

this document downloaded from

vulcanhammer.info

the website about
Vulcan Iron Works
Inc. and the pile
driving equipment it
manufactured

Visit our companion site
<http://www.vulcanhammer.org>

Terms and Conditions of Use:

All of the information, data and computer software ("information") presented on this web site is for general information only. While every effort will be made to insure its accuracy, this information should not be used or relied on for any specific application without independent, competent professional examination and verification of its accuracy, suitability and applicability by a licensed professional. Anyone making use of this information does so at his or her own risk and assumes any and all liability resulting from such use. The entire risk as to quality or usability of the information contained within is with the reader. In no event will this web page or webmaster be held liable, nor does this web page or its webmaster provide insurance against liability, for any damages including lost profits, lost savings or any other incidental or consequential damages arising from the use or inability to use the information contained within.

This site is not an official site of Prentice-Hall, Pile Buck, or Vulcan Foundation Equipment. All references to sources of software, equipment, parts, service or repairs do not constitute an endorsement.

"DEEP FOUNDATIONS - SPECIFICATIONS"

FOR

PRESENTATION AT

UNIVERSITY OF WISCONSIN - EXTENSION

OCTOBER 8, 1980

GAY D. JONES, JR.

HOWARD NEEDLES TAMMEN & BERGENDOFF

THIS SESSION IS CONCERNED WITH SPECIFICATIONS FOR DEEP FOUNDATIONS. WHILE I DO NOT PROFESS TO BE A SPECIFICATIONS WRITER, MY NORMAL DUTIES AS CHIEF OF THE GEOTECHNICAL ENGINEERING DEPARTMENT OF HOWARD NEEDLES TAMMEN & BERGENDOFF, KANSAS CITY, INHERENTLY RESULTS IN OUR DEPARTMENT ASSISTING IN THE DEVELOPMENT OF SPECIFICATIONS FOR OUR ENGINEERING AND ARCHITECTURAL DIVISIONS.

I PLAN TO TOUCH ON THE GENERAL SUBJECT OF SPECIFICATIONS AND THEN DISCUSS SPECIFICATIONS FOR USE WITH THE MORE OBVIOUS TYPES OF DEEP FOUNDATIONS - CAISSONS - DRILLED SHAFTS, AND PILES. I WILL DRAW HEAVILY ON MATERIAL DEVELOPED BY THE CONSTRUCTION SPECIFICATIONS INSTITUTE, VARIOUS FHWA PUBLICATIONS, AND THE PROJECTS AT HNTB. FINALLY, I WILL ATTEMPT TO OFFER A FEW PERSONAL COMMENTS OR OBSERVATIONS CONCERNING SPECIFICATIONS FOR DEEP FOUNDATIONS.

FOR A PROJECT TO BE CONSTRUCTED THE ARCHITECT/ENGINEER MUST PRECISELY DESCRIBE HIS DESIGN TO BIDDERS, TO THE CONTRACTOR AND HIS SUB-CONTRACTORS, AND TO THE A/E FIELD REPRESENTATIVES. THIS REQUIRES A SET OF COORDINATED CONSTRUCTION DOCUMENTS WHICH ARE

EITHER GRAPHIC OR WRITTEN. GRAPHIC DOCUMENTS, THE USUAL ENGINEERING/ARCHITECTURAL DRAWINGS, SHOW THE SIZE AND EXTENT OF CONSTRUCTION AND GENERAL GEOMETRIC RELATIONSHIPS BETWEEN THE VARIOUS CONSTRUCTION COMPONENTS. WRITTEN DOCUMENTS FALL INTO TWO BROAD CATEGORIES: (1) CONTRACTURAL-LEGAL, AND (2) SPECIFICATIONS.

THE SPECIFICATIONS SET REQUIREMENTS FOR STRENGTH AND OTHER PHYSICAL QUALITIES OF COMPONENTS, STANDARDS OF WORKMANSHIP FOR MANUFACTURERS AND FIELD INSTALLATION, AND GUARANTEES OF COMPONENTS AND MATERIALS. SPECIFICATIONS SHOULD INCLUDE SOME, BUT NOT NECESSARILY ALL, OF THE FOLLOWING INFORMATION:

- 0 QUALITY
- 0 OPTIONAL MATERIALS & METHODS
- 0 REQUIRED GUARANTEES
- 0 REQUIRED PRODUCTS
- 0 ACCEPTABLE MANUFACTURERS
- 0 REQUIRED PHYSICAL PROPERTIES
- 0 REQUIRED PERFORMANCE
- 0 TYPE AND GRADE OF FINISH
- 0 FABRICATION METHOD
- 0 INSTALLATION METHOD.

SPECIFICATIONS SHOULD SUPPLEMENT BUT NOT REPEAT INFORMATION SHOWN ON THE DRAWINGS. DRAWINGS AND SPECIFICATIONS SHOULD DOVETAIL LIKE A JIGSAW PUZZLE WITH NO OVERLAP OR GAPS. IF DRAWINGS AND SPECIFICATIONS PERFECTLY CONFORMED TO THEIR IDEAL COMPLEMENTARY ROLES, THERE WOULD BE NO NEED TO ESTABLISH PROCEDURES TO RESOLVE CONFLICT.

