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Research Article

MODULUS OF ELASTICITY FOR BASALT FIBRE REINFORCED RECYCLE AGGREGATE CONCRETE

Ranganath M[1]., Sashidhar C[2] and Venkata Ramana N[3]*

[1] Department of Structural Engineering, JNTUA, Ananthapuramu, A.P (State), India
[2]Department of Civil Engineering, JNTUA, Ananthapuramu, A.P (State), India
[3]Department of Civil Engineering, U.B.D.T College of Engineering, Davangere, Karantaka (State), India

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A B S T R A C T

This article presents the Modulus of Elasticity's (Initial Tangent (E_{IT}), Tangent (E_{TM}) and Secant Modulus (E_{SM})) for basalt recycles aggregate concrete. In the experimental work the recycle aggregate is used in place of natural aggregate in the proportion of 0,25,50,75 and 100% with and without incorporation of basalt fibers. The fibers were added to the recycle aggregate concrete at 4% by volume of the cast specimen. The mixes without addition of fibers were taken as reference mixes. Total 30 cubes and 30 cylinders were cast and tested to obtain compressive strength and modulus of elasticity's for various mixes. The obtained results are compared with IS456-2000 Code provision. Regression models are also deduced to suit the experimental data and also checked its validity. The results found that the strengths are increasing for 25 and 50% RAC and for 75 and 100%RAC are reducing. For basalt fiber incorporation mixes the strengths are increasing for corresponding mixes. The effective replacement for RAC mixes with and without basalt fiber is noticed at 50%.

INTRODUCTION

Reinforced Concrete (RC) structures have become more popular in last few decades due to the wide availability of construction materials, relatively low cost and ease of construction. With RCC structures dominance, concrete became most familiar and preferred material of construction. As its prominence increased, more research was carried out which lead to evolution of different types of concretes for different scenarios. These different types of concretes were obtained by either chemical additions or material replacements which can be partial or full. Different types of concretes were developed for two major reasons, first was to improve properties and behaviour of concrete. Secondly, to see that minimum natural resources were utilised without compromising on properties of concrete. Some of these different types of concretes were developed by keeping sustainability as major goal, which consume minimum natural resources but give required properties for their usage. Recycled aggregate Concrete is one of them. In this type of concrete coarse aggregate is replaced with recycled aggregate and every other raw material remains same.

As mentioned earlier, different types of concretes were developed for two major reasons, first was to improve properties and behaviour of concrete. Secondly, to see that minimum natural resources were utilised without compromising on properties of concrete. Recycled aggregate comes in latter group. Basalt fibres addition for recycled aggregate concrete is one of the ways to see that concrete produced using recycled aggregate has good material properties in order to use it for practical purpose.

These fibres were added to see improvement in elastic properties of the composite material under study. Modulus of Elasticity which is also known as Young's modulus is a measure of the stiffness of a solid material. It is a mechanical property of linear elastic solid materials. It defines the relationship between stress (force per unit area) and strain (proportional deformation) in a material. A solid material will deform when a load is applied to it. If it returns to its original shape after the load is removed, this is called deformation. The Young's modulus enables the calculation of the change in the dimension of a bar made of an isotropic elastic material under tensile or compressive loads. For instance, it predicts how much a material sample extends under tension or shortens under compression. The Young's modulus directly applies to cases of uni-axial stress, that is tensile or compressive stress in one direction and no stress in the other directions. The present experimental work was focused to evaluate the young's modulus of recycle aggregate concrete with and without addition of basalt fibres. For this the cylinders were cast and tested in the laboratory by applying uni-axial stress. Before

Corresponding author:* **Venkata Ramana N
Department of Civil Engineering, U.B.D.T College of Engineering, Davangere, Karantaka (State), India

going to detailed experimental work a recent past literature is presented below to know the scenario.

