QUESTION BANK

CE6702 – PRESTRESSED CONCRETE STRUCTURES

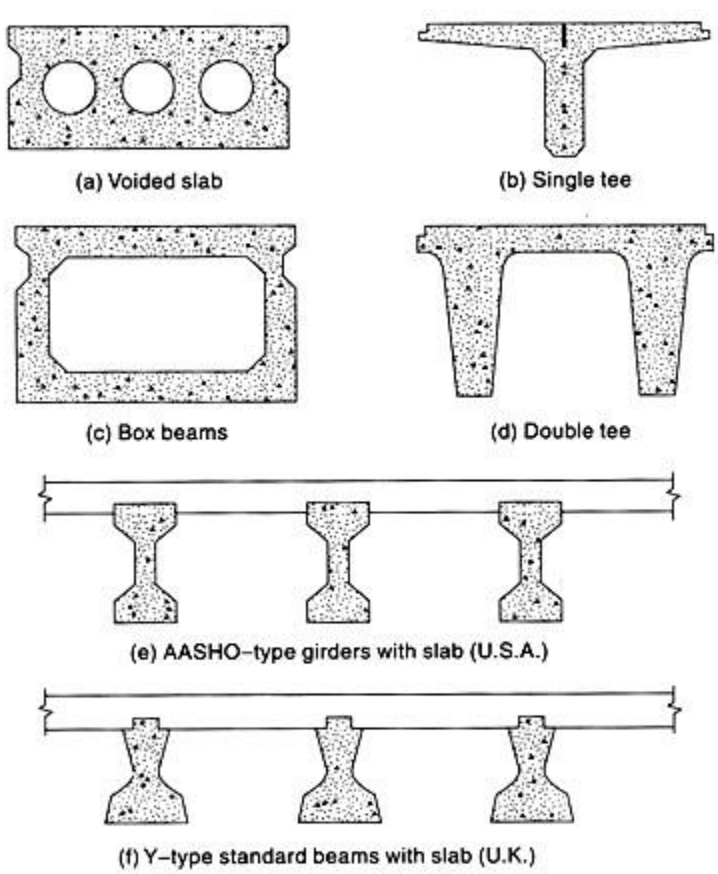
UNIT 5 – MISCELLANEOUS STRUCTURES

PART – A (2 marks)

1. Write the advantages of prestressed concrete bridges.
(AUC May/June 2013, Nov/Dec 2011, 2012 & 2013, Apr/May 2012)

- High strength concrete and high tensile steel, besides being economical make for slender sections which are aesthetically superior.
- In comparison with steel bridges prestressed concrete bridges require very little maintenance.
- Prestressed concrete bridges can be designed as class 1 type structures without any tensile stresses under service loads, thus resulting in a crack free structure.

2. Draw a typical cross section of pretensioned prestressed concrete bridge decks.
(AUC May/June 2013, Nov/Dec 2011 & 2012)



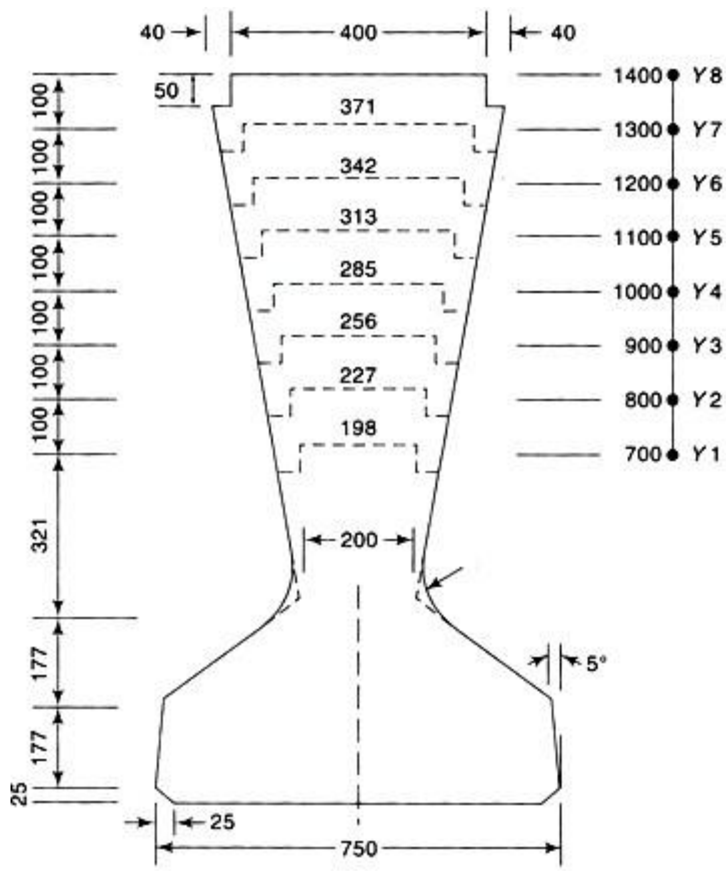
3. **What are span range for solid slab and T-beam slab decks? (AUC Nov/Dec 2013)**

