RGPVNOTES.IN

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RIDGE FOUNDATIONS

The foundations of a bridge are particularly critical because they must support the entire weight of the bridge and the traffic loads that it will carry.

Foundation types depend primarily on the depth and safe bearing pressures of the bearing stratum, also restrictions placed on differential settlement due to the type of bridge deck. Generally in the case of simply supported bridge decks differential settlements of about 20 to 25 mm can be tolerated, whereas multi-span continuous decks 10 mm is usually considered as a maximum. Bridge foundations generally fall into two categories:

i. Strip footings, one for each pier and abutment. However, it is sometimes convenient to split the deck into two halves longitudinally along the centre line, this is then continued to the footing.

ii. Piled foundations.

It is possible to have a combination of both (i.e. piers being piled with abutments on strip footings).

## Design Considerations

The design of foundations comprise of the following stages :

i. From the site investigation report decide upon which stratum to impose the structure load and its safe bearing pressure.

ii. Select the type of foundation, possibly comparing the suitability of several types.

iii. Design the foundation to transfer and distribute the loads from the structure to the ground. Ensure that the factor of safety against shear failure in the soil is not reached and settlement is within the allowable limits.

## Strip Footings

The overall size of strip footings is determined by considering the effects of vertical and rotational loads. The combination of these two must neither exceed the safe bearing capacity of the stratum nor produce uplift. The thickness of the footings is generally about 0.8 to 1.0 m but must be capable of withstanding moments and shears produced by piers or abutments. The critical shearing stress may be assumed to occur on a plane at a distance equal to the effective depth of the base from the face of the column. Cover to reinforcement should never be less than values given in BS 5400: Part 4: Table 13, and crack control calculation must be carried out to ensure the crack width is less than 0.25mm (Table 1). Cover to reinforcement will need to be increased to comply with BS 8500 requirements.

## Piled Foundations

The type of piles generally used for bridge foundations are :

a. Driven Piles; preformed piles of concrete or steel driven by blows of a power hammer or jacked into the ground.

b. Preformed Driven Cast In-Situ Piles; formed by driving a hollow steel tube with a closed end and filling the tube with concrete.

c. Driven Cast In-Situ Piles; formed by driving a hollow steel tube with a closed end and filling the tube with concrete, simultaneously withdrawing the tube.

d. Bored and Cast In-Situ Piles; formed by boring a hole and filling it with concrete.

Pile foundations

Suitability of Pile Foundation:

Pile foundations are used under the following conditions:

(i) When the soil near the ground surface or at a reasonable depth is too soft or loose.

(ii) When the loads are so high that there is not enough plan area to accommodate the size of foundation required.

(iii) When large lateral loads act on the foundation.

(iv) Pile foundations are used when the structure is expected to carry large uplift loads in transmission towers and underground structures below water table.

(v) Pile foundation is used when the foundation is subjected to inclined loads, eccentric loads and moments.

Classification of Piles:

Piles are classified as follows:

(a) Classification based on materials and composition:

(i) Timber piles:

Timber piles are made from tree trunks and are well seasoned, straight and free from all defects. In India, timber piles mostly made up of sal tree trunks. These piles are available in length between 4 to 6 m. Timber piles are used where good bearing stratum is available at a relatively shallow depth.

(ii) Concrete piles:

Concrete piles are either precast or cast in situ. Precast piles are cast and cured at the casting site and then transported to the site for installation. These piles are adequately reinforced to with stand handling stresses along with working stresses. Precast piles are normally suitable for short lengths. Cast-in-situ piles are constructed by drilling hole in the ground and then filling the hole by concrete after placing the reinforcement.

(iii) Steel piles:

Steel piles are usually of rolled H-sections or thick pipe sections. These piles are used to withstand large impact stresses and where less distributance from driving is desired. Steel sheet piles and H-piles are generally used to support the open excavation and to provide seepage barrier.

(iv) Composite piles:

A pile which is made up of two materials like concrete and timber or concrete and steel is called composite pile. Composite piles are used in situations where a part of the pile is permanently under water. The part of the pile which will be under water can be made of untreated timber and the other part can be of concrete.

(b) Classification based on method of installation:

 

(i) Bored piles:Bored piles are constructed in pre-bored holes either using a casing or by circulating stabilizing agent like betonies slurry. The borehole is then filled with concrete after placing the reinforcement. The advantage of board pile is that there is no damage due to handling and driving which is common in driven piles.

