CENTRE COURT APARTMENTS
STATE COLLEGE, PA

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Thesis Proposal
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Executive Summary

Building Description

The Centre Court Apartments stand at 67.5' and contain five levels of student housing atop two levels of parking, intermixed with lobby and commercial area on the ground floor. The building is wrapped with load bearing CMU hollow core blocks that also act as the lateral resisting system of the building. The floor slabs are made of 8" pre-cast hollow core planks, which bear on the CMU exterior walls, and a series of wide flange beams that distribute the load to the concrete columns, which lead to the spread footing foundation below.

Proposal

The main problem that will be addressed in the alternative design of the Centre Court Apartments is the environmental impact of the materials and systems in the building. The main areas of focus will be the structural system and the building envelop, with an overall environmental evaluation and adjustments of the building as a whole. From a structural engineering standpoint, materials that are renewable, have low embodied energy, and/or are made with recycled content are the most preferred building elements. The majority of the materials in the Centre Court Apartments do not follow this philosophy, which is the motivation behind the proposed alternative design.

With the growing interest in green building across the industry, distinguishable green projects are in a prime position to gain public attention. The nature of building green offers direct examples to building occupants of how caring for the structure they inhabit will benefit them. Both of the above topics would directly benefit a structure such as the Centre Court Apartments.

Solution

The exterior walls will be designed with pre-cast, non-load bearing straw bale wall assemblies, which will bear on two-way flat plate slab with a concrete lateral resisting frame system, all specified with high fly ash content replacing up to 50% of the Portland cement.

Breadth Topics

A sustainability breadth will be conducted in order to adjust the HVAC system with an under floor air distribution system and also adjust the electrical design with a photovoltaic array on the roof of the structure. This breadth will also cover all architectural adjustments that will take place due to the replacement of all stud and CMU walls with the 12" straw bale wall assemblies. A breadth in construction management will also be conducted in order to model the schedule of the project and conduct a detailed cost comparison of the alternative method against the existing design.

Contents

Intro

The Centre Court Apartments are located in the borough of State College, Pennsylvania and were designed by Frederick J. Fernsler, AIA with Jesse Smith, PE as the structural engineer. L. S. Fiore Construction was the general contractor on the project that completed it's 16 month construction process in August 06'. The total cost of the project was $13.6 million, which includes a large addition to an adjacent building that will not be covered in this report. The building stands at 67.5' and contains five levels of student housing atop two levels of parking, intermixed with lobby and commercial area on the ground floor.

Existing Structural System

Listed below are the prominent structural elements contained in Centre Court Apartments:

- 8" CMU exterior above grade and 10" CMU exterior below grade
    - Load bearing units conforming to ASTM C90
    - Net Compressive Stress = 3000 PSI
    - Above grade CMU's contain Dur-O-Wall every other course
    - Block cells with bars are grouted a minimum 2 courses below plank bearing

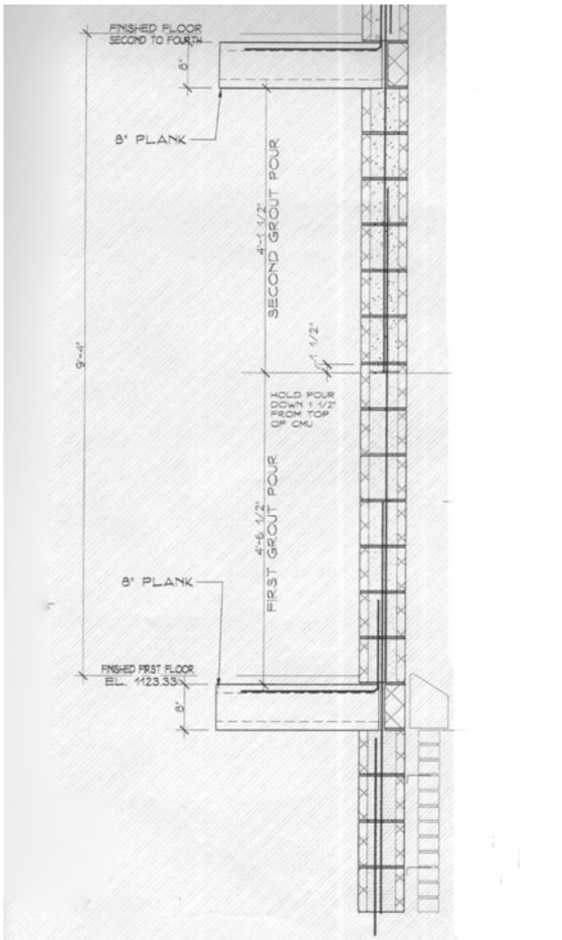
- 8" pre-cast hollow core planks
    - Conform to latest edition of ACI 318
    - Steel bearing will contain weld plates spaced 4' O.C. max.
    - F'c=5000 PSI

