PERFORMANCE STUDY OF ARTIFICAL AGGREGATE ON RC FLEXURAL MEMBERS

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Abstract- The building industry is growing daily in our nation. Sand, aggregate, and other natural resources are needed for that. Natural resources like sand and aggregate are in demand. In order to meet this need, we must look for other sources. One way to address the aforementioned issue is to use artificial aggregate in concrete. In order to achieve so, artificial aggregate production is implemented.. In this project, crusher waste from quarry dust was used to create artificial aggregates. Artificial aggregates were generated in the ratios of 1:1, 1:2, and 1:3 using the pelletization method, which involves varying the amounts of cement and waste material quarry dust. Subsequently, the prepared artificial aggregates undergo testing to determine their strength properties, including specific gravity, water absorption test, sieve analysis, impact test, abrasion test, and aggregate crushing test. Using the IS approach, the conventional aggregate concrete mix has been created for the M20 grade of concrete.
Ultimately, the ideal proportion of artificial aggregate flexural member is compared to the regular aggregate of flexural member to determine the flexural strength.

Keywords – GFRP, quarry dust, fineness modulus, impact resistant, abrasion and crushing test

I. INTRODUCTION

In the twenty-first century, reducing and recycling trash and byproducts has become crucial. One of the main topics of interest for researchers these days is the development of novel waste management systems. This is because there is a need to reuse materials in order to prevent depleting the plentiful natural resources that come with an increasing population. Owing to Additionally, lightweight concrete lowers the building's overall cost.
Typically, clays, siliceous rocks, pumice, or volcanic cinders are used to make lightweight aggregates. Organic A brief discussion of some of the methods employed by the researchers in this work to create light-weight aggregates from trash and byproducts has been provided. Quarry dust was selected as the material for this project in order to.

MATERIAL USED

1.1 Cement

In the presence of water, cement can be defined as a material possessing cohesive and adhesive qualities that enable it to join mineral fragments into a compact whole and solid. The composition and qualities of the ordinary Portland cement used were in line with the standards established by the Nigerian Standard Organization for the manufacturing of concrete. As indicated in Table 4.1, ordinary Portland 53 grade cement with a specific gravity of 3.15 was utilized as a binder.

Table 1.1 **Properties of Cement**

S.NO	Description	Resu lts
1	Specific gravity	3.15
2	Initial setting time	28 Minu tes
3	Standard consistency	36%

1.2 Fine aggregate

Fine aggregate is defined as river sand that is less than 4.75 mm in size and falls under IS 383-1970 zone II. Fine aggregate underwent laboratory testing to ascertain its physical characteristics in accordance with IS: 2386 part (III), as indicated in Table 4.2. River sand is typically used over crushed sand because the former has particles that have been completely worn down by attrition, lowering the water content of the mixture and providing less resistance to pumping..

1.3 Coarse aggregate

Coarse aggregate is one of the concrete filler materials, and its role in the concrete is very important. Aggregate affect the properties of concrete, so the selection of aggregates is an important part in the making of concrete mix. Fine aggregate is generally small while coarse aggregate is the larger one which retained on sieve No.4 (4.75mm) as shown in Table 4.3.

Quarry dust

S.NO	Descript ion	Result
1	Specific gravity	2.65
2	Fineness modulus	2.61

A quarry is a location where slate, riprap, sand, and/or dimension stone have been removed from the earth for construction purposes. An open pit mine used for extracting minerals is the same as a quarry. The term "quarries" is a frequent term used to describe open pit mines that produce dimension stone and construction materials. This is the only minor distinction between the two. The term "quarry" can also refer to the process of mining underground for stones like bath stone. As seen in Figure 4, several quarry stones, including marble, granite, and limestone, are cut into big slabs and taken from the quarry.

