FLEXURAL ANALYSIS OF RUBBER COMPOSITE RCC BEAM IN ABAQUS CAE

Gokul E [1], Sundari S [2]

P.G. Scholar, Department of Civil Engineering, Government College of Engineering, Salem, Tamil Nadu, India [1]

Associate Professor, Department of Civil Engineering, Government College of Engineering, Salem, Tamil Nadu, India [2]

ABSTRACT: This paper deals with the Flexural Analysis of RCC Rubber Mat Composite Beam using Abaqus CAE Software. PVC rubber mats are a type of floor mat that combines the properties of polyvinyl chloride (PVC) and rubber. PVC is a synthetic plastic material known for its durability, flexibility, and resistance to moisture, chemicals, and abrasion. we going to use Rubber-mat to resists some plastic deformation by reducing the Plastic Strain and increasing the Flexural Strength of Structural Beam. By analysing the model Beam with Rubber mat as composite material in various position as various trails to find which trail gives a good result in Bending moment and Plastic strain when compare to Conventional RCC beam using Abaqus CAE software.

KEYWORDS: **RCC RUBBER MAT COMPOSITE BEAM, ABAQUS CAE.**

I. INTRODUCTION

Composite materials: Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties. The combination of these materials creates a new material with improved or unique properties that are not present in any of the individual components alone. The goal of using composite materials is to achieve a combination of desirable characteristics such as strength, stiffness, low weight, corrosion resistance, and durability. Types of composite materials include Fiber Reinforced Composites, Particulate Composites, Structural Composites, Laminar Composites.

Polyvinyl chloride (PVC) rubber mats: Polyvinyl chloride (PVC) rubber mats are commonly used as floor coverings in various settings due to their durability, flexibility, and resistance to moisture and chemicals. PVC is a type of thermoplastic polymer, and its mechanical properties, including plastic strain, play a crucial role in determining the mat's performance. PVC exhibits both elastic and plastic behaviour. When stress is applied within the elastic limit, PVC deforms temporarily and returns to its original shape when the stress is removed. If the applied stress exceeds the elastic limit, the material undergoes plastic deformation, resulting in a permanent change in shape.

Literature review

1. Flexural strengthening of reinforcement concrete beams using high performance fiber reinforcement cement-based composite (HPFRCC) and carbon fiber reinforced polymers (CFRP) - Vladimir José Ferrari a,⇑, João Bento de Hanai b, Rafael Alves de Souza a - This paper presents a strengthening method using a combination of high-performance fiber reinforced cement-based composite (HPFRCC) and carbon fiber reinforced polymers (CFRP). For evaluating the performance of this approach, reinforced concrete (RC) beams strengthened with CFRP sheets have been tested to failure.

2. Mechanical Behaviour of Steel Fiber-Reinforced Concrete Beams Bonded with External Carbon Fiber Sheets - Viktor Gribniak 1,*, Vytautas Tamulenas 1, Pui-Lam Ng 1,2, Aleksandr K. Arnautov - This study investigates the mechanical behaviour of steel fiber-reinforced concrete (SFRC) beams internally reinforced with steel bars and externally bonded with carbon fiber-reinforced polymer (CFRP) sheets. The CFRP sheets were fixed to the concrete surface by epoxy adhesive as well as combined with various configurations of small diameter steel pins.

3. Strengthening of Concrete Beams Using Innovative Ductile Fiber Reinforced Polymer Fabric - Nabil F. Grace, George Abdel-Sayed, and Wael F. Ragheb - The objective of this paper is to introduce a new pseudo-ductile FRP fabric that has a low strain at yield so that it has the potential to yield simultaneously with the steel reinforcement, yet provide the desired strengthening level.

4. Fatigue behavior of stud shear connectors in steel and recycled tyre rubber-filled concrete composite beams - Qing-Hua Han 1,2, Yi-Hong Wang 1, Jie Xu □1,2 and Ying Xing - This paper extends our recent work on the fatigue behavior of stud shear connectors in steel and recycled tyre rubber-filled concrete (RRFC) composite beams. A series of 16 fatigue push-out tests were conducted using a hydraulic servo

testing machine. Three different recycled tyre rubber contents of concrete, 0%, 5% and 10%, were adopted as main variable parameters. Stress amplitudes and the diameters of studs were also taken into consideration in the tests.

