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# A Study on Flat Slab Assessment with ETABS Software

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## ABSTRACT
Flat slabs are becoming increasingly fashionable these days, both architecturally and aesthetically. Flat slabs are gaining popularity these days due to their numerous benefits. Flat slabs are utilised in the construction of high-rise structures because they lower building height, allow for easy reinforce placement, require less time to build, and are easier to shape. Flat slab construction is commonly utilized in reinforced concrete structures all over the world because it decreases the cost of form work, construction time, and is simple to install. Without the need of beams, the floor slab system directly supports the columns. In general, the most common challenge encountered when constructing a flat slab is punching shear and flexure shear failure. In my research, I used ETABS software to develop flat slabs for flexural shear.

## Keywords
Flat Slabs, flexure shear, Drop, ETABS software

## 1. INTRODUCTION
A flat slab is a two-way reinforced concrete slab that often lacks beams and girders and transfers loads straight to the supporting concrete columns. They are exposed to vertical as well as lateral stresses. Based on the applicability of each slab in terms of design and architectural needs, there are primarily four types of flat slabs encountered in practise:
Different types of flat slabs.

- A typical flat slab without drop and column head
- Flat Slab without drop and column with column head
- Flat Slab with drop and column without column
- Flat Slab with drop and column with column head

The ETABS software aids in the design and analysis of flat slabs. It measures flexure shear and punching shear around column supports as well as in concentrated loads. Every part of the engineering design process is integrated by ETABS. This issue must be addressed in structural design by giving appropriate rotational capacity to the members. A greater ductility can be achieved by inserting transversal reinforcement in high-stress zones, and a flexural failure can be induced. In any case, due to the complexity of the behaviour, even a predicted flexural failure might result in a punching failure due to the formation of massive displacements and rotations.

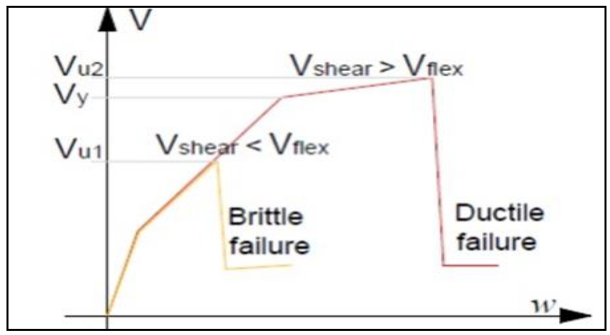


**Figure 1: Failure modes for a flat slab column connection**

A flexural failure corresponds to the moment when tension reinforcement reaches the yielding limit. In order to find the flexural punching value of a flat slab column connection the plasticity-based yield line theory has to be used (figure 1).

## 2. OBJECTIVES OF STUDY
1. Slabs with double headed stud rails have an 8% higher ultimate load bearing capability than the control slab. Slabs with double headed stud rails have a higher deformation capability than slabs with stirrup reinforcement. Slabs with stirrup reinforcement have the highest ultimate load bearing capacity. The slabs without shear reinforcement fail owing to punching, but the slabs with shear reinforcement have flexural punching behavior.

## 3. LITERATURE REVIEW
According to **Renuka Gurusiddappa et al**, [1] flat slabs are increasingly frequently used in commercial constructions. Flat slabs are commonly utilised because they have several advantages over conventional slab systems, including lower storey height, shorter building time, lower construction costs, and a more aesthetically pleasing look. Because flat slabs perform poorly under seismic stress, it is vital to investigate the seismic behaviour of structures with flat slabs above normal slabs.
**Ghafur H Ahmed** [2] study is undoubtedly a suitable beginning point for such a summarization. Their work in 1960 was one of the earliest, and most likely most important, in terms of punching modelling. Other punching shear models were developed as a result of the suggested model. Despite the fact that this method was designed for slabs without punching shear reinforcement, it served as a foundation for future researchers who used punching shear reinforcement.

 

In 1963, based on the model of **Kinnunen and Nylander, Andersson** [3] developed an approach that considers shear reinforcement. In the tests that he performed for the model validation, he used bent-up bars and continuous stirrups as punching shear reinforcement.

**Sumio et al 1974** [4] released a report that provided an overview of testing conducted with various punching shear reinforcement systems such as steel heads, bent-up bars, and stirrups. He concluded that shear reinforcement boosts punching strength even in tiny slabs and that detailing is critical to increasing strength and avoiding undesirable failure modes.

