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Assessment of thermoshock effect on structural element by ansys

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Abstract - The behavior of structural components subjected to fire have received considerable attention in recent years due to different accidental or intentional event, related to important structures. Thus it is very much needed to study the Thermoshock effect on structural element for designing the fire resistance element. The description of the effect of fire on steel and concrete structural members is intended to improve understanding how the structural members respond to fire. The objective of this thesis is to evaluate the effect of Thermoshock at 800°C on slab and beam with different cover thickness by ANSYS 14.5.

In this thesis three slab models of size 1m x 0.25m x 0.075m with varying cover thickness of 15mm, 20mm ,25mm and three beam models of size 5m x .3m x .45m have been created using ANSYS 14.5. From the analytical investigation, it is found that the temperature distribution over the reinforcement of slab with 25mm cover and temperature distribution over the reinforcement of beam with 35mm cover is sufficient than others.

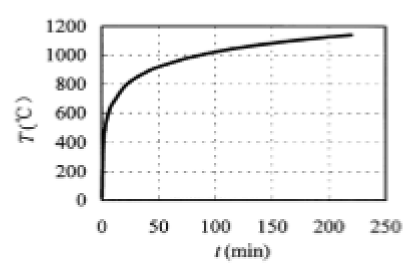
Key Words: Thermoshock,Concrete,Rebars, ANSYS,Deformation

I. INTRODUCTION

Fire resistance of concrete structure is determined by three main factors the capacity of the concrete itself to withstand heat and subsequent action of water without losing strength unduly, without cracking or spalling; the conductivity of the concrete to heat; and coefficient of thermal expansion of concrete. In the case of reinforced concrete, the fire resistance is not only dependent upon the type of concrete but also on the thickness of cover to reinforcement. The fire introduces high temperature gradients and as a result of it, the surface layers tend to separate and spall off from the cooler interior. The heating of reinforcement aggravates the expansion both laterally and longitudinally of the reinforcement bars resulting in loss of bond and loss of strength of reinforcement. In this fact the concrete and reinforcement experiences the expansion due to the temperature which results in formation of the cracks and loss in bond strength between the concrete and reinforcement. If a fire has broken out in a building, the structures made of all the materials would have been subjected to continuous exposure of high temperature for long duration. During the extinguishing of fire with the help of water, the concrete members are subjected to a thermo shock. The reinforcement, which is embedded in the concrete, may be affected by the elevated temperature. The bond strength of concrete may also be weakened due to this effect. The scope of this project is to study the effect of Thermoshock on slabs by ANSYS.

STANDARD FIRE CURVE

Standard fire curve which was given by ISO-834 is shown in figure 3.1.In which the temperature is plotting in Y-axis and the time is plotted in X-axis in minutes. The fire curve followed the Chinese National Standards (CNS) 12514 which is these same as the curve from International Organization for Standardization (ISO) 834.



ISO 834Standard Fire Curve

This paragraph of the first footnote will contain the date on which you submitted your paper for review. It will also contain support information, including sponsor and financial support acknowledgment. For example, "This work was supported in part by the U.S. Department of Commerce under Grant BS123456".

The next few paragraphs should contain the authors' current affiliations, including current address and e-mail. For example, F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (e-mail: author@ boulder.nist.gov).

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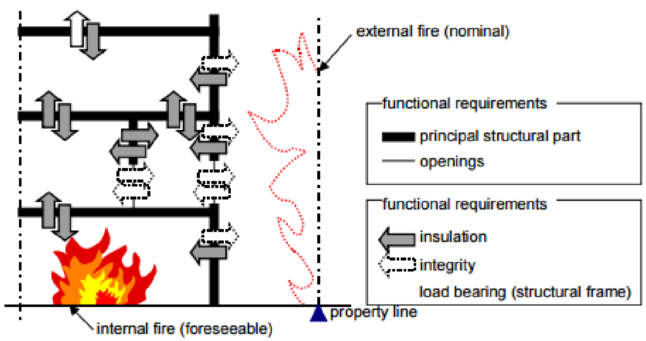
THERMOSHOCK

Thermoshock is the effect which occurs due to sudden heating and cooling. It is obtained by when the structural elements are exposed to high temperatures and suddenly cooled to room temperature thus imparting thermoshock.

