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To study cost effectiveness and safety of modular construction compare to traditional construction

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Abstract: The primary goals of the effort are to examine the current state of modular construction and the economic viability of constructing modular buildings. In order to compare the costs of cast-in-place (in-site) versus modular structures, a case study was conducted. The cost of modular construction for a one-story building is higher than that of in-situ construction, according to a comprehensive analysis of the bills of quantities for the two construction methods. Questionnaire survey was done to study the safety factors affecting modular construction thus the top ten factors were identified with the help of frequency index method.

Index Terms -Cost effectiveness of modular construction compares to traditional construction, Factors, Construction Projects, Frequency index method, Questionnaire survey, Case study

I. INTRODUCTION

Modular building means design, imagination, and engineering. Modular Building can be can be built in any style like modern, craftsman and more. These styles are cheaper and quicker to build. China built 30 storey ark hotel in 15 days. McDonalds in use USA Are constructed in four weeks thanks to modular structures. Thus, more businesses realize that modular construction can benefit them. There is a push to improve technology thus modular construction can be faster, more effective and efficient. CAD software play important role to push the technology. It helps architect to design at macro level and tiny screw. This makes process effective and efficient. This software helps to cut down time and cost, thus this helps architects and builders to do their job effectively and safely.

II. OBJECTIVES

- To identify cost effectiveness of modular construction, compare to traditional construction.
- To study factors affecting on safety of modular construction compare to traditional construction

III. LITERATURE REVIEW

Literature review on Analysis of modular building using E-Tabs software international journal of scientific Research & Engineering Trends, Yi Yang, Wei Pan, Mi Pan Data Analysis This study will offer a thorough overview of current academic viewpoints and suggest future research trajectories. The following suggestions for future research are made: (1) more extensive use of digital manufacturing; (2) deeper investigation of adoption strategies for automated technologies; (3) creation of comprehensive and useful approaches to support DfMA methodology; and (4) well-defined information management systems through BIM. The results should aid in a more thorough understanding of the procedures, difficulties, and cutting-edge research in the production of modular buildings.

Literature review on the industrial building system modular system (IBSMS) Framework AicQol2017Bangkok (April,2017Muhamad Faiz Musa, Mohd Reeza Yusof, Noor Sahidah Samsudin, Faridah Muhamad Halil, Case Study This paper aims to promote Malaysians' knowledge of and interest in modular building. The Malaysian building sector must choose a new and better construction technique, abandoning the traditional approach in favour of OSM, modern construction, and sustainable construction principles. The created IBSMS framework aims to promote modular building and IBSMS in the Malaysian construction sector and raise knowledge of them, leading to a rise in the use of modular building there. Given the benefits and potential of modular building, it is envisaged that its implementation will help Malaysia's built and construction environments become of higher quality. The development of a framework, specifically for modular construction, that fits the Malaysian IBS methodology is what makes this research novel.

V.DATA COLLECTION:

5.1 Background:

The purpose of data collection is to compile more details about the study for accurate outcomes. Two steps are taken to collect the data: a questionnaire, and case study.

5.2 Questionnaire design:

To assure the necessary expertise, the questionnaire included questions requesting professional facts about employment and experience. The questionnaire is produced as a Google Form, in an effort to reach as many experts as feasible. Experts from Field Experience from Lower-Level Management to Top Level Management and Stakeholders have been shortlisted for the method Frequency Analysis, where the requirement is to weigh the factors based on criticality. This is in contrast to an opinion poll, where even members of the community and workers were polled. Because they are competent in their respective disciplines and can rate the elements more precisely, field specialists from other departments have been recruited. The Linkert scale can be used to rate each factor's significance. There are three, four, five, and seven sizes on Linkert's scale. A 5-point scale was employed for a more precise and confident outcome. To give them a variety of ways to express themselves regarding the factor, this is done.

1	2	3	4	5
Not Important	**Less Important**	**Moderately important**	**Important**	**Very important**

Table 1. Liker Scale

5.3 DETERMINATION OF QUESTIONNAIRE & SAMPLE SIZE DETERMINATION:

Several Owners, Engineers, Partners, and Project Managers received the questionnaire after being informed of the study's goals and having their agreement to participate in the study sought. Once the respondents in Ahmedabad demonstrated their initial consent. Calculator.net is used to determine the sample size. Here 98% confidence level is taken.

