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Formulation of Load Chart Table for Precast Prestressed Double Tee Slab

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Abstract

The increasing demand for office buildings, shopping malls, industrial facilities, and residential structures underscores the necessity for rapid construction systems. Among these, precast concrete structures have gained traction in the construction industry, with beam-to-column/wall connections playing a crucial role. Precast prestressed T-slabs, primarily used as floor slab elements, offer advantages such as longer spans (up to 12 m to 15 m) and simplified construction processes due to their one-way slab configuration. The utilization of these T-slabs eliminates the need for formwork, resulting in significant time savings. Recent construction projects have embraced innovative methods to expedite construction timelines and enhance efficiency. The precast concrete approach facilitates efficient construction management by leveraging standardized, high-quality components manufactured in factories and assembled on-site. Double tee slabs, extensively employed in building construction due to their simplicity and cost-effectiveness, undergo design considerations for live load chart table development. This table provides direct live load values for various section configurations, spans, and strand arrangements with differing diameters. The abstract succinctly outlines the paper's content, encompassing the undertaken work, results, and conclusions, aiding potential readers in determining the relevance of the full paper. Adherence to formatting guidelines ensures uniformity and readability, essential for the publication process.

Keywords: Double Tee, Double Tee Slab, Precast concrete, Structural engineering, Reinforced concrete, Construction materials, Bridge construction, Floor systems, Span-to-depth ratio, Load-bearing capacity

INTRODUCTION

Recent construction projects have increasingly adopted various improved methods to expedite construction timelines and enhance efficiency. Particularly in the construction of apartment underground parking lots, reinforced concrete structures, primarily composed of rebar work and formwork, are commonly utilized. The construction of these parking lots significantly impacts the overall construction schedule, serving as both workspace for rebar installation for ground-level structures and storage areas for finishing materials. However, reinforced concrete structures suffer from low construction efficiency, often leading to delays due to the extensive use of temporary materials and wooden formwork. Consequently, there is a growing demand for solutions to improve underground parking lot structures and address these challenges [1–5].

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The adoption of precast concrete methods has gradually increased to meet this need. Prestressed concrete techniques offer efficient construction management by shortening construction periods and reducing labor costs, as standardized, high-quality components are manufactured in factories and assembled on-site. Since its development in the mid-1900s, precast concrete has evolved and gained widespread usage due to its superior constructability and productivity compared to traditional reinforced concrete methods.

However, in many cases involving the construction of retaining walls, the precast concrete method is combined with reinforced concrete processes. This hybrid approach often results in various defects, such as frequent cracking at joints, highlighting the need for further improvements in construction techniques.

Precast Concrete

Pre-cast concrete is a building material created by pouring concrete into a mold that can be used multiple times. After pouring, it undergoes controlled curing in an environment conducive to proper setting before being transported to the construction site for installation. This method differs from traditional concrete pouring, where concrete is poured directly into forms at the construction site and cured on-site. Additionally, precast stone is a variation of precast concrete that incorporates fine aggregates into the mixture, resulting in a final product that closely resembles natural rock or stone in appearance.

Pre-cast concrete stands as a construction element crafted through the casting of concrete in a reusable mold, subsequently undergoing controlled curing in a designated environment, and then transported to the construction site where it is positioned into place. In contrast, conventional concrete is poured into forms tailored to the site's specifications and cured directly on-site. Distinguishing precast stone from precast concrete lies in its incorporation of fine aggregates within the mixture, aiming to achieve a final product closely resembling natural rock or stone in appearance (Figure 1) [6, 7].

Precast Concrete Slab

Precast concrete floor systems offer a versatile range of products suitable for various construction needs, including hollow core slabs, solid slabs, double tees, and inverted tee/rectangular/L-shaped beams. These components can also be combined with steel beams and cast-in-place concrete topping in specific applications to meet specific design requirements.

Figure 1. Precast concrete component-1 (Magic breeze, Hyderabad)

Prestressed floor slabs or ribbed slabs are commonly preferred for a wide range of structural engineering projects, including residential and industrial buildings, hotels, multi-storey car parks, and supermarkets. These slabs typically feature span widths ranging from 8 to 13 meters. The various precast concrete slab systems available include:

- *Solid flat slab:* Suitable for spans up to 8 meters.
- *Hollow core slab:* Designed for spans ranging from 12 to 15 meters.
- *Single tee slab:* Capable of spanning between 20 to 22 meters.
- *Double tee slab:* Ideal for spans extending from 25 to 30 meters.

