

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA UFGS-31 62 23.13 (April 2006)  
-----  
Preparing Activity: USACE Replacing without change  
UFGS-02455 (August 2004)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2007

\*\*\*\*\*

### SECTION TABLE OF CONTENTS

#### DIVISION 31 - EARTHWORK

#### SECTION 31 62 23.13

#### CAST-IN-PLACE CONCRETE PILES, STEEL CASING

04/06

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 BASIS FOR BIDS
- 1.3 BASIS OF PAYMENT
  - 1.3.1 Unit Price
  - 1.3.2 Full Compensation
  - 1.3.3 Load Tests
- 1.4 SUBMITTALS
- 1.5 QUALIFICATIONS
- 1.6 EQUIPMENT
  - 1.6.1 Pile Hammers
  - 1.6.2 Driving Helmets and Pile Cushions
- 1.7 EXISTING CONDITIONS

#### PART 2 PRODUCTS

- 2.1 MATERIALS
  - 2.1.1 Concrete
  - 2.1.2 Reinforcement
  - 2.1.3 Casings
    - 2.1.3.1 Uniform Taper
    - 2.1.3.2 Step-Taper
    - 2.1.3.3 Constant Section
    - 2.1.3.4 Combination Type

#### PART 3 EXECUTION

- 3.1 INSTALLATION
  - 3.1.1 Driving Pile Casings
    - 3.1.1.1 Driving Procedure
    - 3.1.1.2 Tolerance in Driving
    - 3.1.1.3 Jetting of Pile Casings
  - 3.1.2 Filling of Casings
  - 3.1.3 Cutting of Casings
  - 3.1.4 Welding

- 3.1.5 Splicing
- 3.2 FIELD TESTS AND INSPECTIONS
  - 3.2.1 Test Piles
    - 3.2.1.1 Pile Driving
    - 3.2.1.2 Load Tests
  - 3.2.2 Concrete Testing
- 3.3 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

-- End of Section Table of Contents --

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA UFGS-31 62 23.13 (April 2006)  
-----  
Preparing Activity: USACE Replacing without change  
UFGS-02455 (August 2004)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2007

\*\*\*\*\*

### SECTION 31 62 23.13

#### CAST-IN-PLACE CONCRETE PILES, STEEL CASING 04/06

\*\*\*\*\*

NOTE: This guide specification covers the requirements for procurement, installation, and testing of cast-in-place concrete piles utilizing steel casing.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

\*\*\*\*\*

## PART 1 GENERAL

### 1.1 REFERENCES

\*\*\*\*\*

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the

Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

\*\*\*\*\*

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2006; Errata 2006) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 252 (1998; R 2002) Standard Specification for Welded and Seamless Steel Pipe Piles

ASTM D 1143 (1981; R 1994e1) Piles Under Static Axial Compressive Load

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3 (2002) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

1.2 BASIS FOR BIDS

Bids shall be based on the number of piles as indicated, and on lengths from tip to cutoff as follows:

Number of piles	Length, meters feet
<hr/>	<hr/>
[_____]	[_____]

From the data obtained as a result of driving the test piles [and load tests] specified hereinafter, the Government will determine and will list for the Contractor the "calculated" pile tip elevations and the driving resistances for all piles. This list shall be used as the basis for ordering piles. Payment will be on the basis of length of piling from cutoff elevation to final tip elevation, established by the requirements specified elsewhere in this section. Should the total number of piles or the number of each length vary from that specified as the basis for bidding, an adjustment on the contract price and the time for completion will be made. If excavation is made adjacent to piling and below the grade indicated and if piling is driven before backfilling of over-excavation, no payment will be made for the length of piling equal to the depth of the over-excavation. No additional payment will be made for cutting off piles, for any portion of a pile remaining above cutoff elevation, or for broken, damaged, or rejected piles.

### 1.3 BASIS OF PAYMENT

\*\*\*\*\*  
NOTE: Where the basis for bidding is based on unit price, this paragraph should be used instead of paragraph BASIS FOR BIDS.  
\*\*\*\*\*

#### 1.3.1 Unit Price

The Contracting Officer reserves the right to increase or decrease the total length of piles to be furnished and installed, by changing the foundation pile locations or elevations, requiring the installation of additional piles, or requiring omission of piles from the requirements shown and specified. Whether or not such changes are made, the Contractor will be paid at the contract unit price per linear meter foot (including control test piles), multiplied by the total linear meters feet of acceptable piles actually installed.

