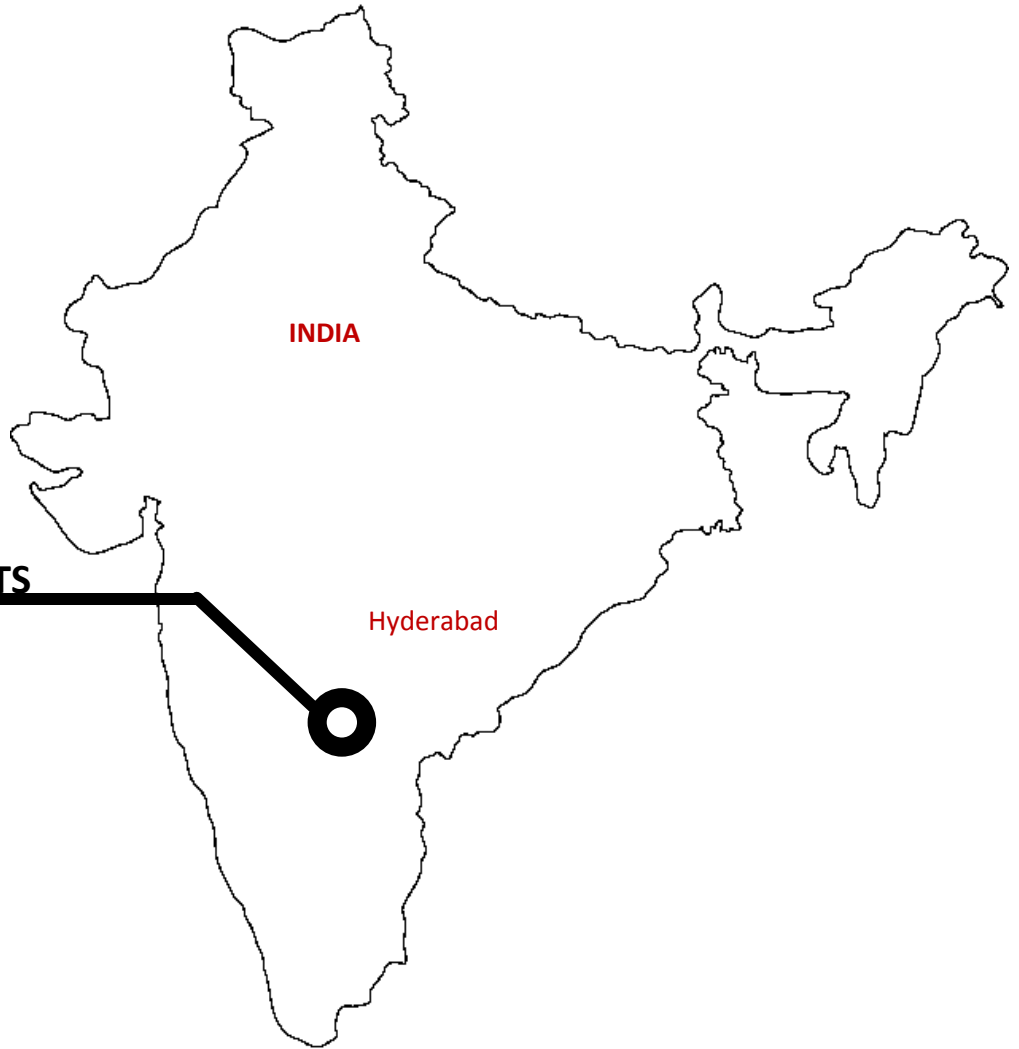


TECHNICAL REPORT 3



HANZA CREST APARTMENTS

Hyderabad

Bhavana Reddy

Advisor: Dr. Robert Leicht

November 9th, 2016

EXECUTIVE SUMMARY

Ambience Construction firm was appetent about introducing their firm into residential construction market through Hanza Crest apartments project and extend the firm's reputation. The apartments are designed for the high-income demographic. The building contains eight stories of residential floors which consists of two basements, five floors with two apartments each floor and a club house. The project is budgeted for \$1.05M and handed-over in 32 months.

The project manager interview was focused on the services of project management team and value engineering topics. The services Ambience Construction firm starts from inception stage to close-out stage. This project has some challenges commonly faced by the entire construction industry in India. Safety, design management, funding and obtaining statutory approval from all the departments. The value engineering topics were focused without a compromise in quality and obtain the same end-results.

This report focuses on The 25th annual PACE roundtable conference, attended by me. The two sessions focused in the conference are exploring innovative solutions in construction safety and modular construction barriers to innovation. This initiated the opportunities in analyzing and researching for Hanza Crest apartments. There was interaction with industry members to obtain feedback for the research ideas initiated during the conference.

Ambience Construction firm did not utilize BIM for this project. However, a BIM execution plan has been developed to enhance means and methods of construction for this project. Though the building is not LEED certified, LEED analysis has been performed to make the construction more sustainable and understand the opportunities available to make the building Silver certified.