Figure 4.1 quarry dust

1.4.1 Physical properties of quarry dust

Table 1.4 Physical Properties of Quarry dust

Constituent	Quarry dust
SiO_2	62.48
Al_2O_3	18.72
Fe_2O_3	6.54
CaO	4.83
MgO	2.56
Na_2O	Nil

1.4.2. Chemical properties of quarry dust

Durable concrete buildings are made using a combination of pozzolan or regular Portland cement and quarry dust. Quarry dust offers higher durability for concrete, allowing buildings to last between 50 and 100 years. Production of Portland cement, high-quality enhanced slag cement, and ready-mixed or site-batched durable concrete with a typical content of 30–70% cement quarry dust. They work best when the quarry dust is of high quality, while interior quality concrete surface two has occasionally seen success with them.
Depending on service circumstances, even high-quality concrete need treatment renewals every year or more.

II. PREPARATION OF ARTIFICIAL AGGREGATE

The formation of artificial aggregates is involved following steps

- Initially take the ratio of 1:1, 1:2 and 1:3 quarry dust and cement (binder material) are mixed well in the concrete mixer and then water is sprayed on it.
- Due to rotary motions the wetted quarry dust particles form of small seed. With increase in duration, the size of aggregates increases in duration due to agglomeration.
- The pellets grow into larger size due to gain in mass and are discharged from the rotating disc.

Property	Quarry dust
Specific gravity (kg/m3)	2.54-2.60
Bulk relative density	1720-1810
Absorption (%)	1.2-1.5
Moisture content (%)	Nil
Fine particle less than 0.075mm (%)	12-15
Sieve analysis	Zone II

3.1 MIX DESIGN

The process of choosing concrete materials and figuring out their proportions in order to produce concrete with the least amount of strength and durability in the most cost-effective manner is known as mix design. Any mix proportion method's goal is to find a cost-effective way to combine the various components of concrete in a first trial batch to create a concrete that strikes a good balance between the many desirable qualities of concrete at the lowest feasible cost.

3.2 Mix ratio of concrete

Table 3.1 Mix ratio of concrete

2.3 SPECIMEN PREPARATION

3.1 Preparation of the mould

The cube and cylinder test molds had inside faces that were milled planar and were constructed of plywood. Using nuts and bolts, the mould's faces were all put together and attached to the base plate. The mold's internal angles must all be ninety-one degrees. Mold oil needs to be applied thinly to the faces to stop leaks during filling.

Material	**Artificial aggregate (Proportion)**	**Mix proportion**
Quarry dust	P1	1:1.58:2.1
	P2	1:1.58:2.0
	P3	1:1.58:2.0
conventional	C	1:1.58:2.0

Figure 3.1 Preparation of the mould

Table 3.2 Size of specimen

3.2 Mixing

Through mixing of material is essential for the production of uniform course. The mixing should ensure that the mass become homogenous, uniform in colour and consistency. In this project hand mixing is adopted. This Figure shows 5.3 in artificial aggregate mixing

Figure 3.2 Mixing

3.3 Casting

Concrete is mixed and then immediately poured into the molds to fill them. To prevent trapped air inside the concrete cubes and a honeycombing effect on the sidewalls, concrete is filled in three layers and thoroughly compressed using a standard-sized tamping rod. For efficient and cost-effective use, it is preferable to prevent wasting concrete when pouring. Little trowels are used to gather the concrete that is coming out of the mold during pouring in

Type of mould	**Size in mm**
Cube	150x150x150
Cylinder	150x300
Beam	1100x 100x150

order to prevent waste, and they are then used again in this procedure.

Figure 3.4 casting

3.4 Compaction

The method used to release the trapped air in the concrete is called compaction. Air may become trapped in the concrete throughout the mixing, moving, and placement processes. The amount of air trapped increases with decreasing workability. Applying hand compaction using a tamping rod

3.5 Demoulding

After a full day of molding, the test cube specimen is demolded. In the event that the concrete has not solidified enough to permit demoulding without causing harm to the cube specimen, the procedure needs to be postponed for an additional 24 hours, as seen in Figure 5.5. It is important to take precautions to avoid breaking the specimen during the procedure because doing so could weaken the concrete.

