Cyclic load Analysis of beam column joint using ANSYS

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ABSTRACT. Work on FE analysis with the addition stirrup bar at different spacing in beam under the cyclic loading for strengthen the joint. The most important part of developing the beam column joint when cyclic loading take place in seismic zone. Six samples with different characteristic are chosen, design as per ductile detailing IS 13920-2016 and non-ductile detailing as per IS 456-2000 and design on ANSYS. The result shows that addition of lateral reinforcement have more shear strength. From the all sample the shear strength is high in addition of stirrups at L/3 scaled and L/4 scaled.

Keywords: ANSYS, Shear Force, Cyclic Load, Longitudinal Reinforcement.

1. INTRODUCTION

The beam and column joint are very major part to design for earthquake point of view. It is difficult task to design beam column joint for structure designer in strong earthquake zone, in joint the maximum bending moment and shear stress occur. Most of joint may fail due to shear failure. Due to strong wind load, earthquake large load is not more efficient for beam and column joint, the toughness of structure. [1]For beam and column joint increase the toughness of model are design as per IS ACI-AIJ design code. [2] conduct the experiment under the seismic loading the one of the outer beams and column increase the energy dissipation of joint. Different types of lateral reinforcement pattern used design as per IS456-2000 and IS13920-2016. [3]used experimental and analytical using the ANSYS software for increase the shear strength of joint, and ferrocement used in exterior beam column joint compare the experimental result and analytical result are satisfy, by changing the orientation of Wire mesh 60° to 45° per ferrocement layer.

In present study shows the non-linear element is used on ANSYS software, the additional lateral reinforcement is used at different spacing it is design as per the ductile reinforcement detailing from IS13920-2016.From which of the reinforcement pattern is best for adoption and study the element have greater shear strength of element.

1.1 Objectives

1. To research the behaviour of beam and column.
2. Adopt the different lateral reinforcement pattern to increase the shear strength of joint.

2. METHODOLOGY

2.1 Test sample and material modelling

With the reference of experimental research paper [4] in this paper they performed experiment on RCC
building which is seven storied in the zone II is analysed. The exterior beam column joint is selected on that building. On present paper for concrete modelling solid65 element is used and for reinforcement in beam and column is connect in concrete element with link8 on ANSYS. There are five type of sample, sample (C) design as per IS code 456-2000 as shown in Figure.1 [4], Sample with additional stirrup bar at 1/3 scaled (C1) as shown in Figure.2, Sample with additional stirrup bar at 1/4 scaled (C2) as shown in Figure.3, Sample with additional stirrup bar at 1/5 scaled (C3) as shown in Figure.4, Sample with additional stirrup bar at 1/2 scaled (C4) as shown in Figure.5. The size of column is 100mmX180mm and beam size is 100mmX150mm and the M20 grade of concrete with medium workability of concrete was designed. HYSD bars Fe 415, 8mm longitudinal bar and for Fe250 grade, 6mm longitudinal bar is used, poison’s ratio is 0.3. The cyclic load is acted on the 50mm from cantilever of beam and both column ends is fixed. From the result it is conclude that the shear strength of structure is more at which added the additional stirrup bar as compare to sample which is design as per IS456-2000.

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Figure 1. Section of sample-C [4]

Figure 2. Section of sample-C1

Figure 3. Section of sample-C2

Figure 4. Section of sample-C3
3. ANSYS Result

The beam column joint under the intermittent force performed under ANSYS. Displacement, shear stress and equivalent stress was calculated and compare, it is shows that the sample with additional added stirrup bar have more strength. Tensile ultimate strength=250MPa (fe250), Tensile ultimate strength=415 MPa(fe415), and other data have similar to the experiment [4]. The boundary condition in ANSYS is, the column at both the support fixed then intermittent force is applied at free end of beam at 50mm from end as shown in Figure 6. The typical idealization of test set up an ANSYS with Nodes = 3026, Element =812.

For calculate cyclic load as below,

\[ F(t) = F_0 \sin(\Omega t) \]

Figure 5. Section of sample-C4

Figure 6. Loading condition of all sample
3.1 Parametric study of Sample-C, C1, C2, C3, C4

As shown in Figure-7 the hysteresis behaviour shows that of sample design as per IS code (Sample-C) the maximum cyclic load on ANSYS is 13.964KN, 13.132KN, 10.04KN (tension), 12.315KN, 11.730KN, 11.64KN (compression) respectively, the sample is failed at 45mm, 50mm, 55mm displacement. The shear stress observed were 0.383N/mm², 0.478N/mm², 0.76N/mm² (tension), 0.2806N/mm², 0.7979N/mm², 0.564N/mm² (compression) respectively as shown in Figure-8 and equivalent stress observed were 0.93Mpa, 0.87Mpa, 0.80Mpa, (tension), 0.82Mpa, 0.782Mpa, 0.864Mpa (compression) respectively.

