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DETAILED STUDY OF THE DIFFERENT RCC JOINTS

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Abstract: RCC joint is the crucial zone in a reinforced concrete moment resisting frame. It is subjected to large forces during severe ground shaking and its behaviour has a significant influence on the response of the structure. The assumption of rigid joint fails to consider the effects of high shear forces developed within the joint. The shear failure is always brittle in nature which is not an acceptable structural performance especially in seismic conditions. This paper presents a review of the postulated theories associated with the behaviour of joints. Understanding the joint behaviour is essential in exercising proper judgments in the design of joints. The paper discuss about basics of RCC joints with its advantages and disadvantages collected from different sources. Also bar detailing with its purpose for each joints are discussed below.

Keywords: Reinforcement detailing, Slab column joints, Beam to beam joints, RCC walls and slab joints, cross beam connection.

I. INTRODUCTION

In reinforced concrete structures, failure in a beam often occurs at the beam column joint making the joint one of the most critical sections of the sudden change in geometry and complexity of stress distribution at joint are the reasons for their critical behaviour. In early days, the design of joints in reinforced concrete structures was generally limited to satisfying anchorage requirements. In succeeding years, the behaviour of joints was found to be dependent on a number of factors related with their geometry; amount and detailing of reinforcement, concrete strength and loading pattern. A heavy damage in RCC joint should be voided during an earthquake because

(a) The gravity load is sustained by the joint,

(b) A large ductility and energy dissipation is hard to achieve in the joint,

(c) A joint is difficult to repair after an earthquake

However, in order to ensure good workmanship and construction, an excessive amount of reinforcement detailing should be avoided. As a result, up to a predicted structural deformation, joint shear failure and considerable beam bar slippage within a joint should be avoided.

RCC joints allow for some horizontal movement while remaining resistant to rotational and vertical movement. Slab-column junctions, beam-to-beam joints, RCC wall-slab joints, and cross beam connections are examples of RCC joints.

If the distance between any discontinuous edge and the nearest support face is less than four times the slab thickness, the slab column junction is an exterior connection, as shown in fig 1.1. Edge and corner connections are the two sorts of connections that can be made. The slab's dead load, live load, floor finish load, and snow load in the case of a roof slab are all examples of loads acting on a slab. Loading on the column from earthquakes and different sorts of loads Self-weight of column per running metre, Self-weight of beams per running metre, Load of walls per running metre, Total Load of Slab (Dead load + Live load + Self weight)

Because the beam column beam column region always causes issues during the erection stage, beam to beam joints (fig. 1.2) are supplied. At both ends, a beam to beam connection is created using a connecting rod with a high quality pull rod and attached to a connecting rod with a high quality pull rod. The large vertical and horizontal styles can be transferred using this type of connection. This type of connection is easier to install than a beam to column connection, and it reduces mid-span deflection.

The wall slab connection (fig. 1.3), which consists of a floor slab directly supported by load bearing walls, is a very sensitive section in a high-rise building. It is particularly successful at minimising earthquake damage to structural and non-structural materials, as well as reducing a building's lateral sway.

Cross beam connections, as seen in fig. 1.4, are supplied between secondary beams of a building and are designed to support slabs or ceilings. Cross beams are used to break the slab's span and support the RCC slab when the maximum span is limited by the deflection limit.