4. SINKING DIAGRAMS SHOULD SHOW SEQUENCE OF OPERATIONS, TIME AND AMOUNT OF CONCRETE INCREMENTS, DREDGING, TIME AND AMOUNT OF ADDITION OF COFFERDAMS, CAISSON DISPLACEMENT UNDER EACH LOAD INCREMENT, AMOUNT OF FREE BOARD ON CAISSON OR COFFERDAM, WATER PRESSURE AT CRITICAL POINTS FOR EACH INCREMENT OF CONCRETE OR COFFERDAM ADDED
5. PNEUMATIC PROCESS - CONTRACTOR PROVIDES ALL PLANT, EQUIPMENT, AIRLOCKS, HOSPITAL LOCKS, COMPLYS WITH REQUIREMENTS OF "MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION" BY ASSOCIATED GENERAL CONTRACTORS, ALSO REQUIREMENTS OF NATIONAL SAFETY COUNCIL INDUSTRIAL SAFETY CONSTRUCTION SERIES No. 2 PAMPHLET, "SAFETY AND HEALTH IN TUNNEL AND CAISSON WORK". THESE MANUALS ARE MENTIONED FOR REFERENCE. THE TREND TODAY IS TO SHY AWAY FROM CITING SPECIFIC SAFETY CODES BECAUSE THE COURTS HAVE INTERPRETED THIS TO MEAN THE ENGINEER IS RESPONSIBLE TO ENFORCE CITED CODES. INSTEAD WE SAY: "THE CONTRACTOR IS SOLELY RESPONSIBLE FOR SAFETY".

CONTRACTOR SHALL RETAIN SERVICE OF AT LEAST ONE LICENSED PHYSICIAN WHO WILL BE READILY AVAILABLE AT ALL TIMES DURING OPERATIONS UNDER COMPRESSED AIR. PROVIDE AUTOMATIC RECORDER IN COMPRESSED AIRLINE TO GIVE PERMANENT RECORD OF AIR PRESSURE, AND ALSO INSTALL IN THE AIR LINES A DEVICE FOR RECORDING THE AMOUNTS OF CARBON MONOXIDE, AND THE DEVICE WILL GIVE AUDIBLE AND VISIBLE WARNINGS (BELL AND LIGHT) WHEN APPROACHING HARMFUL QUANTITIES.

6. CAISSON DESIGN - IT IS USUALLY STATED THE DESIGN EXPECTS THAT SUFFICIENT WEIGHT CAN BE DEVELOPED TO OVERCOME SKIN FRICTION BY DREDGING WITHIN THE WORKING CHAMBER AND BY OPERATING INDEPENDENT JETS OR BY JETTING WELLS OR BOTH. CAISSONS MAY BE CONSTRUCTED ON EARTH OR SANDFILL ENCLOSED WITH SHEET PILING OR SUPPORTED BY TEMPORARY DOCK AND LOWERED TO RIVER BOTTOM FOR SINKING. IF THE CONTRACTOR SELECTS THE METHOD OF FLOATING CAISSON INTO PLACE AND LOWERING TO BOTTOM, AN ADDITIONAL HEIGHT OF STEEL SHELL WILL BE REQUIRED AND CONTRACTOR WILL BE RESPONSIBLE FOR DESIGN OF THE STEEL SHELL. PAYMENT FOR CAISSON CONSTRUCTION WILL BE BASED ON PLAN DESIGN AND QUANTITIES.

CONTRACTOR MAY SUBSTITUTE ALTERNATE DESIGNS FOR CAISSON CUTTING EDGE, HOWEVER, NO CHANGE WILL BE MADE IN THICKNESS OF CAISSON SKIN PLATE OR ARRANGEMENT OF DREDGING WELLS.

7. COFFERDAMS - THE TEMPORARY COFFERDAM AND BRACING ABOVE TOP OF CAISSON SHALL BE DESIGNED BY CONTRACTOR AND THE DESIGN EXAMINED BY THE ENGINEER.

8. TO ENSURE LOCATION OF PIER CAISSONS WITHIN THE LIMITS SPECIFIED, CARE MUST BE EXERCISED IN SINKING CAISSONS. CUTTING EDGES MUST BE SET ON EXACTLY CORRECT HORIZONTAL POSITION AND BE MAINTAINED AT TRUE LEVEL. SINK CAISSONS SO THAT THE CENTER OF THE CAISSON AT THE CUTTING EDGE WILL BE WITHIN A CIRCLE 15 INCHES IN DIAMETER,

AND THE CENTER OF THE CAISSON AT THE TOP WILL BE WITHIN A CIRCLE 12 INCHES IN DIAMETER, THE CENTER OF THESE CIRCLES BEING THE SPECIFIED TRUE VERTICAL AXIS OF THE PIER.

9. CONTRACTOR SHALL MAKE ALL EXCAVATIONS OF EVERY NATURE IN WHATEVER MATERIALS ENCOUNTERED. NO BLASTING SHALL BE DONE WITHOUT WRITTEN APPROVAL OF THE ENGINEER.
10. DISPOSE OF MATERIAL EXCAVATED FROM CAISSONS IN ACCORDANCE WITH AGENCY REQUIREMENTS.
11. A COMPETENT DIVER SHALL BE AVAILABLE AT ALL TIMES TO ASSIST IN REMOVING OBSTRUCTIONS AND TO CHECK FOR SCOUR DURING CONSTRUCTION AND TO CHECK FINAL CLEANING BEFORE SEALING.
12. PLANS SHOW ASSUMED FOUNDING ELEVATIONS, HOWEVER, CONTRACTOR SHOULD BE PREPARED TO CONTINUE SINKING UNTIL SATISFACTORY FOUNDING CONDITIONS ARE REACHED.
13. IN PREPARING FOR THE TREMIE SEAL, ALL MATERIAL BELOW THE HIGH INTERIOR CUTTING EDGES MUST BE REMOVED. ALL CLAY, SILT, BOULDERS, OR FOREIGN MATERIALS SHALL BE REMOVED FROM WALLS AND INTERIOR OF DREDGING CHAMBERS PRIOR TO PLACING TREMIE SEAL.
14. FOLLOWING SEALING OF CAISSONS, TIGHT COVERS ARE PLACED OVER ALL DREDGE WELLS, AND WHEN DIRECTED BY THE ENGINEER, THE CONTRACTOR WILL FILL THE PIER WITH WATER TO THE APPROXIMATE LOW WATER ELEVATION.

