



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 8, August 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# To Investigate the Performance of Metal-Plastic Hybrid Components under Different Loading Conditions and Stress Scenarios by FEA

Mr. Jadhav Vishwajit Tanaji<sup>1</sup>, Prof. Ovarikar G.P.<sup>2</sup>

P.G. Student, ME Mechanical Engineering, STBCE, Tuljapur, India<sup>1</sup>

Assistant Professor STBCE, Tuljapur, India<sup>2</sup>

**ABSTRACT:** The study aims to assess the performance of metal-plastic hybrid components under various loading conditions and stress scenarios through a combined approach of Finite Element Analysis (FEA) and experimentation. Metal-plastic hybrid components have gained prominence due to their potential to offer superior mechanical properties and cost-effectiveness compared to traditional all-metal or all-plastic components. In this investigation, numerical simulations using FEA will be conducted to model the behavior of these hybrid components under different loading conditions, such as tension, compression, bending, and torsion. The FEA simulations will provide valuable insights into stress distributions, deformation patterns, and potential failure points, enabling a deeper understanding of the component's structural integrity and performance. Furthermore, the study will involve experimental testing of physical prototypes to validate the FEA results and gain empirical data on the hybrid component's response under real-world conditions. The experimental setup will subject the hybrid components to controlled loading scenarios, and measurements of strain, displacement, and other relevant parameters will be recorded to compare with the FEA predictions. By combining the findings from numerical simulations and experimentation, the study seeks to comprehensively evaluate the mechanical behavior of metal-plastic hybrid components. This research is expected to contribute valuable knowledge to the design and optimization of such components, leading to the development of more efficient and reliable engineering solutions across various industries.

**KEYWORDS:** FEA, stress distribution, experimental testing, physical prototypes

## I. INTRODUCTION

In recent years, metal-plastic hybrid components have emerged as a promising solution in various engineering applications due to their ability to combine the advantageous properties of both materials. This unique combination offers enhanced mechanical performance, reduced weight, and increased design flexibility. As these components find applications in critical sectors such as automotive, aerospace, and consumer electronics, it becomes imperative to thoroughly understand their behavior under different loading conditions and stress scenarios to ensure their reliable and safe operation.

The present study focuses on investigating the performance of metal-plastic hybrid components through a comprehensive approach involving Finite Element Analysis (FEA) and physical experimentation. FEA is a powerful numerical technique that allows engineers and researchers to simulate the behavior of complex structures subjected to various loading conditions, providing valuable insights into the stress distribution, deformation, and failure modes of the hybrid components. Meanwhile, experimental testing in real-world scenarios enables validation of the FEA results, offering a practical basis for the analysis and furthering our understanding of these advanced materials.

The primary objectives of this research are twofold: firstly, to explore the mechanical behavior of metal-plastic hybrid components, and secondly, to validate the accuracy and reliability of FEA predictions through experimental testing. By achieving these objectives, this study seeks to contribute to the growing body of knowledge on the mechanical behavior of metal-plastic hybrids, thereby facilitating their broader adoption across industries and applications.

The investigation encompasses a diverse range of loading conditions and stress scenarios to comprehensively assess the hybrid components' performance. These include tensile, compressive, and bending loads, as well as cyclic loading to simulate fatigue conditions. The study also considers different environmental conditions and temperatures to examine the components' behavior under various operational circumstances.

To execute the research, a carefully designed experimental setup will be employed, featuring state-of-the-art testing facilities and instrumentation to capture relevant data accurately. Concurrently, FEA models will be developed using



advanced simulation software, incorporating material properties, geometric details, and boundary conditions based on empirical data and literature reviews.

The outcomes of this study hold immense significance in advancing the understanding of metal-plastic hybrid components and their mechanical behavior. Engineers, designers, and researchers can utilize the knowledge gained from this investigation to optimize component design, predict failure modes, and enhance the overall performance of such hybrid systems in real-world applications. Additionally, this research will foster a greater confidence in the adoption of metal-plastic hybrids, contributing to the ongoing drive towards lightweight, efficient, and sustainable engineering solutions.

