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Analysis of Post-Tensioned Flat Slab by using SAFE

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Abstract

The use of post-tensioned flat slab is increasing day by day, due to its advantages over traditional concrete. These slabs have been proved to be the most economical when compared to the RCC slabs. In post-tensioned slab high strength tensioned steel strands are used to compress the slab, keeping the majority of the concrete in compression. The main objective of this paper is to give a review on the response and behavioural properties of Post-tensioned flat slab during earthquake and compare with normal flat slab. A study on analysis and behavior of Post-tensioned flat slab is been done in this thesis. Modeling and analysis of flat slab and PT flat slab is done using SAFE. Two way PT Flat plate of size 8m X 8m is supported on 4 square columns of 400mm X400mm is modeled for different cases and respective properties are assigned. Slab is divided into column strip and middle strips. Results for maximum and minimum moments are calculated using SAFE.

Keywords: *Flat Slab, SAFE, Post-Tensioned Flat Slab.*

1. Introduction

Due to rapid increase in demand for space, construction of multi-storied buildings is becoming a necessary part of our living. The limitation of space is forcing us to raise the height of buildings as much as possible to accommodate maximum number of people. Resisting lateral loads like wind and earthquake also comes into picture with increase in height of the building. Flat slab buildings can be broadly divided into RCC and Prestressed buildings. The flat slab or Post Tensioned Slab buildings in which slab is directly rested on columns, have been adopted in many buildings constructed recently due to the advantage of reduced floor to floor heights to meet the economical and architectural demands. But Punching shear failure observed during the transfer of unbalanced moment from slab to column is the main drawback of using flat slab. Also its behaviour during earthquake due to absence of beams is also the matter to study.

2. Flat Slabs

The traditional method of construction that is a common practice is to support slab by beam; and beam supported by column. This is called as a beam slab load transfer construction technique. Due to this traditional technique of construction net height of the room is reduced. Therefore to improve the aesthetical and structural aspect of multi-storey, shopping malls, offices, warehouses etc. are constructed in such a way where slabs are directly on columns. This type of slab which is directly supported on columns is termed as flat slabs.

2.1 Floor System

The slabs are presented in two group's viz. one-way slabs and two-way slabs. When a rectangular slab is supported on all the four sides and the length-to-breadth ratio is less than two, it is termed as a two-way slab. The slab spans in both the orthogonal directions. Rectangular two-way slabs are divided into the following types:

1) Flat plates: The Flat plate slabs do not have beams between the columns, drop panels or column capitals. Usually, there are spandrel beams at the edges.

2) Flat slabs: These slabs do not have beams but have drop panels or column capitals.

3) Two-way slabs with beams: If the beams are wide and shallow, they are termed as band beams. There are beams between the columns.

These slabs can be cast-in-situ (cast-in-place). Else, the slabs can be precast at ground level and lifted to the final height. These types of slabs are called lift slabs. A slab in a framed building can be a two-way slab depending upon its length-to-breadth (L / B) ratio.

1.1 Advantages of Post-tensioned Flat Slabs:

1. **Reduction in cost**: Stronger structures are made at an affordable price by post-tensioning. There are many structures like parking garages as well as stadiums, as they are required to hold much

more weight than average buildings; this slab becomes a feasible option.

2. **Flexibility in design**: The designs made with this slab are sleek, require lesser space..

3. **Lesser usage of materials**: Since the post tension slab is thin, the materials used with it are also lesser. This slab does not need bulky materials.

4. **Durability**: Being a very strong substitute of the normal concrete, it lasts longer.

1.2 Disadvantages of Post-Tensioned Flat slabs:

1. **Corrosion:** As there are a number of tendons and wires spread inside the post tension slab, it can result in corrosion. But, this tendency to corrode depends on the quality of the material used.

2. **Complexity of work:** Only skillful professional can manufacture post-tensioned slabs. The local workers may not have the necessary knowledge skills required to make this complex slab.

3. **Poor workmanship can lead to accidents**: The main problem with using **post tension slab** is that if sufficient care is not taken while preparing it, it can lead to future fatal accidents.

1.3 Necessity:

While analyzing the post-tensioned slab, there are some secondary moment effects observed. These secondary moment effects when combined with lateral loading become a critical issue in the design of slab. Due to this, there arises an urge to study the behaviour and response of flat slabs and Post tensioned flat slabs during an earthquake. Another arising issue in the present scenario is the scarcity of space which is compelling us to raise the height of buildings to accommodate the growing population. This increase in the height of building enforces consideration of the factors such as lateral loads like wind and earthquake while design and analysis of the structure.