TABLE OF CONTENTS

PROJECT MANAGER INTERVIEW.....3

PROJECT MANAGEMENT SERVICES.....3

VALUE ENGINEERING TOPICS.....6

PACE ROUNDTABLE.....8

CRITICAL INDUSTRY ISSUES.....9

FEEDBACK FROM THE INDUSTRY MEMBER.....16

BIM USE EVALUATION.....17

LEED EVALUATION.....22

APPENDICES.....24

APPENDIX A-PROJECT MANAGER INTERVIEW.....24

APPENDIX B-PACE ROUNDTABLE FORMS.....25

APPENDIX C-BIM EXECUTION PROCESS MAP.....26

APPENDIX D-LEED CHECKLIST.....27

PROJECT MANAGER INTERVIEW

PROJECT MANAGEMENT SERVICES

Ambience construction firm is responsible for all the stages in construction of Hanza Crest apartments. There are only two subcontractors involved for the design, structural and MEP systems. The project management services is performed by Ambience Construction firm.

There are 6 typical stages in project management services. Starting with inception stage, it is briefing about the project to the client to form the contract documents. Succeeding with inception stage is concept stage. Scheduling design meeting, review designs and facilitating sign - off process fits into this stage. Followed by concept stage is the detailed design stage. In this stage, ensuring periodic reviews and obtain detailed schedule and finalize the deliverables.

Succeeded by detailed design stage is the procurement which is crucial to obtain design documentation and review the estimate. Followed by procurement stage is the construction stage, one of the important stages. This stages has reviewing of drawings, site co-ordination and manage the entire construction. Finally, the last stage is close-out stage dealing with final document certification, final evaluation, update quantity variations and complete the final documentation to hand-over the project.

Since Ambience construction firm is the owner's representative, most of the constraints are handled by the firm. Some of the biggest challenges for the client/project management team are obtaining statutory approvals from all the

departments such as fire, water, electricity and GHMC (Greater Hyderabad Municipal Corporation). Apart from this constraint, funding, adhering to the timeline to handover the project on time, man power, machinery, design

management and safety are some of the major constraints. These are some of the major issues leading to delays in the schedule.

The potential key areas identified by the Ambience Construction firm to enhance managements services is the deployment of more site engineers to ensure quality of work and push the progress of the project smoothly. Another method is implementation of share point platform for progressive management. Share point platform has benefits such as enhanced reporting, ease of data and document management, access to all projects of a specific client, high level of security and ease handover and close out of project due to organized structure. The third and most potential implementation mentioned by the project manager, is BIM to mitigate any design and drawing issues during the course of a project.

There would be only minimal costs for implementing these methods.

Approximately \$2265 per month. This is approximately 0.2 percent of the total cost but enhances the project management services colossally.

VALUE ENGINEERING TOPICS

Cost, quality and safety are the three major areas focused for value engineering. Some of the steps taken to execute value engineering is the change of tiles from marble to vitrified tiles. Though the functionality is maintained, vitrified tiles are low at cost for outdoor.



Figure 1: Vitrified tiles

Revising the concrete design mix after escalation of same result in reduction of cement content, leading to reduction of cost though not applied throughout the construction.

The project management team is attempting to arrange quality training of staff and workmen to prioritize quality since, quality is one of the main goals for the client. Marble flooring is opted over wooden flooring for a better quality and basement machine room is changed from RCC (Rolled-compacted concrete) to block foundation to provide sufficient ventilation.

For safety purpose, additional angle is provided for electrical, fire and communication doors. Deployment of staff to guide the workers follow basic safety precautions on site. But this has not been effective in all the phases, since it is difficult to track each worker on site and guide them. Since October, there are only two staff members employed for this purpose apart from site superintendent.

Some of the value engineering topics that were considered but not shown are change of retaining wall footing from isolated to combine, lowering of sump level in underground to increase sump quantity, usage of monolithic beams and hacking for internal plastering. Though these were proposed initially, the project

management team were reluctant towards executing them due to the compromise in quality and end-result.

Some of the value engineering topics that could have been focused are usage of precast concreting and MIVAN formwork. These would ensure faster pace of construction and better quality of work for the project. But the cost would hike up to 20% for these Conventional methods.

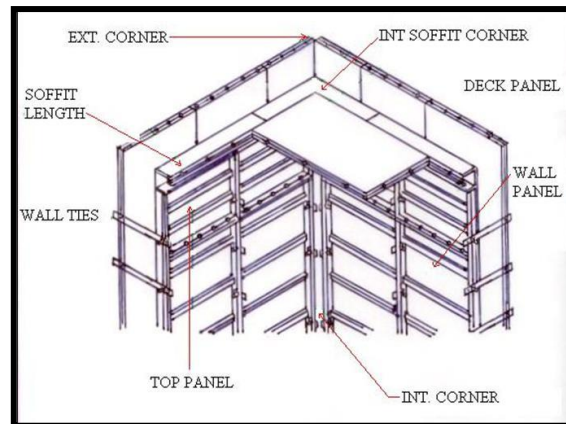


Figure 2: MIVAN formwork (aluminum)

Implementation of share point platforms and BIM to enhance the services and quality are the other topics of value engineering that had the potential to upgrade the entire procedure of this project.

