Analysis 4

Alternate method for placement of the building foundation

Problem

Originally, the general contractor proposed that the entire footprint be excavated to the bottom elevation of the foundation system and then forming will be used for the pour. After the concrete pour, the footings will be stripped and then the area will be backfilled with structural fill and stone. This method (bulk excavation) not only involves more soil to be removed, it also requires more fill.

Goal

The goal of this analysis is to see if pouring the foundation system into excavated pits can reduce labor costs, schedule, and the amount of material used. This method of placement (trench excavation) eliminates the need for forming and reduces the amount of material removed and the amount of fill.

Methodology

1. Determine the quantities of soil to be removed for each placement method (trench vs. bulk).
2. Estimate the forming costs and labor productivity.
3. Assess the change in demand for the excavator.
4. Compare the material costs, labor costs, and activity durations.

Tools

1. R.S. Means 2006 Edition
2. Penn State Architectural Engineering faculty
3. Forrester Construction Company – General Contractor

Outcome

After performing a detailed cost and schedule analysis, it has been determined that the trench excavation method for placing the foundation system is more efficient. The trench excavation method costs less and is faster than the bulk excavation method because it does not require as much material to be removed. This reduction of material can further support the LEED® aspect of Columbia Heights. The following pages will give a detailed view of each analysis and their results.