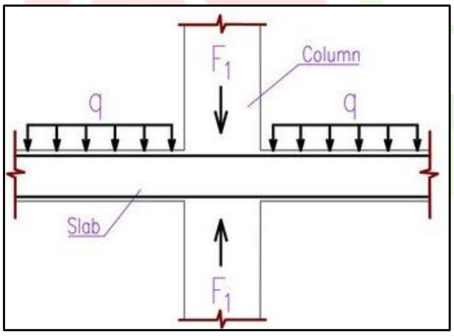

Fig 1.1: slab column joint

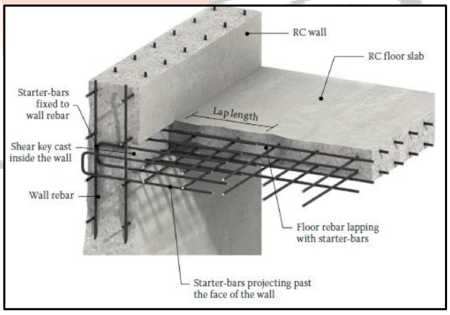

Fig 1.3: RCC wall-slab joint

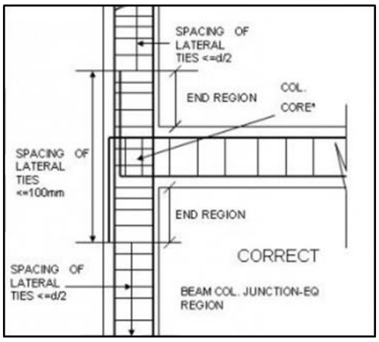

Fig 1.2: Beam to beam joint

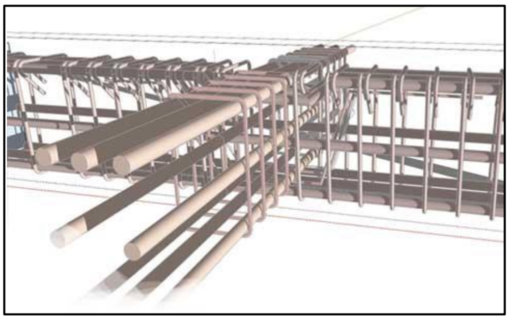
Fig 1.4: Cross beam connection

Reinforcement detailing is crucial in construction to prevent buildings from collapsing due to faulty connections or detailing. Apart from concrete, reinforcement bars are the most significant component of RCC structures. Before the concrete is laid, reinforcement bars must be constructed and installed. Reinforcement costs around a third of the structure's total cost. Fabrication and placement of reinforcement bars must follow the design. Bars that have been poorly cut or twisted are rendered worthless.

As a result, reinforcing should be detailed, and bar bending schedules should be meticulously established. Following the creation of bar bending schedules (BBS), the actual plan for cutting the bars should be established with great care in order to reduce waste.

II. LITERATURE REVIEW

Kristiyanto Hery, Triwiyono Andreas, Muslikh, and Saputra Ashar- MATEC Web of Conferences 258, 0 (2019). The study of providing joint in the beam-column connection zone always causes issues during the erection stage, according to this work. Seismic actions may be vulnerable to the beam-column connection, which is subjected to reserve bending moment and shear force. Alternative connection techniques such as beam-to-beam connections are significantly easier to install than beam-column connections. At both ends, a beam-to-beam connection is created with a connecting rod or a high-quality pull rod and attached to a connecting rod or a high-quality pull rod. Large vertical and horizontal styles can be sent using this link. Moments of a specific quantity may transfer if the connecting rod is put on the top and bottom of the beam. When welding and cast concrete are of good quality, connections can convey a significant amount of vertical force, horizontal force, and moment. The edges of the beams should be either rough or grooved to maximise the vertical shear distribution.

Prakash Panjwania, Dr. S.K. DUBEYb(2005) presented Structural joints should be able to withstand forces that are greater than the connected members. While beams and columns are meticulously built and detailed, the same cannot be said for the joints of RC rigid frames. If the joints are incapable of bearing the forces and deformations caused by the transfer of forces among the parts meeting at the joint, the structural behaviour will differ from that expected in the analysis and design. Opening joints, in particular, must be carefully evaluated because it will result in diagonal cracking of the joint. Due to lateral loads, such joint opening happens in multi-story constructions. The discussions presented pertain to seismic forces, but are of general nature and can be applied to structures subjected to lateral forces. The topics covered are related to seismic forces, although they are universal in nature and can be applied to buildings that are subjected to lateral forces as well.

Mahmood Memon, A.Aziz Aurari and M. Rafique Memon developed that shear reinforcement at the critical section around the wall periphery at the distance of 0.5d from the sides of walls. Where d is effective depth of slab. The reinforcement used was 0.74% of critical area around the wall periphery.

III. OBJECTIVE

The primary goal of this study is to present all of the necessary background information on RCC joints and their many forms. The RCC joint's aim is to allow for some horizontal mobility while remaining inflexible to rotational and vertical movement. It also prevents the concrete structure from failing prematurely. In a concrete structure, joints are required because they allow one concrete element to move independently of other sections of the structure.

IV. METHODOLOGY

RCC JOINTS AND ITS TYPES:

Joints in construction are the division or discontinuity formed in concrete or steel constructions to ignore the effect of contraction, expansion, movement, and settlement in the structure as the external environment changes. The types of RCC joints are discussed below:

1. Foundation to Column Joint

The foundation to column joint is a joint or link between the foundation and the column. Because all of the load will be passed to it, it is considered the most crucial joint.

