Using Opensees Software Analysis of Structure in fire

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Abstract :- The analysis of a steel frame structure under fire circumstances using OpenSees software is presented in this work. According to the ISO-834 standard, a temperature-time curve is used to model the fire situation. By contrasting the simulation results with experimental data from earlier investigations, the OpenSees model is proven to be accurate. The position of fire compartments, the thickness of fire protection materials, and the cross-sectional area of steel components are just a few of the design aspects that the article looks into in relation to the structural reaction. The report concludes by discussing the OpenSees software's shortcomings and the need for additional study to increase its precision and applicability in the field of fire engineering.

Keywords :- Steel Frame Structure, Fire Circumstances, Opensees Software,Iso-834 standard, Cross-sectional area

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1. INTRODUCTION

The study of how structures react to fire is an important subject of study in structural engineering. Structures may sustain severe damage from fire, and failing to account for the impacts of fire can have disastrous repercussions. Hence, precise prediction of the behaviour of structures under fire circumstances is critical for maintaining occupant safety and limiting property loss. Simulation on a computer is an efficient method for predicting the behaviour of structures under fire conditions. OpenSees has gained popularity as a tool for the analysis of structures under fire conditions in recent years.

The ISO-834 standard is widely used for modelling fire scenarios in structural analysis. This standard defines a standard time-temperature curve that represents the average temperature increase of a fire in a compartment. By inputting this temperature-time curve into the OpenSees model, it is possible to simulate the behaviour of a structure under fire conditions. The purpose of this paper is to present a study on the use of OpenSees software for the fire analysis of a steel frame structure. The accuracy of the OpenSees model in predicting the behaviour of the structure under fire conditions will be determined by comparing simulation results to experimental data from previous studies.

The use of OpenSees software for the analysis of structures in fire can significantly improve our understanding of the behaviour of structural systems under extreme conditions and provide crucial insights for the design, operation, and safety of buildings.

2. LOAD MODELLING OF FIRE

Load modelling is a crucial component of fire analysis in structural engineering, as it simulates the effects of heat and fire on the structural system. OpenSees software offers multiple methods for modelling fire loads in structural analysis, including the use of temperature-dependent material properties and heat transfer coefficients.

Using temperature-dependent material properties to simulate the thermal behaviour of the structure under fire conditions is a common load modelling technique in OpenSees. This method involves defining the material properties of the structural elements as functions of temperature, such as the modulus of elasticity and thermal conductivity. This enables the software to simulate the effects of temperature on a structure's mechanical behaviour.

Using heat transfer coefficients to model the heat transfer between structural elements and the surrounding environment is an alternative method. This involves defining the heat transfer coefficients for the various surfaces of the structural elements, allowing the software to simulate the heat transfer between the elements and the surrounding air or other media.

In addition, the OpenSees software permits the modelling of the heat release rate, an essential parameter for simulating the effects of a fire on a structural system. This entails determining the rate at which heat is released by the fire and how it affects the surrounding temperature.

In fire engineering, the load modelling of fire in OpenSees software is a crucial component of structural analysis. Engineers and researchers are able to simulate the effects of a fire on a structural system and evaluate its performance in various scenarios. By accurately simulating the loads and thermal behaviour of the structural system, OpenSees can aid in optimising the design of fire-safe structures and preventing catastrophic failures.

3. STRUCTURAL COMPONENTS OF HEAT TRANSFER

Heat transfer is an essential aspect of fire analysis in structural engineering because it helps to simulate the effects of heat and fire on the structural system. Using thermal conductivity, heat transfer coefficients, and convection coefficients, the OpenSees software offers a variety of techniques for simulating heat transfer in structural analysis.

One of the common methods for modelling heat transfer in OpenSees is to simulate the thermal behaviour of the structural elements using thermal conductivity. This requires defining the thermal conductivity of the material for each structural element, allowing the software to simulate the rate of heat transfer for each element.

Using heat transfer coefficients to model the heat transfer between structural elements and the surrounding environment is an alternative method. This involves defining the heat transfer coefficients for the various surfaces of the structural elements, allowing the software to simulate the heat transfer between the elements and the surrounding air or other media.