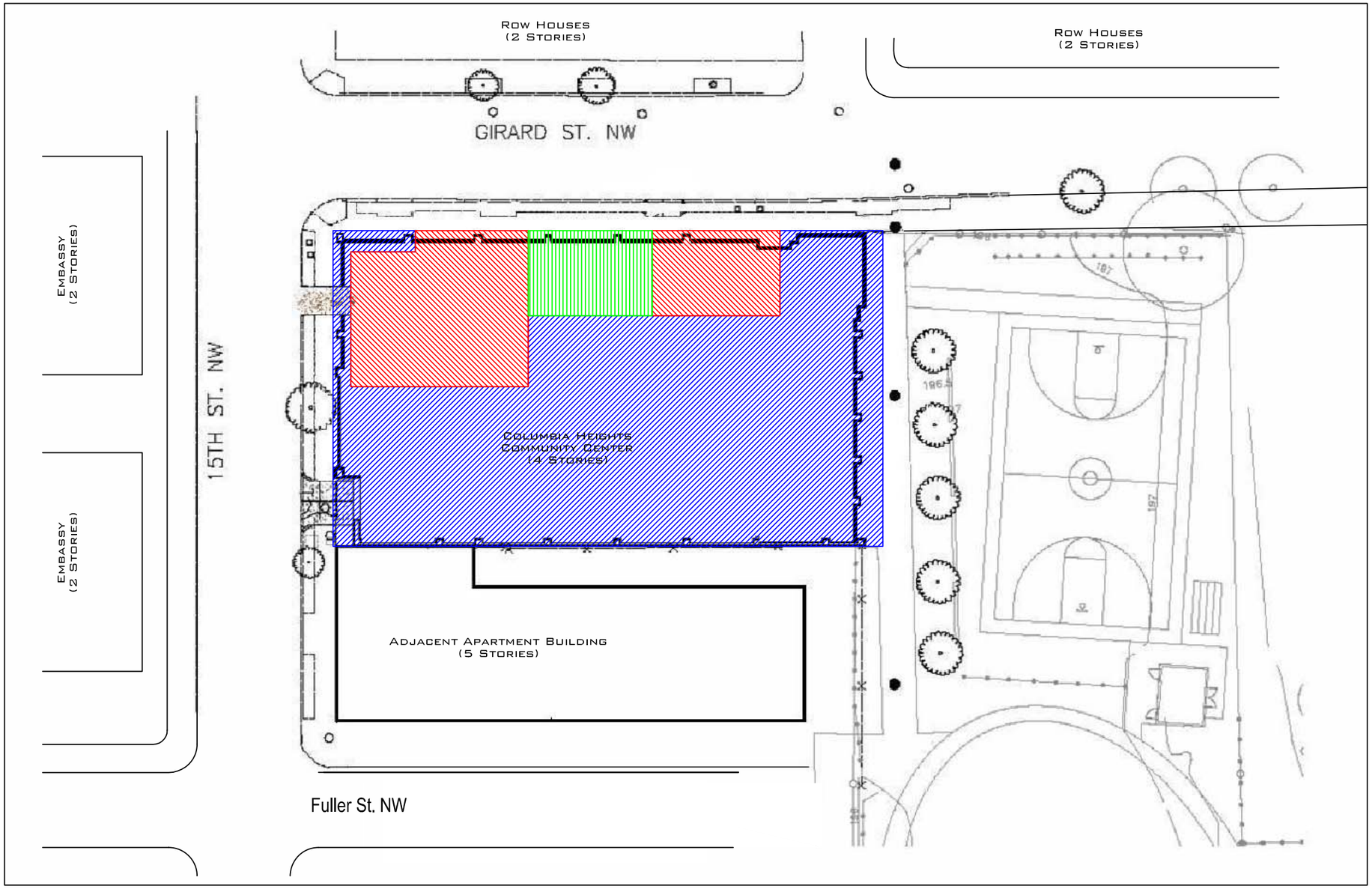
Cost Impacts

In order to perform this analysis, quantities of soils to be removed were taken from the structural foundation plans. For both the trench and bulk method, it was assumed that the excavation would be performed until the bottom elevation of the footing. The difference between this elevation and the grade elevation of 100'-0" would provide the depth of excavation needed. Using this depth, the trench excavation method used the width of each foundation to produce the total quantity of soil. The bulk excavation quantity was determined by using the average depth of three different areas, which can be viewed on the following page (*Excavation Depth Plan*). Please see *"Table 1 – Cost Difference Summary"* below for an overview of the results.

Table 1 – Cost Difference Summary

Item	Trench Excavation	Bulk Excavation	Difference
Material (BCY)	967.09	2620.93	**1653.84**
Material (LCY)	1063.80	2883.02	**1819.22**
Total Costs	$27,893.91	$120,317.59	**$92,423.68**

As it can be seen, the difference in material to be removed is significant. The bulk excavation method quantity is nearly triple that of the trench method. This is what accounts for the large difference in cost. The costs seen above include all excavation, removal, and forming costs. Concrete placement costs were not analyzed because they will not change between the trench and bulk methods, concrete will still be pumped to the location of the footing. By using the trench placement method, it will have a savings of roughly 77%. The exact quantities of soil to be removed, costs, and the assumptions for each method can be found in *"Table2 –Excavation Estimate"* on the page following the *"Excavation Depth Plan"*.



LEGEND:

GRADE AT EL. 100'-0"

AREA 1 (BOTTOM EL. 96'-0")

AREA 2 (BOTTOM EL. 93'-0")

AREA 3 (BOTTOM EL. 88'-0")

EXCAVATION DEPTH PLAN		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 02/27/2006		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-1

Table 2 - Excavation Estimate

Excavation of Footings Only (Trench)