These options provide flexibility in design and construction, catering to diverse project requirements.

Double Tee Slab

Double Tee slabs are comprised of two beams symmetrically aligned and interacting with a slab, resulting in a section featuring a double tee shape. These slabs are constructed using precast, prestressed concrete. These slabs are manufactured on long line casting beds typically ranging from 100 m to 150 m in length. Bulkheads are utilized to create the necessary lengths of double tees for specific projects. Prior to concrete placement, prestressing strands, steel reinforcement, and connection hardware are positioned within the formwork to accommodate individual slab requirements.

Double tee slabs find extensive applications in various settings requiring long-span floor or roof systems, typically spanning from 8 m to 25 + m, or where additional load carrying capacity is necessary. These slabs offer resistance to moisture and corrosion, making them suitable for a wide range of applications including parking garages, office buildings, commercial structures, gymnasiums, pool roofs, food processing plants, paper mills, industrial facilities, sewage and water treatment plants, among others.

Moreover, these slabs have the capability to be cantilevered at one or both ends for a distance of up to four times the depth of the slab. The development of load chart tables aids in the design process of precast prestressed T-slab sections by providing valuable information regarding span length and loading conditions.

OBJECTIVES

1. To develop load chart table for precast pre-stressed double tee slab.
2. To carry out comparison between conventional and precast pre-stressed double tee slab design and construction.

LITERATURE REVIEW

This section provides an overview of various studies focusing on the behavioral analysis of precast concrete structures with fixity at different levels. Additionally, it summarizes the analysis and design of double tee slabs and the preparation of design charts for different spans [8].

A study devised a streamlined numerical method for analyzing the nonlinear material and geometric aspects of reinforced and prestressed concrete slabs and panels. This approach comprehensively accounts for multiple time-dependent factors including load history, temperature variations, creep, shrinkage, and concrete aging, while also addressing prestress relaxation [9].

Another investigation explored the dynamic response and fatigue behavior of prestressed concrete waffle slabs, highlighting the advantages of prestressing in enhancing natural frequencies and increasing fatigue life. The study also examined the influence of skew and aspect ratio on the natural frequencies of such structures [10].

Experimental work focused on the behavior of prestressed composite steel-concrete girders, demonstrating the effectiveness of prestressing in increasing stiffness, enlarging the elastic range, and enhancing ultimate capacity, particularly in the negative moment region.

Shear capacity analysis of prestressed hollow core slabs revealed the importance of accounting for additional shear stresses induced by prestressing tendons. The study emphasized the need to consider prestress effects in shear design, especially in prestressed hollow core slabs [11].

Numerical modeling efforts aimed to analyze prestressed members with bonded and unbonded tendons, highlighting the significance of accurate curvature distributions and effective stress evaluation in predicting structural behavior. Load testing on deteriorated structures provided insights into their live-load behavior and helped develop moment and shear distribution factor equations for double tee bridges [12].

Investigation into rehabilitation strategies for the longitudinal joint of double-tee bridges resulted in the proposal of alternative approaches designed to meet contemporary code standards and enhance structural integrity [13]. Anchorage systems for prestressed basalt FRP grids were proposed and tested on strengthened hollow-core slabs, demonstrating increased flexural capacity and improved crack control with prestressing [14].

A systematic process for integrating precast concrete double wall systems into construction practices was outlined, focusing on joint integrity and streamlined construction management processes.

DESIGN SPECIFICATIONS

Parking structures heavily rely on double tees as the primary structural framework. These double tees often come in standard lengths, typically exceeding 152 meters, which can be tailored to fit specific project requirements. Due to their efficiency in production and overall project scheduling, designs incorporating double tees are often prioritized, allowing for swift commencement of production before other elevation and member designs.

One notable advantage of precast concrete double-tee construction is its rapid pace compared to alternative systems. The width of standard double tees can be adjusted by blocking out most of the flange overhangs. These tees typically range in depth from 460 mm to approximately. At the top, the stem width typically measures around 250 mm, tapering down to approximately 150 mm at the bottom.

