Influence of Grid Spacing of Columns in Flat Slabs by Distributing Moments and Shear using Bonded Post Tensioned System

Venkataraj. M
School Of Mechanical And Building Sciences,
Vit University, Chennai

Helen Santhi. M
School Of Mechanical And Building Sciences,
Vit University, Chennai

Abstract – The optimization in grid spacing of columns for a flat slab structure by distributing moments and shear using bonded post tensioned system can improve performance and sustainability in construction. The Direct design method is used for the modelling and analysis of the structure. Bonded Post tension system has important advantages like higher flexural capacity, good flexural crack distribution, and good corrosion protection. The use of bonded tendons reduces the overall cost than that of unbonded system. The construction of floors in building structures using post tensioned system is emerging. By this method of construction we get longer span, thinner slab, lighter structure, reduction in rebar, early formwork stripping. These slabs have other advantages as reduced cracking and deflections, reduced floor to floor height and quick construction. It reduces the number of columns by increasing grid spacing of column. By this approach the reduction in rebar and the thickness of the slab can be achieved. In this study two flat slab systems with different column spacing is analysed and design using RAPT software. The results show that there is a significant reduction in bending moment and shear force thereby reduction in reinforcement is achieved.

Keywords: **-Flat Slab, bonded Post Tensioned, Grid Spacing, RAPT Software.**

I. INTRODUCTION

The construction of floors in building structures using post tensioned system is emerging. Post-tensioned design of flat slab allows nearly 70% reduction in steel and 30 % reduction in concrete as compared to Reinforced cement concrete flat slab [8]. Generally the design and construction of a structure is to support the slabs by beams and the beams by columns. This method of construction may be called as beam-slab construction. The beams decrease the available net clear ceiling height. In the commercial buildings like offices, warehouses and public halls sometimes slabs are directly supported by columns where beams are avoided. This sort of construction is aesthetically attractive. The slabs which are directly supported by columns are called Flat Slabs. Moments in the slabs are more near the column. Therefore the slab is thickened near the columns by providing the drops. Sometimes the drops are called as capital of the column. We have the following types of flat slabs [1]

(*i*) Slabs without drop and column head.
(*ii*) Slabs without drop and column with column head.
(*iii*) Slabs with drop and column without column head.
(*iv*) Slabs with drop and column head.

II. STRUCTURAL ANALYSIS

The methods that are used to determine the bending moment and shear force in flat slab as per IS 456-2000 are
(*a*) The Direct Design Method
(*b*) The Equivalent Frame Method

In this study the analysis of flat slab systems is carried out using the direct design method as given in Indian code (IS 456-2000).
The following limitations are to be fulfilled:
(*a*) In each direction minimum of three continuous spans.
(*b*) The panels shall be rectangular and the ratio of the longer span to the shorter span within a panel shall not be greater than 2.
(*c*) The span length in each direction shall not differ by more than one-third of longer span.
(*d*) The design live load shall not exceed three times the design dead load.
(*e*) The end span must be shorter but not greater than the interior span.

III. MODELLING and analysis OF FLAT SLAB

Modelling of Post tensioned flat slab is done in RAPT software. The Flat slab is a three span continuous in each direction. The size of column, thickness of slab and thickness of drop is taken as 1 m x 1 m, 0.225 m and 0.450 m, respectively. The flat slab has a span length of 10 m, 10 m and

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10 m in each direction in the system 1. Whereas in the system 2 the span length is taken as 9.5 m, 11 m and 9.5 m in each direction. The details of the flat slab systems 1 and 2 are shown in Figure 1.

