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Effect of Enlargement of Joint on the Performance of Interior and Corner Beam-Column Joint

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Abstract *While constructing a structures in an earthquake prone area, there needs additional design procedures to withstand the effect that comes due to the earthquake. The main part of the bulling that affects badly is the joint portion which needs proper design. The joint are becomes structurally unstable when lateral loads like earthquake loads act on them. Transverse hoops are incorporated in high percentage to withstand the impact of lateral loads. Joint enlargement gives many advantages over other common methods. It becomes economical since conventional materials likes concrete and steel is used for the purpose of joint strengthening. The enlargement can be given to interior joint, exterior joint or corner joint.*

***Key Words*: Beam-column joint, RCC, Joint enlargement, ANSYS, FEM**

1. INTRODUCTION

There were many devastation and destruction of structures due to joint failures during earthquakes. If joints are not properly designed and detailed, it can damage the entire structure. Beam-column connections have been identified as potentially one of the weaker components Numerous researches were carried out on different retrofit techniques including the use of concrete jackets, bolted steel plates, and FRP sheets, which were considered in the structural upgrading, especially for columns and beam–column joints in the moment-resisting frames. Among these retrofit techniques, RC jacketing is widely used because it is more consistent with as-built RC structures than the other retrofit materials, such as steel or FRP jacketing, and the deficient beam– column joints can be easily repaired.

2. MODELING

2.1 General

ANSYS is a finite element analysis tool for structural analysis and explicit studies. ANSYS offers an easy and flexible platform for performing analysis of structures or models with great accuracy. ANSYS consists of two working platforms called APDL and workbench among which workbench provides more automated options for the analysis operations.

This is usually done using numerical approximation in structural analysis is the Finite Element Method

2.2 Details of specimen

The beams are 150mm deep by 100 mm wide and columns are 150 mm deep by 100 mm wide. The M30 grade concrete and Fe 415 grade steel were used. Steel bars of yield stress 415N/mm² were used as main reinforcement and stirrup..

Table -1: Reinforcement details

Column Reinforcement	Beam Reinforcement
Longitudinal	Longitudinal
Four 10-mm diameter	Four 10-mm diameter (at top and bottom)
Transverse	Transverse
6-mm diameter at 100 mm c/c	6-mm diameter at 100 mm c/c

Table -2: Properties of the Specimen

Material model No.	Element type	Material properties
1	Reinforcement	Linear Isotropic Elastic Modulus 2.0×10^5 N/mm² Poisson's Ratio 0.3
2	Concrete	Linear Isotropic Elastic Modulus 27386.12 N/mm² Poisson's Ratio 0.15

Modeling of the corner and interior beam-column joints without joint enlargement is done. The specimen was given to cyclic load for a fixed deformation of 5mm all are done in ANSYS Workbench 16.1

