EXECUTIVE SUMMARY

The Residences at Christina Landing is located in Wilmington, DE. This 22-story apartment tower is a cast-in-place reinforced concrete framed structure with a reinforced concrete shear wall core. The building envelope is comprised mostly of precast concrete panels with embedded brick veneer, however there is also an aluminum curtain wall assembly used. The roof is coated with a two-ply roofing membrane.

The choice of cast-in-place concrete as the main building material was based primarily on the high material costs of steel during the design phase of the tower. Steel structural systems will be explored to replace both the concrete lateral and gravity systems. A comparison of both the materials cost estimate and the schedule of construction between the suggested steel system and the existing concrete system will determine if the steel system is feasible.

If a steel structural system is used for the building, the architecture of the building will be altered due to the constraints of steel members and increase in floor system depth for the steel members. The main emphasis for the proposed architectural changes is that they will try to remain as similar to the existing architecture as possible. The proposed modifications to the architecture will be determined after the proposed structural system is in place but will be considered during the structural design to aid in the simplification of the proposed changes.

The building systems and surrounding areas will be assessed to see if they are capable of being changed to achieve certain LEED Certification requirements. The potential for LEED implementation will be shown through examples of proposed changes. The changes will be documented and compared to the original aspects of the building to show how alterations to the original design could make LEED certification possible.

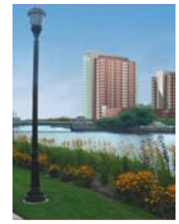
BACKGROUND

General Building Information

Located on the riverfront of the Christina River in Wilmington, Delaware, the Christina Landing community of luxury townhomes and apartments will be completed in 2005. The site is less than a half mile from Interstate 95 and Wilmington's Central Business District, and even closer to the Wilmington Train station (Amtrak). All of the surrounding streets and bridges are to be renovated by the City of Wilmington and a riverwalk connected to its 2-acre park will be installed spanning between the apartments and townhomes. This is the only new development on the south side of the Christina River.


The Buccini-Pollin group will own and operate all buildings on the site; the townhomes, the apartment tower, and eventually the condominiums that will also be onsite. The tower is being built using a construction manager at risk contract with Gilbane Building Company. The cost of the apartment tower alone is $32 million.

The Residences at Christina Landing are luxury apartments with incredible views of the city from any of its 22-stories and high-end finishes all around. A convenience store/ small restaurant, leased commercial space and a dry cleaner are expected to be located on the ground floor. Also, located on the ground floor is a security center, a reception area, a bar and a large recreational great room with pool tables. On the second floor of the tower will be 5 one bedroom units that will be ADA accessible. This floor also includes a fitness center for the residents of the tower. The third through twentieth floors are typical floors which will consist of 6 one bedroom units and 3 two bedroom units per floor. There will be two-story penthouse units located on the top floors of the tower, consisting of 4 one bedroom and 2 two bedroom units.



Building Structural System Description

The main component of the existing structural system in the building is reinforced cast-in-place concrete. There are two separate column grids due to the east wall of the building being rotated outward. In general most exterior walls, columns, beams, slabs and stairways are reinforced cast-in-place concrete, with the exception of the upper roof area and the northeast corner of the building. The upper roof area is an aluminum curtain wall system supported by structural steel framing. The northeast corner is an aluminum curtain wall system supported by the concrete framing system. The rest of the building envelope is comprised of precast concrete panels with embedded brick veneer. The roof is coated with a two-ply roofing membrane.

Lateral System

The existing lateral system consists of a cast-in-place concrete shearwall core located centrally on the western side of the building. The shearwall core is 12 inches thick and reinforced with steel rebar in both the horizontal and vertical directions. There is no evidence on the drawings to suggest that the floor system carries lateral loading. Assuming that this assumption is correct, the floor framing system carries all lateral loading to the shearwall core from the buildings exterior façade. The shearwall is considered to carry its own self-weight, dead load of floor area inside core, and live load on floor area inside core, and all wind loads. However, there are multiple shearwall penetrations per floor for doorways. The penetrations will decrease the capacity of a solid shearwall core but with that in mind were not considered for simplicity of calculations. The two directions considered for the lateral resistance are East-West (E-W) and North-South (N-S).

Considering the residential aspect of the building, the use of a shearwall core allows for the façade to be open and easier to plan for residential usage. Each floor has two bedrooms and two bathrooms located inside the shearwall core, one each for two individual residential units.

Foundation

The building foundation consists of reinforced cast-in-place grade beams, reinforced cast-in-place concrete pile caps and steel H-piles. The H-piles are each driven to a depth averaging 70'. The piles were vibrated into soil, due to unstable soil conditions, and then set into the bedrock using a diesel-powered pile hammer.