e is the sampling error to be estimated is 12%

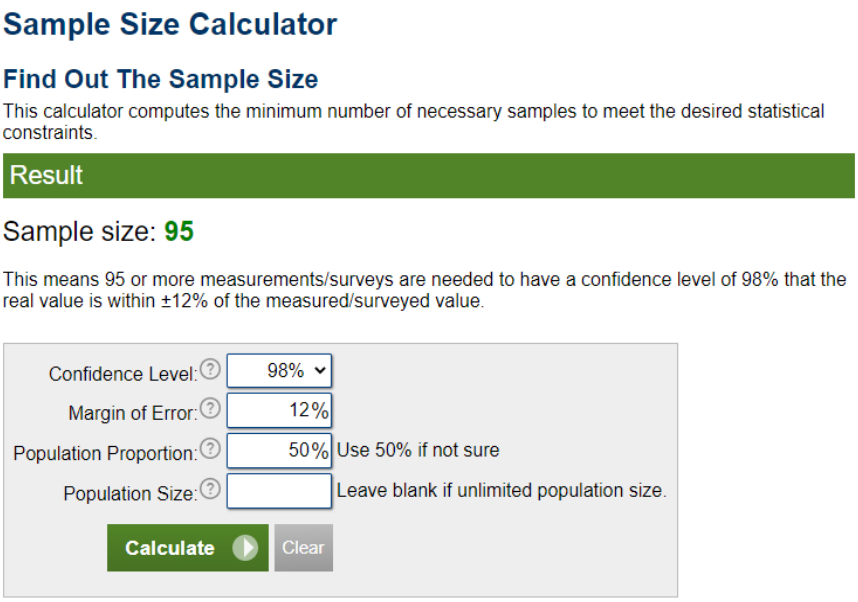


Figure 1. Sample Size

Sr.No.	Factors
1	Participation in the project of experts in workplace safety.
2	The existence of a societal norm that regards everyone's safety as a necessity.
3	The management and staff's safety-conscious actions.
4	Workers receiving instruction on how to carry out the workplace safety programs
5	Instruction on safety program management for all managers and engineers
6	The system and regulations for ensuring the security of personnel and equipment are in place.
7	There is effective legislation in place to put safety measures into practice.
8	An experienced safety engineer working there
9	The administration monitoring and ensuring that safety requirements are being followed
10	Equipment for personal safety and defense should be provided. Ensure the usage of all personnel
11	Recording and examining workplace mishaps to draw conclusions from them
12	The availability of backup plans for accidents
13	The provision of first aid in the workplace
14	The qualification and selection of the contractor based on his record of professional safety
15	The requirement that the contractor provide a strategy for occupational safety

14	The qualification and selection of the contractor based on his record of professional safety
15	The requirement that the contractor provide a strategy for occupational safety
16	Include a plan for safety in the project and designate an engineer or other person who will be in charge of carrying it out and keeping track of it.
17	Senior management's backing of the programme for occupational health and safety helps to increase the project's professional safety
18	Having insurance for every employee on the project makes the contractor more motivated to follow safety protocols.
19	Contracts should contain clauses requiring workplace safety
20	Enhance the project's working environment.
21	Regular upkeep of machinery and equipment to ensure its functionality
22	Occupational safety regulations are followed during the project design phase
23	Total Quality Management (TQM) is used to reduce accidents.
24	Continuous annual evaluation of safety programme and protocols
25	Dissemination of preventive knowledge to all employees through the provision of safety bulletins and brochures
26	Trade Validation Test.
27	Regular Awareness training.
28	Equipment Inspection by TPI And valid document from RTO.
29	All SOP Should be approve before start work.

Table -2: List of Factors

5.4 DATA ANALYSIS:

For the data analysis Frequency Index Method was used and, formula of FI is given below;

$$\text{Frequency Index FI (\%)} = \sum a \times \frac{n}{N} \times \frac{100}{5}$$

Where,

a is the constant weight given to each response (range from 1 to 5),

n is the frequency of the index and

N is the total number of responces.

5.4.1 SAMPLE SIZE & DETERMINATION:

No. of questionnaire distributed	Total Responses	Responses in %
95	86	90.52 %

Table -3: Details of Responses

5.4.2 RELIABILITY TEST:

A researcher study's or a measuring test's consistency is referred to as its reliability.
Under this work, Excel was used for analysis using CRONBACH'Sαmethod.

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\Sigma\, s^2 y}{s^2 x}\right]$$

Where,

K = Number of the test items

$\Sigma\, s^2 y$ = Sum of the item variance

$s^2 x$ = Variance of the total score

$$= \frac{K}{K-1}\left[1 - \frac{s^2y}{s^2x}\right]$$

$$= \frac{29}{29-1}\left[1 - \frac{23.5}{185}\right]$$

$$= 0.9041$$

Here,

Value of α is 0.9041, So it is Acceptable.

