September 12, 2008

TO: **PARTIES INTERESTED IN EVALUATION REPORTS ON BELLED SEGMENTED PIPE FOUNDATION SYSTEMS AND DEVICES**

SUBJECT: Proposed Acceptance Criteria for Belled Segmented Pipe Foundation Systems and Devices, Subject AC406-1008-R1, (MO/BG)

Hearing Information:
Wednesday, October 22, 2008
8:00 a.m.
Holiday Inn, Albany on Wolf Road
205 Wolf Road
Albany, New York 12205
(800) 465-4329

Dear Madam or Sir:

The subject proposed new acceptance criteria will be on the agenda for the Evaluation Committee meeting noted above. The criteria is a proprietary product criteria covering belled segmented steel pipe foundation systems and devices. The foundation system consists of segmented steel pipe sections, a steel bracket connection device attached to the structure, a coupler device for joining steel pipe segments, and a steel bullet assembly that is advanced into the soil by pressure and expands to an increased bearing area at the final depth.

The proposed criteria is based on the ICC-ES Acceptance Criteria for Helical Foundation Systems and Devices (AC358), approved June 2007. Sections where the proposed criteria differs from AC358 are noted as follows: The belled segmented pipe foundation system is described in Section 1.4.1 of the criteria; design, testing and performance for the bracket assembly are covered in Sections 3.2, 3.10 and 4.1; segmented pipe sections are covered in Sections 3.3, 3.11 and 4.2; the bullet assembly is covered in Sections 3.4, 3.12 and 4.3; and soil bearing capacity of the foundation system is covered in Sections 3.5, 3.13 and 4.4.

So the committee can consider the requirements for the proprietary product alone, AC406 is offered as a separate document; however, it is staff's intent to consolidate this criteria, if approved, with AC358. Product definitions, testing and performance requirements that are unique to each foundation system will be located in appropriate appendices. General requirements covering both foundation systems will be in the body of AC358.

Attached to this cover letter are photos of the components of the proprietary system.

You are cordially invited to submit written comments on agenda items, or to attend the Evaluation Committee hearing and present verbal comments. If you wish to contribute to the hearing, please note the following:

1. Written comments that are received by the Los Angeles business/regional office by **October 7, 2008,** will be forwarded to the committee prior to the hearing, and will be posted on the ICC-ES web site shortly after the comment deadline.

2. Written comments received up to ten days before the meeting, and staff memos responding to comments, will be posted to the web site on **October 16, 2008**.

3. ICC-ES is no longer providing printed copies at the meeting of proposed acceptance criteria, staff memos or public comments. These documents will be available on a limited number of CDs at the meeting, for uploading to computers; and ICC-ES will make arrangements with the hotel business center to have hard copies available for photocopying.

4. Written comments that miss the deadline noted in item (1), above, will only be available at the meeting if you provide 35 copies, collated, stapled, and three-hole punched, either at the meeting itself or to the Los Angeles business/regional office by **October 16, 2008**.

5. If you plan to speak for more than 15 minutes, or offer a visual presentation lasting longer, you should notify ICC-ES staff as far as possible in advance. There will be a computer, projector, and screen available at the meeting for anyone wishing to make a visual presentation, and presentations in most cases will need to be in PowerPoint format. Also, ICC-ES will need to be provided with your presentation at least a half-hour before the start of the relevant meeting session (morning or afternoon) on either a CD or a flash card.

6. If you have any special needs related to a presentation, you should contact ICC-ES staff well in advance of the meeting.

7. Any visual aids for viewing at committee meetings (charts, overhead transparencies, slides, videos, electronic presentations, etc.) will be permitted only if a copy is provided to ICC-ES, before the presentation, in a medium that can be retained with other records of the meeting.

8. Any materials submitted for committee consideration are considered nonconfidential and available for public discussion, as noted in Section 2.7 of the ICC-ES Rules of Procedure for the Evaluation Committee.

9. Prior to the meeting, you should refrain from trying to communicate directly with committee members about agenda items, either verbally or in writing. Committee members reserve the right to refuse such communications.

Your cooperation with these guidelines is much appreciated, as is your interest in the deliberations of the Evaluation Committee. If you have any questions, please contact the undersigned at (800) 423-6587, extension 5685. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

Michael P. O'Reardon, P.E.
Senior Staff Engineer

MPO/raf

Enclosures

cc: Evaluation Committee

ICC EVALUATION SERVICE, INC., RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

1.0 PURPOSE

The purpose of the Evaluation Committee is to monitor the work of ICC-ES, in issuing evaluation reports; to evaluate and approve acceptance criteria on which evaluation reports may be based; and to sponsor related changes in the applicable codes.

2.0 MEETINGS

2.1 The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1, subject to Section 3.

2.2 All scheduled meetings shall be publicly announced.

2.3 Two-thirds ($^2/_3$) of the voting Evaluation Committee members shall constitute a quorum. A majority vote of members present is required on any action.

2.4 In the absence of the nonvoting chairman-moderator, Evaluation Committee members present shall elect an alternate chairman from the committee for that meeting. The alternate chairman shall be counted as a voting committee member for purposes of maintaining a committee quorum and to cast a tie-breaking vote of the committee.

2.5 Minutes of the meetings shall be kept.

2.6 An electronic audio record of meetings shall be made by ICC-ES; no other audio, video, electronic or stenographic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, overhead transparencies, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before presentation with a copy of the visual aid in a medium which can be retained by ICC-ES with its record of the meeting and which can also be provided to interested parties requesting a copy. A copy of the ICC-ES recording of the meeting and such visual aids, if any, will be available to interested parties upon written request made to ICC-ES together with a payment as required by ICC-ES to cover costs of preparation and duplication of the copy. These materials will be available beginning five days after the conclusion of the meeting but will no longer be available after one year from the conclusion of the meeting.

2.7 Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members regarding agenda items. All written communications and submissions regarding agenda items should be delivered to ICC-ES. All such written communications and submissions shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting, and shall be delivered at least ten days before the scheduled Evaluation Committee meeting if they are to be forwarded to the committee. Materials delivered to ICC-ES at least ten days before the scheduled meeting will be posted on the ICC-ES web site (www.icc-es.org) prior to the meeting. After this time, parties wishing to submit materials for consideration by the Evaluation Committee must deliver a sufficient number of copies as directed by ICC-ES. Consideration of materials not received by ICC-ES at least ten days before the meeting is at the discretion of the Evaluation Committee. Following the meeting, ICC-ES will make all materials considered by the Evaluation Committee available on the web site for a maximum period of one year following the meeting. The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

3.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that the chairman may call for a closed session to seek advice of counsel.

4.0 ACCEPTANCE CRITERIA

4.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes.

Acceptance criteria may involve a product, material, method of construction, or service. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the Evaluation Committee.

4.2 Procedure:

4.2.1 Proposed acceptance criteria shall be developed by the ICC-ES staff and discussed in open session with the Evaluation Committee during a scheduled meeting, except as permitted in Section 5.0 of these rules.

4.2.2 Proposed acceptance criteria shall be available to interested parties at least 30 days before discussion at the committee meeting.

4.2.3 The committee shall be informed of all pertinent written communications received by ICC-ES.

4.2.4 Attendees at Evaluation Committee meetings shall have the opportunity to speak on acceptance criteria listed on the meeting agenda, to provide information to committee members.

4.3 Approval of acceptance criteria shall be as specified in Section 2.3 of these rules.

4.4 Actions of the Evaluation Committee may be appealed in accordance with the ICC-ES Rules of Procedure for Appeal of Acceptance Criteria or the ICC-ES Rules of Procedure for Appeals of Evaluation Committee Technical Decisions.

5.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA

5.1 Acceptance criteria may be issued without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee when, in the opinion of ICC-ES staff, one or more of the following conditions have been met:

1. The subject is nonstructural, does not involve life safety, and is addressed in nationally recognized standards or generally accepted industry standards.

2. The subject is a revision to an existing acceptance criteria that requires a formal action by the Evaluation Committee, and public comments raised were resolved by staff with commenters fully informed.

3. Other acceptance criteria and/or the code provide precedence for the revised criteria.

5.2 Negative votes must be based upon one or more of the following, for the ballots to be considered valid and require resolution:

a. *Lack of clarity*: There is insufficient explanation of the scope of the acceptance criteria or insufficient description of the intended use of the product or system; or the acceptance criteria is so unclear as to be unacceptable. (The areas where greater clarity is required must be specifically identified.)

b. *Insufficiency*: The criteria is insufficient for proper evaluation of the product or system. (The provisions of the criteria that are in question must be specifically identified.)

c. *The subject of the acceptance criteria is not within the scope of the applicable codes*: A report issued by ICC-ES is intended to provide a basis for approval under the codes. If the subject of the acceptance criteria is not regulated by the codes, there is no basis for issuing a report, or a criteria. (Specifics must be provided concerning the inapplicability of the code.)

d. *The subject of the acceptance criteria needs to be discussed in a public hearings*. The committee member requests additional input from other committee members, staff or industry.

