NCHRP 24-17

LOAD AND RESISTANCE FACTOR DESIGN (LRFD) FOR DEEP FOUNDATIONS

APPENDIX A
SURVEYS - STATE OF PRACTICE DESIGN AND CONSTRUCTION

Prepared for
National Cooperative Highway Research Program
Transportation Research Board
National Research Council

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July 2002

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DISCLAIMER

This is an uncorrected draft as submitted by the research agency. The opinions and conclusions expressed or implied in the report are those of the research agency. They are not necessarily those of the Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, or the individual states participating in the National Cooperative Highway Research Program.

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Survey of Current use of AASHTO Specifications

- **The attached copy of a survey and summary of responses was conducted and kindly provided by Mr. Andy Muñ;oz, Jr., a Geotechnical Engineer with the FHWA Southwest district.**

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
P.O. BOX 902003
819 TAYLOR STREET, ROOM 8A00
FORT WORTH, TEXAS 76102-9003

REGION 6

June 30, 1999

REFER TO: HRC-SO-TX
5021

Mr. Samuel G. Paikowsky
Geotechnical Research Laboratory
Department of Civil & Environmental Engineering
University of Massachusetts Lowell
One University Avenue
Lowell, MA 01854

Dear Sam:

As per our discussion last week in Boston, enclosed for your information is a copy of the three transparencies I recently used for a presentation on *"CURRENT AASHTO STANDARD SPECIFICATIONS FOR GEOTECHNICAL DESIGN"*. The information was obtained from a letter survey I conducted of State DOT Geotechnical Engineers on a nation-wide basis. Responses are considered "unofficial", but provide a good understanding of the current state-of-the-practice at this time.

The following provides a brief explanation of each page:

1. Copy of letter sent to all State Geotechnical Engineers with four questions.
2. Crossed States are those that responded (63%).
3. Summary of responses received with key comments provided by some State DOT.

Sincerely,

Andy

Andy Muñoz, Jr., P.E.
Geotechnical Engineer

Enclosures (3 pages)

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration
819 Taylor Sreet - Room 8A00
FORT WORTH, TEXAS 76102-9003

(817) 978-4382
FAX: (817) 978-4144

May 10, 1999
HNG-06
5021

Dear State Geotechnical Engineer;

The purpose of this letter is to request your comments concerning your involvement with the AASHTO STANDARD SPECIFICATIONS that involve Geotechnical Engineering Design.

This is a topic of discussion at the 24th S.W. Geotechnical Engineers Conference, scheduled for June 16-18, 1999 in Sacramento, California and I need your quick and brief responses by June 1.

I have assembled a summary list of the AASHTO STANDARD SPECIFICATIONS from the subcommittees of "Highway Bridges" and "Materials" that involves Geotechnical Engineering and enclosed is a copy for your information. Please review the list and provide "off-the-cuff" comments on the following:

(1) Does your Geotechnical Department have a copy of the four sources of AASHTO Specs listed in the enclosure?

(2) Are these AASHTO Specs routinely used by the State DOT engineers for their designs and analyses?

(3) Were you involved in the development or revision of any of the AASHTO Specs?

(4) Is your State DOT committed to LRFD for Foundation Design and what is your time-table?

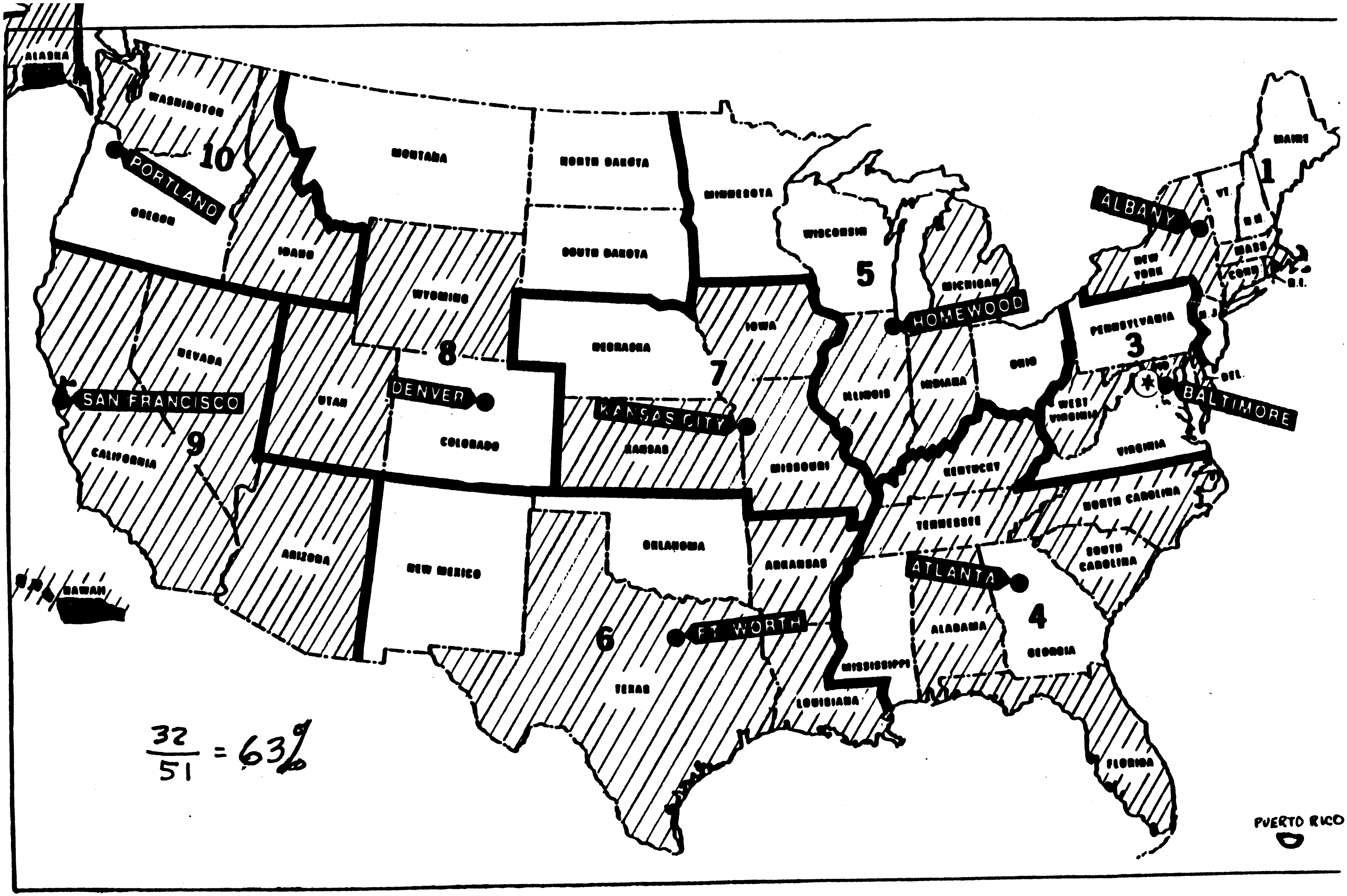
Thank you for returning your response **by June 1** to:

Andy Muñoz, Jr., P.E.
Geotechnical Engineer
Federal Highway Administration
819 Taylor Street - Room 8A00
Fort Worth, TX 76102
E-mail: andy.munoz@fhwa.dot.gov

Sincerely,

Andy Muñoz, Jr., P.E.
Geotechnical Engineer

Enclosure



(*) **Washington, D.C. Headquarters**

● Field Region Headquarters

NOTE: FHWA Region 1 Conforms to Standard Regions 1 and 2

June 1999
A. Muñoz

CURRENT AASHTO STANDARD SPECIFICATIONS FOR GEOTECHNICAL DESIGN

1) Does your Geotechnical Department have a copy of the four sources of AASHTO Specs listed in the enclosure? Yes !

(1) S.S. For Hwy. Bridges --- 30
(2) LRFD Bridge Design Specs -- 25
(3) Materials - S & T ---- 28
(4) Subsurface Investigation -- 29

2) Are these AASHTO Specs routinely used by the State DOT engineers for their designs and analyses?

Yes - *18
No - 3 +CA-HI-SC
Some - 11

* Used primarily as guide or reference
* Some portions are very conservative (ARI)
* AASHTO Specs same as FHWA Manuals & other Guidance (WA)
\+ Have own Manuals & Specs plus use FHWA Manuals & NAVFAC (CA)

3) Were you involved in the development or revision of any of the AASHTO Specs?

Yes --- 8 AK-FL-ID-MIS-NY-TX-UT-WA
No/Review - 24 CA - revising AASHTO to suit own needs

• More Geotechnical Representation needed
• Tony Allan (Wa) only Geotech in Bridge Subcommittee

4) Is your State DOT committed to LRFD for Foundation Design and what is your time-table?

Yes -- 14 [1]AK - DL - [5]FL - ID - Ka - MARY - MASS - MICH - NY - NC - TENN - UT - [7]WA - W.Va.
No/Maybe - 18 AL - ARI - [2]ARK - [3]CA - [4]CONN - HI - Ill - In - Io - KY - MIS - NV - RI - SC - [6]TX - WY - LA. - D.C.

1. When AASHTO sunsets Blue Specs & starts using the Red Spec.
2. Additional Research must be performed on local conditions & materials to establish design parameters.
3. Studying & Modifying AASHTO LRFD & may use on trial basis.
4. Most new projects designed by consultants will use LRFD
5. With some adjustments & celibration for soil resistance factors for piles & drilled shafts.
6. Serious Reservations.
7. Have significently modified the AASHTO LRFD pile spec. For use in WADOT. LRFD Loads & Wall Chapters to be updated with results From NCHRP project 20-07 Task 88. Training For State & Consultants major hurdle. U. of Wash. developing LRFD Training Course for WADOT.

NHI #13068 [illegible]

State of Practice Questionnaire

A questionnaire concerning the design and construction practices of deep foundations used by the Highway Departments was developed and distributed to 298 State Highway officials, TRB representatives and State and FHWA geotechnical engineers.

Appendix A Final Report TOC

Geotechnical Engineering Research Laboratory
One University Avenue
Lowell, Massachusetts 01854
Tel: (978) 934-2277 Fax: (978) 934-3046
e-mail: Samuel_Paikowsky@uml.edu
web site: http://www.eng.uml.edu/Dept/civ/geotechnical

Samuel G. Paikowsky, Sc.D
Professor

University of Massachusetts
UMASS Lowell

DEPARTMENT OF CIVIL AND
ENVIRONMENTAL ENGINEERING

August 9, 1999

RE: NCHRP Project 24-17
Deep Foundation Design and Construction Practices

«Title» «FirstName» «LastName»
«JobTitle»
«Company»
«Address1»
«Address2»
«City», «State» «PostalCode»

Dear «Title» «LastName»,

The Geotechnical Research Laboratory at the University of Massachusetts Lowell in cooperation with the Universities of Maryland, Florida and others is conducting project 24-17 under the AASHTO-sponsored National Cooperative Highway Research Program (NCHRP). The objective of this project is to provide recommended revisions to the driven pile and drilled shaft portions of Section 10 of the AASHTO LRFD Bridge Design Specifications to reflect current practice in geotechnical design and construction. The revisions will include resistance factors based on analyses of databases containing data from case histories.