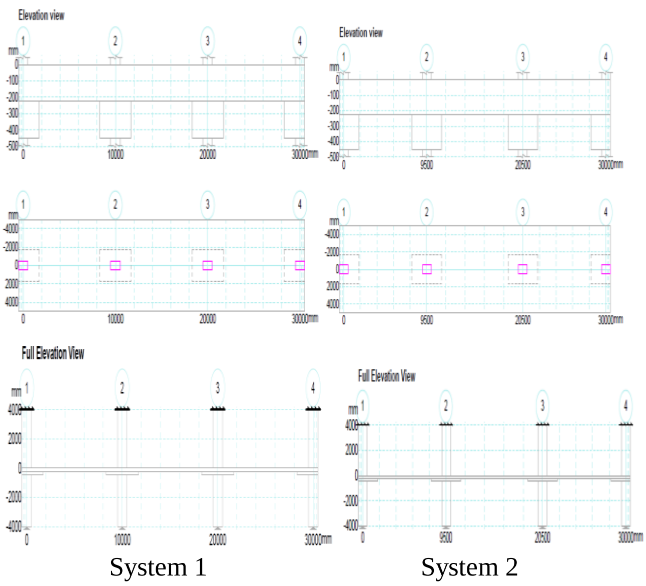

Fig. 1 Details of Flat Slab Systems

III. ANALYSIS OF FLAT SLAB

In direct design method, a flat slab structure having a rectangular column arrangement is divided into a series of longitudinal and transverse directions [9]. In each direction of the flat slab, edge and middle equivalent frames are basically analysed to find the total bending moments and shear forces at different sections of slabs. The flat slab panels are loaded with the uniform gravity dead and imposed loads over the width of panels [5]. The width of beams is divided into two strips, namely column and middle strips. The average bending moment over each strip is obtained as a percentage of the total bending moment at each section. The required reinforcement in each slab section is calculated according to the design bending moment obtained in each section of column and middle strip [4]. The profiles of moment due to flexure and shear are given in Figures 2 and 3, respectively. Figure 4 shows the reinforcement required at different sections and the maximum reinforcement is provided throughout the span.