5.3 An Evaluation Committee member, in voting on an acceptance criteria, may only cast the following ballots:

- Approved
- Approved with Comments
- Negative: Do Not Proceed

6.0 COMMITTEE COMMUNICATION

Direct communication between committee members, and between committee members and an applicant or concerned party, with regard to the processing of a particular acceptance criteria or evaluation report shall take place only in a public hearing of the Evaluation Committee. Accordingly:

6.1 Committee members receiving an electronic ballot should respond only to the sender (staff). Committee members who wish to discuss a particular matter with other committee members, before reaching a decision, should ballot accordingly and bring the matter to the attention of ICC-ES staff, so the issue can be placed on the agenda of a future committee meeting.

6.2 Committee members who are contacted by an applicant or concerned party on a particular matter that will be brought to the committee will refrain from private communication and will encourage the applicant or concerned party to forward their concerns through the ICC-ES staff in writing, and/or make their concerns known by addressing the committee at a public hearing, so that their concerns can receive the attention of all committee members.■

Effective March 18, 2008

PROPOSED ACCEPTANCE CRITERIA FOR BELLED SEGMENTED PIPE FOUNDATION SYSTEMS AND DEVICES

AC406

Proposed September 2008

PREFACE

Evaluation reports issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard Codes. Section 104.11 of the International Building Code® reads as follows:

> The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes, the National Codes, and the Standard Codes.

ICC-ES may consider alternate criteria, provided the report applicant submits valid data demonstrating that the alternate criteria are at least equivalent to the criteria proposed in this document, and otherwise meet the applicable performance requirements of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria proposed in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise meet the applicable performance requirements of the codes, ICC-ES retains the right to refuse to issue or renew an evaluation report, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

Acceptance criteria are developed for use solely for purposes of issuing ICC-ES evaluation reports.

PROPOSED ACCEPTANCE CRITERIA FOR BELLED SEGMENTED PIPE FOUNDATION SYSTEMS AND DEVICES

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for belled segmented pipe foundation systems and belled segmented pipe foundation devices to be recognized in ICC Evaluation Service, Inc. (ICC-ES), evaluation reports under the 2006 *International Building Code*® (IBC) and the 1997 *Uniform Building Code* (UBC). Bases for recognition are IBC Section 104.11 and UBC Section 104.2.8. Applicable code sections are IBC Sections 1801 (Foundation and Soils Investigations), 1802.2.4 (Pile and pier foundations), 1808 (Pier and Pile Foundations), 1809 (Driven Pile Foundations), 1809.3 (Structural Steel Piles), and 1810.8 (Micopiles).

The reason for the development of this acceptance criteria is to supplement general requirements for pile foundations in the IBC and UBC to permit evaluation of belled segmented pipe foundation systems and devices.

1.2 Scope: This criteria provides methods to establish the allowable load and deformation capacities of belled segmented pipe foundation systems and devices used to resist axial compression, axial tension or lateral loads. This criteria applies to belled segmented pipe foundation systems and devices as defined in Section 1.4, and includes provisions for determining soil capacity.

This criteria is limited to belled segmented pipe foundation systems and devices used under the following conditions:

1.2.1 Support of structures in IBC Seismic Design Categories A, B, or C, or UBC

Seismic Zones 0, 1 or 2, only.

1.2.2 Exposure conditions to soil that are not indicative of potential pile deterioration or corrosion situations as defined by the following: (1) soil resistivity less than 1,000 ohm-cm; (2) soil pH less than 5.5; (3) soils with high organic content; (4) soil sulfate concentrations greater than 1,000 ppm; (5) soils located in landfills, or (6) soil containing mine waste.

1.2.3 Belled segmented pipe devices manufactured from carbon steel, with optional zinc or powder coatings.

1.3 Codes and Referenced Standards: Where standards are referenced in this criteria, these standards shall be applied consistently with the code (IBC and/or UBC) upon which compliance is based in accordance with Table 1.

1.3.1 2006 *International Building Code*® (IBC), International Code Council.

1.3.2 1997 *Uniform Building Code* (UBC).

1.3.3 ICC-ES Acceptance Criteria for Corrosion Protection of Steel Foundation Systems Using Polymer (EAA) Coatings (AC228).

1.3.4 ACI 318-05, Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.5 ANSI/AISC 360-05, Specification for Structural Steel Buildings, American Institute of Steel Construction.

1.3.6 ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings, including Supplement No. 1 dated 2006, American Institute of Steel

Construction.

1.3.7 ANSI/ASME B18.2.6-96, Fasteners for Use in Structural Applications, American Society of Mechanical Engineers

1.3.8 ANSI/AWS D1.1/D1.1M, Structural Welding Code—Steel (AWS D1. 1 /D1 .1 M), American Welding Society.

1.3.9 ASTM International:

1.3.9.1 ASTM A 36/A36M-04a, Standard Specification for Carbon Structural Steel.

1.3.9.2 ASTM A 53/A53M-07, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

1.3.9.3 ASTM A 500/A500M-07, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

1.3.9.4 ASTM A 501-07, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

1.3.9.5 ASTM A 618/A618M-04, Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing.

1.3.9.6 ASTM A 847/A847M-05, Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance.

1.3.9.7 ASTM A 123/A123M-02, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

1.3.9.8 ASTM A 153/A153M-05, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.3.9.9 ASTM B 633-07, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

1.3.9.10 ASTM B 695-04, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

1.3.9.11 ASTM C 31/C31M-98, Standard Practice for Making and Curing Concrete Test Specimens in the Field.

1.3.9.12 ASTM C 39/C39M-03, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

1.3.9.13 ASTM C 109/C109M-05, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or (50 mm) Cube Specimens.

1.3.9.14 ASTM C 191-07, Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle.

1.3.9.15 ASTM D 1143-81 (1994)e1 , Standard Test Method for Piles Under Static Axial Compressive Load.

1.3.9.16 ASTM D 1586-99, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

1.3.9.17 ASTM D 3689-90 (1995), Standard Test Method for Individual Piles Under Static Axial Tensile Load.

1.3.9.18 ASTM D 3966-90 (1995), Standard Test Method for Piles Under Lateral Loads.

1.4 Definitions: Terminology herein is based on the Glossary of the AISC and the following definitions:

1.4.1 Belled Segmented Pipe Foundation System: A steel foundation with factory-manufactured steel devices designed to resist axial compression, axial tension, and/or lateral loads from structures, consisting of a bullet assembly with one or more segmented pipe sections, couplers, and a bracket. The bullet assembly is advanced into the ground by application of pressure against the existing structure through the bracket. Coupler and segmented pipe sections are added and advanced into the ground until resistance is reached suitable to activate expansion of the bullet assembly to provide a belled section for additional bearing area. The expanded bullet assembly is then stabilized against collapse of the belled shape in preparation for application of structure loads. Structure loads are introduced into the foundation system by jacking against the segmented pipe foundation. After the structure loads have been applied, the segmented pipe foundation is filled with concrete for stabilization and additional capacity.

1.4.2 Belled Segmented Pipe Foundation Device: For purposes of this criteria, a belled segmented pipe foundation device is any part or component of a belled segmented pipe foundation system.

1.4.3 Bracket: A steel connection device used to connect the segmented pipe sections to the structure.

1.4.4 Coupler: A device for joining the segmented pipe sections.

1.4.5 Bullet Assembly: An assembly of steel components capable of advancing through the soil with a means of expanding to an increased bearing area at the final depth.

1.4.6 Lateral Resistance: Capacity of a belled segmented pipe foundation system or device to resist forces acting in a direction that is perpendicular to the longitudinal direction of the segmented pipe sections.

1.4.7 Conventional Design: Methods for determining design capacities of the belled segmented pipe foundation system that are prescribed by and strictly in accordance with standards and codes referenced in Section 1.3.

1.4.8 Special Analysis: Methods for determining design capacities of the belled segmented pipe foundation system that incorporate finite element modeling, discrete element modeling, strain compatibility, or other conventional analytical/numerical techniques. Computer software developed for the analysis of laterally loaded piles, which incorporate methods of analysis considering the nonlinear interaction of the segmented pipe sections with soil, is an example of special analysis.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted with ICC-ES evaluation report applications:

2.1.1 Summary Document: A tabulated list of the belled segmented pipe foundation systems, devices, and combinations thereof to be included in the ICC-ES evaluation report, along with proposed structural capacities. All systems and devices shall be clearly identified in the documentation with distinct product names and/or product numbering.

2.1.2 Product Description: Belled segmented pipe foundation devices shall be manufactured from carbon steel, with optional zinc or powder coatings. Complete information shall be submitted pertaining to the belled segmented pipe foundation systems or devices, including material specifications and drawings showing all dimensions and tolerances, and the manufacturing processes. All materials, welding processes and manufacturing procedures used in belled segmented pipe foundation systems and devices shall be specified and described in quality documentation complying with Section 5.2. All material specifications shall comply with ASTM, ACI, AISC, UBC, or IBC requirements. Material composition, grade, and sizes of bolts and fasteners shall be based on criteria in AISC, ASTM, or ANSI requirements.

