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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
MANILA

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DEPARTMENT ORDER)
No. 34)
Series of 2006)
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SUBJECT: DPWH Standard Specifications for Drilling Slurry, Item 716

In line with the mandate of the Department in providing effective standard specifications to be used in the implementation of various infrastructure projects and in view of the need of setting standard specifications for drilling slurry, the attached **DPWH Standard Specifications for Drilling Slurry, Item 716,** are hereby prescribed for the guidance and compliance of all concerned.

These specifications shall form part of the revised edition of the DPWH Standard Specifications (Volume II - Highways, Bridges and Airports).

This order shall take effect immediately.

HERMOGENES E. EBDANE, JR.
Acting Secretary

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DPWH STANDARD SPECIFICATIONS FOR

ITEM 716 – DRILLING SLURRY

716.1 Description

716.1.1 Scope

This item shall consist of furnishing and placing either a mineral, polymer, natural slurry or water that will maintain the stability of the side of the drilled hole during the drilling process up to concreting in accordance with this specification and the details shown on the plans.

716.1.2 Definition

Slurry will be defined as either mineral slurry, polymer slurry, natural slurry formed during the drilling process, water or other fluids used to maintain the stability of the drilled hole to aid in the drilling process or to maintain the quality of the rock socket.

In addition, the term mineral slurry and polymer slurry will be defined as the final mixed composite of all additives, including manufactured mineral or polymer slurry additives required to produce the acceptable drilling slurry.

716.1.3 Types and Uses of Slurry

716.1.3.1 The type of drilling slurry to be used will depend on the ground conditions encountered. Use of different types of drilling slurries shall be necessary to drill through different types of ground formations. Some of the factors that influence the decision of what type of drilling slurry to use include economics, ground and groundwater intrusion or contamination, ground temperature, air temperature, and the type of ground formation being drilled through. It is conceivable that different types of drilling slurries may need to be used on the same contract because of the varying ground conditions within the highway right of way. Three types of drilling slurries are provided for in this Item: water, mineral, and polymer.

716.1.3.1.1 *Water* – Water shall be suitable as drilling slurry under the right conditions. It is inexpensive to use but is limited to ground formations that are strong enough not to deform significantly during drilling. Likewise, water may be used as drilling slurry when steel casing is used for the entire length of the drilled hole. In both cases, it either serves as a lubricant to maintain the quality of the borehole or as protection to the drilling tools from overheating.

716.1.3.1.2 *Mineral* – Mineral slurries shall be used in most types of ground formations although; they work best in cohesionless sands and open gravels. Caution shall be taken when using mineral slurries in cohesive materials because they may contain clays that can be incorporated into the mineral slurry and rapidly change the mineral slurry's physical properties. In addition, cohesive materials can reduce filtration and filter cakes may not form.

716.1.3.1.3 *Polymer* – Polymer slurries shall be used in most types of ground formations but it shall not be used in soils classified as "soft" or "very soft" cohesive soils because they will encapsulate and cause settlement of clay particles from the soil cuttings. These encapsulated clay particles are similar in appearance and size as sand particles and will cause excessively high false readings of the sand content test value. This problem may also occur in soils that are only slightly cohesive.

716.1.3.2 Both the mineral or polymer slurries, during usage, shall be maintained to a height sufficient to prevent caving. A minimum of 1.5 m differential head shall be obtained so that the hydrostatic pressure is greater inside the borehole to prevent entry of ground water formation.

716.2 Materials Requirements

716.2.1 General Requirements

The material used to make the drilling slurry shall not be detrimental to the concrete or surrounding ground strata. Mineral slurries shall have both a mineral grain size that remains in suspension, sufficient viscosity and gel characteristics, sufficient percentage and specific gravity to maintain the stability of the borehole and to allow proper concrete placement.

716.2.2 Physical Requirements

716.2.2.1 Water

Water shall be fresh, clean, and free of oils, acids, alkalines, salts, organic matter, or other deleterious substances.

716.2.2.2 Mineral

Mineral slurries are processed from several different types of clay formations. The most commonly used consist of bentonite and attapulgite clay formation.

716.2.2.2.1 Bentonite suspension, as a drilling slurry, is a mixture of powdered bentonite and water. It will flocculate in the presence of acids and ionized salts and is not recommended for ground formations where salt water is present if without the use of chemical additives.