Span ranges

For solid slab decks – 10 to 20 m

For T-beam slab decks – 20 to 40 m

4. **Draw the cross sectional profile of most commonly used prestressed concrete beams in bridges. (AUC Apr/May 2010)**



5. **Write a short note on post tensioned bridge decks. (AUC Apr/May 2012)**

Post tensioned bridge decks are generally adopted for longer spans exceeding 20 m. bridge decks with precast post tensioned girders of either T – type or box – type in conjunction with a cast in situ slab are commonly adopted for spans exceeding 30 m.

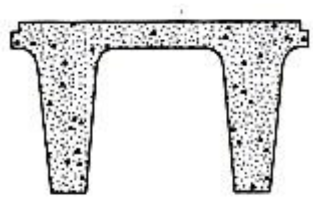
6. **Why the deck slab of prestressed concrete bridges is mostly made of non prestressed concrete? (AUC Apr/May 2010)**

The pretensioned girders are provided with straight tendons. The use of seven wire strands has been found to be advantageous in comparison with plain or indented wires. The deflected strands are employed in larger girders.

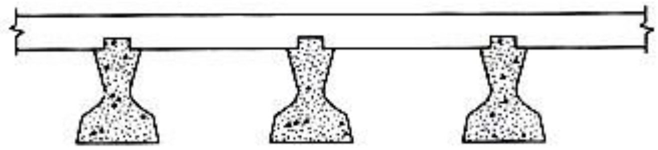
7. **What are the advantages of post tensioning system? (AUC Apr/May 2011)**

- Post tensioning is suitable for heavy cast in place members.
- The waiting period in the casting bed is less.
- The transfer of prestress is independent of transmission length.

8. Draw neat sketches of two efficient sections used for prestressed concrete bridges.
(AUC Apr/May 2011)



Double tee



Y–type standard beams with slab

9. List any four mechanical prestressing systems adopted for bridges in India.
(AUC Nov/Dec 2010)

- Includes weights with or without lever transmission
- Geared transmission in conjunction with pulley blocks
- Screw jacks with or without gear drives
- Wire winding machines

10. What is meant by kern distance in a prestressed concrete bridge? (AUC Nov/Dec 2010)

Kern is the core area of the section in which if the load applied tension will not be induced in the section.

$K_t = Z_b / A$, $K_b = Z_t / A$,

If the load applied at Kt compressive stress will be the maximum at the top most fiber and zero stress will be at the bottom most fiber. If the load applied at K_b compressive stress will be the maximum at the bottom most fiber and zero stress will be at the top most fiber.

11. What are the disadvantages of post tensioning system?

The relative disadvantage of post tensioning as compared to pretensioning is the requirement of anchorage device and grouting equipment.

12. Where the prestressed concrete construction is suited?

The prestressed concrete is ideally suited for the construction of medium and long span bridges.

13. Define pretensioned prestressed concrete bridge decks.

Pretensioned prestressed concrete bridge decks generally comprise precast pretensioned units used in conjunction with cast in situ concrete, resulting in composite bridge decks which are ideally suited for small and medium spans in the range of 20 to 30 m.

14. What is the span ranges for different types of slabs and beams?

- Solid slab decks – 10 to 20 m
- T-beam slab decks – 20 to 40 m
- Single or multicell box girder – 30 to 70 m
- Precast box girders – more than 50 m
- Simply supported, continuous beams – 20 to 500 m
- Composite bridge decks – 20 to 30 m
- Precast prestressed I and T - beam – 7 to 36 m
- Y – beams – 15 to 30 m

PART – B (16 marks)

1. **What are the general aspects of prestressed concrete bridges and its advantages over RC bridges? (AUC May/June 2013, Nov/Dec 2013)**

Prestressed 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 disadvantages of corrosion under aggressive atmospheric conditions.