To maximize the effectiveness of the recommendations, the research team would appreciate your help with the following:

1. Complete the attached survey, which is aimed at obtaining information about the practices of deep foundation design and construction. Your response will enable us to better address the needs of the different DOT agencies. If you find difficulty in completing the questionnaire and would like to discuss it by phone with a member of the research team please contact one of us using the information attached. When completed, please return the questionnaire to:

   Dr Ching L. Kuo
   Geo Structures Corporation
   2713 Falling Leaves Drive
   Valrico, FL 33594

2. We would very much appreciate your help in obtaining information related to pile and/or drilled shaft field-testing. These data can relate to one or all of the following categories:

Geotechnical Engineering Research Laboratory
One University Avenue
Lowell, Massachusetts 01854
Tel: (978) 934-2277 Fax: (978) 934-3046
e-mail: Samuel_Paikowsky@uml.edu
web site: http://www.eng.uml.edu/Dept/civ/geotechnical

Samuel G. Paikowsky, Sc.D
Professor

University of Massachusetts
UMASS Lowell

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

- Dynamic measurements (PDA) during end of driving and/or restrike with the relevant static load test to failure.
- Any testing on drilled shafts (static load test, Osterberg cell load test, Statnamic).

If the information is available in a report we will be glad to make the copies and send you back the originals. Please send the information to the undersigned, which will distribute it to the appropriate team member.

We realize how busy you are and therefore sincerely appreciate your efforts in sharing your department's experience with others that can profit from it. Your cooperation is highly appreciated and the quality of our work depends on it.

Sincerely yours,

Samuel G. Paikowsky

Cc: TRB State Representative

Team Member	Phone	Fax	e-mail
Bjorn Birgisson	(352) 846-3429	(352) 392-3394	bbirg@ce.ufl.edu
Ching L. Kuo	(813) 886-1075	(813) 888-6514	chingkuo@aol.com
Michael McVay	(352) 392-8697	(352) 392-3394	mcm@ce.ufl.edu
Samuel G. Paikowsy	(978) 934-2277	(978) 934-3046	Samuel_Paikowsky@uml.edu

Winword/Research/Ongoing Research/NCHRP LRFD/Databases/Survey/Coverletter

NCHRP PROJECT 24-17
LRFD DEEP FOUNDATION DESIGN

August 1999

SURVEY ON THE APPLICATION OF DEEP FOUNDATIONS

STATE: ______________________ DEPARTMENT: ____________________________

ENGINEER: _____________________ TITLE: _________________________________

PHONE: ___________________ FAX: ____________________

E-MAIL: ____

Please send back to: Dr. Ching L. Kuo
Geo Structures Corporation
2713 Falling Leaves Drive
Valrico, FL 33594

FOUNDATION ALTERNATIVES

1. What is the breakdown of foundation types used in your bridge structures?
   - ☐ Shallow Foundation ______%
   - ☐ Driven Piles ______%
   - ☐ Drilled Shafts ______%
   - ☐ Others

   Comment:
   ____
   ____
   ____

2. Do you have a preferred type of deep foundation?
   - ☐ Driven Pile
   - ☐ Drilled Shaft
   - ☐ Others ________________________

3. Which type of driven piles do you use most (Please rank according to their usage; 1 for most used, 6 for least used)?
- ☐ Prestressed Concrete Pile
- ☐ Steel H-Pile
- ☐ Open-end Steel Pipe Pile
- ☐ Closed-end Steel Pipe Pile
- ☐ Timber Pile
- ☐ Others ____________________

DRIVEN PILES

Design Considerations

1. What are the static axial geotechnical design methods and/or computer programs you use for driven pile design?
- ☐ α - method (Tomlinson, 1987)
- ☐ β - method (Esrig & Kirby, 1979)
- ☐ γ - method (Vijayvergiya and Focht, 1972)
- ☐ Nordlund method (Nordlund, 1963)
- ☐ Nottingham and Schmertmann method for CPT (1975)
- ☐ Schmertmann method for SPT (Sharp, 1987)
- ☐ Meyerhof method (1976) modified by Zeitlen and Paikowsky (1982)
- ☐ Others ____

If computer programs are used in design, are they developed by:
- ☐ In-House
- ☐ FHWA
- ☐ Commercial
- ☐ Others ____

2. What are the dynamic axial geotechnical design methods, and/or computer programs you use for driven pile design?

Dynamic Formula
- ☐ Engineering News Record (ENR) F.S. =____
- ☐ Gates, F.S. =____
- ☐ Other, Specify ________________, F.S. =____

Computer Program
- ☐ WEAP by GRL
- ☐ Other, Specify __

3. What are the primary parameters used in your design and/or computer program?
- ☐ SPT-N Value
- ☐ CPT Data
- ☐ Pressuremeter Data
- ☐ Dilatometer Data
- ☐ Friction Angle (ø) and Cohesion (c)
- ☐ Others ____

4. If friction angle (ø) and cohesion (c) are used in the design, how are the design parameters determined?
- ☐ Laboratory Testing
  Type of Test: _______________________________________
- ☐ Correlation with in-situ testing
  Type of test: ____
  Type of correlation: _________________________________

5. How do you assess the side friction coefficient?
   (a) In cohesive soil (C_A - adhesion)_________________________
   (b) In cohesionless soil (δ - interfacial friction angle) _______________

6. Which methodology are you currently using for geotechnical and structural design?
- ☐ Allowable Stress Design (ASD)
- ☐ AASHTO Load Factor Design (LFD)
- ☐ AASHTO Load and Resistance Factors Design (LRFD)
- ☐ Others ___________________________

7. Do you apply a partial safety factor for the side friction and the end bearing to determine the allowable capacity ASD methodology?
- ☐ No. Use global F.S. = __________
- ☐ Yes. F.S. =______ for Side Friction, F.S. = ______ for End Bearing

8. Do you consider pile settlement in design?
- ☐ No.
- ☐ Yes. Tolerable settlement is typically _____________.

9. What are the lateral geotechnical/structural design methods and/or computer programs you use for driven pile design?
- ☐ Simplified methods (e.g., Broms, 1964)
- ☐ p-y curve methods
- ☐ Others ____

If computer programs are used in design, are they developed by:
- ☐ In-House
- ☐ FHWA
- ☐ Commercial
- ☐ Others ____

9. What are the controlling factors when designing piles subjected to lateral load?
   - ☐ Lateral deflection. The tolerate deflection is _________________.
   - ☐ Lateral pile capacity. The method used is _______________________ and the safety factor is ________________.

10. Do you consider downdrag force in design?
    - ☐ No.
    - ☐ Yes. Which method do you use? ______________________________

11. Do you take into account the construction method in design?
    - ☐ No.
    - ☐ Yes. If yes, please indicate how? ______________________________

11. What is the estimated risk or failure probability of the group foundation design based on the safety factor you used?
    - ☐ Less that 0.1%
    - ☐ Between 0.1 to 1%
    - ☐ Between 1 to 10%
    - ☐ More than 10%
    - ☐ Unknown

What is your assessment for the acceptable maximum failure probability? _____%

12. Have you ever had a pile design that ended in failure?
    - ☐ No.
    - ☐ Yes. If yes, please provide some information as to what happened and why.

<u>Construction Considerations</u>

1. Do you perform static pile load test during construction?
   - ☐ No.
   - ☐ Yes. What criteria are used to justify the test?

     ____

     ____

   What kind of test do you perform? (e.g. slow maintained to twice the design load)____

   ____

2. Do you perform dynamic pile load test during construction?
- ☐ No.
- ☐ Yes. What are the criteria to justify the test? What percentage (%) of piles per bridge is usually subjected to dynamic load testing?

____

3. What type of instrument is used for the dynamic load testing?
- ☐ PDA by GRL
- ☐ Others ______________________

4. Which driving condition do you use to set production pile length and driving criteria?
- ☐ End of initial driving
- ☐ Beginning of redriving
- ☐ Others ____________________________________

5. Do you consider pile freeze or relaxation effects in determining driving criteria?
- ☐ No.
- ☐ Yes. How do you consider this during design?

____
____

DRILLED SHAFTS

Design Considerations

1. What are design methods and/or computer programs do you use for drilled shaft design?
   - ☐ α - Method (Total Stress Approach) (Reese and O'Neill, 1998; Kulhawy, 1989)
   - ☐ β - Methods (Effective Stress Approach) (Reese and O'Neill, 1988)
   - ☐ Reese and Wright (1977) Approach for side friction in cohesionless soils.
   - ☐ FHWA (O'Neill, 1996) Approach for intermediate geomaterials (soft rock)
   - ☐ Carter and Kulhawy (1988) Approach for intermediate geomaterials (soft rock)
   - ☐ Others ____

   If computer programs are used in design, are they developed by?
   - ☐ In-House
   - ☐ FHWA
   - ☐ Commercial

   Others ____

2. What are the primary parameters used in your drilled shaft design and/or computer program?
   - ☐ SPT-N Value
   - ☐ CPT Data
   - ☐ Pressuremeter Data
   - ☐ Dilatometer Data
   - ☐ Friction Angle (ø) and Cohesion (c)
   - ☐ Others _______________________________

3. If friction angle (ø) and cohesion (c) or rock shear strength are used in design, how the design parameters are determined?
   - ☐ Laboratory testing

     Type of test: _____________________________________
   - ☐ Correlation from in-situ testing

     Type of test: _____________________________________

4. Do you consider the roughness of the borehole wall in rock socket design?
   - ☐ No.
   - ☐ Yes. How do you determine the roughness, by
     - ☐ Assumption
     - ☐ Field measurement?

5. Which methodology are you currently using for geotechnical and structural design?
   - ☐ Allowable Stress Design (ASD)
   - ☐ AASHTO Load Factor Design (LFD)
   - ☐ AASHTO Load and Resistance Factors Design (LRFD)
   - ☐ Others ______________________________

6. Do you apply partial safety factor on side friction and end bearing to determine allowable capacity in ASD?
   - ☐ No. Using global F.S. = ___________
   - ☐ Yes. F.S. =______ for Side Friction, F.S. = ______ for End Bearing

7. Do you consider shaft settlement in design process?
   - ☐ No.
   - ☐ Yes. Tolerant Settlement is ________________

8. What are the lateral geotechnical/structural design methods and/or computer programs you use for driven pile design?
   - ☐ Simplified methods (e.g., Broms, 1964)
   - ☐ p-y curve methods
   - ☐ Others ____

   If computer programs are used in design, are they developed by?
   - ☐ In-House
   - ☐ FHWA
   - ☐ Commercial
   - ☐ Others ____

9. What are the controlling factors when designing drilled shafts subjected to lateral load?
   - ☐ Lateral deflection. The tolerate deflection is _____________.
   - ☐ Lateral pile capacity. The method used is ___________________ and the safety factor is __________________.

10. Do you consider downdrag force in design?
    - ☐ No.
    - ☐ Yes. Which method do you use: ________________________________

11. Do you take into account the construction method in design?
    - ☐ Yes.
    - ☐ No.

12. What is the estimated risk or failure probability of the foundation design based on the safety factor you used?
- ☐ Less that 0.1%
- ☐ Between 0.1 to 1%
- ☐ Between 1 to 10%
- ☐ More than 10%
- ☐ Unknown

What is the acceptable maximum failure probability to you? ______%

Construction Considerations

1. Do you perform a static pile load test during construction?
- ☐ No.
- ☐ Yes. What are the criteria to justify the test?

