STRUCTURAL BEHAVIOUR OF PRESTRESSED BOX GIRDER BRIDGE WITH VARIATION OF SLENDERNESS RATIO

Amogh Mishra[1], R.C.Singh[2]

[1]PG Student, ,*Department Of Civil Engineering, RSR Rungta College of Engineering and Technology, Bhilai.*

[2]*Asst.Professor,Chhattisgarh Swami Vivekananda Technical University, Bhilai, Chhattisgarh, India*

Abstract – *Bridge construction today has achieved a worldwide level of importance. Bridges are the key elements in any road network Use of box girder is gaining popularity in bridge engineering fraternity because of its better stability, serviceability, economy, aesthetic appearance and structural efficiency. The structural behavior of box girder is complicated, which is difficult to analyze in its actual conditions by conventional methods. In present study a two lane simply supported Box Girder Bridge made up of prestressed concrete with high strength concrete which is analysis for moving loads as per Indian Road Congress (IRC:6) recommendations, Prestressed Code(IS: 1343) and also as per IRC: 18 specifications. The analyzed of box girder Bridge Wizardand prestressed with parabolic tendons in which utilize full section. The various span/ depth ratio considered to get the proportioning depth at which stresses criteria and deflection criteria get satisfied*

Key Words: Concrete Box Girder Bridge, Prestress Force, Eccentricity, Prestress Losses, Reinforcement ,Flexure strength, shear strength

1. INTRODUCTION

Prestress concrete is ideally suited for the construction of medium and long span bridges. Ever since the development of prestressed concrete by Freyssinet in the early 1930s, the material has found extensive application in the construction of long-span bridges, gradually replacing steel which needs costly maintenance due to the inherent disadvantage of corrosion under aggressive environment conditions. One of the most commonly used forms of superstructure in concrete bridges is precast girders with cast-in-situ slab. This type of superstructure is generally used for spans between 20 to 40 m. T or I-girder bridges are the most common example under this category and are very popular because of their simple geometry, low fabrication cost, easy erection or casting and smaller dead loads. In this paper study the India Road Loading considered for design of bridges, also factor which are important to decide the preliminary sizes of concrete box girders. Also considered the IRC:18-2000 for "Prestressed Concrete Road Bridges" and "Code of Practice for Prestressed Concrete "Indian Standard. Analyze the Concrete Box Girder Road Bridges for various spans, various depth and check the proportioning depth.

The selection of span to depth ratio is generally critical in the design of bridge with girders because the cost of materials and construction of the superstructure is directly affected by span to the depth ratio. For example, using high span to depth ratio reduces the volume of concrete and increases the requirement of prestressing force and simplifies the construction, because in a lighter structure the cost of the bridge is highly dependent on the proportion of the superstructure, so the selection of span to depth ratio is very important for economy.

2. LITERATURE REVIEW

Miss. P.R. Bhivgade (2001)[1] in her paper has studied a simply supported Box Girder Bridge for two lane road made up of prestressed concrete which is analysis for moving loads as per Indian Road Congress (IRC:6) specification, Prestressed Code (IS: 1343) and also as per IRC: 18-2000 specifications. The analysis was done by using SAP 2000 14 Bridge Wizard and prestressed with parabolic tendons in which utilize full section. The various slenderness ratio considered to get the proportioning depth at which stresses criteria and deflection criteria get within the permissible limits recommended by IS codes. It is concluded that the basic principles for proportioning of concrete box girder help designer to design the section. For the torsion of superstructure box girder shows better resistance. The various slenderness ratios are carried out for Box Girder Bridges, deflection and stress criteria satisfied well within recommended limits. As the depth of the box girder increases, the prestressing force decreases and the number of cables decrease.

Rajamoori Arun Kumar, B. Vamsi Krishna (2014)[7] in their paper has studied the practical approach that on a major bridge having 299 meters span, 36 no's of PSC Beams & 8 no's of RCC Beams. The main code that follow in this course is IS: 1343. The title is Code of Practice for Pre-stressed Concrete published by the Bureau of Indian Standards. Remembering that IS: 456 - 2000 which is the Code of Practice for Structural Concrete. Some of the provisions of IS: 456 are also applicable for Pre-stressed Concrete.

The following conclusion were made -

1. Shear force and bending moment for PSC T-beam girder are lesser than RCC T beam Girder Bridge which allow designer to have less heavy section for PSC T-Beam Girder than RCC T-Girder for 24 m span.
2. Moment of resistance of steel for both PSC and RCC has been evaluated and conclusions drawn that PSC T-Beam Girder has more capacity for 24 m and more than 24m of span.

3. Methodology & Analysis

3.1 Basic concept of prestressing

Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads when introduced is counteracted to a desired degree. In reinforced concrete members, the prestress is commonly introduced by tensioning the steel reinforcement.

