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- A. CONSTRUCTION REQUIREMENTS
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	<b>MISSOURI HIGHWAYS AND                  TRANSPORTATION COMMISSION</b> 105 W. CAPITOL AVE. JEFFERSON CITY, MO 65101 Phone (888) 275-6636
	<b>HR GREEN, INC.</b> 520 Maryville Centre Dr., Suite 100 St. Louis, MO 63141 Certificate of Authority # 2002006608 Consultant Phone # (636) 519-0990
	If a seal is present on this sheet, JSP's has been electronically sealed and dated.
	JOB NO. SE0116 Stoddard County, MO Date Prepared: 12/13/2024
	Only the following items of the Job Special Provisions (Bridge) are authenticated by this seal: All

JOB SPECIAL PROVISIONS (BRIDGE)

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A. CONSTRUCTION REQUIREMENTS

**1.0 Description.** This provision contains general construction requirements for this project.

**2.0 Construction Requirements.** The plans and the asbestos and lead inspection report for the existing structure(s) and the geotechnical report for the new structure(s) are included in the contract in the bridge electronic deliverables zip file for informational purposes only.

**2.1** In order to assure the least traffic interference, the work shall be scheduled so that the bridge closure is for the absolute minimum amount of time required to complete the work. The bridge shall not be closed until material is available for continuous construction and the contractor is prepared to diligently pursue the work until the closed bridge is opened to traffic.

**2.2** Provisions shall be made to prevent any debris and material from falling into the waterway. If determined necessary by the engineer, any debris and material that falls below the bridge outside the previously specified limits shall be removed as approved by the engineer at the contractor's expense.

**2.3** Provisions shall be made to prevent damage to any existing utilities. Any damage sustained to the utilities as a result of the contractor's operations shall be the responsibility of the contractor. All costs of repair and disruption of service shall be as determined by the utility owners and as approved by the engineer.

**3.0 Method of Measurement.** No measurement will be made.

**4.0 Basis of Payment.** Payment for the above described work will be considered completely covered by the contract unit price for other items included in the contract.

B. DEWATERING

**1.0 Description.** This provision covers dewatering the site as necessary to provide a suitable condition for construction of the box culvert as approved by the engineer. This work will only be performed at the discretion of the engineer and will be underrun if not required by the engineer. If the engineer determines it necessary to provide dewatering, the work shall be performed in accordance with [Sec 206](#) and this job special provision.

**2.0 Construction Requirements.** Dewatering shall provide a dry work area suitable to construct the box culvert within specifications, as approved by the engineer. Typical dewatering methods consist of, but are not limited to, construction of cofferdams, seal courses, over excavation, well point systems, dewatering and drainage diversion. Any dewatering method utilized shall conform to all environmental laws and regulations.

**3.0 Method of Measurement.** No measurement will be made.

**4.0 Basis of Payment.** Payment for dewatering will be made regardless of which dewatering means is utilized. No payment will be made if the work area is not maintained in a dewatered state as approved by the engineer. The lump sum payment for dewatering will be considered full compensation, and no time extensions will be made regardless of which means and methods are utilized by the contractor.

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	JOB NO. JSE0116 Stoddard County, MO Date Prepared: 2/4/2025

Only the following items of the Job Special Provisions (Bridge) are authenticated by this seal: All

JOB SPECIAL PROVISIONS (BRIDGE)

---

A. CONSTRUCTION REQUIREMENTS

**1.0 Description.** This provision contains general construction requirements for this project.

**2.0 Construction Requirements.** The plans and the asbestos and lead inspection report for the existing structure(s) and the geotechnical report for the new structure(s) are included in the contract in the bridge electronic deliverables zip file for informational purposes only.

**2.1** In order to assure the least traffic interference, the work shall be scheduled so that the bridge closure is for the absolute minimum amount of time required to complete the work. The bridge shall not be closed until material is available for continuous construction and the contractor is prepared to diligently pursue the work until the closed bridge is opened to traffic.

**2.2** Provisions shall be made to prevent any debris and material from falling into the waterway. If determined necessary by the engineer, any debris and material that falls below the bridge outside the previously specified limits shall be removed as approved by the engineer at the contractor's expense.

**2.3** Provisions shall be made to prevent damage to any existing utilities. Any damage sustained to the utilities as a result of the contractor's operations shall be the responsibility of the contractor. All costs of repair and disruption of service shall be as determined by the utility owners and as approved by the engineer.

