

799531
799530

Practical Guidelines for the **SELECTION, DESIGN** **and INSTALLATION of** **PILES**

Prepared by the
Committee on Deep Foundations
of the ASCE Geotechnical Engineering Division



Published by the
American Society of Civil Engineers
345 East 47th Street
New York, New York 10017-2398



CONTENTS

Foreword

<u>Chapter 1 - Introduction</u>	<u>Page</u>
1.1 Purpose and Scope	1
1.2 Interrelationships in Pile Engineering and Construction. .	1
1.3 Organizational and Financial Aspects	2
<u>Chapter 2 - Pile Types</u>	
2.1 General	5
2.2 Timber Piles	5
2.3 Steel Piles	7
2.3.1 Steel H-piles	7
2.3.2 Pipe Piles	7
2.3.3 Other Steel Piles	8
2.4 Concrete Piles	8
2.4.1 Precast Concrete Piles	8
2.4.1.1 Reinforced Precast Concrete Piles	9
2.4.1.2 Prestressed Concrete Piles	9
2.4.1.2.1 Pretensioned Concrete Piles	10
2.4.1.2.2 Post-Tensioned Concrete Piles	11
2.4.2 Cast-in-Place Concrete Piles	11
2.4.2.1 Uncased Cast-in-Place Concrete Piles	13
2.4.2.1.1 Cast-in-Situ Piles	13

Contents (Cont'd)	<u>Page</u>
2.4.2.1.2 Drilled Hole Piles	14
2.4.2.1.3 Auger-Placed Grout Piles	17
2.4.2.1.4 Pressure Injected Footings	19
2.4.2.2 Cased Cast-in-Place Concrete Piles	21
2.4.2.2.1 Cased Driven Shell Piles	21
2.4.2.2.2 Cased Dropped-in-Shell Piles	23
2.4.2.2.3 Drilled-in Caissons	23
2.4.3 Enlarged Base Piles	23
2.4.4 Composite Piles	24
<u>Chapter 3 - Design Considerations</u>	
3.1 General	25
3.2 Preliminary Design	25
3.3 Foundation Investigation	26
3.4 Analysis	27
3.4.1 Lateral Behavior	31
3.4.2 Group Action	32
3.4.3 Dynamic Loading	33
3.4.4 Geometric Effects.	34
3.4.4.1 Spacing	34
3.4.4.2 Axial Alignment	34
3.4.4.3 Pile Butt Location	35
3.5 Final Design	36
3.6 Design Verification	36
3.7 Factors of Safety	36

	<u>Page</u>
Contents (Cont'd)	
<u>Chapter 4 - Installation</u>	
4.1 General	37
4.2 Installation Equipment	37
4.2.1 Pile Driving Hammers	37
4.2.1.1 Drop Hammer	37
4.2.1.2 Single Acting Hammer	38
4.2.1.3 Double Acting Hammer	38
4.2.1.4 Differential Hammer	38
4.2.1.5 Diesel Hammer	40
4.2.1.6 Vibratory Drivers	44
4.2.1.7 Other Types of Hammers	44
4.2.2 Hammer Cushions	45
4.2.3 Drive Head	46
4.2.4 Pile Cushions	46
4.2.5 Follower	46
4.2.6 Mandrel	48
4.2.7 Leaders	48
4.2.8 Spotter	48
4.2.9 Moonbeam	48
4.3 Pile Installation	49
4.3.1 General	49
4.3.2 Handling and Storage of Piles	49

Contents (Cont'd)		<u>Page</u>
4.3.3	Selection of Hammer	49
4.3.4	Driving Piles	49
4.3.5	Drilling Piles	51
4.3.6	Vibratory Driving	51
4.3.7	Jacking Piles	51
4.3.8	Direct Weight	51
4.4	Spudding	52
4.5	Pre-excavation	52
4.5.1	General	52
4.5.2	Prejetting	52
4.5.3	Predrilling	52
4.5.4	Dry Tube Pre-excavation	53
4.6	Jetting While Driving	53
4.7	Concrete Placement	54
4.8	Effect of Pile Driving Vibrations on Fresh Concrete . . .	54
4.9	Precautions During Pile Installation	55
4.9.1	General	55
4.9.2	Timber Piles	55
4.9.3	Steel H-Piles	55
4.9.4	Precast Concrete Piles	56
4.9.5	Cast-in-Situ piles	57
4.9.6	Drilled Hole Piles	58
4.9.7	Auger-Placed Grout Piles	59

