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Experimental Study of Epoxy Granite

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Abstract – *In general conventional materials for machine tool bed such as cast iron has the vibrations. Which affects the accuracy of the product. The machine tool structure must have higher damping and constant stiffness as well as desirable flexural strength. Epoxy granite is alternative material can be used as a machine tool bed. It is a composite material in which epoxy is matrix and granite is reinforcement element. Initially we prepared three specimens of epoxy granite with different compositions for conducting the experiments. In this paper we have found stiffness, flexural strength and compressive strength of epoxy granite. after the experiment we have found that 15 % epoxy, 85% granite composition has better stiffness, flexural strength and compressive strength than other compositions of epoxy granite.*

Keywords – *Epoxy granite, Stiffness, Flexural strength, Compressive strength, Machine tool bed, Vibration, Matrix, Reinforcement.*

I. INTRODUCTION

The conventional materials like cast iron, when used for machine tool structure it affects on the accuracy of the product due to vibrations at high cutting speed. This can be minimised by providing stiffer sections of cast iron but it makes the structure heavy and bulky which increases its cost. Hence an alternative material which provides high stiffness, compressive strength and damping is used for making machine tool structure. One of the alternative materials is epoxy granite which provides good material properties like high stiffness, damping, compressive strength, and flexural strength. In the present work we made the specimens of different compositions of epoxy granite and take test such as stiffness test, compressive test, and flexural test and found the desirable composition of epoxy and granite which gives better material properties.

II. EPOXY GRANITE

Epoxy-granite is a composite material having two different constituent i.e. matrix (Epoxy) & reinforcement (Granite). The capacity to damp mechanical vibrations is one of the most important properties of epoxy-granite composites, even superior to the cast iron one. For this reason, these materials have been adopted for manufacturing of tool machine foundations and precision instruments. Epoxy granite castings are produced by mixing crushed (8mm, 5mm, 3mm) granite aggregates with an epoxy resin at ambient temperature it is cold curing process. Quartz aggregate filler can also be used in the composition. Vibratory compaction during the moulding process tightly packs the aggregate together. Threaded inserts, steel plates, and coolant pipes can be cast-in during the casting process. To achieve an even higher degree of versatility, linear rails, ground slide-ways and motor mounts can be replicated or grouted-in, therefore eliminating the need for any post-cast machining. The surface finish of the casting is as good as the mould surface.

Figure 1. Different size crushed granite

III. MATERIAL & METHOD

3.1 Materials:

The composite material was prepared with granite added to a cold-cured epoxy polymeric resin. The granite used was obtained from company, Accurate gauging Pvt. Ltd. Pune, which construct machine tool beds. From this company we get the scraps in the form rounded shaped granite stones, which were then crushed by hammer and sieved as per requirement of granite aggregate size. The epoxy resin used is the Araldite AY103 and hardner, Ardur HY951.

Figure 2. Granite aggregates, Epoxy resin (Ardur & araldite).

3.2 Sample preparation:

Preparation of epoxy-granite composite samples followed the steps shown below. The granite slabs were broken with a hammer and separated into size classes using sieves with 1, 3, 5 and 8 mm mesh. Table 1 presents the granite particles classification corresponding to the maximum and minimum sizes according to the mesh sizes of the used sieves.

Minimum size > mm	Class	Maximum size < mm
0	1	1
1	2	3
3	3	5
5	4	8

Table 1. Granite particles size and the classification adopted for specimens

3.3 Weighing & mixing of Granite:

Granite composites were prepared by mixing particles of different grain sizes at % weight proportion. Classes 1 to 4 were used to obtain the three compositions which incorporate the indicated size class pairs.

We know that, the density of epoxy granite is given by,

$$\rho = \frac{m}{v}$$

Where, 'ρ' is density of granite = 2300 Kg/m^3

'm' is mass of specimen in Kilogram,

'v' is volume of specimen in m^3 = 50×50×300 =75000 mm^3

$$= \mathbf{7.5 \times 10^{-4}\ m^3}$$

Now, mass of the specimen is,

$$m = \rho \times v$$
$$= 2300 \times 7.5 \times 10^{-4}$$
$$= 1.725\ Kg$$
$$= \mathbf{1725\ gm.}$$

Composition of sample	Class	Epoxy By Percentage (%)	Epoxy By weight (gm)	Granite By Percentage (%)	Granite By weight (gm)
10% Epoxy	1	10	172.5	15	258.75
	2			30	517.50
	3			30	517.50
	4			15	258.75
TOTAL		**10**	**172.5**	**90**	**1552.5**

Table 2. Compositions of epoxy & granite particles With 10% epoxy.

