



Design of Voided U-Boot Beton Deck Slab

Harnisha Patel¹, Jaldhi Patel¹, Vasav Desai¹, Vatsal Desai¹, Shaikh Mohd Saquib²

¹ Students, Dept. of Civil Engineering, LIT – Sarigam, GTU – Ahmedabad, Gujarat, India

² Asst. professor, Dept. of Civil Engineering, GEC– Daman, GTU – Ahmedabad, Gujarat, India

Abstract--- *U-Boot beton deck slab is a modern technology which is used to create lightened two-way voided slabs in reinforced concrete structures. U-Boot beton is a box-like formwork structure which is made up of recycled polypropylene. The use of U-Boot beton helps in reducing the dead weight of the structure. This technology is light, quick and easy to position. It is an eco-friendly technology as it uses recycled materials and it does not emit any toxic substances. It also provides great resistance against fire. In this paper, we have designed a voided U-Boot beton Deck Slab. The main aim is to design and estimate the quantities of various items. The overall cost of constructing the U-Boot beton deck slab has also been determined.*

Keywords – *U-Boot beton, Voided, Slab, Hollow slab, Fire resistance*

I. INTRODUCTION

U-Boot Beton is a recycled polypropylene formwork that was designed to create two-way voided slabs. The U-Boot Beton formwork builds a grid work of mutually perpendicular beams in the concrete casting. These beams are closed from the bottom and the top by a flat plate that is created with a single casting. This results in considerable reduction in the use of concrete and steel. U-Boot Beton is used to create slabs with large span or that are able to support large loads without beams. This technology is light, quick and easy to position. Due to their modularity the designer can vary the geometric parameters as needed to adapt to all situations. This, in turn, gives great architectural freedom.

II. LITERATURE REVIEW

Extensive literature study has been carried out from national and international journals. These literatures are classified as journals, documents collected from web etc. Abstracts of some literature are included here for the review.

2.1 Study of U-Boot Technology in Construction by Ramvath Srikanth, Nampally Anil Kumar, Sandhyaveni Srinath, Chitta Anudeep, Snehalatha Bakshetty

In this paper, the authors have studied about the different properties, parts, sizes and types of U-Boot beton technology. There are mainly 2 types for arranging U-boot betons – Single U-Boot beton and Double U-Boot beton. Parts of U-Boot beton includes foots, U-Boot beton, Spacer joint, Connection bridge and Closing plate. Further the authors have also studied the concepts, advantages, applications and installation of U-Boot beton.

2.2 Modelling and analysis of flyover deck slab with U-Boot technology by Dr. H. Sudarsana Rao and M. Surya Prasanth

The authors have done modeling and analysis of Flyover Deck slab with U-Boot technology in this paper. For modeling of flyover the following components are assembled- Pile, Pile cap, Pier, Pier cap, Bed Block, Rocker and Pin Bearing, Deck Slab with U-Boot. The Project compares two types of flyover i.e., Flyover deck slab With U-Boot and Flyover deck slab without U-Boot. NX-Nastran software has been used for analyzing the model of Flyover Deck slab. The parameters such as maximum principal stress, maximum shear stress and displacements in deck slab have been given due consideration. The comparison of costs of concrete and steel has also been shown.

III. DESIGN METHODOLOGY

The Direct Design Method has been used for designing this slab system. In this method, total moment is calculated and then it is distributed to total negative moment and total positive moment. All the negative and positive moments are distributed in the column strips and middle strips respectively.

3.1 Limitations

Slab system designed by the direct design method should accomplish the following conditions:

- a) There shall be minimum of three continuous spans in each direction,
- 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 2.0
- c) It shall be permissible to offset columns to a maximum of 10 percent of the span in the direction of the offset notwithstanding the provision in (b)
- d) The successive span lengths in each direction shall not differ by more than one-third of the longer span. The end spans may be shorter but not longer than the interior spans, and
- e) The design live load shall not surpass three times the design dead load.

3.2 Total Design Moment

In the direct design method, the total design moment for a span shall be determined for a strip bounded laterally by the centre-line of the panel on each side of the centre-line of the supports. The absolute sum of the positive and negative bending moments in each direction shall be taken as:

$$M_0 = \frac{W L_n}{8}$$

Where,

M_0 = Total moment

W = Design load on the area $L_2 L_n$

L_n = Clear span extending from face to face of columns, capitals, brackets or walls but not less than $0.65 L_1$

L_1 = Length of span in the direction of M_0 ; and

L_2 = Length of span transverse to L_1

3.3 Negative and Positive Design Moments

The total design moment M_0 in a panel is to be distributed into negative moment and positive moment as specified below:

In an interior span

Negative Design Moment = $0.65 M_0$

Positive Design Moment = $0.35 M_0$

In an end span

Interior negative design moment:

$$0.75 - \frac{0.10}{1 + \frac{1}{\alpha c}}$$

Positive design moment:

$$0.63 - \frac{0.28}{1 + \frac{1}{\alpha c}}$$

Exterior negative design moment:

$$\frac{0.65}{1 + \frac{1}{\alpha c}}$$

where αc is the ratio of flexural stiffness of the exterior columns to the flexural stiffness of the slab at a joint taken in the direction moments are being determined and is given by

$$\alpha c = \frac{\sum Kc}{Ks}$$

Where,

Kc = Sum of the flexural stiffness of the columns meeting at the joint; and

Ks = Flexural stiffness of the slab, expressed as moment per unit rotation.