Board piles are of following types:

(i)Small diameter piles-up to 600 mm diameter; large diameter piles-diameter greater than 600 mm; under reamed piles.

(ii) Driven piles:Driven piles may be of concrete, steel or timber. These piles are driven into the soil by the impact of hammer. Boring is not required for this type of piles. When a pile is driven into granular soils it densities the soil and increases strength of soil. But when a pile is driven in saturated clay, the soil instead of being compacted gets remolded with reduction in strength.

(iii) Driven and cast-in-situ piles:It is a type of driven pile. They are constructed by driving a steel casing in to the ground. The hole is then filled with concrete by placing the reinforcement and the casing is gradually lifted.

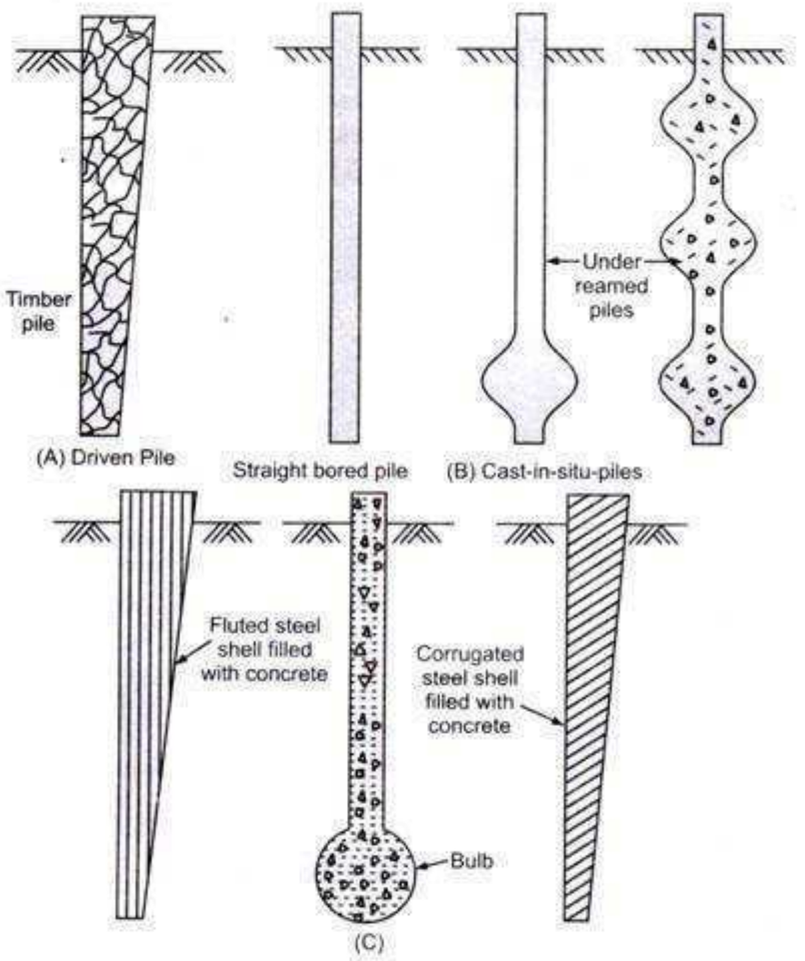


FIG. 11.14 Driven and cast in situ piles

(c) Classification based on the function: Piles are of following types based on its use:

(i) End bearing piles: The piles which transfer its load to a hard and relatively incompressible stratum like rock or dense sand are called end bearing piles. These piles derive its bearing capacity from end bearing at the pile tip.

 

(ii) Friction piles: The piles which do not rest on hard stratum but derives its carrying capacity from skim friction or adhesion between the pile surface and surrounding soil are called friction piles.

(iii) Tension pile: Tension piles are also called uplift piles. These piles are used to anchor down the structures subjected to uplift due to hydrostatic pressure.

(iv) Compaction piles: These piles are used to compact loose granular soil to increase its bearing capacity. Compaction piles do not carry load and hence they can be of weaker material. Sand piles can be used as compaction piles.

(v) Anchor piles: piles are used to provide anchorage against horizontal pull from sheet piling.

(vi) Fender piles and dolphins: Fender piles and dolphins are used to protect water front structure from impact of any floating object or ship.

