Photo courtesy of Steven Holl Architects

The Performing Arts Center

New Jersey, U.S.A.

Turner

Technical Assignment 1: Construction Project Management

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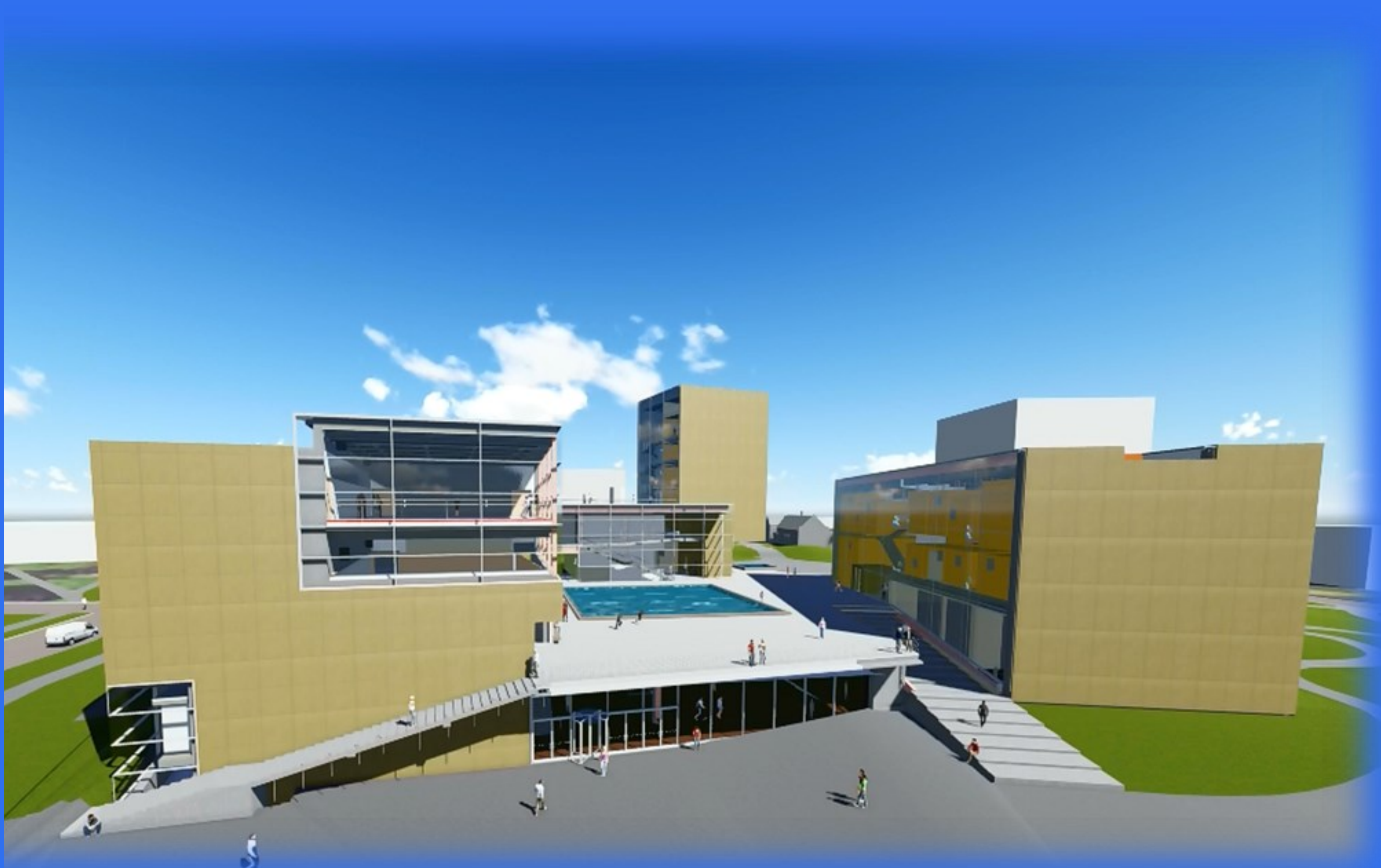

Photo courtesy of Turner Construction Co.

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Executive Summary

The Performing Arts Center will be the premier space for music and performing arts in higher education. It has been chosen to be analyzed for the Penn State Architectural Engineering Senior Thesis in addition to being the focal point of the Schreyer Honors Thesis. The AE Senior Thesis will investigate the construction of this structure in depth from preconstruction, to completion and turnover.

Technical Report One will provide overview of the project scope and reveal the conditions of how the building is constructed. Furthermore, it will reveal design purposes, owner needs and delivery method information. This report will also include project schedule summary, a technical systems summary, local site conditions, cost evaluation, site logistics and staffing.

