GUIDELINES FOR STEEL PEDESTRIAN BRIDGES

(First Revision)

Published by:
INDIAN ROADS CONGRESS
Kama Koti Marg,
Sector 6, R.K. Puram,
New Delhi - 110 022
MAY, 2011

Price Rs. 600/-
(Packing & postage charges extra)

First Published	:	January, 2000
Reprinted	:	November, 2004
First Revision	:	May, 2011
Reprinted	:	October, 2014 (Incorporating all Amendments published upto October, 2014)

Printed at : India Offset Press, New Delhi
(1000 Copies)

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1 INTRODUCTION

1.1 With the rapid development work in the urban sector in India, construction activities for pedestrian crossings over roadways and railways in and around metropolitan and large cities and near centres of pilgrimage or where large congregational fairs are held have increased considerably. This trend is likely to continue with further development leading to demand for pedestrian crossings in suburban towns and rural areas as well. Pedestrian bridges are also built over rivers, canals, valleys and in amusement parks etc.

1.2 Guidelines and recommendations for construction and design of steel pedestrian bridges to suit the Indian conditions was first framed and published in the year 2000 as IRC:SP:56 "Guidelines for Steel Pedestrian Bridges". This satisfied the need and served as a guide for design and construction of steel pedestrian bridges.

1.3 Since then a lot of developments have taken place in the field of steel production technology, construction practice as well as design philosophy and methods of analysis. Consequently, several IRC standard specifications and codes of practices related to bridges have been revised. These include:

a) IRC:24 Section V - Steel Road Bridges
b) IRC:22 Section VI - Steel-Concrete Composite Bridges
c) IRC:6 Section II - Loads and Stresses

1.4 In line with the above trend, it became necessary to revise IRC:SP:56 "Guidelines for Steel Pedestrian Bridges" as well.

The names of the personnel of Steel and Composite Structures Commitee (B-5) are given below:

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The draft approved by Steel and Composite Structures Committee was discussed by Bridges Specifications & Standards Committee (BSS) in the meeting on 25th October, 2010 and was approved, subject to certain modifications. Subsequently, the draft was approved by the Executive Committee on 27th October, 2010. Finally the draft was approved in the 192nd Council meeting held at Nagpur (Maharashtra) on 11th November, 2010.

For preparing this document, literature published by organisations like International Federation for Structural Concrete (fib) and British Standards Institution (BSI) have been consulted. Indian Roads Congress acknowledges with thanks the kind permission given by fib and BSI to use some of their Figures and Appendices of this document.

2 SCOPE

2.1 The revised guideline deals with specific recommendations for the design of superstructure and substructure of pedestrian bridges in structural steelwork. This guideline generally applies to steel pedestrian bridges suitable for plate girder or truss girder bridges.

2.2 These recommendations should be considered as complementary to the requirements of IRC:24.

2.3 For pedestrian bridges envisaging use of special structural forms like steel arch, cable suspended bridge, etc. or for those structures requiring suitable dampers (to reduce human induced vibration), special considerations in analysis and design will be necessary. For such structures, reference should be made to special codes or specialist literature dedicated to the concerned subject.

2.4 Provisions of this document are applicable to cycle-track bridges also.

3 GENERAL CONSIDERATIONS

3.1 One of the primary purposes of pedestrian bridges is to facilitate and encourage walking and cycling whilst ensuring safety for all road users. These bridges should be designed taking into account the pedestrian flows and movements and encourage people to regard walking or cycling as an accepted mode of transport.

3.2 The considerations which generally govern the alignment, layout, structural form and design of a pedestrian bridge include safety, cost, aesthetics, environmental impact, ease of erection, robustness, sustainability, ease of maintenance etc.

3.3 In certain cases study of the user profile becomes important, such as where persons with impaired mobility or vision are likely to use the pedestrian bridge. In such cases ramps may have to be provided for access to the bridge deck.

3.4 In case of goal oriented users, the location of the desire line is usually the highest priority, whereas in the case of recreational users, the crossing should be located so that it adds to the recreational value of the route, which can be done by reducing exposure to traffic, introducing new views, or creating a new circular route.

3.5 All precautions should be taken to discourage the pedestrians from crossing the carriageway at road level.

3.6 For new pedestrian bridges over existing roads, the supports/foundations should be located and designed giving due consideration to the utilities passing under the road and in such a manner so as to cause minimum disruption to the traffic during construction.