PACE ROUNDTABLE CONFERENCE

The Pace (Partnership for Achieving Construction Excellence) roundtable conference was held on 28th October, 2016. The Penn state architectural engineering faculty, architectural engineering students and industry members attended. The students had an opportunity to pick two sessions of group discussion involving faculty and industry members to persuade students thesis research. There were six sessions held during the conference and listed in *table 1* below.

	A. Field Innovation	B. Technology	C. Sustainability & Resiliency
Round 1	Session 1 A: Future Capabilities of Field Construction Personnel	Session 1 B: Identifying Future Technology Opportunities	Session 1 C: Exploring Innovative Solutions in Construction Safety
Round 2	Session 2 A: Modular Construction Barriers to Innovation	Session 2 B: Virtual Reality and Augmented Reality Tool Adoption	Session 2 C: The Future of Sustainability and Resiliency

Table 1: Main discussion topics at PACE roundtable conference

CRITICAL INDUSTRY ISSUES

The PACE roundtable conference concentrated on six critical construction issues during the six sessions mentioned in table 1.

I chose the highlighted sessions which are exploring innovative solutions in construction safety and modular construction barriers to innovation. Safety is one

of the biggest issues in construction industry and there are ream of measures and precautions to be considered apart from OSHA training for safety.

Another topic attended followed by safety was modular construction. There are benefits and consequences for this type of construction. The potential benefits and enablers from modular construction are analyzed along with the consequences faced. The first and most important aspect is to analyze if the modular construction is adequate for the project chosen to proceed.

There was a presentation preceding to the sessions on 27th October, 2016. It was held by Dr.Paul Goodrum to kick start the conference on the next day. The presentation focused on work shift from blue collar to white collar. Dr. Paul spoke about the requirement of younger generation to be involved in the construction industry since the work force is aging and this industry requires active participation. In Europe, some of the schools are enabling students to choose their career path in middle school to have a better career and select appropriate profession.

SESSION 1C: Exploring Innovative Solutions in Construction Safety

This session on safety was held by Dr. Somayeh Asadi and Mr. Mike Toole. During this session, the safety concerns and ways to implement new ideas to increase the safety during construction were discussed.

It was argued that The OSHA teaches only law and pre-task plans guide to interact, enhancing the safety. Interactions and asking questions about the tasks would help the craftsmen. The construction industry is slow but is changing. As per the discussion, 90 percent of them are good builders and 10 percent are not good

builders. So, the motive is to figure that 10 percent people and required to be interacted. Cultural, psychological factors, personality and behavior of craftsmen play significant roles in safety. So connecting with craftsmen and triggering that emotion to understand the importance of safety is a strategy to prioritize safety and better working environment. For example, giving a reward of \$100 gift card to worker(s) for not breaking any safety rule would be strategy to encourage workers follow safety.

The integrated and design are collaborated, but preceding these two aspects, quality and safety should be planned. Schedule and budget create an impact on safety. So considering quality and safety first will help in scheduling and create a budget effectively. Some of the key ideas that were focused in this session are understanding people's behavior and design special training apart from OSHA. Accountability plays an important role in safety as zero tolerance and not sparing if safety is not followed would make the craftsmen follow the rules more appropriately. Owner's involvement in safety by talking to trades directly and show more respect to the trades, by enquiring what do we stand for and what don't we to mutually agree upon issues was one of the key factors discussed. Having webcams on site is already implemented in some of the projects and it has worked well to maintain the site safety. Spending time on material placement would make the job more efficient and less prone to accidents. Keeping the site job clean has direct link to safety. No materials or tools should be placed on the ground. Cleaner and efficient methods, like having materials placed in carts would be make it a better site to work.

There should be sufficient amount of co-ordination between the trades and craftsmen. All the industry members including workers should co-operate and make effort to implement methods for a safe and accident free construction, since

it is about the change and not about following traditional methods that are not improving the safety in expected rate.

Some of the innovate ideas implements by the faculty and students were to have a safety score which is like having a credit score for all the foremen. There needs to be different measures to get scores at each phase of the project. But more research is involved in this, since the credit is to be given based on a specific criteria and for each employee individually. Another idea discussed was having a batch system. This is about scanning the batch of a worker to get the credit score and obtain an idea about how seriously that specific foremen are following safety.

Having a special training in each cluster for the craftsmen would help them understand the task better and the risks involved while performing tasks. This could be implemented through BIM. Finally, the discussion ended with the acknowledgment of providing equal importance given to technology route and human route to improvise safety.

Panel Presentation

The panel presentation focused on owner's role in addressing workforce challenges. This was held by Mr. John Bechtel, Mr. Spencer Brott and Mr. Rodney Spencley.

The presentation kicked off by discussing about technology which included auto machine and AI robotics. The motive was implementing sophisticated software emerging in construction, that requires to be less complicated and user friendly. Focusing on what needs to be communicated and how effectively through technology would enhance the construction industry. Robotics is connected to pre-

fabrication leading to risk management and safety. There is a connection between technology and people, this is important for safety also.

The second topic presented was about safety. The industry members spoke about the way one can address a violation with respect makes a difference. Involving families and making them understand the importance of safety would bring a change.

