Structural Breadth – Impervious Surface Parking vs. Parking Garage

Introduction

Problem/Opportunity Statement

A comparative analysis will be done between the existing and proposed impervious surface parking and a parking structure. The main focus of this analysis will be completed from a sustainable point of view. It will include the design and implementation of a parking garage and eliminating the parking lot. At least three sustainable site points can be gained from this proposal. Also, from a structural standpoint, the most efficient and effective system will be investigated and implemented. A cost and schedule analysis will be studied.

Goal

The intention of this analysis is to incorporate a more sustainable site into Milestone Business Park. By taking away the impervious parking lots, three sustainable site points can be obtained. With the open space on site, a few options can be considered. Instead of driving through the development a road with direct access to Father Hurley Road is feasible. By code, there is a predetermined ratio of pervious surfaces. By eliminating the impervious surfaces, this also allows more space to expand the building, if desired.

Research Steps

1. Quantify amount of parking spaces needed.
2. Determine allowable site usage.
3. Design parking garage, architecturally.
4. Design parking garage, structurally.
5. Locate a site for the structure.
6. Review cost and schedule impacts. Include the cost to tear up existing parking and implementation of new structure.
7. Brainstorm ideas for new open site.
8. Review cost, schedule and revenue for site ideas.

Expected Outcomes

An increase in cost and schedule for this analysis is anticipated. However, an implementation of a parking structure will allow for a more sustainable site and community. One concern I have is justifying this proposal as beneficial, even though it will cost more and increase the schedule.

Comparison

Asphalt Parking Lot

An asphalt parking lot is cheap, easy and fast. However there are some disadvantages to having a site full of asphalt parking. The most critical disadvantage is stormwater runoff. An asphalt parking lot is considered an impervious surface; therefore it will not allow the rain water to seep into the earth. Instead, the water runs off into our stormwater management system picking up oil, antifreeze and other harmful products.

Parking Garage

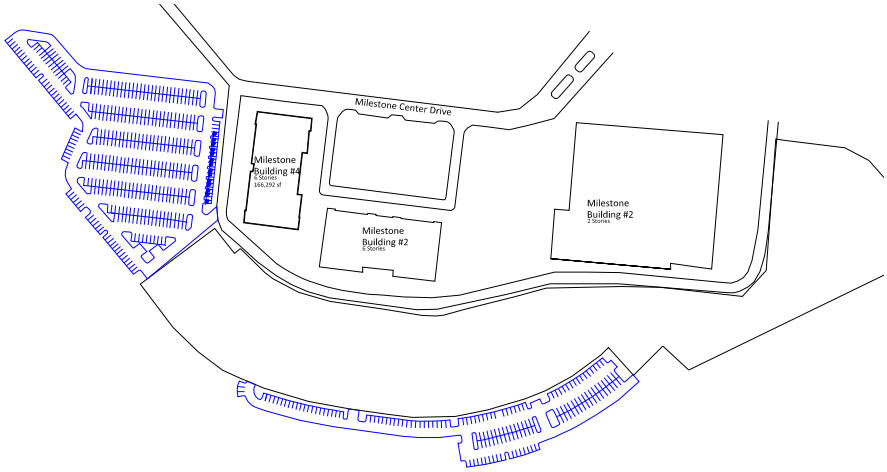
A parking garage builds up instead of out, allowing for more free space on the site. This decreases the amount of harmful products into our stormwater management system. With more space onsite, the more one is able to do with the site. For example, additional buildings, increase current building size and the nice view of an arboretum. However, some codes and zoning variances limit the building area per site. This is the instance at Milestone Business Park. As I implement the parking garage and utilize more building square footage onsite, this square footage can be used as a green roof on Milestone Building #4.