____

2. What type of load test is used?
- ☐ Conventional static load test. If yes, what type? (slow maintained, short duration etc.)
- ☐ Osterberg Load Cell Test
- ☐ Statnamic Load Test
- ☐ Dynamic Load test; Type of Test ______________________
- ☐ Others ____

3. What is the method of excavation usually used in drilled shaft installation?
- ☐ Dry methods
- ☐ Wet methods
- ☐ Casing methods (__ Temporary or __ Permanent)
- ☐ Others. _____________________________

4. If drilled slurry is used during construction, what type of material and criteria are used?
- ☐ Mineral Slurry of Processed Attapulgite
- ☐ Mineral Slurry of Bentonite Clays
- ☐ Synthetic Polymers
- ☐ Others. ___________________________

5. What is the requirement of the shaft cleanliness?

____
____

6. Do you use any type of shaft inspection device to inspect the bottom of the shaft?
- ☐ No.
- ☐ Yes. Type of Equipment __________________________________

7. Do you use integrity testing for drilled shafts quality control?

- ☐ No
- ☐ Yes. If yes, please specify type of tests and frequency of testing:
  - ☐ Cross Sonic Logging (CSL) ☐ Surface Reflection (Pulse Echo Method)
  - ☐ Others ______________________

  What percentage of caissons is tested? _____

TABLE 1 – SUMMARY OF RESPONSES TO SURVEY (as of 9/30/99)

STATE	ENGINEER	TITLE	E-MAIL
Alabama			
Alaska			
Arizona	F, Daniel Davis	State Bridge Engineer	Ddavis@dot.state.az.us
Arkansas	Edward T. Fain	Bridge Engineer	(501)569-2361
California	Tom Shantz	Senior M&R Engineer	Tom.shantz@dot.ca.gov
Colorado	Cheng-Kuang Su	Geotechnical Engineer	Cheng.su@dot.state.co.us
Connecticut	Leo Fontaine	Trans. Principal Engineer	(860)594-3180
Delaware	Dougles E. Finney	Asst. Bridge Design Engineer	Dfinney@mail.dot.state.de.us
Florida	Peter Lai	Asst. State. Geot. Engineer	pwlai@tfn.net
FL	Sastry Putcha	State Construction Geot. Engr.	
FL	Chandra Samakur	District 2 Geot. Engineer	Chandra.samakur@dot.state.fl.us
FL	D. Miro	District 4 Geot. Engineer	(954) 475-4102
FL	F. Tejidor	Dist. Turnpike Geot. Engr.	Ftejidor@pbsj.com
Georgia	Thomas Scruggs	Geotechnical Engineer	Thomas.Scruggs@dot.state.ga.us
Hawaii	Clarence Miyashiro	State Geot. Engineer	Hdotlab@aloha.net
Idaho	R. M. Smith	Asst. M&R Engineer	Bsmith@itd.state.id.us
Illinois	Emile Samara	Chief Found. $ Soil Engr.	Samara.ea@nt.dot.state.il.us
Indiana	Steve Morris	Geot. Engr. Group Leader	(317)232-5280
Iowa	Frank M. Russo	Special Projects Engineer	frusso@ max.state.ia.us
IA	Bob Stanley	Soil Design Engineer	Rstanle1@max.state.ia.us
Kansas	J. J. Brennan /	Soil Engineer	Brennan@ksdot.org
	G. R. Koontz	Chief Geologist	
Kentucky	Darrin Beckett	Geotechnical Engineer	Dbeckett@mail.kytc.state.ky.us
KY	W. H. Phillips	Transp. Engr. Specialist	Hphillips@mail.kytc.state.ky.us
Louisiana			
Maine	Laura Krusinski	Geotechnical Design Engineer	Laura.Krusinski@state.me.us
ME	John E. Buxton	Engin. & Design Manager	John.buxton@state.me.us
Maryland			
Massachusetts	Nabil Hourani	Geotechnical Engineer	Nabil.m.hourani@state.ma.us
Michigan			
Minnesota	Donald J. Flemming	State Bridge Engineer	Don.flemming@dot.state.mn.us
Mississippi			
Missouri			
Montana	W. Fullerton	Bridge Design Engineer	Wfullerton@state.mt.us
Nebraska	Omar Qudus	Geotechnical Engineer	Oqudus@dot.state.ne.us
Nevada			
New Hampshire	Mark Whittemore	Chief Design Engineer	N18mdw@dot.state.nh.us
New Jersey			
New Mexico			
New York	Don Arcari	Associate Soil Engineer	Darcari@gw.dot.state.ny.us
North Carolina	N. Abar	Soil Engineer	Nabaral@dot.state.nc.us
North Dakota	Tim Schwagler	Structural Management Engr.	(701)328-4421
ND	Blane Hoesel	Geotechnical Coordinator	Bhoesel@state.nd.us
Ohio			
Oklahoma			
Oregon	Jan Six	Geotechnical Engineer	Jan.L. Six@dot.state.or.us
Pennsylvania	Scott Christie	Chief Bridge Engr.	Rschristie@hotmail.com
Rhode Island	U. Dash	Bridge QA Engr.	Udash@dashes.com
South Carolina	Tim Adams	Bridge Geot. Engineer	Adamstn@dot.state.sc.us
South Dakota			
Tennessee	M. Leonard Oliver	Civil Engineering Manager	Loliver@mail.state.tn.us
Texas	George Odom	Geotechnical Engineer	Godom@dot.state.tx.us
Utah	Jon Bischoff	Geotechnical Engineer	(801)965-4320
Vermont	Chris Benda	Soil & Foundations Engr.	Chris.benda@state.vt.us
Virginia			
Washington	James Cuthbertson	Chief Foundation Engr.	Cuthbej@wsdot.wa.gov
Washington D.C.			
West Virginia			
Wisconsin			
Wyoming	Mike Hager /	Chief Engineering Gelogist	Mhager@missc.state.wv.us
	Gregg Fredrick	Asst. State Bridge Engr.	Gfredr@missc.state.wv.us
FHWA-EFLHD	William W. Bassett	Supervisory Geot. Engr.	William.basssset@fhwa.dot.gov

2.2 Summary - Design and Construction Practices

2.2.1 General

Section 2.1 presented the questionnaire that was developed and distributed. A table summarizing the responding states as of 9/30/99 was also included.

A total of 45 surveys were returned and analyzed (43 states and 2 FHWA personnel). The analysis of the survey is presented below.

2.2.2 FOUNDATION ALTERNATIVES

14% of Responders primarily used shallow foundations, 75% used driven pile foundations, and 11% used drilled shaft foundations. Of those responding, 64% prefer driven pile foundations, as compared to 5% preferring drilled shaft foundations. Of those responders using driven piles, 21% primarily used prestressed concrete pile, 52% used steel H piles, 2% used open-ended steel pipe piles, and 25% used closed-end steel pipe piles.

2.2.3 DRIVEN PILES - Design Considerations

1. The most common methods for evaluating the static axial capacity of driven piles were: 59% for the α - method (Tomlinson, 1987), 25% for the β - method (Esrig & Kirby, 1979), 5% for the γ - method (Vijayvergiya and Focht, 1972), 75% for Nordlund's method (Nordlund, 1963), 5% for Nottingham and Schmertmann's method for CPT (1975), 9% for Schmertmann's method for SPT (Sharp, 1987), 14% for Meyerhof's method (1976) modified by Zeitlen and Paikowsky (1982), and 25% for in-house methods and other less common methods. Of the computer programs used in design, 39% were developed in-house, 75% came from the FHWA and 20% from commercial vendors.
2. The most common dynamic geotechnical methods used in pile driving included: 45% using the ENR formula, 16% using Gates's equation with safety factors ranging from 2.0 to 3.5, and one (1) State using it's own dynamic formula. Wave Equation Analysis using the program GRLWEAP was used by 80% of the respondents.
3. Of the primary parameters used in design, 86% used SPT-N values, 11% used CPT data, 2% used Dilatometer data, and 77% used friction angle (ø) and cohesion (c). None of the respondents reported the use of Pressuremeter data.
4. The friction angle (ø) and cohesion (c) determined from laboratory testing were from Triaxial test, Direct shear test and Unconfined compression test. The In-situ tests primarily were the SPT, and less than 10% states use CPT, DMT, Vane shear test, or others.
5. The majority (more than 50%) of States used Tomlinson's method to assess the side friction coefficient in cohesive soil (C_A - adhesion), and Nordland's method in cohesionless soil (δ - interfacial friction angle
6. For the methodology currently used for geotechnical and structural design, 93% used Allowable Stress Design (ASD), 37% used AASHTO Load

Factor Design (LFD), and 30% used AASHTO Load and Resistance Factors Design (LRFD).

7. For those respondents using the allowable stress design (ASD) to evaluate capacity, 95% used a global safety factor ranging from 2.0 to 3.0 depending on construction control, 5% used partial safety factors with 1.5 to 2.0 for Side Friction and 3.0 for End Bearing.
8. 48% considered pile settlement in the design with tolerable settlement ranging from 0.25-1.0 inches.
9. 34% used simplified methods (e.g., Broms, 1964) in the lateral pile design methods and/or computer programs, and 88% used methods based on p-y curves.

Of the computer programs used in design, 14% were In-House, 82% were from the FHWA and 55% came from Commercial vendors.

10. In designing piles subjected to lateral load, the tolerable deflection was most often taken to lie between 0.25 to 2.0", and the lateral pile capacity safety factors ranged from 1.5 to 3.0.
11. 25% of the respondents did not consider downdrag forces in design.
12. 48% did not take into account the construction method in design.
13. The estimated risk or failure probability of the group foundation design based on the safety factor used: 27% were less than 0.1%, 4% were between 0.1 to 1%, one percent (1%) of the responses were between 1% to 10%, and 67% were unknown. The assessment for the acceptable maximum failure probability ranged from about zero (0) to 1%.
14. 14% of respondents had experienced pile failure.

2.2.4 DRIVEN PILES - Construction Considerations

1. 77% performed static pile load test during construction, and the primary test method was the Quick Method.
2. 84% performed dynamic pile load test during construction, and about 1% to 10% of piles per bridge were usually subjected to dynamic load testing.
3. All of respondents performing dynamic load testing (86% of responses) used the PDA by GRL.
4. When setting production pile length and driving criteria, 82% used the End of Initial Driving conditions, and 52% used the Beginning of Redriving conditions.
5. 36% did not consider pile freeze or relaxation effects in determining driving criteria.

2.2.5 DRILLED SHAFTS - Design Considerations

1. Of the design methods used in drilled shaft design, 36% used the α - Method (Total Stress Approach) (Reese and O'Neill, 1998; Kulhawy, 1989), 41% used the β - Method (Effective Stress Approach) (Reese and O'Neill, 1988), 9% used the Reese and Wright (1977) approach for side friction in cohesionless soils, 39% used the FHWA (O'Neill, 1996) approach for intermediate geomaterials (soft rock), 11% used Carter and

Kulhawy's (1988) approach for intermediate geomaterials (soft rock), and 27% used other methods.