Amnon Katzstudied (2003) studied the properties of the recycled aggregate and of the new concrete made from it, with nearly 100% of aggregate replacement. Significant differences were observed between the properties of the recycled aggregates of various particle size groups, while the crushing age had almost no effect. M.L.V Prasad and P. Rathish Kumar (2007) studied the mechanical properties of GFRAC with M20 &M40 grade concretes, for different proportions of Recycled Concrete Aggregate (RCA). It was observed that there was 10-17% increase in split tensile strength and about 10-14% improvement in flexural strength with fiber addition in recycled aggregate concrete. There is an improvement in modulus of elasticity of concrete. M.Cauccio *et al*. (2008) have taken three Series of concretes with different compressive strength levels. Each series includes a reference concrete prepared with natural crushed stone and two RAC prepared with two coarse aggregates obtained by crushing a normal strength and high strength concrete,RAC present lightly lower strengths (1-15%), lower modulus of elasticity (13-18%) and prepared with natural coarse aggregates. Takafumi *et al*. (2009) performed statistical analysis on more than 3000 tests, a practical and universal equation for the evaluation of the elastic modulus *E* is proposed. E. Lopez-Gayrre *et al*.(2009) presented the results of experimental research using concrete produced by substituting part of natural coarse aggregate with recycled aggregate from concrete demolition. The elastic modulus is affected by the percentage of replacement. If the percentage of replacement does not exceed 50%, the elastic modulus will only change slightly. Akaninyene A *et al*. (2012) examined the effect of periwinkle shell ash (PSA) as supplementary cementations material on the compressive strength and static modulus of elasticity of concrete with a view to comparing its established relation with an existing model. The compressive strength and static modulus of elasticity were observed to increase with increased in curing age but decreased with increasing PSA content. N.Krishna Murthy *et al*.(2012) presented the effect of metakaolin on the modulus of elasticity of concrete has been presented. The results concluded that, the value of Young's modules increase from 0% upto 10% of metakaloin and then decrease. Jayesh kumar R *et al*. (2013) studied the effect of concrete mixtures were produced to determine the influence of hypo sludge. The cement has been replaced by fly ash and hypo sludge accordingly in the range of 0% (without fly ash and hypo sludge), 10%, 20%, 30% & 40% by weight of cement for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of modulus of elasticity with the conventional concrete and they concluded that Modulus of elasticity decreases with % replacement of fly ash and hypo sludge. J. AlexandreBogas and Augusto Gomes (2014) aimed to characterize the elastic modulus of structural modified normal density concrete (MND) and lightweight aggregate concrete (LWAC) produced with different types of expanded clay lightweight aggregates (LWA). K.Anbuvelan and K.Subramanian (2014) provided the information on the relationship between experimentally obtained modulus of elasticity, modulus of rupture and compressive strength of concrete and steel fibre concrete at 28 days. K. Krizova and R. Hela (2015) studied the modulus of elasticity as function of compressive strength. The lowest mean value of elastic modulus was 26 000 N/mm2 while maximum one was 43 000 N/mm2. The difference of elastic moduli can be well seen for instance with concrete compressive strength moving on the limit of 64.0 N/mm2. He Gao *et al*. (2015) found the influence of the modified recycled aggregates to the mechanical properties of the concrete. The results indicated that the recycled aggregates can reduce the compressive strength, split tensile strength and elasticity modulus. G.CibiJeyanth *et al*. (2016) used the industrial waste and to reduce the cement usage in the concrete by using the Ground Granulated Blast Furnace Slag (GGBS), Metakaolin and copper slag. P.S. Kulkarni *et al*. (2016) determined elastic properties of reinforced cement concrete material. V.S.Sethuraman and K.Suguna (2016) conducted the experimental study to evaluate modulus of elasticity of M60 grade concrete using standard cylinder specimens, tested with compress meter under axial compression**.** Dilbas.H *et al*. (2017) conducted experimental study on the axial compressive behaviour of FRP-confined RAC in which 18 FRP-confined RAC cylinders were tested. The test results show that specimens with a replacement ratio of 20% behave similarly to that of normal concrete, but specimens with a replacement ratio of 100% exhibit a lower strength and a different stress-strain response. Rizgar S *et al*. (2017) aimed in developing an empirical equation to evaluate the modulus of elasticity for High Strength Concrete (HSC). More tests are required to finalize the developed equation, which cover all the parameters influencing modulus of elasticity in the produced HSC. From the above it came to know that, no work has been taken on Young's modulus of basalt fibre reinforced concrete. Hence experimental program is planned to evaluate modulus of elasticity's of concrete and the detained program is furnishing below.