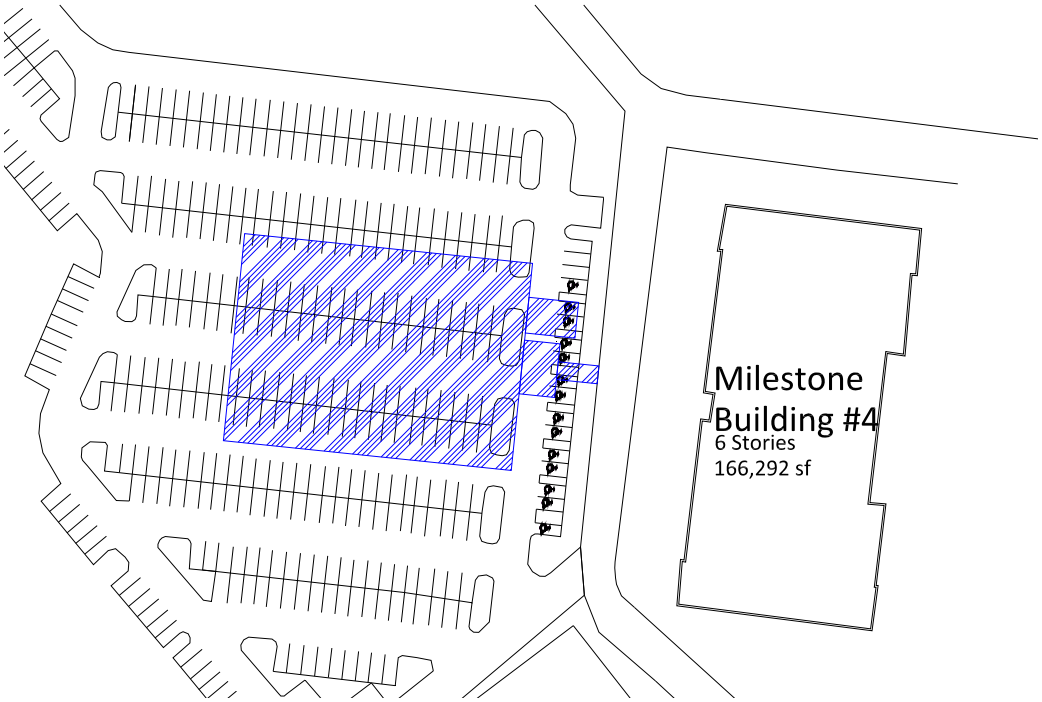
LEED Benefits

The owner of Milestone Business Park and Building #4 gave up three LEED credits by implementing the asphalt parking lot; SS 5.1 Site Development (Protect or Restore Habitat), SS5.2 Site Development (Maximize Open Space) and SS7.1 Heat Island Reduction (Non-Roof).

Site Plan

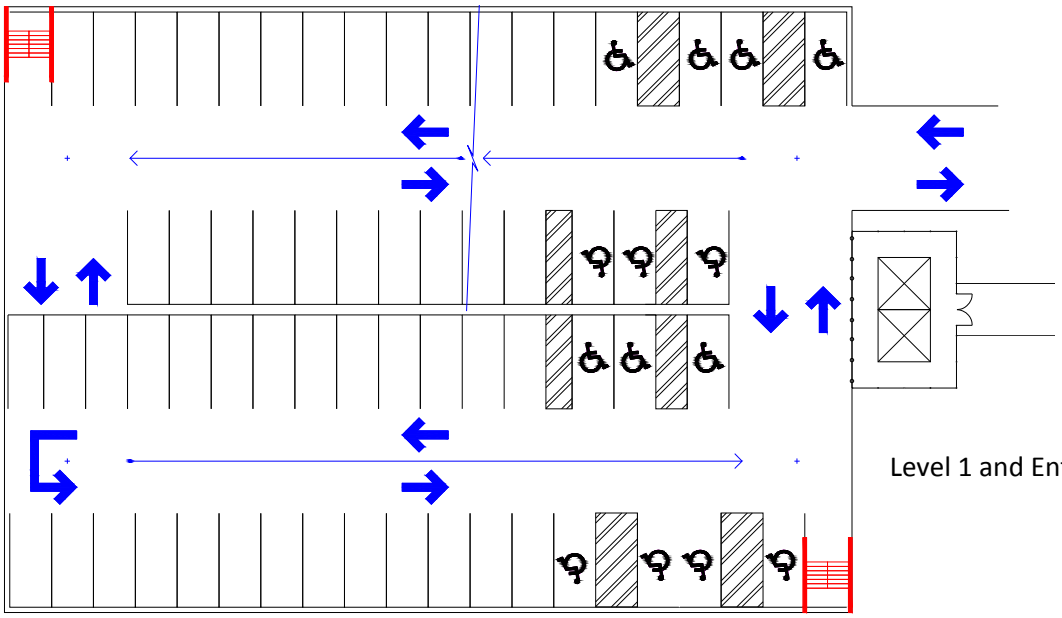
The figures below show the location of the asphalt parking lot addition to this phase and parking garage on site. The placement of the structure was strategically located across the entrance to Building #4 and an easy road connection with the existing road, Milestone Center Drive.



