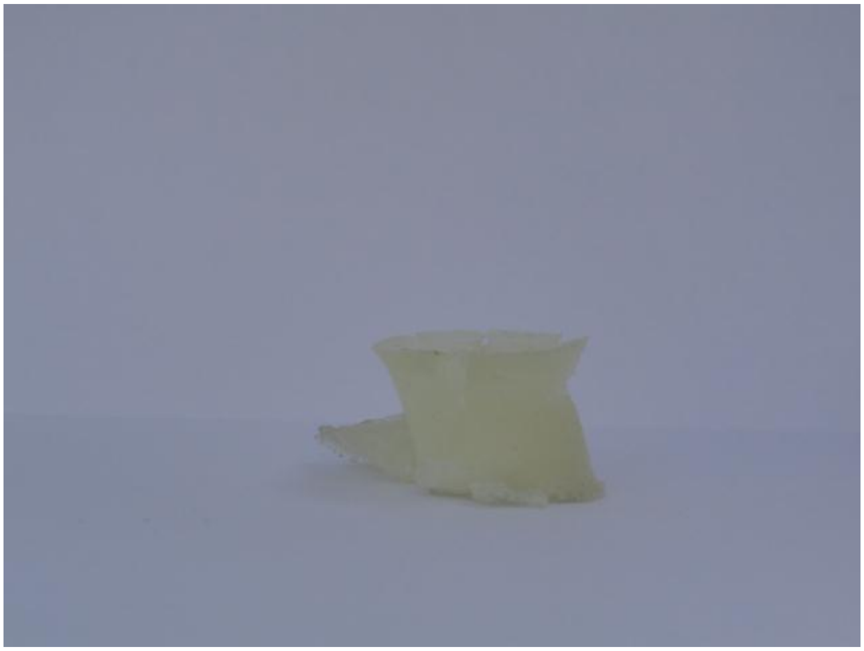

Fig.(5): the shape of failure of unreinforced epoxy specimen after compression test.

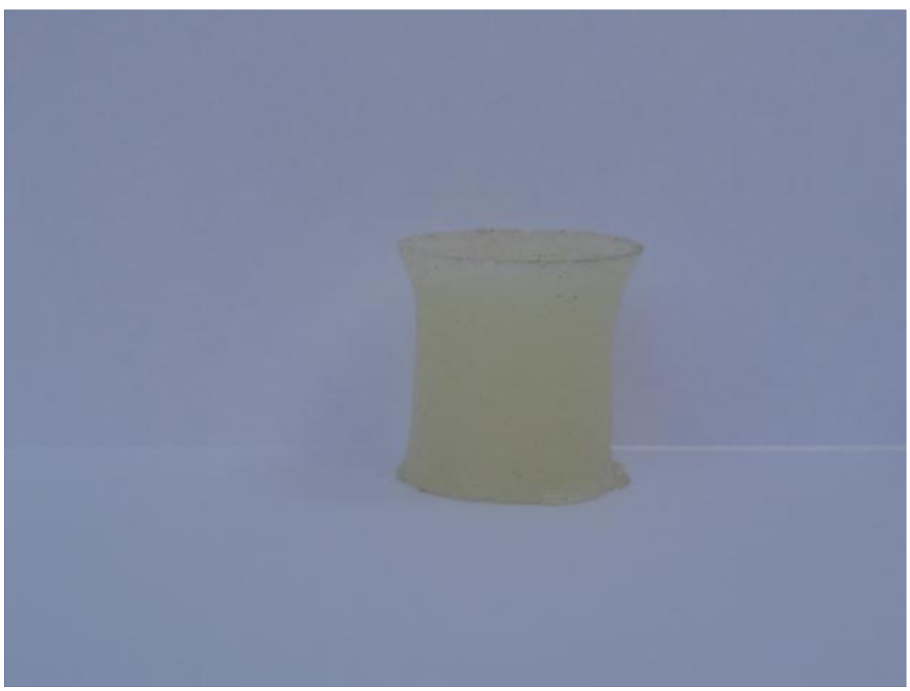

Fig.(6): the shape of failure of epoxy specimen reinforced with 0.12 wt % of CMC after compression test.

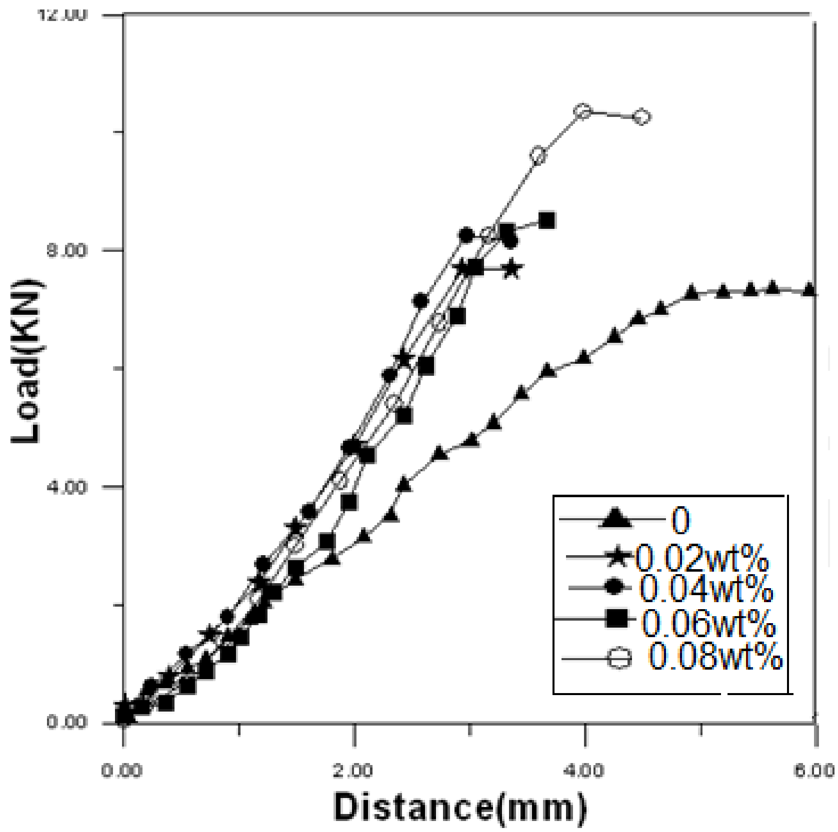

Fig.(7): data of compression test for epoxy specimens reinforced with PEG (0.02-0.08) wt %