#### 1.3.2 Full Compensation

Payment in accordance with the above paragraph, "Unit Price," shall constitute full compensation for furnishing, delivering, handling, and/or installing (as applicable) all material, labor and equipment necessary to meet contract requirements applicable to the foundation piles. The Contractor will not be allowed payment for withdrawn, broken or rejected piles, nor (except for control test piles) for a portion of any pile remaining above the cut-off point.

#### 1.3.3 Load Tests

The contract includes [\_\_\_\_\_] pile load tests. The Contracting Officer reserves the right to increase or decrease the number of pile tests. Adjustments in the contract price will be made for such increases or decreases by the amounts bid for "Additional Pile Load Test" or "Omitted Pile Load Test."

### 1.4 SUBMITTALS

\*\*\*\*\*  
NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority.

Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

\*\*\*\*\*

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

##### Installation

Drawings demonstrating compliance of driving equipment and steel casing with contract documents. Drawings shall include shop and erection details, casing details, end closures, splices, driving helmets, and reinforcement.

##### Driving Pile Casings

A complete and accurate record of each driven pile, within 3 days of completion of driving. The record shall indicate the pile location (as driven), driven length, embedded length, final elevations of tip and top, pile weight, butt and tip diameter, quantity and strength of concrete used in each pile, number of splices and locations, blows required for each meter foot of penetration throughout the entire length of the pile and for the final 150 mm 6 inches of penetration, and the total driving time. The record shall also include the type and size of the hammer used, the rate of operation, and the type and dimensions of driving helmet, pile cushion, and cap block used. Any unusual conditions encountered during pile installation shall be recorded and immediately reported to the Contracting Officer.

#### SD-03 Product Data

##### Equipment

Descriptions of all pile driving equipment to be employed in the work, prior to commencement of pile installations. This shall include details of the pile hammer, power plant, leads, pile cushion, cap block, and helmet.

#### SD-06 Test Reports

##### Test Piles.

A complete report on the load test, within [seven] [\_\_\_\_\_] days of completion of load test, including, but not limited to, a description of the pile driving equipment, driving records for both test piles and reaction piles, complete test data, analysis of test data, and recommended allowable design loads based on the load test results. The report shall be prepared by or under the direct supervision of a registered professional engineer experienced in pile load testing and load test analysis.

## 1.5 QUALIFICATIONS

The work shall be performed by a general Contractor or a specialty subcontractor specializing in the specified foundation system and having experience installing the specified foundation system under similar subsurface conditions.

## 1.6 EQUIPMENT

### 1.6.1 Pile Hammers

The hammer used shall have a delivered energy suitable for the total weight of the pile, the character of subsurface material to be encountered, and the pile capacity to be developed. The driving energy of the hammer shall be not less than [\_\_\_\_\_] ~~newton-meters~~ foot-pounds.

### 1.6.2 Driving Helmets and Pile Cushions

A driving helmet, cap block, and pile cushion shall be used between the top of the pile and the ram to prevent impact damage to the pile. The driving helmet, cap block and pile cushion combination shall be capable of protecting the head of the pile, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over the top of the pile. The driving helmet shall fit loosely around the top of the pile so that the pile is not restrained if the pile tends to rotate during driving. The pile cushion and cap block may be of solid wood or of laminated construction using plywood, softwood, or hardwood boards or other cushion material as approved by the Contracting Officer. The pile cushion shall completely cover the top surface of the pile and shall be retained by the driving helmet. The minimum thickness of the pile cushion and of the cap block shall be ~~76.2 mm~~ 3 inches each and the thickness shall be increased so as to be suitable for the size and length of pile, character of subsurface material encountered, hammer characteristics, and required driving resistance.

## 1.7 EXISTING CONDITIONS

Subsurface soil data logs are shown [on the drawings] [in the specifications]. The subsurface investigation reports [and samples of materials as taken from subsurface investigations] are available for examination at [\_\_\_\_\_] .

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Concrete

\*\*\*\*\*  
**NOTE: Delete or modify second sentence when the job**

is small or the existence of certified plants is beyond acceptable distance of small jobs. Insert the ultimate compressive strength required by design.

\*\*\*\*\*

Materials, mixing, and placing of concrete shall conform with the requirement of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Minimum compressive strength at 28 days shall be [\_\_\_\_\_] MPa psi. Maximum coarse aggregate size shall be 19 mm 3/4 inch.

