# PERCEPTION ABOUT 2D CAD SYSTEM AND COMPETITIVENESS FOR BUILDING INFORMATION MODELING (BIM) IN PAKISTAN CONSTRUCTION INDUSTRY

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**_ABSTRACT:_**

*Building Information Modeling (BIM) is one of the new developments in the construction industry. In Pakistan, research on BIM in academia and construction industry is relatively a new phenomenon. This paper has tried to find out general perception about 2D CAD System and to explore the prospects for BIM in Pakistan context. The main objectives of this research were to assess the general perception about 2D CAD System and to discuss competitiveness for BIM in Pakistan construction industry. The methodology of this research was based on a questionnaire survey to collect data. The questionnaire was designed comprising on research variables for general perception about 2D CAD System and competitiveness for BIM in the construction industry. This survey was conducted among architects, designers, engineers, contractors, sub-contractor, MEP consultants, academia, developers, and facility owners. The collected data were analyzed by conducting different statistical procedures to make inferences. Results of this survey indicated that the construction industry stakeholders have the perception about 2D CAD System that it generates independent 2D views and rework would be required for building performance analysis. They also perceived this system as an electronic drafting board rather than as a design tool. The results further indicated that respondents to this survey were in a view that BIM improves the budgeting, cost estimating and scheduling capabilities. It also helps for early identification of design errors through clash detection and visual coordination of building MEP (Mechanical, Electrical and Plumbing) systems.*

**_KEYWORDS:_** *Building Information Modeling (BIM), Questionnaire, Virtual Building Construction, Virtual Design and Constriction, 2D CAD System, Object-oriented CAD Systems, Perception, Competitiveness*

## 1. INTRODUCTION

"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder" (NBIMS 2012).

Building information modeling is emerging as an innovative way to virtually design and manage construction projects. Predictability of building performance and operation is greatly improved by adopting BIM (Azhar 2011). BIM is an exciting and revolutionary technology and process that has quickly transformed the way buildings are conceived, designed, constructed and operated (Hardin 2009).

In Pakistan, Building Information Modeling (BIM) is a new concept in the construction industry. Very little work has been carried out to explore its potential in the industry. This research has tried to find out general perception about 2D CAD System and to explore the prospects for BIM in Pakistan context. The main objectives of this research were to assess the general perception about 2D CAD System and to discuss competitiveness for BIM in Pakistan construction industry for coordinating, executing and managing the construction projects through a research survey based on a questionnaire.

## 2. LITERATURE REVIEW

The basic idea of a CAD system was to automate the drafting task. The original focus of CAD applications was to represent 2D geometry via graphical elements, such as lines, arcs, and graphic symbols. In this context, walls, for example, are merely represented as parallel lines (Howell and Batcheler 2005). Each building view is drawn separately with no inherit relationship between drawings and other information. The CAD-based drawings are simply a collection of all the manually generated files (Krygiel and Nies 2008). 2D drawing files could be generated and plotted from CAD, but more complex information, such as the relationships between building components could not be represented (Howell and Batcheler 2005).

The emergence of 3D CAD initially focused almost entirely on creating geometry in support of visualization, and subsequent advances concentrated on creating realistic renderings and lighting effects. Building information modeling (BIM) is the latest generation of object-oriented CAD systems in which all of the intelligent building objects that combine to make up a building design can coexist in a single 'project database' or 'virtual building' that captures everything known about the building. This building information model provides a single, logical, consistent source for all information associated with the building and building components (Howell and Batcheler 2005).

"With BIM technology, one or more accurate virtual models of a building are constructed digitally. They support design process through its phases, and allow for better analysis and control than manual processes. When completed, these digital models contain precise geometry and data needed to support the construction process, fabrication, and procurement activities through which the building is realized" (Eastman, Teicholz et al. 2011).

The function of Building Information Modeling (BIM) is to develop and use a virtual model to simulate design parameters, construction process and operation of a facility. BIM has the attributes of both an approach and a process. It is an approach as it provides an alternative to the traditional paper based approach of project design, coordination and management. It is a process as it creates a product called Building Information Model, whose performance can be measured and analyzed. In normal practice, the terms "Building Information Modeling" and "Building Information Model" are being used interchangeably. But to be precise, there is a difference between these two terms as one is a process, and the other is a product (Wong, Wong et al. 2009).

BIM model is very helpful in predicting and analyzing building performance. The improved ability to visualize the design proposals in the early project phases greatly aids in the assessment of the spaces and aesthetic finishes of the project. The design intent could be more easily and accurately communicated to the other project team members, and adjustments could also be made until the design meets the desired goals and objectives (Kymmell 2008). The ability to utilize BIM to design and construct a building digitally before it actually gets built on site provides an opportunity to designer, consultant, engineer and contractor to resolve any ambiguities during the process and to check its constructability in the real world. This allows for more efficient and better designed structures that reduce waste of resources, optimize energy usage, and promote passive design strategies (Bynum, Issa et al. 2012).

## 3. RESEARCH METHODOLOGY

This research was conducted as an exploratory study to measure the perception of the construction industry stakeholders about 2D CAD System and to explore the prospects for BIM in Pakistan construction industry. After the preliminary study, a detailed literature review was carried out and a number of already developed questionnaires were examined. After this review, the research variables for 2D CAD System were grouped in a separate section and the research variables for competitiveness for BIM were grouped in next section.