2.3 Modeling

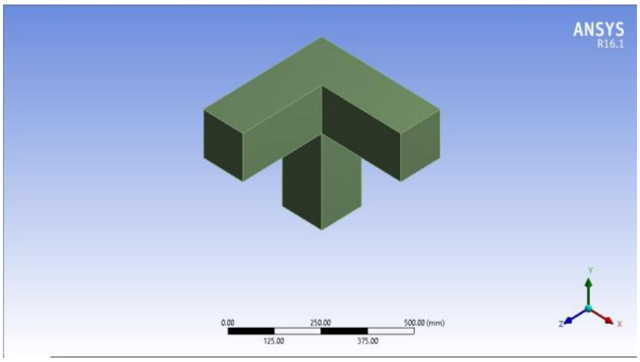

Fig -1 Corner joint without enlargement

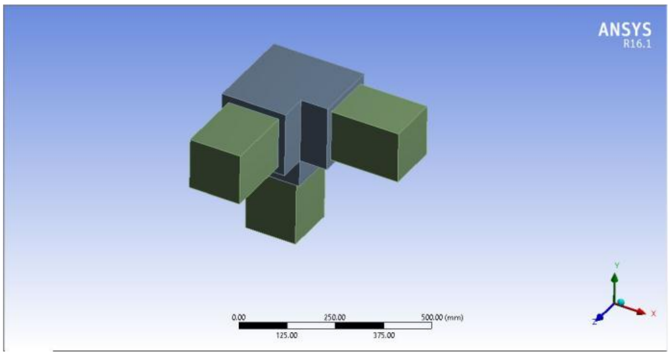

Fig -2 Corner joint with enlargement

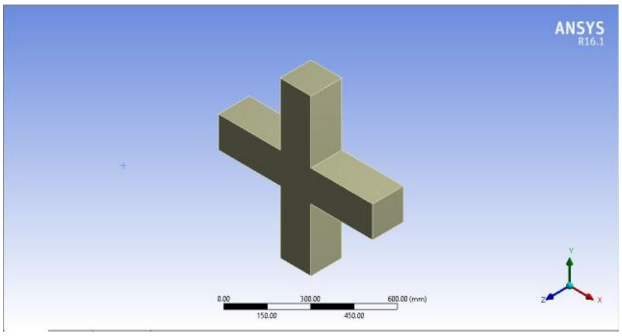

Fig -3 Interior joint without enlargement

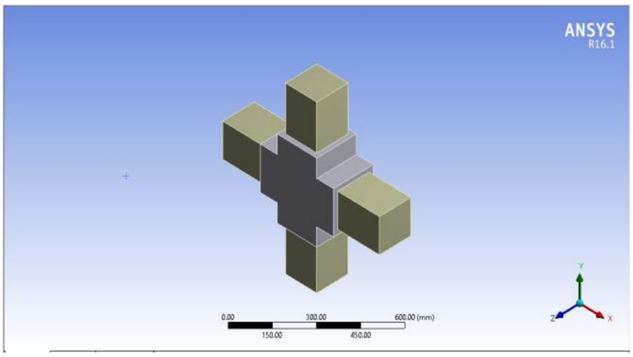

Fig -4 Interior joint with enlargement

3. ANALYSIS

The analysis of the corner beam column joint of given dimensions, is done using the ANSYS software and the details are given. Cyclic loading is done to any of the beams, for a fixed deformation rate.

The following figures show the result of the analysis on the corner beam column joint without enlargement that is given cyclic loading.

