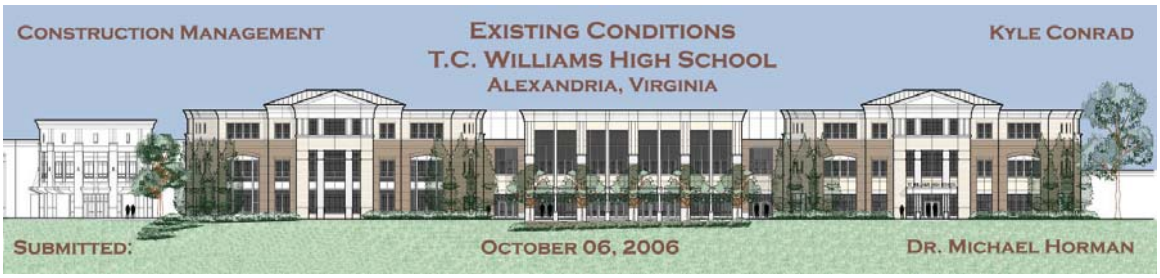
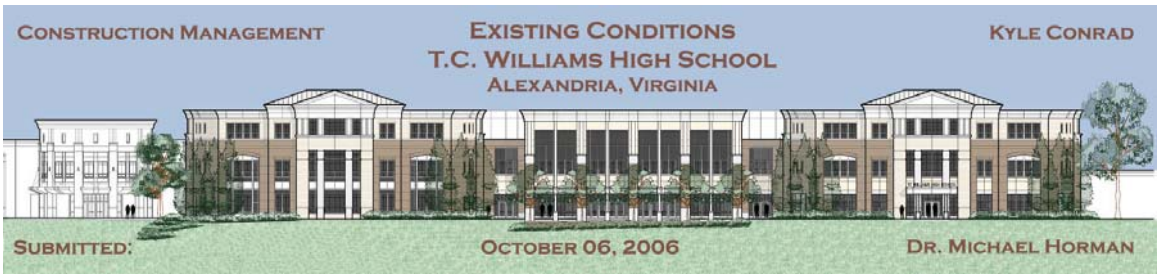


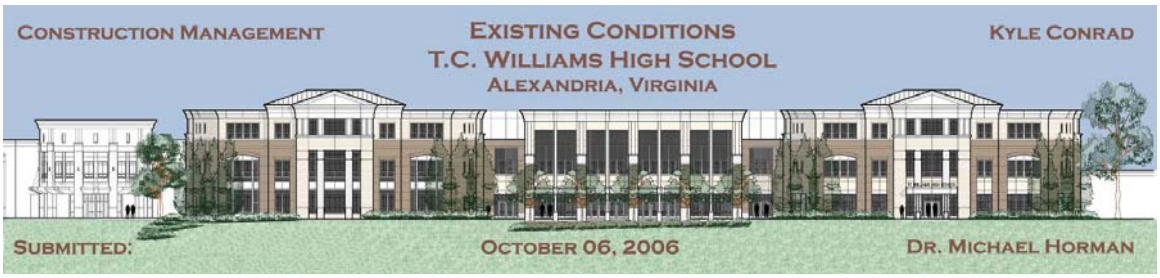
TABLE OF CONTENTS



A. Executive Summary:

Technical assignment #1 provides an understanding into the building systems and project management of the T.C. Williams High School Replacement Project in Alexandria, Virginia. The unique style of project delivery method employed on this project was designed to reduce the risk to the owner. An advanced form of scheduling, the SIPS (short interval production schedule), aims at managing project resources to capitalize on redundant working procedures and deliver the project as efficiently as possible.

The home new of the Titans will provide its students with new amenities to facilitate their learning. The T.C. Williams High School is seeking LEED 'Certified' certification and employs some unique procedures and systems to achieve this goal. Students will be exposed to a permanent measurement and verification system that monitors the facilities water and energy usage and displays the data on a control console in the commons court area. A roof garden provides students with a living laboratory while naturally filtering the rainwater. A 450,000 gallon cistern system will collect the rainwater from the structures immense roof area to service non-potable systems such as the toilets, air conditioning units, and irrigation. The uniqueness of this project expresses the owner's determination to build a sustainable facility while reducing its impact on the environment.



