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FIRE RESISTANT DESIGN OF STRUCTURE: A DETAILED STUDY

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ABSTRACT

With increase in the fire related accidents together with loss of life and property. It becomes very much essential for us to diagnose the incidents of major fires which are occurring in Multi storey buildings, important installations and to prevent this kind of hazardous accident.proper and time bound assessment together with planning and execution work is to be carried out by keeping in mind latest available sophisticated technology and equipment in addition to economic and sustainable structural design technique. This is the main reason why repairs and rehabilitation of fire damaged structures has become a top priority among structural engineers. Fire Resistant Design of Structure is a specialized field which involves Expertise in many areas like concrete and construction technology, material science and testing, structural Engineering, seismic and earthquake engineering, other available analysis and design techniques etc. Various research and developmental efforts are being carried out in this area and other relevant field related to these disciplines. In this topic the expertise and experience of problems that are associated with our real life are presented which add immense value to our genuine concern. This report also provide us a detailed knowledge on the overall strategy for analysis and designing of fire resistant structure, repair, maintenance and restoration of structure which are damaged by the effect of fire. It also provides us immense knowledge on various materials to be used during building construction, which resist and prevent the fire to spread out in larger area.

Generally in most of the cases fire damaged RCC structures are repairable, But depending upon temperature the reinforcing bar sometime losses their ductility.In some cases it has been recommended to use fiber reinforced concrete and asbestos based concrete, as they prevent sudden increase in temperature and spread of fire. Many research works are still going on in this field and in near future we can get very effective and suitable fire resistant structure.

Keywords: asbestos concrete, construction technology, fiber based concrete, hazardous, sophisticated technology

I.INTRODUCTION

We are all aware of the damage that fire can cause in terms of loss of life, homes and livelihoods. The extent of such damage depends on a number of factors such as building design and use, structural performance, fire extinguishing devices and evacuation procedures. Appropriate design and choice of material is crucial in

ensuring fire safe construction. Codes and regulations on fire safety are updated continually, usually as a result of research and development.

Basic concepts of risk-informed decision making for mitigating fire risk, and a general Frame-work for assessing fire risk to building construction and for developing structural design requirements for fire conditions are described. Current best knowledge in thermal and mechanical properties and behaviours of normal strength concrete, high strength concrete, structural steel, and several major groups of common fire protection materials at elevated temperatures, which are necessary for performance-based engineering calculation, are presented. Modern fire resistant design methodologies for concrete and steel structures are discussed, including methods based on standard fire tests as well as performance-based engineering analysis methods that involve heat transfer and structural analysis at elevated temperatures.

One of the main reasons why Portland cement concrete is so widely used in building construction is that it can help satisfy the cardinal need for public safety in the face of the hazards of fire better than most alternative materials. Concrete is non-combustible and a reasonable insulator against the transmission of heat. In many applications, the main role of concrete in a fire is to protect any embedded steel for as long as possible against a rise in temperature to the point where its physical properties are reduced significantly, causing excessive structural deflections that might lead ultimately to collapse. A new approach to high rise safety began emerging that required buildings to be constructed of columns, floors, walls and other elements that were fire resistive, defined as the ability of an element to withstand the effects of fire for a specified period of time without loss of its fire separating or load bearing function. Various temperature-time curves are used today, depending upon the country and application.

In this section a brief review of aspects of structural steel work subjected to fire is given. The strength of all engineering materials reduces as their temperature increases. Steel is no exception. However, a major advantage of steel is that it is incombustible and it can fully recover its strength following a fire, most of the times. During the fire steel absorbs a significant amount of thermal energy. After this exposure to fire, steel returns to a stable condition after cooling to ambient temperature. During this cycle of heating and cooling, individual steel members may become slightly bent or damaged, generally without affecting the stability of the whole structure. From the point of view of economy, a significant number of steel members may be salvaged following a post-fire review of a fire affected steel structure. Using the principle "If the member is straight after exposure to fire – the steel is O.K", many steel members could be left undisturbed for the rest of their service life. Steel members which have slight distortions may be made dimensionally reusable by simple straightening methods and the member may be put to continued use with full expectancy of performance with its specified mechanical properties. The members which have become unusable due to excessive deformation may simply be scrapped. In effect, it is easy to retrofit steel structures after fire. On the other hand concrete exposed to fire beyond say 600oC, may undergo an irreversible degradation in mechanical strength and spalling .However it is useful to know the behaviour of steel at higher temperatures and methods available to protect it from damage done to fire. Provisions related to fire protections are given in section 16 of the IS 800 code.

