Criteria for the Testing of Composite Slabs

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CANADIAN
SHEET STEEL
BUILDING INSTITUTE

Preface

One of the objects of the CSSBI and its Members is the development of standards which promote safety, performance and good practice.

This bulletin is intended to assist those involved in the testing of composite slabs by providing contemporary criteria for conducting the test program.

Acknowledgements

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CRITERIA for the TESTING of COMPOSITE SLABS

1. INTRODUCTION

1.1 This bulletin contains criteria for the testing of composite slabs. Design criteria for composite steel deck acting as a form during construction are given in CSSBI 12M-84. Bulletin S3-88 contains criteria for the design of composite slabs.

1.2 The most common failure mechanism in composite slabs is shear-bond. The ultimate limit states shear-bond resistance of a composite slab section is calculated using parameters determined from a testing program of full-scale slab specimens. The factored shear-bond resistance (V_r) of a composite slab is given by the following expression:

$$V_r = \phi_v V_t$$

where

V_r = factored shear-bond resistance
V_t = tested shear-bond resistance
= $P_t/2 + W/2$ (see Clause 5.3)
ϕ_v = resistance factor for shear-bond failure = 0.70

1.3 When three or more different deck thicknesses are tested, the following equation shall apply:

$$V_t = bd\,[k_1 t/\ell' + k_2/\ell' + k_3 t + k_4]$$

where:

V_t = tested shear-bond resistance, N/m of slab width
b = unit slab width = 1000 mm
d = effective slab depth, mm
ℓ' = shear span, mm
t = base steel nominal thickness, mm
k_1, k_2, k_3, and k_4 are shear-bond coefficients obtained from a multi-linear regression analysis of test data from three or more deck thicknesses tested

1.4 When one or two deck thicknesses are tested, the following equation shall apply:

$$V_t = bd\,[k_5/\ell' + k_6]$$

where:

k_5 and k_6 are shear-bond coefficients obtained from a linear regression analysis of test data for each individual deck thickness tested

1.5 The ultimate flexural limit states capacity may be established by analysis in accordance with conventional reinforced concrete design.

2. SHEAR-BOND TESTS

2.1 The number of tests required in a testing program for establishing shear-bond coefficients is specified in Section 3.

2.2 A testing program shall be conducted for each deck profile and embossment pattern for which design values are required.

2.3 A testing program shall be conducted for each deck surface coating to be used with a given profile or embossment pattern [for example, ZF75 (zinc-iron alloy), Z275 (zinc), AZ150 (aluminum-zinc alloy), and ZincGuard 102-C (electrogalvanized, chromate treated)]. Shear-bond coefficients may be established using the deck surface coating demonstrating the lowest shear-bond strength, provided that verification of a coating's lower shear-bond strength is found from a minimum of two comparison tests.

2.4 A testing program shall be conducted for each type of concrete to be used. Tests using specimens made of structural low density concrete or semi-low density concrete may be used to establish values for normal density concrete provided that at least two comparison tests indicate that the shear-bond strength is lower for the lower density concrete.

NOTE: In this bulletin, the following definitions apply:

Normal density concrete means concrete having a fresh density between 2150 and 2500 kg/m^3 as determined by CSA Standard CAN3-A23.2-6C.

Structural low density concrete means concrete having a 28-day compressive strength in excess of 15 MPa and an air dry density not exceeding 1850 kg/m^3 as determined by ASTM Standard C567.

Structural semi-low density concrete means concrete having a 28-day compressive strength in excess of 15 MPa and an air-dry density between 1850 and 2150 kg/m^3 as determined by ASTM Standard C567.

2.5 Since the shear-span, ℓ', and deck thickness, t, are the most important parameters in the shear-bond equation ($\ell' = \ell/4$ for uniformly loaded single span) the shear span controls the extreme conditions of the shear-bond resistance for any given deck thickness. The shear span is varied to achieve the maximum and minimum shear-bond resistances of any composite slab system: Table 1 may be followed as a guide. However, it is not necessary to test more than one slab depth.

Table 1
Maximum and Minimum Shear-Bond Resistances

Shear-Bond Resistance,	Shear Span Length, ℓ'	Slab Depth, h
Maximum	Shortest Span Length	Thickest
Minimum	Longest Span Length	Thinnest

3. NUMBER OF SHEAR-BOND TESTS REQUIRED

3.1 When three or more different deck thicknesses are used in the testing program, a minimum of two tests in each deck thickness shall be carried out. For each deck thickness, one test shall be carried out at the maximum shear-bond resistance (shortest ℓ') and the second test at the minimum shear-bond resistance (longest ℓ') (i.e. 8 tests are required for four deck thicknesses). This will enable the determination of the coefficients k_1, k_2, k_3, and k_4 of the shear-bond resistance expression which can then be used to predict the shear-bond resistance of all deck thicknesses and shear spans within the range of thicknesses tested.