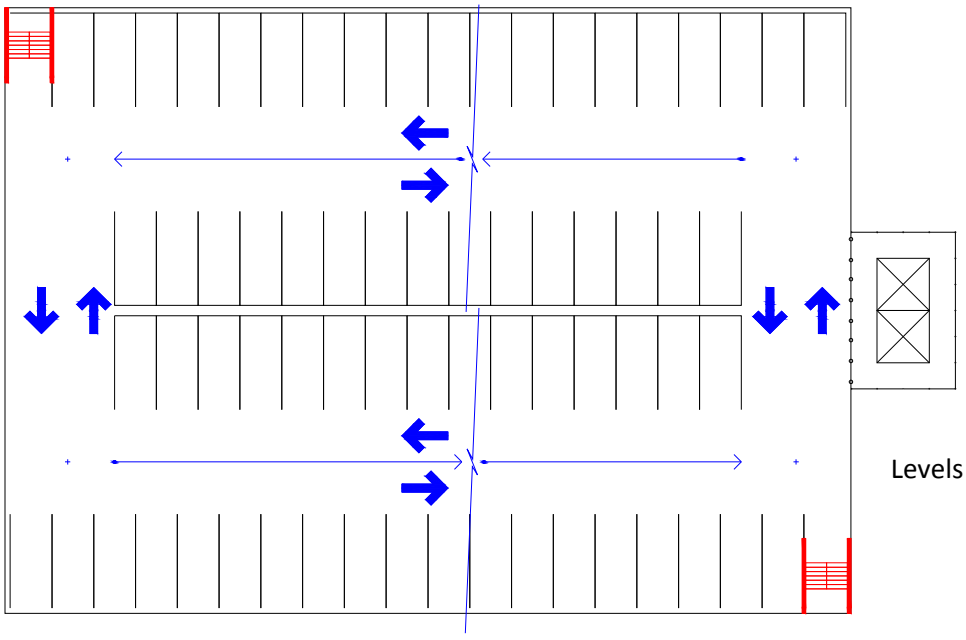


Architectural Design

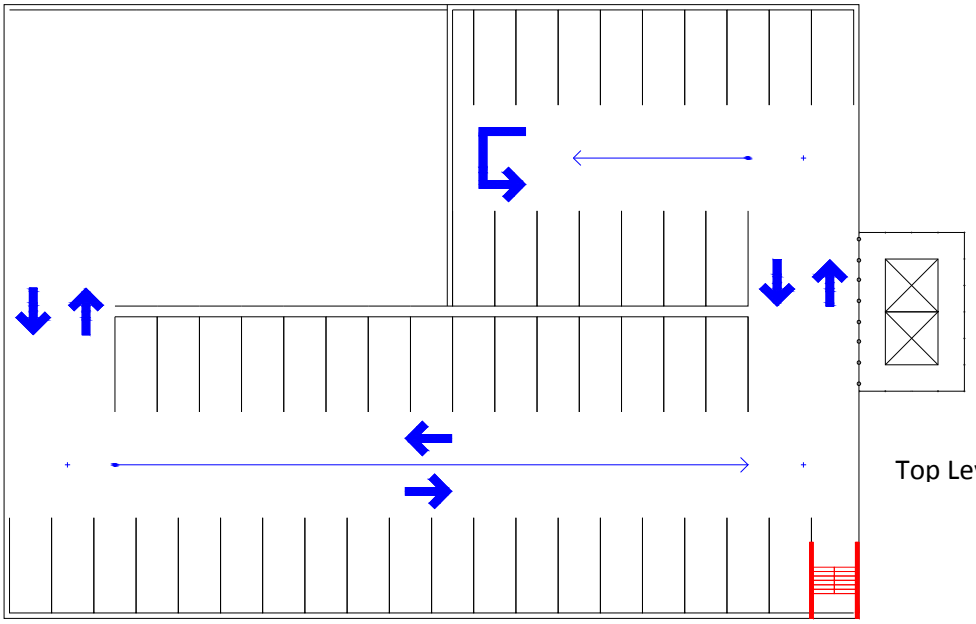
The purpose of this breadth is to look at the structural aspects. But before the structural design can begin, an architectural design needed to be complete. The parking garage was designed architecturally just enough to show that it is feasible. There are 714 parking spaces, including 14 handicap spaces in the parking lot located to the west of Building #4. The designed parking garage includes 429 parking spaces, including 14 handicap spaces. The main design idea was taken from the HUB Parking Deck located in University Park.



