IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

Experimental and Analytical Study of Micro Steel Fiber Reinforced Mortar Subjected to Impact Loading

Abhisek Pattanayak[1], Anandrao Jadhav[2], Hrishikesh Mulay[3]

PG Student, Department of Civil Engineering, MIT School of Engineering, Pune, India[1]

Assistant Professor, Department of Civil Engineering, MIT School of Engineering, Pune, India[2,3]

Abstract: This paper presents both experimental and analytical study on the behavior of Micro Steel Fiber Reinforced Mortars (MSFRM) with different fiber percentage under impact load. Brass coated micro steel fibers are used by 0%,2%,4%,6%,8% volume of the specimen. The cement mortar ratios are adopted for the study was 1:3 and 1:4. After 7days and 28 days of curing the specimens are tested by Charpy impact test in pendulum impact testing machine. The impact test was analyzed by using ANSYS. The impact load, bending stress, shear stress, load deflection and Stress vs strain curve was calculated. Both the results were validated and discussed. From the results it has been concluded that the impact absorption capacity of 1:3 mortar ratio is higher than 1:4 mortar ratio. As the increase in percentage of micro steel fiber the resistance of specimens against impact also increased.

Keywords: MSFRM, Charpy impact test, Pendulum impact testing machine

I. INTRODUCTION

Fiber reinforced cement-based composites were widely used all over the world. There are different types of fibers used in the cement-based matrix, such as steel, glass, synthetic, polymer, asbestos, carbon etc. The main role of different fibers in the cement-based composites are to improve the toughness and the post cracking performance of the matrix.

Mortar is a workable paste used to bind building blocks such as stones, bricks, and concrete masonry units, fill and seal the irregular gaps between them, and sometimes add decorative colors or patterns in masonry walls. Use of the micro steel fiber, this solution increases the tensile and bending resistance. This process helps to produce a matrix with high slenderness and expected bending resistance. Fiber reinforcing is a method to increase the mechanical properties of Fiber Reinforced Mortar (FRM) as compared to conventional mortar. Generally, When the resistance of a conventional mortar sample increased the brittleness also increased. By fiber reinforcing in the mixture the plasticity increases and overcome all the drawbacks of conventional mortar mixture.

Impact resistance is the ability of the material to resist the force or shock applied to the material over a short duration of time. Here the impact load is applied to the Micro Steel Fiber Reinforced Mortar (MSFRM) matrix to test its toughness by Charpy impact test.

II. METHODOLOGY

An experimental and analytical investigation is to be carried out to evaluate the impact absorption of MSFRM. For experiment total 120 specimens were casted out of which 60 specimens were of 1:3 and 60 specimens of 1:4 ratio of mortar. Size of specimen is 25.4 mm x 25.4 mm in cross-section and 50.8 mm in length [1] were casted. Micro steel fibers of length 12 mm were added to the mortar mixture according to percentage i.e. 0% ,2%, 4%, 6% ,8% Specimens are tested after 7 days and 28 days of curing period. After all the experimental work the results were validated using ANSYS.

III. EXPERIMENTAL WORK

A. Cross-section of Specimen

Cross-section of specimen = 25.4mm × 25.4mm × 50.8 mm

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

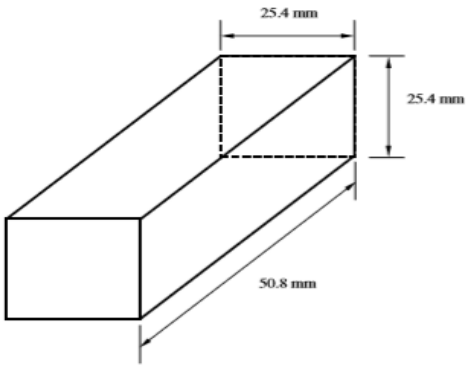

Fig. 1. Dimensions of specimen

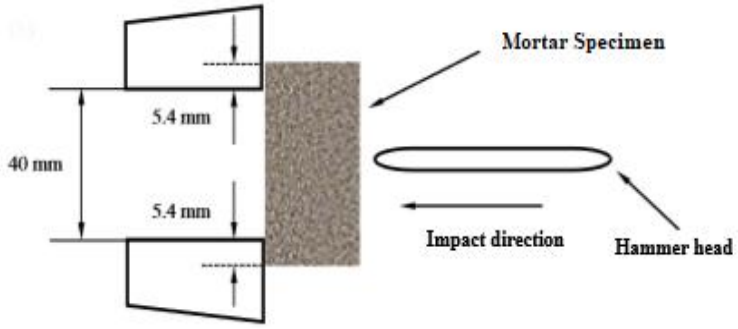

Fig. 2. Configuration of impact loading

B. Material used for casting

Brass coated micro steel fiber
Tensile strength (MPa): 700
Length (mm): 12
Aspect ratio: 20mm – 35mm

Super plasticizer: The admixture used in the work is BASF 8501® Super-plasticizer. It makes the mortar mixture highly workable for longer period.