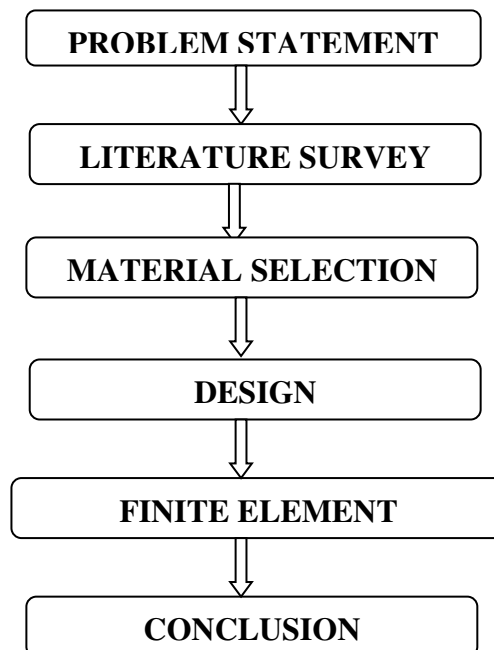
## II. PROBLEM STATEMENT

Metal-plastic hybrid components have gained significant attention in engineering applications due to their potential to offer a unique combination of mechanical properties, cost-effectiveness, and weight reduction. However, the performance of these hybrid components under different loading conditions and stress scenarios remains a subject of investigation. The current study aims to comprehensively evaluate the behavior of metal-plastic hybrid components through a combination of Finite Element Analysis (FEA) simulations and experimental testing.

## III. OBJECTIVES

- To explore the mechanical behavior of metal-plastic hybrid components
- To validate the accuracy and reliability of FEA predictions through experimental testing on UTM.

