Construction and Building Materials 166 (2018) 452–463

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Parametric study on a novel grouted rolling pipe splice for precast concrete construction

Yongfeng Zheng [a,*], Zhengxing Guo [b], Dongzhi Guan [b], Xin Zhang [a]

[a] School of Civil Engineering, Shandong Jianzhu University, Jinan, Shandong 250101, China
[b] School of Civil Engineering, Southeast University, Nanjing, Jiangsu 210096, China

HIGHLIGHTS

- Develop a new type of grouted sleeve using standard low-alloy seamless steel pipe through cold rolling techniques.
- Parametric study is conducted on bond strength of spliced bar.
- Propose a method to design the grouted splice.

ARTICLE INFO

Article history:
Received 17 November 2017
Received in revised form 25 January 2018
Accepted 30 January 2018

Keywords:
Grout-filled pipe splice
Precast connection
Bond
Parametric analysis

ABSTRACT

Grout-filled mechanical splice system, with its remarkable ability to connect precast elements, is one of the most important technologies for precast concrete construction. However, for the time being, its high cost has hindered the implementation of precast concrete structures to a certain degree in developing countries. This paper presents a new type of grouted sleeve which can be easily and economically fabricated with a standard seamless steel pipe through cold rolling techniques. Utilizing this sleeve, 69 sets of coupler specimens were prepared considering parameters of inner cavity structure and cross-sectional dimension of sleeve, grout strength, and diameter and embedded length of steel bar. Through direct pull-out test, it is shown that the proposed splice is capable of developing of 100% of ultimate strength of the bar providing an embedded length of 6 times bar diameter. Increasing the number and height of inner concentric rib which rolled on the sleeve only in inelastic segment is an effective technique to improve the bond strength of the splice. With the increment of the ribs, clearly different effects of sleeve dimension and grout cylinder thickness on the bond strength can be observed due to different confining mechanism. Finally, a design method for the novel deformed grouted splice sleeve is proposed.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

By virtue of reducing construction time, less labor, higher quality control and minimizing impact on environment, the precast concrete structures were widely used all over the world. For this type of structure, the connection between precast elements, which provides the needed integrity to the structure, become decisive, especially in severe seismic regions.

The grout-filled pipe splice, due to its unique working mechanism, is one of the most commonly used mechanical splice in precast construction. It utilizes "bridging action" of the grouted sleeve, to transfer the force from one bar to the inner grout and then to the sleeve by bond, and by the same way to the other bar [1]. In the case of deformed bars, further loading mobilizes mechanical interlocking between the deformations and the grout, which results in a dilation of the grout. Consequently, the restriction provided by the sleeve to this expansion creates confining pressures on different component interfaces. This confinement is well known can greatly increase the bond strength of steel bar [2–4], and thus decrease the embedded length significantly.

Several proprietary grouting couplers are currently being used to splice steel bars of adjacent precast components. Examples are Lenton Interlok, NMB Splice Sleeve, TTK Tops-joint and Reid Bar Grouters. These couplers are all ductile iron casting sleeve, and advanced casting technology is needed due to the complexity of their configuration and the high requirements on mechanical performance. This leads to a high cost of the sleeve especially in developing countries [5].

The main objective of this research was to introduce a new type of grouted sleeve that accommodates current production practices

* Corresponding author at: School of Civil Engineering, Shandong Jianzhu University, Fengming Road 1000, Jinan 210096, China.
E-mail address: zhengyongfeng@sdjzu.edu.cn (Y. Zheng).

https://doi.org/10.1016/j.conbuildmat.2018.01.182
0950-0618/© 2018 Elsevier Ltd. All rights reserved.

Nomenclature

d_b	nominal bar diameter (mm)	f_{sy}	actual yield strength of sleeve (MPa)
$D_{s,out}$	outside diameter of sleeve (mm)	f_{su}	actual tensile strength of sleeve (MPa)
$D_{s,in}$	inside diameter of sleeve (mm)	f_{by}	actual yield strength of steel bar (MPa)
t_s	wall thickness of sleeve (mm)	f_{bu}	actual tensile strength of steel bar (MPa)
t_g	grout cylinder thickness (mm)	f_{buk}	specified tensile strength of steel bar (MPa)
h_r	rib height of sleeve (mm)	f_g	compressive strength of grout (MPa)
l_a	embedded length of steel bar (mm)	τ_b	bond strength at bar-grout interface (MPa)
l_{sp}	thickness of sealing plug (mm)	τ_s	bond strength at grout-sleeve interface (MPa)
L	whole length of sleeve (mm)	τ_e	bond stress in elastic segment (MPa)
L_{min}	required minimum length of sleeve	τ_{ue}	bond stress in inelastic segment (MPa)
l_e	elastic segment length of steel bar (mm)	R_s	diameter-thickness ratio
l_{ue}	inelastic segment length of steel bar (mm)	$P_{u,exp}$	experimental pullout load (kN)
E_s	elastic modulus of sleeve (GPa)	$P_{u,cal}$	calculated pullout load (kN)
E_b	elastic modulus of steel bar (GPa)	R_r	experimental/calculated ratios

and can be conveniently and economically produced. Meanwhile, a parametric study on the tension capacity of the proposed grouted splice were conducted considering the parameters of inner cavity structure and cross-sectional dimension of sleeve, grout strength, diameter and embedded length of steel bar, and eventually developing a design method for the proposed splice sleeve.

