LRFD Facts and Misconceptions: Opportunities and Challenges for the Micropile Community

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By

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- Pin Ball Machine Repairman – 1 yr
- Country Club Maintenance Foreman – 5 yrs
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- Father – 32 yrs
- Civil Engineer (Geotechnical Specialist)-37 yrs
- Husband – 41 yrs
- Retired Principal Bridge Eng., Geotechnical National Program Manager FHWA, Washington D.C. (September 2008)
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LRFD Micropile Community Issues/ Topics

- Brief History of AASHTO Specifications and Evolution of LRFD
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- Available LRFD Resources and training (professional and academic institutions)
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OTHERS? ***

$$\Sigma \eta_i \gamma_i Q_i \leq R_r = \phi R_n$$

η_i	=	Load modifier (eta)
γ_i	=	Load factor (gamma)
Q_i	=	Force effect
R_r	=	Factored resistance
ϕ	=	Resistance factor (phi)
R_n	=	Nominal resistance

Webinar References

- Primary References:
  - AASHTO (2010) – 5th Edition
    - Section 10 – Foundations
    - Sections 3 – Loads and Load Factors
  - FHWA (2006) "Soils and Foundations" 2 volumes (1,056 pages; Free download at) www.ncsconsultants.com
  - The micropile design process is discussed in detail in *Micropile Design and Construction* (*Sabatini*, *et al.*, *2005*). List of info sources provided at end

Legend:
AASHTO: American Association of State Highway and Transportation Officials
FHWA: Federal Highway Administration

AASHTO - Section 10 Outline

Article	Topic	Webinar #
10.1	**Scope**	
10.2	**Definitions**	
10.3	**Notation**	