In addition, the OpenSees software enables the modelling of convection coefficients, a crucial element of heat transfer. Convection is the transfer of heat between a moving surface and a moving fluid (such as air or water). The software permits the definition of convection coefficients for various surfaces of structural elements, thereby simulating the heat transfer between the elements and the surrounding fluid.

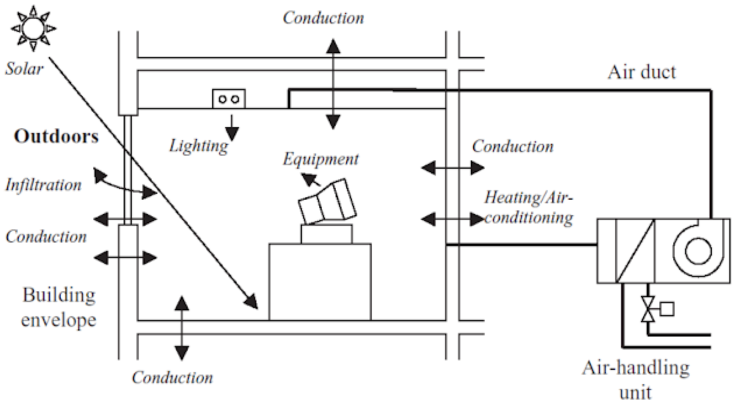

Fig 1 :- Heat transfer process in buildings

4. MATERIALS PROPERTIES USING TEMPERATURE DEPENDENT

The properties of materials can vary significantly with temperature, which can have a substantial effect on the behaviour of structural elements in a fire. In structural analysis, the OpenSees software offers multiple modelling options for these temperature-dependent material properties. The following are examples of material properties that can change with temperature:

I. Modulus of Elasticity: This property relates to a material's stiffness and can vary with temperature. As temperature rises, the modulus of elasticity may decrease, resulting in greater deformations and diminished structural capacity.

II. Thermal Conductivity: A material's thermal conductivity determines its capacity to conduct heat and can vary with temperature. As the temperature rises, the thermal conductivity of some substances may decrease, thereby affecting the rate of heat transfer through the substance.

III. Specific heat capacity is the amount of heat required to raise a material's temperature by a specific amount. This property can also vary with temperature; as the temperature rises, the specific heat capacity of some materials may decrease, thereby affecting the amount of heat energy the material can absorb prior to failure.

IV. Yield and Ultimate Strength: Temperature can also affect the yield and ultimate strength of materials. As the temperature rises, the yield and ultimate strength of some materials may decrease, which can have an effect on the structure's load-bearing capacity.

5. MODELLING FOR THERMO MECHANICAL AND CLASS DIAGRAM

The OpenSees software's structural analysis tools permit the simulation of the mechanical behaviour of structures, including the effects of temperature changes. By combining these tools with thermal analysis tools and thermo-mechanical schemes, engineers and researchers can precisely simulate the behaviour of structures under fire conditions and optimise the design of fire-safe structures.

