Cinema-Dining Terrace Expansion

Suburbia, USA

Thesis Final Report

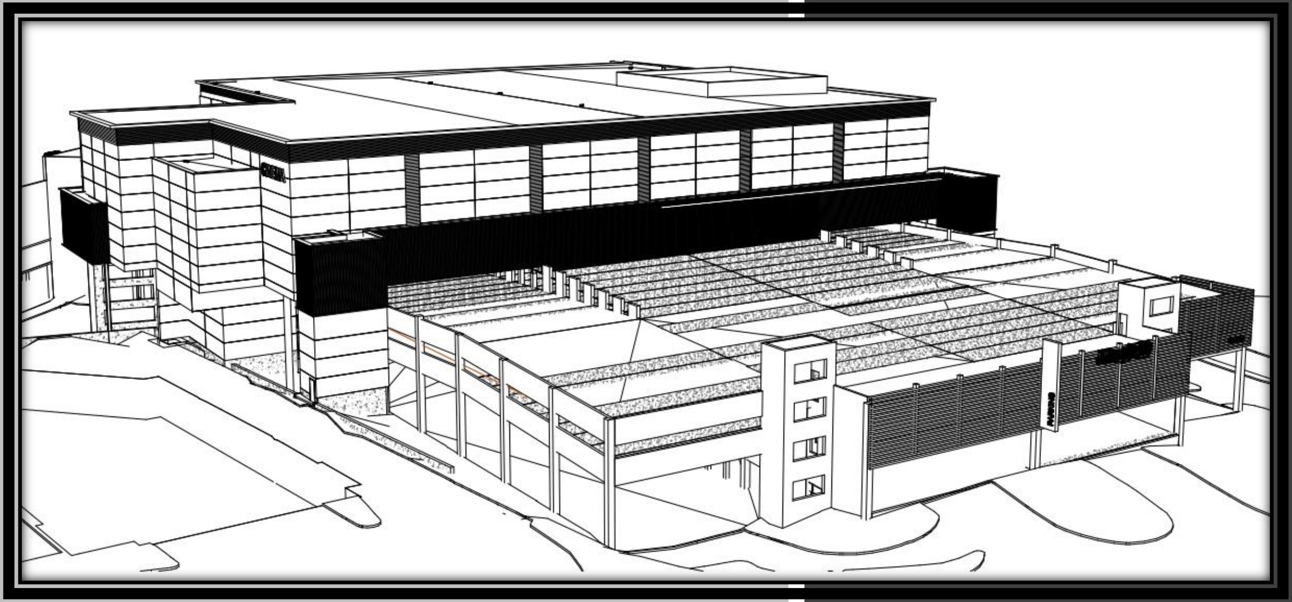


Image Courtesy of The Whiting-Turner Contracting Company

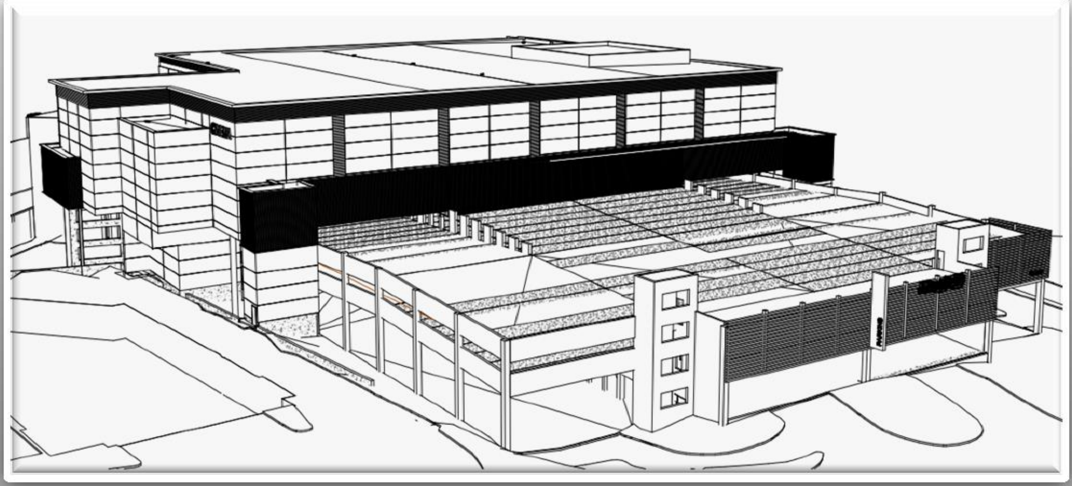
PSUAE

Cinema-Dining Terrace Expansion

4/9/2014

Cinema – Dining Terrace Expansion

Suburbia, USA



Project Information

Owner: Anonymous
GC: The Whiting-Turner Contracting Company
Number of Stories: 3 Above Ground
Negotiated GMP: $50,223,763.00
Architect: Gensler
Size: 91,500 GSF

Architecture

This project incorporates a 16 screen cinema on top of an existing parking garage and an updated foot court. The new entrance and added restaurants use a metal panel and glass facade that complements the metal panel, EIFS , and glass facade of the entire cinema. The modifications to the parking garage and food court combined with the new cinema create a casual yet upscale experience.

Structural

Extensive work was done to the existing parking garage foundations using a combination of micropiles with pilecaps, sandwich footing with threadbars, and spread footings. The foundations then support the structural steel with composite beams and the massive concrete shear walls that support the entire cinema and food court additions.

Electrical

There is a 750 kVA transformer for the existing mall and a 150 kVA transformer for the fire pump. The cinema's electrical system will tie into the existing mall system but it is still being designed at this point.

Mechanical

The food court's existing Variable Air Volume system and the concourse's Constant Volume system will remain with small modifications to the ductwork and diffusers. The cinema's mechanical system is still being designed at this time.

http://www.engr.psu.edu/ae/thesis/portfolios/2014/njk5086/index.html

Nicholas Kline | Construction Option

Advisor: Ray Sowers

EXECUTIVE SUMMARY

This Senior Thesis Report is the result of a full year's evaluation through technical analyses created through from knowledge acquired from the Architectural Engineering curriculum and industry experience. The Cinema-Dining Terrace Expansion construction project is the focus of this report. The evaluation of four analyses was implemented with the goal of accelerating the schedule and decreasing costs through logistics modifications, prefabrication, resource recycling, and Building Information Modeling.

Analysis 1: Site Logistics Modifications

The first analysis evaluated altering the site logistics for the projects primary phases. The modifications implemented the use of two tower cranes to accelerate the demolition and steel erection phases. Through these modifications, the schedule was reduced by 41 workdays and the costs were reduced by $1,533,398.00 when including the prefabricated exterior enclosure.

Analysis 2: Exterior Envelope Prefabrication

The second analysis focused on prefabricating the exterior enclosure. Prefabricating the exterior allowed for quicker installation which helped reduce the schedule from 122 workdays to 37 workdays. The offsite prefabrication ensures quality with the controlled fabrication environment but creates increased project costs that totaled in $738,490.00.

Analysis 3: Water Drainage Recycling

The third analysis investigated the implementation of a rainwater recycling system. With the large roof space and the already designed drainage, the addition of a rainwater recycling system saved approximately $15,000/year on water bills. The system has a 7 year payback period and recycles over 2 million gallons of water a year and its installation has minimal effect on the schedule.

Analysis: BIM Utilization

The final analysis evaluates the possible utilization of BIM on this project. The application of BIM for this project has the potential to assist with phasing and coordination. Employing BIM can be very useful on renovation projects due to the complications of coordinating with on active building. It could be used for MEP coordination, Phasing plans, and support for displaying the analyses to the owner.

ACKNOWLEDGEMENTS

Academic Acknowledgements

Mr. Ray Sowers – CM Faculty Advisor

Prof. Kevin Parfitt

Prof. Charles Cox

Prof. Moses Ling

Penn State AE Faculty

Industry Acknowledgements

WHITING-TURNER

KHS&S CONTRACTORS

Special Thanks

The Whiting-Turner Project Team

Fellow AE Students

My Family and Friends

TABLE OF CONTENTS

SECTION 1 - PROJECT OVERVIEW

PROJECT BACKGROUND AND CLIENT INFORMATION

Project Background

The Cinema-Dining Terrace Expansion is the addition of a new 16 screen movie theater, an expansion to the food court, and the addition of restaurant space at the concourse level. The movie theater is being built on top of an existing parking garage which made for a complicated structural construction and site logistics plan. The project is located in Suburbia, USA and the schedule lasts approximately 500 work days or around 2 years of total time. The project starts in mid-2012 and is projected to finish mid-2014.

Figure 1.1 - New Food Court Design

The project consists of a new 70,000 square foot cinema at the malls level three, a 12,000 square foot expansion to the existing food court at level 2, and 9,500 square feet of additional restaurants at the concourse level. The existing food court will be expanded into an additional level with a new ceiling/roof structure. The existing area will be remodeled, including new flooring, ceiling, lighting, restrooms, and a new family rest room. There will be significant modifications to the existing parking and mall where the cinema connects, including demolition, new foundations, structural upgrades, and reconfigured retail.

The structure is comprised of a combination of concrete foundations and shear walls with a steel frame. Extensive work is to be done to the existing parking garage foundations using a combination of micropiles with pilecaps, sandwich footing with threadbars, and spread footings. The foundations then support the structural steel with composite beams and the massive concrete shear walls that support the entire cinema and food court additions. The façade for the entire expansion is primarily a combination of metal panels, glazing, and EIFS. This curtain wall provides an aesthetically pleasing appearance that the owner hopes will draw more

Figure 1.2 - North East Perspective View

customers. The MEP and fire protection systems will all be tied into the existing systems with selective demolition and necessary equipment additions.

Client Information

The anonymous owner for the Cinema-Dining Terrace Expansion project in Suburbia, USA is the owner of multiple such Malls throughout the US. Subsequently, they deal with renovating and updating on a regular occasion. This often interaction gives great opportunity to find Contractors and Engineering Firms that they like to work with. Once they have chosen the companies that can provide the work to the desired quality on a consistent basis, they can then build strong relationships. These strong relationships lead to repeat work for all the companies. The Whiting-Turner Contracting Company is one of the companies that has built a very strong relationship with the owner. This relationship helps the owner feel comfortable that all their goals for the project will be met. The main goals of the owner are to increase the size and quality of their mall in order to increase their revenue. Thus, the greater quality and size of the mall, will lead to more people that will come and spend money there. The owner's main concerns are that people will be less inclined to come to their mall during construction do to the lack of parking available and the appearance of the site. Getting the parking garage open before the holiday season and keeping a clean site, are two of the main concerns that need to be met to make the owner happy.

EXISTING CONDITIONS AND PHASING PLANS

Existing Conditions

Image Courtesy of The Whiting-Turner Contracting Company

Figure 1.3 - Existing Site

Phase 1

This phase involved the demolition and foundation work done early in the project. For the ground level, foundation work is being done on the column footings and the new North & South stair tower locations. The foundation work became difficult in areas such as on the ring road. The ring road is a driveway that goes directly under the parking garage on the ground level. The mall wanted this to stay open for as long as possible to keep traffic moving, as well for deliveries to the loading docks. The road only closed for a short period in order for the foundation work on the column footings to be performed.

The two hydraulic cranes will be used for the demolition aspect. The west half of the 4th floor precast is to be demolished in order to make room for the Cinema. Precast is also being removed to allow for a tower crane to be placed for the later phases of the project.

The level 4 plan shows the construction trailers, the precast area being demolished, and the food court areas having work done simultaneously. The food court work is being done on the 2nd level, but this plan had the space to display this information.

Phase 2

In phase 2, the primary activity is steel erection using the tower crane. The ground plan shows the tower crane and its span while also showing the laydown areas. During certain activities in this phase, the ring road and parking areas near the site had to be shut down.

The level 4 plan shows the steel sequencing for the theater structure. The sequence goes 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16. While this is going on, work on the food court is still active and has now included the new entrance and restaurant work in the expansion area.

Phase 3

In phase 3, level 1 shows the areas on the garage that are now open to public parking but also shows the theater support areas that are still under construction. These areas are the stairs and elevator shaft locations, such as the areas where the sheeting and shoring were used.

The level 4 plan shows the progression of the steel erection and the progression of the expansion area. The valet area and restaurant area are still under construction but get to fitout by the end of the phase.

(See **Appendix 1A** for phasing plans)

PROJECT DELIVERY SYSTEM

With the owners experience in projects like this, they chose Contractors and Engineers that they had experience with and knew they could trust to accomplish their goals. With B&R Construction Services, they did a Design Build contract because they are confident that B&R will be able to achieve the job set before them relating to the MEP design. This also was true when it came down to the Design-Bid-Build contract; Whiting-Turner was an easy choice for the owner. See Slide 5 for other key contracts and companies involved.

STAFFING PLAN

The staff chosen by Whiting-Turner for this project is a team from Chris Hoyson’s Group at WT. Chris is a VP and has a great group that are all well accustomed to working together. **Figure 1.4** below demonstrates the details of the staffing plan.

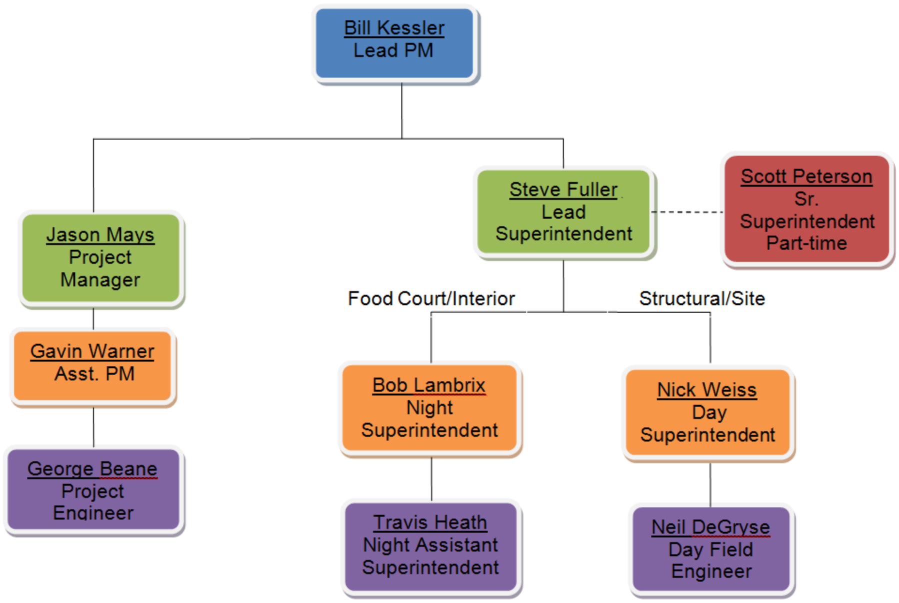


Figure 1.4 - Staffing Plan

BUILDING SYSTEMS SUMMARY

Demolition

In order for this project to begin the construction of the new Cinema, they must first demolish and modify the existing parking garage that it will be mounted on. This demolition consist of removing half of the 4th floor concrete double T's, removing stair and elevator towers where necessary, and building soldier piles in select locations. **Figure 1.5** displays the precast Tees removal and the stair & elevator demolition. Besides the demolition in the garage, there is also demolition inside the food court in tenant spaces and the ceilings to prepare for the renovations in those areas.

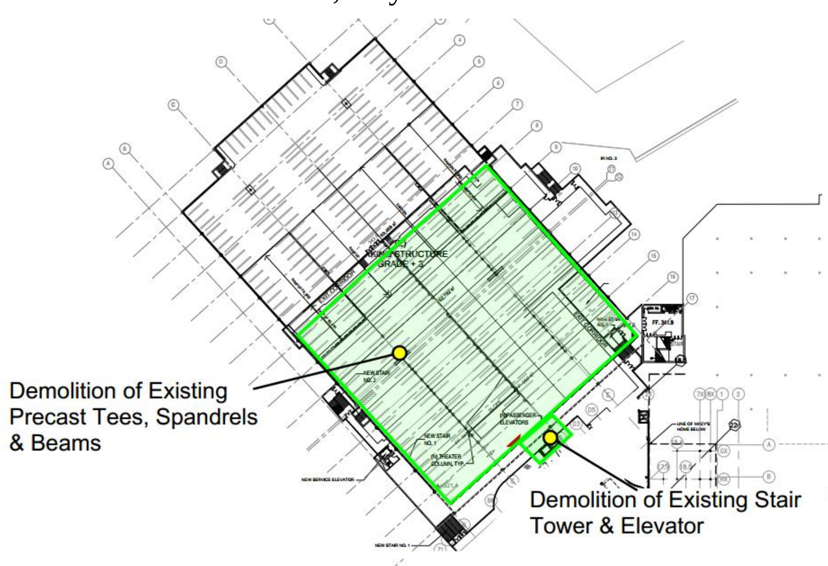


Figure 1.5 - 4th Floor Demolition

Structural

The primary structural design for this cinema and dining terrace is structural steel with composite beams and decking. The steel will also tie into the concrete shear walls to add extra stability to the structure. Complications arose in the design phase when it came to designing the new foundations around the existing foundations. Installing the new foundations and the new structure all had to be done without disturbing the structural stability of the garage itself.

Foundation

The foundation work done to support this new cinema consists of micropiles & pilecaps, sandwich footings, and spread footings. These foundations will work around and with the existing foundation of the parking garage in order to add stability and save time and space.

Mechanical

The HVAC for the existing food court will continue to be used with some modifications to ductwork and diffusers where necessary. The food court runs on a Variable Air Volume system where as the concourse and restrooms run on a Constant Volume system. For the fire suppression system, they will still be using the existing system, with added piping where needed, but will also be adding a Fire Sprinkler Room with a Fire Pump. The new system will contain 7 Roof Top Units and 4 Air Handling Units that will be interfaced with the Malls existing mechanical system. The AHU's have an average CFM range of 388-738 with an average BTUH range of 8,200-25,200. The theater will also compose of a split pipe system running to individual Unit Heaters.

Electrical

The electrical system consists of a 750 kVA transformer for the mall and a 150 kVA transformer for the fire pump. These transformers connect to multiple panels throughout the mall. Selective demolition of the existing electrical equipment/systems will occur in both the parking garage and mall. A new 4000A multi-meter service switchboard will be used to service the theater and new restaurants. This switchboard, multiple existing switchboards for the food court tenants, a 750 kVA transformer for the existing mall and a 150 kVA transformer for the fire pump will supply power to the new HVAC, plumbing equipment, new elevators, escalators, renovated and new spaces, and the fire alarm.

Curtain Wall

The new building façade will primarily consist of metal paneling, glass, and EIFS. The Storefront along the mall has a decorative formed metal trim around composite metal panels and insulated, tempered storefront glazing. The majority of the Cinema is covered by vertical corrugated metal wall panels and an EIFS surface assembly that is surrounded by white sheet metal flashing and trim. The Main entrance to the Cinema and Dining area uses a combination of Storefront Glazing, Viracon Glazing, and EIFS Surface Assemblies to create an attractive and elegant gateway. Along the existing concrete parking garage, a system of Decorative Aluminum Louvers was added to create a more aesthetic appeal. The metal panels are primarily made of glazed aluminum with cold-rolled channels, CMU, or structural steel backing. The EIFS is typically backed by thermal or semi-rigid insulation on either cold-formed channels, furring channels, or structural steel framing.

PROJECT COST EVALUATION

Actual Building Costs

Construction Costs: **$42,700,222.00**

Total Area: **120,000 GSF**
70,000 SF Cinema
50,000 SF Food Court Renovation

Total Project Costs

		Cost
Theater		
	Theater Shell	**$15,877,430**
	Theater Fit Out	**$9,565,305**
Food Court Renovation		
	Food Court Expansion & Renovation	**$13,614,870**
Garage Modifications		
	Garage Modifications / Upgrades	**$1,107,987**
Sitework / Hardscape / Landscape		
	Sitework / Hardscape / Landscape	**$2,534,630**
	COST OF WORK	**$42,700,222**
	CONTINGENCY (7%)	**$2,989,016**
Construction General Conditions / Insurance / Fee's		
	General Conditions	$2,967,400
	Liability Insurance (.85%)	$0
	Contractor's Fee (3%)	$1,281,007
	Builders Risk Insurance	$286,091
	P&P Bond	**NIC**
	TOTAL PROJECT COST	**$50,223,736**
	Corporate OH 4.0%	$2,008,949
	TOTAL ESTIMATE W / OH	**$52,232,685**

Table 1.1 - Project Costs

Major Building Systems Costs

This projects major systems consist of the Mechanical, Electrical, and the Structural systems but they only make up a little under half of the total costs for the building. The aspects of the building not listed below in Table 1.3 that bring the overall cost up are the Finishes that total around $10 million and the Exterior Enclosure that totals in around $4 million. The details of the costs of the major systems can be seen below in **Table 1.2**.

	Theater Shell		Theater Fitout		Food CT Renovation		Garage Modifications		
	70,000 GSF		70,000 GSF		50,000 GSF		360,000 GSF		
	Cost	Cost/SF	Cost	Cost/SF	Cost	Cost/SF	Cost	Cost/SF	
Mechanical System	$934,360.00	13.348	$1,905,000.00	27.21	$1,921,724.00	38.43	$27,091.00	0.08	$4,788,175.00
Electrical System	$248,256.00	3.55	$2,168,125.00	17.44	$1,405,381.00	28.11	$132,746.00	0.37	$3,954,508.00
Structural System	$6,282,635.00	-	$747,500.00	-	$1,801,400.00	-	$46,400.00	-	$8,877,935.00
Demolition	$1,243,600.00	-	-	-	$605,355.00	-	-	-	$1,848,955.00
Construction	$15,877,430.00	227	$9,565,305.00	108	$13,614,870.00	272	$1,107,987.00	3	**$40,165,592.00**
							Total Project Cost =		**$50,223,763.00**

Table 1.2 – Building Systems Cost

Square Foot Estimate

Using RS Means Cost data, a square foot estimate was created for the construction and expansion. With such a unique project the use of multiple square foot estimates was necessary. For the estimate, the building was split into the new cinema construction and the food court/restaurants expansion. **Table 1.3** below shows a brief overview of the square foot estimate.

Square Foot Cost Estimate Report		
Estimate Name:	Cinema-Dining Terrace Expansion	Cinema-Dining Terrace Expansion
Building Type:	Movie Theater with Metal Sandwich Panels/Steel Joists	Food Court/Restaurant with Metal Sandwich Panels/Steel Joists
Story Count:	1	1
Story Height (LF):	30	14
Floor Area (SF):	70,000	50,000
Labor Type:	STD	STD
Basement Included:	No	No
Data Release:	Year 2013 Quarter 3	Year 2013 Quarter 3
Cost Per Square Foot:	$266.35	$164.74
Building Cost:	$18,644,430.00	$8,237,000.00

Table 1.3 - RS Means Square Foot Cost Estimate Summary

The RS Means Square Foot Estimate Total Building Cost: **$26,881,430.00**

The square foot estimate is low when compared to the actual cost of the building. This can be attributed to the structure and finishes for the actual building. As stated above, the costs for finishes and structure account for nearly %50 of the total building cost. The structure is unique to the project and totals nearly $9 million when looking at the actual building costs. The quality of finishes for this building are higher than estimated and total around $10 million. These two features are keys to why the square foot estimate is much lower than the actual building cost.

Detailed Estimate

The detailed estimate primarily focuses on the Structural System and the Exterior Enclosure. The amounts below represent the totals of the takeoffs and calculations using RS Means and project provided prices.

Structural System: $7,930,950.00 Exterior Enclosure: $3,793,035.00

(See **Appendix 1B** for the Detailed takeoffs and Estimates)

DETAILED PROJECT SCHEDULE

The detailed project schedule develops the activities that were discussed in the project summary schedule included in Technical Report I. The schedule overall takes approximately 540 business days starting in mid-2012 and lasting all the way until mid-2014. The schedule describes in detail the major aspects of the project and has to work around the existing shopping centers schedule. This schedule is broken down into 9 major categories including Preconstruction, Dining Terrace Demo & Construction, Site Work, Garage Renovation & Theater Structure, Enclosure, Garage Rough-Ins & Finishes, Expansion Rough-Ins & Finishes, Theater Rough-Ins & Finishes, and Closeout. These categories allow for a more detailed look at the activities in the main phases of the project.

(See **Appendix 1C** for the Detailed Project Schedule)

Activity Name	Durations	Start	Finish
Montgomery Mall Project	**538**	**1-Jun-12**	**8-Jul-14**
Preconstruction	287	1-Jun-12	23-Jul-13
Owner Internal Review/Approvals	162	1-Jun-12	21-Jan-13
Design Development	81	18-Sep-12	11-Jan-13
Construction Documents	103	19-Nov-12	15-Apr-13
Building/Civil Permits	148	10-Dec-12	9-Jul-13
Tenant Coordination	109	18-Dec-12	21-May-13
Early Release Structural Steel	196	24-Jul-12	29-Apr-13
Public Utilities Procurement	53	19-Nov-12	4-Feb-13
Phasing Bid/Awarding	119	10-Dec-12	28-May-13
Procurement	140	7-Jan-13	23-Jul-13
Construction	339	9-Jan-13	14-May-14
Dining Terrace Work	209	9-Jan-13	31-Oct-13
Site Work	345	10-Jan-13	14-May-14
Garage Demolition	61	4-Mar-13	28-May-13
Garage Expansion Substructure	96	12-Mar-13	25-Jul-13
Structural Steel Erection	55	17-May-13	5-Aug-13
Dining Terrace Structure	82	22-May-13	17-Sep-13
Theater Service Area Structure	51	1-May-13	12-Jul-13
Elevator & Stair Structure	62	25-Apr-13	23-Jul-13
Theater Roof	87	23-Jul-13	21-Nov-13
Dining Terrace Roof	26	19-Jul-13	23-Aug-13
Elevations Envelope	133	8-Jul-13	13-Jan-14
Stairway Exterior Finishes	115	12-Jun-13	21-Nov-13
Garage Rough-Ins & Finishes	312	8-Jul-13	10-Jan-14
Expansion Rough-Ins & Finishes	108	30-May-13	30-Oct-13
Theater Rough-Ins & Finishes	190	15-Jul-13	9-Apr-14
Closeout	331	15-Mar-13	8-Jul-14
Phase 1 Turnover	0		15-Mar-13
Dining Terrace Complete	0		31-Oct-13
Theater Shell Turnover	0		9-Apr-14
Theater Fitout Summary	64	10-Apr-14	8-Jul-14
Project Completion	0		8-Jul-14

Table 1.4 Project Duration Overview

GENERAL CONDITIONS ESTIMATE

The General Conditions Estimate was performed with data provided by The Whiting-Turner Contracting Company. Cost data was provided for the General Conditions of Whiting-Turner, the Anonymous Owner, and the Office & Miscellaneous Costs.

Whiting-Turner $1,817,000.00

Anonymous Owner $975,000.00

Office & Misc. Costs $450,200.00

$3,242,200.00

(See **Appendix 1D** for the General Conditions Estimate)

The staffing costs for this project take up most of the General Conditions Cost. It is not typical to have an owner that has employees as involved in a project as this was. The owner had a Project Manager, Accountant, and Administrator in the trailers working with the project team throughout the entire process. This allowed for easy communication and coordination with the owners desires, but is also why their costs are included in the General Conditions.

The trailer complex was placed on the 4^{th} floor of the parking garage so installation became a little more expensive for any aspect of the General Conditions. The trailers included everything a typical trailer would have comprising of phone service, Internet, Copier, Printer, Drinks/Snacks, First Aid, and Fire extinguishers. The General Conditions also include costs for Shipping Postage, Progress Photos, and Builders Risk Insurance. The Progress photos were taken once a month from a plane that flies over the site.

SECTION 2 – SITE LOGISTICS MODIFICATIONS (ANALYSIS 1)

PROBLEM IDENTIFICATION

The demolition for this project required a well-coordinated and organized site logistics plan. This plan involved the use of multiple cranes that added extra complications to the project. In one area, soldier piles and lagging were added to support the excavation wall due to one of the cranes close location. Detailed coordination was essential for the new foundations around the concrete pad for the tower crane located in the middle of the existing parking garage. This tower crane also required extensive means and methods work that caused potential safety hazards and added to the schedule. With one of the cranes needing to be located on the Ring Road that runs under the existing parking garage, the road was required to be shut down during the demolition phase. The planned site logistics plan creates complications and problems that affect the site and the project as a whole logistically and with relation to the schedule.

BACKGROUND RESEARCH

The major demolition work required for the parking garage consists of the removal of half the precast concrete for level 4. The primary pieces of equipment used for the demolition will be two hydraulic cranes on the north and south sides of the building. The hydro crane on the south side of the building forced the excavation to require soldier piles and lagging with tiebacks just to support the load from the crane. The crane had to be located near the excavation due to the limited site space and to ensure it could reach the farthest required pick. A separate hydro crane had to be brought in on the north side to remove the pieces of precast concrete that the first hydro crane couldn't reach. This north side hydro crane had one location available that would allow it to reach its farthest pick, and that was located in the middle of the Ring Road that runs under the parking garage. This forced the Ring Road to close for that period of time, rerouting traffic and customers.

Also during the demolition period is the preparation for the tower crane placement. This tower crane is to be used for the steel erection primarily and is located near the middle of the existing parking garage. The means and methods for installing this tower crane requires the temporary removal of the existing precast concrete double T's located in the middle of the parking garage on the first, second, and third floor. These concrete T's weigh around 50,000 lbs each and due to their location, hydraulic jacks are required for their temporary relocation. The tower crane also requires a large concrete pad to be poured on the ground floor for the crane to rest on. This pad is located near the new foundation work so coordination and planning is necessary to distribute resources properly.

POTENTIAL SOLUTIONS

Alternate site logistics plans will be explored to identify possible benefits with relation to the schedule, cost, constructability, and site coordination. A potential solution can be changing to a two tower crane plan. This analysis will focus on incorporating two tower cranes instead of the two hydraulic cranes and one tower crane previously planned for. The two tower cranes could use foundations that are being placed for new stair towers, as their foundation. The use of these new stair tower foundations as the tower crane pad would require a structural analysis to redesign the stair tower foundations to allow for the loads of a tower crane in addition to the stair tower. These two new tower cranes would now be located outside the foot print of the existing parking garage. This would help to eliminate the mean's and methods of relocating the existing precast concrete double T's that required repositioning for the original tower crane. The two tower cranes could then be used for demolition, steel erection, and other tasks such as placing roof equipment. This potential solution will affect the schedule, cost, construction sequence, and the site coordination so analyses into all these areas will be necessary.

ANALYSIS PROCEDURE

- Constructability Analysis
  - Analyze the tower cranes reach and capacity
  - Analyze sequencing to see if the foundations can be poured early
  - Analysis into whether the foundation work for the whole building will be complete in time to begin steel erection once demolition is complete
  - Analyze worker production rates
- Structural Analysis
  - Analyze the current foundation design
  - Determine loads from the stair tower
  - Determine loads from the tower crane
  - Calculate required foundation design of the footing
  - Analyze excavation to determine if soldier piles and lagging are still required
- Site Analysis
  - Car and pedestrian traffic flow
  - Laydown areas
  - Truck access
  - Tower arm swing restrictions
  - Height restrictions
- Schedule Analysis
  - Collect durations of the existing schedule
    - Soldier piles and lagging
    - Foundations excavations and installation
    - 4th floor demolition
    - Relocation of precast for original tower crane

        - Ring Road closure time periods
        - Steel erection
    - Collect potential durations for proposed plans
        - Foundation excavation and installation
        - Tower crane assembly, erection, and tear down
        - Demolition phase
        - Steel erection phase
- Cost Analysis
    - Cost of two tower cranes
    - Cost of the new stair tower and tower crane pads
    - Cost of less mean's and methods
    - Estimated daily revenue of the mall with the project complete
- Owner impact
    - Up front cost
    - Site traffic plans
    - Schedule
    - Quality control
    - Develop the best way to display the proposal to the owner

RESOURCES

- Industry Professionals
- AE Faculty Members
- Project Documents
- Cinema-Dining Terrace Expansion Project Team
- The Whiting-Turner Contracting Company resources
- RS Means
- Project Subcontractors
- AE Classmates
- Applicable Books, Papers & Websites

EXPECTED OUTCOME

The site logistics plan incorporating two tower cranes is anticipated to help with all the problems mentioned early though it is expected to cost more up front. It is however expected that the stair tower foundations, with proper upgrades, will be sufficient for the two tower cranes to be set on. Besides the problems possibly being eliminated, there is expected to be substantial schedule acceleration involved around the demolition and steel erection phases. These schedule accelerations are also expected to help cover the initial costs by opening the mall sooner allowing more money to be made earlier. It is also expected that the new site plan will allow for easier traffic flow and improve the construction sequence.

SITE LOGISTICS INFORMATION

Current Site Logistics

The current site logistics focuses around the primary phases of demolition, steel erection, and curtain wall installation. The phases rotate through the uses of multiple different cranes for the demolition and steel erection. Once the project is into the exterior envelope installation, the larger cranes are no longer needed and smaller equipment will be used instead to assist.

Figure 2.2 displays the site logistics for the demolition phase at the ground level. The key for the phasing plans can be seen in **Figure 2.1**. This phase primarily revolves around the demolition of the east half of the 4th floor existing precast double Tee's. **Figure 2.3** shows what one of the precast concrete double Tee's looks like. These pieces of concrete are extremely large and weigh around 50,000 lbs. This phase requires the use of two 50-ton hydraulic cranes seen on the north and south side of the building in blue. The portion of the 4th floor that will be demolished, seen in **Figure 2.4** in green, will have temporary shoring placed underneath. This shoring is on every level going all the way down to the stable ground level. The shoring allows the 4th floor double T's to be cut in half with full structural stability for each individual Tee and for the rest of the garage. The concrete double Tee's will be cut in half and then lifted out of place to be either placed in the laydown area or directly onto a truck. The double tees are cut in half to allow the crane to pick them. This is due to their sheer weight and size. Double tee's that are placed in the laydown areas only remain there for no more than a day. Trucks are coming to the site daily during this phase to pick up the removed double tees. The hydro crane places the double tees on the trucks, which can stack two double Tee's each trip. This demolition also includes all the spandrel pieces. These pieces weigh about half as much

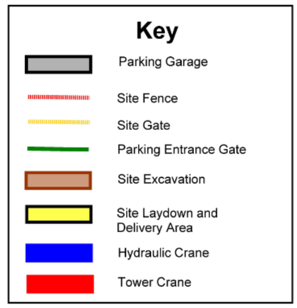


Figure 2.1 – Phasing Plan Key

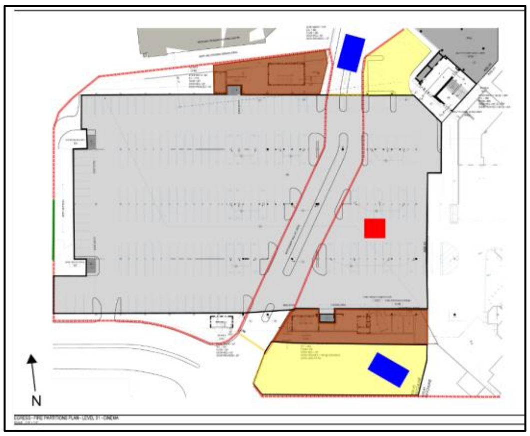


Figure 2.2 – Original Ground Level Site Logistics

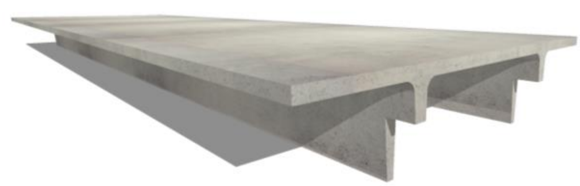


Figure 2.3 – Precast Concrete Double Tee www.kerkstra.com

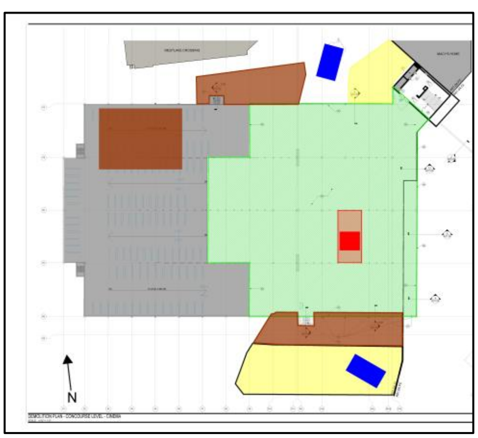


Figure 2.4 – Original Demolition 4th Level Phase

as one of the double tees so they are not required to be cut in half before being picked.

Once the demolition of the 4th is finished, the tower crane will need to be installed in the center of the existing parking garage. Due to the location of the tower crane, extensive means and methods was required for its installation. This tower crane has its foundation on the ground level and required a large excavation and installation process. This pad is located near the new foundation work so coordination and planning is necessary to distribute resources and avoid possible safety hazards. In order for the crane to be placed, two existing precast concrete double tees are to be temporarily moved on both the 2nd and 3rd floors in that location to allow for the crane to reach the ground level where its mat foundation has been installed. The location for the tower crane and the double tees being moved can be seen in **Figure 2.4** in red. These double T's will be moved using shoring and hydraulic jacks and placed off to the side on their respective levels. The foundation takes nearly 3 weeks to install and cure, and the temporary removal of the double T's takes about 2 weeks.

The tower crane will then be assembled using the south side hydro crane. Once assembled, it will go through the necessary inspection process. The installation and inspection process takes about 5 full days. Once the tower crane has been placed, the two hydro cranes will be removed from the site and this will allow for more laydown areas for the structural steel.

The tower crane is a Linden Comansa 21LC550 and will primarily be used for the steel erection, particularly in areas 3 through 11 seen in **Figure 2.5**. The steel erection process begins with the installation of the steel columns and continues all the way through to the last item of prepping and pouring the Slab On Metal Deck (SOMD). Once the steel has been erected in areas 3 through 11, a hydraulic crane will be brought back on-site to remove the tower crane and then to install the remaining steel in areas 1, 2, 9, & 10. The hydraulic crane will also be used to install the steel that had to be left out in the location of the tower crane. Once the remaining steel has been erected, the hydraulic crane will be deconstructed.

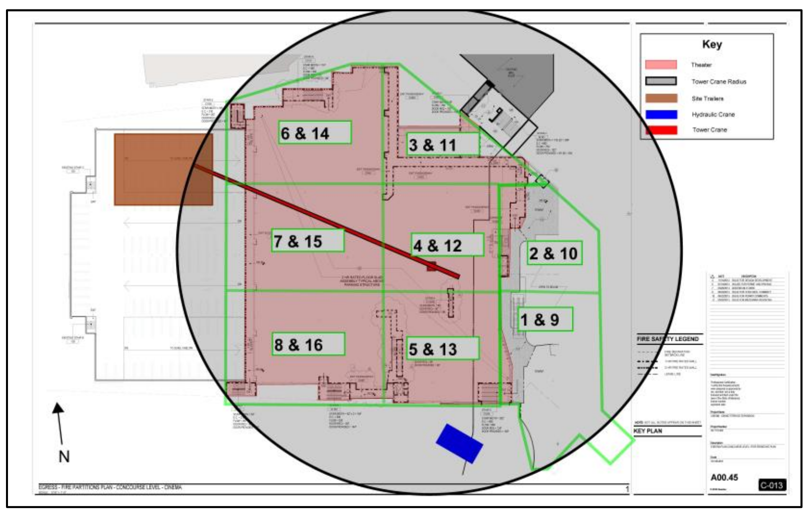


Figure 2.5 – Original Steel Erection Phase

(See **Appendix 1A** for original phasing plans)

As the final steel is being erected, the exterior envelope is beginning to be installed. The envelope is stick built and includes framing, sheathing, an air barrier, insulation, and the finish.

That will be analyzed and discussed in more detail in **Analysis 2**, which focuses on the proposal of prefabricating the exterior façade.

Overall, the original site logistics and sequencing requires the use of many large cranes for the critical demolition and steel erection phases, specifically 3 hydraulic cranes at two separate instances, and the use of one tower crane. The means and methods required and the overall duration of activities makes the site logistics and sequencing a great area to alter in the attempt to improve the schedule and cost.

Proposed New Site Logistics

Based off of the original site logistics plan, this new plan focuses on improving the schedule by implementing a different set of crane logistics. The overall site will not differ too much from the original plan but the major changes will revolve around the large equipment usage and locations. The crane sequencing and logistics for the site controls some of the key aspects to this project including the demolition and steel erection phases. Modifications to the crane logistics could assist in accelerating these phases, and possibly help accelerate the exterior envelope installation if it is prefabricated, which is examined in **Analysis 2**. These schedule improvements could also assist in saving the owner on costs by decreasing the overall schedule as a whole.