When submitted to laboratory test, Bentonite Suspension must conform to the following specifications:

Particular	Specification
Wet Screen Analysis (Residue on 200 mesh)	0.5% - 4%
Moisture Content, max.	15%
Liquid Limit, minimum	440
Marsh Cone Viscosity 1500/1000 of 6%, min.	32"
pH of filtered cake	7 - 10
Cake thickness on filter-press paper	1.5 - 4 mm.

The additives if needed, are to be selected in such a way as to guarantee the above specified mud characteristic and to avoid pollution of the mud electrolytes present in water.

During drilling work, several parameters of the slurry are to be monitored such as viscosity, density, percentage content of sand and the presence of any contaminating substances.

The following are the required specifications:

Property	Specification
Bentonite Dosage	30-80 kg/cu.m water
Specific Gravity	1.08
Marsh Viscosity	30"-50"
PH	8-10
Specific Gravity (Regenerated Slurry)	1.15 max.
Specific Gravity (During Drilling)	1.30 max.
Specific Gravity (Before Pouring)	1.20 max.

The mineral slurries shall be mixed and fully hydrated in mixing tanks prior to placement in the drilled hole. Mixing and hydration of mineral slurries usually requires several hours. One way to determine that the mineral slurry is thoroughly hydrated is to take Marsh funnel viscosity tests at different time intervals. In general, mineral slurries will achieve their highest viscosity test values when they have stabilized at their highest level. The mineral slurry can then be assumed to be fully mixed and fully hydrated.

716.2.2.2.2 Attapulgite is processed from the clay mineral as is similar in structure to Bentonite. However, it does not hydrate in water and will not flocculate in the presence of acids and ionized salts and can be used in ground formations where salt water is present. Due to the expense of transport and the relative rarity of use of this type of drilling slurry it is unlikely that this type of mineral slurry will be encountered on projects.

716.2.2.3 Polymer

Polymer slurries are grouped into three groups: (1) naturally occurring polymers, (2) semi-synthetic polymers, and (3) synthetic polymers. The synthetic polymers currently consist of two types: (1) emulsified Partially Hydrolyzed Polyacrylamide Polyacrylate (PHPA) polymers and (2) dry vinyl polymers conforming to the requirements of the following table:

PHPA and Dry Vinyl Polymer Specifications	
Marsh Funnel Viscosity (MFV) for Drilling	35 seconds per quart minimum
MFV for Concrete Placement	150 seconds per quart, max., unless higher value approved by the Engineer
Density (Unit Weight)	< 1.06 g/cum. Maximum for concrete placement. Add up to 0.03 g/cum. for seawater or contaminated water
PH	7.0 to 11.0

Sand content	Sand and agglomerates or flocs of fine material courser than 200 mesh (>74) shall be held in stable suspension or reduced to not more than 1.0% (one per cent) by volume prior to concrete placement

Prior to mixing, make up water is to be pretreated with a pH conditioner to pH range 8-10. This will aid in fully extending the polymer molecules for maximum viscosity. Water treat (pH conditioner from PICCO) or soda ash (Sodium Carbonate) is recommended from buffering pH. Normally, a 0.1 kg. of pH conditioner per barrel (42 gal/160 liter) of make up water is required. This pH conditioner also buffers the slurry against contamination from calcium and magnesium ions. Higher concentration of pH conditioner is required when salt water is encountered which is approximately 0.45 kg. of pH conditioner per barrel of make up water.

Dosage/Viscosity Guidelines:

FORMAT	**PHPA POLYMER DOSAGE OR CONCENTRATION**				**MARSH FUNNEL V, SEC/QUART**
	Vol./vol. ratio, 1/x	Gal. Per 1000 gal. Or Liters per cum.	Lbs. cu.yd.	Kg./cum.	
Clay & shale	1/800	1.25	2.19	1.30	35-45
Silt & fine to medium sand	1/600	1.87	3.3	1.87	45-60
Coarse sand to pea gravel	1/400	2.5	4.4	2.6	60 min.
In applications where brackish, salt or seawater contaminates slurry or is issued in slurry make up, dosage should be near top of given ranges and developed viscosities may be lower. Treatment of make up water and/or slurry with pH conditioners such as Water treat or soda ash may be required.					

PHPA Polymer Mixing Procedures

1. Pre-treat water with water treat/soda ash for a pH range of 8 – 10.

2. Shake the pail of PHPA polymer (liquid) before adding it to the make up water.

3. Through a venturi type shear mixer, if mixing in surface tank, add PHPA polymer slowly (2 min. per gallon / 4 liter) to the system until a ratio of 800 : 1is achieved. Use of shear mixer / centrifugal pump is to be limited as oversharing can reduce viscosity.