Level 1 and Entrance



Levels 2-6



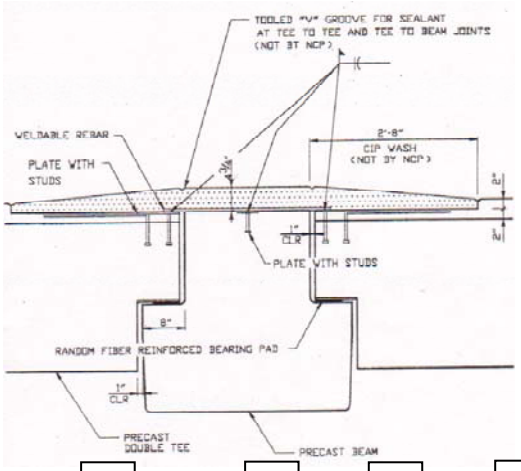
Top Level

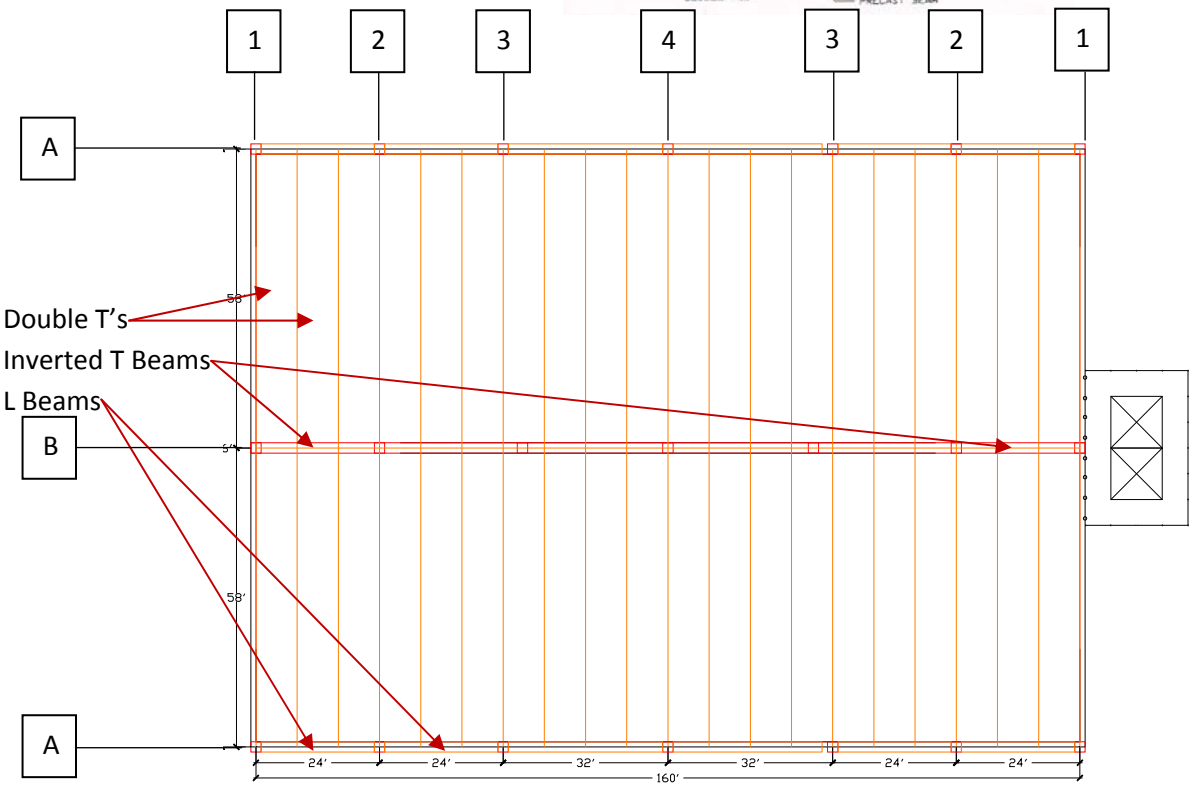
HUB Parking Deck
Sample Elevation

Structural Design

The overall building dimensions are 116'X160' with a deck height of 9'. Precast concrete columns, double T's, L beams and inverted T beams were the main focus. The incline is set at ~4.6%. Therefore the lateral load that it places on the columns is negligible. Also, the parking garage is designed to take all wind loads by the shear walls (located at stairwells), leaving only

axial loads on the columns. The American Society of Civil Engineers Standard (ASCE7-05) states that the live load and snow load for a parking garage in Germantown, Maryland are 40 psf and 25 psf respectively. Connections were not taken into consideration, however the following pictures show typical connection details.





PCI Design Handbook

PCI Design Handbook was used to size the following members; double T's, L beams and inverted T beams. The design charts can be found in Appendix H.

PCAColumn

PCAColumn was utilized for the design of the all the columns, backed up with hand calculations. Three column sizes were used to keep the building as uniform and as easy to construct as possible. PCAColumn calculations are located in Appendix I.

Hand Calculations

The following formulas and calculations were conducted to find loads on the columns, beams and foundation.

Live: $P = 618plf(58') + 8'(40psf)(58') = 54{,}404\ lbs$

