STUDY AND IMPLEMENTATION OF VIRTUAL DESIGN CONCEPT AND BUILDING INFORMATION MODELING IN RESIDENTIAL PROJECT

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Abstract - *The infrastructure growth has envisaged the need for the project engineers to plan the activities in a more accurate and orderly manner. Proper planning can result in optimized use of resources and thereby reduce delay in a greater extent. This paper deals with the improvement of planning by developing a virtual Reality (VR) model of the project which depicts the building in 4D, with time as the fourth dimension. The model is logically integrated such that they can access shared data, and if a user highlights or changes some data, it gets highlighted in the model. The model is said to be multi-disciplinary in the sense that it will represent the Architect, Engineering, contractor (AEC) and Owner of the project, as well as relevant sub disciplines.The model is known as performance models in the sense that they predict some aspects of project performance, track many that are relevant, and can show predicted and measured performance with respect to the stated project performance objectives. It also included the comparison with their experience in using the conventional method of planning for the project through a questionnaire survey. The results were analyzed using SPSS software. The 3D modeling of the building was done using building information modeling (BIM) tools REVIT ARCHITECTURE and the MSP schedule of the same was embedded in to the model using NAVIS WORKS software. The result concluded with the analysis result obtained from survey and their interpretations that virtual model turned to be more efficient and effective in proper planning and identifying the clash detections and quantity estimation in fast pace manner.*

Key Words: Virtual Reality model, Building information modeling (BIM), Questionnaire survey, Planning, Clash detections

1.INTRODUCTION

Construction project planning has been considered as a critical process in the early project phases that determines the successful implementation and delivery of project. During this stage, project planners need to develop main construction strategies, to establish construction path and assembly sequences, to arrange construction methods and resources required for the execution of work packages.

The Building Information Modeling (BIM) is an architectural, engineering and construction workflow of utilizing information which has been loaded into a building design project. The information in a virtual model is commonly utilized in the areas of building design and engineering, material takeoff and cost estimating. Industry focus continues to be on the 3D value of a model which allows the building team to better plan, design, visualize, and construct the built environment. (J. Vinoth Kumar and Mahua Mukherjee (1). Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India. (IIT), reported (3rdNov 2009).These sophisticated 3D computer models allow the project team to see the finished project before any construction work begins, resolve. Construction clashes, and ensure that every team member understands the design exactly as it was intended. On the job site, BIM allows us to save time, save money, and build higher quality projects through

- Better coordination of subcontractors
- Better integration of various construction elements
- Fewer subcontractor change orders in the field
- More opportunities for prefabrication
- Fewer construction delays
- Higher productivity

2 Scope and Objectives

- To create a customer friendly model, which can be used as a single data warehouse.
- This study is done to enhance the pre planning of the construction projects.
- This also extends for the post planning activities like monitoring of activities and tracking of schedule.
- To analyze the resource requirement at various stages of execution of project.

- To reduce the time loss, which is spent in loitering around for data's and other project related papers by making a user friendly model.
- To create a customer and friendly project model.
- The main objectives of this paper are as follows:
- Creation and analysis of virtual model

The main objective of the project is to create a 4D model of a building and to analyze and monitor the construction work. Time is taken as the fourth dimension. The model is further used as a single platform to access whole details of the building at any stage and there by analyze the performance, error, delay and detect any clashes in the drawing.

Comparative study

Apart from creating a virtual model a questionnaire survey is conducted. The results are analyzed and a comparative done is done based on conventional based planning and planning done using virtual model.

3. Methodology

The above said methodology is for developing a virtual design for a residential project and track the activities with respect to time. The detailed methodology can be explained as follows:

• Data collection
• Questionnaire survey and analysis based on conventional planning
• 4D model preparation
• Questionnaire survey based on virtual model
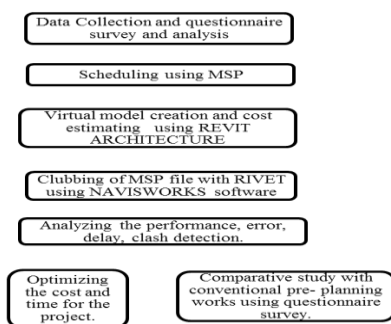• Analysis and comparison of results.

Fig 1 Data collection

The project starts with the data collection from AKSHAYA site, which is a residential project with 13 stories. The project includes 3 bedroom flats with square feet's ranging from 1451-1571 Sq.ft. The basic details of the site and the program used for current execution of the project is got and analyzed.

