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January 25, 2017

Mr. Nathan Will, P.E.
Ms. Amber Klein, P.E.
SRF Consulting Group, Inc.
One Carlson Parkway North, Suite 150
Plymouth, MN 55447

GTE Project No. 95423-C

RE: Geotechnical Project Memo – Hennepin County CSAH 112, Phase 2 – Retaining Wall D

Dear Mr. Will/Ms. Klein:

CSAH 112, Phase 2 between Wolf Point Trail and Wayzata Blvd is proposed to include a bike trail located on the north side of the proposed roadway section. Bike trail inclusion requires the installation of an approximately 300ft long cut wall (Wall D) between approximate stations 1186+00 – 1189+00. The retaining wall is proposed to have an exposed height of between 3 – 5.5ft and preliminary cross sections indicate an approximately 1 – 1.3H:1V, 8-10ft tall upslope behind the wall crest. We understand that the existing slope and area above it is outside the project right-of-way and contains trees and significant vegetation. As a result, SRF is investigating cost effective wall options while trying to limit right-of-way encroachment and impact to area aesthetics. This memo discusses potential cut wall options, such as a cast-in-place cantilever (CIP) concrete retaining wall and a prefabricated modular block wall (PMBW), as well construction requirements associated with those options, such as wall embedment depth and modular block width requirements.

Soil Conditions at Wall D

At the time of our subsurface exploration associated with CSAH 112, Phase 2, no soil borings were performed specifically along the Wall D alignment, however two (2) soil borings and one (1) hand auger were performed for the proposed Wall C alignment, located on the opposite side of the roadway as Wall D along some of its alignment. Soil borings B-65 and B-66 indicate that the Wall D foundation soil will likely consist of a medium stiff to stiff silty clay. Hand auger HA-2, performed through the existing slope behind Wall C, indicates that a soft to medium stiff clay will likely be retained by Wall D.

Results from these soil borings and hand auger were used to determine the following soil parameters to be used for the structural design of a CIP cantilever wall. These soil conditions should be confirmed before or during construction.

Table No. 1: Summary of Recommended Soil Parameters for CIP Wall design at Wall D location

Design Parameter	Wet Unit Weight (pcf)	Angle of Internal Friction (deg.)	Active Earth Pressure Coeff. (Ka)	Passive Earth Pressure Coeff. (Kp)	Active Equivalent Fluid Pressure (Ea) (psf/ft)	Passive Equivalent Fluid Pressure (Ep) (psf/ft)
Value	120	32	0.31	3.25	37	390

Based on a wall bearing soil consisting of a stiff to very stiff clay, with an unconfined compressive strength greater than 1.0 tons per square foot (tsf), we recommend a maximum net allowable bearing pressure of 2500 psf to result in settlement less than 1 inch.

These soil strength parameters were also used to perform a geotechnical stability analysis for a gravity PMBW (big-block wall). The results of the analysis were used to estimate the block widths for the base of the wall, which then would determine the excavation limits required for a PMBW at this location.

PMBW Analysis

The wet-cast, prefabricated modular blocks have a height ranging from 16 – 18 inches and are manufactured in depths of 24, 39, 45 and 60 inches. To meet adequate geotechnical factors of safety with respect to sliding and overturning, larger block depths (39 – 60 inches) are typically required at the wall base, while 24 inch deep blocks are typically used to construct the upper portion of the wall.

An analysis was performed using the software ReCon Wall Version 4.0 to determine the block width requirements at the base of Wall D, considering the medium stiff to stiff clay soil conditions and a 8-10ft tall, 1.1H – 1.3H:1V backslope behind the wall. The stiff clay was assumed to have a density of 120 pcf and an angle of internal friction of 32 degrees. The results of the analysis are given in the table below.