**3.0 Method of Measurement.** No measurement will be made.

**4.0 Basis of Payment.** Payment for the above described work will be considered completely covered by the contract unit price for other items included in the contract.

B. PILE WAVE ANALYSIS

**1.0 General.**

**1.1 Scope of Work.** Scope of work shall include furnishing a wave equation analysis of piles (WEAP) as specified in this special provision.

**1.2 Performance and Design Requirements.** Performance and design conditions for WEAP shall be in accordance with [section 4.0](#) of this special provision.

**1.3 Qualifications.** The contractor shall perform wave equation analysis utilizing the services of an independent dynamic pile testing consultant and qualified personnel. An engineer with a minimum of 5 years WEAP experience shall perform the analysis.

**2.0 Execution.**

**2.1 Pile Driving Modeling.** The contractor shall perform preconstruction wave equation analyses and prepare a summary report of the results. The wave equation analyses shall be used to assess the ability of all proposed pile driving systems to install piles to the required capacity and the desired penetration depth within allowable driving stresses. The report shall include a drivability graph relating pile capacity, blow count and driving stresses to depth. The report shall include a bearing graph relating the pile capacity to the pile driving resistance. The bearing graph shall indicate blow count versus capacity and stroke. The report shall also

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contain a constant capacity analysis or inspector's chart to assist the engineer in determining the required driving resistance at other field observed strokes. The contractor shall perform wave equation analyses in accordance with [section 4.0](#) of this special provision. Acceptability of the wave equation report and the adequacy of analyses will be determined by the engineer.

**2.1.1** WEAP shall provide driving criteria for driving piling to rock. WEAP shall give pile solution for driving piling through hard material to rock or through soft material to rock. WEAP shall provide an inspector's chart to be used for end of driving criteria in soft rock. If hard rock is encountered during driving, then [Sec 702.4.11.1](#) Pile Driving to Hard Rock shall be used as the end of driving criteria. When driving to rock of uncertain strength, the WEAP shall be used as the pile driving verification method up until pile refusal on rock occurs. When pile refusal on rock occurs, as approved by the engineer, the minimum nominal axial compressive resistance is verified and no additional pile driving verification method is required.

**2.1.2** Approval by the engineer of the proposed pile driving system will be based upon the wave equation analyses indicating that the proposed system can develop the specified pile capacity at a maximum equivalent pile driving rate of 10 blows per inch in soil and 20 blows per inch at the end of driving to seat pile in soft rock or penetrate to refusal on hard rock, and within allowable driving stresses per *AASHTO LRFD Bridge Construction Specifications*, Section 4.4.1. With approval of the engineer, a pile driving rate greater than 20 blows per inch may be acceptable if a smaller hammer or shorter stroke is needed to keep pile driving stresses within the allowable range when seating pile in rock. The contractor shall provide preliminary pile driving criteria based on wave equation analyses and any anticipated capacity changes after driving, set-up or relaxation, subject to revision based upon field measurements.

**2.1.3** If any changes or modifications are made to the approved pile driving system, additional wave equation analyses in accordance with [section 2.1](#) of this special provision shall be required.

**3.0 Schedule of Contract Submittals.** Proposed independent dynamic pile testing consultant, and a list of assigned personnel and their experience and qualifications shall be submitted to the engineer. All documents shall be submitted 45 calendar days before pile driving starts.

**4.0 Wave Equation Analysis.** A minimum of one and sufficient additional analyses as needed are required to define performance for all combinations of piles, driving systems and subsurface conditions anticipated. Multiple pile driving systems shall be analyzed as required to find an acceptable system that is capable of driving the piles in accordance with [section 2.0](#) of this special provision. A smaller hammer, shorter stroke, increased cushion, or a combination thereof shall be considered to prevent pile damage when encountering rock.

**5.0 Dynamic Pile Testing.** The contractor has the option to add Dynamic Pile Testing to assist in pile installation. Dynamic Pile Testing shall be in accordance with the Dynamic Pile Testing job special provision and at the contractor's expense. No additional payment will be made for Dynamic Pile Testing.

**6.0 Method of Measurement.** Pile wave analysis will be measured per each bent.

**7.0 Basis of Payment.** Payment for the above described work will be considered completely covered by the contract unit price for Pile Wave Analysis.

