

# Innovative Applications of Headed Bars in Bridges

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**Abstract** Reinforcement bars terminated by headed anchors are a modern alternative to traditional hook anchors and offer a range of benefits including improved anchorage in congested areas, simplified installation process and superior quality control. The paper will showcase innovative applications of headed bars in bridge construction, both for newly built and renovation jobs. The paper will also outline future development opportunities offered by the next generation of EN 1992-1-1 combined with existing European Technical Assessments for proprietary products (ETA 21/0373).

## 1 Introduction

Headed bars have been used in reinforced concrete or composite construction since 1950s. Early research (Figure 1) demonstrated practical benefits and applications of welded headed studs as shear connectors in composite beams in bridges and buildings [1]. The studs are characterized by easy installation, high resistance and ductility, thus among others enabling the use of the plasticity theory for the design of composite beams.

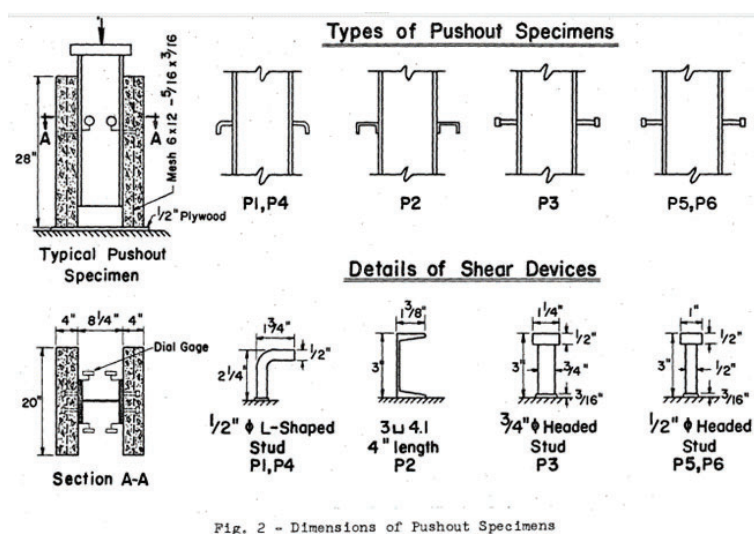
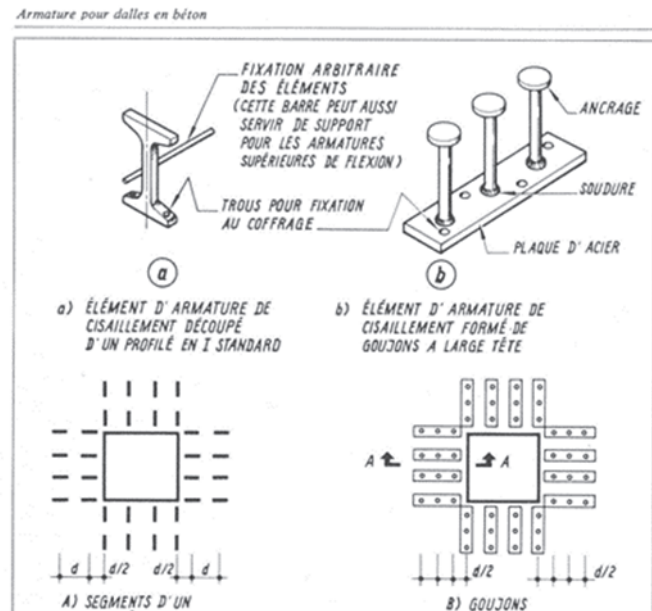


Fig. 2 - Dimensions of Pushout Specimens

Figure 1: Shear studs tested in 1960 at Lehigh [1]

The use of headed bars as punching shear reinforcement in flat slabs has been first proposed and patented in 1970's by Ghali and Dilger [2]. Here again, reinforcement elements incorporating headed studs are characterized by an easier installation and superior resistance and ductility in comparison to traditional reinforcement elements such as stirrups (Figure 2).



**Figure 2:** Punching shear reinforcement proposed by Amin and Ghali in 1979 [2]

Headed bars used as of today are typically made of smooth bars of quality S355 (diameters up to 16mm) or ribbed reinforcement bars of quality B500B or similar for diameters 12 to 40mm (Figure 4). The heads are produced either by cold forging (small diameter bars) or hot forging (small to large diameters of bars)