C. Casting of specimen

Total 120 number of specimens were casted out of which 60 specimens were of 1:3 ratio of mortar and other 60 specimens were of 1:4 ratio of mortar of size 25.4mm x 25.4mm in cross section and 50.8mm in length. Micro steel fibers were added 0% ,2% ,4% ,6% ,8% accordingly with the volume of specimens each of 6 nos. Super plasticizer (1.5% of cement) is added to the mixture. The mixture was mixed well & fabricated mould were filled as shown in fig.3

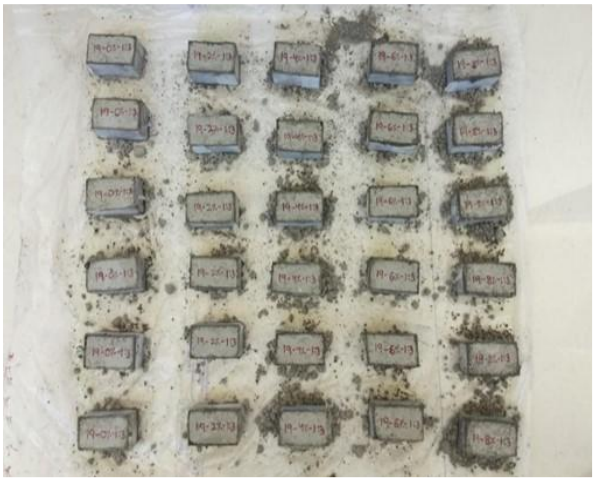

Fig. 3. Casted Specimens

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

D. Testing of specimens

60 nos. of specimens were tested after 7 days and other 60 no. of specimens were tested after 28 days of curing period. Out of 60 specimens, 30 specimens were of 1:3 ratio of mortar and other 30 specimens were of 1:4 ratio of mortar.

Fig. 4. Pendulum impact testing machine

To evaluate the impact absorption capacity of specimens "Charpy impact test" was employed in pendulum impact testing machine, according to the ASTM E23[16]. The equipment is shown in fig. 4, in which maximum kinetic energy output is 300J. The dimension of the specimen and configurations of loading are presented in fig. 1 and fig. 2 [1]. After placing the specimen, the pendulum is released from a height H1 and swing through the specimen to a height H2, as shown in fig. 5. Assuming negligible friction and aerodynamic drag, the energy absorption capacity of the specimen is evaluated by the height difference(H1-H2) multiplied by the weight of the pendulum. During the test, Six Specimens are tested for each batch.

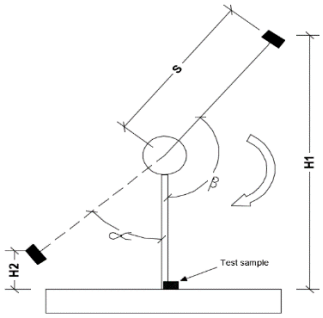

Fig. 5. Working scheme of Charpy impact test

E. Experimental test results

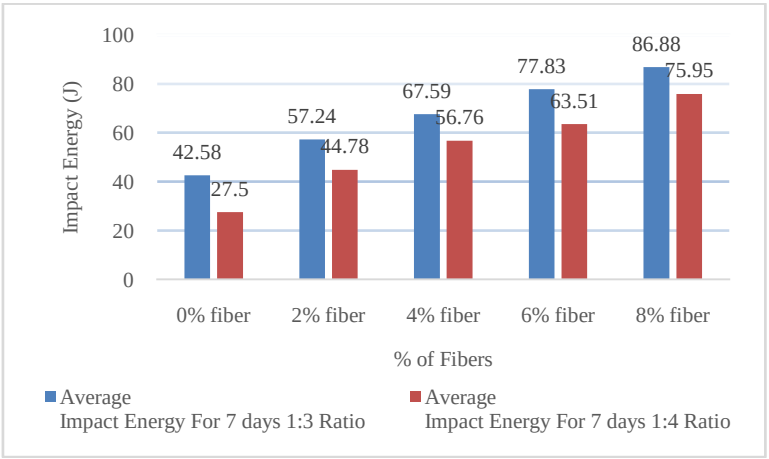

Fig. 6. Impact absorption after 7 days

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

It was observed that the average impact absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2% ,4%, 6%, 8% micro steel fiber by 54.83%, 27.82%, 19.08%, 22.54%, 14.39% respectively.

