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Thermal Behaviour of Reinforced Concrete Beam with Static loading Condition.

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Abstract: ***This work examines the results on the Reinforced concrete beam element under different temperature scenario. The most contagious or maximum temperature distribution in the RC member will be presumed. In Reinforced concrete beam the flexural failure is vigorously reached by the temperature, and also steel reinforcement has experienced. The present work has studied the two-dimensional static analysis in the ABAQUS finite element software when the temperature remains in the steady-state condition during incremental loading applied in the member. The numerical results show that the temperature distribution in the beam element,load versus deflection curve ,ultimate load, Maximum principal stresses are done in the RC beam under different temperature. There fore the reinforced concrete 3D model is usefull in analytical tool for prediction of the behaviour of RC beam under temperature.***

Keywords **:** ***Deflection, finite element analysis, strain,temperature, ultimate load.***

I. INTRODUCTION

Interestingly behaviour of concrete at high temperatures occurs in various places due to causes of fire. Sometimes stresses due to temperature are generated only when the thermal contraction and expansion of concrete are restrained and also the buildings can carry the same intensity of self weight and live load of structures[1].Some time temperature or sudden fire concrete have good strength compared to some other building materials like steel etc. However after fire scenario properties of concrete like Mechanical properties of concrete, Young's modulus and stiffness of the elements are decreased and precious. Depending upon the time of temperature affected in concrete the surfaces heated quickly and inner temperature are very less and the cracks in concrete are formed. Increasing the porosity and permeability of concrete at 105°C around and 70% of dehydration of concrete is destroyed in 500°C[2].

Numerous investigators have performed tests under elevated temperatures or then again fire to explore their impact on basic properties and conduct of concrete. Thinking about the troubles in estimation at high temperatures, the vast majority of the mechanical quality tests are done after cooling, that is, residual properties are researched [3-4].In the reinforced concrete beam applying a temperature as per ISO834 curve for the duration of 1 h, 1.5 h and 2 h are kept inside the oven . Then specimen reached room temperature and tested less than four points loading till failure [5]. The micro structural and compositional changes inside the concrete uncovered to high temperatures were checked by XRD, FTIR, TGA/DTA and SEM strategies to understand the idea of decay of C-S-H gel and the related physic mechanical properties of thermally harmed cement paste with ordinary Portland cement of WC ratio 0.27 was moisturize for 28 days and kept in oven till 750°C reaches for 2 hrs. The percentage of calcium hydrates and portandite was analysed by TGA results [6]. Analytical study was carried by using finite element(FE) method in three dimensional (3D) reinforced concrete beam under elevated temperature by applying mechanical loading are studied. And he suggests that thermo-mechanical is a useful for an analytical and numerical study for the realistic prediction for reinforced concrete structures[7]. In the present work, analytical and experimental study of reinforced concrete beams by using Finite element model and thermal stability like thermogravimetry- Differential Thermal Analysis (TG/DTA), X-ray diffraction and SEM analysis by using a concrete cubes with different heat temperature. The temperature-dependent concrete is applied by using of young's modulus, and the model developed inside its frame work. Analytically obtained the results like ultimate load, failure patterns, initial cracks, deformation and strain in the steel reinforcement. The results are compared experimentally and formulated. In this work, can successfully suggest that the behavior of temperature in concrete with repeated load under varying constant temperature acting in the beam Nevertheless lack of experimental data available, certain assumptions to be made in this which make the vulnerable model[8].

II. RESEARCH SIGNIFICANCE

Understanding the temperature in the concrete behavior is very realistic prediction until the maximum temperature reaches in the reinforced structures is necessary to have adequate design codes. In the current codes simplified, guidelines are followed for RC structures, like the effective cover of the beam and column elements during the fire scenario. Most of the researchers are tried to investigate the live temperature in the buildings and elements experimentally to find the maximum strength capacity and stiffness of the members. But in the present scenario the guidelines is available to find the behavior of concrete under different temperature conditions[9].

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In the RC members calculating the internal temperature is very challenging by using the thermocouple, the inside temperature reaches the value and by applying the repeated loading experimentally is very tedious.

In the analytical approach by using the finite element method is very realistic and calculating final crack patterns, ultimate loadings and load – deformation behaviour when subjected to high temperature or after cooling in room temperature. This approach can be done beam , column , slab element and assemblages of beam column joints with different combination of loadings like dead , live and fire loadings.