Figure 3.5 Demoulding

3.6 Curing

Following compaction, the test material was preserved in this state for a full day. Following that time, the molds were taken out, and the specimens were stored in a regular curing tank for a total of 28 days to cure. The cylinder cast for the compression test and split tensile strength is seen in Figure 5.6. Curing concrete entails preserving moisture in the concrete's body for the first several years and beyond in order to give it the strength and durability that are needed.

Figure 5.6 Curing

IV Compressive strength

Concrete's compressive strength is measured by casting 100 mm x 100 mm x 100 mm cubes made from leftover quarry dust, which was used to substitute artificial aggregates. The specimens were demolded and allowed to cure in water after a full day. After 28 days of moist curing, specimens were removed from the curing tank and tested. The specimen was tested in accordance with IS: 516-195 ultimate load, as illustrated in figure 5.7. The concrete's compressive strength is calculated by dividing the load at failure by the specimen's area

4.1 Spilt tensile strength

The spilt tensile strength of concrete is determined by casting cylinders size 150mm×300mm. after 24 hours the specimen were demoded and subjected to water curing. Thecylinder was tested by placing them uniformly. Specimen was taken out from curing tank at ageof 28 days of moist curing and then the specimen was tested. The specimen was tested accordingto IS: 516-1959, the failure of the cylinder is a narrow direction as shown in Figure 5.10.

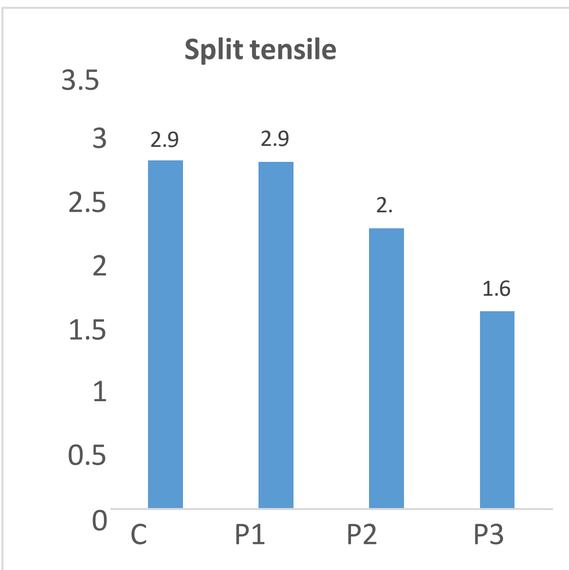


Figure 4.6 Split tensile strength

The spilt tensile strength test result shown in graph. The spilt tensile strength after 28 days, generally increase with decrease in the percentage replacement for artificial aggregates a P3 is respectively.

Table 4.2 Split tensile strength for 28 days

Mix proportion	Split tensile strength (N\mm^2)
Conventional	2.98
P1	2.97
P2	2.40
P3	1.69

4.2 Bonding strength of artificial aggregate

The pull-out test specimen, which had dimensions of 300 mm in length and 100 mm in diameter with a single piece of 12 mm-diameter HYSD bar inserted horizontally in the middle of the cylinder, was ready for the bond strength test as indicated in Figure 5.13. In the center of the specimen, the rebar and concrete come into contact.

4.3 Test setup for pull out test

The pull-out test was carried out in compliance with ASTM C 234-91a guidelines. A 1000KN capacity universal testing apparatus was used to conduct the test. The specimen was positioned on the UTM's upper cross head. The bottom cross head clamped down firmly on the length of the steel bar that protruded from the specimen. This arrangement was subjected to a load that increased monotonically, pushing the concrete with the higher head moving upward and the steel rod remaining stationary. As a result, the specimen included a pull-out mechanism. The pull-out load is the amount at which the reinforcement separates from the test concrete specimen..