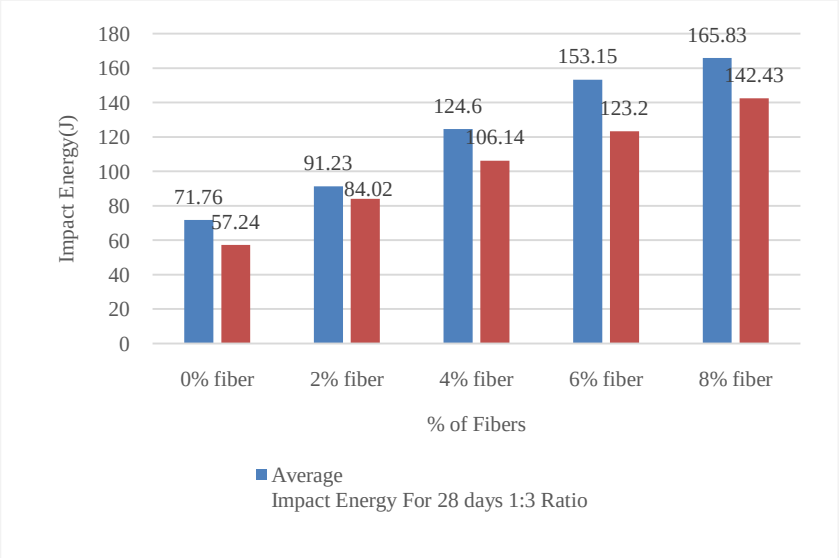

Fig. 6. Impact absorption after 28 days

It was observed that the average impact absorption of 1:3 mortar ratio specimens is higher than 1:4 mortar ratio specimens for addition of 0%, 2%, 4%, 6%, 8% micro steel fiber by 25.36%, 8.58%, 17.39%, 24.31%, 16.42% respectively.

IV. ANALYTICAL STUDY

ANSYS software was used for FEM modelling in this study. This software contains different types of properties and lots of elements types with different material modes in the library. Linear-elastic material model was used for the specimen and hammer. For impact loading explicit dynamics method was used. The dimensions of the specimen and setup and supporting condition were modeled lie in the experimental study. FEM mesh is shown in fig. 5.

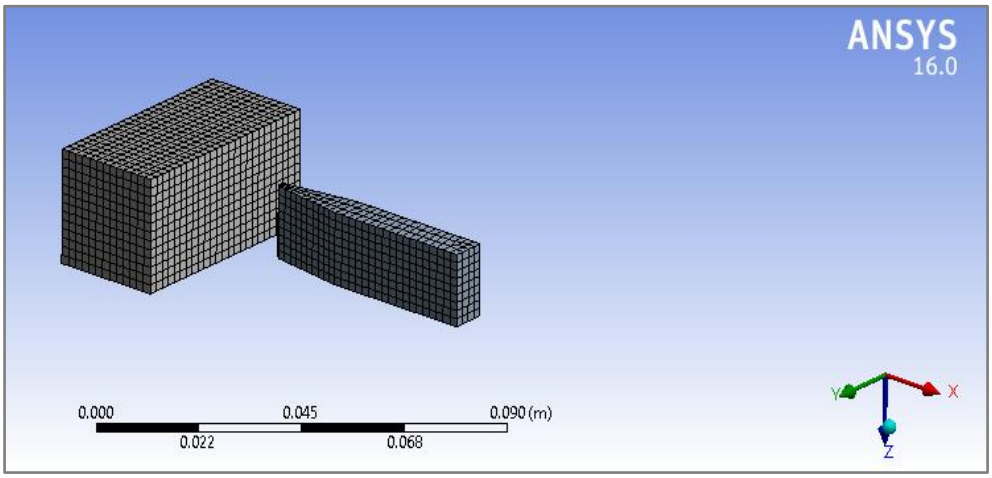

Fig. 5. Finite element mesh of specimen

A. Test results of ANSYS

It was observed that the average impact absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2%, 4%, 6%, 8% micro steel fiber by 54.82%, 27.83%, 19.09%, 22.54%, 14.40% respectively.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

