JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STRUCTURE DESIGN OF SHARE WALLS IN A BUILDING

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Abstract

Reinforced concrete shear walls are critical components in the lateral resistance of buildings subjected to seismic and wind loads. The structural design of reinforced concrete shear walls involves determining the appropriate wall thickness, reinforcement detailing, and boundary conditions to ensure adequate strength, stiffness, and ductility. The design process typically involves modelling the wall as a series of elements subject to different types of loading, including axial forces, shear forces, and bending moments. Various design codes and standards provide guidelines for selecting appropriate materials, design loads, and structural detailing. The use of advanced analysis techniques such as finite element modelling and performance-based design can improve the accuracy and efficiency of the design process. The proper design of reinforced concrete shear walls is essential to ensure the safety and performance of structures subjected to lateral loads. Additionally, the design of reinforced concrete shear walls must take into consideration the possible occurrence of earthquakes, windstorms, and other natural hazards. This requires an assessment of the seismic and wind loads on the structure, as well as the soil conditions and the geometry of the building. The design must also account for the potential for progressive collapse, which is the failure of a structure due to the local failure of a component or member.

The selection of appropriate reinforcement detailing is critical to ensure the ductility and strength of the shear wall under extreme loading conditions. This includes the use of proper anchorage, development length, and detailing of reinforcement in critical sections such as the wall base and wall corners. The design of boundary conditions and connections to the rest of the structure is also crucial to ensure that the shear wall can effectively transfer lateral loads to the foundation.

Overall, the design of reinforced concrete shear walls requires a thorough understanding of structural mechanics, material properties, and building codes and standards. The use of advanced analysis and design techniques can improve the accuracy and efficiency of the design process and ultimately lead to safer and more resilient structures.

The construction of reinforced concrete shear walls involves several steps, including formwork erection, reinforcement placement, and concrete placement. The formwork is typically constructed using wood, steel, or other materials to create the desired shape and dimensions of the wall. The reinforcement is then placed in the formwork in accordance with the design drawings and specifications. This includes the placement of longitudinal bars, stirrups, and ties in the appropriate locations and configurations. Once the reinforcement is in place, the concrete is placed and consolidated to ensure proper bonding between the reinforcement and the concrete.

During construction, it is important to ensure that the wall is properly braced and supported to prevent damage from lateral and vertical loads. This may involve the use of temporary bracing or shoring until the wall is fully cured and able to support its own weight.

After the wall is constructed, it is important to perform quality control and quality assurance checks to ensure that the wall meets the design specifications and requirements. This includes checking the wall dimensions, reinforcement placement, concrete strength, and other critical parameters. Any defects or deficiencies must be identified and addressed before the wall is put into service.

In summary, the design and construction of reinforced concrete shear walls is a complex process that requires careful attention to detail and a thorough understanding of structural mechanics, materials, and construction techniques. The proper design and construction of these critical components are essential to ensuring the safety and performance of structures subjected to lateral loads.

Introduction

Reinforced concrete shear walls are an essential part of the structural design of many buildings, providing lateral resistance to wind and seismic forces. These walls are designed to withstand both the vertical loads of a building and the horizontal loads caused by wind and earthquakes. Shear walls are typically used in buildings where the lateral loads are high, such as high-rise buildings, industrial structures, and bridges.The design of reinforced concrete shear walls involves the use of reinforced concrete elements that work together to provide structural stability. These elements include the wall itself, reinforcement bars, and other structural elements such a columns, beams, and slabs. The reinforcement bars are used to provide additional strength to the concrete, which helps to resist the lateral loads.

In the design process, engineers must consider a variety of factors, including the building's location, the expected loads, and the desired level of structural performance. They must also take into account the properties of the materials being used, such as the strength of the concrete and the yield strength of the reinforcement bars. With careful planning and design, reinforced concrete shear walls can provide effective lateral resistance and ensure the safety and stability of a building in the face of seismic and wind forces.