3. MODELLING AND ANALYSIS

SAFE 2D Post-tensioned flat slab model under consideration are shown in Fig.1

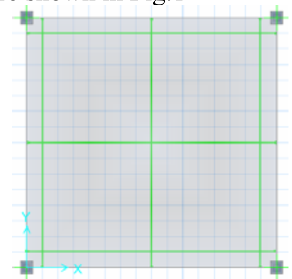

Fig.1. PT flat slab 2D model

Description of model:

Floor height	3m
Depth of Slab	200mm
Grade of Concrete	M30
Grade of steel	Fe415

Flat plate considered is analyzed using SAFE and maximum bending moments and minimum bending moments are calculated in column strip and middle strip.

Sequence No.1 :(all X cables first and then Y)

For the above slab we tried with stretching sequence as cable no.1 at first stage then cable 2 in second stage cable no 3 in third stage cable no 4 in 4th stage cable no 5 in 5th stage cable no 6 in 6th stage. Cable 1, 2 and 3 are all X- tendons and cable 4,5and 6 are all Y- tendons.

Sequence No.2: (alternate X and Y cables)

For the above slab we tried with stretching sequence as cable no 1 at first stage then cable 4 in second stage, cable no 2 in third stage, cable no 5 in fourth stage, cable no 3 in fifth stage, cable no 6 in 6th stage. Where cables no 1, 2 and 3 are all X- tendons and cables no 4,5and 6 are all Y- tendons.

3.1 RESULTS AND ANALYSIS

TABLE I DESCRIPTION OF FLAT SLAB MODEL

		Moments in 1st Column Strip											
		Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6	
		MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
SEQUENCE 1	START	14.268	12.841	12.264	15.370	13.688	15.370	-26.080	84.633	-31.118	-79.53	-33.239	79.6946
	MID	24.276	10.151	34.493	8.5451	39.875	8.545	23.646	26.074	24.627	-31.114	24.617	33.235
	END	10.151	13.331	8.545	13.915	88.900	13.915	158.332	-92.399	164.863	92.110	168.651	90..916
SEQUENCE 2	START	14.268	12.841	10.367	-2.518	7.96	-0.7199	7.555	-5.165	-31.118	-79.530	-33.239	79.694
	MID	24.276	10.151	10.491	-9.715	7.925	-6.254	8.905	10.499	24.627	-31.114	24.617	33.235
	END	10.151	13.331	58.295	30.191	55.516	28.392	62.047	28.104	164.863	92.110	168.651	90.916

TABLE II DESCRIPTION OF FLAT SLAB MODEL

		Moments in Middle Strip											
		Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6	
		MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
SEQUENCE 1	START	16.063	-2.803	14.873	-1.594	15.277	-1.215	10.854	-2.156	1.176	-1.031	0.725	-5.852
	MID	22.484	10.806	17.107	3.936	17.986	7.613	13.336	1.061	13.337	18.052	13.576	24.681
	END	11.815	2.312	11.173	2.914	15.281	-2.028	12.503	-2.080	49.469	4.316	50.335	4.36
SEQUENCE 2	START	16.063	-2.803	11.066	-3.162	10.449	-2.534	0.797	-1.433	1.176	-1.031	0.725	-5.852
	MID	22.484	10.806	15.329	6.160	14.742	-2.702	14.742	22.138	13.337	18.052	13.576	24.681
	END	11.818	2.312	10.717	2.234	12.539	2.862	52.193	9.258	49.469	4.316	50.335	4.361

TABLE III DESCRIPTION OF FLAT SLAB MODEL

		Moments in 2nd Column Strip											
		Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6	
		MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
SEQUENCE 1	START	9.341	-12.265	9.571	12.394	73.596	-13.598	74.238	-8.608	79.228	35.110	95.977	24.537
	MID	24.385	10.306	35.142	9.448	37.018	0.019	37.119	1.093	32.057	-0.571	21.505	28.480
	END	13.559	13.343	13.514	12.869	65.807	110.50	67.776	104.607	68.105	98.109	52.069	33.416
SEQUENCE 2	START	9.343	-12.265	7.439	12.394	8.461	-13.598	5.516	-8.608	79.228	35.110	95.977	24.537
	MID	24.385	10.306	22.427	10.557	34.156	10.523	27.633	8.376	32.057	-0.571	21.505	28.480
	END	13.559	13.343	14.169	11.371	15.191	-9.758	14.638	-9.429	68.105	98.109	52.069	33.416

4. Conclusions

- Stretching of cables can be done 1st in x-direction then in y-direction, alternate stretching can be done to avoid the torsion of slab.
- Stretching one cable produces secondary moment and hence strip moments in both direction changes drastically.

- Hyper static moments are affecting during the construction stage. In stage wise construction hyper static moments play important role.
- In the above flat plate varying eccentricity is not very much possible due to small thickness of slab but force can be worked out for new moments.
- Due to post-tensioning of flat plates slab there is no much effect on axial force but shear and moment on column increases.

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