

# STUDY OF STRUCTURAL BEHAVIOUR OF A FRAMED C, T, L, RECTANGULAR STRUCTURES WITH AND WITH OUT CONSIDERING TEMPERATURE STRESSES AND EXPANSION JOINTS

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**Abstract:** Expansion joints are the gaps in the building structure provided to allow for the movement of the building due to temperature changes. They are provided commonly in the structures of slabs, bridges and other structures where there is a change of expansion of the structure due to temperature. Significance of these joints are mainly to control the uneven surface in the structure when it is subjected to temperature changes. In present scenario the designers of the buildings are not considering expansion joints while designing a multi storied structure. Consideration of expansion joints in the design can reduce the temperature stresses and displacement of R.C. framed structures. In this view studied the effect of expansion joints in structural behaviour of RC framed regular and irregular structures. For this purpose considered four different types of RC framed buildings (C, T, L and Rectangular) in each case compared the lateral displacement and quantity of steel by considering with and without expansion joints by using computer software STAAD Pro.

**Key words-** STAAD, C, T, L, Structural behaviour.

## I INTRODUCTION:

The term “expansion joint” as used refers to the isolation joints provided within a Building to permit the separate segments of the structural frame to expand and contract in response to Temperature changes without adversely affecting the building's structural integrity or serviceability. The normal practice in runways, bridges, buildings and road construction is to provide expansion joints between cutting slabs of reinforced concrete at designing intervals and at intersections with other constructions. These joint filers are then covered with sealing compounds.

Concrete expands slightly when the temperature rises. Similarly, concrete shrinks upon drying and expands upon subsequent wetting. Provision must cater for the volume change by way of joint to relieve the stresses produced. An Expansion joint is actually a gap, which allows space for a building to move in and out of. The movement of the building is caused most frequently by temperature changes, the amount of expansion and contraction of building depends upon the type of material it is constructed out of. A steel framed building will move by a different amount then a concrete framed one. In case of a small building, the magnitude of expansion is less and therefore, no joint is required either in the floor or roof slab. But in case of the long building, the expansion is very large and may be as much as 25 mm. Therefore, buildings longer than 45 m are generally provided with one or more expansion joints.

## II. LITERATURE SURVEY:

**Michael J. Pfeiffer, David Darwin** (1987) is talked about the construction, contraction and expansion joints in reinforced concrete buildings. They are addressed the purpose of each type of joint and emphasizes the selection of joint locations and joint spacing. Some aspects of joint configuration and construction are also covered. Empirical and analytical design techniques are presented.

**HERBERT H. SWINBURNE** (2000) the study was carried out under the direction of the Federal Construction Council Standing Committee on Structural Engineering. The Committee first examined in detail an unpublished report in which horizontal changes in dimension in nine federal buildings were observed and related to recorded temperature changes. Additionally, the Committee studied the current practices of federal agencies regarding expansion joint criteria. To enhance its understanding of the distribution of stresses and associated deformation in frames subjected to uniform temperature change, the Committee formulated and conducted an analytical study of the effects of uniform temperature change on typical two-dimensional elastic frames. A theoretical computer model was developed for this purpose. Observed dimensional changes caused by temperature changes were correlated with data obtained

from the computer analysis. The results of the Committee's study and analysis, as well as its collective experience and judgment, served as the bases for this report.

**Grant T. Halvorsen** (2001), all buildings are restrained to some degree; this restraint will induce stresses with temperature changes. Temperature induced stresses are proportional to the temperature change. Large temperature variations can result in substantial stresses to account for in design. Small temperature changes may result in negligible stresses.

**James M. Fisher, S.E** (2005) he has experienced several issues relative to construction difficulties associated with expansion joints. The first is that temperature changes to which an unenclosed unheated structure is subjected to during construction may exceed the design temperature changes after completion of the structure. These increased temperature changes should be considered by the designer. The temperature to be considered during construction, of course, varies depending upon building location. Sometimes it is very difficult for the steel erector to adjust the expansion joint at the desired location, as normal erection tolerances may force the expansion joint to one end of its travel. This problem can be eliminated if the designer considers a detail at the far end of the member to which the expansion joint is located, as a means of adjustment. In this way, the construction tolerance can be compensated

**A.Plumier, V. Denoël, L. Sanchez, C. Doneux, V. Warnotte**, (2007) an elastic analysis of an existing 20-storey reinforced concrete moment resisting frame divided in 3 blocks shows that beams supported on corbels of the adjacent block at the expansion joint lose their support when each independent block vibrates on its own under earthquake. Different reconnection hypotheses were considered, ranging from fixing totally each block to the adjacent one to more flexible options leaving some free relative movement between blocks. An elastic modal superposition followed by a pushover analysis considering the final reconnection principle was made. The degrees of freedom of the joint reconnections were observed to be an important parameter.