2. Previous research

In precast concrete engineering, grouting couplers have been used to splice reinforcing bars for many years. However, there is only limited information thus far regarding the bond strength between the filler grout and the spliced bars. Hayashi et al. [6] performed a monotonic loading test on grouted splice specimens using experimental variables such as the bonded length and the grout strength. Based on the test result, they found a relationship between the maximum local bond stress and the slip of steel bar. Einea et al. [1] prepared four types of bar splice specimens with different types of sleeves and performed a pullout test study. They evaluated the confining action provided by the sleeve and proposed an equation to calculate the ultimate tensile load of the splice. Unfortunately, the calculated values were clearly different from the test results due to the limitation of the test program. Kim [7] proposed an analytical method to estimate the confining stress provided by grouted sleeve based on the pullout test results of forty bond-failure splice specimens, and hereby created a calculation method of bond strength of spliced bar. However, because all the adopted test results were developed using smooth pipe, the proposed method may not be appropriate for the deformed sleeve.

In recent years, due to the high cost of those well-known grouting couplers owned by a few established companies, some scholars have developed a mount of new grouted sleeves and investigated their featured behaviors. Ling et al. [8,9] performed feasibility studies on several different types of grouted sleeves including welded bar sleeve with steel bars welded on the inner surface (Fig. 1a), tapered head sleeve processed into smaller opening diameter at both ends (Fig. 1b), corrugated aluminum sleeve, mild steel pipe with interlocking rings at both ends, assembly sleeve comprised a set of two-cylindrical mild steel pipes and mild steel square hollow sleeve. Sayadi et al. [10] investigated the effect of interlocking mechanism between the sleeve and filler grout in elastic and inelastic zone on the bond strength of spliced bar using a specially designed bar coupling system (Fig. 1c). They found that increasing the interlocking action in the elastic segment would decrease the bond strength. Henin and Morcous [11] introduced a new grouted bar splice sleeve which featured on their threaded inner surface at one side or at both sides (Fig. 1d). Based on monotonic pullout test, they verified the feasibility of the sleeve with a minimum length of 16 times bar diameter. Seo et al. [12] proposed a novel head-splice-sleeve (HSS) and investigated its design method. From the analysis on the effect of head, they found that the HSS specimens with suitable head size show sufficient ductile behavior and recommended a suitable diameter ratio of 1.3 between head and bar.

3. Proposed splice sleeve and processing method

Different from those well-known ductile iron casting sleeves, the proposed splice sleeve named as grouted deformed pipe splice

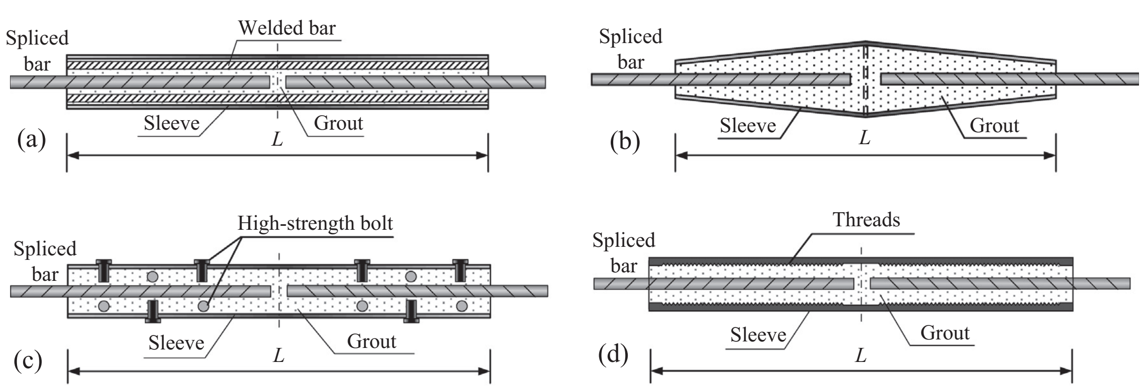

Fig. 1. Configuration of different grouted sleeve.

Download English Version:

https://daneshyari.com/en/article/6715308

Download Persian Version:

https://daneshyari.com/article/6715308

Daneshyari.com