II. METHODOLOGY

1) Literature collections
2) Selection of material properties
3) Design of Model RCC beam in ABAQUS CAE
4) Assembling and Loadings for Four-point Loading test of RCC beam
5) Analysing Rubber mat placed as single layered composite
6) Analysing Rubber mat placed as Double layered composite
7) Comparing Conventional and Rubber Composite trails
8) Results and Conclusions

III.MATERIAL PROPERTIES

1) Concrete:

Property values are taken from tested design mixed concrete

Density : 2.4x10-9 N/mm3

Youngs Modulus : 22360 Mpa

Yield stress : 20 Mpa

Poison Ratio : 0.2

2) Fe415 TMT Steel bars:

Density : 7.6x10-5 N/mm3

Youngs Modulus : 200000 Mpa

Yield stress : 415 Mpa

Poison Ratio : 0.3

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 02 | February - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

3) PVC Rubber Mat:

Property values are taken from the Research Paper

“Buffer Moisture Protection System” by Author Jutta peura

Density : 1.419x10-9 N/mm3

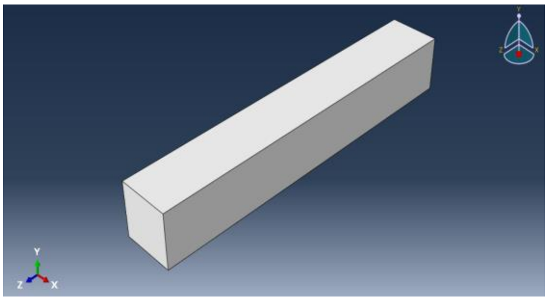
Youngs Modulus : 2.8344 Mpa

Yield stress : 0.08827 Mpa

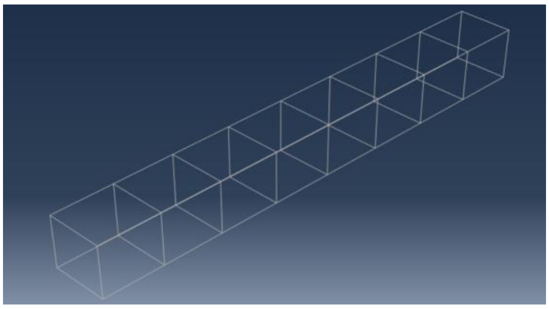
Poison Ratio : 0.42

Property	ASTM Test Method	Units	PVC
Physical			
Density	D 792	kg/m³	1419
Water Absorption	D 570	%	0.06
Cell Class	1784	-	12454-B
Rockwell Hardness	D 785	R scale	115
Shore Durometer	D 2240	D	89
Mechanical			
Tensile Modulus	D 638	bar	28.344
Yield Strength	D 638	bar	0.5172
Flexural Modulus	D 790	bar	33.172
Yield Strength	D 790	bar	0.8827
Izod Impact	D 256	ft-lb/in	1.0

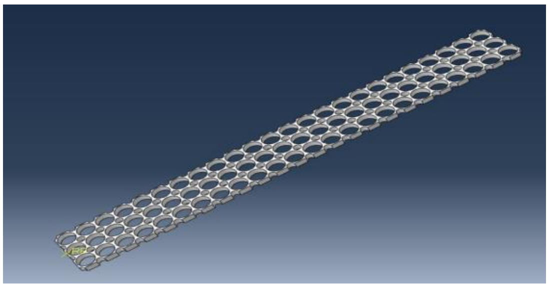
IV.DESIGN OF MODEL RCC BEAM IN ABAQUS CAE