Table 5.6 HYSD bars

Mix proportion	Load (kN)	Ultimate bond stress (N/mm^2)
C	33	6.1

P1	34	8.2
P2	34	5.1

Totally 30 specimens were casted for p1 p2 & p3 of replacement of quarry dust artificial aggregates. Those specimens were tested for compressive strength and split tensile strength. From the result the optimum percentage replacement of artificial aggregate is identified. Then RC beams were casted for the optimum percentage obtained from the above test. Three beams were casted for optimum percentage, four beam is for flexural strength of artificial aggregates .All the beams were tested for flexure under UTM of capacity 1000kN. These beams were tested on an effective span of 1000mm with simply supported conditions under two point loading. Deflection was measured under the mid span using dial gauge.

Flexure Beam Design

Grade of concrete : M20

Length of beam : 1100mm

Effective span length : 1000mm

Breath of beam : 100mm

Depth of beam : 150mm

Loading method : Two point load

End condition : Simply supported Beam

Reinforcement Detailing

The reinforcement detailing for the beam to be tested for flexural behavior

Cross section and longitudinal section of flexure member

Preparation of beam

The raw materials for concrete mixes already described in the previous section were mixed by machine mixing. The steel mould were prepared and lubricated with oil before the concrete was poured. The reinforcement bars were cut to the required lengths. The longitudinal bars and stirrups were secured to each other at correct spacing by means of binding wires.

A mixing time of 3 to 5 minutes was given to ensure uniform mixing. Steel moulds were used to cast the beams. The beam was demoulded after 24 hours and cured for 28 days. After curing, the beams were kept for 24 hours in a dry state. After drying they were cleaned with a sand paper to remove all grit and dirty. Then all the beams were prepared by white washing to all sides. White washing was done to facilitate easy detection of crack propagation

Load deflection characteristics of beam

In constructions site, there are a lot of materials structure are used. Reinforcement concrete structure is the most often used in construction because it's give many advantages when compare with other material structure. Example

of the advantages are it can stand when load in compression or tension, thermal compatibility, ductile and durability. Reinforcement concrete structure was maintained their strength after 28 days until its life time if there is no failure occurred. For example, when reinforcement steel corrodes, the rust will expand and spread tends to crack, flake and loose in bonding between the steel and concrete. Cracking can flow water into the concrete and make the reinforced steel seriously corrode. Besides that, poor design and inadequate reinforced steel will allow the crack with under excess load or internal effect.

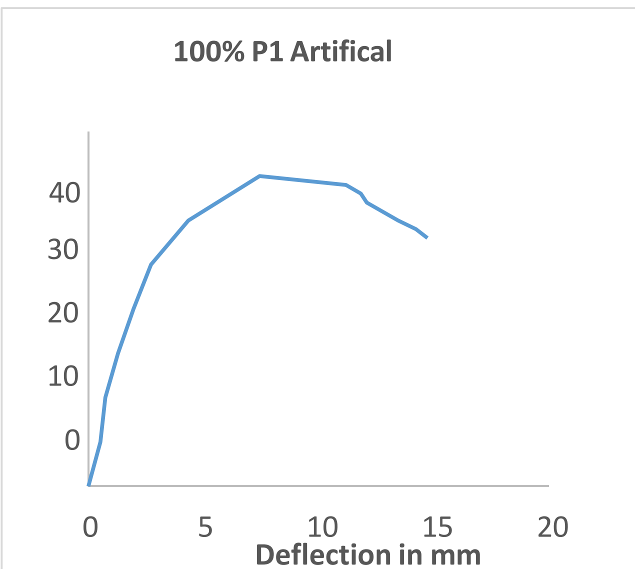
Experimental test set-up for beam specimens

A total of four beams were cast. Those which one beam was caste for control beam M20 grade and remaining were cast with optimum percentage for quarry dust aggregate. All the beams are tested for flexure in universal testing machine of capacity 1000KN. The effective span of 1000mm with simply supported condition under two point loads. Deflection was measured under the mid span using dial gauge. The load is gradually increased at an increment rate of 5KN the crack patterns were also recorded and load VS deflection curve

LOAD DEFLECTION BEHAVIOUR OF FLEXURE MEMBER

Conventional beam load deflection curve

conventional beam of load deflection curve is compare with flexure strength of another three different categories of the load deflection curve to be determined as shown in Figure 6.3



