FLEXURAL BEHAVIOUR OF R.C BEAM USING GRAPHENE OXIDE REINFORCED CEMENT COMPOSITES

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Abstract

Utilization of nano material plays an vital role in improving the fresh and hardened properties of the cement composites. This research presents the flexural behavior of R.C beams fabricated with Graphene oxide cement composites. Graphene oxide of 0.06% by wt was taken for this study. Concrete mix proportioning was done as per IS 10262(2009). Grade of concrete used for this investigation was M20 and M30 to study the flexural behavior of RC beams. A total of six beams were cast, two beam specimens are of the control specimen and the remaining specimens are reinforced with GO. two point load test was conducted to study the flexural behavior of the RC beams. The compressive strength, ultimate load, energy absorption capacity, first crack load and mode of failure was investigated.

Keywords: Graphene oxide, Nanomaterial, Cement, ultimate load, energy absorption capacity, mode of failure

1. Introduction

For a longer period of time Superplastizer modified carbon nano material shows better dispersion behaviour [1]. The dispersion was improved with increase in molecular weight of branched chain in GOM modified composites [2]. to disperse GO in alkaline medium Polycarboxylate based superplasticizer was found to be effective[3]. in nano material fabricated cement composites dispersive agents plays a vital role in transport properties[4].

Workability of cement paste get reduced with the addition of GO and also accelerates the hydration of cement [4-9]. workability of the cement composite is proportional to the amount of GO. workability of the cement composite reduces with increase in amount of GO present in the composite. incorporation of GO in cement will reduce the workability due to high specific surface area and requires more water to wet their surface[5]. GO fabricated cement composites reduces workability due to the increase of interparticle friction, yield strength and viscosity [6].

Chemically functionalized graphene oxide in cement composite enhances the toughness of the composite [2] . GO reinforced composite increases the surface area and volume of gel pores[7]. inclusion of GO nano sheets in cement composites supports formation of flower like hydration crystals and increases the toughness of the composites [8]. GO reinforced cement composites refines the pore structure of the cement composite by filling large pores present in the composites by GO agglomerates[9]. GO fills the micro pores and cracks present in the composites and gives more uniform and compact structure. Due to the more uniform and dense

microstructure enhances the strength and toughness of the composites [10][11]. due to pore structure refinement the sorptivity was reduced about 50% [4].

Incorporation of GO nano sheets in UPHC specimens enhances the compressive and flexural strength at addition of 0.02% of GO further addition of GO nano sheets the strength enhancement was reduced[12]. incorporation of 0.03% of GO increases the flexural strength upto 67% [3]. An optimum dosage of 0.03% addition of GO increases the compressive strength by 15-33% and flexural strength by 41-59% [13]. cement composites tailored with GO enhances the flexural by 41.58% and compressive strength by 15-33% with the addition of 0.05% of GO [7]. compressive, flexural strength of GO nanosheet reinforced composites was increased 38.9% and 60.7% with a optimum of dosage of 0.03% of GO[8]. flexural strength of the GO based cement composites increases about 62% [14].

To study the behavior of R.C beam specimens tailored with GO was done in this investigation. an optimum dosage of 0.06% of GO was used for this study. previously several attempts has been done was done to study the mechanical, durability properties, micro structural characterization and transport properties of cement mortar and concrete. to investigate the behavior of R.C beams with the inclusion of GO was evaluated in terms of first crack load, ultimate load, failure mode and energy absorption capacity was made in this investigation.

2. Materials and Mix Proportioning

2.1 Materials

The specific gravity, fineness, consistency and initial setting time of Ordinary Portland Cement of 53 Grade was 3.15, 6%, 30% and 29 min confirming IS 12269:1987. The fineness modulus and specific gravity of M-sand was 2.36 and 2.68 respectively. The specific gravity and fineness modulus of the coarse aggregate was 2.76 and 7.23 was used for this research.