VARIABLES	DESCRIPTION	Values	Internal consistency
K	No. of test items	29	Excellent
$\Sigma\, s^2y$	Sum of the item variance	22.8	
s^2x	Variance of total	185.32	
α	Cronbach's Alpha	0.9041	

Table 4. Reliability test Result

5.4.3 FI & RANKING OF FACTORS AFFECTING LABOUR PRODUCTIVITY:

Sr.no.	Factor code	Factors	FI	RANK
1	F17	Senior management's backing of the programme for occupational health and safety helps to increase the project's professional safety	76.40	1
2	F5	Instruction on safety program management for all managers and engineers	75.80	2
3	F13	The provision of first aid in the workplace	75.00	3
4	F28	Equipment Inspection by TPI And valid document from RTO.	74.00	4
5	F16	Include a plan for safety in the project and designate an engineer or other person who will be in charge of carrying it out and keeping track of it.	73.80	5
6	F11	Recording and examining workplace mishaps to draw conclusions from them	73.60	6
7	F22	Occupational safety regulations are followed during the project design phase	73.42	7
8	F8	An experienced safety engineer working there	73.40	8
9	F18	Having insurance for every employee on the project makes the contractor more motivated to follow safety protocols.	73.40	9
10	F25	Dissemination of preventive knowledge to all employees through the provision of safety bulletins and brochures	73.20	10
11	F26	Trade Validation Test.	72.82	11
12	F21	Regular upkeep of machinery and equipment to ensure its functionality	72.80	12
13	F6	The system and regulations for ensuring the security of personnel and equipment are in place.	72.72	13
14	F15	The requirement that the contractor provide a strategy for occupational safety	72.60	14
15	F24	Continuous annual evaluation of safety programme and protocols	72.48	15
16	F7	There is effective legislation in place to put safety measures into practice.	72.46	16
17	F29	All SOP Should be approve before start work.	72.42	17
18	F23	Total Quality Management (TQM) is used to reduce accidents.	72.02	18
19	F12	The availability of backup plans for accidents	71.60	19
20	F19	Contracts should contain clauses requiring workplace safety	71.60	20
21	F3	The management and staff's safety-conscious actions.	71.40	21
22	F9	The administration monitoring and ensuring that safety requirements are being followed	71.32	22
23	F20	Enhance the project's working environment.	70.60	23
24	F10	Equipment for personal safety and defense should be provided. Ensure the usage of all personnel	70.60	24
25	F14	The qualification and selection of the contractor based on his record of professional safety	69.80	25
26	F4	Workers receiving instruction on how to carry out the workplace safety programs	69.20	26
27	F1	Participation in the project of experts in workplace safety.	68.88	27
28	F2	The existence of a societal norm that regards everyone's safety as a necessity.	63.76	28
29	F27	Regular Awareness training.	58.60	29

Table 5. FI & Ranking of Factors

Type:	Industrial project
Name of Project:	QC Building
Size	700 sq.m
Floors:	G+1
Location:	Changodar, Ahmedabad
Client:	Zydus Cadila
Civil work Contractor	Riviera Infraprojects Pvt. Ltd.