![Figure 7](image7.png)

**Figure 7**- Graph of Load vs displacement hysteresis graph of Sample-C

![Figure 8](image8.png)

**Figure 8**- Graph of Time vs shear stress of Sample-C

As shown in Figure-9 the hysteresis graph shows that maximum cyclic load of sample with additional stirrup bar at 1/3 scaled (sample-C1) is observed were 14.24KN, 15.021KN, 14.94KN (tension), 14.23KN, 13.98KN, 13.56KN (compression) respectively the sample is failed at 45mm, 50mm, 55mm displacement. The shear stress observed were 0.949Mpa, 1.0Mpa, 0.99 Mpa (tension), 0.948 Mpa, 0.93 Mpa, 0.9 Mpa respectively as shown in Figure-10 and the equivalent stress observed were 11.52Mpa, 25.65 Mpa, 24.23 Mpa (tension), 15.25 Mpa, 24.36 Mpa, 19.89 Mpa (compression) respectively.
From comparison of Figure-7 and Figure-9 the load vs displacement graph shows that the 65.13% is increase with addition of 1/3 stirrups, as well as the Figure -10 graph shows that stress value is 14.42% increase with addition of 1/3 stirrups. By adding the stirrups bar at 1/3 of scaled, increase toughness of beam and column joint.

As shown in Figure-11 the hysteresis graph shows that the maximum cyclic load of sample with additional stirrup bar at 1/4 scaled (sample-C2) is observed were 14.345KN, 13.237KN, 14.363KN (tension), 14.363KN, 13.130KN, 14.265KN (compression) respectively. the sample is failed at 45mm, 50mm, 55mm displacement. The shear stress observed were 0.956Mpa, 0.88 Mpa, 0.97 Mpa(tension), 0.955 Mpa, 0.87 Mpa, 0.957 Mpa (compression) respectively as shown in Figure-12 and the equivalent stress observed were 21.56 Mpa, 18.25 Mpa, 25.66 Mpa (tension), 24.01 Mpa, 16.98 Mpa, 22.23 Mpa (compression) respectively.
From comparison of Figure-7 and Figure-11 the load vs displacement graph shows that 69.46% is increase with addition of 1/4 stirrups, as well as the Figure-12 graph shows that stress value is 18.51% increase with addition of 1/4 stirrups. By adding the stirrups bar at 1/4 of sample, increase toughness of beam and column joint.

As shown in Figure-13 the hysteresis graph shows that the maximum cyclic load of Sample with addition stirrup bar at 1/5 scaled (sample-C3) is observed were 13.864KN, 13.245KN, 12.982KN (tension), 12.870KN, 12.234KN, 13.015KN (compression) respectively. The sample is failed at 45mm, 50mm, 55mm displacement. The shear stress observed were 0.92Mpa, 0.89 Mpa, 0.86 Mpa, (tension), 0.85 Mpa 0.867 Mpa, 0.81 Mpa(compression) respectively as shown in Figure-14 and the equivalent stress observed were 10.23 Mpa, 11.01 Mpa, 9.96 Mpa (tension), 8.56 Mpa, 10.86 Mpa, 9.48 Mpa (compression).
From comparison of Figure-7 and Figure -13 the load vs displacement graph shows that 52.01% is increase with addition of 1/5 stirrups, as well as the Figure-14 shows that stress value is 13.47% is increases with addition of 1/4 stirrups, increase toughness of beam and column joint.

As shown in Figure-15 the hysteresis graph shows that the maximum cyclic load of Sample with additional stirrup bar at 1/2 scaled (sample-C4) is observed were 12.017KN, 12.892KN, 11.726KN (tension), 11.234KN, 11.984KN, 12.453KN (compression) respectively, the sample is failed at 45mm,50mm,55mm displacement. The shear stress observed were 0.801 Mpa, 0.859 Mpa, 0.781 Mpa (tension), 0.748 Mpa, 0.798 Mpa, 0.83 Mpa (compression) respectively as shown in Figure-16 and the equivalent stress observed were 9.32 Mpa, 13.56 Mpa, 12.78 Mpa, (tension), 11.82 Mpa, 12.99 Mpa, 13.48 Mpa (compression).
From comparison of Figure-7 and Figure -15 the load vs displacement graph shows that 48.58% is increase with addition of 1/2 stirrups, as well as the stress value is 12.47% increases with addition of 1/4 stirrups. By adding the stirrups bar at 1/2 of sample, increase toughness of beam and column joint.

**3.2 Failure mode with crack pattern**

After applying the cyclic load on free end of beam the displacement is shows in both direction positive and negative. At maximum loading the maximum displacement is occur and crack is formed in beam column joint and spread through evenly to beam. From hysteresis loops of all sample from ANSYS is compared with sample C without adding stirrup bar then it shows that with adding stirrup bar sample has increase the applied load by 65.13% for Sample with additional stirrup bar at 1/3 scaled (sample-C1),69.49% for Sample with additional stirrup bar at 1/4 scaled (sample-C2),52.01% for Sample with additional stirrup bar at 1/5 scaled sample-C3, 48.58% for Sample with additional stirrup bar at 1/2 scaled (sample-C4).
4. CONCLUSION

The mathematical outcomes got by ANSYS model were confirmed utilizing trial results acquired by the principal creator. A parametric examination was completed utilizing this model to explore the impact of extra factorson the conduct of outside shaft segment joints in building outlines fortified. The fundamental ends can be drawn from this examination as follows:

1. The beam-column joint design as per IS456-2000 undergoes the large displacement as compare to stirrups bar as added sample.
2. From the result shows that shear strength high at sample with additional stirrups bar at 1/3 and 1/4 scaled (C1, C2) as compare to another sample.
3. It increases the load carrying capacity, displacement specially in sample with additional stirrups bar at 1/3 and 1/4 scaled sample-C1 and sample-C2.

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