Item	Length (ft.)	Quantity	Depth to bottom ftg. elev. (ft.)	Volume Soil (BCY)	Volume Soil (LCY)	Material Removal ($ / LCY)	Total Material Removal ($)	Labor ($ / BCY)	Total Labor ($)	Equipment ($ / BCY)	Total Equipment ($)	Total Cost ($)
Column Footings/ Grade Beams												
6' W x 2' Thick (98'-0")	355	1.00	4.00	315.56	347.11	$23.73	$8,236.95	$1.31	$413.38	$1.40	$441.78	$9,092.10
6' W x 2' Thick (97'-0")	18	1.00	5.00	20.00	22.00	$23.73	$522.06	$1.31	$26.20	$1.40	$28.00	$576.26
6' W x 2' Thick (95'-0")	33	1.00	7.00	51.33	56.47	$23.73	$1,339.95	$1.31	$67.25	$1.40	$71.87	$1,479.07
6' W x 2' Thick (94'-0")	8	1.00	8.00	14.22	15.64	$23.73	$371.24	$1.31	$18.63	$1.40	$19.91	$409.78
6' W x 2' Thick (92'-0")	17	1.00	10.00	37.78	41.56	$23.73	$986.11	$1.46	$55.16	$1.56	$58.93	$1,100.20
6' W x 2' Thick (90'-0")	21	1.00	12.00	56.00	61.60	$23.73	$1,461.77	$1.46	$81.76	$1.56	$87.36	$1,630.89
10' x 10' x 2' Thick (98'-0")	--	3.00	4.00	44.44	48.89	$23.73	$1,160.13	$1.31	$58.22	$1.40	$62.22	$1,280.58
10' x 10' x 2' Thick (95'-0")	--	2.00	7.00	51.85	57.04	$23.73	$1,353.49	$1.31	$67.93	$1.40	$72.59	$1,494.01
9' x 9' x 2.5' Thick (98'-0")	--	1.00	4.50	13.50	14.85	$23.73	$352.39	$1.31	$17.69	$1.40	$18.90	$388.98
9' x 9' x 1.5' Thick (98'-0")	--	1.00	3.50	10.50	11.55	$23.73	$274.08	$1.31	$13.76	$1.40	$14.70	$302.54
5' x 5' x 2.5' Thick (98'-0")	--	3.00	4.50	12.50	13.75	$23.73	$326.29	$1.31	$16.38	$1.40	$17.50	$360.16
11' x 11' x 2' Thick (98'-0")	--	2.00	4.00	35.85	39.44	$23.73	$935.84	$1.31	$46.97	$1.40	$50.19	$1,033.00
6' x 6' x 1.5' Thick (98'-0")	--	5.00	3.50	23.33	25.67	$23.73	$609.07	$1.31	$30.57	$1.40	$32.67	$672.30
10' x 10' x 1.5' Thick (98'-0")	--	1.00	3.50	12.96	14.26	$23.73	$338.37	$1.31	$16.98	$1.40	$18.15	$373.50
Strap Beams												
4' W x 1.5' Thick (98'-0")	252	1.00	3.50	130.67	143.73	$23.73	$3,410.79	$1.31	$171.17	$1.40	$182.93	$3,764.90
4' W x 1.5' Thick (96'-0")	31	1.00	5.50	25.26	27.79	$23.73	$659.34	$1.31	$33.09	$1.40	$35.36	$727.80
4' W x 1.5' Thick (94'-0")	54	1.00	7.50	60.00	66.00	$23.73	$1,566.18	$1.31	$78.60	$1.40	$84.00	$1,728.78
Tie Beams												
4' W x 2.5' Thick (98'-0")	77	1.00	4.50	51.33	56.47	$23.73	$1,339.95	$1.31	$67.25	$1.40	$71.87	$1,479.07
			Total:	**967.09**	**1063.80**		**$25,244.02**		**$1,280.96**		**$1,368.93**	**$27,893.91**

**Grade is at elevation 100'-0"*

***Assume average swell factor to be 10%*

****Assume C.Y. of soil to be quantity excavated to bottom of footing elevation*

***** Assume equipment is 1.0 C.Y. Backhoe*

****** Unit Rates for trench (footing) excavation taken from R.S. Means 2006. Price increased as depth increases.*

******* Material Removal cost is based on total hauling costs and fleet size determined below - (3) 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Excavation of Entire Site (Bulk)