Advantages

i. It disperses the structure's weight across a vast region to prevent the underlying soil from becoming overburdened (possibly causing unequal settlement).

ii. To deeply embed the structure in the ground, strengthening its stability and reducing overloading.

iii. It ensures the structure's stability.

iv. It prevents the supported structure from moving to the side (in some cases).

Disadvantages

i. Skilled labours are required.

ii. It is a complex work so a proper supervision is required.

iii. It is time consuming.

iv. It is slightly more expensive than other joints.

2. Beam to column joint

It is the zone where beams and columns connect to allow neighbouring members to grow and maintain their maximum capacity.

Types of joints:

Interior Joint: When four beam frame into the vertical faces of a column it is known as interior joint.

Exterior Joint: When one beam is framed into the column's vertical face and two other beams are framed in a perpendicular direction, the joint is formed.

Advantages

i. Saving in cost, material, time and man-power.
ii. Shuttering and scaffolding is not necessary.
iii. Installation of building services and finishes can be done immediately.
iv. Clean and dry work at site.
v. Independent to weathering conditions.

Disadvantages

i. Need of erection equipment is required.
ii. Skilled labour and supervision is required.
iii. They are exactly to be placed in position otherwise the loads coming on them are likely to change

3. Beam to Slab Joint

It is a joint or intersection between beam and slab it is known as beam to slab joint.

Advantages

i. Reinforcement placement is easier.
ii. Ease of formwork installation.
iii. It is economical as it saves the cost of materials, formwork and labour
iv. It is more applicable to commercial buildings

Disadvantages

i. It creates a spanning problem as a span for structural support is at right angle to each other.
ii. It is not possible for brittle partitions.
iii. It cannot take higher lateral loads

4. Slab-column joints:

If the distance between any discontinuous edge and the nearest support face is less than four times the slab thickness, the slab-column connection is an exterior connection. Edge connection (intermediate) and corner connection are the two types of connections that can be made.

An edge connection (fig 1.5) is an exterior connection for which a discontinuous edge located adjacent to one support face only.

A corner connection (fig 1.6) is an exterior connection for which discontinuous edges are located adjacent to two adjoining support faces.

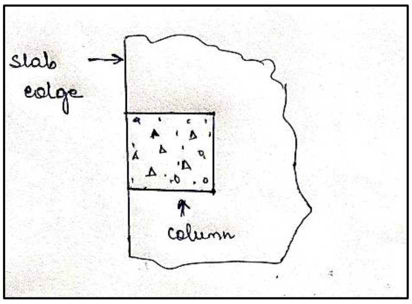

Fig 1.5: edge connection

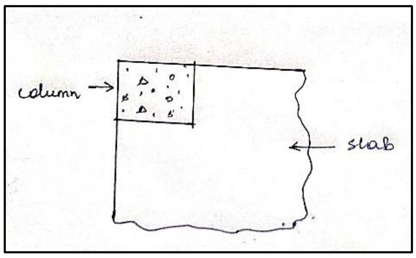

Fig 1.6: corner connection

Advantages:

i. Room layout is adaptable.
ii. It's less difficult to place reinforcements.
iii. Installation of the framework is simple.
iv. Using an automatic sprinkler is more convenient.

Disadvantages:

i. Not designed to support fragile partitions.
ii. The span is average in length.
iii. The use of drop panels may cause mechanical ducting to become obstructed.
iv. Deflection in the centre strip that is critical
v. Increased slab thickness

5. **Beam to Beam joints**:

It's included since the beam-column connection location is notorious for causing problems during the erection process. Both ends of a beam to beam junction with connecting rod on high-quality pull rod are produced and attached to a connecting rod or a high-quality pull rod. Large vertical and horizontal styles can be sent using this link. Moments of a specific quantity may transfer if the connecting rod is put on the top and bottom of the beam.

Advantages:

i. A beam-to-beam connection is easier to install than a beam-column connection.
ii. This type of connection transfers force between precast components and determines the overall structure's strength, stiffness, and ductility.
iii. They are vibration-resistant, making them perfect for load-reversal design in earthquake-prone areas.
iv. It reduces mid-span deflection.
v. They provide many load pathways.

