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# Analysis of Different Grades of Reinforced Concrete Beam After Exposure to Elevated Temperature Using Abaqus

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***Abstract: The effect of fire causes cracking, spalling of concrete, micro-cracking, chemical decomposition. These can impact in reducing its strength, stability , load bearing capacity. After the beam exposure to elevated temperature it is necessary to retrofit and re-strengthing the existing beam by any of the retrofitting method. In this analysis carbon fibre reinforced polymer (CFRP) method adopted.***

***The load-deflection behaviour of beam exposure to temperature is analysed using Abaqus. Two different grades of reinforced concrete of M25 grade and M30 grade were analysed. The beam exposure to temperature of about 400°C for the time duration of 1 hour. Fire effect is applied all around the beam. After being exposure to high temperature, the existing beam was retrofitted using the CFRP technology to reinforce it.***

***Keywords: exposure to temperature, different grades of concrete, elevated temperature using abaqus, analysis of reinforced concrete beam using abaqus.***

## I. INTRODUCTION

The concrete building suffers significant damage from the fire. Concrete surfaces damaged by fire can fracture, peel, craze, and decompose chemically.

The beams are positioned at the top of the building, and they have varied degrees of damage. These effects may dramatically modify the strength, durability, and structural behaviour of structural concrete, as well as its other qualities.

Fire is the main reason to retrofit the structural components. Rehabilitation of a heated structure can be retrofitted with different types of retrofitting method around the structure. Explosive spalling and a reduction in compressive strength and the principal consequence of fire on concrete.

When flammable and combustible materials are exposure to enough heat and a enough amount of oxygen or another oxidizer, a fire will begin. Three conditions must be met for a fire to exit. Fuel, Heat, Oxygen.

The science and technology of retrofitting involves adding new ideas, technologies, features, and components to existing structures in order to improve their performance. It is possible to retrofit an existing reinforced concrete structure by conducting repairs, rehabilitations, or strengthening.

### *A. Levels Of Fire*

1) Fire danger at low condition :- Code of the color is green.
2) Fire danger at moderate condition :- Code of the color is blue.
3) Fire danger at high condition :- Code of the color is yellow.
4) Fire danger at extreme condition :- Code of the color is red.

### *B. Advantages Of Retrofitting*

1) Decreasing an structure susceptibility to harm.
2) Retrofitting is a simple and quick work.
3) Retrofitting method is easy to implement.

## II. OBJECTIVES

A primary goal of this work on research is to study the action of different grade of concrete beam after exposure to a higher temperature with carbon fibre reinforced polymer retrofitting technique. This study is mainly focused on the load-deflection action of the varies reinforced concrete beam grades after being exposure to high temperature.

## III. DESIGN CALCULATION OF BEAMS AS PER IS-456:2000

### *A. Data*

B = 150mm
D = 150mm
L = 1,000mm
Grade of Concrete = M25 & M30
Grade of Steel = Fe500

Table : 1 Design calculation of M25 & M30 grade

| | **M25** | **M30** |
|---|---|---|
| $M_{u,lim}$ | 11.22 kN-m | 13.47 kN-m |
| $M_u$ | 7.48 kN-m | 8.98 kN-m |
| $Ast_{req}$ | 211.84 $mm^2$ | 254.36 $mm^2$ |
| $Ast_{pro}$ | 226.19 $mm^2$ | 339.29 $mm^2$ |
| No. of bars | 2Nos - 12 mm Dia | 3Nos - 12 mm Dia |
| $W_u$ | 89.76 kN/m | 107.76 kN/m |
| Stirrups | 10 mm Dia @ 100 mm centre to centre | 10 mm Dia @ 100 mm centre to centre |
| Shear | Safe | Safe |
| Deflection | Safe | Safe |

## IV. PROPERTIES

1) Young's modulus of concrete = $5000\sqrt{Fck}$
   = $5000\sqrt{25}$
   = 25000 $N/mm^2$ (For M25 grade)
2) Young's modulus of concrete = $5000\sqrt{Fck}$
   = $5000\sqrt{30}$
   = 27000 $N/mm^2$ (For M30 grade)
3) Young's modulus of steel = 210000 $N/mm^2$
4) Poission's ratio of concrete = 0.1 to 0.2
5) Poission's ratio of steel = 0.25 to 0.3
6) Thickness of CFRP = 0.25 mm
7) Depth of CFRP = 150 mm
8) Size of beam = 150 mm x 150mm x 1,000 mm
9) Load on beam for M25 = 89.76 kN/m
10) Load on beam for M30 = 107.76 kN/m

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## V. MODELLING OF BEAM

Modelling of the beam is done using Abaqus software. Beam dimension of 150mmx150mmx1000mm and 2Nos -12mm Dia @ both in compression zone as well as in tension zone and 10mm Dia @ 100mm centre to centre stirrups were placed.