As a space for the music department, theatre, dance, creative and performing arts, the program includes separate buildings uniquely designed around each discipline. To function as a gateway from town to campus, students can walk through the system's courtyard, while most of the building lies in the underground forum. The owner's desire to set a high precedent on this project can be characterized by the goal not to pursue LEED certification, but to exceed energy codes by 50% and "focus on maximum carbon reduction throughout the design, construction and operation of the facility" (BNIM).

The building encompasses 139,000 square feet through 9 total levels with one of the two underground levels as a massive forum. Due to exquisite material selection, complex systems, and unique construction of the building, the center totals $140 Million. It is part of a larger enabling project which includes a Wawa market, major utility and road relocation, and transportation center development. The project is being constructed using a construction management at risk delivery method, leveraging a guaranteed maximum price (GMP) contract between Turner Construction Company and the owner. Construction began in January 2014 and will be completed by May 2017. This is critical so that the university can begin using the facility during fall semester, 2017. Since the project lies on the edge of a historical university, logistics and planning is necessary not to disrupt student and faculty life. The following report will explain the design, construction and scope of work in further detail.

Client Information

*** Note: The Owner has requested for undisclosed identity and location**

Due to the owner's desire to set a high precedent on this project, performance and design are paramount. The precedent set in design using geothermal heating and cooling, green roofs and envelope performance is matched with the construction goals and planning between the University and Turner Construction.

The owner needs the Performing Arts Center so that the music, theatre, dance, creative and performing arts departments can be consolidated at a central location. This building will serve as a space for rehearsal and performance from individual to group settings. It will also function as a portal from town to campus with the goal of being a transparent source of learning and experience between the artists and students passing.

For the University, schedule is the main focus of priority so that the campus runs smoothly and effectively around current construction and completion dates. Completion by May 2017 is imperative so that turnover is smooth and final punch list items are eradicated by the time students come back to campus in Fall 2017. Intertwined with the priority of schedule is logistics. To be successful, this project has been planned out to meet the restrictions of both the University and local town ordinances. As seen in Appendix 1 and discussed in the Site Logistics Section, the entire site is setup to enable safe and uninterrupted student and faculty pedestrian movement. This becomes especially important because the site is located on the threshold of campus and town. Although logistics and schedule are high priority, this project is extremely quality driven. The University will base initial pricing decisions off relationships with contractors and subcontractors that can provide the highest quality work.

Project Delivery System

** Reference Appendix A*

Turner Construction has a history of collaborating with The University to meet schedule, quality and budget needs. As familiar project partners, this allows both parties to be confident in their delivery method approach and contractual arrangements. To best complete the project, the delivery system of a CM-At Risk with GMP contract was chosen. Turner holds the risk of performance and must complete the work within the price of $140 Million. Turner obtained the job from an RFP, was chosen for preconstruction services including schedule, budget and constructability advice and then transitioned into general contractor due its competitive bidding, expertise on the job, and quality client driven relationships. This is the traditional system utilized by the University in large projects, especially when working with Turner Construction. A benefit is that the Turner Somerset staff was involved throughout the entire process with early input from design to construction. The difficulties associated with this delivery method is that the relationship between Steven Holl, Turner and the University can become tense and strained once the price is fixed. This system means that the design by Steven Holl and consultant engineers must have been finished with little to no errors in order to maintain The University's rapid schedule goals.

Both parties excel with this delivery method due to its top-down communication stream from The University to Turner to the subcontractors. The overall contractual arrangement, seen in Appendix A, is setup so the main contract is between Turner Construction and The University. There are then individual contracts between the general contractor and subcontractors with no unique forms of collaboration or joint ventures.

Staffing Plan

**Reference Appendix B*

The staffing plan illustrates the Turner team members from the Somerset, NJ office that work onsite at the Performing Arts Center. Please reference Appendix B to see a graphical representation of the staffing. It follows a fairly traditional staff plan for large complicated projects. The engineering team is responsible for ensuring that everything is procured and constructed according to the project specifications and architect's design. A notable feature is that a superintendent is hired entirely for quality assurance – quality control. This illustrates the importance of quality and attention to detail for finishes and material on this project. The other two superintendents are hired to lead field operations for the structural system and the MEP system. Please note that as the project progresses through construction, staffing may change to address system focus.