III. MODELLING

Previously researchers has developed a finite element analysis model by using commercial software ABAQUS to predict the deflection behaviour, initial and final cracks of reinforced concrete beam subjected to a central loading[10-11]. The same type of technique are used here with different temperature like steady state and transient state with respect to time along with mechanical two point loading condition. The finite element model along with support condition as shown in Fig. 1. Material properties for concrete and steel at different temperatures like elastic modulus, strain and mesh types and sizes, interaction and boundary condition are discussed below.

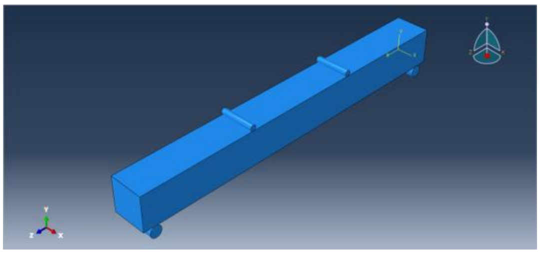


Fig. 1. Finite element beam model

IV. FINITE ELEMENT MODEL

The finite element model was created for the testing specimen of the reinforced concrete beam of length 3000mm, breadth 300mm and depth 300mm. Boundary conditions for the reinforced concrete beam are pinned on both the supports. Reinforcement provided in the beam is 4numbers of 12 mm diameter on both compression and tension zone, 8mm diameter stirrup is provided at 150mm c/c spacings. The two point loading is applied on the beam with the L/3 distance by using circular steel rod are modelled at the top of the beam as shown in Fig. 2(a). Hexahedron mesh type is provided for the beam with size 25mm and surface to surface interaction is used for support and loading point, For steel and concrete embedded interaction is applied is shown in Fig. 2(b).

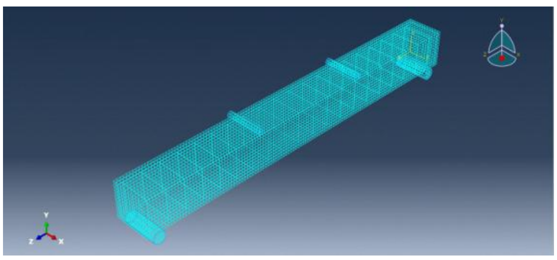


Fig. 2(a) Meshing of finite element model

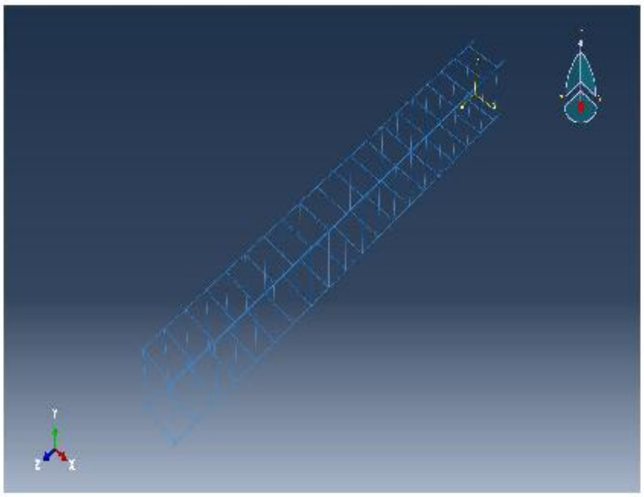


Fig. 2(b) Reinforcement model

V. MATERIAL PROPERTIES FOR STEEL AND CONCRETE

The behavior of beam under elastic plastic stages was to be described in finite element (FE) model[12]. The elastic modulus and strain for the High yield deformed steel bar for different temperature is taken from Euro code 3 design of steel structures.[13]. The initial young's modulus for room temperature are determined by using slopes from stress strain curve. Poisson ratio is taken as 0.3 for elastic stage condition. Concrete damage plasticity is used for behaviour of reinforced concrete beam at plastic stage. Typical stress strain relationship for the different high temperature under steady state condition ranges between room temperature 29°C to 600°C. Concrete grade M30 is used for the cylindrical specimen for the size 100mm diameter and 150mm height and the stress strain curve as shown in Fig. 3. Elastic modulus of concrete for different temperature is taken from Eurocode 2: Design of concrete structures for finite element (FE) modelling..[14].