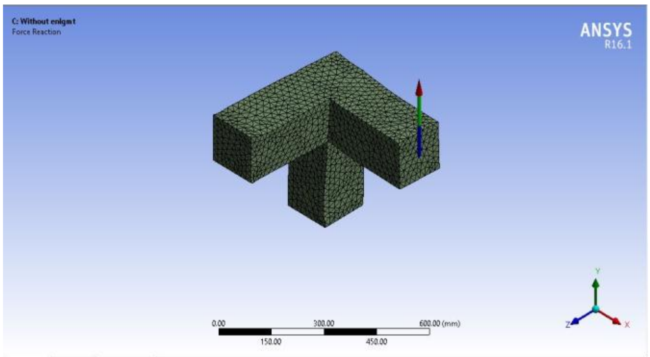

Fig -5 Load in corner joint without enlargement

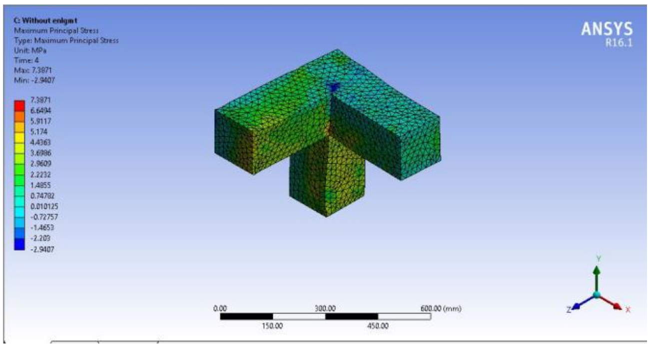

Fig -6 Stress in corner joint without enlargement

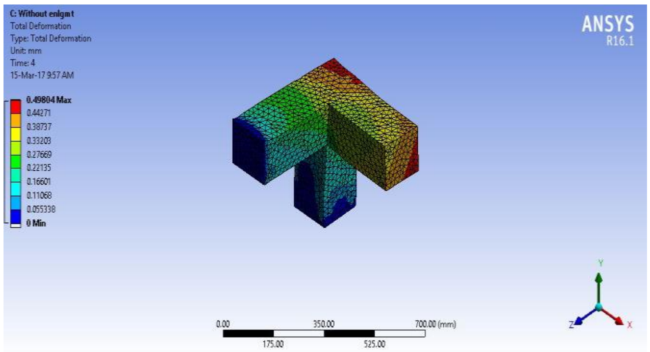

Fig -7 Deformation in corner joint without enlargement

The analysis of the corner beam column joint with 20mm enlargement of given dimensions is done.

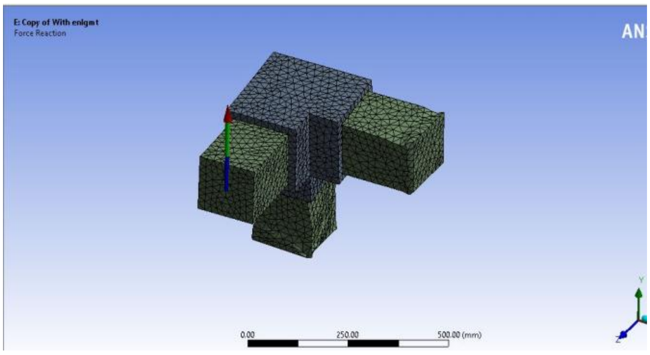

Fig -8 Application of load in corner joint with enlargement

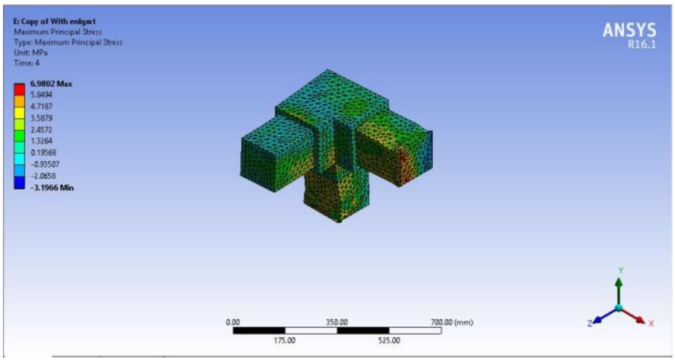

Fig -9 Stress in corner joint with enlargement

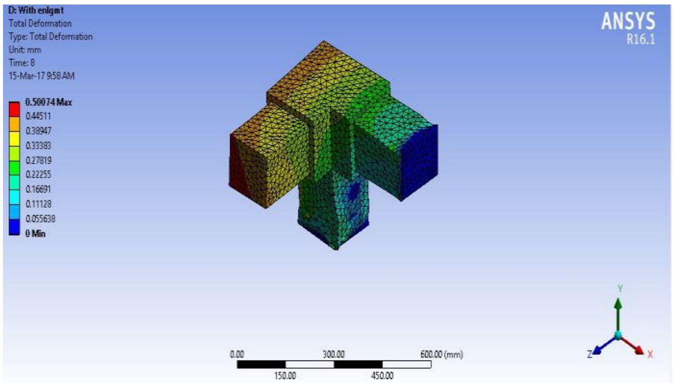

Fig -10 Deformation in corner joint with enlargement

The interior beam column joint without enlargement is then given the cyclic loading for a fixed deformation rate.