### **III. THEORY/METHODOLOGY**

#### ***BASIC MODEL SPECIFICATIONS***

Building type :

RC frames with and without expansion joints for "C", "T", "L", and

RECTANGULAR type Buildings Floor area

"C": 78.81mt X 30.26 mt, "T": 65.25 mt X 30.26 mt, "L": 75.18mt X 30.26 mt, "RECTANGULAR": 88.41MX 10.68 Meters

Storey Height: 3m

No. of Stories: G+4

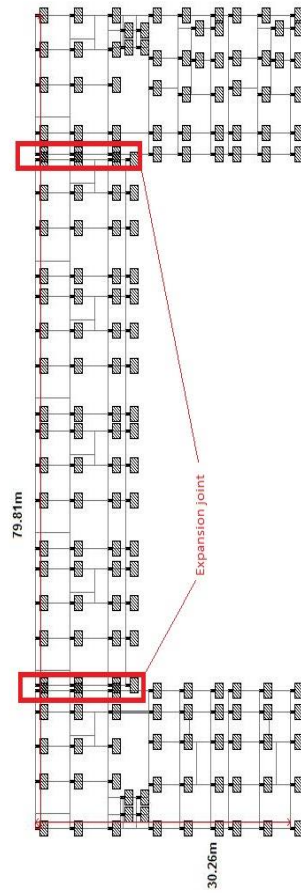
Beam 230X450

Column 230X450

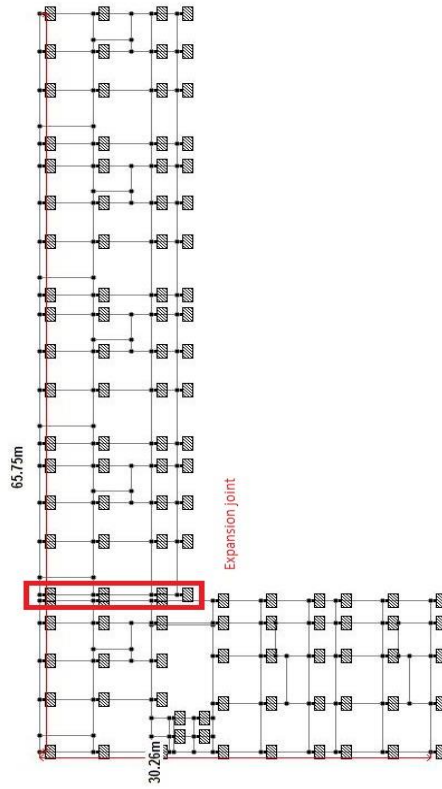
Slab thickness 150

### **IV. ANALYSIS AND DESIGN RESULTS**

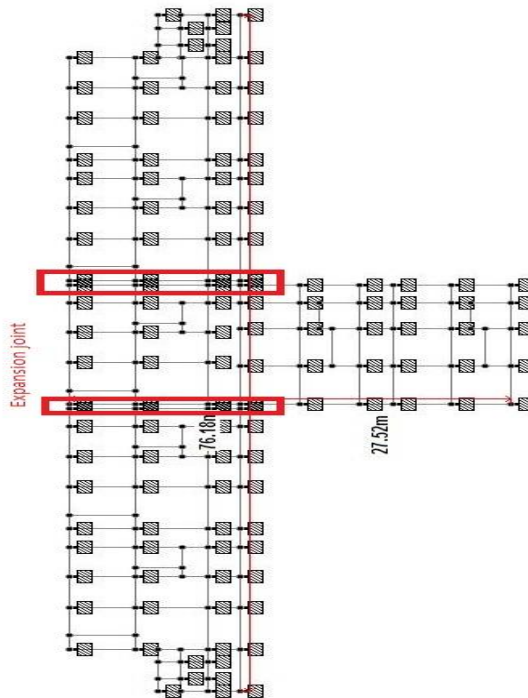
From the study obtained the lateral displacements for limit state of serviceability condition.



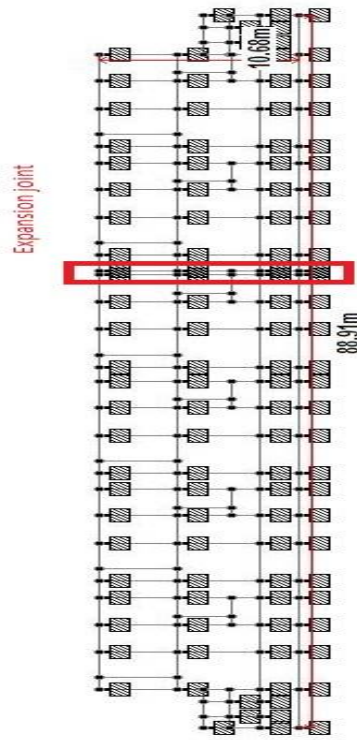
Plan showing "C" type residential building with expansion joints\