Local Conditions

The existing conditions include many existing buildings, paved parking lots and existing NJ Transit lines. Beneath the man-made fill lies residual soil which overlie weathered but intact shale and sandstone bedrock. The Stockton Formation bedrock lies at a shallow depth of 9 to 25 feet. The first stratum soil conditions are described as brown, gray or reddish brown silt with clay. Water conditions indicated by boring logs illustrated dry conditions for the range of 14.1 to 25.1 feet below grade. The highest known water level was at 16.7 feet below grade. For the University parking is a major concern because the majority of the enabling site was parking space at one time. At the time of construction of the Performing Arts Center, other adjacent facilities such as the train station and Wawa will have limited parking due to the construction site takeover. Local bylaws are strict and allow for significant restrictions to construction. Difficulties include restricted deliveries during University move-in weeks, noise elimination during study periods and final exams, and a no work ordinance after 5 PM and before 7 AM. Based on schedule line items, fire protection, smoke evacuation and elevator permits are most concerning to the project.

Site Logistics Planning

**Reference Appendix C*

The Performing Arts Center is tightly surrounded by two main roads and local University facilities. The highest priority of logistics is to maintain safe and effective pedestrian flow around the project site from town to campus. The green strip on the site logistics plan illustrates the temporary pedestrian sidewalk. (See Appendix C). Due to constricting area, site laydown area is limited. To enable smooth logistical practice means the team implements Lean practices including using all piping being pre-fabricated to minimize clutter onsite.

Building Systems Summary

Demolition:

The owner's goal is to salvage and recycle 95% of all nonhazardous demolition materials including but not limited to mechanical equipment, concrete, insulation, roofing, plumbing fixtures and structural steel. Demolition on this job includes clearing the initial site by removing all existing structures and utilities around a 10 foot perimeter space for new building construction. Any asbestos or lead-based paint encountered will require the contractor to stop work immediately and cooperate with the owner and appropriate consultants for removal.

Structural Steel Frame:

The structural steel frame system includes 996 tons of structural steel 100% fabricated from the BIM. A horizontal bracing system is utilized for many of the floors, especially the large courtyard area over the underground forum (See Figure 1). During main superstructure construction, three cranes were on site including the west, east and north. Two cranes are crawler cranes whereas one is Rough Terrain (RT) truck crane. When the large box girders above the forum were installed, a specialty 600 ton capable crane came to site. The flooring slabs will be composed of composite steel floor deck that ranges from 2" to 5" thick slab with 18-22 corrugated steel.

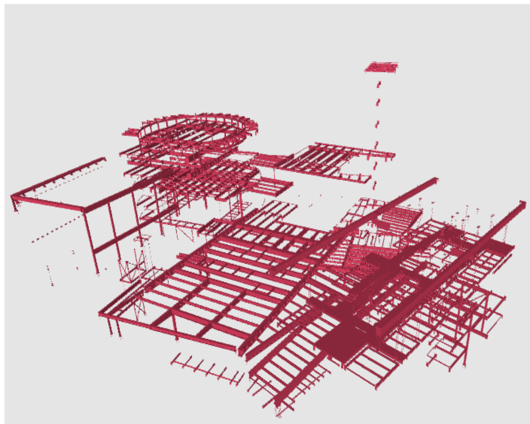


Figure 1: Structural Steel Frame model provided by Turner

Cast In Place Concrete System:

The walls, foundation walls, columns and footings of the building are all cast in place concrete. Many beams and structural slabs are post-tensioned, cast-in-place concrete as well. The formwork for most structural elements is traditional timber formwork. For the architectural concrete finish on many interior walls, pre-fabricated board forms are delivered from Massachusetts. This means that the walls have a concrete, ripple finish along the interior which will be the final finish product. All formwork is pre-fabricated. On average, 13 trucks of concrete arrive 3-4 times a week in order to pour 100 yards of concrete a day.

Pre-Cast Concrete System:

All pre-cast concrete is cast within 500 miles of the project site. The concrete specification is to utilize Portland Cement ASTM C 150. Anchorage and connection will be through bolting, welding or grouting. The 2 crawler cranes that are located in the east and north are utilized to install pre-cast elements including beams and slabs.

Mechanical System:

The mechanical system is enabled through the use of the geothermal heating and cooling wells. A ground-coupled heat pump system consisting of heat pumps, circulating pumps and a ground coupled heat exchanger enables the closed loop system. In the majority of the rooms are overhead VAV boxes except for the use of floor supply in select areas. Radiant heat is leveraged in music offices, practice rooms, the forum and the CoLab. Most of the corridors include both overhead VAV boxes and radiant heat to enable the feasibility for completely geothermal dependency or traditional means.

