

## Shear Strengthening of Pile Cap Girders Using Carbon Fiber Reinforced Polymer (CFRP) Strips

William A. Shekarchi, James O. Jirsa

*The University of Texas at Austin, Austin, TX, USA*

Wassim M. Ghannoum

*The University of Texas at San Antonio, San Antonio, TX, USA*

**Contact:** wshekarchi@utexas.edu

### Abstract

Five large-scale reinforced concrete (RC) pile cap girders were tested to investigate the feasibility of strengthening wide-webbed RC members in shear using Carbon Fiber Reinforced Polymer (CFRP) strips that wrapped around the girder and U-wrap strips with CFRP anchors. CFRP strips were applied to uncracked and pre-cracked 813 mm deep by 813 mm wide pile cap girders to determine the shear performance of strengthened members. The test results indicated that the CFRP anchors developed the fracture strength of the CFRP strips even though some anchors were placed in tension zones. The CFRP shear strengthening improved the shear capacity of the pile cap girders by as much as 56%. Strengthening uncracked and pre-cracked specimens resulted in comparable peak shear capacities. However, the pre-existing shear crack caused the average CFRP fracture strain to be lower than in the uncracked girder.

**Keywords:** carbon fiber reinforced polymer (CFRP); CFRP anchors; shear strengthening; reinforced concrete (RC); shear performance.

### 1 Introduction

Carbon Fiber Reinforced Polymer (CFRP) is an ideal material for rehabilitating aging reinforced concrete (RC) bridges and their elements. CFRP has a high tensile strength-to-weight ratio, can be applied to a variety of member shapes, and can be installed rapidly to minimize disruption in the use of the structure. Unfortunately, without proper anchorage and/or development, the efficiency of the CFRP material is limited by the interfacial bond strength between the CFRP strips and the concrete substrate. Research results indicated that U-wrap

strips without anchors exhibit bond failures at less than half of the CFRP fracture strength [1-3].

In many cases, a fully wrapped CFRP strip cannot be installed due to obstructions (i.e., beams that are cast monolithically with slabs). Therefore, mechanical or CFRP spike anchors have been utilized with U-wrap CFRP layouts to develop the full tensile capacity of the CFRP strips. Unlike mechanical anchors, CFRP spike anchors are not susceptible to durability issues and do not rely on clamping forces to develop the strength of the CFRP strips [4, 5].

The majority of the experimental studies related to CFRP shear strengthening have been conducted on