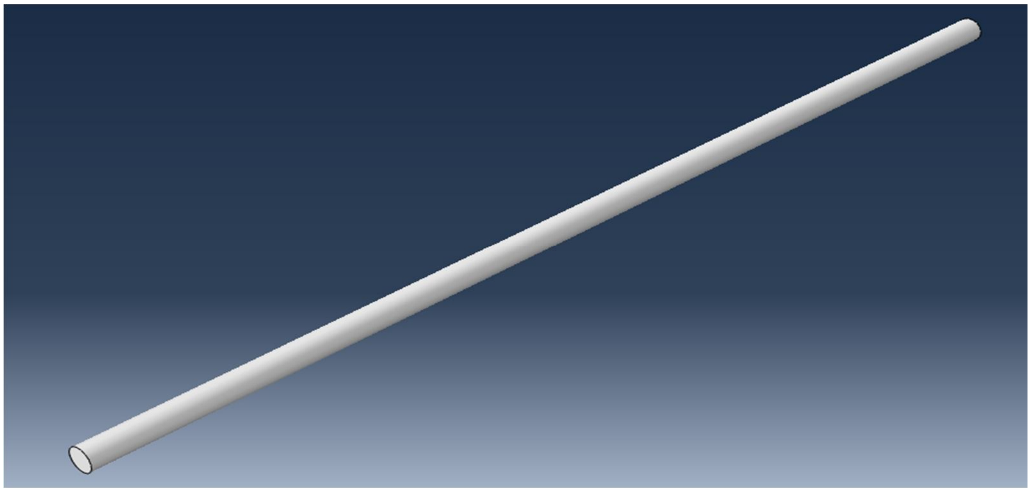

Fig. 1 Reinforced Bar of 12mm

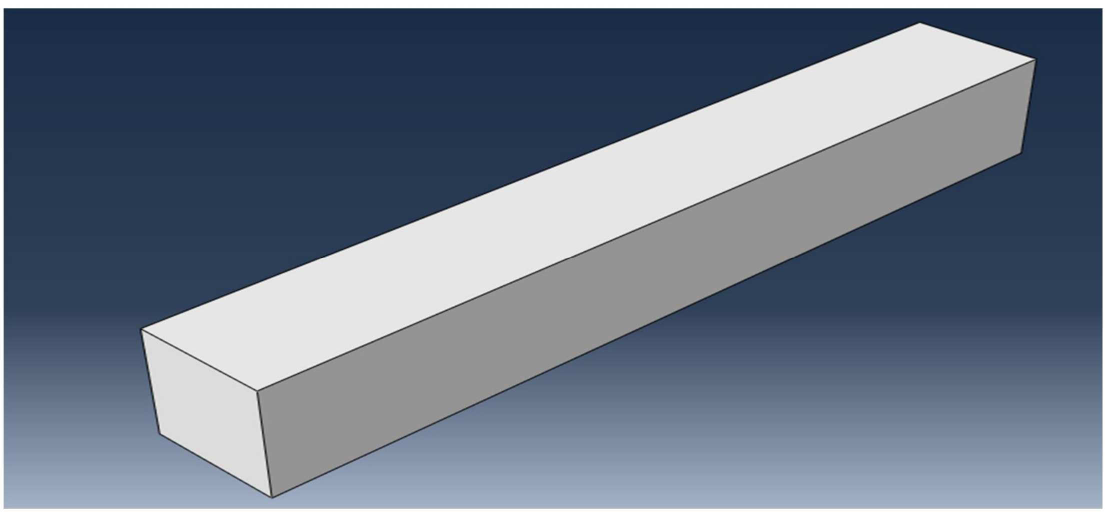

Fig. 2 Beam of Size 150mmx150mmx1000mm