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C. DYNAMIC PILE TESTING

**1.0 General.**

**1.1 Scope of Work.** Scope of work shall include furnishing all labor, equipment and analysis associated with dynamic testing of driven piles as specified in this special provision. Dynamic pile restrike testing is not required on this project, and references to restrike testing in this special provision will not apply.

**1.2 Performance and Design Requirements.** Performance and design conditions for dynamic testing of driven piles shall be in accordance with [section 4.0](#) of this special provision.

**1.3 Approved Manufacturers.** For the following hardware and software components, only the listed manufacturer is recognized as providing the level of quality required. If the contractor wants to propose a non-listed manufacturer that is considered to provide an equivalent level of quality, this manufacturer shall be identified and supporting documentation provided. Acceptance of the manufacturer as a substitute will be at the discretion of the engineer.

<b>Component</b>	<b>Product</b>	<b>Manufacturer</b>
Pile Driving Modeling - Wave Equation Software	<u>GRLWEAP</u>	<u>Pile Dynamics, Inc.</u>
Pile Driving Monitoring - Hardware & Software	Pile Driving Analyzer - Model PAK	Pile Dynamics, Inc.
Pile Driving Analysis – Signal Matching Software	<u>CAPWAP</u>	<u>Pile Dynamics, Inc.</u>

**1.4 Test Requirements.** Dynamic pile testing shall be conducted in accordance with the standard test method indicated below.

<b>Standard Test Method</b>	<b>Designation</b>	<b>Conducted By</b>
High-Strain Dynamic Testing of Piles	ASTM D 4945	Contractor

**1.5 Qualifications.** The contractor shall perform dynamic pile testing utilizing the services of an independent dynamic pile testing consultant and qualified personnel. An engineer with a minimum of three years of dynamic pile testing and analysis experience or who has achieved Basic or better certification under the High-Strain Dynamic Pile Testing Examination and Certification process of the Pile Driving Contractors Association and Foundation QA shall perform pile driving monitoring. An engineer with a minimum of five years of dynamic pile testing and analysis experience or who has achieved Advanced or better certification under the High-Strain Dynamic Pile Testing Examination and Certification process of the Pile Driving Contractors Association and Foundation QA shall perform pile driving modeling and pile driving analyses.

**2.0 Execution.**

**2.1 Pile Driving Modeling.** The contractor shall perform preconstruction wave equation analyses and prepare a summary report of the results. The wave equation analyses shall be used to assess the ability of all proposed pile driving systems to install piles to the required capacity and the desired penetration depth within allowable driving stresses. The report shall include a drivability graph relating pile capacity, blow count and driving stresses to depth. The report shall include a bearing graph relating the pile capacity to the pile driving resistance. The bearing graph shall indicate blow count versus capacity and stroke. The report shall also

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contain a constant capacity analysis or inspectors chart to assist the engineer in determining the required driving resistance at other field observed strokes. The contractor shall perform wave equation analyses in accordance with [section 4.0](#) of this special provision. Acceptability of the wave equation report and the adequacy of analyses will be determined by the engineer.

**2.1.1** Approval by the engineer of the proposed pile driving system will be based upon the wave equation analyses indicating that the proposed system can develop the specified pile capacity at a pile driving rate of 2 to 10 blows per inch at the end of driving, and within allowable driving stresses per *AASHTO LRFD Bridge Construction Specifications*, Section 4.4.1. The contractor shall provide preliminary pile driving criteria based on wave equation analyses and any anticipated capacity changes after driving, set-up or relaxation, subject to revision based upon dynamic pile testing field measurements.

**2.1.2** If any changes or modifications are made to the approved pile driving system, additional wave equation analyses in accordance with [section 2.1](#) of this special provision shall be required.

**2.2 High-Strain Dynamic Pile Testing.**

**2.2.1** The contractor shall perform dynamic pile testing at the locations and frequency required in accordance with [section 4.0](#) of this special provision.

**2.2.2** Dynamic pile testing involves monitoring the response of a pile subjected to heavy impact applied by the pile hammer at the pile head. The testing shall provide information on the driving stresses, pile capacity, structural integrity and hammer efficiency.

