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INVESTIGATION OF FLAT SLAB STRUCTURES WITH AND WITHOUT EXPANSION JOINTS FOR THERMAL STRESSES

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ABSTRACT

In the present scenario there is increase in demand for structural members without expansion joint as per architectectural and aesthetic appearance like malls, commercial spaces, office buildings, IT parks. Indian Standard code, IS-456:2000 states buildings longer than 45m be analysed for the thermal stresses and appropriate measures should be taken during erecting the structural system, whereas IS codes are negligent towards such kind of designs as well as considering temperature load factors along with gravity loads. Added to it there are no proper guidelines available with design engineers to arrive at design temperature value that should be considered during design.

This study mainly deals with design and analysis of structures of length 80m, 138m and 180m with and without expansion joints. Changes in stress at different levels, torsion on the peripheral beam and overall increase in steel quantity on the structure after imparting temperature loads during the design of a structure.

Key words: expansion joints, flat slabs, thermal stresses.

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1. INTRODUCTION

Flat slabs are appropriate for most floor situations and also for irregular column layouts, curved floor shapes, ramps. The benefits of choosing flat slabs include a minimum depth solution, speed of construction, flexibility in the plan layout. The flexibility of flat slab construction can lead to high economy and yet allow the architect great freedom of form.Due to the continuity of reinforced concrete flat slab and the interaction between the slab and the supporting columns and of rigid connections between slab and columns, the slab is not completely free to move under temperature variation. Hence additional stresses due to thermal loads are more prone in such structures. In order to release restrained stresses from temperature variation many designers use thumb rule that set limits on the maximum length between building expansion joints. Although widely used, rules of thumb have the drawback. Due to the complexity of the problem and the previous limitations for using expansion joints in addition to its bad appearance and difficulty of construction and maintenance, designers become interested in the design of buildings without expansion joints and take the effect of temperature variations and additional stresses into account during the design stage.

2. OBJECTIVE

- To study the temperature effect on flat slab RCC buildings of length longer than 45 meters using ETABS/SAFE.
- Comparitive study of the RCC buildings with and without expansion joints for length longer than 45meters.
- To study the variation in steel reinforcement in flat slab due to temperature loads.
- To study the effect of temperature loads on member forces of beams.

3. STRUCTURAL MODELLING AND ANALYSIS

3.1. Structural Details of Model

Table 1

Number of models	6
Length	90 m , 138 m , 180 m
Number of stories	G+9
Height of each storey	3m
Total height of building	27m
Number of bay’s along X	6
Number of bays along Y	15(90m),23(138m),30(180m)
Columns	600*600
Beams	450*600mm
Flat slab Thickness	200mm
Flat drop	350mm
Shear wall Thickness	300mm

3.2. Plan and Elevation of the Model

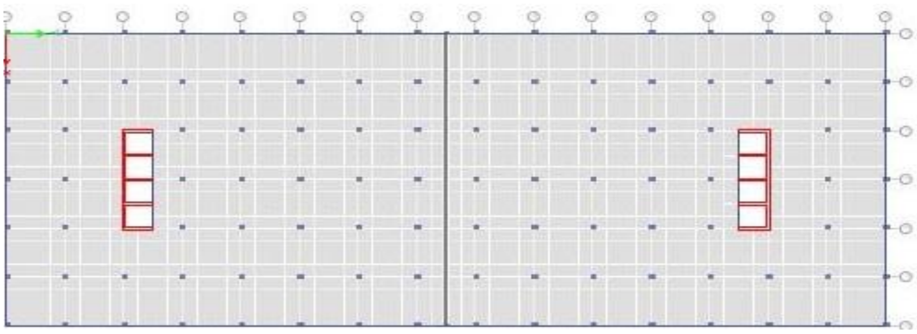

Figure 1 Typical floor plan of G+9 structure of 90m slab length with expansion joint.