Plan showing "L" type residential building with expansion joints



Plan showing "T" type residential building with expansion joints

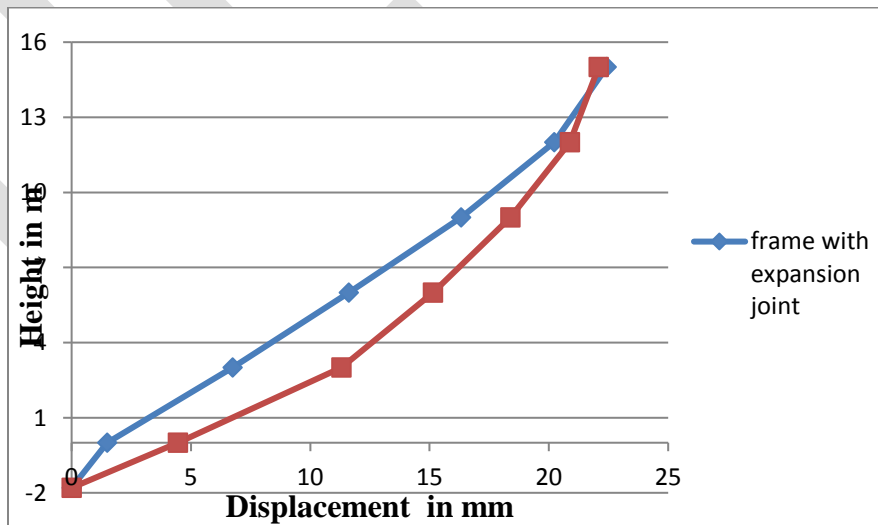


Plan showing “rectangular” type residential building with expansion joints

**V. RESULTS AND DISCUSSIONS**

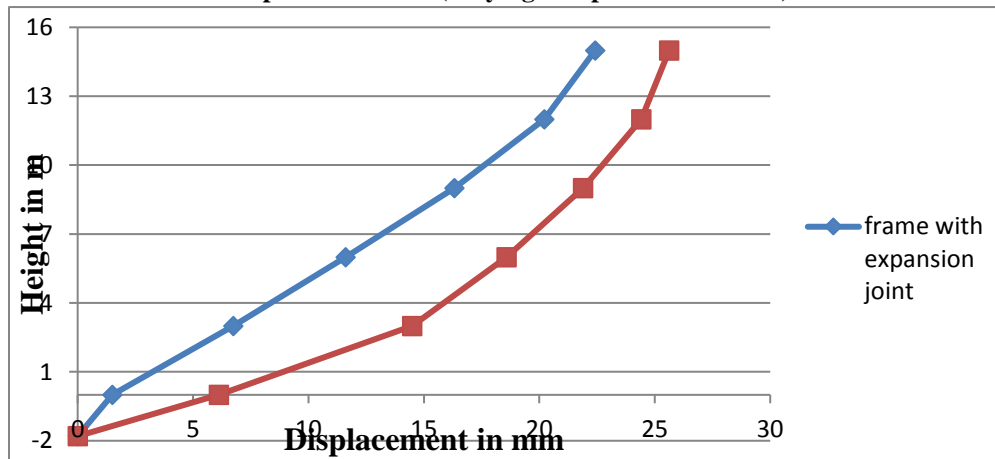
**COMPARISON FOR “C” TYPE BUILDING: COMPARISON OF LATERAL DISPLACEMENT OF RC FRAMES:**

- Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 20°C)



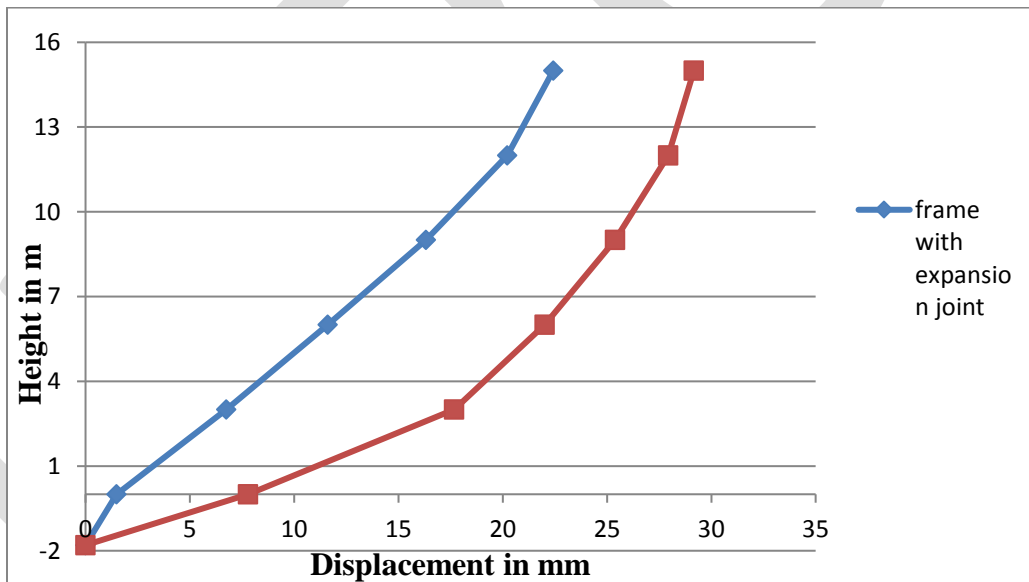
It was observed that there was an decrease in lateral displacement of 1.5% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 20°C)

- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 30<sup>0</sup>C)**



It was observed that there was an increase in lateral displacement of 14.28% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 30<sup>0</sup>C)

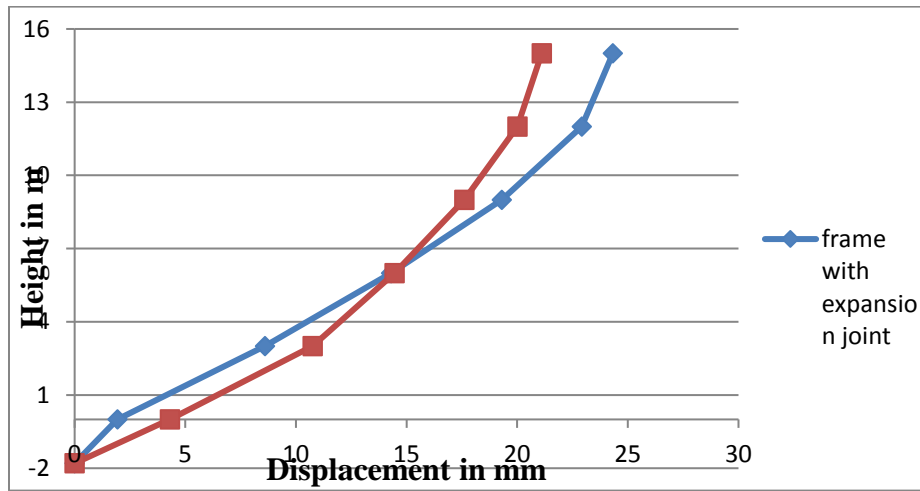
- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 40<sup>0</sup>C)**



It was observed that there was an increase in lateral displacement of 30.07% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 40<sup>0</sup>C).