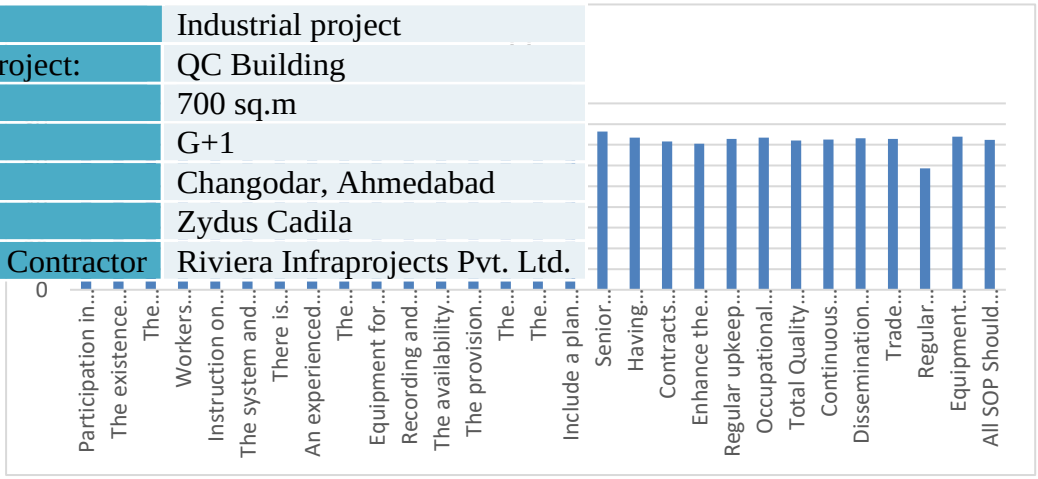


Chart 1. FI of Factors

5.4.4 TOP 10 FACTORS AFFECTING LABOUR PRODUCTIVITY:

Sr.no.	Factors	FI	RANK
1	Senior management's backing of the programme for occupational health and safety helps to increase the project's professional safety	76.40	**1**
2	Instruction on safety program management for all managers and engineers	75.80	**2**
3	The provision of first aid in the workplace	75.00	**3**
4	Equipment Inspection by TPI And valid document from RTO.	74.00	**4**
5	Include a plan for safety in the project and designate an engineer or other person who will be in charge of carrying it out and keeping track of it.	73.80	**5**
6	Recording and examining workplace mishaps to draw conclusions from them	73.60	**6**
7	Occupational safety regulations are followed during the project design phase	73.42	**7**
8	An experienced safety engineer working there	73.40	**8**
9	Having insurance for every employee on the project makes the contractor more motivated to follow safety protocols.	73.40	**9**
10	Dissemination of preventive knowledge to all employees through the provision of safety bulletins and brochures	73.20	**10**