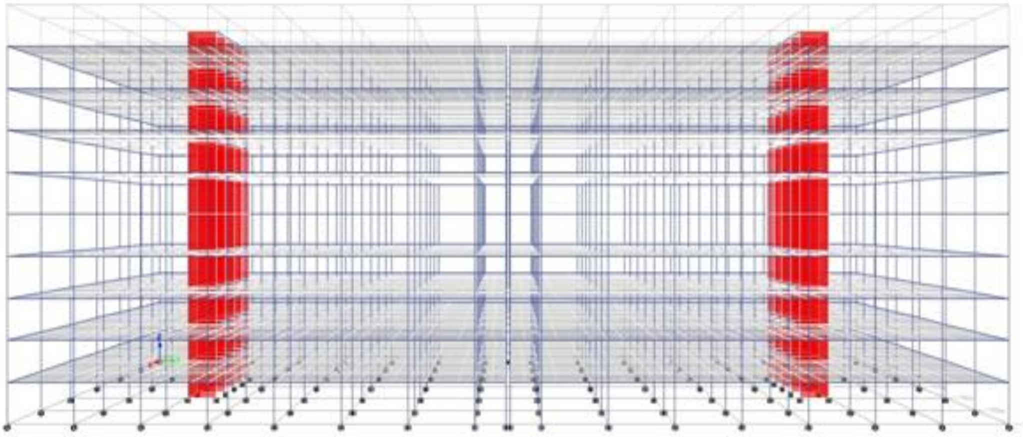

Figure 2 Elevation View of G+9 Structure of 90m slab length with expansion joint.

4. ANALYSIS

- All the six models i.e 90 m , 138 m , 180 m slab length with and without expansion joints are analysed using ETABS 16.1.
- Corner displacements, Torsion on the peripheral beams are obtained.
- Later the slabs at each level is exported to SAFE
- Results like stresses at each level and overall increase in steel reinforcement is obtained.
- During the analysis in ETABS the load of 1.2(D.L+L.L) is applied for structures with expansion joint and 1.2(D.L+L.L+T.L) is applied for structures without expansion joint.

5. RESULTS AND DISCUSSION

5.1. Corner Displacement

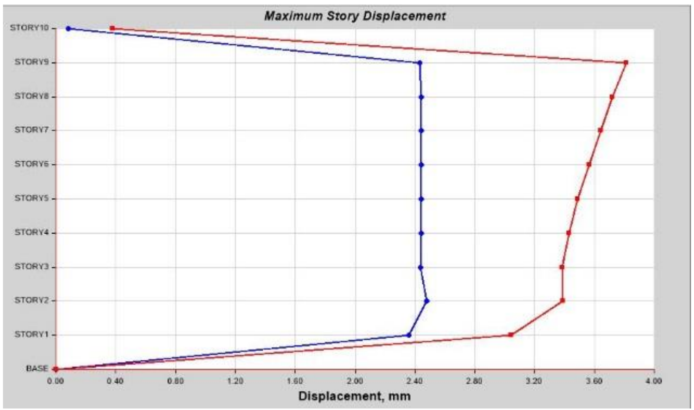

Figure 3 Graph showing the maximum displacement for 90m slab length with expansion joint.

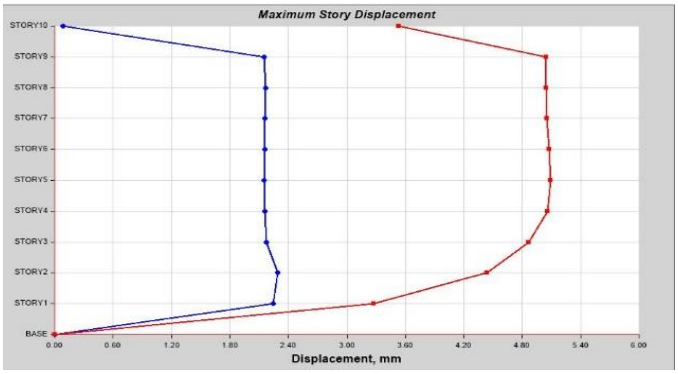

Figure 4 Graph showing the maximum displacement for 90m slab length without expansion joint.