Quarry dust aggregate of beam load deflection curve

This is 100% replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam. This is 100% replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam is load is decreasing and deflection is increasing. Decreasing and deflection is increasing as shown in Fig

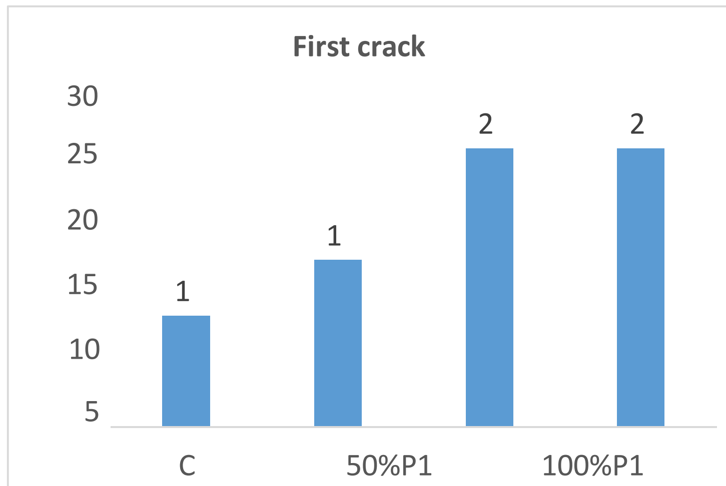
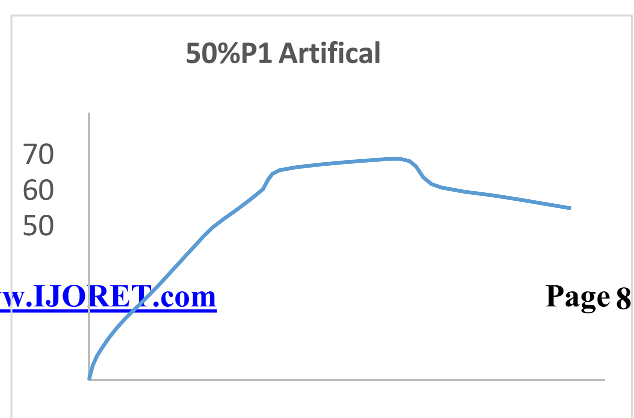


Figure 6.4 Load Vs Deflection of 100% artificial aggregate beam

6.1.1Quarry dust aggregate of beam load deflection curve

This is 50% replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam is load is decrease. This is 50% replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam is load is decreasing and deflection is increasing as shown in Figure 6.5



40
30

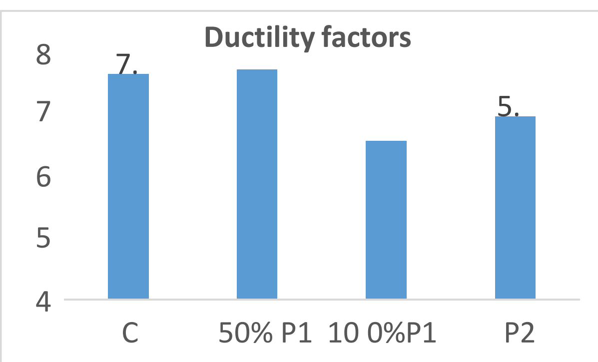
20
10
0 0 5 10 15

Figure 6.5 Load Vs Deflection of 50% artificial aggregate beam

6.1.1 Quarry dust aggregate of beam load deflection curve

This is P2 replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam is load is increase. This is P2replacement of artificial aggregate to be using RC beam the load deflection curve which is compare to conventional beam is load is decreasing and deflection is increasing

6.1.2 Combined load deflection curve for beam



6.1.1First crack load

Two point static loads were applied on all beams and each load increment of 5kN deflection was noted. In control beam initiation of crack take place at load of 10kN. For 50% replacement of quarry dust aggregate proportion p1 takes the first crack load of 15kN. For 100% replacement of quarry dust aggregate proportion p1 takes the first crack load of 25kN. For quarry dust aggregate p2 proportion takes the first crack load of 25kN