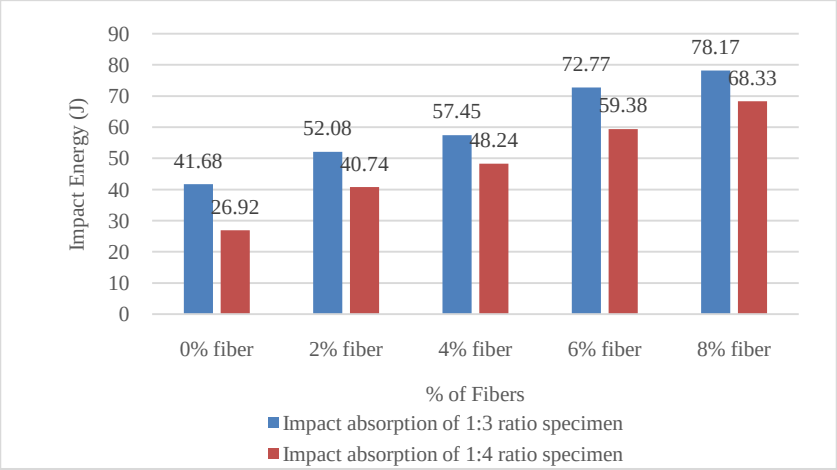

Fig. 6. Impact absorption values of 7 days specimen

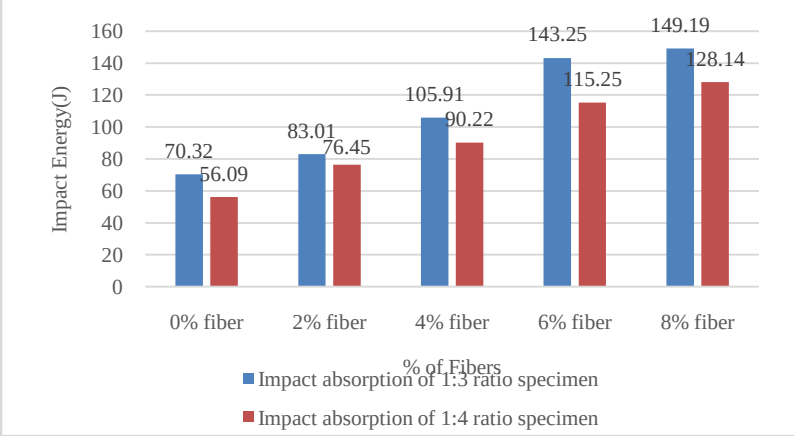

Fig. 7. Impact absorption values of 28 days specimen

It was observed that the average impact absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2%, 4%, 6%, 8% micro steel fiber by 25.36%, 8.58%, 17.39%, 24.29%, 16.42% respectively.

B. Stress Vs Strain curve

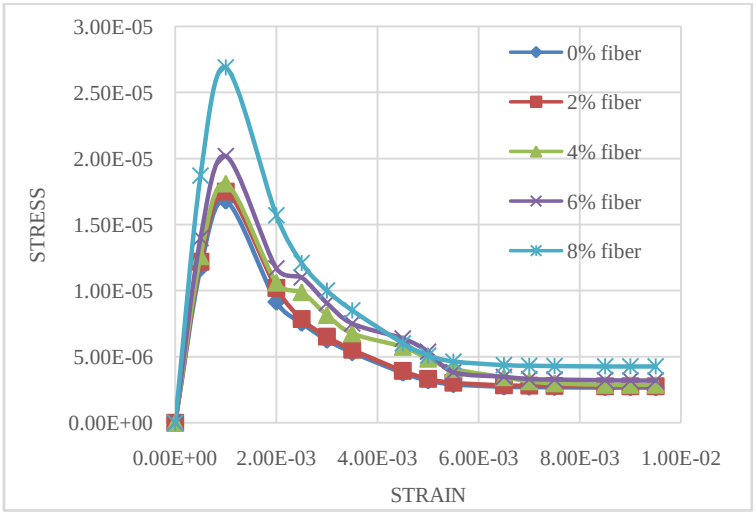

Fig. 8. Stress Vs Strain curve according to % of Steel fiber

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 8, August 2019

It was observed that the Stress increment of fibrous composites from non-fibrous composites for addition of 2%, 4%, 6%, 8% micro steel fibers were 4.16%, 7.73%, 20.23%, 60.11% respectively.