**2.2.3** The contractor shall engage an independent dynamic pile testing consultant and qualified personnel in accordance with [section 1.5](#) of this special provision. Prior to testing, the engineer will review and approve the proposed independent dynamic pile testing consultant, the experience and qualifications of assigned personnel, details of the method of testing, a list of equipment, and the method of analysis of test results. The contractor shall provide all available details of the subsurface conditions, pile dimensions and properties, and pile driving systems to the independent dynamic pile testing consultant.

**2.2.4** All field testing and measurements shall be made in the presence of the engineer.

**2.3 Field Testing.**

**2.3.1 Equipment.** Dynamic pile testing field measurements shall be carried out using approved equipment, software and recording equipment. The data collected at the end of initial driving and the beginning of restrike shall be analyzed using approved signal matching techniques and software.

**2.3.2 Monitoring During Driving.** During pile driving, piles shall be instrumented and monitored with testing equipment satisfying the requirements of [section 1.3](#) of this special provision.

**2.3.2.1** The contractor shall install two sets of strain transducers and accelerometers near the top of each pile to be tested and shall use a compatible measuring and recording system to record the data during driving.

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**2.3.2.2** The equipment required to be attached to the pile shall be appropriately positioned and fixed to the approval of the engineer.

**2.3.2.3** The hammer and all site equipment used shall be capable of delivering an impact force sufficient to mobilize the specified pile capacity indicated in [section 4.0](#) of this special provision without damaging the pile.

**2.3.2.4** The testing equipment shall monitor pile stresses during driving to prevent pile damage and ensure pile integrity and capacity. If the testing equipment indicates overstressing or damage to the pile, the contractor shall immediately discontinue driving and notify the engineer.

**2.3.2.5** If the testing equipment determines that pile stresses during driving exceed acceptable levels, a new pile driving system, modifications to existing system or new pile installation procedures shall be proposed by the contractor. Approval by the engineer of any proposed changes to the pile driving system or pile installation procedures will be based upon the results of additional wave equation analyses in accordance with [section 2.1.2](#) of this special provision.

**2.3.3 Preparation of the Pile Head.** The preparation of the pile head for the application of dynamic test load shall involve, where appropriate, trimming the head, cleaning, and building up the pile using materials that shall, at the time of testing, safely withstand the impact stresses. The impact surface shall be flat and at right angles to the pile axis.

**2.3.4 Dynamic Measurement and Analysis.** Monitoring of pile driving shall begin when pile driving begins. The data shall be recorded and processed immediately in the field by the pile driving monitoring equipment and software. Unless monitoring indicates that additional driving will damage the pile, pile driving and monitoring shall continue until both the specified pile tip elevation and the specified pile capacity are reached. For each pile tested, pile driving analysis using signal matching techniques shall be performed for a selected blow at the end of driving to determine the relative capacities from end bearing and skin friction along the pile.

**2.3.4.1** Restrike tests shall be performed at the frequency indicated in [section 4.0](#) of this special provision. The time interval between end of initial driving and beginning of restrike shall be in accordance with [section 4.0](#) of this special provision. During restrike, the pile shall be instrumented and monitored similar to during initial driving. For each restrike test, pile driving analysis using signal matching techniques shall be performed for a selected blow from the beginning of restrike to determine the relative capacities from end bearing and skin friction along the pile.

**2.3.4.2** The restrike test shall be performed with a warmed-up hammer and shall consist of striking the pile for 20 blows or until the pile penetrates an additional 3 inches whichever occurs first unless testing equipment indicates overstressing or damage to the pile. If such overstressing or damage to the pile is indicated, the contractor shall immediately discontinue driving and notify the engineer. In the event initial restrike testing indicates a pile capacity below the specified capacity additional driving may be required as directed by the engineer.

**2.3.4.3** The engineer may request use of pile driving monitoring equipment and software on additional piles if inconclusive results are obtained or unusual driving conditions are encountered.

**2.3.4.4** Pile bearing capacity and integrity shall be evaluated based on the standard procedure used in practice.



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**2.3.4.5** Tabular records of the dynamic pile testing field measurements obtained at the end of initial driving and at the beginning of restrrike shall be immediately provided to the engineer by the contractor.