Electrical System:

The power distribution system is delivered from the campus by 4.16kV feeders. These feeder services go directly to the north face of the subbasement level where they meet the main switchgear room at two service tap boxes. Emergency power is supplied to areas that need egress lighting and fire alarm system equipment. Standard dry-type transformers serves all theatrical lighting dimmer racks and LED theatrical lighting. Another major electrical concern is power to the acoustical equipment which will be served from 480-208/120V transformers.

Masonry & Curtain Wall System:

The façade system is composed of Lecce Limestone cladding and glazed curtain wall system. The masonry façade features 2' high by 3' wide limestone panels that are supported by or non-corrosive, stainless steel anchors so the loading is transferred to the cast-in-place concrete wall system. (See figure 2 for connection detail of wall system). The curtain wall system varies between vision glass curtain wall system and translucent curtain wall glazing. Both are low-iron insulating glass units. These are built to custom profile steel mullions and glazing frames of built-up steel bar stock construction. The design for the vision glass is to allow for students to visualize the rehearsal and practice of students and learn from their exposure.

Concrete masonry unit (CMU) walls utilized as load bearing walls for floor decking. CMU is fully grouted and connected to steel decking through steel angles. Standard board scaffolding with steel tubing is used on this project.

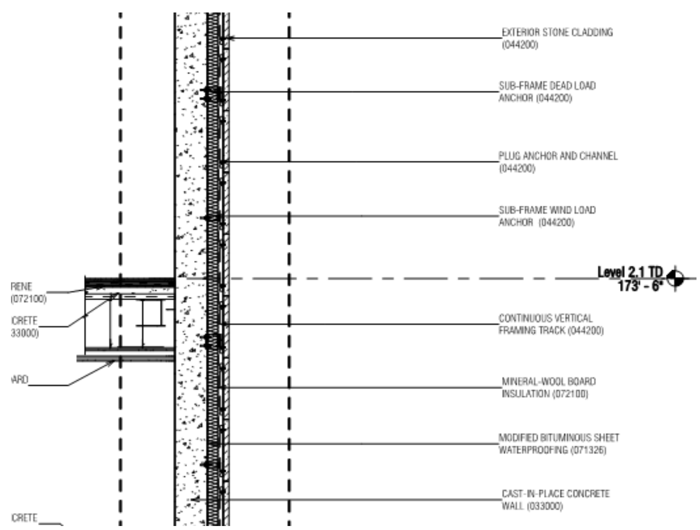


Figure 2: 100% Contract Documents – Volume 6 – Turner Construction – Exterior Wall Sections – A300

Project Schedule Summary

**Reference Appendix E*

Planning and design for the Performing Arts Center began in early 2008. The construction duration began in January 2014 and is projected to be completed earlier than anticipated, by May 2017. The phase of shop Drawings, submittals packages and approvals runs from January 2014 until October 2016. Visual mockups are constructed from July 2015 until October 2015. Materials are fabricated from June 18th 2015 until January 2016. Physical construction did not begin onsite until May 2015. The University would like the facility to be open by September 2017, therefore temporary certificate of occupancy should be finalized by July 24, 2017 at the latest. The summary schedule (Appendix D) is broken down by the major milestones throughout the entire lifecycle of The Performing Arts Center. The construction sequencing is based around each individual building, the DRUM, the Dance Theatre, the Forum, The Arts Tower, and the Music building.

The overall superstructure is to be complete on December 3rd, 2015 with the superstructure completion of the Lewis Arts Tower. Major milestones for the separate buildings include permanent power being energized on December 7th, 2015, the superstructure of the Theater/Dance building to be completed Oct 28th, 2015, the superstructure of the music building to be completed Oct 20th, 2015 and enclosure of the Forum space on May 24th, 2016. Please reference the summary schedule in Appendix D for more information.

Project Cost Evaluation

**Reference Appendix D*

While the Performing Arts Center only totals 139,000 square feet, the total construction cost rises to $140 million. This is the equivalent of $1007/SF. When counting the enabling project, the entire project reaches $300 million and an equivalent to $2,158 per square foot. For the Performing Arts Center itself, 60% of the project is material cost which is vastly larger than most jobs because of specialized materials and construction seen in the job. Examples include exterior Lecce Limestone cladding, 100% roof garden and architectural concrete walls seen throughout the building. In addition, a 110 well geothermal ground-coupled heat pump system is installed underneath part of the enabling project. These systems entail large up-front costs, but allow for return on investment over the long term. Another unique feature of the project is that acoustical provisions made up for 10% of the entire project cost.