- Steel beams and columns
    - Typical beam sizes: W12 X 26 and W14 X 43
    - Grade 50 or ASTM A992
    - Fabricated and erected in accordance to the latest edition of AISC specifications.

- Concrete columns, footings, and slabs
    - Mixed and placed in accordance with ACI 318 "Building Code Requirements for Concrete"
    - Footings and slabs f'c = 3000
    - Columns f'c =4000

Lateral System

The lateral system is comprised of the 8” and 10” CMU walls that wrap the main elevator and stairwell cores. The top two stories of CMU’s are unreinforced. Further down the structure, the blocks are grouted where the #5 bars are present until you reach the bottom two floors that are grouted solid. (*see section below)*

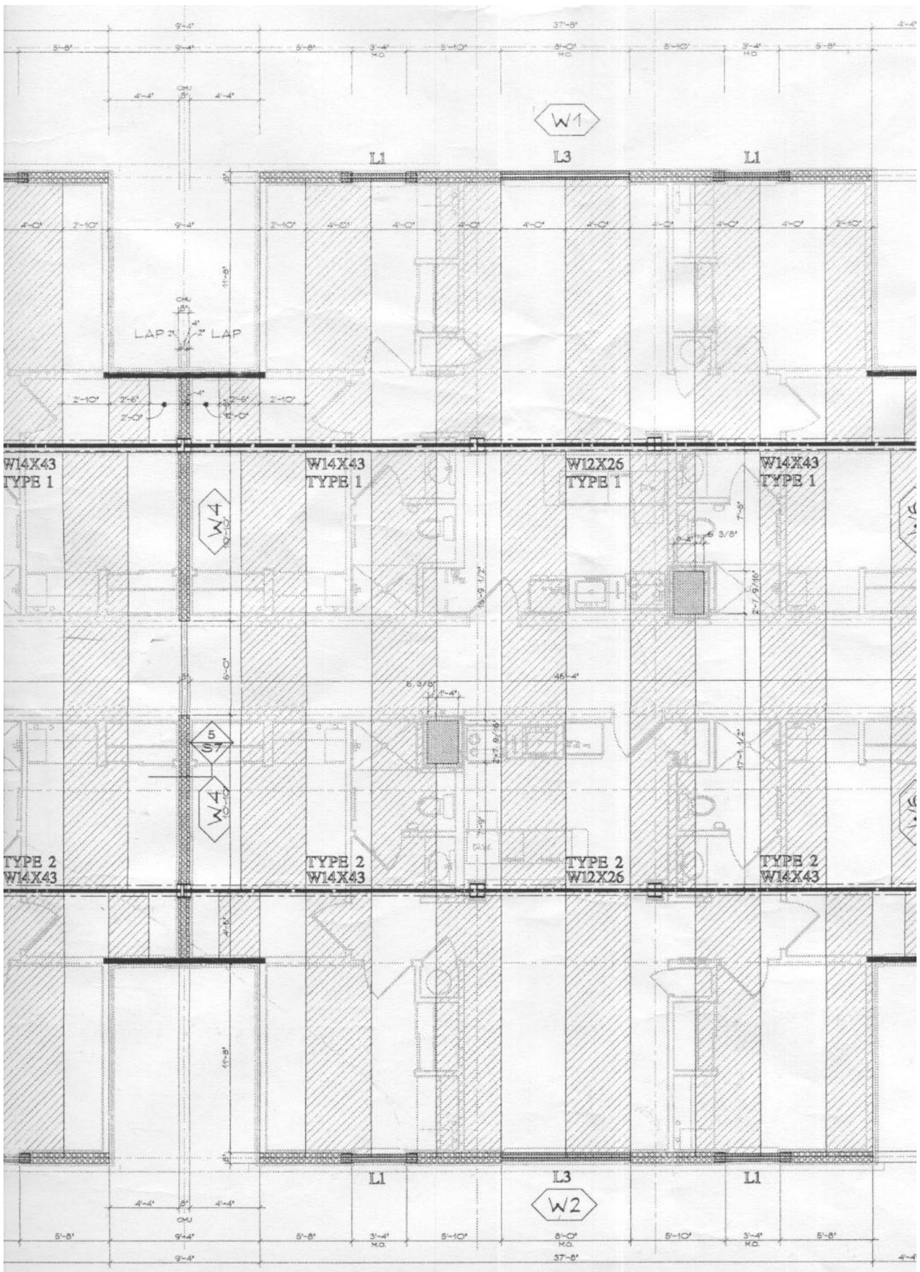


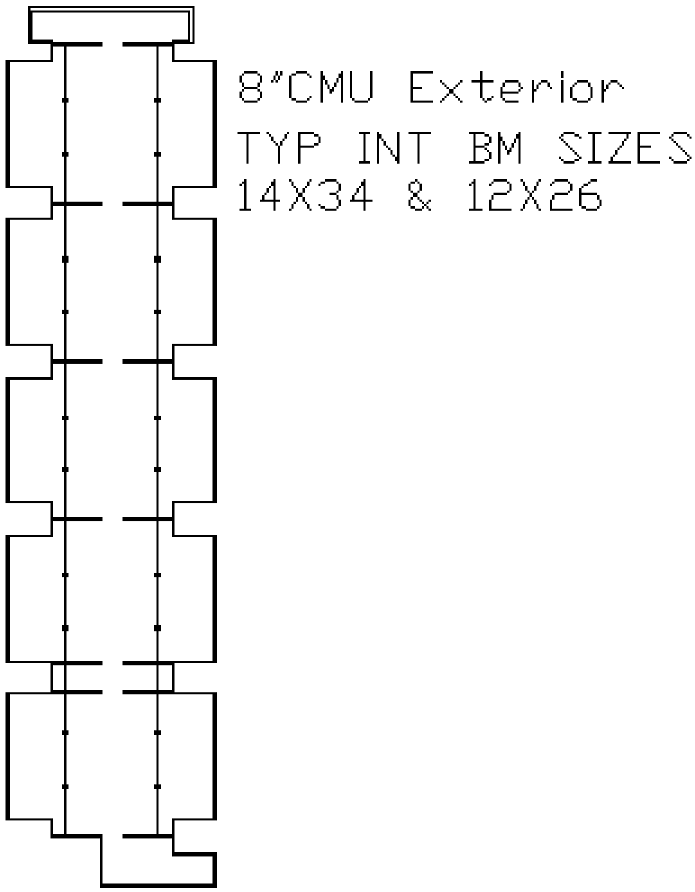
TYPICAL MASONRY WALL SECTION
FIRST TO FOURTH FLOOR LEVELS 2/S5
SCALE: 3/4" = 1'-0"

Gravity System

The vertical loads of the building are also carried to the footing by the CMU system, wrapping the exterior of the structure for much of the structure. The 8” precast hollow core planks distribute the floor loads to the blocks on the exterior of the building and a girder to column grid in the interior of the structure. The typical beam sizes are W12 X 26 and W14 X 43, which distribute the load to a series of W14 X 90 columns that then carry it to the 6’ X 8’ concrete footings below. *(see typical structural bay on the following page)*

Existing Structural Plan





Codes and References

- The International Building Code 2003
- The American Concrete Institute
    - Section 530.1: Masonry
- The American Institute of Steel Construction
- CRSI 2002: Concrete Reinforcing Steel Institute
- United Steel Deck Design Manual 2002