Solid slabs are used for the span range of 10 to 20 m, while T-beam slab decks are suitable for spans in the range of 20 to 40 m. Single or multicell box girders are preferred for larger spans of the order of 30 to 70 m. Prestressed concrete is ideally suited for long-span continuous bridges in which precast box girders of variable depth are used for spans exceeding 50 m. Prestressed concrete has been widely used throughout the world for simply-supported, continuous, balanced cantilever, suspension, hammer-head and bridle-chord type bridges in the span range of 20 to 500 m

Advantages over RC bridge:

- High strength concrete and high tensile steel, besides being economical make for slender sections which are aesthetically superior.
- In comparison with steel bridges prestressed concrete bridges require very little maintenance.
- Prestressed concrete bridges can be designed as class 1 type structures without any tensile stresses under service loads, thus resulting in a crack free structure.
- Prestressed concrete is ideally suited for composite bridge construction in which precast prestressed girders support the cast in situ slab deck. This type of construction is very popular since it involves minimum disruption of traffic.
- Post tensioned prestressed concrete finds extensive applications in long span continuous girder bridges of variable cross section. Not only does it make for sleek structures, but it also effects considerable saving in the overall cost of construction.
- In recent years, partially prestressed concrete (type – 3 structures) has been preferred for bridge construction, because it offers considerable economy in the use of costly high tensile steel in the girder.

2. **Explain in detail about design aspects of pretensioned prestressed bridge decks.**
(AUC Nov/Dec 2011)

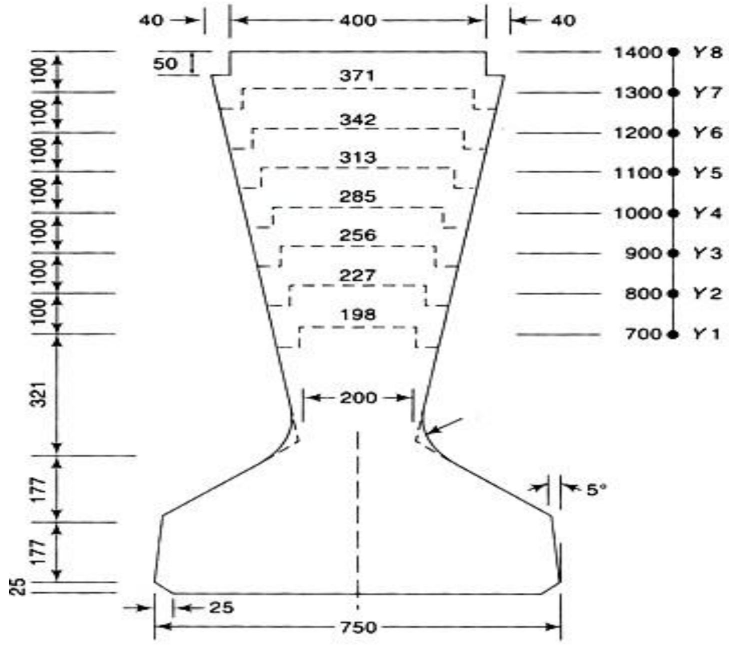
Pretensioned prestressed concrete bridge-decks generally comprise precast pretensioned units used in conjunction with cast *in situ* concrete, resulting in composite bridge decks which are ideally suited for small and medium spans in the range of 20 to 30 m. In general, pretensioned girders are provided with straight tendons. The use of seven-wire strands has been found to be advantageous in comparison with plain or indented wires. In U.S.A.[4], deflected strands are employed in larger girders.

In U.K., the precast prestressed I- and inverted T-beams have been standardised by the Cement and Concrete Association[5] for use in the construction of bridge decks of spans varying from 7 to 36 m. Standard I- and T-units are widely employed in highway bridge beams in U.S.A[6]. Recently in U.K., Y-beams, have been developed to replace the M-beams which were introduced in 1960. The design and development of the Y-beams, which are superior to M-beams, are ideally suited for medium spans of 15 to 30 m.