Item	Area (sf)	Area Elevation	Depth (ft.)	Volume Soil (BCY)	Volume Soil (LCY)	Material ($ / Unit)	Total Material ($)	Labor ($ / Unit)	Total Labor ($)	Equipment ($ / Unit)	Total Equipment ($)	Total Cost ($)
Area 1	10000	96'-0"	4.00	1481.48	1629.63	$31.64	$51,561.48	$1.31	$1,940.74	$1.40	$2,074.07	$55,576.30
Area 2	2955	93'-0"	7.00	766.11	842.72	$31.64	$26,663.73	$1.31	$1,003.61	$1.40	$1,072.56	$28,739.89
Area 3	840	88'-0"	12.00	373.33	410.67	$31.64	$12,993.49	$1.46	$545.07	$1.56	$582.40	$14,120.96
			Total:	**2620.93**	**2883.02**		**$91,218.71**		**$3,489.41**		**$3,729.03**	**$98,437.15**

**Depth is based on Grade at elevation 100'-0"*

***Assume average swell factor to be 10%*

****Assume CY of soil to be quantity excavated to bottom of footing elevation*

***** Material Removal cost is based on total hauling costs and fleet size determined below - (4) 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Forming Costs

Item	Depth (ft.)	Contact Area (SF)	Material $ / Unit		Total Material $	Labor $ / Unit	Total Labor $	Total Cost
Column Footings / Grade Beams	Varies	3004.00	2.31		$6,939	2.76	$8,291	$15,230
Strap Beams	1.5'	1092.00	1.56		$1,704	3.02	$3,298	$5,001
Tie Beams	Varies	360.00	1.56		$562	3.02	$1,087	$1,649
							Total:	**$21,880**

**Grade is at elevation 100'-0"*

***Assume average swell factor to be 10%*

****Assume CY of soil to be quantity excavated to bottom of footing elevation*

Fleet Size per 6 C.Y. Load

Item	Equipment	Labor (hrs/BCY)	BCY/ Hr	LCY / hr	Dump Truck LCY/hr	Dump Trucks Needed
Trench Excavation	1 C.Y. Hydraulic Backhoe	0.040	25.00	27.50	10.8	3
Bulk Excavation	1 C.Y. Hydraulic Backhoe	0.027	37.04	40.74	10.8	4

** Based on 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Schedule and Excavator Demand Impact

The impact to schedule and excavator demand in this analysis are equal. On the Columbia Heights Community Center project, only one excavator was used for removal. After determining the difference in the quantities of soils removed for both excavation methods, it was seen that the trench excavation method was shorter, which contradicts the expected outcome that was noted in the proposal (see "Analysis 4 – Expected Outcome" in *Final Thesis Proposal*). It was expected that the trenching activity would take longer due to the intricate system of foundation members throughout the site. Even though the productivity rate for the trench method was less than that of the bulk method, the large difference in soil quantity was the main factor in the schedule difference. As seen below in "*Table 3 – Schedule / Excavator Demand Impact*", the bulk method takes nearly twice as long as the trench method.

Table 3 - Schedule / Excavator Demand Impact

Item	Equipment	Labor (hrs/BCY)	Total BCY	Total hrs	Total Days
Trench Excavation	1 C.Y. Hydraulic Backhoe	0.040	967.09	38.68	4.8
Bulk Excavation	1 C.Y. Hydraulic Backhoe	0.027	2620.93	70.77	8.8
			Difference:	**32.08**	**4**

**Assume 8 hour work day*

*** Productivity rates taken from R.S. Means 2006*

Conclusion

When viewing these results, it can be seen that the trench excavation foundation placement method is more efficient than the original proposed method of bulk excavation placement. It cuts costs associated with soil removal by roughly 77%.

Even though the trench placement method will take more planning and layout during the excavation phase, it is offset by the planning and layout needed during the forming activity in the bulk excavation placement method. Using the trench method decreases the activity duration and excavator demand by roughly 50%.

With all of these factors in mind, it is strongly recommended that the trench excavation foundation placement method be used in lieu of the original plan of bulk excavation. Not only does it cut costs and durations, it also reduces the amount of waste material, thus supporting Columbia Heights Community Center's LEED® aspect.