IV. PROBLEM STATEMENT AND LOAD CALCULATION

One of the most common components in modern building construction is reinforced concrete slab which consume a lot of concrete. Due to the sheer amount of concrete required to produce these slabs, the dead weight of these slabs tend to be very large. Lighter structures are more preferable to heavier structures in seismically active regions. In our project, we have discussed about the significance of U-Boot beton Deck slab over traditional conventional slab. U-Boot is a recycled polypropylene formwork technology which is used for construction purposes. The use of U-Boot beton helps to create light economical design for the structure. This technology is used to create slabs with large spans or to construct the slabs which support large loads without beams. This type of construction is suitable for high rise buildings, hospitals, parking facilities and for residential and industrial buildings. The most significant cost-effective, practical and operational advantages provided by U-Boot beton for the entire structure includes less use of reinforcement in slabs, columns and foundation up to a total of 15%, less concrete usage, reduced building weight, the architectural freedom of the structure and possibility of slimmer columns and foundations and thus lower cost related to excavation for foundations.

4.1 Structural Loads

The loads acting on the slab may be categorized as:

- Dead Load
- Live Load
- Floor Finish

4.1.1 Dead Loads

Dead Loads are those which are associated with the weight of the structure itself. These loads remain stationary and relatively constant over time.

Dead Load = Effective volume * Density of concrete * width

Effective volume = $0.0481 \times 6 = 0.288 \text{ m}^3$

Width = 1000mm

Density of concrete = 25 N/mm^2

Dead Load = 0.288×25

= 7.129 kN/m^2

4.1.2 Live Load

Live Loads which are also known as applied or imposed loads or variable actions may vary over time. Live load is assumed in accordance with IS 875 (Part-II) – 1987

Live load = 4 kN/m^2 | IS 875 (Part -2)

4.1.3 Floor Finish

Floor Finish = 1 kN/m^2 | IS 875 (Part –2)

V. MODELLING AND DESIGN

5.1 Model Data

- Size of Panel = 21m x 21m
- Size of Column = 400mm x 400mm
- Floor to floor height = 3 m
- $f_{ck} = 25 \text{ N/mm}^2$
- $f_y = 415 \text{ N/mm}^2$
- Dead Load = 7.219 kN/m
- Live Load = 4 kN/m
- Floor Finish = 1 kN/m

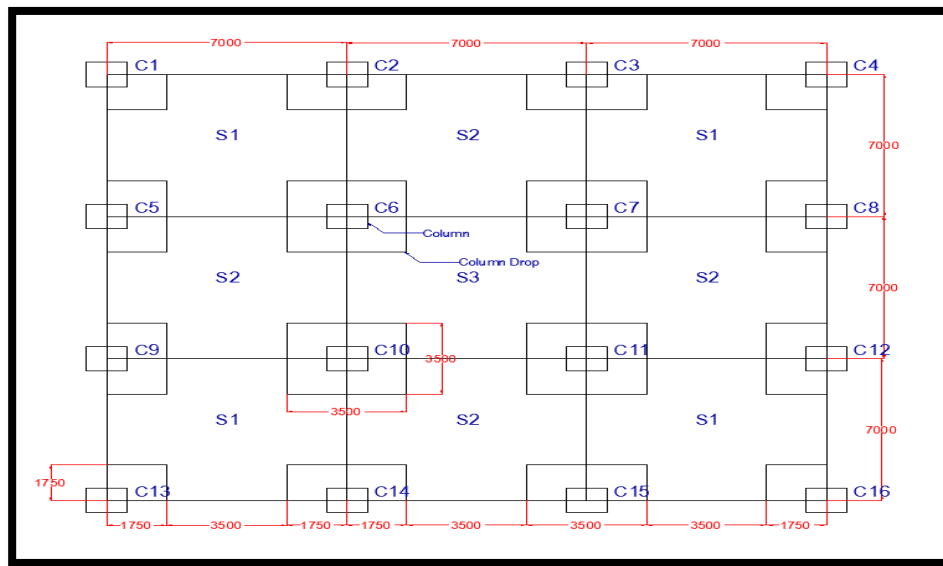


Figure 1: Structural Layout of the panel

1.2 Design of slab

Based on span and end conditions, the entire floor system can be grouped into 3 groups.