B. DRILLED SHAFTS - SOMETIMES REFERRED TO AS DRILLED PIERS, DRILLED CAISSONS, OR LARGE DIAMETER BORED PILES, CAST-IN-SITU BORED PILES.

A DRILLED SHAFT IS A DEEP FOUNDATION CONSTRUCTED BY PLACING CONCRETE, USUALLY WITH REINFORCING STEEL, IN A MACHINE EXCAVATED CYLINDRICAL HOLE, FOR THE PURPOSE OF TRANSFERRING STRUCTURAL LOADS TO BEARING STRATA WELL BELOW THE USEABLE PORTION OF THE STRUCTURE.

THEY ARE CONSTRUCTED BY THE DRY METHOD, CASING METHOD, AND SLURRY DISPLACEMENT METHOD AND GOOD SPECIFICATIONS COVERING THE METHOD OF INSTALLATION ARE NECESSARY TO PRODUCE AN ACCEPTABLE DRILLED SHAFT INSTALLATION. THE SPECIFICATIONS FOR DRILLED SHAFTS SHOULD DEAL WITH CRITICAL ASPECTS OF THE CONSTRUCTION PROCESS AND WOULD INCLUDE:

1. INSPECTION PROVISIONS FOR ADEQUATE INSPECTION OF THE EXCAVATION PRIOR TO PLACING STEEL AND CONCRETE.
2. REINFORCING STEEL - IF USED THE REBAR CAGE CONSISTING OF LONGITUDINAL BARS AND SPIRAL REINFORCEMENT, LATERAL TIES, OR HORIZONTAL BANDS SHOULD BE COMPLETELY ASSEMBLED PRIOR TO PLACEMENT. STANDARD SPECIFICATIONS FOR REBAR STEEL WILL BE CITED. FOR FULL LENGTH REINFORCEMENT, AT LEAST ONE-HALF OF THE LONGITUDINAL BARS REQUIRED IN UPPER PORTION OF THE SHAFT WILL BE EXTENDED TO BOTTOM WITH PROPER LATERAL REINFORCEMENT. TACK-WELDING MAY BE USED

IN ATTACHING SPIRAL REINFORCEMENT, BANDS, OR LATERAL REINFORCEMENT; HOWEVER, WELDING WILL NOT BE PERMITTED OVER TOP PORTION OF REBAR CAGE. THIS DEPTH CAN BE DETERMINED BY ANALYSIS OF SHAFT UNDER LATERAL LOADING.

3. CONCRETE - DESIGN AND MIXING - ITEMS TO BE COVERED INCLUDE:

- o REQUIRED PHYSICAL PROPERTIES OF AGGREGATE, CEMENT, MIXING WATER.
- o ALLOWABLE TEMPERATURE OF THESE MATERIALS.
- o ADDITIONS SUCH AS RETARDERS OR AIR-ENTRAINING AGENTS.
- o 28-DAY COMPRESSIVE STRENGTH.
- o MAXIMUM SIZE OF COARSE AGGREGATE.
- o CLEAR SPACING BETWEEN REBAR, OR BETWEEN REBAR CAGE AND INSIDE OF HOLE OR CASING SHOULD BE AT LEAST THREE TIMES MAXIMUM SIZE OF COARSE AGGREGATE.

4. CONCRETE WORKABILITY -

THIS IS USUALLY SPECIFIED BY THE SLUMP OF CONCRETE WHICH AT TIME OF PLACEMENT SHOULD BE NO LESS THAN 4". IT WILL MORE THAN LIKELY BE AROUND 6" IF CONTRACTOR CAN DEMONSTRATE GOOD QUALITY CONCRETE IS BEING OBTAINED.

5. CONCRETE - TIME BETWEEN MIXING AND PLACING -

SOME SPECIFICATIONS GIVE A LIMITED TIME PERIOD, USUALLY 1 HOUR, BETWEEN THE MIXING OF CONCRETE AND ITS PLACEMENT. FOR SOME JOBS THIS MAY BE TOO SHORT A TIME. MIXES CAN BE DESIGNED SO THAT SEVERAL HOURS CAN ELAPSE BETWEEN MIXING AND FINAL PLACEMENT. THE SPECIFICATION FOR DESIGN OF

CONCRETE, WITH REGARD TO TIME OF PLACEMENT SHOULD BE OF THE PERFORMANCE TYPE, AND MERELY REQUIRE THAT THE QUALITY OF CONCRETE IN THE HOLE MEET APPROPRIATE STANDARDS.

6. SLURRY - CURRENTLY THERE IS NO DATA AVAILABLE THAT WILL ALLOW THE UNIT WEIGHT OF THE DRILLING FLUID TO BE SPECIFIED. A PERFORMANCE SPECIFICATION IS THEREFORE DESIRED AND MIGHT READ AS FOLLOWS: -

"THE DENSITY OF THE DRILLING FLUID EMPLOYED IN ADVANCING AN EXCAVATION IN A CAVING FORMATION SHALL BE SUCH THAT THE FORMATION IS STABILIZED. FURTHERMORE, THE DENSITY OF THE SLURRY SHALL BE SUCH THAT IT IS FULLY DISPLACED BY FLUID CONCRETE. THE CONTRACTOR MAY EMPLOY BENTONITE OR SOME OTHER ADDITIVE, AND IT MAY BE NECESSARY FOR CIRCULATION TO BE EMPLOYED TO MAINTAIN THE QUALITY OF THE DRILLING FLUID (AND SUSPENSION) DURING CONSTRUCTION AND/OR JUST PRIOR TO THE CONCRETE POUR".

7. PLACING REINFORCING STEEL - THIS SPECIFICATION SHOULD MERELY REQUIRE THAT THE REBAR CAGE OR DOWELS BE PLACED IN THE DRILLED SHAFT IN AN UNDAMAGED CONDITION AND ACCORDING TO PLAN.
8. PLACING CONCRETE - SPECIFICATIONS FOR THIS PHASE OF DRILLED SHAFT CONSTRUCTION ARE CRITICAL. IMPROPERLY WRITTEN SPECIFICATIONS CAN LEAD TO A CONSIDERABLE INCREASE IN COSTS, OR TO POOR QUALITY OF CONSTRUCTION.