4. Check Marsh funnel viscosity of 35 – 45 seconds / quart.

5. The pH and viscosity of the slurry should be continually monitored throughout its use. In order to increase pH, add pH conditioner, to increase viscosity, add more PHPA polymer until desired viscosity is reached.

716.3 Application of Drilling Slurry

716.3.1 Equipment/Apparatus

During the course of drilling work up to concreting, it shall be mandatory to prepare the following equipment/apparatus if mineral or polymer slurries is to be used:

Desanding Machine – is used in the desanding process to revitalize the drilling slurry and maintain the required specification by removing the unwarranted sediments and other contamination during operation. It is also used in cleaning the bottom of the borehole of sediments upon completing the drilling work and before pouring the concrete. Although, desanding is not required in the use of polymer slurry, desanding machine shall still be however used in the cleaning of the borehole bottom to assure contact at the base for the stability of the completed bored pile work. In view of the importance of this requirement to ensure the quality of work, mere bucket cleaning of the borehole bottom shall not be allowed. If the Contractor cannot provide a desanding machine and he will use polymer slurry in the drilling works, the Contractor must submit a statement on how he intends to clean the borehole bottom, subject to the approval of the Engineer.

Drilling Slurry Pool – is used in rural areas where space is not a problem. It is a pool to contain the drilling mud improvised thru excavation near the borehole. It is lined with concrete to prevent excessive soil absorption of the drilling slurry.

Drilling Slurry Bin – is used in urban construction where there may not be enough space. It is a transferable bin or a large steel container of sufficient dimensions big enough for batching the required volume of drilling slurry.

Mineral Slurry Mixer – is a turbulent mixer to fully dissolve the mineral powder at the desired proportion.

Baroid Marsh Funnel Viscometer – to measure the viscosity of the drilling slurry, which is an important parameter to control sedimentation by providing the proper thickness of filter cake adjacent to impermeable layers.

pH Indicator Paper – for pH measure

Baroid Sand Content Set – for sand content test

Baroid Mud Balance – for specific gravity test

716.3.2 Preparation

Prior to introduction into the drilling works, the manufactured mineral or polymer slurry admixture shall be pre-mixed thoroughly with clean, fresh water and for adequate time in accordance with the manufacturer's recommendations allotted for hydration. Slurry tanks of adequate capacity will be required for slurry mixing, circulation, storage and treatment. No excavated mineral slurry pool will be allowed in lieu of slurry tanks without written approval from the Engineer.

716.3.3 Sampling, Testing and Cleaning Requirements

716.3.3.1 Mineral Slurries

Prior to drilling works, sampling and testing of the drilling slurry shall be required in order to control its physical properties. Samples shall be taken from the mixing tank for testing prior to the mineral slurry's introduction into the drilled hole. During drilling works, the mineral drilling slurry shall be sampled and tested at different intervals and locations along the depth of the boreholes. In order to implement the close monitoring of the mineral drilling slurry during the course drilling up to concreting, it shall be mandatory for any bored piling works using mineral slurry for the contractor to prepare the equipment / apparatus required in Subsection 716.3.1.

Once the mineral slurry has been introduced into the drilled hole, the mineral slurry shall be required to undergo recirculation or continuous agitation in the drilled hole. The Contractor must address which method of agitation will be used in order to maintain the initial properties of the drilling slurry and for inert particles to remain in suspension.

If the recirculation method is used, it is required that the drilling slurry be cleaned as it is recirculated. This is done using a slurry plant,

which stores, recirculates, and cleans the mineral slurry. Samples for testing shall be taken from the slurry plant storage tank and the bottom of the drilled hole to determine the physical properties of the drilling slurry and the appropriateness of the physical properties. As the mineral slurry is recirculated and cleaned, samples shall be taken every two hours or even earlier if necessary for testing until the test values for the samples taken at the two testing locations are consistent with the specification. Once the test samples have consistent test values, the sampling and testing frequency may be reduced. As the recirculation and cleaning process continues, the properties of the mineral slurry will eventually conform to the specification parameters.

If the continuous agitation in the drilled hole method is used, it is not necessary to require the mineral slurry to be physically cleaned. Samples for testing shall be taken at the mid-height and at the bottom of the drilled hole. As the mineral slurry is continuously agitated, samples shall be taken every two hours for testing. If the samples at the two locations do not have consistent test values, the mineral slurry shall be recirculated. This means that the continuous agitation in the drilled hole method is failing to keep the suspended particles in the mineral slurry from settling. This is also an indication that the mineral slurry is not clean enough to meet the specification parameters. Therefore, the Contractor is required to abandon this method and use the recirculation method. However, if the test samples do have consistent test properties within the specification parameters, the bottom of the drilled hole can be cleaned.