MODEL RCC BEAM PREVIEW
Breadth: 150mm, Depth: 150mm, Length: 1000mm

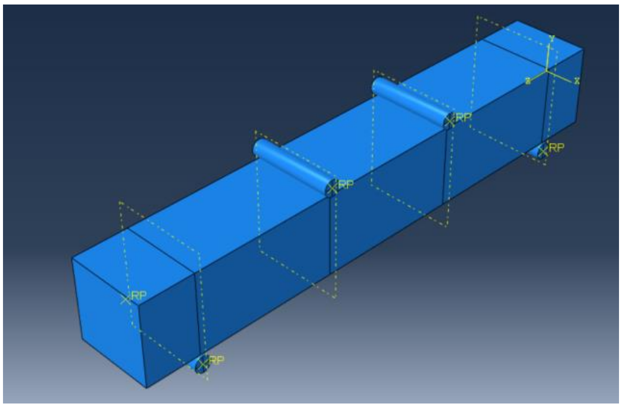


REINFORCEMENT PREVIEW
Cover: 20mm (all sides), Stirrups spacing: 120mm, Bars spacing: 110mm

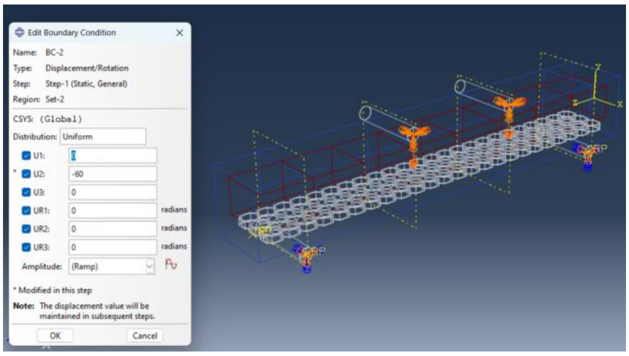


RUBBER MAT PREVIEW
Breadth: 117mm (16.5mm cover from both sides), Depth: 15mm
Length: 936mm (32mm cover from both sides)

V.Assembling and Loadings for Four-point Loading test of RCC beam

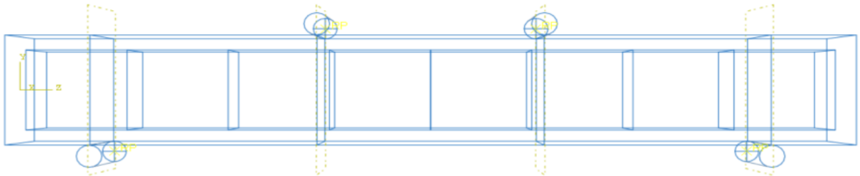


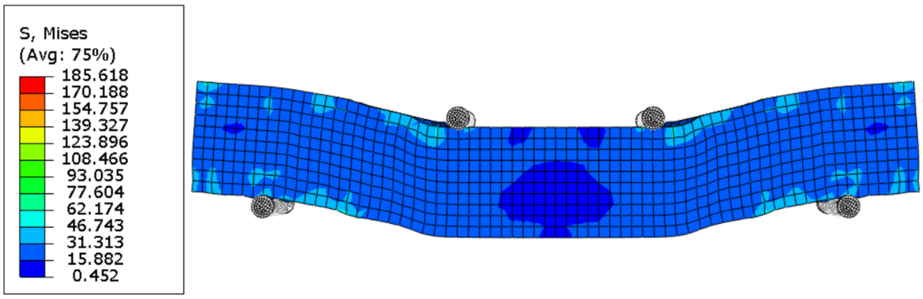
- ✓ Bottom Supports placed from 100mm offset in both sides.
- ✓ Top Loading placed L/3 (266.6mm) for the length of beam (800mm) from Supports.