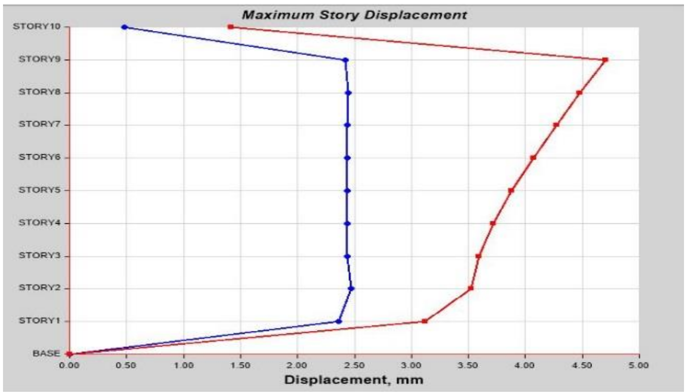

Figure 5 Graph showing the maximum displacement for 138m slab length with expansion joint.

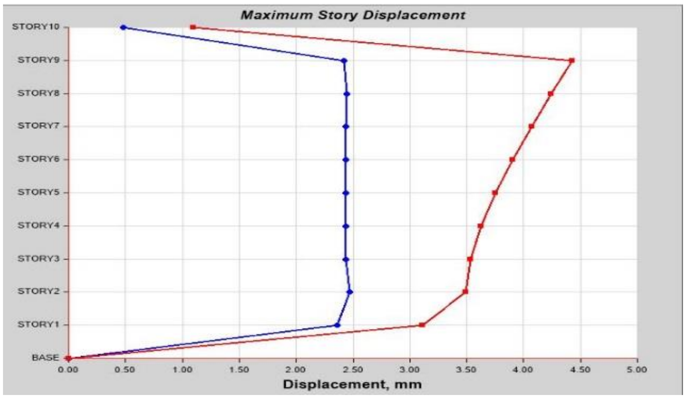

Figure 7 Graph showing the maximum displacement for 180m slab length with expansion joint.

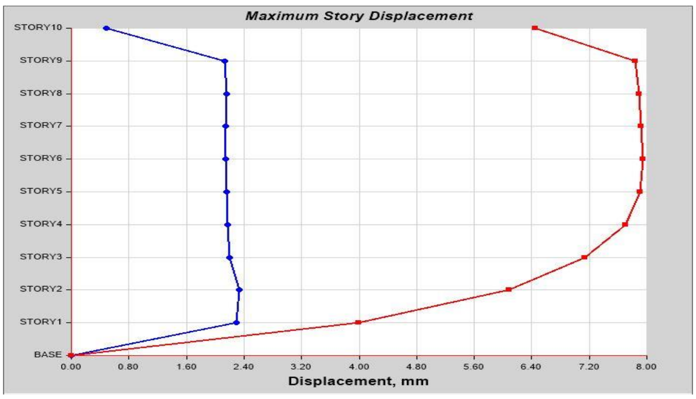

Figure 6 Graph showing the maximum displacement for 138m slab length without expansion joint.

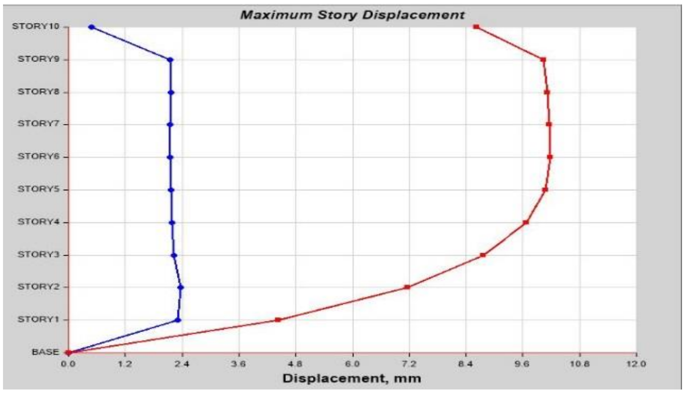

Figure 8 Graph showing the maximum displacement for 180m slab length without expansion joint.