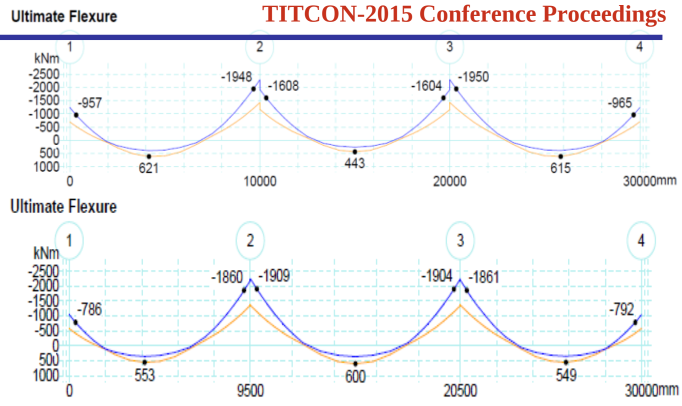

Fig.2 Ultimate Moment due to Flexure for Systems 1 & 2

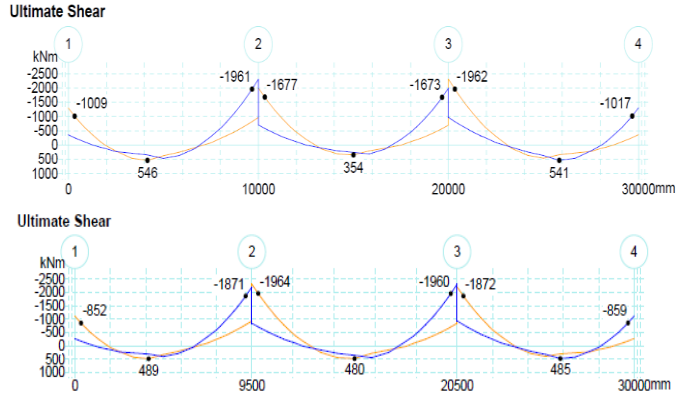

Fig.3 Ultimate Moment due to Shear for Systems 1 & 2

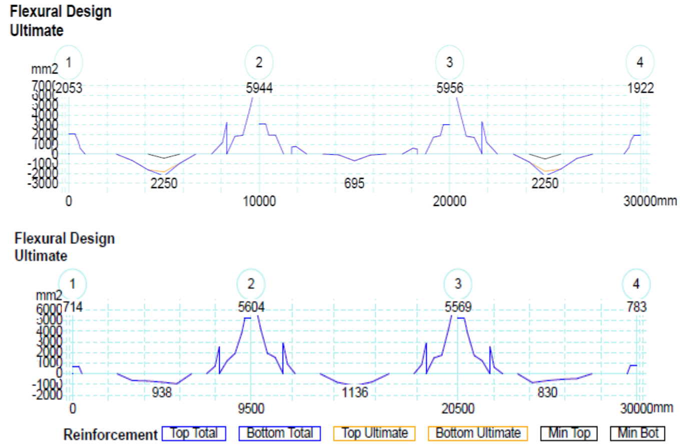

Fig.4 Ultimate Reinforcement for Systems 1& 2

IV. PRESTREESING TENDON

The tendon forces are obtained from the analysis of the flat slab systems by RAPT software. The force for the both systems is more or less equal. Moment of resistance of a section due to tendons can be calculated as per IS: 1343-1980. Table 1 shows the design input to calculate the tendons. Figure.6 & 7 shows the Tendon force and Tendon arrangement for the post tensioned flat slab System 1 & 2.

TABLE I Design Input for Tendon Calculation

Design Data	Values
Grade of concrete f_{ck}	35 N/mm^2
Grade of concrete f_y	415 N/mm^2
Grade of prestressing strand f_p	1860 N/mm^2
Overall depth of slab D	225 mm
Width of panel B	10000 mm
Dia of strand	12.7 mm
Clear cover	35 mm

Total number of strands provided is 20 nos.
Stress at extreme top fiber f_t = **3.07** N/mm^2
Stress at extreme bottom fiber f_b = **-1.12** N/mm^2

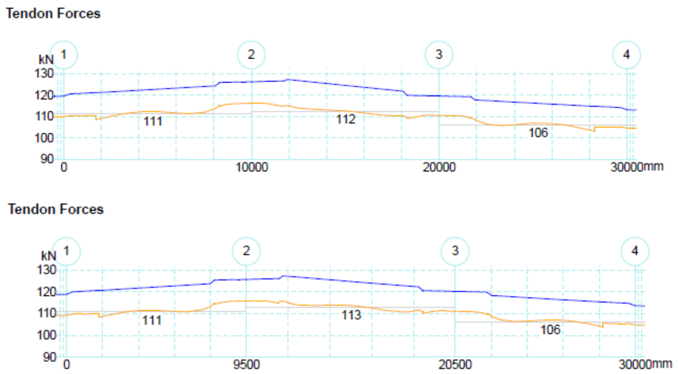

Fig 6.Tendon Force of Systems 1 & 2

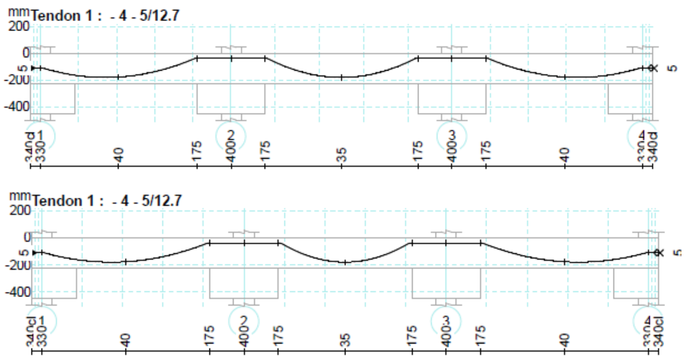

Fig.7 Tendon Arrangements of Systems 1&2

V. Results and Discussion

The influence of grid spacing of column for flat slab System is evaluated by distributing moments and shear using bonded post tensioned system. It is observed that the moment, shear and reinforcement required for the post tensioned flat slab is less as compared. The tendons required for both the system is same. Figure 2 and 3 gives the total moment in the flat slab systems and the reinforcement required for the system 2 is less than that of system 1.