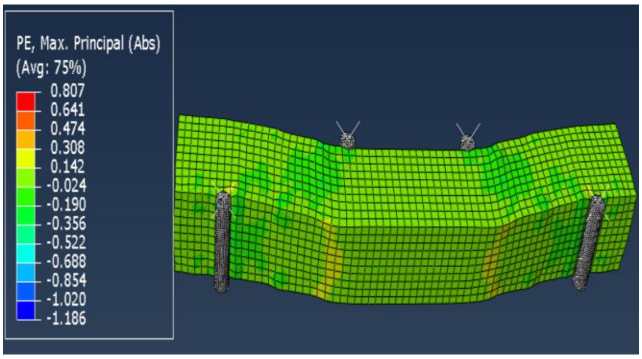


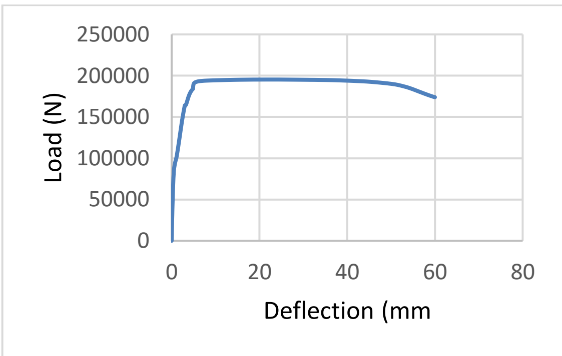
60mm deflection has been applied to all trail beams and compared for maximum bending moment, Flexural strength and Plastic strain at tension zone in all trails.

CONVENTIONAL RCC BEAM RESULTS









Maximum Load: **195307 N**

Maximum Bending Moment: **52.08056 kN-m**

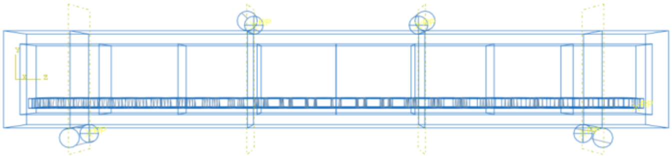
Plastic Strain in Tension zone: **0.308**

Flexural strength of Beam: **57.86874 Mpa**

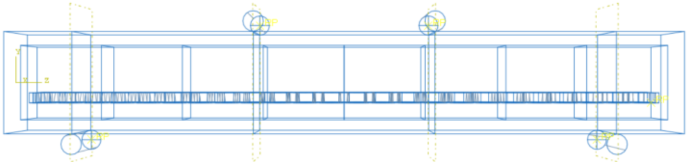
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 02 | February - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

