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# NCDOT's Experience with Predesign Load Testing

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Large-diameter driven pile or drilled pier bridge foundations provide considerable axial load-carrying capacity, substantial stiffness, and lateral resistance. These characteristics are especially advantageous in the design of high-capacity foundations that address vessel impact and scour considerations. In the past, many state highway departments, including North Carolina Department of Transportation, relied solely on construction-phase load testing of foundation elements to determine their constructibility. Predesign load testing is now being used more frequently as DOTs become aware of the potential for large savings offered by this approach. Shortening foundation elements by even modest amounts over an entire project can result in large savings.

## Problem

At NCDOT, bridge foundation designs were traditionally prepared on the basis of engineering parameters gathered from subsurface investigations that were generally limited to borings, standard penetration tests, and laboratory testing. As noted, the NCDOT policy was to conduct verification or proof load testing of piles and drilled piers during the construction phase of a project. Often this testing indicated that a number of the preliminary design parameters were highly conservative, and that money could have been saved if the results of the verification testing had been known before design. The department also was not evaluating the feasibility of driving piles or constructing drilled piers at a project site before letting, thereby increasing the potential for unexpected claims during construction. These policies were adequate for smaller bridge projects, but for larger projects, a more proactive approach to refining design parameters, resolving potential constructibility problems, and mitigating claims was needed.

## Solution

In 1994 NCDOT initiated an in-house research project on load testing in the predesign phase of a project. The first pilot project was the Neuse River Bridge. A load test program was developed and managed in house. The test results indicated that initial subsurface exploration information was inaccurate. With the corrected subsurface information it was possible to reduce significantly the drilled piers' embedment lengths without compromising the required load capacity. The refined design parameters resulted in large savings for the department. The cost of the load test program was $310,000; the resulting estimated savings totaled $10,500,000.

## Application

Experience gained from the predesign load test program on the Neuse River Bridge project was subsequently applied on the following bridge projects: the New River Bridge (1994), the Chowan River Bridge (1995), the Oregon Inlet Bridge (1996), and the Croatan Sound Bridge (1997). NCDOT's current practice is to use predesign load testing as an integral part of the overall design process on all major bridge projects.

The cost savings detailed below appear to be a function of project size, subsurface and site conditions, test program comprehensiveness, project schedule, and expertise of the design team. Generally, more money is saved on drilled piers than on driven piles because the unit cost per load-carrying capacity for drilled piers is higher than that for driven piles. Also, lengths of driven piles are determined most cost-effectively during construction by performing dynamic load tests on production piles. Savings from reducing pile lengths, therefore, are realized during construction-phase load testing. For projects with driven piles, a load test program conducted during the predesign phase can provide a good indication of the potential for dollar savings, while also providing information for use in developing an effective construction-phase load test program.

**Benefits**

NCDOT has found predesign load testing to be the most effective tool for mitigating constructibility problems and reducing exposure to construction claims. Table 1 shows the refinement of design parameters and changes in construction procedures and specifications that resulted from each predesign load test program. In all five projects, the foundation elements were reduced by either shortening lengths or increasing capacities. The table also illustrates how construction practices have been influenced by the evolution of project-specific special provisions, based on constructibility findings from the predesign load test program, that are used by NCDOT to complement its standard specifications.

**TABLE 1 Load Test Program Outcomes**

| Project | Outcomes |
|---|---|
| Neuse River | Reduction in drilled pier embedment length<br>Increase in drilled pier capacity<br>Discovery of inaccuracy of initial subsurface exploration<br>Improvement in drilled pier and slurry special provisions |
| New River | Improved soil parameters<br>Reduction in drilled pier length<br>Improvement in drilled pier special provision |
| Chowan River | Reduced pile lengths and increased pile capacity<br>Reduction in number of piles<br>Reduction in pile embedment required for lateral stability<br>Evaluation of drivability and setup |
| Oregon Inlet | Elimination of drilled pier alternate<br>Evaluation of drivability of large-diameter cylinder piles<br>Increased pile load capacity<br>Evaluation of jetting methods<br>Improvement in cylinder pile special provision |
| Croatan Sound | Reduced pile lengths and increased pile load capacity<br>Reduction in number of piles<br>Reduction in pile embedment required for lateral stability<br>Evaluation of drivability, jetting, and setup |

From 1994 to 1997, use of the predesign load testing approach has saved NCDOT more than $15 million (see Table 2). The estimated savings shown in Table 2 represent the foundation

engineer's rough estimate of savings derived from the refinement of preliminary design assumptions on the basis of results from the predesign load testing program. These savings do not include benefits from claim mitigation, which could be substantial.

**TABLE 2 Summary of Project Costs and Savings**

| Project | Project Cost | Test Program Cost (Bid) | Estimated Savings | Estimated % Savings |
|---|---|---|---|---|
| Neuse River | $92,998,000 (bid) | $310,000 | $10,500,000 | 11 |
| New River | $16,457,000 (bid) | $276,000 | $850,000 | 5 |
| Chowan River | $33,923,000 (bid) | $375,000 | $1,357,000 | 4 |
| Oregon Inlet | $122,800,000 (est.) | $1,155,000 | $1,200,000 | 1 |
| Croatan Sound | $88,963,000 (bid) | $998,000 | $1,800,000 | 2 |

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