CZASOPISMO TECHNICZNE A
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ

z. 4-A/2007
ISSN 0011-4561
ISSN 1897-6271

TOMASZ DOMAŃSKI*

SHEAR STUD CAPACITY IN BISON COMPOSITE BEAMS PROJECT – SAFETY FACTORS

NOŚNOŚĆ ŁĄCZNIKÓW SWORZNIOWYCH W BELKACH ZESPOLONYCH SYSTEMU BISON – WSPÓŁCZYNNIKI BEZPIECZEŃSTWA

A b s t r a c t

Shear connections have to transfer forces between structural members – steel and concrete with an adequate degree of safety.The distributions of horizontal shear resistance within steel – – concrete structures will be described depending on material characteristics of steel and concrete components in Bison project. Laboratory tests provide the only practicable basis for specifying safety margins for ultimate strength of shear connections in steel – concrete beams. The determination of partial safety factors within shear connections will be presented according to EC4 and EC0 (EN 1990). Particulary, safety factors of shear stud capacity in full composite connections will be analised.

Keywords: Bison project, composite beams, shear connections, safety factors

S t r e s z c z e n i e

Przy projektowaniu belek stropów o konstrukcji zespolonej niezbędne jest określenie wartości charakterystycznej i obliczeniowej parametrów wytrzymałościowych.Wartości wytrzymałościowe połączeń elementów stalowych z płytą żelbetową są zależne od wielu parametrów losowych.Wpływ tych czynników losowych jest uwzględniony przy obliczaniu częściowego współczynnika bezpieczeństwa.

Słowa kluczowe: system Bison, belki zespolone, połączenia zespolone, współczynniki bezpieczeństwa

* Dr inż. Tomasz Domański, Instytut Materiałów i Konstrukcji Budowlanych, Wydział Inżynierii Lądowej, Politechnika Krakowska.

1. Introduction

Composite Steel Beam Design is the ise of hollow core and solid slabs together with in-situ infill conjunction with welded studs onto steel beams to enable the slabs and steel beams. The load-carrying mechanism of stud shear connectors is complex and analitycal methods for predicting the shear resistance are not applicable. Instead the resistance of the connectors may be determined using empirical formulas.

Fig. 1. Steel beam and concrete slabs in Bison project

Ryc. 1. Belki stalowe i betonowe prefabrykaty w systemie Bison

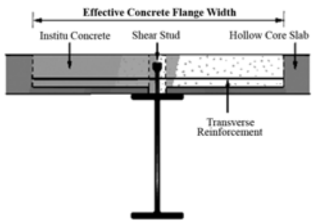

Fig. 2. Composite beam with steel studs in Bison project

Ryc. 2. Łącznik sworzniowy w belce zespolonej systemu Bison

The characteristic shear of the studs is the lesser of the following formulae [9]:
– steel stud shear resistance

$$P_{sk} = 0{,}8\, f_u\, \pi\, \Phi^{\,2/4} \tag{1}$$

– concrete resistance

$$P_{ck} = 0{,}29\, \Phi^2\, (f_{ck}\, E_{\mathrm{cm}})^{\,½} \tag{2}$$

$$P_k = \min\,(P_{ck}, P_{sk}) \tag{3}$$

– the log-normal cov of P value [2] is

$$\sigma_{\ln P} = (V_c^{\,2} + V_s^{\,2})^{1/2} \text{ for } V_c, V_s < 0{,}2 \tag{4}$$

where:
- Φ – the diameter of the stud,
- f_u – the ultimate tensile strength of the stud,
- f_{ck} – the characteristic cylinder strength of concrete,
- E_{cm} – the mean value of elastic modulus of concrete,
- V_s – the coefficient of variation of the stud resistance,
- V_c – the coefficient of variation of the concrete slab.

The basic resistance of shear connector P_k is later modified to take account of attachement of the shear connectors through shape of profiled steel decking [3–5, 9].

The shape of the desk profile has an important effect, but the orientation of the desk is more important. Two cases should be envisaged:
– decking ribs perpendicular to the direction of the applied shear force,
– decking ribs parallel to the direction of the applied shear force.

For through – deck welded shear connections, there are various factors that should be taken into account, as follows [6]:
- the orientation of the decking,
- the shape of the deck,
- the location of the stud within the deck rib,
- the quantity of studs within the deck rib.