Test Programme

The experimental program consists of 30 cubes and 30 cylinders. Cubes are taken for compressive strength evaluation and cylinders are used to know stress strain responses. Total 10 mixes are considered for experimental works and for each mix three specimens were cast and tested. The average of three specimens result was taken as strength of mix. Cylinders were tested in universal testing machine and dial gauge was used to find strains. The stress stain diagram was plotted for the mixes and young's modulus was found from the graphs. Here in three different types of young's modulus are evaluated, first one is initial tangent modulus (at initial state of stress), second one is tangent modulus (at 50% of ultimate load) and third is secant modulus (at 85% of ultimate load). For all the mixes the concrete was designed for M20 grade concrete as per ACI 211 code. Among the many codes, form the past literature it is observed that the ACI code is best, hence here ACI code provisions are used for mix design. The mix proportions are presented in Table 1.In the Table1, the nomenclature can understand as the first three letters indicated as type of concrete(NAC is Natural aggregate concrete and RAC indicates Recycle aggregate concrete), next two/three numerical values are indicated as % of replacement of natural aggregate by the recycle aggregate.

Table 1 Mix proportions of concrete (Kg/m3)

Sl.No	Nomenclature	Mix Proportion for various mixes	
		0% Basalt Fibre(BF)	4% Basalt fibre (BF)
1	NAC-0	1:2.64:2.96	1:2.64:2.96
2	RAC-25	1:2.69:2.91	1:2.69:2.91
3	RAC-50	1:2.76:2.84	1:2.76:2.84
4	RAC-75	1:2.80:2.80	1:2.80:2.80
5	RAC-100	1:2.81:2.79	1:2.81:2.79

Material Used

The following material were used for the present experimental work

***Cement**:* Ordinary Portland cement conforming to IS 8112:1989 was used. The specific gravity of the cement was noticed as 3.12.

***Fine Aggregate**:* Locally available river sand passing through 4.75 mm I.S .Sieve is used. The specific gravity of the sand is found to be 2.75 and it was conformed to zone II.

***Natural Coarse Aggregate**:* Crushed granite aggregate available from local sources has been used. To obtain a reasonably good grading, 60% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 40% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used in preparation of NAC and RA. The specific gravity of the combined aggregate is 2.70.

Recycled concrete aggregate: The raw material of Recycled concrete aggregate was obtained from demolished cement concrete pavement. The generated waste material was is not able to use as it is, as coarse aggregate in the concrete. So there is a need to develop as graded aggregate to use in concrete. To convert the waste as coarse aggregate the waste material was transported to crusher unit and made as 20 and 12.5 mm aggregate. This can be viewed in figure 4.1 and finished product (after crushed) depicted in figure. Two different sizes were obtained from the waste material, so as to use the material effectively. To obtain a reasonably good grading, 50% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 50% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used. The specific gravity of combined aggregate was observed as2.56.

***Water**:* Potable fresh water available from local sources was used for mixing and curing.

***Basalt Fibers**:* The used basalt fiber can be viewed in below figure1. The properties are presented in the below Table 2, which were obtained from the supplier.

Fig 1 Basalt Fiber

Table 2 Physical properties of Basalt Fibers

Sl. No	Property	Units	Value
1	Equivalent length	Mm	50
2	Filament diameter	Micro meter	9-15
3	Specific gravity	No units	2.8
4	Tensile strength	MPa	3000-4840
5	Young's modulus	GPa	79.3-93
6	Ultimate elongation	%	3.1