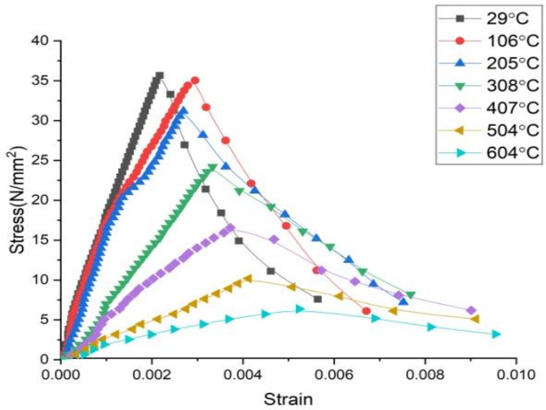


Fig. 3 Stress strain curve for different temperture

In the stress strain curve strain is increasing and also reduction in stress for the different temperature starting from room temperature 29°C to 604°C due to cracking and spalling of concrete and more strain when elongation in the materials.

Curve shows that when the temperature increase elastic modulus of concrete will be decrease.

VI. DEFLECTION

A deflection mode comparison of the reinforced concrete beam from the finite element analysis model is shown in Fig. 4. The applied load is plotted as a function of deflection calculated during static two point loading. In the FE analysis the deflection pattern for room temperature 29°C and 100°C is constant due to there is invariable in the beam. But after 200°C its tends to deflect more and extended till 500°C. after that when 600°C the beam fails immediately at the application of two point loading.

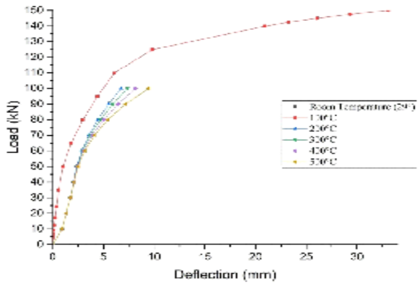


Fig. 4 Deflection pattern for thebeam under varying temperature

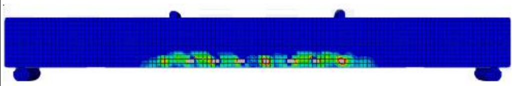
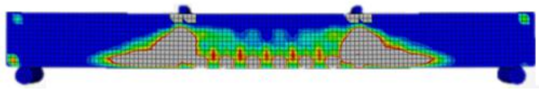
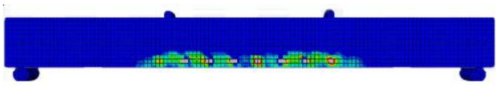
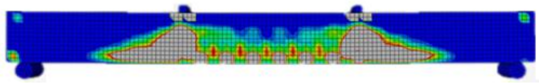
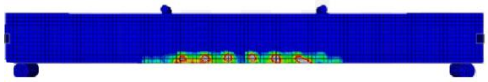
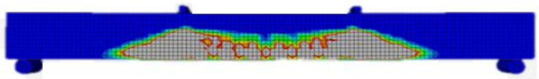
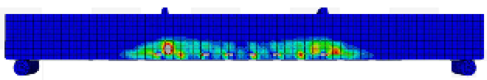
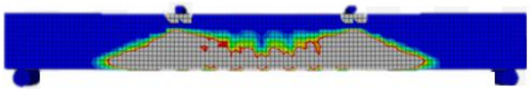
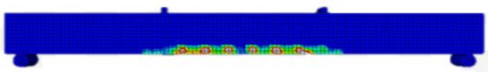
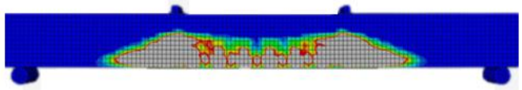
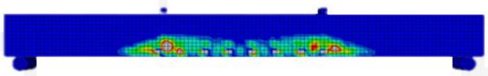
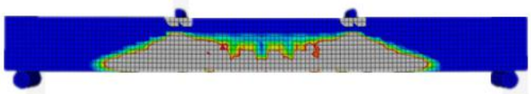
The experimental work are done by the previous researchers but not plotted the load deflection curve due to temperature is in steady state condition are applied at the beam.

VII. FAILURE PATTERN

The initial and final crack pattern at ultimate load for the different temperature 29°C to 500°C on the reinforced concrete beam as shown in Table 2. The crack is extended from 200°C to 500°C is higher compared to room temperature and 100°C. The brittle failure

The failure mode for the experimental verification as shown in Table 1. it shows that the diagonal takes immediately after the temperature and static loading conditions is applied on RC beam. The failure is takes place at the centre of the beam when two point loading is applied at L/3 distance . The beams shows that initial crack at starts at centre of the bending region and then the final cracks are increase in the vertical direction as the loads are increase at RC beam under different temperature[15]. Compared to analytical verification failure pattern are coincides in the FE model in the middle region of the beam.

