



## Florida Department of Transportation

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TO: District Directors of Operations, District Directors of Production, District Design Engineers, District Structures and Facilities Engineers, District Geotechnical Engineers, District Maintenance Engineers, District Construction Engineers, District Structures Design Engineers, District Materials Engineers

FROM: William N. Nickas, State Structures Design Engineer

COPIES: Bob Greer, Freddie Simmons, Bill Albaugh, Tom Malerk, Jack Evans, Larry Jones, Larry Sessions, Marcus Ansley, Jeffrey Ger (FHWA), Ananth Prasad, Sharon Holmes, Henry Bollmann, Steve Plotkin, Tom Andres, Robert Robertson, Tony Mireles, Rafiq Darji, David O'Hagan, Duane Brautigam

SUBJECT: Temporary Design Bulletin C04-06  
Interim Policy for Non-redundant  
Drilled Shaft Bridge Foundations  
Effective Immediately

**Requirement:** Non-redundant drilled shafts shall have special design phase investigation and construction phase testing and inspection requirements meeting the provisions of this bulletin. For the purpose of this bulletin, non-redundant drilled shafts foundations shall be foundations consisting of two or fewer shafts per bridge bent or pier or as those shafts deemed non-redundant per AASHTO LRFD Article 1.3.4. The requirements of this bulletin apply to all Department vehicular and pedestrian bridge projects including contractor VECP's and Design Build Projects. Shafts under miscellaneous structures (ie. sign structures, mast arms, high-mast light poles, noise walls) are exempt from the requirements of this bulletin.

Effective immediately, non-redundant drilled shafts shall be designed, tested and inspected as follows:

1. Perform full depth SPT borings at each shaft location during the design phase. Core the limestone load bearing strata and test core samples in accordance with the Soils and Foundations Handbook (SFH). Depths of borings shall extend not less than 3 shaft diameters below the proposed/final shaft tip elevation or to the depth required by the SFH, whichever is deeper. Pilot holes shall be taken as necessary during construction to meet the intent of this bulletin in cases where the original boring depth is insufficient, where shafts are lengthened or shaft locations are modified. Borings shall be located by survey within 1' of the shaft location. If access during the design phase limits the ability to accomplish this accuracy, plan notes shall be used to require the pilot holes to be taken during

construction.

2. Inspect each drilled shaft excavation using a Shaft Inspection Device (SID) to ensure shaft cleanliness at the time of concrete placement.
3. Install full depth cross-hole-sonic logging (CSL) access tubes and perform CSL testing of each shaft.
4. Extend shaft a minimum of seven (7) shaft diameters below the design ground surface.
5. Until resistance factors are properly calibrated for non-redundant foundations, reduce the compression value phi factors provided in Table 3.5 of the FDOT Structures Design Guidelines by 0.10. These modified factors are comparable to those listed in the proposed revisions to AASHTO Section 10.
6. Consider the effects of combined axial loads and moment to properly evaluate the geotechnical bearing resistance of the shaft and the effect on the distribution of the stresses across the shaft bottom.
7. All shafts in non-redundant foundations shall be minimum of 4' diameter.
8. Shafts over 7' in diameter shall have a minimum of three cores taken below the tip within the limits of the shaft, spaced uniformly around the perimeter when used in Marion, Hillsborough and Pinellas counties, Seminole county west of R31E, Orange county west of R31E, or any other location that may contain highly variable soil strata.

**Background:** Until recently, very few non-redundant drilled shafts bridge foundations have been constructed in Florida. The Hallendale Beach Flyover Ramp utilized piers supported by a single drilled shaft. Highway 20 Bridge over the Apalachicola River utilized two large diameter shafts to support each main pier. The Tri-Rail New River Design-Build Project is currently being constructed on piers founded on a single 10' drilled shaft. Several other projects scattered across the state are currently under design utilizing non-redundant drilled shaft bridge foundations. These non-redundant drilled shaft projects required special design phase investigation and construction phase geotechnical testing and inspection to assure quality of the shaft and assurances that the design assumptions were valid.

LRFD resistance factors are based on the probability of failure ( $P_f$ ) of an element or group of elements resisting structural loads. When resistance factors were calibrated for FDOT, the state of practice utilized redundant drilled shaft foundations, therefore, the design  $P_f$  for each drilled shaft was larger than the design  $P_f$  for the entire bent or pier because multiple drilled shafts would have to fail before the bent or pier could fail. In a non-redundant foundation, the  $P_f$  for each foundation element should be the design  $P_f$  for the entire bent or pier because of the consequence of failure.

**Commentary:** Although the Department has not had a formalized policy for non-redundant foundations in the past, the increase in the drilled shaft sizes in recent years and the need to utilize fewer foundation elements due to space considerations on urban projects has necessitated the need to formalize the policy which has been utilized on several projects. Designer awareness and inspection using greater quality control measures are critical to the success of foundations of this type. Bridges founded on non-redundant structural systems require more site investigation and greater quality control than multi-shaft footings. Due to the critical nature of a non-redundant

foundation, soil sampling to guarantee minimum rock socket length (creditable support strata), soil adequacy below the tip; shaft tip cleanliness; and shaft concrete soundness are all critical issues. The issues are addressed by SPT borings with limestone coring; SID; and CSL testing, respectively.

**Implementation:** On projects currently under design, expand the soil investigation during the design phase to meet the requirements above. Where the schedule, etc. does not permit the specified SPT borings to be taken during the design phase, plan notes shall be used to require pilot holes to be performed during the construction phase. Specification 455 is being revised to include requirements for CSL, coring and pilot holes. The specification will require cores and pilot holes to be a minimum length of 3 shaft diameters below the shaft tip and may be extended to 5 diameters at the Engineer's direction. The specification will be available for all projects beginning with the July 2005 letting. This supplemental specification will be developed into a supplemental standard specification for use on projects with letting dates beginning in January 2006 as part of the regular specification package. For projects with non-redundant drilled shaft elements let prior to July 2005, contact Robert Robertson of the Central Office Structures Design for directions on incorporating the necessary specification changes. Robert can be reached at (850) 414-4267.