Beam Bridges

This type is commonly known as deck-girder bridges, wherein beams (girders) are designed to be the main superstructure component. The girders carry slab (deck) load including dead and live loads in addition to its own and diaphragms weights thus transfer all these loads into the exterior (abutments) and interior (piers) supports. The girders become essential when the span length (L) is about 15 m or more. It is preferred to design the girders as simple spans, despite continuous girders have been utilized in many projects. Generally, two cross-sections for these bridges are exist according to the interfacial (connecting) layer between deck and girders:

Monolithic section: when the deck and the girders are cast at the same time to be one section, such as T-girders and box girders.

Composite section: when the deck and the girders are cast in different circumferences and connected to act as one section, such as CIP concrete deck with precast concrete or steel girders.

Monolithic Sections

Composite Sections

Typical Deck-Girder Sections

Deck Material	Girder Material
CIP Concrete	CIP Concrete
	Precast Concrete
	Steel
Precast Concrete	Precast Concrete
	Steel
Steel	Steel

Design of Deck in Beam Bridges

In the beam bridges, the decks behave as continuous spans in transversely for the girders. The deck can be designed in similar manner to that adopted in slab bridges except regarding the main direction of the deck is perpendicular to the traffic and girders besides needing for additional reinforcement to resist negative moments effect near supports. However, maximum positive and negative live load moments can be gotten from readily Table provided by AASHTO specifications.

Table A4-1: Maximum Live Load Moments Per Unit Width (N.mm/mm)

S mm	Positive Moment	Negative Moment						
		Distance from CL of Girder to Design Section for Negative Moment						
		00 mm	75 mm	150 mm	225 mm	300 mm	450 mm	600 mm
1300	21 130	11 720	10 270	8940	7950	7150	6060	5470
1400	21 010	14 140	12 210	10 340	8940	7670	5960	5120
1500	21 050	16 320	14 030	11 720	9980	8240	5820	5250
1600	21 190	18 400	15 780	13 160	11 030	8970	5910	4290
1700	21 440	20 140	17 290	14 450	12 010	9710	6060	4510
1800	21 790	21 690	18 660	15 630	12 930	10 440	6270	4790
1900	22 240	23 050	19 880	16 710	13 780	11 130	6650	5130
2000	22 780	24 260	20 960	17 670	14 550	11 770	7030	5570
2100	23 380	26 780	23 190	19 580	16 060	12 870	7410	6080
2200	24 040	27 670	24 020	20 370	16 740	13 490	7360	6730
2300	24 750	28 450	24 760	21 070	17 380	14 570	9080	8050
2400	25 500	29 140	25 420	21 700	17 980	15 410	10 870	9340
2500	26 310	29 720	25 990	22 250	18 510	16 050	12 400	10 630
2600	27 220	30 220	26 470	22 730	18 980	16 480	13 660	11 880
2700	28 120	30 680	26 920	23 170	19 420	16 760	14 710	13 110
2800	29 020	31 050	27 300	23 550	19 990	17 410	15 540	14 310
2900	29 910	32 490	28 720	24 940	21 260	18 410	16 800	15 480
3000	30 800	34 630	30 790	26 960	23 120	19 460	18 030	16 620
3100	31 660	36 630	32 770	28 890	23 970	21 150	19 230	17 780
3200	32 500	38 570	34 670	30 770	26 880	22 980	20 380	18 910
3300	33 360	40 440	36 520	32 600	28 680	24 770	21 500	20 010
3400	34 210	42 250	38 340	34 430	30 520	26 610	22 600	21 090
3500	35 050	43 970	40 030	36 090	32 150	28 210	23 670	22 130
3600	35 870	45 650	41 700	37 760	33 810	29 870	24 700	23 150
3700	36 670	47 250	43 310	39 370	35 430	31 490	25 790	24 140
3800	37 450	48 820	44 880	40 940	37 010	33 070	27 080	25 100
3900	38 230	50 320	46 390	42 460	38 540	34 600	28 330	25 550
4000	38 970	51 790	47 870	43 950	40 030	36 110	29 570	26 410
4100	39 710	53 190	49 280	45 370	41 470	37 570	30 770	27 850
4200	40 420	54 560	50 670	46 770	42 880	38 990	31 960	28 730
4300	41 120	55 880	52 000	48 130	44 250	40 380	33 130	29 570
4400	41 800	57 150	53 290	49 440	45 580	41 720	34 250	30 400
4500	42 460	58 420	54 580	50 740	46 900	43 060	35 380	31 290
4600	43 110	59 620	55 800	51 980	48 160	44 340	36 700	32 360

Design Procedure for Deck in Beam Bridges

- Check the deck span length (S) and the its thickness (h_d) that used in the design of girders
- Calculate the unfactored permanent loads force effects per unit width
- Determine the unfactored live loads force effects per unit width from AASHTO Table
- Calculate factored moment (M_u) according to ($LRFD$) method
- Determine the required main reinforcement details for flexure (positive and negative) as well all other distribution, shrinkage and temperature reinforcements
- No need to check shear and bond stresses.

Design of Girders in Beam Bridges

For all deck-girder superstructures, including T-girders, the supporting girders are usually designed first and then followed by design of the deck in order to brief the calculation process. This is so because the deck span depends on the T-girders webs spacing. It is convenient to select a trial size and spacing of girders first and then complete their design. Once the girders design is finalized, the deck design follows based on the final girders spacing. However, the girders design requires knowledge of the dead weight of the deck, which is not known yet. Therefore, the deck thickness is assumed to estimate its dead weight. AASHTO specifications state that the minimum permitted deck thickness ($h_{d,min}$) is 175 mm. A common design practice is to assume initially a deck thickness (h_d) of 200 mm and then check if it satisfies LRFD stipulations; this thickness is usually satisfactory for beam spacing in a range of (2.1 – 3.2) m; greater thickness is required for wider girders spacing or when it is required to increase the concrete cover for the reinforcement.

The design of beam bridges has new features differ from slab bridges design. Some of these features are demonstrated in followings.

Diaphragms

It is short structural elements can be of concrete or steel positioned transversely to and in between adjacent girders that support the deck slab. Diaphragms are provided to ensure lateral distribution of live loads from the bridge deck to its supporting adjacent girders, which depends on both the stiffness of the diaphragms relative to the girders and the method of connectivity.

In typical beam bridges, diaphragms are vertical elements placed in between the girders at the span ends (over the abutments) and also at intervals as required by the specifications. At the span ends, the diaphragms are intended to strengthen the deck edge and to transfer horizontal forces from the superstructure to the abutments. Whereas, the intermediate diaphragms are intended to provide torsional stiffness to the entire superstructure.

AASHTO specifications state that diaphragms should be provided, except that they may be omitted where tests or analysis show adequate strength without them. For T-girders, diaphragms or other means are required to be placed at span ends and intermediate diaphragms are to be placed in between the girders of maximum moment for span over 12 m.