Casting and Testing

The standard cubes (150x150x150 mm) and cylinders (150mm diameter and 300mm height) were taken for the experimental work. All the materials which are required for fabrication is weighed as per mix design and kept a side separately. The cement, sand, coarse aggregate, fibres and recycle aggregate were mixed thoroughly till to reach uniformity to the concrete mix. For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds and the compaction was adopted by mechanical vibrator. The moulds were removed after twenty four hours and the specimens were de-moulded and were exposed to water bath for 28 days in curing pond. After curing the specimens in water for a period of 28 days, the specimens were taken out and allow drying under shade. Three cubes and cylinders were cast for each mix. Compression test on cubes is conducted with 1000 kN capacity of compressive testing machine (figure 1). Cylinders are tested in Universal Testing Machine (UTM) for evaluating the stress strain response (figure 2). From the stress strain curves the modulus of elasticity is determined by subjecting the cylindrical specimen to axial compression and measuring the deformation by means of a dial gauge. The load on the cylinder is applied at a constant rate up to the failure of the specimen. Dial gauge reading divided by gauge length will give the strain and load applied divided by area of cross section will give the stress. A series of readings are taken and the stress-strain relationship is developed. From the stress strain responses, the initial tangent modulus (tangent at lower stage stress), tangent modulus at 50% of ultimate load (UL) and secant modulus at 85% of ultimate load (UL) was calculated and the results are presented in the next section.

Fig 2 Test set up for Cube

Fig 2 Testing of Cylinder

TEST RESULTS AND DISCUSSION

Cube compressive strength

The cube compressive strength results are presented in Table 3. Form this it is noticed that, the compressive strengths increases with the increase in the percentage of recycled up to 50%. For 25, 50 recycled concrete aggregate there is an increase in compressive strength about 4.59%, 11.2% and for 75,100% recycled aggregate there is a decrease in compressive strength about 0.9, 4.2% respectively over reference concrete. From the same table it also observed that, for fiber added mixes, the compressive strength increases at every % of recycled concrete aggregate. In general mechanical properties of concrete (flexure, shear, split tensile strength etc) are related to cube compressive strength. More impotence is given to cube compressive strength. At present the cube compressive strength is depends on % of RAC and basalt fibers. Hence here in the authors would like to develop regression models to estimate the compressive strength as function of cube compressive strength. From this intension the models is developed and the same was furnished below. The performance of regression models are presented in Table 3. From this table it is noticed that, the experimental values are varying about ±10%. From the results it is noticed that the proposed models are made good agreement with the experimental results.

f_{ck}=33.277+0.0135296(R) +0.57306(BF) ……eq(1)

Where
f_{ck}= 28 days cube compressive strength in MPa
R= Recycled aggregate concrete in %
BF= Basalt Fiber in %

Table 3 Compressive Strength (MPa)

Sl.No	Mix	Average Cube Compressive Stress (MPa)					
		0% Fibre			4% Fibre		
		Based on Experiment (EXP)	Based on Regression Model (RM)	EXP/ RM	Based on Experiment (EXP)	Based on Regression Model (RM)	EXP/ RM
1	NAC	33.30	33.28	1.00	36.77	35.57	1.03
2	RAC-25	34.83	33.62	1.04	37.33	35.91	1.04
3	RAC-50	37.03	33.95	1.09	38.33	36.25	1.06
4	RAC-75	33.60	34.29	0.98	36.00	36.58	0.98
5	RAC-100	31.90	34.63	0.92	32.50	36.92	0.88

Modulus of Elasticity (ME)