2.1.3 Installation Instructions: Procedures and details regarding belled segmented pipe foundation system or device installation, including product-specific requirements, exclusions, limitations, and inspection requirements, as applicable.

2.1.4 Packaging and Identification: A description of the method of packaging and field identification of each belled segmented pipe foundation system device. Identification provisions shall include the manufacturer's name and address, product name and model number, evaluation report number and name or logo of the inspection agency.

2.1.5 Design Calculations: Clear and comprehensive calculations of ASD or LRFD structural capacities for the system or device, based on requirements of the IBC or UBC and this criteria. Calculations shall be sealed by a registered design professional.

2.2 Testing Laboratories: Testing laboratories shall comply with Section 2.0 of the

ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Reports of tests required under Section 3.0 of this criteria shall comply with AC85 and reporting requirements in referenced standards.

2.4 Product Sampling: Sampling of devices for tests under this criteria shall comply with Section 3.1 of AC85.

3.0 DESIGN, TEST, AND PERFORMANCE REQUIREMENTS:

3.1 General: The belled segmented pipe foundation systems and devices shall be evaluated for resistance to axial compression, axial tension, lateral loads or a combination of these loads. Load types that are not applicable to the system shall be clearly identified. The required capacities shall be evaluated by considering four primary structural elements of the belled segmented pipe foundation system as shown in Figure 1. These element capacities are described as Bracket Capacity (P1), Segmented Pipe Capacity (P2), Bullet Assembly Capacities (P3a and P3), and Soil Capacity (P4). The allowable capacity of a belled segmented pipe foundation system or device shall be the lowest value of P1, P2, P3, and P4, from each application illustrated in Figure 1. For evaluation of belled segmented pipe foundation devices subject to combined lateral loads and axial compression or axial tension, the allowable lateral capacity and allowable axial capacities shall be determined and reported separately. The allowable strength under combined load conditions shall be determined using the interaction equation provided in the AISC referenced standard.

3.2 P1 Bracket Capacity: The P1 bracket capacity is the maximum load that can be sustained by the bracket device of a belled segmented pipe foundation system based on strength in accordance with Section 3.10.

3.3 P2 Segmented Pipe Capacity: The P2 segmented pipe capacity is the specified load that can be sustained by the pipe and/or coupler elements of a belled segmented pipe foundation system based on strength in accordance with Section 3.11.

3.4 P3a and P3 Bullet Assembly Capacities: The bullet assembly capacity is the specified load that can be sustained by the bullet assembly of a belled segmented pipe foundation system based on strength or deformation in accordance with Section 3.12.

3.4.1 P3a Bullet Assembly Capacity: The P3a bullet assembly capacity is the specified load that can be sustained by the bullet assembly of the belled segmented pipe foundation system during advancement of the segmented pipe sections prior to expansion of the bullet assembly to its belled shape to provide additional bearing area.

3.4.2 P3 Belled Bullet Assembly Capacity: The P3 belled bullet assembly capacity is the specified load that can be sustained by the belled bullet assembly of the belled segmented pipe foundation system after the bullet assembly has expanded to its belled shape and has been stabilized to its final increased bearing area.

3.5 P4 Soil Capacity: The P4 soil capacity is the specified load that can be sustained by the soil or bedrock bearing stratum supporting the foundation system or device based on strength and settlement or pullout in accordance with Section 3.13.

3.6 Determination of Allowable Design Capacities: In accordance with Section 3.7 and Section 3.8, the allowable design capacities of belled segmented pipe foundation elements P1, P2, P3 and P3a shall be evaluated based on conventional design with no testing required, Special Analysis with verification tests, or solely on tests. All load tests shall be conducted in accordance with Section 4.0. The allowable capacity P4 shall be determined by the registered design professional or through direct measurements as specified in Section 3.13.

3.7 Design Methods:

3.7.1 Conventional Design: For conventional design of steel, either Allowable Stress Design (ASD) or Load and Resistance Factor Design (LRFD) methods referenced in the IBC or UBC, may be used to calculate the allowable design capacity, P'. For design of concrete, strength design methods referenced in ACI 318 (IBC) or the UBC shall be used to calculate the design capacity.

3.7.1.1 ASD Method: When using the ASD method, the allowable design capacity, P', shall be taken as the allowable strength, P_a, and shall be determined in accordance with the applicable code or referenced standard (Eq-3).

$$P' = P_a \text{ (ASD)} \qquad \text{(Eq-3)}$$

3.7.1.2 LRFD Method: When using the LRFD method, the allowable design capacity, P', shall be taken as 0.7 times the design strength, ΦP_n, ΦP_n determined in accordance with the applicable code or referenced standard (Eq-4).

$$P' = 0.7\Phi P_n \text{ (LRFD)} \qquad \text{(Eq-4)}$$

3.7.2 Special Analysis: Where special analysis is used, the allowable capacity P' shall be taken as 0.6 times the resistance based on yield strength (P_y) or, when stress concentrations are prevalent, P' shall be 0.5 times the resistance based on maximum strength (P_{max}) (Eq-5).

$$P' = 0.6P_y \text{ or } 0.5P_{max} \text{ (Special Analysis)} \quad \text{(Eq-5)}$$

3.7.3 Direct Measurement: Where load testing only is used and the number of samples is not specified, the allowable capacity shall be reported as the average allowable strength determined in accordance with Section 4.0 from tests conducted on at least five specimens, provided all test results are within 15 percent (±15%) of the average. Otherwise, the allowable capacity from testing only shall be based on the least test result. For direct measurement of belled segmented pipe foundation device capacities, testing shall be conducted in accordance with the applicable test procedure described in Section 4.0. The allowable capacity, P' shall be taken as 0.6 times the resistance based on yield strength (P_y) or 0.5 times the maximum strength (P_{max}), whichever yields the lowest value (Eq-6).

$$P' = 0.6P_y \text{ or } 0.5P_{max} \text{ (Direct Measurement)} \quad \text{(Eq-6)}$$

For direct measurement of soil capacity, testing shall be conducted in accordance with Section 4.4. For determination of allowable soil capacity, a factor of safety equal to 2 or greater shall be applied to the maximum measured soil capacity.

3.8 Capacity Limits: For conventional design, the maximum allowable design capacity of belled segmented pipe foundation systems and devices is 40 kips (177.9 kN) in axial tension, 50 kips (222.4 kN) in axial compression and 6 kips (26.7 kN) in lateral resistance. Belled segmented pipe foundation systems or devices with allowable design capacities greater than these normal capacity limits require special analysis with additional verification testing as prescribed in Sections 3.10 to 3.13 or if capacity is to be determined by testing alone, the number of test samples shall be double the amount otherwise required.

3.9 Corrosion: Belled segmented pipe foundation systems and devices shall be bare steel, powder-coated steel or zinc-coated steel. Powder coatings shall comply with the ICC-ES Acceptance Criteria for Corrosion Protection of Steel Foundation Systems Using Polymer (EAA) Coatings (AC228), and the coating thickness shall be at least 450 µm (0.018 inch). Zinc coatings shall comply with ASTM A 123, A 153, B 633, or B 695, as applicable. Loss in steel thickness due to corrosion shall be accounted for in determining structural capacities by reducing the thickness of all belled segmented pipe foundation components by the sacrificial thickness over a period, *t*, of 50 years. The design thickness, *Td*, of belled segmented pipe foundation components used in capacity calculations and testing shall be computed by Eq-6. For purposes of design calculations and fabrication of test specimens, the thickness of each component shall be reduced by $^{1}/_{2}\ T_s$ on each side, for a net reduction in thickness of T_s.

$$T_d = T_n - T_s \qquad \text{(Eq-6)}$$

where T_n is nominal thickness and T_s is sacrificial thickness (t = 50 yrs).

T_d ~ base-steel thickness

Zinc-coated steel: $T_s = 25\ t^{0.65}$ = 318 µm (0.013 in)

Bare steel, $T_s = 40\ t^{0.80}$ = 915 µm (0.036 in)

Powder coated steel, $T_s = 40(t\text{-}16)^{0.80}$ = 671 ijm (0.026 in)

For bare steel and powder-coated steel, T_n shall be the base-steel thickness. For zinc-coated steel, T_n may be the sum of the base-steel thickness and zinc coating thickness, provided the minimum zinc coating thickness is 86 μm (0.0034 in). Otherwise, the sacrificial thickness, T_s, shall be determined by linear interpolation between bare steel and zinc coated steel using the actual specified zinc coating thickness.

For powder-coated steel, the life of powder coating is taken as 16 years, maximum. Hence, t has been reduced by 16 in the determination of T_s.

For verification of Special Analysis or for determination of allowable capacity through testing only, test specimens shall be constructed using steel thickness equal to T_d. Alternatively, unaltered test specimens may be used and the resulting allowable strength shall be reduced by multiplying the result by a scaling factor that takes into account corrosion and the observed failure mode. Thus, a tension failure result shall be scaled by the area of the fracture surface, while a flexural failure would be scaled by the reduced section modulus. The testing laboratory shall determine the appropriate scaling method and identify the failure mode.

