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Design of T-Beam Rail-Over Bridge

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ABSTRACT:*Beam and slab bridges are the most common form concrete bridge in today. They have the virtue of simplicity, economy, wide availability of the standard sections, and speed of erection. The present beams are placed on the supporting piers or abutments, usually on rubber bearings which are maintenance free. In this project study on design of long span decks, foundation, design of Girders, beams, resistance of vibration in bridge span sections, and difference between RCC girders and heavy steel girders, composite bridge decks, structural analysis of concrete bridges, The Bridge which is in disstress is a R.C. beam- slab type in all spans of the bridge except in one span i.e., railway portion which is of Box girder type. The super structure is divided into two parts independently and each part consists of three girders with deck slab, simply supported on common R.C pier / Abutment.*

This project includes causes and identification of failures and defects in concrete structures. Techniques for repairs and rehabilitation of concrete structure (bridge).Some of the techniques are epoxy resins, polymer concrete composites and corrosion proof epoxy painting.

INTRODUCTION:A bridge is a structure that crosses over a river, bay, or other obstruction, permitting the smooth and safe passage of vehicles, trains, and pedestrians. An elevation view of a typical bridge is A bridge structure is divided into an upper part (the superstructure), which consists of the slab, the floor system, and the main truss or girders, and a lower part (the substructure), which are columns, piers, towers, footings, piles, and abutments. The superstructure provides horizontal spans such as deck and girders and carries traffic loads directly. The substructure supports the horizontal spans, elevating above the ground surface.

Classification of Bridges:

1. **Classification by Materials:**
   Steel Bridges: steel bridge may use a wide variety of structural steel components and systems: girders, frames, trusses, arches, and suspension cables.
   Concrete Bridges: There are two primary types of concrete bridges: reinforced and pre-stressed.
   Timber Bridges: Wooden bridges are used when the span is relatively short.

Metal Alloy Bridges: Metal alloys such as aluminum alloy and stainless steel are also used in bridge construction.

Composite Bridges: Bridges using both steel and concrete as structural materials.

2. **Classification by Objectives**

Highway Bridges: Bridges on highways.

Railway Bridges: Bridges on railroads.

Combined Bridges: Bridges carrying vehicles and trains.

Pedestrian Bridges: Bridges carrying pedestrian traffic.

Aqueduct Bridges: Bridges supporting pipes with channeled water flow. Bridges can alternatively be classified into movable (for ships to pass the river) or fixed and permanent or temporary categories.

3. **Classification by Structural System (Superstructures)**

Plate Girder Bridges: The main girders consist of a plate assemblage of upper and lower flanges and a web. H or I-cross-sections effectively resist bending and shear.

Box Girder Bridges: The single (or multiple) main girder consists of a box beam fabricated from steel plates or formed from concrete, which resists not only bending and shear but also torsion effectively.

T-Beam Bridges: A number of reinforced concrete T-beams are placed side by side to support the live load.

Composite Girder Bridges: The concrete deck slab works in conjunction with the steel girders to support loads as a united beam. The steel girder takes mainly tension, while the concrete slab takes the compression component of the bending moment.

Grillage Girder Bridges: The main girders are connected transversely by floor beams to form a grid pattern which shares the loads with the main girders.

Truss Bridges: Truss bar members are theoretically considered to be connected with pins at their ends to form triangles. Each member resists an axial force, either in compression or tension.

Arch Bridges: The arch is a structure that resists load mainly in axial compression. In ancient times stone was the most common material used to construct magnificent arch bridges.

Cable-Stayed Bridges: The girders are supported by highly strengthened cables (often composed of tightly bound steel strands) which stem directly from the tower. These are most suited to bridge long distances.

Suspension Bridges: The girders are suspended by hangers tied to the main cables which hang from the towers. The load is transmitted mainly by tension in cable.

T-Beam Bridges: Beam and slab bridges are probably the most common form of concrete bridge in the UK today, thanks to the success of standard precast prestressed concrete beams developed originally by the Prestressed Concrete Development Group (Cement & Concrete Association) supplemented later by alternative designs byothers, culminating in the Y-beam introduced by the Prestressed Concrete Association in the late 1980s.

They have the virtue of simplicity, economy, wide availability of the standard sections, and speed of erection.

The precast beams are placed on the supporting piers or abutments, usually on rubber bearings which are maintenance free. An in-situ reinforced concrete deck slab is then cast on permanent shuttering which spans between the beams.

The precast beams can be joined together at the supports to form continuous beams which are structurally more efficient. However, this is not normally done because the costs involved are not justified by the increased efficiency.

