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Free-Field Stations Installation Guidelines for Post-Event Assessment of Nearby Structures

Application Note #71

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SUMMARY

This document provides installation guidelines for free-field stations that are used primarily for assessing the strong-motion input to nearby structures. It is based on the COSMOS document; 'Guidelines for Installation of Advanced National Seismic System Strong-Motion Reference Stations' published in July, 2001 and available on the COSMOS website.

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A typical free-field station will include the following items (additional items may be required):

ITEM	DESCRIPTION	EXAMPLE/NOTES
1	Data Logger/Recorder	Kinemetrics Basalt4X
2	Triaxial Accelerometer	Kinemetrics EpiSensor ES-T
3	Power Supply System	12V, 92Ah Battery with AC or Solar Charger
4	Communication System	GPRS/3G Gateway, Wired Ethernet, Wi-Fi
5	Instrument Enclosure (for items 1-4)	NEMA4 Steel Enclosure
6	Reinforced Concrete Pad	See section 2
7	Fiberglass Station Hut	Powerglass Enclosure NE412000 (WPR)

The most important technical issues to consider when installing free-field stations are related to minimizing the local effects of nearby structures, changes in local topology, and the instrument foundation on recorded motions. It has been shown that certain records from instruments located in basements undergo significant de-amplification and as such are not suitable as representative input motions for other nearby structures within the typical frequency range of interest. Thus, for assessment of input motions to a campus of structures (e.g., a large power plant facility), free-field stations are more appropriate than those located within individual structures.

The remaining sections in this document provide details on

1. Recommended Location
2. Foundation Slab Construction
3. Protective Enclosures
4. Communication and Power requirements

RECOMMENDED LOCATION

To minimize the effects of nearby structures, especially within an urban environment, free-field stations should be located at least one major structural dimension (height or length, whichever is greater) from any large building (>4000 ft^2 or >2 stories) or any building with a significant basement or foundation.

If the goal is capture input motions for an isolated dense campus of structures (e.g., power plant) with a major horizontal dimension of length *L*, then free-field stations should be located within the concentric, campus-surrounding annulus with inner and outer diameters of *2L* and *4L* respectively, as depicted by the gray area in Figure 1.

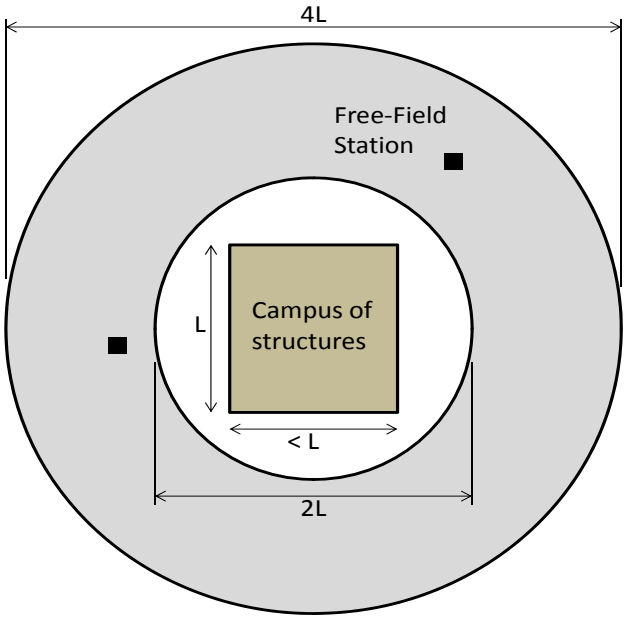


Figure 1. Campus annulus for appropriate free-field station location

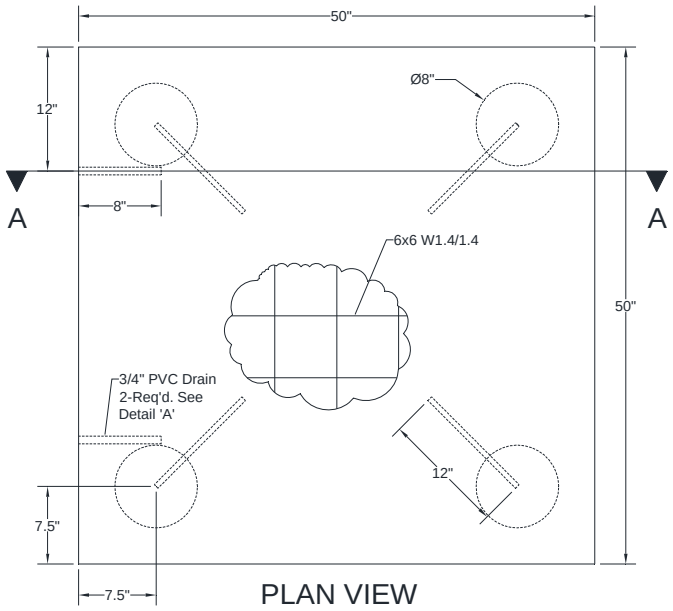
If the campus is not sufficiently isolated because of existing structures located within the campus annulus, or significant changes in underlying geology exist, then free-field stations should be located as far away as possible from these existing structures/geologies but still within the annulus.