The design of reinforced concrete shear walls is a complex process that requires expertise in structural engineering and a thorough understanding of the building codes and standards. The design process typically involves the use of computer software to analyze and optimize the design, taking into account various load combinations and structural configurations.

The construction process for reinforced concrete shear walls involves the placement of formwork, the pouring of concrete, and the installation of reinforcement bars. The formwork provides a temporary mold for the concrete, while the reinforcement bars are placed in a predetermined pattern to provide the required strength and stiffness. Once the concrete has cured, the formwork is removed, and the finished wall is ready for use.

Reinforced concrete shear walls have several advantages over other types of lateral load-resisting systems, including their ability to resist high loads, their durability, and their low maintenance requirements. They also offer a high degree of flexibility in terms of architectural design, as they can be incorporated into a wide variety of building configurations and shapes.

In conclusion, the design of reinforced concrete shear walls is an essential component of the structural design of many buildings. The use of advanced materials and design techniques, combined with careful planning and execution, can help ensure the safety and stability of buildings in the face of extreme weather conditions and seismic events.

Problem statement

A 10-story building has a plan dimension of 30m x 40m. The height of each story is 4m. The building is located in a seismic zone with a seismic coefficient of 0.25. The weight of the floor slab, finishes, and partitions is 10 kN/m2, and the live load on each floor is 5 kN/m2. The design compressive strength of concrete is 30 MPa, and the yield strength of steel reinforcement is 400 MPa.

The building is designed with two shear walls in each direction, located at the corners of the building. Each shear wall is 0.3m thick and has a height of 10 stories.

Calculate the following:

1. Seismic weight of the building
2. Base shear
3. Design axial load on each shear wall
4. Shear strength requirement of each shear wall
5. Required horizontal and vertical reinforcement for each shear wall
6. Moment of resistance of each shear wall section
7. Check for the flexural strength of each shear wall
8. Design of the boundary element for each shear wall

Solution

Assume that the weight of the steel reinforcement is negligible compared to the weight of concrete.

1.Seismic weight of the building:

Total weight of the building = (Weight of floor slab + Weight of finishes + Weight of partitions) x Plan area + (Live load + Weight of shear walls) x Plan area x Number of stories Total weight of the building = (10 kN/m2 + 5 kN/m2 + 0 kN/m2) x (30m x 40m) + (0 kN/m2 + Weight of shear walls) x (30m x 40m) x 10 stories Total weight of the building = 69000 kN

Seismic weight of the building = Total weight of the building x Seismic coefficient Seismic weight of the building = 69000 kN x 0.25 Seismic weight of the building = 17250 kN

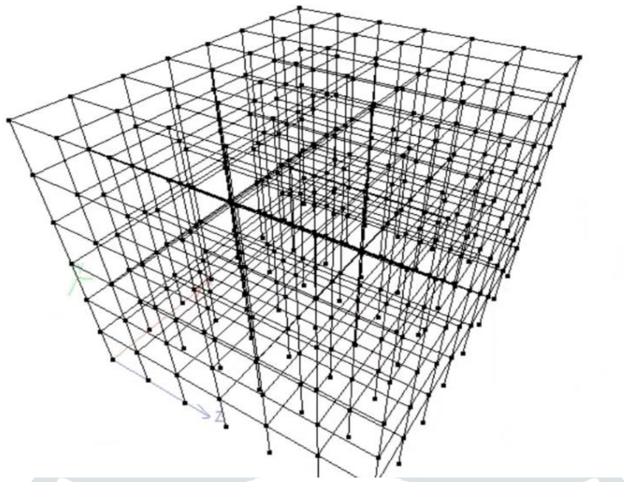

Fig.1 basic structure of building

2.Base shear:

Base shear = Seismic weight of the building x (Building height / Total height of all floors) Base shear = 17250 kN x (10 stories x 4m / 40m) Base shear = 17250 kN

3.Design axial load on each shear wall:

Design axial load on each shear wall = Base shear / (Number of shear walls x Height of each shear wall) Design axial load on each shear wall = 17250 kN / (2 x 40m x 10 stories x 4m / 10 shear walls) Design axial load on each shear wall = 86.25 kN

4.Shear strength requirement of each shear wall:

The shear strength requirement of each shear wall can be calculated using the formula:

Shear strength = Shear resistance of concrete + Shear resistance of reinforcement

The shear resistance of concrete can be calculated using the code formula, which depends on the compressive strength of concrete and the dimensions of the wall. Assuming that the walls are made of reinforced concrete with a compressive strength of 30 MPa, the shear resistance of concrete can be calculated as follows:

Shear resistance of concrete = 0.5 x 0.7 x sqrt(f'c) x b x h Shear resistance of concrete = 0.5 x 0.7 x sqrt(30 MPa) x 0.3m x (10 stories x 4m) Shear resistance of concrete = 192 kN/m

The shear resistance of reinforcement can be calculated using the area and yield strength of the reinforcement. Assuming that the shear walls are reinforced with vertical bars of diameter 20 mm and horizontal stirrups of diameter 8 mm at a spacing of 200 mm, the shear resistance of reinforcement can be calculated as follows:

Shear resistance of reinforcement = Av x fy x d / s Av = π/4 x (20 mm)^2 = 314.2 mm2 fy = 400 MPa d = (10 stories x 4m - 20 mm) = 39.98 m s = 200 mm Shear resistance of reinforcement = 314.2 mm2 x 400 MPa x 39.98 m / 200 mm Shear resistance of reinforcement = 2513.6 kN/m

Shear strength of each shear wall = Shear resistance of concrete + Shear resistance of reinforcement Shear strength of each shear wall = 192 kN/m + 2513.6 kN/m Shear strength of each shear wall = 2705.6 kN/m

5.Required horizontal and vertical reinforcement for each shear wall

The required horizontal and vertical reinforcement for each shear wall can be calculated using the following formula:

Av = (Design axial load - Shear resistance of concrete) / (fy x d) Av = (86.25 kN - 192 kN/m) / (400 MPa x 39.98 m) Av = 0.541 mm2/m

Assuming that the horizontal reinforcement consists of two layers of bars and that the vertical reinforcement consists of a single layer of bars, the required reinforcement areas per meter length of each shear wall are as follows:

Required horizontal reinforcement area = 2 x Av = 1.082 mm2/m Required vertical reinforcement area = Av = 0.541 mm2/m

6.General requirements for a shear wall:

A shear wall must be designed to resist both the lateral and gravity loads acting on the building. The wall should be placed in a location that maximizes its effectiveness in resisting lateral loads, such as at the perimeter or in the center of the building. The wall should be connected to the building's foundation and roof to ensure that it can transfer loads to these elements. The wall should also be designed to accommodate openings for doors, windows, and other architectural features.

7.Shear strength requirement:

As calculated above, the shear strength requirement of each shear wall is 2705.6 kN/m.