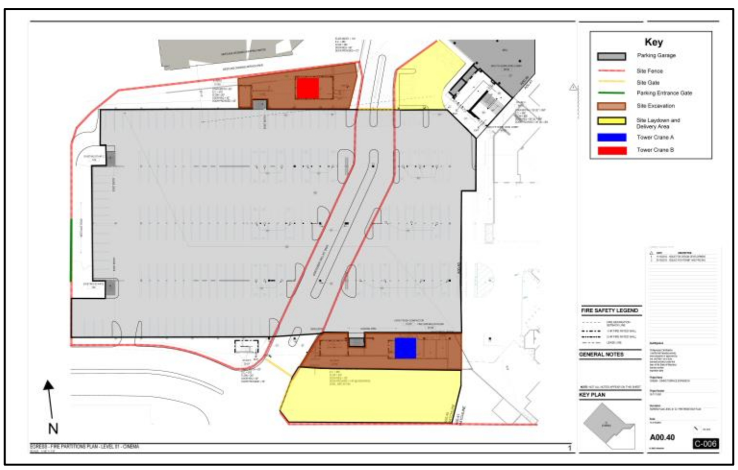


Figure 2.6 –New Ground Site Logistics

The proposed new site logistics plan will remove the original tower crane from the center of the building and implement the use of two tower cranes instead. These new tower cranes will be located one on the North and one on the South side of the building. The cranes will be located outside of the existing parking garage footprint in order to avoid the means and methods work of temporarily removing existing portions of the parking garage. That will assist in improving the schedule while also removing a potentially hazardous activity. The locations of the tower cranes and the logistics of the ground level can be seen in **Figure 2.6**. The red square represents Tower Crane B located on the north side of the building and the blue square represents Tower Crane A on the south side.

Each of the locations chosen for the new tower cranes was done for specific reasons. These areas are two of the main foundation locations for the stairs and elevators. Excavation in those areas is critical to the project so they begin early on. By locating the tower cranes in these locations it allows the excavation and foundation installation to coincide with the already excavations and foundations. This will assist in eliminating extra excavation activities and could save time in the schedule. The specific foundations chosen will also incorporate the stair tower and elevator foundations so it will save on materials and installation. The structural details of designing these foundations is discussed in the **Structural Breadth**.

Tower Crane A will be located on the south side and will be used for the south half of the buildings demolition, steel erection, and prefabricated exterior installation. It is about 136 feet tall with a jib max reach of about 262 feet. The height and length allows it to reach and place nearly anything on the south half of the building. Any items that cant be reached or placed by tower crane A will either be handled by tower crane B or by the hydro crane that will be brought it to remove the tower crane. The reach and location of tower crane A can be seen in **Figure 2.7** that represents the New Demolition Phase.

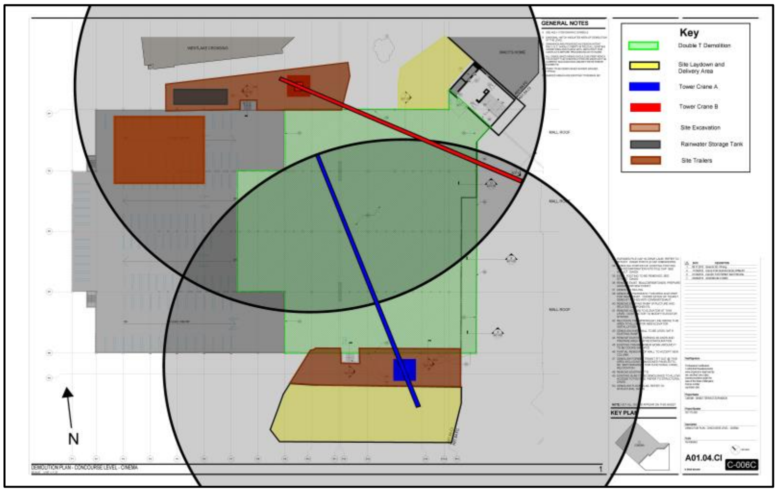


Figure 2.7 – New Demolition Phase

Tower Crane B will be located on the north side of the building and will be used for the north half of the buildings demolition, steel erection, and prefabricated exterior installation. It is about 172 feet tall with a jib max reach of about 262 feet. This crane is much taller than tower crane A in order to prevent collisions since their swing spaces clearly cross as displayed in **Figure 2.7** and **2.8**. Similar to tower crane A, this tower crane will reach and place nearly all the demolition, steel, and prefabricated exterior on the north half of the building. The hydro crane that is brought in to remove the tower crane will handle those items in locations that cannot be reached by the tower crane.

The steel erection sequence can be seen in **Figure 2.8**. The sequence is split up by which tower crane is erecting which section. For example, while tower crane A is erecting section 1A, tower crane B would be erecting section 1B, and so on. This allows the steel to be erected in half the time that the original one tower crane could do. Extensive coordination and communication will be required during this phase due to the tower cranes that swing paths cross.

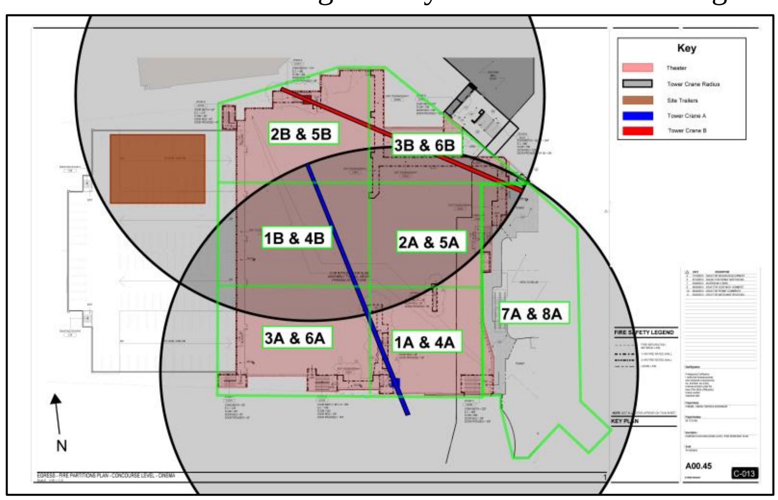


Figure 2.8 – New Steel Erection Phase

These two tower cranes, once installed and inspected, will be able to perform nearly all the work required for the demolition, steel erection, and most of the installation for the proposed prefabricated exterior envelope. The use of two tower cranes will accelerate these activities but will require doubling the manpower during the demolition and steel erection phases. The schedule and cost breakdowns will be shown later on in the **Schedule and Sequencing Evaluation** and the **Cost Evaluation**.

(See **Appendix 2A** for new phasing plans)

TOWER CRANE FOUNDATIONS – STRUCTURAL BREADTH

The tower cranes used for the new site logistics are Linden Comansa 21LC550/52,910 lb.

(See **Appendix 2B** for the tower crane spec sheets)

Tower Crane A is located on the south side of the building and its foundation will be incorporated with the mat foundation of Cinema Elevator 01. The design and calculations show that the recommended concrete is of the same strength so the foundations will be excavated, reinforced, and placed at the same time. The south area already requires plenty of excavation for the foundations including the elevator mat so the added excavation is negligible. The elevator mat includes concrete walls that are formed, reinforced, and placed concurrently. The tower crane foundation replaces some of the elevator mat foundation in a small portion but due to the thickness and reinforcement of the tower crane mat, it is considered structurally acceptable. **Figure 2.9** shows a detail of the foundation designed for. The region inside the red lines represents the adjusted area for the tower crane mat. For economic reasons, the rebar required for the tower crane mat region with also be used for the rest of the original foundation. This rebar is larger than the rebar originally designed for in the foundation so its replacement doesn't affect the structural abilities of the elevator pit. Where the tower crane mat meets the 4' thick elevator pit, there is clearly a thickness difference. In the construction world, the elevator pit foundation would be slanted down to meet the thickness of the tower crane foundation. This can be seen in **Figure 2.9** with the slanted red line.

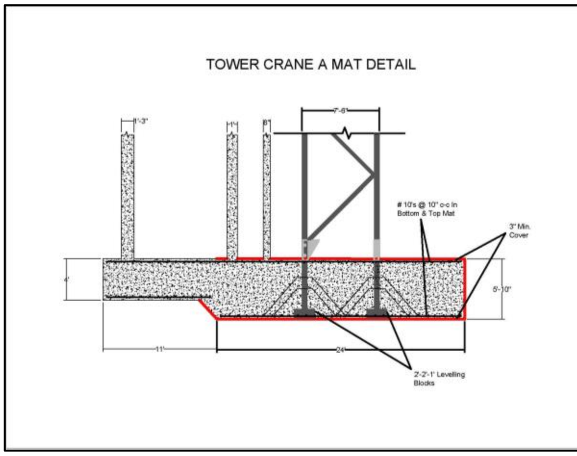


Figure 2.9 – Tower Crane A Foundation Detail

Tower Crane B is located on the North side of the building and its foundation will be incorporated with the mat foundation of Stair Tower A. The design and calculations show that the recommended concrete for both the stair tower and tower crane mats are of the same strength so the foundations will be excavated, reinforced, and placed at the same time. Stair Tower A has a very large foundation that includes a 4 ft thick mat and retaining walls that are located around the edge of the mat. The tower crane mat is completely incorporated within the stair tower mat replacing a large area of the mat but due to the thickness and reinforcement of the tower crane mat, it is considered structurally acceptable. **Figure 2.10** displays the detail of the tower crane B's foundation incorporated into stair tower A's foundation. Similar to the foundations for tower crane A, the rebar designed for in the tower crane mat will be used for the entire foundation for uniformity and economics. Also similar to the foundations for tower crane A, the foundations are slanted where they meet. This is how it will be installed out in the field so that is why the detail is shown that way.

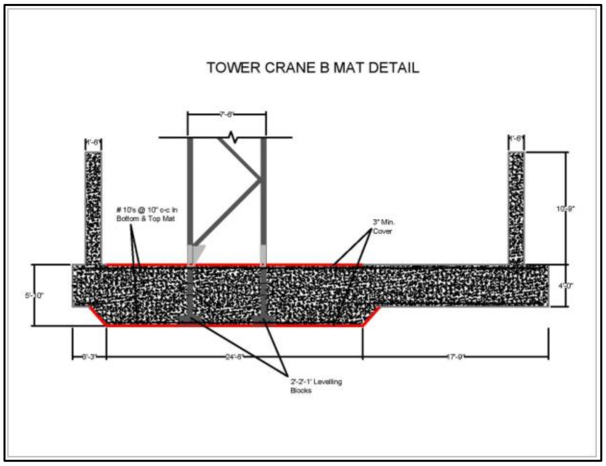


Figure 2.10 – Tower Crane B Foundation Detail

In both foundations, the tower crane legs extend into the foundations for stability and strength. Once the tower cranes are removed, the extensions in the foundation will remain while the rest of the tower will be removed. Each of the tower crane mats will then remain as part of the foundation for their respective structures.

(See **Appendix 2C** for Tower Crane Foundation Details**)**

Calculations Summary

The structural calculations are based on loads and factors received from the tower crane manufacturer Linden Comansa America and requirements from The Whiting-Turner project team. After analyzing the geotechnical report, it was concluded that both proposed tower crane locations were suitable with soil that had an allowable soil bearing capacity of 4000 psf.

TOWER CRANE A

Reaction Forces In Service - 45 mph			
Overturning Moment	Mx =3672 ft-kips	Slewing Moment	Md =564 ft-kips
Vertical Load	V =277 kips	Horizontal Shear	H =7 kips
Reaction Forces Out of Service - 94 mph			
Overturning Moment	Mx =3831 ft-kips	Slewing Moment	Md =0 ft-kips
Vertical Load	V =257 kips	Horizontal Shear	H =21 kips

Governing Load Conditions						
Overturning Moment	Mx =3831 ft-kips			Slewing Moment	Md =564 ft-kips	
Vertical Load	V =277 kips			Horizontal Shear	H =21 kips	
Foundation Specifications						
Concrete Strength (f'c)	W	L	T	Rebar Size & Spacing (Both Directions)		Weight of FDN.
				Bottom	Top	
5,000 psi	22'-6"	24'-0"	5'-10"	#10@10"	#10@10"	472 kips

Table 2.1 – Tower Crane A Results

TOWER CRANE B

Reaction Forces In Service - 45 mph			
Overturning Moment	Mx =4112 ft-kips	Slewing Moment	Md =564 ft-kips
Vertical Load	V =296 kips	Horizontal Shear	H =8 kips
Reaction Forces Out of Service - 94 mph			
Overturning Moment	Mx =4770 ft-kips	Slewing Moment	Md =0 ft-kips
Vertical Load	V =277 kips	Horizontal Shear	H =26 kips

Governing Load Conditions:						
Overturning Moment	Mx =4770 ft-kips			Slewing Moment	Md =564 ft-kips	
Vertical Load	V =296 kips			Horizontal Shear	H =26 kips	
Foundation Specifications						
Concrete Strength (f'c)	W	L	T	Rebar Size & Spacing (Both Directions)		Weight of FDN.
				Bottom	Top	
5,000 psi	24'-6"	24'-6"	5'-10"	#10@10"	#10@10"	525 kips

Table 2.2 – Tower Crane B Results

Table 2.1 and **Table 2.2** display the initial reaction forces acting on the foundations from the crane, and they show the resulting foundation specifications. These foundation specifications are designed to be followed precisely in order to ensure a structurally sound foundation. These foundations will then be incorporated by the new stair towers or elevator pits so quality is that much more important. The loads from tower crane A are slightly lower than those of tower crane B because of the height of the cranes. Crane B is about 36 feet taller than crane A which mostly ends up impacting the overturning moment.

(See **Appendix 2C** for Complete Foundation Calculations)

SCHEDULE AND SEQUENCING EVALUATION

Schedule Evaluation

Table 2.3 shows a summary of the new schedule vs. the original schedule. The original schedule for the project begins June 1st 2012 and finishes July 8th 2014 creating a total duration of 538 workdays. This can then be compared to the new schedule that begins June 1st 2012 and finishes May 12th 2014 creating a total duration of 497 workdays. This is a total savings of 41 workdays or 57 total days including weekends. When analyzing the benefits of this decrease in schedule, it is more useful to look at the workdays for construction savings, but for the overall savings it is more useful to look at the total days. The 57 days sooner this project can open is a large time period that the owner can be making money back. Since this project is a movie theater and food court, the sooner it opens, the sooner the owner can start making money

New Schedule Summary			
Activities	Duration	Start	Finish
Cinema-Dining Terrace Expansion	**497**	**1-Jun-12**	**12-May-14**
Owner Internal Review/Approvals	162	1-Jun-12	29-Jul-13
Preconstruction	220	18-Sep-12	29-Jul-13
Dining Terrace Work	209	9-Jan-13	31-Oct-13
Site Work	179	10-Jan-13	20-Sep-13
Garage Demolition	46	25-Mar-13	28-May-13
Garage Expansion Substructure Area 1	41	21-Feb-13	18-Apr-13
Garage Expansion Substructure Area 2	62	5-Mar-13	30-May-13
Theater Structural Steel Erection	31	15-Apr-13	28-May-13
Dining Terrace Structure	48	29-May-13	5-Aug-13
Theater Service Area Structure	30	15-Apr-13	24-May-13
Stair Structure	73	15-Apr-13	26-Jul-13
Theater Roof	37	28-May-13	18-Jul-13
Dining Terrace Roof	26	5-Aug-13	10-Sep-13
Elevations Envelope	72	3-Jun-13	12-Sep-13
Stairway Finishes	115	15-Apr-13	25-Sep-13
Garage Rough-Ins & Finishes	229	12-Jun-13	2-May-14
Expansion Rough-Ins & Finishes	108	29-May-13	29-Oct-13
Theater Rough-Ins & Finishes	213	15-Apr-13	12-Feb-14
Theater Fit-Out	64	12-Feb-14	12-May-14
Project Completion	0		12-May-14

Original Schedule Summary			
Activities	Duration	Start	Finish
Cinema-Dining Terrace Expansion	**538**	**1-Jun-12**	**8-Jul-14**
Owner Internal Review/Approvals	162	1-Jun-12	29-Jul-13
Preconstruction	220	18-Sep-12	29-Jul-13
Dining Terrace Work	209	9-Jan-13	31-Oct-13
Site Work	171	10-Jan-13	12-Sep-13
Garage Demolition	56	11-Mar-13	28-May-13
Garage Expansion Substructure Area 1	101	5-Mar-13	25-Jul-13
Garage Expansion Substructure Area 2	62	5-Mar-13	30-May-13
Theater Structural Steel Erection	55	17-May-13	5-Aug-13
Dining Terrace Structure	75	3-Jun-13	17-Sep-13
Theater Service Area Structure	51	1-May-13	12-Jul-13
Stair Structure	68	17-Apr-13	23-Jul-13
Theater Roof	37	23-Jul-13	12-Sep-13
Dining Terrace Roof	26	19-Jul-13	23-Aug-13
Elevations Envelope	133	8-Jul-13	13-Jan-14
Stairway Finishes	115	12-Jun-13	21-Nov-13
Garage Rough-Ins & Finishes	229	8-Jul-13	10-Jun-14
Expansion Rough-Ins & Finishes	108	29-May-13	29-Oct-13
Theater Rough-Ins & Finishes	213	11-Jun-13	9-Apr-14
Theater Fit-Out	64	10-Apr-14	8-Jul-14
Project Completion	0		8-Jul-14

Table 2.3 – Original Schedule Summary

Seen highlighted in **Table 2.3** are the activities that were impacted by the new crane logistics and the prefabricated exterior envelope. The new schedule increased the site work duration due to the foundation and crane erection additions. Garage demolition decreased its duration since there were two tower cranes working simultaneously. Theater structural steel erection and dining terrace structure also decreased their durations because of the additional tower crane. The stair structure increased in duration because of the tower cranes location. Stair tower A couldn't be erected until tower crane B had been deconstructed. The last activity that was impacted was the Exterior Envelope installation. This activity would only benefit from the two tower cranes though if the façade is prefabricated. This prefabrication evaluation can be seen in **Analysis 2**.

(See **Appendix 2D** for the amended project schedule)

Sequencing Evaluation

The sequencing evaluation revolves around the activities that are required for the demolition, steel erection, and exterior envelope. Activities will include the foundations for all the steel columns, the excavation and foundations of the north and south side (the locations of the new tower cranes), and the crane erections. The new sequencing was essential when it came to making the new schedule possible.

The new sequencing moved certain activities around in order for others to occur on time. The excavation and foundation work on the north and south sides were pushed forward in order for the tower cranes to be erected on time. The tower cranes had to be installed on time in order for the demolition to occur on schedule. After the demolition phase is the steel erection phase. For that to occur on time, the footing, micro-piles, & pile caps all had to be installed sooner.

The sequences that were delayed were stair tower A's erection and the steel around the south tower crane. These areas could only be worked in once the tower cranes had been removed.

The sequence was altered to fit the new site logistics which in turn helped improve the schedule substantially.

(See **Appendix 2D** for the amended project schedule)

COST EVALUATION

Foundations Costs Evaluation

New Tower Crane Foundation Costs				
Materials (Concrete & Reinforcing)				
	Quantity (Cubic Yard)		Cost ($/CY)	Total
Tower Crane A	116.7		$500	$58,350
Tower Crane B	129.7		$500	$64,850
				$123,200
Crew				
	Quantity	Duration (hrs)	Cost ($/hr)	Total
Tower Crane A	6	56	$48	$16,128
Tower Crane B	6	56	$48	$16,128
				$32,256
			Total New Foundation Costs:	$155,456

Original Tower Crane Foundation Costs				
Materials (Concrete & Reinforcing)				
	Quantity (Cubic Yard)		Cost ($/CY)	Total
Tower Crane	114.3		$500	$57,150
				$57,150
Crew				
	Quantity	Duration (hrs)	Cost ($/hr)	Total
Tower Crane	6	56	$48	$16,128
				$16,128
			Total Orignal Foundation Costs:	$73,278

Table 2.4 – Tower Crane Foundation Costs

From the addition of the second tower crane, the costs related to the structural redesign nearly doubled. Seen in **Table 2.4**, the original cost for the foundation was $73,278 where the new cost is $155,456 since it includes the additional foundation and doubles the crew size in order for them to be installed concurrently. This structural redesign caused an increase in cost of $82,178 but since the foundations will be poured concurrently, the schedule is only marginally affected.

Tower Crane Logistics

As seen in **Table 2.4**, the cost of the original tower crane logistics is $1,775, 112.00 compared to the new tower crane logistics cost of $1,159,536.00. After adding in the tower crane foundation costs, the original cost is at $1,848,390.00 and the new cost is at $1,314,992.00. The estimated savings comes out to be $533,398.00.

The two activities that saved the most money are the Steel Erection of 1A-6A & 1B-6B and the Curtain Wall Installation. The schedule was decreased so much that it saved $290,112.00 for the Steel Erection of 1A-6A & 1B-6B and saved $267,072.00 for the Curtain Wall Installation.

These savings for the Curtain Wall Installation are contingent on implementing the prefabricated exterior envelope that will be discussed in **Analysis 2**. If the prefabricated exterior envelope isn't implemented, the New Tower Crane Logistics would then cost $1,399,536.00 which still has a savings of $293,398.00.

New Tower Crane Logistics													
			Equipment					Labor					Total
			Tower Crane		Hydro Crane			Crane Operator		Laborers			
Activity	Duration	Unit	Qty	Rate	Qty	Rate	Total	Qty	Rate	Qty	Rate	Total	
Tower Crane Erection	3	days	2	$1,200.00	2	$5,000.00	$37,200.00	2	$960.00	14	$336.00	$19,872.00	$57,072.00
Demolition	15	days	2	$1,200.00	0	$5,000.00	$36,000.00	2	$960.00	14	$336.00	$99,360.00	$135,360.00
Steel Erection (1A-6A & 1B-6B	25	days	2	$1,200.00	0	$5,000.00	$60,000.00	2	$960.00	14	$624.00	$266,400.00	$326,400.00
Steel Erection (7A, 8A)	47	days	1	$1,200.00	0	$5,000.00	$56,400.00	1	$960.00	7	$624.00	$250,416.00	$306,816.00
Curtain Wall Installation	37	days	2	$1,200.00	0	$5,000.00	$88,800.00	2	$960.00	14	$336.00	$245,088.00	$333,888.00
													$1,159,536.00

Original Tower Crane Logistics													
			Equipment					Labor					Total
			Tower Crane		Hydro Crane			Crane Operator		Laborers			
Activity	Duration	Unit	Qty	Rate	Qty	Rate	Total	Qty	Rate	Qty	Rate	Total	
Tower Crane Erection	3	days	1	$1,200.00	1	$5,000.00	$18,600.00	1	$960.00	7	$336.00	$9,936.00	$28,536.00
Demolition	15	days	0	$1,200.00	2	$5,000.00	$150,000.00	2	$960.00	14	$336.00	$99,360.00	$249,360.00
Steel Erection (1A-6A & 1B-6B	52	days	1	$1,200.00	0	$5,000.00	$62,400.00	2	$960.00	14	$624.00	$554,112.00	$616,512.00
Steel Erection (7A, 8A)	47	days	1	$1,200.00	0	$5,000.00	$56,400.00	1	$960.00	7	$624.00	$250,416.00	$306,816.00
Curtain Wall Installation	122	days	0	$1,200.00	0	$5,000.00	$0.00	0	$960.00	14	$336.00	$573,888.00	$573,888.00
													$1,775,112.00

Table 2.5 – Tower Crane Logistics Costs

With the schedule improving 57 total days, the mall has started to make its money back much earlier. This then means that the owner is making money back sooner. This expansion of the mall is estimated to make about $500,000.00 per month on rent. The 57 days is nearly 2 months, which means that the owner has made back about $1 million dollars from the project finishing early.

The savings from the new logistics plan and the savings from the schedule decrease combine to save the project and owner and estimated $1,533,398.00 when the exterior envelope is prefabricated. This does not include the new material costs though of the prefabricated façade. That will be evaluated in **Analysis 2**. If the exterior envelope is not prefabricated, the savings are estimated to be $793,398.00.

(See **Appendix 2E** for large tower crane logistics costs)

CONCLUSION AND RECOMMENDATION

Conclusion

By performing this analysis, it showed how the addition of another tower crane can help decrease the schedule and cost if sequenced correctly. The overall project schedule is decreased by 41 workdays and 57 total days. The estimated costs are decreased by $1,533,398.00 when the exterior envelope is prefabricated.

Recommendation

The final recommendation is to implement the new tower crane logistics. It shows improvements in both cost and schedule which are the two main concerns for the owner.

SECTION 3 – EXTERIOR ENVELOPE PREFABRICATION (ANALYSIS 2)

OPPORTUNITY IDENTIFICATION

With the schedule being so important to the owner any opportunity to improve it is worth analyzing. Early in the project, the work is focused on the foundations and steel erections since they are keys to along the critical path. These two activities take up much of the early schedule, which allows the perfect opportunity for the possibility of prefabricating future parts to the project. Prefabrication would be done at an offsite facility and trucked in ready for installation allowing for the potential to have much less on site work. The prefabrication work could be done while the foundation and steel erection work is occurring allowing for the possibility of accelerating the schedule substantially for the activities following the steel erection.

BACKGROUND RESEARCH

Looking into the design of the building, modularization of areas doesn't appear to be the best choice for prefabrication since there aren't many repeated spaces. The physical screen theaters are too large to modularize even if they were repeating. The primary material that is repeatedly used on the project is the curtain wall façade around the movie theater. This curtain wall is a combination of exterior glazing, metal panels, and EIFS. This façade is located on all four sides of the cinema and accounts for the majority of the curtain wall on the project. The façade adds the aesthetic appearance that the owner desires but takes approximately 120 days to install using a stick-built installation method.

POTENTIAL SOLUTIONS

A potential solution to using prefabrication to accelerate the schedule is to unitize the curtain wall. Prefabricating the curtain wall in easily installable units can be a great way to keep the appearance the owner desires while also accelerating the schedule. The analysis will focus on the potential schedule reduction that could come from prefabricating the curtain wall. Prefabrication can significantly reduce the on-site labor and the materials used since the units would be made in an off-site factory. Testing and quality control are also far easier to perform and ensure when the units are assembled in the controlled environment. Far fewer materials would need to be stored on site if the project prefabricates the curtain wall. With the use of prefabricated curtain wall units, different steel connections would need to be redesigned to accommodate easy installation of the units. The cranes from **Analysis 1** can be used for the installation of these prefabricated units. Analyzing the schedule, cost, and constructability of this solution will be the keys to determining if this prefabrication is a valid substitution to the stick-built curtain wall.

ANALYSIS PROCEDURE

- Constructability Analysis
  - Determine whether the curtain wall is easily unitized

- Define if there is a close location to perform the prefabrication
- Evaluate delivery of these prefabricated panels
- Evaluate the man-power requirements
- Assess the qualifications of the installation subcontractor
- Develop an installation procedure
- Analyze site requirements for prefabricated panel installations
- Analyze worker production rates

- Structural Analysis
  - Evaluate Current structure
  - Develop required structure for prefabricated curtain wall units
  - Define new structural changes
- Schedule Analysis
  - Determine Factory time to prefabricate the curtain wall units
  - Define the installation time
  - Determine the time difference for designing the prefabricated panels
- Cost Analysis
  - Define cost of stick-built materials and installation
  - Determine cost of prefabricating and installing the unitized curtain wall panels
  - Determine cost savings from the potentially accelerated schedule
  - Determine the costs of altering the structural system to accommodate the prefabricated panels

RESOURCES

- Industry Professionals
- AE Faculty Members
- Project Documents
- Cinema-Dining Terrace Expansion Project Team
- The Whiting-Turner Contracting Company resources
- RS Means
- Project subcontractors
- AE Classmates
- Applicable Books, Papers & Websites

EXPECTED OUTCOME

Prefabricating the curtain wall is expected to accelerate the schedule but decreasing installation time substantially. It is also probable that the up-front costs for materials and factory prefabrication will increase but the costs of the accelerated schedule and reduced man-power for installation should assist in countering those costs. It is projected that the structure will require minor changes such as easy attachment locations for the panels.

EXTERIOR ENVELOPE INFORMATION

After discussions with the project team about the exterior envelope, it was concluded that it was a large impact on the schedule and that its current installation method could be altered to improve the schedule. The building's exterior envelope consists of 3 basic finishes, which are EIFS, Metal Panels, and Glazing. The EIFS covers about 80% of the building while the metal panels cover about 15%. Both of these materials have a backing that consists of framing, sheathing, air barrier, and insulation.

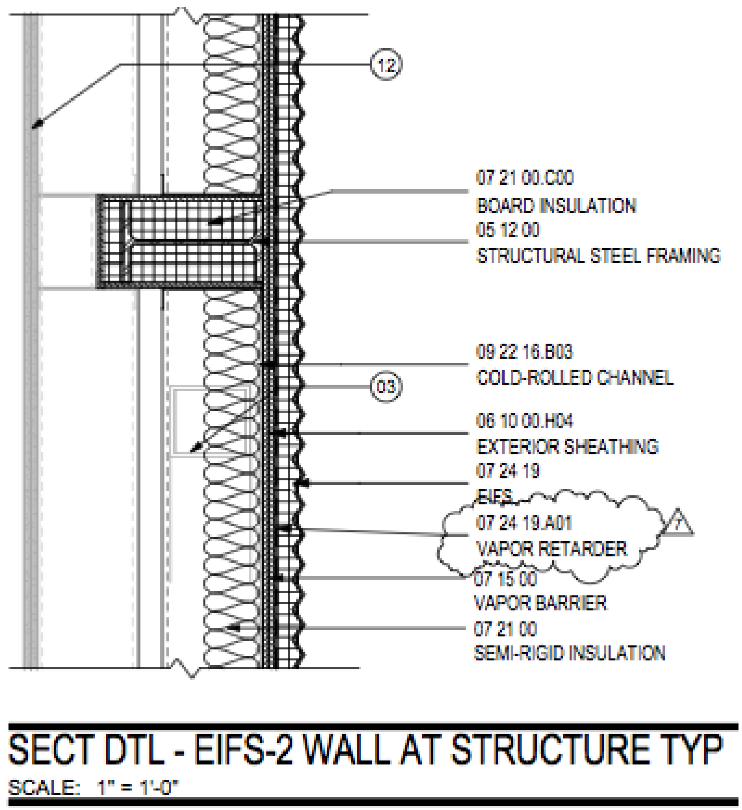


Figure 3.1 – EIFS Enclosure Detail

To the right in **Figure 3.1** is a detail of the current exterior envelope. It displays all the materials that are used in about 95% of the building besides the occasional finish change.

With the size of this project, and the fact that this stick built installation is done by hand, it is understandable why this activity has such a large impact on the schedule. This method is used to install all 4 sides of the theater and portions of the food court, which totals to be about 70,000 SF of materials.

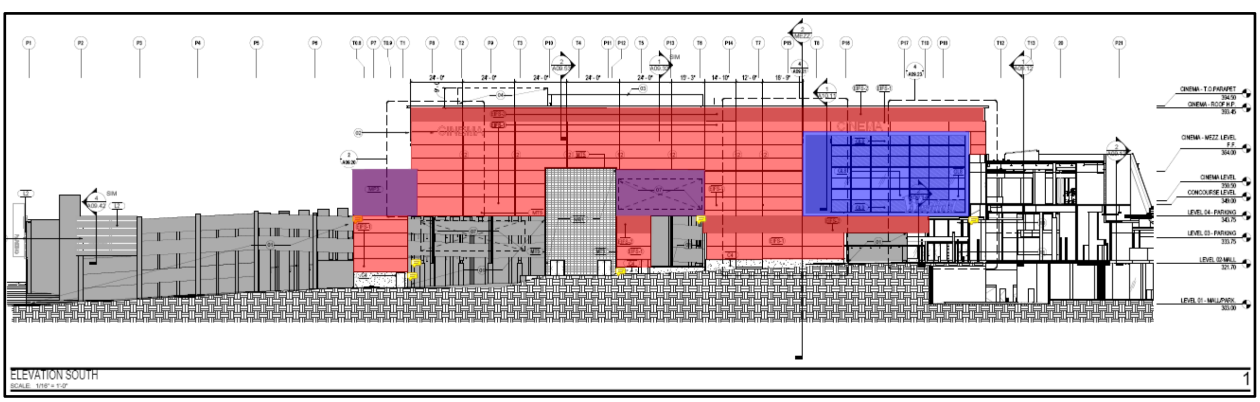


Figure 3.2 – South Theater Elevation

In **Figure 3.2**, the red highlighted area is the EIFS, the purple area is the Metal Paneling, and the blue area is the primary Glazing on the entire theater. The full set of elevations can be found in **Appendix 3A**. These elevations give a perspective that displays the location and appearance of the exterior. It also shows how the materials are split up and what locations they primarily are placed. The areas with the EIFS finish predominantly use a smooth finished EIFS, but around the top there is a switch to a grooved EIFS. This grooved EIFS is also used in various places on the exterior such as on the West Elevation.

(See **Appendix 3A** for the full set of elevations)

Original Exterior Envelope Installation

The original exterior envelope is assembled using a stick built method. The stick built method installs one material at a time over a predetermined area, and then once complete they come in and install the next material. In **Figure 3.3, t**he stick built materials are listed with durations for the North elevation. This Elevation consists of 6500 SF of EIFS and 1500 SF of Metal Paneling.

NORTH ELEVATION		
28250	N: EXT WALL FRAMING THEATER	15
28260	N: EXT WALL SHEATHING THEATER	15
28270	N: AIR BARRIER/INSULATION	5
28280	N: VERTICAL CORROGATED METAL	5
28290	N: EIFS THEATER	20
28300	N: SMOOTH METAL PANELS	3

Figure 3.3 – Original North Elevation Enclosure Schedule

The installation of these materials using the stick built method requires the use of a great deal of scaffolding that can be seen in **Figure 3.4**. The figure is a picture of the stick built installation on the west elevation of the building.

Figure 3.4 – Original Exterior Envelope Installation

New Exterior Envelope Installation

By prefabricating the EIFS and Metal Panels into fully backed panels, the exterior could easily be picked and placed by a crane. This panelized exterior could assist in improving the schedule and decrease the necessary man-power for installation.

EIFS and Metal Panels are two materials that are and can be frequently panelized. The panels would come prefabricated with the finish, framing, sheathing, air barrier, and insulation already on it. The installation process would the only require the crane to pick up the panels off of trucks or from the laydown area and lift it to be placed by 1-2 laborers. The panels are designed to fit the project requirements exactly to eliminate delays, jobsite hassles, and structural concerns.

The advantages of using a prefabricated panel are as follows:

- Accelerates enclosing the building
- Provides few jobsite hassles
- Fabrication is done to exact specifications
- Fabrication is done in a controlled environment
- Panels are delivered ready to install

Dryvit is the combination of insulation and design-flexible aesthetics in a single exterior wall system. KHS&S is the largest Dryvit installer in the United States and they are the only subcontractor to receive an extended warranty from Dryvit on EIFS installed by KHS&S. KHS&S's prefabricated exterior EIFS wall panel system is the system that was examined for this analysis. **Figure 3.5** shows an example of the components of the panel and displays the ease of installation.

Figure 3.5 – KHS&S Prefabricated Wall Installation

SCHEDULE AND SEQUENCE EVALUATION

The original schedule for the Exterior Envelope takes a little over 120 days to build. The enclosure is installed using a stick built method, which involves 6-8 laborers at a time. Based off of numbers received from KHS&S, the installation duration for the prefabricated EIFS panels is estimated to be 1575 SF/day. With there being about 46,356 SF of EIFS paneling, the duration is estimated to be 30 days. The sequencing and adjustments for installation gets the total workdays for installation to be 37 days.

Tower Crane A			
Activities	Duration	Start	Finish
	164	**29-Jan-13**	**20-Sep-13**
Excavations	17	29-Jan-13	20-Feb-13
FRP and Cure Foundations	17	21-Feb-13	15-Mar-13
Erect Crane	5	18-Mar-13	22-Mar-13
Demolition Level 4 Precast	15	25-Mar-13	12-Apr-13
Steel Erection - Theater	31	15-Apr-13	28-May-13
Steel Erection - Dining Terrace	48	29-May-13	5-Aug-13
Exterior Enclosure - West	6	12-Aug-13	19-Aug-13
Exterior Enclosure - South	8	20-Aug-13	29-Aug-13
Exterior Enclosure - East	9	30-Aug-13	12-Sep-13
Deconstruct Crane	5	16-Sep-13	20-Sep-13

Tower Crane B			
Activities	Duration	Start	Finish
	102	**29-Jan-13**	**24-Jun-13**
Excavations	17	29-Jan-13	20-Feb-13
FRP and Cure Foundations	16	21-Feb-13	14-Mar-13
Erect Crane	5	18-Mar-13	22-Mar-13
Demolition Level 4 Precast	15	25-Mar-13	12-Apr-13
Steel Erection - Theater	31	15-Apr-13	28-May-13
Exterior Enclosure - North	6	3-Jun-13	7-Jun-13
Exterior Enclosure - West	8	10-Jun-13	17-Jun-13
Deconstruct Crane	5	18-Jun-13	24-Jun-13

Table 3.1 – Tower Crane A and B Schedules

In **Table 3.1**, the new tower crane sequences are displayed. The activities highlighted in yellow represent the new exterior envelope installations. Tower crane A's exterior enclosure takes a total of 23 workdays to install; while tower crane B's exterior enclosure takes 14 days. Tower crane A begins its installation long after tower crane B due to the dining terrace steel erection.

From start to finish, the exterior enclosure takes 72 days, but when evaluating the total workdays, it only takes 37 days. When comparing this to the original schedule, there is substantial acceleration. The total schedule is improved from 133 days to 72 days, a decrease of 61 days. When comparing workdays, the scheduled is improved from 122 days to 37 days, a decrease of 85 days.

COST EVALUATION

Based off of information received from the project team and KHS&S, the costs were calculated for the original exterior envelope, and for the new prefabricated system. **Table 3.2** shows the breakdown of costs for both systems.

The new exterior envelope costs an estimated $2,857,955.00. The Original exterior envelope costs an estimated $1,879,465.00. The new system cost nearly a million dollars more than the original. The total increase in costs is $978,490 for the change to the prefabricated system.

The installation cost for the prefabricated system comes out to be $333,888.00 compared to the original installation at $573,888.00. This ends up being a savings of $240,000. Combining that with the increased costs from materials, the new cost increase comes out to be $738,490.00.

New Curtain Wall Costs				
Theater Shell				
Activity/Material	Qty	Unit	Cost	Total
Panels	8,654.00	SF	$35.00	$ 302,890.00
EIFS Panels	32,957.00	SF	$45.00	$ 1,483,065.00
				$ 1,785,955.00
Food Court Renovation				
Activity/Material	Qty	Unit	Cost	Total
Framing and Sheathing Panels	13,400.00	SF	$35.00	$ 469,000.00
EIFS Panels	13,400.00	SF	$45.00	$ 603,000.00
				$ 1,072,000.00
				$ 2,857,955.00

Original Curtain Wall Costs				
Theater Shell				
Activity/Material	Qty	Unit	Cost	Total
Exterior Metal Studs & Sheathing	56,686	SF	$18.50	$1,048,691.00
Grooved EIFS	8,600	SF	$12.00	$103,200.00
EIFS	48,086	SF	$9.00	$432,774.00
				$1,584,665.00
Food Court Renovation				
Activity/Material	Qty	Unit	Cost	Total
Framing and Sheathing	13,400	SF	$13.00	$174,200.00
EIFS	13,400	SF	$9.00	$120,600.00
				$294,800.00
				$1,879,465.00

Table 3.2 – New and Original Exterior Enclosure Costs

The increase in costs comes primarily from the cost of prefabricating the panels. The panels come pre-assembled with backing and the finish. This allows them to simply be lifted into place. The up-front costs for prefabrication can be offset by the convenience of installation and schedule improvements.

CONCLUSION AND RECOMMENDATION

Conclusion

This analysis evaluated the advantages and disadvantages of prefabricating the exterior enclosure. The schedule was improved substantially from a 122 workday installation, to only a 37 workdays. The up-front costs of prefabricating the system ended up costing an extra $738,490.00 when accounting for the savings from the schedule improvements.

Recommendation

The final recommendation is to not implement the prefabricated exterior enclosure. Though the schedule is drastically improved, the costs outweigh those improvements. The owners concern with the cost of the project makes this system not optimal.

SECTION 4 – WATER DRAINAGE RECYCLING (ANALYSIS 3)

OPPORTUNITY IDENTIFICATION

This project didn't strive for any LEED certification nor did they strive for any significant sustainability aspects. This creates the opportunity to incorporate some sustainable features without the need for major changes or the costs of LEED certification. Sustainable features primarily affect the lifecycle costs and lifecycle environmental impacts. The opportunity to possibly help the environment and also save money through the lifecycle costs are the major considerations for this analysis.