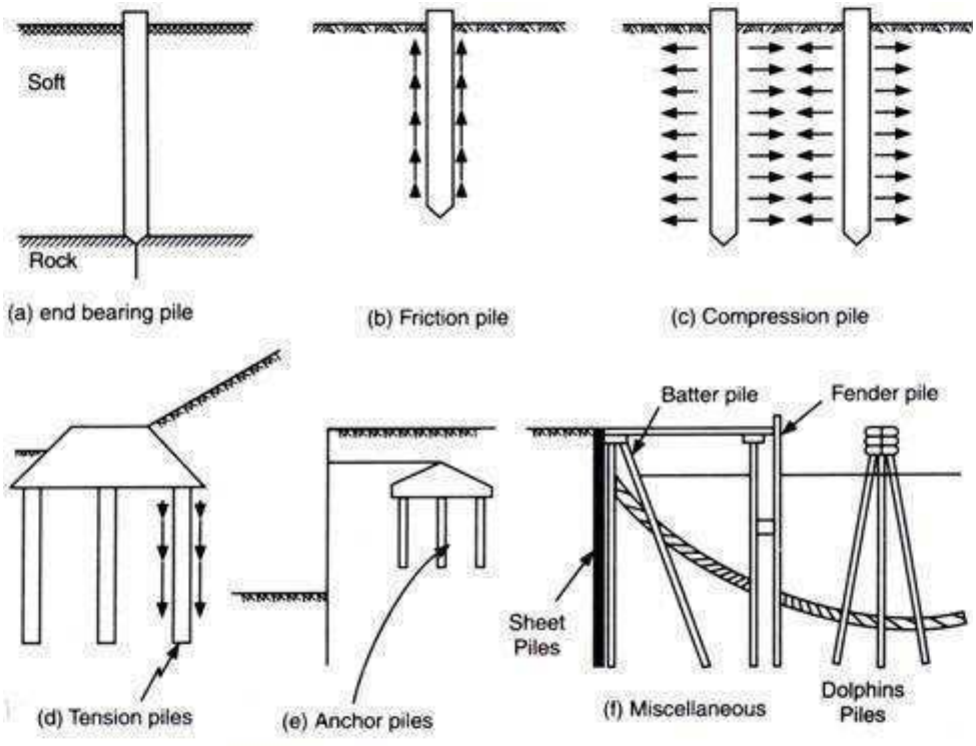


FIG. 11.15 Classification based on function

Well Foundations-Well foundation is a type of deep foundation which is generally provided below the water level for bridges. Caissons or well have been in use for foundations of bridges and other structures since Roman and Munhall periods. The term 'caisson' is derived from the French word cuisse which means box or chest. Hence caisson means a box like structure, round or rectangular, which is sunk from the surface of either land or water to some desired depth.

The caissons are of three types :(i) Box casino:It is open at the top and closed at the bottom and is made of timber, reinforced concrete or steel. This type of caisson is used where bearing stratum is available at shallow depth.

(ii) Open caisson (wells): Open caisson is a box opened both at top and bottom. It is made up to timber, concrete or steel. The open caisson is called well. Well foundation is the most common type of deep foundation used for bridges in India.

 

(iii) Pneumatic caissons has its lower end designed as a working chamber in which compressed air is forced to prevent the entry of water and thus excavation can be done in dry conditions.

Shapes of Wells:

The common types of well shapes are:

(i) Single circular

(ii) Twin circular

(iii) Dumb well

(iv)Double-d

(v)Twin hexagonal

(vi)Twin octagonal

(vii) Rectangular.

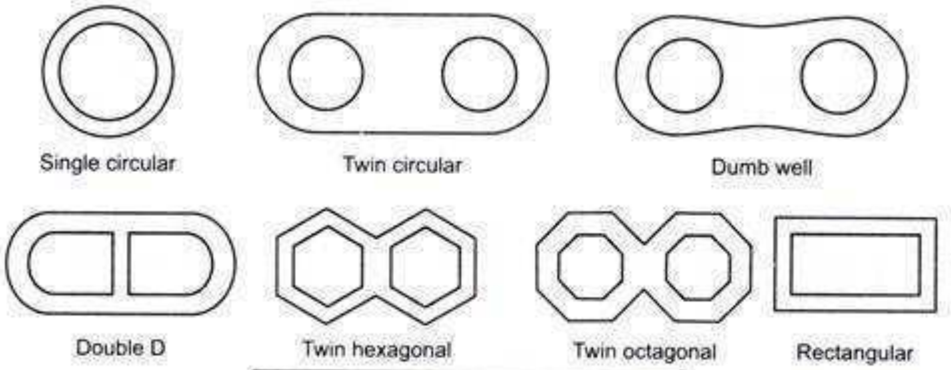


FIG. 11.30 Different shapes of wells

The choice of a particular shape of well depends upon the size of the pier, the care and cost of sinking, the considerations of tilt and shift during sinking and the vertical and horizontal forces to which well is subjected.