2.2 Preparation of specimen

The ingredients of cement, manufactured sand and coarse aggregate was dry mixed and then 70% of water is added with the dry mix and allowed the mixer to rotate about 2 to 3 minutes after that GO suspension of 30% was added and allowed to rotate 2 minutes with the help of concrete mixer. GO is reinforced with cement at dosage of 0.06% by weight. the suspension was sonicated with 30 minutes of sonication. the GO suspension was prepared one hour before the casting of specimens. The cube moulds of size 150 mm x 150 mm x 150 mm was used for this work and the moulds was oiled before placing the fresh concrete. the moulds are removed from the specimen after 24 hours and allowed for water curing of 28 days. the same procedure is followed for casting of R.C beams. the size of R.C the cement, fine aggregate and coarse aggregate was 384 kg/m^3, 698 kg/m^3, 1176 kg/m^3 respectively (1:1.8:3.06) with a w/c ratio of 0.5 adopted for M20 grade concrete. For M30 grade concrete 427 kg/m^3, 666 kg/m^3, 1170 kg/m^3 respectively (1:1.56:2.74) with a w/c ratio of 0.45.

2.3 Description of specimen

A total six R.C beam specimens were cast and all specimens were identical in their dimension. the cross section dimensions of R.C beam was 150 mm x 200 mm x 1200 mm. concrete cover of 25 mm was used for this study. the beam specimens were simply supported and loaded in flexure under two point loading conditions. Two numbers of 10mm dia bars provided at the bottom and two numbers of 8mm dia bars provided at the top of the beam. stirrups of 8mm dia with a spacing of 150 mm are used to hold the reinforcement bars in position.

2.3.1 Labeling of specimen

the specimens were cast and designated according to their grade of concrete.

S1 - Control specimen for M20 Grade concrete

S2,S3 - M20 grade of concrete with GO

S4 - Control specimen for M30 Grade concrete

S5,S6- M30 grade of concrete with GO

2.4 Experimental setup

The beam specimens are tested using a universal testing machine. R.C beam specimens were simply supported and loaded in flexure under two point loading conditions. Two deflectometers were placed under the beam at each 1/3 of the span. the position of the loads and experimental setup were shown in Figure. the beams were loaded incrementally and the first crack loads, maximum crack width total number of cracks and mode of failure was observed. the test setup for the two point loading was shown in Figure.

Figure 1. Experimental setup for two point loading of beam specimen

3.Results and Discussion

3.1 Compressive strength test

The compressive strength test was carried out for concrete cube specimens using compressive strength testing machine. Grahene oxide used for this research was 0.06% by wt. The compressive strength of the specimen was shown in Figure 2. The increase in compressive strength of graphene reinforced specimen for M20 grade concrete was 9.35%, 16.83% for 7

days and 28 days. For M30 grade concrete the increase in compressive strength for graphene fabricated specimen was 52.8%, 42.6% for 7 days and 28 days.

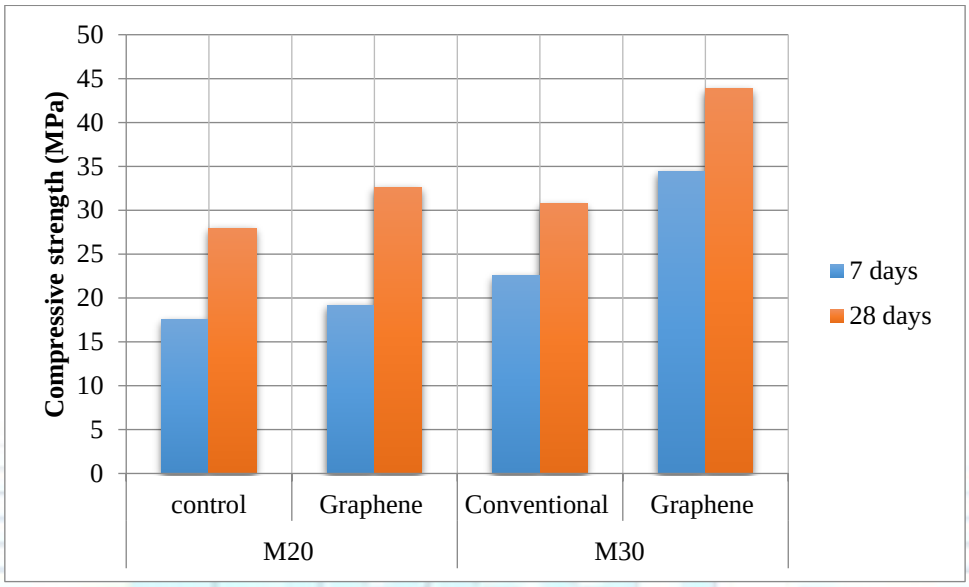

Figure 2. Comparison of Compressive Strength of specimens

3.2 Control specimen of M20 Grade concrete (S1)

First beam specimen is designated as S1 (M20 Grade of concrete) specimen. the specimen was cast and demoulded after 24h of time period. after demoulding of specimens it was allowed for sufficient curing. The specimens are allowed to dry after 28days of curing. the beam specimen was tested using universal testing machine the load is gradually applied until the failure of the specimen was reached. the first crack load of the control specimen was 30 kN and the failure load was observed at 90 kN. the number of crack observed for the specimen was 14. maximum width of cracks are 3mm, 2mm and 1mm.