Corrosion loss shall be accounted for regardless of whether devices are below or above ground or embedded in concrete. Zinc-coated steel and bare steel components shall not be combined in the same system. Powder coated steel may be combined with zinc-coated steel and bare steel components. All belled segmented pipe foundation components shall be galvanically isolated from concrete reinforcing steel, building structural steel, or any other metal building components.

3.10 P1 Bracket Capacity: Belled segmented pipe foundation brackets shall be classified as side vertical load as illustrated in Figure 1. At a minimum, evaluation of P1 shall include determination of strength of the connection of the bracket to the structure, the internal strength of the bracket itself, and the strength of connection of the bracket to the uppermost segmented pipe section. The frictional resistance of concrete on a horizontal bracket component shall be determined using a coefficient of friction of 0.4 or less. The shear strength of concrete also shall be calculated in accordance with the applicable code. Brackets may be evaluated for compression, tension, and/or lateral strengths. If not vertical, the angle of the segmented pipe section with respect to the bracket shall be accounted for in the calculations. The uppermost segmented pipe section and the bracket shall be attached to each other and to the structure by mechanical connections. Installation shall be limited to support of uncracked concrete, as determined in accordance with the applicable code. In order for the segmented pipe sections to be considered sidesway braced, the structure shall provide lateral restraint to the segmented pipe sections equal to or greater than 0.4 percent of the segmented pipe section’s allowable axial compression load.

3.10.1 Side Load: Side load brackets are illustrated in Figure 1 and support tensile or compressive loads that are not concentric with the primary axis of the segmented pipe sections.

3.10.1.1 Eccentricities: Rotational moments caused by vertical load eccentricity shall be subdivided into two components, bracket eccentricity and structure eccentricity, as illustrated in Figure 2. The segmented pipe sections and the connected bracket components, consisting of the connected bracket, connection of the bracket to the segmented pipe, and connection of the bracket to the structure, shall resist bracket eccentricity. Structure eccentricity varies with application and is generally resisted by the internal strength of the structure to which the bracket is attached. Therefore, resistance to structure eccentricity shall be determined on a case-by-case basis. For purposes of bracket eccentricity and internal strength design, the location of the resultant vertical compression force of the concrete structure on an angle bracket shall be taken as the centroid of an area defined by the uniform concrete bearing stress as shown in Figure 2.

3.10.1.2 Structure Bracing: Side load brackets shall only be used to support structures that are braced as defined in IBC Section 1808.2.5.

3.10.2 Analysis: The strength of connected bracket components and segmented pipe sections shall be evaluated based on a static analysis transferring the pipe load through the bracket into the existing structure. The analysis shall also include forces induced from the application of pressure on the segmented pipes for advancement of the segmented pipe sections during installation.

3.10.2.1 Connection to the Structure: Axial compression, axial tension, or lateral load connection capacities shall be determined in accordance with the IBC, UBC, or a current ICC-ES evaluation report. For purposes of evaluation, the structure shall be modeled as a mass of structural plain concrete, semi-infinite in extent, with varying strength. The structure shall be assumed to be fixed in translation and rotation, but can move freely in the vertical direction. At a minimum, design of the connection shall be based on normal-weight concrete with a specified compressive strength of 2,500 psi (17.22 MPa). Other concrete strengths, structural lightweight concrete, masonry and other materials also can be included in the evaluation at the option of the bracket manufacturer. For all combinations of concrete strength and/or material compositions, details regarding connection of the bracket to the structure types (i.e., anchor bolt placement, grouting, surface preparation, etc.) shall be prescriptively specified.

3.10.3 Test Requirements: Except as stipulated in Section 3.10.3.1, verification tests shall not be required for evaluation of foundation brackets provided all analysis is accomplished using Conventional Design as set forth in Section 3.7 and allowable capacities are within the range of Normal Capacity Limits as set forth in Section 3.8. A minimum of three verification load tests shall be conducted in each load direction (axial compression, axial tension, and lateral) on any component of a bracket or bracket / segmented pipe system evaluated using Special Analysis and for brackets exceeding Normal Capacity Limits. Where tests are required for verification of lateral resistance, tests shall be conducted to verify lateral resistance in all directions for which lateral resistance is being claimed. Where testing alone is used without analysis, a minimum of five tests shall be conducted in accordance with Section 3.7.3. Bracket tests shall be conducted in accordance with Section 4.1 for compression and tension and Section 4.4.2 for lateral resistance.

3.10.3.1 Friction Connection of Segmented Pipe to Bracket: When the segmented pipe connection to the bracket is dependent on friction developed by a clamping force, testing shall be required. Testing shall be in accordance with Section 4.1.

3.11 P2 Segmented Pipe Capacity: At a minimum, segmented pipe capacities shall be evaluated for axial compression. Segmented pipe sections may also be evaluated for axial tension and lateral resistance, with consideration of combined lateral and axial loading. Evaluation of segmented pipe sections shall include connections between segmented pipes and cementitious fill. All segmented pipe section connections shall be made via a mechanical coupler. When cementitious fill is used, the system shall be evaluated for both filled and unfilled conditions as appropriate.

3.11.1 Tension: Evaluation of segmented pipe sections for tension shall include yielding on the gross area and fracture at any coupler. At couplers, there shall be consideration of all stresses and failure modes, including increased stresses at bolt holes and welds within the coupler as well as for the attachment of the coupler to the pipe section. Concrete fill shall not be considered to contribute to the tension capacity. Reinforcing steel within the pipe and concrete fill may be considered if shown to be adequately connected with load transfers in accordance with the applicable codes.

3.11.2 Compression: Evaluation of segmented pipe sections for compression shall include buckling resistance, yielding on the gross area and yielding at any couplers. At couplers, there shall be consideration of all stresses and failure modes, including increased stresses at bolt holes and welds within the coupler as well as for the attachment of the coupler to the pipe section. A bending moment shall be applied to the top of the segmented pipe section in buckling calculations in accordance with Section 3.11.2.3.

3.11.2.1 Unsupported Length: Unsupported segmented pipe lengths shall include the length of the segmented pipe sections in air, water, or in fluid soils. For unbraced systems, the lengths specified in IBC Section 1808.2.9.2 shall apply unless determined otherwise by special analysis. In accordance with IBC Section 1808.2.9.1, any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling of systems that are braced. Bracing shall comply with IBC Section 1808.2.5. Firm soils shall be defined as any soil with a Standard Penetration Test blow count of five or greater. Soft soils shall be defined as any soil with a Standard Penetration Test blow count greater than zero and less than five. Fluid soils shall be defined as any soil with a Standard Penetration Test blow count of zero [weight of hammer (WOH) or weight of rods (WOR)]. Standard Penetration Test blow count shall be determined in accordance with ASTM D 1586.

3.11.2.2 Effective Length: Effective lengths shall be determined using the unsupported length defined in Section 3.11.2.1 and the appropriate effective length factor, *K*, determined in accordance with the AISC referenced standard. Slenderness ratio limitations as specified by the AISC referenced standards do not apply.

3.11.2.3 Coupler Rigidity: Coupler rigidity shall be considered for all cases except braced systems in firm or soft soils. To account for coupler rigidity, the eccentricity of the axial compressive load applied to the segmented pipe sections shall be increased by a distance, nAe_c, where n is the number of couplers possible in the unsupported length and e_c is the maximum lateral deflection of the unsupported length of segmented pipe sections due to flexure of the coupler under an applied lateral load of 0.4 percent of the applied axial compressive load. [Maximum lateral deflection of the segmented pipe sections due to coupler flexure shall be determined in accordance with Section 4.2.3].

3.11.3 Lateral Resistance: Lateral resistance of the segmented pipe sections is necessarily coupled with soil capacity and shall be determined in accordance with Section 3.13. Segmented pipe section area, moment of inertia, and elasticity shall be used as inputs in the analysis. Maximum bending moment and shear stress determined from the analysis shall be limited by the allowable bending and shear resistance of the segmented pipe section or the segmented pipe section couplers, whichever is less. Deflection of segmented pipe section couplers shall be included in lateral resistance analysis.

3.11.4 Elastic Shortening or Lengthening: Methods (equations) shall be provided for estimation of elastic shortening/lengthening of the segmented pipe sections under the allowable axial load plus any slip in the couplers. These methods shall be based upon conventional design.

3.11.5 Combined Stresses: Segmented pipe section evaluation shall include combined stresses. Combinations of tension, compression, bending, and lateral loads shall be considered as applicable.

3.11.6 Test Requirements: Verification tests shall not be required for evaluation of segmented pipe section tension, compression, and bending moment provided all analysis is accomplished using conventional design in accordance with Section 3.1 and allowable capacities are within the range of normal capacity limits as set forth in Section 3.8. A minimum of three verification load tests shall be conducted on separate specimens in each direction (compression, tension, bending) on any component of segmented pipe sections evaluated using special analysis, and for segmented pipe sections that exceed normal capacity limits as set forth in Section 3.8. Where testing alone is used without analysis, a minimum of five tests shall be conducted in accordance with Section 3.7.3. Tests are required to determine coupler rigidity as described in Sections 3.11.2. Tests for segmented pipe sections capacity shall be conducted in accordance with Section 4.2.