Once the bottom of the drilled hole has been initially cleaned, recirculation or continuous agitation in the drilled hole shall be required to maintain the specified properties of the mineral slurry. Usually the initial cleaning will stir up the settled materials at the bottom of the drilled hole, thus requiring the mineral slurry to be recleaned so it meets the requirements of the specifications. Several iterations shall be required before both the mineral slurry and the bottom of the drilled hole are clean. To verify the cleanliness of the mineral slurry, the specifications require additional sample to be taken for testing. Samples shall be taken at the mid-height and at the bottom of the drilled hole. Once the test samples show the mineral slurry's properties to be within the specification parameters and there is no settled material on the bottom of the drilled hole, the last cleaning of the bottom of the drilled hole can be considered to be the final cleaning. At this point, the rebar cage can be placed. The specifications require the samples for testing be taken just prior to concrete placement to verify the properties of the mineral slurry. Samples shall be taken at the mid-height and at the bottom of the drilled hole. If the test samples have consistent test properties within the specification parameters, concrete may be placed. Otherwise, additional cleaning of the mineral slurry and

removal of settled materials from the bottom of the drilled hole shall be required.

The reason for testing mineral slurries at different levels is to make sure the physical properties of the mineral slurries is uniform and have consistent physical properties throughout the length of the drilled hole. The mineral slurry's physical properties should be the same at both locations. This indicates that the mineral slurry is completely mixed and that any sand or any particles contained are in suspension.

716.3.3.2 Polymer Slurries

For polymer slurries, samples shall be taken at the mid-height and at the bottom of the drilled hole. Samples for testing shall be taken as necessary to verify the properties of the polymer slurry during the drilling operation. Once the drilling operation has been completed, samples for testing shall be taken. When the polymer slurry's physical properties are consistent at the two sampling locations and meet the physical requirements, the bottom of the drilled hole can be cleaned.

Once the bottom of the drilled hole has been initially cleaned, further settlement periods shall be required. Usually, the initial cleaning will stir up the settled materials at the bottom of the drilled hole, thus requiring the polymer slurry to be recleaned so it meets the requirements of the specifications. Several iterations shall be required before both the polymer slurry and the bottom of the drilled hole are considered clean. To verify the cleanliness of the polymer slurry, the specifications require additional samples to be taken for testing. Samples shall be taken at the mid-height and at the bottom of the drilled hole. Once the test samples show the polymer slurry's properties to be within the specification parameters and there is no settled material on the bottom of the drilled hole, the last cleaning of the bottom of the drilled hole can be considered to be the final cleaning. At this point, the rebar cage can be placed. These specifications require that samples for testing be taken just prior to concrete placement to verify the properties of the polymer slurry. Sample shall be taken at the mid-height and at the bottom of the drilled hole. If the test samples have consistent test properties within the specification parameters, concrete placement shall be allowed. Otherwise, additional settlement periods and removal of settled materials from the bottom of the drilled hole should be required. The reason for testing polymer slurries at different levels is to make sure the polymer slurries are well mixed and have consistent physical properties throughout the length of the drilled hole.

The apparatus used to sample drilling slurry shall be capable of sampling the drilling slurry at a given elevation in the drilled hole without being contaminated by drilling slurry at a different location as the

sampler is removed from the drilled hole. The sampler shall also be large enough to contain enough drilling slurry to perform all required tests. The apparatus shall consist of a hollow tube with caps positioned above and below the tube on a cable that is used to lower the sampler into the drilled hole. Once the sampler has been lowered to the desired level, the drilling slurry contained in the hollow tube at the level is contained by activating the caps so that the ends of the tube are sealed. The sampler is then removed from the drilled hole.

When slurry samples are found to be unacceptable, the Contractor shall bring the slurry in the borehole to within specification requirements. Concrete shall not be poured until resampling and testing results produce acceptable values.

716.3.4 Disposal of Used Drilling Slurry

The Contractor must submit a statement, subject to the approval of the Engineer, on how he intends to dispose the used drilling slurry after the completion of the drilling works. Care must be taken such that the disposal of used drilling slurry will not be of any harm to the environment. Disposal of used drilling slurry to live streams, waterways which will offset marine life, will not be permitted.

References

1. **Construction of Bored Pile Foundation** *Prepared by Bureau of Construction* January 2001 (1st Edition)
2. **Caltrans** July 1997 (Internet)

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