Of the computer programs used in design, 18% were developed In-House, 50% came from the FHWA, 29% from Commercial vendors, and 20% from others.

2. Of the primary parameters used in drilled shaft design, 70% were SPT-N values, 7% were from the CPT test, 2% were Pressuremeter Data, 2% were Dilatometer Data, and 68% were Friction Angle (ø) and Cohesion (c). 27% were obtained by other methods.
3. The friction angle (ø) and cohesion (c) or rock shear strength determined from Laboratory Testing were from the Triaxial test, Direct shear test and Unconfined compression test. The in-situ tests used were primarily the SPT, with less than 10% of States using the CPT, DMT, Vane Shear test, or others.
4. Of the 16% considering the roughness of the bore hole wall in rock socket design, all did so by assumption.
5. For the methodology currently used for geotechnical and structural design of drilled shafts, 86% used Allowable Stress Design (ASD), 32% used AASHTO Load Factor Design (LFD), and 25% used AASHTO Load and Resistance Factors Design (LRFD).
6. In the allowable capacity ASD methodology, 90% used global safety factors ranging from 2.0 to 3.0 depending on construction control, 10% used partial safety factors with 1.5 to 3.0 for side friction and 2.0 to 3.0 for end bearing.
7. 61% considered shaft settlement in the design process, with tolerable settlements ranging from 0.25 inches to 2.0 inches.
8. 27% used Simplified (e.g., Broms, 1964) lateral drilled shaft design methods and/or computer programs, and 82% used methods based on p-y curves.
9. In designing drilled shaft subjected to lateral load, the tolerate deflection ranging from 0.25 to 2.0", and the safety factor of lateral pile capacity ranging from 1.5 to 3.0.
10. 45% of respondents did not consider downdrag force in design.
11. 30% of respondents did not take into account the construction method in design.
12. Of the estimated risk or failure probability of group foundation designs based on the safety factor used, 20% were less than 0.1%, 7% were between 0.1 to 1%, 2% were between 1 to 10%, and 71% were unknown. The assessment for the acceptable maximum failure probability was from about zero (0) to 5%.

2.2.6 DRILLED SHAFTS - Construction Considerations

1. 66% performed static load testing during construction.
2. The type of load test used included 32% that used conventional static load testing, 43% used an Osterberg Load Cell, 11% used the Statnamic Load Test, and 7% used Dynamic Load testing.

3. The method of excavation usually used in drilled shaft installation by respondents included 64% using Dry methods, 52% using Wet methods, and 86% using Casing methods.
4. For the drilling slurry used during construction, 25% used a Mineral Slurry of Processed Attapulgite, 52% used a Mineral Slurry of Bentonite Clays, and 36% used Synthetic Polymer slurries.
5. A majority of the States responding used AASHTO Specifications for shaft cleanliness, which requires more than 50% of base to have less than 0.5 inches of sediment, and the maximum sediment thickness to be less than 1.5 inches.
6. 54% performed inspection of the shaft bottom, in which only one State has specific inspection device. The rest performed inspection by using manual probes or an underwater camera and camcorder.
7. 16% did not perform integrity testing for drilled shaft quality control, 64% used Cross Sonic Logging (CSL), 7% used Surface Reflection (Pulse Echo Method), and 7% Gamma Ray or NX coring.

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Design method and/or computer program used for drilled shaft design

STATE	α Method	β Method	Reese et al	FHWA	Carter et al	Others
AL						
AK						
AZ		*		*	*	
AR						*(AASHTO)
CA	*					
CO	*					
CT						*(Horvath & Kenny)
DE						NO SHAFT
FL		*		*		
GA				*		
HI						NO SHAFT
ID				*		
IL	*	*			*	*(Horvath & Kenny)
IN						
IA				*		*(AASHTO)
KS	*	*				
KY						*
LA	*	*				
ME		*				*(ASSHTO, H&K)
MD						For noise wall
MA	*	*		*	*	*(Zhang & Einstein)
MI	*	*				
MN		*		*		
MS						
MO						*(No end bearing)
MT	*	*		*	*	
NE				*		
NV	*	*				
NH		*				
NJ	*		*	*		
NM			*			
NY			*			
NC				*	*	
ND						NO SHAFT
OH				*		
OK						*
OR	*	*		*		
PA			*			
RI						
SC	*	*		*		
SD						*
TN	*	*		*		
TX						*
UT	*	*		*		
VT						NO SHAFT
VA/FHWA				*		*
WA	*	*				
DC						
WV						
WI	*	*				
WY						*(Modified Nordland)

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Development of computer programs for axial load design

STATE	In-House	FHWA	Commercial	Others	
AL					
AK					
AZ		*			
AR		*			
CA	*				
CO		*	*		
CT				*	
DE				*	
FL	*				
GA		*			
HI					
ID		*	*		
IL	*				
IN					
IA	*				
KS		*			
KY		*			
LA			*		
ME	*	*	*		
MD		*			
MA		*	*		
MI				*	
MN		*	*		
MS					
MO				*	
MT		*	*		
NE			*		
NV		*	*		
NH		*	*		
NJ				*	
NM					
NY		*			
NC		*	*		
ND					
OH		*	*		
OK		*			
OR			*		
PA				*	
RI					
SC		*			
SD				*	
TN		*			
TX	*				
UT	*	*			
VT					
VA/FHWA				*	
WA		*			
DC					
WV					
WI				*	
WY	*				

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Primary parameters used in design and/or computer program

STATE	SPT-N	CPT	Pressuremeter	Dilatometer	C and ϕ	Others
AL						
AK						
AZ	*				*	
AR	*				*	
CA					*	
CO	*				*	
CT						*(RQD, qu)
DE						
FL	*			*		*(RQD, qu,qt)
GA	*					
HI						
ID	*	*			*	
IL	*				*	*(RQD, Recov)
IN						
IA	*				*	*(qu)
KS	*		*		*	
KY	*				*	
LA	*				*	
ME	*				*	*(qu)
MD	*				*	
MA	*				*	* (qu)
MI	*				*	
MN						* (qu)
MS						
MO					*	*
MT	*				*	
NE	*				*	*(qu)
NV	*				*	
NH	*				*	
NJ	*	*				
NM						
NY					*	
NC	*				*	
ND						
OH	*				*	
OK	*	*				
OR	*				*	
PA	*				*	
RI						
SC	*				*	
SD						
TN	*				*	
TX						*
UT	*				*	
VT						
VA/FHWA						*(qu)
WA	*				*	
DC						
WV						
WI	*				*	*(qu)
WY	*				*	

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Determination of friction angle (ϕ) and Cohesion (C)

STATE	Laboratory Testing	In-situ Testing
AL		
AK		
AZ	DS	SPT
AR		SPT, RQD
CA	UU, Pocket Penet.	SPT
CO	qu	SPT
CT	qu	
DE	-	
FL	qu, qt	SPT
GA	-	
HI	-	
ID	Triaxal, DS	SPT, CPT
IL	*	
IN		
IA	Triaxial, qu	SPT, Load test
KS	qu	
KY	Triaxial, UU	SPT
LA	Triaxial, UU	SPT
ME	qu	SPT
MD	-	
MA	Point load, qu	SPT
MI	qu	SPT
MN	-	
MS		
MO	DS	SPT
MT	DS, qu	SPT
NE	qu	
NV	DS, Triaxial	
NH	qu	SPT
NJ	-	
NM		
NY	qu	
NC	*	*
ND		
OH		SPT
OK	-	
OR	Triaxial	SPT
PA	*	*
RI		
SC	Triaxial, qu	SPT
SD	DS	
TN	Triaxial	SPT
TX		Texas Cone
UT	Triaxial	SPT,CPT, Vane shear
VT	-	
VA/FHWA	qt	
WA	UU	SPT
DC		
WV		
WI	DS, Triaxial, qu, in-house rock shear	
WY	qu	SPT

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION
Consideration of borehole wall roughness in rock socket design

STATE	No	Yes/Assumption	Yes/Measurement		
AL					
AK					
AZ	*				
AR	*				
CA	*				
CO	*				
CT	*				
DE					
FL		*			
GA	*				
HI					
ID	*				
IL	*				
IN					
IA		*			
KS	*				
KY		*			
LA	*				
ME		*			
MD	*				
MA		*			
MI	*				
MN	*				
MS					
MO	*				
MT	*				
NE	*				
NV	*				
NH	*				
NJ	*				
NM					
NY		*			
NC	*				
ND					
OH	*				
OK	*				
OR	*				
PA		*			
RI					
SC	*				
SD	*				
TN	*				
TX	*				
UT	*				
VT					
VA/FHWA	*				
WA	*				
DC					
WV					
WI	*				
WY	*				

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Methodology currently being used for geotechnical and Structure design

STATE	ASD	LFD	LRFD	Others	
AL					
AK					
AZ	*	*			
AR	*				
CA	*				
CO	*	*	*		
CT	*		*		
DE					
FL	*	*	*		
GA	*				
HI	*				
ID	*		*		
IL	*				
IN	*				
IA	*	*			
KS	*		*		
KY	*	*			
LA	*				
ME	*				
MD		*			
MA	*	*	*		
MI		*			
MN	*	*	*		
MS	*				
MO	*	*			
MT	*				
NE	*				
NV	*				
NH	*				
NJ	*		*		
NM					
NY	*				
NC	*				
ND					
OH	*				
OK	*				
OR	*	*	*		
PA		*	*		
RI					
SC	*				
SD	*				
TN	*				
TX	*				
UT	*				
VT					
VA/FHWA	*				
WA		*	*		
DC					
WV					
WI	*				
WY	*	*			

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Apply partial safety factor for side friction and end bearing on allowable shaft capacity

STATE	No/ Global F.S.	Yes/Side friction/End Bearing
AL		
AK		
AZ		* 2.0 / 3.0
AR	* 2.5	
CA	* 2.0	
CO	* 3.0	
CT	* 2.0 w/ Load Test	
DE	-	
FL	* 2.5	
GA	* 2.0 to 3.0	
HI	-	
ID	* 3.0	
IL	* 3.0	
IN	* >2.0	
IA	-	
KS	-	
KY	*	
LA	* 3.0	
ME		* 3.0 / 2.0
MD	* 2.5	
MA	* 2.5 w/ load test	
MI	* 2.0 to 2.5	
MN	* 2.0	
MS		
MO	* 2.5 to 3.0	
MT	* 2.0 to 3.0	
NE	* 2.0	
NV	* 2.5	
NH	* 2.5 to 3.0	
NJ	* 3.0	
NM		
NY	* 2.0	
NC		* 2.0 / 3.0
ND	-	
OH	* 3.0	
OK	-	
OR	* 2.0 (Rock), 2.5 (Soil)	
PA	-	
RI		
SC	* 3.0	
SD		* 2.0 / No end bearing
TN	* 2.0 to 2.5	
TX	* 2.0	
UT	* 2.5	
VT	-	
VA/FHWA	*	
WA	* 2.5 to 3.0	
DC		
WV		
WI	* 2.0 to 3.0	
WY		* 1.5 / 2.0

