POST FIRE SEISMIC EVALUATION OF VARIABLE PRECAST COMPOSITE MOMENT CONNECTION

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Abstract - *In the area of moderate to high seismicity, most of the building have issues from post- earthquake fire. Post-earthquake fire losses can be equal to or more than the losses caused by the earthquakes themselves because of the diminished or strained firefighting capabilities, damage to the building's fire protection systems. Composite members of steel and concrete member under fire may sustain various degrees of structural damage without collapse. Precast Composite frame of CFST column and steel beams provides an effective design for minimizing fire damage and containing the effects within the smallest space possible for the longest time. In this research , the performance of CFST column and steel beam connected with hollobolt, coated by intumescent layer and without coating, in post fire seismic exposure condition and without fire exposure conditions are analyzed. Non finite element models were developed by using ANSYS to assess the structural and thermal performance of the composite moment connection. Whether the model can provide a effective composite moment connection in fire exposed seismic area is analyzed. Post fire and seismic analysis can be done by using ANSYS Software.*

Key Words: **CFST column, Hollobolt, Intumescent coating, Thermal Analysis, Structural Analysis, Post fire Seismic analysis, Finite Element Analysis**

1. INTRODUCTION

Post fire seismic condition results in heavy damage in structures. A composite moment connection using CFST column and steel beam provided with intumescent coating can reduce the effect of both fire exposure and can sustain seismic effect on a structure. Concrete-Filled Steel Tubes (CFST) are composite members consisting of an steel tube filled with concrete. In current international practice, CFST columns are used in the primary lateral resistance systems of both braced and un-braced building structures. Under axial compression, the steel tube will sustain partial axial force and meanwhile provides the confinement to the infill concrete. The concrete which has closely-spaced special transverse reinforcement which restrains the concrete in directions perpendicular to the applied stress. Fire rated intumescent paint is used as the coating to protect steel against fire and acts as an insulator, forming a solid char in response to heat. CFST column and steel beam connected using Hollo-bolt which is a type of Blind bolt. A blind bolt is a structural fastener that delivers more strength and adaptability than a typical rivet or weld. They were developed to forge a strong connection where conventional rivets or hex bolts were hard to fit or just couldn't do the job. In this study, analysis of the performance of CFST column and steel beam connected with blind bolt, coated by intumescent layer and without coating, in post fire seismic exposure condition and without fire exposure conditions are done using ANSYS. The finite element model of precast composite moment connection were developed using ANSYS 19.1 and were analyzed under thermal and cyclic loading conditions.

2. MATERIAL PROPERTIES

2.1 CFST Column

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. The inherent buckling problem related to thin-walled steel tubes is either prevented or delayed due to the presence of the concrete core. The performance of the concrete in-fill is improved due to confinement effect exerted by the steel shell. Circular CFST column of dimension 219 x 8 mm is used in this study with column length of 1400mm.Circular steel tube with young's modulus- 2×10^5 N/mm^2, density – 7850 kg/m^3 and poisson's ratio – 0.3 is used.

2.2 Steel Beam and Concrete

Steel beam section consist of a steel beam flange and steel beam web with dimension 300x150x6.5x9 mm. Steel beam flange with thickness-9mm, young's modulus - 1.96×10^5,density-7850N/mm^2 and poisson's ratio-0.3 is used. Steel beam wed with thickness-6.5mm, young's modulus - 1.90×10^5,density-7850N/mm^2 and poisson's ratio-0.3 is used. An curved flush endplate of thickness 18mm is welded to the steel beam with a hole diameters of 28mm and length of 340mm. Length of beam is choosed as 1300mm. M40 concrete with poisson's ratio of 0.12 is used.

2.3 Hollobolt

M16 Grade Hollobolt is using in this model. Hollobolt feature a patented High Clamping Force mechanism to produce three times more clamping force than the same sized product without the mechanism. M16 Grade 8.8 with young's modulus -2×10^5,density-7850N/mm^2 and poisson's ratio-0.15 is used.

2.4 Intumescent Coating

Intumescent coating is providing passive fire protection to the load-bearing structures, especially structural steel. It acts as an insulator, forming a solid char in response to heat. Intumescent coatings also provide anticorrosion protection to steel surfaces, extending their life significantly. In fact, intumescent coatings fight corrosion in much the same way as corrosion resistant coatings. In this study 1200μm thick intumescent layer with density-200kg/m^3 and specific heat as 1200kg/J/K.

