Experimental study on the bond-slip relationship between concrete and deformed rebar embedded in grouted corrugated duct

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Abstract

The grouted corrugated duct (GCD) connection has appeared as an attractive option for joints between precast bridge pier segments due to its large construction tolerance and low cost. However, the bond-slip relationship between the embedded rebar and the mortar has not been clearly established, which underscores the need for experimental investigation. To this end, 24 pull-out experimental tests were conducted with/without GCD in this study. The results showed that GCD specimens had higher bond strength and plumper bond-slip curve than the specimens without GCD connection. Then, an analytical model based on thick-walled cylinder theory was proposed to determine the bond-slip constitutive curve of GCD connection. Finally, a modified cohesive model was developed at the interface between rebar and dummy rebar in finite element model. The proposed bond-slip model, finite element analysis and tested data match well with each other.

Keywords: Grouted corrugated duct connection; pull-out test; bond-slip; thick-walled cylinder theory; finite element model; cohesive.

1 Introduction

Over the past few decades, the concept of accelerated bridge construction (ABC) has gained global acceptance. The ABC technique may not only mitigate traffic and environmental disruptions but also lead to reduced life-cycle costs, expedited construction timelines, and enhanced construction quality [1]. In practice, the dependable static behavior of joints is a design crux to the prefabricated bridge elements and systems. The precast component interface is discontinuous, constituting structural weak zones [2]. Given the increasing popularity of the grouted corrugated duct (GCD) connection in numerous bridge projects owing to its significant construction tolerance and cost-effectiveness, the mechanical characteristics of these joints primarily rely on the bond anchorage properties of the rebars [3]. Although various specifications have provided the bond-slip relationship of rebar, the rebar is embedded in normal concrete (ENC) directly. The corrugated duct will change the bond mechanism of rebar, but the relative research is still lacking. Meanwhile, compared to ENC connection, GCD connection has the following characteristics:

(1) The diameter of rebar in GCD connection is larger. The diameters of rebar for most researches on bond-slip were mostly ranged from 8 mm to 25 mm [4]. However, the diameters of rebar in GCD connection were always large and ranged from 25 mm to 42 mm [5]. The reason is that the GCD connection is usually employed in merge structures, large-diameter rebar is selected to provide adequate bond anchorage effect.

(2) GCD connection has stronger confinement. The bond stress of deformed rebar embedded directly in concrete is comprised of chemical adhesion, friction and mechanical interaction [6]. For GCD connection, the extra mechanical interaction is provided by duct and it will lead to higher confinement level than the rebar directly embedded in normal concrete.

(3) The materials in GCD is discontinuous. It could be found that the GCD connection is comprised of mortar, duct and normal concrete. As the bond stress is generated, the mechanics is transmitted

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