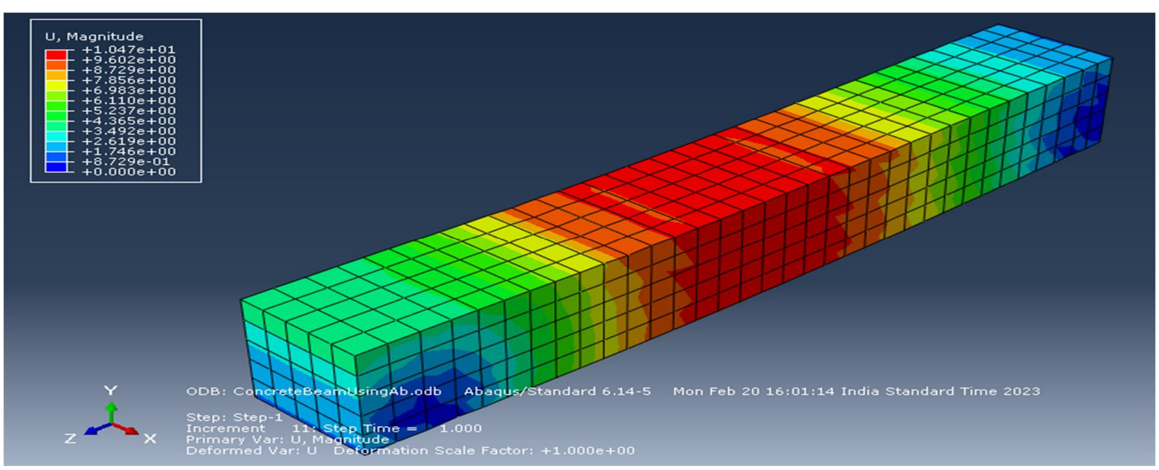


Fig. 3 M25 Grade Beam Before Exposure to Temperature

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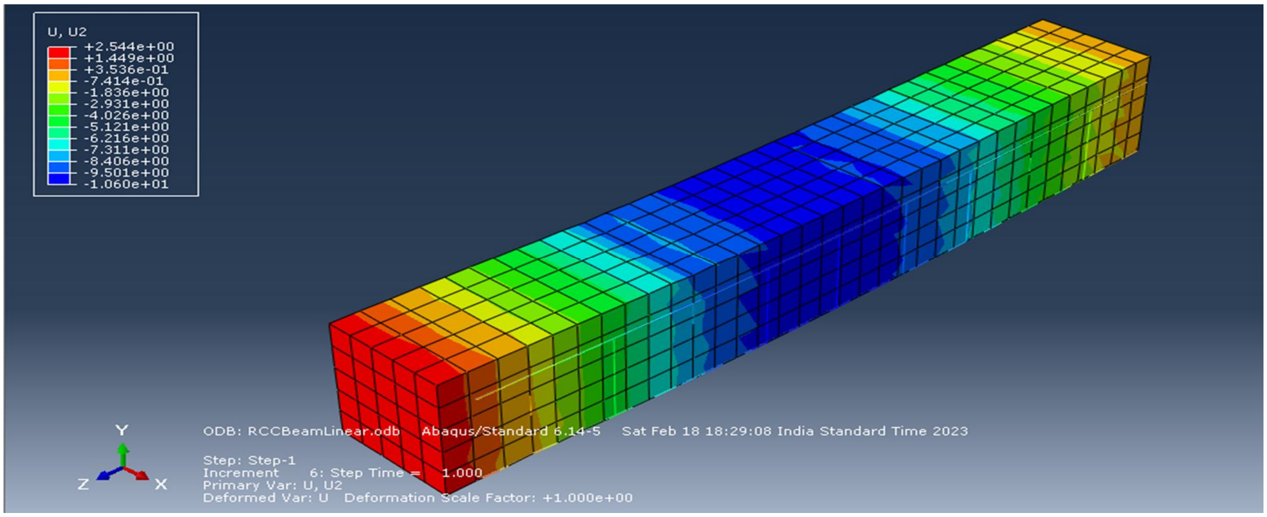