In parking structures, it's common to utilize double tees with lengths around 18 meters to maintain spacious open areas for drive aisles and two sets of parking stalls. These open spaces are favored by both owners and patrons for their functional, aesthetic, and security benefits.

To ensure structural integrity, the design live load for double tees in parking structures is commonly specified as 2 kN/m² or a concentrated 14 kN wheel load distributed over an area of 114 mm × 114 mm. Moreover, it's crucial to account for snow and snow drift loads, as well as potential ponding, especially in regions with specific roof conditions.

Double-tee floor decks often serve as lateral diaphragms in parking structures. As a result, the design of double-tee flange joints needs to integrate sturdy diaphragm connections that can effectively transfer lateral forces from seismic or wind loads, along with vertical shear, all while accommodating joint displacement.

It is imperative that the design and detailing of these double-tee connections and joints account for induced stresses from traffic exposure and volume changes to ensure optimal long-term performance.

RESULT AND DISCUSSION

Load Chart Table

In present work design of precast pre-stressed double tee slab is carried out manually. Load chart table are prepared for various sections, spans and no of strands with different diameter with without topping. Results are given below Tables 1-10.

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Double Tee Slab of 2400 mm × 800 mm

Section properties: B =2400 mm; Grade of prestressing strand = 1860 N/mm^2; D =800 mm; Self-Wt. of DTS per m^2 = 4.375 KN/m^2

Cover = 50 mm

Ixx = 27.802 × 109 mm^4 Y= 490 mm

yt = 310 mm

Zt = 89683870.97 mm^3

Zb =56738775.51 mm^3; Aps = 74.2 mm^2

Table 1. Load chart table without topping.

B=2400 mm	**D=800 mm**	**DTS**		**No topping**					
Strand pattern	***Moment***	***Span(m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–11.1 mm	Qsls	12.7	7.48	4.34	2.3	0.96			
	Msls	512.22	512.22	512.22	512.22	512.22			
	Camber	2.82	4.14	5.8	7.76	10.12			
10–11.1 mm	Qsls	15.55	9.46	5.8	3.41	1.78	0.6		
	Msls	597.67	597.67	597.67	597.67	597.67	597.67		
	Camber	3	4.3	6	8.03	10.47	13.33		
12-11.1 mm	Qsls	18.4	11.44	7.24	4.52	2.65	1.32		
	Msls	683.1	683.1	683.1	683.1	683.1	683.1		
	Camber	3.03	4.44	6.2	8.3	10.8	13.74		
14–11.1 mm	Qsls	21.24	13.42	8.7	5.63	3.53	2.03	1	
	Msls	768.55	768.55	768.55	768.55	768.55	768.55	768.55	
	Camber	3.13	4.6	6.4	8.56	11.14	14.17	17.2	
16–11.1 mm	Qsls		15.4	10.15	6.75	4.41	2.74	1.51	
	Msls		854	854	854	854	854	854	
	Camber		4.8	6.6	8.83	11.5	14.57	17.3	
18–11.1 mm	Qsls		17.4	11.6	7.86	5.3	3.45	2.1	1.06
	Msls		940	940	940	940	940	940	940
	Camber		5	6.81	9.1	11.83	15	18.72	23

For a Given Section by Changing Parameters like Strands Diameter with 50 mm Topping Caculation are Done as Shown in Table.

Topping thickness = 50 mm; Self-Weight of topping = 1.25 KN/m^2

Table 2. Load chart table with 50 mm topping.

B=2400 mm		**D=800 mm**		**DTS**	**With 50 mm topping**			
Strand pattern	***Moment***	***Span(m)***						
		10	*12*	*14*	*16*	*18*	*20*	*22*
8–11.1 mm	Qsls	13.64	7.43	3.68	1.25			
	Msls	409.12	320.68	216.16	95.56			
	Ms	577.87	563.68	546.91	527.56			
	Camber	2.82	4.14	5.8	7.76			
10–11.1 mm	Qsls	17.03	9.78	5.41	2.57	0.63		
	Msls	510.9	422.46	317.93	197.33	60.65		
	Ms	679.65	665.46	648.68	629.33	607.4		
	Camber	2.93	4.3	6	8.03	10.47		