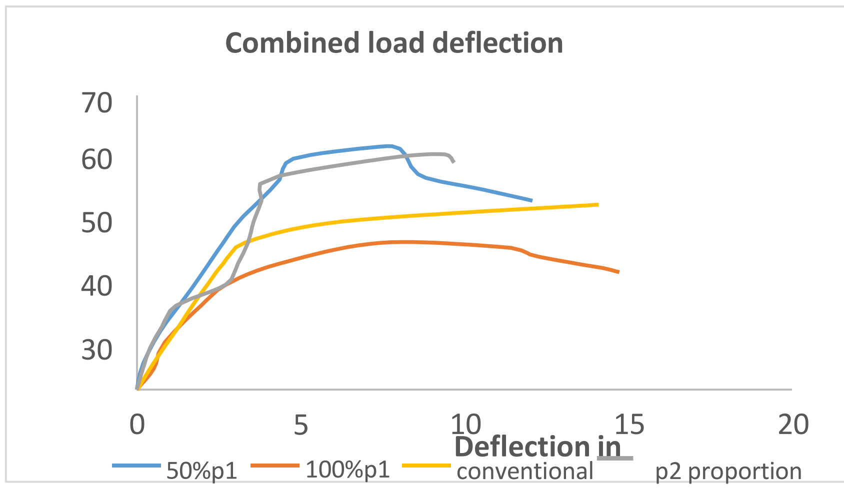


Figure 6.8 first crack load for artificial aggregate RC beam

6.1.1Ultimate load

The control beam was loaded up to their ultimate load. It was noted that all the beams hashigher load compared to the control beam as shown in Figure 6.9. In control beam, ultimate failure took place at a load of 44kN. In beam 100% of quarry dust

aggregates proportion p1 the ultimate load

was 35kN. In beam 50% of quarry dust aggregates proportion p1 of ultimate load 58KN. In beam p2 proportion of quarry aggregates of ultimate load 56KN

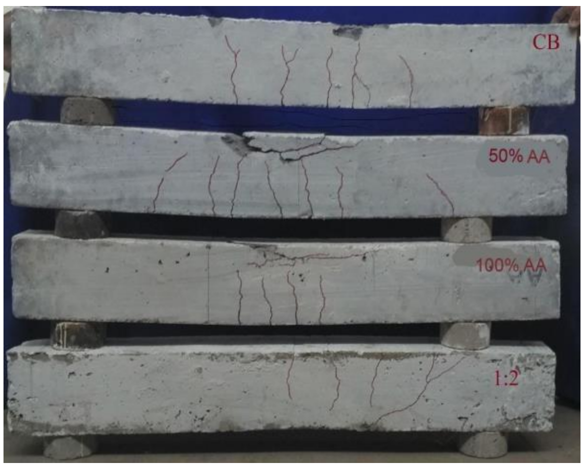


Figure 6.9 Ultimate load carrying capacity

Ductility factor

Ductility is the ratio between deflections at ultimate load to that at the onset of yielding. Ductility factor 50% of quarry dust proportion p1replacement of aggregates were high when compare to conventional beam .

Stiffness

Stiffness is defined as the force applied on the body for a unit displacement. Stiffness for quarry dust aggregates less than when compare conventional specimen as shown in Figure6.11

6.3.0 Energy absorption

The artificial aggregate beam exhibits an increase in energy absorption capacity with reference to conventional beam specimen. The energy absorption capacity was found to comparewith conventional beam the energy will increase with quarry dust aggregate beam

Mode of failure

Flexural failure was observed for all the beam specimen in the reinforced concrete beam the crack were compartively more but the crack width was small and the elongation of the cracks were also not much higher. The cracks were first formed at the bottom tension face of the specimen which then propogated to the compression face and the crushing of the concrete take place at top of the specimen when load reaches its ultimate level where the failure of specimen takes place the failure patterns of all members as shown in Figure 6.13