Composition of sample	Class	Epoxy By Percentage (%)	Epoxy By weight (gm)	Granite By Percentage (%)	Granite By weight (gm)
15% Epoxy	1	15	258.75	15	258.75
	2			30	517.50
	3			25	431.25
	4			15	258.75
TOTAL		**15**	**258.75**	**85**	**1466.25**

Table 3. Compositions of epoxy & granite particles With 15% epoxy.

Composition of sample	Class	Epoxy By Percentage (%)	Epoxy By weight (gm)	Granite By Percentage (%)	Granite By weight (gm)
20% Epoxy	1	20	345	10	172.50
	2			30	517.50
	3			30	517.50
	4			10	172.50
TOTAL		**20**	**345**	**80**	**1380**

Table 4. Compositions of epoxy & granite particles With 20% epoxy.

3.3 Weighing & mixing Epoxy resin:

The samples preparation were made first adding the curing agent to the epoxy resin. After mixing, 15 minutes was the resting time established for volatilization of the curing agent components, which can hinder the granite`s wet ability and could promote heterogeneity in the probe samples. The amount of epoxy used is as per the sample compositions given in tables.

(a) **(b)**

Figure 3. weighing of a) epoxy (araldite ay103); & b) hardner (ardur HY 951).

3.4 Mixing of Granite & Epoxy:

Granite composites were prepared with three different epoxy ratios, 10%, 15% and 20% in weight, and the remaining was the granite composition. The material was then mixed for about 20 minutes, as to allow the wetting of the granite particles by the epoxy and the homogenization of the mixture, thus avoiding the formation of granite particles clusters as shown in below.

3.6 Pouring of mixture into the Mould:

The mixture was poured into the matrix in little amounts, pressing it until fulfilling the whole cavity, on the vibrator machine (sand moulder machine). Next, the matrix was closed with a pressurized cover during the epoxy cure process.

IV. EXPERIMENTATION AND RESULTS

4.1.1 Stiffness test:

Stiffness is the measurement of rigidness. Stiffness test shows how much body is rigid and able to take loads on it. We have carried the stiffness test on the specimen of epoxy granite. Specimen of different proportions of epoxy resin, such as 10% epoxy, 15% epoxy, 20% epoxy.

4.1.2 Experimental set up and testing:

First of all work specimen of 300 mm × 50 mm × 50 mm was fixed in the fixture, which is fitted into the bench vice. The dial gauge with stand is placed on the stool such as its plunger just touches the upper surface of specimen. Specimen fixed in the fixture such as the distance between free end and the fixture is 250 mm that is 50 mm part of specimen is inside the fixture and test should be conducted on remaining 250 mm. A weightless pan is kept at the free end for applying load. Then we took different weights of 500 gm, 1000 gm, and 1500 gm alternately in the weighing pan and measure the deflection on dial gauge.

Figure 4. Experimental Set up of stiffness test

Stiffness (k) = $\frac{F}{\delta}$ **... N/mm**

Sr. no	**Weight** (gm)	**Force** (N) F=mg	**Deflection δ** (μm)
1	500	4.905	50
2	1000	9.81	110
3	1500	14.715	150
4	2000	19.62	190
5	2500	24.525	270

Table 5. Readings of stiffness test

4.1.3 Results of stiffness testing:

From graph the stiffness is calculated as,
By slope point formula,
Stiffness = $k = \frac{y_2 - y_1}{x_2 - x_1}$

Epoxy granite Specimen of 10 % epoxy-

Sr. no.	**Weight** (gm)	**Force** (N) F=mg	**Deflection (δ)** (μm)	**Stiffness (k)** (N/m)
1	0	0	0	0
2	500	4.905	50	98100
3	1000	9.81	110	89181.818
4	1500	14.715	150	98100
5	2000	19.62	190	103263.157
6	2500	24.525	270	90833.333