Table 6. Top 10 Factors

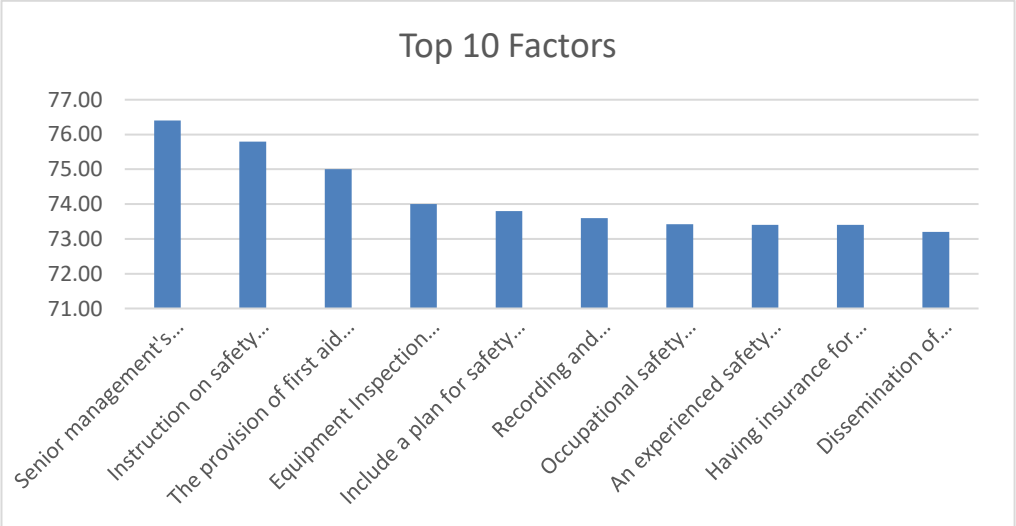


Chart 2. Top 10 Factors

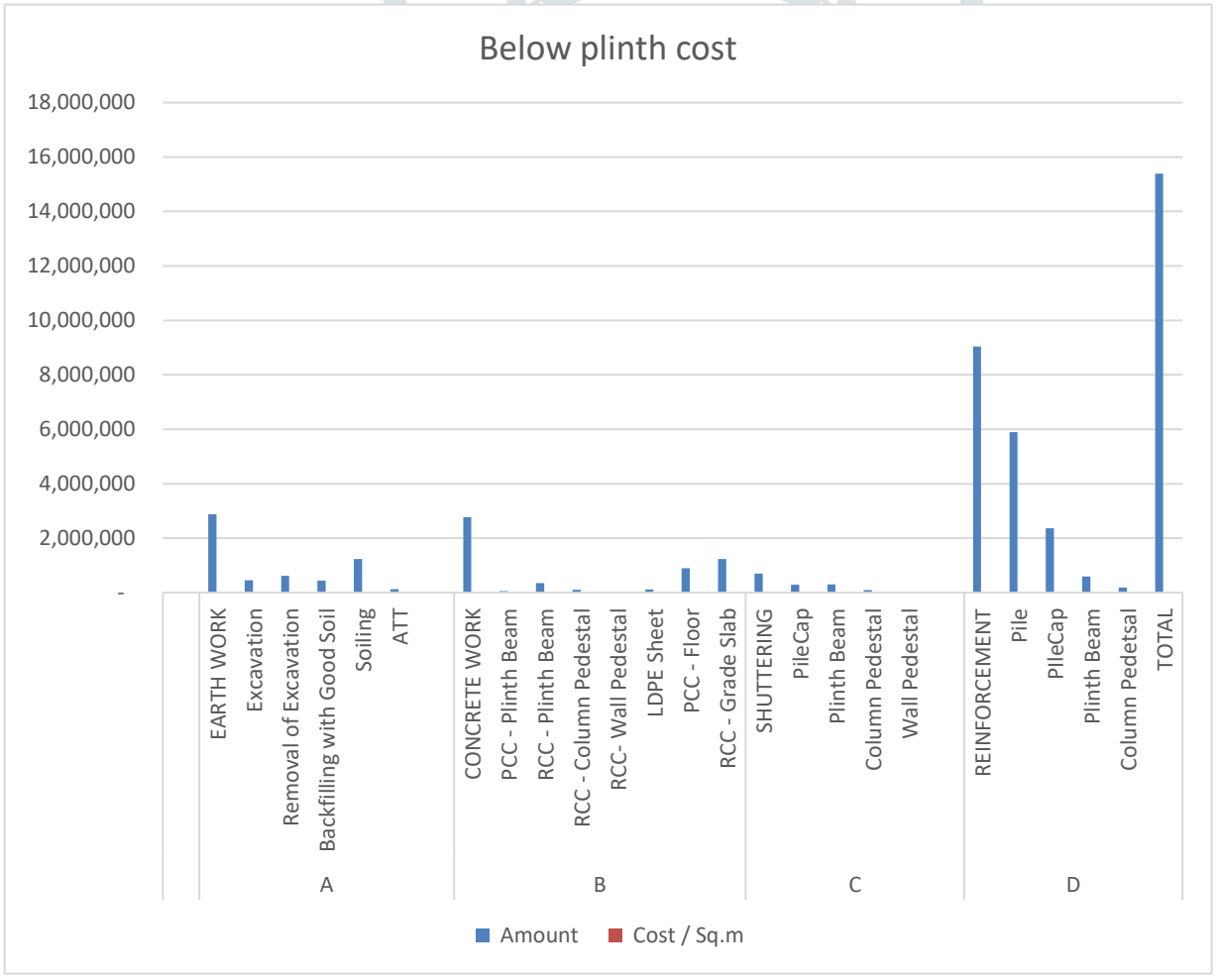
VI. Case Study:

Case study is done to study cost effectiveness of modular construction compare to traditional construction.

