

BRITISH STANDARD CODE OF PRACTICE

CP 117 : Part 2 : 1967

UDC 693.55 : 693.814 : 624.21.093

**COMPOSITE CONSTRUCTION IN
STRUCTURAL STEEL AND
CONCRETE**

PART 2. BEAMS FOR BRIDGES

**THE COUNCIL FOR CODES OF PRACTICE
BRITISH STANDARDS INSTITUTION**

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British Standards House, 2 Park Street, London, W.1

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COMPOSITE CONSTRUCTION IN STRUCTURAL STEEL AND CONCRETE

Part 2. Beams for bridges

This part of the Code of Practice has been prepared by a Committee convened on behalf of the Codes of Practice Committees for Building and for Civil Engineering. Having been endorsed by the Council for Codes of Practice, it was published under the authority of the General Council on 29th September, 1967.

This Code of Practice makes reference to the following British Standards:

- BS 15. Mild steel for general structural purposes
- BS 153. Steel girder bridges. Part 3A. Loads.
- CP 114. The structural use of reinforced concrete in buildings.

British Standard Codes of Practice are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this Code of Practice:

Committee reference BLCP/CVCP/1
Draft for comment D 65/10542

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BRITISH STANDARD CODE OF PRACTICE CP 117
**COMPOSITE CONSTRUCTION IN
 STRUCTURAL STEEL AND CONCRETE**
 Part 2. Beams for bridges

FOREWORD

This Part of the Code is the second in a series dealing with the major aspects of composite construction. Part 1, dealing with simply supported beams in building, was published in January 1965; it is expected that later parts will deal with the following:

Complex and special beams in building.

Columns in building and in bridges

Composite action between steel members and precast units is not specifically covered by this Code. Where this form of construction is used, special consideration should be given to the consequential problems.

At the time of drafting this Code, consideration was given to the possibility of applying limit state design principles and writing the various clauses in a form consistent with them. However, with the present state of knowledge of the behaviour of composite bridge structures, it has not been found possible to codify the design procedures on this basis.

NOTE. In place of the customary, but incorrect, use of the pound as a unit of force, the unit called a pound-force (abbreviation lbf) has been used in this Code. It is that force which, when acting on a body of mass one pound, gives it an acceleration equal to that of standard gravity. Similar considerations apply to the ton-force (tonf).

1. SCOPE

This part of the Code deals with simply-supported and continuous beams used in bridges. It relates to beams, other than filler beams, composed of either rolled or built-up structural steel sections, with or without concrete encasement, acting in conjunction with an in situ reinforced concrete slab, the two elements being so interconnected as to form a composite section acting as a whole.

2. SYMBOLS

The symbols used in this Code are:

- | | |
|-------|---|
| a_t | Total cross-sectional area (in^2) per inch run of beam of reinforcing bars transverse to the steel beam in bottom of slab or haunch. |
| A | Acceleration (in/s^2). |

A_c	Area of concrete (in ²).
A_s	Area of steel beam (in ²).
A'	A parameter (in ⁻²).
b	Actual width (ft) of concrete flange on one side of centre line of steel beam.
b_e	Effective width (ft) of concrete flange on one side of centre line of steel beam.
c	Distance (in) from point at which crack width is being considered to surface of nearest reinforcing bar.
d_c	Depth (in) of centroid of steel beam below the mid-plane of the slab.
d_h	Depth of haunch (in).
E_c	Modulus of elasticity of concrete (lbf/in ²).
E_s	Modulus of elasticity of steel in steel beam (lbf/in ²).
El	Fully composite flexural rigidity of full width of bridge (ft ton units).
f_1	Stress at top of concrete slab (lbf/in ²).
f_2	Stress at bottom concrete slab (lbf/in ²).
f_3	Stress at top of steel beam (lbf/in ²).
f_4	Stress at bottom of steel beam (lbf/in ²).
$\frac{f_{\min.}}{f_{\max.}}$	Ratio of minimum to maximum nominal shear stresses on the weld throat during any load cycle.
$f_{\max.}$	Maximum value of average nominal shear stress on the weld throat during that cycle (lbf/in ²).
f_{tc}	Maximum tensile stress at top of concrete (lbf/in ²).
f_y	Yield stress (lbf/in ²) of steel in reinforcing bars or shear connector.
g	Acceleration due to gravity (32.2 ft/s ²).
I_c	Second moment of area of concrete slab alone (in ⁴).
I_s	Second moment of area of steel beam alone (in ⁴).
k	Reduction coefficient for creep or temperature.
l_s	Length (in) at ends of beam over which temperature and shrinkage forces are transmitted.
L	Actual span of beam or bridge between supports (ft).
L_s	Length (in) of shear plane.
m	Modular ratio = E_s/E_c .
M_c	Moment in concrete slab due to shrinkage (lbf/in).
M_s	Moment in steel beam due to shrinkage (lbf in).