In general, locations should be selected to avoid the following:

- Large structures (buildings, trees, towers)
- Abrupt changes in geology or localized topographic features (hill, ridge, valley)
- Locally anomalous soft or hard soils
- Sources of vibration (large motors, generators, roads with heavy traffic)

FOUNDATION SLAB CONSTRUCTION

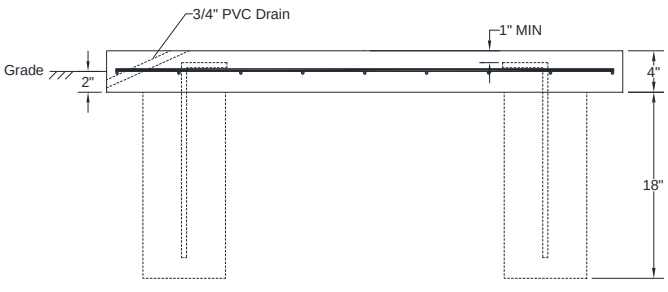
The instrument enclosures should be secured and mounted on a reinforced concrete pad constructed as described here. A 50in^2 square, 4in thick foundation slab with four anchored 6in x 18in piers to ensure effective coupling shall be constructed on site. To minimize cracking, adequate wire mesh reinforcement should be provided. To prevent moisture buildup, two PVC drain pipes should be provided. Figure 2 below illustrates these design requirements – all units are in inches.



PLAN VIEW

CONSTRUCTION NOTES

1. Approximately 1/2 cubic yard of concrete is required for the slab
2. Concrete is six (6) sack mix with 3/4" maximum aggregate
3. Welded wire mesh is 6"x6" W1.4/1.4 (10 gauge wire) with 9 strands in each direction and 1" horizontal cover
4. All rebar is 18" long #4 deformed bars (1/2") with 12" 90-degree hook and 1" min vertical clear cover
5. Corner piers extend approximately 18" below the slab and are 8" in diameter (these are typically made with a post hole digger)
6. Wire mesh and rebar are secured with wire ties
7. Slab surface to be level and troweled to a smooth surface
8. Final surface elevation is to be at 2" above grade
9. Two (2) drain pipes are provided and assembled according to DETAIL A



SECTION A-A

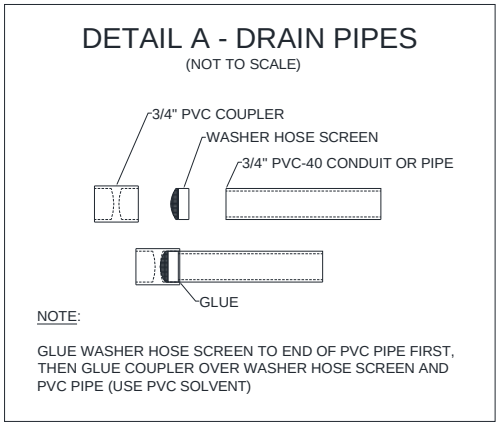


Figure 2. Foundation slab design

PROTECTIVE ENCLOSURES

Sensitive instruments should be protected in small NEMA4 enclosures securely mounted to the slab foundation. Two options are available; a single enclosure for all items (as shown in Figure 3), or separate enclosures for the sensor and all other items. Regardless of the instrument enclosure option, it is important that the sensor is mounted on a relatively thick steel plate to assure a rigid connection between the sensor and the foundation slab.

To protect the free-field station components (e.g., GPS Antenna, external cabling, etc.) from extreme weather, direct sunlight, theft and vandalism, a light weight lockable fiberglass enclosure should be provided as shown. In the past, the enclosure of choice has been a Powerglass Enclosure NE412000 (shown below in Figure 4 and data sheet attached) from Western Power Products, Inc. However, any secure equivalent model from an equivalent local manufacturer is acceptable. It is important that the sensor be towards the middle of the slab, away from the enclosure walls.

Figure 3. NEMA4 enclosure with Basalt, Battery, AC Charger, Episensor, and sensor plate

Figure 4. Powerglass Enclosure NE412000 from Western Power Products.

COMMUNICATIONS AND POWER REQUIREMENTS

Each station requires adequate and reliable power supply. Typically, this is provided by AC power and back-up batteries with a trickle charger. For the system listed in Table 1, a power consumption of 3W (0.25A @12V) is typical. The AC supply should be equipped with circuit breaker of 15Amp. If no AC power is available, a solar charging system is required. A telephone line, DSL line, or other communication link is required to communicate with the digitizer remotely.

Masts for wireless communication antennas and solar cells should be mounted some distance from the station slab to prevent wind-induced noise from contaminating the data. A distance equal to the height of the mast is sufficient.

The digitizer requires a good earth ground. Proper grounding depends greatly on the humidity of the soil at the site. For average-humidity soil, an effective earth ground can be made by wiring the case grounding stud to a 6'- to 8'-long copper rod embedded in the ground. If an antenna is mounted, lighting protection should be provided.