3.2 When a number of different deck thicknesses are produced for design and only the thinnest deck thickness is used in the testing program, a minimum of four tests shall be carried out, two at the maximum shear-bond resistance and two at the minimum shear-bond resistance. This will enable the determination of the coefficients k_5 and k_6 of the shear-bond resistance expression for this one individual deck thickness. These results can now be applied conservatively to all thicker deck thicknesses, provided that a minimum of two additional tests are carried out on the thickest deck thickness to confirm that this procedure is conservative.

3.3 When a number of different deck thicknesses are produced for design (t_1 . . . $t_{(n-1)}$, t_n, where t_1 is the thinnest and t_n is the thickest) and only the t_1 and $t_{(n-1)}$ deck thicknesses are used in the test program, a minimum of four tests in each deck thickness shall be carried out. For each deck thickness tested, two tests shall be carried out at the maximum shear-bond resistance and two at the minimum shear-bond resistance. This will enable the determination of the shear-bond coefficients k_5 and k_6 for each thickness tested. These results may be used for deck thicknesses between t_1 and $t_{(n-1)}$ by straight line interpolation of the shear-bond coefficients. The shear-bond coefficients k_5 and k_6 of the deck thickness $t_{(n-1)}$ can be used concservatively on the t_n deck thickness provided the embossment depths equal or exceed the $t_{(n-1)}$ embossment depths.

4. TESTING PROCEDURE

4.1 Specimen Preparation

4.1.1 The condition of the surface finish of specimen steel deck units shall simulate that prevailing in actual field practice.

4.1.2 Concrete shall be prepared and cured in accordance with CSA Standard CAN3-A23.1 *Concrete Materials and Methods of Concrete Construction.*

4.1.3 All test specimens shall be shored throughout during concrete placement and curing.

4.2 Dimensions of Composite Specimens

4.2.1 Test specimen lengths shall encompass the range of spans used in field applications for the deck profile tested.

4.2.2 The width, b_d, of all slab specimens shall be equal to at least one steel deck panel, but not less than 600 mm.

4.2.3 The minimum slab cover depth, h_c, shall be 50 mm.

4.2.4 The minimum shear span length, ℓ', shall be 300 mm.

4.2.5 The maximum concrete compressive strength, f'_c, shall be 35 MPa, and the minimum concrete compressive strength shall be 20 MPa.

4.3 Testing of Composite Specimens:

4.3.1 Testing shall be conducted after the concrete has reached its specified compressive strength, and not less than seven days after casting. Except as noted, low-density concrete may require a longer curing time. High early strength concrete may be tested earlier.

4.3.2 Specimens shall be tested using concentrated loads as shown in Figure 1. Alternatively, uniform loading may be used with ℓ' taken as equal to $\ell/4$.

4.3.3 Loads shall be applied continuously and without shock, except for pauses to take instrumentation readings.

4.3.4 Load-measuring equipment shall be calibrated within +1 and -0 percent.

4.4 Recording of Data

4.4.1 The following shall be recorded and documented for each test specimen.

4.4.2 **Test Data** The most important data to record is the ultimate failure load, P_t. In addition, a brief description of significant events during testing shall be recorded along with an identification of the final mode and details of failure. The date and place of testing, along with the name of the professional engineer responsible for the tests, shall also be recorded.

4.4.3 **Dimensional Properties**

(a) b_d width of composite test slab, mm

(b) h out-to-out depth of slab, mm (measurements shall be taken on an interior rib and at edges of the specimen, at least at ends, centre, and at 1/4 points or load points)

(c) d_d overall depth of steel deck profile, mm

(d) ℓ length of span, mm

(e) ℓ' length of shear span, mm

(f) t base steel thickness, exclusive of coatings, measured from those specimens used to obtain material properties (for cellular decks, each sheet should be measured), mm

(g) h_t out-to-out depth of slab at failure crack, mm

(h) embossment length, width and depth, spacing and general variation in these dimensions, mm

(i) slab overhang at supports, mm

4.4.4 **Material Properties**

(a) f'_c concrete cylinder compressive strength at time of slab testing, MPa (per CSA CAN3-A23.1)

(b) F_y measured yield strength of steel, MPa (per ASTM A370)

(c) F_u measured tensile strength of steel, MPa (per ASTM A370)

(d) percentage elongation of steel coupon (per ASTM A370)
(e) steel specification and grade

4.4.5 **Dead Loads**
(a) D_d steel deck dead load, kPa
(b) D_c concrete dead load (including load added by deck deflection - calculated or weighed), kPa

4.4.6 **Construction of Test Specimen**
(a) steel surface coating and condition
(b) shoring
(c) concrete mix design and date of casting
(d) type and location of steel welded wire fabric if included in the test
(e) concrete curing procedures
(f) concrete cylinder air dry density (at time of testing)

5. ANALYSIS OF TEST RESULTS

5.1 If two or more deck thicknesses are used in the testing program, a multiple-linear regression analysis shall be used to determined the shear-bond coefficients, k_1, k_2, k_3, and k_4. A comparison of the experimental and computed shear-bond resistances shall be made for all the test data. If their ratio is outside the range of 0.85 to 1.15 inclusive, the shear-bond coefficients, k_1, k_2, k_3, and k_4, shall be reduced by 5%. This reduction is necessary because the calibrated resistance factor, ϕ_v, is based on a maximum scatter limit of 15%.