Fig. 4 M25 Grade Beam After Being Exposure to Temperature

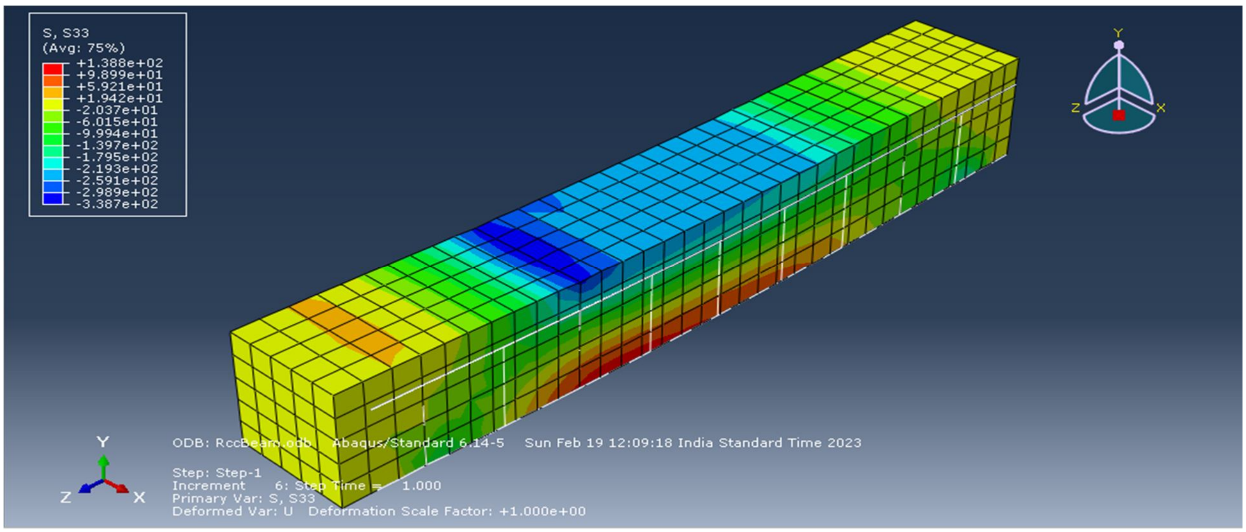


Fig. 5 M30 Grade Beam Before Exposure to Temperature

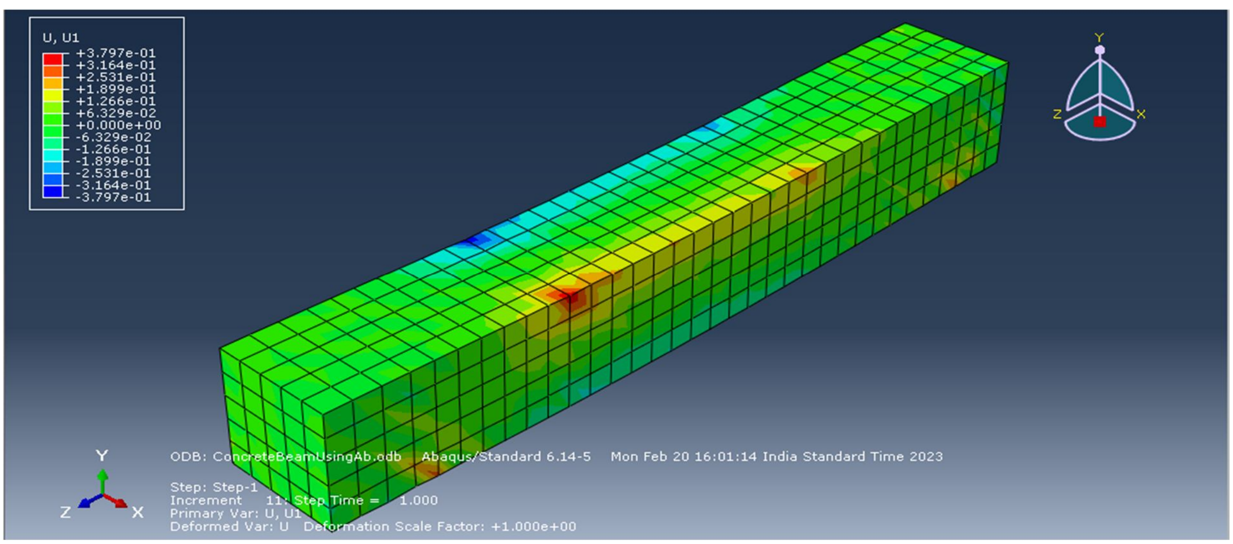


Fig. 6 M30 Grade Beam After Being Exposure to Temperature

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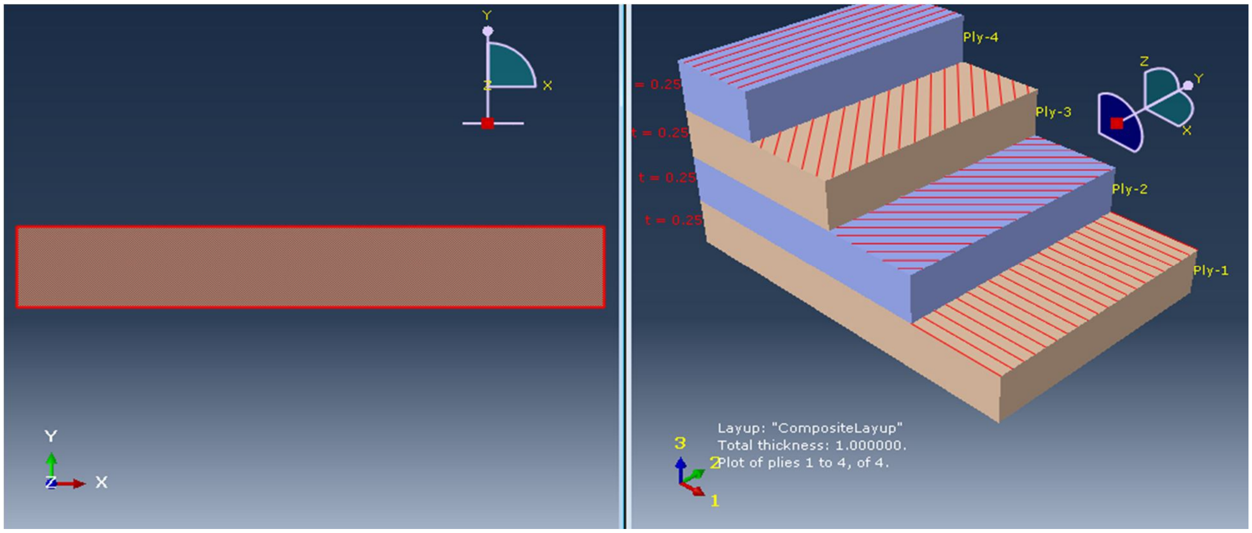