Disadvantages:

i. They strengthen the column's internal forces.
ii. They amplify the lateral forces acting on the supporting beams.
iii. They add complexity to the design and necessitate the employment of specialist professionals to assure appropriate implementation.

6. **Shear wall and slab joints:**

The wall slab connection, which consists of floor slabs directly supported by weight bearing walls, is a very sensitive section in high-rise buildings. Its goal is to withstand lateral earthquake and wind stresses, as well as gravity and vertical loads from its own weight and other living or moving loads.

Advantages:

i. A building's lateral wobble should be reduced.
ii. Simple to construct and implement on the job site
iii. Effective in reducing earthquake damage to both structural and non-structural elements.
iv. Construction is completed quickly.

Disadvantages:

At 40% of the maximal load, the cracking appeared. As the load grew, the cracking progressed. When the load reached 70% of the ultimate load, several cracks occurred (fig 1.7). When the load reached 80 percent of the ultimate load, the fissures were extended and enlarged. Clearly, the shear failure was caused by the wall being punched through the slab.

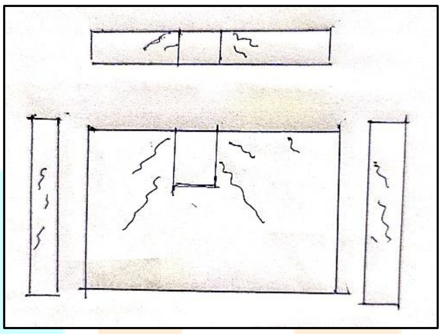

Fig1.7: crack pattern of the slab

7. **Cross beam Joint:**

A cross beam is a structural member that supports a floor or ceiling in the construction of a building. When used over a basement, it sits on a concrete ledge, and when utilised in the framing stage of construction, it sits on ceiling joists. A cross beam can hold a large amount of weight over a long distance.

The loads that must be considered while developing a cross beam for analysis and design purposes are as follows:

i. Dead load
ii. Seismic loads
iii. Vibrational loads

Cross beams are utilised to break the slab's span and provide support for the RCC slab when its maximum span is within deflection restrictions.

Because slabs are built in a monotonous manner with primary and cross beams, all loads are changed uniformly according to the slab's distribution area, rather than ideally as a point load, this assumption of point load transfer is employed in the design stage to adapt a simple technique. Cross beams are supplied to decrease the amount of spam that is effective.

BAR DETAILING OF RCC JOINTS

The basic requirements of a reinforcement bar is depend on the reasons for its inclusion in the structure:

i. To carry internal tensile tensions, resulting in ductility and strength.
ii. To keep flexural cracking at bay.
iii. To keep restrained structures from cracking due to direct tension.
iv. Its purpose is to carry compressive pressures.
v. To keep bars in compression restrained.
vi. To keep the concrete in compression contained.
vii. To keep the concrete in compression contained.
viii. To keep long-term deformation to a minimum.
ix. To provide anti-spalling protection.
x. During construction, to give temporary support for other reinforcement.

1. Foundation and Column Joint

Reinforcement detailing:

a. Column longitudinal bar

In conjunction with the concrete, longitudinal bars in columns help to support the load. These bars are evenly distributed around the circumference of the columns, as close to the surface as is possible. Transverse reinforcement, often called lateral binders, holds the longitudinal bars in place.

b. Dowel bar

To transport the load column to the footing, they are installed in reinforced concrete footings.

c. Standard hook

It is the minimum length of steel that must be kept inside concrete such that the bond strength does not fall below that of the concrete.

d. Lateral ties

i. to strengthen the connection and prevent buckling
ii. to connect longitudinal reinforcement and ensure proper concrete distribution

The right spacing of lateral ties confines concrete (like holding the concrete encased between the lateral ties), preventing bits of failing concrete from slipping away.

2. **Column and beam joint**

Reinforcement detailing:

a. **Longitudinal Rebars**

It has a high self-centering ability, which helps to reduce residual deformation and protect the column from seismic damage.

b. **Top bars**

i. Extra top bars are supplied at the support to strengthen the tensile strength of the beam (and hence control the negative moment).

ii. To withstand diagonal tension stress and to prevent inclined fissures caused by maximum shear forces that concrete cannot withstand.

c. **Bottom bars**

To give the same steel throughout the bottom face, as well as more steel for increased hogging moments at the faces. It saves money while also meeting design criteria.

d. **Stirrups**

They aid in the retention of reinforcing bars, the prevention of buckling in columns and beams, and the resistance to lateral loads.