KINDS OF FIRES

Two kinds of fires are referred. One is the internal fire applied to structural frame (columns, beams and floors) for checking loadbearing capacity and to compartment boundaries for checking integrity (external walls and roofs) and insulation (floors and partition walls). The severity of internal fire is deemed foreseeable, because the fire severity depends only on the condition of the building itself. In the evaluation method, the calculation method of internal fire is provided.



The other is the external fire that may take place around the building. It is referred normal (unforeseeable) because the severity depends on neighboring conditions that the owner of building cannot control. In the evaluation method, no calculation method for external fire is provided, but ISO 834 fire is assured.

STRUTURAL ELEMENTS

BEAMS

Beam is the horizontal member of a structure, carrying transverse loads. Beam is rectangular in cross-section. Beams carry the Floor slab or the roof slab. Bram transfer all the loads including its self-weight to the columns or walls.

TYPES OF BEAMS

- Simply Supported Beam
- Fixed Beam
- Cantilever Beam
- Continuous Beam
- Overhanging Beam

SLABS

Slabs are the structures that transmit the loads to their plane. Concrete slabs are widely used in use for the roofs and floors not only in residential buildings but also in industrial buildings. The design of reinforcement concrete slabs is divided into following types:

- Flat slabs
- One way slabs
- Two way slabs
- Waffle slabs

ANSYS

The ANSYS computer program is a general purpose Finite Element Modeling package for numerically solving a variety of mechanical problems. These problems include static and dynamic structural analysis (both linear and non-linear), steady state and transient heat transfer problems, mode-frequency and buckling analyses, acoustic and electro magnetic problems and various types of field and coupled-field applications. The program contains many special features which allow nonlinearities or secondary effects to be included in the solution such as plasticity, large strain, hyper elasticity, creep, swelling, large deflections, contact, stress stiffening, temperature dependency, material anisotropy and radiation.

II. ELEMENT TYPE

S.NO	ELEMENT TYPE	ANSYS ELEMENT
1	CONCRETE	CONCRETE
2	REINFORCEMENT	REBARS

III. MATERIAL PROPERTIES

The CONCRETE element requires linear isotropic material properties to properly model reinforced concrete and REBARS element is for reinforcing bar. The multilinear isotropic material uses the Von Mises failure criterion to define the failure of the concrete and steel. Poisson's ratio (μ) of concrete was assumed as 0.15 and for steel as 0.30.The elastic modulus of the concrete is 25000 MPa and for steel is 200000 MPa and temperature of 800°C.

MATERIAL NO.	ELEMENT TYPE	MATERIAL PROPERTIES	
1	CONCRETE	Linear Isotropic	
		EX	5000√fck=25000N/mm^2
		PRXY	0.15
		Density	2.4 E – 05 N/mm^3
		Thermal Conductivity	0.72 W/mm ^{o} C
		Specific Heat	750J/kg ^{o} C
2	REBAR	Linear Isotropic	
		EX	200000 N/mm2
		PRXY	0.3
		Density	78.6E – 06N/mm3

		Thermal Conductivity	63 W/mm ^{o} C
		Specific Heat	420J/kg ^{o} C

IV. MODEL DIMENSIONS

BEAM

Size of the Beam : 450 mm x 300 mm

Span of the Beam : 5000 mm

Diameter of reinforcement at Bottom: 4 Nos of 16 mm dia

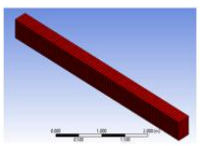
Diameter of secondary reinforcement: 2 Nos of 8mm Dia

Edge conditions : Both end fixed

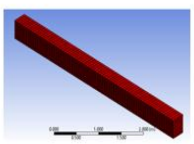
Load applied : Uniformly distributed load of 1.5kN/m2