3.1.1 Post – tensioning systems

Freyssinet system

The Freyssinet system of post tensioning anchorages which was developed in 1939, impetus to the various new system devised over the years. At present according to abeles there are over 64 patented post tensioning system are compiled in table. The post-tensioning system based on wedge-action include the Freyssinet. Gifford Udall, anderson and magnel -blatom anchorages .

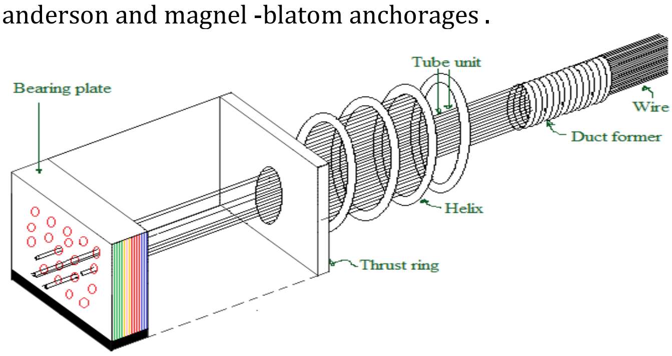

Figure 3.1 Gifford Udall Tube Anchorage Systems

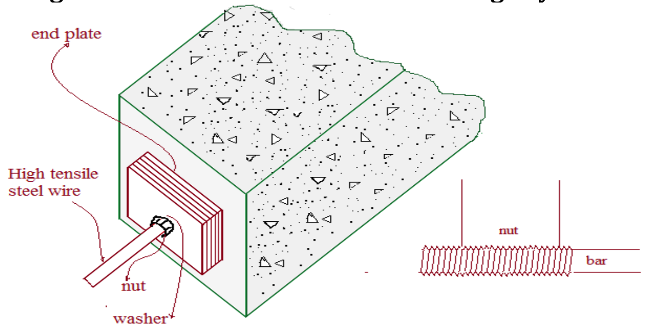

Figure 3.2 Lee Mccall System

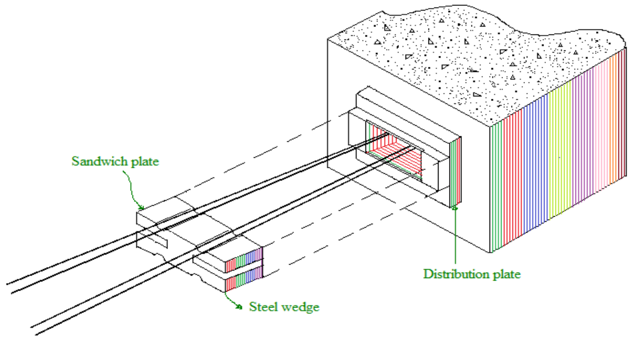

Figure 3.3 Magnel Blaton System

3.2 Materials and Data Collection

Tables 3.1 and 3.2 summarize the material properties and resistance factors used in the analysis. To illustrate the effects of high-strength materials on span-to-depth ratios, a concrete compressive strength of 40 MPa ,50MPa and 60MPa are used in the design, because this value is the minimum strength requirement of high performance concrete as defined by IS: 1343-1980.

3.2.1High Strength Concrete

Prestressed concrete requires concrete which has a compressive strength at a reasonably early age, with comparatively higher tensile strength than ordinary concrete. Low Shrinkage, minimum creep characteristic and high value of Young's modulus is age generally deemed necessary for concrete used for prestressed members. Many desirable properties such as durability impermeability and abrasion resistance age highly influenced by the strength of concrete with the development of vibration technique in 1930 it became possible to produce without much difficulty high strength concrete having 28 days cube compressive strength in the range of 30 to 70 Newton's per square millimeter the minimum 28 days cube compressive strength prescribed in the Indian Standard code IS:1343-1980 is 40 Newton's per square millimeter for pre tension members and 30 Newton's per square millimeter for post tension members the ratio of standard cylinder 2 cube strength may be assumed to be pointed in the absence of any elegant test data minimum cement content of 300 to hundred 60 kg per meter cube is prescribed mainly to Cater to the durability equipments in high strength concrete mixes the water content should be as low as possible with due date to adequate workability in the concrete should be suitable for common compaction by the means available at the site it is general practice to adopt vibration to achieve through compaction of concrete used for prestressed members.

3.2.3 High tensile Steel

All analysis cases utilize Fresynet systems with anchorage type 27 K-15 (27 strands of 15.2mm diameter) in 110mm diameter cable duct with properties summarized in table 3.1, 3.2, 3.3 and 3.4 respectively.

