Executive Summary

Located along the highly desirable Glenwood South corridor, 510 Glenwood offers the convenience of modern living in one of the most sought-after destinations in downtown Raleigh.

510 Glenwood Avenue is a seven-story, 150,000 sq. ft. Class A mixed-use building (restaurant, retail, office, residential and parking) consists of a cast-in-place concrete flat plate and flat slab systems. Cast-in-place concrete shear walls resist lateral loads.

The cast-in-place concrete structural system produces very heavy dead loads, which in retrospect produce bigger columns and slabs. In addition, the existing structural system requires tedious and expensive formwork.

As a proposed solution for a redesign of the structural system for 510 Glenwood Avenue a steel framing system will be designed. Two floor systems will be considered, a metal deck with slab or hollow core planks. For the lateral system, either braced or moment frames will be incorporated into the final design. The most economical combination of the floor and lateral systems will be the final design. The final design will be compared to the original design by cost, schedule, and architectural intent.

For one of the breadth topics, the effect of the steel redesign on the architectural intent will be investigated and a complete redesign of the architecture will be performed.

The other breadth topic will go into fire protection design, since the steel redesign will need a complete redesign of the fire protection for the building.
Background

Located along the highly desirable Glenwood South corridor, 510 Glenwood offers the convenience of modern living in one of the most sought-after destinations in downtown Raleigh. The condos are of a graceful and stylish quality and are positioned on the top floor of a building that houses restaurants and clubs below. 510 Glenwood offers the convenience of downtown life that is literally only seconds away. Each condo is specially designed to make city living truly relaxing, with nine-foot ceilings, hardwood floors and gas-log fireplaces - to mention just a few of the luxurious amenities that complement the convenience of the 510 Glenwood location.

The architects decided for a brick veneer façade and aluminum window frames, but what makes this building unique is its atrium corner of the L-shaped building. The atrium is the first thing that will catch your eye, as soon as you come into that part of the town.

Existing Structural System

510 Glenwood Avenue located in downtown Raleigh, NC is a seven-story, 150,000 sq. ft. Class A mixed-use building (restaurant, retail, office, residential and parking) consists of a cast-in-place concrete flat plate and flat slab systems. Cast-in-place concrete shear walls resist lateral loads.

The foundation of the building consists of caissons, located underneath every concrete column and underneath the shear walls, and a 9” thick cast in place slab on grade. Concrete Grade Beams were chosen for the support of the slab on grade and the exterior wall system around the perimeter of the building.
The first through fourth floor consist of a 9" thick cast in place two-way flat slab with 4" drop panels around each concrete column. The fifth and sixth floor and the roof are made of 10" thick cast in place two-way flat plate. Each floor is supported by 20"x20" TYP columns, which are spaced 25' or 30' on center throughout the building. Above the ground floor, for each floor the perimeter is constructed of concrete beams placed on top of the exterior concrete columns. These concrete beams support the perimeter of each floor slab and give more support for the exterior wall system.

Concrete shear walls were chosen for the lateral support system. These shear walls are located around each elevator shaft and around the stairs located at the northeast and southwest part of the building. The shear walls are 12" thick cast-in place concrete and the vertical and horizontal reinforcement is #5@12". All shear walls run for the entire height of the building except the one located around the office elevator (north west corner of building).

Typical Frame
Appropriate Building Codes

- ASCE 7-96
- American Concrete Institute (ACI) 301, “Specifications for Structural Concrete for Buildings”
- ACI 318, “Building Code Requirements for Reinforced Concrete”
- Concrete Reinforcing Steel Institute (CRSI) “Manual of Standard Practice”
- AISC’s “Load and Resistance Factor Design (LRFD) Specification for Structural Steel Buildings”

Required Loads

Design Live Loads
- Roof.............................20 PSF
- Residential......................40 PSF
- Parking..........................50 PSF
- Retail............................75 PSF
- Office.............................80 PSF
- Corridors 2nd to 6th Floor.......80 PSF
- Corridors Ground & 1st Floor.....100 PSF
- Restaurants......................100 PSF
- Stairs.............................100 PSF
Wind Load Analysis

N-S DIRECTION WIND

E-W DIRECTION WIND
Problem Statement

510 Glenwood Avenue is located in downtown Raleigh, North Carolina. The main building material chosen for this building was cast-in-place concrete. Concrete is a heavy material and therefore the dead loads for this building tend to very high, which ultimately result in bigger columns and slabs. In addition the formwork is very tedious and expensive for an all around cast-in-place building. Cost and time is an inevitable issue in all building projects. It is therefore important to analyze different structural systems and incorporate the most economical in the structure. Unfortunately a lot of times a time restraint does not allow for a complete analysis of multiple structural systems.

