DOI: 10.1002/best.200710103

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Load Bearing Behaviour of Cast-in Shear Dowels

Dowel bars are often used to transfer shear forces across expansion joints and also to create shear key connections, for example in precast concrete buildings, fixed on both sides into the adjacent reinforced concrete elements. This article gives an overview of the current state of the technology.

Recent shear tests performed with cast-in rebars, away from the edge, are presented and analysed. A design formula is derived to determine the transverse shear capacity of dowels cast into concrete, based on a modified support modulus method and taking into consideration the concrete yielding, and this is compared with existing theoretical approaches and experimental results.

1 Problem statement

The way that a dowel cast-in on both sides and under shear load functions was first clearly described by *Paulay*. In [1], he differentiates between the effects of bending, shear resistance and inclined tension (kinking effect) of dowels (Fig. 1). For design purposes, the bending resistance is of most importance; the inclined tension effect first builds up after considerable displacement. While the maximum bending moment occurs in each case slightly above or below the joint, the maximum shear under approximately symmetrical conditions results at the shear surface, the bending moment at this section being $M = 0$. Pure steel shear failure is, however, in general not significant, because the concrete cannot withstand the maximum bearing stress without correspondingly yielding.

Failure finally occurs, at sufficiently large distance from the edge (min. 8–10 dowel diameters d_s), and with a cast-in length of at least 5–6 d_s (see also section 2.2), through steel rupture mainly caused by bending of the bar: With increasing shear load the concrete bearing stress rises strongly and it can happen, like with an anchor loaded in shear [2], that shell-shaped chips break out from the concrete near the surface. This spalling of the concrete further increases the inner lever arm of the load and the bar is increasingly loaded in bending. This failure process is considered and analysed in more detail in the following sections. With a cast-in length of less than about 5 d_s, failure can occur by the concrete breaking out behind the dowel. Concrete failure can also happen if the distance to the edge in the direction of the load is small [3]. In these cases, approaches from fastening technology can be used for design [3].

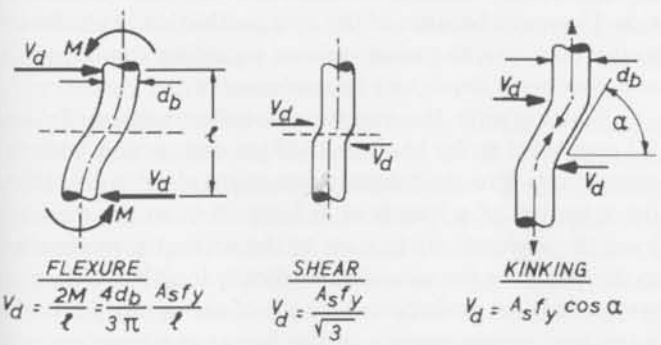

Fig. 1. Dowel action according to Paulay et al. [1]

2 State of the technology

2.1 Investigations into the load bearing behaviour of shear dowels

To investigate the load bearing behaviour of cast-in shear dowels, the bars should either be cast-in on both sides of the shear plane or, if they are cast-in only on one side, the shear force has to be introduced without excentricity ideally at the concrete surface. The precondition for the first case is that the adhesion of the two halves of the concrete specimen has been effectively broken by a slip joint. Tests where plastic sheets have been used to minimise the coefficient of friction are especially suitable for the study of the load bearing behaviour.

Paulay et al. [1] paid special attention to the shear capacity of cast-in bars during their investigations into shear transfer at joints in 1972–1974: flat trowelled surfaces were subsequently painted with wax for this purpose, and this reduced any friction effects to an absolute minimum. The results of the investigation are shown in the force-displacement diagram in Fig. 2. The increase of shear capacity proportional to steel area is noticeable. Using strain measurements, it was possible to confirm that the bars (diameter 6.3/9.5/12.7 mm) started yielding at displacements of about 2.5 mm. With further displacements up to more than 12 mm, further load increases of in some cases up to 88% were recorded on account of the kinking effect.

Also worth mentioning are the tests by *Bennett* and *Banerjee* [4] into the transfer of forces in the connections between precast columns and beams. Their tests included the investigation of the shear resistance of steel reinforcing bars, in which they arranged a joint with polyethylene