3.12 P3 Bullet Assembly Capacity: Bullet assembly capacity and weld strength shall be evaluated for compression and tension (if applicable). The bullet assembly shall be evaluated for both during advancement through the soil P3a and the belled condition P3.

3.12.1 P3a Bullet Assembly Expansion: Expansion of the bullet assembly shall be determined by testing in accordance with Section 4.3.1. A minimum of five samples, with an equal number of samples from three or more separate production batches, shall be used in the testing. The mean ultimate (maximum) applied axial force to cause expansion to the belled shape shall be determined from the test population.

3.12.2 P3 Belled Bullet Assembly: The bullet assembly belled capacity shall be determined after stabilization, by testing in accordance with Section 4.3.2. A minimum of five samples, with an equal number of samples from three or more separate production batches, shall be used in the testing. These may be the same samples used for testing specified in Section 3.12.1. The mean ultimate (maximum) axial resistance force shall be determined from the test population.

3.12.2.1 Stabilization by Cementitious Material: When a cementitious material is used to stabilize the belled shape of the bullet assembly, compression testing of each material used for stabilization shall be conducted and reported.

3.12.3 Lateral Capacity: Lateral capacity of the bullet assembly shall not be considered.

3.12.4 Test Requirements: Each bullet assembly with differing properties, for which evaluation is being sought, shall be tested. The allowable capacity for each size and type of bullet assembly shall be reported as the average result of at least five test specimens. In order to allow the mean values, individual results determined from testing shall be within 15 percent of the average of tests. Otherwise, the least test result shall apply. Bullet assembly tests shall be conducted in accordance with Section 4.3.

3.13 P4 Soil Capacity: Soil capacity includes the tension, compression, and/or lateral resistance of a belled segmented pipe foundation embedded in ground, as applicable.

3.13.1 Axial Capacity Verification: For all belled segmented pipe foundation systems, full-scale field installation and load tests shall be conducted to verify the axial capacity on specimens installed to the resistance required to expand the bullet assembly to its increased bearing area determined in accordance with Section 3.11.3. The tests shall be regarded as a successful verification of installation and allowable capacity, provided all full-scale axial load tests exceed the allowable capacity of the system by a factor of safety of at least 2.0.

At least two specimens of each type of segmented pipe sections shall be tested in each load direction (tension or compression) for which evaluation is being sought. Variations in foundation device size and material strengths shall constitute a different type of specimen. Two separate specimens shall be tested in each direction (compression and/or tension) for which evaluation is being sought. Test specimens shall consist of a minimum of a bullet assembly, two pipe sections and at least one coupler. The test specimen may include a bracket. All verification tests shall be conducted at sites described in Section 3.13.4. Additional information on testing is provided in Section 4.4.1. The determination of soil capacity, P4, on any specific site or with any configuration of belled segmented pipe foundation devices other than the test site and test specimen is outside the scope of this acceptance criteria. The evaluation report shall indicate that soil capacity shall be determined by a registered design professional for each site considering groundwater and other geotechnical conditions. As an alternative, load capacity correlations for specific soil conditions may be determined in accordance with Section 3.13.2.

3.13.2 Load Capacity Correlations: Evaluation reports may include a correlation between measured axial force at which bullet assembly expansion occurs, the ratio of the square of the diameter of the expanded bullet assembly to the square of the diameter of the bullet assembly during advancement and the ultimate soil capacity. This correlation shall be based on the results of testing the bullet assembly as outlined in Section 3.12.4 and full-scale field tests as outlined in Section 3.13.1.

3.13.3 Lateral Resistance: Allowable soil capacity in the lateral direction shall be determined through load tests on specimens installed in different soil conditions. The allowable soil capacity shall be determined based on deflection criteria set forth in Section 4.4.2. In order to be valid, allowable capacities determined for each type of specimen in each soil type shall be within 15 percent of the average allowable capacity for those tests.

A minimum of four specimens of each type of segmented pipe section shall be tested in each soil type for which evaluation is being sought. Variations in segmented pipe section size, geometry, total length and material strength shall constitute a different type of specimen. Variations in bullet assembly size, geometry or material strength does not require separate tests. Four separate specimens shall be tested in each transverse direction for which evaluation is being sought if the segmented pipe section is not axially symmetric. Test specimens shall consist of a segmented pipe section, at least one coupler located with the manufacturer’s smallest extension length from the ground surface and a bullet assembly. The test may include a bracket. The subsurface profile at all test sites shall be characterized in a soil investigation by a registered design professional. Additional information on testing is provided in Section 3.13.4. Allowable soil capacity for different specimens in different soil categories shall be tabulated in the evaluation report. The evaluation report shall contain a statement that soil capacity for lateral resistance in soil conditions that substantially differ from actual test sites included in the evaluation shall be determined by a registered professional engineer on a case–by–case basis.

3.13.4 Test Requirements: Axial compressive, tensile, and lateral allowable load capacity shall be verified through field load tests as provided in Section 3.13. At least two verification tests are required for axial compression and at least two verification tests are required for axial tension. If a load capacity correlation is specified, then at least four tests are required for axial compression verification and at least four tests are required for axial tension verification for each segmented pipe section size for which evaluation is being sought. The two verification tests required for compression and tension may be included in the tests for load capacity correlations. If evaluation of lateral resistance is requested, four verification tests are required for each segmented pipe section size, segmented pipe section geometry, and soil type.

Tests for axial compression and tension soil capacity shall be conducted in accordance with Section 4.4.1 and tests for lateral resistance shall be conducted in accordance with Section 4.4.2. Tension and compression verification load tests are required to be conducted at the facility or field station of a testing laboratory complying with Section 2.2. The subsurface profile at other test sites shall be characterized in a soil report by a registered design professional. Subsurface profile characterization shall include soil borings, standard penetration resistance tests, and basic laboratory classification tests essential for soil classification according to the Unified Soil Classification System. All field penetration tests, laboratory tests, and soil classifications shall be conducted in accordance with ASTM D 1586.

4.0 TEST METHODS

4.1 P1 Bracket Capacity: Where specified herein, each size and configuration of the bracket shall be tested. The configuration of the bracket and direction of applied loads in the test apparatus shall be as close to actual field conditions as practical. Pertinent data such as maximum load applied, maximum bracket rotation, failure mode, etc., shall be reported.

4.1.1 Side Load:

4.1.1.1 Setup: Compression and tension tests can be conducted in a horizontal configuration, as illustrated in Figure 3. The bracket shall be mounted to a block of plain concrete of known strength that is fixed with respect to translation and rotation. The connection of the bracket to the concrete shall be in accordance with manufacturer's installation instructions. Load shall be applied to the bracket using a standard length section of segmented pipe section secured to the bracket in a manner that duplicates actual field conditions. The loaded end of the segmented pipe section shall be rotationally fixed. Axial load shall be applied in the direction of the longitudinal axis of the segmented pipe section. Any eccentricity inherent in the bracket configuration and angle of the segmented pipe section to bracket shall be accounted for and shall be modeled to match the anticipated design purpose.

4.1.1.2 Procedure: Axial deflection shall be recorded as a function of applied load at regular intervals equal to or less than 20 percent of the anticipated allowable load. The rate of load application shall be sufficiently slow to simulate static conditions. Each load increment shall be held for a minimum of one minute. Yield strength and ultimate (maximum) strength of the bracket shall be determined using conventional analysis of a plot of load versus deflection. The allowable strength of the bracket shall be determined from yield or ultimate (maximum) strength using the equations provided in Section 3.7.3, whichever formula results in the lowest value. Compression tests shall be conducted within 24 hours of the bracket test on concrete cylinders cast at the same time as the test specimen to establish concrete compressive strength. Cylinders shall be stored and cured according to Section 9.3.1 of ASTM C 31 (field cure). The tested concrete compressive strength shall be within 15 percent of the specified compressive strength. Concrete cylinder compression tests shall be conducted in accordance with ASTM C 39.

4.2 P2 Segmented Pipe Section Capacity:

4.2.1 Axial Tension and Compression:

4.2.1.1 Setup: Compression and/or tension tests shall be conducted on two sections of segmented pipes with a coupler located between the pipe section specimens. When filled pipe sections are specified, tests shall be performed for both hollow and filled sections. Additionally, standard compression tests shall be performed on specimens of the fill material in accordance with ASTM standards. The test specimens shall be mounted to a vertical or horizontal load frame with one end attached to a fixed platform and the other end attached to a mobile platform with the capability to apply the load to the specimen in the axial direction. The coupler connection shall be done in accordance with manufacturer's specific published recommendations. Direction of loading shall be coaxial with the longitudinal axis of the segmented pipe sections. The testing apparatus shall provide sufficient rigidity as to minimize any slip or deformation not associated with the test specimens.

4.2.1.1.1 Setup for Laterally Braced Belled Segmented Pipe Foundation System: To evaluate braced buckling resistance, compression specimens shall be evaluated to simulate segmented pipe section advancement through the upper layers of soil, with a total specimen length of 5 feet. All other testing shall be in accordance with Section 4.2.1.1.