Simply supported concrete beams and slab bridges are now giving way to integral bridges which offer the advantages of less cost and lower maintenance due to the elimination of expansion joints and bearings.

Nearly 590,000 roadway bridges span waterways, dry land depressions, other roads, and railroads throughout the United States. The most dramatic bridges use complex systems like arches, cables, or triangle-filled trusses to carry the roadway between majestic columns or towers. However, the work-horse of the highway bridge system is the relatively simple and inexpensive concrete beam bridge.

Also known as a girder bridge, a beam bridge consists of a horizontal slab supported at each end. Because all of the weight of the slab (and any objects on the slab) is transferred vertically to the support columns, the columns can be less massive than supports for arch or suspension bridges, which transfer part of the weight horizontally.

A simple beam bridge is generally used to span a distance of 250 ft (76.2 m) or less. Longer distances can be spanned by connecting a series of simple beam bridges into what is known as a continuous span. In fact, the world's longest bridge, the Lake Pontchartrain Causeway in Louisiana, is a pair of parallel, two-lane continuous span bridges almost 24 mi (38.4 km) long. The first of the two bridges was completed in 1956 and consists of more than 2,000 individual spans. The sister bridge (now carrying the north-bound traffic) was completed 13 years later; although it is 228 ft longer than the first bridge, it contains only 1,500 spans.

A bridge has three main elements. First, the substructure (foundation) transfers the loaded 1weight of the bridge to the ground; it consists of components such as columns (also called piers) and abutments. An abutment is the connection between the end of the bridge and the earth; it provides support for the end sections of the bridge. Second, the superstructure of the bridge is the horizontal platform that spans the space between columns. Finally, the deck of the bridge is the traffic-carrying surface added to the superstructure.

Construction Materials and Their Development:

Most highway beam bridges are built of concrete and steel. The Romans used concrete made of lime and pozzalana (a red, volcanic powder) in their bridges. This material set quickly, even under water, and it was strong and waterproof. During the Middle Ages in Europe, lime mortar was used instead, but it was water soluble. Today's popular Portland cement, a particular mixture of limestone and clay, was invented in 1824 by an English bricklayer named Joseph Aspdin, but it was not widely used as a foundation material until the early 1900s.

Concrete has good strength to withstand compression (pressing force), but is not as strong under tension (pulling force). There were several attempts in Europe and the United States during the nineteenth century to strengthen concrete by embedding tension-resisting iron in it. A superior version was developed in France during the 1880s by Francois Hennebique, who used reinforcing bars made of steel. The first significant use of reinforced concrete in a bridge in the United States was in the Alvord Lake Bridge in San Francisco's Golden Gate Park; completed in 1889 and still in use today, it was built with reinforcing bars of twisted steel devised by designer Ernest L. Ransome.

The next significant advance in concrete construction was the development of

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prestressing. A concrete beam is prestressedby pulling on steel rods running through the beam and then anchoring the ends of the rods to the ends of the beam. This exerts a compressive force on the concrete, offsetting tensile forces that are exerted on the beam when a load is placed on it. (A weight pressing down on a horizontal beam tends to bend the beam downward in the middle, creating compressive forces along the top of the beam and tensile forces along the bottom of the beam.)

Prestressing can be applied to a concrete beam that is precast at a factory, brought to the construction site, and lifted into place by a crane; or it can be applied to cast-in-place concrete that is poured in the beam's final location. Tension can be applied to the steel wires or rods before the concrete is poured (pretensioning), or the concrete can be poured around tubes containinguntensioned steel to which tension is applied after the concrete has hardened (postensioning).

Design: Each bridge must be designed individually before it is built. The designer must take into account a number of factors, including the local topography, water currents, river ice formation possibilities, wind patterns, earthquake potential, soil conditions, projected traffic volumes, esthetics, and cost limitations.

In addition, the bridge must be designed to be structurally sound. This involves analyzing the forces that will act on each component of the completed bridge. Three types of loads contribute to these forces. Dead load refers to the weight of the bridge itself. Live load refers to the weight of the traffic the bridge will carry. Environmental load refers to other external forces such as wind, possible earthquake action, and potential traffic collisions with bridge supports. The analysis is carried out for the static (stationary) forces of the dead load and the dynamic (moving) forces of the live and environmental loads.

Construction Procedure: Because each bridge is uniquely designed for a specific site and function, the construction process also varies from one bridge to another. The process described below represents the major steps in constructing a fairly typical reinforced concrete bridge spanning a shallow river, with intermediate concrete column supports located in the river.