Table 3.1 Permissible stresses in concrete

1	2	IS:1343-1980
At transfer of prestressing force on cable	Compressive stress	Varies linearly from .54 to .37 fci for post tensioned work and from .51 to .44 fci for pretension work depending on the strength of concrete.
	Tensile stress	-
At service load	Compressive stress	Varies linearly from .41 to .35fck depending upon the strength of concrete.
	Tensile stress	Type 1 members: None Type 2 members: Tensile stresses not to exceed 3 N/mm2 Type 3 members: Tensile stresses vary from 3.2N/mm2 for M-30 Grade to a 7.3 N/mm2 and for M-50 Grade concrete depending upon the limiting crack width.

Table 3.2 Tensile strength and elongation characteristics of cold-drawn stress relieved wires (IS: 1785-part 1-1983)

Nominal diameter (mm)	Tensile strength minimum (N/mm^2)	Elongation (percent)
2.50	2010	2.5
3.00	1865	2.5
4.00	1715	3.0
5.00	1570	4.0
7.00	1470	4.0
8.00	1375	4.0

Table 3.3 Mechanical properties of high-tensile steel bars (IS: 2090-1983)

(a) Characteristic tensile strength (minimum)	980 N/mm2
(b) Proof stress	Not less than 80 percent minimum specified tensile strength
(c) Elongation at rupture on gauge length of 5.65A (minimum) Where A=cross section area	10 percent

Table 3.4 Mechanical properties of high-tensile intended wires (IS: 6003-1983)

Nominal diameter (mm)	Tensile strength (minimum) (N/mm2)	Elongation (percent)
5.00	1570	4.00
5.00	1570	4.00
4.00	1715	3.00
3.00	1865	2.50

3. RESULT ANALYSIS & DISSCUSSION

4.1 Analysis Results of segmental Box Girder

This section summarizes the analysis results which include the structural response under ULS and SLS, the material consumptions, and the factors that limit further increase of slenderness ratios.

4.1.1 Structural Behavior and Dimensioning

Table 4.1 4.2 and 4.3 describes the ultimate strength at the most critical location, for all 21 cases.

Table 4.1 Summary of structural behavior for segmental box girder

L m	L/d	Flexural strength		
		M_{ULS}	$M_{r.}$	M_{ULS}/ $M_{r.}$
		(kN m)	(kNm)	%
35	10	17685	18200	97
	15	16589	17985	92
	20	16041	17310	93
	25	15385	16300	94
50	10	22557	24250	93
	15	22194	23300	95
	20	21887	22800	96
	25	21623	22430	96
	30	20200	21530	94
60	10	38043	39110	97
	15	32522	33700	97
	20	29762	32510	92
	25	28105	29280	96
	30	27001	88900	30
	35	26212	27113	97
75	10	59868	61305	98
	15	49085	50930	96
	20	43693	44210	99
	25	40459	410404	10
	30	38302	39000	98
	35	36761	37490	98

Table 4.2 Summary of structural behavior for segmental box girder

m	L/d	Shear strength		
		V	Vr	Vb
		kN	k N	kN
35	10	2661.66	2069	592.66
	15	2388.24	2200	188.24
	20	2251.53	2150	101.53
	25	2169.504	2012	157.504
50	10	3906	3710	196
	15	3348	3280	68
	20	3069	2850	219
	25	2901.6	2712	189.6
	30	2790	2609	181
60	10	4902.96	4712	190.96
	15	4099.44	3801	298.44
	20	3697.68	3593	104.68
	25	3456.624	3120	336.624
	30	3295.92	3110	185.92
	35	3181.131429	3021	160.1314

m	L/d	Shear strength		
		V	Vr	Vb
75	10	6649.5	6110	539.5
	15	5394	4997	397
	20	4766.25	4322	444.25
	25	4389.6	4150	239.6
	30	4138.5	4028	110.5
	35	3959.142857	3512	447.142 9

Table 4.3 Stresses variation for different span and span to depth ratio

	L/d	Finf (N/mm²)	Fci (N/mm²)
35	10	2.759027698	22.5
	15	6.215903477	22.5
	20	11.46564801	22.5
	25	18.941658	22.5
50	10	2.852058045	22.5
	15	6.193101104	22.5
	20	11.00705983	22.5
	25	17.53387677	22.5
	30	26.05582045	36.2
60	10	2.924937558	22.5
	15	6.266426078	22.5
	20	10.97733711	22.5
	25	17.23507917	22.5
	30	25.24878255	22.5
	35	35.25654092	36.2
75	10	3.031511154	22.5
	15	6.417130601	22.5
	20	11.08420448	22.5
	25	17.15208924	22.5
	30	24.76588462	36.2
	35	34.09061615	36.2

4. CONCLUSION

This study examines the slenderness ratios of 21 cases to determine the range of span to depth ratios usually used for the construction over the past 50 years. The most optimal ratio is 23 determined by sensitivity analysis with their satisfactory performance. The variation of stresses is about 2.3% when the high strength concrete is used instead of ordinary concrete and deflection is 1.6% less in high strength concrete.

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