The basic idea is that the structure should not collapse prematurely without giving adequate time for the occupants to escape to safety. As briefly outlined earlier, there are two ways of providing fire resistance to steel

structures. In the first method of fire engineering, the structure is designed using ordinary temperature of the material and then the important and needed members may be insulated against fire. Fire safety is provided in a building by a combination of active fire suppression and passive fire protection. Active fire suppression includes fire-fighting and automatic devices, such as sprinklers, to control the spread of fire. Passive fire protection includes measures, such as fire barriers, that control the spread of fire or insulations, such as concrete cover and spray applied fire protection that delay the effects of fire on the structure collapse in fire.

The following approaches can enhance fire resistance in buildings:

i. Control fuel quantity and locations.

ii. Control fire spread.

iii. Control ventilation characteristics.

iv. Protect construction materials.

Changes in Concrete due to Fire:

- Condition of plaster and finish deteriorates.
- Colour of concrete changes.
- Spalling of concrete.
- Crazing of concrete.
- Distortion and Delamination of concrete.
- Reduction in ductility of steel.

Alternative fireproofing methods:

Among the conventional materials, purpose designed spray fireproofing plasters have become abundantly available the world over.

The inorganic methods include:

i. Gypsum plasters

ii. Cementitious plasters

iii. Fibrous plasters

Gypsum plasters have been lightened by using chemical additives to create bubbles that displace solids, thus reducing the bulk density. Also, lightweight polystyrene beads have been mixed into the plasters at the factory in an effort to reduce the density, which generally results in a more effective insulation at a lower cost. Fibrous plasters, containing either mineral wool or ceramic fibres tend to simply entrain more air, thus displacing the heavy fibres. Spray gypsum based plaster fireproofing being installed.

List of fire-retardant materials:

Fire retardant materials should not be confused with fire resistant materials. Whilst a fire resistant material is one that is designed to resist burning and withstand heat, fire retardant materials are designed to burn slowly.

i. Rock wool

ii. Gypsum boards

iii. Asbestos cement

iv. Perlite boards

v. Proplex Sheets

vi. Calcium silicate boards, Treated lumber plywood etc.

