COMPARISION OF FLAT SLAB BY USING STUD RAIL OR SHEAR STIRRUPS NEAR SLAB COLUMN CONNECTION

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Abstract: ***Flat slab construction is among the most efficient methods of construction, enabling a consistent head space to be achieved across the entire floor with the resulting benefits of easier layout of services and reduced overall floor to floor heights. The design of a flat plate structure is generally governed either by serviceability limits on deflection or punching shear strength of the column slab connections. However, the punching shear failure at the slab column junction has to be considered properly in such flat slab. Disregards to this criterion has resulted in several collapses in the past. Using traditional link as punching shear reinforcement is time consuming and expansive. To increase the strength of a column-slab connection, a new type of shear reinforcement, referred to as shear stud, is popular now a days. Therefore, study of the flat slab will be carried out with comparison of different structural parameters. Conclusion will be carried out on improvement of punching shear failure due to shear stud rail.***

Keywords- Reinforced concrete flat slab, Punching shear, Shear stud rail, column slab connection.

I. INTRODUCTION

Although the introduction of Reinforced Concrete flat slab floors is a significant advancement in the building technology. From 1910-1911 slab, beam and girder system reigned supreme but at this time the girder less floors sometimes called as Mushroom slab, known as flat slab were also happening Historically, flat slabs predate both two-way slabs on beams and flat plates, several systems of placing of reinforcement have been developed.

Reinforcement concrete flat slab are being adopted increasingly in several parts of the world due to their aesthetic appearance, as well as economic advantages and speed of construction. In addition, the elimination of beams and girders reduces the overall floor depths of multistory buildings thus creating additional floor space for a given building height. For these reasons, flat plates are widely used for multistory structures such as office buildings and carparks in many countries. In the design of concrete flat slabs, the punching shear strength around the column slab connections always poses a critical analysis problem. Punching shear failure would occur at a load well below the flexural capacity due to the concentration of shear forces. The local and brittle nature of the punching shear failure is in the form of column punching through the slab along a truncated cone caused by diagonal cracking around the column.

If the punching shear is critical, either the slab thickness may be increased or punching shear reinforcement be provided. The first option is expensive and hence punching shear reinforcement is often provided. A number of alternative punching shear reinforcement have been developed and used.

In the recent past, a range of alternative prefabricated punching shear reinforcing system have been developed and many of these have been used in situ concrete buildings. These alternative system have been found to offer saving in time and cost.

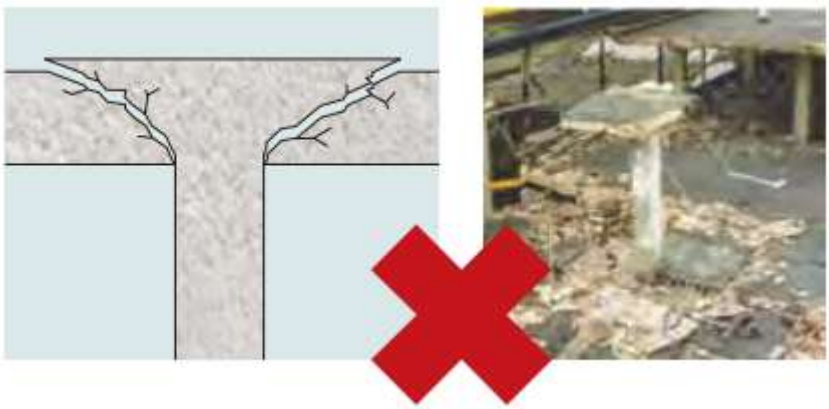

Figure 1. Punching shear failure

II. ANALYSIS OF FLAT SLAB

3D analysis of flat slab (wherein shear wall is introduced) for gravity loading and lateral loading is carried out using software ETABS (Extended 3D Analysis of Building systems). This software is used for modelling of flat slab. Gravity and lateral load effect analyzed in ETABS software for the flat slab is then transferred to the SAFE software for analyzing punching shear effect along with lateral loads SAFE (Slab Analysis by the Finite Element Method) software is used.

- **MODEL DATA**

Four storey building with different panel width (6m, 8m, and 10m) is considered. Two grades of concrete M25 and M30 are considered and different slab thickness are used under each grade of concrete.