The cost breakdown by system can be seen in Table 1. Appendix B illustrates the square foot estimate of this project based on an auditorium model. This model can be assumed because of the zoning designation as theatre/performance space and the focus on acoustical performance throughout the project. Furthermore, the majority of space is utilized for performance or rehearsal space. However, the R.S. Means estimate proves to be extremely low compared to the high actual cost / SF for this project. R.S. Means cost data only reaches 16% of the true cost of this project, a strikingly low estimate because of the usage of basic materials. The complex system choice and high quality material, design and construction enabled by the owner explains the difference in cost compared to the R.S. Means estimate. Furthermore, R.S. Means did not offer a model that resembled the diverse usage or occupancy type of the building that included specialized construction such as acoustical isolation of rooms and structural components that hang individual rehearsal rooms.

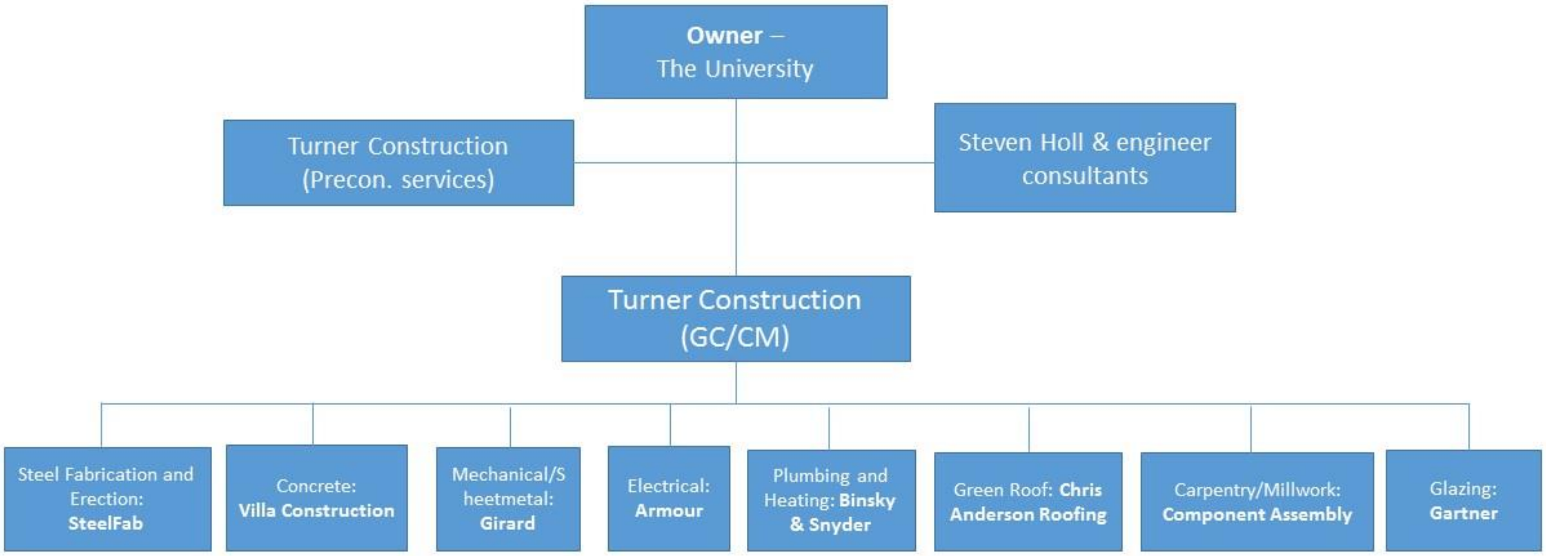
Table 1: Major system breakdown costs including material and labor cost

The Performing Arts Center System Breakdown Costs	
Architectural (Carpentry, flooring, paint, etc.)	$70 Million
Structural System	$30 Million
Mechanical (plumbing included)	$25 Million
Electrical System	$15 Million