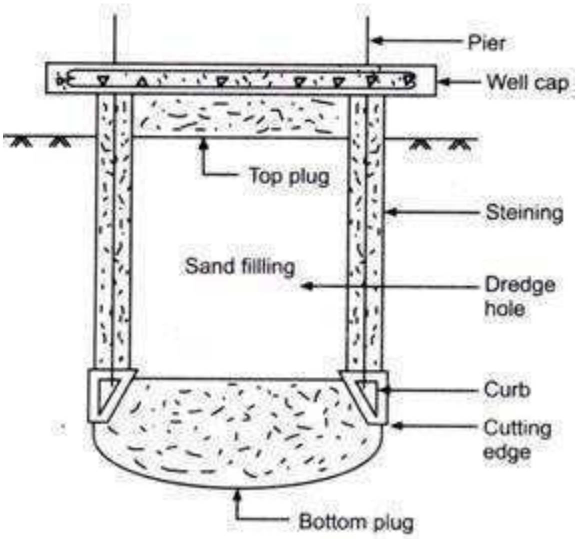


FIG. 11.31 Section of well foundation

A circular well has the minimum perimeter of a given dredge area. Since the perimeter is equidistant at the points from the center of dredge hole, the sinking is more uniform than the other shapes.

 

However, the circular well is that in the direction parallel to the span of bridge, the diameter of the well is much more than required to accommodate minimum size of pier and hence circular well obstruct water way much in comparison to other shapes.

**Forces Acting On a Well Foundation:**

In addition to the self-weight and buoyancy, it carries the dead load of superstructure, bearing and piers and subjected to the following horizontal forces:

(i) Braking effort of the moving vehicle.

(ii) Force due to the resistance of bearings against movement due to temperature variations.(iii) Force of water current(iv) Seismic forces(v) Wind force.(vi) Earth pressure.

**Description of Parts (Elements) of Well:**

1. Staining: It is the wall or shall of the well, made of R.C.C. and which transfer the load to the curb. It acts as an enclosure for excavating the soil for the penetration of well.

2. Curb: It is a R.C.C. ring beam with steel cutting edge below. The cross- section of the curb is wedge shaped which facilitates the sinking of the well. The curb supports well stewing. The curb is kept slightly projected from the stoning to reduce the skin friction.

3. Cutting edge:It is the lowest part of the well curb which cuts the soil during sinking.

4. Bottom plug:After completion of well sinking the bottom of well is plunged with concrete. The bottom plug which is confined by the well curb acts as a raft against soil pressure from below.

5. Back fill:The well is dewatered after setting of the bottom plug and it is backfilled by sand or excavated material.

6. Top plug:It is a concrete plug provided over the filling inside the well.

7. Well cap:It is a R.C.C. slab provided at the top of stewing to transmit the load of superstructure to the stewing and over which pier is laid. The minimum thickness of the slab is about 750 mm.

## COFFER DAMS

### INTRODUCTION

Cofferdams are temporary enclosures to keep out water and soil so as to permit dewatering and construction of the permanent facility (structure) in the dry.

• A cofferdam involves the interaction of the structure, soil, and water. The loads imposed include the hydrostatic forces of the water, as well as the dynamic forces due to currents and waves.

• In construction of cofferdams maintaining close tolerances is difficult since cofferdams are usually constructed offshore and sometimes under severe weather conditions. Under these circumstances, significant deformations of cofferdam elements may happen during the course of construction, and therefore it may be necessary to deviate from the design dimensions in order to complete the project according to plan.

• The loads imposed on the cofferdam structure by construction equipment and operations must be considered, both during installation of the cofferdam and during construction of the structure itself.

 

• Removal of the cofferdam must be planned and executed with the same degree of care as its installation, on a stage-by-stage basis. The effect of the removal on the permanent structure must also be considered. For this reason, sheet piles extending below the permanent structure are often cut off and left in place, since their removal may damage the foundation soils adjacent to the structure.