3. FINITE ELEMENT MODELLING

Finite element modeling used for post fire seismic analysis of the precast composite moment connection by using ANSYS 19.1 as shown in fig-1. Solid 186 element were used to model the moment connection. Fine mesh was adopted to achieve max accuracy in result. Solids model converted to finite element model after meshing as fig-1

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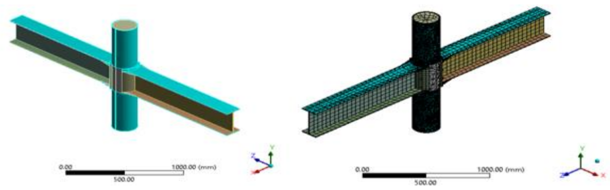

Fig -1: Model and finite element meshing

3.1 Loading and Boundary Condition

Column is provided with fixed supported condition on top and bottom and '0' displacement in X, Y and Z direction. Thermal load applied as according to ISO-Curve and cyclic load is applied as according to FEMA-Protocol.

4. ANALYTICAL RESULTS AND DISCUSSIONS

4.1 Thermal Loading with Coating

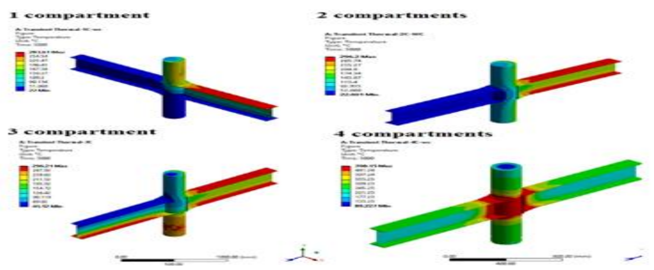

Fig -2: Temperature distribution on thermal loading based on ISO-Curve on 1, 2, 3 and 4 compartments.

4.2 Thermal Loading without Coating

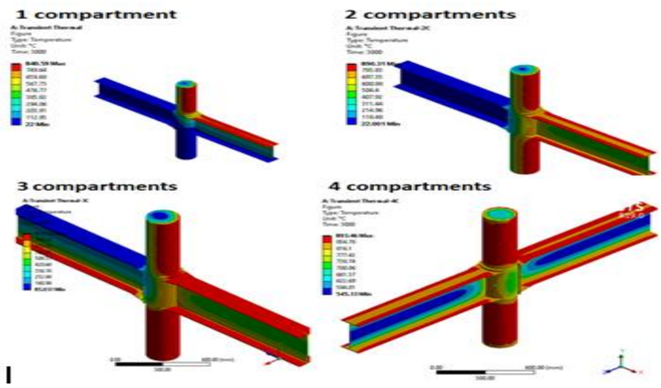

Fig -3: Total deformation under cycling loading coupled with thermal load on 1 ,2, 3 and 4 compartments.

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4.3 Post fire-seismic loading without coating

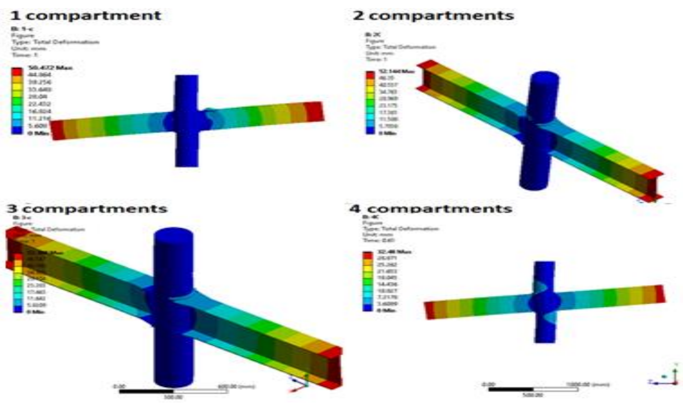

Fig -4: Total deformation under cycling loading coupled with thermal load on 1 ,2, 3 and 4 compartments.