4 LAYOUT AND STRUCTURAL FORM

4.1 While finalising the alignment of a pedestrian bridge, effort should be made to maximise the use of the topography in order to minimise the need for stairs or ramps to access the deck. Possibility of locating steps or ramps into the contour of the landscape should be explored.

4.2 Provision of stairs/escalators/elevators/ramps should be decided in consultation with the appropriate authority. However, ramps would be preferable to stairs/escalators.

4.3 In case ramps are provided, their geometry should be simple and practical. Landings at suitable intervals should be provided for mobility-impaired users, particularly wheel-chair users. Straight ramps with 180° turns should be avoided. Spiral ramps with large radii may be adopted.

4.4 If a pedestrian bridge crosses a dual carriageway carrying traffic with permitted speeds in excess of 40 km/h, both carriageways should be crossed with a single span to avoid need for support in the central reserve. In case it becomes necessary to provide central support, the same should be designed considering vehicle collision loads as per the relevant Clause of IRC:6.

4.5 In case a pedestrian bridge is located alongside a road bridge, a gap of minimum 2 m should be provided between the structures to prevent people from crossing from one bridge to the other. Also, appropriate barrier system should be installed on approaches to the pedestrian bridge to prevent roadway vehicles from impacting on to the pedestrian bridge structure or its users. However, care should be taken to design the barrier system to allow the passage of wheelchairs through the system. The barrier system should be adequately painted using paints in contrast colour, night glowing paints etc. to eliminate the risk of accident.

4.6 Where the approach to stairs or ramp of a pedestrian bridge is located adjacent to a roadway, the pedestrians walking towards the bridge should be facing the oncoming traffic, instead of the latter coming from behind.

4.7 In case cycling is allowed on a particular pedestrian bridge, separate and dedicated lane(s) should be provided for the use of cyclists.

4.8 In case sub-structures are situated in railway or waterway property, the appropriate authority's requirements shall be satisfied.

4.9 Some possible layouts of pedestrian bridges are shown in **Fig.1.**

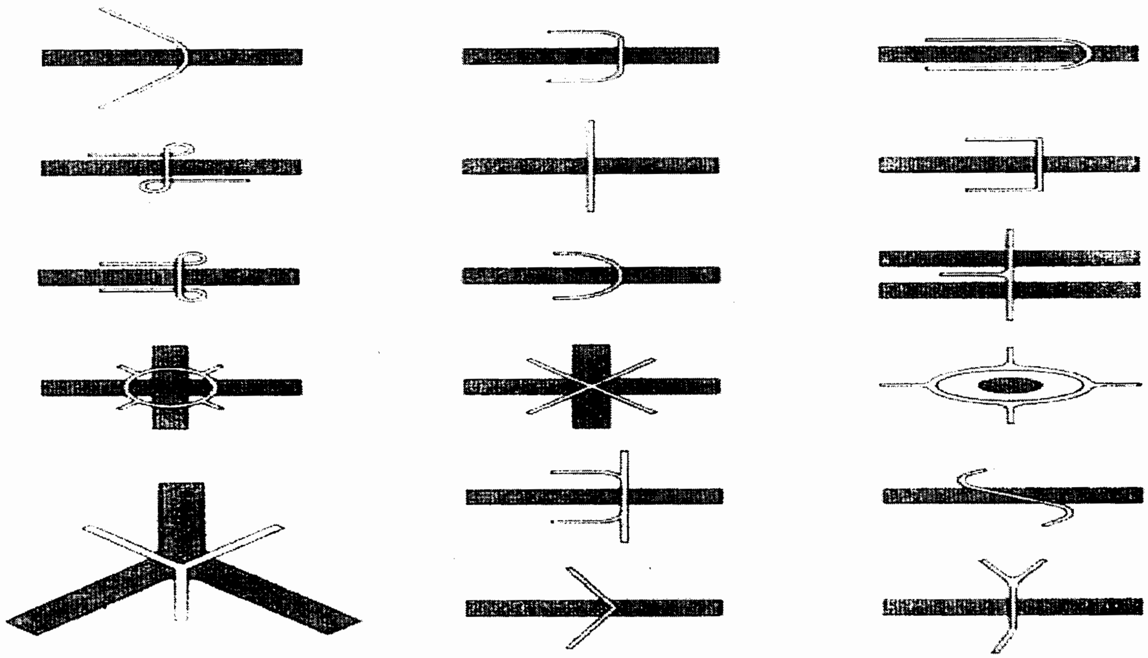


Fig.1 Some Possible Layouts for Pedestrian Bridges

[*Source: Guidelines for the design of foot bridges. Figure reproduced by permission of the International Federation for Structural Concrete (Federation Internationale du beton, fib).*

4.10 Structural form to be adopted in a pedestrian bridge depends largely on the proposed span. For smaller spans twin steel beams or plate girders may be the optimum solution, while for larger spans steel truss or box girders may be required. Various options of structural forms and their corresponding span ranges are given in **Table 1** as guideline.