Succeeding with safety, the discussion continued about owner's role. The discussion was focused on pre-qualified list which concentrated on work force development program and this is different for union and non-union members. The owners should develop the idea of contractors investing in training and education.

35 percent of hired members are required to be residents of that city and this would lead to 25 percent of increase in budget and longer schedule. But if the owners can think of this issue ahead of time then it would make the issue less complicated.

Finding workers should be everyone's responsibility and work as team strategically. The owners should focus on not to overboard the cliff.

The owner has a pivot role in design decisions and pre-fabrication involves owner colossally. The owner has to pay earlier in pre-fabrication process and this proceeds to work starting earlier in shop than site. Since the schedule is decreased, it turns into an advantage. If the module is not delivered on time, there is no advantage for the owner to pay earlier for pre-fabrication. The potential risk involved here is transporting the module on site. There needs to be quality inspection before and after getting the module to site.

Some of the topics covered in the other sessions were summarized during panel presentation. The virtual reality session discussed about people being able to swap materials/tools, construction simulation and leveraging and site safety specific

training. Though hardware is ahead of software, this session involved the ability of growth in technology collaborating with people and the methods to adopt this.

The next topic summary was about sustainability. The focused topics were recycling construction material, back-up system for making energy more renewable and energy which is a diverse topic. The issues faced with modularization, especially material evolution.

SESSION 2 A: Modular Construction Barriers to Innovation

The second session attended was about modular construction. This session was held by Dr. Robert Leicht and Mr. Mike Toole. This session focused on potential benefits, enablers, areas of research and the consequences of implementing modularization.

The session kicked off by discussing about the expected outcome of this session for the students. Modularization is not the same as standardized. As long as the module fits into the specific box, it can be pre-fabricated and module could be non-standardized. Typically, the public restrooms have repetitive layout and fits into modularization. Modularization demands working with different trades/ unions and construct the unit together.

As mentioned above, the potential benefits, enablers, areas of research and consequences were discussed simultaneously. The consequences were schedule in terms of layout pre-fabrication and schedule's intensity. Unfamiliarity with this concept and very slow change in the construction industry is another aspect.

Some of the customers do not ask for pre-fabrication but the contracts do ask for the approval pre-fabrication. The perception/aesthetics is an issue since it is repetitive. There is a level of risk in investing to set up ware house. Shipping limitations is applied along with the width of the module to get transported.

The potential benefits from modularization is the consistency in quality, fast track construction that helps with schedule. Modular construction has an effective impact on safety since it showed lower injury rates, cost/productivity, difference in labor rates and reduction in “lost” materials and tools.

Some of the possible enablers for modularization are build pre-fabrication into design, process to identify which section of the building has modularization opportunity. The scope to find availability of capable contractors for this type of construction and analyze the portfolio approach of risk.

This session covered and discussed a lot of research topics and certainly initiated ideas for thesis research. Some of the areas to research discussed are the potential ways to map “how” modularization can achieve project goals, where to start using modularization. Ownership of ‘design’ of modular components, type of contracts involved, insurance, designer concerns over making standardize design and standardize work. Some of the research topics related to business aspect were shifts in set up cost versus insurance costs and business/CAP cost to set up.

After attending both the sessions, I have a certainty about considering safety as a part of my analysis and modularization for research. In safety session, the most

interesting part that caught my attention was the ways that could be implemented to enhance safety especially through BIM. Since workers are very negligible are hard to communicate verbally with everyone, Implementing BIM would be effective and scope for enhancing safety in India. Due to the repetitive layout for my thesis project, Pre-fabrication got connected to my ideas for analysis instantly. This category would be adequate to research and analyze to understand if pre-fabrication works for my thesis building, a residential building. Succeeding with these ideas, sustainability is another topic that I would to analyze for my thesis. India is dealing with colossal pollution issues. This can be controlled if sustainability can be implemented on a larger scale.

FEEDBACK FROM PACE INDUSTRY ROUNDTABLE

The final session of the PACE round table conference was a 30 minutes feedback session to discuss ideas with an industry member. I had the opportunity to talk with Mr. Alexander Ward. He is a former student at Penn State University and graduated in 2012. Mr. Ward is currently working at Balfour Beatty Construction and discussed his views and gave his valuable feedback for my ideas to implement in thesis.

One of the ideas that we connected on was safety, one of the biggest concerns in the construction industry. Understanding certain facts about workers are untrained and not being familiar with the project, there are higher chances for accident to occur. We discussed about the advancing the safety through presenting the kind of risks involved. I had asked Mr. Ward if the safety training could be enhanced with the idea of using virtual reality for this process. Mr. Ward continued this further and had recommended me about BIM implementation in not just safety but to also show phase to phase sequence.

Another main topic that we had discussed was about pre-fabrication. Since there were a lot of aspects to be considered and understand if residential projects would best fit for pre-fabrication or not. Mr. Ward had recommended to do research on pre-fabrication since my thesis project has a repetitive layout.

The industry contacts Mr. Ward suggested me were Professor John Messener for BIM, Dr. Robert Leicht for pre-fabrication and Dr. Somayeh Asadi for safety analysis. In conclusion, this discussion was very constructive and gave me a scope to research on specific ideas for research to understand the benefits and consequences of implementing them in India.