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Consider drilled shaft settlement in design

STATE	No	Yes/Tolerable settlement	
AL			
AK			
AZ		* 1.0"	
AR		* AASHTO 4.4.7.2.5	
CA	*		
CO	*		
CT		* 0.25"	
DE		-	
FL		* 1.0"	
GA		* 0.5"	
HI		-	
ID	*		
IL	*		
IN			
IA		* Varies, typically 0.5"	
KS	*		
KY	*		
LA		* 0.5" @ 1.5 design load, 1" @ 2 design load	
ME		* 1.0 to 1.5"	
MD	*		
MA		* 5% Shaft Dia. In soils	
MI	*		
MN	*		
MS			
MO	*		
MT		* 1.0"	
NE		* 0.4"	
NV		* 1.0"	
NH		* Load transfer in rock socket	
NJ	*		
NM			
NY		* < 2.0"	
NC		*	
ND			
OH		* 0.5"	
OK			
OR		* Structure dependent	
PA	*		
RI			
SC		* Determined by structural engineer	
SD	*		
TN		* 0.25"	
TX	*		
UT		* Project dependent, typically <25mm	
VT			
VA/FHWA	*		
WA		* < 25mm	
DC			
WV			
WI	*		
WY	*		

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION
Design method and/or program for lateral load analysis

STATE	Simply Method (Broms)	p-y Curve Method	Others
AL			
AK			
AZ	*	*	
AR		*	
CA		*	
CO	*	*	
CT		*	
DE		*	
FL		*	
GA		*	
HI			
ID	*	*	
IL	*	*	
IN			
IA		*	
KS		*	
KY		*	
LA		*	
ME		*	
MD		*	
MA	*	*	
MI	*	*	
MN		*	
MS			
MO		*	
MT		*	
NE		*	
NV		*	*
NH	*	*	
NJ		*	
NM			
NY	*	*	
NC		*	
ND			
OH		*	
OK			
OR		*	
PA	*	*	
RI			
SC		*	
SD			
TN	*	*	
TX		*	
UT		*	
VT			
VA/FHWA	*		
WA		*	
DC			
WV			
WI	*		
WY		*	

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Development of computer programs for lateral load analysis

STATE	In-House	FHWA	Commercial	Others	
AL					
AK					
AZ		*			
AR		*			
CA	*	*	*		
CO	*	*	*		
CT		*			
DE					
FL	*				
GA		*			
HI					
ID		*			
IL	*	*			
IN					
IA		*			
KS		*			
KY		*			
LA		*			
ME		*	*		
MD		*			
MA		*	*		
MI	*	*			
MN		*	*		
MS					
MO		*			
MT		*	*		
NE			*		
NV		*	*		
NH		*	*		
NJ		*		*	
NM					
NY		*			
NC		*	*		
ND					
OH		*	*		
OK					
OR		*	*		
PA		*			
RI					
SC		*	*		
SD					
TN		*			
TX		*			
UT			*		
VT					
VA/FHWA		*			
WA		*	*		
DC					
WV					
WI				*	
WY			*		

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Control factors of drilled shaft design subjected to lateral load

STATE	Lateral Deflection/Tolerate Deflection	Lateral Capacity/Method used/Safety factor
AL		
AK		
AZ	* 1.0"	* 2.0
AR		* 2.5
CA	*	*
CO	* Varies	* Varies
CT	* Structure dependent	
DE		
FL	* 2.0"	
GA	*	
HI		
ID	* 0.25"	
IL	*	*
IN		
IA		* Structural reinforcement
KS		* 3.0
KY	* 0.5"	
LA	*	*
ME	* 1" or as directed by structural engineer	* 2.5
MD	* 0.5"	* 2.5
MA	Project dependent	* 1.5
MI	* Varies	
MN	* Determined by structural engineer	
MS		
MO		* 2.5
MT	* Structure dependent, typically <50 mm	
NE	* Structure dependent	
NV	* 1.0"	
NH	* Structure dependent	
NJ	* 0.5"	
NM		
NY	* 1.0"	
NC	* 1.0"	
ND		
OH	* Project dependent	
OK		
OR	* Structure dependent, typically <1.0"	*
PA	* 0.5"	
RI		
SC	* 2.0" from free head condition	
SD		* Point of fixity method
TN		*
TX	* 0.5"	
UT	* Determined by structural engineer	
VT		
VA/FHWA	*).5"	
WA	* Structure dependent	*
DC		
WV		
WI	*	
WY	* 2.0"	

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Consideration of downdrag force in design

STATE	No	Yes/Methodology		
AL				
AK				
AZ		* FHWA		
AR	*			
CA	*			
CO	*			
CT	*			
DE				
FL		*		
GA	*			
HI				
ID		* α method		
IL		*		
IN	*			
IA	*			
KS		* FHWA, DM-7, Poulos and Daves		
KY		* DM-7		
LA	*			
ME	*			
MD	*			
MA		* DM-7		
MI	*			
MN		* Neutral plane		
MS				
MO	*			
MT	*			
NE		*		
NV		* α method		
NH		*		
NJ		*		
NM				
NY		*		
NC		*		
ND				
OH		*		
OK				
OR		* α method		
PA	*			
RI				
SC	*			
SD	*			
TN	*			
TX	*			
UT		* Fellenios		
VT				
VA/FHWA		*		
WA		*		
DC				
WV				
WI	*			
WY	*			

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Consideration of construction method in design

STATE	No	Yes		
AL				
AK				
AZ		*		
AR		*		
CA		*		
CO		*		
CT	*			
DE				
FL		*		
GA	*			
HI				
ID	*			
IL		*		
IN				
IA		*		
KS	*			
KY		*		
LA		*		
ME		*		
MD	*			
MA		*		
MI		*		
MN		*		
MS				
MO		*		
MT	*			
NE		*		
NV		*		
NH		*		
NJ		*		
NM				
NY		*		
NC		*		
ND				
OH	*			
OK				
OR		*		
PA		*		
RI				
SC	*			
SD	*			
TN	*			
TX	*			
UT		*		
VT				
VA		*		
WA		*		
DC				
WV				
WI	*			
WY	*			

DRILLED SHAFT ALTERNATIVE/DESIGN CONSIDERATION

Estimated risk or failure probability based on the safety factor used

STATE	<0.1%	0.1 to 1%	1 to 10 %	>10%	Unknown	Acceptable %
AL						
AK						
AZ					*	0.1
AR					*	~0
CA					*	
CO	*					1.0
CT					*	
DE						
FL					*	1.0
GA					*	1.0
HI						
ID					*	
IL	*					0.1
IN						
IA					*	
KS	*					~0
KY			*			
LA					*	
ME		*				5.0
MD					*	
MA					*	1.0
MI		*				
MN					*	
MS						
MO					*	
MT					*	0.1 – 1.0
NE					*	0.1
NV					*	
NH					*	
NJ					*	
NM						
NY					*	
NC					*	
ND						
OH	*					
OK					*	
OR	*					0.1
PA	*					
RI					*	
SC						
SD	*					
TN	*					
TX	*					0.1
UT					*	0.1
VT						
VA/FHWA					*	
WA		*				0.5
DC						
WV						
WI					*	
WY					*	

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION
Perform static load test during construction

STATE	No	Yes/Criteria to justify	
AL			
AK			
AZ	*		
AR		* Failure of cross sonic logging	
CA		* Possible shaft defect	
CO		* Potential saving or difficult to predict	
CT		* Cost saving	
DE			
FL		*	
GA		* Friction shaft in soil or rock type previously not tested	
HI			
ID	*		
IL		* Major project	
IN			
IA		* Design phase for database	
KS	*		
KY		* Critical bridge	
LA		* Need to be verified	
ME		* Cost saving	
MD	*		
MA		* Cost saving, verify capacity	
MI		*	
MN	*		
MS			
MO		*Very rarely, only on big project w/ cost saving	
MT	*		
NE	*		
NV	*		
NH	*		
NJ		* Quality control	
NM			
NY		* High load, unknown soil conditions	
NC		*	
ND			
OH	*		
OK	*		
OR	*		
PA		*	
RI			
SC		* As necessary	
SD			
TN	*		
TX		*	
UT		*	
VT			
VA/FHWA		*	
WA	*		
DC			
WV			
WI	*		
WY		*	

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Type of load test performed during construction

STATE	Conventional/Static	Osterberg	Statnamic	Dynamic	Others
AL					
AK					
AZ	*				
AR				* Controlled drop weight	
CA	*	Occasionally	Occasionally		
CO	*				
CT		*			
DE					
FL	*	*	*		
GA		*			
HI					
ID					
IL		*			
IN					
IA				* Controlled drop weight	
KS	*				
KY		*			
LA		*			
ME		*			
MD					
MA	*	*			
MI		*			
MN		* (1)			
MS					
MO	*	*	*		
MT					
NE					
NV		* (1)			
NH					
NJ		*			
NM					
NY	*	*(>700 tons)			
NC		*	*		
ND					
OH					
OK					
OR					
PA		*		*	
RI					
SC	*	*			
SD					
TN					
TX	*				
UT	*		*		
VT					
VA/FHWA	*				
WA					
DC					
WV					
WI	*				
WY	*	*			

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Methods of shaft excavation used during installation

STATE	Dry	Wet	Casing	Others	
AL					
AK					
AZ	*	*	* Temporary		
AR	*	*	*		
CA	*	*	*		
CO	*		* Temporary		
CT			*		
DE					
FL		*	*		
GA	*	*			
HI					
ID	*		*		
IL	*	*	*		
IN					
IA	*	*	*		
KS	*	*	*		
KY	*	*	*		
LA	*	*	*		
ME			* Permanent		
MD	*		*		
MA	*	*	*		
MI	*		* Permanent		
MN			*		
MS					
MO			*		
MT		*	*		
NE			* Permanent		
NV	*		* Temporary		
NH		*	*		
NJ		*	* Permanent		
NM					
NY	*		*		
NC	*	*	*		
ND					
OH	*	*	*		
OK	*		*		
OR	*	Rarely	*		
PA	*	*	*		
RI					
SC	*	*	*		
SD	*	*	*		
TN	*		*		
TX	*	*	*		
UT	*	*	*		
VT					
VA/FHWA	*	*	* Temporary		
WA					
DC		*	*	Oscillator	
WV					
WI			* Permanent		
WY	*		* Temporary		

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Type of slurry used during shaft installation

STATE	Mineral/Processed Attapulgite	Mineral/Bentonite	Synthetic Polymers	Others
AL				
AK				
AZ	*	*		
AR		*	*	
CA	*	*	*	
CO	*	*	*	
CT	*	*	*	
DE				
FL	*			
GA		*		
HI				
ID				
IL		*		
IN				
IA			*	
KS		*	*	
KY	*	*	*	
LA	*	*	*	
ME				
MD				
MA		*	*	
MI			*	
MN		*		
MS				
MO	*	*		
MT			*	
NE		*		
NV	*			
NH		*	*	
NJ		*		
NM				
NY		*		
NC		*		
ND				
OH		*	*	
OK				
OR	*		*	
PA		*		
RI				
SC		*		
SD				
TN				
TX		*		
UT		*	*	
VT				
VA/FHWA	*			
WA			*	
DC				
WV				
WI				*
WY				*