B. Project Schedule Summary:

To permit the continued education of the student body on campus through the duration of the construction, the T.C. Williams High School Replacement Project was separated into four phases. The two A phases encompass the construction processes for the new school facility, while the B phases cover the construction of the two deck parking garage. Refer to **Appendix A** for a project summary schedule of phases A-1 and A-2.

- Phase A-1:

  As depicted below, Phase A-1 **(see figure 1)** involved the demolition of the existing career tech wing, the removal of five temporary classroom buildings and the installation of two temporary classroom units in the center of the renowned Titan football field. Student parking was relocated to the eastern side of the lot and construction fence was installed around the perimeter of the A phase construction site boundary. Modifications to the bus loop and the storm sewer at King Street were required as well as the construction of a retaining wall along the East property line.

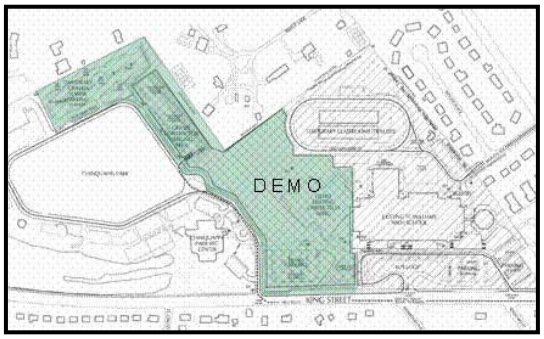


Figure 1. Phase A-1

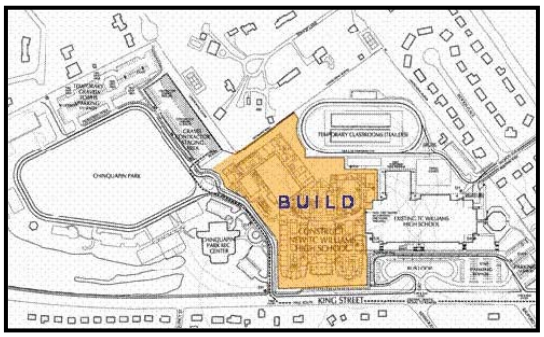


Figure 2. Phase A-2

- Phase A-2:

  Phase A-2 **(see figure 2 above)** concludes on 20 July 2007, as the construction of the new T.C. Williams High School reaches final completion.

- Phase B-1:

  Over the summer months of 2007, the district transitions from the existing school building to their new facility as the contractors repair the football field, after the removal of the temporary classroom units, and prepare for the demolition of the old school building. The contractor staging area is relocated to the North end of the construction site and another temporary parking area established in its place. After the temporary construction site fence is relocated, the demolition of the old school commences in Phase B-1 **(see Figure 3 below).**

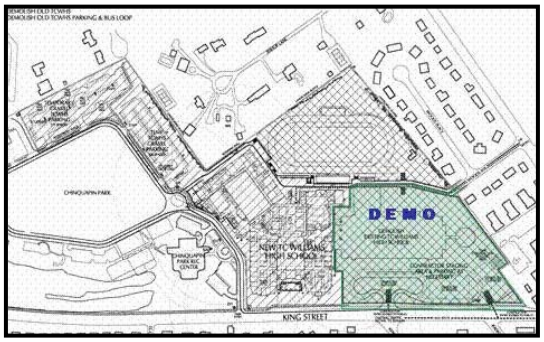


Figure 3. Phase B-1

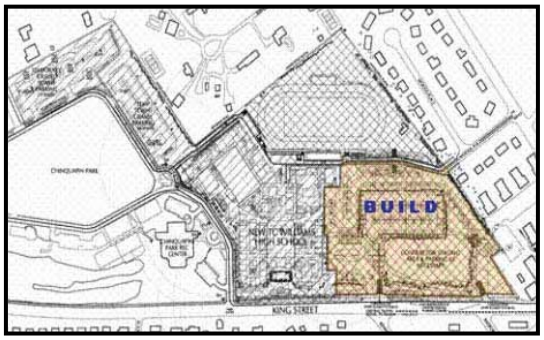


Figure 4. Phase B-2

- Phase B-2:

  The project concludes with Phase B-2 **(see Figure 4 above)**: The construction of the pre-cast concrete parking garage. As the project comes to a close, the bus and entry loops are completed and the practice fields are graded and restored. B phases will not be considered in the development of this thesis project, due to the size and complexity of the high school facility.

