Washington State
Department of Transportation

Memorandum

Date: October 21, 1993

From: Vinh Q. Dang/Dave Berg
VQD
Phone: 440-4379

Subject: Soil Investigation in the Signal Design Process

Thru: Les Jacobson

To: Bill Carter, MS-110
Bill Dues, MS-147
Ron Mattila, MS-114

We met with the Bridge Design, Traffic, and Material offices from HQ and the District on September 30, 1993 to discuss and streamline the signal foundation design process. To minimize Headquarters involvement (special design) and keep most of the decisions in the District, we agreed to the following:

1. HQ Bridge Design will develop a Design Table to tabulate foundation depths for different soil (bearing capacity) conditions. They will also expand the wind load table to cover higher wind load where we (District One) often exceed the upper limits. These two expanded Design Tables should cover more than 90 percent of the designs. This means we can keep HQ out of the process 90 percent of the time. Bridge Design will have these two tables ready by mid-December 1993.

2. HQ Bridge Design agreed to treat the foundation for a double mast arm pole as a standard foundation. The District can select a foundation design from the standard tables using the higher wind load of the two arms.

3. Both HQ Bridge and HQ Material will change their operating procedure so that the District can make requests for both special soil confirmation and special foundation design at the same time. Once confirmed, HQ Materials will forward the results to HQ Bridge for Special Foundation Design. Bridge Design then would send the design back directly to the Traffic office when it is done. The bottom line is that once triggered by the District, the process will go "non-stop" all the way through.

4. The District is committed to keep on using the Standard Portable Penetrometer and Visual Inspection as the primary exploration effort. Drilling will be avoided as much as possible.

Except for item 1 - being dictated by the mid-December 1993 finish date - all changes will take effect immediately. Please let us know if we need to discuss any other issues.

VQD:na
attach.
cc: Attendees
File:930930a

MEETING MINUTES

9:00 AM - 11:00 September 30, 1993

Attendees:

David Berg, D-1 Traffic
Steve Chick, D-1 Traffic
Elise Ching, D-1 Traffic
Vinh Dang, D-1 Traffic
Terry Thayer, D-1 Traffic
Allen Stiles, D-1 Materials
Richard Swanson, D-3 Traffic
Bill Brown, HQ Traffic
Tony Allen, HQ Materials
Rich Zeldenrust, HQ Bridge

BACKGROUND:

In 1983, Bill Brown from HQ Traffic recommended that signal foundations be designed based upon some assumed average soil condition. The foundation depth could be extended in accordance with Sections 8-20.3(4) and 1.04.4 (Change Order). Due to the small amount of special design cases, HQ Bridge determined that further generalization of foundation design would be more costly. The foundation continued to be designed using the limited table.

As more signals are being built in the high speed, high volumes, and wide roadway, deeper foundation (outside of the conventional range) becomes more popular. The current design table is also inadequate and too conservative. We called this meeting to peruse the current practice as well as expanding the design table to cover a wider range of soil condition.

The discussions are summarized as follows:

1. Soil investigation is needed.

Soil investigation during design will give us the basic information to select the proper foundation depth. We agreed that soil investigation is needed for type II, type III (mast arm standards), type IV, and type V (metal strain pole standards) due to the depth and the critical location of these foundations. These investigation certainly will minimize Change Order under category IF, aka "Inadequate Field Investigation during the design phase".

2. The investigation normally is not extensive.

The District Material Engineer or the Assistant will first look at the available data in the office or make an initial field visit to scope out the investigation effort. When soil data is available on file for the vicinity, the Engineer might elect to use them with (or without) minimum visual site inspection or further sample collection. The next level of effort would be to use the Standard Portable Penetrometer (SPP) to determine soil bearing capacity in situ. Should the SPP test indicate soft material, a soil sample would then be collected for further lab testing. The sample is normally collected as deep as at the base elevation. This level of investigation effort requires drilling or boring. Historically, 90 percent of the investigation efforts stop at the SPP level.