Table 1 Structural Forms

Structural Form	Span Range (m)
Twin Steel beam/plate girder	10 to 30
Composite beams/plate girder	10 to 50
Box girder	20 to 60
Truss (preferably through truss)	15 to 60
Vierendeel girder	15 to 45
Arch bridge	25 upwards
Cable stayed bridge	40 upwards
Suspension bridge	70 upwards

5 AESTHETICS

5.1 Pedestrian bridges offer a wide range of opportunities for imaginative and innovative architectural designs. A designer should, therefore, try to design the bridge to be as attractive as possible keeping in mind the functional requirements. A few guidelines towards this end are offered hereunder:

a) A bridge structure should be in harmony with the surrounding environment and enhance its quality. It is best attained by merging the lines of the bridge structure with those of the surrounding landscape or cityscape. If necessary, landscaping with trees should be considered, specially in flat environment.

b) A pedestrian bridge is likely to be viewed from various angles and at different times of the day and night. Consequently, good proportions are necessary in the relative sizes of its various parts, e.g. length/breadth/width, so that these are in harmony with each other.

c) External finish and painting should be such as to enhance the elegance of the bridge and be attractive to the viewer.

d) The lighting on the bridge should not only be adequate for the pedestrians, but should be tastefully designed to create an aesthetically pleasing environment at night. The quality of lighting should comply with relevant standards and also match with the surrounding lighting of heritage buildings and important public structures.

e) Signs and signal equipment erected in close proximity of a pedestrian bridge create an impression of clutter to the users of the bridge. This aspect needs due consideration while finalising the layout of the bridge.

f) Detailing of handrails of approach stairs and ramps should be tastefully designed so as to impress those who will appreciate these from close quarters and travelling at a slow pace.

6 LOADS

6.1 Imposed Vertical Loads

6.1.1 The imposed load due to pedestrian traffic shall be treated as a uniformly distributed load over the clear footway.

6.1.2 For design of pedestrian/cycle track bridges, the intensity of loading shall be taken as 500 kg/sq.m.

6.1.3 Kerbs, 0.6 m or more in width, shall be designed for the above loads and for a local lateral force of 150 kg per m, applied horizontally at top of the kerb. If kerb width is less than 0.6 m, no live load shall be applied in addition to the lateral load specified above.

6.1.4 The above loadings are to be considered for the design of all parts of the bridge floors and general stability of the structure.

6.1.5 No allowance need be made for impact for imposed vertical load. However, vibration and dynamic response due to pedestrian activities need to be examined as required in **Clause 20.**

6.2 Imposed Horizontal Loads

A crowd of people pushing against a balustrade may exert horizontal load. Railings and parapets together with the members which give them structural support shall be designed to resist a lateral horizontal force and a vertical force of 150 kg/m applied simultaneously at a height of 1.1 m above datum level, irrespective of the actual height of the barrier, if necessary, by providing additional structural member at that level. For this purpose the datum level should be taken as the finished level of the bridge floor.

6.3 Wind Load

For calculation of wind load of a pedestrian bridge, due consideration as per the relevant Clause of IRC:6 should be given on the bridge structure, as also on hoardings or any other obstructions which may be fixed on the bridge, taking into account the position and size of the hoardings or obstructions.

6.4 Seismic Load

Structures shall be designed considering earthquake effect as per the relevant Clause of IRC:6.

6.5 Vehicle Collision Load

6.5.1 Vehicle collision load on supports shall be considered as per the relevant Clause of IRC:6 or in accordance with the requirement of appropriate authority.

6.5.2 Collision loading on pedestrian bridges over navigable water shall be as per relevant Clause of IRC:6, or as agreed by appropriate authority.

6.6 Temperature Effect

Pedestrian bridges shall be designed considering the temperature effect as per the relevant Clause of IRC:6.

7 DEFLECTION OF GIRDERS

7.1 Rolled steel beams, channels, plate girders or lattice girders, either simple or continuous spans, shall be designed so that the total vertical deflection due to live load should not exceed 1/300 of the span. However, this limit may be exceeded in cases where greater deflection would not impair the strength or efficiency of the structure or lead to damage of the finishing. The deflection limitations due to dead load may be taken care of by providing suitable camber.