3.2 Questionnaire survey and analysis based on conventional planning

The project is half way through and so a questionnaire survey is conducted based on their conventional mode of planning implemented on the project. The questionnaire is analyzed using SPSS (Statistical Package for the Social Sciences) software. Using SPSS we can manipulate data, make graphs and performs statistical techniques varying from means to regression. The result gives an idea of how the project managers feel about the usage of CAD drawings, complexity and level of understanding using it and also about the conventional mode of planning adopted in the project.

The survey is conducted on a set of 30 companies based on below mentioned factors. The survey is based on companies involved in doing residential projects. The samples were taken and analyzed using SPSS.

S.NO	2D Drawings Domain
1	Better Overview of Project
2	Understanding of work environment
3	Better Detailing
4	Sufficient to experience future work
5	Understand details outside field of expertise
6	Building looking alike as imagined
7	Easy to explain the details
8	Easy to Remember
9	Easy to make decisions
10	Internal environment understanding
11	External environment understanding
12	Cooperation within same group
13	Cooperation outside group
14	Understanding detailing of other area
15	More information required
16	Future need of cad
17	Difficult to plan
18	Documentation
19	Good accuracy
20	High complexity level
21	Easy resource planning
22	Schedule
23	More errors
24	Freq schedule revisions
25	More time delay
26	Quality
27	Cost
28	Time consumption for understanding
29	High cost
30	More time
31	Face clash
32	Frequent plan change due to error
33	Freq plan change due to clashes
34	Difficult to locate clashes
35	Misunderstanding of drawing
36	More errors/delays due to misunderstanding
37	Tough

38	Difficult to analyze dimension Less accuracy
39	Time consuming
40	Size of new env
41	Assurance of client satisfaction
42	Delivery
43	Timely finish

3.3 4D model preparation

3D model is prepared using RIVET ARCHITECTURE software. Modeling is done based on all the details obtained from site. The model is based on the correct dimensions of each element so that the project can be seen in its real form in a virtual platform. (JP Zhang, Z.Z Hu (2010), Automation in Construction 155-166). Cost estimate of the whole project is also prepared from the same. We can also have a walk through effect through the model. A detailed schedule for the project is made using MSP (Microsoft Project) software based on the base program. Care is taken to avoid all delays and optimize the resources at the scheduling phase. Once the schedule is done, this is followed by clubbing of data's of MSP with RIVET using NAVISWORKS software. Hence a 3D model with time scale embedded in to it results in a 4D model which helps to monitor the project throughout the execution stage at any point of time. The model can also be oriented at any angle to view any part or element of it. It also shows the details of the structural elements and shows if any clashes occur during the execution. A model of the 13 storied residential apartment is done using RIVET ARCHITECTURE for sample reference. From the model, clash detections and quantity estimation can be done.
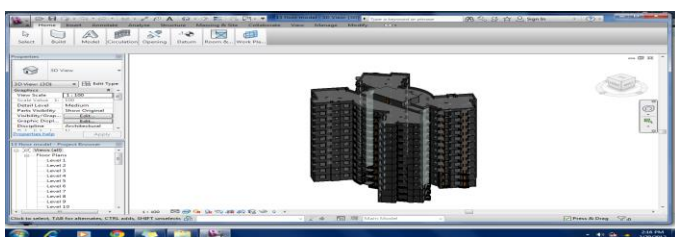

Figure 3.1 RIVET model of the 13 storied building

By appending the rivet model in to the NAVIS WORKS software, a 4D model is obtained with time as the fourth dimension. As the time scale is moved we get to know the progress in the building by changes in the model. The main advantage of this is that we can analyze the performance of the activities in the project in a single platform. The screen shots of the performance at various stages are shown below:

Figure 3.2 4D MODEL showing the progress of the building at 27th week

The red circle in the above Figure 3.2 shows the time liner, which when moved shows the progress of the building at a particular time period, which can be mentioned in minutes, seconds, days, weeks or months. The blue circle shows the day, date and the time in terms of week and days. The yellow outline in the figure shows the schedule being appended in to NAVIS WORKS at the beginning.