12–11.1 mm	Qsls	20.42	12.13	7.14	3.9	1.67		
	Msls	612.67	524.22	419.7	300	162.42		
	Ms	781.42	767.22	750.45	732	709.17		
	Camber	3.03	4.44	6.19	8.29	10.8		
14–11.1 mm	Qsls	23.82	14.5	8.87	5.22	2.72	1	
	Msls	714.44	626	521.48	400	264.2	111.43	
	Ms	883.2	869	852.23	832	811	786.43	
	Camber	3.13	4.6	6.4	8.56	11.14	14.17	
16–11.1 mm	Qsls		16.85	10.6	6.55	3.77	1.78	
	Msls		727.77	623.24	502.64	366	213.2	
	Ms		970.77	954	934.64	912.7	888.2	
	Camber		4.75	6.6	8.83	11.5	14.6	
18–11.1 mm	Qsls		19.2	12.33	7.87	4.81	2.63	1.01
	Msls		829.54	725	604.42	467.73	314.97	146.13
	Ms		1072.54	1055.75	1036.42	1014.5	990	963
	Camber		5	6.81	9.1	11.83	15	18.72

For a Given Section by Changing Parameters like Topping Caculation are Done as Shown in Table

Grade of prestressing strands = 1860 N/mm^2; Diameter of prestressing strand = 12.7 mm

Area of prestressing strands (Aps)= 98.7 mm^2

Table 3. Load chart table without topping.

B=2400 mm	**D=800 mm**	**DTS**		**No topping**				
Strand pattern	***Moment***	***Span(m)***						
		10	*12*	*14*	*16*	*18*	*20*	*22*
8–12.7 mm	Qsls	16.46	10.1	6.25	3.76	2.05	0.83	
	Msls	625.08	625.08	625.08	625.08	625.08	625.08	
	Camber	2.96	4.34	6.05	8.12	10.57	13.46	
10–12.7 mm	Qsls	20.25	12.73	8.19	5.25	3.23	1.78	0.71
	Msls	738.73	738.73	738.73	738.73	738.73	738.73	738.73
	Camber	3.09	4.54	6.33	8.47	11.03	14.02	17.5
12–12.7 mm	Qsls	24.05	15.35	10.12	6.73	4.4	2.73	1.5
	Msls	852.38	852.38	852.38	852.38	852.38	852.38	852.38
	Camber	3.23	4.75	6.6	8.83	11.47	14.58	18.18
14–12.7 mm	Qsls	26.62	17.15	11.44	7.73	5.19	3.38	2.03
	Msls	930	930	930	930	930	930	930
	Camber	3.48	5.09	7.06	9.42	12.25	15.51	19.34
16–12.7 mm	Qsls		19.66	13.28	9.15	6.31	4.28	2.78
	Msls		1038.38	1038.38	1038.38	1038.38	1038.38	1038.38
	Camber		5.3	7.36	9.82	12.74	16.14	20.06
18–12.7 mm	Qsls		22.18	15.13	10.56	7.43	5.18	3.53
	Msls		1146.88	1146.88	1146.88	1146.88	1146.88	1146.88
	Camber		5.52	7.66	10.22	13.24	16.75	20.81

For a Given Section by Changing Parameters like Strands Diameter Without Topping Caculation are Done as Shown in Table

Grade of prestressing strands = 1860 N/mm^2

Diameter of prestressing strand = 15.2 mm

Area of prestressing strands (Aps) = 140 mm

No. of strands	Eccentricity
8, 10, 12	415 mm
14, 16, 18	390 mm
20, 22, 24	365 mm

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Table 4. Load chart able without topping.

B=2400 mm	**D=800 mm**	**DTS**		**No topping**					
Strand pattern	***Moment***	***Span(m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–15.2 mm	Qsls	22.8	14.5	9.5	6.24	4.01	2.42	1.24	
	Msls	815.29	815.29	815.29	815.29	815.29	815.29	815.29	
	Camber	6.04	7.6	8.54	8.47	6.84	3.13	-3.34	
10–15.2 mm	Qsls		18.23	12.23	8.34	5.67	3.76	2.35	1.28
	Msls		976.5	976.5	976.5	976.5	976.5	976.5	976.5
	Camber		10.4	12.36	13.45	13.16	10.92	6.1	-2.1
12–15.2 mm	Qsls		22	15	10.44	7.33	5.1	3.46	2.21
	Msls		1137.7	1137.7	1137.7	1137.7	1137.7	1137.7	1137.7
	Camber		13.2	16.18	18.44	19.47	18.71	15.52	9.18
14–15.2 mm	Qsls			16.84	11.87	8.46	6.02	4.22	2.85
	Msls			1230	1230	1230	1230	1230	1230
	Camber			18.38	21.32	23.12	23.21	20.97	15.67
16–15.2 mm	Qsls			19.46	13.88	10.05	7.3	5.28	3.74
	Msls			1401.53	1401.53	1401.53	1401.53	1401.53	1401.53
	Camber			21.97	26.01	29.05	30.54	29.83	26.21
18–15.2 mm	Qsls				15.88	11.63	8.6	6.34	4.63
	Msls				1555.41	1555.41	1555.41	1555.41	1555.41
	Camber				30.7	35	37.8	38.7	36.75