	Page
Contents (Cont'd)	
4.9.8 Pressure Injected Footings	60
4.9.9 Cased Driven Shell Piles	61
4.9.10 Mandrel Driven Shell Piles	61
4.9.11 Drilled-in Caissons	61
4.9.12 Enlarged Base Piles	62
4.9.13 Splicing Piles	62
4.10 General Pile Installation Problems	63
4.10.1 Obstructions	63
4.10.2 Heave	63
4.10.3 Ground Pressures	64
4.10.4 Ground Compaction	64
4.10.5 Ground Water	65
4.10.6 Pile Misalignment	65
4.10.7 Pile Butt Mislocation	66
4.10.8 Soil Freeze	67
4.10.9 Soil Relaxation	67
4.10.10 Unstable Soils	68
4.10.11 Unsound Rock	68
4.10.12 Installing Piles Through Overburden	69
4.10.13 Adjacent Construction Activity	70
4.10.14 Adjacent Structures	70
<u>Chapter 5 - Construction Control</u>	
5.1 Supervision	71

Contents (Cont'd)	<u>Page</u>
5.2 Inspection	71
5.2.1 General	71
5.2.2 Pile Installation Equipment	72
5.2.3 Pile Material	72
5.2.3.1 Timber Piles	72
5.2.3.2 Precast Concrete Piles	73
5.2.3.3 Pile Shells	74
5.2.3.4 Steel H-Piles, Pipe Piles and Thick-Walled Shells.	74
5.2.3.5 Reinforcing Steel	75
5.2.3.6 Prestressing Steel	75
5.2.3.7 Concrete and Grout	76
5.2.4 Pile Installation	76
5.2.4.1 General	76
5.2.4.2 Timber Piles	78
5.2.4.3 Steel Piles	79
5.2.4.4 Precast Concrete Piles	79
5.2.4.5 Cast-in-Situ Piles	79
5.2.4.6 Drilled Hole Piles	80
5.2.4.7 Auger-Placed Grout Piles	81
5.2.4.8 Pressure Injected Footings	82
5.2.4.9 Concrete Filled Shell and Pipe Piles	83
5.2.4.10 Drilled-in Caissons	83

	<u>Page</u>
Contents (Cont'd)	
5.2.4.11 Enlarged Base Piles	83
5.2.5 Vibratory Driving	84
5.2.6 Pile Load Testing	84
5.2.7 Integrity Testing	86
5.2.8 Inspection Records and Reports	87
Appendix -- References	91

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
2.1	Typical Timber Pile	6
2.2	Typical Design of a Pretensioned Concrete Pile	12
2.3	Drilled Hole Pile Constructed by Slurry Displacement (Ref. 143)	15
2.4	Conical Underreaming Tool	16
2.5	Installation of Auger-Placed Grout Pile (Courtesy Lee Turzillo Contracting Co.)	18
2.6	Pressure Injected Footing (Courtesy Stone and Webster Engineering Corporation)	20
2.7	Mandrel Driven Shell Pile (Courtesy Raymond International Builders, Inc.)	22
4.1	Single Acting Hammer	39
4.2	Air/Steam Differential Hammer (Courtesy Raymond International Builders, Inc.)	41
4.3	Hydraulic Hammer (Courtesy Raymond International Builders, Inc.)	42
4.4	Closed-Top Diesel Hammer (Courtesy Stone and Webster Engineering Corporation)	43
4.5	Hammer Cushion/Drive Head/Pile Cushion System	47
4.6	Pile Driving System (Courtesy Raymond International Builders, Inc.)	49
5.1	Pile Load Test Arrangement	85