BIM USE EVALUATION

BIM (Building Information Modelling) is widely adapted for design and management during different phases of a construction project. It enhances the entire procedure of construction procedure, leading towards efficient productivity and avoid delays by solving clash detection. BIM also known as Virtual Design and Construction (VDC) is continuing to emerge in India. Unfortunately, BIM was not adapted by Ambience Construction firm for this project.

There are several scopes of BIM that could be implement on this project. The proposed uses of BIM have been listed below in *Table 2*:

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING		DESIGN AUTHORIZING	X	SITE UTILIZATION PLANNING	X	BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
			LIGHTING ANALYSIS		3D CONTROL AND PLANNING	X	DISASTER PLANNING
			ENERGY ANALYSIS		RECORD MODELING		RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABILITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Table2: Proposes uses of BIM for Hanza Crest Apartments

The design, construction and operation phase has more scope to be implemented in this project. Detailed description of BIM scopes that could be utilized are mentioned below.

DESIGN PHASE

3D Co-ordination

The 3D co-ordination can be utilized in early stages of design phase. This can be used to avoid any delay in the schedule and determine any conflicts with the other systems of the building.

Structural Analysis

The superstructure phase is one of the most critical and largest phases of this project. BIM can be implemented to have an optimal plan for this phase and avoid delays, as it would create a major impact in the schedule due to small errors during the superstructure phase. The structural analysis would help to show the capacity of the structure, type and size of beam and girders to be used. This would complete the superstructure phase without errors since it is easy to follow by viewing this analysis.

4D Model

The usage of 4D- model in India has been increasing in construction industry. 4D model implemented through BIM, will create a positive impact in displaying the ideas and designs of the architect in the early designs. 4D modelling is efficient for both architect and engineers to show the building including all the systems and detect any clashes with the design and systems before the construction begins. This would create a positive impact on schedule as early detection of clashes would avoid delays.

CONSTRUCTION PHASE

Site utilization Planning

Due to the space constraint, the site is used for storing materials and equipment during section 1 and section 2 construction and there are subsequent changes in the site which is considered for logistics. This Planning will enhance the productivity on site. This 3D model will give a pre-headed plan and portrays the utilization of both the sites in each phase.

3D Coordination

Similar to the design phase, BIM can be implemented in the construction phase. This 3D model visualizes the construction procedure and helps to reduce the errors while performing a construction activity and increases productivity, maintaining the schedule on time. This model is also constructive for safety purpose.

Phase Planning (4D Modeling)

In construction phase, 4-D model is effective to show the construction sequence. This would allow for a better quality, low risk of delays and efficient co-ordination between the workers. This will make an enhancement in quality control and maintaining the schedule. BIM can also be implemented to maintain the quality, consistency of the structure and establishes the steps to construct in 4D phase. This would be very effective if phase planning is done in every phase to improve the construction with less errors.

OPERATION PHASE

Building Maintenance Scheduling

This project is designed for government officials. So the maintenance of the building after completion is prioritized. So implementing BIM would give each department a schedule to check with each system and enhance the efficiency to maintain the building secured. Apart from the MEP systems, fire - fighting, the security system of the building is meant to be monitored on daily basis.

Disaster Planning

For any project, disaster planning is essential in India. The disaster planning would help to reduce the risk for occupants. This can also safe guard the building with reduction of damages with the information from this plan, which could be utilized during an emergency.

SUSTAINIBILITY

The Hanza Crest apartments is not a LEED certified building. The LEED evaluation is specific to certain buildings based on the size and budget. Evaluating small and medium size buildings should be adapted in India to reduce the consequences of pollution which is one of the biggest concerns. After analyzing the LEED checklist for new construction, there is a scope of obtaining LEED silver for this project. This would also enhance the value of the building and give effective support to protect the environment. The LEED categories have been summarized below for Hanza Crest apartments. The LEED checklist is attached in **Appendix**.

Transportation (13/16)

Though Hanza Crest apartments is located in a residential yet active zone. The site has a 40 feet main road adjacent and a 30 feet street road opposite. This helps with easy transportation and parking is done at the street road. The building is surrounded with residential buildings and commercial stores with a distance of less than 0.2 miles with different uses.



Figure 3: Auto rickshaw

There is never a problem with quality of transit. The public transportation can be accessed easily including auto rickshaws, buses and taxis are in abundance as they are always passing by the main road.

Sustainable Site (5/10)

The Rocks were demolished, though chemical blasting procedure was followed and could have a reduction in points. The contaminated soil was removed during excavation phase. Natural rainwater system is adapted to this site attempting to make the

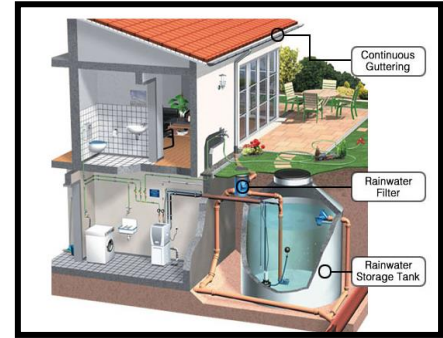


Figure 4: Storage tanks in India

building sustainable. Typically, there are tanks for the rainwater system in India.