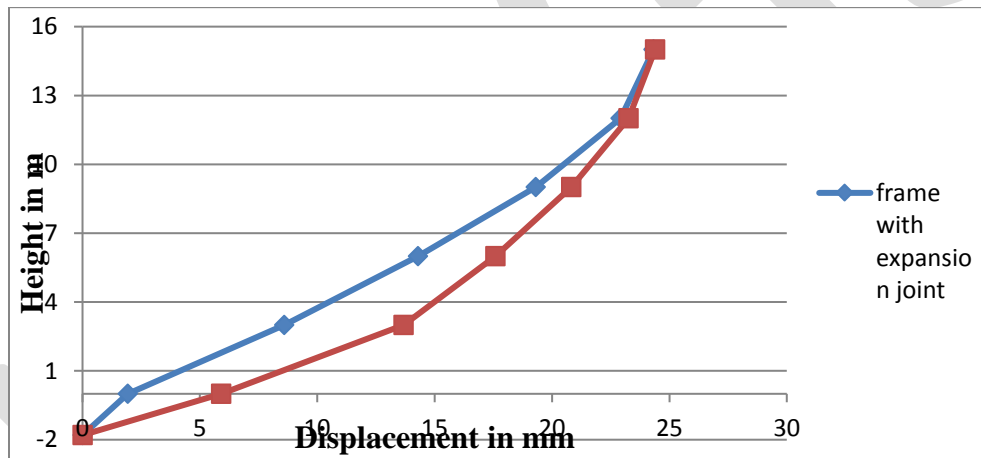
**FOR “L” TYPE BUILDING**

- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 20<sup>0</sup>C)**



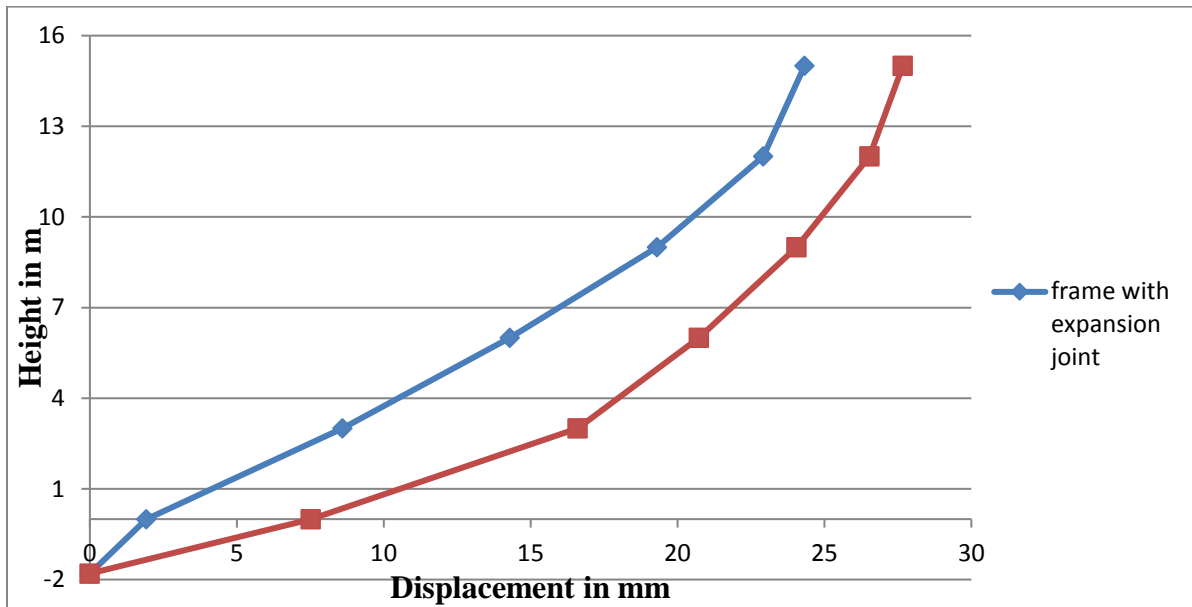
It was observed that there was an decrease in lateral displacement of 13.22% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 20°C)

- Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 30°C)



It was observed that there was an decrease in lateral displacement of 0.263% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 30°C)

