Influence of 4D Planning in Indian Construction Industry

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ABSTRACT

Construction industry is under constant pressure to increase the quality and speed of its construction delivery processes. Construction planning plays vital role in the development of construction industry. There is still a huge discrepancy between execution and plan. Therefore, an efficient and effective planning method is intensively needed to enhance the project performance and to minimize the risk of cost overrun and delays. In Engineering and Construction, building construction schedule is prepared by visualizing 2D design documents of a building project. This process is difficult to associate components in the 2D documents with their related construction activities, and then visualize the construction sequence. 4D Planning technologies, visually representing the construction schedule along with the 3D model components, has the potential to aid this process by providing a common visual language for Planners. The research presented an assessment based survey to identify knowledge, features, benefits & barriers in implementation of 4D planning in construction project. Better visualization of works, reducing the conflicts between the design/execution were the key benefits in 4D planning as observed from an assessment.
participants as well as the interaction between them are identified K.W. Chau et al. (2003), discussed a new 4D site management model has been proposed & prospective requirements for 4D applications to support practical use on site management have also been highlighted. 4D model, representing the actual implementation of the model to link a 3D geometrical model with scheduling data, was demonstrated to have the capability to overcome drawbacks of conventional means in construction planning. This comprehensive computing system embraces the activity schedule, the pertinent resource allocation as well as site layout planning at any specified time interval. This tool can facilitate the planning process, foresee any site problem prior to occurrence and thus enhance the quality of site management. The study on 4D visualization practice has certainly far-reaching impacts in the field of construction management.

Allen and Smallwood (2008), this article elaborates the construction planning was important role within the development of construction industry. It involves tracing back from the result and identifying the sequences of events which lead to that result. This is a challenging job for the planner since the final outcomes of construction projects are not possible to observe until they are completed. Moreover, the inevitable nature of uncertainties and complexity of construction projects are also put together to create more complicated challenges for project team in accomplish construction planning.

Zanen and Hartmann (2010), pointed out that it is important to effectively plan ahead in the early stage of a project; to specify potential errors, prepare possible solutions and to assign work tasks to the right people with the right techniques. Those are what will enhance the percentage of success. However, construction planning is not a process only limited in the period before construction’s actual start; it should be considerably taken into account during the project life cycle and would require re-planning if something wrong should happen. Not only can an effective and proper plan limit the possibility of problems occurring it also lessens the adverse consequences of such problems.

Zanen and Hartmann (2013), explained that the aim of planning is to generate required activities as well as their interdependence and thereby ensuring that the project will be completed within the best manners of economics, safety and environmental acceptance

Data Collection

This chapter includes the methodology used in this research and provides information about the research strategy, research design & various approaches for data collections.

Research strategy can be defined as the way in which the research objectives can be questioned. The explanation of mass behavior often requires mass attitude data that can only be obtained by a survey. There are two types of research strategies, namely 'quantitative research' and 'qualitative research'. Data may take the form of narrative information (qualitative data) or numerical values (quantitative data). Quantitative research is 'objective' in nature. It is defined as an inquiry into a social human problem, based on testing a hypothesis or a theory composed of variables, measured with members, and analysis with statistical procedures. It investigates facts and tries to establish relationships between these facts. It is selected under the following circumstances

- When you want to collect factual evidence and study the relationship between these facts in order to test a particular theory or hypothesis.

Qualitative data consists of detailed descriptions of people, events, situations, or observed behavior. Qualitative research is 'subjective' in nature. It emphasizes meanings, experiences (often verbally described), and description and so on.

In this research, a quantitative approach is selected because it is an objective measurement of the problem. It investigates facts and tries to establish relationships between these facts.

The research design is the overall plan for obtaining answers to the questions being studied and for handling some of the difficulties encountered during the research process. Research design is an action plan for getting from 'here' to 'there' where 'here' may be defined as the initial set of questions to be answered, and 'there' is some set of conclusion (answers) about these questions. Between 'here' and 'there' may be found a number of major steps, including the collection and analysis of relevant data.

The design normally specifies which of the various types of research approaches will be adopted and how the researcher plans to implement scientific controls to enhance the interpretability of the results.

There are a variety of survey designs that can be used to accommodate different substantive needs and problems if those problems are anticipated in the planning of the survey.

The structured questionnaire is probably the most widely used data collection technique for conducting surveys to find out facts, opinions and views. In quantitative studies, research designs tend to be highly structured and to include tight controls designed to eliminate the effects of contaminating influences.