For a Given Section by Changing Parameters like Strands Diameter with 50 mm Topping Caculation are Done as Shown in Table.

Topping thickness = 50 mm; Self weight of topping = 125 KN/m^2

Aps = 140 mm^2

Table 5. Strands diameter with 50 mm topping.

B=2400 mm	**D=800 mm**	**DTS**		**With 50 mm topping**					
Strand pattern	***Moment***	***Span(m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–15.2 mm	Qsls	25.67	15.78	9.82	5.94	3.29	1.39		
	Msls	770.11	682	577.15	456.55	319.87	167.1		
	Ms	938.9	924.67	907.9	888.55	866.62	842.1		
	Camber	3.19	4.68	6.51	8.71	11.34	14.4		
10–15.2 mm	Qsls		20.23	13.08	8.45	5.27	3	1.31	
	Msls		873.7	769.17	648.57	511.88	359.12	190.28	
	Ms		1116.7	1100	1080.57	1058.63	1034.12	1007.03	
	Camber		5	6.9	9.22	12	15.17	18.93	
12–15.2 mm	Qsls		24.7	16.35	11	7.24	4.6	2.63	1.14
	Msls		1065.71	961.2	840.6	704	551.46	382.3	197.37
	Ms		1308.71	1292	1272.6	1250.65	1226.14	1200	1170
	Camber		5.25	7.28	9.72	12.6	16	19.9	24.36
14–15.2 mm	Qsls			18.58	12.65	8.59	5.68	3.53	1.9
	Msls			1092.14	971.54	834.86	682.07	513.25	328.3
	Ms			1420	1403.54	1381.61	1357.1	1330	1300
	Camber			8	10.58	13.7	17.32	21.5	26.3

16–15.2 mm	Qsls			21.7	15.04	10.48	7.21	4.8	2.96
	Msls			1275.44	1154.84	1018.15	865.4	697	511.62
	Ms			1606.2	1586.84	1564.9	1540.4	1513.75	1483.62
	Camber			8.37	11.13	14.4	18.19	22.54	27.58
18–15.2 mm	Qsls				17.43	12.36	8.74	6.06	4.02
	Msls				1338.13	1201.45	1048.7	880	695
	Ms				1770.13	1748.2	1723.7	1697	1667
	Camber				11.7	15.11	19.04	23.6	28.8

Double Tee Slab of 3000 mm × 900 mm

Section properties: B =3000 mm; Grade of prestressing strand = 1860 N/mm^2; D =900 m; Self-Wt. of DTS per m^2 = 4.8 KN/m^2

Cover = 50 mm

I_{XX} = 4.81 × 10^{10} mm^4 Y_b= Y= 543 mm

y_t = 310 mm

Z_t = 1.34 × 10^8 mm^3

Z_b =88627885 mm^3; A_{ps} = 74.2 mm^2

No. of strands	Eccentricity
8 , 10 , 12 .	465 mm
14 , 16 , 18 .	440 mm
20 , 22 , 24 .	415 mm

Table 6. Load chart table without topping.