**2.3.5 Results.**

**2.3.5.1 Preliminary Reports.** The contractor shall prepare a preliminary report for each pile tested for review by the engineer. Each report shall contain tabular as well as graphical presentation of the dynamic test results versus depth. Each report shall also indicate the pile driving criteria for the additional piles to be installed at the substructure unit of the pile tested. Each preliminary report shall include the following:

- (a) The maximum force applied to the pile head.
- (b) The maximum pile head velocity.
- (c) The maximum energy imparted to the pile.
- (d) The assumed soil damping factor and wave speed.
- (e) Static capacity estimate.
- (f) The maximum compressive and tensile forces in the pile.
- (g) Pile integrity.
- (h) Blows per inch.
- (i) Stroke.
- (j) Summary results of pile driving analysis from selected blow analyzed using signal matching techniques and software.

**2.3.5.2 Summary Report.** The contractor shall prepare a summary report of all piles tested for review by the engineer. The report shall include the results of hammer performance, pile driving stresses, and pile capacity during initial driving and restrrike for all piles tested. The report shall also include the following:

- (a) Date of testing and date of pile installation.
- (b) Pile identification number and location.
- (c) All information given in preliminary reports as follows:
  - (1) Length of pile below commencing surface.
  - (2) Total length of pile, including projection above commencing surface at time of test.
  - (3) Length of pile from instrumentation position to tip.
- (d) Hammer type, drop and other relevant details.

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- (e) Blow selected for signal matching analysis.
- (f) Maximum compressive and tensile stresses, stroke, and capacity versus penetration depth.
- (g) Temporary compression.
- (h) Pile integrity and location of damage, if any.
- (i) Force/velocity versus time trace.
- (j) Force/velocity match curve.
- (k) Resistance distribution along the pile.
- (l) Detailed graphical and tabular results from blow analyzed using signal matching techniques and software.

**3.0 Schedule of Contract Submittals.**

<b>Item Number</b>	<b>Submittal Item</b>	<b>Type</b>	<b>Calendar Days</b>	<b>Event/Date</b>	<b>Liquidated Damages Apply</b>
1	Proposed independent dynamic pile testing consultant, and a listing of assigned personnel and their experience and qualifications.	DOCS	45 Before	Start of pile driving monitoring	No
2	Details of the components, method of testing, pile driving equipment and materials to be used, and the results of wave equations analyses.	DOCS	15 Before	Start of pile driving monitoring	No
3	Two copies of each Preliminary Report as defined in <a href="#">section 2.3.5.1</a> of this special provision	DOCS	3 After	Completion of each field test	No
4	Four copies of the Summary Report as defined in <a href="#">section 2.3.5.2</a> of this special provision	DOCS	7 After	Completion of all field tests	No

**4.0 High-Strain Dynamic Pile Testing Specification.**

<b>Item</b>	<b>Requirement</b>
Wave Equation Analysis	Minimum of one and sufficient additional analyses as needed to define performance for all combinations of piles, driving systems and subsurface conditions anticipated.

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<b>Item</b>	<b>Requirement</b>
Dynamic Testing Pile Capacity	Nominal Axial Pile Compressive Resistance or 2.25 times the Design Bearing shown on the plans or as required by engineer
End of Initial Driving Test Frequency	As shown in the contract plans
Restrike Test Frequency	As shown in the contract plans
Time Interval between End of Initial Driving and Restrike	Minimum of 7 days or as required by the engineer
Pile Driving Analyses using Signal Matching Techniques	For each End of Initial Driving Test and each Restrike Test

**5.0 Method of Measurement.** No measurement will be made.

**6.0 Basis of Payment.** Payment for the above described work, including all material, equipment, tools, labor and any other incidental work necessary to complete this item, will be considered completely covered by the contract unit price for Pile Wave Analysis.

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- A. CONSTRUCTION REQUIREMENTS
- B. DYNAMIC PILE TESTING

 <p>STATE OF MISSOURI              ☆ KEVIN J. BREHM ☆              PE-2010024490              PROFESSIONAL ENGINEER</p>	<p><b>MISSOURI HIGHWAYS AND                  TRANSPORTATION COMMISSION</b>                  105 W. CAPITOL AVE.                  JEFFERSON CITY, MO 65101                  Phone (888) 275-6636</p>
	<p><b>HR GREEN, INC.</b>                  520 Maryville Centre Dr., Suite 100                  St. Louis, MO 63141                  Certificate of Authority # 2002006608                  Consultant Phone # (636) 519-0990</p>
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	<p>JOB NO. JSE0127                  Stoddard County, MO                  Date Prepared: 2/4/2025</p>
	<p>Only the following items of the Job Special Provisions (Bridge) are authenticated by this                  seal: All</p>

JOB SPECIAL PROVISIONS (BRIDGE)

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A. CONSTRUCTION REQUIREMENTS

**1.0 Description.** This provision contains general construction requirements for this project.

**2.0 Construction Requirements.** The plans and the asbestos and lead inspection report for the existing structure(s) and the geotechnical report for the new structure(s) are included in the contract in the bridge electronic deliverables zip file for informational purposes only.