#### 2.1.2 Reinforcement

\*\*\*\*\*

NOTE: Reinforcement should be required for the unsupported sections of piles, for uplift or tension piles, for piles exposed to high bending stresses not resisted by batter piles, and for anchoring the top of the pile to the pile cap or slab. Tension or uplift piles shall be reinforced throughout their entire length.

\*\*\*\*\*

Materials, assembly, and placement of reinforcement shall conform to the requirements of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. Reinforcement shall be assembled and placed in the casing as a unit as detailed and scheduled.

#### 2.1.3 Casings

\*\*\*\*\*

NOTE: Closed-end steel pipes should generally be used. Open-end steel pipes should be considered where:

- a. It is important to avoid soil displacement as in piles driven adjacent to existing structures.
- b. Soil conditions indicate a dense or clayey soil, or extremely coarse granular soil is present, such as gravel.

Where open-end pipes are specified, concrete should not be placed until all soil, water and foreign material are removed from inside casing.

\*\*\*\*\*

Casings shall be of steel of sufficient strength to prevent harmful distortions during driving, after completion of driving, and during driving of adjacent casings. Casings driven without the use of an internal mandrel shall have walls of a thickness sufficient to withstand the driving stresses. Casings shall be closed at the tip, except for steel pipe casings conforming to ASTM A 252 that may be open-end driven. Joints and tip connections shall be watertight. Nominal circumference at any cross-section in length shall be circular, whether or not modified by helical corrugations or flutings. Casings shall be left permanently in place and shall be of any one of the following types or combination of types; but only one type or combination shall be used throughout.



#### 2.1.3.1 Uniform Taper

Diameter shall increase from tip to cutoff at a uniform rate. Minimum nominal diameter at tip and two-third points above tip shall be as indicated.

#### 2.1.3.2 Step-Taper

Section increments shall increase in diameter uniformly. Minimum nominal diameter at tip and two-third points above tip shall be as indicated.

#### 2.1.3.3 Constant Section

Steel pipes, conforming to **ASTM A 252**, Grade 2, may be used in lieu of casings of constant section. Minimum nominal diameter shall be as indicated.

#### 2.1.3.4 Combination Type

Combination type cast-in-place concrete piles, steel casing, may be any of the following or other types, depending upon design criteria. Specification requirements shall be in accordance with applicable paragraphs of this section.

- a. Steel pipe lower section with metal casing taper or constant-diameter upper section.
- b. Constant-diameter or tapered lower section with tapered upper section.
- c. Tapered lower section with constant-diameter upper section.

### PART 3 EXECUTION

#### 3.1 INSTALLATION

##### 3.1.1 Driving Pile Casings

##### 3.1.1.1 Driving Procedure

\*\*\*\*\*

**NOTE:** The next-to-last sentence, concerning tip elevation and driving resistance, should be edited to conform to subsurface conditions and type of pile (friction or end bearing).

Insert the radius distance (3 to 6 meters (10 to 20 feet)) and the time (2 to 7 days). No concrete shall be placed in any pile until all other casings within a radius of 3 to 6 meters (10 to 20 feet) have been driven and inspected.

\*\*\*\*\*

Excavation shall be stopped at 300 mm (1 foot) above foundation grade before casings are driven. When pile driving is completed, excavation shall be completed to lines and grades shown. Permanent pile casings shall be driven without interruption to the "calculated" tip elevation to reach a driving resistance in accordance with the schedule which the Government will prepare from the test-pile driving data. The pile hammer used for

driving shall be the same type and operated at the same rate and in the same manner as that used for driving the test piles. Diesel powered hammers shall be operated at the rate recommended by the manufacturer throughout the entire driving period. Sufficient pressure shall be maintained at the steam hammer so that:

- a. For a double-acting hammer, the number of blows per minute during and at the completion of driving of a pile is equal approximately to that at which the hammer is rated.
- b. For a single-acting hammer, there is a full upward stroke of the ram.
- c. For a differential-type hammer, there is a slight rise of the hammer base during each upward stroke.

A new pile cushion shall be used at the start of driving for each pile and the cushion shall be replaced whenever it has become highly compressed, charred, burned, or deteriorated in any manner during driving. The Contracting Officer shall be notified, and will determine what procedure shall be followed, if a pile reaches the "calculated" pile tip elevation without reaching the required driving resistance; or if the required driving resistance is reached before the "calculated" pile tip elevation. Casings will not be driven within a radius of [\_\_\_\_\_] mfeet of any other casing in which the concrete and reinforcement has been placed for less than [\_\_\_\_\_] days.