7.2 Care should also be taken to ensure adequate stiffness of the structure so that the horizontal deflection or vibrations are kept limited to provisions of **Clause 20** to avoid uncomfortable feeling of the pedestrians using the bridge.

8 MINIMUM SECTIONS

For minimum sections to be used for pedestrian bridges see **Appendix A**.

9 WIDTH AND HEADROOM

9.1 The minimum clear width of a pedestrian bridge should preferably be 1.8 m and may be increased to suit specific requirements in busy areas. Where the clear width is more than 1.8 m, dividers (or pillars) should be fixed at each end of the bridge to prevent vehicles from plying over the bridge. The dividers should be appropriate to the environmental system and should be such as to allow easy passage of wheel chairs. The dividers should be painted in contrast colour to avoid risk of accidents.

9.2 Where the bridge is covered or has members across at top of walkway, the minimum clear headroom should be 2.5 m measured from the finished level of the bridge floor to the underside of the support member of the covering.

9.3 Where the slant portion of staircase or ramp is also covered the minimum clear headroom should be 2.5 m measured from the top of the riser or ramp to the ceiling or to the underside of the support member of the covering at that location.

9.4 For pedestrian/cycle track bridges recommended minimum widths for various situations are given in **Table 2.**

Table 2 Minimum Width of Pedestrian/Cycle Track Bridges

Sl.No.	Situations	Pedestrian Path (m)	Cycle Path (m)	Total Width (m)
1)	When segregated by kerb not less than 50 mm or segregated by white line, contrast colour, or surface texture	1.8	1.8	3.6
2)	Segregated by railings not less than 900 mm high	2.0	2.0	4.0
3)	Unsegregated			3.0

10 CLEARANCE

10.1 The horizontal and vertical clearance of the pedestrian bridge over roadways or railways or other locations shall comply with the clearance requirements of IRC or of concerned authorities as appropriate.

10.2 Recommended minimum clearances between the pedestrian bridge and electric power line are given **Table 3.**

Amendment No. 1/August, 2013/IRC:SP:56-2011
to
IRC:SP:56-2011 "Guidelines for Steel Pedestrian Bridges"
(*First Revision*)
Replace the Table 3 by the following:

Table 3 Minimum Clearance Between Pedestrian Bridge and Power Line

Sl. No.	Voltage of Power lines	Minimum Vertical Clearance	Minimum Horizontal Clearance
1	Less than or equal to 11,000 Volts	3.7 m	1.2 m
2	More than 11,000 volts but less than or equal to 33,000 volts	3.7 m	2.0 m
3	Extra-high voltage (i.e. more than 33,000 volts)	3.7 m + 0.3 m for every additional 33,000 volts or part thereof	2.0 m + 0.3 m for every additional 33,000 volts or part thereof

(**Source :** Indian Electricity Rules, 1956)

11 APPROACH STAIRS AND OTHER ELEMENTS

11.1 The following terms are generally used:

11.1.1 *Tread*

Tread is the horizontal upper surface of a step upon which the foot is placed. Tread should be level throughout and made with rough surface to reduce slipping. Tread width should not be less than 250 mm and not more than 300 mm. It should be uniform in a single flight.

11.1.2 *Riser*

Riser is the vertical portion of a step. In general the number of risers in a single flight should not be more than 15.

Completely open risers shall not be used. However, perforated risers may be used. For perforated risers the principal dimension of perforation should not exceed 50 mm and may be provided in staggered way. Also the ratio of the open area to the total area of the riser shall be not greater than 0.4.

11.1.3 *Rise*

Rise is the vertical height between upper surfaces of two successive steps, which should not be more than 200 mm and not less than 150 mm. It should be uniform in a single flight.

11.1.4 *Nosing*

Nosing is the exposed edge of the tread usually protruding/projecting.

11.1.5 *Going*

Going is the horizontal distance between two riser faces.

11.1.6 *Pitch*

Pitch is the angle of inclination of the stair with the horizontal. The pitch shall be uniform for the bridge and shall be maximum 40° and minimum 30°. A suitable shape for a step is 170 mm rise and 250 mm going with 25 mm nosing to give a tread of 275 mm, with skid free surface.

11.1.7 *Landing*

Landing is a level platform at the top of a flight between floors. It shall be of length equal to the width of stairs and shall be provided at the end of each flight.

