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Analysis on Shear Force Demand in Beam-Column/shear wall Connection and PRC beam with different concrete grade by using Etabs Software

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Abstract: **The most important components of reinforced concrete (RCC) systems are the connections between beams and shear walls. They take up a significant amount of the overall shear and act as a load switch course. In RCC systems built without seismic precautions, joints have insufficient potential and ductility under lateral loads, which can lead to the gradual failure of the entire structure. Older shear wall joints or beam-column joints made of concrete that lack transverse bracing are prone to significant damage and may even collapse during powerful earthquakes. There are tools to predict the shear strength of joints with ductile details. Calculating joint shear calls for is essential due to the complex behavior of the joint center. Therefore, confinement is offered at such places. Congestion develops at joints as a result of this restriction. A fresh proposed design for plate-reinforced composite (PRC) coupling beams has undergone experimental investigation, which also aids us in beams carrying significant shear stress. In this study, an effort is made to comprehend how shear stress and ductile shear demand capacity behave at the intersection of a beam-column or shear wall composed of various grades of concrete using Etabs 2020 Software.**

Keywords —Aseismic, Transverse, Confinement, Coupling, Capacity, Composite, Intersection, Collapse

I. Introduction

The beam column or shear wall joint is the essential sector in a reinforced concrete body. Its miles subjected to large forces during severe ground shaking and its behavior has a significant affect at the response of the structure. The idea of joint being rigid fails to do not forget the outcomes of excessive shear forces developed in the joint. The shear failure is usually brittle in nature which isn't a suitable structural performance mainly in seismic conditions. Know-how the joint conduct is important in exercise proper judgments inside the layout of joints. Therefore, it is vital to talk about approximately the seismic movements on various sorts of joints and to focus on the critical parameters that affect joint performance with unique connection with bond and shear switch. The anchorage period necessities for beam bars, the provision of transverse reinforcement and the role of stirrups in shear switch at the joint are the principal trouble. A take a look at of the use of extra pass-willing bars at the joint core suggests that the willing bars introduce an extra new mechanism of shear transfer and diagonal cleavage fracture at joint can be averted.

A beam, column, and slab connection consist of a junction and the adjacent beam, column, and slab. A joint is sometimes described as the area of the column that is framed by the deepest beam but is inside its intensity. Three different types of connectors make up a beam slab connection. There are three types of connections: connections between interior beam columns, connections between exterior beam columns, and connections between nook beam columns.

1.1 Beam-Column Junction-

A beam-column- slab connection is the combination of joint and beam, column, slab adjacent to the joint. And a joint is defined as that portion of column within the depth of deepest beam that frames into the column.

There are 3 types of junctions-

1. Corner beam-Column-Slab Junction
2. Interior beam-Column-Slab Junction
3. Exterior beam-Column-Slab Junction

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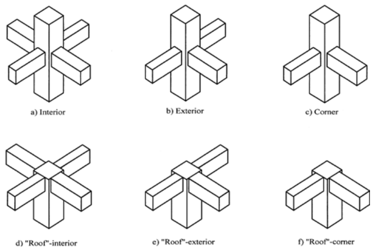

1.2 Connection failure of the structure can be classified-

1. Bond failure due to excess tension in reinforced bar.
2. Material failure at connection.
3. Shear failure before formation of plastic hinge in the beam.

High-strength concrete resists loads that cannot be resisted by normal-strength concrete. It also increases the strength per unit cost, per unit weight, and per unit volume as well. The hybrid structures consisting of RC columns and steel beams are suitable for use in high seismic risk zones. RCS moment-resisting frame systems, consisting of Reinforced Concrete (RC) columns and Steel (S) beams, take advantage of the inherent stiffness and damping, as well as low-cost of concrete, and the lightweight and construction efficiency of structural steel.

II. OBJECTIVE

As we discussed above Beam and shear wall junction play a major role in earthquake resistant building will can resist doing ductile detailing and understanding behaviors of shear stress and shear demand capacity at junction.