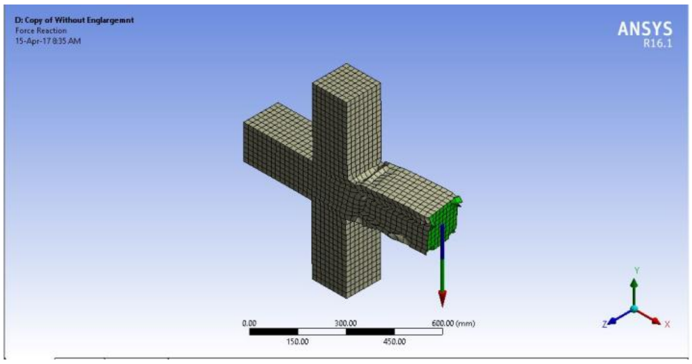

Fig -11 Load in interior joint without enlargement

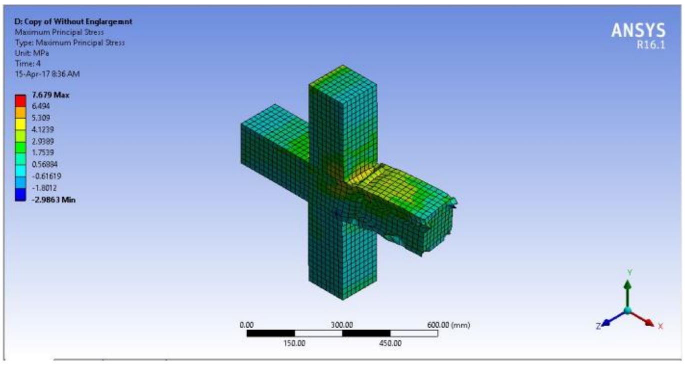

Fig -12 Stress in interior joint without enlargement

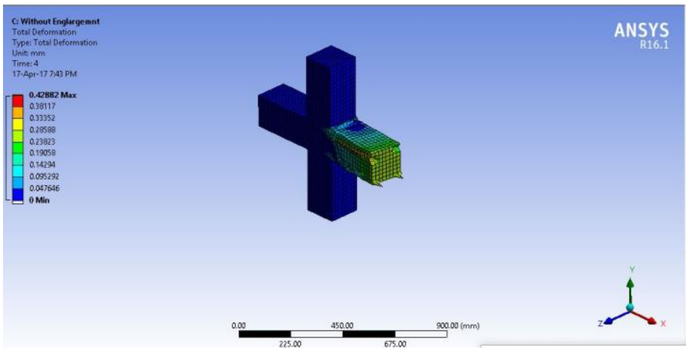

Fig -13 Deformation in interior joint without enlargement

The interior beam column joint with 20 mm enlargement is given cyclic loading. The result of deformation obtained for the cyclic loading is directly obtained from the ANSYS Workbench-16.1.

