Robert M. Arnold Public Health Sciences Building
The Fred Hutchinson Cancer Research Center
Seattle, Washington

Thesis Proposal:

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Architectural Engineering
Structural

Executive Summary

The Robert M. Arnold Public Health Sciences Building was constructed on the campus of the Fred Hutchinson Cancer Research Center (FHCRC). The Public Health Sciences Building houses four programs: Epidemiology, Cancer Biology, Biostatistics & Mathematics, and Cancer Prevention. Both laboratories and offices occupy Arnold Building. The building height is five stories (60') above grade. The structure also extends three stories below ground. There is an entrance plaza, service road, and turnaround at the building entrance. These public spaces are supported by a portion o f the submerged structure.

The existing structural system is cast in place concrete. The slabs are typically two-way post-tensioned slabs with drop panels. The majority of the columns are made of reinforced concrete. The lateral force resisting system consists of reinforced concrete shear walls. This paper proposes the structure below grade remain the same construction as was originally design. The portion of the building which extends above ground will be redesigned using steel instead of concrete. This section of the building will be divided into 3 separate structures surrounding the atrium. In addition to this alternative structural system a green roof system will be designed for the existing design. Finally a construction management study will be completed regarding both the alternate structural system and the green roof design. Both cost estimating and construction scheduling will be done for the structural system. The green roof retrofit will only be analyzed on the basis of cost and a life cycle comparison to more typical roof constructions.

Background:

The Robert M. Arnold Public Health Sciences Building is an interesting collage of structural systems. Different portions of this building employ different methods of supporting the necessary loads. The building itself consists of five floors above grade plus a mechanical "penthouse" on the roof. It also extends 3 stories below grade.

The main framing system in the Public Health Sciences Building is a cast in place concrete framing system. Almost all of the remaining portions of the structure are made of concrete. The columns are continuous cast in place reinforced concrete columns. The typical columns are 24 inches square and are on an average grid of 30 feet by 30 feet. The columns do not taper towards the top, however, the amount of reinforcement can vary. The shape of some columns changes from rectangular to circular on certain floors. For these situations the columns have a diameter of 24 inches. Supporting Campus Drive, the turnaround, and the entrance plaza, under which the building extends, is an area of the building which uses cast in place reinforced concrete. The average beam size is 24 inches wide by 30 inches deep.

Although the framing of Arnold building is mainly composed of concrete structural elements there are some portions of the building where steel has been used. Steel framing was used for the stairs and skylight in the atrium. A special stipulation was made by the structural engineers that the structure of the atrium be designed so that only no torsion resulted on the rest of the building. The columns on the fifth story are made of tube steel with the typical size being TS 12x12x$^{5}/_{8}$. Steel was also employed in the design of the roof structure that houses the building's mechanical equipment. The typical steel column in this area is a TS 4x4x4$^{1}/_{4}$. The irregularity of the steel roof structure lends itself to atypical beam and girder sizes ranging from W 10x12 to W 30x132. There also are a few steel columns scattered throughout in the main structure.

The floor system of Arnold Building is mainly composed of two way post-tensioned concrete floor slabs. The slab in the basement is not post-tensioned but instead is made of fiber reinforced concrete. The portion of the building located under the entrance plaza uses reinforced concrete slabs. The roof slab is also composed of reinforced concrete. With the noted exceptions the typical floor system is a flat post-tensioned concrete slab with drop panels.

The foundation of the Public Health Sciences Building consists mainly of spread footings and wall footings. Where the foundation is required to resist lateral loads carried down by shear walls, the Building uses deeper drilled piers. The average footing is about 12 feet square, however, sizes ranging from eight feet square to 28 feet by 24 feet. The depth ranges from 30 inches to 48 inches deep, but is typically around 40 inches deep.

The lateral forces exerted on the building are resisted by a combination of shear walls and braced frames The braced frames are isolated to the fifth floor, the mechanical penthouse, and the roof structure. Shear walls are used on all other levels. They extend down through the parking structure where openings for vehicular traffic reduce the efficiency of the design.

Proposed Alternateve

Arnold Building will be divided into 4 main structures. The portion of the building below grade will be a monolithic flat plate concrete slab construction as was originally designed. The section of the building that is above ground will be divided into three sections. These sections will be determined by the vertices of the triangular atrium. These structures will have independent lateral systems. The above grade portions of the building will be redesigned to employ steel for both gravity and lateral elements of the structure. Stringent drift tolerances will be required to prevent collisions between the separate structures. The roof levels and the mechanical levels will remain unchanged except for where new joints in the building exist. These areas are currently designed using steel.