C. Bending Stress and Shear stress

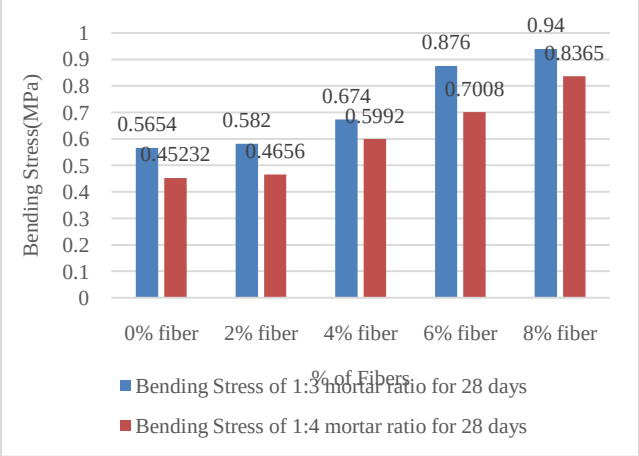

Fig. 9. Bending Stress after 28 days

It was observed that the bending stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 24.44%, 26.08%, 13.55%, 24.28%, 13.25% respectively.

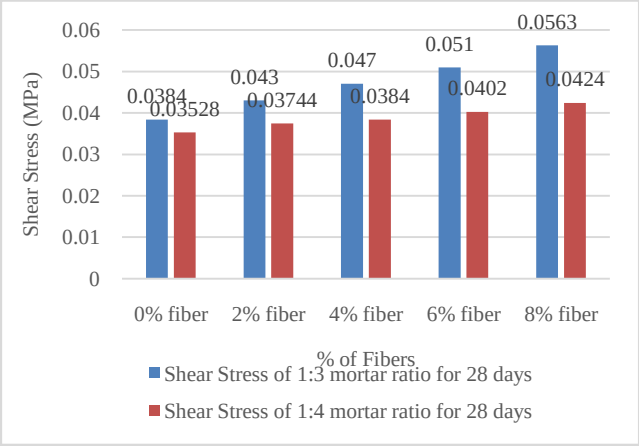

Fig. 10 Shear Stress after 28 days

It was observed that the Shear stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 8.57%, 16.21%, 23.68%, 27.5%, 33.33% respectively.

V. CONCLUSION

1. Experimental Average Impact energy absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2% ,4%, 6%, 8% steel fibers after 7 days by 54.83%, 27.82%, 19.08%, 22.54%, 14.39% respectively.
2. Experimental Average Impact energy absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2% ,4%, 6%, 8% steel fibers after 28 days by 25.36%, 8.58%, 17.39%, 24.31%, 16.42% respectively.
3. Analytical Impact energy absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2% ,4%, 6%, 8% MSF after 7 days by 54.82%, 27.83%, 19.09%, 22.54%, 14.40% respectively.
4. Analytical Impact energy absorption of 1:3 mortar ratio specimens are higher than 1:4 mortar ratio specimens for addition of 0%, 2% ,4%, 6%, 8% MSF after 28 days by 25.36%, 8.58%, 17.39%, 24.31%, 16.42% respectively.
5. With increase in Steel fiber percentage, the resistance of specimens against impact also increases. The performance of 8% addition of steel fiber reinforced mortar is better than other Specimens.

6. The stress increment of 8% addition of micro steel fiber composites was 60.11% more compared to non-fibrous composites so it can be preferred.
7. After 7 days the Bending stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 29.62%, 18.75%, 39.02%, 20.40%, 20.75% respectively.
8. After 7 days the Shear stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 28.57%, 16.66%, 15.38%, 18.51%, 17.24% respectively.
9. After 28 days the Bending stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 24.44%, 26.08%, 13.55%, 24.28%, 13.25% respectively.
10. After 28 days the Shear stress of 1:3 mortar ratio from 1:4 mortar ratio for addition of 0%, 2%, 4%, 6%, 8% micro steel fibers were higher by 8.57%, 16.21%, 23.68%, 27.5%, 33.33% respectively.