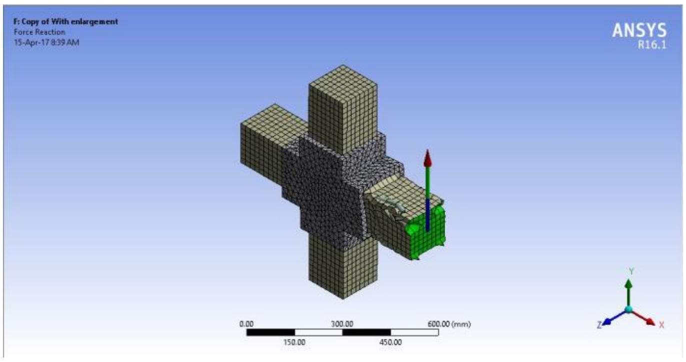

Fig -14 Load in interior joint with enlargement

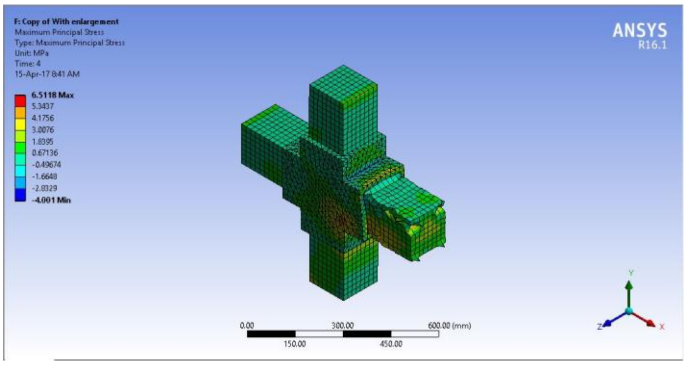

Fig -15 Stress in interior joint with enlargement

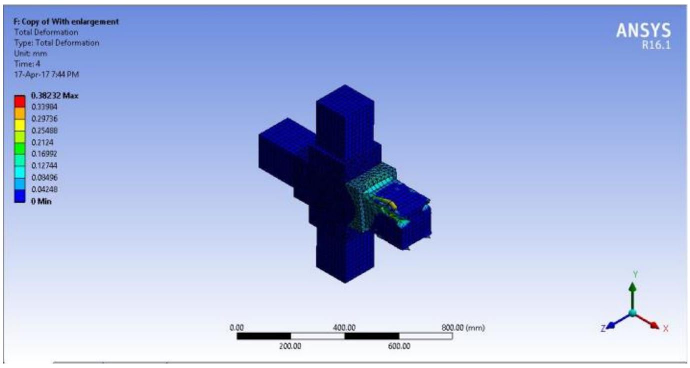

Fig -16 Deformation in interior joint with enlargement

4. RESULT AND DISCUSSION

4.1 General

The beam-column joints were analysed in ANSYS workbench 16.1. The deformations values, load-deformation relations and the capacity to withstand the load, of each specimen are included in the results

4.2 Result of the analysis

The analysis is done after giving cyclic loading to the structures. The results are shown below.

Table -3: Load v/s Deformation details for corner joint

Deformation (mm)	Load (N)	
	Without enlargement	With enlargement
0	0	0
1	175367	22253
2	20047	23674
3.5	22031	24618
5	2319	25610
4	-3208	-13836
3	-11384	-19090
1.5	-16204	-21899
0	-19051	-23328
-1	-20407	-23966
-2	-21506	-24447
-3.5	-22620	-24971
-5	-23498	-25357
-4	2492	13366
-3	10531	18663
-1.5	15498	21594
0	18663	23113

The maximum load that the corner joint without enlargement can withstand is found to be 23.2kN and for the corner joint with enlargement is found 25.2kN. Maximum stress acting on the corner joint without enlargement is obtained as 7.38MPa and that of with enlargement is 6.91 MPa. This gives reduction in stress about 6.37MPa.

Table -4: Load v/s Deformation details for interior joint.

Deformation (mm)	Load (N)	
	Without enlargement	With enlargement
0	0	0
1	21787	26508
2	23819	27906
3	25317	28644
4.5	26818	29490
5	27137	29736
4	-5711	-18702
3	-14126	-23495
2	-18438	-25355
1.25	-20504	-26212
0.5	-21950	-26844
0	-22740	-27234
-0.5	-23435	-27577
-1	-24068	-27893
-1.75	-24819	-28340
-2.875	-25815	-28932
-4.5625	-27064	-29705
-5	-27361	-29898
-4.5	-2283.3	11552
-4	-67212	18549
-3.5	6279	21676
-2.75	1510	23964
-2	18123	25194
-0.875	21014	26361
0	22495	27092

The maximum load that the interior joint without enlargement can withstand is found to be 27.1kN and for the interior joint with enlargement is found 30kN. The maximum stress acting on the interior joint without enlargement is obtained as 7.68MPa and that of with enlargement is 6.51MPa. There is reduction in the stress about 15.2% when the joint is enlarged.