Figure 6.13 Tested beams of crack patterns

NUMERICAL INVESTIGATION

For many engineering problem theoretical solution are not suitable because of the complexity of the boundary condition, the material properties and the structure. The Ansys is the representation of a body or a structure by an assemblage of subdivisions. Ansys is a software which gives approximate results on analysis of structural elements

INTERPRETATION OF RESULTS

The obtained result of the members with Ansys of conventional beam as shown in Figure
7.1 and 7.2 respectively

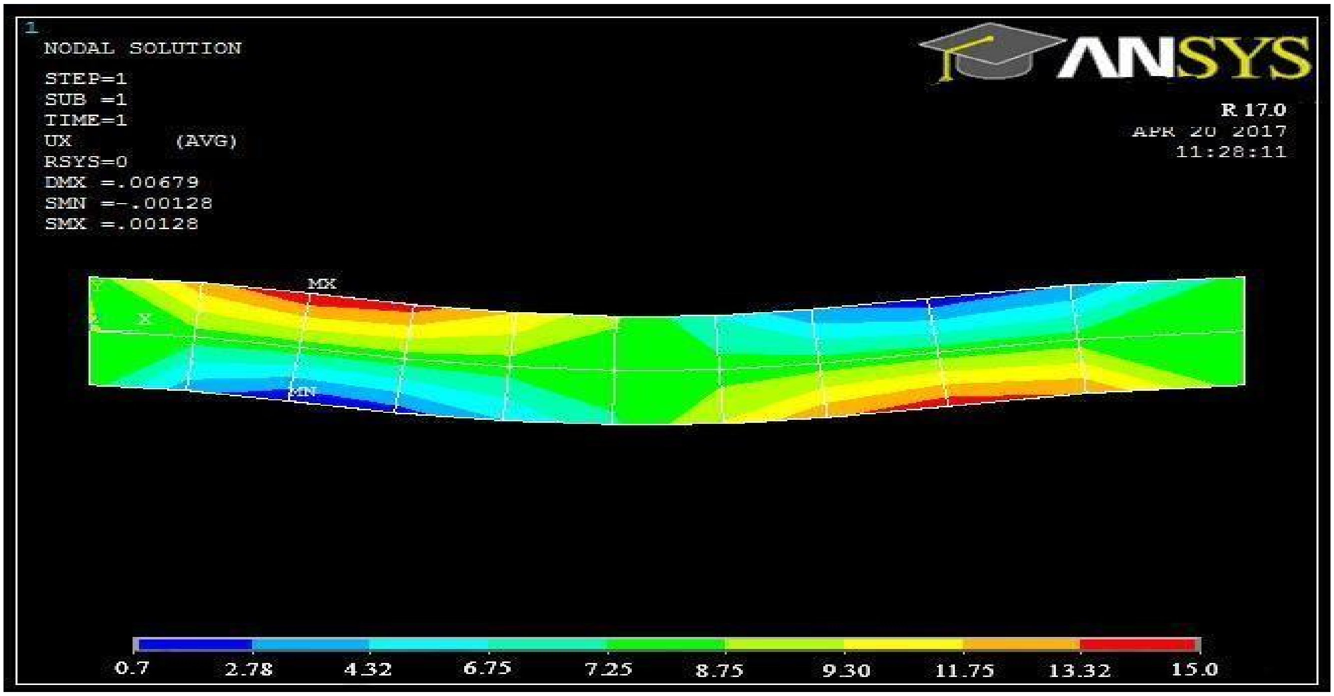


Figure 7.1 Deflection of conventional RC beam for ultimate load

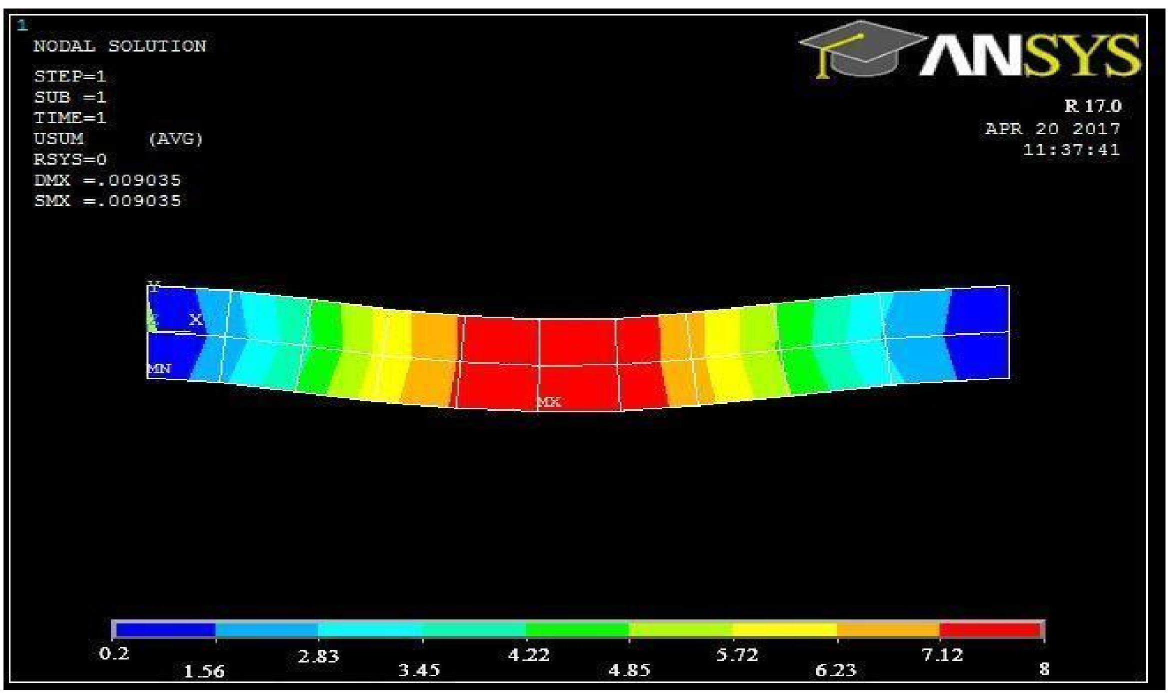


Figure 7.2 Deflection of p1- proportion (50%) of artificial aggregate for ultimate load