3.3.1 Clash Detection:

One of the significant features of NAVIS WORKS is that we can find the clashes or interferences in a building before executing so that future errors can be eliminated. A sample of the report is given below in Figure 1.6 Along with the descriptions of the type and positions it will also show the image view of the clashes.
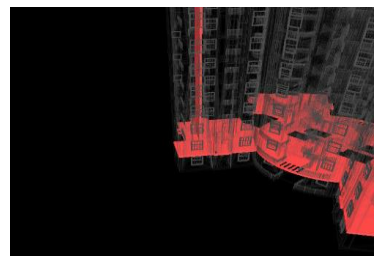

Figure 3.3 Clash detection

3.4 Questionnaire survey based on virtual model

Once the 4D model is prepared it is shown to the employees and a questionnaire is prepared based on its performance, easiness, complexity, usefulness etc. Apart from the factors mentioned in pre-analysis survey, the following factors or domains and variables as mentioned in below table are also included in the survey based on virtual model. The answers are analyzed using SPSS software.

Domain	Variables
Age	21-30 31-50 >50
Educational qualification	Diploma Under graduate Post graduate Others

Sex classification	Male
	Female
Nativity of client	Rural
	Urban
	Metro

3.5 Analysis and comparison

Once the survey is conducted, the answers are analyzed using the SPSS software and both the survey analysis are compared and studied. The result includes the correlations and descriptive statistics between and of different variables. The model is done and analyzed and it's used to find out the clashes and errors in the drawings and lag in schedule. (Youngsoo Jung, Mihee Joo, and Automation in Construction 20 (2011)126-133).The virtual model which is constructed can be used for advanced level of planning and thereby reduce the time and cost factors involved in conventional method planning. The final result is based on the comparative analysis of questionnaire and the result interpretations from model.

3.5.1 Pre-Analysis

The results are analyzed based on questionnaire survey using SPSS 11.5.The analysis factors are:

• Experience of participants using CAD.

• Planning

• Information processing

• Time, cost and quality

• Execution

• Estimation

• Client satisfaction

The result of the pre-analysis of 30 samples is tabulated using one sample statistics as shown in Table 3.1 and bar chart for different variables are also derived from SPSS software. The mean, standard deviation and the standard error mean of various factors are obtained.

Table 3.1 One Sample Statistics

Variable	N	Mean	Std.deviation	Std.error mean
Better overview	30	7.167	3.86927	0.70643
Understanding	30	3.167	4.25144	0.7762
Better detailing	30	5.5	4.61445	0.84248
Sufficient to exp	30	2.667	3.8804	0.70846
Understand outside detailing	30	4	4.43342	0.80943
As imagined	30	4.5	4.61445	0.84248
Explanation	30	5.833	4.37141	0.79811
Remember	30	5.833	4.37141	0.79811

Decision making	30	4	4.43342	0.80943
Internal env understanding	30	4.5	4.79763	0.87592
External env understanding	30	2	3.61987	0.66089
Cooperation within same group	30	5.667	4.30183	0.7854
Cooperation outside group	30	4.433	6.82128	1.24539
Understanding detailing of other area	30	4.833	3.82445	0.69825
More information required	30	3.167	4.2918	0.78357
Proper execution	30	4.5	4.42368	0.80765
Cad users present	30	9.667	1.82574	0.33333
Future need of cad	30	2.833	3.39455	0.61976
Difficult to plan	30	6.833	3.59198	0.6558
Documentation	30	3.167	4.25144	0.7762
Good accuracy	30	3.667	4.34172	0.79269
High complexity level	30	6.667	4.42043	0.80706
Easy resource planning	30	2.833	3.63699	0.66451
Schedule	30	2.833	4.2918	0.78357
More errors	30	6	4.62378	0.84418
Freq schedule revisions	30	6.5	4.1833	0.76376
More time delay	30	3.833	4.6763	0.85377
Quality	30	5.333	4.72217	0.86215
Cost	30	1.833	3.59198	0.6558
Time consumption for understanding	30	5.833	4.56435	0.83333
High cost	30	5.667	4.09654	0.74792
More time	30	5.333	4.53594	0.82814
Face clash	30	7.667	308804	0.70846
Frequent plan change due to error	30	8.167	3.07474	0.56137
Freq plan change due to clashes	30	7.5	4.10004	0.74856
Difficult to locate clashes	30	4.333	3.8804	0.70846
Misunderstanding of drawing	30	5.833	4.16954	0.76125
More errors/delays due to misunderstanding	30	6.667	4.22091	0.77063
Tough	30	4	4.23451	0.77311

Difficult to analyze	30	3.333	3.79049	069205
Less accuracy	30	4.667	4.34172	0.79269
Time consuming	30	7.167	3.86927	0.70643
Size of new env	30	3	4.27503	0.78051
Assurance of client satisfaction	30	5.167	3.82445	069825
Delivery	30	5.167	3.82445	0.69825
Timely finish	30	3.667	3.45746	0.63124
Convince client	30	5.333	3.45746	0.63124