4.2.1.1.2 Setup for Laterally Unbraced Belled Segmented Pipe Foundation System: To evaluate unbraced buckling resistance, compression specimens shall have enough segmented pipe sections to achieve the minimum unbraced length equal to or greater than the effective length as specified in Section 3.11.2.2. All other testing shall be in accordance with Section 4.2.1.1.

4.2.1.2 Procedure: Loads shall be applied to the specimen in increments not exceeding 20 percent of the design allowable load of the specimen. Each load increment shall be held for a minimum of one minute. The specimen shall be loaded to failure. Application of the load shall be performed at a slow rate to simulate a statically applied load. Pertinent data such as maximum load applied, maximum segmented pipe section or connection deformation, failure mode, etc., shall be reported. Yield strength and ultimate (maximum) strength of the segmented pipe sections and coupler shall be determined using conventional analysis of a plot of load versus deflection. The allowable strength of the segmented pipe sections and coupler shall be determined from yield or ultimate (maximum) strength and the equations provided in Section 3.7.3, whichever equation results in a lower value.

4.2.2 Bending:

4.2.2.1 Setup: Bending tests shall be conducted on a segmented pipe section that is horizontally arranged in a compression load frame, as illustrated in Figure 4. For segmented pipe sections with a non-circular cross section, as a minimum, the tests shall be conducted with the least resistant orientation. The distance between segmented pipe section supports shall be at least 36 inches (914 mm) or 12 times the maximum outside cross-sectional dimension of the segmented pipe section, whichever is greater. A coupler shall be located approximately in the center of the specimen. Loads shall be applied using a two point test where the load points straddle the coupler so that a uniform bending moment is produced in the coupler.

4.2.2.2 Procedures: Load shall be applied and deflections measured at intervals of less than or equal to 20 percent of the load corresponding to the theoretical allowable bending moment. Application of load shall be performed at a slow rate to simulate a statically applied load. Pertinent data such as maximum load applied, maximum segmented pipe section or coupler deformation, failure mode, etc., shall be reported.

Yield strength and ultimate (maximum) strength of the segmented pipe section and coupler shall be determined using conventional analysis of a plot of load versus deflection. The allowable bending strength of the segmented pipe section and coupler shall be determined from yield or (maximum) strength and the equations provided in Section 3.7.3, whichever equation results in a lower value.

4.2.3 Coupler Rigidity:

4.2.3.1 Setup: The maximum lateral deflection of segmented pipe sections due to coupler flexure shall be determined using segmented pipe sections with a length equal to the unsupported length [60 or 120 inches (1524 or 3048 mm) as specified by Section 1808.2.9.2 of the IBC]. The segmented pipe sections shall have the maximum number of couplers possible over its length based on the standard length of segmented pipe sections. The segmented pipe sections shall be horizontally or vertically arranged in a load frame at the evaluation report applicant's option with one end fixed and the other end unsupported, as illustrated in Figure 5. A load shall be applied perpendicularly to the unsupported end of the segmented pipe section.

4.2.3.2 Procedures: A vertical load equal to 0.4 percent of the allowable compression load on the belled segmented pipe foundation segmented pipe section system shall be applied. The total deflection of the loaded end of the segmented pipe section, including any free deflection, shall be measured relative to a horizontal plane extending from the fixed end. The total deflection shall be reported and used in segmented pipe section eccentricity computations.

4.2.4 Shear Strength:

4.2.4.1 Setup: The maximum shear strength of segmented pipe sections and couplers shall be determined using specimens with lengths as appropriate for the test apparatus. The specimen shall be horizontally or vertically arranged in a load frame with one end fixed and the other end free. A load shall be applied normal to the segmented pipe or coupler using a roller or slide to avoid inducing flexure into the system.

4.2.4.2 Procedure: The loads shall be applied in increments not exceeding 20 percent of the allowable shear load on the segmented pipe section or coupler. The total deflection of the segmented pipe section or coupler at the point of load application shall be measured at each increment. Load shall be applied at a slow rate to simulate statically applied load. Each load increment shall be held for a minimum of one minute. Yield and ultimate (maximum) strength of the segmented pipe or coupler shall be determined using a conventional analysis of a plot of load versus deflection.

4.3 P3 and P3a Bullet Assembly Capacity: Where specified herein, each size and configuration of bullet assembly shall be tested.

4.3.1 P3a Bullet Assembly:

4.3.1.1 Setup: Compression tests shall be conducted on each bullet assembly prior to expansion to its belled shape. The test specimen shall be placed in a load frame with the top of the bullet assembly snug against a fixed platform and the base placed on a mobile platform with the capability to apply the load to the specimen in the axial direction. The testing apparatus shall provide sufficient rigidity so as to minimize any slip or deformation not associated with the test specimens.

4.3.1.2 Procedures: Loads shall be applied to the specimen in either continuously increasing increments, or in increments not exceeding 10 percent of the design ultimate capacity. If the load is applied in continuously increasing increments, the rate of loading (load increase per second) should be equal to the design ultimate capacity divided by 120 to 150. If the load is applied in increments, each load increment should be held for 30 to 60 seconds, and application of the load shall be at a moderate rate to simulate actual field loading conditions. Pertinent data such as maximum load applied, maximum bullet deformation, failure load, etc., shall be reported.

4.3.2 P3 Belled Bullet Capacity for Compression:

4.3.2.1 Setup: Compression tests shall be conducted on each stabilized belled bullet assembly. The previously tested specimens (Section 4.3.1) may be stabilized and tested. Where the bullet assembly is stabilized with hydraulic cement, grout, or concrete, the materials shall reach 100 percent of their design compressive strength prior to testing. The stabilized test specimen shall be placed in a load frame with the top of the bullet assembly snug against a fixed platform and the base placed on a mobile platform with the capability to apply the load to the specimen in the axial direction. The testing apparatus shall provide sufficient rigidity as to minimize any slip or deformation not associated with the test specimens.

4.3.2.2 Procedure: Loads shall be applied to the specimen in either continuously increasing increments, or in increments not exceeding 10 percent of the design ultimate capacity. If the load is applied in continuously increasing increments, the rate of loading (load increase per second) should be equal to the design ultimate capacity divided by

120 to 150. If the load is applied in increments, each load increment should be held for 30 to 60 seconds, and application of the load shall be performed at a moderate rate to simulate actual field loading conditions. Pertinent data such as maximum load applied, maximum bullet deformation, failure mode, etc., shall be reported.

4.3.3 P3 Belled Bullet Capacity for Tension:

4.3.3.1: Setup: Tension tests shall be conducted on each stabilized belled bullet assembly for which recognition for tension is desired. Where the bullet assembly is stabilized with hydraulic cement, grout, or concrete, the materials shall reach 100 percent of their design compressive strength prior to testing. The stabilized test specimen shall be mounted in a vertical or horizontal load frame with the expanded end attached to a fixed platform, and the other end attached to a mobile platform with the capability to apply the load to the specimen in the axial direction. The expanded end should be encased in a high-strength concrete mold with a steel backer plate, designed to impart the expected reaction force of soil against the expanded bullet assembly during uplift. A bond break should be placed on the outside of the expanded bullet assembly to prevent adhesion of the concrete to the bullet. Direction of loading shall be coaxial with the longitudinal axis of the bullet assembly. The testing apparatus shall provide sufficient rigidity as to minimize any slip or deformation not associated with the test specimens.

4.3.3.2 Procedure: Loads shall be applied to the specimen in either continuously increasing increments, or in increments not exceeding 10 percent of the design ultimate capacity. If the load is applied in continuously increasing increments, the rate of loading (load increase per second) should be equal to the design ultimate capacity divided by 120 to 150. If the load is applied in increments, each load increment should be held for 30 to 60 seconds, and application of the load shall be performed at a moderate rate to simulate actual field loading conditions. Pertinent data such as maximum load applied, maximum bullet deformation, failure mode, etc. shall be reported.

4.4 P4 Soil Capacity:

4.4.1 Full-scale Load Tests:

4.4.1.1 Setup: Full-scale load tests shall be conducted in accordance with ASTM D 1143 for axial compression and ASTM D 3689 for axial tension. The quick load test procedure set forth in Section 5.6 of ASTM D 1143 shall be used in compression tests. Installation of the belled segmented pipe sections shall be done in accordance with the installation instructions. The brand, model number, and maximum capacity of the installation device shall be reported. All test segmented pipe sections shall be installed as close to vertical as possible. Pertinent data such as belled segmented pipe foundation depth and final installation load achieved shall be reported. Load should be measured with a calibrated jack. Calibration of jacks shall be performed on equipment whose calibration is traceable back to NIST (National Institute of Standards and Technology). For tension tests, the belled segmented pipe foundation shall be installed such that the minimum depth from the ground surface to the bottom of the bullet assembly is 24*D*, where *D* is the diameter of the expanded belled bullet assembly.

