International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 457-461 www.ijaem.net ISSN: 2395-5252

Finite Element Analysis of Scrap Aluminum Wire Reinforced Concrete

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Date of Submission: 20-06-2020 Date of Acceptance: 06-07-2020

ABSTRACT: Recently, fiber reinforcement in concrete is frequently being used to improve its mechanical performance. Use of scrap aluminium wires as reinforcement in concrete will ensure positive effect on environments by scrap reduction in addition to improving mechanical properties. In this study, scrap aluminium wire is used as reinforcement in concrete. The percentage of scrap aluminium wire is taken as 0%, 1%, 2% and 3% with fine aggregate in the preparation of samples. Modeling was done for cube, beam and cylinder with the help of finite element analysis on ANSYS Software 20.The mechanical properties such as compressive strength, flexural strength and splitting tensile strength are analyzed for normal concrete as well as wire reinforced concrete. With the help of finite element analysis, it was found that mechanical performance of scrap aluminium wire reinforced concrete was increased up to 2% of wire reinforcement when compared with normal concrete results.

KEYWORDS: Concrete, Wire reinforcement, Scrap aluminium wire, Finite element analysis, Mechanical performance.

I. INTRODUCTION

In the past, many researchers have studied to calculate the mechanical behaviour of scrap electrical wire reinforced concrete by experimentally or by using simulation analysis on software, they have reported that by using scrap electrical wire in concrete, capacity to withstand load was increased which prevents fracture of concrete structure besides scrap wire is also increased tensile strength of wire reinforced concrete [1], [2]. Sree Rameswari et al 2018 describes that flexural performance of rubberized concrete was improved by using finite element analysis on ANSYS Software [7]. Satya Prakash et al 2016 explain the modulus of elasticity of RC structure through finite element analysis on ANSYS Software [10]. Mostafa jala studied that by using scrap fibres obtained from milling and Machining in concrete increased the compressive strength of concrete. Meddah and Bencheikh investigated that by using metallic and polypropylene fibres with different lengths in a concrete, compressive strength decreased by 1.5% [6], [12]. Yung et al. 2013 investigated that by using 5% scrap tyre rubber powder as a replacement of fine aggregate to produce self-compacting rubber concrete (SCRC) by which Compressive strength and durability enhanced [13]. Zheng et al. investigated the damping properties of rubberized concrete. Damping properties of concrete can be increased by replacing 20% fine aggregate with shredded rubber. These researchers studied that damping properties increased while compressive strength decreased [14]. Wanget. al. 2000 have found that by using recycled fibres including tire/wire, steel and wood fibre, the mechanical properties of fibre reinforced concrete such as compressive strength, flexural strength, impact strength, tensile strength and shear strength can be improved [5], [8]. Zheng et al. have found that by replacing up to 20% of the fine aggregate with shredded rubber, damping capacity was increased while compressive strength decreased [14]. Asia S. Hameed and A.P. Shashikala 2016 investigated that by increased 14% of fine aggregate with crumb rubber, fatigue failure load and impact resistance can be improved [11], [16], [17]. Aluminium is a lightweight and less corrosive material than steel. According to International Aluminium Institute, there is an approximate 17 million tonnes of aluminium scrap accumulated worldwide, which will be increase to roughly 21million by 2020 [6], [3]. Aluminium wire is used invarious commercial as well as residential applications and scrap form of this wire is dangerous to the environment so recycling of aluminium wire is very important.

In this research, scrap aluminium wire reinforced concrete model was analyzed by using finite element analysis through ANSYS Software 20 and determine the fundamental mechanical properties for compressive, tensile and flexural

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strength at different percentage of wire reinforcement (0%, 1%, 2% & 3%).

II. FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is a computer based simulation analysis to solve a complex problem by using some designing software such as ANSYS and MATLAB software. Finite element analysis (FEA) is an effective technique to determining the performance of reinforced concrete. Finite element analysis involves of making geometry of model, meshing, apply boundary conditions, solver, post-processing and results analysis [7], [18]. Flow diagram of ANSYS software is given below:

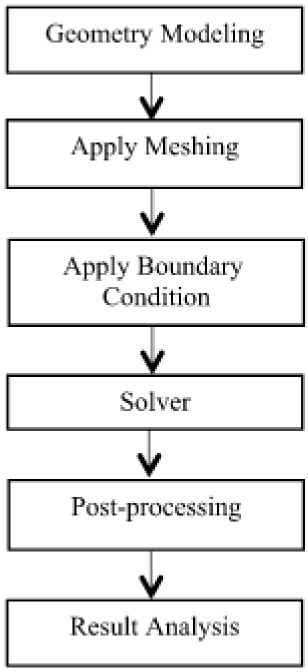


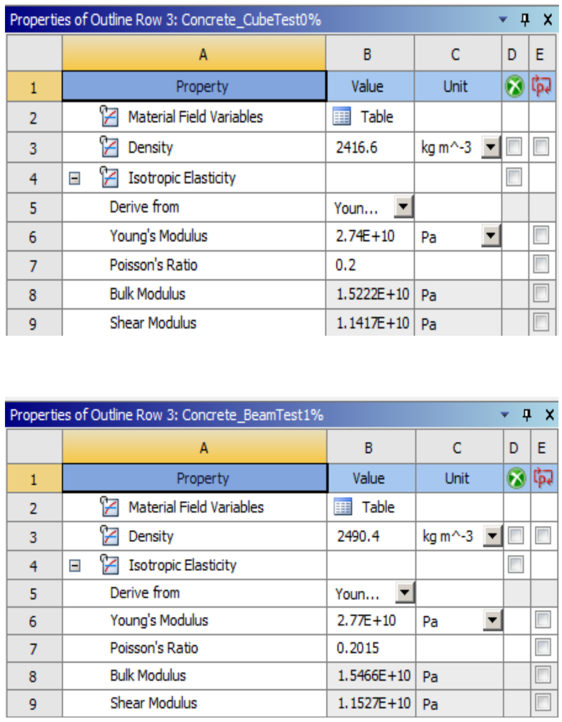
Figure 1. ANSYS Software flow diagram.

III. MATERIAL PROPERTIES

For analysis on software, materials properties for each mixture of concrete are required and modulus of elasticity and poisson's ratio of reinforced concrete and normal concrete at different percentage of wire reinforcement (WR) was determined with the help of rule of mixtures which is given in Table 1 [4], [18].

Table 1. Properties of materials.

Material properties	0% WR	1% WR	2% WR	3% WR
Young's modulus(GPa)	27.4	27.7	28	28.3
Poisson's ratio	0.20	0.2015	0.203	0.205



Properties of Outline Row 3: Concrete_CubeTest0%

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	2416.6	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Youn...			
6	Young's Modulus	2.74E+10	Pa		
7	Poisson's Ratio	0.2			
8	Bulk Modulus	1.5222E+10	Pa		
9	Shear Modulus	1.1417E+10	Pa		

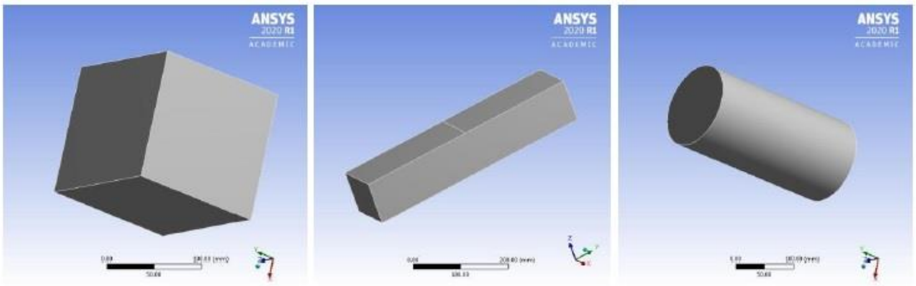
Properties of Outline Row 3: Concrete_BeamTest1%

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	2490.4	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Youn...			
6	Young's Modulus	2.77E+10	Pa		
7	Poisson's Ratio	0.2015			
8	Bulk Modulus	1.5466E+10	Pa		
9	Shear Modulus	1.1527E+10	Pa		

Figure 2. Properties of materials.