## IV. METHODOLOGY

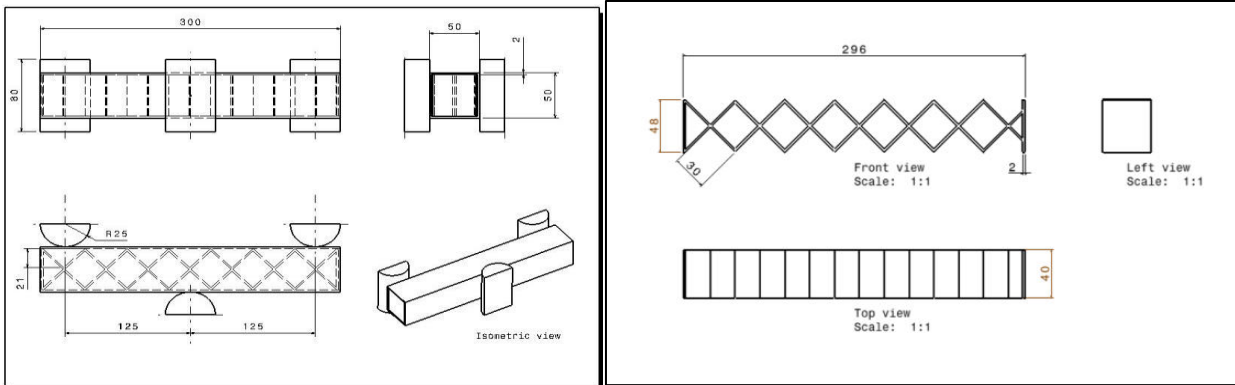


## V. MATERIAL SELECTION

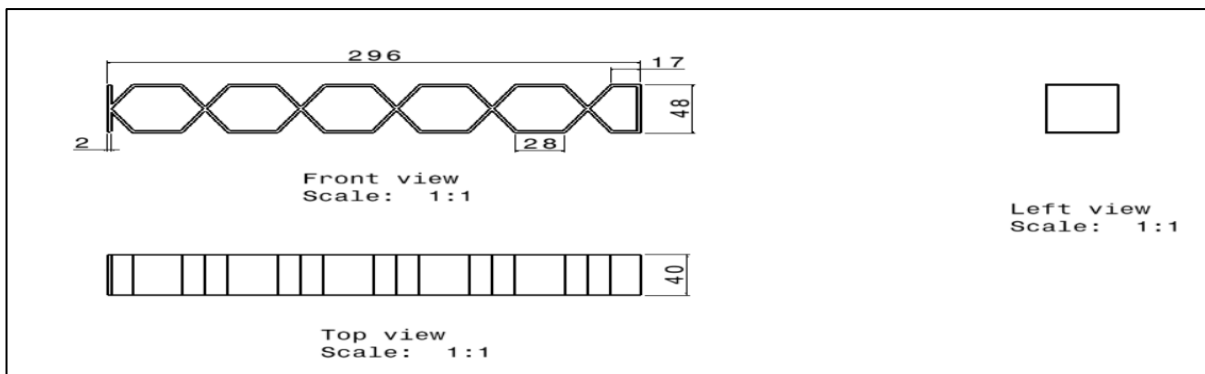
Hybrids made of metal and plastic offer a desirable means of achieving these goals. The selection, characteristics, and experimental approach for examining metal-plastic hybrids in the automotive sector are described in this material part. For our analysis, we used structural steel with the following properties: density of 7850 kg/m<sup>3</sup>, Young's modulus of  $2 \times 10^{11}$  pa, poisson's ratio of 0.3, bulk modulus of  $1.66 \times 10^{11}$  pa, and shear modulus of  $1.69 \times 10^{11}$  pa. The plastic material that we have chosen is made of ABS. Because ABS can be used in 3D printing, it was chosen for plastic structures that

will be reinforced in existing components. Possessing the following characteristics: density of 1040 kg/m<sup>3</sup>, Young's modulus of 2.39\* 10<sup>11</sup> pa, poisson's ratio of 0.39, bulk modulus of 3.94\* 10<sup>11</sup> pa, and shear modulus of 8.54\* 10<sup>11</sup> pa.

**VI. DESIGN**



Design and Drafting of cross structure reinforced with existing metallic square tube



Design and Drafting of honeycomb structure reinforced with existing metallic square tube

In design we have designed base component which having dimensions as given in figure. Accordingly we have designed the cross structure and honeycomb structure for analysis and experimentation purpose.

**VII. FINITE ELEMENT ANALYSIS**

Properties of Outline Row 3: ABS			
	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	1040	kg m <sup>-3</sup>
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Po...	
6	Young's Modulus	2.39E+09	Pa
7	Poisson's Ratio	0.399	
8	Bulk Modulus	3.9409E+09	Pa
9	Shear Modulus	8.5418E+08	Pa

Material properties for structural steel

Properties of Outline Row 4: Structural Steel			
	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m <sup>-3</sup>
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisso...	
6	Young's Modulus	2E+11	Pa
7	Poisson's Ratio	0.3	
8	Bulk Modulus	1.6667E+11	Pa
9	Shear Modulus	7.6923E+10	Pa
10	Specific Heat, C <sub>p</sub>	494	J kg <sup>-1</sup> C <sup>-1</sup>