• In cofferdam construction, safety is a paramount concern, since workers will be exposed to the hazard of flooding and collapse.

• Safety requires that every cofferdam and every part thereof shall be of suitable design and construction, of suitable and sound material and of sufficient strength and capacity for the purpose for which it is used, proper construction, verification that the structure is being constructed as planned, monitoring the behavior of the cofferdam and surrounding area, provision of adequate access, light and ventilation, and attention to safe practices on the part of all workers and supervisors, and shall be properly maintained.

Types of cofferdam:

1. Braced: It is formed from a single wall of sheet piling which is driven into the ground to form a “box” around the excavation site. The box is then braced on the inside and the interior is dewatered. It is primarily used for bridge piers in shallow water (30 - 35 ft depth)

2. Earth-Type: It is the simplest type of cofferdam. It consists of an earth bank with a clay core or vertical sheet piling enclosing the excavation. It is used for low-level waters with low velocity and easily scoured by water rising over the top.

3. Timber Crib: Constructed on land and floated into place. Lower portion of each cell is matched with contour of river bed. It uses rock ballast and soil to decrease seepage and sink into place, also known as “Gravity Dam”. It usually consists of 12’x12’ cells and is used in rapid currents or on rocky river beds. It must be properly designed to resist lateral forces such as tipping / overturning and sliding.

4. Double-Walled Sheet Pile: They are double wall cofferdams comprising two parallel rows of sheet piles driven into the ground and connected together by a system of tie rods at one or more levels. The space between the walls is generally filled with granular material such as sand, gravel or broken rock.

5. Cellular: Cellular cofferdams are used only in those circumstances where the excavation size precludes the use of cross-excavation bracing. In this case, the cofferdam must be stable by virtue of its own resistance to lateral forces. Advantages of Cofferdam Performing work over water has always been more difficult and costly than performing the same work on land. And when the work is performed below water, the difficulties and cost difference can increase geometrically with the depth at which the work is performed.

COFFERDAM COMPONENTS:

• Sheet piling Sheet piling is a manufactured construction product with a mechanical connection “interlock” at both ends of the section. These mechanical connections interlock with one another to form a continuous wall of sheeting. Sheet pile applications are typically designed to create a rigid barrier for earth and water, while resisting the lateral pressures of those bending forces. The shape or geometry of a section lends to the structural strength. In addition, the soil in which the section is driven has numerous mechanical properties that can affect the performance.

• Bracing frame

 

• Concrete seal the typical cofferdam, such as a bridge pier, consists of sheet piles set around a bracing frame and driven into the soil sufficiently far to develop vertical and lateral support and to cut off the flow of soil and, in some cases the flow of water.

CHOICE OF MATERIALS FOR BRIDGE CONSTRUCTION

FOR SUPERSTRUCTURE-

1.Stone masonry arches-For road bridges of moderate spans Brick masonry arches- For culverts

2.Timber structures-For temporary bridges near forest areas and military bridges of small spans

3.Reinforced cement concrete-Slabs for small spans up to 8m.

4.For girders and T-beams-For spans in the range of 10 to 20m.

5.Hollow grids- For spans from 25 to 30m

6.Balanced cantilevers-For spans of 30 to 60m

7.Continuous Girders-For spans up to 40m

8.RCC arches-For span up to 200mm

9.RCC rigid frames -For spans up to 20m



10.Pre-stressed concrete girders-For major bridges with spans of 30 to 120m.

FOR SUBSTRUCTURE

1.Masonry-This can be of brick or stone

2.Steel-This can be used for piers formed by trestle bents

3.Cement concrete-Usually M20 is adopted for piers and abutments.

FOR FOUNDATION

1.Masonry-Coursed rubble masonry is used for spread footings in building of piers,Sometimes it is used for well foundation also.

2.Timber- For sheet-piling for temporary structure like cofferdams, and bracings for excavations

3.Steel- For grillage foundations consisting of steel girders and joists placed in both directions in the form of open structure.

4.Cement concrete- Used in spread foundations,either for footings,as also for the bottom bed, cast-in-situ piles,under-reamed piles.