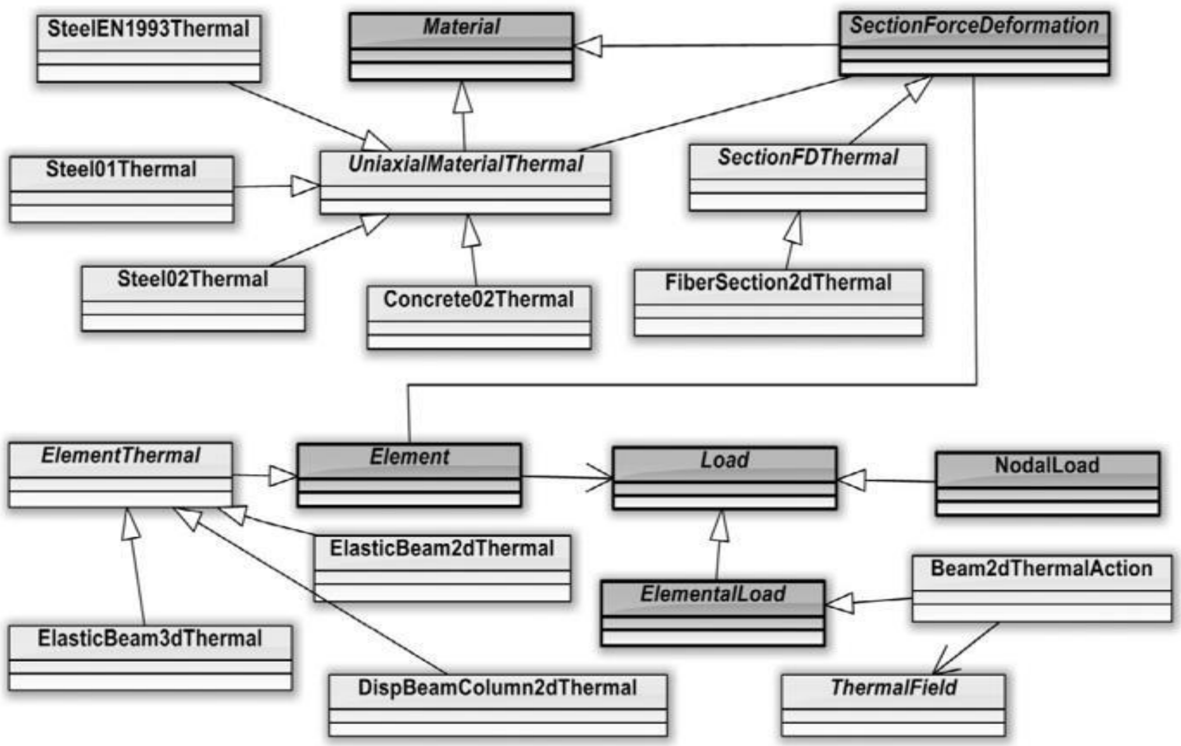

Fig 2. Thermo mechanical new classes

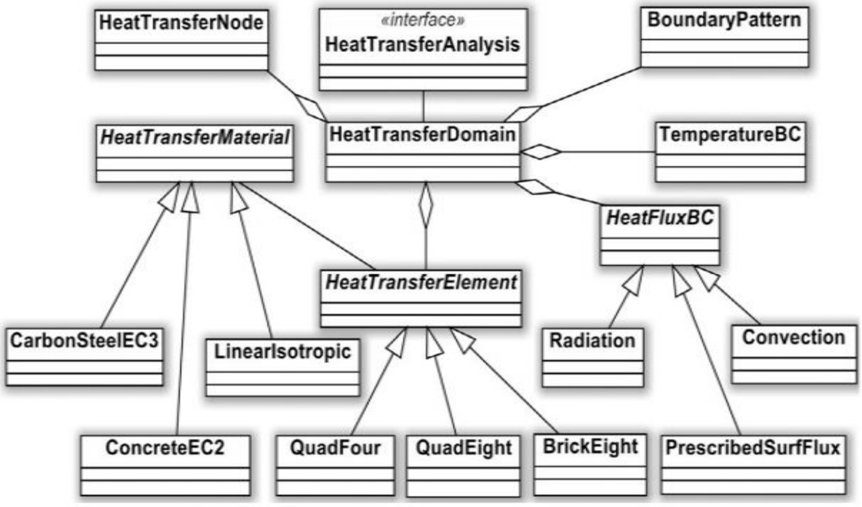

Fig 3. Class Diagram Representing heat transfer FE Components

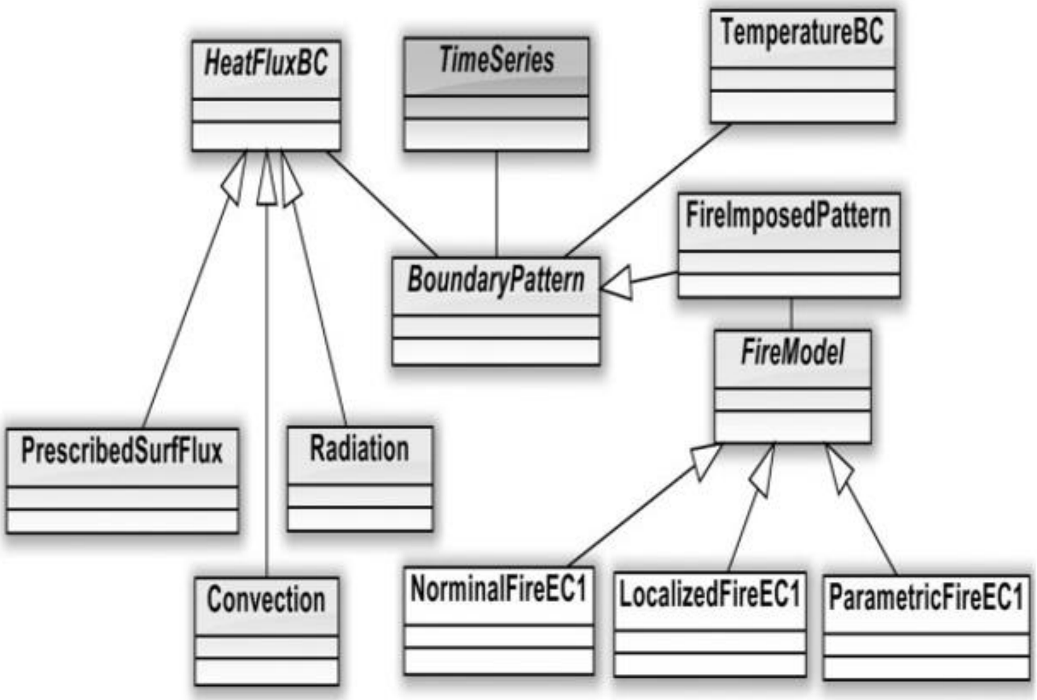

Fig 4. Class Diagram representing time-dependent boundary conditions and the fire models.

6. TEST EXAMPLE

The work that we have implemented is being testing with different scenario and at different temperature. In this section we will shows all the tested results.

The 1st example is of testing just a simple test of expansion of thermal modelling in a beam made of steel we have increased the temperature when it reached half , we can observe that on both end of the beam it is restrained and it will be continuously increasing towards the cold part end which has resulted in that the beam is displacing towards right from the mid of the beam and stress is also increasing at both points of beam.

The curve to represent stress vs strain is elastic with havinga stress of 280Mpa and young modules of 200000 MPa. With the help of Eurocode with temperature constant to 1000ºC.

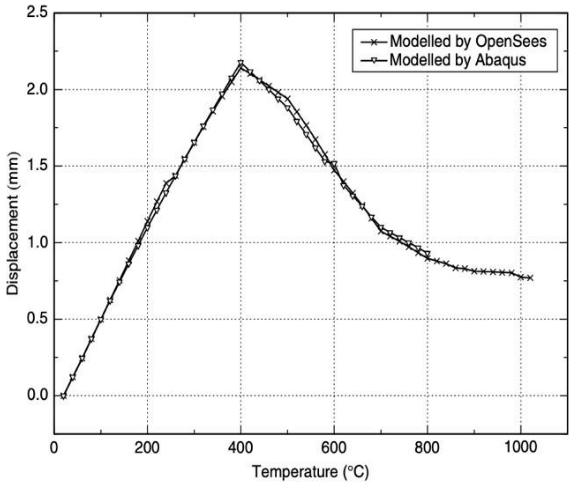

Fig 5. Node 2 displacement

We can see the displacement from node 2 at temperature of 400ºC. and this will be observed as a linear curve. We canalso observe that from node 2 at 400ºC temperature it will starts moving from right to left. This will happen due to low stress in the half that is heated with comparison of unloadingof unheated half of beam.

7. CONCLUSION

The software program OpenSees is a potent instrument for analyzing structures under fire conditions. It offers a variety of sophisticated capabilities for modelling, simulating, and analyzing the behavior of structures subjected to fire loads, in addition to tools for result analysis and test analysis.

Engineers and researchers can accurately simulate the behavior of structures under fire conditions and evaluate their performance in a variety of scenarios using the OpenSees software. This can aid in optimizing the design of structures for fire safety, identifying potential failure points, and preventing potential catastrophes.

In addition, OpenSees software is an open-source platform, which means that it is freely accessible to users and can be tailored to meet specific requirements. This makes it a versatile and customizable tool for analyzing structures under fire conditions, allowing users to tailor it to their specific needs.

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