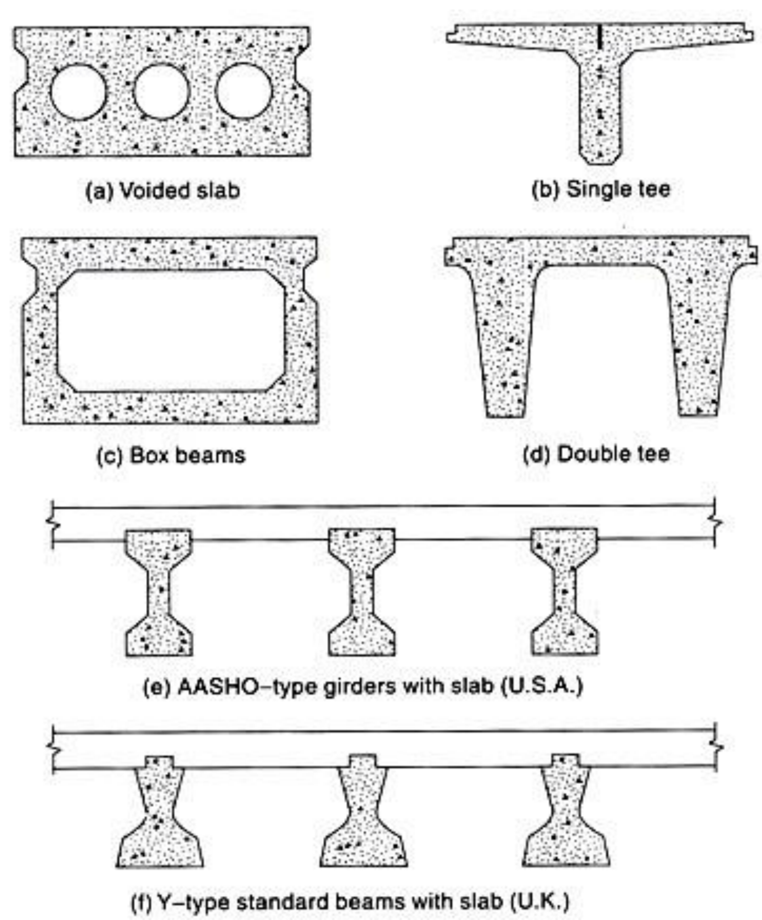
The typical cross-section of the standard inverted Y-beams developed by the research group in U.K.[7, 8, 9] is shown in Fig. 21.1 and the section properties of the Y-beam are compiled in Table 21.1. The salient features of composite bridge decks with precast pretensioned standard beams are shown in Fig.

Table *Section Properties of Standard Y-beams (U.K.)*

Section	*Depth (mm)*	*Area* (mm^2)	*Height of centroid above soffit* y_b *(mm)*	*Section modulus*		*Approximate self-weight (kN/m)*
				Top fibre Z_t ($mm^3 \times 10^6$)	*Bottom fibre* Z_b ($mm^3 \times 10^6$)	
Y-1	700	309202	255.24	24.85	43.40	7.42
Y-2	800	339882	298.68	35.02	58.78	8.14
Y-3	900	373444	347.12	47.88	76.27	8.95
Y-4	1000	409890	399.71	63.53	95.41	9.82
Y-5	1100	449220	455.72	82.06	116.02	10.78
Y-6	1200	491433	514.50	103.58	138.00	11.78
Y-7	1300	536530	575.54	128.15	161.31	12.86
Y-8	1400	584708	638.54	155.98	186.01	14.02



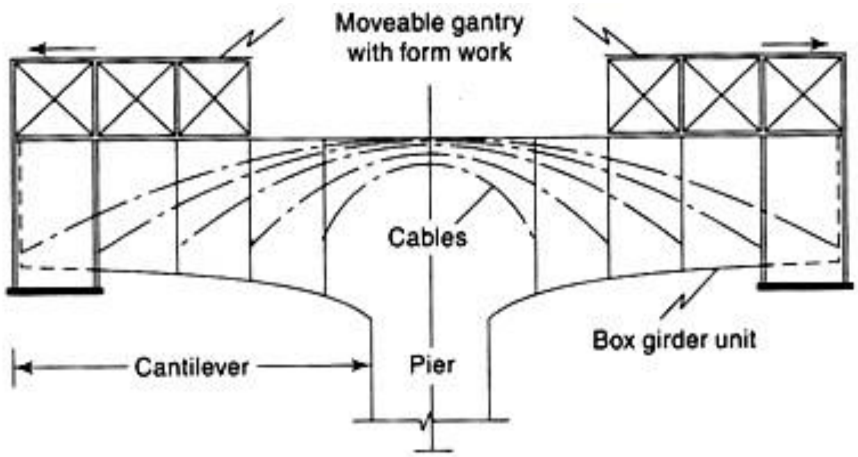
3. **Draw neat sketches showing the typical cross sections of pre tensioned PSC bridge decks. (AUC Nov/Dec 2012)**