C. Building Systems Summary:

SCOPE OF WORK	YES	NO
Demolition	✓	
Structural Steel Frame	✓	
Cast-in-Place Concrete	✓	
Precast Concrete	✓	
Mechanical System	✓	
Electrical System	✓	
Masonry	✓	
Curtain Wall	✓	
Support of Excavation	✓	

a. Demolition:

Phase A-1 was the demolition of the existing one story, career tech wing that was built on to the original school structure in the 1970's. The 22 ft. high structure required abatement for asbestos. Since the lead paint was contained, no abatement was required to remove the lead. After the new school facility is completed, phase B-1 will commence. In this phase, the existing three story, 45 ft., T.C. Williams High School building will be demolished to make room for the construction of the parking garage. Asbestos abatement will be required during the demolition in phase B-1 as well.

b. Structural System (includes aspects of Structural Steel Frame, Cast-in-Place Concrete & Masonry):

The foundation is designed for an allowable bearing capacity of 6000 psf. Due to poor soil conditions, areas of the foundation are supported with geopier rammed aggregate soil reinforcements. A machine, similar to a caisson drilling rig, bores holes into the soil and then packs crushed stone, in thin lifts, into the cavity to provide a solid base for the footing that rests on top of the geopier. A continuous footing system, 16 inches in depth, supports the extensive lengths of exterior and interior CMU walls. Spread footings distribute the loads from the steel columns. A series of grade beams and braces tie between the spread footings.

The classroom towers are three story, steel moment frame structures. The beams and girders are a wide range of ASTM A992 wide flange sizes and the columns range anywhere from ASTM A992 wide flange shapes (W) to ASTM A500 rectangle and round hollow structural shapes (HSS). The 4000 psi, cast-in-place, elevated concrete slabs are typically 4-1/2 inches thick over 1-1/2 inch – 18 gage composite galvanized floor deck that spans the beams. The concrete will be pumped to the areas where concrete is being poured. The k series open web steel joists bear on the beams which transfer the roof loads from the various specified metal roof decking to the columns. A 50 ton, mobile all-terrain crane was utilized by the steel erector. The mobile crane was primarily set in locations between the two classroom towers.

The East wing of T.C. Williams and the rooms at the South end of the classroom towers are single level, multi height spaces. Load bearing CMU walls, of varying thicknesses, run around the perimeter of the auditorium, gymnasiums, exterior of the East (technology) wing, and South wall of the school. Beam pockets in the CMU provide a bearing surface for the W-shape beams while the majority of the k series roof joists are tied into bond beams at the top of the CMU load bearing walls. The loads in these areas of the structure are transferred to the continuous footing.

Classification of Building Category / Use Group: II

Codes: 2000 VUSBC
2000 IBC (Effective 10/01/2003)
ACI 318-95 Building Code Requirements for Structural Concrete
ACI 301-96 Standard Specifications for Structural Concrete
AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design – June 1, 1989
AISC Code of Standard Practice for Steel Buildings and Bridges – March 7, 2000

c. Pre-cast Concrete:

An architectural pre-cast concrete ribbon runs around the majority of the building's perimeter and below various window units. The east and west sides of the facility contain architectural pre-cast concrete coping.

d. Mechanical System:

Seventeen rooftop air handling units, ranging from 1,400 to 23,295 cfm, supply conditioned air to the majority of the spaces and employ the use of enthalpy wheels to recover total energy. Supply air entering the gymnasium, auto services, and building trades / construction technology spaces passes through reheat coils. Four additional indoor air handling units control the air in the auxiliary gymnasium, east and west commons areas and the remaining spaces in the East (technology) wing. The variable air volume (VAV) system utilizes 305 terminal units; most of them are equipped with reheating coils which are only activated when the minimum amount of supply air is being forced into a space. A four pipe system supplies and returns hot and chilled water to and from twelve fan coil units that locally returns and supplies conditioned air.

In addition, a water unit heater and an electric unit heater service the mechanical and equipment rooms respectively. A direct gas heating, make-up unit in the kitchen activates when the demand arises due to the large quantities of room air that are exhausted through the hoods.