BACKGROUND RESEARCH

The flat roof design requires dozens of water drains for rain and snow. These drains have a piping system that leads to the general water drainage for the building. Water is essential for sustainability and improving the lifecycle costs.

POTENTIAL SOLUTION

Through the use of a water drainage recycling system, rain and snow water could be recycled and used as toilet water throughout the Cinema-Dining Terrace Expansion. Drains already located on the roof can be used to pipe the rain and snow water into a new piping design that would allow the water to be used for toilet water. This has the potential to save water usage over time decreasing the environmental impact and lifecycle costs. Since the building is public, people won't notice or care about this sort of system so its public affect will be negligible. People won't be hesitant to go to a mall or Movie Theater that recycles water for its toilets or uses a grey water system since they probably won't even realize. The analysis will primarily focus on the new water recycling system, its effect on the schedule, and the cost impacts.

ANALYSIS PROCEDURE

- Constructability Analysis
  - Determine the components of a water recycling system
  - Analyze the current drainage pipe system
  - Determine the current designs water usage
  - Calculate water savings with new system
- Cost Analysis
  - Define the cost of the current drainage system
  - Determine the cost of the new drainage recycling system
  - Evaluate the lifecycle costs of water savings
- Schedule Analysis
  - Define the duration for the current systems installation

- Determine the durations for the new designs and for the new installations for a water recycling system

RESOURCES

- Industry Professionals
- AE Faculty Members
- Project Documents
- Cinema-Dining Terrace Expansion Project Team
- The Whiting-Turner Contracting Company resources
- RS Means
- Project subcontractors
- AE Classmates
- Applicable Books, Papers & Websites

EXPECTED OUTCOME

It is expected that this analysis will show reasonable constructability with relation to the additions of a new drainage recycling system and to the water usage. It is predicted that the initial costs will be minimal when compared to the lifecycle savings from the reduced water usage. This system is anticipated to have very little impact on the schedule.

RAINWATER RECYCLING EVALUATION

Rainwater recycling is an easy way to improve the environmental impact from a building, while also potentially saving money in the long run. This process makes use of the free resource and can help reduce demand on the communities drinking water supply. Collected rainwater can be used for multiple applications, including irrigation, non-potable water, and as a fire cistern.

For this building it will be used for the toilet and urinal fixtures. The rainwater being recycled wouldn't be suitable as potable water unless extensively filtered. This process takes advantage of its geographic location and the a large flat roof that is ideal for collecting rain.

A rainwater recycling system would require a large storage tank including accessories, a filtration system, a pump system, and the necessary piping. Calculating the size of these items will depend on the size of the building, its function, the amount of rainfall that part of the country gets, and the location of the storage tank on the site.

MECHANICAL BREADTH

The mechanical calculations for this rainwater recycling system are based on average rainfall values from Weather.com and the 2012 International Plumbing Code. The calculations will include the pump sizing, how much water is used by the toilets and urinals, and how much water is collected through the roof drains.

After finding how many square-feet the roof area of collection was, that number was then multiplied by the average monthly rainfall in that region to find out how many cubic-feet of water was collected. It was assumed that there would be about a 10% loss of rainwater due to initial abstractions such as surface wetting, evaporation, and transpiration. Based on **Figure 4.1**, the average rainfall for this location is 3.81 inches per month. July averages the most at 4.59, and January averages the least at 3.02. This gives a range of water collection that can be seen in the calculations below.

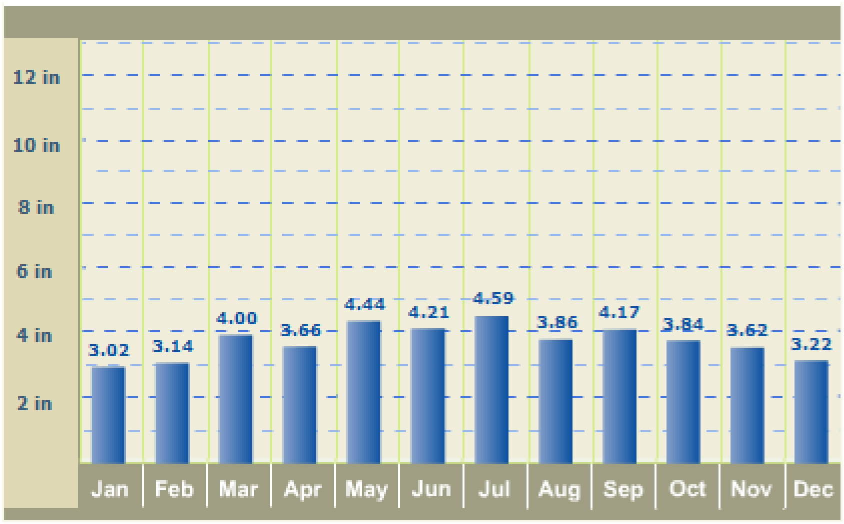


Figure 4.1 – Weather.com Average Monthly Rainfall

Roof: 86,640 SF **Monthly Avg. (in.):** 3.81 in **CF to Gallon Factor:** 7.48 CF/G

$$86{,}64 * \left(\frac{3.81}{12}\right) * (.9) * 7.48 = 185{,}185.2 \; Gallons\ per\ month$$
$$= \mathbf{2{,}222{,}222.4}\ \boldsymbol{Gallons\ per\ year}$$

The roof area being incorporated for rainwater recycling includes the theater and new food court roof. The (.9) multiplier represents the 10% loss of rainwater due to initial abstractions. The Gallons per year represents the estimated amount of water that could be collected in a full year. This number is then compared to the Demand of the building using calculations based on the toilet fixtures water usage.

PLUMBING FIXTURE OR FIXTURE FITTING	MAXIMUM FLOW RATE OR QUANTITY[b]
Lavatory, private	2.2 gpm at 60 psi
Lavatory, public (metering)	0.25 gallon per metering cycle
Lavatory, public (other than metering)	0.5 gpm at 60 psi
Shower head[a]	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Urinal	1.0 gallon per flushing cycle
Water closet	1.6 gallons per flushing cycle

Table 4.1 – 2012 International Plumbing Code Maximum Flow Rates

The recycled rainwater will only be used for the toilets since it isn't potable water. There are 46 toilets and 10 urinals total in the cinema and food court. These calculations are based on a 25 day month of business. The toilets and urinals are based on the data found in **Table 4.1** and the 2012 International Plumbing Code.

Toilets: 120 flushes per day **Urinals:** 75 flushes per day

Toilets: 1.6 gallons per flush **Urinals:** 1.0 gallon per flush

$$(46 * 120 * 1.6) + (10 * 75 * 1.0) = 9{,}582\ Gallons\ per\ day = 239{,}550\ Gallons\ per\ month = \mathbf{2{,}874{,}600\ Gallons\ per\ year}$$

The rainwater recycling system saves approximately **77%** of the water demanded for by the buildings toilets and urinals.

Once the water quantities have been calculated, the pump must be sized. Using a 20,000 gallon storage tank, the Total Dynamic Head was calculated using an online calculator. The calculations can be seen in **Figure 4.2** below.

Pump Flow Rate	Pipe Diameter(ID)	Pipe Length	Differential Elevation	Pipe Material	Total Dynamic Head(TDH)
US GPM	in.	ft.	ft.	New Steel	ft.
200	4	600	40		64.2785598185C
Compute Total Dynamic Head(TDH) Reset					

Figure 4.2 – pumpworld.com Total Dynamic Head Calculator

The Pump Flow Rate is based on the max of 2 flushes per minute for all the fixtures based on their respective gallons per flush. The Pipe Diameter and Pipe Length were taken from the project drawings.

Using the calculated Head, a Taco Pump Selection App was used to size and choose a pump. The pump fitting the calculated criteria can be seen in **Figure 4.3** below.

Pump Details

SKV/SKS3006-3600-5.00

Specifications

Flow: 200
Head: 64
RPM: 3600
Imp Dia.: 5.25
Size: 3 x 3
Design Hz 53.55

Eff 68%
NOL HP 5.00
NPSH 15 ft
Control Head 25.6
Control Head Hz 30.31

Figure 4.3 – www.taco-hvac.com Hydronic Pump

This pump is a SelfSensing Variable Speed pump to allow for the precise amount of flow and pressure required for the building at each part of the day.

(See **Appendix 4A** for pump sizing curve)

RAIN-WATER RECYCLING SYSTEM

System Details

The system will include a 20,000 gallon storage tank and a selfsensing variable speed pump. The rainwater will be collected off of the Theater roof and piped down using the original roof drains but altering the piping to lead to the storage tank.

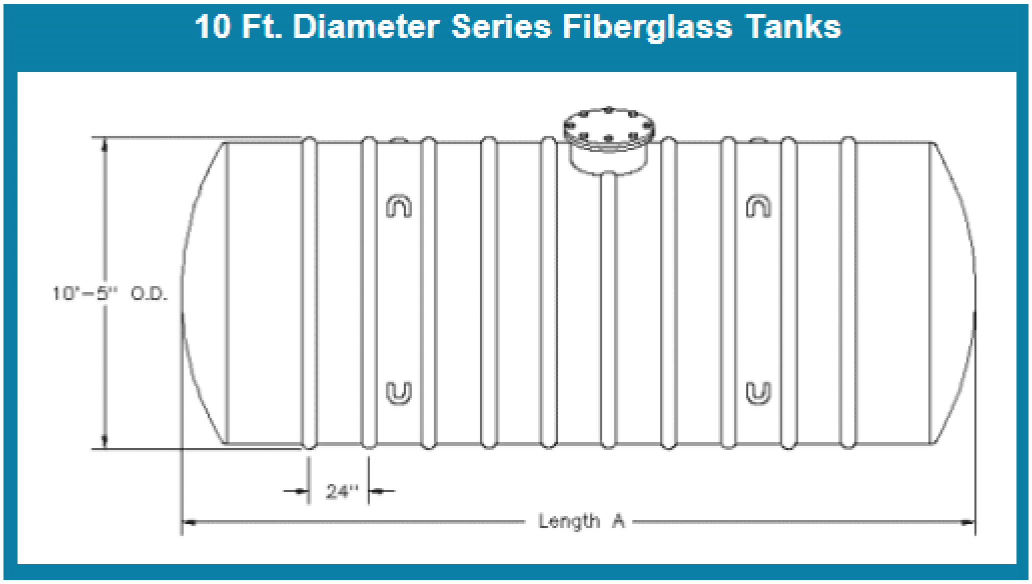


Figure 4.4 – Darco Inc. Fiberglass Storage Tank

Figure 4.4 shows the size of the 20,000 storage tank that will be used for the system. A detail of the storage tank can be seen in **Appendix 4B.**

This system being used will pipe the rainwater down to the tank where it will be filtered before storage. The storage tank will have an overflow valve for the times when the supply to the tank is far greater than the demand. Once stored, the water will be sucked up to the pump inside the building. This is still connected to the buildings domestic water for when the demand is greater than the storage tanks supply. **Figure 4.5** below shows a simple diagram of a similar but smaller system.

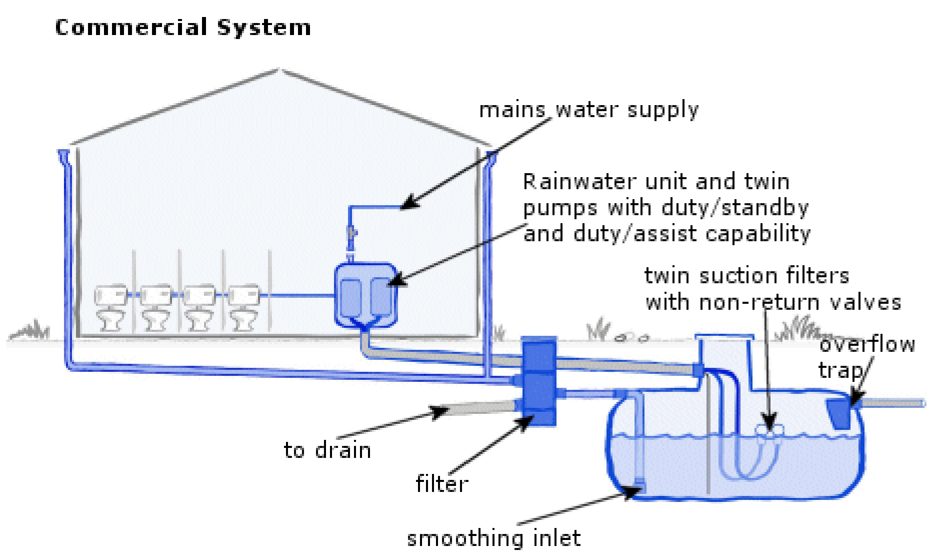


Figure 4.5 – Diagram of a Commercial Rainwater Recycling System
www.gslplumbers.com

Installation Details

Installation is based off of the Darco Inc. Fiberglass Tank Installation Brief that can be found in **Appendix 4C**. The installation process should be followed precisely to ensure the overall quality of the tank and the system.

10 Ft. Diameter Fiberglass Tank Series			
Capacity (1)	*Length (2)*	*Dry Weight (3)*	*Price (4)*
15,000	26' 6"	4,500	See "Risk Free Quick Quote" at top of this page
20,000	35' 0"	5,500	
25,000	43' 7"	7,000	
30,000	52' 1"	8,000	
35,000	60' 7"	10,000	
View Accessories for this product line			

Table 4.2 – Darco Inc. Underground Tank Series Size and Weight

Seen in **Table 4.2**, the dry weight of the storage tank will be 5,500 lbs which can be placed by the tower crane. The storage tank was chosen to be located on the north side of the building; its location can be seen on the new demolition phasing plan in **Appendix 2A**. Since the north side was already going through extensive excavation and it has extra space west of the new tower crane, it only made sense to place the storage tank there.

COST AND SCHEDULE EVALUATION

Cost Evaluation

Based on the Washington Suburban Sanitary Commission, the cost of water per 1000 gallons is $6.76 for a property that consumes 9,000 gallons or more daily.

Underground Tank Project Estimate

You are looking for an underground tank system to store 20,000 gallons of water.

Here is your fiberglass tank estimate.

10' Diameter 20,000 Gallon storage tank	Included
Accessories (Average)	Included
Shipping	Included
Total Estimated Cost	**$31,630.00**
Required Deposit *(Balance COD)*	**$10,437.90**

Lead Time: 7 to 9 weeks

Figure 4.6 – Darco Inc. Underground Tank Estimate

Shown in **Figure 4.6** is an estimate from Darco Inc. for the storage tank, the accessories, and for the shipping. There will also be costs related to the extra piping necessary for this system. Though the original drainage pipes can be reused, new pipe will still be required for pumping the stored water to the fixtures. This is estimated to add another $50,000 to the project.

Evaluating the overall costs of the system shows the following results:

Storage Tank: -$31,630.00

New Plumbing: -$50,000.00

Domestic Water Annual Demand: ($6.76/1000 G)*2,874,600 G = -$19,432.29

Annual Savings: ($6.76/1000 G)*2,222,222.4 G = $15,022.22

Total Annual Costs: $19,432.29 - $15,022.22 = $4,410.07

Original Annual Water Costs							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Costs	$ (19,432.29)	$ (19,432.29)	$ (19,432.29)	$ (19,432.29)	$ (19,432.29)	$ (19,432.29)	$ (19,432.29)
Savings	$ -	$ -	$ -	$ -	$ -	$ -	
New Annual Water Costs							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Costs	$ (86,040.07)	$ (4,410.07)	$ (4,410.07)	$ (4,410.07)	$ (4,410.07)	$ (4,410.07)	$ (4,410.07)
Savings	($66,607.78)	($51,585.56)	($36,563.34)	($21,541.12)	($6,518.90)	$8,503.32	$15,022.22

Table 4.3 – Original and New Water Costs

Seen in **Table 4.3** from the red and green colors, the first 5 years the owner is still paying off the initial costs of the recycling system, but the payback period takes a total of 7 years. The red numbers represent how much is still owed each year to pay for the systems initial cost. After 6 years of using nearly all the savings to pay for the initial system, it is finally paid off and the savings from the system can be seen. In the seventh year and from then on, the rainwater recycling system will be saving the owner approximately $15,000 a year on water bills. For each of the first 5 year, all of the savings will go toward paying for the initial costs of the system.

Schedule Evaluation

Also shown in **Figure 4.6** is the lead time of 7 to 9 weeks. Since the storage tank won't be an item on the critical path, its installation has some float to it. The key will be to order it 7 to 9 weeks before the chosen installation date. This would ideally be while the tower crane is still located on the north side to assist with placement. The excavation and installation will add an estimated 2 days to the total process

The piping already to be installed for the roof drains will be redesigned to accommodate the flow to the storage tank, and then new piping will be installed to pipe the water from the tank to the toilet fixtures. All the piping will be installed when the other plumbing pipes are being installed, besides the new pipe from the storage tank to the building. The new pipe is estimated to take 5 days to install so it could impact the schedule slightly.

Overall, the schedule is minimally affected by an estimated 3 days for the installation of the rainwater recycling system.

CONCLUSION AND RECOMMENDATION

Conclusion

Performing this analysis showed the effects a rainwater recycling system can have on a project. Pertaining to the Cinema-Dining Terrace Expansion, the system costs approximately $80,000 to implement, but once it is implemented, it has a consistent savings of about $15,000 per year. This creates an overall payback period of 7 years. The schedule is only affected by a few days so its impact can be considered negligible.

Recommendation

The final recommendation is to implement this rainwater recycling system. Water is precious resource and this system will pay for its self within 7 years. Without drastically affecting the schedule, the system saves about $15,000 per year in water bills.

SECTION 5 – BIM UTILIZATION (ANALYSIS 4)

PROBLEM IDENTIFICATION

Though the schedule is the primary concern for the owner, the project's cost is still a top priority. The owner's concern about the cost has the potential to create hazards when attempting to add aspects that could improve the project. This cost awareness could create resistance to pay what seemed to be unnecessary up-front costs if the owner cannot see the benefits. Beneficial modifications such as change orders could also be over-looked by the owner if they do not see the potential for them.

BACKGROUND RESEARCH

The three analyses stated previously all have up-front costs that are potentially more than the original plan but the lifecycle costs are where the possible savings can be seen. For the site logistics modifications, the use of two tower cranes is potentially be more expensive than the originally planned cranes but the savings from the schedule accelerations may cover the added costs. In Analysis 2, prefabricating the curtain wall will possibly cost more than the original stick-built plan but the probable savings in the accelerated schedule could allow the project to open earlier creating the ability to pay back the initial costs sooner. Analysis 3 implements a rain-water recycling system that could add extra design, mechanical equipment, and installation costs but the environmental impact and the savings on water usage can be benefits that outweigh the initial costs over the building lifecycle.

This project includes the addition of a movie theater and dining terrace connecting to an existing food court renovation, meaning that coordination between trades is a potential problem. Coordinating the site activities around the still open mall can be a large task to keep the project on schedule while ensuring the safety of all parties. Demolition and steel erection are two activities that pose some of the largest risks for coordination and safety. Connecting new MEP systems to the existing systems can add complications that require an excess of RFI's and change orders, as well. These coordination complications, particularly the site coordination, could cause potential delays in the schedule and potential hazards for all parties involved.

POTENTIAL SOLUTION

A possible solution to displaying potential project savings and to coordination complications could be the use of Building Information Modeling (BIM). It can be used for the site logistics modifications to display the changes to the owner, while also presenting the sequencing and benefits and negatives of the new site logistics. A 4D model could be used to show the new site logistics and how the new demolition and steel erection phases will be sequenced. 4D modeling could also be used to display to the owner and the project team the delivery and installation of the prefabricated curtain wall units as seen in **Analysis 2**. The implementation of a 4D model is useful to help demonstrate the procedure to the owner but also even more important to accurately display it to the team and subcontractors. A 4D model could assist in improving the safety and quality of nearly all the phases of the project. The BIM utilizations for **Analyses 1, 2, &3** and the safety implications will be the focus.

BIM also has the potential to be used for Facility Management but this analysis will not cover that.

ANALYSIS PROCEDURE

- Evaluate a 4D model
    - Determine Analysis 1 and 2 utilizations
    - Analyze safety impacts
    - Examine coordination influences
- Evaluate a 3D model
    - Determine the uses of a 3D model for coordination and Analysis 3
    - Investigate the safety impacts of BIM

RESOURCES

- Industry Professionals
- AE Faculty Members
- Project Documents
- Cinema-Dining Terrace Expansion Project Team
- The Whiting-Turner Contracting Company resources
- Project subcontractors
- AE Classmates
- Applicable Books, Papers & Websites
- PACE Roundtable Breakout Session
- AE 473 course materials

EXPECTED OUTCOME

The use of a 4D model for **Analyses 1 and 2** is expected to be useful in displaying the procedure and benefits. A 3D model used for MEP coordination and the rainwater recycling system is predicted to help substantially preventing change orders and displaying the new rain-water recycling system. The use of BIM is projected to be very influential on the job site safety, improving it for all parties including the workers and pedestrians. Overall, it is expected that the use of BIM will assist displaying the advantages of **Analyses 1, 2, and 3** while also improving the job sites safety.

CRITICAL INDUSTRY ISSUE ANALYSIS

At the PACE Roundtable, many topics that are critical to today's construction industry were discussed. Safety in construction through design was one of the key discussion topics for one of the breakout sessions. Designing for safety is one of the best ways to ensure accidents are being prevented. Not every safety aspect can be designed for ahead of time, but if done right, many unsafe scenarios can be prevented or properly dealt with in the field. The use of BIM to display these safety designs was a main subtopic throughout the breakout sessions. BIM can not only design for actual safety equipment and precautions, but also properly designing for easy installations can be an effective way to keep the workers safe. The use of BIM to display the site logistics, deliveries, and installations can also be extremely beneficial to the workers by accurately defining the procedures for everyone to see. By simply getting everyone on the same page, activities can run much smoother and accidents can be avoided.

Investigating into how safety can be included into and displayed from the BIM that is or could be used for **Analyses 1, 2, and 3** is a focus of this research. The goal of this research is to investigate how BIM can be used to design for safety in terms of site logistics and installations for the benefit of the workers, the project team, and the owner.

BIM UTILIZATIONS

Building Information Modeling (BIM) can be utilized for many different aspects of a project. Construction Phasing and 3D Coordination are two of the biggest utilizations of BIM. Typical BIM programs used could be a program such as Autodesk Revit that can be used for 3D modeling, or a program such as Navisworks that can be used for clash detection and 4D modeling.

When implementing BIM on a project, the project team and workers will need to be able to implement the programs to take advantage of BIM’s capabilities. Training sessions can be used on site for the project team and workers, which allows them the opportunity to benefit fully from BIM programs and models. This does not mean that the workers will need to know how to build and model in Revit, it means that they will simply need to be able to navigate through a model to find what they need. These programs can be extremely beneficial when used properly.

BIM was not utilized on the Cinema-Dining Terrace Expansion but that does not mean that it could not have been beneficial. The benefits can also be seen when applied to **Analyses 1, 2, and 3**. Each of these analyses would benefit from BIM in multiple ways. Two of the main benefits would be displaying the proposed changes to the owner in a way that the owner can clearly see the advantages, and also the improvements in coordination and safety throughout the site.

Phasing

For the Cinema-Dining Terrace Expansion, the three main phases were the demolition, steel erection, and exterior enclosure installation. Each of these phases was critical for the project’s success. These phases revolve around activities that involve large equipment and materials. One way these analyses can display the new phases is through the use of BIM. A 4D model is a great way to display how new phases will work. **Analyses 1 and 2** implement alternate equipment and installation techniques in order to improve the phasing of the project. This alternate of equipment and sequencing can be displayed accurately and to scale with the use of BIM.

BIM is a great tool for supporting analyses especially when attempting to convince and owner of the advantages. Using a 4D model to show the sequencing and schedule improvements for the site logistics modifications could have been an effective way to persuade the owner.

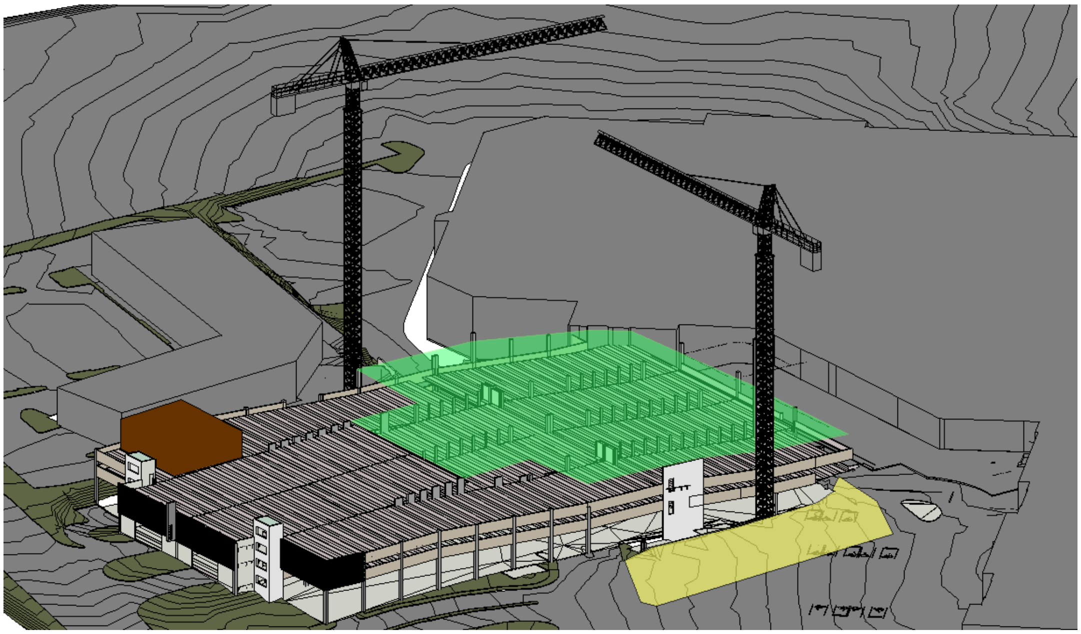


Figure 5.1 – Demolition Phase

In a 4D model, the new equipment examined in **Analysis 1** can clearly be displayed in its exact uses for that particular phase. **Figure 5.1** shows the demolition phase where the green area represents the demolished 4th floor precast concrete and the yellow area represents the laydown pick-up area. This figure displays how BIM can be used to show basic aspects of a phase while still explaining how the phase will flow.

BIM is also a great tool for identifying schedule, sequencing, or phasing issues. Seeing a visual of what the phases will include and where can be extremely beneficial. This can not only help prevent construction issues, such as delays, but it can also help prevent accidents.

The site logistics modifications revolve around the use of two tower cranes as opposed to the original crane set up that uses multiple hydro cranes and one tower crane. These two tower cranes will be used for the demolition, steel erection, and prefabricated curtain wall installation. When looking at each of these phases, they each require a specific site layout with precise areas and locations. Areas that could be displayed on a phasing model would be the laydown areas, equipment areas, traffic flow areas, and installation locations.

In **Figure 5.2 below,** the prefabricated exterior enclosure is clearly displayed by colors around the exterior. The brown area shows the location of the construction trailers and the yellow region displays the location of the delivery and laydown area for tower crane A. Each of the other colors represents a different portion of the phase that will be installing the prefabricated exterior enclosure. This type of BIM image gives a clear picture of the phases for the prefabrication installation.

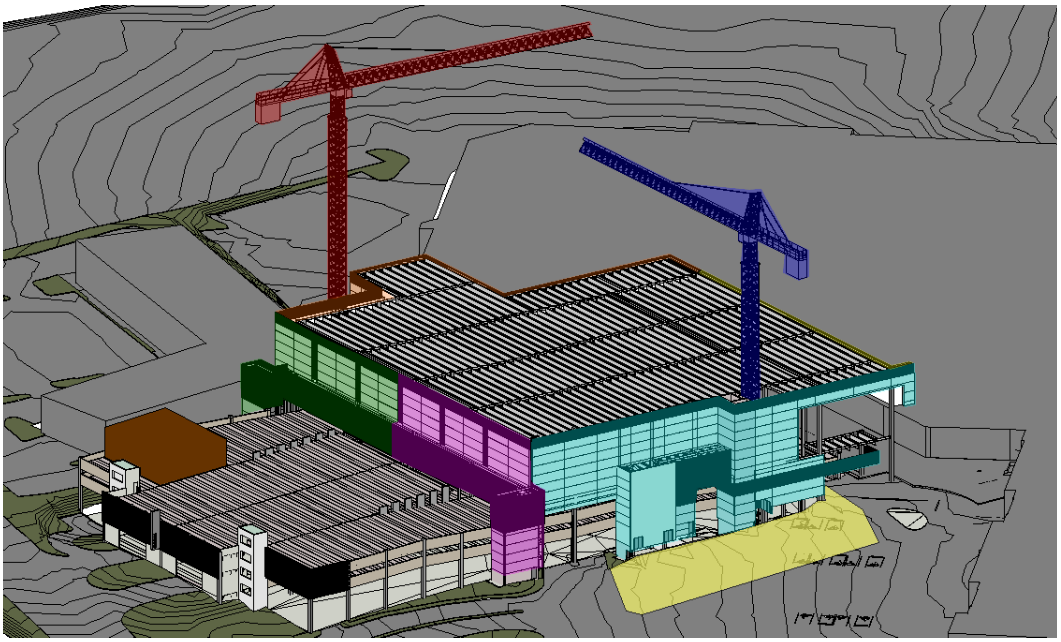


Figure 5.2 – Prefabricated Exterior Enclosure Installation Phase

Using BIM for phasing is also important when dealing with renovation and expansion work since it is likely that the project must work around still occupied areas. The Cinema-Dining Terrace works around a mall that is still in full operation throughout construction. This can create complications when dealing with site access, deliveries, mall access, and pedestrian traffic flow. The use of a BIM model could allow the team to accurately see exactly how the site is laid out for each phase. This understanding of the layout assists in improving the safety for all parties involved, including the workers, the project team, and the pedestrians.

A BIM model can help create maps for each phase that can be placed around the site on the interior and exterior to allow for the workers and pedestrians to see the traffic flow. These maps can help keep pedestrians stay out of danger zones during all phases but specifically during a demolition or steel erection phase. These types of phases require movement of large pieces of equipment and materials so the safety hazards are heightened.

(See **Appendix 5A** for Revit Model Phasing)

3D model Coordination

In **Analysis 3**, a rainwater recycling system is examined and implemented. This system would add to the already extensive MEP coordination required for this project due to the renovation work in the food court. A 3D model could assist coordinate all the MEP since the locations will be easily visualized. Piping and ductwork will be much easier to install if the exact locations are determined beforehand using a 3D model. This can be especially useful in above ceiling spaces and in mechanical shafts. The rainwater recycling piping will be pumping water to the bathroom fixtures so coordinating all the new piping with the existing food court piping will be essential. Clash detection software is a useful tool in this type of coordination.

When used properly, 3D coordination can help increase productivity, decrease change orders and RFI's, decrease construction time, and can help create more accurate as built drawings. 3D coordination creates a convenient environment for multiple trades to work together. The advantages that a 3D model creates in coordination are why it can be extremely useful for renovation and expansion projects.

CONCLUSION AND RECOMMENDATION

Conclusion

In conclusion, the utilization of BIM for this project has the potential to assist with phasing and coordination. Employing BIM can be very useful on renovation projects due to the complications of coordinating with on active building. It could be used for MEP coordination, Phasing plans, and support for displaying the analyses to the owner.

Recommendation

The final recommendation is to implement small scale BIM such as a basic 4D model and a 3D model for connection between the new building and the existing mall.

REPORT CONCLUSIONS

The evaluation of four analyses was implemented with the goal of accelerating the schedule and decreasing costs through logistics modifications, prefabrication, resource recycling, and Building Information Modeling for the Cinema-Dining Terrace Expansion.

The first analysis evaluated altering the site logistics for the projects primary phases. The modifications implemented the use of two tower cranes to accelerate the demolition and steel erection phases. Through these modifications, the schedule was reduced by 41 workdays and the costs were reduced by $1,533,398.00 when including the prefabricated exterior enclosure.

The second analysis focused on prefabricating the exterior enclosure. Prefabricating the exterior allowed for quicker installation which helped reduce the schedule from 122 workdays to 37 workdays. The offsite prefabrication ensures quality with the controlled fabrication environment but creates increased project costs that totaled in $738,490.00.

The third analysis investigated the implementation of a rainwater recycling system. With the large roof space and the already designed drainage, the addition of a rainwater recycling system saved approximately $15,000/year on water bills. The system has a 7 year payback period and recycles over 2 million gallons of water a year and its installation has minimal effect on the schedule.

The final analysis evaluates the possible utilization of BIM on this project. The application of BIM for this project has the potential to assist with phasing and coordination. Employing BIM can be very useful on renovation projects due to the complications of coordinating with on active building. It could be used for MEP coordination, Phasing plans, and support for displaying the analyses to the owner.

Implementing the new tower crane site logistics, the curtain wall prefabrication, and the rainwater recycling system all have serious benefits that should be considered. The new tower crane logistics is advantageous for both improving the schedule and cost. Prefabricating the exterior enclosure assists in the schedule improvements but ends up costing more than is saved in the end. The rainwater recycling system has minimal impact on the schedule , it saves substantial amounts of money on the water bill, and it has a payback period of only 7 years. Of these first three analyses, analysis 1 and 2 would be highly beneficial, while analysis 3's cost might outweigh the benefits. This project and all three of these analyses could benefit from the implementation of BIM whether it be for persuading the owner, site phasing, or for 3D coordination.

RESOURCES

General

Reed Construction Data. *RSMeansOnline.* http://rsmeansonline.com/SearchData.

Analysis 1

"Linden Comansa 2100 Series." http://www.lindencomansaamerica.com/ourcranes/2100-series/

Microsoft Excel (2010)

Bluebeam Revu iPad (2013)

AutoCAD (2014)

Primavera P6 Professional R8.3 (2013)

Analysis 2

"Exterior Wall Panel Construction." ..\Analyses\Analysis 2\KHSS_Exterior_Wall_Panels_web.pdf

"Prefabricated Construction." ..\Analyses\Analysis 2\KHSS_Prefabrication_Web.pdf

Microsoft Excel (2010)

Bluebeam Revu iPad (2013)

Analysis 3

"International Plumbing Code." http://publicecodes.cyberregs.com/icod/ipc/index.htm

"Pump Power Calculator." http://www.engineeringtoolbox.com/pumps-power-d_505.html

"Taco Pump Selection App." https://www.taco-hvac.com/en/wizard_pumps.html#

"Total Dynamic Head Calculator." http://www.pumpworld.com/total-dynamic-head-calculator.htm

Microsoft Excel (2010)

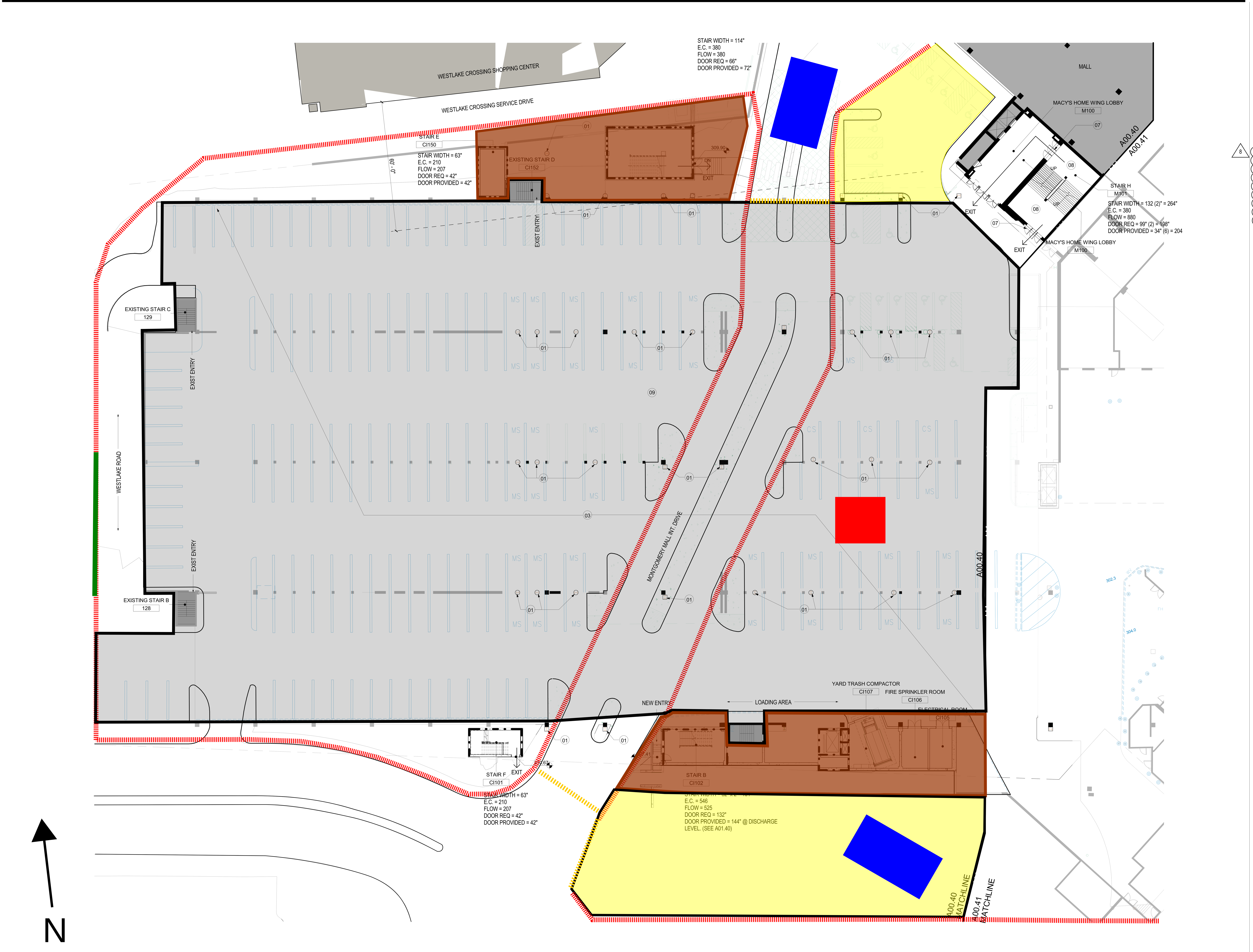
Analysis 4

"Phase Planning." http://bim.psu.edu/Uses/Phase_Planning.aspx

"Site Utilization Planning." http://bim.psu.edu/Uses/Site_Utilization_Planning.aspx

Autodesk Revit (2014)

APPENDIX 1A – EXISTING PHASING PLANS



EGRESS - FIRE PARTITIONS PLAN - LEVEL 01 - CINEMA
SCALE: 1/16" = 1'-0"

1

Key

- Parking Garage
- Site Fence
- Site Gate
- Parking Entrance Gate
- Site Excavation
- Site Laydown and Delivery Area
- Hydraulic Crane
- Tower Crane

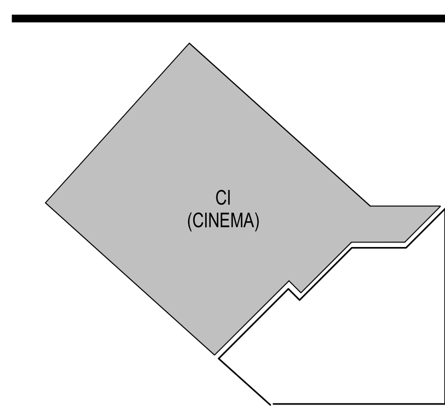
FIRE SAFETY LEGEND

- FIRE SEPARATION SETBACK LINE
- 1 HR FIRE RATED WALL
- 2 HR FIRE RATED WALL
- LEASE LINE

GENERAL NOTES

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN



△	DATE	DESCRIPTION
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING

Seal/Signature

Professional Certification.
I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