VI.DESIGN OF SINGLE LAYERED RUBBER COMPOSITE RCC BEAM

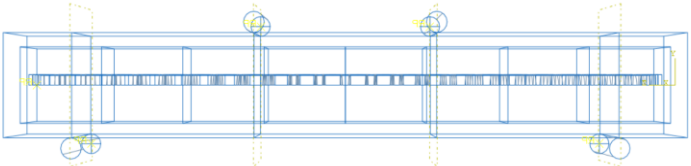
TRAIL 1: RUBBER MAT PLACED 30MM FROM BOTTOM OF BEAM RESULTS



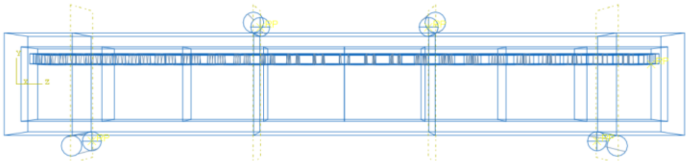
TRAIL 2: RUBBER MAT PLACED 45MM FROM BOTTOM OF BEAM RESULTS



TRAIL 3: RUBBER MAT PLACED 75MM FROM BOTTOM OF BEAM RESULTS

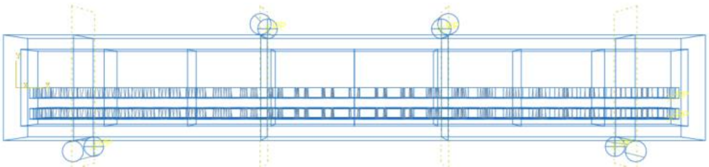


TRAIL 4: RUBBER MAT PLACED 105MM FROM BOTTOM OF BEAM RESULTS

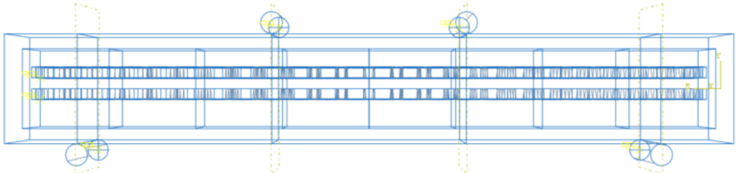


VII.DESIGN OF DOUBLE LAYERED RUBBER COMPOSITE RCC BEAM

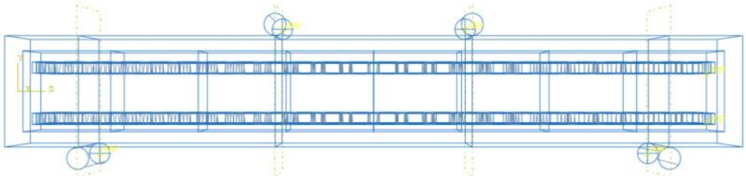
TRAIL 5: RUBBER MAT PLACED 30MM AND 60MM FROM BOTTOM OF BEAM RESULTS



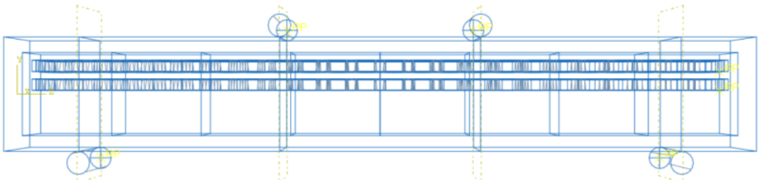
TRAIL 6: RUBBER MAT PLACED 60MM AND 90MM FROM BOTTOM OF BEAM RESULTS

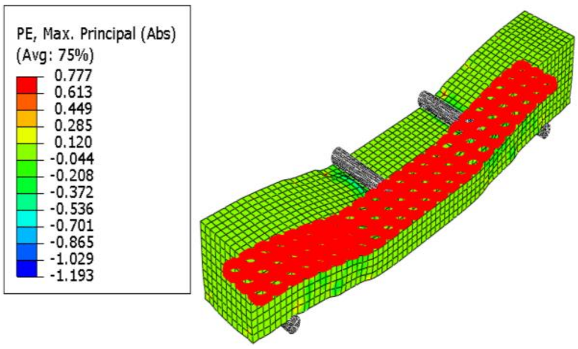


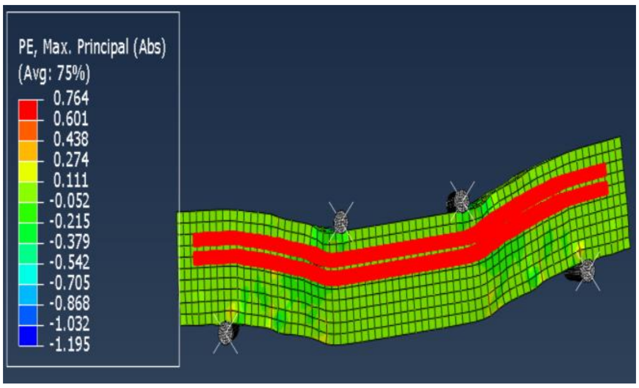
TRAIL 7: RUBBER MAT PLACED 30MM AND 100MM FROM BOTTOM OF BEAM RESULTS



TRAIL 8: RUBBER MAT PLACED 80MM AND 105MM FROM BOTTOM OF BEAM







VIII.Comparing Conventional and Rubber Composite trails

Comparison of Conventional and Single layered Rubber Composite beam

Trails	Max. Load (N)	Max.Bending Moment(kN-m)	Flexural Strength (Mpa)	Plastic Strain
Conventional	195307	52.08056	57.8687	0.308
30mm from Bottom	195417	52.1099	57.9013	0.287
45mm from bottom	**195421**	**52.1110**	**57.9025**	**0.285**
75mm from bottom	195420	52.1107	57.9022	0.285
105mm from bottom	195412	52.1086	57.8998	0.326

Comparison of Conventional and Double layered Rubber Composite beam

Trails	Max. Load (N)	Max.Bending Moment(kN-m)	Flexural Strength (Mpa)	Plastic Strain
Conventional	195307	52.08056	57.8687	0.308
30 and 60mm from Bottom	195396	52.1043	57.8951	0.281
60 and 90mm from bottom	195401	52.1056	57.8966	0.295
30 and 100mm from bottom	195387	52.1019	57.8924	0.274
80 and105mm from bottom	**195390**	**52.1027**	**57.8933**	**0.274**

IX.RESULTS

CONCLUSION

- In comparison of Conventional Model Beam with Rubber mat is placed as single layer of 45mm from bottom of Beam there is a **7.47%** decreased in Plastic strain at Tension Zone without affecting the Flexural strength of beam.