Corner displacements for flat slabs with and without expansion joints are compared and tabulated as follows:

Table 2

Slab Length	With Expansion Joint (mm)	Without Expansion Joint(mm)
90 m	3.8	4.9
138 m	4.4	7.5
180 m	3.4	9.9

- The displacement difference is about 1.1 mm for 90 m slab length , 3.1 mm for 138 m slab length and 6.4 mm for 180 m slab length.
- The displacement is observed to increase as the length of slab increases.
- This displacement is comparatively more in Y direction than X direction.

5.2. Beam Forces

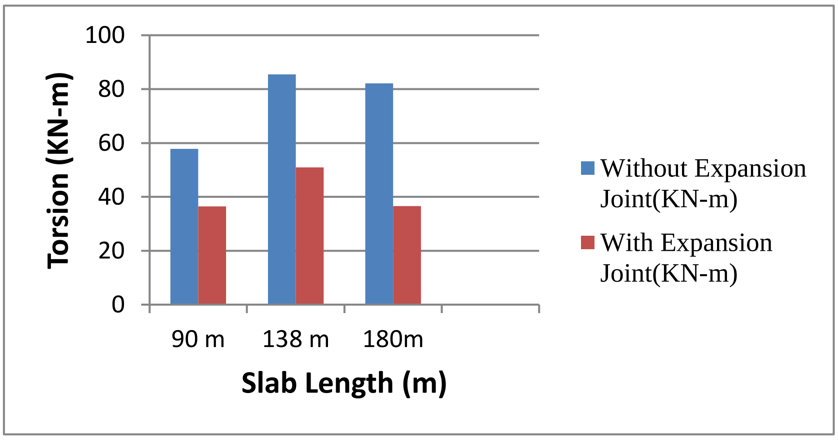

Figure 9 Graph showing max torsion on the peripheral beams of the structures

- Torsion on peripheral beams for the different slabs for structures of varying length are compared.
- Torsion on the peripheral beams is higher for slabs without expansion joint.
- The torsion on peripheral beam for 180 m slab length is less compared to 138 m.