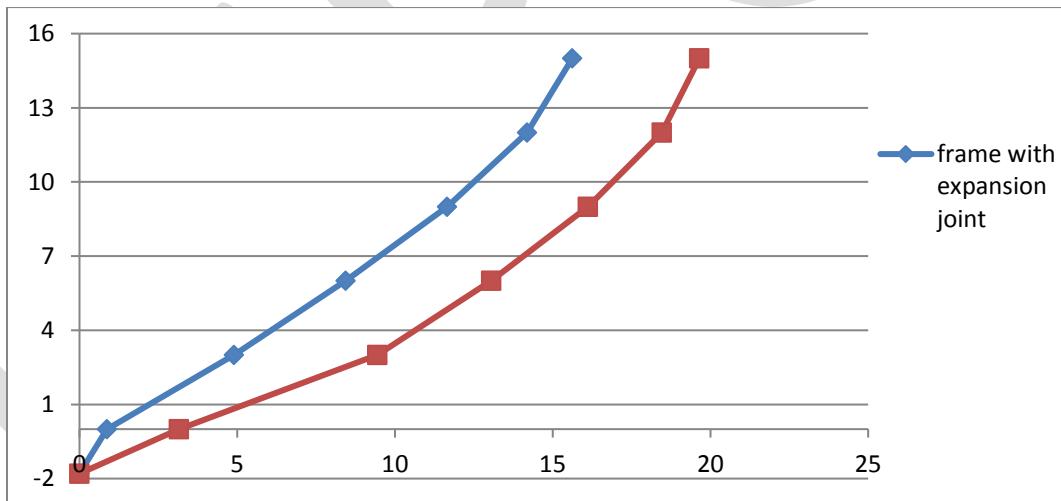
- Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 40°C)



It was observed that there was an increase in lateral displacement of 13.75 % for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 40°C)

**FOR “T” TYPE BUILDING**

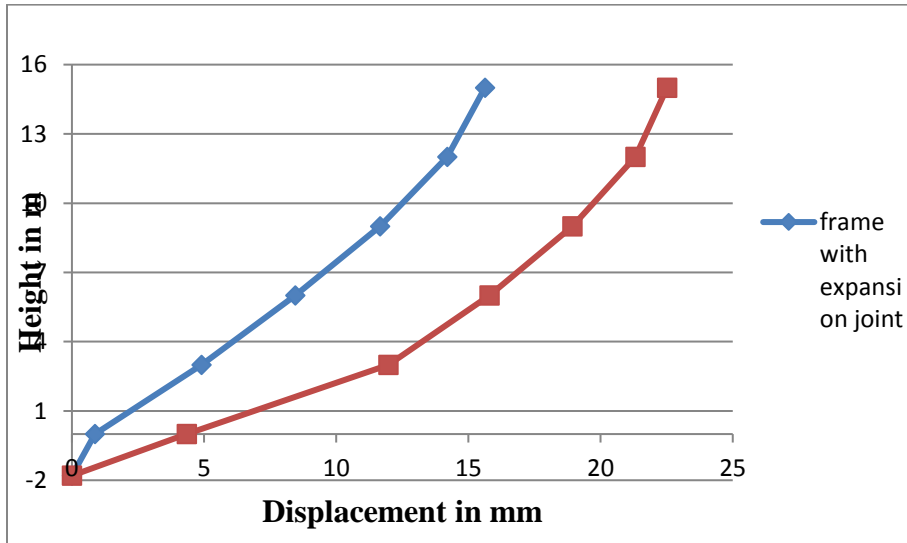
- Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 20°C)



It was observed that there was an increase in lateral displacement of 25.77% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 20°C)

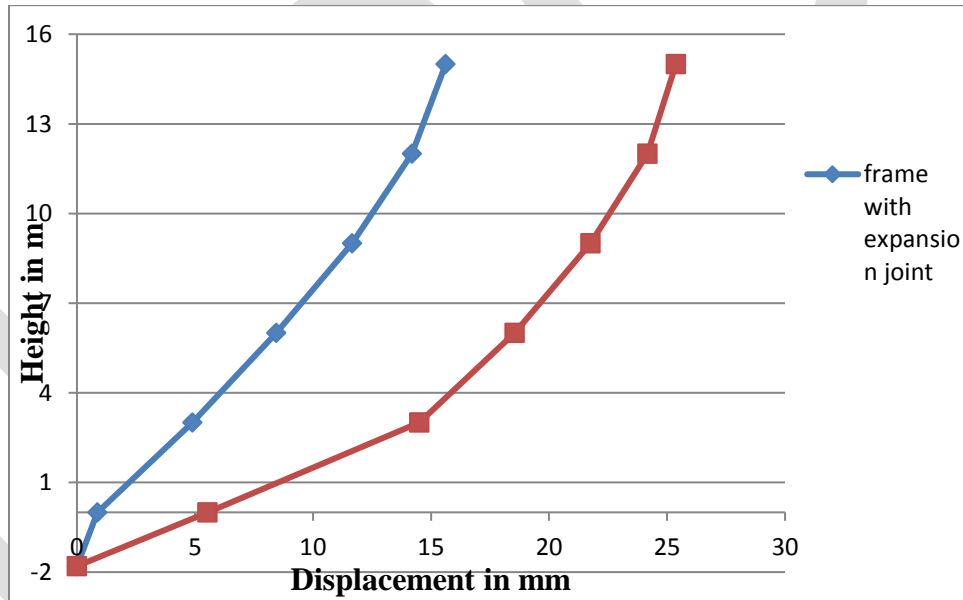
- Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 30°C)





It was observed that there was an increase in lateral displacement of 44.10 % for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 30°C)