11.1.8 *Flight*

Flight is a series of steps between any two consecutive landings or any landing and its immediately preceding/succeeding floor. No more than three successive flights should be used in line, provided there is a change in direction of at least 30° in any two adjacent flight.

11.1.9 *Height of flight*

Height of a flight should be limited to 3 m.

12 APPROACH RAMPS

12.1 Where approach ramps are preferred to approach stairs, the gradient should be guided by **Clauses 12.2 to 12.7.**

12.2 Ramps should not be steeper than 1 in 20. For special reasons a steeper ramp may be used, preferably not greater than a gradient of 1 in 15. However, no ramp shall have a gradient steeper than 1 in 12.

12.3 In case a ramp is steeper than 1 in 20, there should be a change in the horizontal alignment (e.g. offset by at least one ramp width) at every 3.5 m rise of the ramp at an intermediate landing. Alternatively, change in the direction (30° or more) of the ramp with a landing at every 3.5 m rise may be provided.

12.4 For ramps of gradient 1 in 20, intermediate landings should be provided at equal intervals of maximum 2.5 m rise.

12.5 For gradients flatter than 1 in 20, intermediate landings will not be required.

12.6 For ramps of gradients steeper than 1 in 20, intermediate landings should be provided at equal intervals of maximum 650 mm rise.

12.7 For spiral and curved ramps, the effective gradient should comply with the requirements of straight ramps. The effective gradient and governing dimensions shall be measured at a distance of 900 mm from the walkway edge on the inside of the curve. The minimum inside radius of walkway for spiral and curved ramps should be 5.5 m.

13 HAND RAILS AND PARAPETS

13.1 The minimum height of railings should be 1.1 m. measured vertically above the floor of the bridge or the line joining the noses of the stairs. If the railing is composed of balustrades, the spacing between them and any adjacent member should not be more than 75 mm. The lowest rail shall be maximum 150 mm and minimum 50 mm above the floor of the bridge or nose of the steps.

If the pedestrian bridge is located at a place having high winds or if the bridge is only meant for pedestrian use and the clearance under the bridge is greater than 10 m, the height of the railings may be increased to 1.3 m after consultation with the appropriate authority.

For ensuring safety, minimum gap between vertical in-fills should not be more than 200 mm. Where vertical in-fills are not provided minimum gap between horizontal rails should not exceed 150 mm.

13.2 Handrails should be provided on both sides of the floor, stairs and ramps. Where the width of the stairs or ramps exceeds 3 m, additional central handrails need to be provided.

13.3 Where handrails of circular section are provided, they should preferably be of 40-50 mm diameter. For non-circular sections, preferred size would be 50 mm wide by 38 mm deep with rounded edges.

13.4 For ease of visually impaired users, handrails should preferably be of a contrasting colour.

13.5 For pedestrian bridge with cycle track, the minimum height of the railing shall be 1.4 m. However, in case cyclists are physically segregated from pedestrian facilities, the increased railing height need only be provided on the cycle track side of the bridge.

14 ENCLOSED PEDESTRIAN BRIDGES

14.1 Provision of enclosure to pedestrian bridges shall be considered in areas exposed to adverse weather conditions (such as high winds or heavy rains) and where they are at such a height from the roadway that the pedestrians may feel insecure.

14.2 In such cases aerodynamic effects and wind tunnel testing may be done if considered necessary. For this purpose relevant Clauses of IRC:6 and IS 875 may be referred. However, aerodynamic effect need not be examined when pedestrian bridges are surrounded by structures and/or buildings of similar height.

14.3 Structural framing and cladding should be decided, depending on the condition of the individual site and in consultation with the appropriate authority. Cladding may be corrosion resistant steel mesh or solid panels of transparent materials. High parapets with inward canted top or full enclosures may be provided. Where solid panels are provided in full enclosure, openings at suitable spaces should be provided for ventilation purpose; and there should also be provision for cleaning.

15 HOARDINGS

Normally, no hoarding should be allowed in a pedestrian bridge. However, it is common practice, particularly in urban areas, to fix hoardings on to pedestrian bridges for advertisements or other notifications, since they form an attractive source of revenue. In such cases and eventualities it is better that plan for its location, its size and extent are predetermined and covered in the original scheme itself. It should be ensured that the size of the hoardings do not interfere with the ventilation or vision of the pedestrian using the bridge. For this purpose, a minimum clearance of 2 m from the finished level of the bridge to the lowest level of the hoarding is recommended. Also, advertisements outside the hand railing etc. should be such and so regulated that the attention of drivers is not diverted. Facilities for maintenance/renewal works for hoardings may be provided integrally with the bridge structure.