After the pilot study, the questionnaire was further reviewed and adjustments were made to refine it further. A five-point Likert scale, with 1 being strongly disagree to 5 being strongly agree, was utilized to judge the current level of perception of construction industry stakeholders about 2D CAD System and competitiveness for BIM. The principal consideration for using Likert scale was to determine the extent to which respondents agree or disagree with a particular statement or view (Cormack 2000).

The online questionnaire form was designed using Google documents. The link of the questionnaire was sent to architects, designers, engineers, MEP (Mechanical, Electrical, and Plumbing) consultants, contractors, developers, facility owners, academia and construction industry related members via email and by hand where it was required. The emails were acquired from the websites of Pakistan Engineering Council (PEC), Pakistan Council of Architect and Town Planners (PCATP), Institute of Architects Pakistan (IAP) and personal contacts and relations.

Out of 175 questionnaires sent out, 157 were received. Twenty three (23) incomplete questionnaires were excluded and analysis was carried out on 134 questionnaires. The collected data were analyzed using MS Excel and SPSS. Cronbach's Coefficient Alpha was measured to check the reliability of the collected data and to examine the internal consistency of the items of the questionnaire when research variables were on Likert scale. The Shapiro-Wilk Normality Test was performed to check whether data is parametric or non-parametric i.e. whether it were normally distributed or otherwise. Kruskal-Wallis test was performed to check the differences or similarities in the perception of stakeholders about the research variables. A 5% level of significance was considered to represent statistically significant relationships in the collected data. The perception level of the respondents to this survey about the research variables was assessed by using the mean score (MS) computed by the following formula (Chan and Kumaraswamy 1996):

$$\text{MS} = \frac{\sum(fxs)}{N} \quad (1 \leq \text{MS} \geq 5) \qquad (3\text{-}1)$$

Where 's' is score given to each research variable by the respondents and ranges from 1 to 5 when 1 is "Strongly disagree" and 5 is "Strongly agree"; f is frequency of responses to each rating (l-5) for each research variable; and N is total number of responses (134). In addition to the mean score, the five-point scale was transformed to relative importance indices using the relative index ranking technique (Chan and Kumaraswamy 1997, Sambasivan and Soon 2007) to determine the rankings of the research variables and verify the evaluation by mean score.

$$\text{Relative Importance Index (RII)} = \sum w / (A*N) \qquad (0 \leq \text{RII} \geq 1) \qquad (3\text{-}2)$$

$$\text{RII} = \left(\frac{1n1+2n2+3n3+4n4+5n5}{(A*N)}\right)$$

Where
*w* = weighting assigned to each research variable by the respondents having range from 1 to 5
n1 = number of respondents for Strongly disagree
n2 = number of respondents for Disagree
n3 = number of respondents for Not sure
n4 = number of respondents for Agree
n5 = number of respondents for Strongly agree
A= highest weight is 5
N = sample size taken as 134

A random sample for this study was selected from a population of more than 30,000 construction industry establishments registered with Pakistan Engineering Council (PEC 2012). It was fairly a large population and the sample is representative of various construction experts.

## 4. FINDINGS AND DISCUSSION

This research survey was one of the first steps towards assessing the general perception about 2D CAD System and to discuss prospects for BIM in Pakistan construction industry for designing, coordinating, communicating and managing the construction projects.

### 4.1. Respondent's Profile:

The respondents to this survey were Architects / Designers (22.4%), Engineers / MEP Consultants (35.8%), Contractors / Specialty Contractors (18.7%), Academicians (14.9%) and Developers / Facility Owners (8.2%), as reflected in Figure 1, with the varied professional experience from 0-5 years (35.8%), 5-10 years (16.4%), 10-15 years (17.2%), 15-20 years (7.5%) and more than 20 years were 23.1%. They were holding positions in their organizations as Managing Director (14.2%), Project Director / Manager (16.4%), Project Architect / Engineer / Planner (33.6%), Contract Manager (3.7%), Site Manager (6.7%), Site Supervisor (2.2%), Facility Manager (2.2%), Professor / Lecturer in Academia (9.0%) and others (11.9%). The recorded level of knowledge about BIM was 44% for little, 44% for general and 11.2% for working and with no answer was 0.7%. Most of them (64.9%) have no working experience with BIM (because of varied adoption barriers) but quite a number of them (35.1%) were having varied experience with BIM.

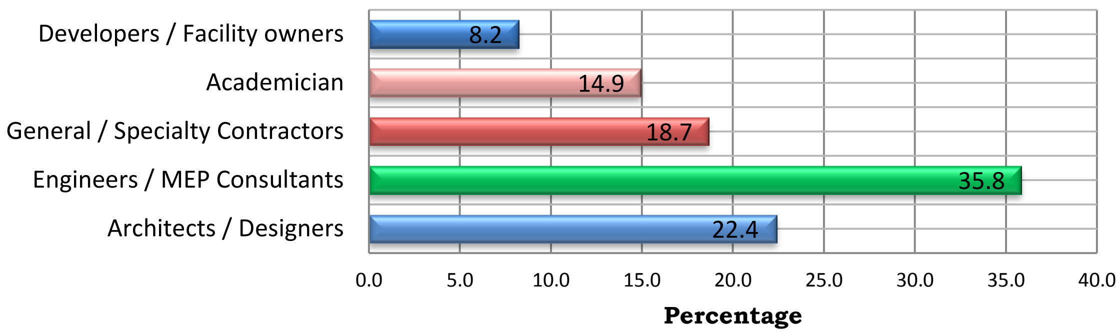


Figure1: Construction Industry Stakeholders

The intention of getting respondents' profile was to establish that the respondents were qualified to respond this survey with varied professional experience in construction industry and having working knowledge or experience with BIM.