Table 6. stiffness test

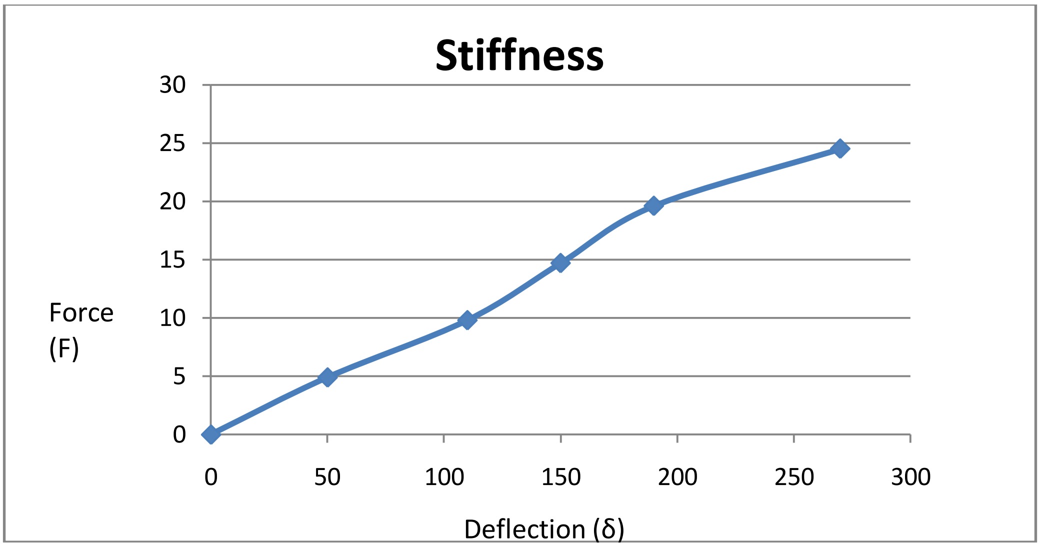

Figure 5. Load VS. Deflection for 10% epoxy granite.

From any two points on line (50, 4.905) and (110, 9.81)

$k = \frac{9.81 - 4.905}{110 - 50} \times 10^6$

k = 81750 N/mm

Specimen of 15 % epoxy-

Sr. no.	Weight (gm)	**Force** (N) F=mg	**Deflection δ** (μm)	**Stiffness k** (N/m)
1	0	0	0	0
2	500	4.905	80	61312.5
3	1000	9.81	120	61312.5
4	1500	14.715	210	70071.4285
5	2000	19.62	290	67655.1724
6	2500	24.525	400	61312.5

Table 7. Results of stiffness test

From graph the stiffness is calculated as,
By slope point formula,
Stiffness = $k = \frac{y_2 - y_1}{x_2 - x_1}$
From any two points on line (80, 4.905) and (120, 9.81)
$k = \frac{9.81 - 4.905}{120 - 80} \times 10^6$
k = 122625 N/mm

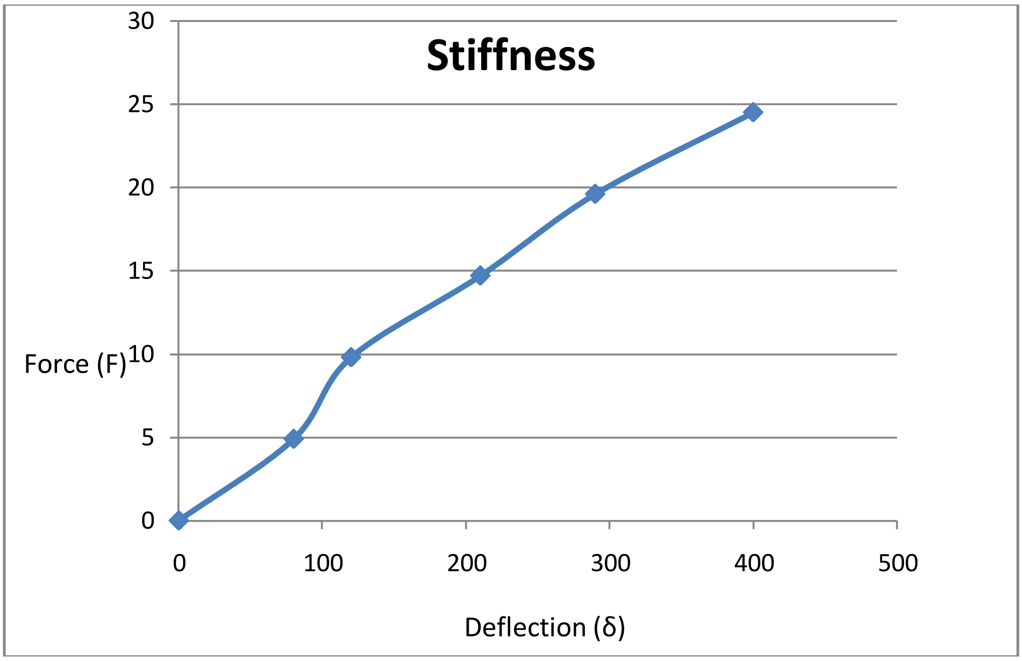

Figure 6. Load VS. Deflection for 15% epoxy granite

Specimen of 20 % epoxy-

Sr. No.	**Weight** (gm)	**Force** (N) F=mg	**Deflection δ** (μm)	**Stiffness k** (N/m)
1	0	0	0	0
2	500	4.905	80	61312.5
3	1000	9.81	160	61312.5
4	1500	14.715	260	56596.1538
5	2000	19.62	370	53027.027
6	2500	24.525	530	46273.58