First Floor

This floor is 10,200 SF and is commercial and general public space. The floor slab is an 8” reinforced cast-in-place concrete two-way flat slab, with varying reinforcement. The columns are both rectangular and circular reinforced cast-in-place concrete, with varying sizes based on location in building.

Second Floor

This floor is 9,225 SF and has general public space and 5 one-bedroom handicap accessible rental units. The floor slab is an 8” reinforced cast-in-place concrete two-way flat slab, with varying reinforcement. The columns are both rectangular and circular reinforced cast-in-place concrete, with varying sizes based on location in building.

Typical Floors (3-20)

This floor is 12,012 SF and each floor has 6 one-bedroom and 3 two-bedroom rental units. The floor slabs are 8” reinforced cast-in-place concrete two-way flat slabs, with varying reinforcement. The columns are both rectangular and circular reinforced cast-in-place concrete, with varying sizes based on location in building.

Twenty-First Floor

This floor is 6,785 SF and has 4 one-bedroom and 2 two-bedroom penthouse rental units. The floor slab is an 8” reinforced cast-in-place concrete two-way flat slab, with varying reinforcement. The columns are both rectangular and circular reinforced cast-in-place concrete, with varying sizes based on location in building.

Twenty-Second Floor

This floor is 5,759 SF and is the upper level of the penthouses rental units from the previous floor. The floor slab is an 8” reinforced cast-in-place concrete two-way flat slab, with varying reinforcement. The columns are both rectangular and circular reinforced cast-in-place concrete, with varying sizes based on location in building.

Roof

This floor is 12,012 SF and is mostly unused except for mechanical equipment space on the upper roof. The lower roof floor slab is an 8" reinforced cast-in-place concrete two-way flat slab, with varying reinforcement, and a two-ply roofing membrane. The upper roof floor slab is an 8" reinforced cast-in-place concrete two-way flat slab, with varying reinforcement, and a two-ply roofing membrane. The upper roof also has an aluminum mechanical equipment enclosure supported with structural steel beams (HSS 8x4x$^{1}/_{2}$, W 18x46, W 8x15) and structural steel columns (HSS 8x4x$^{3}/_{8}$, HSS 12x4x$^{3}/_{8}$).

Materials

Concrete

All normal weight concrete with reinforcing (147 pcf, f_y = 60,000 psi)

- Pile Caps (f_c' = 4,000 psi)
- Slabs above elevation of +44'-0" (f_c' = 4,500 psi)
- Slabs below elevation of +44'-0" (f_c' = 5,600 psi)
- Columns above elevation of +44'-0" (f_c' = 5,000 psi)
- Columns below elevation of +44'-0" (f_c' = 8,000 psi)
- Shear walls (f_c' = 5,000 psi)
- Exterior slabs and paving (f_c' = 5,000 psi)
- Topping fills (f_c' = 4,000 psi)

Steel

All steel is A992 (f_y = 60,000 psi).

- H piles (minimum of HP 12x74)
- W shapes
- HSS shapes
- Bolts A490 or A325 with minimum diameter of $^{3}/_{4}$" (slip critical connections for lateral systems)
- E70XX Welds (must conform to the Structural Welding Code)

Building Codes and Standards

- Building Officials and Code Administrators (BOCA) National Building Code [1996] with City of Wilmington Amendments
- American Institute of Steel Construction (AISC) Load and Resistance Factor Design Manual (LRFD)
- American Welding Society (AWS) Structural Welding Code for Steel [D1.1, 1.4]
- Steel Structures Painting Council (SSPC) Painting Manuals Volumes 1-2
- American Concrete Institute (ACI) Building Code Requirements for Structural Concrete [318-02]
- Concrete Reinforcing Steel Institute (CRSI) Manual of Standard Practice
- American Society for Testing and Materials (ASTM)

PROPOSAL

Feasibility of Structural Steel Redesign

The choice of cast-in-place concrete as the main building material was based primarily on the high material costs of steel during the design phase of the tower. Material costs are an inevitable issue in all construction projects, as they can affect the construction schedule. With that in mind, steel structural systems will be explored to replace both the concrete lateral and gravity systems. A comparison of both the materials cost estimate and the schedule of construction between the suggested steel system and the existing concrete system will determine if the steel system is feasible.

There are number of gravity systems, lateral systems, and combinations of these that can be investigated to determine a steel structural system. Preliminary designs of composite and non-composite floor systems will be investigated further and compared based on architecture and economics. The floor systems influence the plenum space of each floor, which has an impact on the architecture as well as other building systems, but more importantly this adds height to the building which can greatly effect the cost. The options to explore for the lateral system include moment frames and braced frames. Braced frames are more economical than moment frames due to construction times and connection costs. However, moment frames allow for an open plan and unobstructed views and passageways, which is important considering the residential aspect of the building. The two lateral systems will be designed and compared to obtain the optimum lateral system considering all criteria. The floor system and the lateral system, each of which have the optimal design, will be combined to create the overall structural system that will be investigated further and designed using computer modeling and hand-calculations.