Project Number
09.7179.000

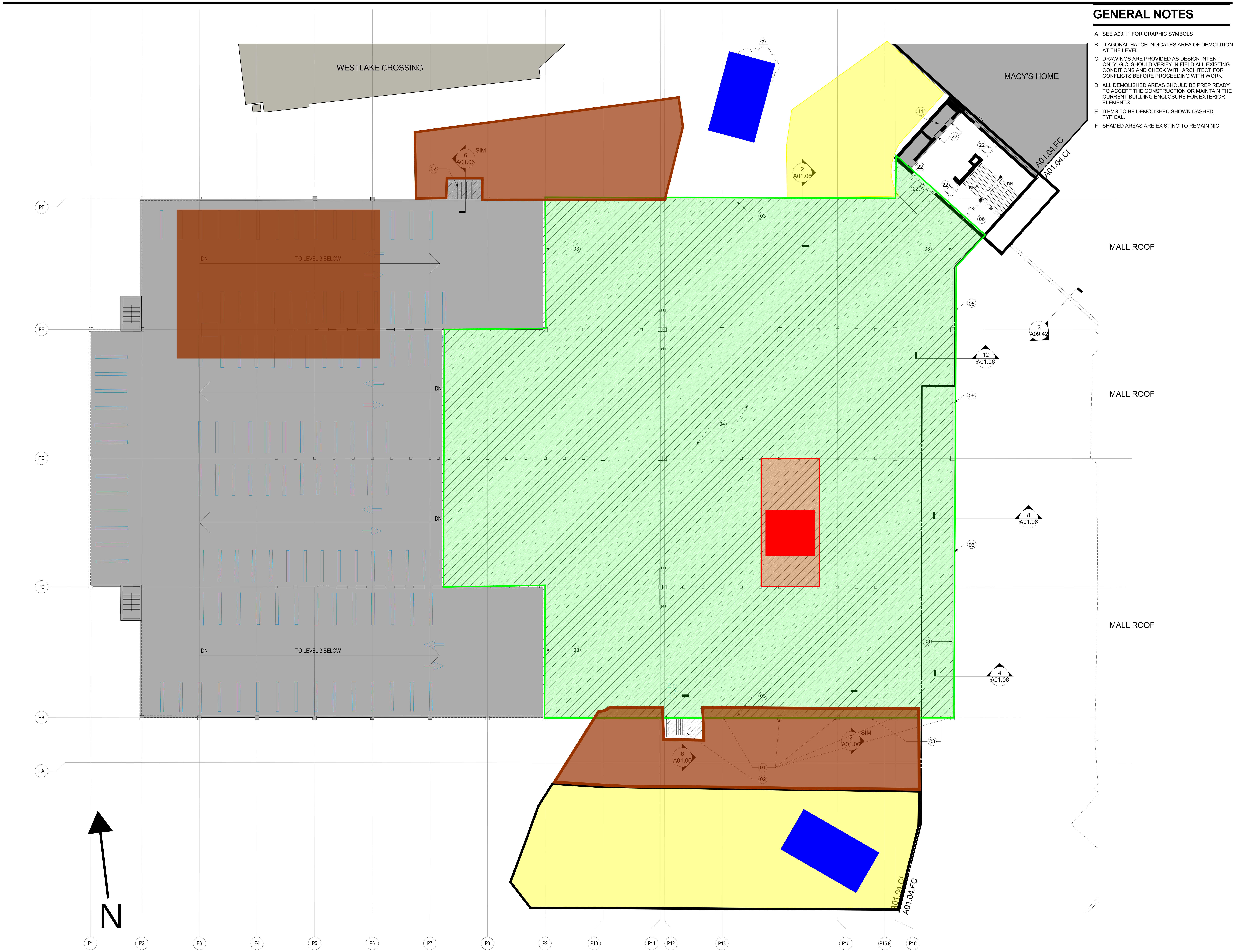
Description
EGRESS PLAN LEVEL 01 CI / FIRE RESISTANT PLAN

Scale
As indicated

Ref. North

A00.40

C-006



DEMOLITION PLAN - CONCOURSE LEVEL - CINEMA

SCALE: 1/16" = 1'-0"

1

GENERAL NOTES

A SEE A00.11 FOR GRAPHIC SYMBOLS
B DIAGONAL HATCH INDICATES AREA OF DEMOLITION AT THE LEVEL
C DRAWINGS ARE PROVIDED AS DESIGN INTENT ONLY, G.C. SHOULD VERIFY IN FIELD ALL EXISTING CONDITIONS AND CHECK WITH ARCHITECT FOR CONFLICTS BEFORE PROCEEDING WITH WORK
D ALL DEMOLISHED AREAS SHOULD BE PREP READY TO ACCEPT THE CONSTRUCTION OR MAINTAIN THE CURRENT BUILDING ENCLOSURE FOR EXTERIOR ELEMENTS
E ITEMS TO BE DEMOLISHED SHOWN DASHED, TYPICAL.
F SHADED AREAS ARE EXISTING TO REMAIN NIC

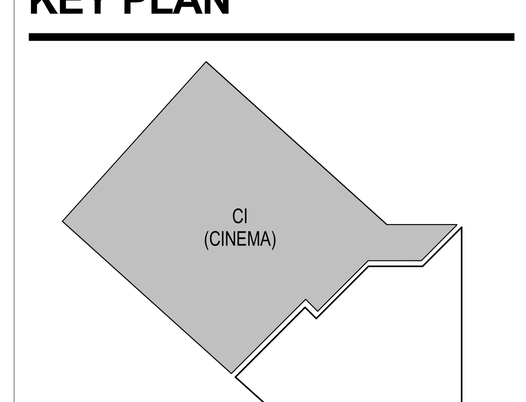
Key

Double T Demolition
Site Laydown and Delivery Area
Hydraulic Crane
Tower Crane
Site Excavation
2nd & 3rd level Double T Removal

33 EXPOSED PILE CAP IN DRIVE LANE. REFER TO STRUCT. DWGS FOR PILE CAP DIMENSIONS.
34 DEMOLISH PORTION OF EXISTING FOOTING FOR INCORPORATION INTO PILE CAP. SEE STRUCT. DWGS.
35 EXIST. FOOTING TO BE REMOVED. SEE STRUCT. DWGS.
36 REMOVE EXIST. BOULDERS/STONES. PREPARE GRADE FOR NEW CONST.
37 DEMOLISH RAILING.
38 DEMOLISH FINISHES IN THIS AREA AND PREP FOR NEW CONST. COORD EXTEN OF TENANT DEMO AT NICHES WITH OWNER/TENANT.
40 REMOVE EXISTING RAMP STRUCTURE AND RELATED COMPONENTS.
41 REMOVE ACCESS TO ELEVATOR AT THIS LEVEL. CONTRACTOR TO MODIFY ELEVATOR SYSTEM
42 RELOCATE FIRE SPRINKLER LINE ABOVE THIS AREA TO ALLOW FOR NEW ELEVATOR INSTALLATION.
43 DEMOLISH KNEE WALL TO BE LEVEL WITH EXISTING RAMP.
44 REMOVE EXISTING PARKING ISLANDS AND PREPARE AREA FOR RECONFIGURATION
45 EXISTING TRANSFORMER WORK AROUND IT TO BE COORD W/PEPCO
46 PARTIAL REMOVAL OF WALL TO ACCEPT NEW COLUMN
47 DEMOLISH FORMER TENANT FIT OUT @ THIS AREA INCLUDING ABANDONED PANELS ETC. RE: MEP DRAWINGS FOR FUNCTIONAL PANEL RELOCATION
48 REMOVE EXISTING "T"S
49 EXISTING SLAB TO BE DEMOLISHED TO ALLOW ACCESS TO FOOTING. REFER TO STRUCTURAL DWGS.
50 DEMOLISH FLOOR SLAB. REFER TO STRUCTURAL DWGS.

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN



△	DATE	DESCRIPTION
1	09.17.2012	Issue for SD / Pricing
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING
7	03/26/2013	ADDENDUM 4 C006C

Seal/Signature

Professional Certification.
I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

Project Number
09.7179.000

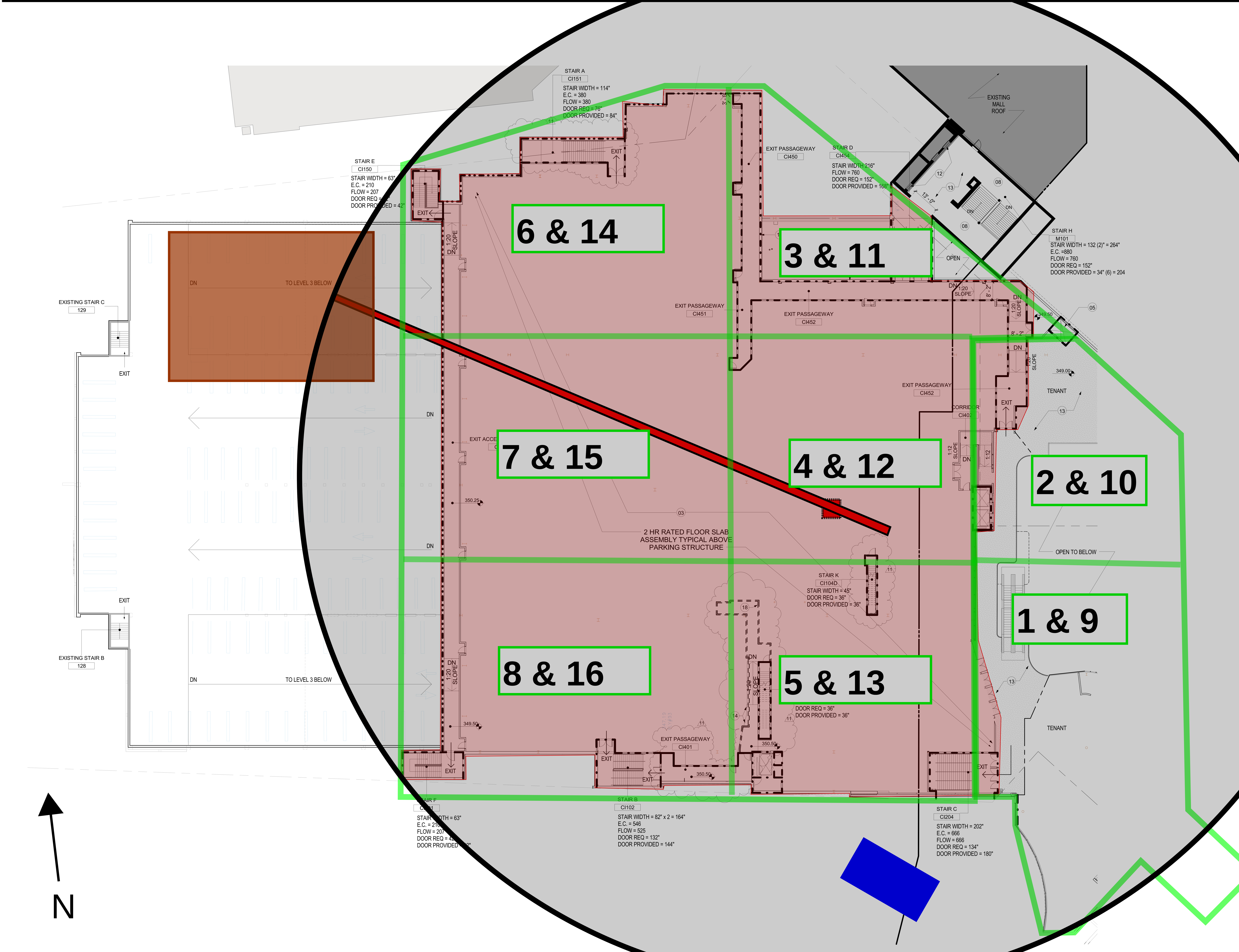
Description
DEMOLITION PLAN - CONCOURSE LEVEL - CINEMA

Scale
As indicated

Ref. North

A01.04.CI

C-006C



Key

- Theater
- Tower Crane Radius
- Site Trailers
- Hydraulic Crane
- Tower Crane

FIRE SAFETY LEGEND

- FIRE SEPARATION SETBACK LINE
- 1 HR FIRE RATED WALL
- 2 HR FIRE RATED WALL
- LEASE LINE

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN

△	DATE	DESCRIPTION
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING
7	03/26/2013	ADDENDUM 4 C006C
9	04/03/2013	ISSUE FOR CODE MOD. COMMENT
10	04/22/2013	ISSUE FOR PERMIT COMMENTS
11	05/02/2013	ISSUE FOR MEZZANINE REVISIONS

Seal/Signature

Professional Certification.
I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

Project Number
09.7179.000

Description
EGRESS PLAN CONCOURSE LEVEL / FIRE RESISTANT PLAN

Scale
As indicated

A00.45

C-013

EGRESS - FIRE PARTITIONS PLAN - CONCOURSE LEVEL - CINEMA
SCALE: 1/16" = 1'-0"

1

APPENDIX 1B – DETAILED TAKEOFFS AND ESTIMATES

Detailed Structural Estimate				
Description	**Quantity**	**Unit**	**Actual Cost/Unit**	**Actual Total Cost**
Structural Concrete				
Column Footings	360	CY	$ 500.00	$ 180,000.00
Pressure Grouted Piles	8100	LF	$ 110.00	$ 891,000.00
Pile Caps	260	CY	$ 500.00	$ 130,000.00
Continuous Footings	260	CY	$ 500.00	$ 130,000.00
12" Shearwalls	140	CY	$ 625.00	$ 87,500.00
Elevator Shaft Walls	170	CY	$ 625.00	$ 106,250.00
Retaining Walls	90	CY	$ 500.00	$ 45,000.00
Slab On Deck	114300	SF	$ 7.00	$ 800,100.00
Wall Strip Footings	35	CY	$ 500.00	$ 17,500.00
				$ 2,387,350.00
Structural Steel				
Columns	62	EA	$ 40,000.00	$ 2,480,000.00
Beams/Framing Theater Level 1	85800	SF	$ 15.00	$ 1,287,000.00
Beams/Framing Theater Mezzanine	31800	SF	$ 15.00	$ 477,000.00
Beams/Framing Theater Roof	64900	SF	$ 13.00	$ 843,700.00
Beams/Framing Food Court Level 4	9500	SF	$ 12.00	$ 114,000.00
Beams/Framing Food Court Roof	26300	SF	$ 13.00	$ 341,900.00
				$ 5,543,600.00
				$ 7,930,950.00

Detailed Exterior Enclosure Estimate					
	Description	Quantity	Unit	Actual Cost/Unit	Actual Total Cost
Theater Shell					
Metals					
	Pre-Finished Corrugated Metal Panel	7420	SF	$ 30.00	$ 222,600.00
Roofing					
	Single Ply EPDM	69520	SF	$ 8.00	$ 556,160.00
Glazing & Windows					
	Glass Curtain Wall	2220	SF	$ 125.00	$ 277,500.00
Exterior Wall Finishes					
	Exterior Metal Studs & sheathing	43610	SF	$ 18.50	$ 806,785.00
	EIFS	33970	SF	$ 12.00	$ 407,640.00
					$ 2,270,685.00
Food Court Renovation					
Metals					
	Canopy Metal Panel	3130	SF	$ 50.00	$ 156,500.00
Roofing					
	Single Ply EPDM	17120	SF	$ 8.00	$ 136,960.00
Glazing & Windows					
	Exterior Storefront Glazing	7840	SF	$ 90.00	$ 705,600.00
Finishes					
	Framing & Sheathing	16530	SF	$ 13.00	$ 214,890.00
	EIFS	13400	SF	$ 9.00	$ 120,600.00
					$ 1,334,550.00
Garage Modifications					
Metals					
	Decorative Aluminum Grille	3130	SF	$ 60.00	$ 187,800.00
					$ 187,800.00
					$ 3,793,035.00

Group (Items Only)

WBS	Quantity 1	
Envelope		
Envelope.Aluminum grille	3,133.377	ft²
Envelope.Canopy Metal Panel	3,134.082	ft²
Envelope.Corrugated Metal Panel	9,020.301	ft²
Envelope.EIFS	33,971.784	ft²
Envelope.Exterior Storefront Glazing	8,490.718	ft²
Envelope.Viracon Glazing	1,573.404	ft²
Foundations		
Foundations.Pile Caps		
Foundations.Pile Caps.EPC-1	7.000	ea
Foundations.Pile Caps.EPC-2	4.000	ea
Foundations.Pile Caps.EPC-3	1.000	ea
Foundations.Pile Caps.EPC-4	1.000	ea
Foundations.Pile Caps.EPC-5	1.000	ea
Foundations.Pile Caps.EPC-6	1.000	ea
Foundations.Pile Caps.P-5	1.000	ea
Foundations.Pile Caps.PC-3	2.000	ea
Foundations.Pile Caps.PC-8	1.000	ea
Foundations.Sandwich Footings		
Foundations.Sandwich Footings.FE15	3.000	ea
Foundations.Sandwich Footings.FE35	1.000	ea
Foundations.Sandwich Footings.FE5	8.000	ea
Foundations.Sandwich Footings.FE6	6.000	ea
Roof		
Roof.Food Court		
Roof.Food Court.Single Ply EPDM	17,123.460	ft²
Roof.Theater		
Roof.Theater.Single Ply EPDM	69,522.717	ft²
Steel Beams		
Steel Beams.Theater Level 1 Framing	85,743.983	ft²
Steel Beams.Theater Mezzanine	31,789.834	ft²

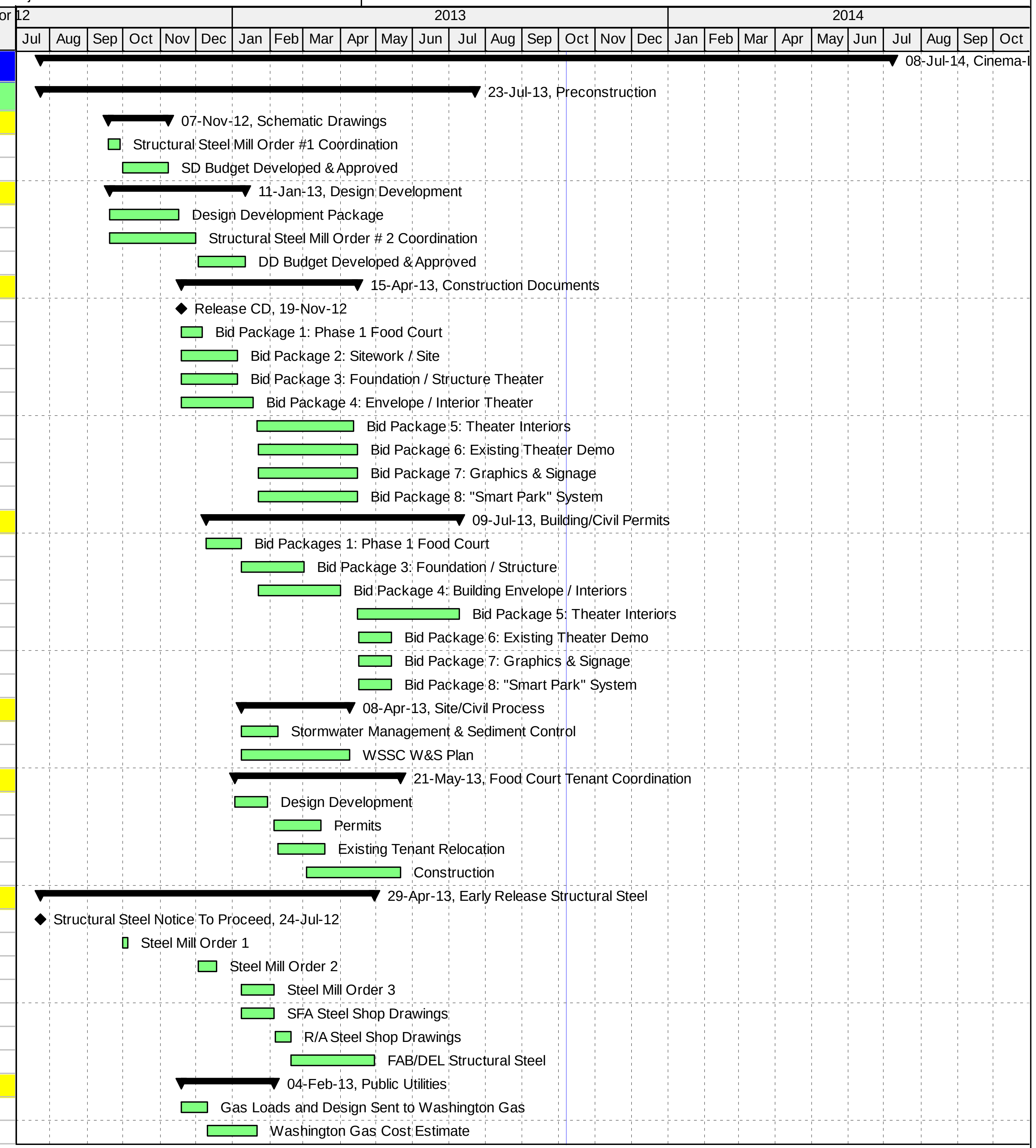
Group (Items Only)

WBS	Quantity 1	
Steel Beams.Theater Roof Framing	64,830.387	ft^2

APPENDIX 1C – DETAILED PROJECT SCHEDULE

Cinema-Dining Terrace Expansion | Detailed Project Schedule | 15-Oct-13 23:49

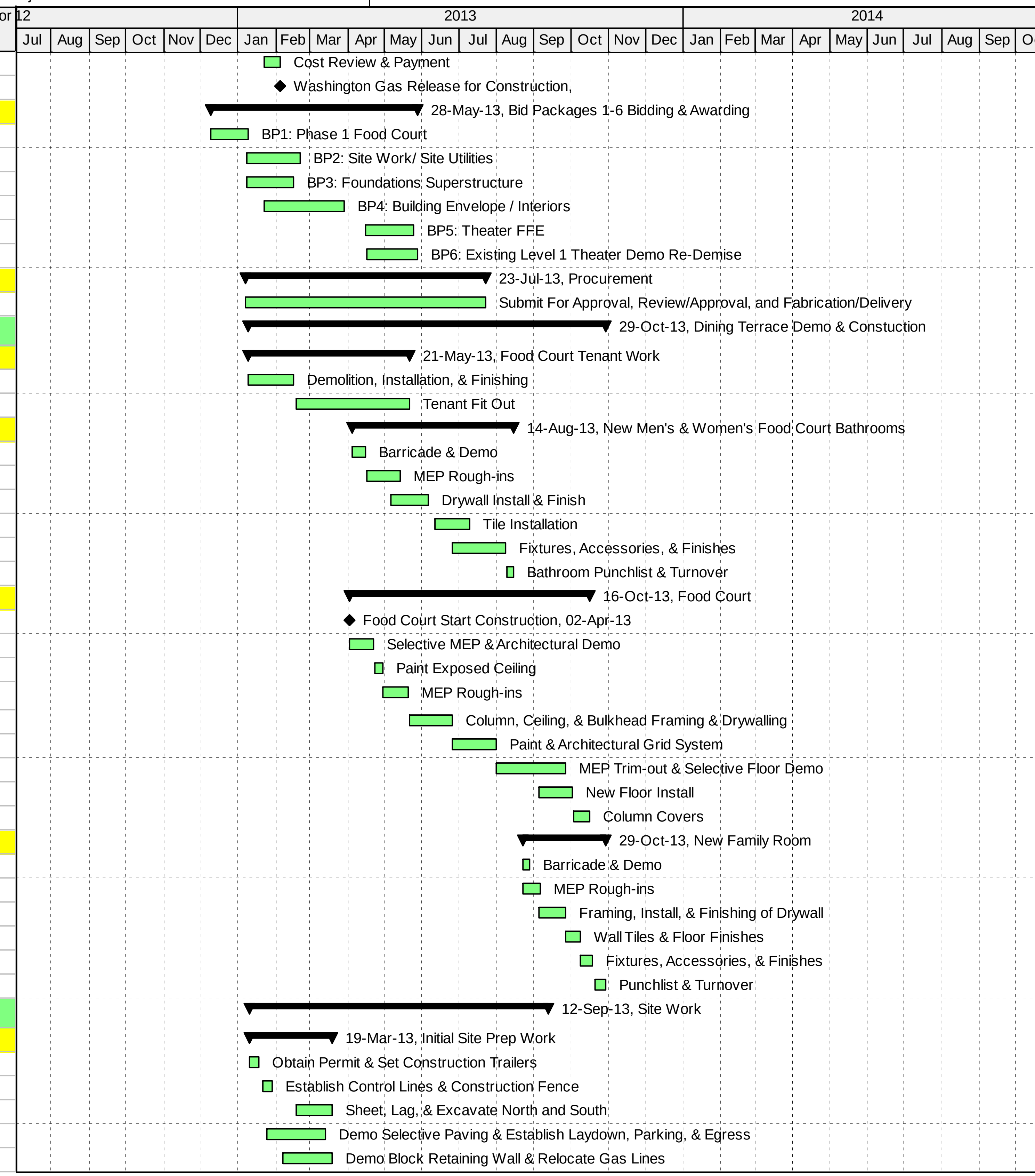
Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
	Cinema-Dining Terrace Expansion	502	24-Jul-12	08-Jul-14		
	Preconstruction	255	24-Jul-12	23-Jul-13		
	Schematic Drawings	37	18-Sep-12	07-Nov-12		
A1000	Structural Steel Mill Order #1 Coordination	9	18-Sep-12	28-Sep-12		A1010, A
A1010	SD Budget Developed & Approved	28	01-Oct-12	07-Nov-12	A1000	
	Design Development	80	19-Sep-12	11-Jan-13		
A1020	Design Development Package	43	19-Sep-12	16-Nov-12		A1040
A1030	Structural Steel Mill Order # 2 Coordination	52	19-Sep-12	30-Nov-12		A1040, A
A1040	DD Budget Developed & Approved	28	03-Dec-12	11-Jan-13	A1030, A	A1540
	Construction Documents	103	19-Nov-12	15-Apr-13		
A1050	Release CD	0	19-Nov-12			A1051, A
A1051	Bid Package 1: Phase 1 Food Court	13	19-Nov-12	06-Dec-12	A1050	A1060, A
A1052	Bid Package 2: Sitework / Site	32	19-Nov-12	04-Jan-13	A1050	A1080, A
A1053	Bid Package 3: Foundation / Structure Theater	32	19-Nov-12	04-Jan-13	A1050	A1061, A
A1054	Bid Package 4: Envelope / Interior Theater	42	19-Nov-12	18-Jan-13	A1050	A1055, A
A1055	Bid Package 5: Theater Interiors	60	21-Jan-13	12-Apr-13	A1054	A1063, A
A1056	Bid Package 6: Existing Theater Demo	60	22-Jan-13	15-Apr-13	A1054	A1064, A
A1057	Bid Package 7: Graphics & Signage	60	22-Jan-13	15-Apr-13	A1054	A1065
A1058	Bid Package 8: "Smart Park" System	60	22-Jan-13	15-Apr-13	A1054	A1066
	Building/Civil Permits	148	10-Dec-12	09-Jul-13		
A1060	Bid Packages 1: Phase 1 Food Court	20	10-Dec-12	08-Jan-13	A1051	A1310, A
A1061	Bid Package 3: Foundation / Structure	39	08-Jan-13	01-Mar-13	A1053	
A1062	Bid Package 4: Building Envelope / Interiors	50	22-Jan-13	01-Apr-13	A1054	
A1063	Bid Package 5: Theater Interiors	60	15-Apr-13	09-Jul-13	A1055	
A1064	Bid Package 6: Existing Theater Demo	20	16-Apr-13	13-May-13	A1056	
A1065	Bid Package 7: Graphics & Signage	20	16-Apr-13	13-May-13	A1057	
A1066	Bid Package 8: "Smart Park" System	20	16-Apr-13	13-May-13	A1058	
	Site/Civil Process	65	08-Jan-13	08-Apr-13		
A1070	Stormwater Management & Sediment Control	23	08-Jan-13	07-Feb-13	A1052	
A1080	WSSC W&S Plan	65	08-Jan-13	08-Apr-13	A1052	
	Food Court Tenant Coordination	99	03-Jan-13	21-May-13		
A1090	Design Development	20	03-Jan-13	30-Jan-13		A1100, A
A1100	Permits	30	04-Feb-13	15-Mar-13	A1090	
A1110	Existing Tenant Relocation	28	08-Feb-13	19-Mar-13	A1090	A1120
A1120	Construction	57	04-Mar-13	21-May-13	A1110	
	Early Release Structural Steel	196	24-Jul-12	29-Apr-13		
A1130	Structural Steel Notice To Proceed	0	24-Jul-12			
A1140	Steel Mill Order 1	4	01-Oct-12	04-Oct-12	A1000	A1190
A1150	Steel Mill Order 2	12	03-Dec-12	18-Dec-12	A1030	A1190
A1160	Steel Mill Order 3	20	08-Jan-13	04-Feb-13	A1053	
A1170	SFA Steel Shop Drawings	20	08-Jan-13	04-Feb-13	A1053	A1180
A1180	R/A Steel Shop Drawings	10	05-Feb-13	18-Feb-13	A1170	
A1190	FAB/DEL Structural Steel	50	19-Feb-13	29-Apr-13	A1140, A	
	Public Utilities	53	19-Nov-12	04-Feb-13		
A1200	Gas Loads and Design Sent to Washington Gas	15	19-Nov-12	10-Dec-12	A1050	A1210
A1210	Washington Gas Cost Estimate	28	11-Dec-12	21-Jan-13	A1200	A1220



Actual Level of Effort | Remaining Work | ◆ ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

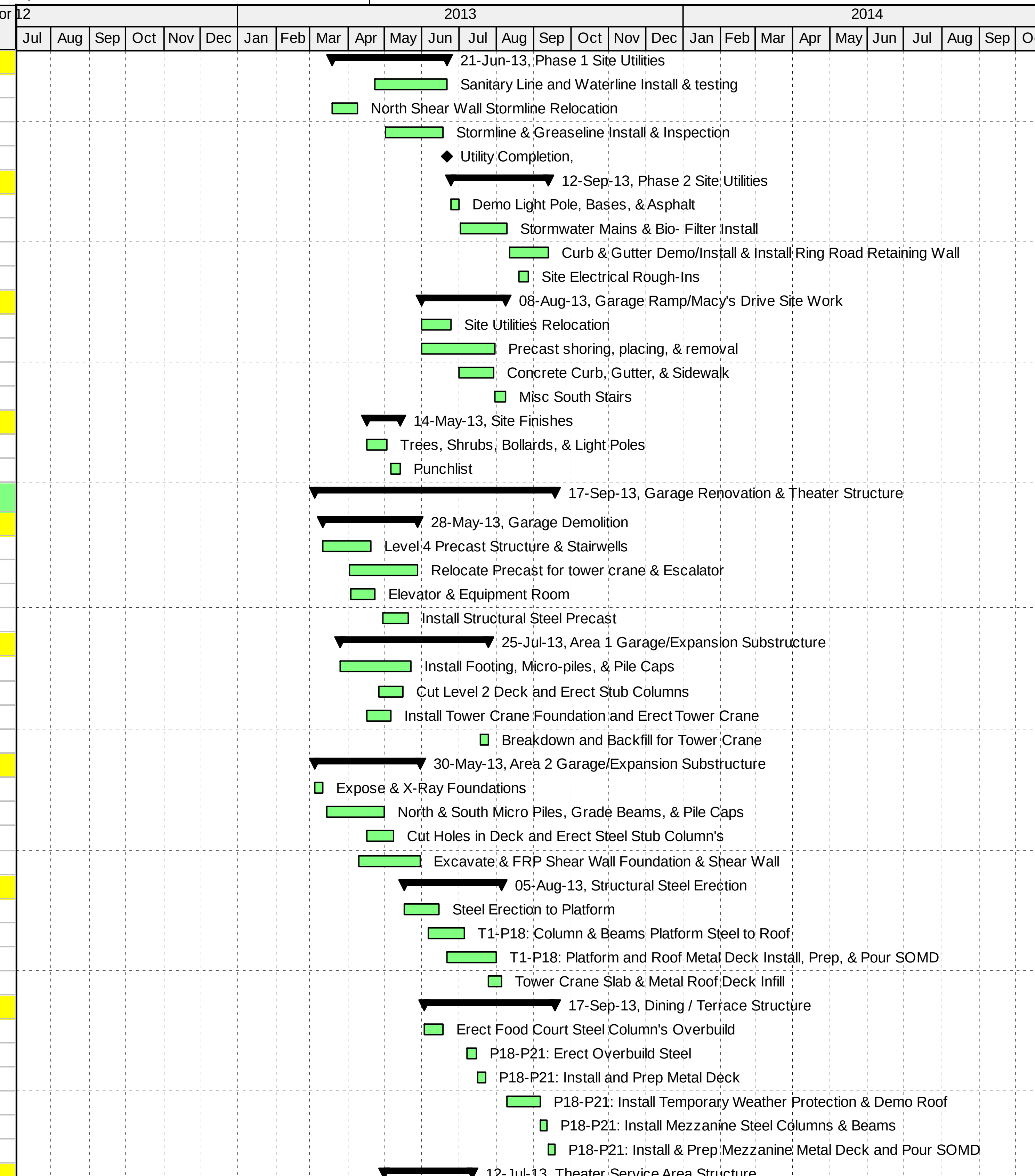
Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
A1220	Cost Review & Payment	10	22-Jan-13	04-Feb-13	A1210	A1230
A1230	Washington Gas Release for Construction	0		04-Feb-13	A1220	
	Bid Packages 1-6 Bidding & Awarding	119	10-Dec-12	28-May-13		
A1240	BP1: Phase 1 Food Court	21	10-Dec-12	09-Jan-13	A1051	A1300, A
A1250	BP2: Site Work/ Site Utilities	32	08-Jan-13	20-Feb-13	A1052	A1600, A
A1260	BP3: Foundations Superstructure	29	08-Jan-13	15-Feb-13	A1053	A1730, A
A1270	BP4: Building Envelope / Interiors	49	22-Jan-13	29-Mar-13	A1054	
A1280	BP5: Theater FFE	30	15-Apr-13	24-May-13	A1055	
A1290	BP6: Existing Level 1 Theater Demo Re-Demise	30	16-Apr-13	28-May-13	A1056	
	Procurement	140	07-Jan-13	23-Jul-13		
A1300	Submit For Approval, Review/Approval, and Fabrication/Delivery	140	07-Jan-13	23-Jul-13	A1240	
	Dining Terrace Demo & Constuction	207	09-Jan-13	29-Oct-13		
	Food Court Tenant Work	95	09-Jan-13	21-May-13		
A1310	Demolition, Installation, & Finishing	28	09-Jan-13	15-Feb-13	A1060	A1320
A1320	Tenant Fit Out	67	18-Feb-13	21-May-13	A1310	
	New Men's & Women's Food Court Bathrooms	93	04-Apr-13	14-Aug-13		
A1330	Barricade & Demo	8	04-Apr-13	15-Apr-13	A1060	A1340
A1340	MEP Rough-ins	20	16-Apr-13	13-May-13	A1330	A1350
A1350	Drywall Install & Finish	22	06-May-13	05-Jun-13	A1340	A1360
A1360	Tile Installation	20	11-Jun-13	09-Jul-13	A1350	A1370
A1370	Fixtures, Accessories, & Finishes	32	25-Jun-13	08-Aug-13	A1360	A1380
A1380	Bathroom Punchlist & Turnover	4	09-Aug-13	14-Aug-13	A1370	
	Food Court	139	02-Apr-13	16-Oct-13		
A1390	Food Court Start Construction	0	02-Apr-13		A1240	A1400
A1400	Selective MEP & Architectural Demo	15	02-Apr-13	22-Apr-13	A1390	A1410, A
A1410	Paint Exposed Ceiling	5	23-Apr-13*	29-Apr-13	A1400	A1420
A1420	MEP Rough-ins	15	30-Apr-13	20-May-13	A1410	A1430
A1430	Column, Ceiling, & Bulkhead Framing & Drywalling	25	21-May-13	25-Jun-13	A1420	A1440
A1440	Paint & Architectural Grid System	25	26-Jun-13	31-Jul-13	A1430	A1450
A1450	MEP Trim-out & Selective Floor Demo	40	01-Aug-13	26-Sep-13	A1440	A1460
A1460	New Floor Install	20	05-Sep-13	02-Oct-13	A1450	A1470
A1470	Column Covers	10	03-Oct-13	16-Oct-13	A1460	
	New Family Room	48	22-Aug-13	29-Oct-13		
A1480	Barricade & Demo	5	22-Aug-13	28-Aug-13	A1060	A1490
A1490	MEP Rough-ins	10	22-Aug-13*	05-Sep-13	A1480	A1500
A1500	Framing, Install, & Finishing of Drywall	16	05-Sep-13	26-Sep-13	A1490	A1510
A1510	Wall Tiles & Floor Finishes	8	27-Sep-13	08-Oct-13	A1500	A1520
A1520	Fixtures, Accessories, & Finishes	8	09-Oct-13*	18-Oct-13	A1510	A1530
A1530	Punchlist & Turnover	7	21-Oct-13*	29-Oct-13	A1520	
	Site Work	173	10-Jan-13	12-Sep-13		
	Initial Site Prep Work	49	10-Jan-13	19-Mar-13		
A1540	Obtain Permit & Set Construction Trailers	6	10-Jan-13	17-Jan-13	A1040	A1550, A
A1550	Establish Control Lines & Construction Fence	6	21-Jan-13*	28-Jan-13	A1540	A1560, A
A1560	Sheet, Lag, & Excavate North and South	22	18-Feb-13	19-Mar-13	A1550	
A1570	Demo Selective Paving & Establish Laydown, Parking, & Egress	35	24-Jan-13	13-Mar-13	A1540	A1770
A1580	Demo Block Retaining Wall & Relocate Gas Lines	29	07-Feb-13	19-Mar-13	A1550	



Actual Level of Effort | Remaining Work | ◆ ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