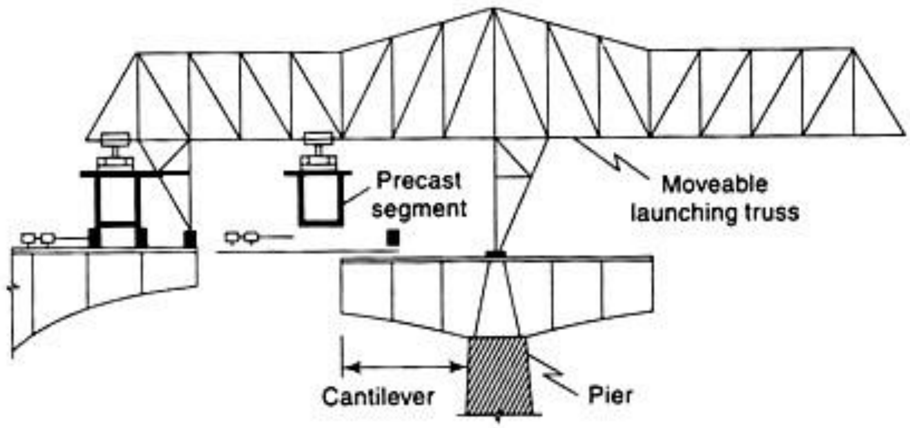
4. Explain in detail the general aspects of post tensioned concrete bridges decks.
(AUC Apr/May 2010, Nov/Dec 2010, 2012 & 2013)

Post-tensioned bridge decks are generally adopted for longer spans exceeding 20 m. Bridge decks with precast post-tensioned girders of either T-type or box-type, in conjunction with a cast *in situ* slab are commonly adopted for spans exceeding 30 m. Post-tensioning facilitates the use of curved cables, which improve the shear resistance of the girders

Post-tensioning is ideally suited for prestressing long-span girders at the site of construction, without the need for costly factory-type installations like pre-tensioning beds. Segmental construction is ideally suited for post-tensioning work. In this method, a number of segments can be combined by prestressing, resulting in an integrated structure. In India, a large number of long-span bridges have been constructed using the cantilever method of construction . Some of the notable examples being the Barak bridge at Silchar built in 1960 with a main span of 130 m and the Lubha bridge in Assam with a span of 130 m between the bearings. Long-span continuous prestressed concrete bridges are invariably built of multicelled box girder segments of variable depth using the post-tensioning system. Typical cross-sections of post-tensioned prestressed concrete bridge decks are shown in Fig. The salient features of the cantilever construction method using cast *in situ* segments and precast concrete elements are shown in Figs