6.1.1 Project 01 Zydus VTC

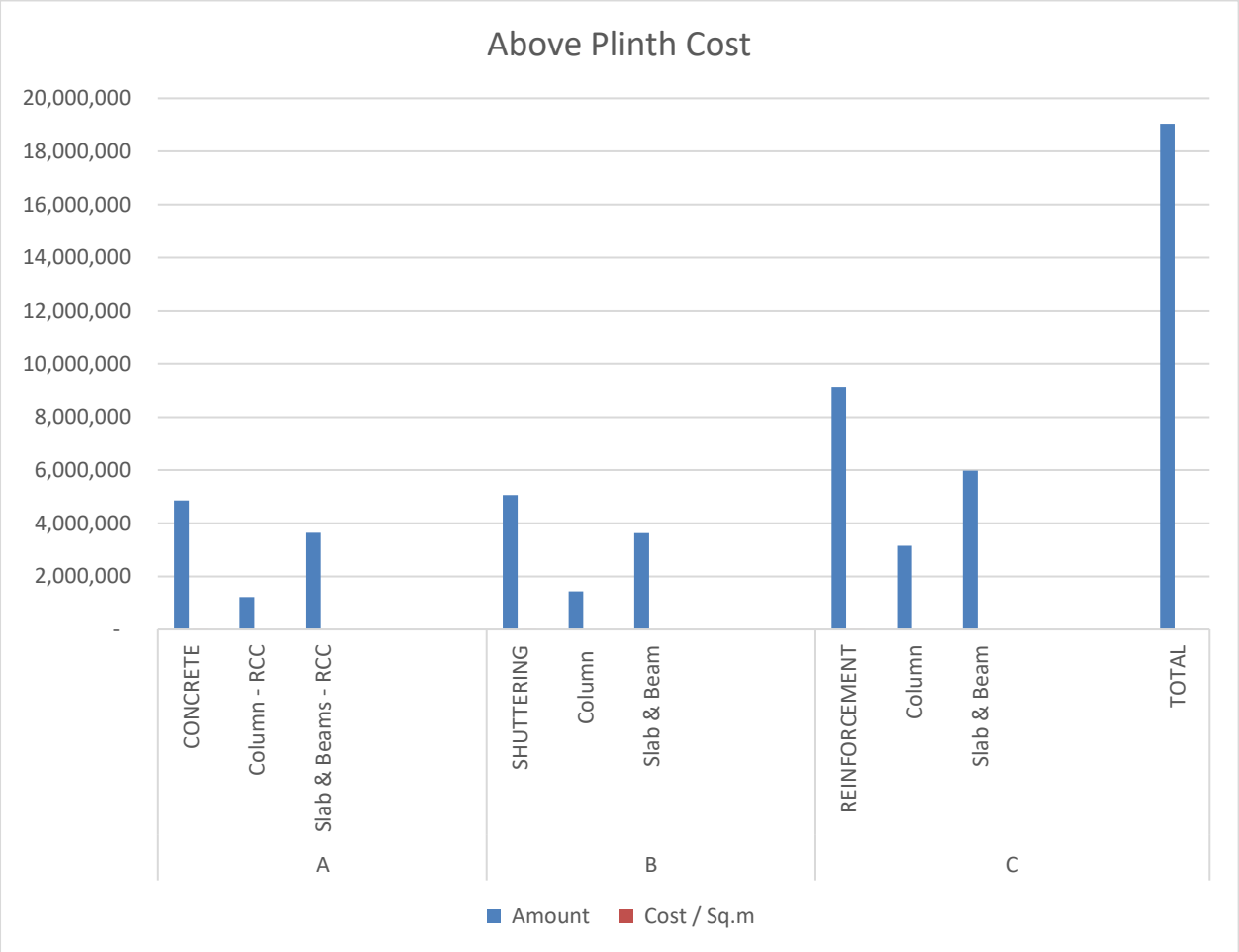
6.1.2 Below plinth cost

ZYDUS - VTC				
Total Area		1400	Sq.m	
Below Plinth Cost				
		VTC		
Sl.No	Particular	Amount	Cost / Sq.m	Remarks
A	EARTH WORK	28,78,595	2,056	
	Excavation	4,55,601		
	Removal of Excavation	6,17,080		
	Backfilling with Good Soil	4,38,994		
	Soiling	12,33,920		
	ATT	1,33,000		
B	CONCRETE WORK	27,69,633	1,978	
	PCC - Plinth Beam	54,576		
	RCC - Plinth Beam	3,50,154		
	RCC - Column Pedestal	1,08,935		
	RCC- Wall Pedestal	6,679		
	LDPE Sheet	1,13,306		
	PCC - Floor	9,00,100		
	RCC - Grade Slab	12,35,882		
C	SHUTTERING	6,97,367	498	
	PileCap	2,91,581		
	Plinth Beam	3,01,969		
	Column Pedestal	96,312		
	Wall Pedestal	7,505		
D	REINFORCEMENT	90,45,114	6,461	
	Pile	59,00,000		
	PIleCap	23,69,714		
	Plinth Beam	5,90,003		
	Column Pedetsal	1,85,397		
	TOTAL	1,53,90,709	10,993	