Here we taking residential building plan with dimension 41m X 17.1m having G+30 floor. Analysis done with different grade of concrete M70 & M30 gradually decrease with above floor. Considering Zone-4 seismic with 1.2 importance factor.

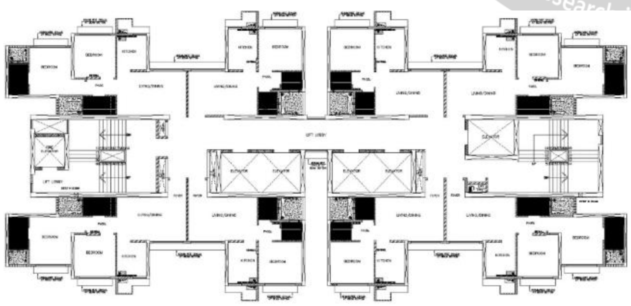

Fig.1: Architecture Plan

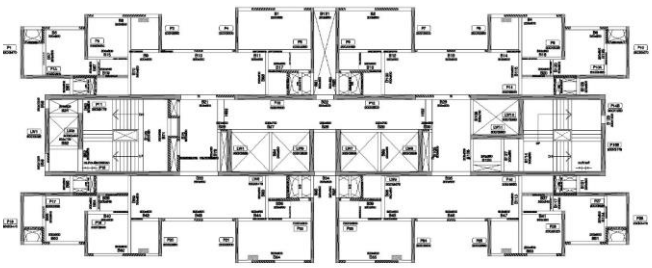

Fig.2: Framing Plan layout with Shear wall & Beam Sizes

III. METHODOLOGY

1. Selection of types of structures.
2. Preparing framing layout plan. (Finalize location of column/shear wall & beams).
3. Modeling of Structure in Etabs 2020.
4. Loading data as per IS code
5. Assigning & applying all design parameters as mention in Table 1, 2, & 3. (As per IS 1893 Part-1:2016 – criteria for earthquake resistant design of structure).
6. Load Combination as per IS code.
7. Performing dynamic analysis on selected building models and comparison of the analysis results.

Standards Codes which we are using-

1. IS 456:2000	:	Reinforced Concrete – Code of practice
2. IS 1893 Part-1:2016	:	Criteria for earthquake resistant design of structure
3. IS 13920:2016	:	Ductile design and detailing standard
4. IS 961-1975	:	Shear Stud (For PRC Beam)
5. ACI PRC-352-02	:	For Study of PRC Beam

When a building is subjected to seismic force, it responds by vibrating. A seismic force is resolved in three mutually perpendicular directions and the predominant direction of shaking is horizontal. This force is called as the seismic design base shear. To find out the base shear, the analysis of structure is carried out using Etabs 2020 Software. The program calculates the base shear that resists the design lateral loads at connection. It also calculates the moments, center of mass and rigidity of the building. Firstly, we analysis the whole building & at specific analysis beam-shear wall junction at 5^{th}, 12^{th} & 23^{rd} floor with effect of different concrete grade. With high ductile shear force generated at junction PRC beam introduced.

Building Configuration

The building model in the study has low, medium, and high story with constant story height of 3m. After considering multiple literature reviews we have selected few parameters which are supposed to affect the shear demand of beam-column-slab connection. This work studies the influence and correlation of these parameters. All the building models with different parameters have been designed with ETABS according to IS: 456:2000.

Following are the range of parameters which has been taken to study the influence on the connection shear demand.