$P = 618plf(29') + 8'(40psf)(29') = 28{,}072\ lbs$

Live + Snow: $P = 618plf(58') + 8'(65psf)(58') = 66{,}004lbs$

$P = 618plf(29') + 8'(65psf)(29') = 33{,}002lbs$

L Beam: $w_l = \frac{28.1K(3)}{24'} = 3{,}512.5plf$

$w_{l+s} = \frac{33.1K(3)}{24'} = 4{,}137.5plf$

$w_l = \frac{28.1K(4)}{32'} = 3{,}512.5plf$

$w_{l+s} = \frac{33.1K(4)}{2432'} = 4{,}137.5plf$

Inverted T: $w_l = \frac{54.4K(3)}{24'} = 6{,}800plf$

$w_{l+s} = \frac{66.1K(3)}{24'} = 8{,}262.5plf$

Columns:

A1 $P_l = 28.1K(1.5) = 42.15K$

$P_{l+s} = 33.1K(1.5) = 49.65K$

A2 $P_l = 28.1K(3) = 84.3K$

$P_{l+s} = 33.1K(3) = 99.3K$

A3 $P_l = 28.1K(3.5) = 98.35K$

$P_{l+s} = 33.1K(3.5) = 115.85K$

A4 $P_l = 28.1K(4) = 112.4K$

$P_{l+s} = 33.1K(4) = 132.4K$

B1 $P_l = 54.4K(1.5) = 81.6K$

$P_{l+s} = 66.1K(1.5) = 99.15K$

B2 $P_l = 54.4K(3) = 163.2K$

$P_{l+s} = 66.1K(3) = 198.3K$

B3 $P_l = 54.4K(3.5) = 190.4K$

$P_{l+s} = 66.1K(3.5) = 231.35K$

B4 $P_l = 54.4K(4) = 217.6K$

$P_{l+s} = 66.1K(4) = 264.4K$

Member Sizes

Double T's

D+L:	8DT24 + 2" topping slab	108-S
D+L+S:	8DT24 + 2" topping slab	128-D1

L Beams

24'	D+L:	20LB24	108-S
	D+L+S:	20LB28	128-S
32'	D+L:	20LB32	148-S
	D+L+S:	20LB36	168-S

Inverted T's

D+L:	28IT32	158-S
D+L+S:	28IT36	168-S

Columns

20x20	Bars:	(12) #10	B3 (Level 1), B4 (Levels 1-2)
18x18	Bars:	(8) #10	B2 (Levels 1-3), B3 (Level 2-4), B4 (Levels3-5)
14x14	Bars:	(4) #8	A1-A4, B1, B2 (Levels 4-6), B3 (Levels 5-7), B4 (Level 6-7)

Cost

The total square foot cost was calculated using RS Means.