Problem Statement

The main problem that will be addressed in the Centre Court Apartments is the environmental impact of the materials and systems in the building. With green building becoming more of an easily obtainable goal for owners, builders, and designers alike, it is important to not overlook any steps that can be taken to make our buildings more efficient, create less waste in construction and destruction, and use materials that have been created in the safest and most environmentally friendly way as possible. Of the 4,859,000 buildings in the United States, the USGBC has calculated that they account for the following as compared to the US as a whole:

- 65% of electricity consumption
- 36% of energy use
- 30% of greenhouse gas emissions
- 30% of raw materials use
- 30% of waste output (136 million tons annually)
- 12% of potable water consumption.

The marketability of the USGBC's LEED ranking system is growing stronger everyday and is easily visible by last year's 12,685 and over 42,512 LEED Accredited Professionals worldwide. Such an acknowledgement would place the Centre Court Apartments on a higher pedestal than its peers and would set precedence for all future downtown apartment buildings for the borough of State College, Pennsylvania. Public relations aside, the USGBC has calculated that LEED-certified projects:

- Lower operating costs and increased asset value
- Reduce waste sent to landfills
- Conserve energy and water
- Are healthier and safer for occupants
- Reduce harmful greenhouse gas emissions
- Qualify for tax rebates, zoning allowances, and other incentives in hundreds of cities

The alternative construction method presented in this thesis will not attempt to make Centre Court Apartments gain a LEED Certification, but will lay out the guidelines to become LEED Certified because it will help the building become more environmentally friendly. Owners and occupants of sustainable buildings understand their role in the everyday living and breathing of the structure they inhabit. By having such constant reminders of the role you have in the functions of the building and it's impacts on your health can help to make an often times neglectful student population more conscious of the how they can help. Such a building could also attract a populous of more aware caring occupants that would prefer to live in such an environment.

Solution

Structural
From a structural engineering standpoint, materials that are renewable, have low embodied energy, and/or are made with recycled content are the most preferred building elements. Due to the 67.5' height of the Centre Court Apartments, use of load bearing natural structural elements such as straw bale are prohibited by code and the bearing ability of the bales, therefore a non-load bearing straw bale wall assembly will be used. Traditionally this post and beam system is done with timber framing. Chapter 5 of the IBC 2006 height restrictions bans the use of timber frame, so a redesign of the CMU and hollow core slabs system will be done with a concrete frame lateral resisting system with two way flat plate slabs. A high volume of fly ash or class C pozzolans, which is a waste product from coal burning power plants, will be incorporated into the concrete design mix, replacing up to 50% of the required Portland cement. Not only does this create a safe, alternative use of contaminates from the power industry, but Portland cement is the most toxic and energy intensive ingredient in concrete due to the need of being heated to 2700 °F.

Breadths

Sustainability
There will be an extensive LEED certification evaluation done on the existing building and then once again on the structure when the alternative design is complete. The addition of an under floor air distribution system, a photovoltaic array on the roof, and other mechanical and electrical changes that are found to be feasible will incur significant changes to the HVAC and electrical system. If time permits, an energy model using E-Quest of the building will be constructed to evaluate the LEED criteria in more detail.

The straw bale walls will be built on end with a width of 12". In this orientation, the bales have better thermal qualities and their structural value is not compromised because the entire load of the building is being carried by the concrete system. These straw bale wall assemblies will take the place of all stud and CMU walls in the building, which will cause a need for minor alterations to the architectural layout. Due to the stucco finish that already exists on the exterior of the building, no large aesthetical changes will need to be conducted. Other indoor environmental quality additions to the building may have an effect on the architecture as well, so although the basic layout of the building is not intended to be changed, new floor plans will need to be generated.