Fig. 7 CFRP LAMINATION

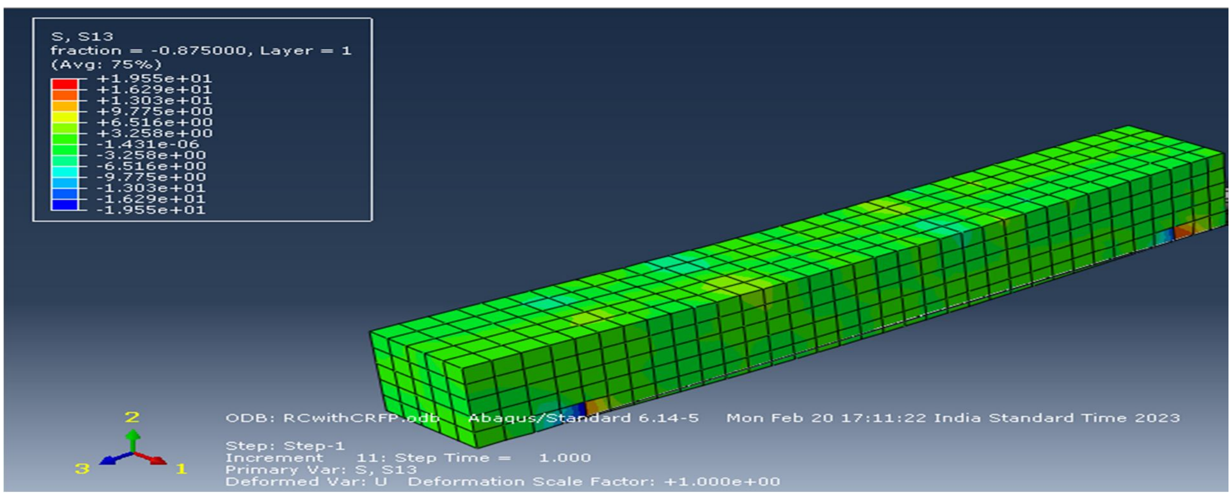


Fig. 8 M25 Grade Beam with CFRP After Being Exposure to Temperature

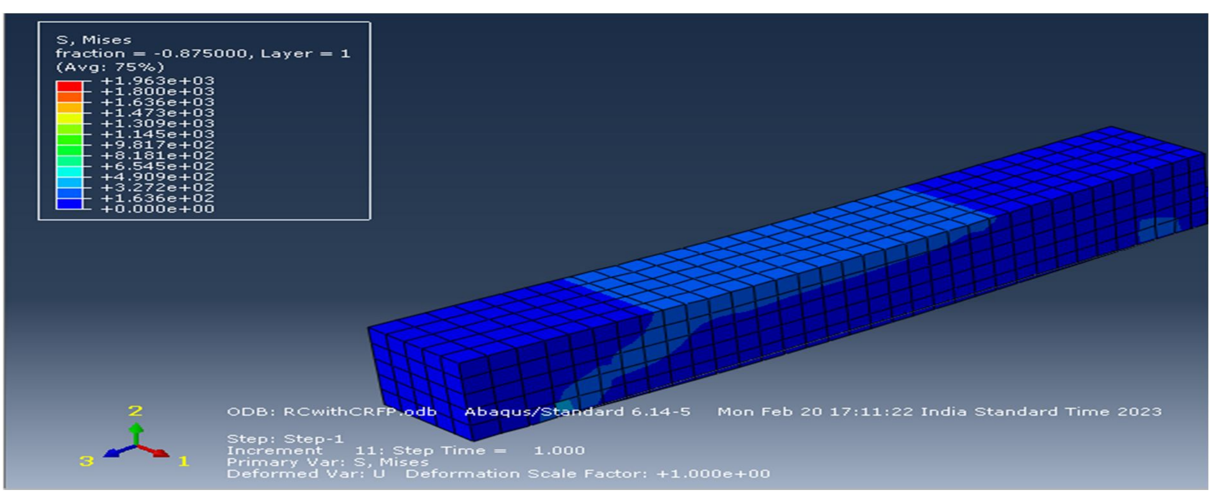


Fig. 9 M30 Grade Beam with CFRP After Being Exposure to Temperature

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## VI. RESULTS

The analysis result of load-deflection curve for M25 grade and M30 grade beam before exposure to a high temperature and after exposure to high temperature and load-deflection for M25 grade and M30 grade beam with CFRP after exposure to high temperature.