Material properties for plastic

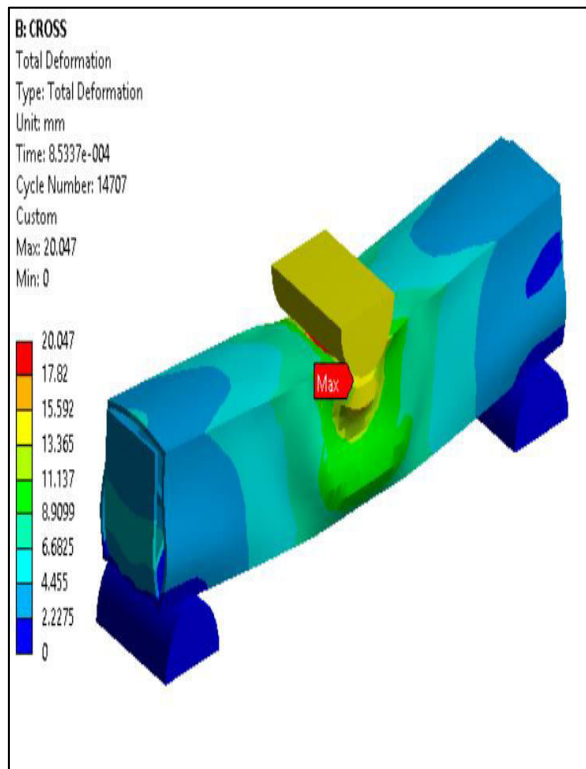
Statistics	
Nodes	75970
Elements	54588

Meshing details

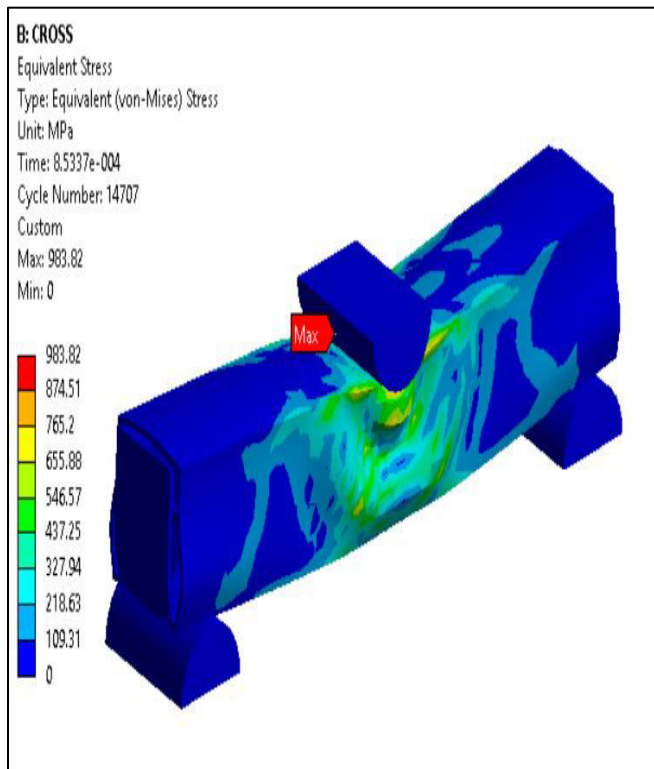
Boundary condition

According to the Global NCAP crash test, the average speed of the vehicle during a collision is 35 to 40 miles per hour. Due to the boundary condition we applied, this velocity was changed to meters per second. Additionally, we supplied the object with two supports at its two ends.

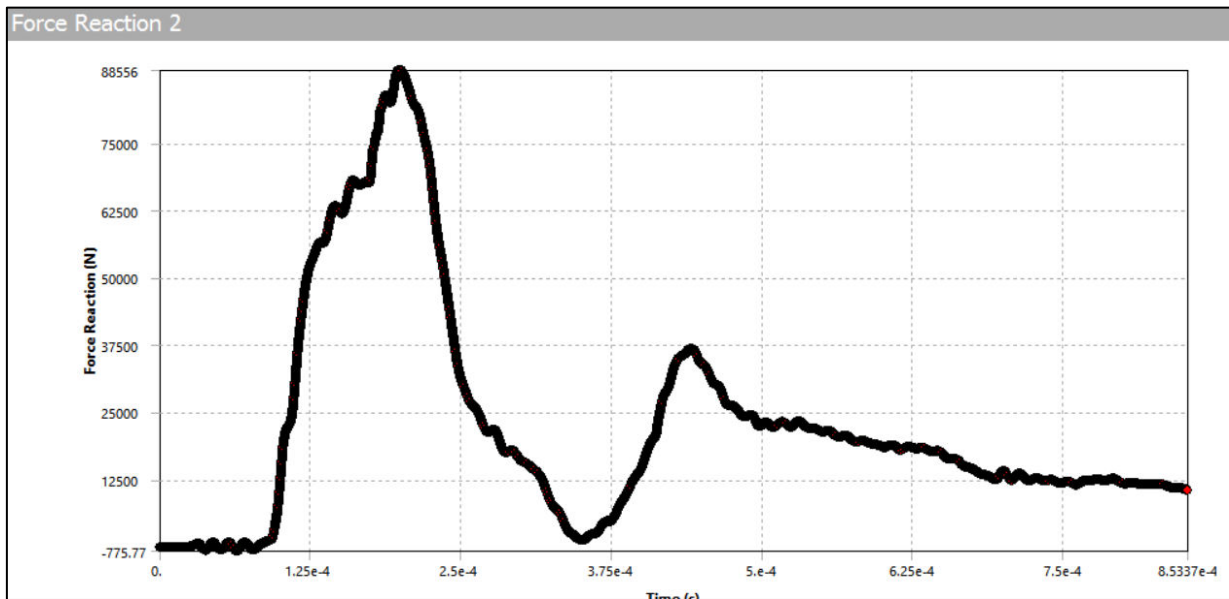
Results:



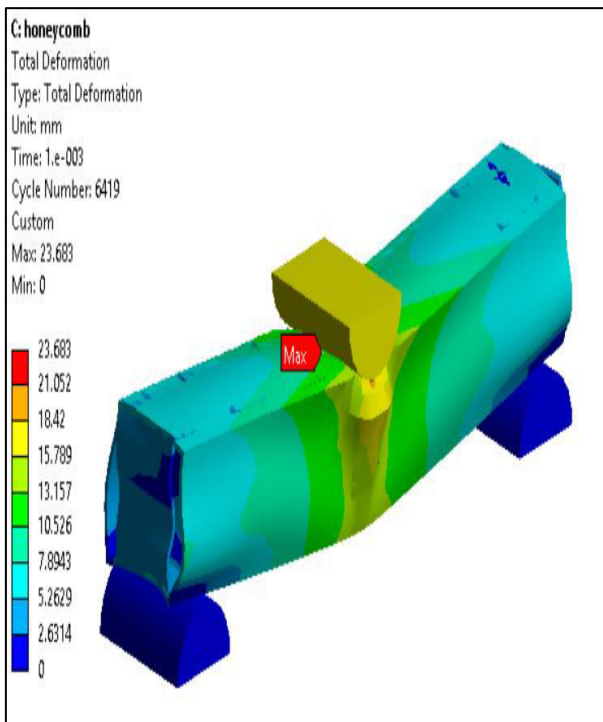
Total deformation of 3D printed cross structure



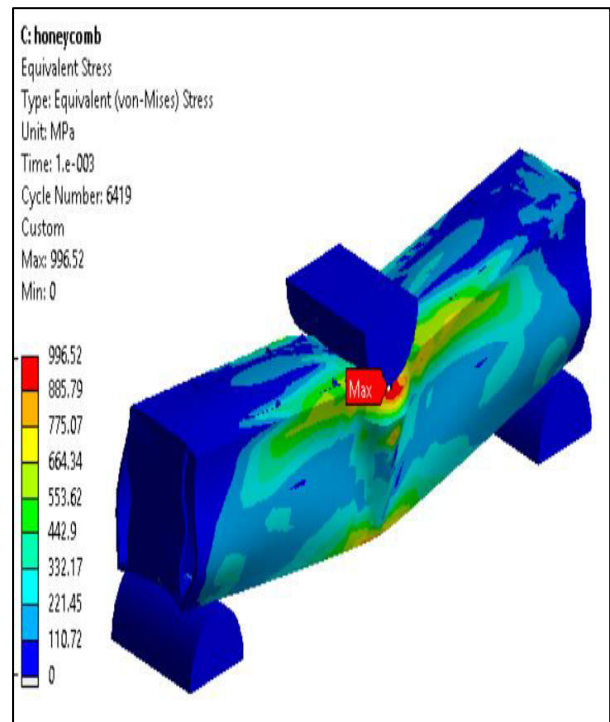
Equivalent stress on specimen 3D printed cross structure