✔ 10.4	**Soil Properties and Materials**	3
✔ 10.5	**Limit States and Resistance Factors**	5, 6, **7**, 8, 9, 10, 11
10.6	**Spread Footings**	4
10.7	**Driven Piles**	5
10.8	**Drilled Shafts**	6
✔ 10.9	**Micropiles**	**7**
✔ **Refer to Section 3 for Loads and Load Factors**		1-2

Micropile Foundations

Topic	Slides
General (Section 3, Section 10.4, 10.9.1)	6 – 28
10.5 Limit States and Resistance Factors	29 – 33
10.9.2 Service Limit State	34 – 40
10.9.3 Strength Limit State	41 – 73
10.9.4 Extreme Event Limit State	74 – 77
10.9.5 Corrosion and Deterioration	78 – 81

The sequence of Article 10.9 in AASHTO

AASHTO Table 3.4.1-1

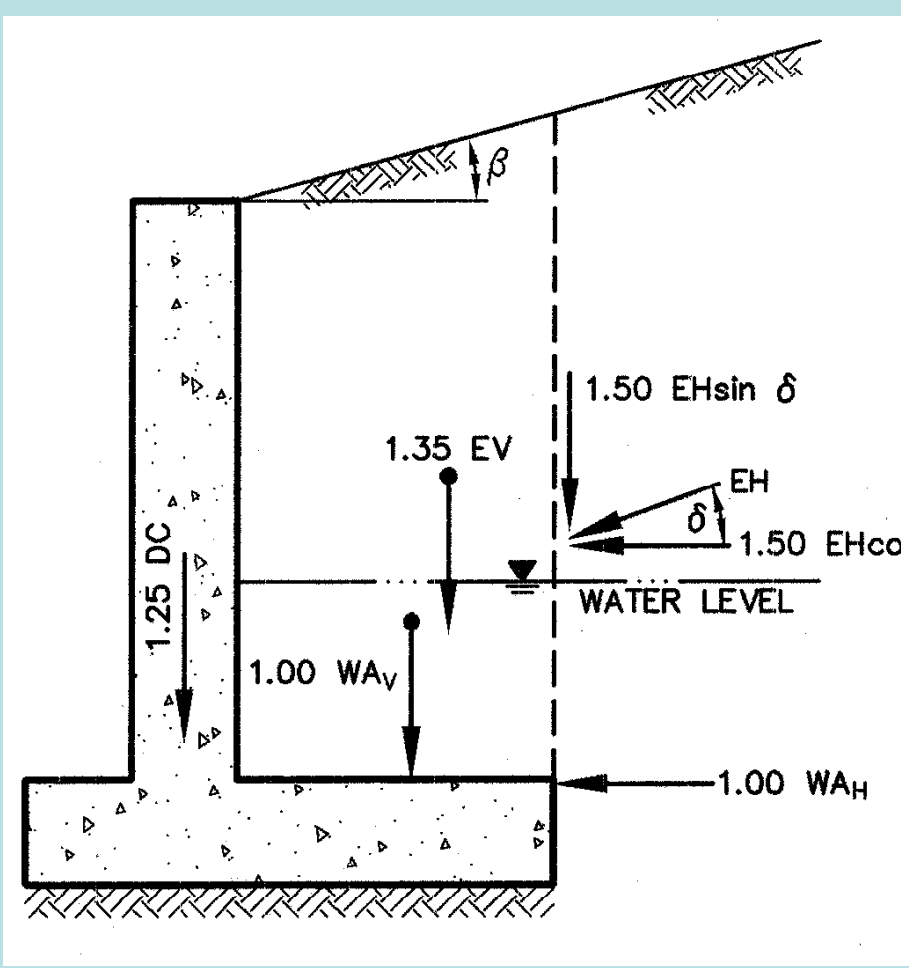
Load Combination Limit State		*DC* *DD* *DW* *EH* *EV* *ES* *EL* *PS* *CR* *SH*	*LL* *IM* *CE* *BR* *PL* *LS*	*WA*	*WS*	*WL*	*FR*	*TU*	*TG*	*SE*	Use One of These at a Time			
											EQ	*IC*	*CT*	*CV*
STRENGTH LIMIT	**I**	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
	II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
	III	γ_p	—	1.00	1.40	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
	IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—
	V	γ_p	1.35	1.00	0.40	1.0	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—
EXTREME EVENT	**I**	γ_p	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—
	II	γ_p	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00
SERVICE LIMIT	**I**	1.00	1.00	1.00	0.30	1.0	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—
	II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—
	III	1.00	0.80	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—
	IV	1.00	—	1.00	0.70	—	1.00	1.00/1.20	—	1.0	—	—	—	—
FATIGUE - *LL*, *IM* & *CE* only	**I**	—	1.50	—	—	—	—	—	—	—	—	—	—	—
	II	—	0.75	—	—	—	—	—	—	—	—	—	—	—