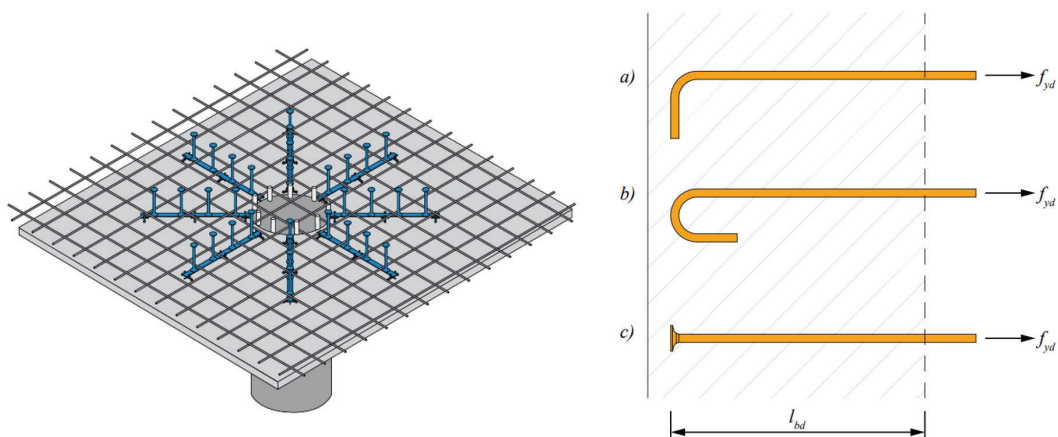
## 2 Design Recommendations

The development of practical applications for headed bars went hand in hand with the development of a normative framework for the use of these products in Europe. The use of shear studs in composite construction has been extensively researched and studied for past 70 years and is nowadays regulated by the design standard EN 1994-1-1 and the product standard EN ISO 13918. Until recently, no harmonized European standard was available for the design of headed bars as punching shear reinforcement. The lack of normative framework has been compensated by first local approvals (eg. Z 15.1-231 [3] that referred to DIN 1045-1) and subsequently by European Technical Assessments (eg. ETA 13/0151 [4] of PSB® punching shear reinforcement) based on extensive research [5], [6]. The new generation of EN 1992-1-1 [11] will incorporate design rules for slabs reinforced with doubleheaded studs, while still referring to the ETA's for the assessment of the quality and constancy of performance of the particular building products. The Eurocode [11] will also allow for the use of headed bars as end anchors of reinforcement bars, enabling multiple new applications of the technology in buildings, but also bridges. The characteristics of



**Figure 3:** PSB® Headed bars manufactured by hot forging

the bars designed in accordance with the Eurocode [11] shall be assessed by ETA's following EAD 160012-01-0301 [7]. One of such products covered with the recently published ETA 21/0463 [8] is the PSB® headed anchor.



**Figure 4:** Left - PSB® punching shear reinforcement (ETA 13/0151 [4]); Right - PSB® end anchor (ETA 21/0463 [8])

### 3 Innovative use of headed bars in bridge overlays

Short headed bars are very practical solution for the strengthening of concrete beams by adding overlays. The headed bars are post-installed in holes drilled in the old concrete (Figure 5), the holes are injected with mortar and the overlay concrete is cast after the hardening of the mortar. The

headed bars thus act as connectors between old and new concrete. The design of the strengthening job is done according to EN 1992-1-1. More information about the system, including performance requirements of the different components can be found in literature [9]. In comparison to traditional solutions – eg. hooks bent on site – the use of prefabricated headed anchors allows to speed up the construction process and offers superior guarantees in terms of quality.



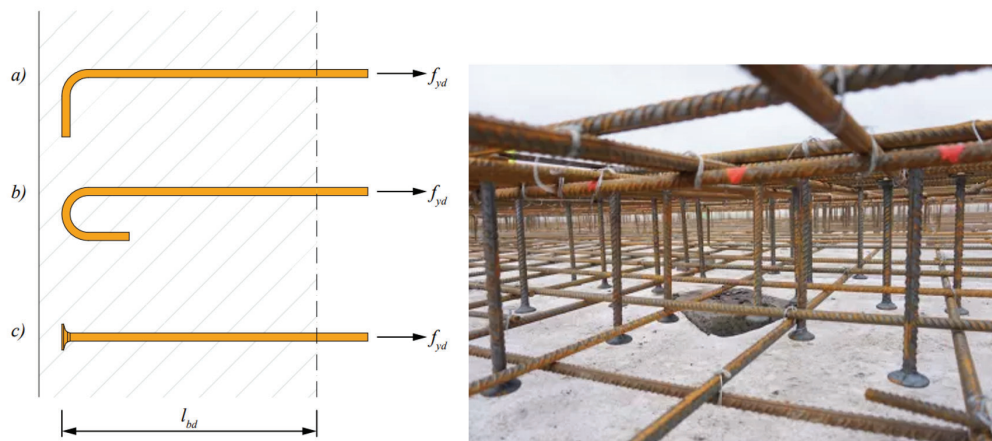
**Figure 5:** PSB® Headed bars use in bridge overlay, Helsinki 2022

#### **4 Innovative use of headed bars in pile caps**

A new approval issued by the Finnish road authority in 2023 [10] allows for the use of PSB® headed bars as punching shear reinforcement in pile supported slabs, technology typically used in road or short bridge construction. The design is performed following ETA 13/0151 [4] with additional requirements set by the Finnish standard SFS EN 1992-1-1. First reference projects allowed to confirm practical benefits of PSB headed studs in comparison to traditional solutions, namely saving of time and material (Figure 6).

#### **5 Conclusions**

Headed bars are a well-known technology that over past decades found several practical applications (shear connection in composite beams, punching shear reinforcement in buildings). Latest research and code developments [11] do open new possible use cases for headed bars in bridge and



**Figure 6:** PSB Headed bars used in pile caps, Turku, Finland 2021

road construction. Some of these possible applications are illustrated in this paper on reference projects.

## 6 References

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