

## CHAPTER 10

### COST INFORMATION OF COMPOSITE PILES

#### 10.1 INTRODUCTION

Composite materials have attractive features such as high resistance to corrosion, high strength to weight ratios, and the possibility of being used in infrastructure projects without maintenance or with low maintenance (Meiarashi et al. 2002). Recent studies have found that the reduced weight of bridge decks made of FRP composite materials have resulted in cost effective bridges due to the reduction of both the construction periods and the cost of the bridge superstructure (Ehlen 1999). The economical competitiveness of composite piles needs to be assessed. To help provide data for such assessments, this chapter provides cost information for the composite piles and prestressed concrete piles used in this research project.

#### 10.2 COST INFORMATION FOR THE ROUTE 40 BRIDGE PROJECT

The cost per unit length of the concrete-filled FRP composite piles used at the Route 40 project was \$312/m (\$95/ft). This cost includes the materials (GFRP tube and concrete infill), the manufacturing costs (including FRP tube and concrete casting), and the shipping to the job site. The cost of driving the composite piles was \$66/m (\$20/ft). This results in a total cost of \$378/m (\$115/ft) for the installed composite pile. On the other hand, the total cost of the installed 508 mm (20 in.) square prestressed concrete pile was \$213/m (\$65/ft). Therefore, the initial cost comparison indicates about 77 percent higher unit cost for the composite pile. No instrumentation was installed in these piles.

No significant time differences were observed in the installation time for these piles. The unit weights of the two piles were similar due to the concrete infill, therefore the high strength to weight ratio of the composite material was not utilized. The handling and

lifting of the composite piles was not easy and required special arrangements and equipment. For example the slickness of the FRP outer surface made it difficult to use conventional slings to lift the piles with the crane. In addition, the number of pick-up points had to be increased due to the lower cracking moment of these piles compared to the prestressed concrete pile. Difficulties encountered by the contractor in handling these piles may have also been associated with lack of experience in dealing with these piles. However, such problems are expected to be present in other projects until the use of composite piles becomes more common.

### **10.3 COST INFORMATION FOR THE ROUTE 351 BRIDGE PROJECT**

The cost information for the three types of piles tested at the Route 351 project is provided below. The test piles were heavily instrumented, and the costs provided below do not include the instrumentation or its installation. However, pile fabrication and handling costs may have been increased due to the presence of the instrumentation.

#### **10.3.1 Hardcore FRP Composite pile**

The cost for the 24-inch FRP tubes was \$165/m (\$50/ft). This cost is freight-on-board (FOB) at the Hardcore plant in New Castle, Delaware. The cost associated with steel reinforcement, concrete infill, and transportation was about \$541/m (\$165/ft). The resulting total unit cost for the pile delivered on site is \$705/m (\$215/ft). The cost of pile installation for the test piles at this project was about \$82/m (\$25/ft). Therefore, the initial cost of the installed FRP composite pile is \$787/m (\$240/ft).

#### **10.3.2 Plastic pile**

The ordinary unit cost for this type of pile FOB at the Plastic Piling, Inc. plant in Rialto, California is \$410/m (\$125/ft). The cost for delivery of this test pile from Rialto, California to Hampton, Virginia was \$209/m (\$64/ft). The resulting total unit cost for the pile delivered on site was \$619/m (\$189/ft). The cost of pile installation for the test piles

at this project was about \$82/m (\$25/ft). Therefore, the initial cost of the installed Plastic composite pile was \$701/m (\$214/ft).

### **10.3.3 Prestressed concrete pile**

The total cost of the installed 610 mm (24 in.) square prestressed concrete pile was about \$180/m (\$55/ft).

### **10.3.4 Summary of the Route 351 cost information**

The above initial cost information indicates that unit costs for the plastic composite pile and the Hardcore composite pile are 289% and 337% higher than for the prestressed concrete pile, respectively.

No significant installation time differences were observed during handling and installation of the composite piles compared to the prestressed concrete pile. The handling and lifting of the FRP composite piles was the most difficult due to the slickness of the outer surface of the FRP shell. Special arrangements were required to handle this pile including using steel anchors for keeping the lifting slings from sliding and rolling. The location and number of picking points used to handle this pile had to be modified with respect to conventional practice due to the lower cracking moment of these piles compared to the prestressed concrete piles. These kinds of complications were not encountered during the handling and installation of the plastic composite pile.

## **10.4 SUMMARY**

Initial costs of the composite piles studied in this project were found to be higher than the initial unit costs for prestressed concrete piles. The initial unit costs of the installed composite piles at the Route 40 bridge were about 77 % higher than the unit costs for the prestressed concrete piles. The initial unit costs for the composite piles installed at the Route 351 bridge were higher than cost of the prestressed concrete piles by about 289% and 337% for the plastic and FRP piles, respectively.

The cost effectiveness of the composite piles is expected to improve with economies of scale as production volume increases, and by considering life-cycle costs of low-maintenance composite piles. Such life-cycle cost analyses should consider the pile life span, the annualized maintenance costs, and the replacement costs of composite piles compared to prestressed concrete piles. The number of years to be used in the life-cycle cost analyses may not only be related to the life span of the piles, but may also be governed by the actual life span of the bridge superstructure, which may be related to deterioration or increased traffic demands. A life-cycle cost analyses was not performed for this study due to lack of maintenance cost and frequency information.