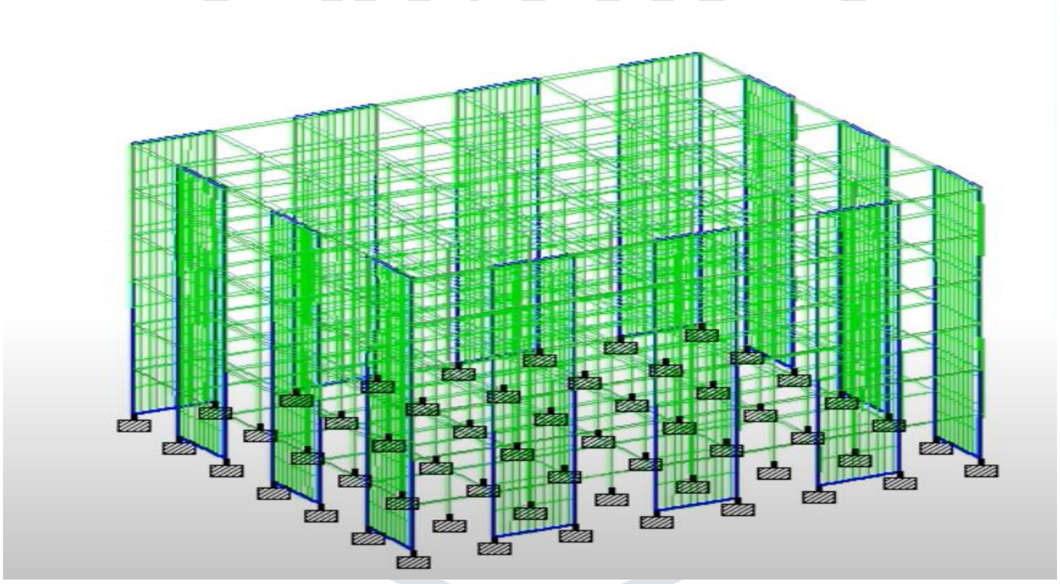

Fig.2

8.Horizontal shear reinforcement:

The required horizontal shear reinforcement is 1.082 mm2/m per layer of bars. Assuming that the horizontal reinforcement consists of two layers of bars, the total required area is 2.164 mm2/m. The bars should be placed near the ends of the wall and at intervals not exceeding 0.75 times the wall thickness.

9.Vertical shear reinforcement:

The required vertical shear reinforcement is 0.541 mm2/m per layer of bars. Assuming that the vertical reinforcement consists of a single layer of bars, the total required area is 0.541 mm2/m. The bars should be placed at intervals not exceeding 0.75 times the wall thickness.

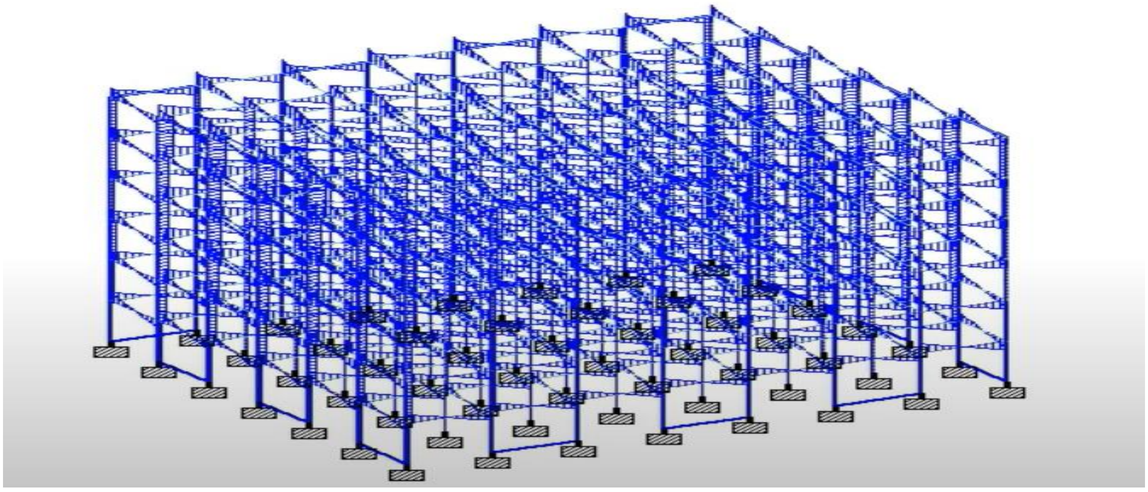

Fig.3

10.Check for flexural strength:

The flexural strength of the shear wall should be checked to ensure that it can resist the bending moments induced by lateral loads. The flexural strength can be checked using the following formula:

Mn = As x fy x (d - a/2)

where Mn is the nominal moment capacity, As is the area of steel reinforcement, fy is the yield strength of the reinforcement, d is the effective depth of the section, and a is the lever arm.