B=3000 mm		**D=900 mm**		**DTS**		**No Topping**		
Strand pattern	***Moment***	***Span(m)***						
		10	*12*	*14*	*16*	*18*	*20*	*22*
8–11.1 mm	Qsls	12.55	7.25	4.06	1.98	0.56		
	Msls	650.4	650.4	650.4	650.4	650.4		
	Camber	1.3	0.97	-0.09	-2.24	-6		
10–11.1 mm	Qsls	15.12	9.03	5.37	3	1.35		
	Msls	746.54	746.54	746.54	746.54	746.54		
	Camber	2	1.94	1.23	-0.53	-3.73		
12–11.1 mm	Qsls		10.81	6.67	4	2.14	0.83	
	Msls		842.66	842.66	842.66	842.66	842.66	
	Camber		3	2.54	1.2	-1.54	-6.14	
14–11.1 mm	Qsls		12.06	7.61	4.7	2.71	1.29	
	Msls		911.63	911.63	911.63	911.63	911.63	
	Camber		3.5	3.36	2.25	-0.21	-4.5	
16–11.1 mm	Qsls		13.8	8.87	5.67	3.47	1.9	
	Msls		1004	1004	1004	1004	1004	
	Camber		4.41	4.6	3.87	1.84	-2	
18–11.1 mm	Qsls		15.51	10.12	6.63	4.23	2.52	1.25
	Msls		1096.12	1096.12	1096.12	1096.12	1096.12	1096.12
	Camber		5.32	5.84	5.5	3.9	0.6	-4.9
20–11.1 mm	Qsls		16.5	10.85	7.18	4.67	2.87	1.54
	Msls		1150	1150	1150	1150	1150	1150
	Camber		5.72	6.37	6.2	4.68	1.68	-3.6

For a Given Section by Changing Parameters like Strands Diameter without Topping Caculation are Done as Shown in Table.

Grade of prestressing strands = 1860 N/mm^2

Diameter of prestressing strand = 12.7 mm

Area of prestressing strands (Aps) = 98.7 mm^2

Table 7. Load chart table without topping.

B=3000 mm	**D=900 mm**	**DTS**	**No topping**						
Strand pattern	***Moment***	***Span (m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–12.7 mm	Qsls	16	9.6	5.78	3.31	1.61			
	Msls	774.4	774.4	774.4	774.4	774.4			
	Camber	2.17	2.25	1.65	0	-3.04			
10–12.7 mm	Qsls	19.35	12	7.52	4.64	2.66	1.24		
	Msls	905.25	905.25	905.25	905.25	905.25	905.25		
	Camber	3.06	3.53	3.4	2.3	-0.15	-4.4		
12–12.7 mm	Qsls		14.34	9.26	6	3.71	2.1	1	
	Msls		1033.12	1033.12	1033.12	1033.12	1033.12	1033.12	
	Camber		4.81	5.14	4.6	2.73	-0.84	-6.7	
14–12.7 mm	Qsls		16.04	10.51	7	4.47	2.71	1.41	
	Msls		1124.85	1124.85	1124.85	1124.85	1124.85	1124.85	
	Camber		5.61	6.22	6	4.53	1.38	-4	
16–12.7 mm	Qsls		18.31	12.18	8.2	5.48	3.53	2.08	0.98
	Msls		1247.56	1247.56	1247.56	1247.56	1247.56	1247.56	1247.56
	Camber		6.82	7.87	8.16	7.26	4.75	0.11	-7.23
18–12.7 mm	Qsls			13.9	9.5	6.5	4.34	2.76	1.55
	Msls			1370.3	1370.3	1370.3	1370.3	1370.3	1370.3
	Camber			9.52	10.3	10	8.11	4.18	-2.4
20–12.7 mm	Qsls			14.7	10.11	7	4.75	3.1	1.83
	Msls			1431.02	1431.02	1431.02	1431.02	1431.02	1431.02
	Camber			10.05	11	10.85	9.2	5.5	-0.83

For a Given Section by Changing Parameters like Strands Diameter with 50 mm Topping Caculation are Done as Shown in Table.

Topping thickness = 50 mm; Self-weight of topping = 1.25 KN/m^2; Aps = 98.7 mm^2

Table 8. Load chart table with 50 mm topping.