The stress stain curves for various mixes can be viewed in figure 3 and 4 for 0% and 4% basalt fibers respectively. Here in the main attention is to evaluate the three modulus of Initial tangent (at lower stresses), Tangent (at 0%UL) and Secant modulus (at 85%UL) for various mixes. The initial tangent modulus is determined by using tangent drawn at initial state of stresses (figure 4) to the stress-strain curve and the slope of the tangent will gives the Modulus of elasticity. The tangent Modulus is determined by drawing a tangent through the selected point on the stress-strain curve. In the present experimental work tangent modulus is calculated by using tangent drawn at 50% of ultimate load (figure 4) and slope of the tangent gives the tangent modulus. The secant tangent is drawn (figure 4) by joining the origin to the point on the curve 85% of ultimate load the slope of is tangent is known as secant modulus. The initial tangent modulus, tangent modulus and secant tangent modulus values are shown in the Table 4 and figure 6. From those table and figure it is observed that, initial tangent, tangent modulus and secant modulus of elasticity values increases up to 50% RAC in the concrete mix. Above 50% RAC the modulus of elasticity is decreases as it was noticed in the compressive strength of concrete. For RAC -50 there is percentage increase in initial tangent(E_{IT}) modulus, tangent modulus (E_{TM}) and secant modulus(E_{SM}) by 21.78, 12.58, and 7.92% respectively over NAC (without addition of fibres). For RAC100 the % of decrease for initial tangent modulus (E_{IT}), tangent modulus (E_{TM}), secant modulus (E_{SM}) is 19.47, 7.5 and 2.97% respectively over NAC for 0% basalt fibre. For RAC -50 there is percentage increase in initial tangent modulus (E_{IT}) , tangent modulus (E_{TM})and secant modulus (E_{SM}) is about 3.47, 9.00 and 6.38% respectively over NAC for 4% basalt fibre. For RAC100 there is % decrease for initial tangent modulus (E_{IT}) , tangent modulus(E_{TM}) , secant modulus (E_{SM}) is around 28.11,1.34 and 4.47% respectively over basalt fibre reinforced NAC.In general secant modulus is less than the initial tangent and tangent modulus. But in this experimental work the tangent modulus is less than the other two modulus because the stress strain curves are convex at intermediated state, this may be due to the failure in the inter face of recycle aggregate and natural aggregate and also the cement paste adhering capacity for recycle aggregate concrete is less when compared with natural aggregates.

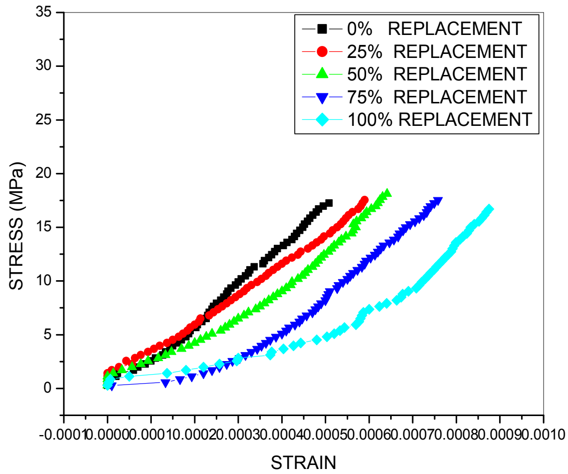

Fig 3 Stress – Strain response of 0% of Fibre

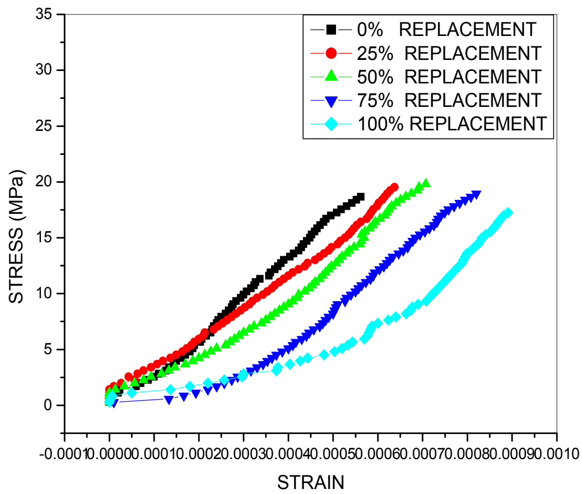

Fig 4 Stress – Strain response of 4% of Fibre

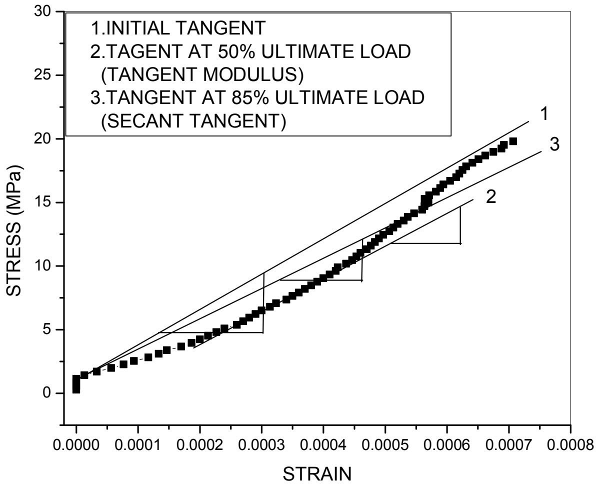

Fig 5 Tangents at various locations

Table 4 Modulus of Elasticity (10^4MPa)