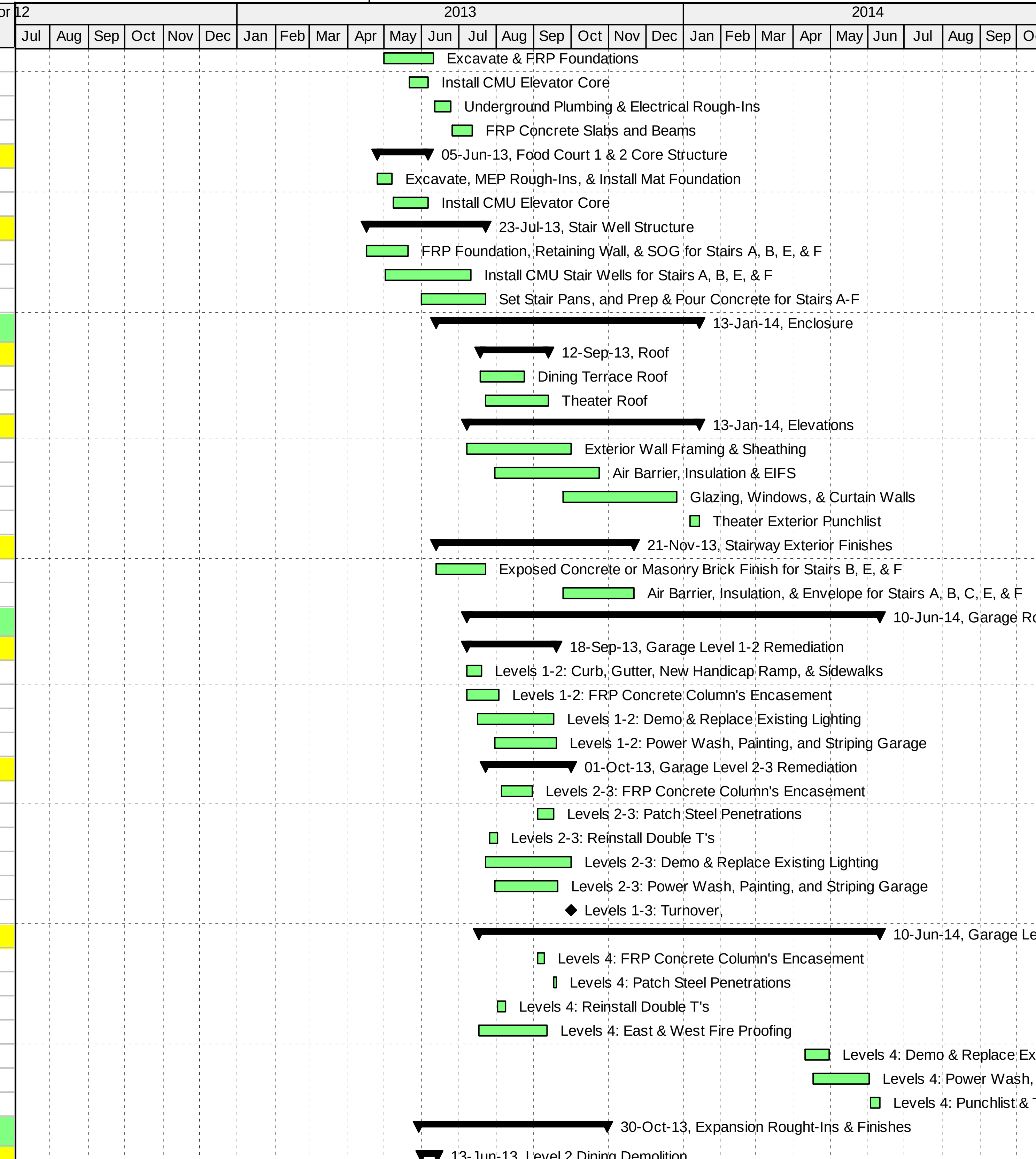
Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
	Phase 1 Site Utilities	68	19-Mar-13	21-Jun-13		
A1590	Sanitary Line and Waterline Install & testing	43	23-Apr-13	21-Jun-13		
A1600	North Shear Wall Stormline Relocation	16	19-Mar-13	09-Apr-13	A1250	A1610
A1610	Stormline & Greaseline Install & Inspection	33	02-May-13	18-Jun-13	A1600	A1620
A1620	Utility Completion	0		21-Jun-13	A1610	A1630
	Phase 2 Site Utilities	57	24-Jun-13	12-Sep-13		
A1630	Demo Light Pole, Bases, & Asphalt	6	24-Jun-13	01-Jul-13	A1620	A1640
A1640	Stormwater Mains & Bio- Filter Install	28	02-Jul-13	09-Aug-13	A1630	A1650, A
A1650	Curb & Gutter Demo/Install & Install Ring Road Retaining Wall	23	12-Aug-13	12-Sep-13	A1640	
A1660	Site Electrical Rough-Ins	6	19-Aug-13	26-Aug-13	A1640	
	Garage Ramp/Macy's Drive Site Work	49	31-May-13	08-Aug-13		
A1670	Site Utilities Relocation	17	31-May-13	24-Jun-13	A1250	A1690
A1680	Precast shoring, placing, & removal	42	31-May-13	30-Jul-13	A1250	
A1690	Concrete Curb, Gutter, & Sidewalk	20	01-Jul-13	29-Jul-13	A1670	A1700
A1700	Misc South Stairs	8	30-Jul-13	08-Aug-13	A1690	
	Site Finishes	20	17-Apr-13	14-May-13		
A1710	Trees, Shrubs, Bollards, & Light Poles	12	17-Apr-13	02-May-13	A1250	A1720
A1720	Punchlist	7	06-May-13	14-May-13	A1710	
	Garage Renovation & Theater Structure	138	05-Mar-13	17-Sep-13		
	Garage Demolition	56	11-Mar-13	28-May-13		
A1730	Level 4 Precast Structure & Stairwells	30	11-Mar-13	19-Apr-13	A1260	
A1740	Relocate Precast for tower crane & Escalator	40	02-Apr-13	28-May-13	A1260	
A1750	Elevator & Equipment Room	15	03-Apr-13	23-Apr-13	A1260	A1760
A1760	Install Structural Steel Precast	15	30-Apr-13	20-May-13	A1750	
	Area 1 Garage/Expansion Substructure	86	26-Mar-13	25-Jul-13		
A1770	Install Footing, Micro-piles, & Pile Caps	42	26-Mar-13*	22-May-13	A1570	A1780
A1780	Cut Level 2 Deck and Erect Stub Columns	15	26-Apr-13	16-May-13	A1770	
A1790	Install Tower Crane Foundation and Erect Tower Crane	15	16-Apr-13	06-May-13	A1260	A1850, A
A1800	Breakdown and Backfill for Tower Crane	5	19-Jul-13	25-Jul-13	A1870	A2180, A
	Area 2 Garage/Expansion Substructure	62	05-Mar-13	30-May-13		
A1810	Expose & X-Ray Foundations	5	05-Mar-13	11-Mar-13		A1820, A
A1820	North & South Micro Piles, Grade Beams, & Pile Caps	33	15-Mar-13	30-Apr-13	A1810	A1830, A
A1830	Cut Holes in Deck and Erect Steel Stub Column's	16	17-Apr-13	08-May-13	A1820	
A1840	Excavate & FRP Shear Wall Foundation & Shear Wall	36	10-Apr-13	30-May-13	A1810	
	Structural Steel Erection	55	17-May-13	05-Aug-13		
A1850	Steel Erection to Platform	20	17-May-13	14-Jun-13	A1790	A1860
A1860	T1-P18: Column & Beams Platform Steel to Roof	21	06-Jun-13	05-Jul-13	A1850	A1870, A
A1870	T1-P18: Platform and Roof Metal Deck Install, Prep, & Pour SOMD	28	21-Jun-13	31-Jul-13	A1860	A1800, A
A1880	Tower Crane Slab & Metal Roof Deck Infill	8	25-Jul-13	05-Aug-13	A1870	
	Dining / Terrace Structure	75	03-Jun-13	17-Sep-13		
A1890	Erect Food Court Steel Column's Overbuild	11	03-Jun-13	17-Jun-13	A1790	A1900
A1900	P18-P21: Erect Overbuild Steel	6	08-Jul-13	15-Jul-13	A1890	A1910
A1910	P18-P21: Install and Prep Metal Deck	6	16-Jul-13	23-Jul-13	A1900	A1920, A
A1920	P18-P21: Install Temporary Weather Protection & Demo Roof	19	09-Aug-13	05-Sep-13	A1910	A1930
A1930	P18-P21: Install Mezzanine Steel Columns & Beams	4	06-Sep-13	11-Sep-13	A1920	A1940
A1940	P18-P21: Install & Prep Mezzanine Metal Deck and Pour SOMD	4	12-Sep-13	17-Sep-13	A1930	
	Theater Service Area Structure	51	01-May-13	12-Jul-13		



Actual Level of Effort | Remaining Work | ◆ ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

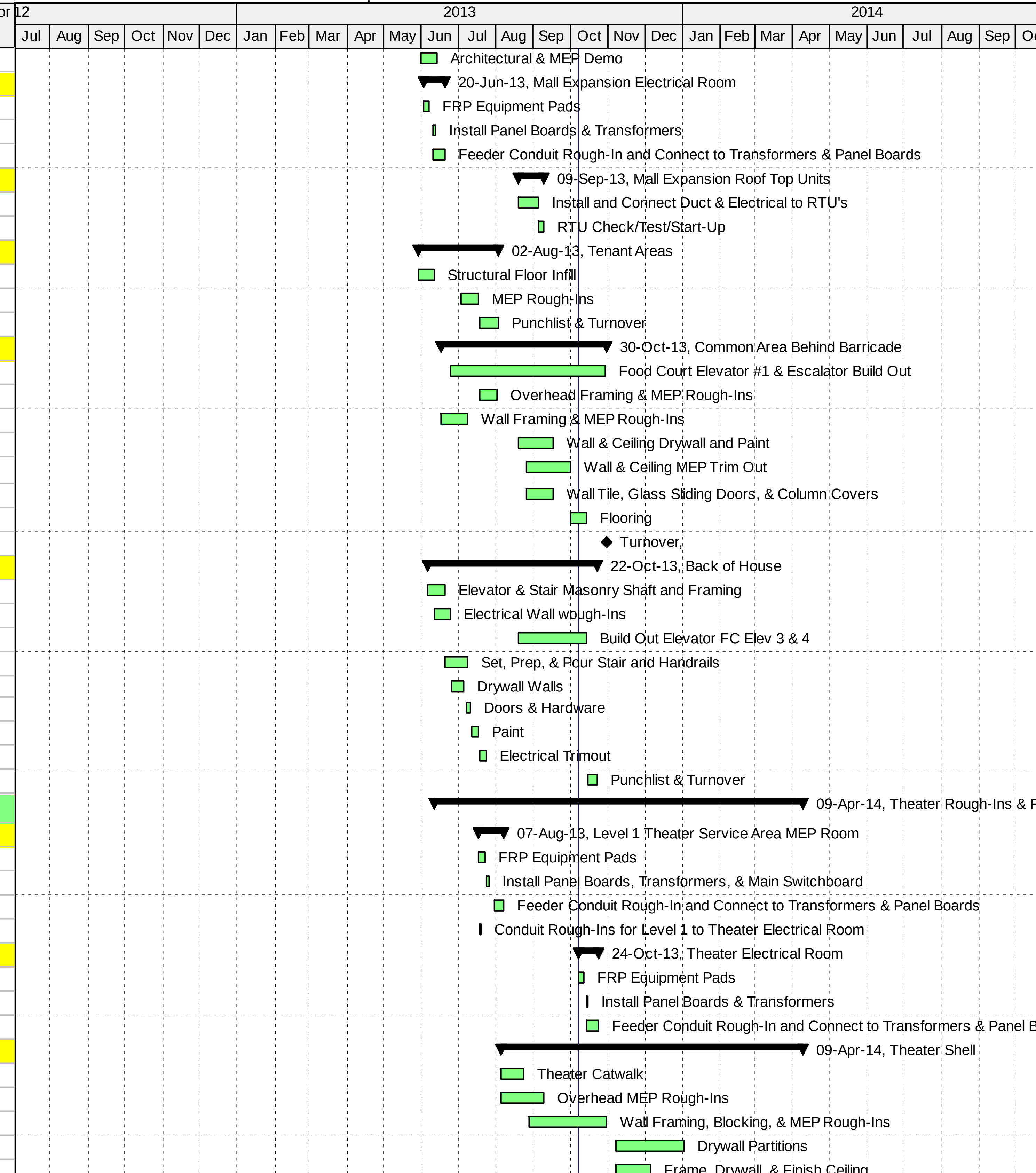
Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
A1950	Excavate & FRP Foundations	28	01-May-13	10-Jun-13	A1810	A1970, A
A1960	Install CMU Elevator Core	12	21-May-13	06-Jun-13	A1810, A	
A1970	Underground Plumbing & Electrical Rough-Ins	10	11-Jun-13	24-Jun-13	A1950	A1980
A1980	FRP Concrete Slabs and Beams	13	25-Jun-13	12-Jul-13	A1970	
Food Court 1 & 2 Core Structure		29	25-Apr-13	05-Jun-13		
A1990	Excavate, MEP Rough-Ins, & Install Mat Foundation	9	25-Apr-13	07-May-13	A1260	A2000
A2000	Install CMU Elevator Core	20	08-May-13	05-Jun-13	A1990	
Stair Well Structure		68	17-Apr-13	23-Jul-13		
A2010	FRP Foundation, Retaining Wall, & SOG for Stairs A, B, E, & F	24	17-Apr-13	20-May-13	A1260	A2020
A2020	Install CMU Stair Wells for Stairs A, B, E, & F	48	02-May-13	10-Jul-13	A2010	A2030
A2030	Set Stair Pans, and Prep & Pour Concrete for Stairs A-F	37	31-May-13	23-Jul-13	A2020	A2100
Enclosure		150	12-Jun-13	13-Jan-14		
Roof		39	19-Jul-13	12-Sep-13		
A2040	Dining Terrace Roof	26	19-Jul-13	23-Aug-13	A1910	
A2050	Theater Roof	37	23-Jul-13	12-Sep-13	A1870	A2330
Elevations		133	08-Jul-13	13-Jan-14		
A2060	Exterior Wall Framing & Sheathing	60	08-Jul-13	30-Sep-13	A1910	A2070
A2070	Air Barrier, Insulation & EIFS	61	30-Jul-13	23-Oct-13	A2060	A2080
A2080	Glazing, Windows, & Curtain Walls	66	24-Sep-13	26-Dec-13	A2070	A2090
A2090	Theater Exterior Punchlist	6	06-Jan-14*	13-Jan-14	A2080	
Stairway Exterior Finishes		115	12-Jun-13	21-Nov-13		
A2100	Exposed Concrete or Masonry Brick Finish for Stairs B, E, & F	28	12-Jun-13	22-Jul-13	A2030	A2110, A
A2110	Air Barrier, Insulation, & Envelope for Stairs A, B, C, E, & F	43	24-Sep-13	21-Nov-13	A2100	
Garage Rough-Ins & Finishes		239	08-Jul-13	10-Jun-14		
Garage Level 1-2 Remediation		52	08-Jul-13	18-Sep-13		
A2120	Levels 1-2: Curb, Gutter, New Handicap Ramp, & Sidewalks	10	08-Jul-13	19-Jul-13	A1820	A2150
A2130	Levels 1-2: FRP Concrete Column's Encasement	20	08-Jul-13	02-Aug-13	A1820, A	A2150
A2140	Levels 1-2: Demo & Replace Existing Lighting	44	16-Jul-13	16-Sep-13		A2150
A2150	Levels 1-2: Power Wash, Painting, and Striping Garage	35	31-Jul-13	18-Sep-13	A2130, A	
Garage Level 2-3 Remediation		50	23-Jul-13	01-Oct-13		
A2160	Levels 2-3: FRP Concrete Column's Encasement	20	05-Aug-13	30-Aug-13	A1860	A2170, A
A2170	Levels 2-3: Patch Steel Penetrations	10	03-Sep-13	16-Sep-13	A2160	A2200
A2180	Levels 2-3: Reinstall Double T's	5	26-Jul-13	01-Aug-13	A1800	A2200
A2190	Levels 2-3: Demo & Replace Existing Lighting	49	23-Jul-13	30-Sep-13		A2200, A
A2200	Levels 2-3: Power Wash, Painting, and Striping Garage	38	30-Jul-13	20-Sep-13	A2180, A	A2210
A2210	Levels 1-3: Turnover	0		01-Oct-13	A2200, A	
Garage Level 4 Remediation		232	17-Jul-13	10-Jun-14		
A2220	Levels 4: FRP Concrete Column's Encasement	5	03-Sep-13	09-Sep-13	A1860	A2230
A2230	Levels 4: Patch Steel Penetrations	3	17-Sep-13*	19-Sep-13	A2220	
A2240	Levels 4: Reinstall Double T's	5	02-Aug-13	08-Aug-13	A1800	
A2250	Levels 4: East & West Fire Proofing	40	17-Jul-13	11-Sep-13	A1910	
A2260	Levels 4: Demo & Replace Existing Lighting	15	10-Apr-14*	30-Apr-14		A2270
A2270	Levels 4: Power Wash, Painting, and Striping Garage	33	17-Apr-14*	02-Jun-14	A2260	A2280
A2280	Levels 4: Punchlist & Turnover	6	03-Jun-14*	10-Jun-14	A2270	
Expansion Rought-Ins & Finishes		109	29-May-13	30-Oct-13		
Level 2 Dining Demolition		10	31-May-13	13-Jun-13		



Actual Level of Effort | Remaining Work | ◆ ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

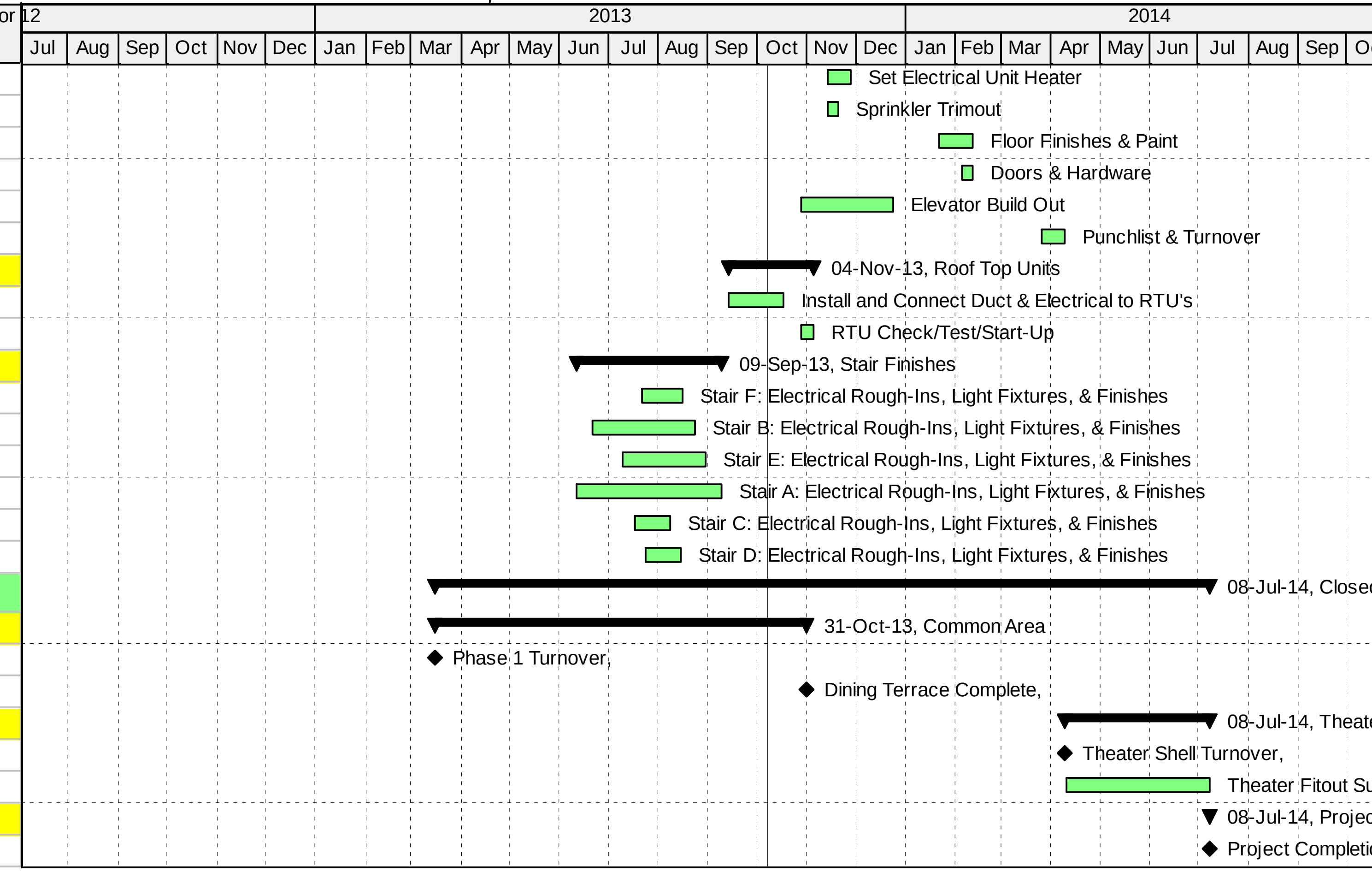
Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
A2290	Architectural & MEP Demo	10	31-May-13	13-Jun-13	A1400	
Mall Expansion Electrical Room		14	03-Jun-13	20-Jun-13		
A2300	FRP Equipment Pads	5	03-Jun-13	07-Jun-13		A2310
A2310	Install Panel Boards & Transformers	3	10-Jun-13	12-Jun-13	A2300	A2320
A2320	Feeder Conduit Rough-In and Connect to Transformers & Panel Bo	9	10-Jun-13	20-Jun-13	A2310	
Mall Expansion Roof Top Units		15	19-Aug-13	09-Sep-13		
A2330	Install and Connect Duct & Electrical to RTU's	12	19-Aug-13	04-Sep-13	A2050	A2340
A2340	RTU Check/Test/Start-Up	3	05-Sep-13	09-Sep-13	A2330	
Tenant Areas		47	29-May-13	02-Aug-13		
A2350	Structural Floor Infill	10	29-May-13	11-Jun-13		A2360
A2360	MEP Rough-Ins	10	03-Jul-13	17-Jul-13	A2350	A2370
A2370	Punchlist & Turnover	12	18-Jul-13	02-Aug-13	A2360	
Common Area Behind Barricade		96	17-Jun-13	30-Oct-13		
A2380	Food Court Elevator #1 & Escalator Build Out	90	24-Jun-13	29-Oct-13		
A2390	Overhead Framing & MEP Rough-Ins	10	19-Jul-13	01-Aug-13		A2410
A2400	Wall Framing & MEP Rough-Ins	15	17-Jun-13	08-Jul-13		A2410
A2410	Wall & Ceiling Drywall and Paint	20	19-Aug-13	16-Sep-13	A2400, A	A2420
A2420	Wall & Ceiling MEP Trim Out	25	26-Aug-13	30-Sep-13	A2410	A2440, A
A2430	Wall Tile, Glass Sliding Doors, & Column Covers	15	26-Aug-13	16-Sep-13	A2420	
A2440	Flooring	10	01-Oct-13	14-Oct-13	A2420	A2450
A2450	Turnover	0		30-Oct-13*	A2440	
Back of House		97	06-Jun-13	22-Oct-13		
A2460	Elevator & Stair Masonry Shaft and Framing	11	06-Jun-13	20-Jun-13		A2480
A2470	Electrical Wall wough-Ins	10	11-Jun-13	24-Jun-13		A2500, A
A2480	Build Out Elevator FC Elev 3 & 4	40	19-Aug-13	14-Oct-13	A2460	A2540
A2490	Set, Prep, & Pour Stair and Handrails	12	20-Jun-13	08-Jul-13	A2470	
A2500	Drywall Walls	8	25-Jun-13	05-Jul-13	A2470	A2510
A2510	Doors & Hardware	4	08-Jul-13	11-Jul-13	A2500	A2520
A2520	Paint	4	12-Jul-13	17-Jul-13	A2510	A2530
A2530	Electrical Trimout	5	18-Jul-13	24-Jul-13	A2520	
A2540	Punchlist & Turnover	6	15-Oct-13*	22-Oct-13	A2480	
Theater Rough-Ins & Finishes		213	11-Jun-13	09-Apr-14		
Level 1 Theater Service Area MEP Room		16	17-Jul-13	07-Aug-13		
A2550	FRP Equipment Pads	5	17-Jul-13	23-Jul-13		A2560
A2560	Install Panel Boards, Transformers, & Main Switchboard	3	24-Jul-13	26-Jul-13	A2550	A2570
A2570	Feeder Conduit Rough-In and Connect to Transformers & Panel Bo	6	31-Jul-13	07-Aug-13	A2560	
A2580	Conduit Rough-Ins for Level 1 to Theater Electrical Room	2	18-Jul-13	19-Jul-13	A2470	A2600
Theater Electrical Room		14	07-Oct-13	24-Oct-13		
A2590	FRP Equipment Pads	5	07-Oct-13	11-Oct-13		A2600
A2600	Install Panel Boards & Transformers	2	14-Oct-13*	15-Oct-13	A2590, A	A2610
A2610	Feeder Conduit Rough-In and Connect to Transformers & Panel Bo	9	14-Oct-13*	24-Oct-13	A2600	
Theater Shell		175	05-Aug-13	09-Apr-14		
A2620	Theater Catwalk	15	05-Aug-13	23-Aug-13		A2670, A
A2630	Overhead MEP Rough-Ins	25	05-Aug-13	09-Sep-13		A2710
A2640	Wall Framing, Blocking, & MEP Rough-Ins	45	28-Aug-13	30-Oct-13		A2650, A
A2650	Drywall Partitions	38	07-Nov-13*	01-Jan-14	A2640	A2720, A
A2660	Frame, Drywall, & Finish Ceiling	20	07-Nov-13*	05-Dec-13	A2640	



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

Activity ID	Activity Name	Original Duration	Start	Finish	Predecess	Successor
A2670	Set Electrical Unit Heater	10	14-Nov-13*	27-Nov-13	A2620	
A2680	Sprinkler Trimout	5	14-Nov-13*	20-Nov-13	A2620	
A2690	Floor Finishes & Paint	15	22-Jan-14*	11-Feb-14	A2650	A2720
A2700	Doors & Hardware	5	05-Feb-14*	11-Feb-14	A2650	A2720
A2710	Elevator Build Out	41	28-Oct-13*	24-Dec-13	A2640, A	A2720
A2720	Punchlist & Turnover	11	26-Mar-14*	09-Apr-14	A2710, A	
Roof Top Units		37	13-Sep-13	04-Nov-13		
A2730	Install and Connect Duct & Electrical to RTU's	25	13-Sep-13	17-Oct-13		A2740
A2740	RTU Check/Test/Start-Up	6	28-Oct-13*	04-Nov-13	A2730	
Stair Finishes		63	11-Jun-13	09-Sep-13		
A2750	Stair F: Electrical Rough-Ins, Light Fixtures, & Finishes	20	22-Jul-13	16-Aug-13	A2100	
A2760	Stair B: Electrical Rough-Ins, Light Fixtures, & Finishes	45	21-Jun-13	23-Aug-13	A2100	
A2770	Stair E: Electrical Rough-Ins, Light Fixtures, & Finishes	38	10-Jul-13	30-Aug-13	A2100	
A2780	Stair A: Electrical Rough-Ins, Light Fixtures, & Finishes	63	11-Jun-13	09-Sep-13	A2100	
A2790	Stair C: Electrical Rough-Ins, Light Fixtures, & Finishes	17	17-Jul-13	08-Aug-13	A2100	
A2800	Stair D: Electrical Rough-Ins, Light Fixtures, & Finishes	17	24-Jul-13	15-Aug-13	A2100	
Closeout		337	15-Mar-13	08-Jul-14		
Common Area		161	15-Mar-13	31-Oct-13		
A2810	Phase 1 Turnover	0		15-Mar-13		
A2820	Dining Terrace Complete	0		31-Oct-13*		
Theater Shell		64	09-Apr-14	08-Jul-14		
A2830	Theater Shell Turnover	0		09-Apr-14*		
A2840	Theater Fitout Summary	64	10-Apr-14*	08-Jul-14		
Project Completion		0	08-Jul-14	08-Jul-14		
A2850	Project Completion	0		08-Jul-14*		



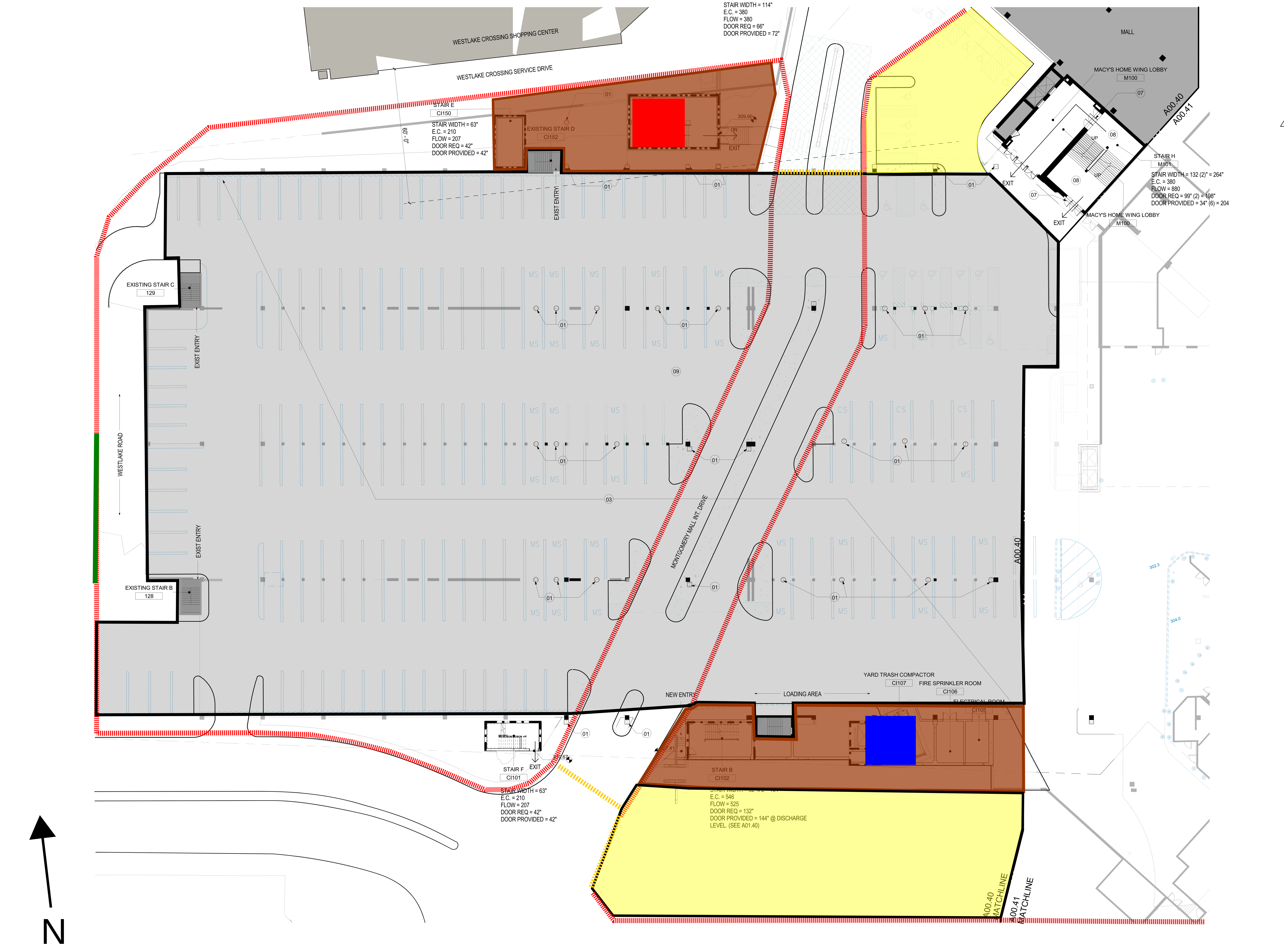
Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

APPENDIX 1D – GENERAL CONDITIONS ESTIMATE

General Conditions Estimate					
Description	**Quantity**	**Unit**	**Actual Cost/Unit**	**Installation**	**Actual Total Cost**
Whiting-Turner					
Project Manager	19	Month	$ 18,000.00	-	$ 342,000.00
Assistant Project Manager	18	Month	$ 11,000.00	-	$ 198,000.00
Project Engineer	18	Month	$ 9,500.00	-	$ 171,000.00
Project Engineer	18	Month	$ 9,500.00	-	$ 171,000.00
					$ -
Superintendent	17	Month	$ 18,000.00	-	$ 306,000.00
Night Superintendent	17	Month	$ 12,000.00	-	$ 204,000.00
Assistant Superintendent	17	Month	$ 10,000.00	-	$ 170,000.00
Assistant Superintendent	17	Month	$ 10,000.00	-	$ 170,000.00
Clerical	17	Month	$ 5,000.00	-	$ 85,000.00
					$ 1,817,000.00
Anonymous Owner					
Project Manager	19	Month	$ 22,500.00	-	$ 427,500.00
Accountant	18	Month	$ 18,000.00	-	$ 324,000.00
Administrator	18	Month	$ 8,250.00	-	$ 148,500.00
Site Testing/Commisioning Coordinator	5	Month	$ 15,000.00	-	$ 75,000.00
					$ 975,000.00
Office & Miscellaneous Costs					
Trailer Rental	18	Month	$ 2,200.00	$ 10,000.00	$ 49,600.00
Trailer Temp Power Service	18	Month	$ 750.00	$ 5,000.00	$ 18,500.00
Trailer Phone Service	18	Month	$ 700.00	$ 2,500.00	$ 15,100.00
Trailer Water Service	18	Month	$ 1,000.00	$ 2,500.00	$ 20,500.00
Trailer Internet Service	18	Month	$ 500.00	$ 2,500.00	$ 11,500.00
Trailer Office Furniture/Supplies	18	Month	$ 800.00	$ 4,000.00	$ 18,400.00
Trailer Copier & Printers	18	Month	$ 750.00	$ 1,000.00	$ 14,500.00
Trailer Drinks/Snacks	18	Month	$ 125.00	-	$ 2,250.00
Progress Photos	18	Month	$ 125.00	-	$ 2,250.00
First Aid/Fire Extinguishers	1	LS	-	$ 2,500.00	$ 2,500.00
Shipping/Postage	18	Month	$ 500.00	-	$ 9,000.00
Builders Risk Insurance	0.67%				$ 286,091.00
					$ 450,191.00
					$ 3,242,191.00

APPENDIX 2A – NEW PHASING PLANS



EGRESS - FIRE PARTITIONS PLAN - LEVEL 01 - CINEMA

SCALE: 1/16" = 1'-0"

1

Key

- Parking Garage
- Site Fence
- Site Gate
- Parking Entrance Gate
- Site Excavation
- Site Laydown and Delivery Area
- Tower Crane A
- Tower Crane B

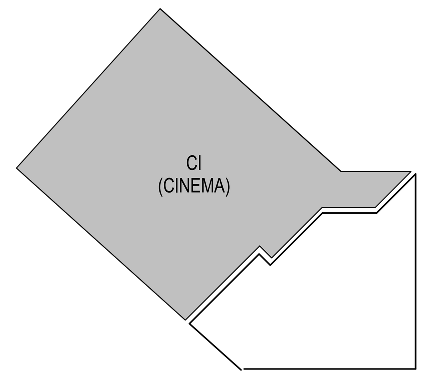
FIRE SAFETY LEGEND

- FIRE SEPARATION SETBACK LINE
- 1 HR FIRE RATED WALL
- 2 HR FIRE RATED WALL
- LEASE LINE

GENERAL NOTES

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN



△	DATE	DESCRIPTION
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING

Seal/Signature

Professional Certification. I certify that these documents were prepared or approved by me, and that I am a duly licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

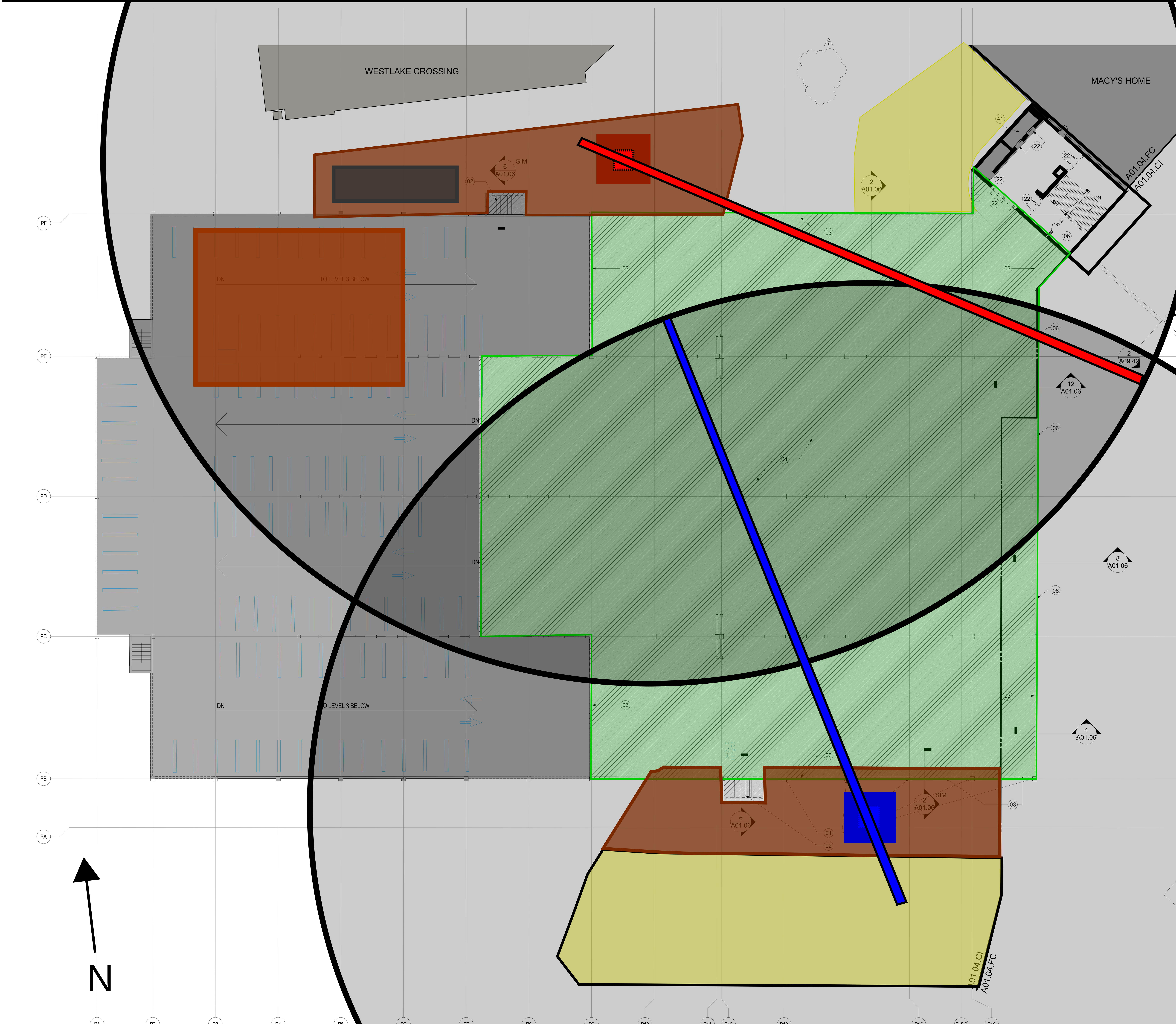
Project Number
09.7179.000

Description
EGRESS PLAN LEVEL 01 CI / FIRE RESISTANT PLAN

Scale
As indicated

A00.40

C-006



DEMOLITION PLAN - CONCOURSE LEVEL - CINEMA

SCALE: 1/16" = 1'-0"

1

GENERAL NOTES

A SEE A00.11 FOR GRAPHIC SYMBOLS

B DIAGONAL HATCH INDICATES AREA OF DEMOLITION AT THE LEVEL

C DRAWINGS ARE PROVIDED AS DESIGN INTENT ONLY, G.C. SHOULD VERIFY IN FIELD ALL EXISTING CONDITIONS AND CHECK WITH ARCHITECT FOR CONFLICTS BEFORE PROCEEDING WITH WORK

ALL DEMOLISHED AREAS SHOULD BE PREP READY TO ACCEPT THE CONSTRUCTION OR MAINTAIN THE CURRENT BUILDING ENCLOSURE FOR EXTERIOR ELEMENTS

E ITEMS TO BE DEMOLISHED SHOWN DASHED, TYPICAL.

F SHADED AREAS ARE EXISTING TO REMAIN NIC

Key

- Double T Demolition
- Site Laydown and Delivery Area
- Tower Crane A
- Tower Crane B
- Site Excavation
- Rainwater Storage Tank
- Site Trailers

EXPOSED PILE CAP IN DRIVE LANE. REFER TO STRUCT. DWGS FOR PILE CAP DIMENSIONS.