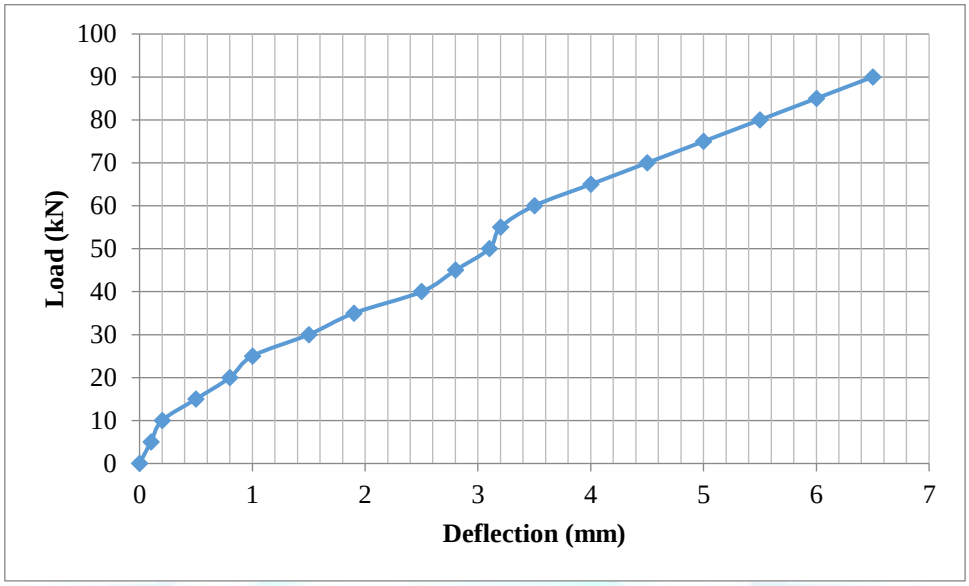

Figure 3. Load Vs Deflection curve for S1 specimen

Figure 4. Failure pattern of S1 specimen

3.3 S2 and S3 specimen (M20 Grade of concrete with GO)

Second and third beam specimen was designated as S2 and S3 (M20 Grade of concrete).the R.C beam specimens are demoulded after 24h and allowed for sufficient curing. The beam specimens are allowed to dry after 28days of curing. the specimen was tested using universal testing machine the load is gradually applied until the failure load was reached. the first crack load of the S2 and S3 specimen was 50 kN and the failure load was observed at 120 kN. the number of crack observed for the S3 specimen was 13. maximum width of cracks are 3.1 mm, 2.5 mm and 0.2 mm. The number cracks observed for the S4 specimen was 11 and the maximum width of cracks observed was 2.9 mm, 2 mm and 0.9 mm.