3. **Beam and Slab joint**

Reinforcement detailing: The cover to reinforcement, length of reinforcement, curtailment of reinforcement, and number and diameter of reinforcement to be provided are all specified in the beam reinforcement details.

a. **Main bar**

The main bar is installed in the shorter span direction to transfer the bending moment generated at the slab's bottom. The main bar's role is to transfer the bending stress created at the slab's bottom to the beams.

b. **Distribution bar**

On top of the main bar, distribution bars are put. They're utilized to keep the slabs in place in both directions while also preventing cracks and shear stress from forming at the top.

4. **Column and slab joint**

Detailing of bars/reinforcement: The slab contains bent up bars or crank bars, which are necessary for preparing a bar bending programme.

a. **Bent up bars**

i. To lessen the danger of brittle slab-to-column connection failure.

ii. To withstand a bending moment that is negative (hogging).

iii. To withstand increased shear forces at supports.

iv. To cut down on the amount of steel that is used.

v. In order to save money on materials.

b. Bottom reinforcement

Main bars is another name for it. The main bar's role is to transport the bending load created at the slab's bottom to the beam and to withstand the positive mid-span bending moment.

Top reinforcement

Distribution bars placed on top of the main bar. The bending moment created at the slab's bottom is transferred using Main Reinforcement Bars. Distribution Bars are utilised to keep the slabs in place in both directions while also resisting cracks and shear stress that occur at the top.

c. Hook Bars/U-shaped hook bars

The main purpose of Hook bars is provided to develop anchorage.

There may be times when the requisite length is not available to meet the development length requirements, in which case anchorages in the shape of hooks are given.

d. Lateral reinforcement in column

It prevents the formation of longitudinal reinforcing bars. It resists shear forces and hence helps to prevent shear failure.

e. Offset bent longitudinal bars

It is the bending of vertical reinforcing bars of a column at a certain level in order to bring the bars inside the limit of an above limit for horizontal support (smaller column).

f. Ties

The major aim is to keep the longitudinal bars in place in the forms while the concrete is being poured. By shattering the thin concrete cover, it prevents the highly stressed slender longitudinal bars from buckling outward.

5. Beam to beam joint

Reinforcement detailing:

Beam to beam connection (fig 1.9) is basically between secondary beam and primary beam.

Secondary beams: to provide rigidity around slab apertures, reduce the span of a wide slab, and maintain slab depth.

Primary beam: it supports the secondary beams and transfer the loads to the column.

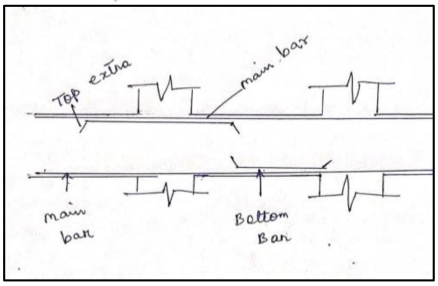

Fig1.8: Bar detail of beam

a. Longitudinal Reinforcement

The major goal is to absorb bending tensile stress in the longitudinal direction of the structural component's main support direction.

b. Shear reinforcement (vertical stirrups or bent up longitudinal bars)

The goal is to prevent shear failure and promote beam ductility.

Because beams are predominantly flexural components, top and bottom reinforcement offer moment resistance.

c. Stirrup

The purpose of providing stirrups in a beam is to keep the major reinforcing rebars in the construction together. It is installed at the proper internals of beams and columns to prevent buckling and to protect the RCC structure.

Fig1.9: beam-beam joints

Why rebars are bend at the end of beam?

The purpose of bending the top bars down and the bottom bars up is to produce a box that will act as an additional ductile component to hold the end part of the beam in place even if it is cracked.

Concrete can break into little bits in a big earthquake or in the event of a catastrophic failure, losing its rigidity. Rebars bent in this manner will hold the fractured joint together, preventing the building from collapsing and giving valuable time for evacuation.

6. Shear wall and slab joint

Reinforcement detailing:

Under stress and moments, the U-shaped bar prevents the concrete from slipping. The rigidity of the U-shaped bar prevents the concrete from slipping away from the reinforcement, as can happen when using simple cranked bars.