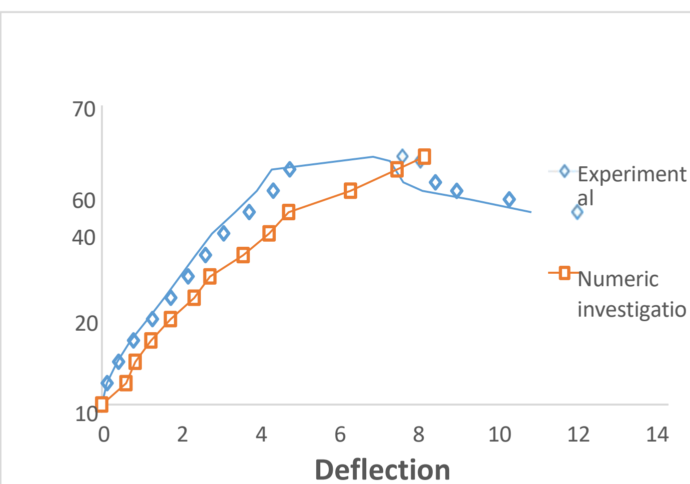
The results from the numerical analysed conveyed that both the member had slight increase in the maximum deflection when compared with the experimental result.

Table 7.1 Comparison of maximum deflection of conventional beam and 50%p1 proportion of artificialaggregate beam for ultimate load

Specimen	Experiment investigation	Numerical investigation
conventio nal	14mm	15mm
50% p1 proportion	6.5mm	8mm

CONCLUSIONS

The load vs. deflection behaviour comparison of both experimental and numerical analysis of the both conventional and p2 proportion artificial aggregate beam specimen are plotted and are shown in Figure 7.3 respectively



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