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Numerical Study on Seismic And Temperature Effects in a RCC Building

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***Abstract*— Reinforced concrete structures are widely used in the construction of high rise buildings all around the world. This is due to the strength, economy and abundant availability of the reinforced concrete materials to take part in this type of structural considerations. The analytical software used for the analysis and design was E-Tabs. The study deals with the comparison of seismic and temperature effect in a RCC building. The design was carried out based on the dominating effect from both the condition. Comparison was carried out for both the analytical models on maximum load transfer from columns, rebar percentage and slab shell stresses etc. The design process for structural elements like columns and Slabs is carried out using finite element analysis. The main objective of this study is to understand the behaviour and application of temperature loads on architecturally important structures without any expansion joints.**

I. INTRODUCTION

Reinforced concrete is one of the widely used materials for the construction of structures all around the world. During a new project an engineer should give satisfactory thoughts about the material and shape of the structure so that during earthquake the structure won't undergo any critical or major failure issues. Considering the behaviour of structures during major earthquakes is a better way of making the engineers to improve their thoughts in the design of new upcoming constructions of earthquake resistant structure.

Provision of expansion join is one of the major things so that the behaviour of structure is maintained during severe temperature conditions in heat zones or high temperature areas. To an architecturally important structure without expansion joints, the effects that occur due to the transfer of temperature stresses are considered for the design of structure. Providing expansion join is a way of relieving the stresses due to temperature effects or the additional stresses caused by the temperature effects are included during the design of structures. The variation in temperature is different for all regions under seasonal conditions. The maximum and minimum temperature that takes part in the locality where the structure is designed is considered in the analysis of the structure.

ETABS is the abbreviation for Extended 3D Analysis of Building Systems. ETABS software is used for the purpose of analysis and design for building systems. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviours, making it the tool of choice for structural engineers in the building industry.

II. OBJECTIVE OF THE PROJECT

The present study involves the analysis of a RCC structure without expansion join and the effect of temperature loads are carried out in the analytical study to determine the behaviour of the structure. Separate structures were formed for both seismic and temperature loads and the analysis are carried out using E-Tabs software.

- *Analysis of the RCC building without expansion joints for seismic and temperature effects using design software.*
- *Response behavior of structural members for different loading conditions.*
- *Comparison of analysis details for the seismic and temperature models.*

III. FORMULATION OF MODEL:

The structure is mainly used for commercial purposes. Separate models were formed in E-Tabs for both the effects and the behaviour of the structure is determined. Ground floor height was 6m and first floor height was 5.9m with a total height of the building as 11.9m with span in length and breadth (X and Y) directions are 67m and 40m respectively. Based on IS 1893 (Part-1): 2002, Seismic intensity is 0.24 (Zone-IV) along with T_a value for X and Y direction as 0.152 and 0.187 respectively. Soil type is kept soft, importance factor as 1.0 and response reduction factor taken as 5 (SMRF). The temperature load is applied to another model based on the ambient temperature values from IS 875 (Part-5): 1987. The ambient temperature of concrete, highest maximum temperature, minimum temperature and room temperature are taken as 28°C, 46°C, 2.5°C and 22°C respectively. The temperature loads are applied on top of the slab elements. The model formulated in E-Tabs is shown in Figure 1,