The questionnaire design was undertaken to determine the opinion of contractors regarding the Influence of 4D Planning in Indian construction industry. The questionnaire was classified into close form or restricted type. Closed questions often require short responses in the form of Yes or No, Agree or Disagree, Important or Not Important, etc. Closed-ended questions are easy to ask and quick to answer.

A ten page questionnaire, accompanied by a covering letter was used for gathering data. The letter indicated the objectives of the research and explained to respondents that the results of the questionnaire would be used to analysis the potential benefits & limitation in implementation of 4D planning in construction Projects.

The questionnaire composed of six sections to accomplish the aim of this research, as follows:

1. Knowledge of 4D Planning in Construction Industry
2. The General perception and acceptance of 4D Planning technology in construction industry
3. Features of 4D Planning in Construction Industry
4. Benefits of 4D Planning in Construction Industry
5. Barriers to the implementation of 4D Planning
6. Measures to overcome barriers to the implementation of 4D Planning

In order to be able to select the appropriate method of analysis the level of measurement must be understood. For each type of measurement, there is/are appropriate methods that can be applied and not others. Ordinal scale is a ranking or a rating that normally uses integers in ascending or descending order.

The numbers assigned to the agreement or degree of influence (1, 2, 3, 4, 5) don’t indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels. Ascending ordinal scale was used in this research as follows
1. Very low influence  
2. Low influence  
3. Neutral  
4. High influence  
5. Very high influence  

**Method of Analysis**  
Quantitative statistical analysis for the questionnaire was done by using Statistical Package for Social Sciences (SPSS). The analysis of data is done to rank the various factors involved in the 4D planning. Ranking was followed by comparison of mean values within groups and for the overall sub-factors. The following statistical analysis steps were done:  
- Definition and coding of variables.  
- Summarizing the data on recording scheme.  
- Finding Mean and Rank of each variable.  
- Comparing of mean values for each main group and overall sub-factors.  

**Data Analysis**  
This chapter describes the results that have been obtained from processing of Fifty Seven questionnaires using Statistical Package for Social Sciences (SPSS). The results are prepared to present the information about the sample size, response rate and contracting companies’ characteristics in construction industry. The presentation of analysis will be conducted in the form of bar charts, pie charts and matrix tables to show the distribution and frequencies of the particular variables.  

**Administering the Questionnaire**  
Totally 57 questionnaires surveyed and hard copies of 42 filled surveys have been obtained. This gives a higher confidence in the quality of answers. The break up is as follows in the below Figure 1 – 2.  

**Response Rate of Survey**  
Out of the 48 surveys distributed on the construction companies, 41 responses were received with 85% return rate in this study. The other 7 surveys as follows, 6 (13%) have not been received, 1 (2%) not aware as shown in the Figure 3.  

**Section 1 - Knowledge on 4D Planning**  
Out of the 42 construction companies, 9 companies are using the 4D technique in their projects & other 33 companies belong to highly unused & unused category as shown in the Figure 4.  
- No of Respondents using the Technique – 9 Nos  

Out of the 42 professionals, 11 professionals are involved in 4D technique in their projects, 30 professionals are aware about the technique & 1 professional is not aware about the technique as shown in the above Figure 5.  
- No of Respondent’s having knowledge about the Technique – 11 Nos  
- No of Respondent’s aware about the Technique – 30 Nos  

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**Fig 1. Sector wise survey receipts**  
**Fig 2. Designation wise survey receipts**  
**Fig 3. Response rate of surveys**  
**Fig 4. Usage of 4D technique in Construction companies**  
**Fig 5. Knowledge of 4D technique in Construction companies**
### Table I. Mean & Ranking of Principle of 4D Planning

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>A7</td>
<td>Avoiding out of sequence of activities</td>
<td>4.512</td>
<td>1</td>
</tr>
<tr>
<td>A8</td>
<td>Increasing visual perception at Planning stage itself</td>
<td>4.512</td>
<td>1</td>
</tr>
<tr>
<td>A5</td>
<td>Involving the whole Project team through planning from design to construction</td>
<td>4.415</td>
<td>2</td>
</tr>
<tr>
<td>A1</td>
<td>Delivering what the client wants</td>
<td>4.195</td>
<td>3</td>
</tr>
<tr>
<td>A2</td>
<td>Establishing continuous improvement: thus, reduction of cost &amp; time</td>
<td>3.951</td>
<td>4</td>
</tr>
<tr>
<td>A3</td>
<td>Doing the right thing at first time: thus achieve Zero reworks</td>
<td>3.683</td>
<td>5</td>
</tr>
<tr>
<td>A6</td>
<td>Constantly seeking better ways to do things</td>
<td>3.561</td>
<td>6</td>
</tr>
<tr>
<td>A4</td>
<td>Increasing the Output value through systematic consideration of customer requirements</td>
<td>3.439</td>
<td>7</td>
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</table>