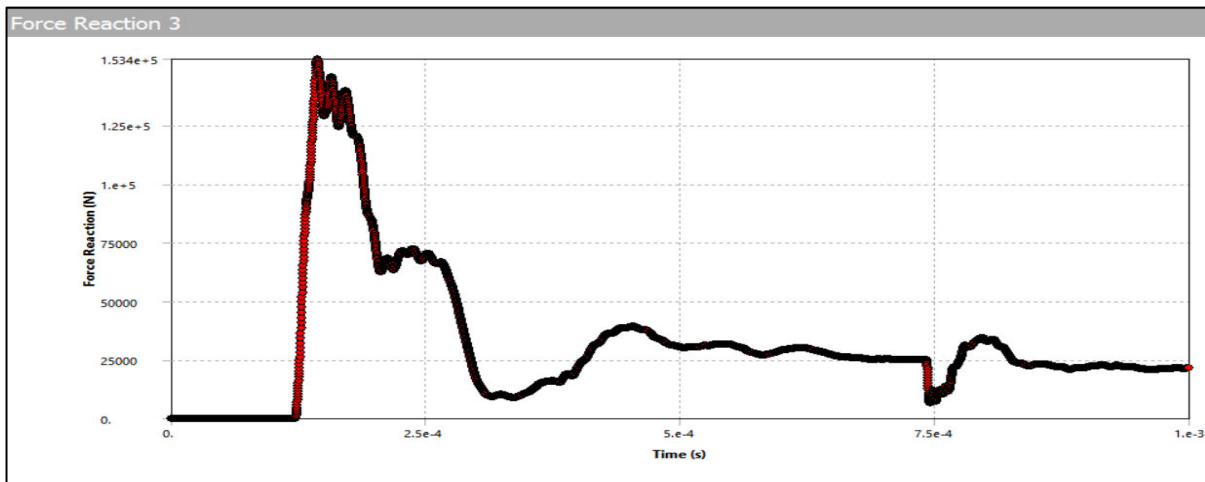
Force reaction at fixed support for cross structure



Total deformation of honeycomb structure



Equivalent stress on honeycomb structure



Force reaction at fixed support

### VIII. CONCLUSION

Sr. No.	Type of Structure	Deformation	Max. equivalent Stress
1	CROSS STRUCTURE	20.04 mm	983.82 MPa
2	HONEYCOMB STRUCTURE	23.68 mm	996.52 MPa

- After investigating the performance of cross structure component in FEA at impact of 17.77 m/s the maximum stress induced in component is 983.82 MPa and deformation is 20.04 mm.
- We also investigate the honeycomb structure reinforced with existing component the maximum deformation of after impact is 23.68 mm and maximum equivalent stress is 996.52 MPa.
- Hence both the structure after impact test on FEA shows nearly same behavior. For application of dynamic or static loading condition we can recommend any one of above discussed structure reinforced with original component. Reinforcing the plastic with metallic component can enhance the performance of component.

### REFERENCES

- 1] Energy absorption on metal-composite hybrid structures: Experimental and numerical simulation” by Gang Zheng, Zhen Wang, Kai Song.
- 2] “Separation and reclamation of automotive hybrid structures made of metal and fibre-reinforced plastic” by Svetlana Schweizer, Anna Becker-Staines, Thomas Tröster.
- 3] “Process combinations for the manufacturing of metal-plastic hybrid parts” by W-G Drossel, C Lies, A Albert, R Haase, R Müller and P Scholz.
- 4] “Laser-based surface pre-treatment for metal-plastic hybrids using a new process strategy” by C. Wunderling, L. Mayr, S.P. Meyer, M.F. Zaeh.
- 5] “Metal-plastic hybrid 3D printing using catalyst-loaded filament and electroless plating” by Jing Zhan, Takayuki Tamura, Xiaotong Li, Zhenghao Ma, Michinari Sone, Masahiro Yoshino, Shinjiro Umezu, Hirotaka Sato.
- 6] A. Ghadianlou, S.B. Abdullah, Crashworthiness design of vehicle side door beams under low-speed pole side impacts, Thin-Walled Struct. 67 (2) (2013) 25–33.
- 7] S. Li, X. Guo, Q. Li, D. Ruan, G. Sun, On lateral compression of circular aluminum, CFRP and GFRP tubes, Compos. Struct 232 (2020) 111534.



**INNO SPACE**  
SJIF Scientific Journal Impact Factor  
**Impact Factor: 8.423**



**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

**9940 572 462** **6381 907 438** **ijirset@gmail.com**



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details