B=3000 mm	**D=900 mm**	**DTS**	**With 50 mm topping**					
Stran pattern	***Moment***	***Span (m)***						
		10	*12*	*14*	*16*	*18*	*20*	*22*
8–12.7 mm	Qsls	17.38	10	5.37	2.43	0.42		
	Msls	652	534	394.5	233.6	145		
	Ms	878.6	860.25	838.6	813.6	790		
	Camber	2.5	3.7	5.1	6.82	7.8		
10–12.7 mm	Qsls	21.42	12.7	7.43	4.01	1.67		
	Msls	803.23	685.25	545.82	385	202.61		
	Ms	1030	1011.5	990	965	936.7		
	Camber	2.6	3.8	5.27	7.04	9.16		
12–12.7 mm	Qsls		15.5	9.5	5.6	2.91	1	
	Msls		836.6	698	536.3	354	150.15	
	Ms		1163	1141.21	1116.27	1088.1	1056.4	
	Camber		4	5.43	7.3	9 .45	12	
14–12.7 mm	Qsls		17.5	11	6.72	3.81	1.72	
	Msls		945.15	805.72	644.83	462.5	258.72	

	Ms		1271.4	1250	1224.83	1196.6	1165	
	Camber		4.13	5.73	7.64	10	12.57	
16–12.7 mm	Qsls		20.19	12.94	8.23	5	2.7	0.98
	Msls		1090.4	951	790	607.73	404	178.71
	Ms		1410	1395.1	1370	1341.8	1310.25	1275.3
	Camber		4.27	6	7.88	10.23	13	16.11
18–12.7 mm	Qsls			14.91	9.74	6.2	3.66	1.78
	Msls			1096.2	935.3	753	549.2	324
	Ms			1540.3	1515.3	1487.06	1455.5	1420.6
	Camber			6.11	8.16	10.55	13.35	16.6
20–12.7 mm	Qsls			15.9	10.5	6.8	4.14	2.18
	Msls			1168.06	1007.2	824.85	621.06	396
	Ms			1612.12	1587.2	1559	1527.31	1492.6
	Camber			6.5	8.63	11.2	14.13	17.53

For a Given Section by Changing Parameters like Strands Diameter without Topping Calculation are Done as Shown in Table.

Grade of prestressing strands = 1860 N/mm^2
Diameter of prestressing strand = 12.7 mm
Area of prestressing strands (Aps) = 98.7 mm^2

No. of strands	Eccentricity
8 , 10 , 12 .	465 mm
14 , 16 , 18 .	440 mm
20 , 22 , 24 .	410 mm

Table 9. Load chart table without topping.

B=3000 mm	**D=900 mm**		**DTS**		**No topping**				
Strand pattern	***Moment***	***Span(m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–15.2 mm	Qsls	21.65	13.6	8.7	5.54	3.37	1.82	0.67	
	Msls	991.4	991.4	991.4	991.4	991.4	991.4	991.4	
	Camber	3.66	4.4	4.57	3.84	1.8	-2	-8.06	
10–15.2 mm	Qsls		16.93	11.16	7.42	4.86	3.03	1.67	0.64
	Msls		1172.76	1172.76	1172.76	1172.76	1172.76	1172.76	1172.76
	Camber		6.21	7.04	7.07	5.88	3.05	-1.95	-9.68
12–15.2 mm	Qsls		20.3	13.63	9.31	6.35	4.24	2.67	1.48
	Msls		1354.14	1354.14	1354.14	1354.14	1354.14	1354.14	1354.14
	Camber		8.03	9.51	10.3	10	8.1	4.16	-2.41
14–15.2 mm	Qsls		22.7	15.4	10.67	7.42	5.1	3.4	2.08
	Msls		1484.25	1484.25	1484.25	1484.2	1484.25	1484.25	1484.25
	Camber		9.16	11.06	12.31	12.52	11.24	8	2.13
16–15.2 mm	Qsls			17.8	12.48	8.89	6.26	4.34	2.89
	Msls			1658.3	1658.3	1658.3	1658.3	1658.3	1658.3
	Camber			13.4	15.37	16.4	16.02	13.75	9.01
18–15.2 mm	Qsls			20.14	14.3	10.3	7.42	5.3	3.7
	Msls			1832.35	1832.35	1832.35	1832.35	1832.35	1832.35
	Camber			15.75	18.43	20.26	20.8	19.53	15.9
20–15.2 mm	Qsls			21.31	15.2	11	8	5.78	4.09
	Msls			1918.52	1918.52	1918.52	1918.52	1918.52	1918.52
	Camber			16.48	19.4	21.5	22.32	21.37	18.08

For a Given Section by Changing Parameters like Strands Diameter with 50 mm Topping Caculation are Done as Shown in Table

Table 10. Load chart table with 50 mm topping.