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Requirement of shaft cleanliness

STATE		
AL		
AK		
AZ	* FHWA Specification	
AR	* 1% sand content of polymer slurry	
CA	* Cleanness of slurry for wet method, visual inspection for dry method	
CO	-	
CT	* <1.5 to 2 " sediment on bottom	
DE		
FL	* More than 50% of base <0.5", max. 1.5" sediment	
GA	* More than 50% of base <0.5", max. 1.5" sediment	
HI		
ID	* <2% sediment for end bearing shaft, <6" for friction shaft	
IL	*	
IN		
IA	* More than 50% of base <15mm, max. 35 mm sediment	
KS	* Visual inspection	
KY	* <0.5" sediment	
LA	* <0.5" for end bearing shaft, <2" for friction shaft	
ME	* More than 50% of base <0.5", max. 1.0" sediment	
MD		
MA	* <0.5" sediment on bottom, <4% sand in slurry	
MI	* <1" sediment on bottom	
MN	*	
MS		
MO	* Approved by engineer	
MT	* No standard specification	
NE	* Shaft has to be dry and clean	
NV	* Sand content <4% in slurry	
NH	* More than 50% of base <0.5", max. 1.5" sediment, AASHTO	
NJ	* Visual Inspection	
NM		
NY	*	
NC	* <1" sediment on bottom	
ND		
OH	* To be cleaned	
OK		
OR	* <50 mm for end bear shaft, < 150 mm for friction shaft	
PA	*	
RI		
SC	* < 0.5" sediment on bottom	
SD	* As approved by engineer	
TN	* No loose on bottom	
TX	* 10% max. sand content in slurry	
UT	* AASHTO	
VT		
VA		
WA	* <50 mm for end bearing shaft, <150 mm for friction pile	
DC		
WV		
WI	*	
WY	* Visual inspection (very subjective)	

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Type of shaft inspection device for shaft bottom

STATE	No	Yes	
AL			
AK			
AZ	*		
AR		* Manual probe	
CA	*		
CO	*		
CT		* Manual probe	
DE			
FL		* SID	
GA	*		
HI			
ID		* Manual probe	
IL			
IN			
IA		* Manual probe, camcorder	
KS	*		
KY		* Manual probe	
LA		* Manual probe	
ME		* Manual probe, underwater camera/video	
MD	*		
MA		* Manual probe	
MI		* Manual probe	
MN	*		
MS			
MO		* Camcorder, underwater inspection	
MT	*		
NE	*		
NV	*		
NH		* Underwater camera, downhole inspection if possible	
NJ	*		
NM			
NY		* Manual probe	
NC		* Manual probe	
ND			
OH	*		
OK	*		
OR		* Manual probe	
PA		* Camera	
RI			
SC		* Manual probe	
SD		* Manual probe	
TN		* Downhole visual inspection	
TX	*		
UT	*		
VT			
VA/FHWA	*		
WA	*		
DC			
WV			
WI	*		
WY	*		

DRILLED SHAFT ALTERNATIVE/CONSTRUCTION CONSIDERATION

Type of integrity testing for drilled shaft quality control

STATE	No	Cross Sonic Logging	Surface Reflection	Others	% Shaft tested
AL					
AK					
AZ		*		* Gamma Ray	100%
AR		*			100%
CA		*		* Gamma Ray	
CO		*	*		Only suspect
CT		*			10 to 20%
DE					
FL		*			?
GA		*			<5%
HI					
ID	*				
IL		*			Very small %
IN		*			100%
IA		*			100%
KS	*				
KY		*			<5%
LA		*			100%
ME		*			100%
MD	*				
MA		*	*		On 100% uncased
MI	*				
MN	*				
MS					
MO		*	*	NX coring	Project dependent
MT		*			~15%
NE	*				
NV		*			80%
NH		*(2 projects)			15 – 40%
NJ		*			100%
NM					
NY		*			100%
NC		*			100%
ND					
OH		*			1%
OK					
OR		*			1 / bent
PA	*				
RI					
SC		*			100% if 2 shafts/bent
SD		*			10%, 1 / bent
TN		*			~50%
TX		*			
UT		*			
VT					
VA					
WA					~50%
DC					
WV					
WI					
WY					

FOUNDATION ALTERNATIVE

% of foundation types used for bridge structure?

STATE	Shallow Foundation	Driven Pile	Drilled shaft	Others	Deep Found.	Remarks
AL						
AK						
AZ	30	5	65		70	
AR	25	73	1	1	75	
CA	5	70	25		95	
CO	10	40	50		90	
CT	75	23	1	1	25	
DE	50	50	-		50	
FL	-	70	30		100	
GA	10	85	5		90	
HI	?	?	?			
ID	>15	80	<5		85	
IL	15	65	20		85	
IN	5	94	1		95	
IA	<10	>90	<1		90	
KS	35	40	25		65	
KY	50	40	10		50	
LA	-	95	5`		100	
ME	68	31	<1		32	
MD	?	?	?			
MA	40	30	20	<1	60	
MI	25	75	<1		75	
MN	10	85	5		90	
MS						
MO	45	45	10		55	
MT	10	60	30		90	
NE	1	96	3		99	
NV	45	20	35		55	
NH	70	25	5		30	
NJ	44	55	1		56	
NM						
NY	37	60	2	1	62	
NC	5	55	40		95	
ND	5	95	-		95	
OH	15	75	10		85	
OK	15	35	50		85	
OR	15	70	15		85	
PA	25	70	5		75	
RI						
SC	5	60	35		95	
SD	5	75	20		95	
TN	45	50	5		55	
TX	-	20	80		100	
UT	5	80	15		85	
VT	60	40	-		40	
VA/FHWA	15	70	15		85	
WA	33	33	33		66	
DC						
WV						
WI	7	90	3		93	
WY	44	41	15		56	

FOUNDATION ALTERNATIVE
Preferred type of deep foundation

STATE	Driven Pile	Drilled Shaft	Others		
AL					
AK					
AZ		*			
AR	*				
CA	*	*			
CO	*	*			
CT	*				
DE					
FL	*				
GA	*				
HI	*				
ID	*				
IL	*	*			
IN	*				
IA	*				
KS	*				
KY	*				
LA	*				
ME	*				
MD	*				
MA	*	*			
MI	*				
MN	*				
MS					
MO	*				
MT	*	*			
NE	*				
NV	*	*			
NH	*				
NJ	*				
NM					
NY	*				
NC	*	*			
ND	*				
OH	*	*			
OK	*				
OR	*				
PA	*				
RI					
SC	*	*			
SD	*	*			
TN	*				
TX	*	*			
UT	*				
VT	*	*			
VA/FHWA	*	*			
WA		*			
DC					
WV					
WI	*				
WY	*				

FOUNDATION ALTERNATIVE
Preferred type of driven pile

STATE	PSC Pile	Steel H Pile	Steel Pipe Pile/Open	Steel Pipe Pile/closed	Timber Pile	Others
AL						
AK						
AZ	6	1	3	2	6	
AR	1	2	6	3	4	
CA	1	3	2	4	6	
CO	6	1	3	2	6	
CT	4	1	3	2	5	
DE	1	4	6	2	3	
FL	1	4	2	3	6	
GA	1	2	4	3	5	
HI	1	6	6	6	6	
ID	6	1(85%)	6	2(15%)	6	
IL	6	2	6	1	6	
IN						
IA	2	1	6	6	3	
KS	3	1	4	2	6	
KY	2	1	6	6	6	
LA	1	3	2	4	5	
ME	4	1	3	2	6	
MD	5	1	2	3	4	
MA	5	1	3	2	4	
MI	6	1	6	2	3	
MN	5	2	3	1	4 (Ct. Brg.)	
MS						
MO	4	1	6	2	6	3(precast)
MT	6	2	1	4	5	3(monotube)
NE	2	1	4	3	6	
NV	3	2	6	1	6	
NH	4	1	2	3	5	
NJ	3	2	5	1	4	
NM						
NY	3	1	5	2	4	
NC	2	1	3	6	6	4(cyl. Pile)
ND	6	1	6	6	6	
OH	6	2	6	1	6	
OK	6	1	6	6	6	
OR	5	3	2	1	4	
PA	6	1	3	3	6	2(monotube)
RI						
SC	1	2	4	5	3	
SD	5	1	4	3	2	
TN	2	1	3	4	5	
TX	1	3	2	6	6	
UT	6	2	6	1	6	
VT	4	1	5	2	3	
VA/FHWA	2	1	4	3	5	
WA	5	2	3	1	4	
DC						
WV						
WI	6	2	6	1	3	
WY	6	1	6	6	6	

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Design method for static axial capacity

STATE	α	β	γ	Nordlund	Nottingham/CPT	Schmertmann/SPT	Meyerhof	Others
AL								
AK								
AZ	*	*		*				
AR	*			*				
CA	*			*(sand)				
CO	*			*				
CT				*				
DE	*			*				
FL						*		
GA				*		*		
HI				*(SPILE)		* (SPT89)		
ID	*			*				
IL								*(in-house)
IN								
IA								*(In-house)
KS	*	*		*				
KY	*	*		*				
LA	*				*			*(in-house)
ME	*			*			*(End-B)	*
MD				*				
MA	*		*	*				
MI	*			*				
MN				*				
MS								
MO				*				
MT	*	*		*	*		*	
NE				*			*	
NV	*	*	*	*				
NH	*			*				
NJ	*			*			*	*(DM-7)
NM								
NY	*	*		*				
NC								*(Vesic)
ND								*(in-house)
OH	*			*			*	
OK	*	*		*				
OR	*	*		*				
PA				*				
RI								
SC	*					*	*	
SD								*
TN	*	*		*				
TX								*(in-house)
UT								*(Fellenios)
VT	*	*		*				
VA/FHWA	*			*				
WA	*	*		*				*(LCPC-cpt)
DC								
WV								
WI	*			*				
WY				*				

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Development of computer program for static capacity analysis by:

STATE	IN-House	FHWA	Commercial	Others	
AL					
AK					
AZ		*			
AR		*			
CA	*				
CO		*	*		
CT		*			
DE		*			
FL	*				
GA		*			
HI		*			
ID		*	*		
IL	*				
IN					
IA	*				
KS		*			
KY				*	
LA	*	*			
ME	*	*			
MD		*			
MA		*	*		
MI	*				
MN		*			
MS					
MO		*			
MT		*	*		
NE		*			
NV		*	*		
NH		*			
NJ		*			
NM					
NY		*			
NC	*	*			
ND	*				
OH	*	*			
OK		*			
OR	*	*			
PA	*	*	*		
RI					
SC		*			
SD				*	
TN		*			
TX	*				
UT			*		
VT		*			
VA/FHWA		*	*		
WA	*	*	*		
DC					
WV					
WI		*			
WY	*	*			

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Dynamic formula or computer program to estimate pile capacity