- Building type: Surat office building (4-storey)
- Live load = 4 kN/m^2
- Dead load = self-weight and floor finish = 1 kN/m^2
- Zone = 3
- Soil type = medium soil
- Importance factor = 1
- Response reduction factor = 5
- Earth quake forces act in both x and y direction
- Shear walls are provided at all corners.

A. Slab without drop 200mm (M-25) [6mx6m]

slab without drop (M25) [6mx6m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	5	12	No. of shear stirrups	15	32
	No. of stud on each rail	3	4	No. of legged in each set	6	6
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	85	stirrup spacing	127.5	120
	Stud spacing (s_0)	70	68	Stirrups extend	476.12	960
At edge slab column connection	No. of stud rails	6	9	No. of shear stirrups	16	24
	No. of stud on each rail	2	4	No. of legged in each set	6	6
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	85	stirrup spacing	127.5	120
	Stud spacing (s_0)	70	68	Stirrups extend	680	960

B. Slab 150mm with drop 190mm (M-25) [6mx6m]

slab with drop (M25) [6mx6m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	6	12	No. of shear stirrups	15	32
	No. of stud on each rail	4	4	No. of legged in each set	6	6
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	120	120
	Stud spacing (s_0)	80	65	Stirrups extend	450	960
At edge slab column connection	No. of stud rails	6	9	No. of shear stirrups	18	24
	No. of stud on each rail	2	4	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	120	120
	Stud spacing (s_0)	80	65	Stirrups extend	720	960

C. Slab without drop 175mm (M-30) [6mx6m]

slab without drop (M30) [6mx6m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	6	12	No. of shear stirrups	19	36
	No. of stud on each rail	4	4	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	70	stirrup spacing	108	100
	Stud spacing (s_0)	72.5	58	Stirrups extend	513	900
At edge slab column connection	No. of stud rails	7	9	No. of shear stirrups	19	27
	No. of stud on each rail	4	4	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	70	stirrup spacing	108	100
	Stud spacing (s_0)	72.5	58	Stirrups extend	684	900

D. Slab 125mm with drop 165mm (M-30) [6mx6m]

slab with drop (M30) [6mx6m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	9	12	No. of shear stirrups	15	36
	No. of stud on each rail	3	5	No. of legged in each set	6	6
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	65	stirrup spacing	100	100
	Stud spacing (s_0)	67.5	50	Stirrups extend	375	900
At edge slab column connection	No. of stud rails	10	12	No. of shear stirrups	19	27
	No. of stud on each rail	5	5	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	65	stirrup spacing	100	100
	Stud spacing (s_0)	9	12	Stirrups extend	633	900

E. Slab without drop 250mm (M-25) [8mx8m]

slab without drop (M25) [8mx8m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	8	12	No. of shear stirrups	32	32
	No. of stud on each rail	3	4	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	110	stirrup spacing	165	165
	Stud spacing (s_0)	105	88	Stirrups extend	1320	1320
At edge slab column connection	No. of stud rails	8	9	No. of shear stirrups	36	36
	No. of stud on each rail	4	4	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	110	stirrup spacing	165	165
	Stud spacing (s_0)	105	88	Stirrups extend	1320	1320

F. Slab 175mm with drop 240mm (M-25) [8mx8m]

slab with drop (M25) [8mx8m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	N.A.	N.A.	No. of shear stirrups	N.A.	N.A.
	No. of stud on each rail	N.A.	N.A.	No. of legged in each set	N.A.	N.A.
	Diameter of stud	N.A.	N.A.	Diameter of shear stirrup	N.A.	N.A.
	Stud spacing (s)	N.A.	N.A.	stirrup spacing	N.A.	N.A.
	Stud spacing (s_0)	N.A.	N.A.	Stirrups extend	N.A.	N.A.
At edge slab column connection	No. of stud rails	9	9	No. of shear stirrups	36	36
	No. of stud on each rail	5	6	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	100	stirrup spacing	157.5	155
	Stud spacing (s_0)	105	84	Stirrups extend	1890	1860

G. Slab without drop 225mm (M-30) [8mx8m]

slab without drop (M30) [8mx8m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	9	12	No. of shear stirrups	30	32
	No. of stud on each rail	3	5	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	146.25	145

	Stud spacing (s_0)	97.5	70	Stirrups extend	1096.87	1160
At edge slab column connection	No. of stud rails	9	9	No. of shear stirrups	36	36
	No. of stud on each rail	5	5	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	146.25	145
	Stud spacing (s_0)	97.5	70	Stirrups extend	1755	1750