Table No. 2: Base Block Depth v. Exposed Wall Height for PMBW at Wall D

Exposed Wall Height (ft)	Required Base Block Width (inches)
4ft or Less	24
4 - 5ft	39
5 – 5.5ft	45

The results of the analysis indicate that a 39 – 45 inch base block will be required for the majority of the wall alignment. Typically, a concrete or Class 5 aggregate base leveling

pad extends 6 inches beyond the back of the block, which would set the final wall width and excavation requirements for wall installation.

Wall Embedment Depth

CIP Cantilever Retaining Wall

The MnDOT standard plans sheets for CIP retaining wall design require a minimum 4.5ft embedment depth to the bottom of the wall footing. The purpose for this wall embedment depth is for frost protection. For a 5ft tall exposed (10ft total) exposed height, a wall footing width of 6ft is required, per the MnDOT Standard Plans.

PMBW (Big Block Walls)

MnDOT requires a minimum 4ft embedment depth to the bottom of the leveling pad for PMBW walls, also to reduce the potential for frost heave. A concrete leveling pad is also required per MnDOT. This embedment depth can be accomplished by constructed a concrete leveling pad up to 2ft thick and providing a 2ft block embedment, or by placing a 6 inch thick concrete leveling pad with a 3.5ft block embedment.

The 4ft embedment depth for modular block walls, though specified by MnDOT is conservative for a "flexible" wall system. Unlike CIP cantilever retaining walls, prefabricated modular block walls are not a monolithic concrete mass and thus can tolerate some heaving due to frost action, without comprising the structural integrity of the wall system. The National Concrerte Masonry Association (NCMA) Segmental Retaining Wall Design Manual recommends a minimum of 0.5ft embedment depth for modular block walls. This issue could be further explored by contacting the State Aid Engineer or the MnDOT Foundations Unit for additional guidance/recommendations.

Alternative Cut Wall Options

Alternatives to a CIP cantilever wall or a PMBW wall could also be considered if it is desired to minimize the excavation associated with wall installation. Some potential options could a Rockery, or a boulder faced wall or a wall type constructed using a top-down construction approach, such as a soldier pile wall with a concrete panel facing.

Rockeries, or boulder faced walls, are gravity retaining wall that use large, angular boulders stacked up to create a wall face and resist lateral earth pressures. FHWA design manual CFL/TD-06-006 could be used to develop the rockery design for Wall D. Rockery design typically consists of specifying the minimum base boulder diameter, a wall batter angle, a maximum facing void spacing and the filtration/separation geotextile placed behind the boulder face. Alternatives to this system, such as a gabion basket gravity wall system could also be considered.

The other alternatives to a gravity retaining structure could be a structure constructed using a top-down construction technique. For a wall of this height, this would most likely consist of a soldier pile wall with timber lagging and a permanent concrete panel facing.

This type of wall construction involves installing H-piles into the ground every 8-10ft along the wall alignment and then excavating between the H-piles and placing timber lagging between the piling. This type of structure would not require excavation behind the wall face, but would probably be less economical then a PMBW or Rockery type wall. Construction vibrations generated from pile driving may also cause damage to nearby residential structures. If this type of wall option is to be considered, then a precondition survey and vibration monitoring plan is recommended.

Summary

If excavation for a conventional CIP wall or 4ft embedded PMBW wall is not feasible, then we recommend that the County and/or MnDOT State Aid be contacted to determine if an alternate wall type, such as a Rockery or gabion wall, or if a reduced PMBW embedment depth could be considered for Wall D. If one of these wall types is to be considered, we would be pleased to provide a geotechnical stability analysis, and aid in plan and specification development.

Respectfully,

GALE-TEC ENGINEERING, INC.

Nathan M. Lichty, P.E.
Project Engineer

Stephan M. Gale, P.E.
Principal Engineer

I hereby certify that this plan, specification, calculation, or report was prepared by me or under my direct supervision and that I am a Registered Professional Engineer under Minnesota Statute, Sections 326.02 to 326.15.

Nathan M. Lichty

Date: 1/25/2017 Reg. No. 51331

NML/SMG
REPORT/ SRF, Hennepin County CSAH 112, Phase 2 Wall D, Long Lake, MN