A) PLACING CONCRETE BY FREE-FALL METHOD -

CONCRETE CAN BE PLACED BY FREE-FALL IF IT FALLS INTO ITS FINAL POSITION THROUGH AIR WITHOUT STRIKING THE SIDES OF THE HOLE, THE REBAR CAGE, OR ANY OTHER OBSTRUCTION.

B) VIBRATION OR RODDING -

COMPLETE VIBRATION OR RODDING OF CONCRETE IS NOT REQUIRED. SOME MINOR RODDING NEAR THE OUTSIDE OF THE SHAFT IS NECESSARY TO ELIMINATE HONEY-COMBING WHERE THE HYDROSTATIC PRESSURE IN THE FRESH CONCRETE IS LOW. RODDING IS NECESSARY ONLY IN THE TOP 3 FT. OF THE SHAFT.

C) PLACING CONCRETE IN CASING & PULLING CASING -

IF THE CASING METHOD OF CONSTRUCTION IS EMPLOYED, THE CONCRETE MUST BE BROUGHT ABOVE THE LEVEL OF THE EXTERNAL FLUID BEFORE THE CASING IS PULLED. THE TOP OF THE CASING SHALL BE AT GROUND SURFACE OR ABOVE. THE HYDROSTATIC PRESSURE IN THE CONCRETE COLUMN SHALL BE GREATER AT ALL TIMES THAN THE PRESSURE IN ANY COLUMN OF FLUID TRAPPED BEHIND THE CASING. THUS, THE DRILLING SLURRY WILL BE EXPELLED FROM THE EXCAVATION AS THE CASING IS PULLED. BECAUSE THE CONCRETE COLUMN WILL SLUMP AS THE CASING IS PULLED, IT WILL BE NECESSARY IN SOME CASES TO ADD FRESH CONCRETE IN THE TOP OF THE PARTIALLY-PULLED CASING TO ENSURE THAT THE CONCRETE COLUMN IS AT THE PROPER HEIGHT WHEN THE CASING IS COMPLETELY EXTRACTED.

D) SLUMP OF REBAR CAGE WHEN CASING IS PULLED -

MANY SPECIFICATIONS REQUIRE THE CONTRACTOR TO HOLD THE TOP OF THE REBAR CAGE DURING THE PULLING OF THE CASING AND THAT THE TOP OF THE CAGE NOT RACK OR MOVE DOWNWARD MORE THAN A SMALL AMOUNT. SUCH A PROCEDURE IS POSSIBLE, BUT NOT VERY PRACTICAL. AN EXTRA CRANE AND CREW WOULD BE NEEDED, AND PERHAPS THEY WOULD WORK ONLY DURING THE PULLING OF CASING. THE CRANE HOLDING THE REBAR CAGE WOULD HAVE TO BE VERY LARGE, BECAUSE THE CASING WOULD HAVE TO BE LIFTED ALONG THE LINE TO THE TOP OF THE CAGE. A MORE PRACTICAL PROCEDURE IS TO USE THE SLURRY DISPLACEMENT METHOD OF CONSTRUCTION WHERE THE CONCRETE COLUMN IS MOVING UP WITH RESPECT TO THE REBAR CAGE, OR TO DESIGN THE CAGE AS A STRUCTURE THAT WILL RESIST DOWNWARD FORCES FROM THE COLUMN OF FLUID CONCRETE. DESIGN OF THE REBAR CAGE OF PROPER STRUCTURAL CHARACTERISTICS IS DIFFICULT BECAUSE THE SHEARING STRENGTH OF THE COLUMN OF FRESH CONCRETE IS NOT WELL KNOWN, NOR ARE THE TORSIONAL AND BUCKLING CHARACTERISTICS OF THE REBAR CAGE. A SOLUTION NORMALLY USED CONSISTS OF WELDING HORIZONTAL BANDS (2" IN WIDTH AND ABOUT 3/8" IN THICKNESS) TO THE REBAR CAGE AT INTERVALS OF 5 FEET, AND OVER THE LOWER PORTION OF CAGE BELOW THE ZONE OF SIGNIFICANT BENDING MOMENT. THE WORKABILITY OF THE CONCRETE MUST BE GOOD AND THE CASING MUST NOT BE PULLED TOO FAST, IN ORDER TO MINIMIZE THE DOWNWARD FORCE.

e) PLACING CONCRETE UNDER SLURRY OR UNDER WATER -

IF THE SLURRY DISPLACEMENT METHOD IS EMPLOYED, OR IF THE ENGINEER HAS ALLOWED THE CONTRACTOR TO PLACE THE CONCRETE UNDER A COLUMN OF WATER, CARE MUST BE TAKEN TO ENSURE THAT ALL THE FLUID IS EXPELLED FROM THE HOLE. THE CONCRETE MUST BE PLACED BY A TREMIE OR PUMPED. IN ORDER TO PREVENT CONTAMINATION OF THE CONCRETE PLACED INITIALLY, THE BOTTOM OF THE TREMIE PIPE IS SEALED WITH A DIAPHRAGM OR PLUG THAT IS FLUSHED OUT WHEN THE HYDROSTATIC PRESSURE FROM THE COLUMN OF CONCRETE EXCEEDS THAT OF THE FLUID IN THE HOLE. AN ACCEPTABLE ALTERNATIVE PROCEDURE IS TO EMPLOY A PLUG THAT WILL MOVE DOWN THE PIPE TO KEEP THE CONCRETE SEPARATE FROM THE SLURRY. AN INFLATABLE BALL HAS BEEN USED FOR THIS PURPOSE. THE TREMIE MUST BE WATER-TIGHT, THE CONCRETE MUST HAVE GOOD FLOW CHARACTERISTICS, AND THE BOTTOM OF THE TREMIE, OR PUMP PIPE, MUST ALWAYS REMAIN BELOW THE TOP OF THE COLUMN OF FLUID CONCRETE. THE CONCRETING SHOULD ALWAYS BE CARRIED OUT IN A CONTINUOUS OPERATION.