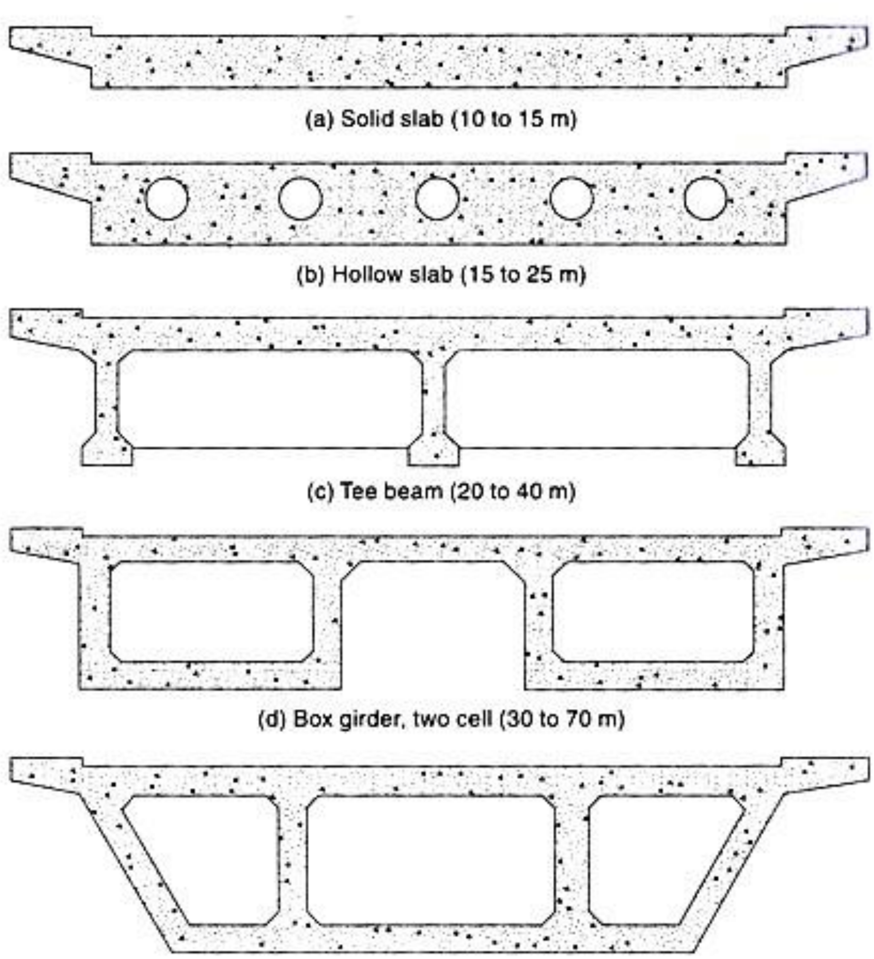


(a) Using cast *in Situ* segments



(b) Using precast girder segments

5. Draw neat sketches showing the typical cross sections of post tensioned PSC bridge decks. (AUC Nov/Dec, Apr/May 2012)


(a) Solid slab (10 to 15 m)

(b) Hollow slab (15 to 25 m)

(c) Tee beam (20 to 40 m)

(d) Box girder, two cell (30 to 70 m)

(e) Box girder, trapezoidal (30 to 80 m)

Fig. *Typical Cross-sections of Post-Tensioned Prestressed Concrete Bridge Decks*

6. **Briefly outline the design procedure of post tensioned prestressed concrete slab bridge deck.** **(AUC May/June 2013, Nov/Dec 2011 & 2013)**

Design procedure of post tensioned prestressed concrete slab bridge deck:

Step 1: Data collections

Clear span, width of bearing, clear width of roadway, footpath, kerbs, thickness of wearing coat, live load and type of structure.

Step 2: Permissible stresses

The permissible compressive stresses in concrete at transfer and working loads as recommended in IRC – 18.

Step 3: Depth of slab and effective span

Assuming the thickness of the slab at span for highway bridge decks and to find the overall thickness of the slab.

Step 4: Dead load bending moments

To calculate the dead weight of the slab and find the dead load bending moment.

Step 5: Live load bending moments

Generally the bending moment due to live load will be maximum for IRC class AA tracked vehicle.

Step 6: Shear due to class AA tracked vehicle

For maximum shear force at the support section the IRC class AA tracked vehicle is arranged.

Step 7: Check for minimum section modulus

Step 8: Minimum prestressing force

Step 9: Eccentricity of cables

Step 10: Check for stresses at service loads

Step 11: Check for ultimate strength (IRC: 18 – 2000)

Step 12: Check for ultimate shear strength

Step 13: Supplementary reinforcement

Step 14: Design of end block reinforcement

7. **Write the design procedure of post tensioned PSC T - beam slab bridge deck.** **(AUC Apr/May 2010, Apr/May 2011)**

Design procedure of post tensioned PSC T - beam slab bridge deck:

Step 1: Data collections

Clear span, width of bearing, clear width of roadway, footpath, kerbs, thickness of wearing coat, live load and type of structure.

Step 2: Permissible stresses

The permissible compressive stresses in concrete at transfer and working loads as recommended in IRC – 18.

Step 3: Cross section of deck

Step 4: Design of the interior slab panel

Step 5: Design of longitudinal girders

i. Reaction factors
ii. Dead load from slab per girder
iii. Dead load of the main girder
iv. Dead load moments and shears in the main girder
v. Live load bending moments in the girder
vi. Live load shear forces in girders
vii. Design bending moments and shear forces
viii. Properties of main girder section
ix. Check for minimum section modulus
x. Minimum prestressing force
xi. Permissible tendon zone

Step 6: Check for stresses

Step 7: Check for ultimate flexural strength

i. Failure by yielding of steel
ii. Failure by crushing of concrete

Step 8: Check for ultimate shear strength

Step 9: Supplementary reinforcement

Step 10: Design of end block reinforcement

Step 11: Cross girders

8. Explain the advantages of prestressed concrete bridges. (AUC Apr/May 2012)

- High strength concrete and high tensile steel, besides being economical make for slender sections which are aesthetically superior.
- In comparison with steel bridges prestressed concrete bridges require very little maintenance.
- Prestressed concrete bridges can be designed as class 1 type structures without any tensile stresses under service loads, thus resulting in a crack free structure.
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