### Table II. Mean & Ranking of Perception & Acceptance of 4D Planning

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>Rank</th>
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<tbody>
<tr>
<td>B1</td>
<td>Good for Planning &amp; Scheduling</td>
<td>3.756</td>
<td>1</td>
</tr>
<tr>
<td>B6</td>
<td>Good for Co-ordination between services</td>
<td>3.707</td>
<td>2</td>
</tr>
<tr>
<td>B5</td>
<td>Good for Cost Minimization</td>
<td>3.659</td>
<td>3</td>
</tr>
<tr>
<td>B3</td>
<td>Good for Reporting</td>
<td>3.634</td>
<td>4</td>
</tr>
<tr>
<td>B2</td>
<td>Good for Tracking &amp; analyzing</td>
<td>3.610</td>
<td>5</td>
</tr>
<tr>
<td>B4</td>
<td>Good for Time Saving</td>
<td>3.317</td>
<td>6</td>
</tr>
<tr>
<td>B8</td>
<td>Good tool for Lean Technology</td>
<td>3.268</td>
<td>7</td>
</tr>
<tr>
<td>B7</td>
<td>User friendly software</td>
<td>2.415</td>
<td>8</td>
</tr>
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### Table III. Mean & Ranking of Features of 4D Planning

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>C8</td>
<td>It contributes in improving in construction management</td>
<td>4.366</td>
<td>1</td>
</tr>
<tr>
<td>C4</td>
<td>The reports &amp; outputs are clear and easy to read &amp; understanding</td>
<td>3.415</td>
<td>2</td>
</tr>
<tr>
<td>C3</td>
<td>It saves time &amp; Effort</td>
<td>3.341</td>
<td>3</td>
</tr>
<tr>
<td>C5</td>
<td>The information can be inquired easily</td>
<td>3.220</td>
<td>4</td>
</tr>
<tr>
<td>C2</td>
<td>In General, it is easy to use</td>
<td>3.146</td>
<td>5</td>
</tr>
<tr>
<td>C1</td>
<td>The Software is flexible &amp; data can be updated easily</td>
<td>2.854</td>
<td>6</td>
</tr>
<tr>
<td>C6</td>
<td>Training to use the 4D Planning software is easy</td>
<td>2.707</td>
<td>7</td>
</tr>
<tr>
<td>C7</td>
<td>It does not need a professional user to deal with it</td>
<td>2.000</td>
<td>8</td>
</tr>
</tbody>
</table>
### TABLE IV. MEAN & RANKING OF BENEFITS OF 4D PLANNING

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6</td>
<td>Improves Visualization for client, construction review &amp; Project review meeting</td>
<td>4.683</td>
<td>1</td>
</tr>
<tr>
<td>D12</td>
<td>Accurate quantities Takeoff</td>
<td>4.366</td>
<td>2</td>
</tr>
<tr>
<td>D4</td>
<td>Reduce the conflicts between Design &amp; Construction towards reducing design time &amp; planning clashes</td>
<td>4.317</td>
<td>3</td>
</tr>
<tr>
<td>D1</td>
<td>Deliver services that enable customers to better accomplish their goals</td>
<td>3.927</td>
<td>4</td>
</tr>
<tr>
<td>D2</td>
<td>Deliver services on time with in the Budget</td>
<td>3.927</td>
<td>4</td>
</tr>
<tr>
<td>D3</td>
<td>Minimize reworks &amp; rectification cost through effective Project Planning Process</td>
<td>3.927</td>
<td>4</td>
</tr>
<tr>
<td>D9</td>
<td>Assist in reduction overall Project duration</td>
<td>3.829</td>
<td>5</td>
</tr>
<tr>
<td>D13</td>
<td>Better in Site Logistics plan in the Program itself</td>
<td>3.756</td>
<td>6</td>
</tr>
<tr>
<td>D10</td>
<td>Better communication regarding the Progress to client or stake holders</td>
<td>3.585</td>
<td>7</td>
</tr>
<tr>
<td>D8</td>
<td>Increased Planning reliability on the Project</td>
<td>3.561</td>
<td>8</td>
</tr>
<tr>
<td>D5</td>
<td>More accurate &amp; detailed work plan</td>
<td>3.537</td>
<td>9</td>
</tr>
<tr>
<td>D11</td>
<td>Planning of Temporary structures &amp; works</td>
<td>3.415</td>
<td>10</td>
</tr>
<tr>
<td>D7</td>
<td>Increased field Productivity</td>
<td>2.976</td>
<td>11</td>
</tr>
</tbody>
</table>