f) INSPECTION OF CONCRETE -

THERE IS ONE ASPECT OF THE INSPECTION OF FRESH CONCRETE THAT REQUIRES MENTION. IN SOME CASES A CONSIDERABLE AMOUNT OF TIME CAN BE EXPENDED WHILE INSPECTORS TAKE TEST CYLINDERS, PERFORM SLUMP TESTS, AND MEASURE AIR ENTRAINMENT. THE TRUCKS ARE STANDING BY, THE CONTRACTOR IS WAITING, AND THE CONCRETE IS HYDRATING.

THE ENGINEER SHOULD DO AS MUCH INSPECTION AS POSSIBLE AT THE PLANT SITE. IF HE REQUIRES A PERIOD OF 15 TO 20 MINUTES TO PERFORM TESTS OF EACH TRUCK OF CONCRETE DELIVERED TO THE JOB, THE SPECIFICATIONS SHOULD SO STATE.

C. PILING

STATE DEPARTMENTS OF TRANSPORTATION ARE POSSIBLY THE LARGEST AGENCY USERS OF FOUNDATION PILING AND OVER MANY YEARS HAVE DEVELOPED PRACTICAL SPECIFICATIONS FOR PILING, APPLICABLE TO THEIR GEOGRAPHICAL LOCATION. PILING INSTALLATION CONTRACTORS ARE, OR SHOULD BE, FAMILIAR WITH THESE STANDARD SPECIFICATIONS.

IN OUR PRACTICE THE SPECIFICATIONS FOR FOUNDATION PILING ARE FREQUENTLY FURNISHED BY THE OWNER AND WE NEED ONLY TO ADAPT THE SPECIFICATIONS TO THE INTENDED CONSTRUCTION, USUALLY WITH SPECIAL PROVISIONS OR SUPPLEMENTAL SPECIFICATIONS

FOR A PRIVATE, NON-AGENCY CLIENT, WE CUSTOMARILY PATTERN SPECIFICATIONS FOR THEIR PILING JOBS AFTER THOSE IN CURRENT LOCAL USEAGE, USUALLY THE STATE DOT SPECIFICATIONS. SOME GEOTECHNICAL ENGINEERING FIRMS, AND ARCHITECTS/ENGINEERS PREFER TO WRITE "THEIR OWN" PILING SPECIFICATIONS, HOWEVER, IF YOU WILL CHECK THEM CLOSELY, YOU WILL FIND GREAT SIMILARITY TO LOCAL "STANDARD" DOT SPECIFICATIONS.

FOR THIS DISCUSSION I HAVE SELECTED AS REFERENCE SPECIFICATIONS THOSE IN CURRENT USE BY THE STATES OF LOUISIANA AND TEXAS, WHERE SEVERAL TYPES OF END BEARING AND/OR FRICTION PILES ARE INSTALLED.

IMPORTANT ITEMS TO COVER IN PILING SPECIFICATIONS INCLUDE:

1. MATERIALS:

A. PRECAST CONCRETE PILES -

RE-STEEL, USUALLY ASTM A 615,
CONCRETE - 3000 PSI COMPRESSIVE STRENGTH.

B. PRESTRESSED PILING -

CONCRETE - GENERALLY 5000-PSI COMPRESSIVE STRENGTH.
PRESTRESSING STEEL - ASTM A 416, OR A-421, UNCOATED
STRESS-RELIEVED STRANDS.

THE DESIGN, MIXING, PLACING, CURING, QUALITY OF CON-
CRETE CONSTRUCTION, REMOVAL OF FORMS, PRESTRESSING
DETAILS, TENSIONING AND RELEASE OF STRESS AND
INSPECTION FACILITIES ARE VERY IMPORTANT TO PRODUCTION
OF AN ACCEPTABLE PRODUCT.

C. CAST-IN-PLACE CONCRETE PILES - (SOMETIMES REFERRED TO
AS METAL SHELL PILING).

METAL SHELL PILING - ASTM A-252, GRADE 2, OR A-36.
CONCRETE - USUALLY 3000 PSI COMPRESSIVE STRENGTH
RE-STEEL - (WHERE REQUIRED) USUALLY ASTM A-615.

D. STEEL PILING -

STEEL (H SECTION & SHEET) - ASTM A-36.

E. TIMBER - ASTM D-25

UNTREATED PILING - ANY SPECIES OF DURABLE TIMBER THAT
WILL SATISFACTORILY STAND DRIVING.

TREATED PILING - SOUTHERN PINE OR DOUGLAS FIR
IMPREGNATED WITH A PRESERVATIVE.

SPECIFICATIONS ARE USUALLY LENGTHY, INCLUDING DISCUSSIONS ON: KNOTS, CHECKS, SPLITS, SHAKES, DENSITY, PEELING & TRIMMING, SOUNDNESS, SEASONING, STRAIGHTNESS.

