G.Muttrah Commercial & Residential Complex

Muscat, Sultanate of Oman

Thesis Proposal

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Structural Option

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Executive Summary

The G.Muttrah Commercial & Residential Complex is an 8 story multi use building located in the city of Muscat in the Sultanate of Oman. Located on the coast, the 280,000 square foot reinforced concrete structure consists of two-way flat plate system on the first two floors and a typical two-way slab system on the rest of the building. The lateral system consists of 10 shear walls that are located in the core of the building. Considered a safe seismic zone, the sultanate of Oman also has low average wind speeds compared to the United States which results in relatively few shear walls for such a building.

As a senior thesis design project, changes will be made to the structural system of the G.Muttrah complex. The building would be relocated to the United States for a more dynamic design of the lateral system which would include greater seismic and wind loads. Since the building is originally located in a unique environment, a city that most resembles Muscat had to be chosen in order to reduce the changes in the initial design condition while adding greater wind and seismic loads. The city chosen for the senior design thesis is Houston Texas.

In addition to the new loads due to the relocation of the building, the floor system will also be changed. The flat plate on the first two floors and the two way slabs on beam on the rest of the floors will be replaced with a two way post-tensioned flat plate system for the entire building.

Different structural design software's such as ETABS and RAM concept will be used along with hand calculations to design a new structural system for the G.Muttrah Building. The new wind and seismic loads would change the lateral system, possibly increasing the number of shear walls while the new floor system would also affect the overall weight of the building. The new design would be conducted using US codes and standards.

Furthermore, breadth topics will be addressed as part of the thesis design. The first breadth topic would be a study of the change in the construction schedule and cost of the new structural system. The second breadth topic would be a study on the architecture of the building since more shear walls will possibly be added and also the lower weight of the building might require less or smaller columns.

Introduction

The G.Muttrah Commercial & Residential Complex is a mixed use building in a commercially developing region in the city of Muscat, Sultanate of Oman. Covering an area of approximately 280,000 square feet, the reinforced concrete building will consist of eight floors excluding the parking at the basement level. Retail space will occupy the ground floor, offices in the second floor and 96 apartments in the rest of the 6 floors. A set back of about 35 feet from the north side starts from the fourth floor onwards. The parking garage in the basement will serve 115 slots for the tenants due to the limited parking spaces in the area. More parking spaces will be available around the perimeter of the building which will only provide space for 63 cars.

The typical floor height is 10 ft for the basement level, 14 ft for the retail, 12 ft for the offices and 10 ft on the rest of the residential floors. A flat roof is used to place all the HVAC equipment. The plot has a slope of about 10 ft from the northwest corner to the southeast corner. This slope is used to incorporate the basement level as a parking garage. The ground level is set at 2.6 ft cm below grade while the basement level floor is constructed at 12 ft below grade (Figure 1). Like a typical parking garage, the concrete reinforced columns are placed in a rectangular grid in order to accommodate all the spaces and for ease of transportation.