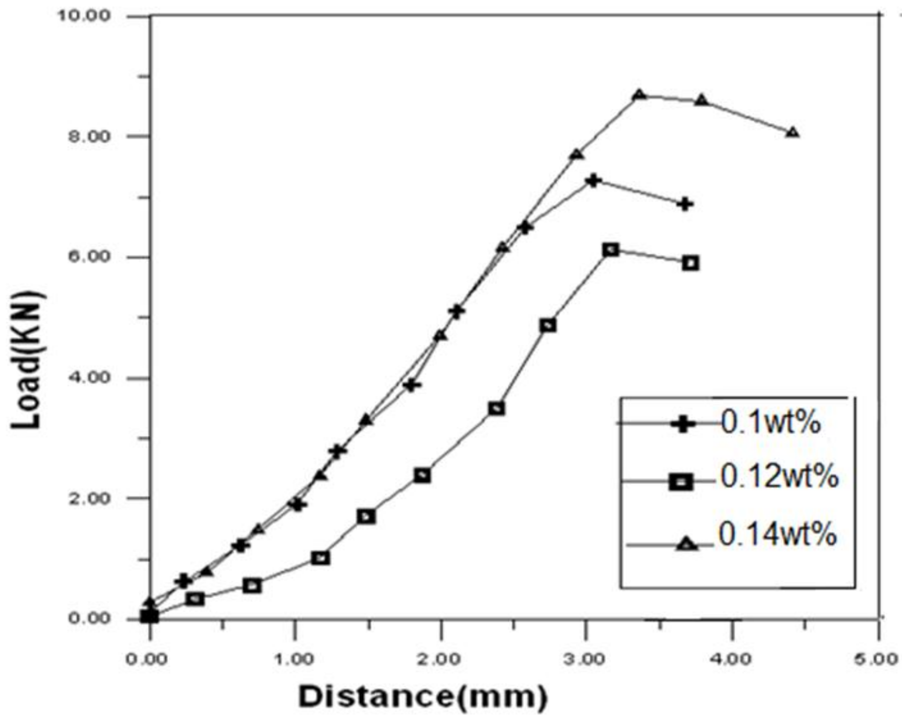

Fig.(8): data of compression test for epoxy specimens reinforced with PEG (0.1-0.14) wt %

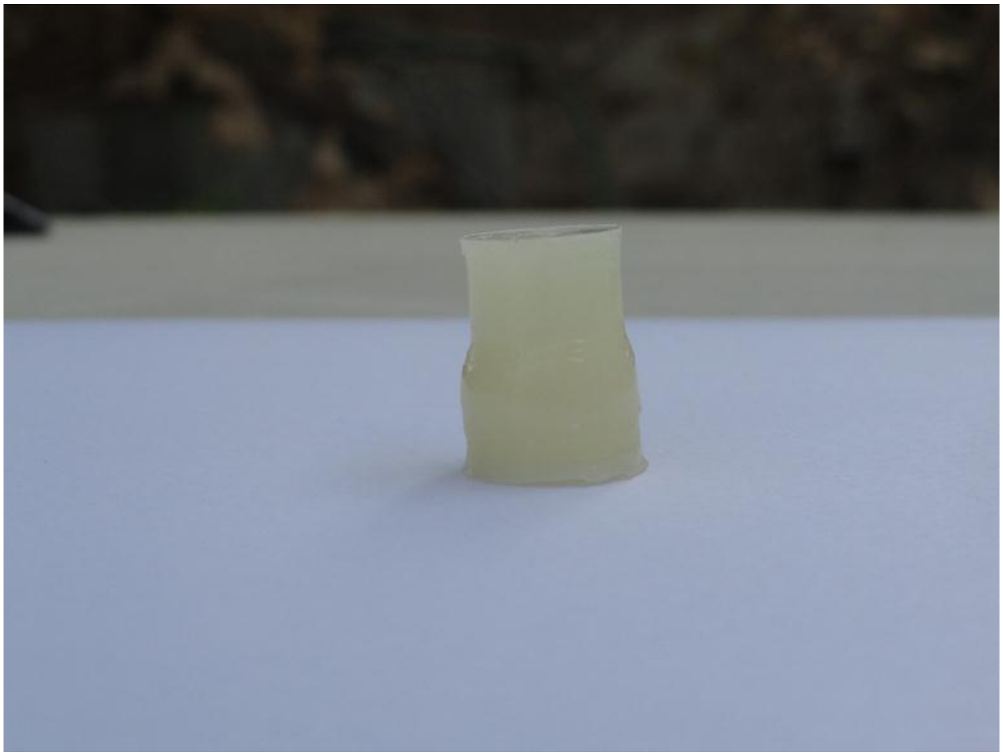

Fig.(9): the shape of failure of epoxy specimen reinforced with 0.04 wt% of PEG after compression test.