Construction Management
Straw bale construction on a story level of 67.5' is not a very convenient task due to the unique nature of constructing a straw bale wall. The walls will be pre-cast either on site or offsite locally, and shipped in using methods similar to those of pre-casting straw bale companies in California. It also goes without saying that a wall assembly such as this is not a common practice by most local contractors or estimators, therefore, an extensive cost breakdown and comparison of the alternative system will be conducted against the original. A detailed Microsoft Project schedule will be drafted to outline the feasibility of constructing such a system.

Tasks and Tools

Task One: Structural

1. Calculate new dead, live, and Lateral loads in accordance with IBC 2006
    a. Investigate High Fly Ash Concrete design
    b. Investigate that the 2 Way Flat Plate system is the most economical

2. Size all members in accordance with ACI 318-05
    a. Slabs
    b. Columns
    c. Lateral Frames

3. Model on ETABS
    a. Compute story drift
    b. Compute torsion effects

Task Two: Sustainability Breadth

1. Preliminary LEED Analysis
    a. Analyze existing structure
    b. Establish obtainable points

2. Analyze under floor air distribution
    a. Effects on the HVAC system

3. Analyze Photovoltaic array on the roof
    a. Effect on the Electrical system

4. Perform detailed LEED evaluation
    a. Create energy model on E-quest (if time permits)
    b. Perform full LEED credit evaluation for new obtainable points

5. Architectural adjustments
    a. Adjust typical floor plans to new wall layout
    b. Draft straw bale to concrete details and specifications

Task Three: Construction Management Breadth

1. Investigate Straw Bale wall system
    a. Cost and process of prefabricated wall system
    b. Local cost and availability of Bales

2. Perform Cost Analysis

3. Create Schedule in Microsoft Project

Schedule

Spring Semester Schedule 08'

Week Of	Semester Week	Tasks
7th	Winter Break	Research[1]
14th	1	Research[1]
		LEED evaluation of existing building
		Analyze of obtainable LEED points
21st	2	Evaluate new dead, live, and lateral loads;
		Begin redesign of high fly-ash content structural system
28th	3	Redesign of high fly-ash content structural system
		Create ETABS model to calculate story drifts
4th	4	Redesign of high fly-ash content structural system
		Write Structural Report
		Trip to San Francisco for ESW National Conference, Feb. 6-10
11th	5	Analyze under floor air distribution system with Photovoltaic Array
		Continue analysis of Photovoltaic Array and their effects on the HVAC and Electrical system
18th	6	Continue analysis of under floor air distribution system
		Continue analysis of Photovoltaic Array and their effects on the HVAC and Electrical system
25th	7	Detailed LEED Evaluation
		Energy model if time permits

Date	Week	Tasks
3rd	8	Draft architectural additions Draft straw bale wall specifications and details **Write Sustainability Report**
10th		SPRING BREAK
17th	9	Cost analysis and Microsoft Project scheduling model Microsoft Project scheduling model
24th	10	Cost analysis and Microsoft Project scheduling model Microsoft Project scheduling model
31st	11	Cost analysis and Microsoft Project scheduling model Microsoft Project scheduling model **Write Construction Management Report**
7th	12	Catch up Prepare for presentation
14th	13	THESIS PRESENTATIONS

January
February
March
April

[1] Research refers to and is not limited to:
Fly Ash Concrete Design
Straw bale to concrete connection details
Pre-cast straw bale paneling system: process, cost
Local availability and cost of straw bales

Conclusion

All economic benefits aside, it is not to be forgotten that the main objective of this thesis is to show a route that could be taken in order to assume responsibility as an owner, builder, or designer for the environmental impacts of a structure you have a hand in creating. In the environmental crisis that our planet is currently undergoing, we can no longer go about any daily activities in our lives and believe that due to comfort in an old method or upfront costs that we aren't contributing to the problem. With the industry fully recognizing the feasibility of building green, although this alternative design may be an extreme example, a sustainable building can be a very natural shift in the way we build.

The alternative method represented in this thesis is being investigated in hopes to offer a clear cut example that thinking innovatively and thinking green will not only benefit the species and eco system we exist with in communion, but also will aid the goals of the project as well. Building sustainably doesn't have to cost more in the long run and will add satisfaction to a project that is truly genuine and irreplaceable.