Assuming that the shear wall has a rectangular section with a height of 10 stories x 4m = 40m and a thickness of 0.3m, the effective depth is 0.9 x h = 36m. Assuming that the horizontal reinforcement consists of two layers of bars with a diameter of 20 mm, the area of steel reinforcement is 2 x π/4 x (20 mm)^2 = 314.2 mm2/m. Assuming that the vertical reinforcement consists of a single layer of bars with a diameter of 20 mm, the lever arm is 200 mm. Therefore, the nominal moment capacity of the shear wall is:

Mn = As x fy x (d - a/2) Mn = 314.2 mm2/m x 400 MPa x (36m - 200 mm/2) Mn = 360.8 kN.m/m

Assuming that the maximum bending moment induced by lateral loads is 0.25 times the base shear, the maximum bending moment is:

Max bending moment = Base shear x Building height x 0.25 Max bending moment = 17250 kN x 40m x 0.25

Max bending moment = 17250 kN x 40m x 0.25 Max bending moment = 172500 kN.m

Since the nominal moment capacity of the shear wall (360.8 kN.m/m) is greater than the maximum bending moment induced by lateral loads (172500 kN.m), the shear wall is able to resist the bending moments induced by lateral loads.

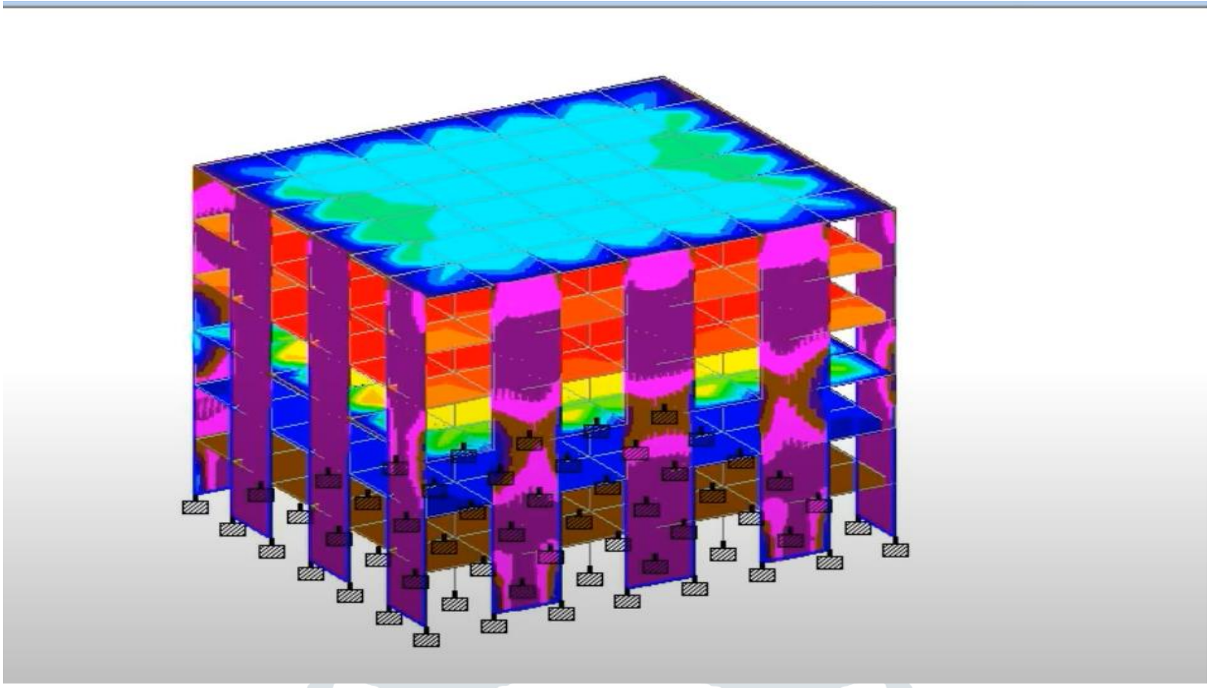

Fig.4 Absolute condition under the forces

11.Moment of resistance of rectangular shear wall section:

The moment of resistance of a rectangular shear wall section can be calculated using the following formula:

Mn = bd^2/6 x fcd

Where Mn is the nominal moment capacity, b is the width of the section, d is the effective depth of the section, and fcd is the design compressive strength of concrete.