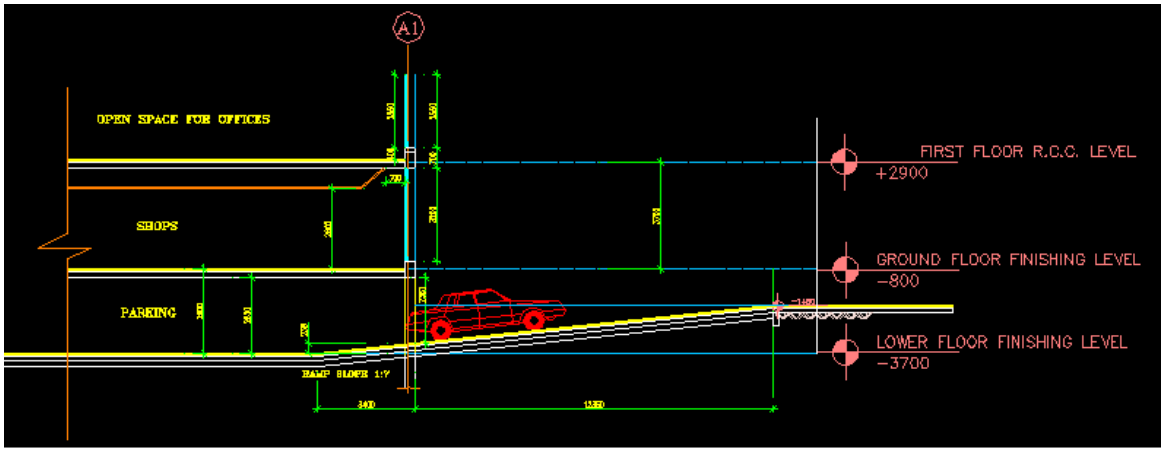

Figure 1: A section showing the entrance of the garage level

Structural System Overview

Summary

The G.Muttrah Commercial & Residential Complex is a reinforced concrete frame building with shear walls. The flooring system consists of a combination of reinforced concrete flat plate slabs on some floors, and typical two way slabs on beam frame system on the others. The dimensions of the building plan are about 300ft by 132ft. The typical roofing/floor system span is between 10ft and 30ft. The material strength used is approximately 5,500 psi strength concrete and 60,000 psi steel strength. Finally, the roof of the building is a 6 in thick slab that only has to carry the loads from the mechanical equipment on the rooftop. There are no snow loads for this building since the weather statistics show that the chances of snow in Oman are slim to none.

Floor Slabs & Beams

The second and third floor of the G.Muttrah complex consists of a flat plate slab system with drop panels. The floors have 2 varying slab thickness; one at 10in slab thickness with a drop panel of 14in and reinforcement of # 3's and #4's in U.S standard. The second is at 14in slab thickness with a drop panel of 22in and reinforcement of #5's (see figure 2). The rest of the floors have a typical two-way slab system with slabs thickness varying from 6in to 8in. The slabs are supported by the usual rectangular beams that range from 6in x 20in to 32in x 20in.