## 4.2. Respondent's Organization Profile:

Randomly selected 87 number of organizations participated to this survey across the country in which there were 26 for Architecture / Designers, 26 for Engineers / MEP Consultants, 16 for General / Specialty Contractors, 9 for Academic Institutions and 10 for Developers / Facility Owners. The geographical location of the projects (as indicated in Figure 2) undertaken by the respondent's organization was across the country (31% in Punjab, 15.1% in Khyber Pakhtunkhwa, 17% in Sind, 10.1% in Balochistan, 9.9% in Kashmir, and 8.5% in Gilgit Baltistan, whereas some were also working in abroad and having 8.5%). The average number of employees were from 0-25 (29.9%), 25-50 (14.2%), 50-100 (11.2%), 100-500 (21.6%), and more than 500 was 20.1% with 3.0% for no answer. The financial strength in terms of the projects undertaken was from 0-100 million (20.1%), 100-200 million (11.9%), 200-300million (8.2%), 300-400 million (9.0%), 400-500 million (6.0%) and more than 500 million was 30.6% with not applicable 14.2%. The type of the projects undertaken by these organizations were residential (15.8%), commercial (15.4%), educational (13.2%), healthcare (9.4%), institutional (9.8%), civil and cultural (7.6%), industrial (5.6%), hospitality (4.2%), entertainment and sports (3.0%), transportation (6.2%), religious (5.2%), and others (4.4%).

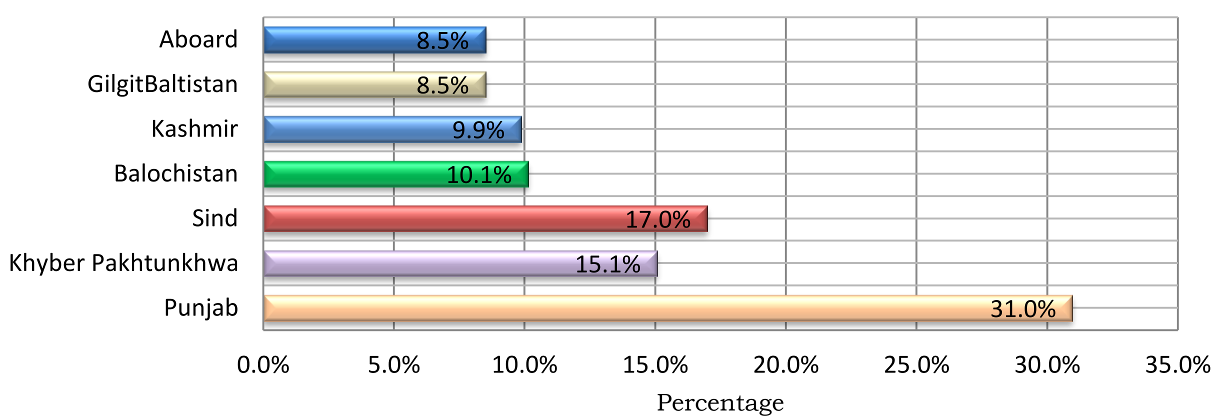


Figure2: **Geographical Location of Projects**

The intent of getting organization profile was to make sure that the respondents were working in well-established organizations working in different parts of the country on different kind of projects.

## 4.3. Nature of the collected data and Statistical Tests

The validity of the collected data was measured and it was found the *p*-values for each research variable was less than 0.05 or 0.01. The correlation coefficient of each research variable was positive and significant at $\alpha = 0.01$ or $\alpha = 0.05$. Cronbach's Coefficient Alpha value was 0.823 and this value reflected a higher degree of internal consistency of the collected data. After conducting the normality test, the significance values were found 0.000 which were less than 0.05 indicating that the collected data was not normally distributed or the data was non-parametric in nature and non-parametric tests were required for further analysis. A Kruskal-Wallis test was conducted to compare the outcome of the research variables and no significant difference ( as $p > 0.05$) was found among the construction industry stakeholders from each other indicating that all the stakeholders have similar perception about 2D CAD System and competitiveness for BIM in Pakistan construction industry.

## 4.4.Frequency Analysis:

Descriptive Statistics were used for frequency analysis of the research variables to draw the results. The findings of the responses to these variables and research questions have been discussed in this section.

The most widely used primary CAD application was Autodesk AutoCAD (77.1%) followed by Autodesk Architectural Desktop (11.5%) and the rest were others as this is reflected in Figure 3.