4.4 Post fire seismic loading with coating

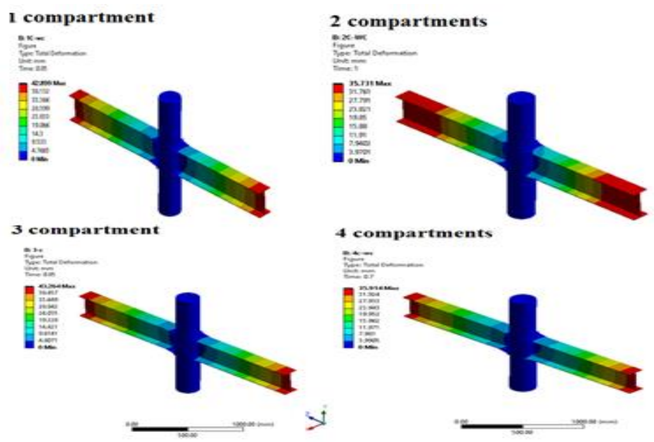

Fig -5: Temperature distribution on thermal loading based on ISO-Curve on 1 ,2, 3 and 4 compartments.

Chart -1: Displacement and load comparison of without coating

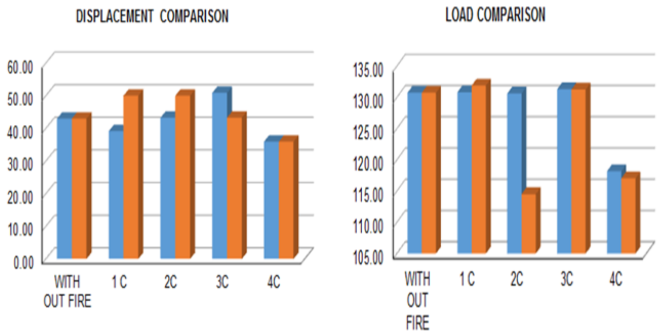

Chart -2: Displacement and load comparison of with coating

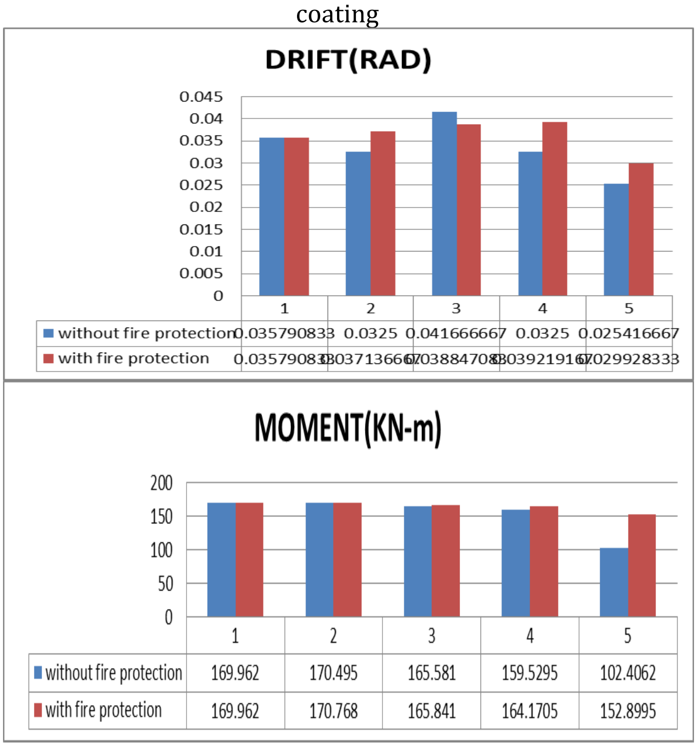

Chart -3: Comparison of drift and moment due to, 1-without fire, 2-1 compartment, 3-2compartment, 4-3 compartment and 5-4 compartment post fire seismic loading condition.

5. CONCLUSIONS

In this study a precast moment connection is analyzed with and without fire protection coating under thermal and seismic loading.

- As rate of fire exposure increases, rate of deflection increased and the strength of structure decreased.
- Loss of strength due to fire exposure and seismic load is studied.
- Damages are more in 3 and 4 compartments loading condition.
- By providing composite moment connection with intumescent coating moment capacity can be improved by 49.3% in 4 compartment loading and 2.9 % in 3 compartment loading.
- By providing composite moment connection with intumescent coating drift can be improved by 20.67% in 4-compartment loading and 17.75% in 3-compartment loading.
- CFST column and steel beam connected with blind bolt, coated by intumescent layer can provide a effective composite moment connection in fire exposed seismic areas.
- This research presents a FE modeling approach to predict the thermal and thermo-mechanical response of unprotected and protected composite moment connection.
- This study provides a simple composite moment connection able to resist thermal and seismic load.

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