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**2.3** Provisions shall be made to prevent damage to any existing utilities. Any damage sustained to the utilities as a result of the contractor's operations shall be the responsibility of the contractor. All costs of repair and disruption of service shall be as determined by the utility owners and as approved by the engineer.

**3.0 Method of Measurement.** No measurement will be made.

**4.0 Basis of Payment.** Payment for the above described work will be considered completely covered by the contract unit price for other items included in the contract.

B. DYNAMIC PILE TESTING

**1.0 General.**

**1.1 Scope of Work.** Scope of work shall include furnishing all labor, equipment and analysis associated with dynamic testing of driven piles as specified in this special provision. Dynamic pile restrrike testing is not required on this project, and references to restrrike testing in this special provision will not apply.

**1.2 Performance and Design Requirements.** Performance and design conditions for dynamic testing of driven piles shall be in accordance with [section 4.0](#) of this special provision.

**1.3 Approved Manufacturers.** For the following hardware and software components, only the listed manufacturer is recognized as providing the level of quality required. If the contractor wants to propose a non-listed manufacturer that is considered to provide an equivalent level of quality, this manufacturer shall be identified and supporting documentation provided. Acceptance of the manufacturer as a substitute will be at the discretion of the engineer.

<b>Component</b>	<b>Product</b>	<b>Manufacturer</b>
Pile Driving Modeling - Wave Equation Software	<u>GRLWEAP</u>	<u>Pile Dynamics, Inc.</u>
Pile Driving Monitoring - Hardware & Software	Pile Driving Analyzer - Model PAK	Pile Dynamics, Inc.

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<b>Component</b>	<b>Product</b>	<b>Manufacturer</b>
Pile Driving Analysis – Signal Matching Software	<u>CAPWAP</u>	<u>Pile Dynamics, Inc.</u>

**1.4 Test Requirements.** Dynamic pile testing shall be conducted in accordance with the standard test method indicated below.

<b>Standard Test Method</b>	<b>Designation</b>	<b>Conducted By</b>
High-Strain Dynamic Testing of Piles	ASTM D 4945	Contractor

**1.5 Qualifications.** The contractor shall perform dynamic pile testing utilizing the services of an independent dynamic pile testing consultant and qualified personnel. An engineer with a minimum of three years of dynamic pile testing and analysis experience or who has achieved Basic or better certification under the High-Strain Dynamic Pile Testing Examination and Certification process of the Pile Driving Contractors Association and Foundation QA shall perform pile driving monitoring. An engineer with a minimum of five years of dynamic pile testing and analysis experience or who has achieved Advanced or better certification under the High-Strain Dynamic Pile Testing Examination and Certification process of the Pile Driving Contractors Association and Foundation QA shall perform pile driving modeling and pile driving analyses.

**2.0 Execution.**

**2.1 Pile Driving Modeling.** The contractor shall perform preconstruction wave equation analyses and prepare a summary report of the results. The wave equation analyses shall be used to assess the ability of all proposed pile driving systems to install piles to the required capacity and the desired penetration depth within allowable driving stresses. The report shall include a drivability graph relating pile capacity, blow count and driving stresses to depth. The report shall include a bearing graph relating the pile capacity to the pile driving resistance. The bearing graph shall indicate blow count versus capacity and stroke. The report shall also contain a constant capacity analysis or inspectors chart to assist the engineer in determining the required driving resistance at other field observed strokes. The contractor shall perform wave equation analyses in accordance with [section 4.0](#) of this special provision. Acceptability of the wave equation report and the adequacy of analyses will be determined by the engineer.

**2.1.1** Approval by the engineer of the proposed pile driving system will be based upon the wave equation analyses indicating that the proposed system can develop the specified pile capacity at a pile driving rate of 2 to 10 blows per inch at the end of driving, and within allowable driving stresses per *AASHTO LRFD Bridge Construction Specifications*, Section 4.4.1. The contractor shall provide preliminary pile driving criteria based on wave equation analyses and any anticipated capacity changes after driving, set-up or relaxation, subject to revision based upon dynamic pile testing field measurements.