But in USA, it is challenging to execute a natural rain water system and typically, there are advanced techniques to enhance the rain water system. Storage tanks and domestic water system are typically used in USA.

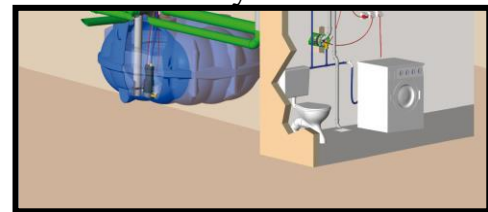


Figure5: Domestic rainwater system

Water Efficiency (9/11)

Irrigation is required for this building to get water from other resources. The process of utilizing used water by treating it, enhances the score. Voluntary participation by workers during construction and by occupants after completion in reduction of water usage, could be easily adapted and increase the score. There is no cooling water tower for this building due to space constraint leading to reduction in score by two points.

Energy and Atmosphere (7/33)

This project will not fit into the category since, the concept renewing energy and production is not adapted. The points can be increased with the enhancement of refrigerant management and commissioning. There in enhanced commissioning and energy metering for this project to have a check on the amount of electricity used.

Materials and Resources (11/13)

The usage of materials with less chemical has been adapted in few materials likely ash bricks, lead free paint and waterproofing cement without lead to score points in material ingredients. Other adaptations implemented are building life-cycle impact reduction, sourcing of raw materials that are transported from local areas reducing time and cost. Construction and demolition waste management is adapted and active on site. This category was prioritized since there was huge amount of demolition on site and it was crucial to manage that waste for the surroundings and site.

Indoor Air Quality (8/16)

This category is moderately less adapted for Hanza crest apartments. There is minimum indoor air quality performance by providing a lot of sources for ventilation to provide indoor air quality and daylight purposes. The wall units are fixed in the apartment for cooling. But this has low amount of fresh air and reducing the air quality. Low-emitting materials can easily be considered to enhance the air quality.

APPENDIX -A

PROJECT MANAGER INTERVIEW

Project Manager Interview

Project Management Services

1. Describe the project management services provided to client including preconstruction services, sustainability and procurement if provided?

We offer complete professional services to the client starting from the inception stage right up to handover and technical/commercial close out.

1. Inception Stage

- a. Collate Client/Project Brief
- b. Agree on scope delineation
- c. Review scope of works and deliverables for consultants (Designer Engagement Process)
- d. Appropriate contractual structure (for designers)

2. Concept Stage

- e. Schedule of design meetings
- f. Draw up a design program for the Project (Design Program for Construction work)
- g. Review Concept drawings for conformance to Client requirement
- h. Facilitate the Sign off process by Client

3. Detailed Design Stage

- i. Ensure periodic reviews of the design development with Finger 6 and S.D Consultants
- j. Facilitate Clients Sign Off on Design Brief
- k. Instruct Consultants to prepare sample board
- l. Obtain Detailed Schedule of Finishes and Room data sheets
- m. Prepare format of final design information (deliverables)

4. Procurement stage

- n. Follow up with Consultants to obtain design documentation.
- o. Review Bill of quantity (BOQ) and estimate

5. Construction Stage

- p. Facilitate preparation of master drawing register
- q. Review drawings with respect to conformance to Client requirements & constructability aspects and co-ordinate sample approvals.
- r. Request for Information co-ordination, tracking and closure – Impact
- s. Site Role
- t. Coordination with on-site team members
- u. Change Management

6. Close-out Stage

- v. Document Certification of testing of equipment's
- w. Assist in final evaluation of works
- x. Seek justification on quantity variations
- y. Track evaluation & sign-off on close out documentations both technical and commercial.

2. What are the biggest challenges or constraints for the client?

1. Obtaining statutory approvals from all departments such as fire, water, electricity etc.
2. Funding
3. Adhering to the timelines to ensure handover to customers on time.
4. Quality of work is one of the biggest differentiators in the way customers view builders.
5. Deploying sufficient manpower and machinery to adhere to the timelines.
6. Design management
7. Safety

3. What are key areas that have potential to better fit the project approach or management services to the clients' needs?

1. Deployment of more dedicated site engineers for the project. This will not only ensure quality of works but will also push the progress of the project smoothly.

2. Implementation of share point platform for management of projects. This has the potential to provide many fold benefits to the client.

- Enhanced reporting
- Ease of data and document management
- 24/7 access to all projects of a particular client
- High level of security - Right people will have the access to right content
- Integrates outlook and MS project
- Ease of handover and close out of projects due to organized structure

3. Implementation of BIM (Building Information Modeling) to mitigate any design and drawing issues that creep up during the course of a project.

3. What would be the costs and methods for implementing these?

Minimal increase in the costs for implementing the above methods. Approximately 1.5 lakhs per month for a period of 12 months. (This works out to be lesser than 0.2 percent of the project cost).