Proposed Solution

My proposed solution is to do a redesign of the buildings structural system by using wide flange steel members as the main material. A steel structure can be efficiently erected and decrease the labor costs created by the formwork needed for all the cast-in-place concrete.
Within a new steel design there are number of gravity systems, lateral systems, and combinations of these that can be investigated to determine an optimum steel system.

Wide flange steel shapes will be utilized in the columns, the girders and the beams. The existing concrete columns will be replaced by steel columns, which should not change the floorplan much at all. Fireproofing will now need to be taken into account due to the fact that steel is not naturally fire resistant like the previously designed concrete.

For the floor system two options will be explored to see which would be more economical. Metal deck and slab floor system is easy to install and very common in the construction industry. Hollow core precast planks resting on steel beam would be another option. It provides a reduction of sound between floors important fire separation with a minimum UL fire rating of two hours and will create a lesser floor to floor height than the metal deck and slab floor system. The hollow core precast plank system is also light, easy and quick to install.

The options to explore for the lateral system include moment frames and braced frames. Due to construction time and connection cost braced frames are more economical moment frames. However, moment frames allow for an open plan and unobstructed views. The moment connections also inhibit the disassembly of a structure, but the additional members of a braced frame contribute more material to the overall structure. A preliminary check for both systems will be done to see which one would be more feasible in 510 Glenwood Avenue. Whichever lateral system is more economical will be incorporated in the final design.

The price of the structure should be fairly comparable to the previous design since the labor costs will be decreased as will erection time. Therefore, a comparison estimate and schedule can be produced. The resulting steel system will be compared to the existing concrete structure considering cost, schedule, architecture and fire protection.
Solution Process

Loads will be determined by combining originally specified loads with loads calculated using ASCE7-02. Preliminary typical frame analysis of the floor system will be analyzed using the LRFD method in RAMSteel. Hand calculations will be performed using the forces determined by RAM and 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 integrally with the architectural redesign. Trial members will be determined using gravity loads only. The resulting frames will be modeled and analyzed in STAAD. Individual members of the braced frame will be checked for axial loading and flexure will be checked in the moment frame members.

For both systems cost information will be collected from steel manufacturers. To further analyze the structure the resulting systems will be combined in a RAMSteel model. Final members will be chosen. A cost estimate of both the steel and concrete structures will be determined using information gathered from steel fabricators, contractors, and R.S. Means.

Breadth Topics

The first thing that needs to addressed after a finished steel redesign of the building is the effect the redesign will have on the architecture of the building. Since 510 Glenwood is located in downtown Raleigh in one of the most sought after location in town the original architectural intent needs to be kept. With a redesign in steel comes a change in floor to floor height and in retrospect will change the exterior facade. An architectural redesign will be completed through hand sketches and AutoCAD drawings. In attempt to keep the architectural intent the same, original materials should be used in the redesign of the architecture. New connections will have to be researched and designed for the new floor to floor heights. Any implications on loading will be calculated and applied to loading
conditions. All the necessary drawings will be produced to convey the redesign of the exterior facade.

The other topic that needs to be addressed is fire protection. Since original design used concrete, much of the fire protection was already incorporated into the design. With the steel redesign though fire protection becomes a bigger issue. For this breadth work different methods of fire protection and their impact on the building will have to researched and analyzed. For the final design the most economical solution will be chosen and designed for the building complying with the newest building code.

**Tasks** (approximate weeks to be spent on particular topic)

Task 1: Revise and Review Gravity and Lateral Loads (1)
Task 2: Design Steel System (7)
  A. Framing plan (1)
  B. Floor System (1)
  C. Columns (1)
  D. Seismic (1)
  E. Braced Frame (1)
  F. Cost and Schedules Comparison Analysis (2)
Task 3: Breadth Topics (4)
  A. Architectural Redesign (2)
  B. Fire Protection Redesign (2)
Task 4: Final presentation (1)

**Timetable**

Task 1 Jan. 10\textsuperscript{th} - 17\textsuperscript{th}, 2005
Task 2 Jan. 18\textsuperscript{th} - Mar. 1\textsuperscript{st}, 2005
Task 3 Mar. 2\textsuperscript{nd} - Mar. 30\textsuperscript{th}, 2005
Task 4 Mar. 31\textsuperscript{st} - Presentation Date