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Number of Story: G+30 floors

Seismic Zone: IV

Following design parameter are mention in below tables –

Table 1 Basic design parameters

1.	Location	Mumbai
2.	Type	Residential
3.	Floor Height	3m
4.	Framing System	Beam & slab System
5.	Lateral Framing System	SMRF
6.	Column/Shear wall, Beam & Slab - concrete Grade	M70 = Base to 6th Fl M50 = 6th Fl to 15th Fl M40 = 15th Fl to 22nd Fl M30 = 22nd Fl to 30th Fl
7.	Steel Grade	Fe550
8.	Wall Thickness	200mm, 300mm
9.	Beam	All 200x600mm
10.	Slab	125mm, 150mm
11.	X – Dimension	41 m
12.	Y – Dimension	17.1 m
13.	Superimposed Dead Load	1.5 kN/m^2
14.	Live Load	2 kN/m^2
15.	Spectrum	SpecX, SpecY

Table 2 Earthquake & Wind design parameters

1.	Zone	Zone-4, Z=0.16
2.	R	4
3.	I	1.2
4.	Soil Type	1
5.	Damping	5%
6.	Wind Speed	44m/s

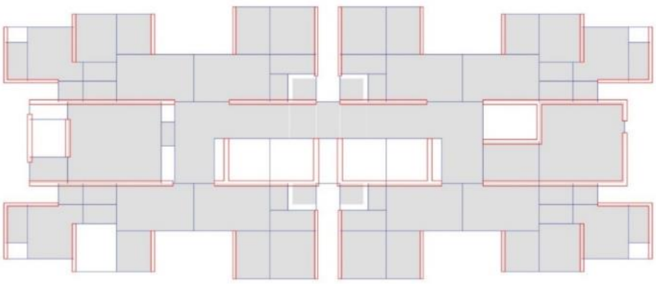

Fig.3: Etabs Model framing Plan

There are different Etabs model with different etas model as mention below –

1. Case-1: Basic Etabs model with Concrete grade as mention in above Table 2.
2. Case-2: From 15^{th} Fl to 30^{th} Fl = M40

After modelling both models, we check & analysis marked beam (marked in Fig-4) at 5^{th},12^{th} & 23^{rd} floor.

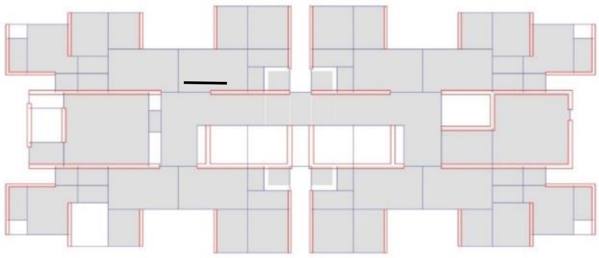

Fig.4: B1 -Beam Marking For analysis

IV. MODELLING AND ANALYSIS

Model done as per all parameter mention in above table. EQX, EQY, SPECX, SPECY load applied in model. As already discuss we have made 2 Etabs model. With different concrete grade. We have followed all IS code parameter file modelling model. Hence model done we put it on Run analysis.

During analysis we observed that some beam fails due to exceeding shear stress permissible limit. We have checked calculation by manually also.

The structure is modelled through following steps of different storey of RCC is made and analysis can be done using ETABS 2020 software.

Load Considered

The loads considered are as follows:

The self-weight of Slab 125mm = 0.125 x 1 x 25 = 3.125kn/m2

150mm = 0.150 x 1 x 25 = 3.75kn/m2

Live Load and Super Imposed Dead Load:

Live load adopted for floor slab and roof according to IS 875 part-II:

General Area = 2 KN/m2

Passage Area = 3 KN/m2

Earthquake Load:

Response Reduction Factor: Depends on the perceived seismic damage of structure, it is characterised by ductile or brittle deformation; was taken from table-7 (clause 6.4.2) IS1893 Part-1:2002.

Importance Factor:

Depends on the functional use of building characterized by hazardous consequences of its failure, it is taken from table-6(clause 6.4.2) of IS1893Part-1:2002.