16 DECK MATERIAL AND WALKWAY SURFACES

16.1 Deck material should be selected keeping in view its performance in exposed condition and also to ensure protection against corrosion. In general concrete slabs or ribbed steel plates with non skid surface are considered desirable material for this purpose.

16.2 Walkway surface system should be selected considering resistance to slip, corrosion resistance, durability, etc. The surfacing should be waterproof and be sealed to prevent the ingress of water to the deck below.

16.3 Exposed gap in walkway surface joint should be limited to 12 mm. If cover plates are provided in such locations, these should be set flush with the surface level in order to prevent tripping. These should also be so treated as to avoid slippage.

17 DRAINAGE

17.1 Drainage of water from the walkway surface, steps, ramps and roof (in case of enclosed pedestrian bridges) should be taken care of in the detailing of the bridge for the water to run-off. Care should be taken to ensure that the water is not discharged from the structure on to the carriageway or footpath below. It should be carried away by means of a suitable drainage system (e.g. pipes) so that the water is prevented from coming in contact with the underside of the bridge structure or entering into the structure.

17.2 Drainage pipes and their layout should be so designed as to have easy access for cleaning properly.

18 LIGHTING

18.1 In areas where public lighting is provided, pedestrian bridges should also be illuminated in order to improve night time visibility and to promote safer and efficient use of the facilities such as walkways, ramps, stairs, etc. in conformity with recommendations of appropriate authority. Minimum illumination level should be 40 LUX.

18.2 Illumination may be done from posts either mounted on the ground level or on the bridge structure. All components of the lighting system, such as fitting and connections should be as per relevant standards and be robust and tamper proof. Parapet members should not be used as cable ducts.

18.3 Preventive maintenance schedule should be established so that the lighting system is checked at appropriate intervals.

19 PRECAUTIONARY MEASURES

19.1 Proper care should be taken in detailing of steel superstructure of the pedestrian bridges to ensure not only the functional requirements but also to avoid any hazards such as gaps and stumbling objects in flooring and projecting objects from sides which might hurt the user.

19.2 Adequate protection arrangement should also be introduced to prevent users from coming in contact with nearby potential dangers such as live electrical wires, telephone cable etc. or moving objects. Flush type hidden system with adequate luminosity may be used.

19.3 Pedestrian bridges can be more prone to misuse and vandalism by users or anti-social elements. This aspect needs to be considered while designing and detailing these bridges. In locations with considerable risk of vandalism, materials of high scrap value should not be used for mounting, etc.

19.4 In desolate areas, where there is high risk of objects being dropped from the pedestrian bridge or of persons jumping on to the carriageway below, provision of full or partial enclosure in the sides of the bridge and its ramps and stairs may be considered, in consultation with appropriate authorities.

19.5 Being very light structures pedestrian bridges are very vulnerable to be dislodged by oversized equipments such as crane passing under these bridges. Special signage should be provided in the approaches to warn against such possibility.

19.6 There should be no concealed areas or recesses on pedestrian bridges which may cause bridge users to become concerned about their personal security while crossing.

19.7 Local fire safety regulations should be followed.

20 VIBRATION AND DYNAMIC RESPONSE

20.1 Long span pedestrian bridges are likely to be susceptible to vibrations induced by unintentional pedestrian activities such as walking, jumping or by some deliberate action by vandals. This aspect needs to be examined by designers. If necessary, provision of installing dampers to reduce vibration may be considered. Also, study of foundation isolation may be considered as necessary. However, studies show that pedestrian bridges of less than 30 m span are much less susceptible to such vibration and therefore, checking on this account is not necessary (**Ref. 3**). For pedestrian bridges of longer spans specialist documents and relevant literature should be consulted.

20.2 For vibration serviceability requirements reference may be made to **Appendix-B**. In case more accurate analysis is warranted, appropriate software may be used.

21 POST CONSTRUCTION MAINTENANCE

For Post-construction maintenance relevant clauses of IRC:24 may be referred.

22 REFERENCES

1) Design Criteria for Footbridges : BD-29/04 (Design Manual for Roads and Bridges, UK)

2) Composite Version of BS 5400 : BD-37/01, BD 60/04, TD-27/05

3) Enhancing Urban Aesthetics:
Design of Elegant Foot Over Bridges, Institute for Steel Development and Growth (INSDAG), Kolkata, Publication No.INS/PUB/109.