Following the modification of the above grade structure the below grade elements will be analyzed and changed accordingly. The intention is to reduce the self weight of the structure ultimately reducing foundation size; additionally by a reducing the weight of the structure, the participating mass in a seismic event will be minimized.

Methods

The majority of the structural design for the proposed changes will be carried out through the development of a RAM Model. This main computer model in RAM Structural System will be supplemented by the use of RISA, Spreadsheets, and hand calculations; as is required by the project. The design of footings in the ram model will be compared with CRSI manuals and adjustments will be made. These adjustments will be made because sometimes RAM Footing design produce an overly conservative result. The final design will be based upon the structural requirements of the building as well as constructability.

Scheduled Tasks

A summary of the tasks necessary to accomplish the proposed design modifications are listed on the opposite page. The chart groups the various related tasks into phases numbered in the Arabic numerals.

TASKS TO BE COMPLETED

1		**GRAVITY**
	I.	Sever Structures
	II.	Create Modified Design Model in RAM
	III.	Preliminary Gravity Design & Analysis
2		**LATERAL**
	I.	Change Shear Walls to Braced Frames
	II.	Place Additional Lateral Elements as required
	III.	Preliminary Lateral Design & Analysis
3		**FINALIZATION**
	I.	Finalize Modified Structural Design
4		**Green ROOF**
	I.	Architectural Design of Green Roof
	II.	Green Roof System Design
	III.	Structural Analysis of Impact on existing Structure
	IV.	Recommendations for Strengthening (only if necessary)
5		**Construction Management**
	I.	Estimate of Alternative Structural Design
	II.	Scheduling of Alternative Structural Design
	III.	Estimate of Green Roof Renovation
6		**Report**
	I.	Compile & Write Final Report
7		**Presentation**
	I.	Summarize Report and Generate Final Presentation

Proposed Task Schedule

	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
				1	2	3	4
January	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
			PHASE 1				
	19	20	21	22	23	24	25
			PHASE 2				
	26	27	28	29	30	31	1
			PHASE 3				
February	2	3	4	5	6	7	8
			PHASE 4				
	9	10	11	12	13	14	15
			PHASE 5				
	16	17	18	19	20	21	22
			PHASE 6				
	23	24	25	26	27	28	29
			PHASE 7				
Mar	1	2	3	4	5	6	7
			COMPLETE REMAINING COURSE REQUIREMENTS				

Breadth Topic : Architectural Design

Both the City of Seattle and the Fred Hutchinson Cancer Research Center have openly declared their commitment to the environment. They each have recognized the ecological effects of development and they each have taken appropriate courses of action. The combination of FHCRC's & the City of Seattle's devotion to the environment make the campus a prime candidate for the promotion of green roof technology.

The integration of the architectural design and the engineering of building systems can significantly reduce the ecological footprint of a building. Green Roofs are a specific example of the integration of design and engineering.

Implementing a Green Roof system provides multiple benefits both to building occupants and the environment. One such benefit is mitigation of the urban heat island effect. The urban heat island effect is the tendency of more metropolitan areas to have a higher average temperature than surrounding rural areas. Rising temperatures of urban areas can directly impact local, and potentially global, weather patterns and environments. Green Roofs radiate significantly less heat than asphalt roof systems. The plants of the Green Roof also actively cool the roof through the process of evapo-transpiration; the cooling effect felt by a person sitting under a tree. The release of water by plants cools the air through the process of evaporation. Green Roofs also significantly improve the effects of stormwater runoff.

The design for a Green Roof will be completed for Arnold Building. Existing conditions will considerably impact the design. The design of this alternative roof system will be completed with the existing structure. It will address the feasibility of retrofitting Arnold Building as it was constructed for a Green Roof application. Structural implications will be investigated. The cost of the roof installation will be addressed as well as anticipated maintenance costs.

Breadth Topic 2 Construction Management

A detailed cost analysis for the alternative structural design will be completed. This analysis will be compared to the system that was built in order to determine if this alternative system would have been practical. In addition to the estimate a construction schedule will be created and compared to the one that was implemented. Independent of these two tasks a third task of estimating the proposed Green Roof Renovation in Breadth Topic 1 will be completed.