2. PREPARATION FOR DRIVING

- A. EXCAVATION - PILES ARE NOT USUALLY DRIVEN UNTIL EXCAVATION IS COMPLETE.
- B. EMBANKMENT - CONSTRUCT EMBANKMENT AT BRIDGE ENDS TO ELEVATION OF BOTTOM OF ABUTMENT BENT CAP PRIOR TO DRIVING PILES IN THAT UNIT.
- C. TRANSPORTATION-PRECAST CONCRETE PILING -
PRECAST - PRESTRESSED PILES ARE TO BE SUPPORTED AT EACH OF THE PICKUP POINTS AS SHOWN ON PLANS FOR PARTICULAR LENGTH OF PILES. SUPPORTS NOT MORE THAN 1 FOOT FROM THEORETICAL POSITION FOR EACH SUPPORT, AND DISTANCE BETWEEN 2 SUPPORTS WILL NOT BE MORE THAN 1 FOOT FROM THEORETICAL.
- D. SUPPORT HOLES - WHEN APPROVED BY ENGINEER
PILES MAY BE SET IN SUPPORTING HOLES - 10 FEET OR LESS FOR PILES UP TO 50 FEET IN LENGTH, OR 20% OF DESIGNATED PENETRATION FOR PILES OVER 50' IN LENGTH. FILL HOLE AROUND PILE WITH GRANULAR MATERIAL. THIS IS USUALLY A COSMETIC ITEM FOR AFTER A FEW SHOVELS OF SAND THE HOLE, IF OPEN TO START WITH, IS SEALED OFF AND RODDING IS NOT USUALLY PERFORMED.

3. DRIVING PILING

- A. TOLERANCES - BENTS - TRANSVERSE TO C , WITHIN 2" OF PLAN.
PARALLEL TO C BENT - WITHIN 4" OF PLAN.

FOUNDATION PILING - TOP NOT MORE THAN 4"
IN ANY DIRECTION FROM PLAN POSITION.

CUTOFF - 2"± OF PLAN CUT-OFF GRADE.

- B. SIZES OF DRIVING EQUIPMENT.

THERE ARE SOME GENERAL RULES FOR SELECTING DRIVING EQUIPMENT, BASED ON PILE TYPES AS FOLLOWS:

<u>PILE TYPE</u>	<u>MIN. HAMMER ENERGY, FT.-LBS</u>
TIMBER	330 R
STEEL H	250 R OR 2½ WP (LARGER OF TWO)
METAL SHELL	350 R (FOR LENGTH > 65', 430 R).
METAL SHELL W/MANDREL INSERT	220 R BUT NOT LESS THAN 1-FT.-LB. PER LB. PILE WEIGHT, INCLUDING MANDREL.
CONCRETE	250 R BUT NO LESS THAN 1-FT.-LB PER LB. PILE WEIGHT.

R = DESIGN LOAD IN TONS

WP = WEIGHT OF PLAN LENGTH PILE, IN POUNDS.

- C. POINTING - TIMBER OR STEEL BEARING PILE TO BE POINTED
AS SOIL CONDITIONS REQUIRE.

D. SPLICING -

PRECAST PILES - FURNISHED AND DRIVEN IN FULL LENGTHS.
CAST-IN-PLAST CONCRETE PILE SHELLS - CAN BE FIELD SPLICED
BUT NOT IN TOO SHORT SECTIONS. USE MANUFACTURER'S
RECOMMENDATIONS TO SATISFACTION OF ENGINEER.

STEEL BEARING PILES - FURNISHED AND DRIVEN IN FULL
LENGTHS. IF SPLICE AUTHORIZED, NOT MORE THAN 2 PER
PILE BY WELDING.

TIMBER - FURNISH AND DRIVE FULL LENGTH WHERE PRACTICABLE.
SPLICING ONLY BY WRITTEN PERMISSION, IN ACCORDANCE
WITH SPLICING DETAIL FURNISHED OR APPROVED BY ENGINEER.

E. PAINTING - NORMALLY NO PAINTING REQUIRED EXCEPT WHERE STEEL
OR STEEL SHELL PILES EXTEND ABOVE GROUND.

F. PILOT HOLES -

HOLES WITH DIAMETER EQUAL TO $7/8$ THE FACE WIDTH OF A
SQUARE PILE, OR $7/8$ AVERAGE DIAMETER OF A ROUND PILE, BUT
SHALL BE OF A SIZE THAT WILL PROVIDE DESIRED RESULTS.
FILL OPEN SPACE WITH GRANULAR MATERIAL. IN NO CASE
SHALL PILOT HOLE EXTEND WITHIN 5' OF TIP ELEVATION OF PILE.

G. LEADS - TEMPLATES - FIXED OR SWINGING LEADS MAY BE USED.
SWINGING LEADS USED IN COMBINATION WITH RIGID TEMPLATE.
INCLINED LEADS USED IN DRIVING BATTER PILES.

H. FOLLOWERS & UNDERWATER HAMMERS - PERMITTED ONLY BY WRITTEN
APPROVAL OF ENGINEER. WHEN FOLLOWER OR UNDERWATER HAMMER
IS USED, 1 PILE IN EACH GROUP OF 10 SHALL BE FURNISHED LONG
ENOUGH TO PERMIT BEING DRIVEN WITHOUT A FOLLOWER OR UNDER-

WATER HAMMER AND SHALL BE USED ^{as} BY A TEST PILE TO DETER-
MINE AVERAGE BEARING OF GROUP.