S1 = Corner Panel

S2 = Exterior Panel

S3 = Interior Panel

1.2.1 Design of Interior Panel (S3)

Reinforcement Details

$$A_{st \min} = \frac{0.12}{100} \times 1000 \times 225 = 270 \text{ mm}^2$$

$$D = 200 \text{ mm}^2$$

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1	-67.25	1045.2	12	100	1130.97
Zone 2	28.97	419.66	12	250	452.39
Zone 3	-22.42	321.22	12	300	376.99
Zone 4	19.31	275.48	12	400	282.74
Along Y					
Zone 1	-67.25	1045.2	12	100	1130.97
Zone 2	-22.42	419.66	12	300	376.99
Zone 3	28.97	321.22	12	250	452.39
Zone 4	19.31	275.48	12	400	282.74

Table 5.1: Reinforcement Details for Interior Panel

1.2.2 Design of Corner Panel (S1)

Effective depth of slab = 200 mm

Effective depth of drop = 200 + 100 = 300 mm

Reinforcement Details

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1 (exterior)	-26.07	375.89	12	300	376.99
Zone 1 (interior)	-72.59	1140.78	12	90	1256.63
Zone 2	40.92	604.91	12	180	628.31
Zone 3 (interior)	-24.19	347.80	12	300	376.99
Zone 4	27.27	394.07	12	280	403.91
Along Y					
Zone 1 (exterior)	-26.07	375.89	12	300	376.99
Zone 1 (interior)	-72.59	1140.78	12	90	1256.63
Zone 2 (interior)	-24.19	347.80	12	300	376.99
Zone 3	40.92	604.91	12	180	628.31
Zone 4	27.27	394.07	12	300	403.91

Table 5.2: Reinforcement Details for Corner Panel

1.2.3 Design of Exterior Panel (S2)

Reinforcement Details

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1 (exterior)	-38.63	568.87	12	180	628.31
Zone 1 (interior)	-71.66	1123.94	12	100	1130.97
Zone 2	38.83	572.03	12	180	628.31
Zone 3 (interior)	-23.88	343.17	12	300	376.99
Zone 4	25.89	373.17	12	300	376.99
Along Y					
Zone 1 (exterior)	-38.63	568.87	12	180	628.31
Zone 1 (interior)	-71.66	1123.94	12	100	1130.973
Zone 2 (interior)	-23.88	343.17	12	300	376.99
Zone 3	38.83	572.03	12	180	628.31
Zone 4	25.89	373.17	12	300	376.991

Table 5.3: Reinforcement Details for Exterior Panel

VI. ESTIMATION AND COSTING

6.1 Estimating the quantities of various items of work

6.1.1 Quantity of Concrete:

Volume of Concrete = $L \times B \times H = 21 \times 21 \times 0.225 = 99.225 \text{ m}^3$

Volume of bubble = $0.52 \times 0.52 \times 0.178 = 0.0481 \text{ m}^3$

For 1296 bubble Volume = 62.33 m^3

Volume of Drop panel = $3.5 \times 3.5 \times 0.1 = 1.225 \text{ m}^3$

Volume of Concrete required = $99.225 - 62.33 + 1.225 = 38.12 \text{ m}^3$

6.1.2 Shuttering:

Shuttering = 21×21
 $= 441 \text{ m}^2$

6.1.3 Weight of steel: The weight of steel has been calculated in the following categories:

- a) Exterior Panel Bottom Steel
- b) Exterior Panel Top Steel
- c) Interior Panel Bottom Steel
- d) Interior Panel Top Steel
- e) Corner Panel Bottom Steel
- f) Corner Panel Top Steel

$$\begin{aligned}\text{Total Steel Required} &= 1457.49 + 406.97 + 355.94 + 45.02 + 1014.12 + 254.73 \\ &= 3534.27 \text{ kg}\end{aligned}$$

6.2 Rate Analysis:

The following table shows the total amount which will be required for construction of U-Boot beton Deck slab.

Sr. No.	Description	Quantity	Rate	Per	Amount
1.	Concrete	38.12 m ³	4300	m ³	Rs. 1,63,916
2.	Shuttering work (material and labor)	441	450	m ²	Rs. 1,98,450
3.	Reinforcement	3534.27 kg	45	kg	Rs. 1,59,042
4.	U-Boot	1296	8.5	Nos.	Rs. 11,016
5.	Labor for cutting, bending and tying reinforcement	3534.27	8	kg	Rs. 28,275
6.	Labor for laying of concrete	38.12 m ³	200	m ³	Rs. 7,624
	Total				Rs. 5,68,323

Table 6.1: Rate Analysis

VII. CONCLUSION

Based on our study regarding U-Boot beton Deck slab system, the following conclusions can be made:

- The U-boot technology is an advanced, economical, eco-friendly and fastest method of construction of slab.
- This technology provides great resistance against fire.
- It provides good architectural freedom due to its innovative shape.
- It is an eco-friendly product due to the lack of dangerous substances in its composition and due to the lack of emissivity of toxic substances.
- It requires skilled labours.
- It helps in saving of cost by using U-Boot in the slab.

VIII. REFERENCES

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