**AM Said et al 2011** [5] found that equivalent frame method is not appropriate in accurately predicting the response of two-way slab systems under lateral loads. Currently design code, aci 318-05[2.1] permit the efm for the analysis of two-way slab system under gravity loads and lateral loads such as seismic loads.

## 4. EXPERIMENTAL STUDY AND RESULTS

ETABS is a revolutionary software that is acts as a boon for the structural designs. ETABS unifies all component of the engineering design process, from design idea through schematic drawing creation. Model creation has never been easier - straightforward sketching instructions enable the quick development of floor and elevation framing. CAD designs may be immediately turned into ETABS models or utilised as templates on which ETABS objects can be superimposed. ETABS offers a comprehensive set of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the largest commercial high-rises. Since its inception decades ago, ETABS has been known for being extremely competent while being simple to use, and its latest iteration maintains that legacy by giving engineers with the technologically complex, but intuitive, software they need to be at their most productive.

This part includes data on model geometry, such as narrative levels, point coordinates, and element connectivity.

**Table 1: Slab Data**

| Load (KN) | Deflection in mm | | | |
|---|---|---|---|---|
| | Centre location | Location A | Location B | Location C |
| 4.98 | 0.16 | 0.08 | 0.05 | 0.11 |
| 8.30 | 0.29 | 0.18 | 0.13 | 0.20 |
| 15.00 | 0.95 | 0.34 | 0.29 | 0.43 |
| 21.58 | 2.51 | 2.41 | 2.10 | 2.89 |
| 27.4 | 4.83 | 3.65 | 3.27 | 4.35 |
| 33.20 | 7.47 | 6.11 | 5.13 | 5.43 |

In the above table 1 the deflections along with the load are mentioned. The load is increasing from 4.98 KN to 33.20 KN for various locations.

### 4.1 ETABS Analysis and Design

**Table 2: Story Data**

| Name | Height Mm | Elevation mm | Master Story | Similar To | Splice Story |
|---|---|---|---|---|---|
| **Story 1** | 2000 | 2000 | Yes | None | No |
| **Base** | 0 | 0 | No | None | No |

The height,elevation and other details are mentioned in the above table 2

**Table 3: Grid Data**

| Name | Type | Story Range | X Origin M | Y Origin m | Rotation Degree |
|---|---|---|---|---|---|
| G1 | Cartesian | Default | 0 | 0 | 0 |

In the above table 3 the type, story range and coordinates are mentioned

**Table 4: Material Properties – Summary**

| Name | Type | E MPa | ν | Unit Weight kN/m³ | Design Strengths MPa |
|---|---|---|---|---|---|
| A416Gr270 | Tendon | 196500.6 | 0 | 76.9729 | Fy=1689.91 Fu=1861.58 |
| A615Gr60 | Rebar | 199947.98 | 0.3 | 76.9729 | Fy=413.69 Fu=620.53 |
| M25 | Concrete | 25000 | 0.2 | 24.9926 | Fc=25 |
| Mild250 | Rebar | 200000 | 0 | 76.9729 | Fy=250 Fu=410 |

All the details of the materials are mentioned in the above table 4

**Table 5: Frame Sections**

| Name | Material | Shape |
|---|---|---|
| COLUMN 1 | M25 | Concrete Rectangular |

Type of structural element along with the material and shape also play a key role in the strength of an element.

**Table 6: Shell Sections**

| Name | Design Type | Element Type | Material | Total Thickness Mm |
|---|---|---|---|---|
| DROP 1 | Slab | Shell-Thin | M25 | 160 |
| Slab1 | Slab | Shell-Thin | M25 | 160 |

As per the IS Code the grade of concrte to be used was set as M-25 and thickness was 160 mm.The same is depicted in Table 6.

 

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**Table 7**: **Frame Assignments**

| Story | Label | Unique Name | Design Type | Length Mm | Analysis Section | Design Section | Min Number Stations |
|---|---|---|---|---|---|---|---|
| Story1 | C1 | 1 | Column | 2000 | COLUMN 1 | N/A | 3 |
| Story1 | C2 | 2 | Column | 2000 | COLUMN 1 | N/A | 3 |
| Story1 | C3 | 3 | Column | 2000 | COLUMN 1 | N/A | 3 |
| Story1 | C4 | 4 | Column | 2000 | COLUMN 1 | N/A | 3 |

In the above Table 7 the details of structural elements are recorded.