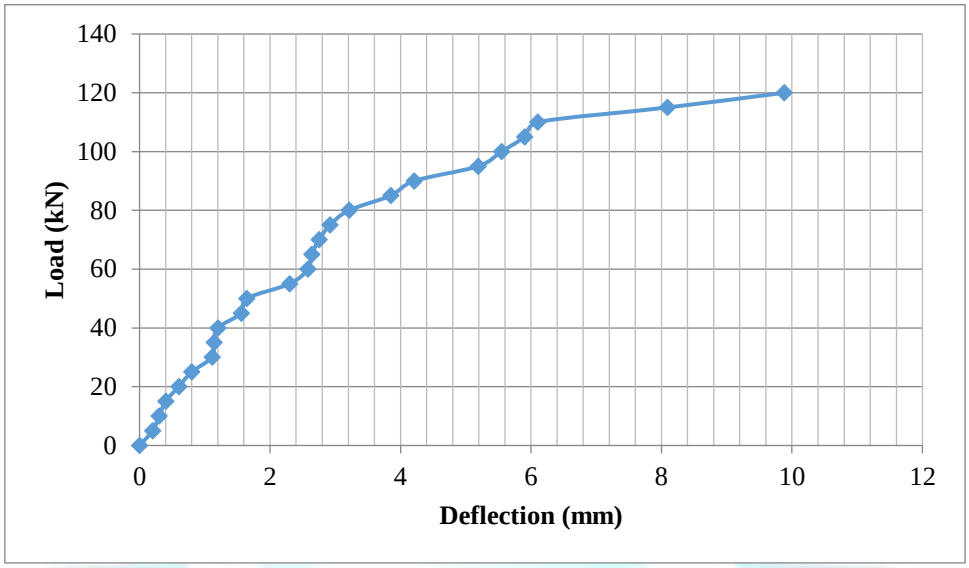

Figure 5. Load Vs Deflection curve for S2 specimen

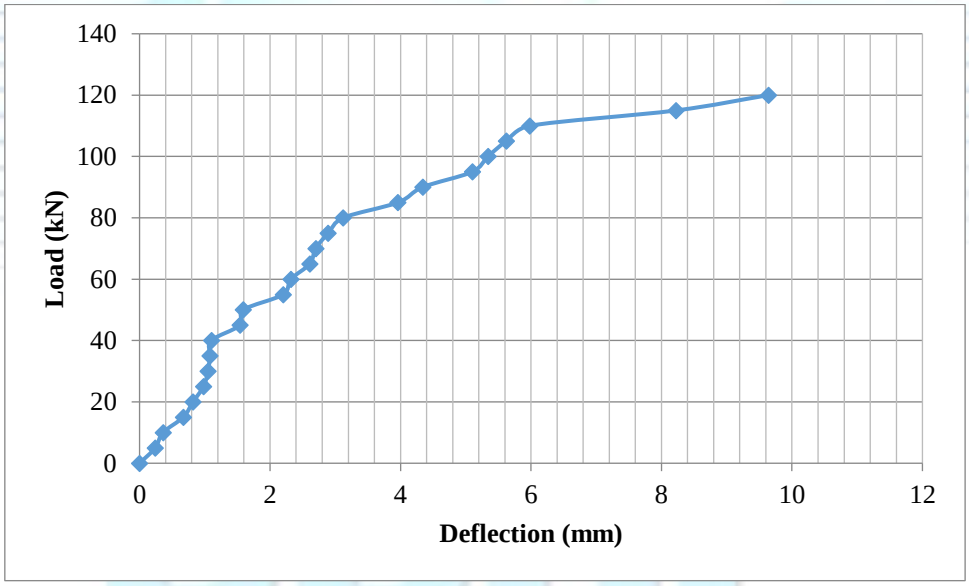

Figure 6. Load Vs Deflection curve for S3 specimen

Figure 7. Failure pattern of S2 specimen

3.4 Control specimen of M30 Grade concrete (S4)

Fourth beam specimen was designated as S4 (M30 Grade of concrete). the R.C beam specimens are demoulded after 24h and allowed for sufficient curing. the beam specimens are allowed to

dry after 28days of curing. the specimen was tested using universal testing machine the load is gradually applied until the failure load was reached. the first crack load of the control specimen was 40 kN and the failure load was observed at 100 kN. the number of crack observed for the specimen was 8. maximum width of cracks are 1.8 mm, 0.8 mm and 0.3 mm.