### TABLE V. MEAN & RANKING OF BARRIERS IN IMPLEMENTATION OF 4D PLANNING

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>E11</td>
<td>Lack of knowledge in Supporting software (Revit)</td>
<td>4.366</td>
<td>1</td>
</tr>
<tr>
<td>E1</td>
<td>Lack of interest from Clients</td>
<td>4.341</td>
<td>2</td>
</tr>
<tr>
<td>E8</td>
<td>Lack of Technically skilled person</td>
<td>4.317</td>
<td>3</td>
</tr>
<tr>
<td>E4</td>
<td>Lack of Top management support &amp; Commitment</td>
<td>4.195</td>
<td>4</td>
</tr>
<tr>
<td>E2</td>
<td>Lack of Training</td>
<td>4.122</td>
<td>5</td>
</tr>
<tr>
<td>E6</td>
<td>Long Implementation period</td>
<td>4.122</td>
<td>5</td>
</tr>
<tr>
<td>E3</td>
<td>Delay in Decision Making</td>
<td>3.927</td>
<td>6</td>
</tr>
<tr>
<td>E13</td>
<td>Lack of Involvement</td>
<td>3.878</td>
<td>7</td>
</tr>
<tr>
<td>E9</td>
<td>Difficult in understanding concepts &amp; technology</td>
<td>3.829</td>
<td>8</td>
</tr>
<tr>
<td>E12</td>
<td>License amount for 4D Planning software</td>
<td>3.707</td>
<td>9</td>
</tr>
<tr>
<td>E10</td>
<td>The Fragmented nature of construction Industry</td>
<td>3.463</td>
<td>10</td>
</tr>
<tr>
<td>E7</td>
<td>In adequate planning</td>
<td>3.366</td>
<td>11</td>
</tr>
<tr>
<td>E5</td>
<td>Poor Communication</td>
<td>3.220</td>
<td>12</td>
</tr>
</tbody>
</table>
The mean of each of the sub-factors of the Knowledge of 4D planning group are presented in Table I in a descending order. Avoiding out of sequence of activities, increasing visual perception at planning stage itself & involving the whole project team through planning from design to construction had the highest means 4.51, 4.51 and 4.41 respectively.

Similarly increasing the output value through systematic consideration of customer requirements & constantly seeking better ways to do things had the lowest rank with means 3.44 and 3.56 respectively.

Survey results indicated that the following are the top five major advantages of 4D planning technique in the current construction industry with respect to opinion of the professionals.

• Avoiding out of sequence of activities.
• Increasing visual perception at Planning stage itself.
• Involving the whole Project team through planning from design to construction.
• Delivering what the client wants.
• Establishing continuous improvement: thus, reduction of cost & time.

Doing the right thing at first time: thus achieve Zero reworks.

Section 2 - Perception and Acceptance of 4D Planning

The mean of each of the sub-factors of the General perception & acceptance of 4D planning technique are presented in the below Table II in a descending order. Rank of each factor is also listed.

Good for Planning & Scheduling, Good for Co-ordination between services & Good for Cost Minimization had the highest means 3.76, 3.71 and 3.66 respectively. Similarly user friendly software had the lowest rank with mean 2.42. Survey results indicate that the following are the top five major roles of 4D planning technique in the construction industry with respect to opinion of the professionals.

• Good for Planning & Scheduling.
• Good for Co-ordination between services.
• Good for Cost Minimization.
• Good for Reporting.
• Good for Tracking & analyzing.

Survey results indicated that the following is the major disadvantages of role of 4D planning

• User friendly software – It states that the application is not user friendly to work in the industry.

Section 3 - Features of 4D Planning

The mean of each of the sub-factors of the General perception & acceptance of 4D planning technique are presented in the below Table III in a descending order. Rank of each factor is also listed.

It contributes in improving in construction management, the reports/outputs are clear and easy to read/understanding & it saves time/Effort had the highest means 4.37, 3.41 and 3.34 respectively. It does not need a professional user to deal with it & Training to use the 4D Planning software is easy had the lowest rank with means 2.00 and 2.70 respectively.

Survey results indicate that the following are the top three major features of 4D planning technique in the current construction industry It contributes in improving in construction management.

• The reports & outputs are clear and easy to read & understanding.
• It saves time & Effort.

Survey results indicated that the following is the major requirement of features in 4D planning

• It needs a skilled user to deal with it.
• Training to use the 4D planning software is not very easy.