TESTING AND STRENGTHENING OF BRIDGES:

The following list of strengthening methods

1. Replace existing deck with a lighter weight deck.

 

2. Provide composite action between deck and supporting members.

3. Increase transverse stiffness of bridge deck.

4. Replace deficient members.

5. Replace structurally significant portions of deficient members. Increase cross section of deficient members.

6. Add supplemental members.

7. Post-stress members.

8. Add supplemental spanning mechanisms.

9. Strengthen critical connections.

10. Add supplemental supports to reduce span length.

11. Convert a series of simple spans to a continuous span.

TESTING OF BRIDGES-

Testing of bridges becomes necessary if old bridges that have been in operation for sometime are affected to such an extent that the deficiencies are seen even on visual inspectionTesting is also essential in the case of newly constructed bridges in which new materials and /or new techniques of construction have been used.

TYPES OF TESTS-

1.BEHAVIOUR TEST

2.PROOF LOAD TEST

3.STRESS HISTORY TEST

4.ULTIMATE LOAD TEST

5.DIAGNOSTIC TESTS.

BRIDGE FAILURE-

Although absolute safety is not attainable for any structure including a bridge,every possible care should be taken in the design and construction of a bridge structure.This is because the failure of bridges,especially of major ones,entails interruption to traffic and failure of vital communication links and loss of human life and property.

CAUSES OF BRIDGE FAILURE

The failure of bridge is normally due to combination of several causes,defects and deficiencies.

1.Floods,scour and foundation movements.

2.Unsuitable or defective material or poor workmanship

3.Over loading and accidents

4.Inadequate temporary works during construction or improper erection procedure

5.Earthquake effects

 

6.Inadequate design procedures

7.Wind forces

8.Fatigue under traffic

9.Corrosion of steel components

## INDIAN LOADING STANDARD FOR RAILWAY BRIDGES

The loads specified herein shall be taken into consideration in calculating the strength of all bridges, including turntable girders and foot-bridges but excluding road bridges in which case, the loads to be considered shall be in accordance with the Standard Specifications and Codes of Practice for Road Bridges (IRC Codes). The details of design shall be controlled by the appropriate Codes of Practice as given below:

(a) The design of steel bridges shall be in accordance with the Indian Railway Standard Code of Practice for the Design of Steel or Wrought Iron Bridges carrying Rail, Road or Pedestrian Traffic (Steel Bridge Code).

(b) The design of concrete bridges shall be in accordance with the Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-stressed Concrete for General Bridge Construction (Concrete Bridge Code).

(c) The design of masonry and plain concrete arch bridges shall be in accordance with the Indian Railway Standard Code of Practice for the Design and Construction of Masonry and Plain Cement Concrete Arch Bridges (Arch Bridge Code).

(d) The design of sub-structures of bridges shall be in accordance with the Indian Railway Standard Code of Practice for the design of Substructures of Bridges (Bridge SubStructure Code). (e) The design of sub-structures and super-structures of road bridges shall be in accordance with Standard Specification and Codes of Practice for Road Bridges and other codes as specified by the appropriate authorities.

(f) The design of sub-structures and super-structures of rail-cum-road bridges shall be in accordance with the relevant Indian Railway Standard Codes of Practice except that the Standard Specifications and Codes of Practice for Road Bridges issued by the Indian Roads Congress may apply for the design of such members as are subjected to loads from road traffic alone.

NOTE: (1) Unless otherwise specified the word „Span‟ shall mean effective span.

(2) SI and Metric system of units are given in all cases, but only one system of unit is to be adopted for the design.

(3) Attention is drawn to the fact that equations in the text, for which no units are specified, are applicable in any system of units - SI or Metric provided the unit of length and the unit of force used in an equation are the same throughout. 1.2 Any revision or addition or deletion of the provisions of the Bridge Rules shall be issued only through the correction slip to these Bridge Rules. No cognizance shall be given to any policy directives issued through other means.

 

## LOADS

For the purpose of computing stresses, the following items shall, where applicable, be taken into account:

(a) Dead load

(b) Live load

(c) Dynamic effects.