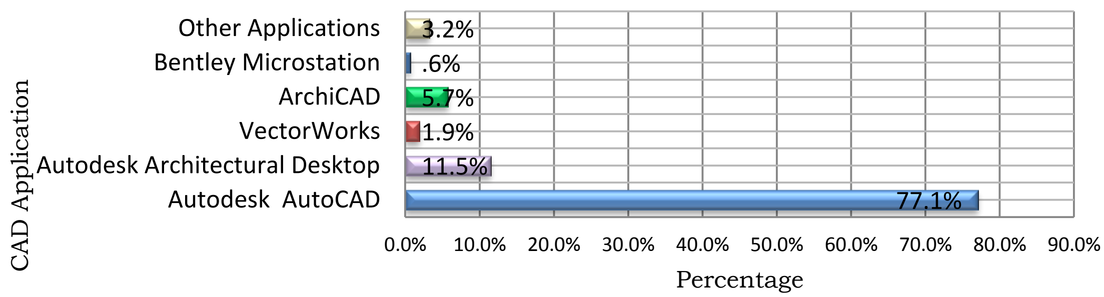


Figure 3: Primary CAD Application used by organizations

Table 1 has shown the Mean Score (MS) values of the research variables about 2D CAD system that the respondents to this survey were agreed that 'Normally CAD is used as an electronic drafting board rather than as a design tool', and '2D CAD system generates independent 2D views and reworking is required for building performance analysis', whereas they were somehow agree to '2D CAD drawings are prone to conflicts and rework is required to fix the conflict issues not identified during design and coordination'. They were not sure about '2D CAD document system is lacking of data linkages, inconsistent, tedious and time consuming process'. This may be due to fact that majority of the respondents were comfortable in working with 2D CAD system as this is reflected from Figure 1 and most of them were having no working knowledge and experience with BIM technology and its processes as discussed above.

Similarly Table 2 indicated the Mean Score (MS) values of the research variables about Competitiveness for BIM that the respondents to the survey were agreed that 'BIM helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP', 'BIM helps in integrating and coordinating requests for information, change orders and punch list information', 'BIM model is accessible anytime anywhere for coordination, fabrication and shop drawings to reduce errors and delays', 'BIM increases productivity with higher quality of work', 'BIM helps to manage the constraints in the project schedule to remove the bottlenecks', 'Safety management can be improved on site with BIM based modeling prior to the execution work starts', 'BIM leads to define and control the scope of the project in an effective way', 'BIM leads to enhance the feedback, quality assurance and quality control', 'BIM based construction management leads to increase the negative risk reduction', and 'BIM leads to help timely procurement', whereas they were somehow agree to 'BIM facilitates mobile computing and to update data in real time', 'BIM increases the profit margin and firm growth', and 'BIM adoption gives strategic competitive advantage in business and reduced litigations/arbitrations'. This may be due to the reason that with all the efficiencies and savings that BIM technology can provide, its use is not without risk (Dean B. Thomson 2006).

Table 1: Perception about 2D CAD System

| Research Variables | MS | 1<br>Strongly Disagree | 2<br>Disagree | 3<br>Not sure | 4<br>Agree | 5<br>Strongly Agree | No. of Respondents |
|---|---|---|---|---|---|---|---|
| Normally CAD is used as an electronic drafting board rather than as a design tool. | 3.66 | 7 | 21 | 12 | 65 | 29 | 134 |
| 2D CAD document system is lacking of data linkages, inconsistent, tedious and time consuming process. | 3.39 | 7 | 19 | 34 | 63 | 11 | 134 |
| 2D CAD drawings are prone to conflicts and rework is required to fix the conflict issues not identified during design and coordination. | 3.56 | 1 | 17 | 38 | 62 | 16 | 134 |
| 2D CAD system generates independent 2D views and reworking is required for building performance analysis. | 3.80 | 3 | 6 | 23 | 85 | 17 | 134 |
| **Mean** | **3.60** | | | | | | |

Table 2: Perception about Competitiveness for BIM

| Research Variables | MS | 1<br>Strongly Disagree | 2<br>Disa gree | 3<br>Not sure | 4<br>Agree | 5<br>Strongly Agree |
|---|---|---|---|---|---|---|
| BIM helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP. | 3.87 | 1 | 3 | 25 | 88 | 17 |
| BIM helps in integrating and coordinating requests for information, change orders and punch list information. | 3.71 | 0 | 3 | 42 | 80 | 9 |
| BIM facilitates mobile computing and to update data in real time. | 3.54 | 2 | 3 | 58 | 62 | 9 |
| BIM model is accessible anytime anywhere for coordination, fabrication and shop drawings to reduce errors and delays. | 3.66 | 3 | 4 | 40 | 75 | 12 |
| BIM increases productivity with higher quality of work. | 3.74 | 1 | 8 | 33 | 75 | 17 |
| BIM improves the budgeting, cost estimating and scheduling capabilities. | 3.91 | 0 | 2 | 24 | 92 | 16 |
| BIM increases the ability to reduce waste and apply the lean construction techniques. | 3.69 | 0 | 5 | 46 | 69 | 14 |
| BIM optimizes human resource at design and execution stage. | 3.76 | 0 | 4 | 34 | 86 | 10 |
| BIM helps to manage the constraints in the project schedule to remove the bottlenecks. | 3.63 | 0 | 6 | 49 | 68 | 11 |
| Safety management can be improved on site with BIM based modeling prior to the execution work starts. | 3.69 | 1 | 3 | 46 | 70 | 14 |
| BIM increases the profit margin and firm growth. | 3.56 | 0 | 7 | 55 | 62 | 10 |
| BIM leads to define and control the scope of the project in an effective way. | 3.78 | 0 | 3 | 35 | 84 | 12 |
| BIM leads to enhance the feedback, quality assurance and quality control. | 3.71 | 1 | 2 | 43 | 77 | 11 |
| BIM based construction management leads to increase the negative risk reduction. | 3.68 | 0 | 7 | 40 | 76 | 11 |
| BIM leads to help timely procurement. | 3.74 | 0 | 6 | 38 | 75 | 15 |
| BIM adoption gives strategic competitive advantage in business and reduced litigations/arbitrations. | 3.57 | 1 | 5 | 51 | 70 | 7 |
| **Mean** | **3.70** | | | | | |