Table 8. Results of stiffness test

From graph the stiffness is calculated as,
By slope point formula,
Stiffness = $k = \frac{y_2 - y_1}{x_2 - x_1}$
From any two points on line (80, 4.905) and (160, 9.81)
$k = \frac{9.81 - 4.905}{160 - 80} \times 10^6$
k = 61312.5 N/mm

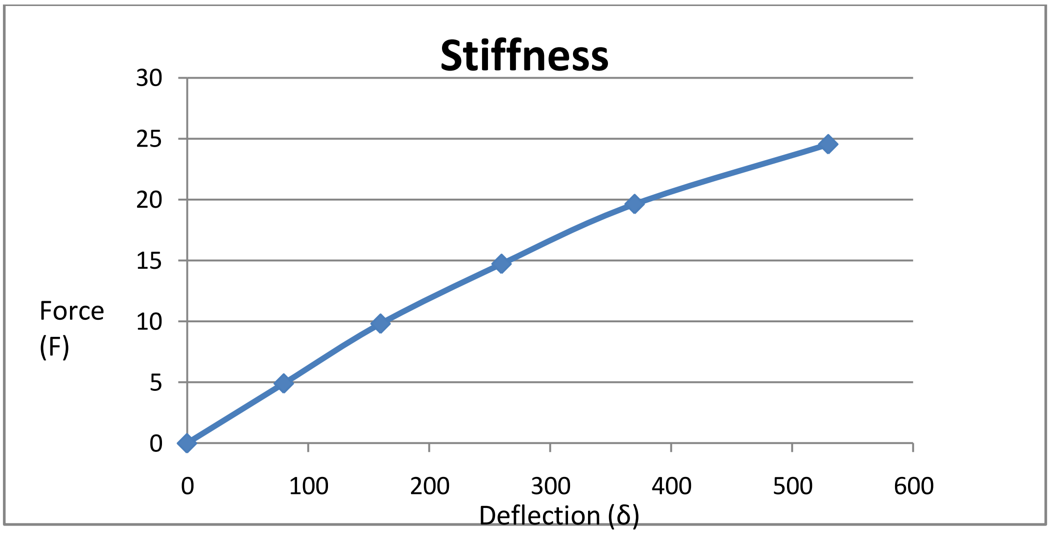

Figure 7. Load VS. Deflection for 20% epoxy granite

Specimen of M.S. – From graph the stiffness is calculated as

Length (mm)	**Weight** (gm)	**Force** (N) F=mg	**Deflection δ** (μm)	**Stiffness k** (N/m)
1	0	0	0	0
2	500	4.905	70	70071.42
3	1000	9.81	150	65400
4	1500	14.715	220	66886.36
5	2000	19.62	290	67655.17
6	2500	24.525	400	61312.5

Table 9. Results of stiffness test

,By slope formula,

Stiffness = k = $\frac{y_2-y_1}{x_2-x_1}$

From any two points on line (70, 4.905) and (150, 9.81)

k= $\frac{9.81-4.905}{150-70}\times10^6$

k= 61312.5 N/mm

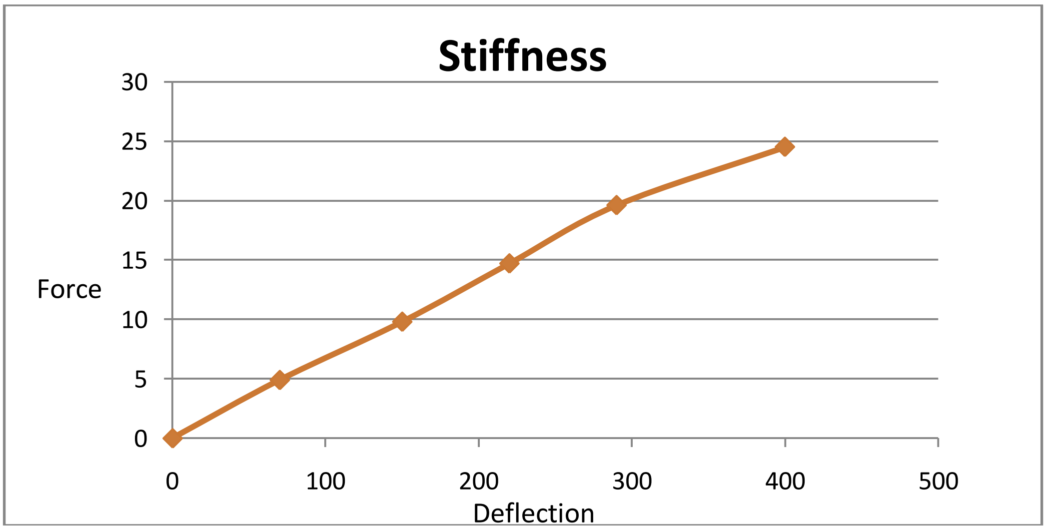

Figure 8. Load VS. Deflection for M.S. specimen

From above results we have seen that epoxy granite having 15% epoxy has better stiffness than other compositions of epoxy granite.