These factors are represented by global strength reduction factor formula applied to the basic resistance of the studs in solid slabs. The EC4 strenght reduction factors r_p with cov = 0,9.

The characteristic resistance of shear connector in profiled steel decking is

$$Q_k = r_p P_k \tag{5}$$

The log-normal cov of Q value is

$$\sigma_{\ln Q} = (\sigma_{\ln P}^2 + \sigma_{\ln rp}^2)^{1/2} \tag{6}$$

where:

$\sigma_{\ln rp} = V_{rp}$ for $V_{rp} < 0,2$ is the standard deviation of ln r_p.

The design resistance of shear connector in profiled steel decking [7] is

$$Q_d = Q_k / \gamma_m \tag{7}$$

where:

γ_m is the partial safety factor (= 1,25 in EC4).

2. Determination of partial safety factor

Partial safety factor γ_m is the function of the independent components: statistical characteristics of material propertys of concrete and steel stud separately and random thickness for all parameters of cross-sections – profiled steel decking.

According to the design Q_d and characteristic Q_k values is obtained as

$$Q_d = Q_m \exp(-3,04\ \sigma_{\ln Q} - 0,5\ \sigma_{\ln Q}^2) \tag{8}$$

$$Q_k = Q_m \exp(-1,64\ \sigma_{\ln Q} - 0,5\ \sigma_{\ln Q}^2) \tag{9}$$

where:

Q_m – the median value in log-normal distribution of Q value,
$\sigma_{\ln Q}$ – the log-normal cov of Q value.

The partial safety factor of shear connection with profiled steel decking is obtained as

$$\gamma_m = Q_k / Q_d = \exp(1,4\ \sigma_{\ln Q}) \tag{10}$$

For example, the obtaining of γ_m is as follows:
– steel studs f_{ks} < 355, class of concret – B25

$$V_c = 0{,}15,\ V_s = 0{,}10,\ V_{rp} = 0{,}6$$

$$\sigma_{\ln Q} = (0{,}15^2 + 0{,}10^2 + 0{,}06^2)^{1/2} = 0{,}19$$

$$\gamma_m = \exp(1{,}4\ \sigma_{\ln Q}) = 1{,}30$$

For different classes of steels (studs) and concretes (slabs) the γ_m factor is presented in Table 1.

Table 1

γ_m factors for full shear connections

Resistance of steel studs	B25	B30	B37	B45
f_{ks} < 355 MPa	1,30	1,31	1,32	1,33
355 < f_{ks} < 460 MPa	1,40	1,41	1,42	1,43
460 < f_{ks} < 590 MPa	1,46	1,47	1,48	1,50

3. Conclusions

The safety factor γ_m is not the only value, it depends on several independent factors like steel, concrete resistance, shape diameters of the steel decks, level of connections.

More research is needed on the coefficients of variation, as found on practice, of the basic variables, and the assumption that the distribution of resistance of shear connection in profiled steel decking is log-normal.

References

[1] EN 1994-1-1 Eurocode 4: Design of composite steel and concrete structures, Part 1.1, General rules and rules for buildings, 2004.
[2] Murzewski J., *Design of steel structures for differential reliability levels*, *Progress in Steel, Composite and Aluminum Structures*, Giżejowski, Kozłowski & (eds.), Taylor & Francise Group, London 2006.
[3] Hicks S.J., Lawson R.M., *Design of Composite Beams Using Precast Concrete Slabs*, The Steel Construction Institute, Ascot, Publication No. SCI P287, 2003.
[4] Patrick M., *Composite Beam Shear Connection Design and Detailing Practices*, University of Sydney, Report No. CCTR-CBS-001-04, July 2004.
[5] Braford M.A., Filonov A., Hogan T.J., *Push testing procedure for composite beams with deep trapezoidal slabs*, *Progress in Steel, Composite and Aluminum Structures*, Giżejowski, Kozłowski & (eds.), Taylor & Francise Group, London 2006.
[6] Lawson R.M., *Shear connection in composite beams-influence of steel deck shape*, Proc. of an Eng Fund. Conf., Irsee 1996, 312-324.
[7] EN 1993-1-1 Eurocode 3: Design of steel structures, Part 1-1: General rules, May 2002.
[8] EN 1990, Eurocode 1, Part 1-1, Basis of structural design, 2002.
[9] www.bison.com.