34 DEMOLISH PORTION OF EXISTING FOOTING FOR INCORPORATION INTO PILE CAP. SEE STRUCT. DWGS.

35 EXIST. FOOTING TO BE REMOVED. SEE STRUCT. DWGS.

36 REMOVE EXIST. BOULDERS/STONES. PREPARE GRADE FOR NEW CONST.

37 DEMOLISH RAILING.

38 DEMOLISH FINISHES IN THIS AREA AND PREP FOR NEW CONST. COORD EXTEN OF TENANT DEMO AT NICHES WITH OWNER/TENANT.

40 REMOVE EXISTING RAMP STRUCTURE AND RELATED COMPONENTS.

41 REMOVE ACCESS TO ELEVATOR AT THIS LEVEL. CONTRACTOR TO MODIFY ELEVATOR SYSTEM

42 RELOCATE FIRE SPRINKLER LINE ABOVE THIS AREA TO ALLOW FOR NEW ELEVATOR INSTALLATION.

43 DEMOLISH KNEE WALL TO BE LEVEL WITH EXISTING RAMP.

44 REMOVE EXISTING PARKING ISLANDS AND PREPARE AREA FOR RECONFIGURATION

45 EXISTING TRANSFORMER WORK AROUND IT TO BE COORD W/PEPCO

46 PARTIAL REMOVAL OF WALL TO ACCEPT NEW COLUMN

47 DEMOLISH FORMER TENANT FIT OUT @ THIS AREA INCLUDING ABANDONED PANELS ETC. RE: MEP DRAWINGS FOR FUNCTIONAL PANEL RELOCATION

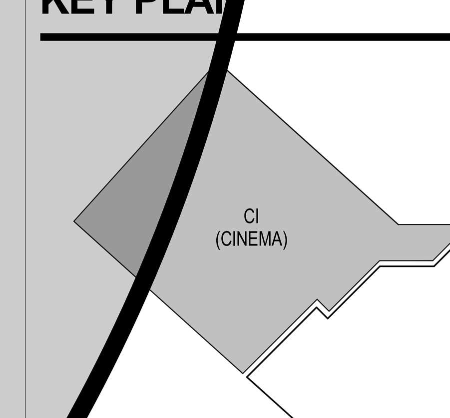
48 REMOVE EXISTING "T"S

49 EXISTING SLAB TO BE DEMOLISHED TO ALLOW ACCESS TO FOOTING. REFER TO STRUCTURAL DWGS.

50 DEMOLISH FLOOR SLAB. REFER TO STRUCTURAL DWGS.

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN



△	DATE	DESCRIPTION
1	09.17.2012	Issue for SD / Pricing
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING
7	03/26/2013	ADDENDUM 4 C006C

Seal/Signature

Professional Certification.
I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

Project Number
09.7179.000

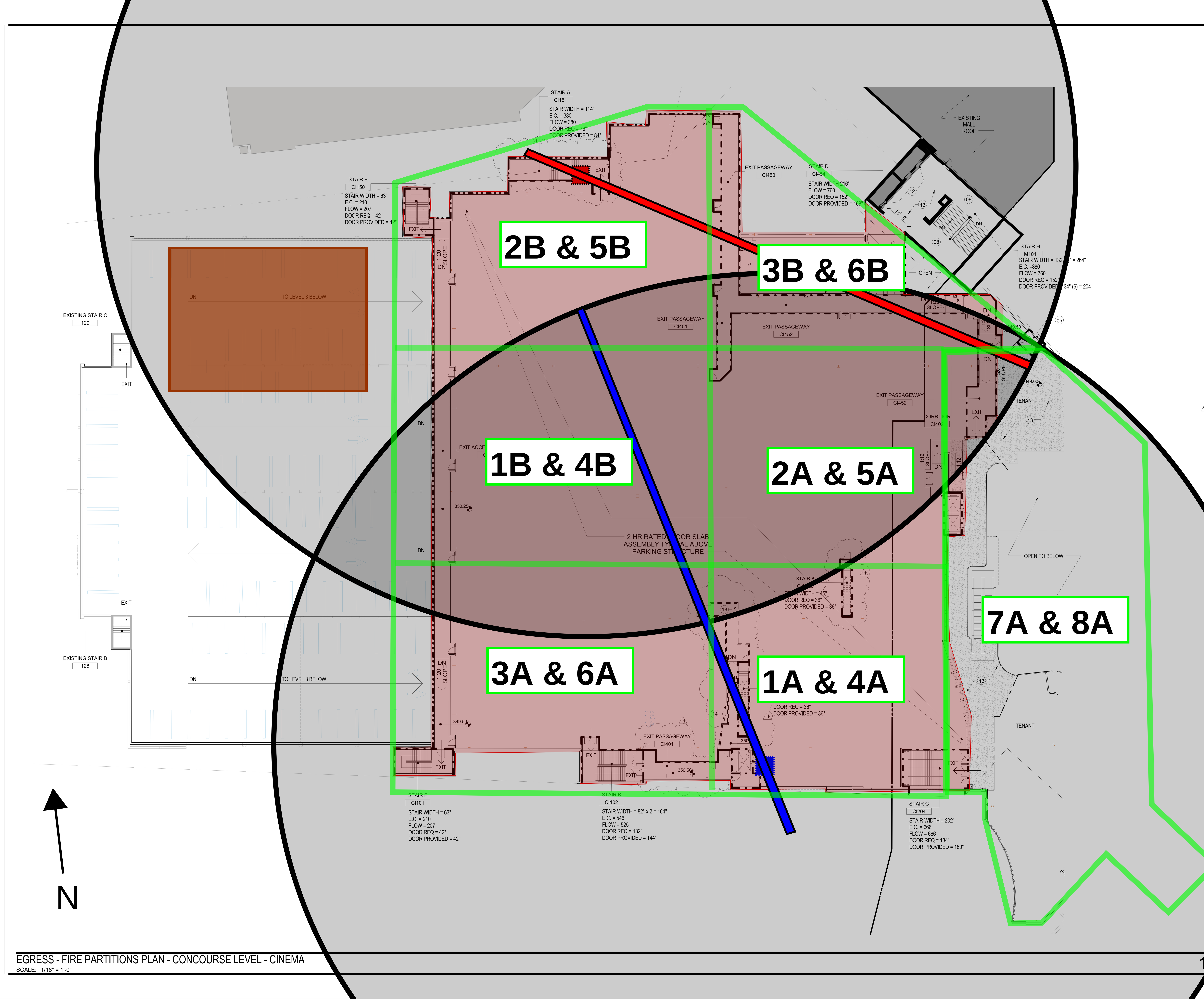
Description
DEMOLITION PLAN - CONCOURSE LEVEL - CINEMA

Scale
As indicated

Ref. North

A01.04.CI

C-006C



Key

- Theater
- Tower Crane Radius
- Site Trailers
- Tower Crane A
- Tower Crane B

FIRE SAFETY LEGEND

- FIRE SEPARATION SETBACK LINE
- 1 HR FIRE RATED WALL
- 2 HR FIRE RATED WALL
- LEASE LINE

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN

△	DATE	DESCRIPTION
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING
7	03/26/2013	ADDENDUM 4 C006C
9	04/03/2013	ISSUE FOR CODE MOD. COMMENT
10	04/22/2013	ISSUE FOR PERMIT COMMENTS
11	05/02/2013	ISSUE FOR MEZZANINE REVISIONS

Seal/Signature

Professional Certification. I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

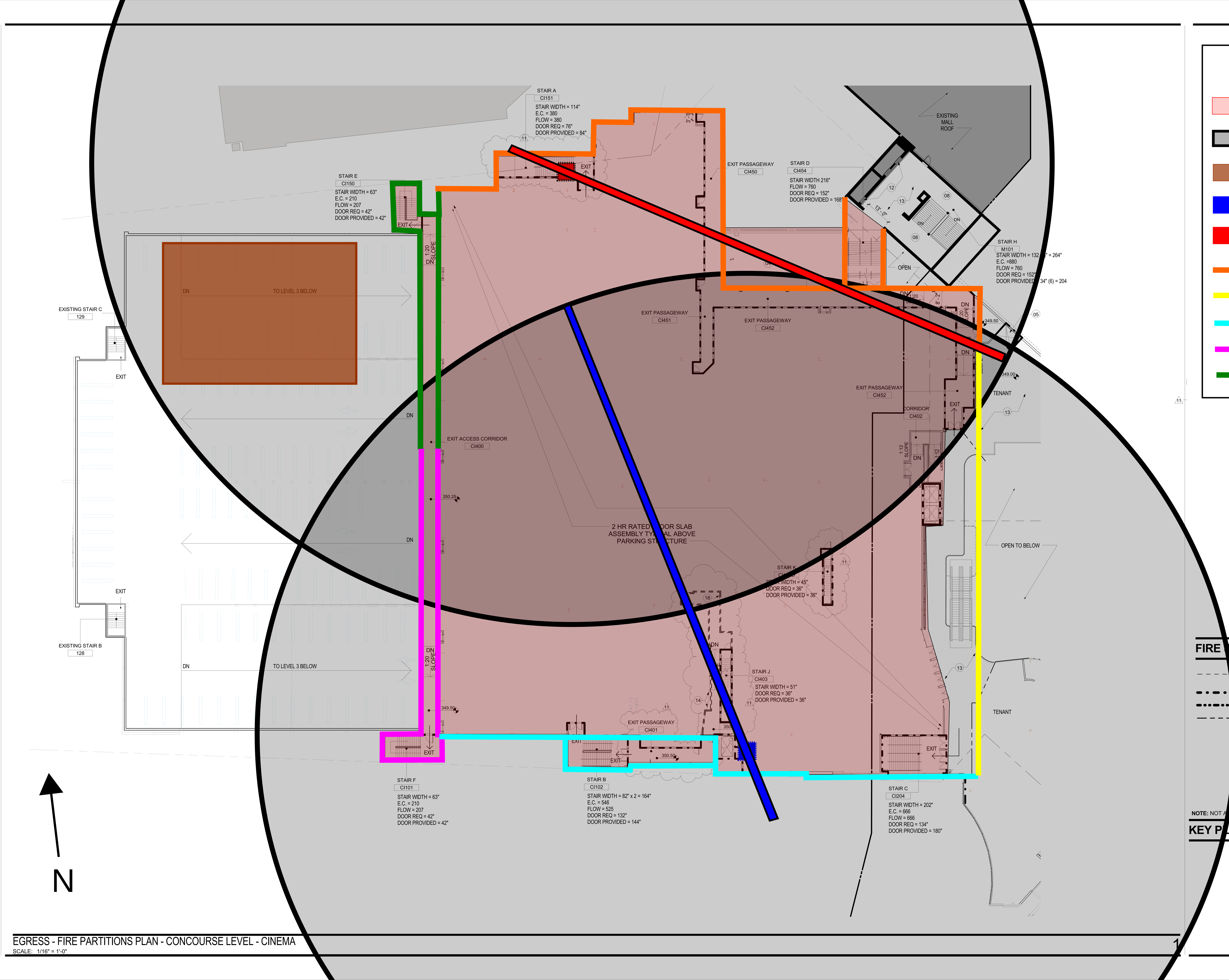
Project Number
09.7179.000

Description
EGRESS PLAN CONCOURSE LEVEL / FIRE RESISTANT PLAN

Scale
As indicated

A00.45

C-013



Key

- Theater
- Tower Crane Radius
- Site Trailers
- Tower Crane A
- Tower Crane B
- North Façade
- East Façade
- South Façade
- West Façade (Crane B)
- West Façade (Crane A)

FIRE SAFETY LEGEND

- FIRE SEPARATION SETBACK LINE
- 1 HR FIRE RATED WALL
- 2 HR FIRE RATED WALL
- LEASE LINE

NOTE: NOT ALL NOTES APPEAR ON THIS SHEET

KEY PLAN

△	DATE	DESCRIPTION
4	11/16/2012	ISSUE FOR DESIGN DEVELOPMENT
5	01/18/2013	ISSUED FOR PERMIT AND PRICING
7	03/26/2013	ADDENDUM 4 C006C
9	04/03/2013	ISSUE FOR CODE MOD. COMMENT
10	04/22/2013	ISSUE FOR PERMIT COMMENTS
11	05/02/2013	ISSUE FOR MEZZANINE REVISIONS

Seal/Signature

Professional Certification.
I certify that thesedocuments were prepared or approved by me, and that I am a duty licensed architect under the laws of the State of Maryland, license number expiration date

Project Name
CINEMA - DINING TERRACE EXPANSION

Project Number
09.7179.000

Description
EGRESS PLAN CONCOURSE LEVEL / FIRE RESISTANT PLAN

Scale
As indicated

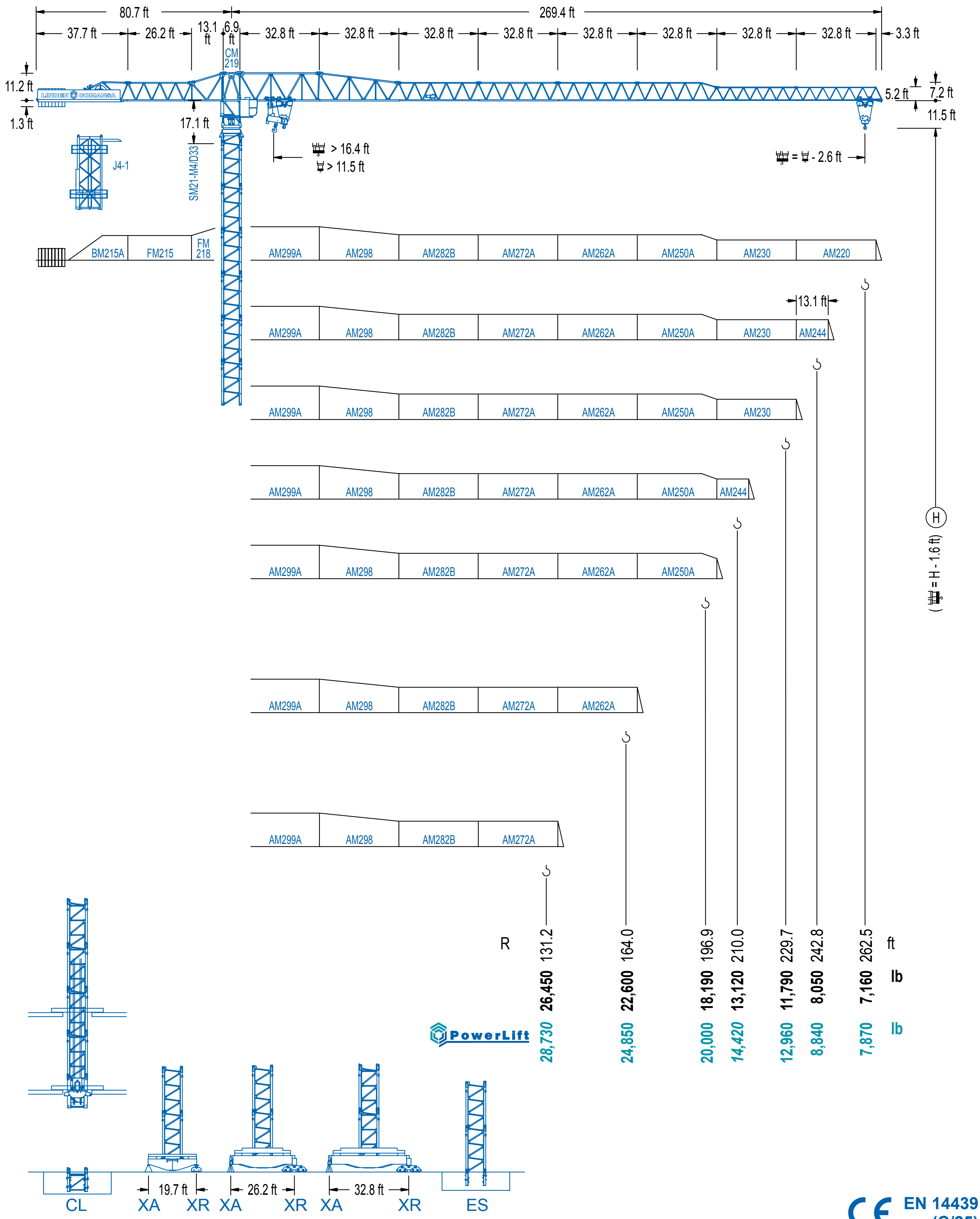
A00.45

C-013

APPENDIX 2B – TOWER CRANE SPEC SHEETS

LINDEN COMANSA

LC 2100 — 21 LC 550 — 52,910 lb



R (ft)	131.2	164.0	196.9	210.0	229.7	242.8	262.5
lb	26,450	22,600	18,190	13,120	11,790	8,050	7,160
PowerLift lb	28,730	24,850	20,000	14,420	12,960	8,840	7,870

LC 2100

CE EN 14439 (C/25)

DIAGRAMA DE CARGAS
Load chart / Diagramme de charges / Lastdiagramm / Diagramma di carico / Диаграмма распределения нагрузки

R (ft)																
262.5	50.2	59.1	65.6	86.9	93.5	114.8	131.2	147.6	164.0	180.4	196.9	210.0	229.7	242.8	262.5	ft
	52,910	43,230	37,910	26,450	26,450	20,740	17,680	15,320	13,440	11,900	10,640	9,760	8,640	8,000	7,160	lb
242.8	49.9	59.1	65.6	86.6	93.5	114.8	131.2	147.6	164.0	180.4	196.9	210.0	229.7	242.8	ft	
	52,910	43,120	37,830	26,450	26,450	20,830	17,760	15,380	13,510	11,970	10,690	9,810	8,680	8,040	lb	
229.7		61.4	65.6	82.0	107.0	117.5	131.2	147.6	164.0	180.4	196.9	210.0	229.7	ft		
		52,910	48,800	37,140	26,450	26,450	23,250	20,260	17,870	15,930	14,320	13,200	11,790	lb		
210.0		60.7	65.6	82.0	106.0	116.8	131.2	147.6	164.0	180.4	196.9	210.0	ft			
		52,910	48,210	36,680	26,450	26,450	23,100	20,120	17,740	15,820	14,210	13,110	lb			
196.9			73.2	82.0	98.4	114.8	128.3	142.7	164.0	180.4	196.9	ft				
			52,910	46,160	36,970	30,480	26,450	26,450	22,530	20,150	18,180	lb				
164.0			72.8	82.0	98.4	114.8	127.6	143.0	164.0	ft						
			52,910	45,850	36,720	30,260	26,450	26,450	22,590	lb						
131.2			72.5	82.0	98.4	127.3	131.2	ft								
			52,910	45,720	36,610	26,450	26,450	lb								

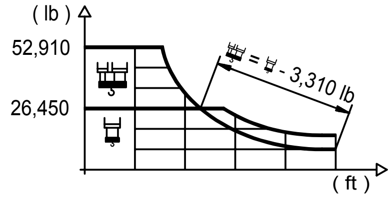
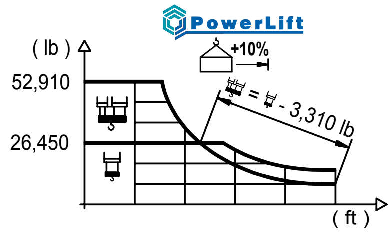


DIAGRAMA DE CARGAS POWERLIFT
Load chart PowerLift / Diagramme de charges PowerLift / Lastdiagramm PowerLift / Diagramma di carico PowerLift / Диаграмма распределения нагрузки PowerLift

R (ft)																
262.5	51.8	65.6	75.5	89.6	99.4	114.8	131.2	147.6	164.0	180.4	196.9	210.0	229.7	242.8	262.5	ft
	52,910	39,460	33,110	26,450	26,450	22,390	19,110	16,600	14,590	12,940	11,590	10,640	9,450	8,770	7,870	lb
242.8	51.8	65.6	75.5	89.9	100.1	114.8	131.2	147.6	164.0	180.4	196.9	210.0	229.7	242.8	ft	
	52,910	39,570	33,200	26,450	26,450	22,530	19,240	16,710	14,680	13,050	11,680	10,730	9,520	8,840	lb	
229.7		64.6	75.5	82.0	98.4	112.5	126.3	147.6	164.0	180.4	196.9	210.0	229.7	ft		
		52,910	43,760	39,520	31,480	26,450	26,450	22,090	19,510	17,410	15,690	14,480	12,960	lb		
210.0		63.98	75.46	82.02	98.43	111.88	125.98	147.64	164.04	180.45	196.85	209.97	ft			
		52,910	43,400	39,190	31,190	26,450	26,450	21,970	19,420	17,320	15,600	14,410	lb			
196.9			77.8	82.0	98.4	114.8	136.5	154.5	164.0	180.4	196.9	ft				
			52,910	49,730	39,920	33,000	26,450	26,450	24,710	22,130	19,990	lb				
164.0			77.8	82.0	98.4	114.8	136.5	155.2	164.0	ft						
			52,910	49,710	39,900	32,980	26,450	26,450	24,840	lb						
131.2			78.1	82.0	98.4	114.8	128.6	ft								
			52,910	49,860	40,030	33,090	28,720	lb								

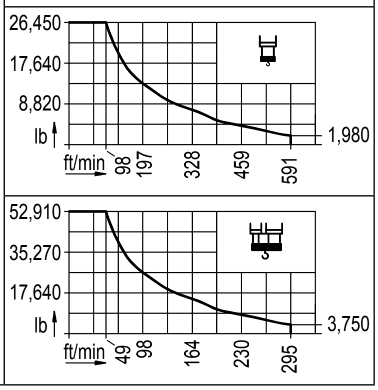


MECANISMOS
Mechanisms / Mécanismes / Antriebe / Meccanismi / Механизмы

2,100 ft

EFU6-65-60

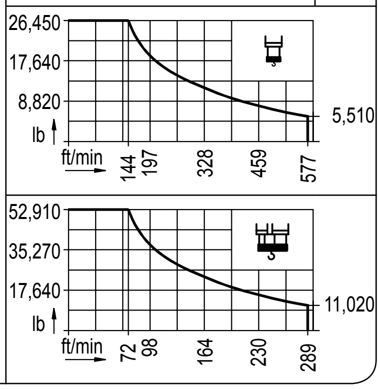
87 hp



2,100 ft

EFU4-110-60 *

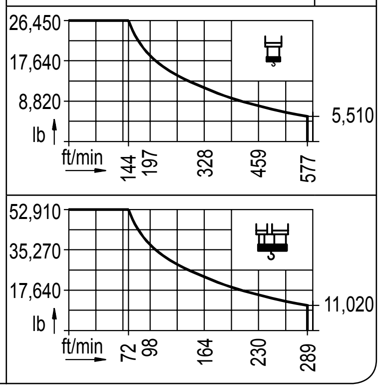
148 hp



4,755 ft

EFU4L-110-60 *

148 hp



MECANISMOS
Mechanisms / Mécanismes / Antriebe / Meccanismi / Механизмы

	CFU-7.5
	10 hp
0 ⇨ 262 ft/min	

	GFU-7.5
	4x 10 hp
0 ⇨ 0,7 rpm	

	TRA-7.5	TRA-7.5
	2x 55 ft·lb	4x 55 ft·lb
	0 ⇨ 78 ft/min	
	5XR43	7XR63 / 10XR83

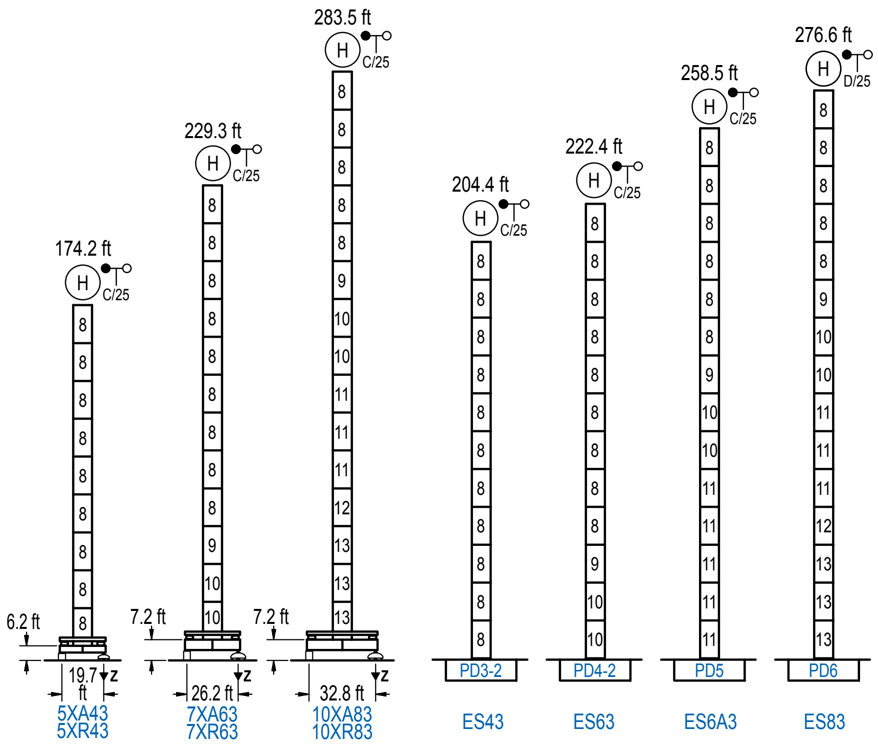
*	TRA-7.5VC	TRA-7.5VC
	2x 55 ft·lb	4x 55 ft·lb
	0 ⇨ 78 ft/min	
	5XR43	7XR63 / 10XR83

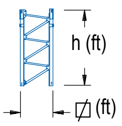
POTENCIA / POWER / PUISSANCE / LEISTUNG / POTENZA / МОЩЬНОСТЬ				Tensión de alimentación / Operating voltage / Tension de service / Betriebsspannung / Tensione di alimentazione / Напряжение источника питания	Generador / Generator / Générateur / Generator / Generatore / Генератор
Elevación / Hoist / Levage / Hub / Sollevamento / Тип механизма (подъем)	Carro / Trolley / Chariot / Laufkatze / Carrelo / Грузовая тележка	Giro / Slewing / Rotation / Drehbewegung / Rotazione / Поворот	Traslación / Travel / Translation / Verfahrbewegung / Traslazione / Ход		
EFU6-65-60	CFU-7.5	(4x) GFU-7.5	(2x) TRA-7.5	480 V	195 kVA
EFU4-110-60			(4x) TRA-7.5	3ph	260 kVA
EFU4L-110-60				60 Hz	260 kVA

Opcional / Optional / En option / Kaufoption / Opzionale / Опционально
*

ALTURAS BAJO GANCHO
Heights under hook / Hauteurs sous crochet / Hakenhöhen / Altezza sotto gancio / Высота под крюком

⌀ 8.2 ft

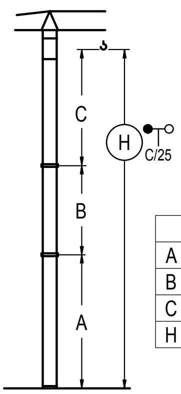




nº	Ref.	⌀	h
8	D33	8.2	18.0
9	TD34	8.2	18.0
10	D34	8.2	18.0
11	D35	8.2	18.0
12	TD36B	8.2	18.0
13	D36	8.2	18.0

Z máx.	En servicio / In operation / En service / In Betrieb / In servizio / При работе	5XR43.... 295 kip 7XR63.... 267 kip 10XR83.. 260 kip
	Fuera de servicio / Out of service / Hors service / Ausser Betrieb / Fuori servizio / В стационарном состоянии	5XR43.... 205 kip 7XR63.... 254 kip 10XR83.. 410 kip

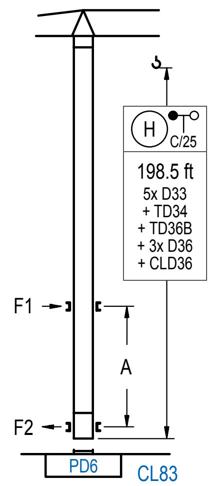
GRÚA ARRIOSTRADA
Braced crane / Grue à entretoisement / Abgespannter Kran / Gru ancorata / Наращиваемый кран

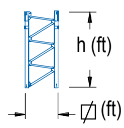


	5XA43		7XA63		10XA83	
A max	132.5		187.7		241.8	
B max	-	108.3	-	108.3	-	108.3
C max	168.0	149.9	149.9	149.9	149.9	149.9
H max	300.5	390.7	337.6	445.9	391.7	500.0

	ES43		ES63		ES6A3		ES83	
A max	49,6		55,1		66,1		71,6	
B max	-	108.3	-	108.3	-	108.3	-	108.3
C max	149.9	149.9	149.9	149.9	149.9	149.9	149.9	149.9
H max	312.7	420.9	330.7	439.0	366.8	475.1	384.8	493.1

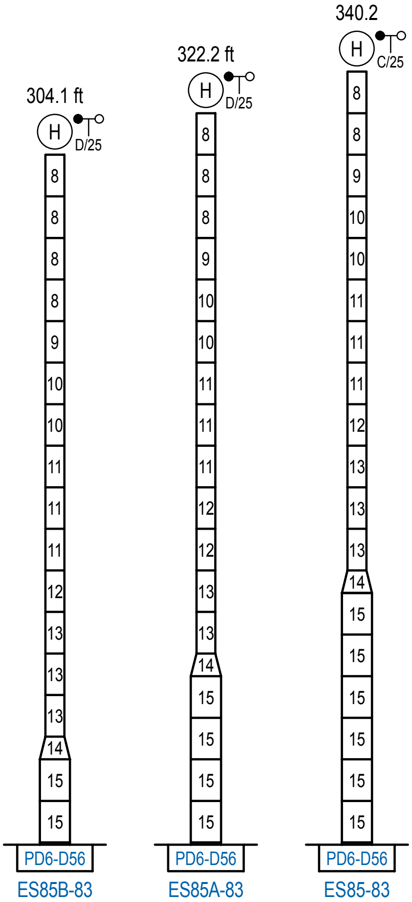
GRÚA TREPADORA
Internal climbing crane / Grue avec cage de télescopage intérieure / Kran mit klettern im Gebäude / Gru in rampante in cavedio / Монтажная клеть

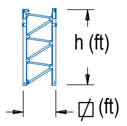




nº	Ref.	⌀	h
8	D33	8.2	18.0
9	TD34	8.2	18.0
12	TD36B	8.2	18.0
13	D36	8.2	18.0
19	CLD36	8.2	12.5

Otras zonas de viento, alturas superiores, arriostramientos o trepado interno consultar / Other wind zones , additional hook heights, tie frames or internal climbing on request / Autres zones de vent, des hauteurs supplémentaires, entretoisements où grues avec cage de télescopage intérieure, sur demande / Andere Windzonen, weitere Hakenhöhen, Abspannungen zum Gebäude oder Klettern im Gebäude auf Anfrage / Per zone con velocità del vento particolari, altezze superiori, ancoraggi o rampante in cavedio, consultare il fabbricante / При других ветренных зонах, при бόльшой высоте, привязках к зданию или наращивании крана внутри здания проконсультируйтесь с нами





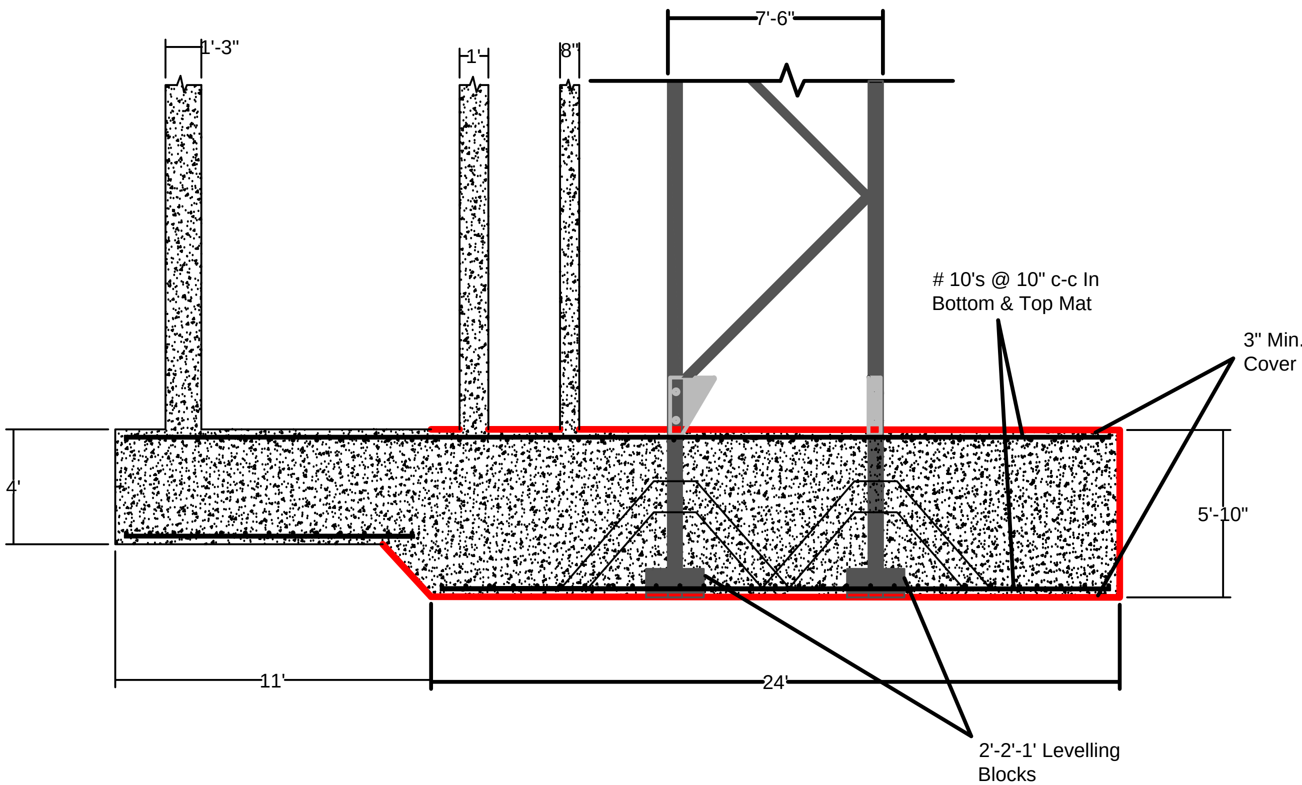
nº	Ref.	⍁	h
8	D33	8.2	18.0
9	TD34	8.2	18.0
10	D34	8.2	18.0
11	D35	8.2	18.0
12	TD36B	8.2	18.0
13	D36	8.2	18.0
14	TD56D36	13.1	9.8
15	D56	13.1	18.0

Otras zonas de viento o alturas superiores consultar / Other wind zones or additional hook heights on request / Autres zones de vent ou des hauteurs supplémentaires sur demande / Andere Windzonen oder weitere Hakenhöhen auf Anfrage / Per zone con velocità del vento particolari o altezze superiori consultare il fabbricante / При других ветренных зонах о при бóльшой высоте проконсультируйтесь с нами

LINDEN COMANSA
Construcciones Metálicas COMANSA S. A.
Tel.: (34) 948 335 020 / Fax: (34) 948 330 810 / e-mail: info@comansa.com
Polígono Urbizkain E-31620 HUARTE-PAMPLONA.- SPAIN

APPENDIX 2C – TOWER CRANE FOUNDATION CALCULATIONS AND DETAILS

TOWER CRANE A MAT DETAIL



Tower Crane Mat Design:

CRANE CONFIGURATION:

Model: LINDEN COMANSA 21 LC 550

Hook Height: 136.8 ft | Crane Mast Base Plan Dimension, Bc = 7.5 ft

Jib Reach: 262.4 ft

BASE FORCES AT TOP OF MAT:

	M		H		V		Md	
In Operation	3672	ft-kips	7	kips	277	kips	564	ft-kips
Out of Operation	3831	ft-kips	21	kips	257	kips	0	ft-kips
GOVERNING LOAD CONDITION:	3831	ft-kips	21	kips	277	kips	564	ft-kips

ALLOWABLE SOIL BEARING CAPACITY 4000 psf

MAT MATERIALS:

f'c= 5000 psi | **Fy=** 60 ksi | ASTM A615 Grade 60

Min. Cover 3 in

MAT SIZE ASSUMPTIONS:

Plan Size B x L **B=** 22.5 ft **L=** 24 ft

Thickness **D=** 5.833 ft

Mat Dead Load **Wm=** 472 kips (150 pcf x L x B x D)

Overturning Moment **Mot=** M+(HxDf) = 3831+(2*5.83)

Mot= 3953 ft-kips

Loading Eccentricity **e=** Mot/(V+Wm)>B/6 = 3953/(277+472)>20/6

e= 5.28 ft >B/6 3.75 => OK

Max Soil Stress **fbr max=** (2x(V+Wm)/(3xLx(B/2-e))) = (2*(277+472)/(3*24*(22.5/2-5.28))

fbr max= 3484 psf < Allowable Soil Bearing Capacity =>OK

COMPUTE SOIL STRESS @ FACE OF MAST

Edge Distance **Ed=** .5(B-Bc) = .5(22.5-7.5) **Lfbr =** 3(B/2-e) = 3(22.5/2-5.28)

Ed= 7.50 ft **Lfbr =** 17.92 ft

L2 Ed/2 = 7.50/2 **L1=** 2/3(B/2 - Bc/2) = 2/3(22.5/2 - 7.5/2)

L2 3.75 **L1=** 5.00 ft

fbrmast= fbrmax(Lfbr-B/2+Bc/2)/Lfbr = 3772(17.92-22.5/2+7.5/2)/17.92

fbrmast= 2026.44 psf

RESISTANCE TO OVERTURNING

Resisting Moments Mr= (Wm+V)B/2 = (472+277)22.5/2

Mr= 8431.571 ft-kips

Factor of Safety for Overturing (FSot)= Mr/Mot >= 1.5 = 8431.57/3953

FSot= 2.13

FSot= 2.13 => OK for Overturning

Design Reinforcement for Tower Crane Mat:

COMPUTE BENDING MOMENT FOR BOTTOM REBAR:

V1u= (fbrmax-fbrmast)(Ed/2)1.6 x L		V2u= (fbrmast) x Ed x 1.6 x L
V1u= ((3484-2026.44)(7.5/2)1.6*24)/1000		V2u= (2026.44*7.5*1.6*24)/1000
V1u= 209.93 kips		V2u= 583.6 kips
M1u= V1u x L1 = 209.93*5.00		M2u= V2u x L2 = 583.6*3.75
M1u= 1049.67 ft-kips		M2u= 2188.55 ft-kips

Total Mu= M1u + M2u = 1049.67 + 2188.55

Total Mu= 3238.226 ft-kips

TRY **See Rebar Calculations**

No. 11's Spaced at	10 in. oc	As= 42.1 in.^2	d= 66.29 in.
No. 10's Spaced at	10 in. oc	As= 34.2 in.^2	d= 66.36 in.
No. 9's Spaced at	10 in. oc	As= 27.0 in.^2	d= 66.44 in.
No. 8's Spaced at	10 in. oc	As= 21.4 in.^2	d= 66.50 in.

TRIAL SECTION No. 10 10 in. oc As= 34.2 in.^2 d= 66.36 in.

ΦMn= 0.9(AsFy(d-AsFy/(1.7f'cB)))>=Increased Mu

ΦMn= (0.9(34.2*60*(66.36-(34.2*60/(1.7*(5000/1000)*22.5*12))))/12)>=Increased Mu

ΦMn= 10075.2 ft-kips

Total Mu= 3238.226 ft-kips

=> OK

USE: #10's @10" O.C. IN BOTTOM MAT

COMPUTE BENDING MOMENT FOR TOP REBAR:

Vu= D*0.150kcf*Ed*L*1.6 =5.83*0.150kcf*7.5*24*1.6

Vu= 251.9856 kips

Mu= Vu*Ed/2 = 251.99*7.5/2

Mu= 944.95 ft-kips

TRY

No. 10's Spaced at	10 in. oc	As= 34.2 in.^2	d= 66.36 in.
No. 9's Spaced at	10 in. oc	As= 27.0 in.^2	d= 66.44 in.
No. 8's Spaced at	10 in. oc	As= 21.4 in.^2	d= 66.50 in.

TRIAL SECTION No. 10 10 in. oc As= 34.2 in.^2 d= 66.36 in.

ΦMn= 0.9(AsFy(d-AsFy/(1.7f'cB)))>=Increased Mu

ΦMn= (0.9(34.2*60*(66.36-(34.2*60/(1.7*(5000/1000)*22.5*12))))/12)>=Increased Mu

ΦMn= 10075.2 ft-kips

Total Mu= 944.95 ft-kips

=> OK

USE: #10's @10" O.C. IN TOP MAT

COMPUTE MINIMUM TEMPERATURE & SHRINKAGE REINFORCEMENT

Asmin= 0.0018 x B x D = 0.0018*22.5*12*5.83*12

Asmin= 34.01806 in.^2

As (top) + As (bot)= 68.4 in.^2 >Asmin => OK

Check Resistance to Slewing Moment:

Resisting force is assumed to be a triangular force distribution on all four sides as developed by passive soils

Soil Unit Weight:	γ=	120	pcf		
Friction Angle	Φ=	30	degrees		
	Kp=	tan^2(45+Φ/2)			
	Kp=	tan^2(45+30/2)			
	Kp=	3.00			
Max. Allow. Resisting Pressure	Qr=	0.5 x Kp x γ x Df^2			
	Qr=	(0.5*3.00*125*5.83^2)/1000			
	Qr=	6.12	kips/LF		
Resistance Along B Side of Footing	Mrb=	Qr(B/2)	Moment Arm	Br=	B/3
	Mrb=	6.12(22.5/2)		Br=	22.5/3
	Mrb=	68.90	kips	Br=	7.50 ft
Resistance Along L Side of Footing	Mrl=	Qr(L/2)	Moment Arm	Lr=	L/3
	Mrl=	6.12(24/2)		Lr=	24/3
	Mrl=	73.49	kips	Lr=	8.00 ft
Resisting Moments	ΣMr=	2((Mrb x Br) + (Mrl x Lr))			
	ΣMr=	2((68.9*7.50) + (73.49*8.00))			
	ΣMr=	2209.34	kips		
	FSsm=	ΣMr/Md >=1.5			
	FSsm=	2209.34/564			
	FSsm=	3.92	=> OK for Slewing Moment		

Check Shear in the Mat Slab:

CHECK ONE WAY SHEAR IN THE MAT:

Shear Area

Av= L x (D-6)

Av= 24*12*((5.83*12)-6)

Av= 18430.85 in^2

Vu= V1u + V2u

Vu= 209.93 + 583.6

Vu= 793.55 kips

fvu= Vu/Av

fvu= (793.55/18430.85)*1000

fvu= 43.06 psi

ΦVu= 0.85(2)(f'c^0.5)

ΦVu= 0.85*2*(5000^0.5)

ΦVu=	120.21	psi	>fvu => OK in Shear

CHECK PUNCHING SHEAR AT ERECTION:

f'c= 2000 psi MINIMUM

Critical Section

Bo= 4 sides (Bc + d) Punching shear control for this temporary condition

Bo= 4 sides (7.5 + 66.36)

Bo= 625.44 in.