## 4.5. Ranking for 2D CAD System

Table 3 has shown the comparison of the ranks for perception about 2D CAD System. This ranking reflected how 2D CAD System was perceived by different construction industry stakeholders in which General / Specialty Contractors have the perception that CAD is used as an electronic drafting board rather than as a design tool whereas Architects / Designers perceived this system that it is lacking of data linkages, inconsistent, tedious and time consuming process, and prone to conflicts. Academicians were in a view that 2D CAD system generates independent 2D views and reworking would be required for building performance analysis.

Table 3: Comparison of Ranks for 2D CAD System

| Research Variable | Construction Industry Stakeholders | Mean | RII | Rank |
|---|---|---|---|---|
| Normally CAD is used as an electronic drafting board rather than as a design tool. | Architects / Designers | 3.6667 | 0.7333 | 3 |
| | Engineers / MEP Consultants | 3.4792 | 0.6958 | 4 |
| | General / Specialty Contractors | 4.0400 | 0.8080 | 1 |
| | Academician | 3.8500 | 0.7700 | 2 |
| | Developers / Facility owners | 3.1818 | 0.6364 | 5 |
| 2D CAD document system is lacking of data linkages, inconsistent, tedious and time consuming process. | Architects / Designers | 3.4667 | 0.6933 | 1 |
| | Engineers / MEP Consultants | 3.4583 | 0.6917 | 2 |
| | General / Specialty Contractors | 3.3600 | 0.6720 | 3 |
| | Academician | 3.3000 | 0.6600 | 4 |
| | Developers / Facility owners | 3.0909 | 0.6182 | 5 |
| 2D CAD drawings are prone to conflicts and rework is required to fix the conflict issues not identified during design and coordination. | Architects / Designers | 3.7667 | 0.7533 | 1 |
| | Engineers / MEP Consultants | 3.6458 | 0.7292 | 2 |
| | General / Specialty Contractors | 3.2800 | 0.6560 | 4 |
| | Academician | 3.6000 | 0.7200 | 3 |
| | Developers / Facility owners | 3.1818 | 0.6364 | 5 |
| 2D CAD system generates independent 2D views and reworking is required for building performance analysis. | Architects / Designers | 3.7000 | 0.7400 | 3 |
| | Engineers / MEP Consultants | 3.8750 | 0.7750 | 2 |
| | General / Specialty Contractors | 3.6800 | 0.7360 | 4 |
| | Academician | 4.1000 | 0.8200 | 1 |
| | Developers / Facility owners | 3.4545 | 0.6909 | 5 |

In overall ranking as indicated in Figure 3, this reflected that most of the construction industry people have the perception about 2D CAD System that it generates independent 2D views and rework would be required for building performance analysis. They also perceived this system as an electronic drafting board rather than as a design tool.

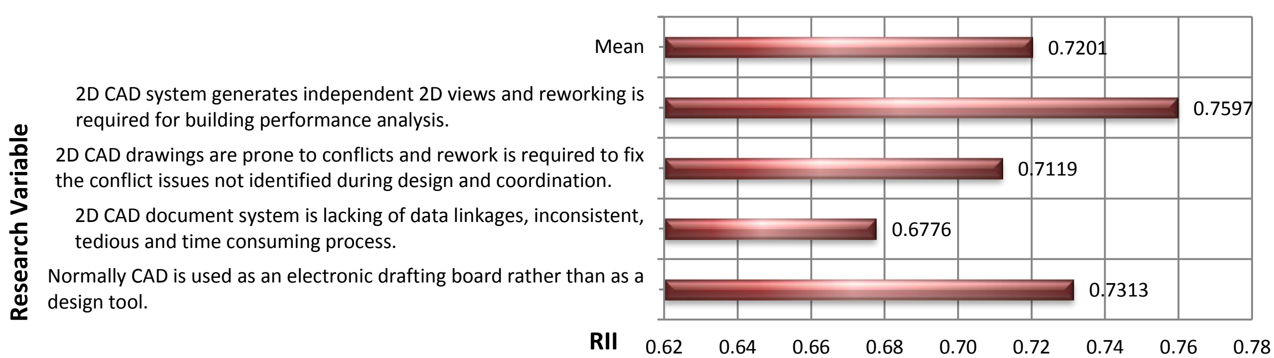


Figure 4: Overall ranking for 2D CAD System

## 4.6.Ranking for Competitiveness for BIM:

The comparison of ranking shown in Table 4 indicated the perception of different construction industry stakeholder about the Competitiveness for BIM. Architects / Designers believe BIM increases productivity with quality of work whereas Engineers / MEP Consultants were in a view that BIM improves the budgeting, cost estimating and scheduling capabilities. General / Specialty Contractors have the perception about BIM model that it is accessible anytime anywhere for coordination, fabrication and shop drawings to reduce errors and delays. Academicians indicated that BIM helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP, reduces waste, and enhances quality control and Safety management. Developers / Facility Owners have thought about BIM that it helps in integrating and coordinating requests for information and change orders, leads to help timely procurement, leads to define and control the scope of the project, and also leads to increase the negative risk reduction. Architects / Designers and General / Specialty Contractors both believed BIM also increases the profit margin and firm growth.