IV. MODELING

In this step, CAD model for cube, cylinder and cuboid are done in ANSYS Software 20 by using geometric tool which is available in any design software. Dimensions of cube, cylinder and cuboid are 150 mm x 150 mm x 150 mm, 150 mm x 300 mm, 100 mm x 100 mm x 500 mm respectively. The geometric model is given in figure 3 [9], [15].

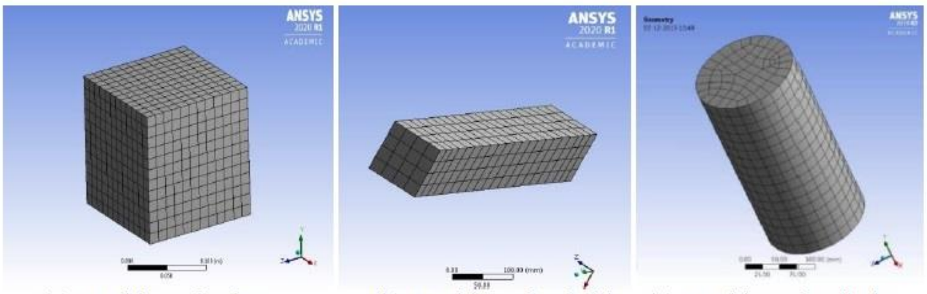


(a) Model of cube (b) Model of cuboid (c) Model of cylinder

Figure 3. Geometric modeling.

V. MESHING

Meshing involves division into small pieces of the entire model with the help of tool available in any FEA software. The goal is to make a mesh that accurately captures the models with high-quality cells [18]. The meshing on models is shown in Figure 4.



(a) Meshing of cube (b) Meshing of cuboid (c) Meshing of cylinder

Figure 4. Meshing on Models

VI. RESULTS AND DISCUSSION

Finite element analysis is carried out on ANSYS Software 20 on models which are shown in figure. Compressive strength, flexural strength and tensile strength of models were determined through software and the results of this analysis are given below:

Compressive Strength Results

Compressive strength of cube model is carried out for different wire reinforcement which is given in Figure 5 and Table 2.

Table 2. Compressive strength for cube model (MPa).

Percentage of WR	0%WR	1%WR	2%WR	3%WR
Compressive strength	31.669	34.487	36.432	35.32

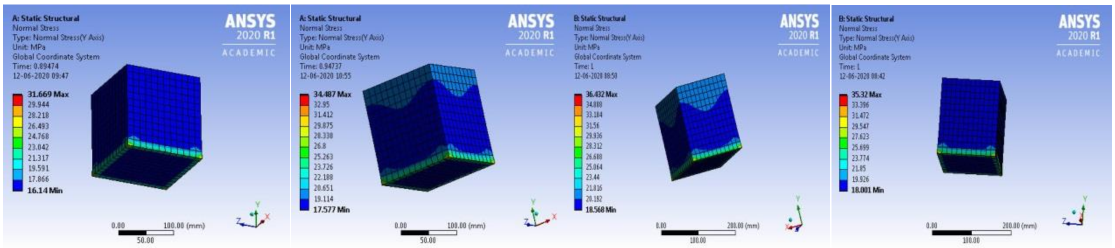


Figure 5. Compressive strength of cube models.

Flexural Strength Results

Flexural strength for beam model of Al wire reinforced concrete as well as normal concrete is given in Figure 6 and Table 3.

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Table 3. Flexural strength for beam model (MPa).