The variable flow, hot and chilled water plant is driven by variable speed control pumps. Four natural gas-fired condensing boilers, with capacities of 1.68 million BTUH, heat water from 120^{o}F to 160^{o}F. Water is cooled to 38^{o}F by two, 600 ton water cooled, electric driven centrifugal chillers. Two 750 ton cooling towers condense the R-123 refrigerant so that it can be re-circulated through the chillers which will accept the heat from the systems chilled water lines.

The mechanical contractor brought in a 100 ton mobile, all-terrain crane for a duration of two days to set the mechanical equipment.

A five zone, wet pipe sprinkler system services T.C. Williams High School. Each zone covers 49,855 to 51,000 sq. ft. A 100 hp vertical in-line fire pump produces a flow rate of 1,000 GPM with a total head pressure of 120 psi. A mixture of sidewall and pendant sprinkler heads will service the spaces while concealed heads are required in all the stairwells.

Required Codes: NFPA 13
VUSBC
Local Authority: Virginia – American Water Company

e. Electrical System:

A 480 Y / 277, 3 phase, 4 wire primary feed services the building. Two main 4000 ampere, 3 phase switchboards distribute the required power to the electrical loads throughout the building. Separate switchboards for the chiller units are feed directly from the utility service. The life safety system is backed up by two 800kW, 480V, 3 phase 60 Hz, diesel fueled generators.

f. Masonry:

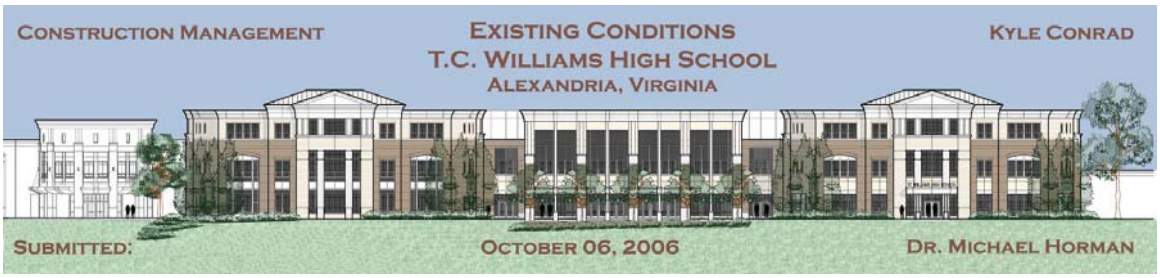
The majority of the exterior wall system is face brick with CMU backing. The interior partition walls are primarily constructed of CMU as well. The masons utilize two scaffold systems which include a standard Mason King tube and coupling scaffold and a jacking platform system that mechanically raises and lowers to facilitate the laying of block and brick.

g. Curtain Wall:

The court is enclosed in a pre-finished aluminum curtain wall system. Aluminum curtain wall units also span from the majority of second floor to first floor window openings of the classroom towers. The units are hoisted into place via a crane and secured on the floor levels to transfer the applied loads through the structural steel frame.

h. Support of Excavation:

Since the building was designed as a slab on grade structure and the site was relatively level, no significant excavation was performed that required additional support systems to be implemented. Permanent retaining walls were constructed at the south east corner of the site. Shot-Crete was sprayed onto the reinforcing rebar cage to minimize the amount of formwork required on site.



D. Project Cost Evaluation:

PROJECT COST EVALUATION		
DESCRIPTION	**COST**	**COST / SQ. FT.**
Total Project	$ 90,000,000	$ 191.70
Total Building	$ 87,416,000	$ 186.20
Mechanical System	Withheld from Public at Contractor's Request	
Electrical System	Withheld from Public at Contractor's Request	
Structural System	Withheld from Public at Contractor's Request	
Fire Protection System	Withheld from Public at Contractor's Request	

Table 1. Project Costs Breakdown

The project costs, displayed in **Table 1** above, were provided by the general contractor for the purpose of cost comparisons. D4 Cost 2002 estimating software was used to develop a parametric estimate based the comparison of data with a project of similar attributes. Aberdeen High School, in Aberdeen, Maryland, was the educational facility that was selected to generate the estimate. The high school was also a three story structure that had facilities in common with T.C. William High School at comparable levels of quality. However, Aberdeen High School only had a floor area of 206,442 square feet and cost $31,832,611 to construct the building in 2001. Refer to the summary estimate in **Table 2** below and the full breakdown located in **Appendix B**.