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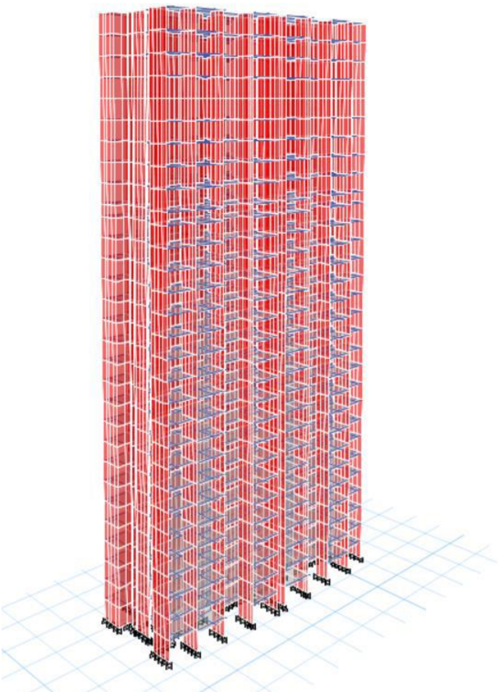

Fig.5: 3-D view of G+30 building from ETABS

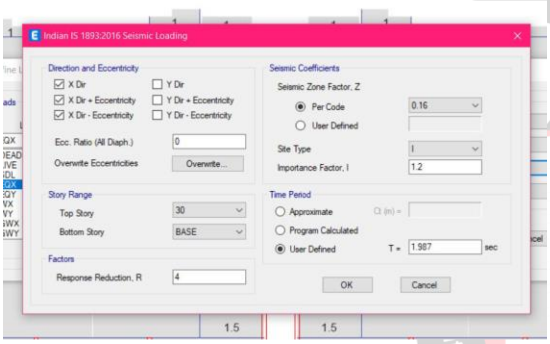

Fig.6: Static Earthquake Definition

Functions

Functions are defined for dynamic earthquake analysis.

1. Func1: It is defined for lateral earthquake in X and Y direction.
2. Func2: It is defined For Vertical earthquake in Z Direction. Please provide the basis of applying the Value of 0.4 in Func2.

As per IS 1893, For Zone 3, I = 1.2 and R=4

Av = 2/3*(0.16/2) *2.5/ (4/1.2)

Av = 0.04

V. RESULT

As we analysis run model and observation model result, moment diagram, shear force, shear demand capacity at junction where high load occurs, for all load combination. All observation on model result mention below –

1. Mostly periphery beam design fails due to high shear force, exceeding shear stress permissible limit.
2. For Case-1 at 5th floor, M70 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 590KN. Sher stress is within limit.
3. For Case-1 at 12th floor, M50 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 510KN

   Shear stress exceeding.
4. For Case-1 at 23rd floor, M30 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 450KN. Shear stress exceeding permissible limit.
5. For Case-2 at 5th floor, M70 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 590KN. Sher stress is within limit.
6. For Case-2 at 12th floor, M50 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 510KN

   Shear stress exceeding.
7. For Case-2 at 23rd floor, M40 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 400KN. Shear stress exceeding permissible limit.
8. There is B2 beam with dimension 300x1200 at 5th floor. For Case-1 at 5th floor, M70 concrete grade shear force for B1 beam for (1.5DL+1.5EQX) is 1978KN. Shear stress exceeding permissible limit Where beam shear stress exceeding permissible limit, we have introduced PRC beam (plate reinforcement concrete beam), here we have insert late with stud as per design to resist shear force.
9. Refer calculation for PRC beam B2 below-

PRC Beam Calculation

Beam fails due to high shear force induce in beam-column junction support. PRC plate reinforced concrete beam introduced.