Section 4 - Benefits of 4D Planning

The mean of each of the sub-factors of the benefits of 4D planning technique are presented in the Table IV in a descending order. Rank of each factor is also listed.

Improves Visualization for client, construction review & Project review meeting. Reduce the conflicts between Design & Construction towards reducing design time & planning clashes. Survey results indicated that the following are not benefits in 4D planning technique in the current construction industry with respect to opinion of the professionals.

• Improves Visualization for client, construction review & Project review meeting.
• Accurate quantities Takeoff.
• Reduce the conflicts between Design & Construction towards reducing design time & planning clashes.

Survey results indicated that the following are the top three major benefits of 4D planning technique in the current construction industry with respect to opinion of the professionals.

• Improves Visualization for client, construction review & Project review meeting.
• Accurate quantities Takeoff.
• Planning of Temporary structures & works.

Section 5 – Barriers in Implementation of 4D Planning

The mean of each of the sub-factors of the barriers to the implementation of 4D planning technique are presented in the below Table V in a descending order. Rank of each factor is also listed. Lack of knowledge in Supporting software (Revit), Lack of Training & Long Implementation period.

Survey results indicated that the following is the major barriers in the implementation of 4D planning technique in the current construction industry & works.

• Lack of knowledge in Supporting software (Revit).
• Lack of Training & Long Implementation period.

Survey results indicated that the following are the top five major barriers in the implementation of 4D planning technique in the current construction industry & works.

• Lack of knowledge in Supporting software (Revit).
• Lack of Training & Long Implementation period.
• Lack of Top management support & Commitment.
• Lack of Technically skilled person.

Section 6 – Measures to Overcome from Barriers

The mean of each of the sub-factors of the measures to overcome the barriers in implementation of 4D planning technique are presented in the below Table VI in a descending order. Rank of each factor is also listed. Management should train employees on Concepts/Technology of 4D Planning, Top Management need to take quick decision/support in Implementation of 4D Technology & Planner should be trained in revit software had the highest means 4.61, 4.49 and 4.46 respectively.

Contractor need to consider the cost towards software license at the time of tender itself & Communication should be improved among players in the construction Projects had the lowest rank with means 3.66 and 4.05 respectively.
Survey results indicated that the following are the top five major measures to overcome barriers in the implementation of planning technique in construction industry:

- Management should train employees on Concepts & Technology of 4D Planning.
- Top Management need to take quick decision & support in Implementation of 4D Technology.
- Planner should be trained in revit software.
- Contractor need to create awareness of benefits of 4D Technology in Projects to Clients.
- Planning should ensure the Improvement, thus reduction cost & saving time.

Survey results indicated that the following is of moderate importance in measures to overcome barriers in the implementation of 4D planning technique in the current construction industry with respect to opinion of the professionals.

- Contractor need to consider the cost towards software license at the time of tender itself.

Conclusions

Construction projects are scheduled according to the availability of resources and depend on many external factors. As time progresses these parameters also change and hence it is important to keep a check on important activities to finish the project without any significant delays. The admired 3D BIM does not help in establishing the relationship between the schedule and sequence of construction activities to be carried out during the project execution. A 4D planning technique incorporates time as the added 4th dimension and hence improves the quality and accuracy of the entire project life cycle management.

The study found 4D planning to be a promising tool for construction planning. There are many positive impacts of 4D planning discovered which cannot be achieved through traditional planning methods being used. The most significant benefits of 4D planning are found out to be better visualization of construction work, reducing the conflicts between design/execution and increased planning efficiency.

In addition, 4D planning assists in achieving customer goals, reducing reworks /repairing works, quantity takeoffs and achieve the budget within the stipulated time. With the help of better visualization and communication, the planners, project team and client can achieve a better and common understanding of the project scope and objectives, which can improve the construction planning and execution process significantly leading to the success of project. Implementing 4D planning allows planners to detect the problems prior to construction phase which lead to reduction in the amount of rework and clashes. Therefore, a more reliable and detailed work plan can be obtained which assists the project to complete within prescribed time and budget.

Design-build projects encourage cooperation between designers and builders, and also try to ensure that unforeseen delays are accounted for beforehand. The 4D technique seems to be a suitable planning tool for such a delivery system as it must be built together by project participants, and allows better detection of unanticipated problems.

All things considered, it is recommended that 4D planning should be widely introduced into construction industry. Implementing 4D technology could be propitious development for construction firms and can help mitigating the most common problems faced in the construction projects with enhanced planning efficiency.

References


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