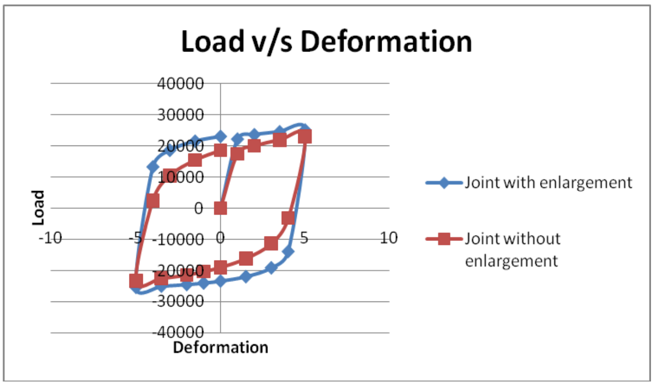

Chart -1 : Comparison of Load-Deformation variation for corner joint with and without enlargement

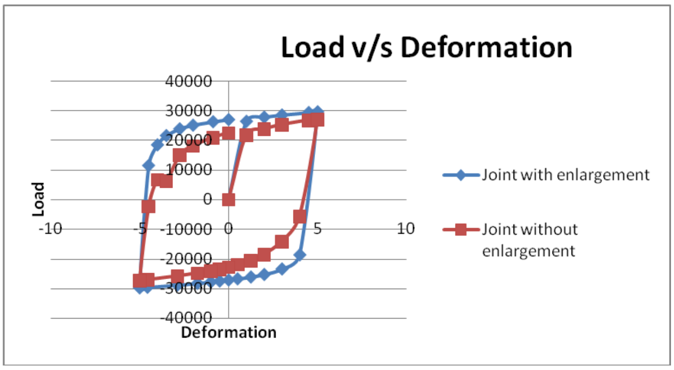

Chart -2 : Comparison of Load-Deformation variation for interior joint with and without enlargement

The load- deformation graph for the corner joint with and without joint enlargement shows that capacity of the joint is increased as the joint portion is enlarged. The maximum load that the joint without enlargement is found to be 23.2kN; and that of corner joint with enlargement is 25.18kN. In the same way, for the interior joint with and without joint enlargement; shows that the capacity of the joint is increased as the joint portion is enlarged. The maximum load that the joint without enlargement is found to be 27.1kN; and that of interior joint with enlargement is 30kN The increment in the load capacity is the result of enlargement of the beam column joint. This shows that there is increment in strength when the joint portion is enlarged.

Table -5: Result of the Analysis

	Corner joint		Interior joint	
	Without enlargement	With enlargement	Without enlargement	With enlargement
Load (kN)	23.2	25.2	27.1	30
Stress (MPa)	7.38	6.91	7.68	6.51

4.3 Discussion

- It is found that the maximum load that can be carried by the joint is increased when the joint is enlarged
- For corner joint, the capacity of joint without enlargement is 23.2kN and for the joint with enlargement is 25.2kN
- For interior joint, the capacity of joint without enlargement is 27.1 kN and for the joint with enlargement is 30kN
- Total stress at joint decreases as the joint is enlarged.
- For corner joint, stress reduces from 7.38MPa to 6.91MPa
- For the interior joint, stress reduces from 7.68MPa to 6.51MPa

3. CONCLUSIONS

Many parameters affect the design of joint enlargement, for example, the size, reinforcement and material strengths of beam, column and joint panels. The joint region was enlarged 20mm than the control specimen. The results yield the following conclusions.

1) The corner joint with enlargement can withstand 10 % more load than that in the joint without enlargement

2) There is reduction in the stress about 6.37% when the joint is enlarged. It is obtained that when the joint region is enlarged; stress in the joint has reduced.

3) The interior joint with enlargement can withstand 12 % more load than that in joint without enlargement

4) There is reduction in the stress about 15.2 % when the joint is enlarged. It is obtained that when the joint region is enlarged; stress in the joint has reduced

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