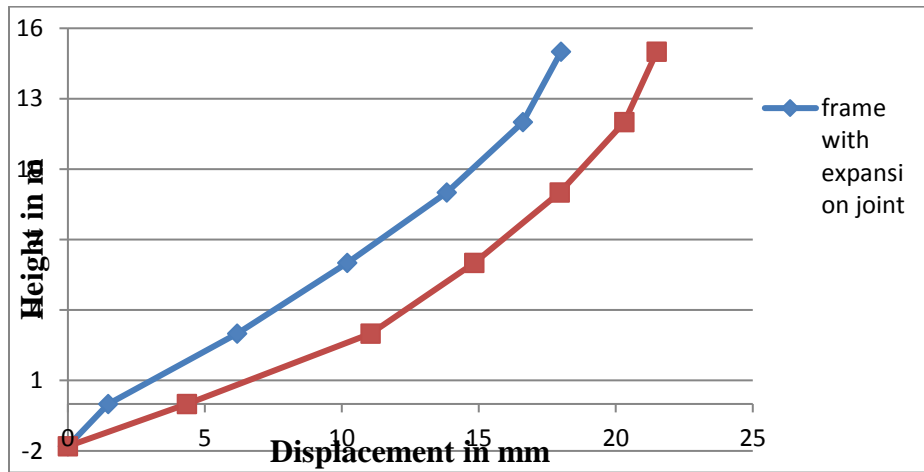
- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 40°C)**



It was observed that there was an increase in lateral displacement of 62.43% for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 40°C)

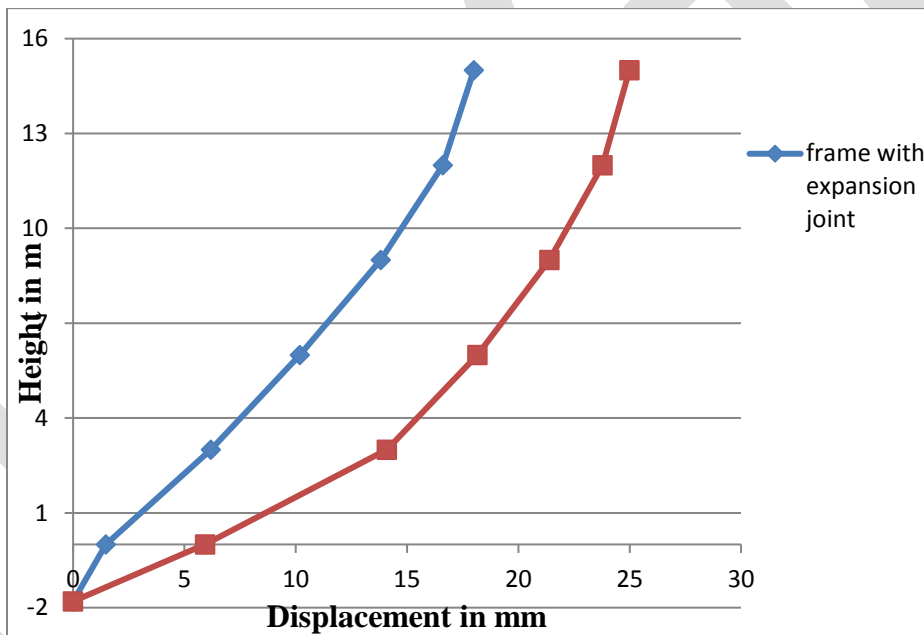
**FOR RECTANGULAR BUILDING**

- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 20°C)**



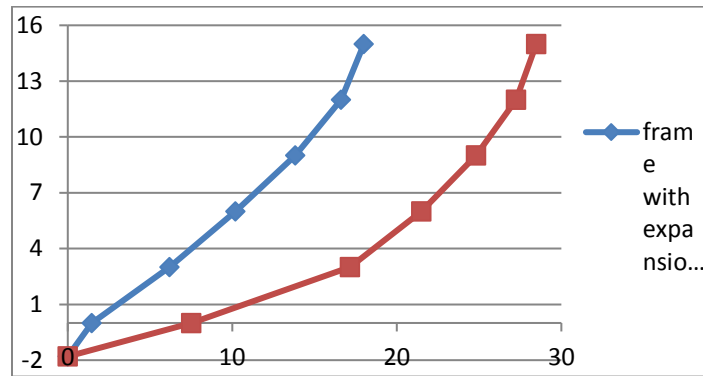
It was observed that there was an increase in lateral displacement of 19.42 % for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 20°C)

- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 30°C).**



It was observed that there was an increase in lateral displacement of 38.8 % for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 30°C)

- **Comparison of lateral displacement of frames with Expansion joint and without expansion joint subjected to temperature stress (varying temperature of 40°C)**



It was observed that there was an increase in lateral displacement of 58.21 % for frames with Expansion joint when compared to structure without expansion joint subjected to temperature stress (varying temperature of 40<sup>0</sup>C)