Vu= 1.6V

Vu= 1.6*277

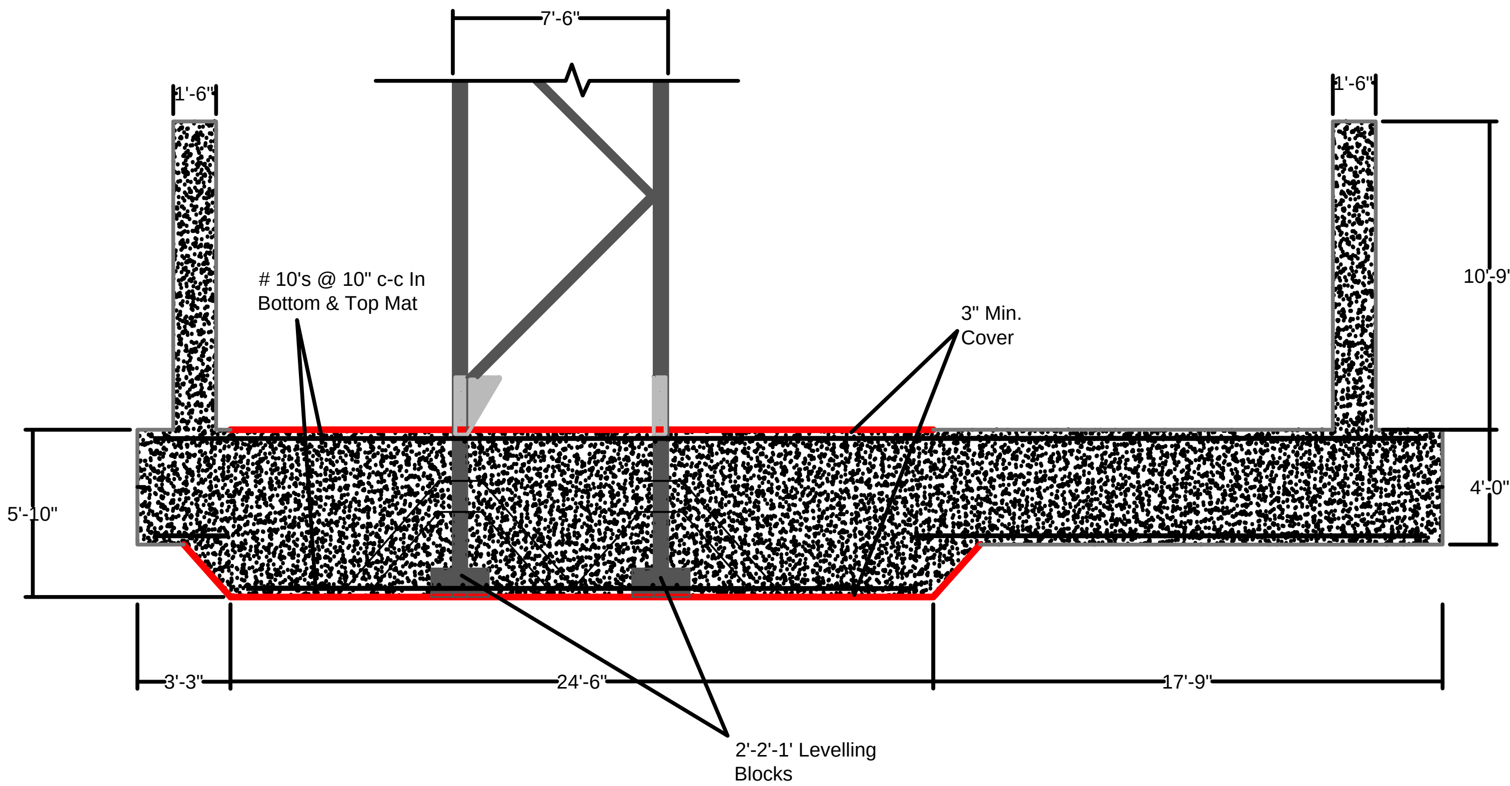
Vu= 443.2 kips

ΦVc= 0.85(4)(f'c^0.5)(Bo)(d)

ΦVc= (0.85*4*(5000^0.5)*625.44*66.36)/1000

ΦVc=	9978	kips	>Vu => OK for Punching Shear at Erection

TOWER CRANE B MAT DETAIL



Tower Crane Mat Design:

CRANE CONFIGURATION:

Model: LINDEN COMANSA 21 LC 550

Hook Height: 172.9 ft | Crane Mast Base Plan Dimension, Bc = 7.5 ft

Jib Reach: 262.4 ft

BASE FORCES AT TOP OF MAT:

	M	H	V	Md
In Operation	4112 ft-kips	8 kips	296 kips	564 ft-kips
Out of Operation	4770 ft-kips	26 kips	277 kips	0 ft-kips
GOVERNING LOAD CONDITION:	4770 ft-kips	26 kips	296 kips	564 ft-kips

ALLOWABLE SOIL BEARING CAPACITY= 4000 psf

MAT MATERIALS:

f'c= 5000 psi | **Fy=** 60 ksi | ASTM A615 Grade 60

Min. Cover 3 in

MAT SIZE ASSUMPTIONS:

Plan Size B x L | **B=** 24.5 ft | **L=** 24.5 ft

Thickness | **D=** 5.833 ft

Mat Dead Load | **Wm=** 525 kips (150 pcf x L x B x D)

Overturning Moment | **Mot=** M+(HxDf) = 4770+(26*5.83)

Mot= 4922 ft-kips

Loading Eccentricity | **e=** Mot/(V+Wm)>B/6 = 4922/(296+525)>24.5/6

e= 5.99 ft >B/6 4.08 => OK

Max Soil Stress | **fbr max=** (2x(V+Wm)/(3xLx(B/2-e))) = (2*(296+525)/(3*24.5*(24.5/2-5.99))

fbr max= 3571 psf < Allowable Soil Bearing Capacity =>OK

COMPUTE SOIL STRESS @ FACE OF MAST

Edge Distance | **Ed=** .5(B-Bc) = .5(24.5-7.5) | **Lfbr =** 3(B/2-e) = 3(24.5/2-5.99)

Ed= 8.50 ft | **Lfbr =** 18.77 ft

L2 Ed/2 = 8.5/2 | **L1=** 2/3(B/2 - Bc/2) = 2/3(24.5/2 - 7.5/2)

L2 4.25 | **L1=** 5.67 ft

fbrmast= fbrmax(Lfbr-B/2+Bc/2)/Lfbr = 3571(18.77-24.5/2+7.5/2)/18.77

fbrmast= 1954.11 psf

RESISTANCE TO OVERTURNING

Resisting Moments | Mr= (Wm+V)B/2 = (525+296)24.5/2

Mr= 10059.562 ft-kips

Factor of Safety for Overturning (FSot)= Mr/Mot >= 1.5 = 10059.56/4922

FSot= 2.04

FSot= 2.04 => OK for Overturning

Design Reinforcement for Tower Crane Mat:

COMPUTE BENDING MOMENT FOR BOTTOM REBAR:

V1u=	(fbrmax-fbrmast)(Ed/2)1.6 x L		V2u=	(fbrmast) x Ed x 1.6 x L
V1u=	((3571-1954.11)(8.5/2)1.6*24.5)/1000		V2u=	(1954.11*8.50*1.6*24.5)/1000
V1u=	269.45	kips	V2u=	651.1 kips
M1u=	V1u x L1 = 269.45*5.67		M2u=	V2u x L2 = 651.1*4.25
M1u=	1526.86	ft-kips	M2u=	2767.21 ft-kips

Total Mu= M1u + M2u = 1526.86 + 2767.21

Total Mu= 4294.0765 ft-kips

TRY **See Rebar Calculations**

No. 11's Spaced at	10 in. oc	As= 45.8 in.^2	d=	66.29 in.
No. 10's Spaced at	10 in. oc	As= 37.2 in.^2	d=	66.36 in.
No. 9's Spaced at	10 in. oc	As= 29.4 in.^2	d=	66.44 in.
No. 8's Spaced at	10 in. oc	As= 23.3 in.^2	d=	66.50 in.

TRIAL SECTION No. 10 10 in. oc As= 37.2 in.^2 d= 66.36 in.

ΦMn= 0.9(AsFy(d-AsFy/(1.7f'cB)))>=Increased Mu

ΦMn= (0.9(37.2*60*(66.36-(37.2*60/(1.7*(5000/1000)*24.5*12))))/12)>=Increased Mu

ΦMn= 10970.773 ft-kips => OK

Total Mu= 4294.0765 ft-kips

USE: #10's @10" O.C. IN BOTTOM MAT

COMPUTE BENDING MOMENT FOR TOP REBAR:

Vu= D*0.150kcf*Ed*L*1.6 =5.83*0.150kcf*8.50*24.5*1.6

Vu= 291.53334 kips

Mu= Vu*Ed/2 = 291.53*8.50/2

Mu= 1239.02 ft-kips

TRY **See Rebar Calculations**

No. 11's Spaced at	10 in. oc	As= 45.8 in.^2	d=	66.29 in.
No. 10's Spaced at	10 in. oc	As= 37.2 in.^2	d=	66.36 in.
No. 9's Spaced at	10 in. oc	As= 29.4 in.^2	d=	66.44 in.
No. 8's Spaced at	10 in. oc	As= 23.3 in.^2	d=	66.50 in.

TRIAL SECTION No. 10 10 in. oc As= 37.2 in.^2 d= 66.36 in.

ΦMn= 0.9(AsFy(d-AsFy/(1.7f'cB)))>=Increased Mu

ΦMn= (0.9(37.2*60*(66.36-(37.2*60/(1.7*5000/1000*24.5*12))))/12)>=Increased Mu

ΦMn= 10970.773 ft-kips => OK

Total Mu= 1239.02 ft-kips

USE: #10's @10" O.C. IN TOP MAT

COMPUTE MINIMUM TEMPERATURE & SHRINKAGE REINFORCEMENT

Asmin= 0.0018 x B x D = 0.0018*24.5*12*5.83*12

Asmin= 37.04 in.^2

As (top) + As (bot)= 74.5 in.^2 >Asmin => OK

Check Resistance to Slewing Moment:

Resisting force is assumed to be a triangular force distribution on all four sides as developed by passive soils

Soil Unit Weight:	γ=	120	pcf			
Friction Angle	Φ=	30	degrees			
	Kp=	tan^2(45+Φ/2)				
	Kp=	tan^2(45+30/2)				
	Kp=	3.00				
Max. Allow. Resisting Pressure	Qr=	0.5 x Kp x γ x Df^2				
	Qr=	(0.5*3.00*120*5.83^2)/1000				
	Qr=	6.12	kips/LF			
Resistance Along B Side of Footing	Mrb=	Qr(B/2)		Moment Arm	Br=	B/3
	Mrb=	6.12(24.5/2)			Br=	24.5/3
	Mrb=	75.02	kips		Br=	8.17 ft
Resistance Along L Side of Footing	Mrl=	Qr(L/2)		Moment Arm	Lr=	L/3
	Mrl=	6.12(24.5/2)			Lr=	24.5/3
	Mrl=	75.02	kips		Lr=	8.17 ft
Resisting Moments	ΣMr=	2((Mrb x Br) + (Mrl x Lr))				
	ΣMr=	2((75.02*8.17) + (75.02*8.17))				
	ΣMr=	2450.74	kips			
	FSsm=	ΣMr/Md	>=1.5			
	FSsm=	2450.74/564				
	FSsm=	4.35	=> OK for Slewing Moment			

Check Shear in the Mat Slab:

CHECK ONE WAY SHEAR IN THE MAT:

Shear Area

Av= L x (D-6)

Av= 24.5*12*((5.83*12)-6)

Av= 18814.824 in^2

Vu= V1u + V2u

Vu= 269.45+ 655.1

Vu= 920.56 kips

fvu= Vu/Av

fvu= 920.56/18814.82*1000

fvu= 48.93 psi

ΦVu= 0.85(2)(f'c^0.5)

ΦVu= 0.85*2*(5000^0.5)

ΦVu= 120.21 psi >fvu => OK in Shear

CHECK PUNCHING SHEAR AT ERECTION:

f'c= 2000 psi MINIMUM

Critical Section Bo= 4 sides (Bc + d) Punching shear control for this temporary condition

Bo= 4 sides ((7.5*12) + 66.36)

Bo= 625.44 in.

Vu= 1.6V

Vu= 1.6*296

Vu= 473.6 kips

ΦVc= 0.85(4)(f'c^0.5)(Bo)(d)

ΦVc= (0.85*4*(5000^0.5)*625.44*66.36)/1000

ΦVc= 9978 kips >Vu => OK for Punching Shear at Erection

Tower Crane A

REBAR CALCULATIONS D= 70 in. Min. Cvr. = 3.0 in.

Bar	Spacing	As(bar)	Ftg. B	Tot. As	Diam. (bar)	Depth (d)
				As*(Ftg. L -2)		D-Min.Cvr.-Diam/2
No. 11's	10 in. oc	1.87	22.5	42.1	1.410	66.30
No. 10's	10 in. oc	1.52	22.5	34.2	1.270	66.37
No. 9's	10 in. oc	1.20	22.5	27.0	1.128	66.44
No. 8's	10 in. oc	0.95	22.5	21.4	1.000	66.50

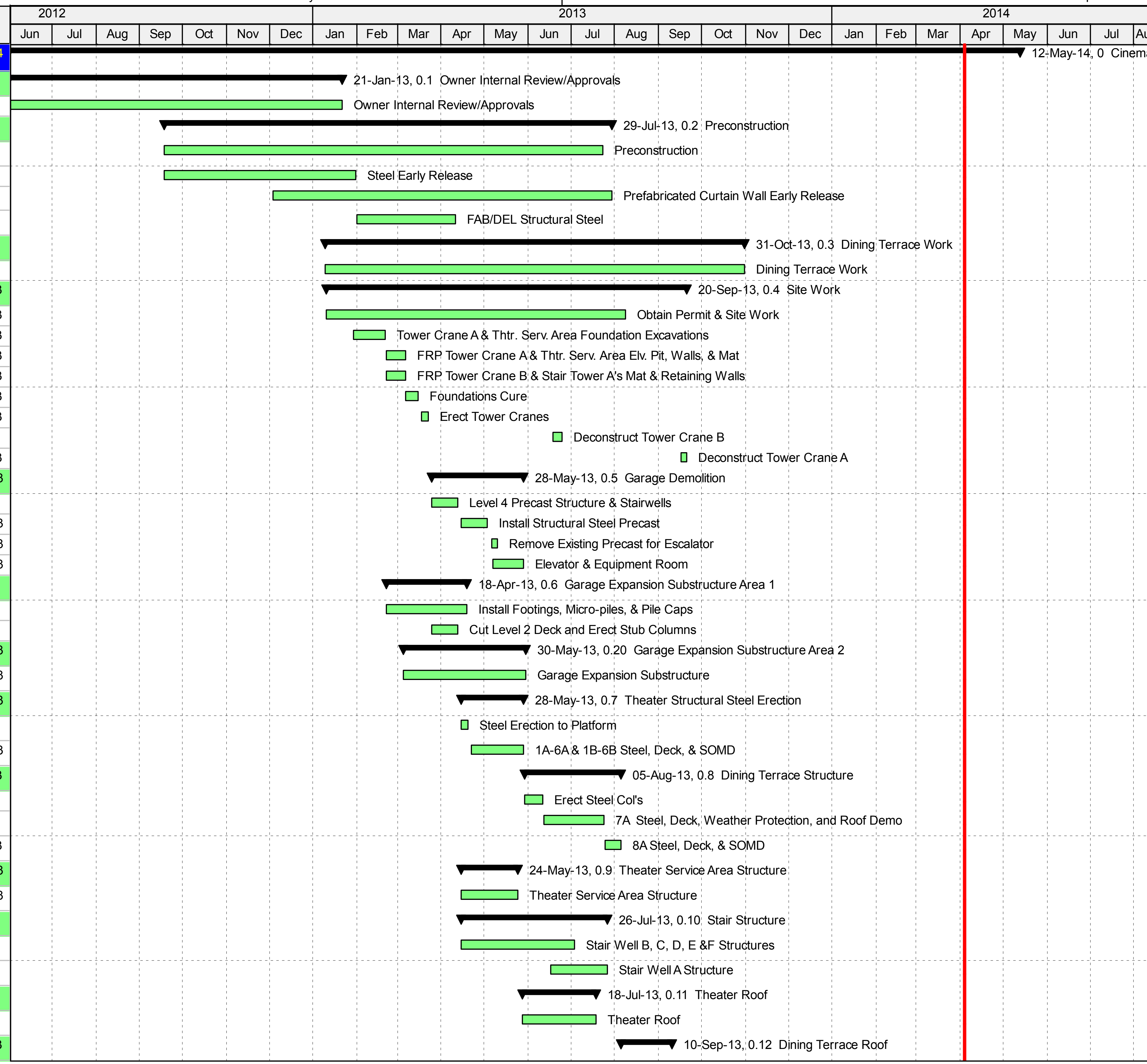
Tower Crane B

REBAR CALCULATIONS D= 70 in. Min. Cvr. = 3.0 in.

Bar	Spacing	As(bar)	Ftg. B	Tot. As	Diam. (bar)	Depth (d)
				As*(Ftg. B -2)		D-Min.Cvr.-Diam/2
No. 11's	10 in. oc	1.87	24.5	45.8	1.410	66.30
No. 10's	10 in. oc	1.52	24.5	37.2	1.270	66.37
No. 9's	10 in. oc	1.20	24.5	29.4	1.128	66.44
No. 8's	10 in. oc	0.95	24.5	23.3	1.000	66.50

APPENDIX 2D – NEW PROJECT SCHEDULE

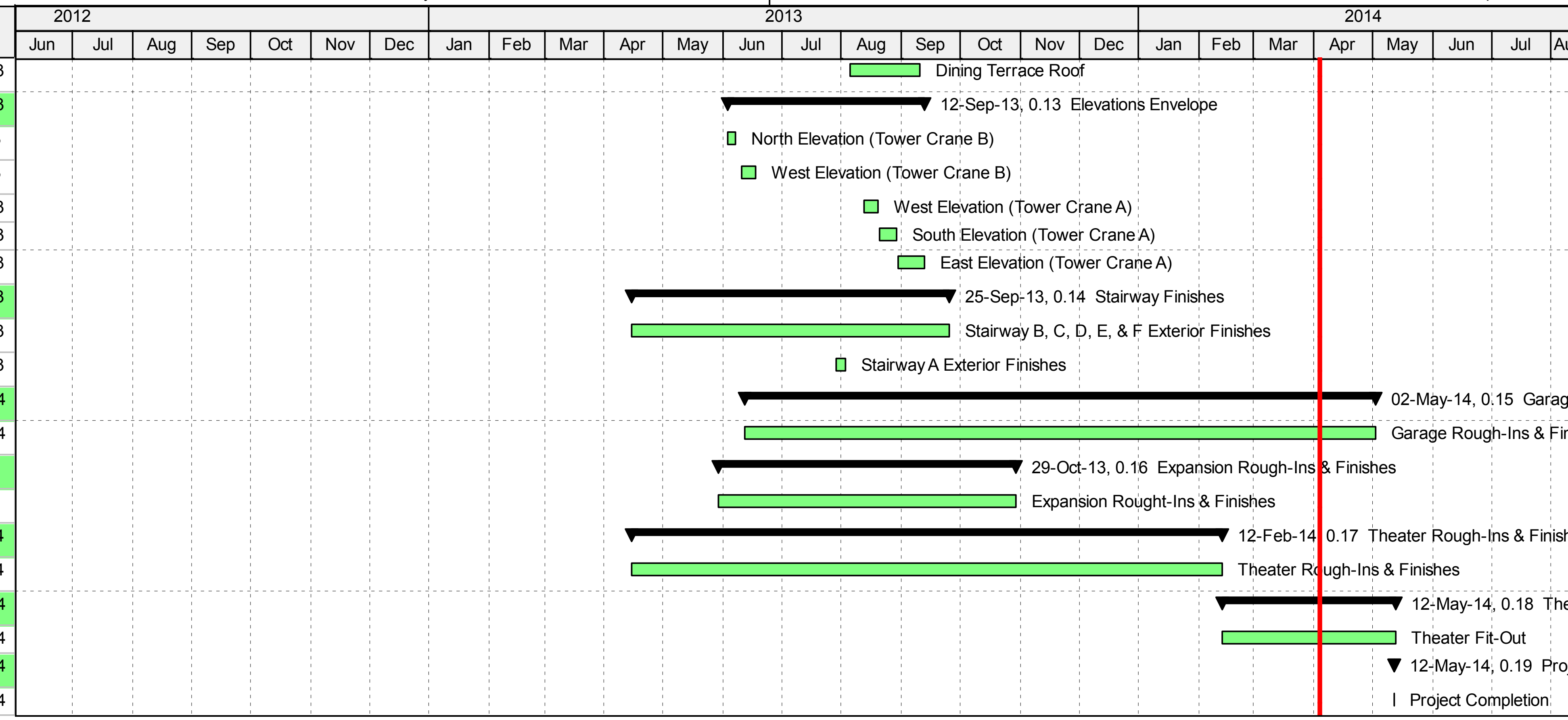
Activity Name	Original Duration	Start	Finish
0 Cinema Dining Terrace Expansion Summary	497	01-Jun-12	12-May-14
0.1 Owner Internal Review/Approvals	162	01-Jun-12	21-Jan-13
Owner Internal Review/Approvals	162	01-Jun-12	21-Jan-13
0.2 Preconstruction	220	18-Sep-12	29-Jul-13
Preconstruction	216	18-Sep-12	23-Jul-13
Steel Early Release	94	18-Sep-12	30-Jan-13
Prefabricated Curtain Wall Early Release	167	03-Dec-12	29-Jul-13
FAB/DEL Structural Steel	50	31-Jan-13	10-Apr-13
0.3 Dining Terrace Work	209	09-Jan-13	31-Oct-13
Dining Terrace Work	209	09-Jan-13	31-Oct-13
0.4 Site Work	179	10-Jan-13	20-Sep-13
Obtain Permit & Site Work	149	10-Jan-13	08-Aug-13
Tower Crane A & Thtr. Serv. Area Foundation Excavations	17	29-Jan-13	20-Feb-13
FRP Tower Crane A & Thtr. Serv. Area Elv. Pit, Walls, & Mat	10	21-Feb-13	06-Mar-13
FRP Tower Crane B & Stair Tower A's Mat & Retaining Walls	10	21-Feb-13	06-Mar-13
Foundations Cure	7	07-Mar-13	15-Mar-13
Erect Tower Cranes	5	18-Mar-13	22-Mar-13
Deconstruct Tower Crane B	5	18-Jun-13	24-Jun-13
Deconstruct Tower Crane A	5	16-Sep-13	20-Sep-13
0.5 Garage Demolition	46	25-Mar-13	28-May-13
Level 4 Precast Structure & Stairwells	15	25-Mar-13	12-Apr-13
Install Structural Steel Precast	15	15-Apr-13	03-May-13
Remove Existing Precast for Escalator	5	06-May-13	10-May-13
Elevator & Equipment Room	15	07-May-13	28-May-13
0.6 Garage Expansion Substructure Area 1	41	21-Feb-13	18-Apr-13
Install Footings, Micro-piles, & Pile Caps	41	21-Feb-13	18-Apr-13
Cut Level 2 Deck and Erect Stub Columns	15	25-Mar-13	12-Apr-13
0.20 Garage Expansion Substructure Area 2	62	05-Mar-13	30-May-13
Garage Expansion Substructure	62	05-Mar-13	30-May-13
0.7 Theater Structural Steel Erection	31	15-Apr-13	28-May-13
Steel Erection to Platform	5	15-Apr-13	19-Apr-13
1A-6A & 1B-6B Steel, Deck, & SOMD	26	22-Apr-13	28-May-13
0.8 Dining Terrace Structure	48	29-May-13	05-Aug-13
Erect Steel Col's	10	29-May-13	11-Jun-13
7A Steel, Deck, Weather Protection, and Roof Demo	30	12-Jun-13	24-Jul-13
8A Steel, Deck, & SOMD	8	25-Jul-13	05-Aug-13
0.9 Theater Service Area Structure	30	15-Apr-13	24-May-13
Theater Service Area Structure	30	15-Apr-13	24-May-13
0.10 Stair Structure	73	15-Apr-13	26-Jul-13
Stair Well B, C, D, E &F Structures	57	15-Apr-13	03-Jul-13
Stair Well A Structure	29	17-Jun-13	26-Jul-13
0.11 Theater Roof	37	28-May-13	18-Jul-13
Theater Roof	37	28-May-13	18-Jul-13
0.12 Dining Terrace Roof	26	05-Aug-13	10-Sep-13



Actual Level of Effort | Remaining Work | ◆ Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

Activity Name	Original Duration	Start	Finish
Dining Terrace Roof	26	05-Aug-13	10-Sep-13
0.13 Elevations Envelope	72	03-Jun-13	12-Sep-13
North Elevation (Tower Crane B)	5	03-Jun-13	07-Jun-13
West Elevation (Tower Crane B)	6	10-Jun-13	17-Jun-13
West Elevation (Tower Crane A)	6	12-Aug-13	19-Aug-13
South Elevation (Tower Crane A)	8	20-Aug-13	29-Aug-13
East Elevation (Tower Crane A)	9	30-Aug-13	12-Sep-13
0.14 Stairway Finishes	115	15-Apr-13	25-Sep-13
Stairway B, C, D, E, & F Exterior Finishes	115	15-Apr-13	25-Sep-13
Stairway A Exterior Finishes	5	29-Jul-13	02-Aug-13
0.15 Garage Rough-Ins & Finishes	229	12-Jun-13	02-May-14
Garage Rough-Ins & Finishes	229	12-Jun-13	02-May-14
0.16 Expansion Rough-Ins & Finishes	108	29-May-13	29-Oct-13
Expansion Rought-Ins & Finishes	108	29-May-13	29-Oct-13
0.17 Theater Rough-Ins & Finishes	213	15-Apr-13	12-Feb-14
Theater Rough-Ins & Finishes	213	15-Apr-13	12-Feb-14
0.18 Theater Fit-out	64	12-Feb-14	12-May-14
Theater Fit-Out	64	12-Feb-14	12-May-14
0.19 Project Completion	0	12-May-14	12-May-14
Project Completion	0	12-May-14	12-May-14



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

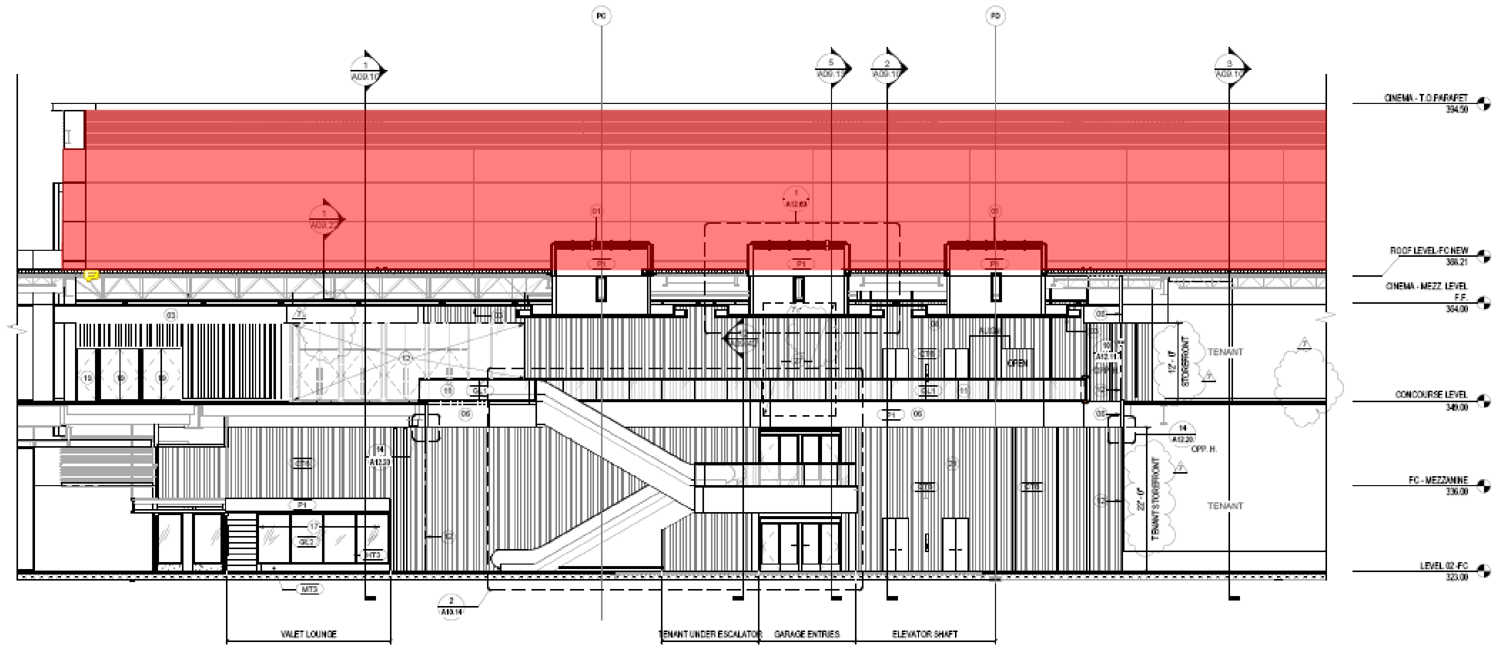
TASK filter: All Activities

APPENDIX 2E – TOWER CRANE LOGISTICS COSTS

New Tower Crane Logistics														
			Equipment					Labor					**Total**
			Tower Crane		Hydro Crane			Crane Operator		Laborers			
Activity	Duration	Unit	Qty	Rate	Qty	Rate	Total	Qty	Rate	Qty	Rate	Total	
Tower Crane Erection	3	days	2	$1,200.00	2	$5,000.00	$37,200.00	2	$960.00	14	$336.00	$19,872.00	$57,072.00
Demolition	15	days	2	$1,200.00	0	$5,000.00	$36,000.00	2	$960.00	14	$336.00	$99,360.00	$135,360.00
Steel Erection (1A-6A & 1B-6B)	25	days	2	$1,200.00	0	$5,000.00	$60,000.00	2	$960.00	14	$624.00	$266,400.00	$326,400.00
Steel Erection (7A, 8A)	47	days	1	$1,200.00	0	$5,000.00	$56,400.00	1	$960.00	7	$624.00	$250,416.00	$306,816.00
Curtain Wall Installation	37	days	2	$1,200.00	0	$5,000.00	$88,800.00	2	$960.00	14	$336.00	$245,088.00	$333,888.00
													$1,159,536.00

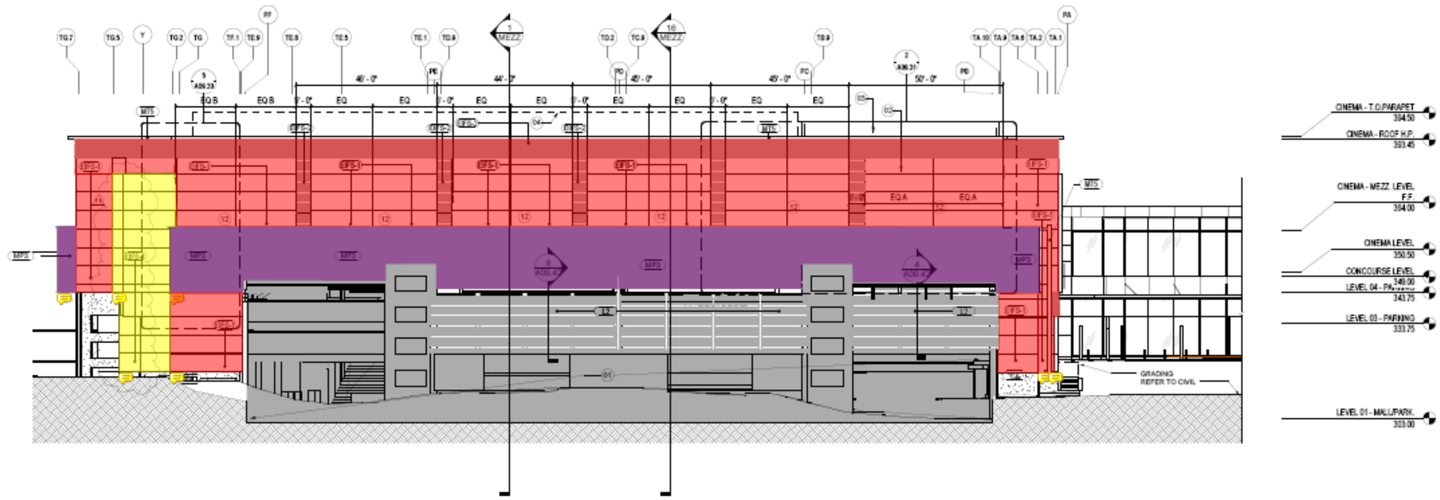
Original Tower Crane Logistics													
			Equipment					Labor					**Total**
			Tower Crane		Hydro Crane			Crane Operator		Laborers			
Activity	Duration	Unit	Qty	Rate	Qty	Rate	Total	Qty	Rate	Qty	Rate	Total	
Tower Crane Erection	3	days	1	$1,200.00	1	$5,000.00	$18,600.00	1	$960.00	7	$336.00	$9,936.00	$28,536.00
Demolition	15	days	0	$1,200.00	2	$5,000.00	$150,000.00	2	$960.00	14	$336.00	$99,360.00	$249,360.00
Steel Erection (1A-6A & 1B-6B)	52	days	1	$1,200.00	0	$5,000.00	$62,400.00	2	$960.00	14	$624.00	$554,112.00	$616,512.00
Steel Erection (7A, 8A)	47	days	1	$1,200.00	0	$5,000.00	$56,400.00	1	$960.00	7	$624.00	$250,416.00	$306,816.00
Curtain Wall Installation	122	days	0	$1,200.00	0	$5,000.00	$0.00	0	$960.00	14	$336.00	$573,888.00	$573,888.00
													$1,775,112.00

APPENDIX 3A – EXTERIOR ENVELOPE ELEVATIONS



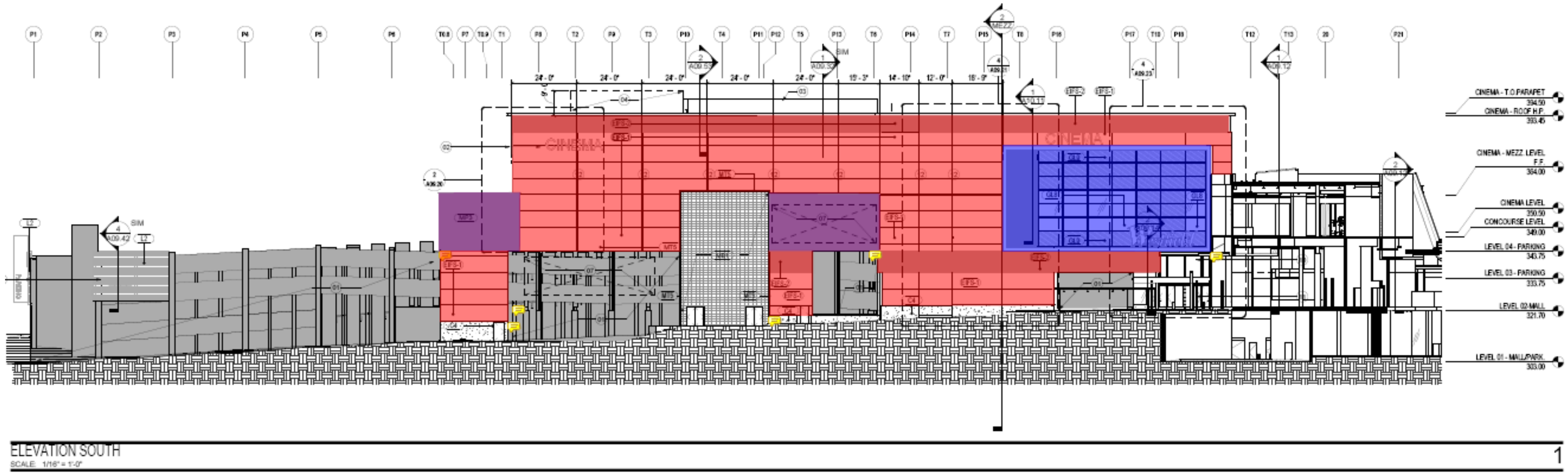
BUILDING SECTION NORTH-SOUTH LOOKING WEST - FOOD COURT
SCALE: 1/8" = 1'-0"

East Theater Elevation



ELEVATION WEST
SCALE: 1/16" = 1'-0"

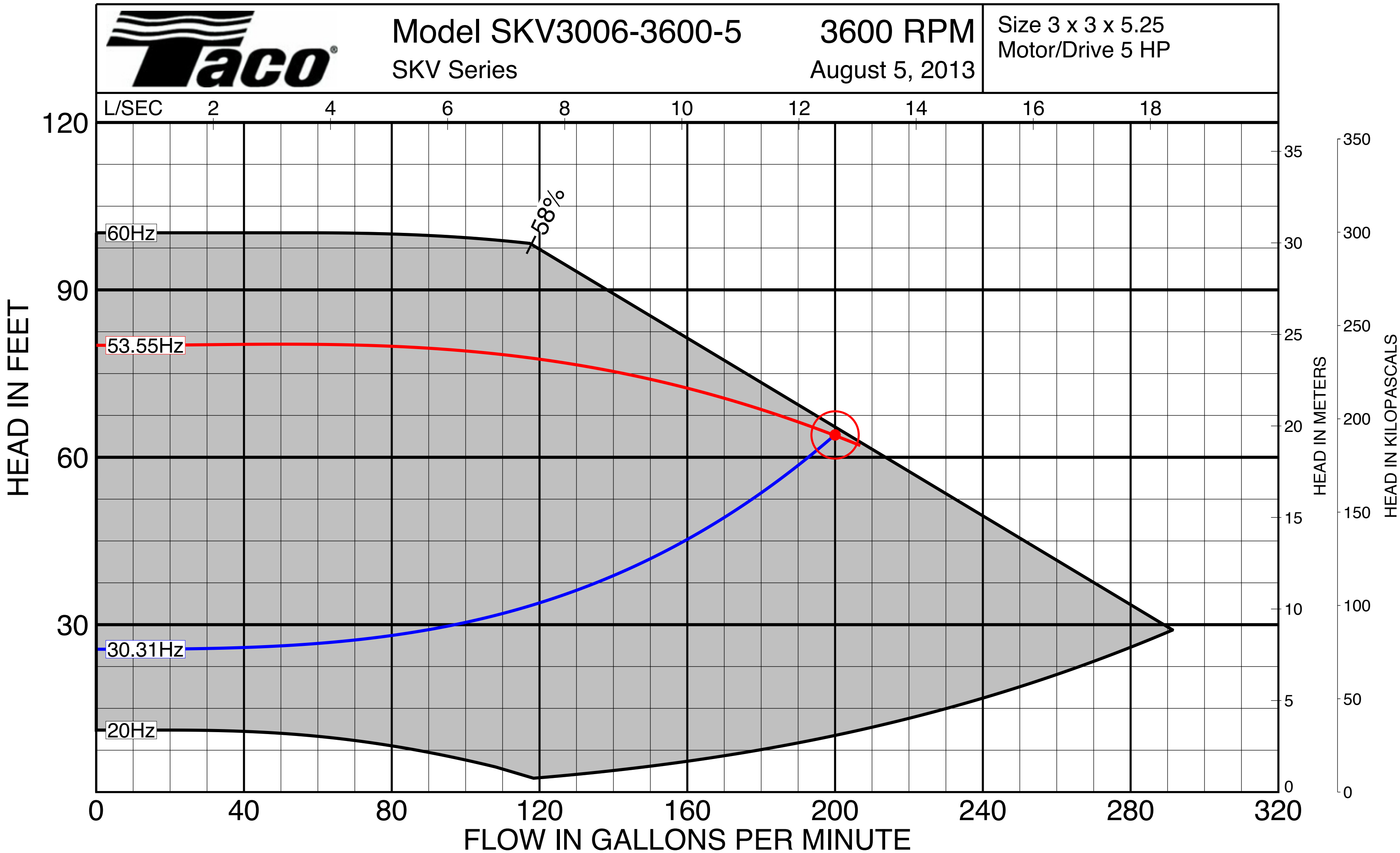
West Theater Elevation



South Theater Elevation

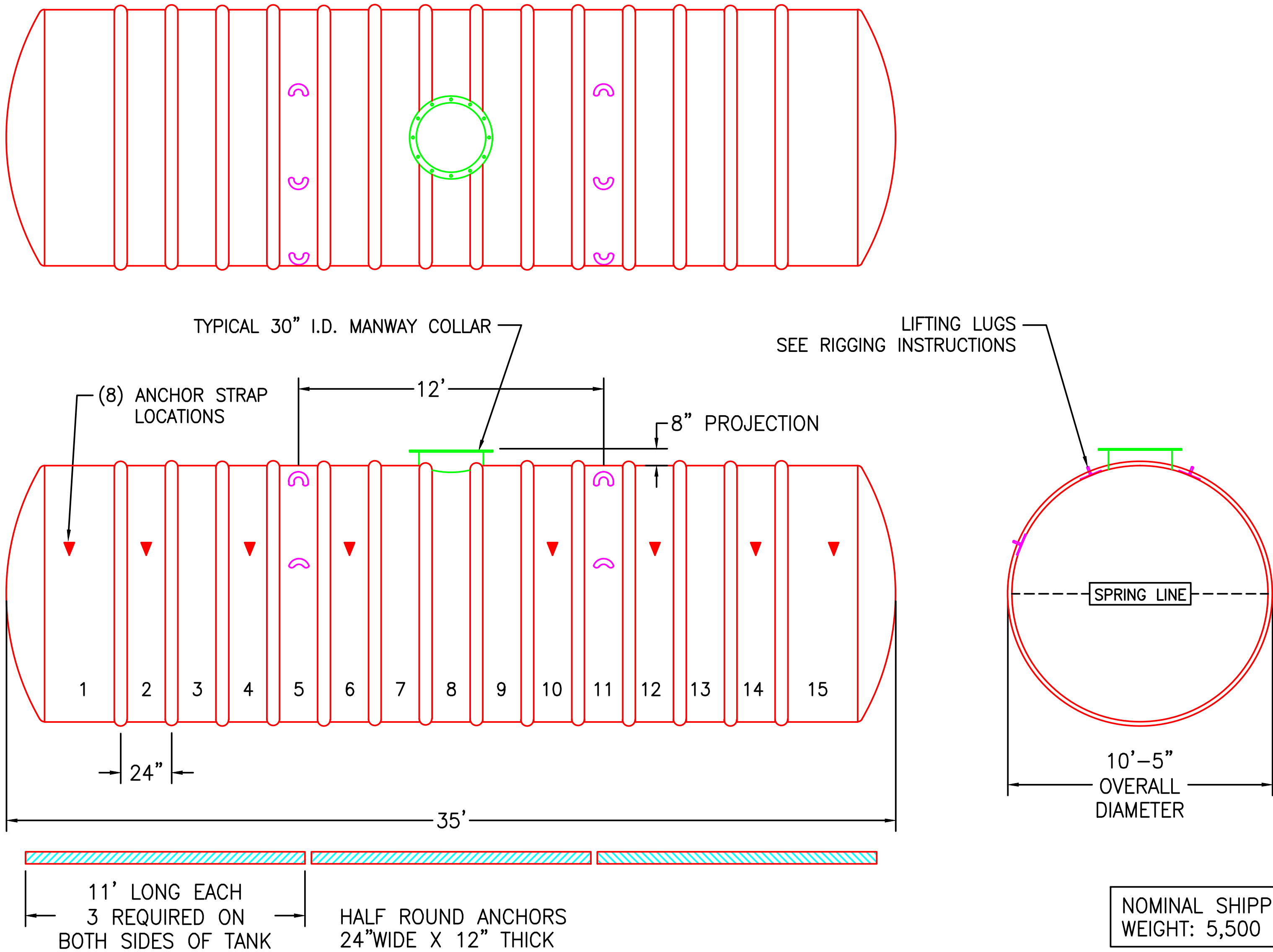
North Theater Elevation

APPENDIX 4A – STORAGE TANK PUMP CURVE



Taco
Model SKV3006-3600-5
SKV Series
3600 RPM
August 5, 2013
Size 3 x 3 x 5.25
Motor/Drive 5 HP
L/SEC
2
4
6
8
10
12
14
16
18
120
90
60
30
HEAD IN FEET
58%
60Hz
53.55Hz
30.31Hz
20Hz
35
30
25
20
15
10
5
0
HEAD IN METERS
350
300
250
200
150
100
50
0
HEAD IN KILOPASCALS
0
40
80
120
160
200
240
280
320
FLOW IN GALLONS PER MINUTE

APPENDIX 4B – RAINWATER STORAGE TANK DETAIL



NOMINAL SHIPPING WEIGHT: 5,500 POUNDS

WARNING

- DEADMAN ANCHORING SYSTEMS APPLY ONLY TO LOCATIONS WHERE GROUND WATER WILL NOT RISE ABOVE "SPRING LINE".
- MINIMUM SOIL DEPTH ABOVE TANK, WHEN USING DEADMAN ANCHORS, IS 2 FEET.
- CONFIRM ANCHOR SIZE AND TYPE ON "ANTI-FLOATATION ANCHORS" DETAIL DRAWING.

