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The influence of profiled sheeting thickness and shear connector's position on strength and ductility of headed shear connector

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ABSTRACT

A three-dimensional finite element model is developed, validated and used in the parametric study to investigate the influence of shear stud's position and profiled sheeting thickness on the strength, ductility and failure modes of the headed shear stud welded to the modern profiled sheeting. A total of 240 push tests were analysed with different sheeting thicknesses, positions of the shear stud in the trough, concrete strengths and transverse spacings. The results showed that the sheeting thickness influenced the shear connector resistance of studs placed in the unfavourable position more than studs placed in favourable and central positions. The strength of the shear connector placed in the unfavourable position increased by as much as 30% when the sheeting thickness was increased. The shear connector resistance of the unfavourable stud was found to be primarily a function of the strength and the thickness of the profiled sheeting rather than the concrete strength. The strength prediction equations for unfavourable and central studs were also proposed. The results suggested that the strength of the shear connector increased as the distance of the shear stud increased from the mid-height of the deck rib in the load bearing direction of the stud. The load–slip behaviour of the studs in the unfavourable position was more ductile than the studs in the favourable position, with slip of 2–4 times higher. It was found that the increase in sheeting thickness and transverse spacing improved the ductility of the stud in unfavourable position, but had no effect on the stud in the favourable position. The failure modes suggested that the favourable and central studs failed by concrete cone failure and unfavourable studs failed by rib punching together with crushing of the narrow strip of the concrete in front of the stud.

1. Introduction

Steel concrete composite beams with trapezoidal profiled sheeting are the most common form of construction in recent times. Headed shear studs are typically used to ensure composite action between the steel beam and the composite slab. The strength and ductility of the shear connector depend on various factors such as the geometry of the profiled sheeting, layout and position of the studs in the trough, the thickness of the profiled sheeting and the number of studs in a rib.

The appearance of small central stiffening rib at the bottom of the trough in the modern profiled sheeting has led to a change in the position of the shear stud, either in the favourable or unfavourable side of the trough. The shear stud is considered to be stronger in the favourable position and weak in the unfavourable position, primarily because of the larger zone of concrete under compression in front of the favourable stud in its load bearing direction than the compressive zone behind it. In a beam, the stud placed on the side of the stiffener away from the mid-span is on the favourable side, while the stud placed closest to the location of maximum moment for a simply supported beam is in the unfavourable position. Many researchers and design codes recommend that studs be placed in the favourable position. However, it is not practically possible to make sure that shear connectors are always placed on the favourable side of the trough.

The effect of favourable and unfavourable positioned studs on the shear connector resistance has been studied by Easterling et al. [1] with the help of beam and push tests. The authors found that the load–slip behaviour of unfavourable studs was more ductile than that of studs in the favourable position. The failure mode was rib punching and eventual tearing of the steel deck in the case of unfavourable studs and concrete cone failure for favourable studs. The authors also found that the stud strength in the unfavourable position was influenced more by the profiled sheeting strength rather than the concrete strength. Some push tests with unfavourable locations have also been conducted by Johnson and Yuan [2]. They also found that the failure mode for unfavourable studs was rib punching, and unfavourable studs behaved in a ductile manner as compared with favourable ones.

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