**Table 8**: **Load Patterns**

| Name | Type | Self-Weight Multiplier |
|---|---|---|
| Dead | Dead | 1 |
| Live | Live | 0 |

Self-weight and Live weight is the two weight that a structural element has to carry. Same is mentioned above in table 8

**Table 9**: **Shell Loads – Uniform**

| Story | Label | Unique Name | Load Pattern | Direction | Load kN/m² |
|---|---|---|---|---|---|
| Story1 | F1 | 1 | Dead | Gravity | 4 |
| Story1 | F1 | 1 | Dead | Gravity | 15 |
| Story1 | F2 | 2 | Dead | Gravity | 4 |
| Story1 | F2 | 2 | Dead | Gravity | 15 |
| Story1 | F3 | 3 | Dead | Gravity | 4 |
| Story1 | F3 | 3 | Dead | Gravity | 15 |
| Story1 | F4 | 4 | Dead | Gravity | 4 |
| Story1 | F4 | 4 | Dead | Gravity | 15 |
| Story1 | F5 | 5 | Dead | Gravity | 4 |
| Story1 | F5 | 5 | Dead | Gravity | 15 |

In the above table 9 the loading patterns for different stories are given.

**Table 10**: **Load Cases**

| Name | Type |
|---|---|
| Dead | Linear Static |
| Live | Linear Static |

In the table 10 types of loads viz static or dynamic is mentioned

**Table 11**: **Concrete Slab Design Summary: Flexure and Shear Data**

| Story | Strip Name | SpanID | FTopCombo | FBotCombo | VCombo | Location | FTopMoment kN-m | FTopArea mm² | FBotMoment kN-m | FBotArea mm² | VForce kN | VArea mm²/m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Story1 | CSN1 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Start | -80.8847 | 2054 | 37.3956 | 830 | 22.0882 | 0 |
| Story1 | CSN1 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Middle | -0.0176 | 0 | 55.1431 | 1284 | 55.7821 | 0 |
| Story1 | CSN1 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | End | -80.8847 | 2054 | 37.3956 | 830 | 55.7821 | 0 |
| Story1 | MSN1 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Start | -13.5965 | 283 | 39.2802 | 847 | 27.3914 | 0 |
| Story1 | MSN1 | Span 1 | | DSlbU4 | DSlbU4 | Middle | 0 | 0 | 71.9794 | 1637 | 39.8071 | 0 |
| Story1 | MSN1 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | End | -13.5965 | 283 | 39.2802 | 847 | 39.8071 | 0 |
| Story1 | CSN2 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Start | -80.8847 | 2054 | 37.3956 | 830 | 22.0882 | 0 |
| Story1 | CSN2 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Middle | -0.0176 | 0 | 55.1431 | 1284 | 55.7821 | 0 |
| Story1 | CSN2 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | End | -80.8847 | 2054 | 37.3956 | 830 | 55.7821 | 0 |

 

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Story1 | CSN3 | Span 1 | DSlbU4 | | DSlbU4 | Start | -80.8847 | 2517 | 0 | 1420 | 22.0882 | 0 |
| Story1 | CSN3 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Middle | -0.0176 | 0 | 55.1431 | 1568 | 55.7821 | 0 |
| Story1 | CSN3 | Span 1 | DSlbU4 | | DSlbU4 | End | -80.8847 | 2517 | 0 | 1420 | 55.7821 | 0 |
| Story1 | MSN2 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | Start | -13.5965 | 328 | 39.2802 | 996 | 27.3914 | 0 |
| Story1 | MSN2 | Span 1 | | DSlbU4 | DSlbU4 | Middle | 0 | 0 | 71.9794 | 1972 | 39.8071 | 0 |
| Story1 | MSN2 | Span 1 | DSlbU4 | DSlbU4 | DSlbU4 | End | -13.5965 | 328 | 39.2802 | 996 | 39.8071 | 0 |

In the above table 11 provides all the information about the analysis done on the structural elements by the use of ETABS software

## 5. CONCLUSION

- ETABS helps in showing higher deflection to lateral loads.
- It provides all detailing about the flat slabs.
- Flat slab construction is a developing technology in India as it has so many advantages.
- Flat slab can be a very better option for modern construction demanding structural stability and state of aesthetic aspects and prospects.

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