The bar charts are derived for various factors like respondents experience using CAD, planning, information processing, time cost and quality, execution, and estimation. The respondents feel that the drawing gives good overview but difficult to maintain good cooperation among other work groups.
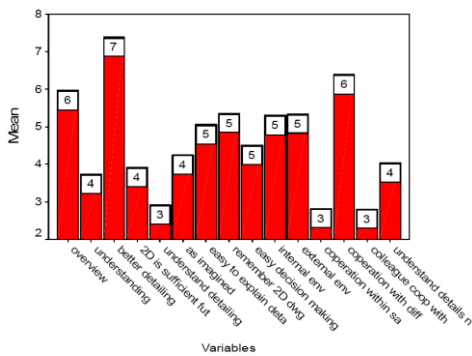
Figure 3.4 Means of various factors affecting the experience of

Participants using CAD

From Figure 4.1 it's noticed that, the experience using CAD was average and the mean rounds up to 4.57. The workers feel that it gives a good over view but difficult to explain the external environment and to maintain a good cooperation among other groups.
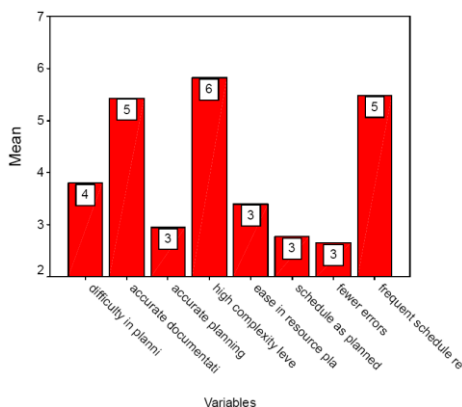

Figure 3.5 Means of factors affecting planning using conventional method

In the Figure 3.5 the various factors regarding planning is plotted against their means and it infers that planning using conventional method is tough which results in frequent schedule revision and the workers experience it as less accurate. The mean obtained is 4.81.

3.5.2 Post-Analysis

The results are analyzed of questionnaire survey using SPSS 11.5.The demographic details and other domains as mentioned in Table 3.1 are also added apart from the factors included in pre- analysis.

The frequencies of the age groups of the people who were interviewed are shown in Figure 3.6. The chart shows that nearly 37% are of age group 21-30, 24% of them are of age group above 51 and 40% of them between31-50. The output is tabulated using SPSS.

Table 3.2 Age Analysis - Frequencies

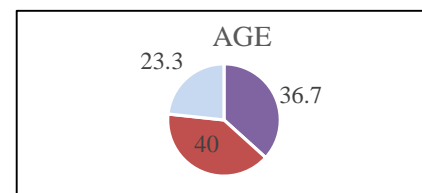|		Frequency	Percent
Valid	21-30	12	40
	31-50	11	36.7
	>51	7	23.3
	Total	30	100

Figure 3.6 Age Analysis - Frequencies

The qualifications of the people who were interviewed in different firms are shown in Figure 3.7 the persons who have done their under graduation are higher among the interviewed personnel's. The tabulations are shown in Table 3.3

Table 3.3 Education Qualification

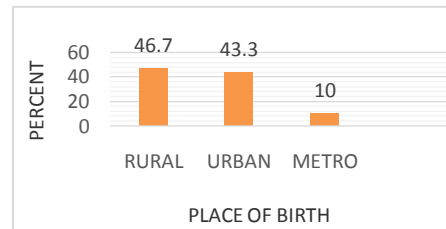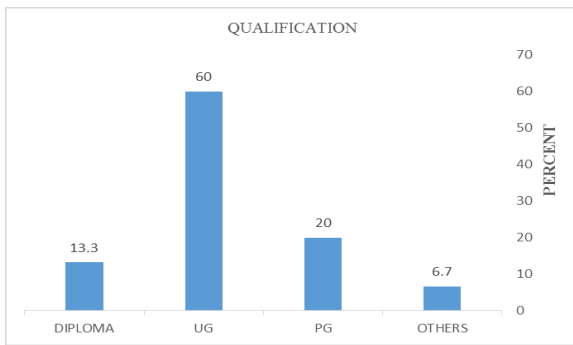|	Education	Frequency	Percent
Valid	Diploma	4	13.3
	UG	18	60
	PG	6	20
	Others	2	6.7
	Total	30	100

Figure 3.7 Education Qualification

The tabulations of the sex groups of the people who were interviewed are shown in Table 3.4. The result shows that out of 30 only 2 were ladies and the rest were gents. The schematic representation is shown below in Figure 3.8. Thus the result shows that males dominates in the industry.