KEY	
LIFT LUG	⋂
ANCHOR STRAP	▼
DEADMAN	▨

DARCO INC UNDERGROUND TANKAGE

Rev Date		Rev. No.
06/05/07	10'-0" I.D. 20,000 GAL. FIBERGLASS HORIZONTAL TANK	A

980 Darco Drive, Bennett, Colorado 80102
800-232-8660 (phone) 303-644-5001 (fax)

APPENDIX 4C – FIBERGLASS TANK INSTALLATION BRIEF

DARCO INC UNDERGROUND TANKAGE
P.O. Box 779
980 Darco Drive
Bennett, CO 80102

Technical Support
800-232-8660 ext. 9

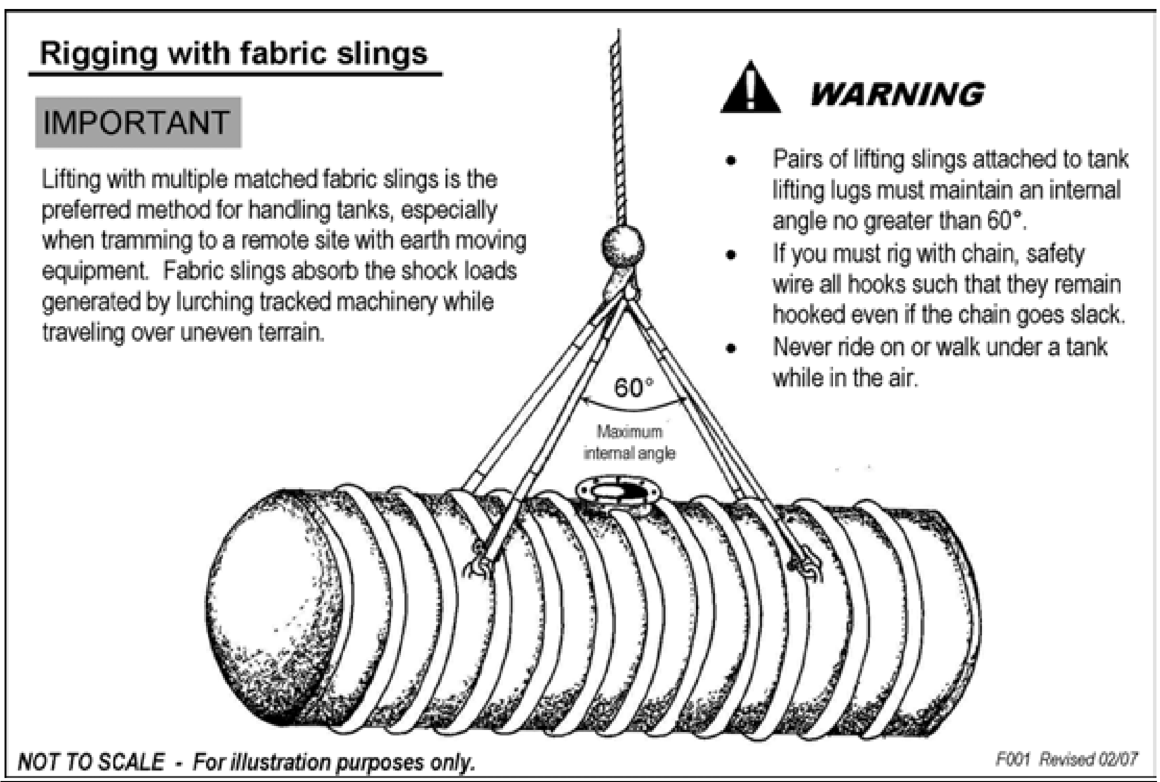
Fiberglass Tank Installation Brief

You will find the following preliminary tank installation information helpful when making plans for your water storage project. A complete Installation Manual will be forwarded to you upon receipt of a tankage order. Please review this information with your installation contractor and contact Darco for additional information or specific details regarding this process.

DELIVERY OF YOUR FIBERGLASS TANK

1. Deliveries are made only on or very close to public roadways. Do not expect delivery to remote or difficult to access construction sites.
2. Owner or G.C. must inspect tank and sign shipping documents upon delivery.
3. Owner or G.C. is responsible for rigging and offloading in a safe and timely manner.
4. Always lift vessels from above rigging to all 4 designated lifting lugs.
5. Use a spreader beam to properly rig and handle large vessels.
6. Improper rigging angles may destroy the lifting lugs and cause damage or injury.
7. Always use opposing tag lines to control a tank while in the air.
8. **DO NOT** air pressure test any Darco vessel on site.

WARNING: Review OSHA 1926.650/P EXCAVATIONS

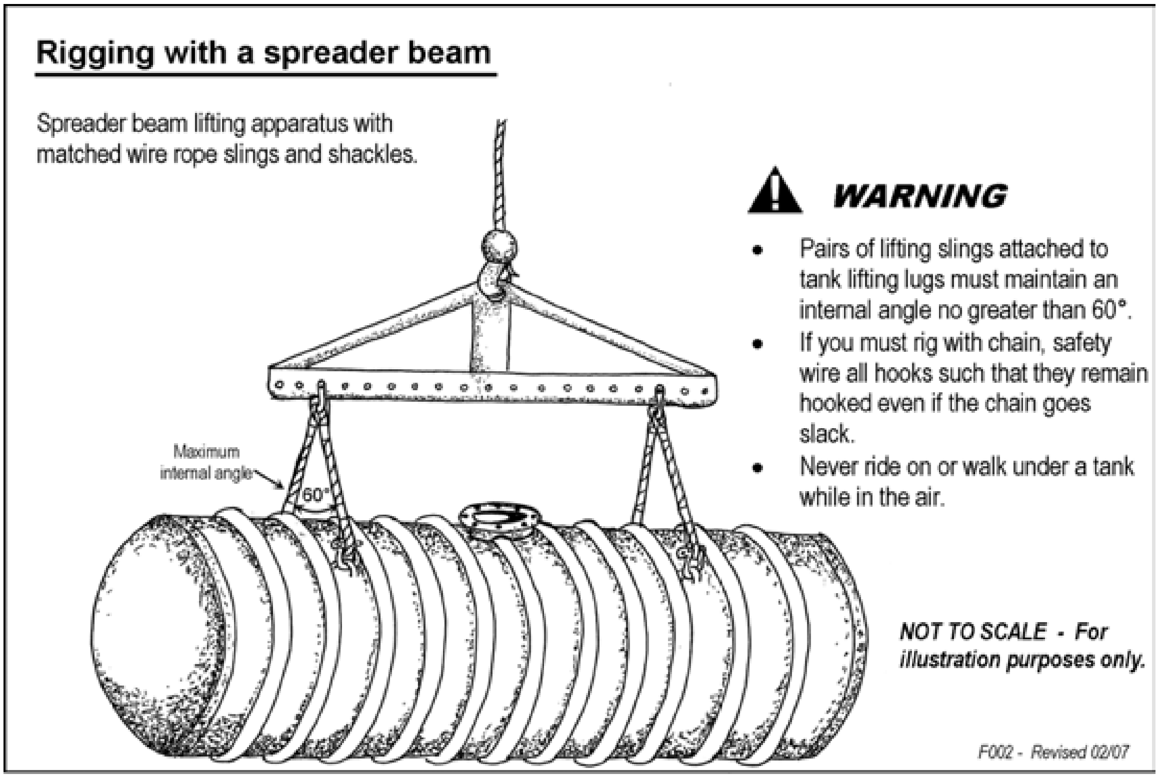


Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

DARCO INC UNDERGROUND TANKAGE
P.O. Box 779
980 Darco Drive
Bennett, CO 80102

Technical Support
800-232-8660 ext. 9

Fiberglass Tank Installation Brief



TEMPORARY STORAGE OF VESSELS AT THE JOB SITE

1. Set FRP tanks on a temporary flat bed of soft soil or backfill material.
2. Chock in place with rubber tires and rope down if high winds are likely.
3. Never roll a tank into position over rocky or frozen ground.

STANDARD STABLE SOIL SITE REQUIREMENTS

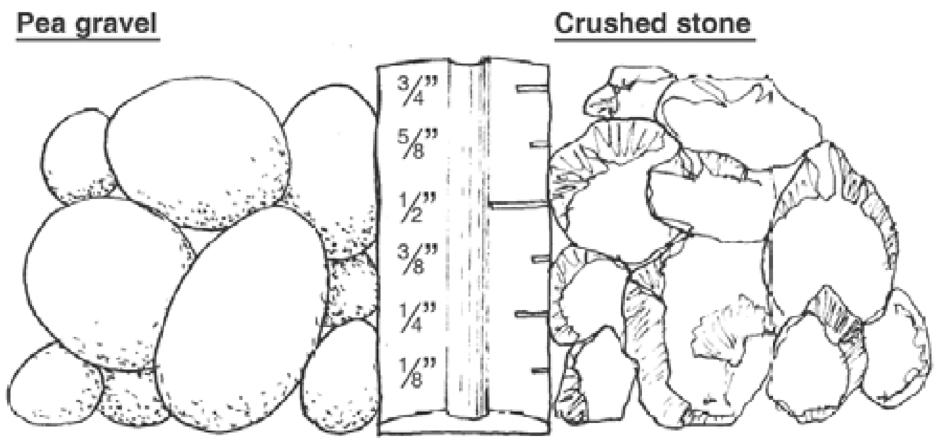
1. Soil bearing must be at least 2000 lbs. / sq. ft. (consult geotechnical engineer).
2. Soil cohesion must be at least 500 lbs. / sq. ft. for vertical side wall integrity.
3. Backslope or bench walls per OSHA 1926.650/P guidelines for stability and excavation safety.
4. If site may be subject to seasonal or unpredictable ground water, do consider:
    - *Using deadman anchors or a reinforced slab anchor.*
    - *Burying the tank above probable ground water with mounded soil cover.*
    - *Installing a tank bed underdrain ground water collection / discharge pipe.*

Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

Fiberglass Tank Installation Brief

TANK BEDDING AND BACKFILL MATERIAL REQUIREMENTS

1. Gravel backfill medium must totally **bed**, **surround**, and **cover** the entire vessel.
2. Backfill must be clean, dry, screened and washed aggregate.
3. Individual particles may range from 1/8 to 1/2 inch in size with minimal fines.
4. Aggregate must be structurally sound and weigh at least 95 lbs. / cu. ft.
5. Materials customarily used are natural "pea gravel" or crushed rock "chips".
6. Never use soil, sand, road base, structural fill, or crusher fines as backfill.



Approved gravel must consist of clean, naturally rounded aggregate with a mix of particle sizes not less than 1/8" or more than 1/2".

No more than 5% may pass the #8 sieve. Dry gravel must be sound with a minimum density of 95 pounds per cubic foot.

Approved crushed stone or crushed gravel must be washed with angular particle size not less that 1/4" or more than 1/2".

No more than 5% may pass the #8 sieve. Dry stone must be sound with a minimum density of 95 pounds per cubic foot.

Revised 6/04

BURY DEPTHS FOR DARCO FRP TANK DESIGNS

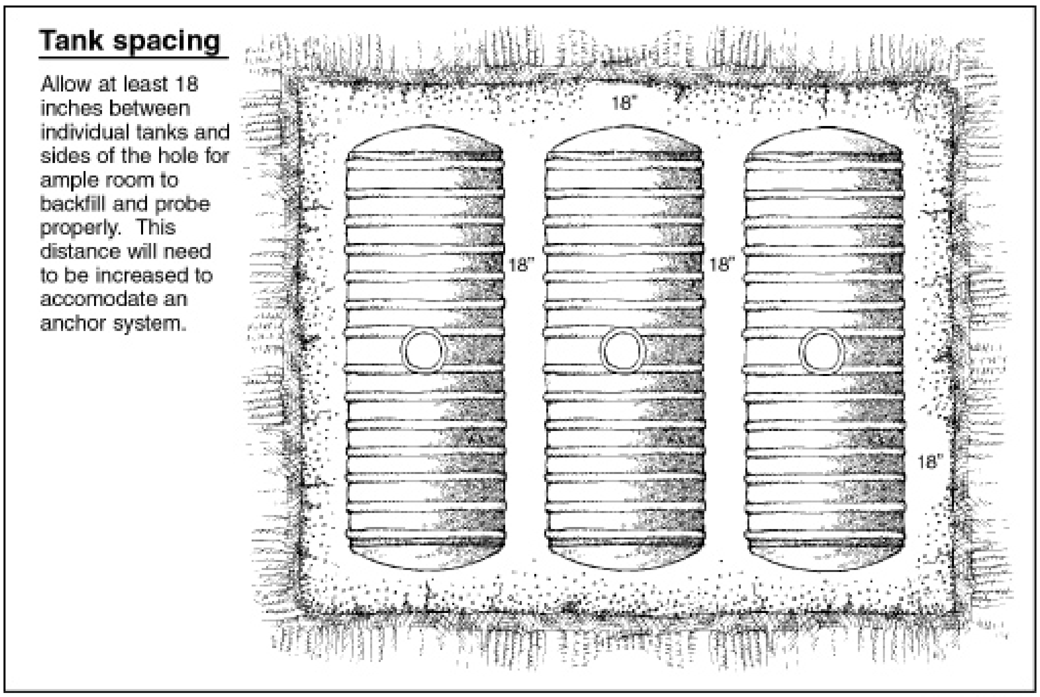
1. Maximum soil cover depth is 5 feet for tanks with standard wall thickness.
2. Deeper bury depths require additional structure and tank wall thickness.
3. Minimum depth requires burial to "spring line" with mounded cover such that the BOTTOM HALF of the tank is fully cradled into the excavation for support.

Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

HOLE SIZE AND WORKING CLEARANCE FOR BACKFILL

WARNING: Review OSHA 1926.650/P EXCAVATIONS

1. Allow for 12 inches of bedding material below each vessel.
2. Allow a minimum of 18 inches from the tank to the excavation walls.
3. Allow 18 inches between individual tanks set side by side or end to end.
4. Clearances will need to be increased to accommodate any anchor system.
5. Follow OSHA 1926.650/P open trench excavation safety guidelines when installing tanks.



Revised 7/02

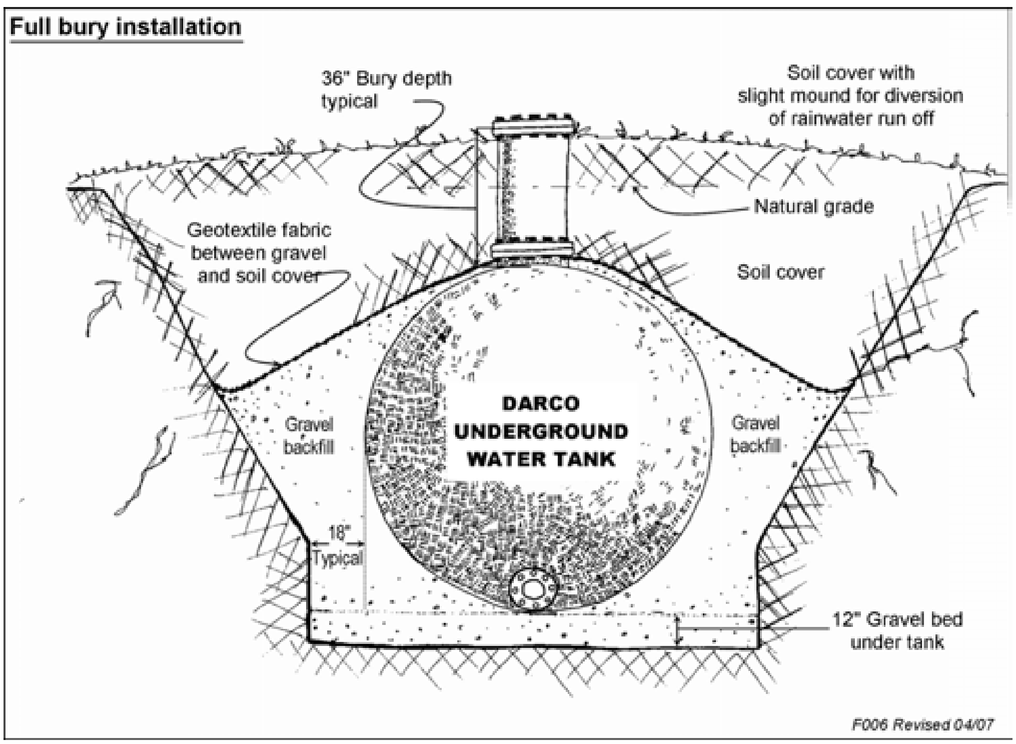
DARCO INC UNDERGROUND TANKAGE
P.O. Box 779
980 Darco Drive
Bennett, CO 80102

Technical Support
800-232-8660 ext. 9

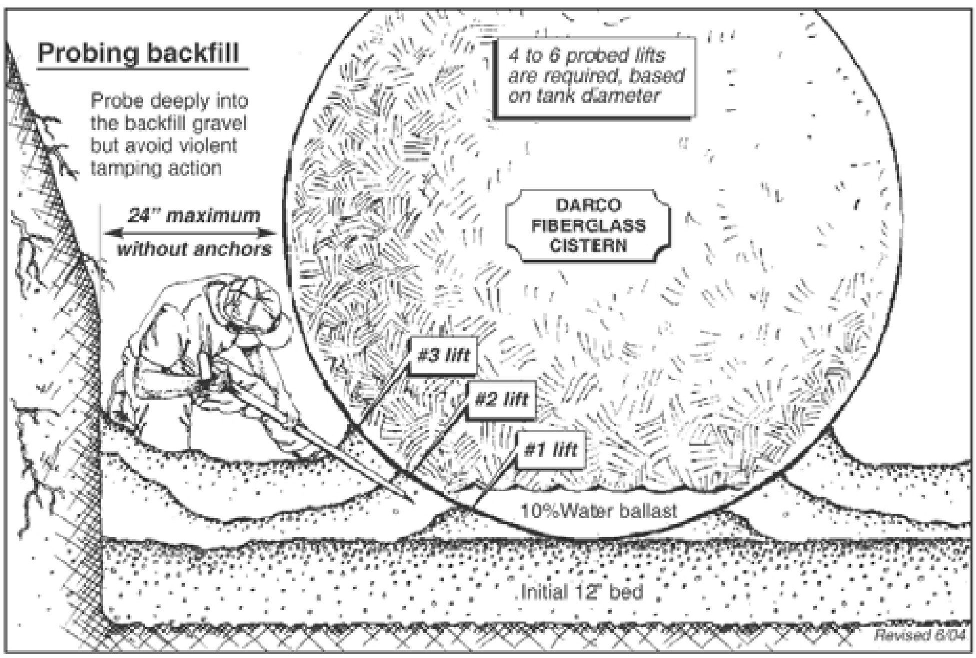
Fiberglass Tank Installation Brief

FULL BURY INSTALLATION PROCEDURE

1. Follow the Darco "Fiberglass Tank Installation Manual" provided with your order.
2. Provide 12 inch minimum bedding over soil or anchor slab below tanks.
3. Allow room around and between tanks for hand probing - 18 to 24 inches.
4. Rig and place tank into theprepared excavation using 4 lift lugs.
5. When practical, add 10% water ballast to stabilize the tank during backfill. ***Burial may be done dry (without water).***
6. Apply backfill in uniform layers or lifts no more than 12 inches deep.
7. Hand probe under and around the vessel after each lift as illustrated.
8. Backfill with approved gravel until tank is ***totally covered*** and no longer visible.
9. Rake surface smooth and apply approved foam insulation board as required in extreme cold climate areas.
10. When insulation is not necessary, overlay the entire exposed gravel surface with geotextile fabric prior to soil cover.
11. Replace soil only as top fill and mound final cover - 5 foot maximum bury depth.
12. Fill tank with water immediately after backfill is complete to reduce uplift.
13. Secure the manway cover at all times to discourage children and vandals.



14. Review the illustration below depicting the probing process.
    - *Probe tool is a 3/4 inch metal pipe about 4 to 5 feet long with tee handle and flattened tip to more easily penetrate deep into the gravel backfill.*
    - *No voids or air pockets may exist under tank belly for proper support.*
    - *Probe thoroughly from 4 o'clock to 8 o'clock positions from both sides.*
    - *Probe deeply, but avoid violent tamping, which may disturb the tank.*
    - ***IMPORTANT Select backfill gravel must completely cover and encapsulate the tank - below, on all sides, and above - such that the tank is no longer visible.***



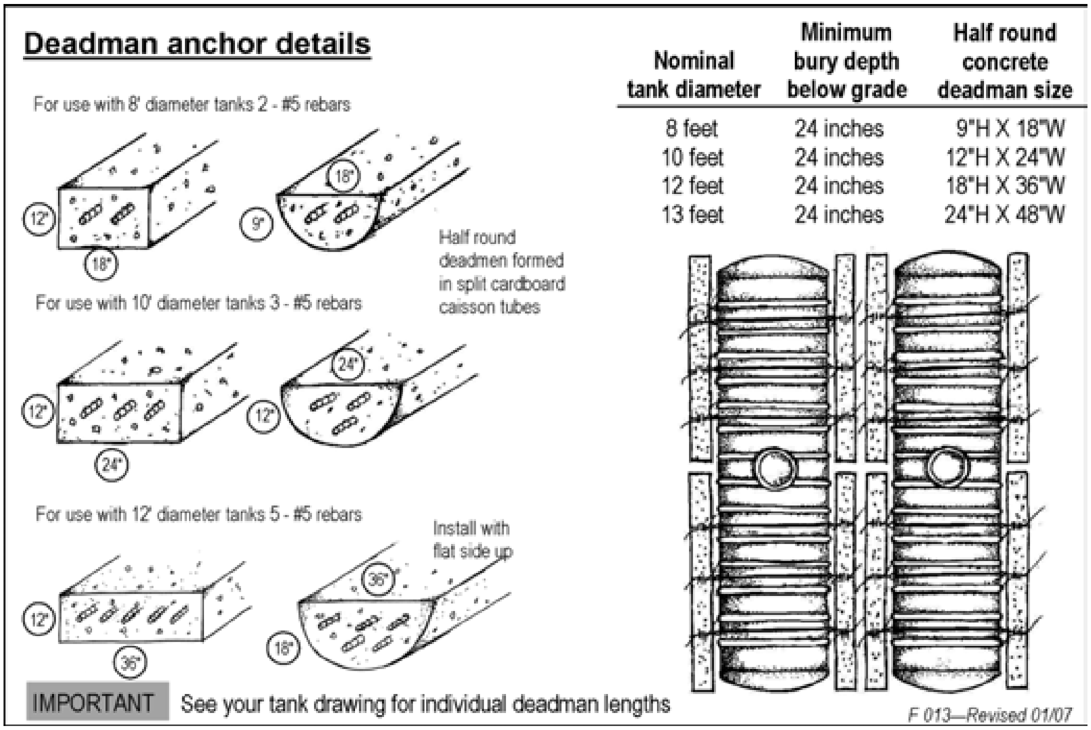
Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

Fiberglass Tank Installation Brief

OPTIONAL ANTI-FLOATATION ANCHOR DETAILS

When FRP tanks are subject to known high ground water conditions created by riparian locations, heavy seasonal run off, natural springs, tidal effects, etc.:

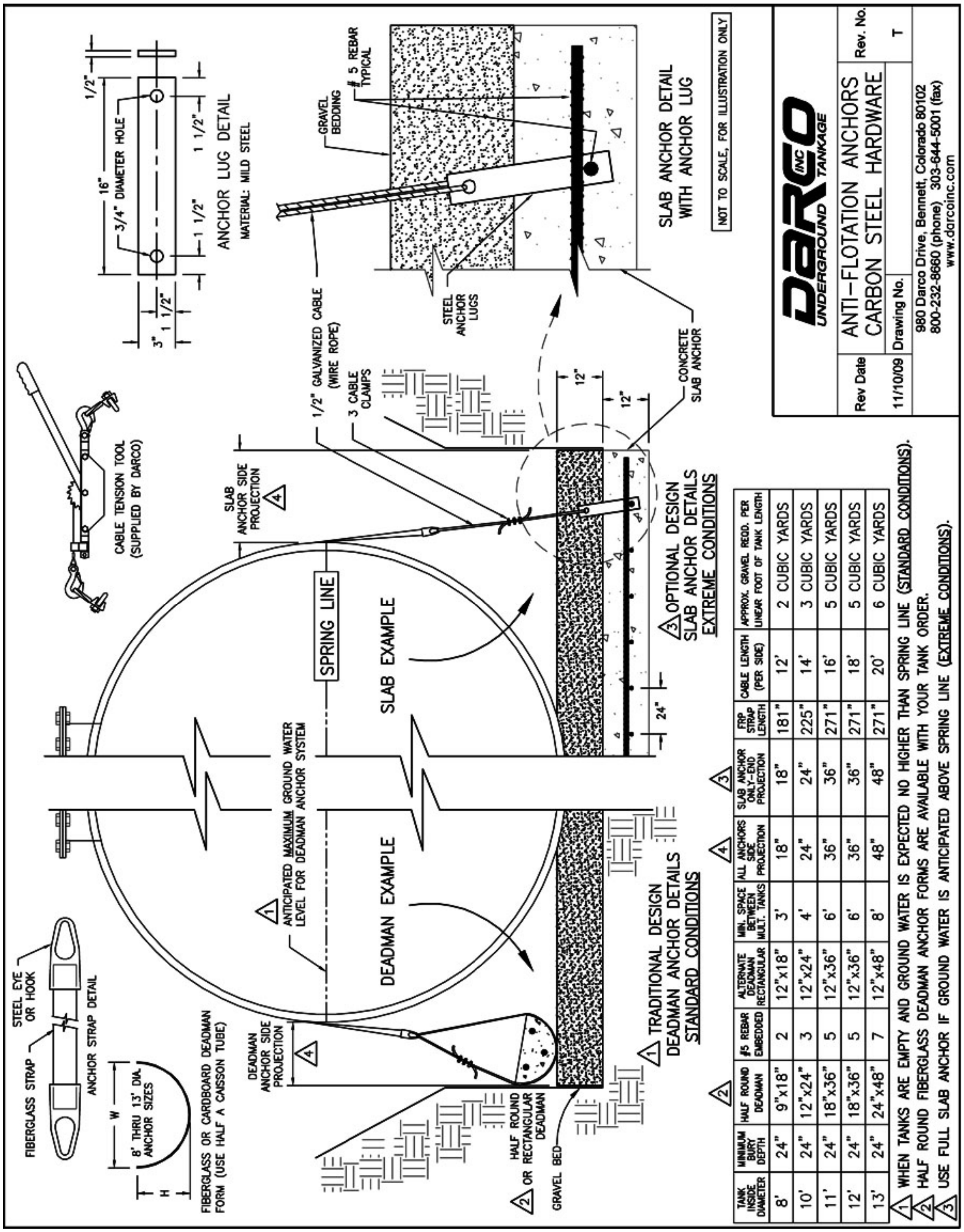
1. Follow our installation manual carefully / call Darco for advice if necessary.
2. Form and install ***deadmen*** or a reinforced ***slab anchor*** below the vessel.
3. Use designated strap locations, anchor hardware, and installation procedure.



Nominal tank diameter	Minimum bury depth below grade	Half round concrete deadman size
8 feet	24 inches	9"H X 18"W
10 feet	24 inches	12"H X 24"W
12 feet	24 inches	18"H X 36"W
13 feet	24 inches	24"H X 48"W

Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

Fiberglass Tank Installation Brief



TANK INSIDE DIAMETER	MINIMUM BURY DEPTH	HALF ROUND DEADMAN (2)	#5 REBAR EMBEDDED	ALTERNATE DEADMAN RECTANGULAR	MIN. SPACE BETWEEN MULT. TANKS	ALL ANCHORS SIDE PROJECTION (4)	SLAB ANCHOR ONLY-END PROJECTION (3)	FRP STRAP LENGTH	CABLE LENGTH (PER SIDE)	APPROX. GRAVEL REQD. PER LINEAR FOOT OF TANK LENGTH
8'	24"	9"x18"	2	12"x18"	3'	18"	18"	181"	12'	2 CUBIC YARDS
10'	24"	12"x24"	3	12"x24"	4'	24"	24"	225"	14'	3 CUBIC YARDS
11'	24"	18"x36"	5	12"x36"	6'	36"	36"	271"	16'	5 CUBIC YARDS
12'	24"	18"x36"	5	12"x36"	6'	36"	36"	271"	18'	5 CUBIC YARDS
13'	24"	24"x48"	7	12"x48"	8'	48"	48"	271"	20'	6 CUBIC YARDS

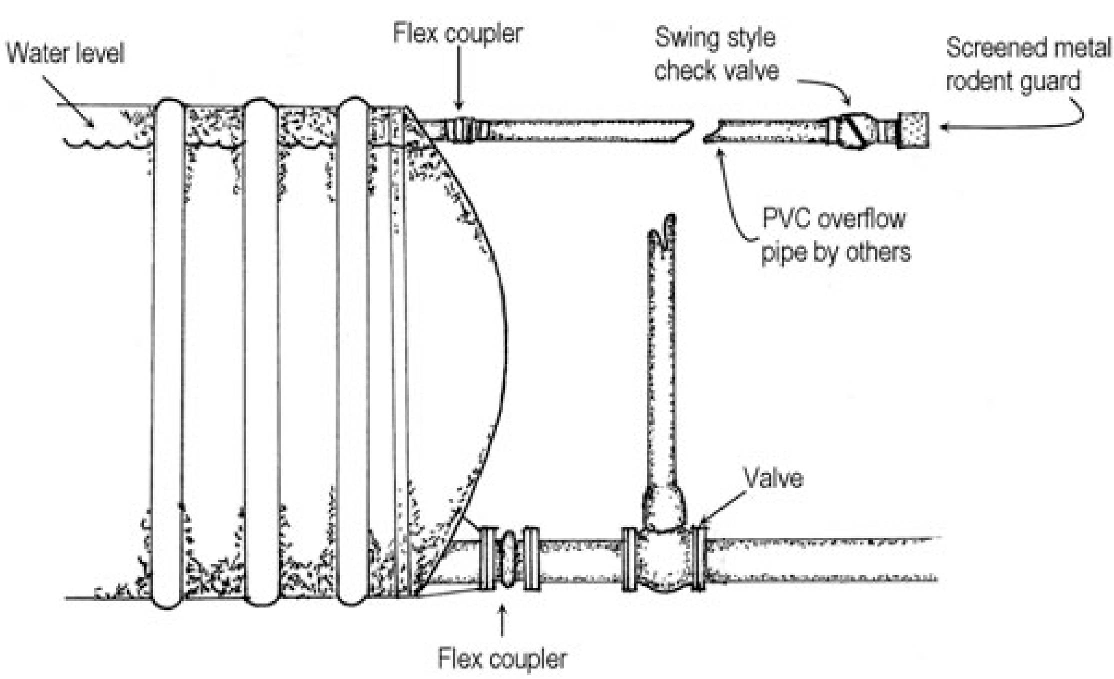
1. WHEN TANKS ARE EMPTY AND GROUND WATER IS EXPECTED NO HIGHER THAN SPRING LINE (STANDARD CONDITIONS).
2. HALF ROUND FIBERGLASS DEADMAN ANCHOR FORMS ARE AVAILABLE WITH YOUR TANK ORDER.
3. USE FULL SLAB ANCHOR IF GROUND WATER IS ANTICIPATED ABOVE SPRING LINE (EXTREME CONDITIONS).

OPTIONAL FLEXIBLE TANK-TO-PIPE CONNECTIONS

It is always a good idea to use some type of flexible coupling between any tank and connecting horizontal pipelines, additional manifolded tanks, or a wet well.

1. Limited tank movement is often caused by minor settling after installation.
2. Pipeline alignment with tank fittings is less critical.
3. Tank shell and fitting strain is kept to a minimum.
4. A full range of axial and radial movement is designed into each elastomeric or stainless steel flexible coupling manufactured or supplied by Darco. Order these optional accessory flex-couplers with your tank if you wish.

Overflow and discharge with flex couplings



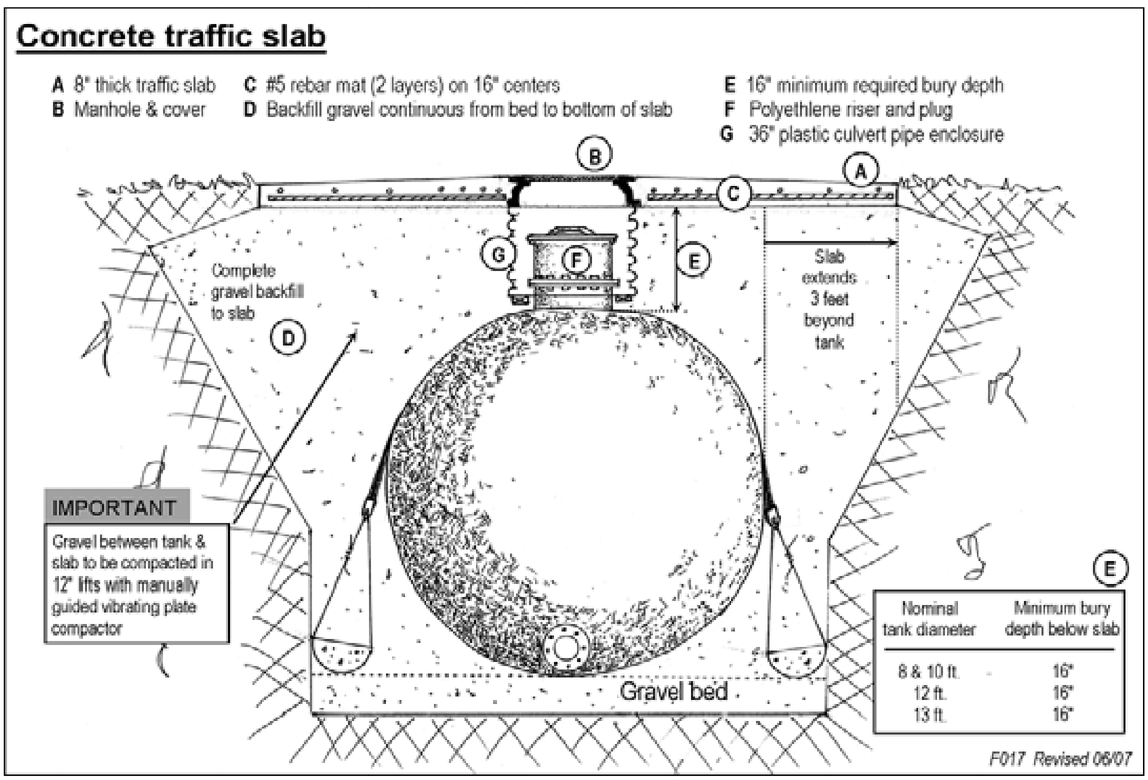
F023a - Revised 06/07

Fiberglass Tank Installation Brief

TRAFFIC SLABS FOR HEAVY VEHICLES

We recommend that you install tanks under a driveway ***only as a last resort*** when no other suitable alternate location is available.

1. Follow our installation manual carefully and call Darco if you have questions or concerns.
2. Observe the proper 16-inch minimum backfill depth from tank to slab underside.
3. Select backfill must be used exclusively - ***no soil may be replaced between the tank and the bottom of the concrete slab on grade***.
4. Manually probe each 12 inch lift to spring line followed by mechanical compaction with a hand-guided vibrating plate machine.
5. Traffic slabs must be properly reinforced, cured, and of correct thickness and strength.



STANDARD DARCO FIBERGLASS CISTERNS

8 foot diameter x 28 feet long +	10,000 gallons @ 3,500 lbs. ship weight
8 foot diameter x 33 feet long +	12,000 gallons / 4,000 lbs.
8 foot diameter x 41 feet long	15,000 gallons / 5,000 lbs.
8 foot diameter x 49 feet long	18,000 gallons / 6,000 lbs.
10 foot diameter x 27 feet long	15,000 gallons / 4,500 lbs.
10 foot diameter x 35 feet long	20,000 gallons / 5,500 lbs.
10 foot diameter x 44 feet long	25,000 gallons / 7,000 lbs.
10 foot diameter x 52 feet long	30,000 gallons / 8,000 lbs.
10 foot diameter x 61 feet long	35,000 gallons / 10,000 lbs.
12 foot diameter x 37 feet long	30,000 gallons / 8,500 lbs.
12 foot diameter x 43 feet long	35,000 gallons / 10,000 lbs.
12 foot diameter x 49 feet long	40,000 gallons / 11,000 lbs.
12 foot diameter x 60 feet long **	50,000 gallons / 13,500 lbs.
13 foot diameter x 52 feet long **	50,000 gallons / 14,000 lbs.

+ *These sizes also available in our lower cost polyethylene OcTank series.*

** *The 50,000 gallon tanks and larger vessels may not be shippable through some states due to wide and tall load restrictions.*

NOTE: All the above lengths and weights are nominal and may vary.

AREA MFG. AND SHIPPING POINTS FOR DARCO TANKS

Fiberglass Underground Tanks
San Antonio, Texas

Polyethylene Uderground OcTanks
Denver, Colorado

Darco Incorporated || P.O. Box 779 || Bennett, CO 80102
Phone: (800) 232-8660 || Fax: (303) 644-5001 || Email: info@darcoinc.com || Web: www.darcoinc.com

APPENDIX 5A – REVIT MODEL PHASING