Table 4: Comparison of Ranks for Competitiveness for BIM

| **Research Variable** | **Construction Industry Stakeholders** | **MS** | **RII** | **Overall Rank** |
|---|---|---|---|---|
| BIM helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP. | Architects / Designers | 4.0333 | 0.8067 | 2 |
| | Engineers / MEP Consultants | 3.7708 | 0.7542 | 4 |
| | General / Specialty Contractors | 3.7200 | 0.7440 | 5 |
| | Academician | 4.1000 | 0.8200 | 1 |
| | Developers / Facility owners | 3.8182 | 0.7636 | 3 |
| BIM helps in integrating and coordinating requests for information, change orders and punch list information. | Architects / Designers | 3.5333 | 0.7067 | 4 |
| | Engineers / MEP Consultants | 3.6875 | 0.7375 | 3 |
| | General / Specialty Contractors | 3.8000 | 0.7600 | 2 |
| | Academician | 3.8000 | 0.7600 | 2 |
| | Developers / Facility owners | 3.9091 | 0.7818 | 1 |
| BIM facilitates mobile computing and to update data in real time. | Architects / Designers | 3.6667 | 0.7333 | 2 |
| | Engineers / MEP Consultants | 3.5625 | 0.7125 | 3 |
| | General / Specialty Contractors | 3.4000 | 0.6800 | 4 |
| | Academician | 3.4000 | 0.6800 | 4 |
| | Developers / Facility owners | 3.7273 | 0.7455 | 1 |
| BIM model is accessible anytime anywhere for coordination, fabrication and shop drawings to reduce errors and delays. | Architects / Designers | 3.6667 | 0.7333 | 4 |
| | Engineers / MEP Consultants | 3.5625 | 0.7125 | 5 |
| | General / Specialty Contractors | 3.8000 | 0.7600 | 1 |
| | Academician | 3.7000 | 0.7400 | 3 |
| | Developers / Facility owners | 3.7273 | 0.7455 | 2 |
| BIM increases productivity with higher quality of work. | Architects / Designers | 3.9333 | 0.7867 | 1 |
| | Engineers / MEP Consultants | 3.7500 | 0.7500 | 3 |
| | General / Specialty Contractors | 3.5600 | 0.7120 | 4 |
| | Academician | 3.8000 | 0.7600 | 2 |
| | Developers / Facility owners | 3.4545 | 0.6909 | 5 |
| BIM improves the budgeting, cost estimating and scheduling capabilities. | Architects / Designers | 3.8667 | 0.7733 | 4 |
| | Engineers / MEP Consultants | 4.0208 | 0.8042 | 1 |
| | General / Specialty Contractors | 3.7200 | 0.7440 | 5 |
| | Academician | 3.9500 | 0.7900 | 3 |
| | Developers / Facility owners | 3.9091 | 0.7818 | 2 |
| BIM increases the ability to reduce waste and apply the lean construction techniques. | Architects / Designers | 3.6667 | 0.7333 | 3 |
| | Engineers / MEP Consultants | 3.6458 | 0.7292 | 4 |
| | General / Specialty Contractors | 3.6400 | 0.7280 | 5 |
| | Academician | 3.8500 | 0.7700 | 1 |
| | Developers / Facility owners | 3.7273 | 0.7455 | 2 |
| BIM optimizes human resource at design and execution stage. | Architects / Designers | 3.6333 | 0.7267 | 5 |
| | Engineers / MEP Consultants | 3.6875 | 0.7375 | 4 |
| | General / Specialty Contractors | 3.8800 | 0.7760 | 2 |
| | Academician | 3.9500 | 0.7900 | 1 |
| | Developers / Facility owners | 3.8182 | 0.7636 | 3 |