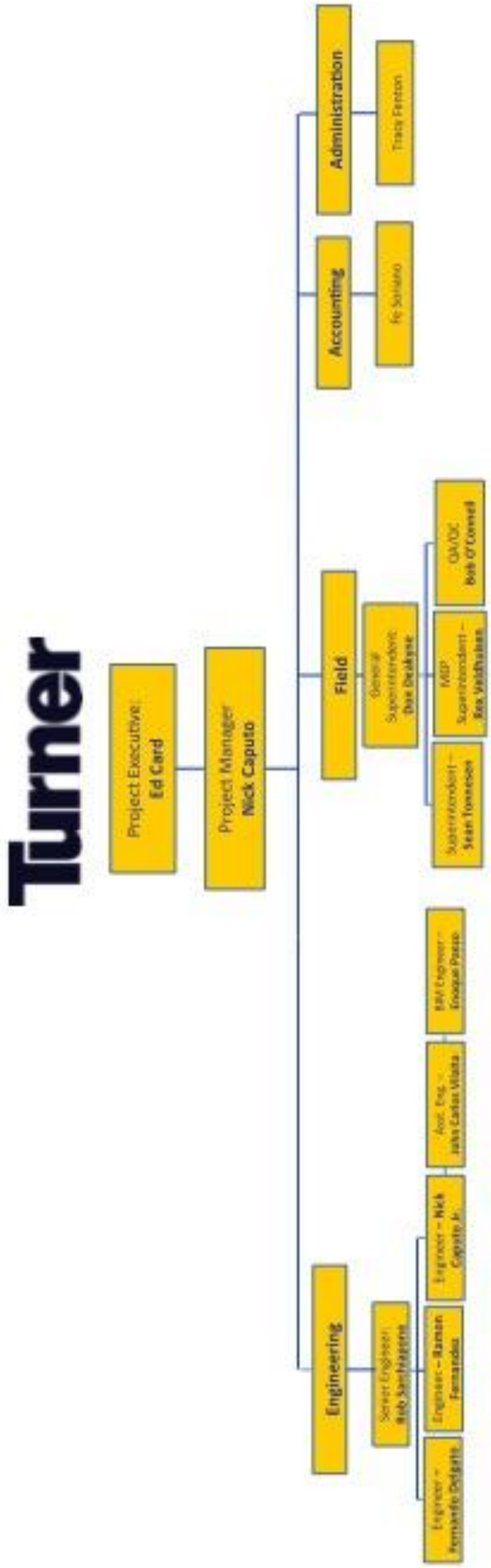
Bibliography

"Lewis Center for the Arts | BNIM." Lewis Center for the Arts | BNIM. N.p., n.d. Web. 16 Sept. 2015.

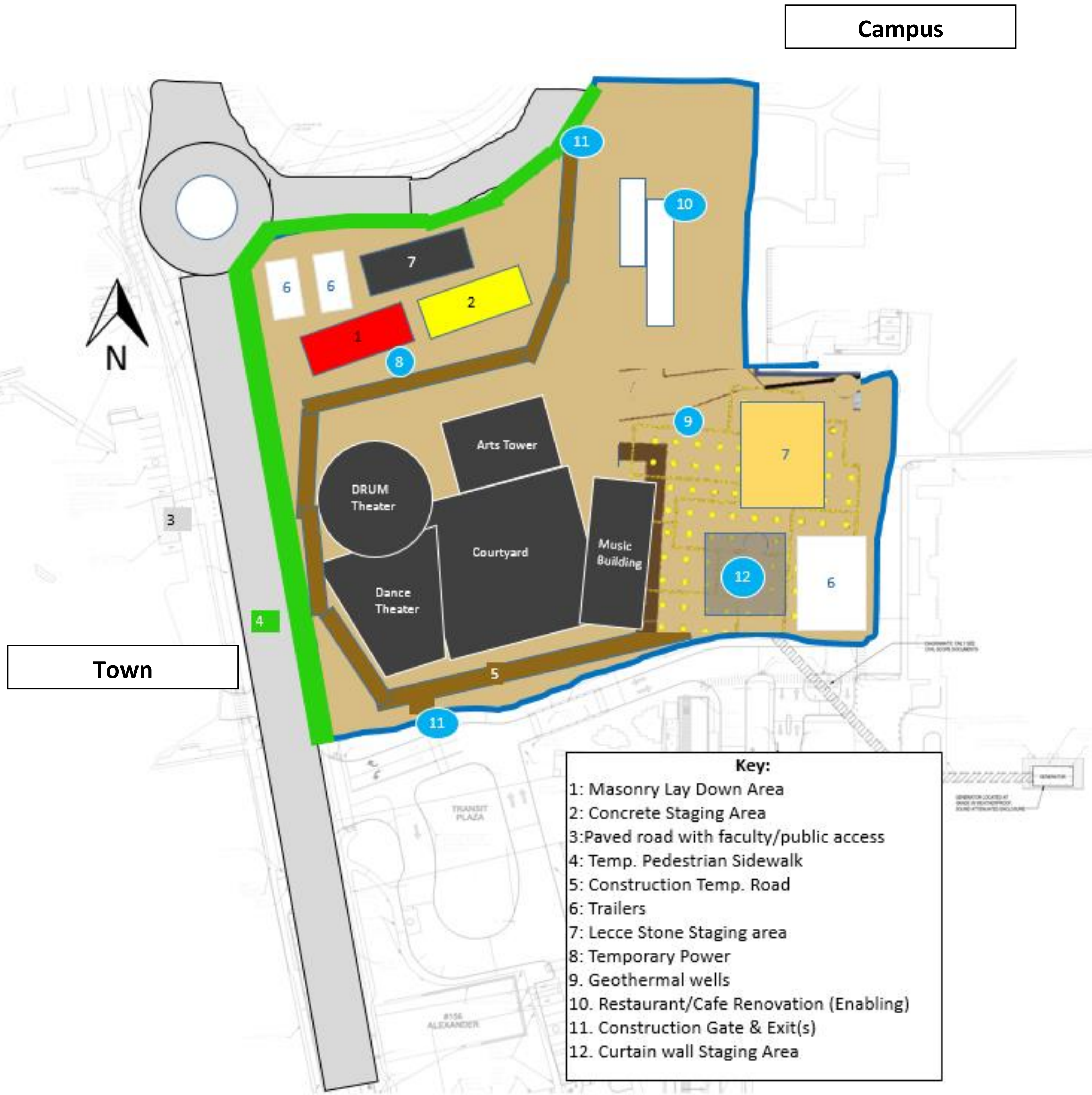
Appendix A | The Performing Arts Center Organization Structure



