FEMA Foundation Design:
TEST PLAN

Prepared by

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FEMA Foundation System Test Plan

Dates

August 2017 through October 2018

Location

Test site: Selma, AL

Installer:

TBD

Project contacts

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Goal

The objective of this task is to develop, test and refine a set of foundation designs for use with each of the MHUs. These designs are intended to standardize the home set-up process at the disaster recovery sites, while ensuring that they are responsive to a variety of soil types, wind zones and seismic zones across the contiguous United States. Standardizing the foundation system promotes a consistent quality of construction by identifying best-practice solutions and providing detailed installation guidelines.

The foundation designs developed will be installed and tested with the two prototype units—an Express and a three bedroom unit. The installation process will be observed and evaluated to help improve the foundation designs and installation methods. Information gathered from the tests will be used in developing an installation manual for installers.

The key questions to be addressed by this task include but are not limited to the following:

- Are the foundation designs easy and quick to install?
- Do any of the components of the foundations system pose challenges to installers? What qualifications/skills are required?
- Do the installation steps offer precise guidance to minimize errors and maximize quality?
- Does the design offer enough flexibility and variations for use in a wide range of site conditions such as soil types, wind zones and seismic zones?
- Under design loading conditions, do the designs withstand the loads, without showing any signs of apparent damage over the test period?
- Are there any features of the design that could result in installation bottlenecks? If so, how can these issues be ameliorated?
- What is the best method for disassembling the foundation and recycling the foundation components?

Scope of Work

The goal of this task is to test a set of designs, details, installation guidelines and specifications for MHU foundation systems. The designs are required to be flexible in meeting the following criteria:

- A variety of site conditions (location, topography, soil type and bearing pressure)
- A range of MHU sizes and loads: live/dead loads based on unit type
- Withstanding typical structural loads (dead, live, wind and seismic)

Key tasks to be performed are listed below.

Task 1. Develop Design Criteria

The range of design conditions and loads that the foundation design should withstand have been characterized. These include a variety of soil types, wind, seismic zones, etc. Foundation design solutions that meet the criteria established will be developed, while considering the following criteria: first cost and cost effectiveness, quality, product availability, skills needs for installation, and speed of installation.

Task 2. Develop design and installation guidelines

A draft design of the foundation system and components shall be prepared that accommodates a range of site conditions, soil bearing capacity, wind zones, and other design variables. Installation steps shall be provided to guide installers through the entire process of foundation installation.

Task 3. Conduct soil testing at test site (Selma)

The soil-bearing capacity at Selma(psf) shall be determined with a pocket penetrometer, using the following method:

- Select a location that will be under a footing.
- Clear an area of a minimum of one square foot at least four inches deep or to the depth of the bottom of the planned footing.
- Take at least five readings with the penetrometer.
- Discard the high and low readings and average the remaining readings. Round this result down to the nearest soil-bearing value shown in Table 1.
- Determine the soil type from Table 1.

Table 1 Soil Bearing capacity by soil type

Soil Type and Classification	Allowable Pressure (psf)
Rock or hard pan (class 1)	4,000
Sandy gravel and gravel; very dense and/or cemented sands; course gravel/cobbles; preloaded silts, clays and coral (class 2)	2,000
Sand; silty sand; clayey sand; silty gravel; medium dense course sands; sandy gravel; very stiff silt, sand clays (class 3)	1,500
Clay, sandy clay, silty clay, clayey silt (classes 4A and 4B)	1,000
Uncompacted fill, peat, organic clays (class 5)	Professional testing required

If the soil bearing capacity at the test site is not the worst case (1000 psf), the foundation design (size and configuration) shall be modified to account for the worst case condition (see design documentation).

Task 4. Procure foundation materials/components

Based on the foundation design, the required quantities of materials, components and tools needed for the foundation installation shall be procured and delivered to the FEMA storage facility including:

- Gravel
- Pads (concrete or ABS)
- Concrete blocks or metal piers
- Ground anchors
- Stabilizer plates
- Tie down straps
- Skirting material

Task 5. Install foundation at test site

With the assistance of a professional installer, the test site will be prepared and the foundation will be installed for the two prototypes as per the installation instructions prepared in Task 2.

Task 6. Test and evaluate process

- **Installation evaluation.** The performance of the foundation installation will be assessed from a variety of perspectives including: ease of installation and bottlenecks encountered, time taken for each component, skills required etc. The installation instructions provided shall be evaluated to ensure that they are precise and comprehensive. (Performance metrics are detailed in the 'Evaluation Criteria' section of this document.)

- **Structural evaluation**. To measure floor deflection, a dial gage will be installed at mid-span of the doubled joists under the sprinkler tank on the nearest footings. An initial measurement will be taken before filling the tank. Another measurement will be taken immediately after the tank is filled, to determine the actual deflection of the joists, if any, relative to the structure. Subsequently, measurements shall also be taken once a day for the first week and once a week for the next three weeks. If any deflection is detected over the testing period, it shall be noted and determined if it is within the acceptable range.

Task 7. Develop test report and final design guidelines

A report documenting the findings of the assessment of the foundation design and installation will be prepared providing recommendations for refining the design. The recommendations will be incorporated into the final set of designs and home installation guidelines for each of the MHUs.

Evaluation Criteria

Each step in the installation process will be documented, identifying bottlenecks and other observations that can be used to improve the foundation designs. The following criteria will be used to evaluate suitability of the foundation system.

- **Site preparation:**
  - Is the soil cleared of debris before installation?
  - Is the ground properly graded to prevent water accumulation?
  - Is a moisture retarder installed below the home?
- **Foundation Installation:**
  - Are the footings properly sized and installed at specified locations?
  - Are the piers properly constructed and vertical?
  - Are the anchors are installed at the specified angles and spacing?
  - Are the factory installed tie-down brackets appropriate to facilitate anchoring of units?
  - Do any of the materials/components of the foundation system pose challenges to installers?
  - What is the time taken to install each component of the foundation system?
  - Has skirting been installed per manufacturer's instructions?
- **Structural Integrity:**
  - Do the designs withstand the loads, without showing any visual signs of apparent damage?
  - Does the dial gage show any deflection of floor joists post installation of TPS? (Check once a day for first week and once a week for the next three weeks) Is this above the stipulated amount according to the structural engineer?
  - Is the design suited for use in a wide range of site conditions such as soil types, wind and seismic zones?

Deliverables

The installation process will be observed and evaluated to help improve the foundation designs. The following deliverables will be provided:

1. **Foundation Installation Summary report,** containing the following:
   - Photographs and description of the foundation installation process
   - A summary of the tests performed and results
   - Recommendations for improvement of design
2. **Foundation Installation guide**, including the final foundation design for each unit and a detailed step by step method of preparing the site and installing the foundation.

Timeline

Tasks/Subtasks		Jan		February				March				April				May			
		22-26	29-2	5-9	12-16	19-23	26-2	5-9	12-16	19-23	26-30	2-6	9-13	16-20	23-27	30-4	7-11	14-18	21-25
Foundation System Design and Assessment																			
Task 1	Develop Design Criteria																		
Task 2	Develop design and installation guidelines																		
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Task 4	Procure foundation materials/components																		
Task 5	Install foundation at test site																		
Task 6	Test and evaluate process																		
Task 7	Develop test report and final design guidelines																		