STATE	ENR/F.S.	Gates/F.S.	GRLWEAP	Others	
AL					
AK					
AZ		*/3.0	*		
AR	*		*		
CA	*		*		
CO			*		
CT			*		
DE			*		
FL			*		
GA	*		*		
HI			*		
ID			*		
IL	*				
IN					
IA	*(County, City)		*		
KS			*		
KY	*		*		
LA	*	*/3.5	*		
ME			*		
MD	*				
MA		*/3.5	*		
MI	*		*		
MN	*(Modified)		*(Occasionally)		
MS					
MO	*				
MT	*		*		
NE	*(Modified)		*		
NV			*		
NH			*		
NJ			*		
NM					
NY			*		
NC			*		
ND	*(Modified)				
OH	*		*		
OK		*/2.0			
OR		*/3.0	*		
PA			*		
RI					
SC			*		
SD	*(Modified)				
TN	*				
TX	*		*		
UT			*		
VT			*		
VA/FHWA		*/2.5	*		
WA			*	*(In-house)	
DC					
WV					
WI	*				
WY	*	*/2.0	*		

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Primary parameters used in design and/or computer program

STATE	SPT-N	CPT	Pressuremeter	Dilatometer	C and ϕ	Others
AL						
AK						
AZ	*				*	
AR	*					
CA					*	
CO	*				*	
CT	*				*	
DE	*					
FL	*					
GA	*					
HI	*					
ID	*	*			*	
IL	*				*	
IN	*				*	
IA	*					
KS	*				*	
KY	*				*	
LA	*	*			*	
ME	*				*	
MD	*				*	
MA	*				*	
MI	*				*	
MN	*				*	
MS						
MO	*				*	
MT	*	*			*	
NE	*					
NV					*	
NH	*				*	
NJ	*				*	
NM						
NY					*	
NC	*				*	
ND	*				*	
OH	*	*			*	
OK	*	*		*		
OR	*				*	
PA	*				*	
RI						
SC	*				*	
SD	-					
TN	*				*	
TX						*(TX Cone)
UT	*				*	
VT	*				*	
VA/FHWA	*				*	
WA					*	
DC						
WV						
WI	*				*	
WY	*				*	

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Determination of friction angle (ϕ) and Cohesion (C)

STATE	Laboratory Testing	In-situ Testing
AL		
AK		
AZ	Direct Shear (DS)	-
AR	-	SPT
CA	UU	SPT, CPT
CO	-	SPT
CT	-	ϕ from gradation and relative density
DE	-	-
FL		SPT, CPT, DMT
GA	-	-
HI	Triaxial, Direct shear	
ID	Triaxial, Direct shear	SPT, CPT
IL		Field Remac compression test
IN	UU	-
IA	-	Loads test
KS	CIU, UU, DS	Vane shear, Iowa borehole shear
KY	Triaxial, qu	SPT
LA	Triaxial, qu	SPT
ME	Cu, UU, DS, Torevane, qu	SPT
MD	-	-
MA	Triaxial	SPT
MI	Transverse shear, qu	SPT
MN	UU	SPT
MS		
MO	DS, qu	SPT
MT	DS, qu	SPT
NE	-	SPT
NV	Triaxial, DS	
NH	-	SPT
NJ		SPT
NM		
NY	Triaxial	SPT
NC	*	*
ND	Triaxial, qu	-
OH	-	SPT
OK	DS	SPT
OR	CIU	SPT
PA	*	SPT
RI		
SC	Triaxial	SPT
SD	DS	-
TN	Triaxial, DS, qu	-
TX	Triaxial	-
UT	Triaxial, DS, qu	SPT, Vane shear
VT	Triaxial	Vane Shear
VA/FHWA	Triaxial, DS	-
WA	UU	SPT
DC		
WV		
WI	Triaxial, Ds, qu	-
WY	Triaxial, DS	SPT

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Assess the side friction coefficient

STATE	C_A for Cohesive Soil	δ for Cohesionless Soil	
AL			
AK			
AZ	DM-7	DM-7	
AR	FHWA	FHWA	
CA	αSu	DM-7	
CO	Su	ϕ	
CT	Published data		
DE	-	-	
FL	Empirical	Empirical	
GA	Triaxial	SPT	
HI	-	-	
ID	Tomlinson	Nordland	
IL	*		
IN	Tomlinson	Nordland	
IA		Load test	
KS	DM-7	DM-7	
KY	Tomlinson		
LA	-	-	
ME	Tomlinson	Nordland	
MD	-	-	
MA	-	-	
MI	In-House	DM-7	
MN	Tomlinson	Nordland	
MS			
MO	-	-	
MT	Tomlinson	Nordland	
NE	Lab test	SPT	
NV	Tomlinson	Nordland	
NH	Tomlinson	Nordland	
NJ	DM-7	DM-7	
NM			
NY	Tomlinson	Nordland	
NC	-	-	
ND	-	-	
OH	SPT	SPT	
OK	-	-	
OR	Tomlinson	Nordland	
PA	-	-	
RI			
SC	αSu	Meyerhof	
SD	-	-	
TN	αSu	SPT/FHWA	
TX	C, ϕ	ϕ	
UT	Shear test	Shear test	
VT	Tomlinson	Nordland	
VA/FHWA	-	-	
WA	Bowles	Nordland	
DC			
WV			
WI	αSu	SPT	
WY	FHWA	FHWA	

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Methodology currently being used for geotechnical and Structure design

STATE	ASD	LFD	LRFD	Others	
AL					
AK					
AZ	*	*			
AR	*	*			
CA	*				
CO	*	*	*		
CT	*		*		
DE			*		
FL	*	*	*		
GA	*				
HI	*				
ID	*		*		
IL	*				
IN	*				
IA	*				
KS	*		*		
KY	*	*			
LA	*				
ME	*				
MD	*				
MA	*	*	*		
MI		*			
MN	*	*	*		
MS					
MO	*	*			
MT	*				
NE	*				
NV	*				
NH	*	*			
NJ	*		*		
NM					
NY	*				
NC	*				
ND	*				
OH	*				
OK	*		*		
OR	*	*	*		
PA		*	*		
RI					
SC	*				
SD	*				
TN	*	*			
TX	*	*			
UT	*				
VT	*				
VA/FHWA	*				
WA	*	*	*		
DC					
WV					
WI	*	*			
WY	*	*			

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Apply partial safety factor for side friction and end bearing on allowable pile capacity

STATE	No/ Global F.S.	Yes/Side friction/End Bearing
AL		
AK		
AZ		2.0 / 3.0
AR	3.0	
CA	2.0	
CO	3.0	
CT	2.0 w/ Load test	
DE	-	-
FL	2.0	
GA	3.0	
HI	3.0	
ID	3.0	
IL	3.0	
IN	2.5	
IA	2.2	
KS	3.0	
KY	*	
LA	2.0 w/Load test, 3.0	
ME	3.0, 2.25 w/PDA	
MD	2.0 – 3.5 per AASHTO	
MA	3.5, 2.75 w/WEAP, 2.25 w/PDA	
MI	2.0	
MN	3.0	
MS		
MO	3.5	
MT	2.0 – 3.0	
NE	2.0	
NV	3.0 for clay, 2.5 for sand	
NH	1.9 to 2.75	
NJ	2 to 2.75	
NM		
NY	2.0	
NC	2.0	
ND	*	
OH	2.0	
OK	3.0	
OR	2.5 – 3.0	
PA	-	
RI		
SC	3.0, 2.5 w/PDA, 2.0 w/Load test	
SD	-	
TN	2.0	
TX	2.0	
UT	2.25 w/CAPWAP	
VT	2.0 – 3.0	
VA/FHWA	*	
WA	2.5	
DC		
WV		
WI	2.0	
WY		1.5 / 3.0

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Consider pile settlement in design

STATE	No	Yes/Tolerable settlement	
AL			
AK			
AZ		0.75"	
AR	*		
CA	*		
CO	*		
CT		0.25"	
DE	*		
FL		1.0"	
GA	*		
HI	*		
ID	*		
IL	*		
IN		0.75"	
IA	*		
KS	*		
KY		0.5"	
LA	*		
ME		1.0"	
MD	-		
MA		Structure / soil dependent	
MI	*		
MN	*		
MS			
MO	*		
MT		Project depend	
NE	*		
NV		1.0"	
NH		*	
NJ		0.5"	
NM			
NY		<2.0"	
NC		*	
ND	*		
OH		0.5"	
OK		0.5"	
OR		Project dependent, typically <1.0"	
PA	*		
RI			
SC	*		
SD	*		
TN		0.25"	
TX	*		
UT		25 mm	
VT		1.0"	
VA/FHWA		1.0"	
WA		25 mm	
DC			
WV			
WI	*		
WY	*		

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Design method in lateral load analysis and/or program

STATE	Simply Method (Broms)	p-y Curve Method	Others
AL			
AK			
AZ	*	*	
AR		*	
CA		*	
CO	*	*	
CT		*	
DE		*	
FL		*	
GA		*	
HI		*	
ID	*	*	
IL		*	
IN		*	
IA		* (but seldom check)	
KS		*	
KY	*		
LA		*	
ME		*	*
MD		*	
MA	*	*	
MI	*	*	
MN		*	
MS			
MO		*	
MT		*	
NE		*	
NV		*	*
NH		*	
NJ	*	*	
NM			
NY	*	*	
NC		*	
ND	*		
OH		*	
OK	*	*	
OR	* (No seismic)	* (Seidmic)	
PA		*	
RI			
SC		*	
SD	-	-	
TN	*	*	
TX		*	
UT		*	
VT	*	*	
VA/FHWA	*		
WA		*	
DC			
WV			
WI	*		
WY		*	

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Development of computer programs for lateral load analysis

STATE	In-House	FHWA	Commercial	Others	
AL					
AK					
AZ		*			
AR		*	*		
CA	*	*	*		
CO	*	*	*		
CT		*			
DE		*			
FL	*				
GA		*	*		
HI		*			
ID		*	*		
IL		*	*		
IN		*			
IA		*			
KS		*			
KY			*		
LA		*			
ME		*	*		
MD		*			
MA		*	*		
MI	*	*			
MN			*		
MS					
MO		*			
MT		*	*		
NE		*			
NV		*	*		
NH				-	
NJ		*	*		
NM		*	*		
NY		*	*	*	
NC		*	*		
ND				-	
OH		*	*		
OK		*	*		
OR		*	*		
PA		*	*		
RI					
SC		*	*		
SD				-	
TN		*			
TX		*			
UT			*		
VT				*	
VA/FHWA		*			
WA		*	*		
DC					
WV					
WI		*			
WY			*		

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Control factors of pile design subjected to lateral load

STATE	Lateral Deflection/Tolerate Deflection	Lateral Capacity/Method used/Safety factor
AL		
AK		
AZ	1.0”	3.0
AR	0.25”	
CA	Varies 2.0 to 6.0”	
CO	Varies	Varies
CT	Structure dependent	
DE	*	*
FL	2..0”	
GA	*	
HI	*	
ID	0.25”	
IL	*	*
IN	Typically not check	
IA	-	
KS	0.5”	
KY	0.5”	
LA	-	
ME	1.0”	
MD	-	
MA	Project dependent, usually 1.0”	1.5
MI	*	
MN	Determined by Structural Engineer	
MS		
MO		2.5
MT	Structure dependent, usually <50 mm	
NE	*	
NV	1.0”	
NH	Structure dependent	
NJ	0.5”	
NM		
NY	1.0”	
NC	1.0”	
ND		*
OH	Project dependent	
OK	-	
OR	Varies, usually <1.0”	
PA	0.5”	2.5
RI		
SC	2.0 at free head condition	
SD	-	
TN		2.0
TX	0.5”	
UT	Up to stress limit	
VT	0.5”	
VA/FHWA	0.5”	
WA	Structure dependent	Varies w/ load case
DC		
WV		
WI	Project dependent	
WY	2.0”	