Appendix B | Staffing Plan | Turner Construction Co. (Somserset, NJ)



Appendix C | Site Logistics Plan



Appendix D | Square Foot Estimation Data

The Performing Arts Center – Square Foot Schematic Estimate

Cost Data based off of:

Phelan, Marilyn, AIA. R.S. Means Square Foot Costs 2015. N.d. Construction Cost Data. Norwell, Massachusetts.

The Performing Arts Center - Square Ft. Schematic Estimate

RS Means Source	R.S. Means Square Foot Costs 2015		**Model #**		M.040 Auditorim
Page(s)	86-87		**Ext Wall Type**		Face Brick with Concrete
Area	125,900		**Frame**		Steel Frame
Area Falls Between	125,900		and	+	
			Base cost per SF		**$137.40**
Cost Adj Type:	Perimeter			**Per SF Adj**	$45.35
Cost Adj Type:	Story Height			**Per SF Adj**	-$10.00
			Adj Base cost per SF		**$172.75**
Base Bldg Cost	172.75	x	125,900	=	$21,749,225.00
	Adj Base Cost / SF		FloorArea		
Basement Cost	30.15	x	30,023	=	$905,193.45
	Basement Cost / SF		Basement Area		
			Total Base Bldg Cost		**$22,654,418.45**
Additive Source	**Type**	**Quantity**	**Price/Unit**		**Total**
RS Means Additions	Closed Circuit Sur	3	1975	Amount	$5,925.00
RS Means Additions	Seating	200	320	Amount	$64,000.00
RS Means Additions	Emergency Lighting	100	$780	Amount	$78,000.00
RS Means Additions	Sound System	2700	$130	Amount	$351,000.00
			New Subtotal Cost		**$23,153,343.45**
Multiplier Type	Time			Value	1.05
Multiplier Type	Location			Value	0.94
			New Subtotal Cost		**$22,852,349.99**
			Total Cost	$	**$22,852,349.99**

	Assembly	% of Total	Cost per SF	Total Cost
A	Substructure	7.50%	$13.61	$1,713,926.25
B	Shell		$45.71	$0.00
B10	Superstructure	8.80%	$19.41	$2,011,006.80
B20	Exterior Enclosure	21.70%	$20.46	$4,958,959.95
B30	Roofing	4.60%	$5.84	$1,051,208.10
C	Interiors	18.80%	$26.19	$4,296,241.80
D	Services		$0.64	$0.00
D10	Conveying	2.70%	$6.90	$617,013.45
D20	Plumbing	9.50%	$23.33	$2,170,973.25
D30	HVAC	9.60%	$2.91	$2,193,825.60
D40	Fire Protection	2.90%	$15.69	$662,718.15
D50	Electrical	13.90%	$2.93	$3,176,476.65
E	Equipment & Furnishings	0.00%	$0.00	$0.00
F	Special Construction	0.00%	$0.00	$0.00
G	Building Sitework	N/A	N/A	N/A
	Additions	N/A	N/A	N/A
			Subtotal	$22,852,349.99
	Jobsite OH & GC's	20.00%		$4,570,470.00
	Contractors Fee	5.00%		$1,142,617.50
	Designer's Fee	5.00%		$1,142,617.50
			Total	$29,708,054.98

Assumptions and Clarifications:

Assume building type is M.040 Auditorium
Assume Face Brick Concrete Block Back Up based on the given parameters and actual Lecce Limestone façade.
Assume steel frame structural system
Assume maximum ceiling height of 16'