Loads will be determined by calculations and equations from ASCE7-02. Preliminary studies of composite and non-composite floor systems will be analyzed using the LRFD method in RAM. Using the forces determined by RAM, hand calculations will be performed using the design procedure prescribed by the AISC LRFD Steel Manual to ensure the economy of members. Layout and geometry of both moment frames and braced frames will be determined with the architectural assessment in mind. Trial members will be determined using gravity loads only. The resulting frames will be modeled and analyzed in RAM. Individual members of the braced frame will be check for axial loading and flexure will be checked in the moment frame members. The resulting systems will be combined in a RAM model to further analyze the structure. Final members will be chosen. A cost estimate of both the steel and concrete structures will be determined using information gathered mainly from R.S. Means.

Architectural Intent

If a steel structural system is used for the building, the architecture of the building will be altered due to the constraints of steel members and increase in floor system depth for the steel members. The architectural intent of the building may be rectified through simple modifications to the interior spatial layouts and the exterior façade. The main emphasis for the proposed architectural changes is that they will try to remain as similar to the existing architecture as possible. The proposed modifications to the architecture will be determined after the proposed structural system is in place but will be considered during the structural design to aid in the simplification of the proposed changes. The proposed architectural changes will be documented using AutoCAD and compared against the original architectural documentation of the building.

Potential for LEED Implementation

Green Building Design is becoming an important factor in large-scale design today. Aside from improving the quality of the environment, there are certain advantages for those who are exposed to these designs. Most times it only takes small changes to the building systems or surrounding areas to improve the quality of building sustainability. The building systems and surrounding areas will be assessed to see if they are capable of being changed to achieve certain LEED Certification requirements. Once all aspects of the building have been investigated for potential changes a list of their descriptions will be generated. Using the list, the potential for LEED implementation will be shown through examples of proposed changes. The changes will be documented and compared to the original aspects of the building to show how alterations to the original design could make LEED certification possible.

TASKS AND TOOLS

Task 1: Determine Gravity System

- Calculate gravity loads using ASCE7-02
- Model composite and non-composite systems in RAM
- Obtain preliminary sizes
- Check sizes with hand calculations using method prescribed by AISC LRFD Steel Manual
- Check deflection and vibration criteria
- Determine system costs from information gathered
- Compare systems based on architectural integration and cost

Task 2: Determine Lateral System

- Calculate wind and seismic loads using ASCE 7-02
- Design layouts of both systems based on architectural integration
- Calculate trial sizes using gravity loads
- Create models of frames in RAM using LRFD load combinations
- Check drift criteria
- Determine frame costs from information gathered
- Compare frames based on architectural integration and cost

Task 3: Determine Overall Structural System

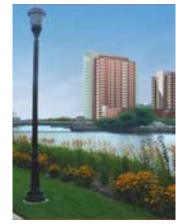
- Create structural system model in RAM using previously determined systems
- Analyze model using RAM and AISC LRFD methods
- Make necessary adjustments to members
- Spot check members with hand calculations to verify economy of RAM chosen sizes
- Finalize steel design
- Determine system costs from information gathered and compare to existing building costs
- Determine system schedule of construction and compare to existing building schedule of construction

Task 4: Architectural Integration

- Research and determine how existing materials are affected by the structural system, specifically the precast panel façade
- Determine impact, if any, of new floor system on architecture propose solution accordingly
- Determine impact, if any, of lateral system on architecture and propose solution accordingly
- Create necessary sketches and drawings (elevation, plan, details, etc.)
- Compare to existing architecture of building

Task 5: LEED Implementation

- Research and determine how existing systems and surrounding areas will be affected by the LEED Certification requirements
- Determine which systems or areas will be examples of LEED Implementation
- Analyze solutions to proposed changes.
- Document how changes dictate the premise that LEED Certification may be possible
- Compare changes to original design to observe how LEED requirements effect the existing building



SCHEDULE

Week of:	Task Description
10-Jan	Research different steel systems for both gravity and lateral application
17-Jan	
24-Jan	Calculate lateral and gravity loads
31-Jan	Design floor system
7-Feb	Design lateral system
14-Feb	Combine systems and create RAM model
21-Feb	Create cost estimate and compare to original system
28-Feb	Create schedule and compare to original system
7-Mar	Spring Break
14-Mar	Analyze impacts on architectural intent; determine solutions for architectural impacts
21-Mar	Research LEED implementation; determine solutions for building systems or areas selected from research
28-Mar	Compile all analysis results and compare with original system requirements; Compose final report
4-Apr	Compose final presentation
11-Apr	Presentations
18-Apr	TBD
25-Apr	TBD
2-May	Final Exams
13-May	Graduation