**2.1.2** If any changes or modifications are made to the approved pile driving system, additional wave equation analyses in accordance with [section 2.1](#) of this special provision shall be required.

**2.2 High-Strain Dynamic Pile Testing.**

**2.2.1** The contractor shall perform dynamic pile testing at the locations and frequency required in accordance with [section 4.0](#) of this special provision.

**2.2.2** Dynamic pile testing involves monitoring the response of a pile subjected to heavy impact applied by the pile hammer at the pile head. The testing shall provide information on the driving stresses, pile capacity, structural integrity and hammer efficiency.

**2.2.3** The contractor shall engage an independent dynamic pile testing consultant and qualified personnel in accordance with [section 1.5](#) of this special provision. Prior to testing, the engineer will review and approve the proposed independent dynamic pile testing consultant, the experience and qualifications of assigned personnel, details of the method of testing, a list of equipment, and the method of analysis of test results. The contractor shall provide all available details of the subsurface conditions, pile dimensions and properties, and pile driving systems to the independent dynamic pile testing consultant.

**2.2.4** All field testing and measurements shall be made in the presence of the engineer.

### **2.3 Field Testing.**

**2.3.1 Equipment.** Dynamic pile testing field measurements shall be carried out using approved equipment, software and recording equipment. The data collected at the end of initial driving and the beginning of restrike shall be analyzed using approved signal matching techniques and software.

**2.3.2 Monitoring During Driving.** During pile driving, piles shall be instrumented and monitored with testing equipment satisfying the requirements of [section 1.3](#) of this special provision.

**2.3.2.1** The contractor shall install two sets of strain transducers and accelerometers near the top of each pile to be tested and shall use a compatible measuring and recording system to record the data during driving.

**2.3.2.2** The equipment required to be attached to the pile shall be appropriately positioned and fixed to the approval of the engineer.

**2.3.2.3** The hammer and all site equipment used shall be capable of delivering an impact force sufficient to mobilize the specified pile capacity indicated in [section 4.0](#) of this special provision without damaging the pile.

**2.3.2.4** The testing equipment shall monitor pile stresses during driving to prevent pile damage and ensure pile integrity and capacity. If the testing equipment indicates overstressing or damage to the pile, the contractor shall immediately discontinue driving and notify the engineer.

**2.3.2.5** If the testing equipment determines that pile stresses during driving exceed acceptable levels, a new pile driving system, modifications to existing system or new pile installation procedures shall be proposed by the contractor. Approval by the engineer of any proposed changes to the pile driving system or pile installation procedures will be based upon the results of additional wave equation analyses in accordance with [section 2.1.2](#) of this special provision.

**2.3.3 Preparation of the Pile Head.** The preparation of the pile head for the application of dynamic test load shall involve, where appropriate, trimming the head, cleaning, and building up the pile using materials that shall, at the time of testing, safely withstand the impact stresses. The impact surface shall be flat and at right angles to the pile axis.

**2.3.4 Dynamic Measurement and Analysis.** Monitoring of pile driving shall begin when pile driving begins. The data shall be recorded and processed immediately in the field by the pile driving monitoring equipment and software. Unless monitoring indicates that additional driving will damage the pile, pile driving and monitoring shall continue until both the specified pile tip elevation and the specified pile capacity are reached. For each pile tested, pile driving analysis using signal matching techniques shall be performed for a selected blow at the end of driving to determine the relative capacities from end bearing and skin friction along the pile.

**2.3.4.1** Restrike tests shall be performed at the frequency indicated in [section 4.0](#) of this special provision. The time interval between end of initial driving and beginning of restrike shall be in accordance with [section 4.0](#) of this special provision. During restrike, the pile shall be instrumented and monitored similar to during initial driving. For each restrike test, pile driving analysis using signal matching techniques shall be performed for a selected blow from the beginning of restrike to determine the relative capacities from end bearing and skin friction along the pile.