(d) Forces due to curvature or eccentricity of track

(e) Temperature effect

(f) Frictional resistance of expansion bearings

(g) Longitudinal force

(h) Racking force

(i) Forces on parapets

(j) Wind pressure effect

(k) Forces and effects due to earthquake

(l) Erection forces and effects

(m) Derailment loads

(n) Load due to Passer's Quick Relay System (PQRS)

## ERECTION OF BRIDGE GIRDERS

Erection of concrete bridge generally means erection of pre-stressed concrete bridges as erection of reinforced concrete bridges is rarely done. However, one reinforced concrete arch bridge was erected in Japan by means of a new construction method unprecedented in the world as claimed. A cantilever construction method was adopted in this bridge in which the segments formed of an arch rib, struts and floor slab were supported by pre-stressing steel bars and the over hanged bodies extended their length in stages from both the banks towards the center until the last segment is placed at the center .Erection of PSC beams can be done by the use of gantry. This method is suitable for land spans or in river bed, where the dry weather flow is small and is limited to a very small width of the bed. The height of erection is about 10 meters.The erection of PSC beams in the approach viaduct of the second Hooghly Bridge, Calcutta was done by the use of tilting derricks. Two derricks were used, one at each and of the girder, to lift the girder over the pier. These derricks were then tilted by releasing one of the guy ropes and tightening the other very slowly and carefully keeping both the guy ropes taut. The girder was then placed over the pier cap and side-shifted to its actual position by usual process. The pre-stressed concrete girders, 46.0 meters in length between centerlines of bearings were cast and stressed on the approaches, placed over two trolleys at two ends. The trolleys were than run over rail lines and the girders were brought near the abutments where a launching truss as shown in Fig. 24.6a was standing. Both ends of the girder were lifted from the trolley simultaneously and suspended from the bottom boom of the launching truss. The suspenders had a pair of wheel at top resting on the bottom boom through which the girders could be moved longitudinally. In this way, the girders were brought over the first span and lowered one by one by the use of sand jacks and side-shifted to their actual position.

## EQUIPMENT'S AND PLANTS

1. Pneumatic/Hydraulic
2. Tools
3. Air Compressor/ Hydraulic Pump
4. Rock Drill/Jack Hammer/Other Drills
5. Concrete Breaker
6. Asphalt Cutter
7. Impact Wrenches/Nail Driver
8. Grinder
9. Concrete Vibrator
10. Circular saw/ Chain Saw
11. Road Broom
12. Aggregate Producer
13. Rock Crushers, Screen, and Conveyors
14. Central Mix Plant (Asphalt), (Batch Plant/Continuous Mix Plant)
15. Bitumen Decanter, Bitumen Heater
16. Bitumen Distributor
17. Portable Mix Plant
18. Pavers (Asphalt/Concrete)
19. Aggregate Spreader
20. Concrete Mixers/Concrete Batch Plant
21. Concrete Vibrator.

## INSPECTION AND DATA COLLECTION

 

**When they arrive at the project site, examine the beams/girders carefully for the following defects and report significant ones to the Project Administrator:**

**KINKS: Sharp bends in flange or web plates that do not reveal warps. Kinks are occasionally required by the design so check the plans before you report a kink as a defect.**

**WARPS: Wavy sections in flange or web plates that are an indication of buckling or excessive temperature effects caused by welding.**

**BENDS: Gradual curves in plates that are not indicated as being part of the design.**

**CRACKS: These are very serious defects when in a steel beam because they can grow and eventually cause sudden failure of a plate, which can cause collapse of the beam or even the entire superstructure.**

**PLUMBNESS: Using a Plumb Bob or square, check to see that flange plates are perpendicular to the web plate and that stiffener plates are perpendicular to top and bottom flange plates.**

**WELDED AND BOLTED CONNECTIONS: Examine all welds that join plates together, such as flange to web connections, for obvious welding defects and make sure that any bolted connections are properly assembled and that bolts appear to be snug. A loose bolt can be revealed by the sound it makes when lightly taped with a hammer.**

**HANDLING AND STORAGE: When the beams/girders arrive at the project site very often they are lifted from a truck or barge and are placed directly in their permanent position. You must make sure that the proper lifting devices are used and placed at the proper locations so that lifting stresses will not cause damage to the girder. These devices are usually special clamps that attach to the top flange. If they are used improperly, there can be damage structurally or to the beam's protective coating. Pay particular attention to box girders and curved girders since they can be larger, heavier, or far more unstable then single straight beams and are; therefore, more difficult to handle property. If the beams/girders are placed in a temporary storage site prior to permanent placement, they must be supported at least at the points of bearing shown in the plans and they must be high enough off the ground to avoid being submerged in, or being splashed by, water. The beams should also be kept free of dirt, oil, or any other detrimental contaminant**

 