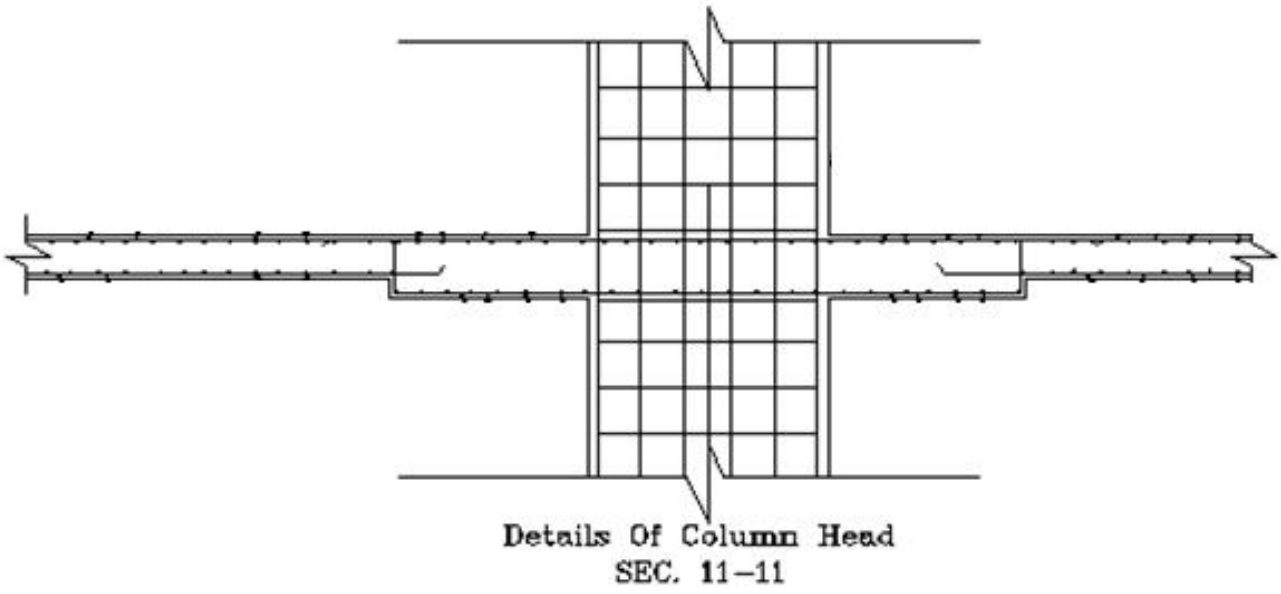

Figure 2: Flat plate slab and column on the second floor

Foundation & Columns

As for the foundation, a 4 ft thick mat slab is used to carry the loads from the different columns. The mat slab is reinforced with 2 layers of #20's and 2 layers of # 10's mesh running both ways. Gravity loads from the building are carried down through reinforced concrete columns that are aligned together in a simple grid, with the majority running throughout the entire building. The columns have a base at the foundation slab level (see figure 2) and range between 14in x 21in to 28in x 47in.

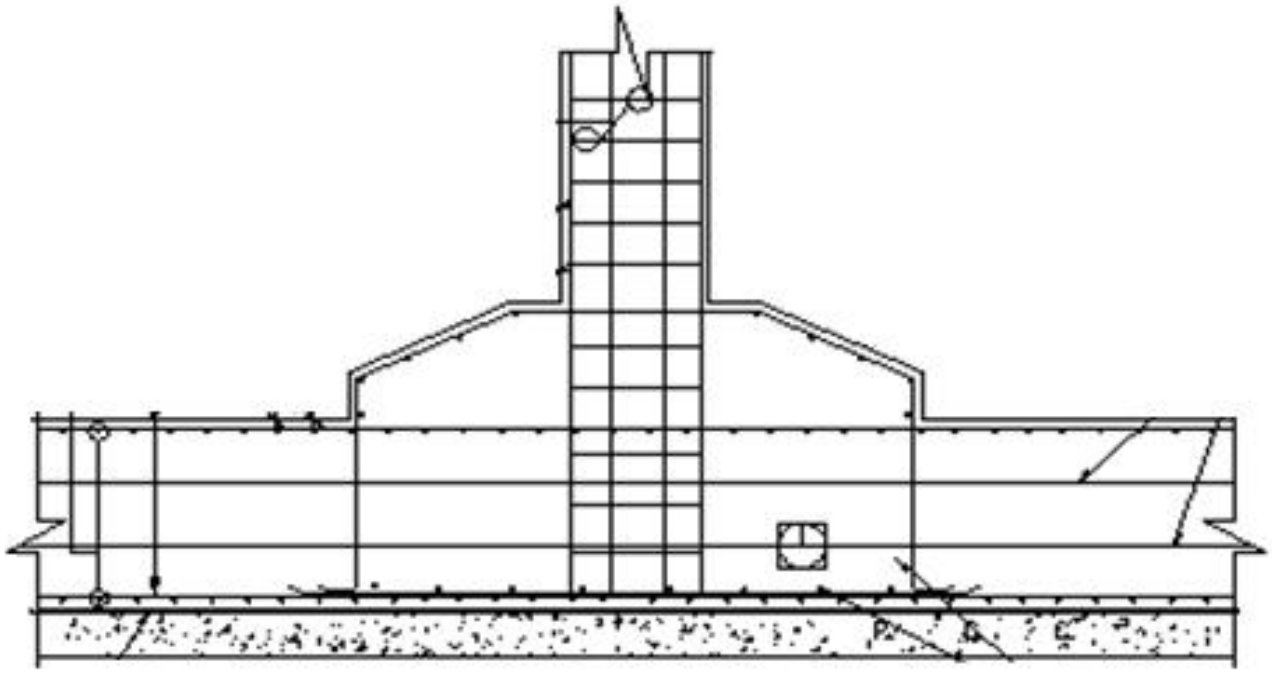

Figure 3: Typical column base at foundation level

Lateral System

Shear walls are used to resist the lateral force in the G.Muttrah complex. The shear walls are located in the core of the building and start at a thickness of 14in at the basement and decrease to 8in as they reach the roof. These walls run in the North-South direction which is expected since that is the weaker axis due to the wind direction and exposure to a larger surface area. There is only one shear which runs in the East-West direction. The following plan shows the location of the shear in the building:

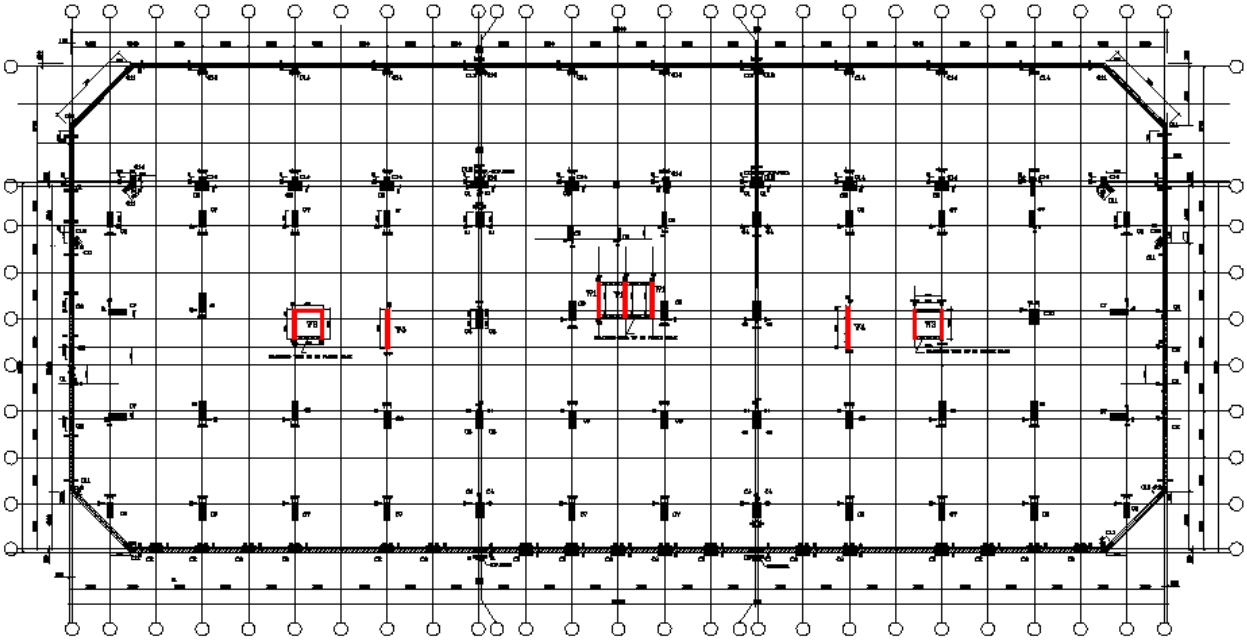

Figure 4: Plan showing location of shear walls

Problem Statement

Project Goal: To design an efficient structural system for the G.Muttrah Commercial & Residential Complex in a location with greater seismic and wind loads.

The G.Muttrah building was designed based on the codes provided by the Municipality of Muscat where no seismic consideration was required. The wind loads were also significantly lower hence such a design would not be applicable for a different location other than Muscat. The floor systems were also designed differently where a flat plate system was used for the retail and office space and a two way slab on beam for the residential floors. A typical floor system for all floors would be more efficient for construction while a flat plate system would be more ideal for the residential floors for a minimized floor to floor height.

Problem Solution

Proposal: To redesign the G.Muttrah complex with post-tensioned flat plate systems for all the floors and also redesigning the shear walls. The new location of the building will be Houston, Texas.

The post-tensioned flat plate will be an ideal system for a building with residential floors. A typical floor system throughout the building will be more efficient in the construction process while also providing a finished ceiling and a flexible column layout. The column layout might change or the size of columns might be smaller due to the decrease in the weight of the building. The original design had varying sizes of columns while an attempt will be made in the new design to keep them as uniform in size as possible. The new location, Houston, was picked due to the similarities in weather conditions compared to Muscat. Although the average wind speed and temperature are slightly higher in Houston, they are the closest to the average data recorded in Muscat. Moreover, the seismic requirements in Houston would require a significant change in the shear walls.

Breadth Topics

Construction:

For the first breadth topic, a study will be conducted on the construction schedule of the new design. The cost and construction process will be compared to the old design. The post-tensioned floor system is a relatively new approach in Muscat and hence might have a greater impact on the schedule. Contractors might be reluctant to use such a system and that might increase the cost. Safety is also an issue with post-tensioned systems and that might also affect the pace of construction process.