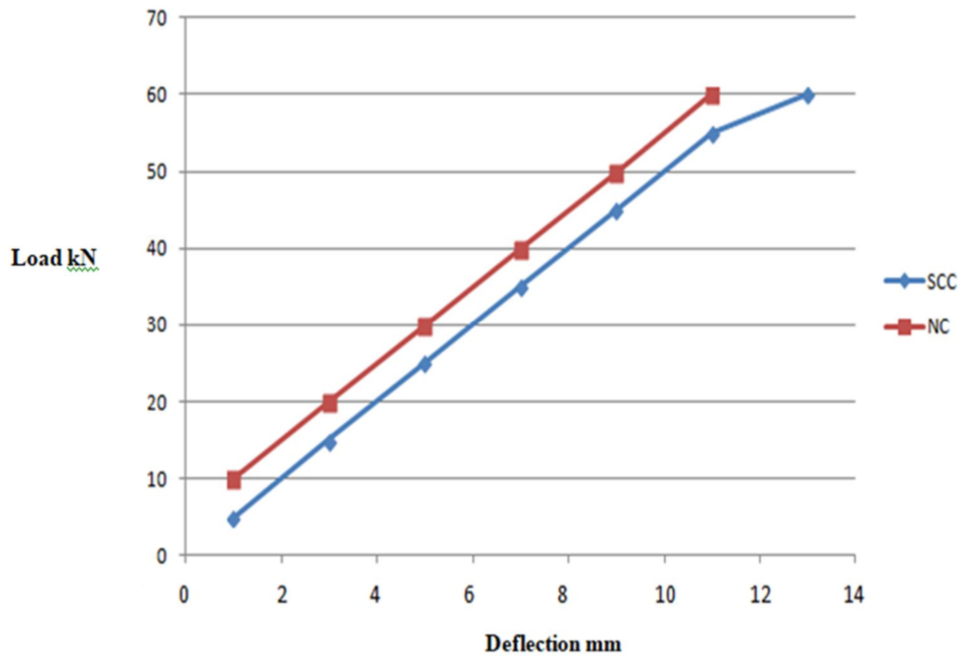


Fig. 10 Load - Deflection Curve for Pre-Heated M25, M30 Grade Beams

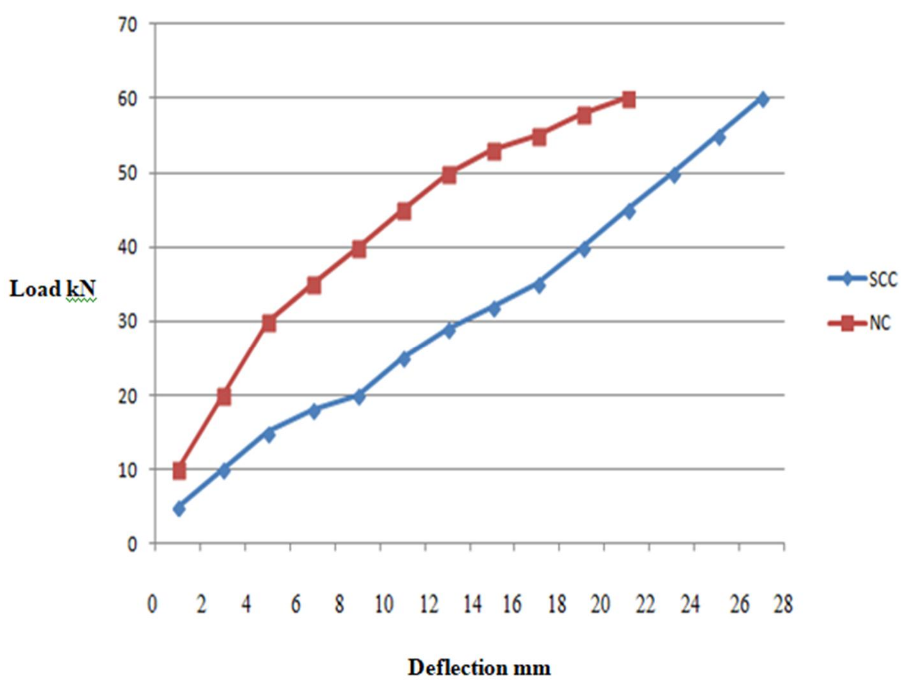


Fig. 11 Load - Deflection Curve for Post-Heated M25, M30 at 400°C

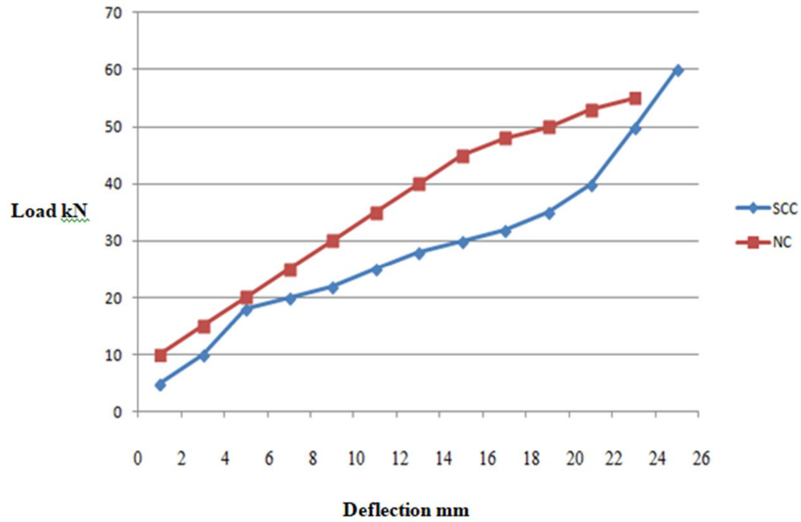


Fig. 12 Load - Deflection Curve for After-Heated M25, M30 with CFRP at 400°C

## VII. OBSERVATION AND DISCUSSIONS

Following observations are made based on the analysis results.

1) Different grades of concrete reinforced beams after being exposure to high temperature. These includes the heat transfer to the beam. The variation in the M25 and M30 beam are to be clearly noted. Exposure for one hour has no effect on M30 than M25. If temperature and the duration increases effect will be more especially on M25.
2) M25 and M30 beams have the approximately the same failure load under 400°C for 1hr. The deflections of the M25 and M30 grade beams were of 2, 4, 6, 8, 10mm, correspondingly, which exhibit the rise in deflection of M25 than that of M30 grade.
3) The modes of failure of these beams changes to deflection at 400°C due to the considerable weakness of the M25 grade compressive strength. The influence led to a behaviour for M25 grade beams under 400°C at any exposure time, which decreased the beam capacity.
4) CFRP laminates are the methods utilized to adopt the various varieties of concrete beams of M25 and M30 grade after being exposure to high temperature. CFRP is used at the exterior of the beam. The failure mode of the CFRP for M25 and M30 grade beams improves the behaviour of deflection in the beam.
5) After the beams were exposure to 400°C for one hour, the CFRP retrofitting systems for various types of concrete beams, such as M25 grade and M30 grade, produced satisfactory improvements in beam capacity.
6) The failure loads of all the beams were higher than those of the unheated beam. When compared to other types of concrete beams like M25 and M30 grade, CFRP demonstrated better behaviour.
7) In comparison to unheated beams of M25 grade and M30 grade, the failure load of beams exposed to 400°C for one hour was improved by CFRP.
8) CFRP retrofitting of M30 grade compare to unheated beams, beams have a higher capacity.
9) The failure mode of the M25 grade beam exposed to 400°C for one hour was improved by the CFRP retrofitting system.