Cover thickness : 25mm, 30mm and 35mm

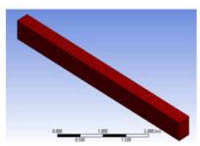
Type of Beam Model	Description
Beam25	Beam with cover thickness of 25mm
Beam30	Beam with cover thickness of 30mm
Beam35	Beam with cover thickness of 35mm



MODEL OF BEAM25



MODEL OF BEAM30



MODEL OF BEAM35

SLAB

Size of the slab : 5000mm x 2000mm

Thickness of the slab : 150mm

Diameter of primary reinforcement: 8mm

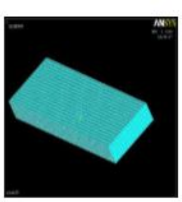
Diameter of secondary reinforcement: 6mm

Edge conditions : Two short edges fixed and two long edges are free

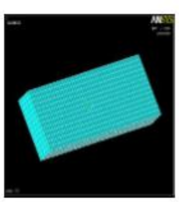
Load applied : Uniformly distributed load of 1.5kN/m2

Cover thickness : 15mm, 20mm and 25mm

Type of slab Model	Description
Slab15	Slab with cover thickness of 15mm
Slab20	Slab with cover thickness of 20mm
Slab25	Slab with cover thickness of 25mm



Model of SLAB15



Model of SLAB20

Model of SLAB25

V. BOUNDARY CONDITIONS

There are three mediums - Solid, Gas, Liquid

In general Thermal Problems, three types of boundary conditions

- Conduction or (Temperature in ANSYS)– Heat transfer from Solid to Solid
- Convection - Heat transfer from Solid to Air
- Radiation – Rays (E.g. Sunlight it's not any preferred medium)

VI. RESULTS

EFFECT OF COVER THICKNESS ON DEFLECTION OF SLAB MODELS

From the Table, it is found that the maximum deflection for SLAB15 model without subjecting it thermal load is 0.7% and 1% greater than that of deflection of SLAB20 and SLAB25 models respectively. The maximum deflection for SLAB15 model after subjecting it to Thermal load is 1% and 3.2% greater than that of SLAB20 and SLAB25 models respectively.

Maximum Deflection of Slab Models

S.no	Type of model	Deflection in mm		%increases in deflection due to the effect of fire
		without effect of fire	With effect of fire	
1	SLAB15	**5.83**	**9.8**	68.3
2	SLAB20	**5.79**	**9.7**	67.1
3	SLAB25	**5.77**	**9.5**	64.6

EFFECT OF COVER THICKNESS ON DEFLECTION OF BEAM MODELS

From the Table, it is found that the maximum deflection for BEAM25 model without subjecting it thermal load is 1% and 1.37% greater than that of deflection of BEAM30 and BEAM35 models respectively. The maximum deflection for BEAM25 model after subjecting it to Thermal load is 1.74% and 3.6% greater than that of BEAM30 and BEAM35 models respectively.

Maximum Deflection of Beam Models

S.no	Type of model	Deflection in mm		%increases in deflection due to the effect of fire
		without effect of fire	With effect of fire	
1	BEAM25	**11.66**	**17.2**	48%
2	BEAM30	**11.54**	**16.9**	46.25%
3	BEAM35	**11.50**	**16.58**	44.2%

VII. CONCLUSIONS

It is found that the temperature distribution over the reinforcement of slab with 25mm cover and temperature distribution over the reinforcement of beam with 35mm cover is sufficient than others.

It is found that the maximum deflection for SLAB15 model without subjecting it thermal load is 0.7% and 1% greater than that of deflection of SLAB20 and SLAB25 models respectively. The maximum deflection for SLAB15 model after subjecting it to Thermal load is 1% and 3.2% greater than that of SLAB20 and SLAB25 models respectively.

It is found that the maximum deflection for BEAM25 model without subjecting it thermal load is 1% and 1.37% greater than that of deflection of BEAM30 and BEAM35 models respectively. The maximum deflection for BEAM25 model after subjecting it to Thermal load is 1.74% and 3.6% greater than that of BEAM30 and BEAM35 models respectively.

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