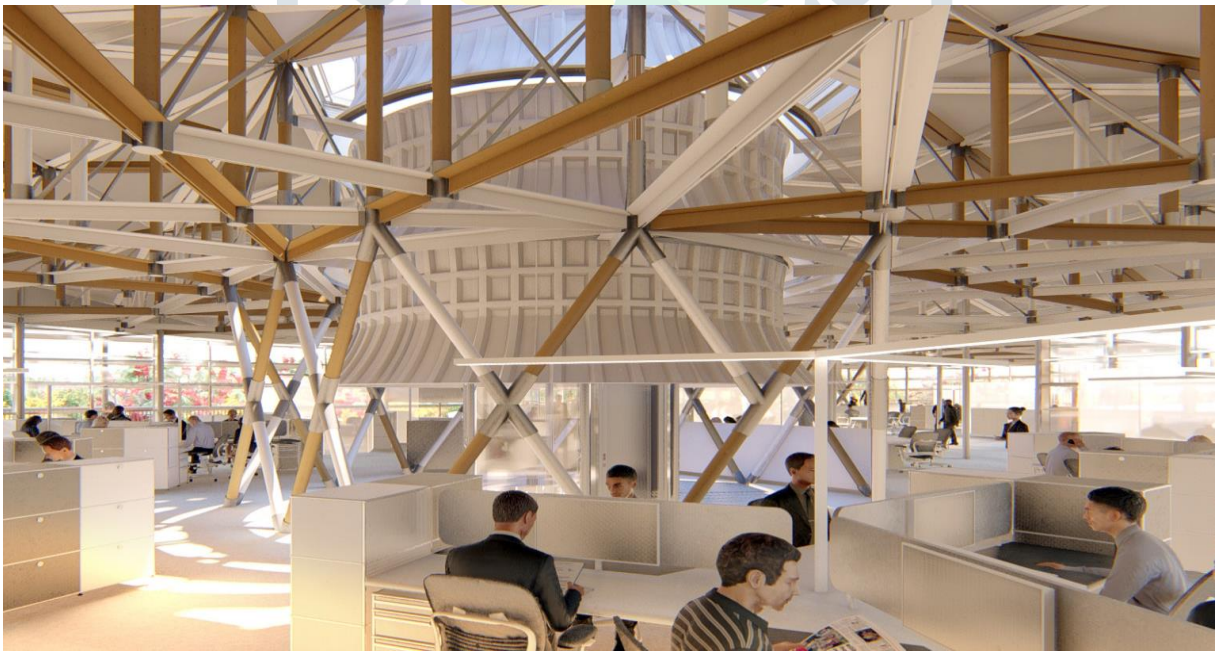
6.1.3 Above plinth cost

Total Area		1400	Sq.m	
Above Plinth				
		VTC		
Sl.No	Particular	Amount	Cost / Sq.m	Remarks
A	CONCRETE	48,57,623	3,470	
	Column - RCC	12,12,877		
	Slab & Beams - RCC	36,44,746		
B	SHUTTERING	50,54,191	3,610	
	Column	14,30,666		
	Slab & Beam	36,23,525		
C	REINFORCEMENT	91,33,638	6,524	
	Column	31,55,604		
	Slab & Beam	59,78,034		
	TOTAL	1,90,45,452	13,604	



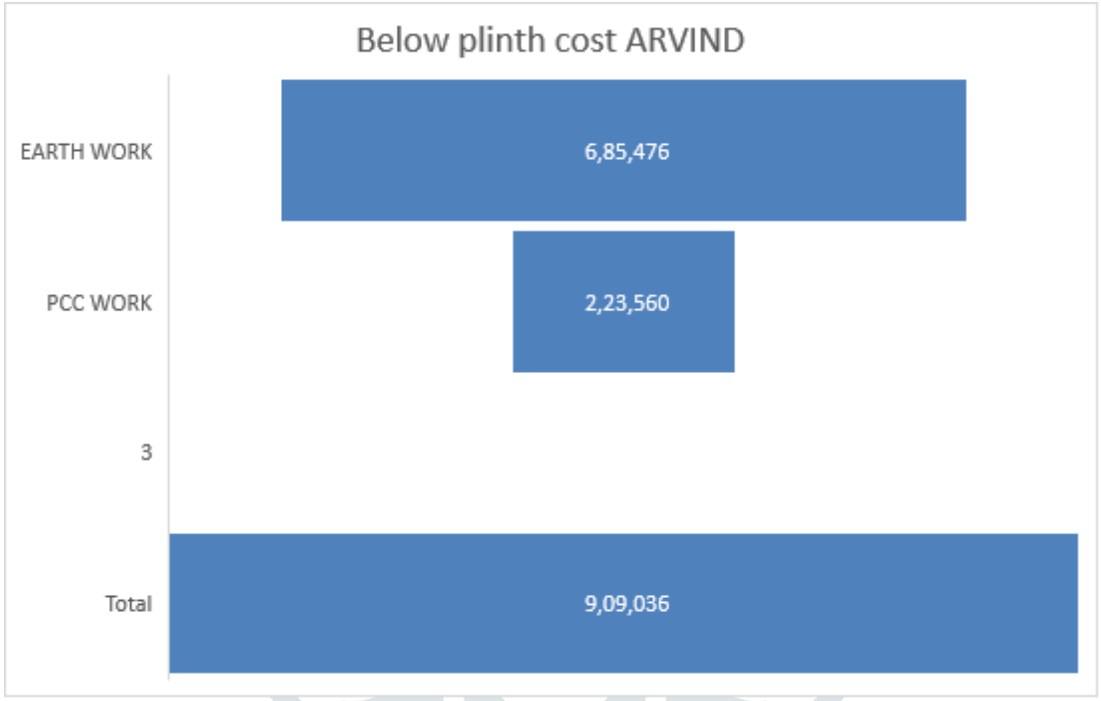
6.2 Project 02: Centre of excellence

Type:	Industrial project
Name of Project:	Envisol centre
Size:	700 sq.m
Location:	Arvind limited mill, santej, Ahmedabad
Client:	Arvind Group
Civil work Contractor	Riviera Infraprojects Pvt. Ltd.