| | | | | |
|---|---|---|---|---|
| BIM helps to manage the constraints in the project schedule to remove the bottlenecks. | Architects / Designers | 3.4000 | 0.6800 | 5 |
| | Engineers / MEP Consultants | 3.7708 | 0.7542 | 2 |
| | General / Specialty Contractors | 3.6000 | 0.7200 | 3 |
| | Academician | 3.5500 | 0.7100 | 4 |
| | Developers / Facility owners | 3.8182 | 0.7636 | 1 |
| Safety management can be improved on site with BIM based modeling prior to the execution work starts. | Architects / Designers | 3.5000 | 0.7000 | 5 |
| | Engineers / MEP Consultants | 3.6667 | 0.7333 | 4 |
| | General / Specialty Contractors | 3.8400 | 0.7680 | 2 |
| | Academician | 3.8500 | 0.7700 | 1 |
| | Developers / Facility owners | 3.7273 | 0.7455 | 3 |
| BIM increases the profit margin and firm growth. | Architects / Designers | 3.6000 | 0.7200 | 1 |
| | Engineers / MEP Consultants | 3.5625 | 0.7125 | 2 |
| | General / Specialty Contractors | 3.6000 | 0.7200 | 1 |
| | Academician | 3.5000 | 0.7000 | 3 |
| | Developers / Facility owners | 3.4545 | 0.6909 | 4 |
| BIM leads to define and control the scope of the project in an effective way. | Architects / Designers | 3.8333 | 0.7667 | 2 |
| | Engineers / MEP Consultants | 3.7917 | 0.7583 | 3 |
| | General / Specialty Contractors | 3.7200 | 0.7440 | 4 |
| | Academician | 3.7000 | 0.7400 | 5 |
| | Developers / Facility owners | 3.9091 | 0.7818 | 1 |
| BIM leads to enhance the feedback, quality assurance and quality control. | Architects / Designers | 3.7000 | 0.7400 | 4 |
| | Engineers / MEP Consultants | 3.7083 | 0.7417 | 3 |
| | General / Specialty Contractors | 3.6000 | 0.7200 | 5 |
| | Academician | 3.8500 | 0.7700 | 1 |
| | Developers / Facility owners | 3.7273 | 0.7455 | 2 |
| BIM based construction management leads to increase the negative risk reduction. | Architects / Designers | 3.6333 | 0.7267 | 4 |
| | Engineers / MEP Consultants | 3.6458 | 0.7292 | 3 |
| | General / Specialty Contractors | 3.6400 | 0.7280 | 5 |
| | Academician | 3.8000 | 0.7600 | 2 |
| | Developers / Facility owners | 3.8182 | 0.7636 | 1 |
| BIM leads to help timely procurement. | Architects / Designers | 3.6667 | 0.7333 | 5 |
| | Engineers / MEP Consultants | 3.7917 | 0.7583 | 2 |
| | General / Specialty Contractors | 3.6800 | 0.7360 | 4 |
| | Academician | 3.7500 | 0.7500 | 3 |
| | Developers / Facility owners | 3.8182 | 0.7636 | 1 |
| BIM adoption gives strategic competitive advantage in business and reduced litigations/arbitrations. | Architects / Designers | 3.5667 | 0.7133 | 3 |
| | Engineers / MEP Consultants | 3.5833 | 0.7167 | 2 |
| | General / Specialty Contractors | 3.5600 | 0.7120 | 4 |
| | Academician | 3.6000 | 0.7200 | 1 |
| | Developers / Facility owners | 3.5455 | 0.7091 | 5 |

Figure 5 shows that construction industry stakeholders have the perception that BIM improves the budgeting, cost estimating and scheduling capabilities. It also helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP. They have least perception that BIM facilitates in mobile computing and to update data in real time. This perception may be improved as industry people would be having more working experience and knowledge of practicing BIM processes on different projects also by increased used of internet technologies and mobile devices like laptop and tablet etc.

Architecture, engineering, and construction industry is an interdisciplinary working environment which creates challenges for successful project execution and implementation. Timely transfer of information among owners, architect, engineers, consultants, project managers, general contractors is the bases for project success. This task is made difficult by the lack of standard systems of data interchange among project participants (Rojas and Songer 1999). Computer aided design (CAD) in many ways failed in its role of aiding design (Coates, Arayici et al. 2010). Initially it was based on two dimensional drawings and lately on 3D views. However, these drawings lacked the interactivity and the change in one view was not automatically updated in other views (Wong, Wong et al. 2011). 2D CAD system is error-prone and labor-intensive during design and coordination. (Eastman, Teicholz et al. 2011). It is used as a digital drafting board rather than as a design tool and the CAD data remains in the form of 2D geometry (Tse, Wong et al. 2005). Abstract objects, like a space, could be defined by the relationships between physical building components, identified (e.g. room number, room name, etc.), described (e.g. area, volume, use, occupancy, etc.), and referenced (e.g. listed in a room schedule, counted to calculate total floor area, etc.). Capturing these relationships and the richness of the intelligence are just not possible in 2D CAD systems (Howell and Batcheler 2005). BIM addresses these problems in that it allows for the virtual construction of building components and coordination among all building systems prior to the execution process (Eastman, Teicholz et al. 2011). BIM also allows a 3D simulation of the building and its components. This simulation goes beyond demonstrating how different building assemblies could be combined in a project. It can predict collisions, environmental variables on different building designs, and calculate material and time quantities etc. (Krygiel and Nies 2008).