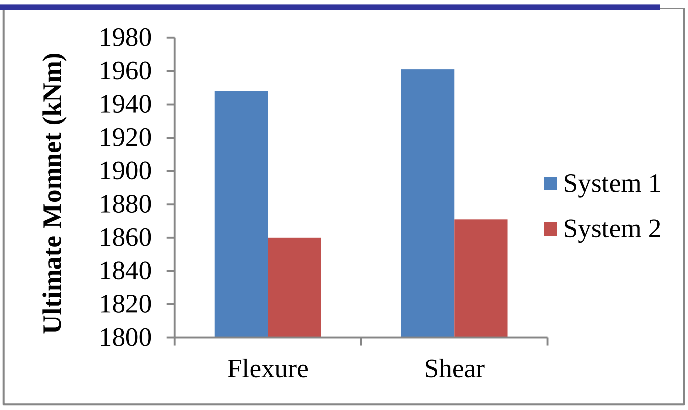

Fig.8 Ultimate Flexure and shear force.

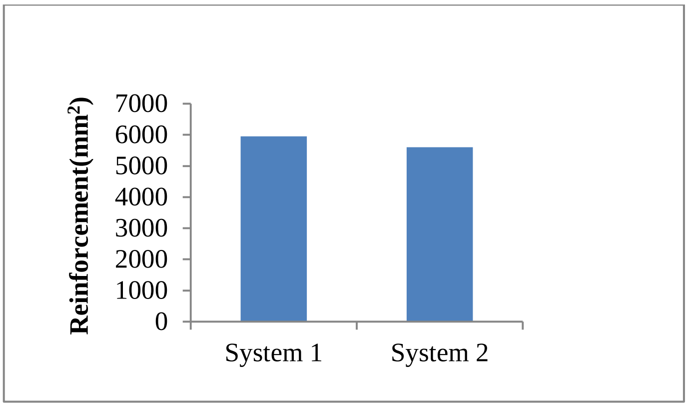

Fig.9 Required Reinforcement

VI. Conclusion

In this paper the influence of grid spacing of column in flat slab systems is studied using RAPT Software. Modelling and analysis are carried out on post tensioned flat slab systems to determine the moment and shear. The results show that the influence of increase in grid spacing of column is slightly modified the reinforcement requirement. The flexure and shear demand of PT flat slab is less. The tendon required for both the systems is same. When more space is required in particular area this method can be adopted. The reinforcement required for the flat slab can be reduced. This work will be extended to find the optimized grid spacing in flat slab system. The optimization of grid spacing in flat slab systems would provide valuable suggestions to the engineers and designers.

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REFERENCE

[1] I.S.456, "Plain and Reinforced Concrete - Code of Practice", Bureau of Indian Standards, 2000.
[2] I.S 1343, "Prestressed Concrete -Code of Practice", Bureau of Indian Standards, 2012.
[3] SP 24, "Explanatory Hand book on Indian Standards code of practice for plain and reinforced concrete, 1983.
[4] R. P. Apostolska, G. S. Necevska-Cvetanovska, J. P.Cvetanovskaand N. Mircic (2008) "Seismic Performance of flat slab building structural systems " (World Conference on Earthquake Engineering)
[5] Amit A. Sathawane & R.S. Deotale (2012)"Analysis and design of flat slab and grid slab and their cost comparison"(International Journal of Advanced Technology in Civil Engineering)
[6] Kiran S. Patil, N.G.Gore, P.J.Salunke(2014) "Minimum Cost Design of Reinforced Concrete Flat Slab "(International Journal of Recent Technology and Engineering)
[7] Boskey Vishal Bahoria, Dhananjay K. Parbat (2013)"Analysis and design of RCC and Post-tensioned flat slabs considering seismic Effect" (*IACSIT International Journal of Engineering and Technology, Vol. 5, No. 1, February)*
[8] Kiran S. Patil, N.G.Gore, P.J.Salunke(2013) "Optimum design of reinforced concrete flat slab with drop panel" (International Journal of Recent Technology and Engineering)
[9] S.S.Patil, Rupali Sigi(2014) "Analysis and design of flat slabs using various codes" (International Journal of Research in Engineering and Technology)