#### 3.1.1.2 Tolerance in Driving

Casings shall be driven with a variation of not more than 20 mm per m 0.25 inch per foot of pile length from the vertical. Butts shall be within 100 mm 4 inches of the location indicated. Manipulation of casings to force them into position will not be permitted. Casings shall be checked by the Contractor for heave, after all piles are driven in a cluster or under any conditions of relatively close spacing; those found to have heaved shall be redriven to the required tip elevation. The center of gravity of each group of footing piles shall be maintained by templates or other approved means to conform to locations shown. Casings damaged, mislocated, or driven out of alignment shall be replaced or additional casings driven as directed.

#### 3.1.1.3 Jetting of Pile Casings

\*\*\*\*\*

NOTE: Jetting should generally not be permitted for piles:

- a. Dependent on side friction in fine-grained, low-permeability soils (high clay or silt content) where considerable time is required for soil to reconsolidate around the piles.
- b. Subject to uplift.
- c. Adjacent to existing structures.
- d. In closely spaced clusters unless the load capacity is confirmed by test and unless all jetting is done before final driving of any pile in the

cluster.

\*\*\*\*\*

Jetting of pile casings [may be used when permitted by the Contracting Officer] [will be permitted by the Contracting Officer as indicated] [will not be permitted]. [Jetting shall be discontinued when the pile tip is approximately 1.5 m 5 feet above the "calculated" pile tip elevation and the final 1.5 m 5 feet of penetration shall be made by driving. Before commencing with the driving of the final 1.5 meters 5 feet, the pile casing shall be firmly seated in place by the application of a number of reduced energy hammer blows.]

#### 3.1.2 Filling of Casings

Each casing shall be visually inspected by the Contractor after its final installation and prior to depositing the concrete and placing the reinforcement. The Contracting Officer shall be notified prior to each such inspection to allow for quality assurance inspections of all casings. The inspection will verify the integrity of the casing throughout its length and the absence of distortion and reduction in area. Concrete shall be deposited in the casing in a continuous operation by means of a funnel or hopper; after all mud, water and other extraneous material has been removed from its interior.

#### 3.1.3 Cutting of Casings

Cutting of casings shall be with an acetylene torch or saw with prior approval by the Contracting Officer.

#### 3.1.4 Welding

Shop and field welding, qualification of welders, and inspection of welds shall be in accordance with AWS D1.1/D1.1M.

#### 3.1.5 Splicing

Splices may be used after review by the Contracting Officer. No more than two splices per full length of casing will be permitted. They shall be able to transmit any vertical and lateral forces adequately, and in addition, shall develop no less than 50 percent of the flexural capacity of the ordinary pile casing cross section. Lateral joints shall be made with a continuous full penetration butt weld in accordance with AWS D1.1/D1.1M or as approved by the Contracting Officer.

### 3.2 FIELD TESTS AND INSPECTIONS

#### 3.2.1 Test Piles

##### 3.2.1.1 Pile Driving

\*\*\*\*\*

NOTE: Insert the number of test piles required. A minimum of three driving tests should be made; and possibly more, where subsurface conditions are questionable.

\*\*\*\*\*

Test piles shall be driven in the manner specified for all piling elsewhere in this section. A record shall be kept for each test pile of the number

of blows required for each foot of penetration throughout the entire length of the pile, the penetration per blow at such intervals as directed, and the number of blows for the final 150 mm 6 inches of penetration. The record shall include the type and size of the hammer used, the rate of operation, and the type and dimensions of casings. Any unusual occurrence during driving of the pile casing and any increase and decrease of driving resistance shall be recorded by the Contractor and brought to the attention of the Contracting Officer. The Government will use load test and test pile data to determine the "calculated" pile tip elevation and the necessary driving resistance. [ ] test piles shall be driven in the locations indicated, with surrounding earth at the elevations shown. Test piles properly driven and located and with adequate driving resistance may be used in the finished work. Jetting will be permitted by the Contracting Officer only when test pile driving clearly establishes the validity of its use.