Data –
Beam Size
Grade of Concrete = M70
Steel Grade = Fe 550
Shear Force = 1978Kn

Shear plate calculation

Material Properties

Fy = 250 N/mm2

Fck = M70

Permissible stress

Shear stress	0.57*Fy = 142.5 N/mm2
Bearing stress steel	0.75*Fy = 187.5 N/mm2

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Bearing stress concrete 0.6*Fck = 42 N/mm2

Design Factored shear Force	Vu	=	1978 KN
Required areas of plate	Areq	=	13880.7 mm2
Depth of plate	D	=	450 mm
Thk of plate req.	T req	=	30.85 mm
Provided plate THK	Tp	=	32 mm
Check for bearing stresses			
Embedment depth of plate req.		=	220 mm
Embedment depth of plate req (concrete bearing)	Abp, req.	=	47095.25 mm2
	Bbp	=	210 mm
	Lbp, req.	=	224 mm
	Lbp, provided.	=	225 mm

Provided 2 Nos 16x450mm Plate

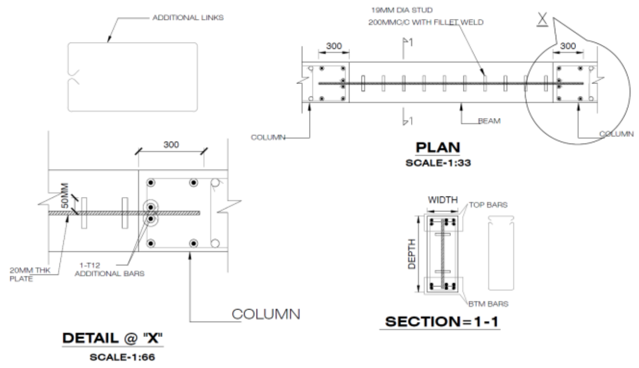

Fig.7: Plan detail for PRC beam and stud detail

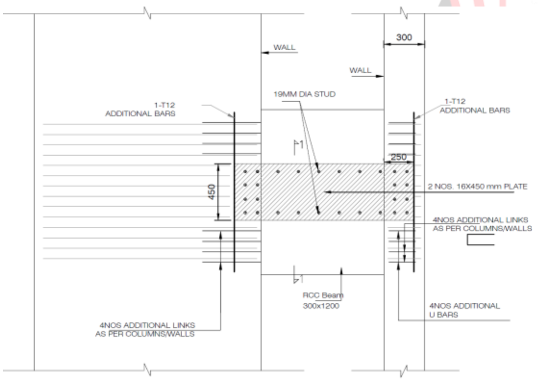

Fig.8: PRC beam detail Elevation

VI. Conclusion

1. Introducing the PRC (plate reinforced composite (PRC) coupling beams) with all design parameters, in case high shear stress and exceeding permissible concrete shear stress limit (Tc max).
2. Due to higher shear force with lower concrete grade shear stress exceeding, hence we have to provide diagonal rebar or PRC steel plate in beam to resist shear forces.
3. For higher shear force in building, we need to provide higher concrete grade of material.
4. As we observed as by going above storey shear force decrease due to earthquake forces at above stories.
5. We analysis with different concrete grade of material, for higher grade of concrete shear stress permissible limit increase and beam safe in shear stress, but as lower grade of concrete beam fails due to exceeding shear stress permissible limit. Shear stress.
6. Which beam shear stress exceeding permissible limit, we have introduced PRC beam (plate - reinforced concrete beam) to resist higher shear forces at support.
7. Introducing the PRC (plate reinforced composite (PRC) coupling beams) with all design parameters, in case high shear stress and exceeding permissible concrete shear stress limit (Tc max).
8. Due to higher shear force with lower concrete grade shear stress exceeding, hence we have to provide diagonal rebar or PRC steel plate in beam to resist shear forces.
9. For higher shear force in building, we need to provide higher concrete grade of material.

VII. FUTURE SCOPE

The following are future scope of point for research:

1. Due to composite structure, there is increase in the shear strength of the concrete in the joint core. A model can be formulated to calculate the increase in shear strength of the joint core.
2. The above result clearly shows that increase in the storey of the building there is increase in shear demand at beam column slab connection which may leads to the increase in the joint confinement reinforcement. Further a formulation can be generated to calculate that how much reinforcement increased due to increase in height and how to decrease it cost effectively.
3. Due to higher shear force diagonal reinforcement also help to resist shear stress

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