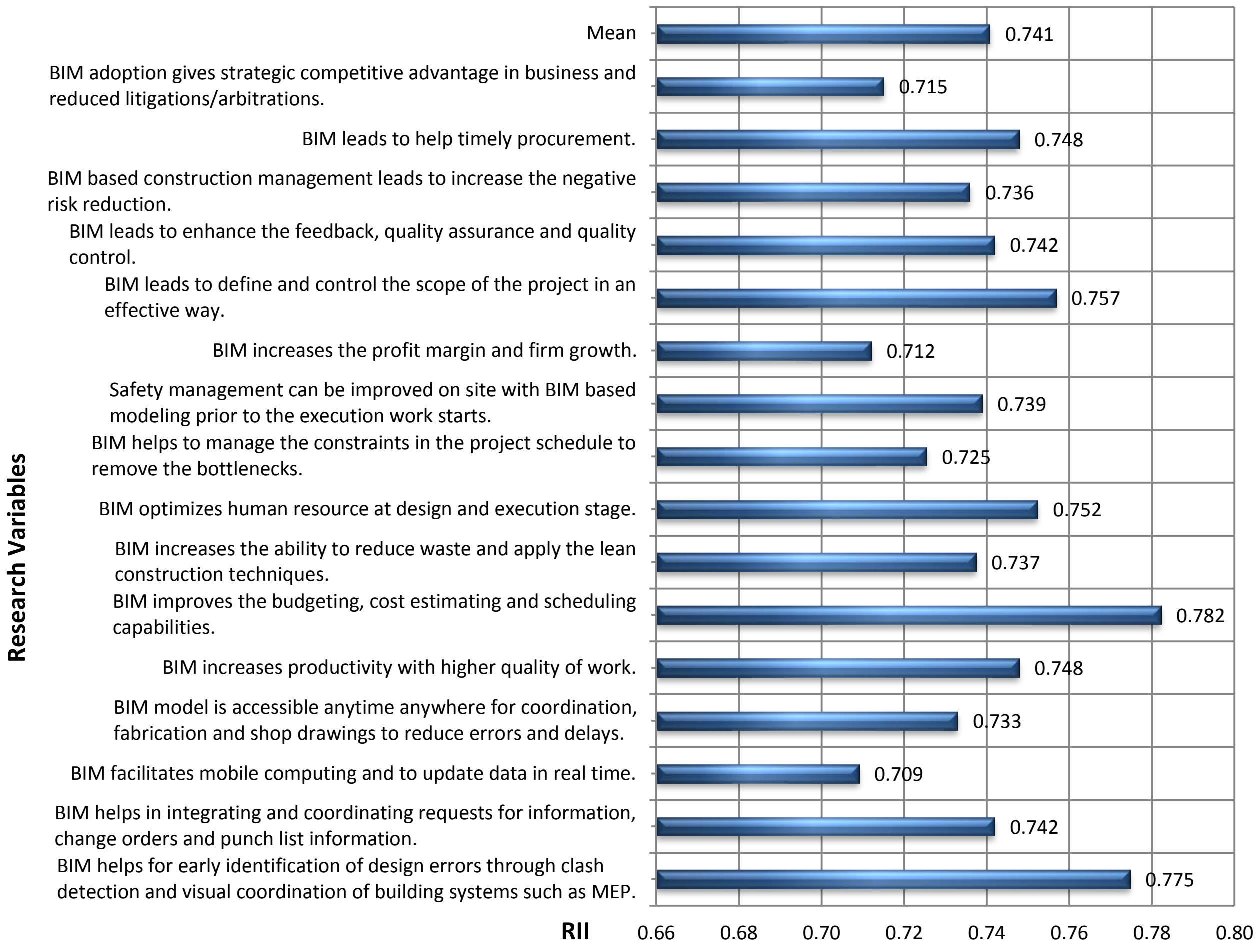


Figure 5: Overall Ranking for BIM in Construction Management

The entire building process from preliminary design, through construction documentation, in execution process, and even in facility management has been transformed through BIM (Krygiel and Nies 2008). Architects could have the benefits which may include better design by rigorously analyzing digital models and visual simulations, and receiving more valuable input from project owners and consultants and contractors, early incorporation of sustainability features in building design to predicts its environmental performance, and better code compliance via visual and analytical checks (Azhar, Khalfan et al. 2012). Owners can use a building information model to increase building performance, reduce the financial risk, shorten project schedule, obtain reliable and accurate cost estimates, assure program compliance, optimize facility management and maintenance. Consultants and engineers could have direct benefits which include easy methods guaranteeing consistency across all drawings and reports, automating spatial interference checking, providing a strong base for interfacing analysis/simulation/cost applications and enhancing visualization/communication at all scales and phases of the project life (Eastman, Teicholz et al. 2011).

Contractors can use the model to review construction process, prepare cost data, coordinate drawings, accurate clash detection, constructability analysis, site safety planning and prepare shop and fabrication drawings (Hardin 2009).

## 5. CONCLUSIONS

This survey based research work has tried to find out general perception about 2D CAD system and to explore the potential and prospects for BIM in local context. General / Specialty Contractors were in the view that CAD is used as an electronic drafting board rather than as a design tool whereas Architects / Designers believed that system is lacking of data linkages, inconsistent, tedious and time consuming process, and prone to conflicts. Academicians indicated that 2D CAD system generates independent 2D views and reworking would be required for building performance analysis. Whereas Architects / Designers thought about BIM that it increases productivity with quality of work and Engineers / MEP Consultants were in a view that BIM improves the budgeting, cost estimating and scheduling capabilities. General / Specialty Contractors have the perception about BIM model that it is accessible anytime anywhere for coordination, fabrication and shop drawings to reduce errors and delays. Academicians believed that BIM helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP, reduces waste, and enhances quality control and safety management. Developers / Facility Owners have thought about BIM that it helps in integrating and coordinating requests for information and change orders, leads to help timely procurement, leads to define and control the scope of the project, and also leads to increase the negative risk reduction.

In overall perception 2D CAD System was believed that it generates independent 2D views and this system was as an electronic drafting board rather than as a design tool whereas BIM is perceived as it improves the budgeting, cost estimating and scheduling capabilities and it also helps for early identification of design errors through clash detection and visual coordination of building systems such as MEP.

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