Horizontal shear reinforcement is used in RCC walls to prevent diagonal tension failure.

In order to resist inplane lateral force, such as wind and seismic loads, vertical shear reinforcement is used.

7. Cross beam Connection

Reinforcement detailing:

The principal beams and the building's walls are joined by cross beams. Longitudinal reinforcement, shear reinforcement, reinforcement cover, stirrups, standard hooks and bends, Reinforcement Curtailment, and development length are all included.

a. Longitudinal reinforcement

The major goal is to absorb bending tensile stress in the longitudinal direction of the structural component's main support direction.

b. Shear reinforcement

The main purpose of shear reinforcement is to prevent failure in shear and to increase beam ductility.

c. Reinforcement cover

The rebars are provided with covers to protect them from corrosion and fire. Protection against the aforementioned will be insufficient if less coverage is supplied. And if more concrete is provided than is required, any structural member's concrete on the tension side will crack under tension.

d. Stirrups

They help to keep reinforcing bars in place, prevent buckling in columns and beams, and provide resistance to lateral loads.

e. Standards hooks and bends

Steel bar anchorage is supplied in the form of bends and hooks when straight length is insufficient to develop bars and resist seismic movement. To keep concrete from cracking inward. It keeps steel from slipping off the concrete.

f. Curtailment reinforcement

Curtail bar in beam is a method of lowering the area of tensile reinforcement at points/areas (on a beam/slab) when the bending moment is minimal or non-existent in order to achieve a cost-effective design.

g. Development length

The development length is required to provide support for the beam and limit the likelihood of it breaking free from the concrete column.

V. RESULTS AND DISCUSSION

In this research, we look at how different RCC joints contribute to the strength of any construction. It covers the fundamentals of joints, including their function, benefits, and drawbacks. We've gathered information regarding RCC joints from a variety of credible sources. The major goal of this paper is to compile all of the essential information about RCC joints into one text so that any reader can understand it.

VI. CONCLUSION

The majority of India is in a seismic zone. To avoid any type of structure collapse, it is first necessary to understand each joint in depth prior to any construction. According to the material, RCC joints must be carefully considered during construction because the building's strength is dependent on its joints. Structural strengthening has proven to be a highly successful method of restoring structural integrity and strength. Whatever type of strengthening is required, it is critical to determine the most appropriate strengthening approach, as well as its applicability and suitability for the current structure. This study contributes to the unavoidable requirement for engineers to understand the fundamental theory of joint behaviour.

Reference

[1]. Prakash Panjwania, Dr. S.K. Dubey (2015) “Study of Reinforced Concrete Beam-Column Joint”, International Journal of Engineering Research Volume No.4, Issue No.6, pp :321-324, 1 June 2015

[2]. Detailing of Reinforcement Concrete Structures Structures by R.I. Gilbert Gilbert, 28 August, 2012

[3]. Ahmed M. Hameed, Husain M. Husain, Mohannad H. Al-Sherrawi(2019) “Analysis of Corner Column-Slab Connections in Concrete”, East African Scholars Journal of Engineering and Computer Sciences, Volume-2, Issue-1, January-2019

[4]. P. R. Walker and P. E. Regan “corner column-slab connections in concrete flat plates” from ascelibrary.org by Universidad De Sevilla on 05/13/15.

[5]. Riawan Gunadi, Iswandi Imran (2014) “The Behavior of Slab-Column Connections with Modified Shear Reinforcement under Cyclic Load”. Journal of Engineering and Technological Sciences · April 2014, 10.5614/j.eng.technol.sci.2014.46.1.2

[6]. K. Padmanabham, Dr. K. Rambabu (2018), “Design and construction aspects of reinforced concrete Beam and column joint under seismic conditions”. International Research Journal of Engineering and Technology (IRJET), volume: 05, Issue: 08 Aug 2018

[7]. Zhuangnan Zhang, Yan Zhang (2018), “Research Status on Reinforcement Connection Form of Precast Concrete Shear Wall Structure”. Journal of IOP Conf. Series: Materials Science and Engineering 322 (2018) 042001

[8]. Greeshma, S. and Jaya, K.P. (2008) “Seismic Behaviour of Shear Wall-Slab Connection”. Journal of Research, 14th World Conference on Earthquake Engineering, Beijing, 12-17 October 2008, Article ID: 14-0059.