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n	Number of cycles of a particular range of loading on a bridge.
N	Maximum allowable number of occurrences of a particular load cycle.
N_f	Fundamental natural frequency of bridge (c/s).
P	Test failure load (ton) on a shear connector.
P_u	Ultimate static capacity (ton) of a shear connector.
q	Percentage of ultimate static capacity of shear connector.
Q	Longitudinal shear force (lbf) per inch run.
$Q_c = Q_s$	Longitudinal shear force (lbf) due to shrinkage.
$\frac{S_{min.}}{S_{max.}}$	Ratio of minimum to maximum load on a connector during any load cycle.
$S_{max.}$	Maximum load on a connector during any load cycle.
t	Temperature difference between concrete slab and steel beam (degC).
u	Cube strength of concrete at time of test (lbf/in ²).
u_w	Specified cube strength of concrete (lbf/in ²).
w	Width of crack.
W_d	Dead weight, including finishes, in tons per foot of bridge.
Z_{c1}	Section modulus for top of concrete slab alone (in ³).
Z_{c2}	Section modulus for bottom of concrete slab alone (in ³).
Z_{s3}	Section modulus for top of steel beam alone (in ³).
Z_{s4}	Section modulus for bottom of steel beam alone (in ³).
β	Linear coefficient of thermal expansion (0.000011/degC).
δ	Increment in deflection (in) of bridge due to 20-ton vehicle.
Δ	Amplitude of vibration (in).
ϵ	Shrinkage strain, taken as 300×10^{-6} , or strain due to differential temperature.
ϵ_a	Apparent tensile strain in the concrete.
μ	$\frac{\text{Spacing of connectors (in)}}{\text{Connector modulus (lbf/in)}}$

3. MATERIALS

Materials shall comply with the appropriate clauses of BS 153* and CP 114†.

* BS 153, 'Steel girder bridges'.

† CP 114, 'The structural use of reinforced concrete in buildings'.

4. FORCES TO BE TAKEN INTO ACCOUNT

For the purpose of calculating stresses and forces acting on elements the following items shall, where applicable, be taken into account:

- (1) Dead load.
- (2) Live load.
- (3) Impact effect.
- (4) Lurching effect.
- (5) Nosing effect.
- (6) Centrifugal force.
- (7) Longitudinal force.
- (8) Wind pressure effect.
- (9) Temperature effect.
- (10) Resistance to movement of expansion bearings.
- (11) Forces on parapets.
- (12) Erection forces and effects.
- (13) Shrinkage effects.
- (14) Forces and effects due to settlement of supports.

The definitions, values and application of items (1) to (11) inclusive shall be those given in BS 153*, except where modified by this Code or the appropriate Authority.

5. COMBINATION OF FORCES

The following combinations of forces shall be considered:

Combination 1. The worst combination possible of dead load with live load, impact lurching and centrifugal force.

Combination 2. The worst combination possible of any or all of items (1) to (11) inclusive in Clause 4, together with either item (13) or item (14).

Combination 3. The worst combination possible of any or all of items (1) to (11) inclusive and (13) and (14) in Clause 4.

Combination 4. The worst combination possible of forces-during erection.

6. ALLOWABLE STRESSES

The basic working stresses in structural steel and reinforced concrete shall be in accordance with BS 153* and CP 114† respectively, except where modified

* BS 153, 'Steel girder bridges'.

† CP 114, 'The structural use of reinforced concrete in buildings'.