Sl.No.	Mix	0% FIBER			4% FIBER		
		E_{IT}	E_{TM}	E_{SM}	E_{IT}	E_{TM}	E_{SM}
1	NAC	3.03	2.78	3.03	3.45	2.98	3.13
2	RAC-25	3.33	2.98	3.12	3.53	3.12	3.19
3	RAC-50	3.69	3.13	3.27	3.57	3.24	3.33
4	RAC-75	3.02	3.03	2.99	3.12	3.08	3.02
5	RAC-100	2.44	2.57	2.94	2.48	2.84	2.99

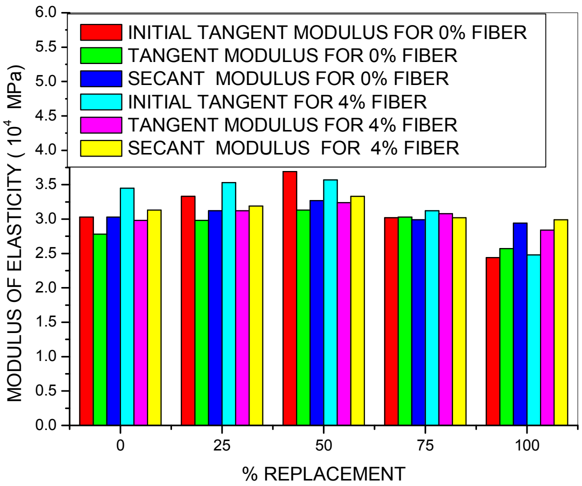

Fig 6 Modulus of Elasticity vs %RAC

Regression Models for Modulus of Elasticity's

The IS 456-2000 code has provided an equation [$E_c=5000(f_{ck})^{0.5}$] to estimate the initial tangent modulus for conventional concrete. Herein the authors would like to test the validity of the IS equation for RAC concrete. In this concern the IS equation was tested with experimental date and found that it is varying about 27% (Table 5). Hence, it is necessary to reduce the % variation for RAC mixes, in this concern a new regression model was developed and the performance of was presented in Table 5. From this it is noticed that, the proposed model was suited and the variation among the experimental and regression model (RM) is within 20%. To evaluate tangent and secant modulus, the IS code not mention any suitable equations, hence here it is proposed to develop regression models for tangent and secant modulus by using the existing equation of modulus of elasticity (E_c) in the IS456 code. The proposed regression model (RM) equations are

E_{IT}= -12.869+5.473(5000$\sqrt{f_{ck}}$)..........eq(2)

E_{TM}= -3.856+2.314(5000$\sqrt{f_{ck}}$)...........eq(3)

E_{SM} = 2.605+0.1632(5000$\sqrt{f_{ck}}$)……..eq(4)

Where

E_{IT} = initial tangent modulus in MPa

E_{TM} = tangent modulus of elasticity in MPa

E_{SM}= secant modulus in MPa

f_{ck}= Cube compressive stress(MPa) of concrete at 28 days (can use of eq(1))

The performance of Regression Models (RM) for tangent and secant modulus of elasticity's can be observed in Table 6. Form this it noticed that the ratio between experimental results and the proposed models are varying about ± 8%. This shows as the proposed models are well associated with experimental data.