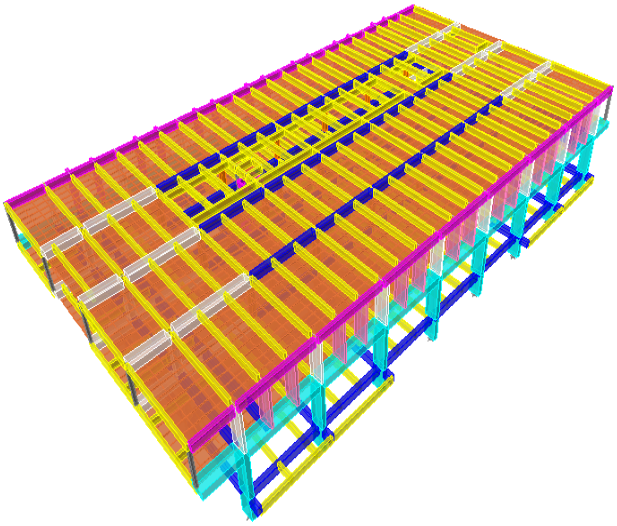

Figure 1: E-Tabs model of structure

IV. PERFORMANCE OF THE MODEL:

The performances of models during the applied earthquake load and temperature loads on both X and Y directions along with the stress distribution on slabs are taken into account for the design of major structural elements. Figure 2 shows the seismic and temperature performance of models.

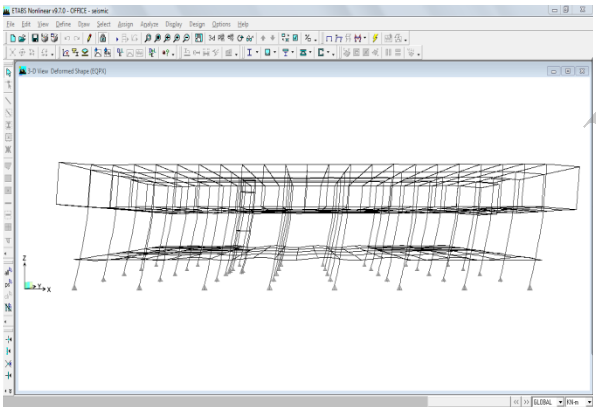

Figure 2: *a*) EQ X-Direction

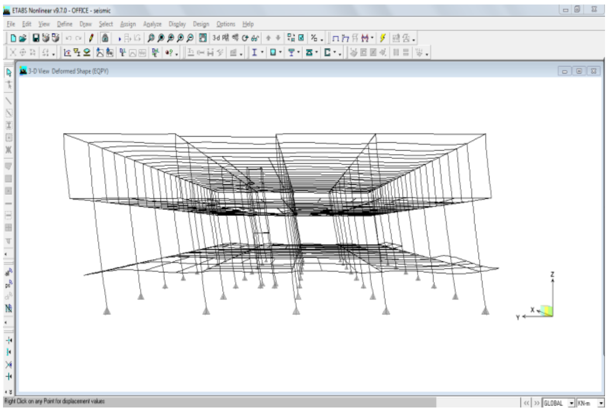

Figure 2: *b*) EQ Y-Direction

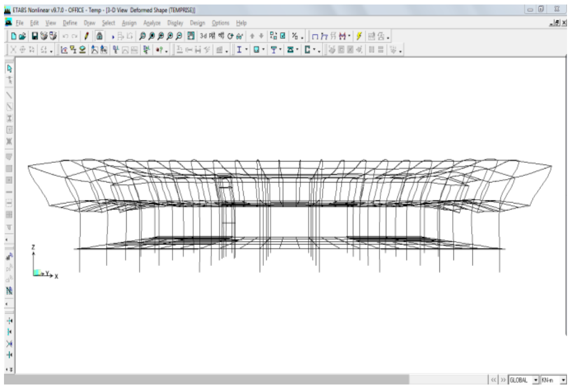

Figure 2: *c*) Temperature expansion

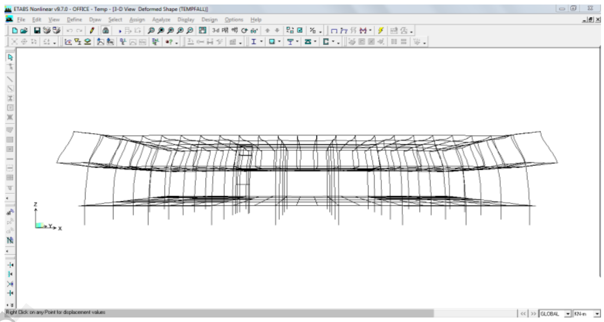

Figure 2: *d*) Temperature contraction

V. COMPARISON OF ANALYSIS RESULTS:

The results from the earthquake and temperature models are compared in case of support reactions, Column reinforcement details and slab stress comparison for both models. Support reactions developed in each model for various column sizes are considered for the comparison. It seems that for a symmetric one storey RCC building, seismic loads having slightly higher effect rather than that of temperature. Figure 3 shows the support reaction value for different columns sizes in a graphical representation.