5.2 If each deck thickness is treated separately, a linear regression analysis shall be used to determine the shear-bond coefficients k_5 and k_6 for each deck thickness. If the ratio of experimental to computed shear-bond resistances is outside the range of 0.85 to 1.15 inclusive, the shear-bond coefficients k_5 and k_6 shall be reduced by 5%.

5.3 The tested shear-bond resistance is determined as follows for specimens tested under concentrated loads:

$$V_t = P_t/2 + W/2$$

where:
V_t = tested shear-bond resistance, N/m of slab width
P_t = ultimate failure load from test, N/m of slab width
W = weight of the composite slab specimen, N/m of slab width

6. EXISTING TESTS

Data from tests predating these criteria may be used when evaluated in conformance with Section 5 provided such tests were performed on composite slab systems for which design values are currently being sought. Such previous test data is not required to be in a specific region as defined in Table 1, but must be approved by a properly licensed professional engineer. The predated data may be used in fulfilling the requirements for the number of tests, except that at least one test shall fall in each of the regions of maximum and minimum shear-bond resistances outlined in Table 1.

7. TESTS FOR SPECIAL CASES

When the configuration, details, or use of a composite slab are such that the test provisions of this bulletin do not apply, tests shall be performed and evaluated in accordance with the general testing requirements of CSA Standard CAN3-A23.3 *Design of Concrete Structures for Buildings*.

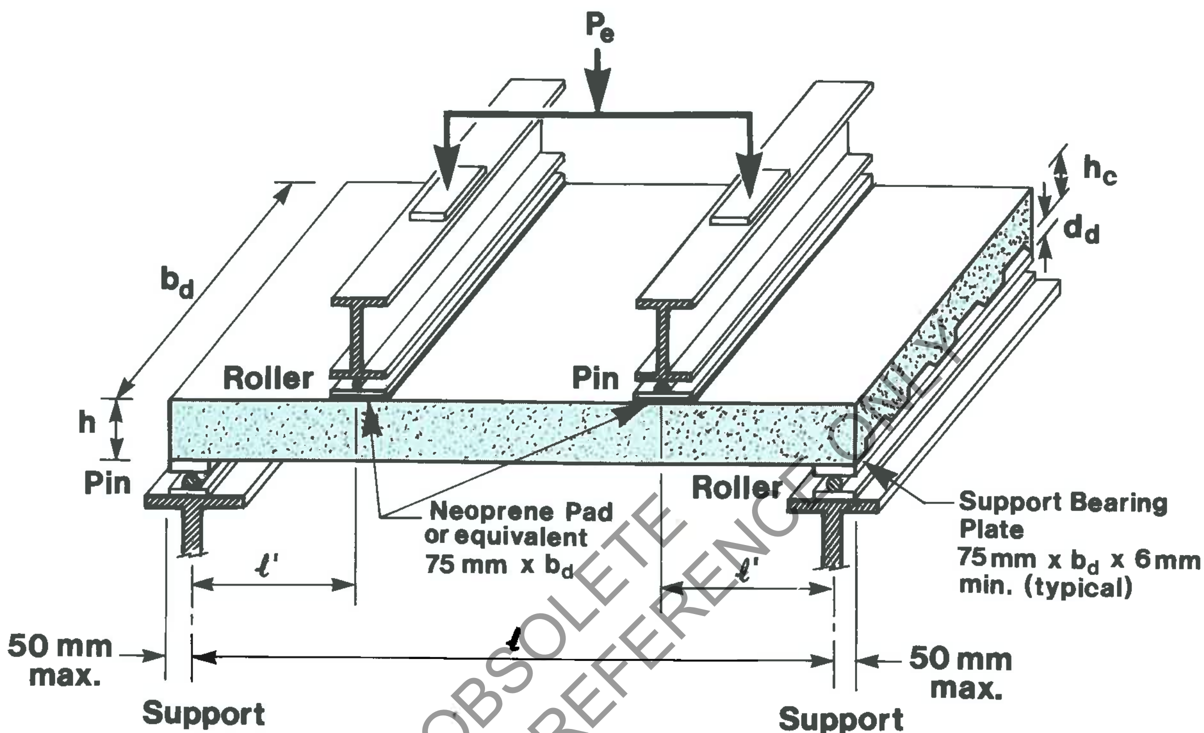

Figure 1: Test Assembly

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