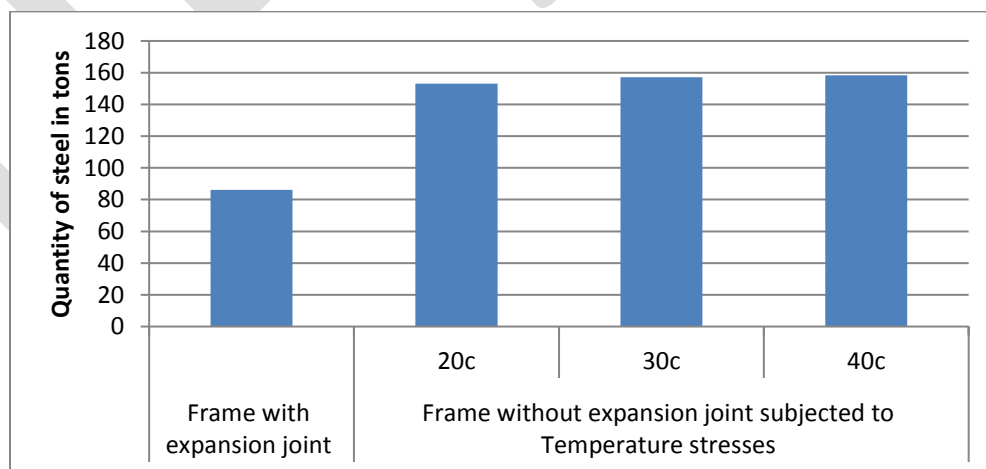
### COMPARISON OF QUANTITY OF STEEL

Comparison of quantities of steel in frames with Expansion joints and without Expansion joints subjected to temperature stress (varying temperatures of 20<sup>0</sup>C, 30<sup>0</sup>C and 40<sup>0</sup>C).

#### FOR C TYPE BUILDING

Quantities of steel for frame with expansion joints and without expansion joints subjected to temperature stresses (varying temperatures of 20<sup>0</sup>C, 30<sup>0</sup>C and 40<sup>0</sup>C).

Type	Frame with expansion joint	Frame without expansion joint subjected to Temperature stresses of		
		20 <sup>0</sup> c	30 <sup>0</sup> c	40 <sup>0</sup> c
quantity of steel	86.155	153.145	157.09	158.258

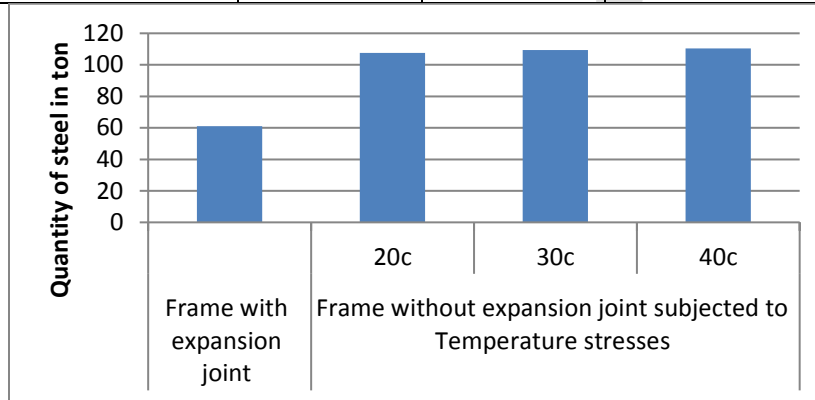


When compared to R.C frame with expansion joints and without expansion joint subjected to temperature stresses (i.e. varying temperature of 20<sup>0</sup>C, 30<sup>0</sup>C and 40<sup>0</sup>C), there was a increase in percentage of steel of 77.75, 82.33 and 83.68 respectively.

**FOR L TYPE BUILDING**

Quantities of steel for frame with expansion joints and without expansion joints subjected to temperature stresses (varying temperatures of 20°C, 30°C and 40°C).

Type	Frame with expansion joint	Frame without expansion joint subjected to Temperature stresses of		
		20°C	30°C	40°C
quantity of steel (Ton)	61.056	107.52	109.44	110.321

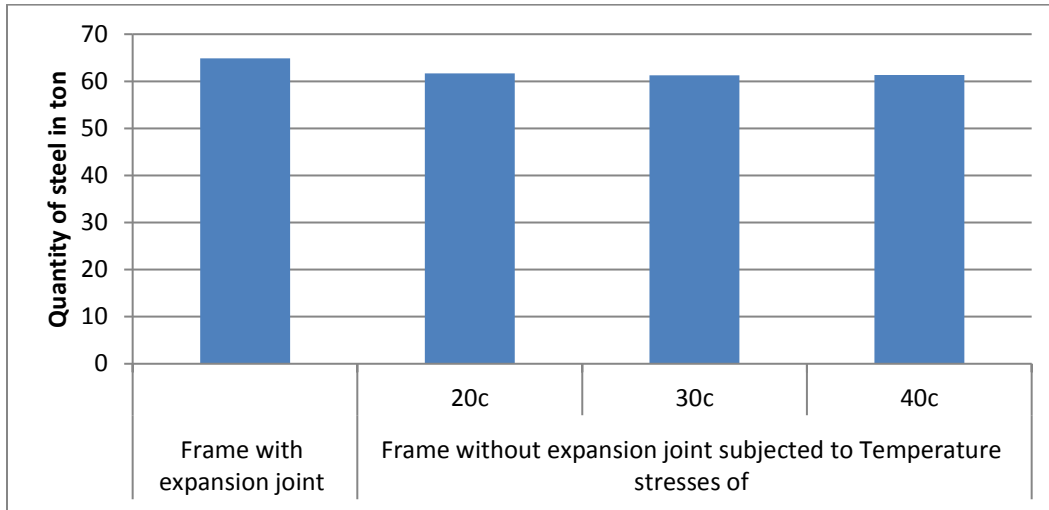


when compared to R.C frame with expansion joints and without expansion joint subjected to temperature stresses (i.e. varying temperature of 20°C, 30°C and 40°C), there was an increase in percentage of steel of 76.1, 79.24 and 80.68 respectively.