Smaller columns will be considered for the design since the weight of the building will be reduced. These new columns will save time and reduce the cost of the construction. More shear walls might be added to resist the seismic loads, thus an adjustment to the schedule is needed to accommodate them.

Architecture:

For the second breadth topic, the architecture of the building will be examined for any necessary changes to the plans that might be needed to accommodate the new structural system. The new shear walls might conflict with the existing layout of space and hence a revised floor plan might be needed. In addition, the column layout and sizes might be affected by the new weight of the building and so a more efficient grid might be considered if the existing grid is not satisfactory.

The facade of the building should not change significantly since only the interior spaces are likely to change, except if the retail and offices spaces changes drastically which would then affect the exterior glazing at the corner of the buildings. The height of the building will also remain the same since the restriction of the plot are by number of stories and not building height.

Solution Method

The thesis design for the G.Muttrah Commercial & Residential Complex will be conducted using ASCE-05, ACI 2008, and PCI. A new column grid will be considered if the existing grid is not sufficient, while the loads applied on the building will be specific to the new location, Houston, Texas.

ETABS, structural design software, will be used to design the shear walls for the lateral systems. The design will also be double checked using hand calculations. As for the floor system, RAM concept program will be used to design the post-tensioning which will also be checked using hand calculations. PCA columns will be used to design the concrete columns. Finally, the foundation will be checked for adequacy and if not adequate a new foundation design will have to be considered.

Task And Tools

Depth

1. Design of Post-Tensioned Floor System:
   - Create Ram Model and design slab
   - Design post-tensioned tendon layout
   - Check deflections, shear and moment capacities

2. Design Concrete Columns:
   - Determine loads from the new floor system
   - Design columns using PCA Column
3. Design Shear Walls:
   - Determine lateral loads for the new location using ASCE 7-05
   - Design Shear Walls using ETABS
   - Check deflections, story drift, torsion, shear and overturning moment.
4. Check/Design Foundation:
   - Check if the foundation is adequate to carry the loads and overturning moment.
   - If foundation is not adequate design new foundation or find alternative solution.

Breadth

Construction:

1) Examine cost and time to construct post-tensioned floor system in Muscat.
2) Analyze change in schedule due to new shear walls and floor systems.

Architecture

1) Redesign plans and layout of space in areas that are affected by new shear walls/column grid.
2) Check if the new design satisfies building codes and requirements

Time Table

Tasks	Jan 11-15	Jan 18-22	Jan 25-29	Feb 1-5	Feb 8-12	Feb 15-19	Feb 22-26
Design of Post-Tensiond Floor System							
Creat Ram Model and design slab							
Design post-tensioned tendon layout							
check defletction, shear and moment							
Design Concrete Columns							
Determine loads from floor system							
Design columns using PCA Column							
Breadth							
Examine affect of column on space							
Examin changes to schedule and cost							
	March 1-5	**March 8-12**	**March 15-19**	**March 22-26**	**March 29-Apr 2**	**Apr 5-9**	**Apri 12-16**
Design Shear Walls							
Determine lateral loads							
Design shear walls							
Check shear wall capacity/deflection							
Check Foundation							
Check if foundation is adequate							
Design foundtation/ find alternative							
Breadth							
Adjust plans and spaces							
Adjust schedule							
Additional time for review/correction							

Table 1: Timeline of Tasks to be performed

Conclusion

The G.Muttrah Commercial & Residential Complex will be relocated in Houston, Texas for the purpose of thesis design project. The structural system will go through various changes such as a post-tensioned floor system for all the floors and a redesigned shear walls to resist the lateral loads. ETABS, RAM concept and PCA columns will be used to direct the design along with hand calculations for verification.

Along with the depth study of the structural system, two breadth topics will be covered in the thesis design project. A construction depth will look at the effect of the system on the schedule and cost of the construction while an architecture depth will focus on the changes in plans and layout of spaces due to the redesigned shear walls and columns. The two topics along with the depth study will provide a solid study for a design of the G.Muttrah complex relocated to the United States.