VALUE ENGINEERING TOPICS

1. Describe key areas of value engineering that were implemented on the project. How did these improve or detract from the goals of the owner?
 - Cost – change of tiles from marble to vitrified tiles. Though the functionality is maintained, vitrified tiles are low at cost for outdoor. Also, revising the concrete design mix after escalation of same result in reduction of cement content
 - Quality – to arrange quality training of staff and workmen and machine room is changed from RCC (Rolled-compacted concrete) to block foundation for more ventilation.
 - Safety – Provision of additional angle for electrical, fire and communication doors. Deployment of staff to guide the workers follow basic safety precautions on site. But no that effective. It was started since this October.

2. What ideas for value engineering were considered but not shown? Why?

Below are some of the points considered but not shown as value engineering since there was a compromise with the quality and the decision was not to execute them.

1	Retaining wall footing changed from isolated to combined
2	Lowering of underground sump level resulting in increase of underground sump quantity.
3	Retaining wall waterproofing thickness revised from 40 to 20 mm.
4	Hacking for internal plastering done using machine.
5	Monolithic beams (.9m depth) incorporated instead of individual beams (1.2m depth)

3. What systems were not a focus of Value Engineering but could offer opportunities based on the current status?

- Use of latest construction technologies such as use of precast concreting and Mivan formwork for shuttering. These technologies ensure faster pace of construction and better quality of works. They are however found to be 15-20% more expensive than conventional methods.
- Implementation of share point platforms to manage complete projects.
- Implementation of BIM (Building Information Modeling) to mitigate any design and drawing issues that creep up during the course of a project.

APPENDIX -B

PACE FEEDBACK FORMS

STUDENT FORM

Student Name Bhavana Reddy Cycum

Session 1: Topic: IC Construction Safety

Research Ideas:

- 1) Implementing BIM for Safety Purpose: ways to connect with workers. ~~manually~~.
- 2) Interaction with workers and enhancement of accountability.

Session 2: Topic: Modularization

Research Ideas:

- 1) ~~How~~ "map" howif prefabrication can be achieved with thesis project (Residential building)
- 2) Type of contracts involved, ~~under~~ analyze the work flow for pre-fab and its requirements to construct modules in India.

Session 3: Topic: _____

Research Ideas:

1)

2)

STUDENT FORM

Industry Member:

Alex Ward

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

- need of it ~~you~~ would advance the safety in site.
- Plan, to present the risks they are facing and pin point the risks.
- Scope of Sustainability.
- Phase to Phase Virtual Reality.
- ways to communicate.
- Repetitive layout → Pre-fabrication

Suggested Resources:

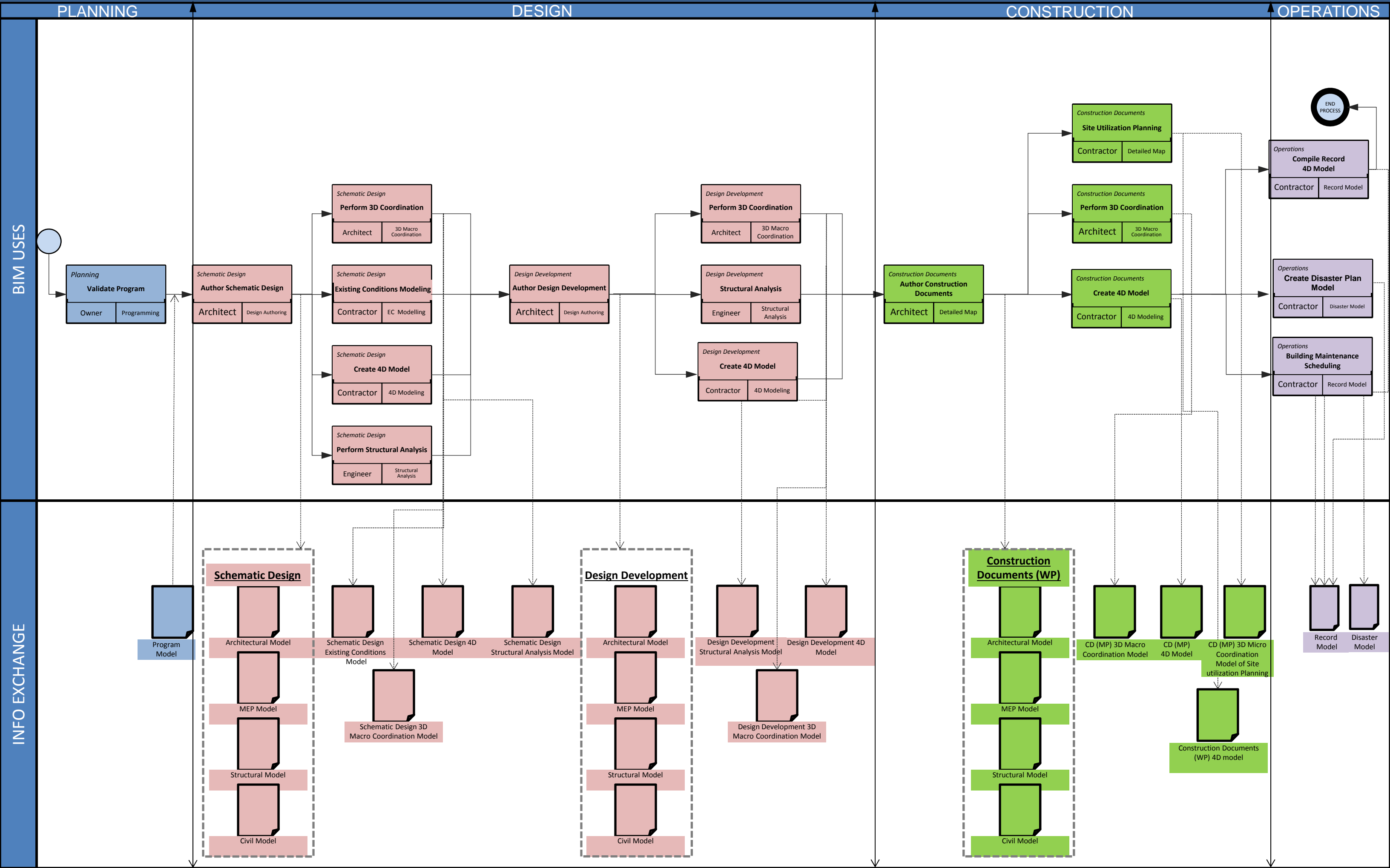
What industry contacts are needed? Is the information available?

