Statistical calibration of safety factors for headed stud shear connectors in composite construction

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Summary

Headed stud shear connectors are an integral element in the design of steel-concrete composite beams in bridges and buildings. This paper presents a calibration study for the new Australian composite bridge Standard AS5100.6 and the New Zealand steel structures Standard NZS3404. Following a review of international push test data, the paper presents the results from a structural reliability study which evaluates the safety factors for the existing design equations given in AS 5100.6, NZS 3404 and EN 1994. Due to EN 1994 and AS5100.6 equations being generally conservative, some revised design equations are proposed, which provide more competitive resistances whilst still maintaining the required level of safety. For NZ 3404, it was found that the existing equations provided unconservative predictions and it is recommended that they be revised.

Keywords: headed studs; shear connectors; composite steel and concrete beams; structural reliability; EN 1990; calibration of partial safety factors

1 Introduction

1.1 Evaluation of partial factor

For partial factor design, the design resistance is determined using the characteristic resistance divided by an appropriate partial factor γ_M. The partial factor accounts for uncertainties of the basic variables contained within the theoretical resistance function (i.e. material and geometrical uncertainties) as well as uncertainties in the theoretical resistance function when compared with experimental values from tests. For elements subjected to shear, the target partial factor used in the Eurocodes is $\gamma_V = 1{,}25$.

According to EN 1990[1], for a 50 year reference period, the target reliability index $\beta = 3{,}8$. For resistances, the First Order Reliability Method (FORM) sensitivity factor $\alpha_R = 0{,}8$ and the design value corresponds to the product $\alpha_R\beta = 0{,}8 \times 3{,}8 = 3{,}04$. It is assumed that the statistical distribution of dimensions and strengths of materials is log-normal (as resistances don't normally have negative values) and, according to EN 1990, the design resistance is related to the mean resistance of the resistance function by:

$$r_d = b g_{rt}\left(\underline{X}_m\right)\exp\left(-k_{d,\infty}\alpha_{rt}Q_{rt} - k_{d,n}\alpha_\delta Q_\delta - 0{,}5Q^2\right) \quad (1)$$

where b is the correction factor (= experimental resistance r_e / theoretical resistance r_t), $g_{rt}\left(\underline{X}_m\right)$ is the resistance function of the basic variables $\underline{X}$ used as the design model, α_{rt} is the weighting factor for Q_{rt}, Q_{rt} is a coefficient for variation of the variables in the resistance function, α_δ is the weighting factor for Q_δ, Q_δ is a coefficient for variation of the error term δ, Q is a coefficient for

https://doi.org/10.2749/222137912805110277
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