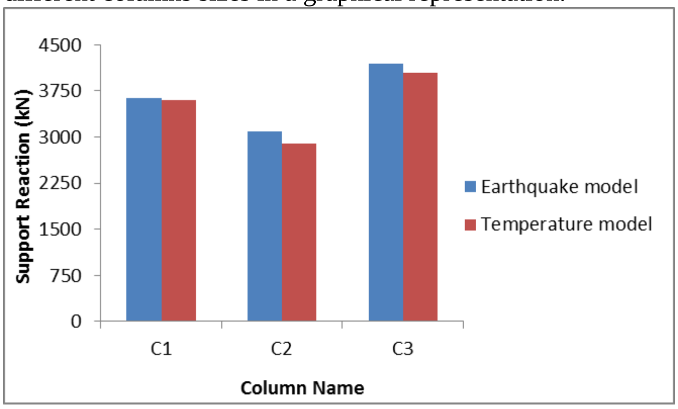

Figure 3: Support reactions of different column sizes

The above graph represents the variation of support reaction of different models for the same columns. The maximum reaction generated for seism model for columns C1, C2 and C3 are 3627 kN, 3093 kN and 4187 kN respectively.

Similarly for temperature model the loads for columns C1, C2 and C3 are 3606 kN, 2901 kN and 4042 kN respectively.

The design of column is directly considered based on the rebar percentage from E-Tabs software. The maximum rebar percentage from both the models is compared and detailing has been carried out based on the dominating effects. Figure 4 represents the column rebar comparison

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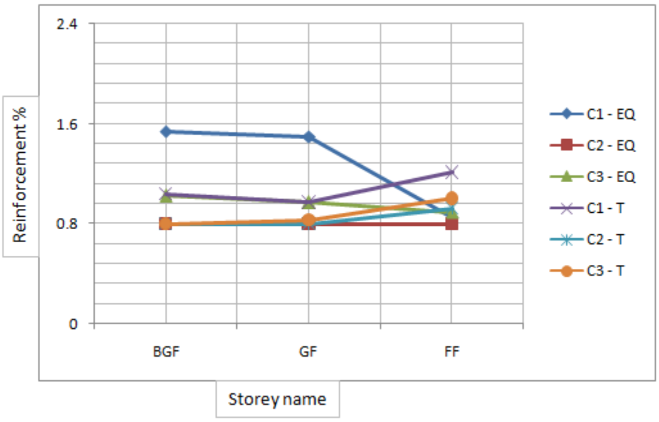

Figure 4: Column rebar comparison between seismic and temperature model

The rebar percentage of column C1 was 1.54%, 1.50% and 0.85% for base, ground and first floors respectively. The C1 rebar percentage for temperature model shows 1.04%, 0.97% and 1.21% for the consecutive floors. The above comparison clearly explains that the seismic effect is predominant on the RCC model. But on the other hand, due to the temperature loads on first and roof floor slab, there is a gradual increase in reinforcement at the top storey when compared to the bottom storey.

In normal buildings, unless there is a substantial difference in day and night temperature, no special temperature analysis is necessary. The main element that will be affected by this temperature is the roof slab when compared to the floor slabs which are exposed to only the room temperature. To the design and detailing of slab, the stresses that are obtained from the temperature load model are considered. The results provide a rather competitive stress values than the effect of earthquake. A section cut has been considered in the structural layout and the detailing is carried throughout based on the average stress values along the cross section of the slab. Figure 5 and 6 shows the variation in slab stresses.