- In comparison of Conventional Model Beam with Rubber mat is placed as double layer of 80 and 105mm from bottom of Beam there is a **11.04%** decreased in Plastic strain at Tension Zone without affecting the Flexural strength of beam.

- By closely observing the trail-4 in single layered Rubber composite RCC beam the Rubber mat does not absorbing the load when it placed in compression zone of beam. The rubber mat directly transfers the load to tension zone.

- When comparing trail-4 to trail-2 the rubber mat placed in tension zone slightly absorbing some load and resits transferring of load to the bottom of beam. So, there is comparatively less plastic strain in tension zone of beam.

- In the other hand the double layered Rubber composite RCC beam clears that there will be no effect of load absorbing and transferring job for rubber mat when is placed in neutral axis of beam.

- By comparing trail-6 to trail-8 we can surely say there is a good load absorbing capacity of rubber increased and resits some plastic strain in tension zone when the rubber mat placed in both compression and tension zone as double layered composite in RCC beam.

- So, our Rubber mat resists some Plastic deformation in Tension zone of RCC beam. It may reduce the cracks depth and increase the initial cracking time of beam.

REFERENCES

[1]IS-10262-2019 : Concrete mix proportioning – Guidelines 2019

[2]Jutta peura : "Buffer Moisture Protection System" Journal in ResearchGate.2013

[3]ASTM D 3039, 2000, "Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials," Annual Book of ASTM Standards, V. 15.03, pp. 106-118.

[4]Bunsell, A. R., and Harris, B., 1974, "Hybrid Carbon and Glass Fibre Composites," Composites, V. 5, pp. 157-164.

[5]Chow, T. W., and Kelly, A., 1980, "Mechanical Properties of Composites," Annual Review of Composite Science, V. 10, pp. 229-259.

[6]Fukuda, H., and Chow T. W., 1981, "Monte Carlo Simulation of Strength of Hybrid Composites," Journal of Composite Materials, V. 16, pp. 371-385.

[7]Grace, N. F.; Soliman, K.; Abdel-Sayed, G.; and Saleh, K., 1999, "Strengthening Reinforced Concrete Beams Using Fiber Reinforced Polymer CFRP Laminates," Journal of Composites for Construction, ASCE, V. 2, No. 4.

[8]Manders, P. W., and Bader, M. G., 1981, "The Strength of Hybrid Glass/ Carbon Fibre Composites: Part 1—Failure Strain Enhancement and Failure Mode," Journal of Materials Science, V. 16, pp. 2233-2245.

[9]Nanni, A.; Henneke, M. J.; and Okamoto, T., 1994, "Tensile Properties of Hybrid Rods for Concrete Reinforcement," Construction and Building Materials, V. 8, No. 1, pp. 27-34.

[10]Norris, T.; Saadatmanesh, H.; and Ehsani, M. R., 1997, "Shear and Flexure Strengthening of R/C Beams with Carbon Fiber Sheets," Journal of Structural Engineering, ASCE, V. 123, No. 7, pp. 903-911.

[11]Philips, L. N., 1976, " The Hybrid Effect—Does it Exist?" Composites, V. 7, pp.7-8.

[12]Ritchie, P. A.; Thomas, D. A.; Lu, L.; and Connelly, G. M., 1991, "External Reinforcement of Concrete Beams using Fiber Reinforced Plastics," ACI Structural Journal, V. 88, No. 4, July-Aug., pp. 490-500.

[13]Saadatmanesh, H., and Ehsani, M. R., 1991, "RC Beams Strengthening with GFRP Plates I: Experimental Study," Journal of Structural Engineering, ASCE, V. 117, No. 11, pp. 3417-3433.

[14]Somboonsong, W.; Frank, K. K.; and Harris, H. G., 1998, "Ductile Hybrid Fiber Reinforced Plastic Reinforcing," ACI Materials Journal, V. 95, No. 6, Nov.-Dec., pp. 655-666.

[15]Harris, H. G.; Somboonsong, W.; and Frank, K. K., 1998, "New Ductile Hybrid FRP Reinforcement Bar for Concrete Structures," Journal of Composites for Construction, ASCE, V. 2, No. 1, pp. 28-37.