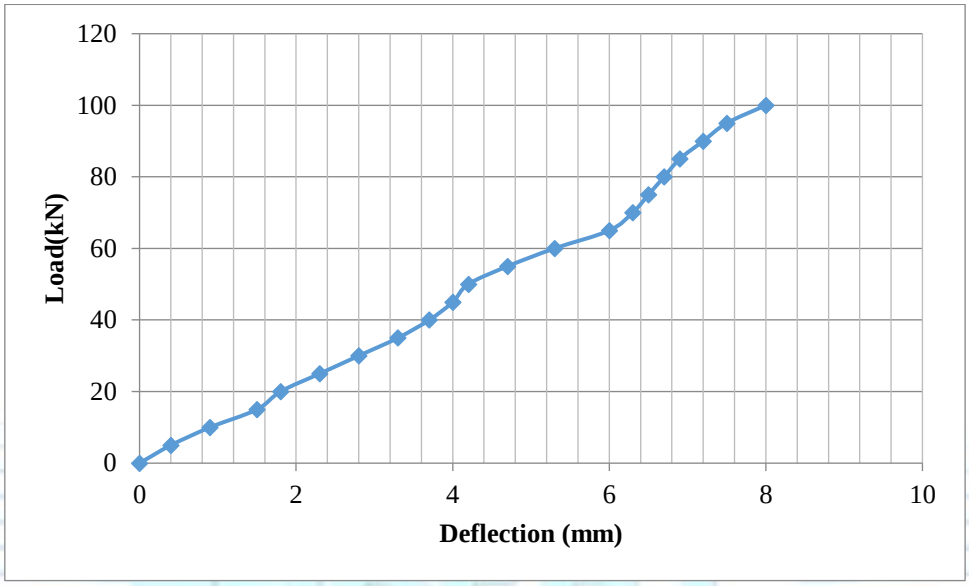

Figure 8. Load Vs Deflection curve for S4 specimen

Figure 9. Failure pattern of S4 Specimen

3.5 S5 and S6 specimen (M30 Grade of concrete with GO)

Fifth and Sixth beam specimen was designated as S5 and S6 (M30 Grade of concrete). The R.C beam specimens are demoulded after 24h and allowed for sufficient curing. the beam specimens are allowed to dry after 28days of curing. After drying the beam specimen was tested using universal testing machine the load is applied gradually until the failure load was reached. the first crack load of the S5 and S6 specimen was 60 kN and the failure load was observed at 120 kN. the number of crack observed for the S3 specimen was 12. maximum

width of cracks are 3.3 mm, 2.4 mm and 0.8 mm. The number cracks observed for the S4 specimen was 10 and the maximum width of cracks observed was 1.3 mm, 1 mm and 0.5 mm.