Table 5 Comparison of Initial Modulus of Elasticity

Sl.No	Mix	Modulus of Elasticity (10^4 MPa) 0% Fiber					4% Fiber				
		Exp E_{IT}	E_{IT}	E_C	Exp $E_{IT}:E_{IT}$	Exp $E_{IT}:E_C$	Exp E_{IT}	E_{IT}	E_C	Exp $E_{IT}:E_{IT}$	Exp $E_{IT}:E_C$
1	NAC	3.03	2.92	2.88	1.04	1.05	3.45	3.45	2.98	1.16	1.05
2	RAC-25	3.33	3	2.9	1.11	1.15	3.53	3.53	3	1.18	1.14
3	RAC-50	3.69	3.08	2.91	1.2	1.27	3.57	3.61	3.01	1.19	1.26
4	RAC-75	3.02	3.16	2.93	0.96	1.03	3.12	3.68	3.02	1.03	1.03
5	RAC-100	2.44	3.23	2.94	0.76	0.83	2.48	3.76	3.04	0.82	0.82

Table 6 Performance of Regression Model (RM)

Mix	Tangent and Secant Modulus of Elasticity's (10^4MPa) 0% Fiber						4% Fiber					
	Exp E_{TM}	RM E_{TM}	(Exp: RM)E_{TM}	Exp E_{SM}	RM E_{SM}	(Exp: RM) E_{SM}	Exp E_{TM}	RM E_{TM}	(Exp: RM)E_{TM}	EXP E_{SM}	RM E_{SM}	(Exp: RM) E_{SM}
NAC	2.78	2.82	0.99	3.03	3.08	0.99	2.98	3.04	0.98	3.13	3.09	1.01
RAC-25	2.98	2.85	1.04	3.12	3.08	1.01	3.12	3.08	1.01	3.19	3.09	1.03
RAC-50	3.13	2.89	1.08	3.27	3.08	1.06	3.24	3.11	1.04	3.33	3.1	1.08
RAC-75	3.03	2.92	1.04	3.03	3.08	0.98	3.08	3.14	0.98	3.02	3.1	0.97
RAC-100	2.84	2.95	0.96	2.94	3.09	0.95	2.94	3.17	0.93	2.99	3.1	0.96

CONCLUSIONS

The following conclusions are drawn for the present experimental work.

1. The compressive strength and modulus of elasticity's are increasing up to 50% RAC and for above 50% of RAC in mix the compressive strength decreases.
2. As the % of basalt fibres increases for the RAC mixes the compressive strength and modulus of elasticity's are increasing.
3. A secant module of elasticity is more than the tangent modulus of elasticity for all mixes of RAC.
4. A regression models were developed for initial tangent, tangent and secant tangent modulus of elasticity and performance of regression models are varying about±8%.
5. For RAC -50 there is percentage increase in cube compressive strength, initial tangent(E_{IT}) modulus, tangent modulus (E_{TM}) and secant modulus(E_{SM}) by 11.20, 21.78, 12.58, and 7.92% respectively over NAC and for 0% basalt fiber.
6. For RAC -100 there is percentage decrease in cube compressive strength, initial tangent modulus (E_{IT}), tangent modulus (E_{TM}), secant modulus (E_{SM}) 4.2,19.47,7.5 and 2.97% respectively over NAC for 0% basalt fiber.

7. For RAC -50 there is percentage increase in cube compressive strength, initial tangent modulus (E_{IT}), tangent modulus (E_{TM}) and secant modulus (E_{SM}) 4.24,3.47,9 and 6.38% respectively over NAC for 4% basalt fiber.
8. For RAC -100 there is percentage decrease in cube compressive strength, initial tangent modulus (E_{IT}), tangent modulus(E_{TM}), secant modulus (E_{SM}) 11.62,28.11,1.34 and 4.47% respectively over NAC for 4% basalt fiber