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II.FIGURES

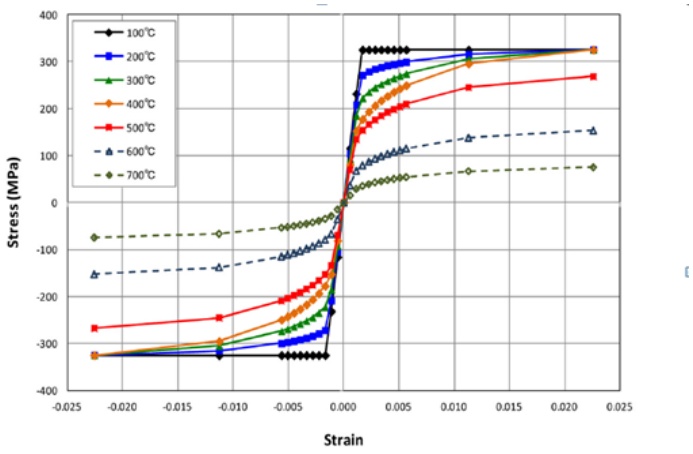

Fig. 1 stress-strain curve at elevated temperatures

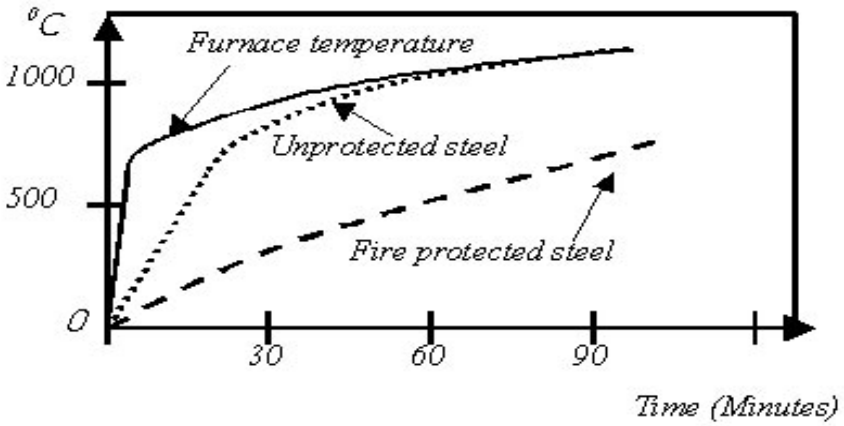

Fig. 2 Rate of heating of steel work

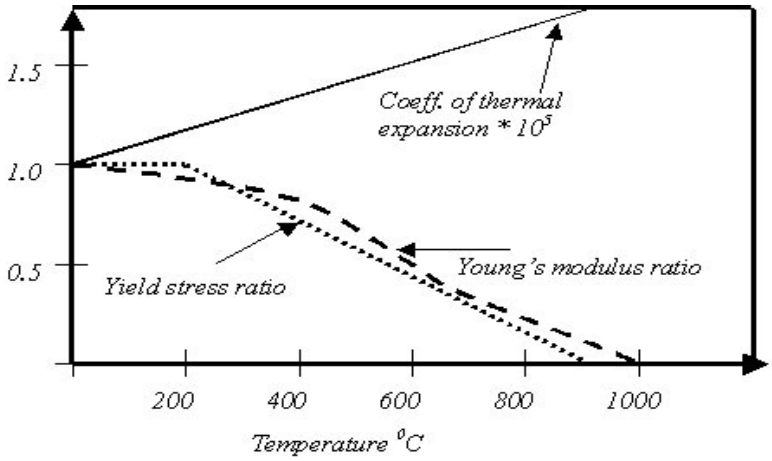

Fig. 3 Mechanical properties of steel at elevated temperatures

III.LITERATURE REVIEW

In recent years, the fire performance of large-frame structures has been shown in some instances to be better than the fire resistance of the individual structural elements (Moore and Lennon 1997). These observations have been supported by extensive computer analyses, including Franssen, Schleich, and Cajot (1995) who showed that, when axial restraint from thermal expansion of the members is included in the analysis of a frame building, the behaviour is different from that of the column and beam analysed separately.

A large series of full-scale fire tests was carried out between 1994 and 1996 in the Cardington Laboratory of the Building Research Establishment in England. A full-size eight-story steel building was constructed with composite reinforced concrete slabs on exposed metal decking, supported on steel beams with no applied fire protection other than a suspended ceiling in some tests. The steel columns were fire-protected.

The good performance of the floor/beam systems in such buildings has been attributed to a complex interrelated sequence of events, described rather simply as follows (Buchanan 2001)

1. The fire leads to heating of the beams and of the slab.
2. The deformation of theslab and beam is downward as a result of thermal bowing.
3. Compressive axial restraint forcesarise as a result of thermal expansion.
4. The compressive axial restraint forces increases as a result of stiff surrounding structure.
5. Modulus of elasticity and strength of the reinforcement reduce steadily.
6. The deflection of structure is rapid due to the combined effects of the applied loads, and high axial compressive forces.
7. The axial restraint forces reduce due to the increased deflections and the reduced
8. Modulus of elasticity, limiting the horizontal forces on surrounding structure.
9. Higher temperatures lead to a further reduction of flexural and axial strength and

Stiffness.

10. The slab–beam system deforms into a catenary, resisting the applied loads with tensile

membrane forces.

11. As the fire decays, the structural members cool down and attempt to shorten in length.
12. High tensile axial forces are induced in the slab, the beam, and the beam connections.

FIRE RESISTANT BUILDINGSREQUIREMENTS

A building may be made more fire resistant by:-

1. Using suitable fire resisting materials.
2. Taking precautions at the time of construction of building.
3. By providing fire alarm systems and fire extinguishers.

Using Suitable Materials:-

The fire resisting material is having the following characters:

(a) It should not disintegrate under the effect of heat

(b) It should not expand under the effect of heat so as to introduce unnecessary stresses in the building

(c) The material should not catch fire easily

(d) It should not lose its strength when subjected to fire accident.

IV.CONCLUSION

Concrete is an excellent fire resisting material and it has been proven by many scientists and researchers who performed and observed the numerous results of tests for over 60 years. The American Concrete Institute and various other design building codes of other country have developed a mathematical and analytical method which is based on the fire tests on various components of structures. This methodalso allows engineers and researchers a relatively easy and simple way to select member proportions and reinforcement requirements for all but the very unusual structures. Some alternate methods are also available for these unusual structures to adequately model and to test the numerous critical and complex behaviour of reinforced concrete components subjected to fire. Despite potential deficiencies in performance of structural components at very high temperatures arising from dehydration and thermal incompatibilities, concrete has very excellent property as a fire-resistant material, notwithstanding a long-recognized need for better means of testing and specifying Endurance. Due to advancement and development of temperature based structural behaviour models and greater technical know-how of thermal and mechanical properties of the member of structure are leading to greater improvements in specification, design and analysis against the extreme effects of fire and for relatively high temperature applications such as nuclear reactors. More advancement have been made in this field of fire resistant design of structure, full physical-chemical, thermodynamic explanations that bind together all the aspects of the complex viscos-elastic, moisture dependent behaviour pattern of concrete at elevated temperatures are still awaited.

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