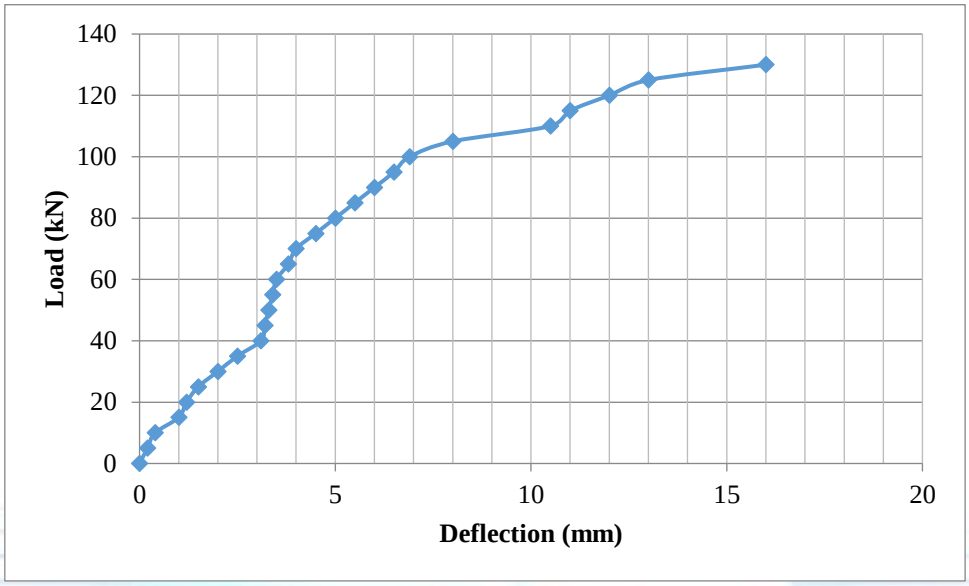

Figure 10. Load Vs Deflection curve for S5 specimen

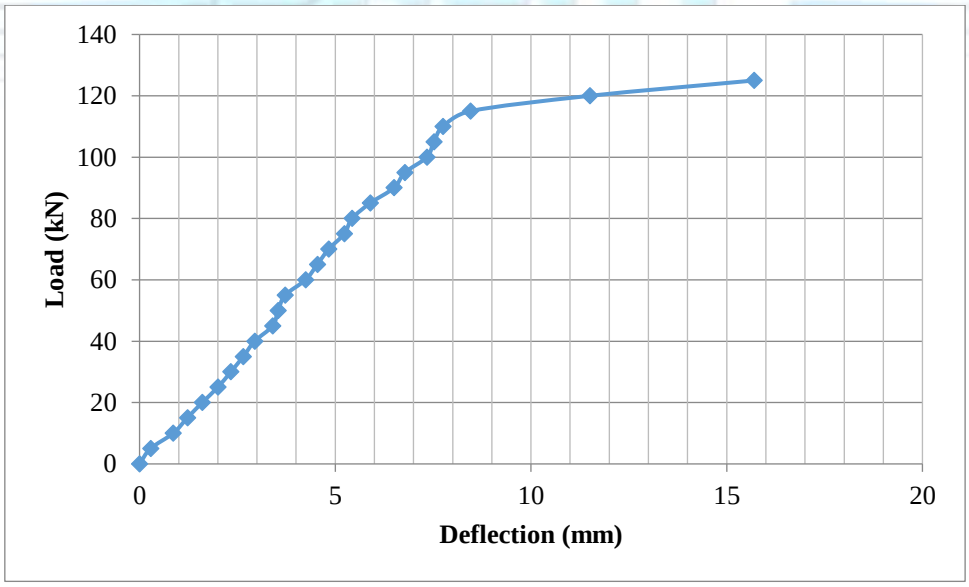

Figure 11. Load Vs Deflection curve for S6 specimen

Figure 12. Failure pattern of S5 specimen

3.6 Ultimate load carrying capacity

The load carrying capacity of the S1,S2,S3,S4,S5 and S6 specimens are 90 kN, 120 kN, 120 kN, 100 kN, 125 kN, 130 kN respectively. compared to the control specimen GO reinforced specimens the load carrying capacity was increased due to the compact and dense structure of the composite. the first crack load of the specimen is delayed due to the tough and compact structure. the first crack load of the S1,S2,S3,S4,S5 and S6 specimens are 30 kN, 50 kN, 65 kN, 40 kN, 55 kN, 75 kN respectively. the ultimate load and first crack load and of the specimens are shown in Figure. Maximum width of crack observed for S1, S2 and S3 specimens are 3mm, 3.1 mm and 2.9 mm respectively and Maximum width of crack observed for S4, S5 and S6 specimens are 4 mm, 3.5 mm and 1.3 mm respectively. the maximum width and number of cracks of GO reinforced composites of M20 grade concrete was less compared to the control specimen. due to the Pore filling effect of GO reinforced composites forms dense and compact structure which leads enhanced toughness to the beam. GO reinforced M30 grade concrete the number of cracks slightly high among 12 number of cracks 6 number of cracks are of hair line cracks and the width of cracks are also less.