RS Means - Parking Garage

SF Area	115,000	145,000	125,334	Building Cost
LF Perimeter	638	723	556	
Cost/SF	$44.65	$43.50	$44.25	$5,546,030
Adjustments				
Perimeter	$1.05	$0.85	$1.38	$172,961
Story Height	$0.45	$0.40	$0.50	$62,667
Additives				
Elevator			$2.84	$356,440
Total Cost/SF			**$48.97**	**$6,138,097**

Perimeter Adjustment (LF) Cost/SF

	Design Case

		638'	723'	556'
Adjustment Case	100'	$1.05	$0.85	$1.24
	111.28'	$1.17	$0.95	$1.38

Story Height Adjustment (Ft) Cost/SF

	Design Case			
		638'	723'	556'
Adjustment Case	10'	$0.45	$0.40	$0.50
	9'	$0.45	$0.40	$0.50

Additives

Item	Unit	Cost/Unit	Quantity	Total Cost
Elevator (2000#, 7 stops)	Each	$178,220	2	$356,440

A unit cost was compiled for the precast structural members only, using RSMeans.

Unit Costs

	Material	Labor	Equipment	Subtotal	Quantity	Total
L Beams						
20"x24"x24'	$1,582.12	$119.80	$74.54	$1,776.50	62	$110,143.00
20"x28"x24'	$1,645.00	$125.40	$78.30	$1,848.70	12	$22,184.40
20"x32"x32'	$2,447.00	$144.00	$89.30	$2,680.30	42	$112,572.60
20"x32"x32'	$2,566.00	$150.00	$93.40	$2,809.40	8	$22,475.20
Inverted T						
28"x32"x24'	$1,899.00	$144.00	$89.50	$2,132.50	9	$19,192.50
28"x36"x24'	$1,974.00	$151.00	$94.00	$2,219.00	2	$4,438.00
Double T's						
24"x8'x58'	$2,987.00	$220.40	$137.00	$3,344.40	256	$856,166.40
Columns						
14"x14"x9'	$423.00	$229.50	$141.30	$793.80	38	$30,164.40
18"x18"x9'	$738.00	$283.50	$176.85	$1,198.35	9	$10,785.15
20"x20"x9'	$738.00	$283.50	$176.85	$1,198.35	3	$3,595.05
Total	$15,100.12	$1,054.60	$656.04	$16,810.80		**$1,191,716.70**

Barks Daily from Nitterhouse Concrete Products provided an approximate but more accurate estimate.

Double T's = $15/sf
L Beams = $300/lf
Inverted T = $250/lf
14x14 Column = $39/lf
18x18 Column = $273/lf
20x20 Column = $415/lf

Unit Cost by Nitterhouse

	Cost	Unit	Span (ft)	Width (ft)	Subtotal	Quantity	Total
Double T	$15.00	SF	58	8	$6,960.00	256	$1,781,760.00
L Beam	$250.00	LF	24		$6,000.00	74	$444,000.00
L Beam	$250.00	LF	32		$8,000.00	50	$400,000.00
Inverted T	$300.00	LF	24		$7,200.00	11	$79,200.00
14x14	$39.00	LF	9		$351.00	38	$13,338.00
18x18	$273.00	LF	9		$2,457.00	9	$22,113.00
20x20	$415.00	LF	9		$3,735.00	2	$7,470.00
Total							**$2,747,881.00**

Schedule

RSMeans shows a C-11 crew to perform the work of the precast structural members. A C-11 crew includes:

1 Structural Steel Forman
6 Structural Steel Workers
1 Crane Operator
1 Crane Oiler
1 Crane

The crew can erect the members in:

Columns 3.75 days
Double T's 16 days
L Beams 5.39 days
Inverted T 0.48 days

Total erection duration for the structural system is 33 working days.

Conclusion

The implementation of a parking garage allows for a more sustainable site by eliminating the impervious surfaces. The space that has been freed up can be used for other amenities such as an arboretum or restore habitat, small strip mall or direct access road to Father Hurley Boulevard. The erection time is longer and the structure costs more, but there are other benefits to our environment.