H. Slab 150mm with drop 225mm (M-30) [8mx8m]

slab with drop (M30) [8mx8m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	9	12	No. of shear stirrups	27	28
	No. of stud on each rail	3	5	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	146.25	145
	Stud spacing (s_0)	97.5	70	Stirrups extend	987.1	1015
At edge slab column connection	No. of stud rails	9	9	No. of shear stirrups	36	36
	No. of stud on each rail	5	5	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	8	8
	Stud spacing (s)	100	80	stirrup spacing	146.25	145
	Stud spacing (s_0)	97.5	70	Stirrups extend	1755	1740

I. Slab without drop 350mm (M-25) [10mx10m]

slab without drop (M25) [10mx10m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	8	12	No. of shear stirrups	34	36
	No. of stud on each rail	3	8	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	76	75	stirrup spacing	240	205
	Stud spacing (s_0)	76	100	Stirrups extend	2040	1845
At edge slab column connection	No. of stud rails	8	9	No. of shear stirrups	36	36
	No. of stud on each rail	4	8	No. of legged in each set	6	6
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	76	75	stirrup spacing	240	205
	Stud spacing (s_0)	76	100	Stirrups extend	2880	2460

J. Slab 225mm with drop 325mm (M-25) [10mx10m]

slab with drop (M25) [10mx10m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	N.A.	N.A.	No. of shear stirrups	N.A.	N.A.
	No. of stud on each rail	N.A.	N.A.	No. of legged in each set	N.A.	N.A.
	Diameter of stud	N.A.	N.A.	Diameter of shear stirrup	N.A.	N.A.
	Stud spacing (s)	N.A.	N.A.	stirrup spacing	N.A.	N.A.
	Stud spacing (s_0)	N.A.	N.A.	Stirrups extend	N.A.	N.A.
At edge slab column connection	No. of stud rails	8	9	No. of shear stirrups	40	42
	No. of stud on each rail	4	8	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	100	75	stirrup spacing	221.25	220
	Stud spacing (s_0)	76	100	Stirrups extend	2949.2	3080

K. Slab without drop 325mm (M-30) [10mx10m]

slab without drop (M30) [10mx10m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	9	12	No. of shear stirrups	36	36
	No. of stud on each rail	3	7	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	76	90	stirrup spacing	221.25	220
	Stud spacing (s_0)	76	95	Stirrups extend	1991.2	1980
At edge slab column connection	No. of stud rails	8	9	No. of shear stirrups	41	42
	No. of stud on each rail	4	7	No. of legged in each set	7	7
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	76	90	stirrup spacing	221.25	220
	Stud spacing (s_0)	76	95	Stirrups extend	3022.2	3080

L. Slab 200mm with drop 290mm (M-30) [10mx10m]

slab with drop (M30) [10mx10m]						
	Stud rail in orthogonal layout			Shear stirrups		
		Safe software output	Manually provided		Safe software output	Manually provided
At center slab column connection	No. of stud rails	N.A.	N.A.	No. of shear stirrups	N.A.	N.A.
	No. of stud on each rail	N.A.	N.A.	No. of legged in each set	N.A.	N.A.
	Diameter of stud	N.A.	N.A.	Diameter of shear stirrup	N.A.	N.A.
	Stud spacing (s)	N.A.	N.A.	stirrup spacing	N.A.	N.A.
	Stud spacing (s_0)	N.A.	N.A.	Stirrups extend	N.A.	N.A.
At edge slab column connection	No. of stud rails	9	9	No. of shear stirrups	40	42
	No. of stud on each rail	5	5	No. of legged in each set	8	8
	Diameter of stud	12	12	Diameter of shear stirrup	10	10
	Stud spacing (s)	100	90	stirrup spacing	195	195
	Stud spacing (s_0)	76	90	Stirrups extend	2599.35	2730

III. COCLUSION

- It can be observed from the cost comparison of punching shear reinforcement; By using shear stud rails cost can minimized up to 35-80% compared to shear stirrups.
- Volume of concrete reduced by 20-33% when using flat slab with drop as compared with the slab without drop.
- Required quantity of steel reduced around 20% for flat slab without drop as compared to slab with drop.
- The total cost of flat slab with drop is around 20-35% less than the total cost of slab without drop.

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