B=3000 mm	D=900 mm	DTS	With 50 mm Topping						
Strand pattern	***Moment***	***Span(m)***							
		10	*12*	*14*	*16*	*18*	*20*	*22*	*24*
8–15.2 mm	Qsls	24.14	14.6	8.81	5.07	2.51	0.67		
	Msls	905.17	787.2	647.8	486.87	304.54	100.76		
	Ms	1131.73	1113.45	1092	1066.87	1038.6	1007		
	Camber	2.64	3.87	5.38	7.2	9.35	11.9		
10–15.2 mm	Qsls		18.55	11.73	7.31	4.27	2.1	0.5	
	Msls		1001.84	862.42	701.53	519.2	315.42	90.19	
	Ms		1328.1	1306.48	1281.53	1253.26	1221.67	1186.75	
	Camber		4.05	5.63	7.51	9.76	12.37	15.41	
12–15.2 mm	Qsls		22.53	14.65	9.54	6.04	3.53	1.68	
	Msls		1216.5	1077.07	916.2	733.9	530	304.84	
	Ms		1542.8	1521.13	1496.2	1468	1436.4	1401.4	
	Camber		4.23	5.87	7.83	10.16	12.87	16.02	
14–15.2 mm	Qsls			16.75	11.15	7.31	4.56	2.53	0.98
	Msls			1231.06	1070.17	887.94	684.06	458.83	212.14
	Ms			1675.12	1650.17	1622	1590.31	1555.4	1517.14
	Camber			6.27	8.37	10.83	13.7	17.01	20.85
16–15.2 mm	Qsls			19.55	13.3	9	5.93	3.66	1.94
	Msls			1437.05	1276.16	1093.83	890.05	664.82	418.13
	Ms			1881.11	1856.16	1828	1796.3	1761.4	1723.13
	Camber			6.54	8.71	11.28	14.25	17.68	21.63
18–15.2 mm	Qsls			22.35	15.44	10.7	7.31	4.8	2.89
	Msls			1643.04	1482.15	1300	1096.04	870.81	624.12
	Ms			2087.1	2062.15	2034	2002.3	1967.4	1929.12
	Camber			6.81	9.06	11.71	14.8	18.33	22.41
20–15.2 mm	Qsls			23.74	16.5	11.54	8	5.36	3.36
	Msls			1745.02	1584.13	1401.8	1198.02	972.78	726.1
	Ms			2189.08	2164.13	2135.86	2104.27	2069.34	2031

CONCLUSIONS

In the current study, the manual design of precast prestressed double tee slabs was undertaken. Load charts were meticulously prepared, considering various sections, spans, and the number of strands with different diameters, both with and without topping. Based on the results obtained, several noteworthy conclusions can be drawn:

- The stability of the double tee during storage, transport, and erection stands out as a significant advantage compared to single tees and other similar members with single stems and wide flanges.
- The dual functionality of the top flange, serving as both the floor/ceiling and compression side of flexural resistance, coupled with the tensile strength and shear resistance provided by the stems, underscores the structural and functional efficiency of the double tee.
- The width of the top flange is pivotal for structural efficiency, as a narrower flange requires fewer precast concrete components, resulting in fewer connections. This reduction minimizes production, handling, transport, and erection expenses. Concrete strength at the time of prestress transfer is rarely a controlling factor in service, owing to the wide top flange. However, considerations regarding concrete release strength in the narrow stems become pertinent.

- Increasing the diameter of strands can significantly enhance load capacity, provided there is adequate concrete release strength.
- Enhanced prestress force for a given section size improves span capability, minimizes cracking, and boosts member durability.
- Increasing the prestress force can improve the load capacity, but it might lead to the need for higher concrete strength during prestress release, potentially impacting camber, deflection, and vibration characteristics. Double tees can have span lengths reaching approximately 100 feet (30 meters). The utilization of ultra-high-performance concrete may not substantially affect capacity under full service loads due to the broad top flange. However, increased concrete strength at prestress release enables more prestressing, indirectly improving service-load capacity.

In Terms of Future Prospects

Further exploration into variations in tee slab depth, alternative shapes such as a pi girder, and incorporation of openings in the double tee web section warrants attention. In regions where Indian Standards code lacks design load charts, the developed load chart from this study can serve as an effective resource.

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