References

1. Akaninyene A. Umoh, K. O. Olusola, 2012.Compressive strength and static modulus of elasticity of periwinkle shell ash blended cement concrete. *International Journal of Sustainable Construction Engineering & Technology*,Vol 3,pp 18-22
2. Amnon Katz, 2003. Properties of concrete made with recycled aggregate from partially hydrated old concrete. Cement and Concrete Research. Vol.33,pp703-711
3. E. Lopez-Gayrre, P. Serna, A. Domingo-cabo, M. A. serrno Lopez, C.Lopez-colina, 2009. Influence of recycled aggregate quality and proportioning criteria recycled concrete properties. Waste management, 29,pp3022-3028
4. G.CibiJeyanth, N.Sakthieswaran, G.Shiny Brintha and O.Ganesh Babu.2016.Modulus of Elasticity and Flexural Strength of Concrete with Industrial By-Products. *International Journal for Research in Applied Science & Engineering Technology* (IJRASET).vol 4, pp 424-425
5. He Gao1, Guoping Wu and Xiaowen Yuan.2015. Experimental Research on Mechanical Properties of Recycled Aggregate Concrete with Different Modification Methods, 3rd International Conference on Material. *Mechanical and Manufacturing Engineering*. Vol 27. Part 1-3
6. Jayeshkumar R. Pitroda, Dr F S Umriga, 2013. Evaluation of Modulus of Elasticity of Concrete with Partial Replacement of Cement by Thermal Industry Waste (Fly Ash) and Paper Industry Waste (Hypo Sludge). *International Journal of Engineering Science and Innovative Technology* (IJESIT).Volume 2, pp 133-138.
7. J. Alexandre Bogas,Augusto Gomes, 2014 .Static and dynamic modulus of elasticity of structural lightweight and modified density concrete with and without nanosilica-characterization and normalization. *International Journal of Civil Engineering* (Transaction A: Civil Engineering),Vol. 12, No. 2,pp 268-278
8. K.Anbuvelan, Dr.K.Subramanian.2014. Experimental investigations on Elastic Properties of Concrete containing Steel fibre. K.Anbuvelan *et al*. / *International Journal of Engineering and Technology (IJET*). pp 1625-1629
9. K. Krizova, R. Hela.2015. Evaluation of static modulus of elasticity depending on concrete compressive strength. World Academy of Science. Engineering and Technology *International Journal of Civil and Environmental Engineering* Vol:9, No:5,pp 654-657
10. M.Cauccio, M.C.Torrijos, G.Giaccio, R.Zerbino, 2008. Failure mechanism of recycled aggregate concrete. Construction and Building Materials,22,pp1500-1506
11. M.L.V Prasad and P. Rathish Kumar.2007. Strength studies on glass fibre reinforced recycled aggregate concrete. *Asian Journal Of Civil Engineering* (Building And Housing) Vol 8, No 6,pp 677-690
12. Nihal P P, ShinuShajee.2017.Experimental Studies on Steel and Basalt Fiber Reinforced Concrete, *International Journal of Innovative Research in Science. Engineering and Technology.* vol 6. pp 6753-6761.
13. N.Krishna Murthy, A.V.Narasimha Rao, M.Vijaya Sekhar Reddy, P.Pamesh. Nov 2012. The Influence of Metakaolin on the Modulus of Elasticity of Concrete. Vol 2.pp 18-23.
14. P.S.Kulkarni, A.Ghatge, O.Kank, A.Nair and R.Aswar.2016. Experimental Investigation on Modulus of Elasticity of Recycled Aggregate Concrete. *International Journal of Earth Sciences and Engineering*. Vol. 09, No. 03, pp. 415-419
15. Rizgar S. Amin1 and Dr Samal M. Rashied, 2017. Evaluation of modulus of elasticity for high strength concrete using aggregates in Iraq. *Kufa journal of engineering,* vol. 8, no. 1,pp 108-118
16. R.Kumutha and K.Vijai, 2010. Strength of concrete incorporating aggregates recycled from demolition waste. ARPN *Journal of Engineering and Applied Science.* No 5,Vol 5,pp 1419-1423
17. Takafumi Noguchi, FuminoriTomosawa, Kamran M. Nemati, Bernardino M. Chiaia, and Alessandro P. Fantilli, 2009. A Practical Equation for Elastic Modulus of Concrete. *ACI Structural Journal*,pp 690-696
18. V.S. Sethuraman, K. Suguna, 2016.Computation of Modulus of Elasticity of High Strength Concrete using Silica Fume. *Asian Journal of Applied Sciences*, Volume 04,pp 54-62.

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