- I. WATER JETS - SIZE OF JETS, VOLUME AND PRESSURE OF WATER AT JET NOZZLES SUFFICIENT TO ERODE MATERIAL ADJACENT TO PILE. 150 PSI PRESSURE AT TWO 3/4" JET NOZZLES IS PROBABLY A MINIMUM. WITHDRAW JETS AS DRIVE WITH HAMMER TO SECURE FINAL PENETRATION. NO JETTING WITHIN 5 FEET OF TIP ELEVATION OF PILES UNLESS AUTHORIZED. WATER JETS WILL NOT BE PERMITTED WHERE EMBANKMENT STABILIZATION OR OTHER IMPROVEMENTS WOULD BE ENDANGERED.
- J. INTERRUPTED DRIVING - FOR INTERRUPTION BEFORE REACHING FINAL PENETRATION, THE RECORD FOR RESISTANCE SHALL NOT BE TAKEN UNTIL AT LEAST 12 INCHES OF PENETRATION HAS BEEN OBTAINED AFTER DRIVING RESUMED.
- K. PROTECTION OF PILE HEADS - NATURE OF DRIVING MAY REQUIRE PROTECTION FOR HEADS OF CONCRETE AND TIMBER PILES. USE APPROVED CAP, HAVING ROPE OR OTHER CUSHION NEXT TO PILE HEAD AND FITTED INTO A CASTING WHICH SUPPORTS A TIMBER SHOCK BLOCK.
- L. CUT-OFFS PRECAST CONCRETE PILE - MAKE CUTOFF PERPENDICULAR TO PILE AXIS AT ELEVATION SHOWN. AVOID SPALLING OF CONCRETE. RE-STEEL REMAINS TO ENGAGE BODY OF FOOTING OR CAP.
 - STEEL BEARING PILES - CUT AT RIGHT ANGLES TO AXIS OF PILE.
 - TIMBER PILES - SAW AT RIGHT ANGLES TO AXIS.PILE SUPPORTING TIMBER CAPS SHOULD BE SAWED TO HORIZONTAL PLANE.
SHIMMING ON TOPS OF PILES NOT PERMITTED.

- CAST-IN-PLACE CONCRETE PILES - AFTER FULLY DRIVEN, INSPECTED, AND APPROVED, BUT NEATLY AT RIGHT ANGLES TO PILE AXIS.

M. EXTENSION OF PRECAST CONCRETE PILING - BY CASTING IN PLACE OR BY SPLICING A PRECAST SECTION.

4. BEARING RESISTANCE - USUALLY DETERMINED BY:

A. HAMMER FORMULA METHOD - MOST DOT SPECIFICATIONS UTILIZE THE ENR FORMULA:

$$P = \frac{2WH}{S+1.0} \quad (\text{GRAVITY HAMMERS})$$

$$P = \frac{2WH}{S+0.1} \quad (\text{SINGLE ACTING HAMMER})$$

$$P = \frac{2E}{S+0.1} \quad (\text{DOUBLE ACTING HAMMER})$$

B. WAVE EQUATION METHOD - IF SPECIFIED ON PLANS THAT BEARING CAPACITY WILL BE DETERMINED BY WAVE EQUATION METHOD CONTRACTOR SHALL SUBMIT TO ENGINEER, FOLLOWING:

- O MANUFACTURER'S SPECIFICATION DATA FOR PROPOSED HAMMER.
- O COMPLETE DESCRIPTION AND DIMENSIONS INCLUDING TOTAL THICKNESS OF ALL CUSHIONING MATERIAL USED BETWEEN PILE AND HELMET.
- O COMPLETE DESCRIPTION AND DIMENSIONS INCLUDING TOTAL THICKNESS OF CUSHIONING MATERIAL IN CAP BLOCK INCLUDING DIRECTION OF GRAIN IF WOOD IS USED.

5. BEARING AND LENGTH DETERMINATION -

- A. PENETRATION DATA - PILES SHOULD BE DRIVEN TO "MINIMUM", OR "REQUIRED" PENETRATION AS GIVEN IN PLANS AND SPECIFICATIONS.
- B. TEST PILING - TEST PILING IS DRIVEN AND WITH THE PERTINENT HAMMER FORMULA OR WAVE EQUATION BEARING GRAPH TO DETERMINE BEARING RESISTANCE: APPROVED LENGTHS ARE DETERMINED.
- C. TEST LOAD - WHEN REQUIRED BY PLANS, PILING SHALL BE DRIVEN AND TEST LOADED. APPROPRIATE HAMMER FORMULA USED TO ESTABLISH DYNAMIC RESISTANCE OF TEST LOAD PILE AND ANCHOR PILES. TEST LOAD DATA IS USED TO DETERMINE PILE LENGTHS AND TO DEVELOP "K" FACTOR TO MODIFY HAMMER FORMULA.
- $$K = \frac{L}{P} \text{ WHERE}$$
- K = STATIC CORRECTION FACTOR TO A DYNAMIC FORMULA.
L = MAXIMUM SAFE STATIC LOAD PROVEN BY TEST LOAD.
P = DYNAMIC RESISTANCE OF TEST LOADED PILE DETERMINED BY HAMMER FORMULA.
- D. SOIL TESTS - PILING ARE DRIVEN TO TIP ELEVATIONS SHOWN ON PLANS. DYNAMIC RESISTANCE DETERMINED BY HAMMER FORMULA. SUBSEQUENT PILING DRIVEN TO APPROVED TIP ELEVATIONS TO OBTAIN REQUIRED BEARING DETERMINED BY HAMMER FORMULA MODIFIED BY K FACTOR OR TO MAXIMUM PENETRATION SHOWN ON PLANS.

$$K = \frac{R}{P} \text{ WHEN}$$

K = STATIC CORRECTION FACTOR TO A DYNAMIC FORMULA

R = MAXIMUM SAFE STATIC LOAD PREDETERMINED BY SOIL STUDIES.

P = DYNAMIC RESISTANCE OF PILING BY HAMMER FORMULA;

6. TEST LOADS - OVER THE LAST SEVERAL YEARS, WE HAVE ROUTINELY RECOMMENDED TO CLIENTS THAT THE SO-CALLED "QUICK" LOAD TEST BE PERFORMED. THIS PROCEDURE DEVELOPED OUT OF THE CONSTANT RATE OF PENETRATION (CRP) TEST IN 1961. THIS METHOD REQUIRES LOAD INCREMENTS BE APPLIED IN 5 TO 10-TON INCREMENTS WITH LOAD, GROSS SETTLEMENT, AND OTHER PERTINENT DATA RECORDED IMMEDIATELY BEFORE AND AFTER THE ADDITION OF A LOAD INCREMENT. THE LOAD IS MAINTAINED CONSTANT FOR 2½ MINUTES BEFORE THE NEXT INCREMENT IS ADDED.