**FOR T TYPE BUILDING**

Quantities of steel for frame with expansion joints and without expansion joints subjected to temperature stresses (varying temperatures of 20°C, 30°C and 40°C).

Type	Frame with expansion joint	Frame without expansion joint subjected to Temperature stresses of		
		20°C	30°C	40°C
quantity of steel (ton)	64.893	61.7	61.25	61.357

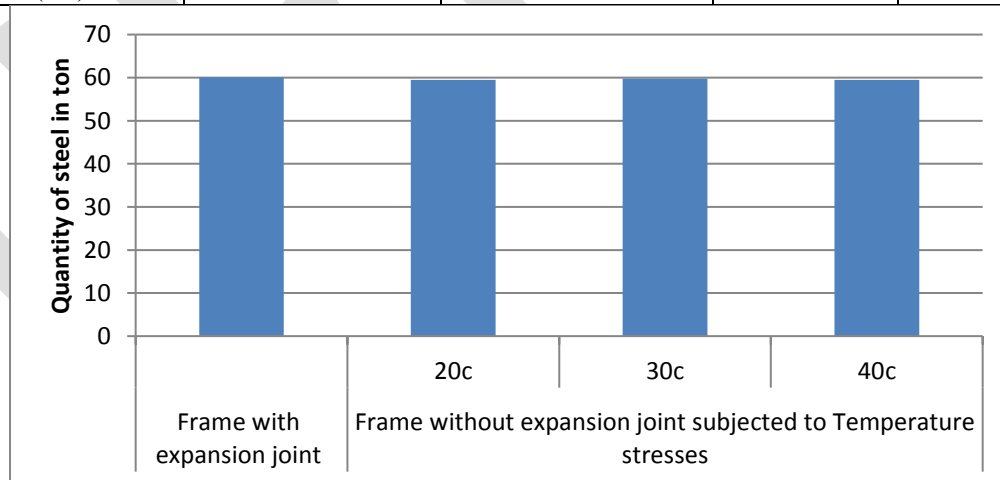


When compared to R.C frame with expansion joints and without expansion joint subjected to temperature stresses (i.e. varying temperature of 20°C, 30°C and 40°C), there was a decrease in percentage of steel of 4.9, 5.61 and 5.44 respectively.

### FOR RECTANGULAR TYPE BUILDING

Quantities of steel for frame with expansion joints and without expansion joints subjected to temperature stresses (varying temperatures of 20°C, 30°C and 40°C).

Type	Frame with expansion joint	Frame without expansion joint subjected to Temperature stresses of		
		20°C	30°C	40°C
quantity of steel (ton)	60.06	59.514	59.76	59.47



When compared to R.C frame with expansion joints and without expansion joint subjected to temperature stresses (i.e. varying temperature of 20°C, 30°C and 40°C), there was a slightly decrease in percentage of steel of 0.909, 0.49 and 0.98 respectively.

## CONCLUSIONS:

The lateral displacements and quantity of steel for Regular and Irregular R.C framed structures with and without expansion joints were investigated using the linear static analysis. Following were the conclusions drawn from the study.

1. For “C” type G+4 storey building, it was observed, when compared to frame with expansion joint to frame without expansion joints, there was an decrease in percentage of lateral displacement of 4.17 at a temperature stress of 20<sup>0</sup>c and there was an increase in percentage of lateral displacements of 10.73 and 25.236 at a temperature stresses of 30<sup>0</sup>c and 40<sup>0</sup>c respectively.
2. For “L” type G+4 storey building, it was observed, when compared to frame with expansion joint to frame without expansion joints, there was an decrease in percentage of lateral displacements of 17.18 and 4.865 at a temperature stresses of 20<sup>0</sup>c and 30<sup>0</sup>c and there was an increase in percentage of lateral displacement of 7.45 at a temperature stresses of 40<sup>0</sup>c respectively.
3. For “T” type G+4 storey building, it was observed, when compared to frame with expansion joint to frame without expansion joints, there was an increase in percentage of lateral displacement of 26.84, 44.63 and 62.41 at a temperature stresses of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c respectively.
4. For “Rectangular” type G+4 storey building, it was observed, when compared to frame with expansion joint to frame without expansion joints, there was an increase in percentage of lateral displacement of 21.49, 40.619 and 59.74 at a temperature stresses of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c respectively.
5. For “C” type building it was observed, when compared to frame with and without expansion joint subjected to temperature stresses (i.e. varying temperatures of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c) there was an increase in percentage of steel of 77.75, 82.33 and 83.68 respectively.
6. For “L” type building it was observed, when compared to frame with and without expansion joint subjected to temperature stresses (i.e. varying temperatures of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c) there was an increase in percentage of steel of 76.1, 79.24 and 80.68 respectively.
7. For “T” type building it was observed, when compared to frame with and without expansion joint subjected to temperature stresses (i.e. varying temperatures of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c) there was an decrease in percentage of steel of 4.9, 5.61 and 5.44 respectively.
8. For “Rectangular” type building it was observed, when compared to frame with and without expansion joint subjected to temperature stresses (i.e. varying temperatures of 20<sup>0</sup>c, 30<sup>0</sup>c and 40<sup>0</sup>c) there was an decrease in percentage of steel of 0.9, 0.49 and 0.98 respectively.
9. From the study, concluded that consideration of expansion joints in analysis of structure (wherever applicable) can improve stiffness as well as it will be cost effective.

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