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Consideration of downdrag force in design

STATE	No	Yes/Methodology	
AL			
AK			
AZ		* FHWA	
AR	*		
CA		* (Sometimes)	
CO		* Effective Stress	
CT		* α method, 50% reduction w/bitumen coating	
DE		*	
FL		*	
GA		*	
HI		* PILENEG	
ID		* α method	
IL		*	
IN			
IA		*	
KS		* FHWA, DM-7, Poulos & Daves	
KY		* DM-7	
LA	*		
ME		* β method per Sanford (1998)	
MD	*		
MA		* FHWA	
MI	*		
MN		* Neutral Plane method	
MS			
MO	*		
MT		* α Method	
NE		*	
NV		* α method	
NH		*	
NJ		* DM-7	
NM			
NY		* DM-7	
NC		*	
ND		*	
OH		*	
OK	*		
OR		α method	
PA	*		
RI			
SC		* α method	
SD	*		
TN	*		
TX	*		
UT		* Fellenios	
VT		*	
VA/FHWA		*	
WA		*	
DC			
WV			
WI		* FHWA	
WY	*		

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Consideration of construction method in design

STATE	No	Yes		
AL				
AK				
AZ		*		
AR		*		
CA	*			
CO		*		
CT	*			
DE		*		
FL		*		
GA	*			
HI		*		
ID	*			
IL	*			
IN				
IA		*		
KS	*			
KY	*			
LA		*		
ME	*			
MD	*			
MA		*		
MI		*		
MN	*			
MS				
MO		*		
MT	*			
NE		*		
NV		*		
NH		*		
NJ		*		
NM				
NY		*		
NC		*		
ND	*			
OH	*			
OK	*			
OR		*		
PA	*			
RI				
SC		*		
SD	*			
TN	*			
TX	*			
UT		*		
VT	*			
VA/FHWA		*		
WA		*		
DC				
WV				
WI	*			
WY	*			

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION
Estimated risk or failure probability based on the safety factor used

STATE	<0.1%	0.1 to 1%	1 to 10 %	>10%	Unknown	Acceptable %`
AL						
AK						
AZ					*	0.1
AR					*	~0
CA					*	-
CO	*					1.0
CT					*	-
DE	*					-
FL					*	1.0
GA					*	1.0
HI					*	~0
ID					*	-
IL	*					0.1
IN						
IA					*	-
KS	*					~0
KY			*			-
LA					*	-
ME					*	-
MD					*	-
MA					*	1.0
MI		*				-
MN					*	-
MS						
MO					*	-
MT					*	-
NE					*	0.1
NV					*	-
NH					*	-
NJ					*	-
NM						
NY					*	-
NC					*	-
ND					*	-
OH	*					-
OK	*					0.1
OR	*					-
PA	*					-
RI						
SC					*	-
SD	*					-
TN	*					0.1
TX	*					-
UT	*				*	0.1
VT					*	1.0
VA/FHWA					*	-
WA		*				0.5
DC						
WV						
WI					*	-
WY					*	-

DRIVEN PILE ALTERNATIVE/DESIGN CONSIDERATION

Experience on pile design failure

STATE	No	Yes	
AL			
AK			
AZ	*		
AR	*		
CA	*		
CO		* Scour in super flood	
CT	*		
DE	*		
FL	*		
GA	*		
HI	*		
ID	*		
IL	*		
IN	*		
IA		* Failure due to scour, landslide	
KS		* Consultant Strikes	
KY	*		
LA		*Test pile was design to plunge as close to 2X design load	
ME	*		
MD	*		
MA	*		
MI		* Extract sheet pile causing excessive pile settlement	
MN	*		
MS			
MO	*		
MT	*		
NE	*		
NV	*		
NH	*		
NJ	*		
NM			
NY	*		
NC		*	
ND	*		
OH	*		
OK	*		
OR	*		
PA	*		
RI			
SC	*		
SD	*		
TN	*		
TX	*		
UT	*		
VT	*		
VA/FHWA	*		
WA	*		
DC			
WV			
WI	*		
WY	*		

<u>**DRIVEN PILE ALTERNATIVE/CONSTRUCTION CONSIDERATION**</u>

Perform static load test during construction and type of test

STATE	No	Yes/Criteria to justify	Type of Test
AL			
AK			
AZ	*		
AR	*		
CA		* Ptroject dependent, not meeting ENR blow count	Quick
CO		* Potential cost saving and difficult to predict	-
CT		* High end bearing pile (12ksi), most friction pile	Varies
DE		* More than 100 piles, unusual soil condition	Quick
FL		* Cost saving, unusual soil condition, high capacity design	Quick
GA		* Cost saving from using low Safet factor	Quick
HI		*Project dependent	Quick
ID	*	(Barely)	
IL		* Major project	Slow
IN			
IA		*Unusual soil condition, major structure but not now	Quick
KS		* Unusual soil condition, pile type	Quick
KY		*	Texas Quick
LA		* Cost saving, inadequate soil information	Quick
ME	*		
MD		* Project dependent	Quick/Slow
MA		* Cost saving, major project	Quick
MI		* Major project, high capacity	Slow
MN	*		
MS			
MO		*Major project, cost saving	Slow
MT		*New construction method (occasion), high capacity	Texas Quick
NE	*		
NV		* Cost saving	Quick
NH		*Generally for friction pile only	Quick
NJ		*Project dependent	Quick
NM			
NY		* Confirm Design, unknown soil condition	Quick
NC		* Project dependent	Quick
ND		* Cost saving	-
OH		* Pile over 45 tons, more 10,000 feet pile	Quick
OK	*		
OR	*		
PA		* (Sometimes)	Quick
RI			
SC		*	Texas Quick
SD	*		
TN		*	-
TX		* Major project more than 100,000 feet pile	Quick to fail
UT		*Cost saving	Quick
VT		*Large no. of friction piles	Quick
VA/FHWA		*	Quick
WA		*	Quick
DC			
WV			
WI	*		-
WY		*	Quick

DRIVEN PILE ALTERNATIVE/CONSTRUCTION CONSIDERATION

Perform dynamic pile load test during construction

STATE	No	Yes/Criteria to justify	Yes/% of Pile per bridge
AL			
AK			
AZ		*	10% or mini. 2 / bridge
AR		*Relatively high capacity	1%
CA		* Hard or problem driving	
CO		* Friction pile, soft shal	1% to 5%
CT	*		
DE		*	1 / substructure unit
FL		*	On test pile, mini. 2 /bridge
GA		*	5%
HI		*	On test pile
ID		* Major structure	<5%
IL		*Major or special project	Very small %
IN		* On large project w/ ult.>240 tons	2%
IA		*Problem conditions	<2%
KS		*	
KY		* Critical bridge	10%
LA		* For driving criteria	On test pile
ME		*Cost saving from low safety factor	5% to 20%
MD	*		
MA		*QC	5% to 10%
MI		*	1 or 2 / bridge
MN		* On large project	5 %to 10%
MS			
MO		* On large project	1%
MT		* Occasion used w/ static load test	-
NE		* Major project, or not meeting ENR blow count	1 / substructure
NV	*		
NH		*	On test pile
NJ		*	On test pile
NM			
NY		*	2%
NC		*	1*
ND	*		
OH		* More than 1,500 feet piles	1 / Bridge
OK		*	-
OR		* More than 100 tons design load	-
PA		*	<10%
RI			
SC		*	<5%
SD	*		
TN	*		
TX	*		
UT		*	
VT		*	1/ substructure unit
VA/FHWA		*	1 to 2 / bridge
WA		*	<5% or 1 / bridge
DC			
WV			
WI		*	
WY		* Friction pile	10%

DRIVEN PILE ALTERNATIVE/CONSTRUCTION CONSIDERATION
Type of instrument used in dynamic pile load test

STATE	PDA/GRL	Others			
AL					
AK					
AZ	*				
AR	*				
CA	*				
CO	*				
CT	*				
DE	*				
FL	*				
GA	*				
HI	*				
ID	*				
IL	*				
IN	*				
IA	*				
KS	*				
KY	*				
LA	*				
ME	*				
MD			No		
MA	*				
MI	*				
MN	*				
MS					
MO	*				
MT	*				
NE	*				
NV			No		
NH	*				
NJ	*				
NM	*				
NY	*				
NC	*				
ND			No		
OH	*				
OK	*				
OR	*				
PA	*				
RI					
SC	*				
SD			No		
TN			No		
TX			No		
UT	*				
VT	*				
VA/FHWA	*				
WA	*				
DC					
WV					
WI	*				
WY	*				

<u>**DRIVEN PILE ALTERNATIVE/CONSTRUCTION CONSIDERATION**</u>

Driving condition used to set driving criteria and production pile length

STATE	EOD	BOR	Others		
AL					
AK					
AZ	*				
AR	*				
CA		*			
CO	*	*			
CT	* (end bearing)				
DE		*			
FL	*	*			
GA	*				
HI	*				
ID	*	* (if expected)			
IL	*				
IN	*				
IA	*	*			
KS	*				
KY	*	*			
LA	*	*			
ME		*			
MD					
MA	*	*			
MI	*				
MN	*	* (occasionally)			
MS					
MO	*	*			
MT	*	*			
NE	*	*			
NV	*				
NH	* (end bearing)	* (friction)			
NJ	*				
NM					
NY		*			
NC	*				
ND	*				
OH	*				
OK	*				
OR	*	*(In cohesive soil)			
PA	*				
RI					
SC	*	*			
SD	*				
TN	*				
TX		*			
UT		*			
VT		*			
VA/FHWA	*	*			
WA	*	*			
DC					
WV					
WI	*				
WY	*				

DRIVEN PILE ALTERNATIVE/CONSTRUCTION CONSIDERATION

Consideration of pile freeze or relaxation in setting driving criteria

STATE	No	Yes	
AL			
AK			
AZ	*		
AR	*		
CA		*	
CO		*	
CT		* Based on experience, load test may delay for one week or more	
DE		*	
FL		*	
GA		* In loose/soft soils to avoid excessive pile length	
HI		* Project dependent	
ID	*		
IL	*		
IN		*	
IA	*		
KS		* Experience	
KY	*		
LA		*	
ME		* Relaxation	
MD	-		
MA		* Restrike after 2 to 7 days	
MI		* Specify restrike in some soil profiles	
MN	*	(In some cases)	
MS			
MO	*		
MT	*		
NE		* Experience	
NV	*		
NH		*	
NJ		*	
NM			
NY		*	
NC		*	
ND	*		
OH		*	
OK	*		
OR		*	
PA		*	
RI			
SC		*	
SD	*		
TN	*		
TX	*		
UT		*	
VT	*		
VA/FHWA		*	
WA		*	
DC			
WV			
WI		*	
WY		*	

DYNAMIC FORMULA OR COMPUTER PROGRAM TO ESTIMATE PILE CAPACITY