Example sizes for many of the bridge components are included in the following description as an aid to visualization. Some have been taken from suppliers' brochures or industry standard specifications. Others are details of a freeway bridge that was built across the Rio Grande in Albuquerque, New Mexico, in 1993. The 1,245-ft long, 10-lane wide bridge is supported by 88 columns. It contains 11,456 cubic yards of concrete in the structure and an additional 8,000 cubic yards in the pavement. It also contains 6.2 million pounds of reinforcing steel.

Substructure:

1. A cofferdam is constructed around each column location in the riverbed, and the water is pumped from inside the enclosure. One method of setting the foundation is to drill shafts through the riverbed, down to bedrock. As an auger brings soil up from the shaft, a clay slurry is pumped into the hole to replace the soil and keep the shaft from collapsing. When the proper depth is reached (e.g., about 80 ft or 24.4 m), a cylindrical cage of reinforcing steel (rebar) is lowered into the slurry-filled shaft (e.g., 72 in or 2 m in diameter). Concrete is pumped to the bottom of the shaft. As theshaft fills with concrete, the slurry is forced out of the top of the shaft, where it is collected and cleaned so it can be reused. The aboveground portion of each column can either be formed and cast in place, or be precast and lifted into place and attached to the foundation.
2. Bridge abutments are prepared on the riverbank where the bridge end will rest. A concrete backwall is formed and poured between the top of the bank and the riverbed; this is a retaining wall for the soil beyond the end of the bridge. A

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ledge (seat) for the bridge end to rest on is formed in the top of the backwall. Wing walls may also be needed, extending outward from the back-wall along the riverbank to retain fill dirt for the bridge approaches.

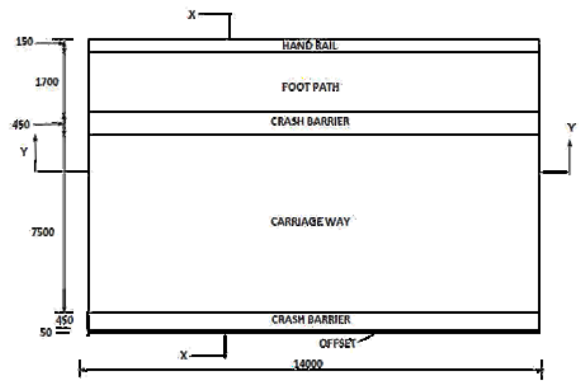
Super structure:A crane is used to set steel or prestressed concrete girders between consecutive sets of columns throughout the length of the bridge. The girders are bolted to the column caps. For the Albuquerque freeway bridge, each girder is 6 ft (1.8 m) tall and up to 130 ft (40 m) long, weighing as much as 54 tons.

Steel panels or precast concrete slabs are laid across the girders to form a solid platform, completing the bridge superstructure. One manufacturer offers a 4.5 in (11.43 cm) deep corrugated panel of heavy (7-or 9-gauge) steel, for example. Another alternative is a stay-in-place steel form for the concrete deck that will be poured later.

Deck:A moisture barrier is placed atop the superstructure platform. Hot-applied polymer-modified asphalt might be used, for example.

A grid of reinforcing steel bars is constructed atop the moisture barrier; this grid will subsequently be encased in a concrete slab. The grid is three-dimensional, with a layer of rebar near the bottom of the slab and another near the top.

Concrete pavement is poured. A thickness of 8-12 in (20.32-30.5 cm) of concrete pavement is appropriate for a highway. If stay-in-place forms were used as the superstructure platform, concrete is poured into them. If forms were not used, the concrete can be applied with a slipform paving machine that spreads, consolidates, and smooths the concrete in one continuous operation. In either case, a skid-resistant texture is placed on the fresh concrete slab by manually or mechanically scoring the surface with a brush or rough material like burlap. Lateral joints are provided approximately every 15 ft (5 m) to discourage cracking of the pavement; these are either added to the forms before pouring concrete or cut after a slipformed slab has hardened. A flexible sealant is used to seal the joint.



Plan of Bridge Deck

Project Statement:

A reinforced concrete bridge was to be constructed over a railway line. It was required to Design the bridge superstructure and to sketch the layout of plan, elevation and reinforcement details of various components for the following data:

Width of carriage way = 7.5 m

Effective span = 14 m

Centre to centre spacing of longitudinal girders = 3.2 m

Number of longitudinal girders = 3

No. of cross girders = 4

Thickness of wearing coat = 56 mm

Material for construction = M-35 grade concrete and Fe-415 steel conforming to IS 1786.