4) Guidelines for the design of footbridges, International Federation for Structural Concrete (fib), Laussanne, Switzerland.

Appendix A
(Clause 8)

MINIMUM SECTIONS

A1 For all members of the structure, except parapets and packing plates, the following minimum thicknesses of plates and rolled sections shall apply :

a) 8 mm when both sides are accessible for painting or are in close contact with other plates or rolled sections, or are otherwise adequately (refer **Annex D of IRC:24-2010**) protected against corrosion.

b) When one side is not readily accessible for painting or is not in close contact with another member, or is not otherwise adequately (refer **Annex D of IRC:24-2010**) protected and where the thickness required by calculation is less than 12.5 mm, 1.5 mm shall be added to the calculated thickness subject to the total thickness being not less than 10 mm.

c) 6 mm for box members when the inside of the member is effectively sealed.

d) For rolled steel beams and channels the controlling thickness shall be taken as the mean thickness of the flange, regardless of the web thickness

A2 In floor plates and parapets not designed to carry stresses a minimum thickness of 6 mm shall be used if both sides are accessible or 8 mm if only one side is accessible. For packing plates the thickness shall not be less than 1.5 mm.

A3 In riveted construction no angle less than 75 mm x 50 mm shall be used for the main members of the girders.

A4 No angle less than 65 mm x 45 mm and no flat less than 50 mm wide shall be used in any part of a bridge structure, except for hand railings and shear connectors.

A5 Thickness of end angles connecting stringers to cross girders or cross girders to main girders shall be not less in thickness than three quarters of the thickness of the web plates of the stringers and cross girders respectively.

Note: The above stipulations are taken from **Clause 504.7 of IRC:24-2010**. Any change therein will be automatically applicable to the above stipulations.

Appendix B
(Clause 20.2)

VIBRATION SERVICEABILITY REQUIREMENTS FOR PEDESTRIAN BRIDGES

B1 General : For superstructures for which the fundamental natural frequency f_o of vibration exceeds 5Hz for the unloaded bridge in the vertical direction, and 1.5 Hz for the loaded bridge in the horizontal direction, the vibration serviceability requirement is deemed to be satisfied.

For superstructures where fundamental natural frequency in the vertical direction is equal to or less than 5Hz, the maximum vertical acceleration of any part of the superstructure shall be limited to $0.5\sqrt{f_o}$ m/s^2. The maximum vertical acceleration shall be calculated in accordance with **Clauses B2 or B3** as appropriate. A method for determining the vertical fundamental frequency f_o is given in **Clause B2.3.**

Where the fundamental frequency of horizontal vibration is less than 1.5Hz, special consideration shall be given to the possibility of excitation by pedestrians of lateral movements of unacceptable magnitude. Bridges having low mass and damping and expected to be used by crowds of people are particularly susceptible to such vibrations. The method of deriving maximum horizontal acceleration should be agreed with the appropriate authority.

B2 Simplified method for deriving maximum vertical acceleration: This method is valid only for single span, or two-or-three-span continuous, symmetric superstructures, of constant cross-section and supported on bearings that may be idealised as simple supports.

The maximum vertical acceleration a (in m/s^2) shall be taken as

$$a = 4\pi^2 f_o^2 y_s k \psi$$

where

f_o is the fundamental natural frequency (in Hz) (**see Clause B2.3**)

y_s is the static deflection (in m) (**see Clause B2.4**)

k is the configuration factor (**see Clause B2.5**)

ψ is the dynamic response factor (**see Clause B2.6**)

For values of f_o greater than 4Hz the calculated maximum acceleration may be reduced by an amount varying linearly from zero reduction at 4Hz to 70 percent reduction at 5Hz.

B2.1 Modulus of elasticity: In calculating the values of f_o and y_s, the modulus of elasticity for steel shall be equivalent to the values given in IRC:24.

B2.2 Second moment of area: In calculating the values of f_o and y_S, the second moment of area shall be considered without taking into account the effects of shear lag in steel bridges.

B2.3 Fundamental natural frequency f_o: The fundamental natural frequency f_o is evaluated for the bridge including superimposed dead load and may be calculated from the following formula.

$$f_o = (C^2/2\pi l^2)\sqrt{(EIg/M)}$$

where

g is the acceleration due to gravity (in m/s^2)

l is the length of the main span (in m)

C is the configuration factor (see **Table B.1**)

E is the modulus of elasticity (in kN/m^2) (see **Clause B2.1**)

I is the second moment of area of the cross section at mid span (in m^4) (see **Clause B2.2**)

M is the weight per unit length of the full cross-section at mid span (in kN/m)

Mid span values of I and M shall be used only when there is no significant changes in depth or weight of the bridge throughout the span. Where the value of I/M at the support exceeds twice, or is less than 0.8 times, the value at mid span, average values of I and M shall be used.