5.3. Flat Slab Stresses

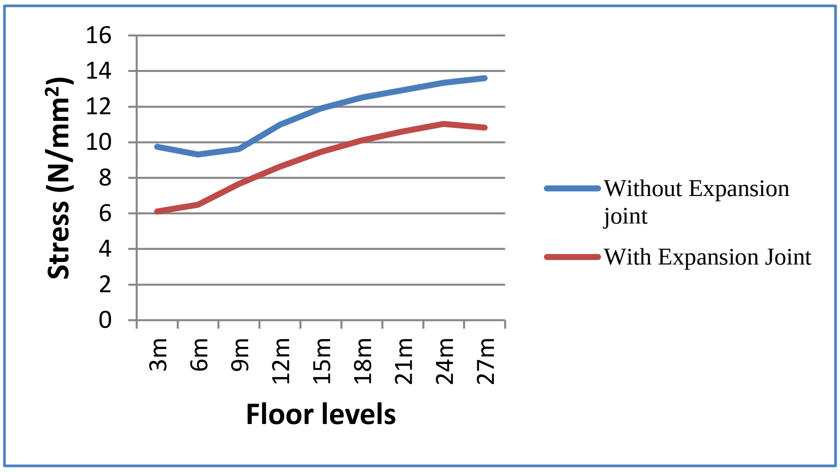

Figure 10 Graph showing stresses in flat slab at varying levels 90 m

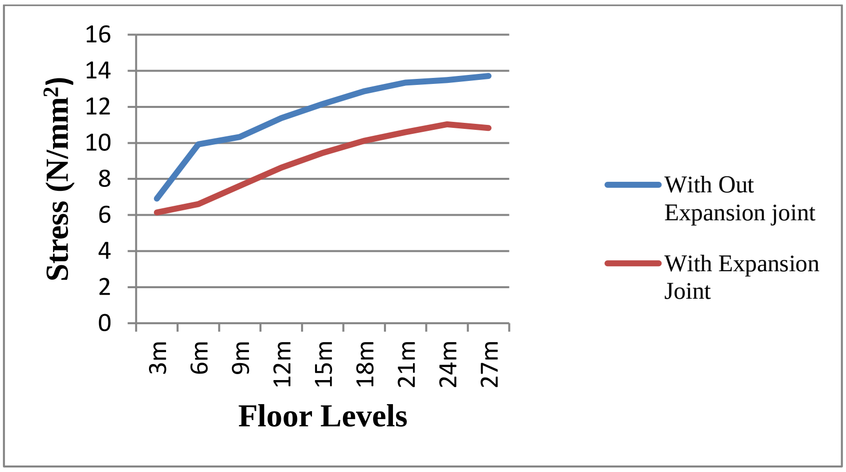

Figure 11 Graph showing stresses in flat slab at varying levels 138 m

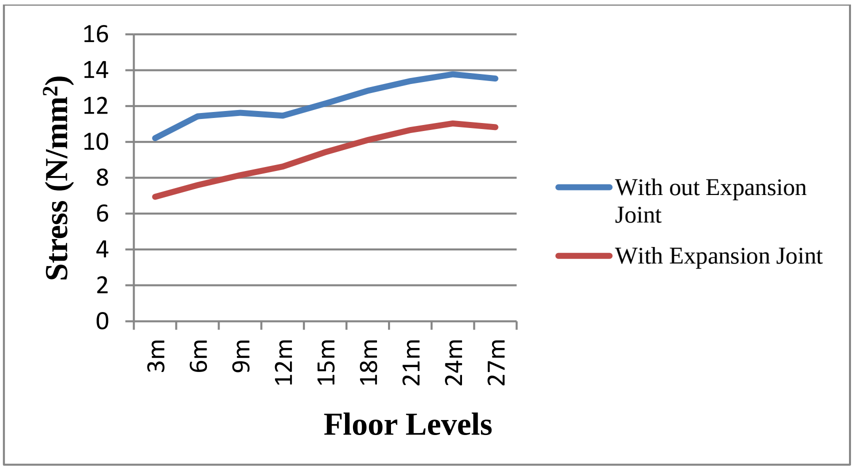

Fig 12: Graph showing stresses in flat slab at varying levels 180 m

- Flat slab stresses for structures of different slab lengths are represented and the stresses are observed higher for slabs without expansion joints.
- It is significantly seen that there is an average increase of 3N/mm ^{2} overall.

5.4. Steel Quantity

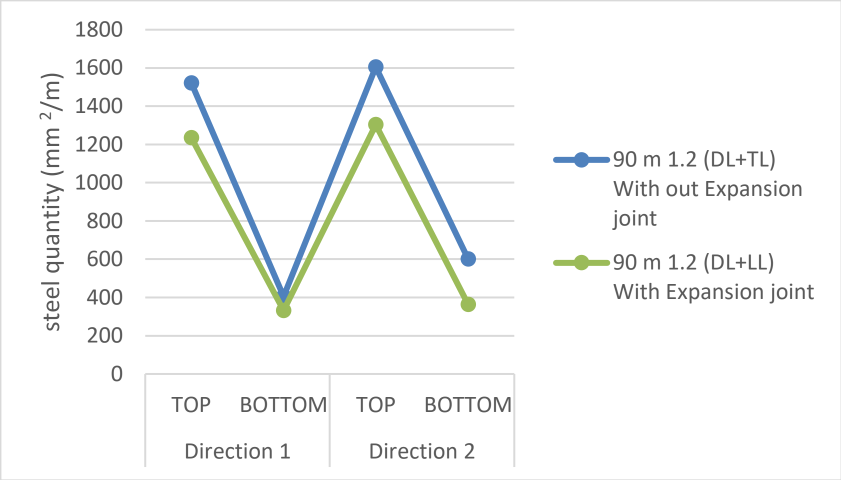

Figure 13 Graph showing overall steel quantity in flat slab (90 m)