ACKNOWLEDGMENT

Project work was carried out using the facilities in Civil Engineering Department laboratory of MIT-SOE, Pune. I express my heartiest gratitude and sincere thanks to my project guide **Prof. Anandrao Jadhav** and co-guide, **Prof. Hrishikesh Mulay,** Department of Civil Engineering for their valuable guidance, authorities and expert comments. Finally I am thankful to the supporting staff and all those who directly or indirectly contributed to this project work.

REFERENCES

[1]. Static properties and impact resistance of a green Ultra-High-Performance Hybrid Fiber Reinforced Concrete (UHPHFRC): Experiments and modelling By R. Yu, P. Spiesz, H.J.H. Brouwers.
[2]. Impact resistance of poly (vinyl alcohol) fiber reinforced high-performance organic aggregate cementitious material Bo Xu a , Houssam A. Toutanji a, John Gilbert b.
[3]. Goran Baloevic, Jure Radnica, Domagoj Matesana, Nikola Grgica "Behavior of fiber reinforced mortar composites under impact load" University of Split, Faculty of Civil Engineering, Architecture and Geodesy Matice hrvatske 15, 21000 Split, Croatia.
[4]. Hoang Quoc Vu, Thuy Ninh Nguyen, Nguyen Vo Hoang Giang "The Properties of Fiber Reinforced Mortar Applied in Decorative Products" Building Materials Lab., Faculty of Civil Engineering, Ho Chi Minh City University of Technology, Viet Nam
[5]. Marcos Venicius Pereiraa, Roberto Fujiyamab, Fathi Darwishc, Gilvania Terto Alvesa "On the Strengthening of Cement Mortar by Natural Fibers" Department of Materials Engineering, Catholic University of Rio de Janeiro
[6]. Tug˘çe Sevil, Mehmet Baran, Turhan Bilir, Erdem Canbay "Use of steel fiber reinforced mortar for seismic strengthening" Department of Civil Engineering, Structural Mechanics Laboratory, Middle East Technical University, Cankaya, Ankara 06531, Turkey
[7]. Hu Feng, M. Neaz Sheikh, Muhammad N.S. Hadi, Danying Gao, Jun Zhao "Mechanical properties of micro-steel fibre reinforced magnesium potassium phosphate cement composite" School of Civil Engineering, Zhengzhou University, Henan 450001, China
[8]. Smitha Gopinath, R Ayashwarya, V Ramesh Kumar "Low velocity impact behaviour of ultrahigh strength concrete panels CSIR - Structural Engineering Research Centre, Taramani, Chennai 600 113 June 2014.
[9]. Sajjad Roudsari, Sameer Hamoush, Sayed Soleimani, "Analytical Study of Reinforced Concrete Beams Strengthened by FRP Bars Subjected to Impact Loading Conditions" Department of Computational Science and Engineering, North Carolina A and T State University.
[10]. Stephen Jebamalai Raj J, Vailada Vinay, Habtu Birhanu "An Analytical Study on Static and Fatigue Analysis of High Strength Concrete Beams with FRP Laminates" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS02079 (This work is licensed under a Creative Commons Attribution 4.0 International License.) Vol. 4 Issue 02, February-2015.
[11]. Erkan Kantar, R. Tugrul Erdem1 and Ozgur Anıl "nonlinear finite element analysis of impact behavior of concrete beam" Mathematical and Computational Applications, Vol. 16, No. 1, pp. 183-193, 2011.
[12]. Wang Jianhua1, Lou Jun and Yang Haiping "The study on steel fiber reinforced concrete under dynamic compression by damage mechanics method" Journal of Chemical and Pharmaceutical Research, 2014.
[13]. Dr. M. Vinod Kumar, Y.M. Siddharamaiah, "Analytical Investigation on Hybrid Fiber Reinforced Concrete Beam" International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 10, October 2018.
[14]. Vass, Gergely "Master thesis: Finite Element Modelling of Different Strengthening Strategies for Reinforced Concrete Deep Beams".
[15]. Behaviour of FRC Slabs Subjected to Impact Loading by Kiran. T and N.Jayaramappa, IJTRD Volume 4(3), ISSN: 2394-9333.
[16]. ASTME23, Standard test methods for notched bar impact testing of metallic materials. American Society for Testing and Materials; 1992