The stiffness of the parapets shall be included where they contribute to the overall flexural stiffness of the superstructure.

Values of C shall be obtained from **Table B.1**

B2.4 Static Deflection y_S: The static deflection y_S is taken at the midpoint of the main span for a vertical concentrated load of 0.7 kN applied at this point. For three-span superstructures, the centre span is taken as the main span.

B2.5 Configuration factor K: Values of K shall be taken from **Table B.2**.

Table B.1 Configuration Factor C

Bridge Configuration	Ratio l_1/l	C
	–	π
 $l > l_1$	0.25 0.50 0.75 1.00	3.70 3.55 3.40 π
 $l > l_1$	0.25 0.50 0.75 1.00	4.20 3.90 3.60 π

For two-span and three-span continuous bridges, intermediate values of C may be obtained by linear interpolation.

Table B.2 Configuration Factor k

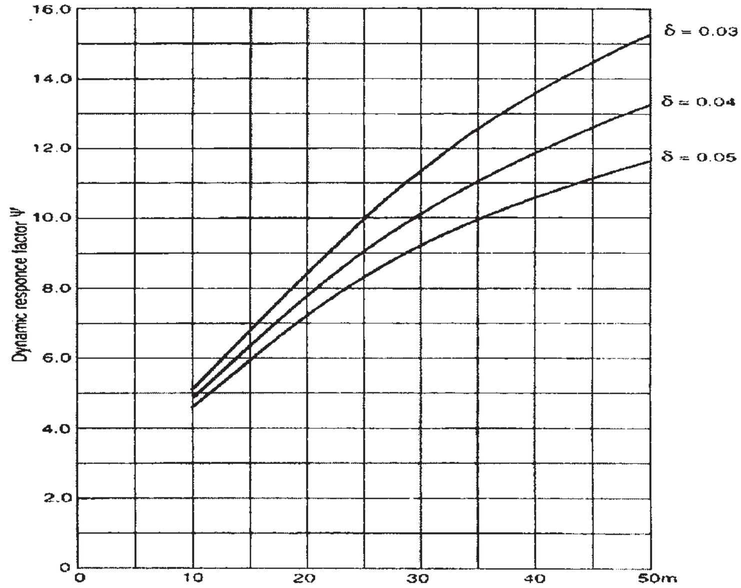
Bridge Configuration	Ratio l_1/l	K
	-	1.0
	-	0.7
 $l > l_1$	1.0 0.8 0.6 or less	0.6 0.8 0.9

For three-span continuous bridges, intermediate values of k may be obtained by linear interpolation.

B2.6 Dynamic response factor ψ : values of ψ are given in **Fig. 2**. In the absence of more precise information, the value of δ (the logarithmic decrement of the decay of vibration due to structural damping) given in **Table B.3** should be used.

Table B.3 Logarithmic Decrement of Decay of Vibration δ

Bridge Superstructure	δ
Steel with asphalt or epoxy surfacing	0.03
Composite steel/concrete	0.04



Main span l

Note 1 Main span l is shown in **Table-B.2**.

Note 2 Values of logarithmic decrement of decay of vibration δ for different types of construction are given in **Table-B.3**.

Fig. 2 Dynamic Response Factor ψ

B3 General method for deriving maximum vertical acceleration: For superstructures other than those specified in **Clause B.2**, the maximum vertical acceleration should be calculated assuming that the dynamic loading applied by a pedestrian can be represented by a pulsating point load F, moving across the main span of the superstructure at a constant speed v_t as follows:

$F = 180 \sin 2\pi f_0 T$ (in N),where T is the time (in s)

$v_t = 0.9 f_0$ *(in m/s)*

For values of f_0 greater than 4Hz, the calculated maximum acceleration may be reduced by an amount varying linearly from zero reduction at 4Hz to 70 percent reduction at 5Hz.

B4 Damage from forced vibration: Consideration should be given to the possibility of permanent damage to a superstructure by a group of pedestrian deliberately causing resonant oscillations of the superstructure. As a general precaution, therefore, the bearings should be of robust construction with adequate provision to resist upward or lateral movement.