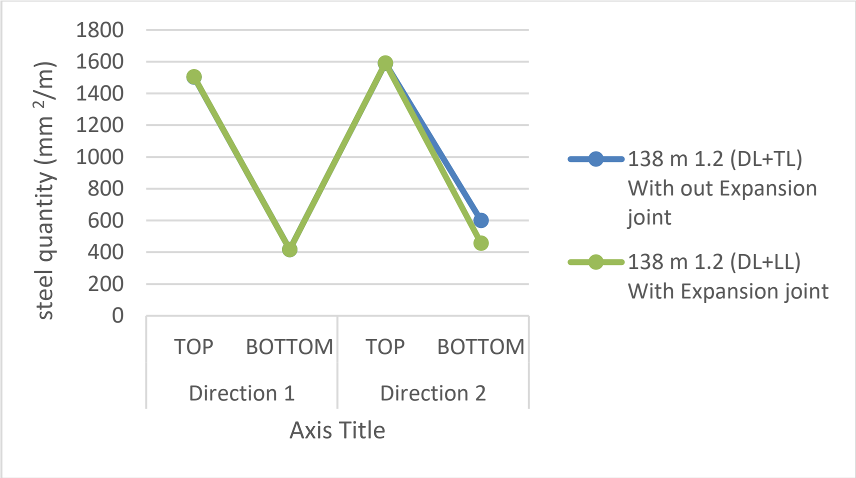

Figure 14 Graph showing overall steel quantity in flat slab (138 m)

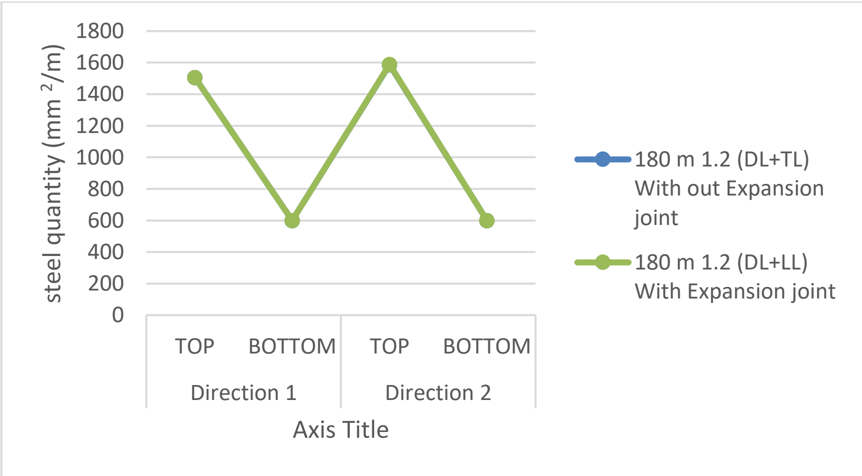

Figure 15 Graph showing overall steel quantity in flat slab (180 m)

- Overall Steel quantity for 90m slab length is 18% more compared to slabs with expansion joints.
- Steel quantity for 138 m and 180 m slab length remains almost similar.

6. CONCLUSISON

- Corner displacements between flat slabs with and without expansion joint is very negligible.
- Torsion in beam is higher in case of flat slabs without expansion joints which increases the dimension of beam, torsion increases in the beams upto 138m slab length and beyond which it decreases hence the beam sizes can be standardised for flat slab structures beyond 138 m.
- Stresses in flat slab without expansion joints increases with increase in levels due to temperature loads, average increase of 3 N/mm^2 is observed which results in increase in steel quantity in flat slab without expansion joint.
- Based on the over all steel quantity it can be concluded that flat slab structures beyond 138 m length can be adopted for construction due to the non variance in steel quantity between flat slabs with and without expansion joint.
- From the above results it can be concluded that considering the temperature loads during design of flat slab structures the provision of expansion joints can be eliminated.
- Flat slab structures without expansion joints beyond 138 m length can be adopted for construction due to its marginal non variation in the steel quantity and stresses.

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