### 3.2.1.2 Load Tests

\*\*\*\*\*

NOTE: Delete this paragraph for projects for which load testing is not specified. Insert the number of piles to be load tested. The provisions of ASTM D 1143, such as pile set-up time after driving, test load, method of applying load, loading and unloading procedures, instrumentation, etc., should be carefully examined and modified as necessary to fit the specific load test being conducted. When it is desirable to show analysis for determination of pile capacities from load tests and for relating load test capacities to job capacities, the following shall be included:

a. Test Measurements: The ultimate test load shall be maintained for not less than 24 hours and then released. The safe design capacity of a test pile as determined from the results of load tests shall be the lesser of the two values computed according to the following:

(1) One-half the load that causes a net settlement after rebound of not more than 0.23 mm per metric ton (0.01-inch per ton) of total test load.

(2) One-half the load that causes a gross settlement of not more than 25 mm (1 inch) provided that the load settlement curve shows no sign of failure.

b. Pile Capacity: The capacity, as driven, of single piles not in clusters in the structure shall be not less than [ ] metric ton (tons). The capacity will be determined by the following formulas, modified according to the data obtained by the load tests:

For single-acting hammers:  $R = 166.7WH / (s + 2.54P/W)$   
( $R = 2WH / (s + 0.1P/W)$ )

For double-acting hammers:  $R = 166.7E / (s + 0.1P/W)$

$$(R = 2E/(s=0.1P/W))$$

Where: R is the allowable static pile load in newtons (pounds).

W is the weight of the striking part of the hammer in newtons (pounds).

H is the effective height of fall in meters (feet).

E is the actual energy delivered by the hammer per blow in newton-meters (foot-pounds).

S is the average net penetration in millimeters (inches) per blow for the last five blows after the pile has been driven to a depth where successive blows produce approximately equal net penetration a minimum distance of 1 meter (3 feet) for friction piles.

P is the weight of the pile in newtons (pounds). If P is less than W, P/W shall be taken as unity.

Dynamic pile stresses should not exceed the crushing strength of piles.

\*\*\*\*\*

Load tests shall be in accordance with [ASTM D 1143](#), [\_\_\_\_\_] loading method.

The apparatus for applying the vertical loads shall be as given by the method, either for load supported directly by the pile, or load from weighted box or platform or reaction frame attached to sufficient uplift piles to take safely the required load applied to the pile by hydraulic jack. The load tests at locations shown or directed shall be made on test piles driven to the tip elevation used for establishing lengths of piles for bidding, except as otherwise directed. Additional load test, at the expense of the Government, may be required. Pile shall have been in a place a minimum of 3 days before loading. Loading, testing, and recording of data shall be under the direct supervision of a registered professional engineer. The analysis of the load test data shall be done by the registered professional engineer. The registered professional engineer shall be provided and paid for by the Contractor.

### 3.2.2 Concrete Testing

\*\*\*\*\*

NOTE: The following table is recommended for use in determining the number of test cylinders required in relation to the size of each lot of piles to be tested.

File Lot	Number of Test Cylinders
25	2
100	4
1,000	20
5,000	50
10,000	100

Samples taken from random batches of concrete.

\*\*\*\*\*

During Concrete placement, strength tests will be made by a testing service provided and paid for by the Contractor in accordance with requirements of Section 03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE. At least two specimens shall be taken from each random batch and one test will be made for every [\_\_\_\_\_] piles with no less than two tests for any 1 day's operation.

### 3.3 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

\*\*\*\*\*

NOTE: Include this paragraph only when special inspection and testing for seismic-resisting systems is required by paragraph 3.2 of FEMA 302, NEHRP RECOMMENDED PROVISIONS FOR SEISMIC REGULATIONS FOR NEW BUILDINGS AND OTHER STRUCTURES.

This paragraph will be applicable to both new buildings designed according to UFC 3-310-03A SEISMIC DESIGN FOR BUILDINGS, and to existing building seismic rehabilitation designs done according to UFC 3-301-05A SEISMIC EVALUATION AND REHABILITATION FOR BUILDINGS.

The designer must indicate on the drawings all locations and all features for which special inspection and testing is required in accordance with Chapter 3 of FEMA 302. This includes indicating the locations of all structural components and connections requiring inspection.

Add any additional requirements as necessary.

\*\*\*\*\*

Special inspections and testing for seismic-resisting systems and components shall be done in accordance with Section 01 45 35 SPECIAL INSPECTION FOR SEISMIC-RESISTING SYSTEMS.

-- End of Section --