4.4.1.2 Procedures: Direction of loading shall be coaxial with the longitudinal axis of the segmented pipe sections. Application of load shall be done at a slow rate to simulate a statically applied load. Segmented pipe sections shall be installed until the bullet assembly expands to its belled shape. Maximum load capacity shall be that which is achieved when plunging of the belled bullet assembly occurs or when total deflection exceeds 1 inch (25.4 mm), whichever occurs first.

4.4.2 Lateral Load Tests:

4.4.2.1 Setup: Lateral load tests shall be conducted in accordance with ASTM D 3966. These tests can be performed in two ways. If verification of lateral resistance of brackets is required, the test setup shall consist of a belled segmented pipe foundation representative of a standard installation with a bracket above the ground surface. The bracket shall be connected to a structure constructed from wood, steel, or concrete depending on the particular detail for which evaluation is being sought. The test setup shall be such that lateral load is applied to the structure being supported immediately above the bracket elevation. The tests shall be conducted with a free head arrangement in accordance with ASTM D 3966. Where the bracket is intended to support a structure that is rotationally restrained, the test may be conducted using fixed head or free head arrangements in accordance with ASTM D 3966.

If verification of bracket capacity is not required, as in the case of conventional design, then the tests shall be conducted with the segmented pipe section extending a minimum of 12 inches (304.8 mm) from the ground surface. The lateral load shall be applied to the segmented pipe section immediately above the ground surface. Depending on whether the segmented pipe section is intended to support a structure that is rotationally restrained, the test may be conducted using fixed head or free head arrangements in accordance with ASTM D 3966.

Bracket and segmented pipe section installation shall be done in accordance with the standards set forth in manufacturer's specific published recommendations. All test segmented pipe sections shall be installed within the manufacturer's specified tolerances for angle of installation for the bracket type. The minimum depth of the bullet assembly shall be 180 inches (4572 mm).

4.4.2.2 Procedures: For tests including brackets or pipe sections that are nonsymmetrical, separate specimens shall be loaded in all lateral directions for which evaluation is being sought. Application of load shall be done at a slow rate to simulate a statically applied load. The allowable load capacity reported shall be equal to half the load required to cause ¾ inch (19.1 mm) of lateral deflection at the ground surface.

4.5 General Testing Requirements: Test equipment shall be adequate to impose anticipated maximum loads. If loading is not carried to failure, the highest value achieved will be considered the maximum load.

5.0 QUALITY CONTROL

5.1 Manufacturing: All products shall be manufactured under an approved quality control program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or otherwise acceptable to ICC-ES.

5.2 Quality Control Documentation: Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

6.0 EVALUATION REPORT RECOGNITION

6.1 General: The evaluation report shall include a description of the belled segmented pipe foundation device or system, typical applications and limitations. The evaluation report shall state that (1) the device or system shall be limited to support of structures in IBC Seismic Design Categories A, B, and C or UBC Seismic Zones 0, 1, and 2, only; (2) and the device or system shall not be used in conditions that are indicative of a potential pile corrosion situation such as might be brought about by soil resistivity less than 1,000 ohm-cm, pH less than 5.5, soils with high organic content, sulfate concentrations greater than 1,000 ppm, landfills, or mine waste.

System and device descriptions shall include the dimensions of primary components as well as engineering drawings of the product. Any bracket connections to structures shall be prescriptively specified in construction details, including type and condition of structure to be supported, drill holes, bolts, washer plates, field welds, minimum concrete cover, concrete reinforcement, and leveling grout, as applicable. The recommended angle of segmented pipe section installation and maximum permissible departure from that angle shall be specified for each bracket. Construction details for bracket connections shall indicate that materials with different corrosion protection coatings shall not be combined in the same system and that belled segmented pipe foundation devices and systems shall not be placed in electrical contact (galvanically isolated) with structural steel, reinforcing steel, or any other metal building components.

A table of allowable capacities (tension, compression, and/or lateral) for all elements (P1, P2, P3, and P4, as applicable) shall be provided, with listings for each system or device and all possible combinations and configurations. The evaluation report shall state that the allowable capacity of a belled segmented pipe foundation device or system shall be governed by the least allowable capacity, P1 through P4, as applicable.

If lateral resistance is included in the evaluation report, a table of soil capacity in the lateral direction based on load tests shall be provided for each type of segmented pipe section in each test soil condition. The evaluation report shall indicate that soil capacity in the lateral direction needs to be determined by a registered design professional unless the soil conditions for the site in question are generally consistent with soil types described in the evaluation report. For any belled segmented pipe foundation device subject to combined lateral and axial compression or axial tension, the evaluation report shall contain the maximum allowable lateral strength and the maximum allowable axial strength and shall state that the strength of the device is governed by the interaction equation given in the AISC reference standard.

The evaluation report shall provide a discussion of elastic shortening/lengthening, anticipated settlements, and typical elastic deflections, as applicable, depending on the end use. The discussion shall contain design values from analysis or load tests.

6.2 Brackets: Bracket capacities, P1, shall include reference to the type of bracket and shall include provisions for segmented pipe section capacity, P2. The allowable capacities of brackets connected to or embedded in concrete shall provide values for systems installed in the different concrete strengths that were evaluated. Installation shall be limited to uncracked concrete as defined in the applicable code. The table of capacities for brackets and segmented pipe sections shall indicate whether the structure to be supported has to be side-sway braced or rotationally fixed based on assumptions used in the design and testing of the product.

6.3 Segmented Pipe Sections: Segmented pipe section capacities shall be tabulated for each size of segmented pipe for the conditions of being braced or unbraced in soft and firm soils, as applicable. The evaluation report shall define these conditions by reference to Chapter 18 of the IBC. Standard penetration resistance blow count ranges for firm and soft soils described in Section 3.11.2.1 of this criteria shall be repeated in evaluation reports. The evaluation report shall state that the segmented pipe capacity of belled segmented pipe foundations in fluid soils shall be determined by a registered professional engineer. For evaluation reports including provisions for lateral resistance, the structural properties of the segmented pipe shall be provided including gross area, section modulus, modulus of elasticity, maximum allowable bending moment, and maximum allowable shear.

6.4 Bullet Assemblies: Bullet assembly compression and tension capacities shall be tabulated for each type available.

6.5 Soil Capacity: If a soils load capacity correlation was validated, it shall be listed in the evaluation report. Otherwise, the evaluation report shall indicate that soil capacity in compression or tension needs to be determined by a registered design professional. For lateral soil resistance, the evaluation report shall contain a table of capacities for all soil types used in the lateral load testing. The evaluation report shall state that lateral soil resistance shall be determined by a registered design professional for soil conditions that differ from those shown in the table.

6.6 Materials: The evaluation report shall list the material composition, including steel grades, of system and device components. Minimum material specifications for structures to be supported on brackets included in the evaluation report shall be included, as applicable.

6.7 Design: The evaluation report shall describe general procedures for design and application of the belled segmented pipe foundation system or device and state whether bracket capacity is based on a braced or unbraced belled segmented pipe system or device in accordance with IBC Section 1808. An explanation shall be provided of the structural analysis that shall be performed by the design professional for proper application of the system or device, including consideration of the internal shears and moment due to structure eccentricity and maximum span between belled segmented pipe foundations. The magnitude of shear and moment forces exerted on the structure due to the connection of the structure to the belled segmented pipe foundation or device, shall be provided. The results of this analysis and the structural capacities shall be used to select segmented pipe foundation devices. The evaluation report shall indicate that Section 1808 of the IBC shall apply to these products.

6.8 Foundation and Soils Investigation Report: The evaluation report shall indicate that a site-specific foundation and soils investigation report is required for proper application of these products. The foundation and soils investigation report shall address corrosive properties of the soil to ensure that a potential pile corrosion situation does not exist. The foundation and soils investigation report shall address the support conditions for the segmented pipe section. The foundation and soils investigation report shall address the axial compression, axial tension, and lateral load soil capacities if values cannot be determined from the evaluation report. The foundation and soils investigation report shall address effects of groundwater and other questionable characteristics.

6.9 Installation: The evaluation report shall note any special training or certification required for installation professionals, equipment required for installation, and a detailed description of proper installation techniques. Requirements and procedures for quality assurance inspection of product installation shall be described, including procedures for field verification of ultimate maximum soil capacity for tension and compression through correlations with final bullet assembly elevation, as applicable. The evaluation report shall state that for tension applications, the total length of segmented pipe sections shall be determined by a registered professional engineer.

6.10 Special Inspection: For installation, the evaluation report shall state that special inspection in accordance with Section 1704.9 of the IBC or Section 1701 .5.11 of the UBC is required. Where on-site welding is required, the evaluation report shall state that special inspection in accordance with Section 1704.3 of the IBC or Section 1701 .5.5 of the UBC is required. The evaluation report shall state the items to be observed by the special inspector. At a minimum, these items shall include verification of manufacturer, segmented pipe sections, couplers, bullet assembly and bracket configuration, the installation depth of the foundation, and compliance of the installation of belled segmented pipe foundation system with the approved construction documents and this evaluation report. In lieu of continuous special inspection, periodic special inspection in accordance with IBC Section 1701 .6.2 may be permitted when structural observations in accordance with IBC Section 1702, a periodic inspection schedule (prepared by the registered design professional), and evidence of installer training by the report holder are provided to the code official.