Percentage of WR	0%WR	1%WR	2%WR	3%WR
Flexural strength	4.124	6.6251	7.9502	7.2877

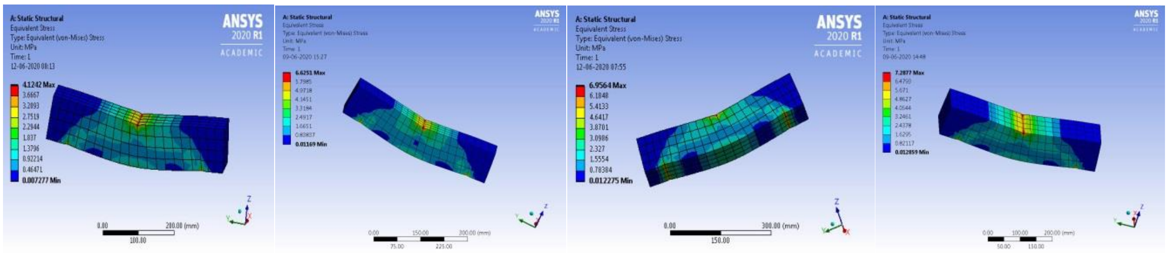

Figure 6. Flexural strength of beam model.

Tensile Strength Results

Tensile strength for cylindrical model of Al wire reinforced concrete as well as normal concrete is given in Figure 7 and Table 4.

Table 4. Tensile strength of cylindrical model.

Percentage of WR	0%WR	1%WR	2%WR	3%WR
Tensile strength	3.3144	4.6995	5.5652	5.0705

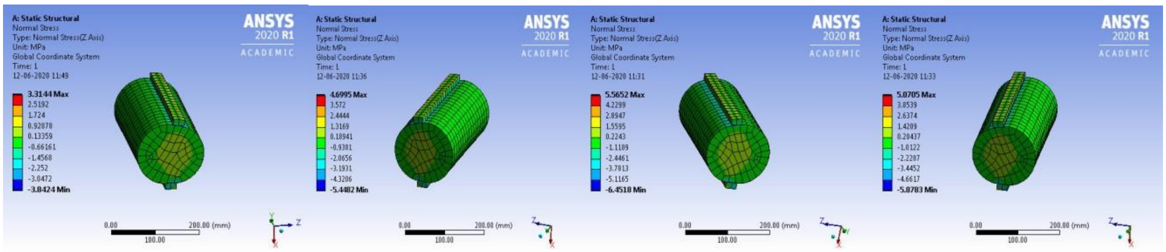

Figure 7. Tensile strength of cylindrical model.

With the help of finite element analysis, it was found that mechanical properties of reinforced concrete were increased up to 2% of scrap wire reinforcement due to better bonding between wire and concrete matrix as shown in figure but on further increasing wire dosage (3% wire reinforcement), mechanical properties start decreasing because bonding between wire and concrete matrix become poor. Maximum compressive, flexural and tensile strength was obtained at 2% wire reinforcement which was 36.432 MPa, 7.9502 MPa and 5.5652 MPa respectively.

VII. CONCLUSION

In this study, finite element analyses was carried out through ANSYS Software 20 for normal concrete as well as scrap Al wire reinforced concrete and conclusion of this analysis is given below:

a) Compressive strength of scrap Al wire reinforced concrete was increased by 8.9%, 15.04% and 11.53% when compared with cube model for 0% wire reinforcement.

b) Flexural strength of scrap Al wire reinforced concrete was increased by 60.64%, 92.77% and 173.7% when compared with cuboid model for 0% wire reinforcement.

c) Tensile strength of scrap Al wire reinforced concrete was increased by 41.8%, 68% and 52.98% when compared with cylinder model for 0% wire reinforcement.

Hence, by this analysis, it could be concluded that mechanical properties of wire reinforced concrete were increased by using scrap aluminium wire as reinforcement in concrete structure which is beneficial for reducing scrap which is harmful to the environment

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