4.2 Flexural strength test:
4.2.1 Experimental set-up:-

The specimen was made simply supported on the UTM, and central load was applied on the specimen gradually. The test is also called as three point test. The applied load and displacement of specimen were seen on digital display.

Figure 9. Experimental set up of Flexural test.

4.2.2 Experimental Procedure:
First we found out the centre of the specimen. Then we placed the specimen on two simply supports of UTM such that the specimen became a simply supported beam. After that the gradually increasing point load is applied at the centre of the specimen until the specimen breaks. Finally the total applied load and the displacement of the specimen was recorded and stress is calculated. Similar procedure was done for all remaining specimen.

Figure 10. Flexural strength test specimen after test.

Flexural strength (σ) = $\frac{F}{A}$ **N/mm^2**

Sr. No.	Specimen (% of Epoxy)	Area(mm^2)	Load (N)	Flexural strength (N/mm^2)
1	10%	2500	8.31×1000	3.324
2	15%	2500	15.96×1000	6.384
3	20%	2500	17.49×1000	6.996

Table 10. Readings of flexural strength test.

4.2.3 Results of Flexural strength test:

Sr. No.	Specimen (% of Epoxy)	Area(mm^2)	Load (N)	Flexural strength (N/mm^2)
1	10%	2500	8.31×1000	3.324
2	15%	2500	15.96×1000	6.384
3	20%	2500	17.49×1000	6.996

Table 11. flexural strength

The flexural strength of epoxy granite having 15% epoxy is reliable than other composition of epoxy granite. So from above results epoxy granite having 15% epoxy has better flexural strength.

4.3 Compressive strength test:

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. Compressive strength can be measured by plotting applied force against deformation in a testing machine, such as a universal testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. Compressive strength is often measured on a universal testing machine; these range from very small table-top systems to ones with over 53 MN capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard.

4.3.1 Experimental set-up:-

The experimental set up contains the UTM and test specimen of a size 50×50. The specimen was simply rest on the UTM, and compressive load was applied on the specimen gradually. The applied load and displacement of specimen were seen on digital display.

***Figure 11. Experimental set up of Compression test*.**

4.3.2 Experimental Procedure:

We placed the specimen on base of UTM such that the specimen simply rests on the base. After that the gradually increasing compressive load is applied on the specimen until the specimen breaks. Finally the total applied load and the displacement of the specimen was recorded and compressive strength is calculated. Similar procedure was done for all remaining specimen.

Sr. No.	Specimen (% of Epoxy)	Area(mm^2)	Load (N)	Compressive strength (N/mm^2)
1	10%	51×50=2550	106.77×1000	41.87
2	15%	51×51=2601	313.02×1000	120.34
3	20%	51×50=2550	312.30×1000	122.47

Table 12. Readings of compressive strength test

Compressive strength (σ) = $\frac{F}{A}$ **N/mm^2**

Figure 12. Compression test specimen after compression.

4.3.3 Results of Compressive strength Test:

Sr. No.	Specimen (% of Epoxy)	Area(mm^2)	Load (N)	Compressive strength (N/mm^2)
1	10%	51×50=2550	106.77×1000	41.87
2	15%	51×51=2601	313.02×1000	120.34
3	20%	51×50=2550	312.30×1000	122.47

Table 8.6 Compressive strength

The compressive strength of epoxy granite having 15% epoxy is reliable than other composition of epoxy granite. So from above results epoxy granite having 15% epoxy has better compressive strength.

V. CONCLUSION

A combination with 15% epoxy resin and 85% granite aggregate is observed to produce better stiffness, flexural strength and compressive strength. Further implementation of characterization of stiffness and flexural strength of epoxy granite is future scope of study. The stiffness of epoxy granite (15% epoxy) has highest stiffness value but compressive strength and flexural strength of epoxy granite having 20% epoxy resin has slightly greater than 15% epoxy component. As stiffness of 15% epoxy component is greater than others and its compressive strength and flexural strength is reliable, so that we have observed that 15% epoxy component gives better properties.

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