6.11 Identification: The evaluation report shall describe the identification method used by the manufacturer as set forth in Section 2.1.4.

6.12 Findings: The evaluation report shall list approved manufacturing facilities and their inspection agencies

TABLE 1—REFERENCE STANDARD EDITIONS

STANDARD	IBC	UBC
ANSI AF&PA NDS	2005	1991 revised
AISC ASD	AiSC 360-05	June 1, 1989
AISC LRFD	AISC 360-05	March 16, 1991
AWS D1.1	2004	1992

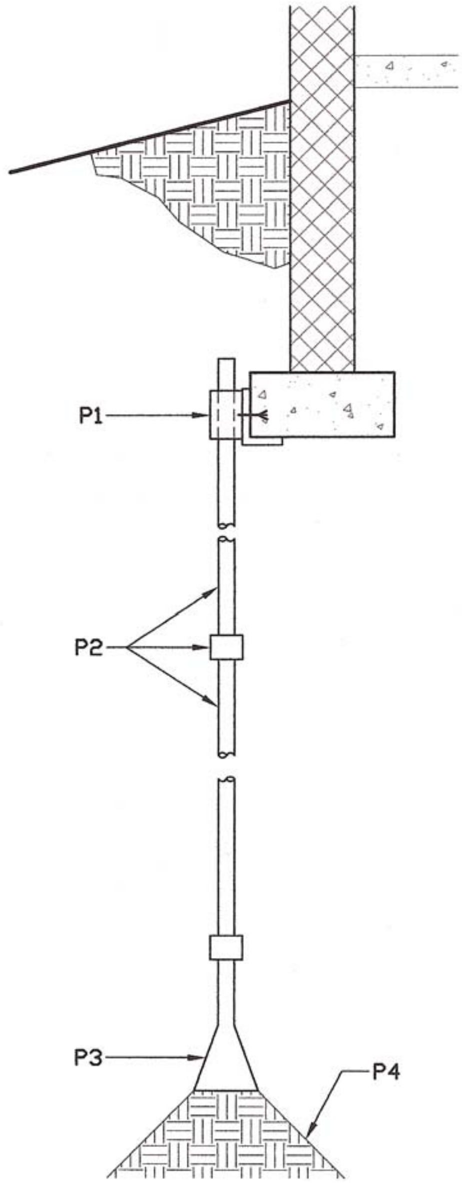

FIGURE 1—SEGMENTED PIPE FOUNDATION DEVICES

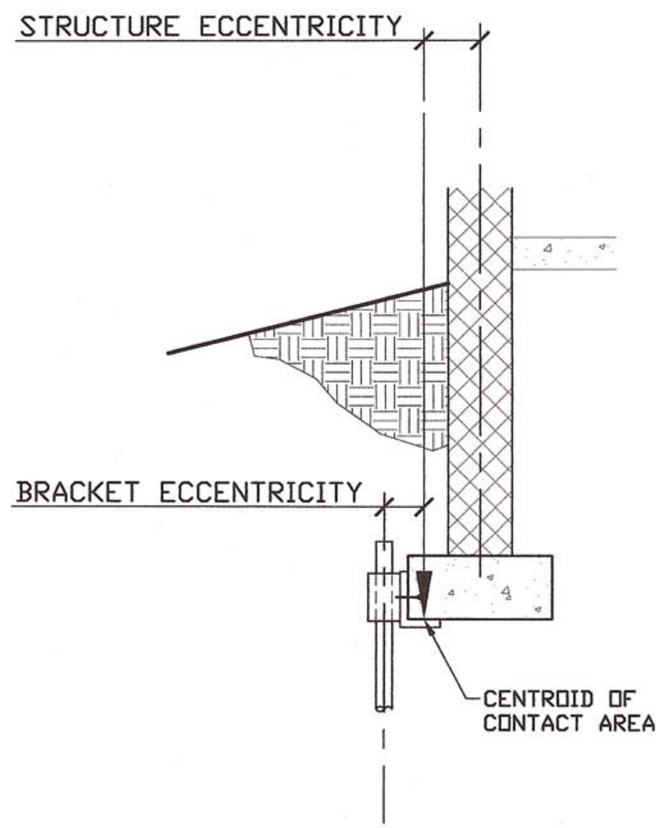

FIGURE 2—SIDE LOAD BRACKET FREE BODY DIAGRAM

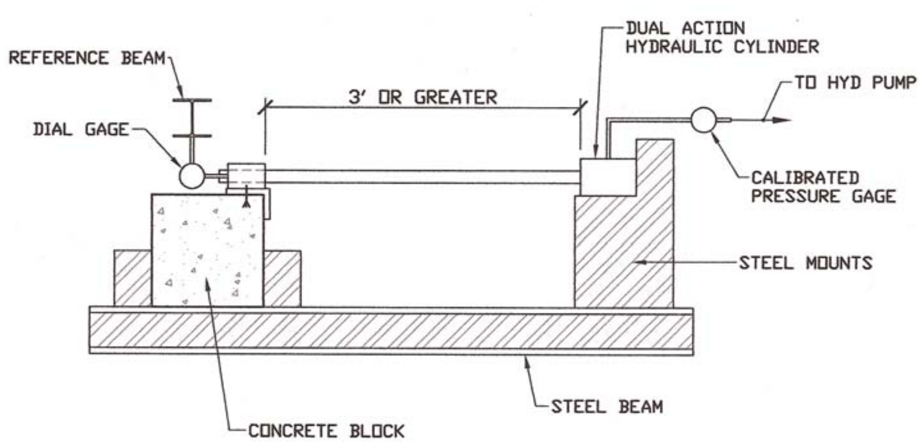

FIGURE 3—BRACKET EXAMPLE LABORATORY TEST SETUP

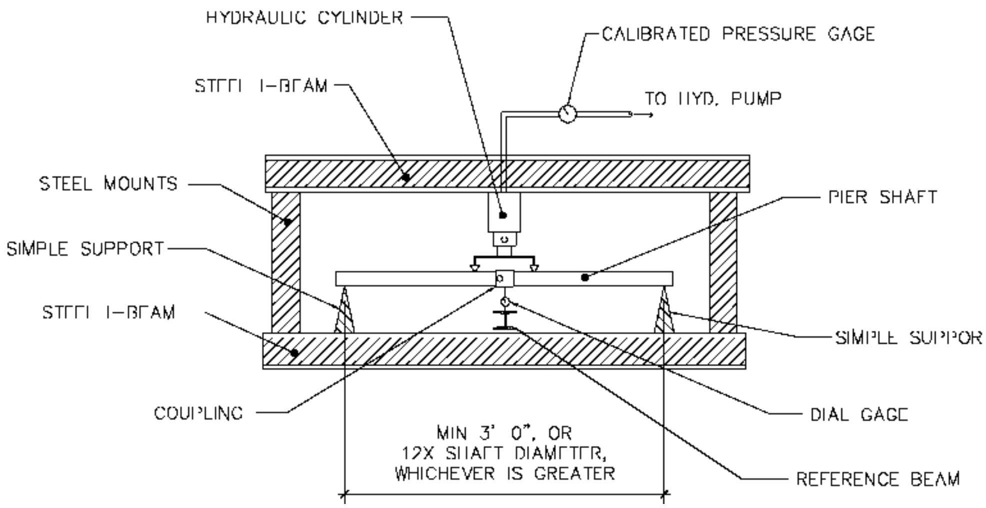

FIGURE 4 —SEGMENTED PIPE SECTION BENDING EXAMPLE LABORATORY TEST SETUP

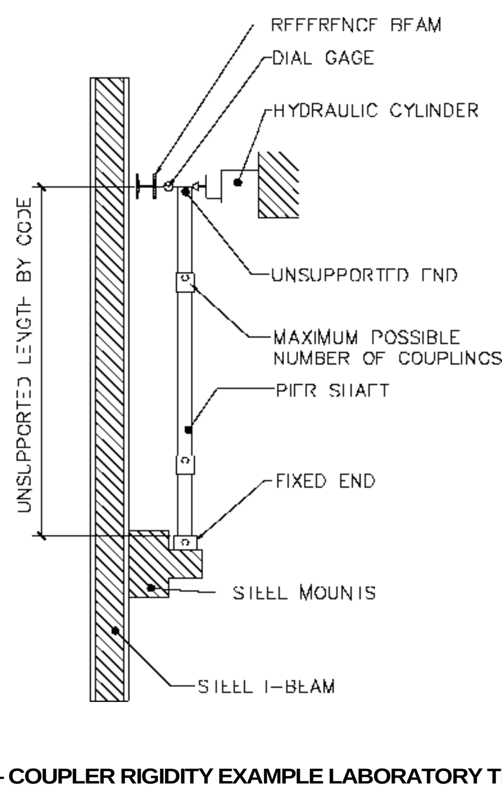

FIGURE 5 — COUPLER RIGIDITY EXAMPLE LABORATORY TEST SETUP