- Prof. John Messener, Dr. Somayeh Asadi, Dr. Robert Leicht.

APPENDIX –C

BIM EXECUTION PROCESS MAP

HANZA CREST APARTMENTS BIM PLAN



APPENDIX –D

LEED CHECKLIST



LEED v4 for BD+C: New Construction and Major Renovation

Project Checklist

Project Name:
Date:

Y ? N

1	Credit	Integrative Process	1
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13	0	19	Location and Transportation	16
16	Credit	LEED for Neighborhood Development Location	16	
1	Credit	Sensitive Land Protection	1	
2	Credit	High Priority Site	2	
5	Credit	Surrounding Density and Diverse Uses	5	
5	Credit	Access to Quality Transit	5	
1	Credit	Bicycle Facilities	1	
1	Credit	Reduced Parking Footprint	1	
1	Credit	Green Vehicles	1	

5	0	5	Sustainable Sites	10
Y	Prereq		Construction Activity Pollution Prevention	Required
1	Credit		Site Assessment	1
2	Credit		Site Development - Protect or Restore Habitat	2
1	Credit		Open Space	1
3	Credit		Rainwater Management	3
2	Credit		Heat Island Reduction	2
1	Credit		Light Pollution Reduction	1

9	0	2	Water Efficiency	11
Y	Prereq		Outdoor Water Use Reduction	Required
Y	Prereq		Indoor Water Use Reduction	Required
Y	Prereq		Building-Level Water Metering	Required
2	Credit		Outdoor Water Use Reduction	2
6	Credit		Indoor Water Use Reduction	6
2	Credit		Cooling Tower Water Use	2
1	Credit		Water Metering	1

7	0	26	Energy and Atmosphere	33
Y	Prereq		Fundamental Commissioning and Verification	Required
Y	Prereq		Minimum Energy Performance	Required
Y	Prereq		Building-Level Energy Metering	Required
Y	Prereq		Fundamental Refrigerant Management	Required
6	Credit		Enhanced Commissioning	6
18	Credit		Optimize Energy Performance	18
1	Credit		Advanced Energy Metering	1
2	Credit		Demand Response	2
3	Credit		Renewable Energy Production	3
1	Credit		Enhanced Refrigerant Management	1
2	Credit		Green Power and Carbon Offsets	2

11	2	0	Materials and Resources	13
Y	Prereq		Storage and Collection of Recyclables	Required
Y	Prereq		Construction and Demolition Waste Management Planning	Required
5	Credit		Building Life-Cycle Impact Reduction	5
2	Credit		Building Product Disclosure and Optimization - Environmental Product Declarations	2
2	Credit		Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
2	Credit		Building Product Disclosure and Optimization - Material Ingredients	2
2	Credit		Construction and Demolition Waste Management	2

8	0	8	Indoor Environmental Quality	16
Y	Prereq		Minimum Indoor Air Quality Performance	Required
Y	Prereq		Environmental Tobacco Smoke Control	Required
2	Credit		Enhanced Indoor Air Quality Strategies	2
3	Credit		Low-Emitting Materials	3
1	Credit		Construction Indoor Air Quality Management Plan	1
2	Credit		Indoor Air Quality Assessment	2
1	Credit		Thermal Comfort	1
2	Credit		Interior Lighting	2
3	Credit		Daylight	3
1	Credit		Quality Views	1
1	Credit		Acoustic Performance	1

0	0	6	Innovation	6
5	Credit		Innovation	5
1	Credit		LEED Accredited Professional	1

0	4	0	Regional Priority	4
1	Credit		Regional Priority: Specific Credit	1
1	Credit		Regional Priority: Specific Credit	1
1	Credit		Regional Priority: Specific Credit	1
1	Credit		Regional Priority: Specific Credit	1

53	6	67	TOTALS	52 Credits	Possible Points: 110
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Certified: 40 to 49 points, Silver: 50 to 59 points, Gold: 60 to 79 points, Platinum: 80 to 110