Table 1. Initial and Final Crack Pattern

Temperature	Initial Crack	Final Crack
29°C		
100°C		
200°C		
300°C		
400°C		
500°C		

VIII. INITIAL CRACKING AND ULTIMATE LOAD

In the finite element analysis the extend of cracks in the after the loading and application of temperature in RC beam. The beam have the maximum deflection in the mid span region, several flexural cracks are occurred in under the two point loading. The width of crack is very small at the initial stage and extended at the final crack at failure condition.

The initial cracking load and ultimate load in the beam are decreasing when the temperature is increasing from 100°C to 500°C as shown in Fig. 6 and Fig. 7..

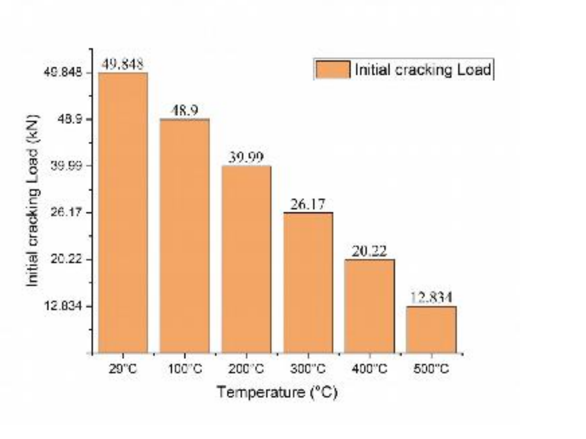


Fig. 6 Initial Cracking Load for different temperature

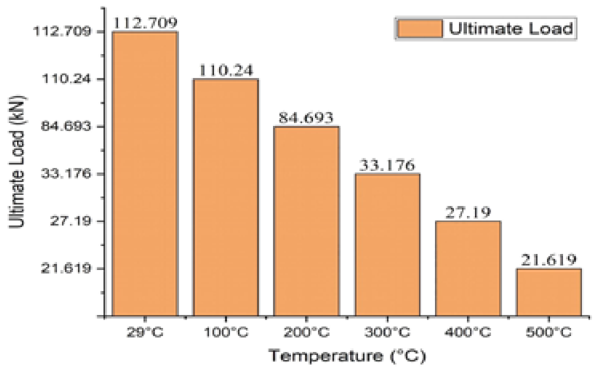


Fig. 7. Ultimate load for different temperature

The stiffness of the beam at initial crack also getting reduced in the temperature changes at reinforced concrete beam . In the room temperature and 100°C the initial stiffness is 21.075kN/m and gradually decreasing by 19.69kN/m to 8.67kN/m as shown in Fig. 8

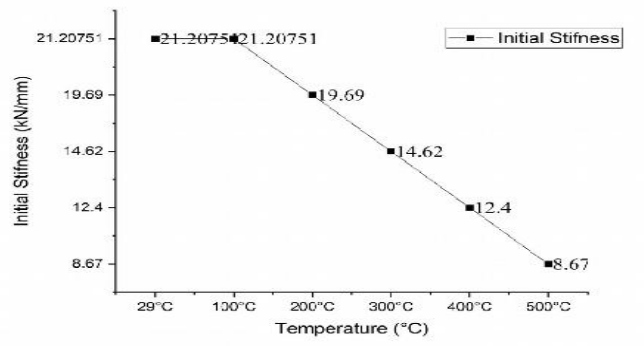


Fig. 8 Stiffness of beams

IX. CONCLUSIONS

The analytical results are obtained from ABAQUS for the beam subjected to load and temperature and the following conclusions are made based on the results.

Comparison of finite element analysis against a high temperature in the reinforced concrete beam that the model develops in this paper can used to realistic performance on temperature.The distribution of the crack pattern from initial load to ultimate load are higher in the above 200°C to 500°C. The deflection pattern for the for the beams is increased twice a times when compared to beam under room temperature. And the ultimate load reduced on all types of beams especially on 80% on beam at 500°C is reduced. The maximum principal stress is also reduced from 337.2N/mm^2 to 17.02N/mm^2.

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