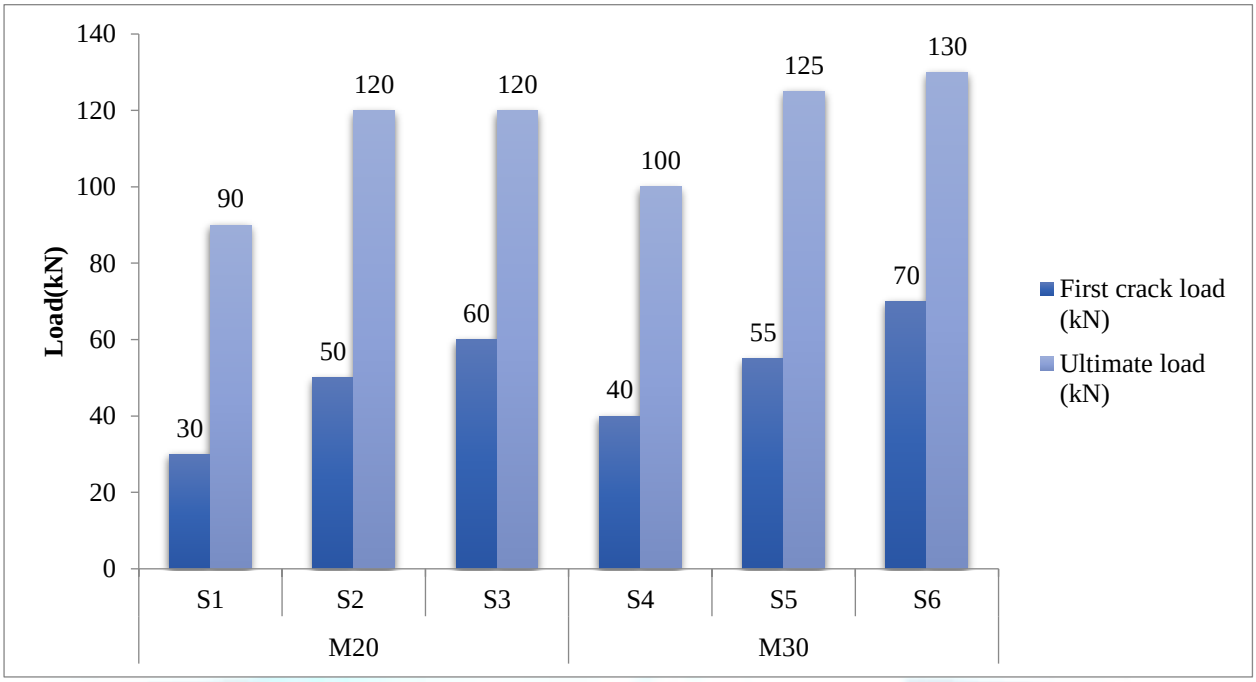

Figure 13.Comparison of first crack load and ultimate load of S1, S2, S3, S4, S5 and S6 Specimens

3.7 Energy absorption capacity

The toughness of the beam specimen is assessed by energy absorption capacity and is expressed by area under load deflection curve. Graphene oxide reinforced cement composites enhances the toughness of the composites and it increases the load carrying capacity and energy absorption capacity of the specimen. The energy absorption capacity of the beam specimens S1,S2,S3,S4,S5 and S6 are 338.25 kNmm,839.7 kNmm,813.55 kNmm,370 kNmm,1430 kNmm,1370.55 kNmm. The energy absorption capacity of the specimen was shown in Figure. due to the composite and dense structure the number of cracks are gradually reduced. the number of cracks for the specimens S1,S2,S3,S4,S5 and S6 are shown in Figure 14.

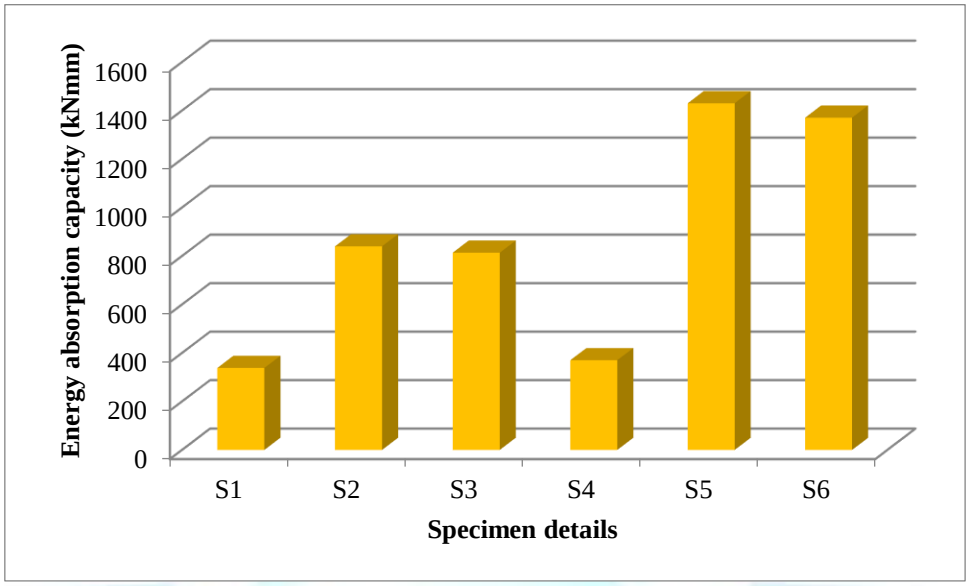

Figure 14. Energy absorption capacity

4. Conclusion

The increase in compressive strength of graphene reinforced specimen for M20 grade concrete was 9.35%, 16.83% for 7 days and 28 days. For M30 grade concrete the increase in compressive strength for graphene fabricated specimen was 52.8%, 42.6% for 7 days and 28 days. cube and R.C beams were reinforced with Graphene oxide of 0.06% by wt. GO reinforced specimens accelerates early age strength their after the compressive strength was stable. Incorporation of GO in cement composites increases the toughness of the composite. due to the enhanced toughness the compressive strength, ultimate load and energy absorption capacity of the specimen was increased. the first crack load of the specimen is delayed due to the dense and compact structure. compact and dense structure of GO reinforced composites enhances the toughness of the composites and increases the ultimate load carrying capacity and energy absorption capacity of the specimens. The increase in load carrying capacity of the S1,S2,S3,S4,S5 and S6 specimens are 90 kN, 120 kN, 120 kN, 100 kN, 125 kN, 130 kN respectively. Ductile mode of failure was observed for all the specimens.

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