PROJECT ESTIMATES			
DESCRIPTION		**COST**	**COST / SQ. FT.**
D4 Cost 2002 Parametric Estimate	Total Project	$85,448,006	$182.00
	Total Building	$81,043,618	$172.60
	Total Site	$4,404,388	$9.38
2006 R.S. Means – Sq. Ft. Costs	Total Building	$47,157,300	$100.44

Table 2. Project Estimates using D4 Cost and R.S. Means

The estimate generated from the 2006 R.S. Mean Square Foot Costs Manual was far less accurate than the D4 Cost estimating software. Model number M.570 in the commercial/industrial/institutional section calculated its costs based on a two story high school with a 12' story height and a floor area of 130,000 square feet. Therefore, significant adjustments were required for the estimate. Since there was not an option for a curtain wall assembly, the face brick with concrete block back-up had to be used for the entire estimate. The largest cost per square footage available on the

R.S. Means chart for a steel framed structure was $123.00 for only a 50,000 square foot facility. At that point, an inaccurate estimate was inevitable, knowing that the actual building cost per square foot was $182.00 and that the chart values became lower as the square footage increased. Significant interpolation had to be performed in the estimate since the largest square foot area on the chart was merely 210,000 square foot, adding to the inaccuracy of the estimate. The calculations below demonstrate the procedures for performing a square foot estimate with R.S. Means. T.C. Williams High School was designed with more technical facilities and building assemblies than a typical high school building which would account for the discrepancy between the R.S. Means Square Foot Cost estimate and the value of the actual bid.

2006 R.S Means Square Foot Estimate Calculations:

T.C. Williams High School
Alexandria, Virginia (commercial city adjustment factor of 0.93)

Square Foot of Floor Area: 469,507 s.f.
Building Perimeter: 3,200 lf.
Story Height: 15'-4" => 15.33 ft.

Face Brick with Concrete Block Back-up

Interpolation for linear foot perimeter value on chart based on a Square Foot Area of 469,507 s.f.:

$$\frac{(469{,}507 - 190{,}000)}{(210{,}000 - 190{,}000)} = \frac{(A - 1{,}566)}{(1{,}700 - 1{,}566)}$$

(13.97535) x (134) = A – 1,566 A = 3,438.6969 => 3,400 l.f.

Interpolation for the Building Unit Price Cost:

$$\frac{(469{,}507 - 190{,}000)}{(210{,}000 - 190{,}000)} = \frac{(B - 106.95)}{(106.65 - 106.95)}$$

(13.97535) x (-0.3) = B – 106.95 B = 102.757395 => $102.76 s.f.

Interpolation for Perimeter Adjustment:

$$\frac{(469{,}507 - 190{,}000)}{(210{,}000 - 190{,}000)} = \frac{(C - 0.75)}{(0.55 - 0.75)}$$

(13.97535) x (-0.2) = C – 0.75 C = - 2.045

Perimeter Adjustment:

$$\frac{(3{,}200 \text{ l.f.} - 3{,}440 \text{ l.f.})}{100 \text{ l.f.}} \times (-2.045) = \$4.91 / \text{s.f.}$$

Interpolation for Story Height Adjustment:

$$\frac{(469{,}507 - 190{,}000)}{(210{,}000 - 190{,}000)} = \frac{(D - 0.80)}{(0.75 - 0.80)}$$

(13.97535) x (-0.05) = D – 0.80 D = 0.10

Story Height Adjustment:

$$\frac{(15.33 \text{ ft.} - 12.00 \text{ ft.})}{1 \text{ l.f.}} \times (0.10) = \$0.33 / \text{s.f.}$$

Total Adjusted Cost:

$102.76 / s.f. + $4.91 / s.f. + $0.33 / s.f. = $108.00 / s.f.

Total Building Cost:

(469,507 s.f.) x ($108.00 / s.f.) x (0.93 location factor) = $ 47,157,283.08

Total Building Cost: $47,157,300