## VIII. CONCLUSIONS

On the basis of the investigation, the following conclusions can be made.

1) M30 grade exhibits good efficiency with any of the retrofitting systems and has stronger resistance to exposure to high temperatures than M25 grade.
2) The influence of higher temperatures on load – deflection curves begins quickly at 400°C for one hour.
3) The retrofitting system CFRP creates a positive improvements in beam deflection after being exposure to 400°C for one hour.
4) After one hour of exposure to 400°C , CFRP retrofitting improves and restores the M30 grade beam deflection.
5) An one- hour heating period at 400°C, M30 grade beams behave well when retrofitted with CFRP.

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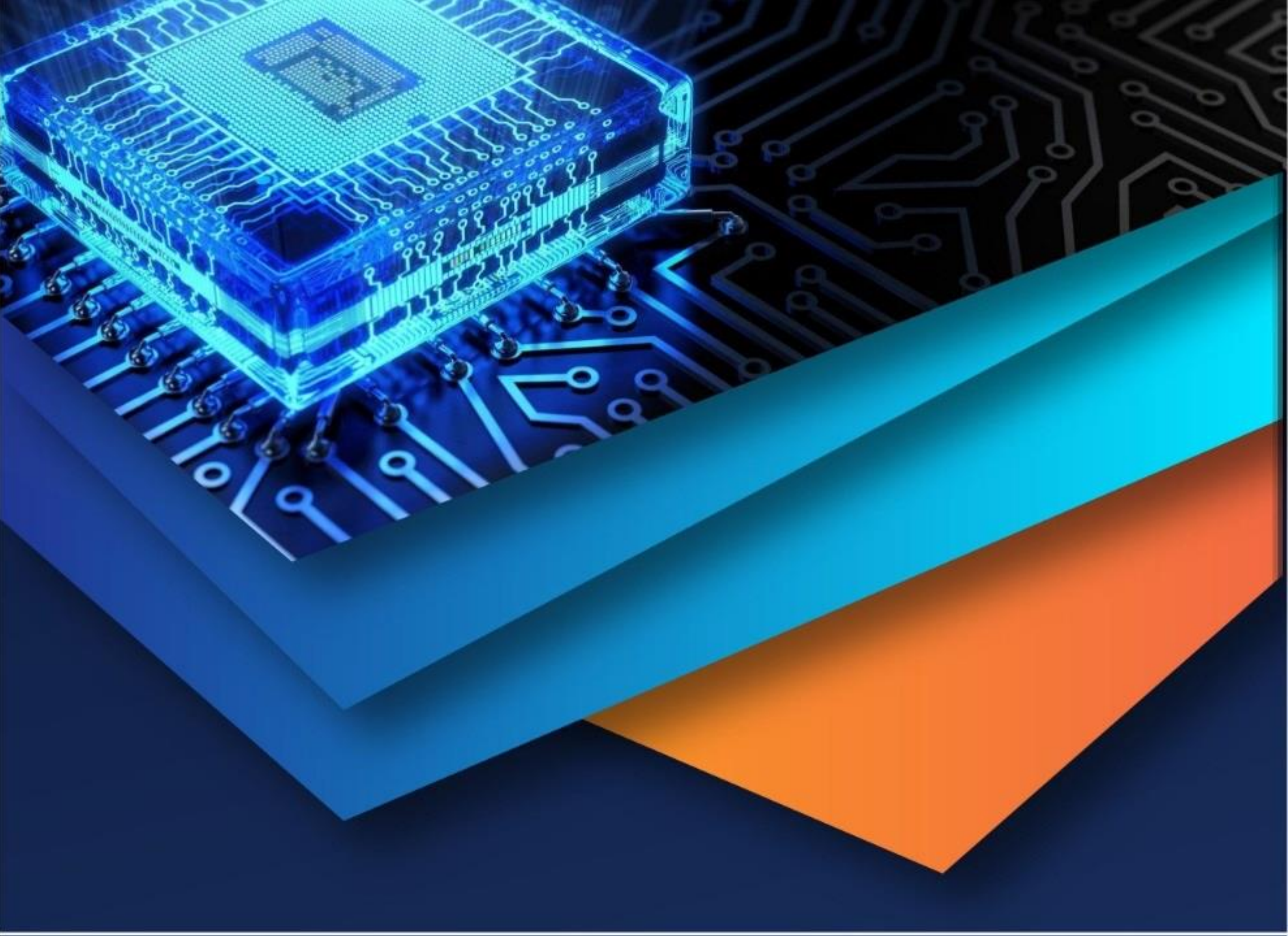


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