Load Factors for Permanent Loads, γ_p

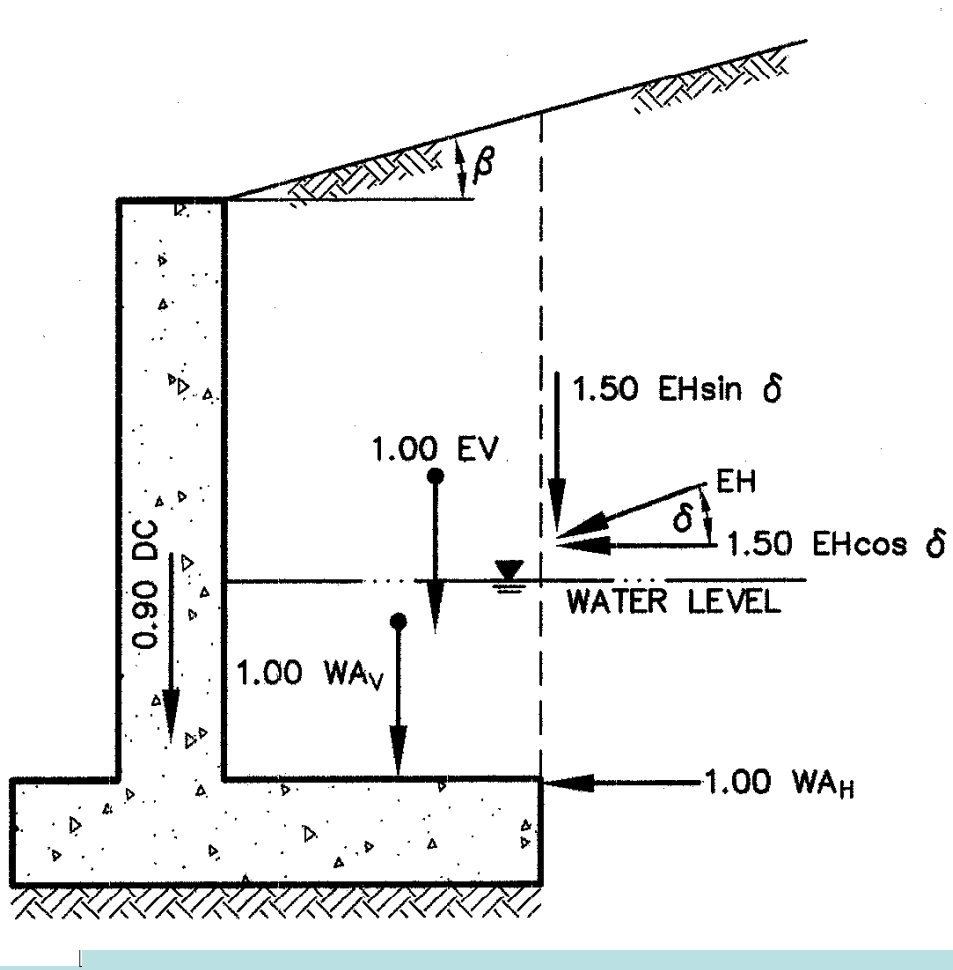
AASHTO Table 3.4.1-2

Type of Load, Foundation Type, and Method Used to Calculate Downdrag		Load Factor Maximum	Load Factor Minimum
DC: Component and Attachments		1.25	0.90
DC: Strength IV only		1.50	0.90
DD: Downdrag	Piles, α Tomlinson Method	1.4	0.25
	Piles, λ Method	1.05	0.30
	Drilled shafts, O'Neill and Reese (1999) Method	1.25	0.35
DW: Wearing Surfaces and Utilities		1.50	0.65
EH: Horizontal Earth Pressure			
• Active		1.50	0.90
• At-Rest		1.35	0.90
• *AEP* for anchored walls		1.35	N/A
EL: Locked-in Construction Stresses		1.00	1.00
EV: Vertical Earth Pressure			
• Overall Stability		1.00	N/A
• Retaining Walls and Abutments		1.35	1.00
• Rigid Buried Structure		1.30	0.90
• Rigid Frames		1.35	0.90
• Flexible Buried Structures other than Metal Box Culverts		1.95	0.90
• Flexible Metal Box Culverts and Structural Plate Culverts with Deep Corrugations		1.50	0.90
ES: Earth Surcharge		1.50	0.75

Figure C11.5.5-1, 2—Typical Application of Load Factors



Bearing



Sliding and Eccentricity

AASHTO Section 10.4
Soil and Rock Properties

4.1 Informational Needs

4.2 Subsurface Exploration

4.3 Laboratory Tests

4.4 In-situ Tests

4.5 Geophysical Tests

4.6 Selection of Design Properties

Table 10.5.5.2.5-1 Geotechnical Resistance Factors of Axially Loaded Micropiles

Limit State	Method/ Ground Condition	Resistance Factor
Compression Resistance of Single Micropile, ϕ_{stat}	Side Resistance (Bond Resistance): Presumptive Values	0.55(1)
	Tip Resistance on Rock O'Neill and Reese (1999)	0.50
	Side Resistance and Tip Resistance Load Test	Values in Table 10.5.5.2.3-1, but no greater than 0.70
Block Failure, ϕ_{bl}	Clay	0.60
Uplift Resistance of Single Micropile, ϕ_{up}	Presumptive Values	0.55(1)
	Tension Load Test	Values in Table 10.5.5.2.3-1, but no greater than 0.70
Group Uplift Resistance, ϕ_{g}	Sand & Clay	0.50

(1) Apply to presumptive grout-to-ground bond values for preliminary design only in Article C10.9.3.5.2.

Table 10.5.5.2.5-2
Structural Resistance Factors for Axially Loaded Micropiles

Section / Loading Condition		Resistance Factor
Pile Cased Length	Tension, φ_{TC}	0.80
	Compression, φ_{CC}	0.75
Pile Uncased Length	Tension, φ_{TU}	0.80
	Compression, φ_{CU}	0.75

10.7.3.13 Pile Structural Resistance

Concrete (5.5.4.2.1)

Axial Comp. = 0.75

Flexure = 0.9

Shear = 0.9

Steel (6.5.4.2)