**2.3.4.2** The restrike test shall be performed with a warmed-up hammer and shall consist of striking the pile for 20 blows or until the pile penetrates an additional 3 inches whichever occurs first unless testing equipment indicates overstressing or damage to the pile. If such overstressing or damage to the pile is indicated, the contractor shall immediately discontinue driving and notify the engineer. In the event initial restrike testing indicates a pile capacity below the specified capacity additional driving may be required as directed by the engineer.

**2.3.4.3** The engineer may request use of pile driving monitoring equipment and software on additional piles if inconclusive results are obtained or unusual driving conditions are encountered.

**2.3.4.4** Pile bearing capacity and integrity shall be evaluated based on the standard procedure used in practice.

**2.3.4.5** Tabular records of the dynamic pile testing field measurements obtained at the end of initial driving and at the beginning of restrike shall be immediately provided to the engineer by the contractor.

### **2.3.5 Results.**

**2.3.5.1 Preliminary Reports.** The contractor shall prepare a preliminary report for each pile tested for review by the engineer. Each report shall contain tabular as well as graphical presentation of the dynamic test results versus depth. Each report shall also indicate the pile driving criteria for the additional piles to be installed at the substructure unit of the pile tested. Each preliminary report shall include the following:

- (a) The maximum force applied to the pile head.
- (b) The maximum pile head velocity.
- (c) The maximum energy imparted to the pile.
- (d) The assumed soil damping factor and wave speed.
- (e) Static capacity estimate.



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- (f) The maximum compressive and tensile forces in the pile.
- (g) Pile integrity.
- (h) Blows per inch.
- (i) Stroke.
- (j) Summary results of pile driving analysis from selected blow analyzed using signal matching techniques and software.

**2.3.5.2 Summary Report.** The contractor shall prepare a summary report of all piles tested for review by the engineer. The report shall include the results of hammer performance, pile driving stresses, and pile capacity during initial driving and restrike for all piles tested. The report shall also include the following:

- (a) Date of testing and date of pile installation.
- (b) Pile identification number and location.
- (c) All information given in preliminary reports as follows:
  - (1) Length of pile below commencing surface.
  - (2) Total length of pile, including projection above commencing surface at time of test.
  - (3) Length of pile from instrumentation position to tip.
- (d) Hammer type, drop and other relevant details.
- (e) Blow selected for signal matching analysis.
- (f) Maximum compressive and tensile stresses, stroke, and capacity versus penetration depth.
- (g) Temporary compression.
- (h) Pile integrity and location of damage, if any.
- (i) Force/velocity versus time trace.
- (j) Force/velocity match curve.
- (k) Resistance distribution along the pile.
- (l) Detailed graphical and tabular results from blow analyzed using signal matching techniques and software.

**3.0 Schedule of Contract Submittals.**

Item Number	Submittal Item	Type	Calendar Days	Event/Date	Liquidated Damages Apply
1	Proposed independent dynamic pile testing consultant, and a listing of assigned personnel and their experience and qualifications.	DOCS	45 Before	Start of pile driving monitoring	No
2	Details of the components, method of testing, pile driving equipment and materials to be used, and the results of wave equations analyses.	DOCS	15 Before	Start of pile driving monitoring	No
3	Two copies of each Preliminary Report as defined in <a href="#">section 2.3.5.1</a> of this special provision	DOCS	3 After	Completion of each field test	No
4	Four copies of the Summary Report as defined in <a href="#">section 2.3.5.2</a> of this special provision	DOCS	7 After	Completion of all field tests	No

**4.0 High-Strain Dynamic Pile Testing Specification.**

Item	Requirement
Wave Equation Analysis	Minimum of one and sufficient additional analyses as needed to define performance for all combinations of piles, driving systems and subsurface conditions anticipated.
Dynamic Testing Pile Capacity	Nominal Axial Pile Compressive Resistance or 2.25 times the Design Bearing shown on the plans or as required by engineer
End of Initial Driving Test Frequency	As shown in the contract plans
Restrike Test Frequency	As shown in the contract plans
Time Interval between End of Initial Driving and Restrike	Minimum of 7 days or as required by the engineer
Pile Driving Analyses using Signal Matching Techniques	For each End of Initial Driving Test and each Restrike Test

**5.0 Method of Measurement.** Dynamic pile testing will be measured per each.

**6.0 Basis of Payment.** Payment for the above described work, including all material, equipment, tools, labor and any other incidental work necessary to complete this item, will be considered completely covered by the contract unit price for Dynamic Pile Testing.