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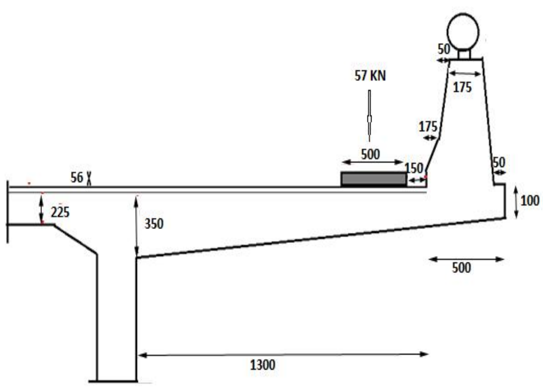
Loading = IRC class A-A and IRC class A ,which given worst effect

Footpath = 1.7 m on left hand side of the bridge. Total width of road = 10.3 m.

Cantilever Slab:



Cantilever Slab with Class A Wheel

Computation of Dead Load Bending Moment due to Cantilever Slab.

Component	Dead load	Level arm	B.M(KN-m)
Vehicle crash barrier	0.275x24=6.6	1.65 m	10.89
Slab (rectangular)	1.8x0.1x24=4.32	0.9m	3.89
Slab(Triangular)	0.25x1.8x0.5x24=5.4	0.6m	3.24
Wearing coat	0.056x22x1.3=1.6	0.65 m	1.04
Total	17.92		19.06

Design of Longitudinal Girders:

The reaction factors will be maximum if eccentricity of the C.G. of loads with respect to the axis of the bridge is maximum.

According to Courbon's method, reaction factor Ri is given by

Ri= PIi(1 + ΣIi . e di)

ΣIiΣIidi2

P = total live load

II = moment of inertia of longitudinal girder i e = eccentricity of the live load

di = distance of girder I from the axis of the bridge Effective span = 14.00 m

Slab thickness = 225 mm

Width of rib = 300 mm

Spacing of main girder = 3200 mm

Overall depth = 1600 mm.

Girder	**Max. D.L. B.M.**	**Max. L.L.B.M.**	**Total B.M.**
Outer girder	1021.46	1535.2	2556.66
Inner girder	1021.46	781.68	1803.14
	Max. D.L.S.F.	**Max. L.L.S.F.**	**Total S.F.**
Outer girder	309.42	449.3	758.72
Inner girder	309.42	239.47	548.89

The loads are arranged on the span such that the max. Moment will occur under the fourth load from the left. The loads shown in figure are corresponding Class A train load multiplied by 1.33 (reaction factor at intermediate beam) and further multiplied by impact factor of 1.225. For example:- the first load of 22 KN, if the product of first train load of 13.5 KN and the factor 1.33 and 1.225.

RESULTS:

Deck Slab:

Overall Depth = 225 mm

Reinforcement 16 mm Dia @140 mm c/c (1408 mm^2) along shorter span.

Reinforcement 16 mm Dia @140 mm c/c (1408 mm^2) along longer span.

Cantilever Slab:

Depth at support = 350 mm

Depth at cantilever side = 100 mm

Main Steel Provide 16mm Dia bars @150 c/c (A_{st} = 1340.67 mm^2)

Distribution Steel Provide 8 mm Dia bars @150 c/c (A_{st} = 335.33 mm^2)

Longitudinal Girders:

Width of rib = 300 mm

Spacing of main girder = 3200 mm

Overall Depth = 1600 mm

Outer Longitudinal Girder

Main reinforcement of 16 bars of 32 mm Dia in 4 rows(A_{st} = 12873.14 mm^2) Shear reinforcement of 10 mm Dia 4 legged stirrups @150 c/c

Inner Longitudinal Girder

Main reinforcement of 12 bars of 32 mm Dia in 3 rows(A_{st} = 12873.14 mm^2) Shear reinforcement of 10 mm Dia 4 legged stirrups @200 c/c

Cross Girders

Width of rib = 250 mm

Spacing of main girder = 4667 mm

Overall depth = 1600 mm

Main reinforcement of 5 bars of 25 mm Dia (A_{st} = 12873.14 mm^2)

Shear reinforcement of 8 mm Dia 2 legged stirrups @160 c/c

Bearings

Outer Bearings

Plan dimensions = 250 mm x 500 mm

Overall thickness = 40 mm

Thickness of individual layer = 10 mm

Number of internal elastomer layers = 2

Number of laminates = 3

Thickness of each laminate = 3 mm

Thickness or top or bottom cover = 5 mm

Inner Bearings

Plan dimensions = 320 mm x 500 mm

Overall thickness = 39 mm

Thickness of individual layer = 10 mm

Number of internal elastomer layers = 2

Number of laminates = 3

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Thickness of each laminate = 3 mm

Thickness or top or bottom cover = 5 mm

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