Axial = 0.5-0.6

Combined

Axial= 0.7-0.8

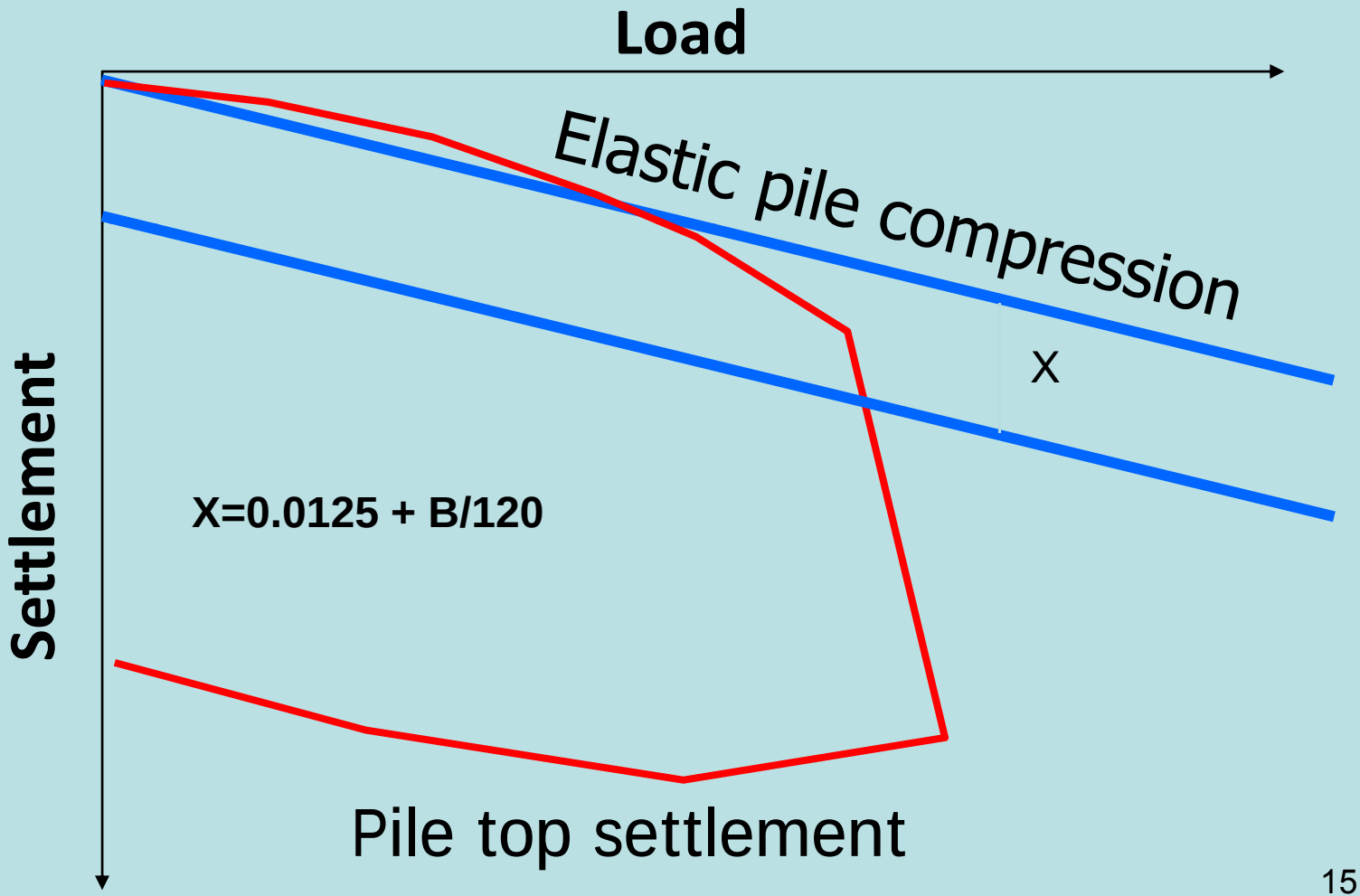
Flexure = 1.0

Shear = 1.0

Steel
Article 6.9.4.1 for noncomposite piles and
Article 6.9.5.1 for composite piles
Concrete
Articles 5.7.4.3 and 4.5.3.2

Potential for buckling should be as in Article 10.7.3.12.

Static Load Test: Failure Definition



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SHRP2

STRATEGIC HIGHWAY RESEARCH PROGRAM

Accelerating solutions for highway safety, renewal, reliability, and capacity

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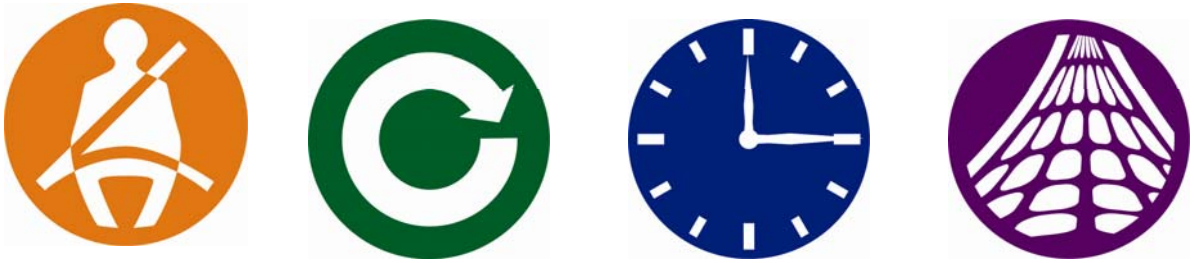

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SINCE THE 1500's THE NAME and FAMILY DIMAGGIO HAS REPRESENTED THE VERY BEST IN COFFEE, BASEBALL AND GEOENGINEERING AND GEO-CONSTRUCTION EXCELLENCE!

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THANK YOU!

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