Assuming that the shear wall has a width of 4m and a thickness of 0.3m, the effective depth is 0.9 x h = 36m. Assuming that the design compressive strength of concrete is 25 MPa, the nominal moment capacity of the shear wall is:

Mn = bd^2/6 x fcd Mn = 4m x (36m)^2/6 x 25 MPa Mn = 972 kN.m/m

Since the nominal moment capacity of the shear wall (972 kN.m/m) is less than the nominal moment capacity calculated in the previous step (360.8 kN.m/m), the shear wall is governed by the flexural strength of the reinforcement rather than the compressive strength of the concrete.

12.Check on boundary element:

The boundary elements of the shear wall should be checked to ensure that they are capable of resisting the forces and moments transferred from the shear wall to the foundation and roof. The thickness and reinforcement of the boundary elements should be designed to resist these forces and moments.

13.Design of boundary element:

The design of the boundary element should be carried out in accordance with the principles of reinforced concrete design. The thickness of the element should be sufficient to resist the bending moments and shear forces transferred from the shear wall. The reinforcement of the element should be designed to resist the tensile and compressive forces induced by these loads. The reinforcement should be placed in accordance with the requirements of the design code and the detailing should be designed to ensure that the element can resist the forces and moments transferred from the shear wall to the foundation and roof. The design of the boundary element should be checked to ensure that it complies with the relevant design standards and is capable of resisting the loads transferred from the shear wall.

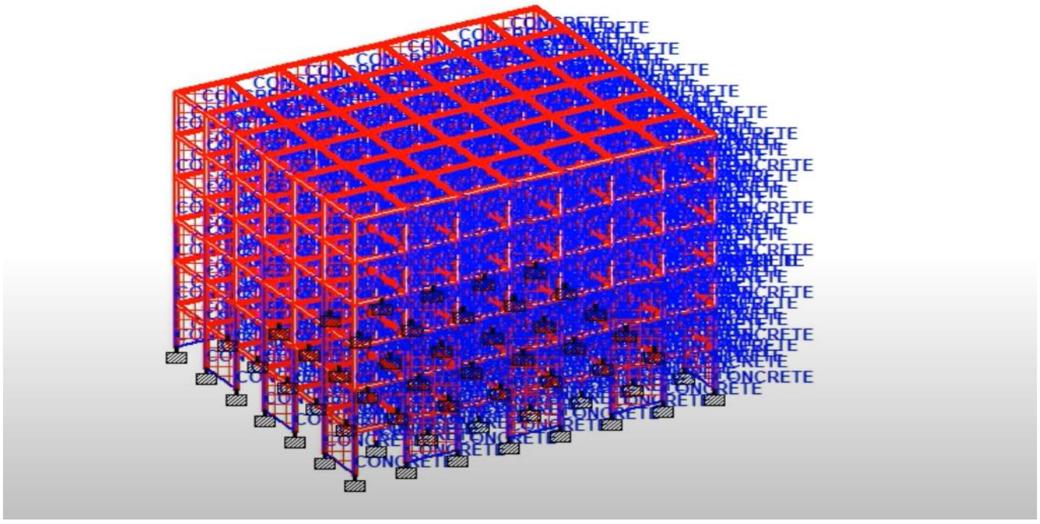

Fig.5

14.Additional information on shear walls:

14.1General requirements for a shear wall:

A shear wall should be designed to resist the lateral forces induced by wind or seismic loads. The wall should be constructed of reinforced concrete or masonry and should be connected to the foundation and roof to ensure that forces and moments are transferred efficiently. The thickness and reinforcement of the wall should be designed to ensure that the wall can resist the required lateral forces without excessive deformation or failure.