The SPP test is simple and inexpensive. The portable penetrometer is driven down into the ground by a hammer. The number of blows to advance the penetrometer each unit depth (foot) determines the bearing capacity of the material. The penetrometer can be driven down to a maximum depth of seven feet. This operation requires two persons and a pick-up truck for one day. The followup report recommending foundation depth can be finished in one day. Using the SPP test, the approximate turnaround time for soil investigation and preparing the soil report is two weeks. This whole process costs anywhere from $400 to $800.

When the soil bearing capacity appears to fall below 2,500 psf, the District Materials Engineer might order drilling for material sample. The sample would then be transmitted to the HQ Materials lab for testing and recommendation. HQ Lab would review these samples and recommend whether the type of soil requires a special foundation or not. This process could be lengthy and expensive. Turnaround time could be up to a few months and the costs could go up to $4,000 for soil exploration and testing effort. Fortunately, we have not been drilling for signal designs very often.

Once the HQ Materials office concurs that special soil conditions exist, HQ Bridge would then be notified to prepare special foundation design. Again, this would add to the overall design cost as well as affect the schedule.

3. Special Design:

A special foundation design is currently required for the following conditions:

- Soil bearing capacity falls below 1,000 psf.*
- Rock outcrop is encountered.
- Wind load exceeds 1,700 ft3.
- Double mast arm design.
- High water table.

Historically, wind load has been the main reason for special foundation design. The high wind load is due to wide intersection, or complicated intersection. Signal mast arms in the District occasionally have to span more than 50 feet. Sometimes the mast arm have to carry additional displays or lane control signs. The current maximum load is 1,700 ft3. HQ Bridge will expand the load table to cover up to 2,500 ft3. This would reduce the special foundation design effort from HQ. However, the signal standard itself would need to be redesigned to be included as part of the preapproved plans.

The current foundation design table assumes an average soil bearing capacity of 2,500 psf. Every time the District Materials office encounters soil having less than this capacity, a request for special design is submitted to HQ. Quite often, the special designed foundation is not deeper than the standard design. HQ Bridge advised us the empirical design table we are using is too conservative. They will tabulate a new table for bearing capacity at 1,000 psf, 1,500 psf, and 2,500 psf. With this table, the District can determine foundation depth for a wide range of soil conditions (by interpolation) without relying on HQ Mat Lab or Bridge Design.

We also requested that the foundation for double mast arm pole should be treated as a standard foundation using the wind load generated by the longer arm. HQ Bridge concurred. They have checked and verified this would be within 15 percent of the worst case arm arrangement (arms at acute angle).

4. Other agencies' practices.

City of Seattle uses some average soil condition without investigation during design. They rely on their construction Project Engineer to verify these assumptions during construction when the Contractor is excavating for foundation. King County does not perform any investigation ("not even kicking the dirt"). They have been using the State empirical table and only ran into bad soil conditions twice out of 40 signals during construction.

ACTION / RECOMMENDATION

1. Design Changes.

Bridge Design will develop new Design Tables to cover a wider range of soil conditions so that Bridge Design can almost be cut out of the loop.

2. Process Changes.

Special Design Requests will go from District Materials to HQ Materials for concurrence. Upon concurrence, HQ Mat would forward to HQ Bridge for design with instruction for the design to be sent back to Traffic Design directly.

FOUNDATION DEPTH TABLE							
Allowable Lateral Bearing Pressure (psf)	Foundation Type	XYZ (cubic feet) Type II, III and SD mast arm standards.					
		600	900	1,200	1,500	1,900	2,300
1,000	3' Round	10'	10'	11'	11'	13'	15'
	3' Square	8'	8'	9'	9'	10'	11'
	4' Round	8'	8'	9'	9'	10'	11'
1,500	3' Round	8'	8'	9'	11'	13'	15'
	3' Square	7'	7'	7'	8'	8'	9'
	4' Round	7'	7'	7'	8'	8'	9'
2,500	3' Round	6'	6'	7'	11'	13'	15'
	3' Square	6'	6'	6'	6'	7'	7'
	4' Round	6'	6'	6'	6'	7'	7'

This table is based on a phi value of 26 degrees. For double mast arm standards, use the larger XYZ value for foundation depth selection." only if arms @ 90 degrees to each other."