Table 3.4 Sex Classification

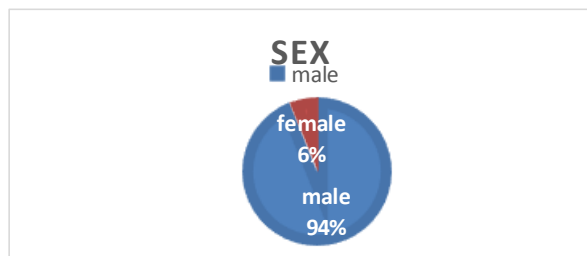|	Gender	Frequency	Percent	Valid percent	Cumulative percent
Valid	Male	28	93.3	93.3	93.3
	Female	2	6.7	6.7	100.0
	Total	30	100.0	100.0	

Figure 3.8 Sex Classification

The below Figure 3.9 shows the birth place of the groups of the people who were interviewed. Table 3.5 shows that equal numbers of people are from urban and rural areas where as only 10% are from metro.

Table 3.5 Nativity of the Client

	Nativity	Frequency	Percent	Valid percent	Cumulative percent
Valid	Rural	14	46.7	46.7	46.7
	Urban	13	43.3	43.3	90
	Metro	3	10	10	100
	Total	30	100	100	

Figure 3.9 Nativity of the Client

The below Table 3.6 shows the descriptive statistics of respondents experience using VR model. The mean and the standard deviation values shows that more than 2D drawing, the virtual model is easy to understand and for using as decision making tool and also gives good idea about the internal and external environment.

Table 3.6 Nativity of the Client

Variables	N	Minimum	Maximum	Mean	Std.Deviation
Better overview	30	50	100	88.33	21.509
Better detailing	30	50	100	98.33	9.129
Easy to explain	30	50	100	88.23	21.509
Ability to navigate	30	50	100	98.33	9.129
Good understanding of future env	30	50	100	90	20.342
Building looks alike as imagined	30	50	100	96.67	12.685
Gives idea about int env	30	50	100	90	20.342
Gives idea about ext env	30	50	100	96.67	12.685
Decision making easy	30	50	100	90	20.342
Easy understanding of details	30	50	100	86.67	22.489
2D gives idea about int env	30	50	100	53.67	17.317
2D gives idea about ext env	30	50	100	23.67	22.967
Cooperation	30	50	100	100	0

with same occupational group					
Cooperation with other group	30	50	100	88.33	21.509
Valid N(list wise)	30	50	100	32	36.615

4 . Conclusion

From the analysis of questionnaires based on importance and relevance of 2D drawing and importance and relevance of Virtual Reality, using SPSS software the result were obtained and the conclusion is made based on the comparison of both the result and are as follows:

As per the pre-analysis, the workers feel that CAD drawing gives a good over view but it's difficult to explain the external environment and to maintain a good cooperation among other groups. It also infers that it's tough to plan using conventional method which results in frequent schedule revision and the workers experience it as less accurate.

The model of the building is done using RIVET ARCHITECTURE. The interference reports and the quantities are derived and the cost is calculated from it. The 4D model with time as the fourth dimension is made using NAVIS WORKS. The progress and the clashes can be identified from it which can be identified in a single platform. The clash detections are also obtained from this.

From post-analysis, it is understood that most of the respondents are in the age group 21-30 yrs. So switching over from conventional method of planning to 4D will be easy for them to learn and adopt in future and it's easy to adopt and be aware of the technology changes since most of them have done under graduation or above.

Comparison of the post and pre SPSS result analysis says that, the virtual model is easy to understand and a better decision making tool which also gives good idea about the internal and external environment. The respondents feel the model is not costly and it is easy to understand and which makes planning easy and thereby detecting clashes and update the progress in a fast pace compared to the conventional planning. Hence the objectives are satisfied.

Domain	Variables	Post-analysis		
		Frequency	Percent	Cumulative percent
Age	21-30 31-50 >50	12 11 7	40 36.7 23.3	40 76.7 100

Educational qualification	Diploma Undergraduate Post graduate Others	4 18 6 2	13.3 60 20 6.7	13.3 73.3 93.3 100
Sex classification	Male Female	28 2	93.3 6.7	93.3 100
Navity of client	Rural Urban Metro	14 13 3	46.7 43.3 10	46.7 90 100

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