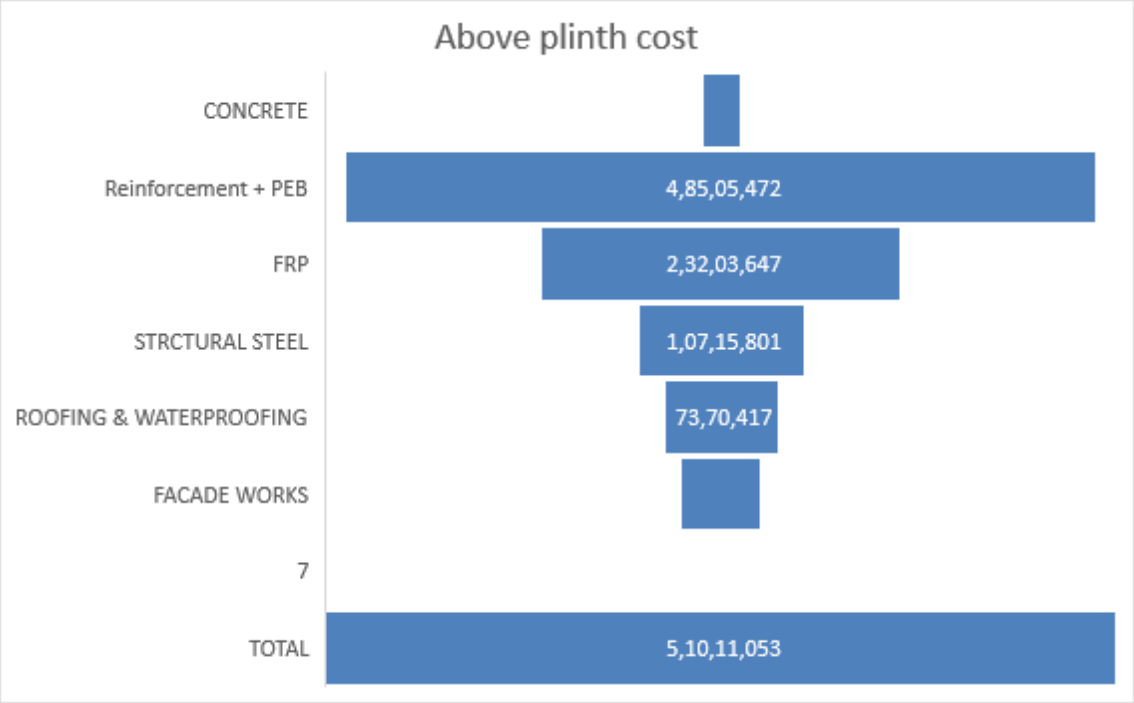
6.2.1 Below plinth cost

ZYDUS - ARVIND				
Total Area		700	Sq.m	
Below Plinth Cost				
		ARVIND		
Sl.No	Particular	Amount	Cost / Sq.m	Remarks
A	EARTH WORK	6,85,476	979	
B	PCC WORK	2,23,560	319	
	Total	9,09,036	1,299	



6.2.2 Above plinth cost

Total Area		700	Sq.m	
Above Plinth				
		ARVIND		
Sl.No	Particular	Amount	Cost / Sq.m	Remarks
A	CONCRETE	25,05,581	3,579	
B	Reinforcement + PEB	4,85,05,472	69,294	
	FRP	2,32,03,647		
	STRCTURAL STEEL	1,07,15,801		
	ROOFING & WATERPROOFING	73,70,417		
	FACADE WORKS	52,06,009		
	TOTAL	5,10,11,053	72,873	



VIII.CONCLUSION:

All data are collected from the online plat form, so all Factors are collected from the literatures. All the factors are validated from the industrial expert's engineer, Project manager, supervisor, head. With the guidance of all experts Total 29 factors are identified after the validation of the experts. Then after google forms were floated and 85 responses were collected. The below table shows the top 10 factors which affect the safety of modular construction.
From the case study the cost of modular construction of above plinth level is 72873/-
Per sq.m and cost of traditional construction of above plinth level is 13604/- Per sq.m
From this we can conclude that the cost of modular construction is higher than traditional construction.

1	Senior management's backing of the programme for occupational health and safety helps to increase the project's professional safety	76.40	**1**
2	Instruction on safety program management for all managers and engineers	75.80	**2**
3	The provision of first aid in the workplace	75.00	**3**
4	Equipment Inspection by TPI And valid document from RTO.	74.00	**4**
5	Include a plan for safety in the project and designate an engineer or other person who will be in charge of carrying it out and keeping track of it.	73.80	**5**
6	Recording and examining workplace mishaps to draw conclusions from them	73.60	**6**
7	Occupational safety regulations are followed during the project design phase	73.42	**7**
8	An experienced safety engineer working there	73.40	**8**
9	Having insurance for every employee on the project makes the contractor more motivated to follow safety protocols.	73.40	**9**
10	Dissemination of preventive knowledge to all employees through the provision of safety bulletins and brochures	73.20	**10**

VIII. ACKNOWLEDGEMENT:

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