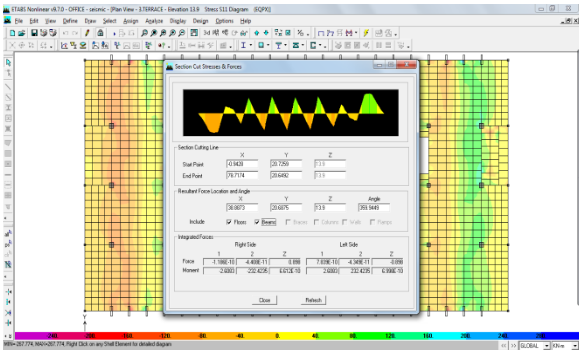

Figure 5: Seismic model slab stress a) X-direction

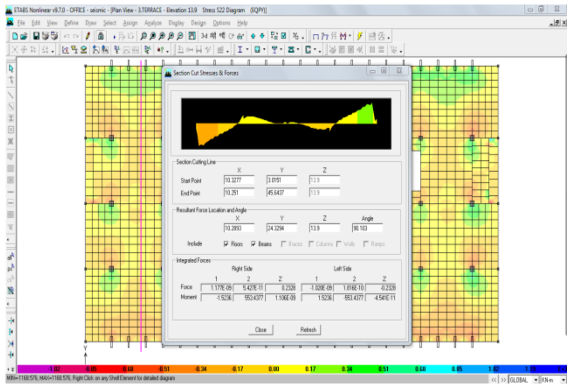

Figure 5: Seismic model slab stress b) Y-direction

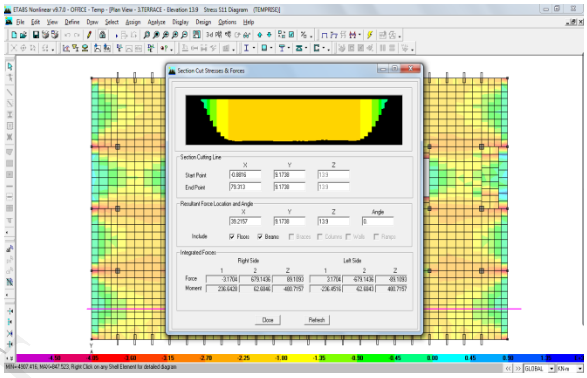

Figure 6: Temperature model slab stress a) Expansion

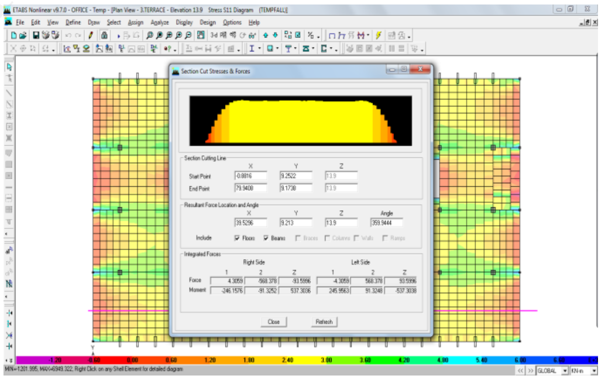

Figure 6: Temperature model slab stress b) Contraction

The effects from both the models clearly indicates that the stress developed during the transfer of heat and cold at seasonal variation cause a much greater effect when compared to the seismic slab stresses. From this it is identified that the temperature effects are more predominant in the slab elements when compared to the seismic load transfer on slabs.

VI. CONCLUSION:

The correlation studies between the earthquake and temperature results and the parametric studies associated with them lead to the following conclusions,

1. The support reactions obtained from the results for both the models are having a very minimum difference.
2. Reinforcement variation in columns is showing a significant dominating effect on earthquake model when

compared to temperature model. Although, the reinforcement percentage is quite higher in top stories of temperature model due to thermal loads on roof slabs.

3. Slab design was created based on the stresses developed on the shell elements (meshed slab). The stresses developed on both the models are compared. The stresses produced during the expansion and contraction of the slabs cause major variations when compared to the seismic loads on slabs.

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