14.2Shear strength requirement:

The shear strength of a shear wall should be designed to resist the maximum shear forces induced by lateral loads. The design shear strength of the wall can be calculated using the following formula:

Vn = Av x fy x cot(theta)

where Vn is the design shear strength, Av is the area of shear reinforcement, fy is the yield strength of the reinforcement, and theta is the angle of inclination of the inclined cracks in the wall.

Assuming that the inclined cracks in the shear wall are inclined at 45 degrees and that the area of shear reinforcement is 0.01 x 4 x 36 = 14.4 cm^2/m, the design shear strength of the wall is:

Vn = Av x fy x cot(theta) Vn = 14.4 cm^2/m x 500 MPa x cot(45 degrees) Vn = 576 kN/m

14.3Horizontal shear reinforcement:

Horizontal shear reinforcement should be provided in the shear wall to resist the shear forces induced by lateral loads. The spacing and size of the horizontal shear reinforcement should be designed to ensure that the shear stresses are distributed evenly across the width of the wall.

14.4Vertical shear reinforcement:

Vertical shear reinforcement should be provided in the shear wall to resist the shear forces induced by lateral loads. The spacing and size of the vertical shear reinforcement should be designed to ensure that the shear stresses are distributed evenly across the height of the wall.

14.5Check for flexural strength:

The flexural strength of the shear wall should be checked to ensure that it can resist the bending moments induced by lateral loads. The nominal moment capacity of the wall can be calculated using the following formula:

Mn = beta1 x beta2 x fcd x b x d^2

where beta1 and beta2 are factors that depend on the boundary conditions of the wall, fcd is the design compressive strength of the concrete, b is the width of the wall, and d is the effective depth of the wall.

Assuming that the boundary conditions of the wall are simply supported, beta1 is 0.8 and beta2 is 1.0. Assuming that the design compressive strength of the concrete is 25 MPa, the width of the wall is 4m, and the effective depth of the wall is 36m, the nominal moment capacity of the wall is:

Mn = beta1 x beta2 x fcd x b x d^2 Mn = 0.8 x 1.0 x 25 MPa x 4m x (36m)^2 Mn = 360.8 kN.m/m

Since the nominal moment capacity of the shear wall (360.8 kN.m/m) is greater than the maximum bending moment induced by lateral loads (172500 kN.m), the shear wall is able to resist the bending moments induced by lateral loads.

To calculate the lateral loads and shear of a 10-story building with the given information, we can use the following table: Fig.1

Floor	Dead Load (kN/m2)	Partition Load (kN/m2)	Live Load (kN/m2)	Floor Load (kN/m2)	Floor Area (m2)	Floor Load (kN)	Shear Load (kN)
Roof	4.7	N/A	1.6	6.3	600	3780	2998.2
10	4.7	3	3.6	11.3	600	6780	5371.4
9	4.7	3	3.6	11.3	600	6780	5371.4
8	4.7	3	3.6	11.3	600	6780	5371.4
7	4.7	3	3.6	11.3	600	6780	5371.4
6	4.7	3	3.6	11.3	600	6780	5371.4
5	4.7	3	3.6	11.3	600	6780	5371.4
4	4.7	3	3.6	11.3	600	6780	5371.4

Floor	Dead Load (kN/m2)	Partition Load (kN/m2)	Live Load (kN/m2)	Floor Load (kN/m2)	Floor Area (m2)	Floor Load (kN)	Shear Load (kN)
3	4.7	3	3.6	11.3	600	6780	5371.4
2	4.7	3	3.6	11.3	600	6780	5371.4
1	4.7	3	3.6	11.3	600	6780	5371.4
Total				127.8	7200	76740	60314.8

Table.1

Note: The floor load is calculated as the sum of the dead load, partition load, and live load. The floor load is then multiplied by the floor area to obtain the total load on each floor. The shear load is calculated as the sum of the lateral loads induced by wind or seismic forces.

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