Square Foot Takeoff and Calculations:

	Perimeter	Area	
Forum Level	996.75'	49,860	SF Takeoffs
Mezzanine Level	(All from above)	16,705	3,751
			891
			630
			11,433
Plaza Level		16,262	4,711
			2,345
			4,369
			3,065
			1,772
Level 2 Plan		24,715	532
			4,447
			15,522
			4,214
Level 3 Plan		18,357	13,565
			1,532
			3,260
	Total Area:	**125,899**	
	Perimeter:	**996.75'**	

Appendix E | The Performing Arts Summary Schedule

Activity	Description	Start	Finish	Duration
PCA The Performing Arts Center		01-Jan-08	07-Dec-17	2569
PCA.1 Design Phase		01-Jan-08	01-Jan-14	1543
A1530	Design Phase	01-Jan-08	01-Jan-14	1543
PCA.2 Land & Permit Development		09-Jun-14	27-Oct-15	362
A1580	Building Permit	09-Jun-14	27-Oct-15	362
A1570	Mechanical Permit	22-Apr-15	22-Oct-15	132
A1540	Fire Protection Permit	27-May-15	22-Oct-15	107
PCA.3 Procurement		30-Jun-15	25-Sep-15	64
A1590	Procurement	30-Jun-15	25-Sep-15	64
PCA.4 Shop Drawings and Approvals		27-Jan-14	25-Oct-16	717
A1600	Exterior Stone Shop Drawings, Approvals, Fa	27-Jan-14	25-Oct-16	717
A1610	Superstructure Shop Drawings, Approvals	01-May-14	13-Aug-15	336
PCA.5 Visual Mockups		31-Jul-15	14-Oct-15	54
A1630	Arts Tower Concrete Stair Mockup	31-Jul-15	18-Sep-15	36
A1620	Exterior Stone Visual Mockup	28-Sep-15	14-Oct-15	13
PCA.6 Fabrication and PieceDrawings		18-Jun-15	06-Jan-16	145
A1640	Theater Dance (DRUM)	18-Jun-15	05-Nov-15	101
A1650	Arts Tower	10-Sep-15	06-Jan-16	85
PCA.7 Material Fabrication		27-Mar-15	07-Mar-16	247
A1670	Facade Glass and Steel Fab and Shipment	27-Mar-15	07-Mar-16	247
A1680	Fabricate and delivery casework and wood p	28-Aug-15	21-Jan-16	105
A1660	Design-Assist Curtainwall Fab and Shipment	16-Sep-15	22-Sep-15	5
PCA.8 Construction		04-May-15	23-Jun-17	560
A1690	MEP Installation and Testing	04-May-15	23-Jun-17	560
A1750	Theater/Dance Wall Form, Reinforcement, C	01-Jul-15	30-Nov-16	371
A1710	Theater DRUM Perimeter Wall Pour, Masonr	13-Jul-15	26-May-16	229
A1760	Theatre/Dance Core & Shell	31-Jul-15	29-Jun-16	239
A1860	Arts Tower Core Wall Pour and Form	24-Aug-15	23-Oct-15	45
A1700	Theater/Dance Enclosure Completion	16-Sep-15	22-Sep-15	5
A1790	Music Building Perimeter Wall Pour, Masonry	16-Sep-15	22-Sep-15	5
A1720	DRUM Steel to Roof Truss Systems	15-Oct-15*	04-Nov-15	15
A1830	Forum CMU Wall Construction	03-Nov-15	23-Nov-15	15
A1870	Tower Concrete Structure Complete	03-Dec-15	03-Dec-15	1
A1880	Total Superstructure Complete	03-Dec-15	03-Dec-15	1
A1820	Practice Box Level 2 Completion	08-Feb-16	31-Mar-17	300
A1770	Theatre/Dance Fitout	13-Apr-16*	11-Jan-17	196
A1780	Black Box Theatre Fitout	21-Apr-16	31-Mar-17	247
A1740	DRUM Enclosure Completion	22-Apr-16*	12-May-16	15
A1810	Practice Box Level 3 Completion	01-Jun-16	16-Mar-17	207
A1800	Music Building Enclosure Completion	01-Dec-16*	06-Jan-17	27
A1840	Fitout Forum - MEP Drops, Flooring finish	26-Jan-17	15-Feb-17	15
PCA.9 Project Closeout		24-Jul-17	07-Dec-17	99
A1550	Achieve TCO of Performing Arts Center	24-Jul-17*	24-Jul-17	1
A1850	Final Completion	07-Dec-17	07-Dec-17	1