THIS PERMITS A LOAD TEST TO BE PERFORMED IN A MATTER OF ONLY SEVERAL HOURS AS COMPARED TO OTHER METHODS, ASTM D 1143 WHICH MIGHT TAKE WELL IN EXCESS OF 48 HOURS.

D. COMMENTS -

- o REALISTIC, ENFORCEABLE SPECIFICATIONS ARE NECESSARY TO ACHIEVE QUALITY CONSTRUCTION. ADEQUATE TIME SHOULD BE MADE AVAILABLE FOR THE DRAFTING AND EDITING OF SPECIFICATIONS, TAILORED FOR SPECIFIC OBJECTIVES. YOU WILL HAVE BETTER SPECIFICATIONS IF YOU COMPLETE THE PLANS OR WORKING DRAWINGS IN TIME FOR THE SPECIFICATION WRITERS TO STUDY THEM AND DISCUSS THE INTENDED CONSTRUCTION WITH THOSE INVOLVED IN DESIGN AND PLANS.

- o THERE IS A TENDENCY TO UTILIZE MASTER FILE SPECIFICATIONS. THIS CAN BE A TIME-SAVER IF THE SO-CALLED MASTER SPECIFICATIONS ARE PROPERLY ADAPTED FOR SPECIFIC OBJECTIVES. ALL TOO OFTEN WE SEE JOB SPECIFICATIONS STRAIGHT FROM THE FILES WITH LITTLE OR NO ATTEMPT TO RELATE THEM TO THE SITE SPECIFIC CONDITIONS. THIS WILL GET YOU IN TROUBLE.

- o IN OUR DESIGN PRACTICE, WE ROUTINELY DISCUSS DIFFICULT CONSTRUCTION PROBLEMS OR CONCERNS WITH LOCAL, COMPETENT, CONSTRUCTION FIRMS, DURING THE DESIGN AND PLAN STAGE. THE CONTRACTOR'S INFLUENCE AT THAT STAGE OF THE PROJECT CAN MORE THAN OFFSET ANY EMBARRASSMENT TO YOU BY ASKING QUESTIONS.

0 THE CURRENT TREND IS TOWARD UTILIZATION OF THE WAVE EQUATION ANALYSES IN DESIGN AND CONSTRUCTION OF PILE FOUNDATIONS, AND THERE ARE MANY PROJECTS WHERE THIS IS BENEFICIAL TO THE OWNER. I BELIEVE THIS PROCEDURE IS BEING OVER SOLD. THERE ARE MANY PILE FOUNDATIONS WHERE THE WAVE EQUATION IS NOT NEEDED IN DESIGN AND WHERE ADEQUATE DOCUMENTATION OF PILE INSTALLATIONS UTILIZING THE CONVENTIONAL HAMMER FORMULAS WILL BE QUITE ADEQUATE.

0 HIGH CAPACITY PILE LOAD TESTS INVOLVING 1000 TONS ARE QUITE COMMON NOW, PARTICULARLY IN THE AXIAL TEST LOADING OF SINGLE DRILLED SHAFTS.

HANDLING LOADS OF THIS MAGNITUDE BY HYDRAULIC JACKS CAN BE VERY DANGEROUS AND THE SPECIFICATIONS SHOULD PROVIDE FOR ADDED PRECAUTIONS RELATING TO EQUIPMENT AND SYSTEMS, AND WORKING IN THE AREA.

LOADING SHOULD BE PERFORMED IN NORMAL DAYLIGHT HOURS, IF AT ALL POSSIBLE. IF NOT, THE SPECIFICATIONS MUST CLEARLY ADDRESS THE MATTER OF ADEQUATE LIGHTING BEING READY AT THE SITE BEFORE ANY LOADING IS PERMITTED.

0 IN HIGH CAPACITY LOAD TESTING OF PILE AND DRILLED SHAFTS, THE SPECIFICATIONS SHOULD REQUIRE ALL LOAD-DEFLECTION READINGS BE BY TRANSIT LOCATED AT A SAFE DISTANCE. DIRECT READING OF THE DIALS BENEATH THE LOADING FRAME CAN BE A DANGEROUS ASSIGNMENT.

- o THE QUICK LOAD TEST PROCEDURE FOR PILES AND DRILLED SHAFTS IS AN ACCEPTABLE PROCEDURE AND REDUCES THE COST OF TEST LOADING CONSIDERABLY AS THE TIME REQUIRED MAY BE 1 TO 3 HOURS IN LIEU OF THE 48-HOUR PROCEDURE.

- o PROBLEMS FREQUENTLY DEVELOP WHERE A LARGE NUMBER OF DISPLACEMENT PILES ARE DRIVEN, AT MINIMUM SPACING, IN A COFFERDAM. COFFERDAM MOVEMENTS, ALWAYS A CONCERN, CAN BE VERY DISTURBING. THE SPECIFICATIONS SHOULD REQUIRE THE CONTRACTOR TO SUBMIT TO THE ENGINEER AN ACCEPTABLE DRIVING SEQUENCE; ALONG WITH HIS SHOP DRAWINGS AND DESIGN FOR THE COFFERDAM.

- o IN DRILLED SHAFT WORK WHERE THERE IS A DRY HOLE AND GOOD STABILITY, WE FIND THAT CONTRACTORS PREFER TO DELAY CONCRETING UNTIL LATE IN THE DAY. THIS IS PARTICULARLY TRUE WHERE THE DRILLED SHAFT SUB-CONTRACTOR ONLY EXCAVATES THE HOLE, AND THE PRIME OR GENERAL CONTRACTOR PLACES THE STEEL AND CONCRETE. SPECIFICATIONS SHOULD BE WRITTEN TO ENCOURAGE THE CONTRACTOR TO FOLLOW-UP THE SHAFT DRILLING CLOSELY WITH THE CONCRETE. NIGHT POURS SHOULD BE AVOIDED.