Adaptability of BIM in India's Aviation sector Projects

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Abstract

Always India has entrusted its priority towards infrastructure development, and government has taken immense interest in developing many sectors to build strong Infrastructure facilities for the future. But many of the construction projects in this country are hit by substantial time delays, finally resulting in cost and time overruns. There are many reasons for such delays - starting from clearances and finance till commissioning. This study focuses on some construction aspects of a recently completed Airport project in India in conjunction with some selected international airports. From this study the various advantages of adapting "Building Information modeling" in Aviation sector projects is detailed with.

Key words: Building Information Modelling, Infrastructure, Aviation projects, Delays.

Introduction

India is one of the fast developing countries in the world. The overall infrastructure development happening in the country gives much credit to this growth. However the development achieved in the aviation sector so far is comparatively less with respect to the other infrastructure sectors, and also with the aviation sector of other countries. India is having only less than 500 number of Airports which is only one percentage of world's total number of airports. Even out of these 500 airports, only less than 100 airports are in a stage of operating one flight per day. Among these 100 airports itself, the number of world class airports are only a few. [12]. As India being a large country geographically, it is imperative that the infrastructure facilities pertaining to the aviation sector needs a major planned improvement. Many new Greenfield projects are announced already by the government, and the major challenge will be to complete the projects without time and cost overruns. This research thrives to propose that the major part of the issues associated with construction delays can be reduced by mitigating the controllable and avoidable issues, during planning and implementation phase itself using "Building Information Modelling" -hereinafter referred as BIM.

Building information modeling

BIM is an actual visual representation of the assembly pattern of the design incorporating time also, and not the traditional two dimensional representations. In current Industry practise, 2D representation occupies major volume and this scenario is slowly been replaced by practice of BIM, in other developed countries. But Indian Industry's growth towards the practice of BIM is still underlying, and has not attracted the players in the Industry. BIM has its own ability to collaborate various disciplines involved in the planning and design co-ordination phase of construction projects. This is the most admirable advantage of BIM and as we all know that construction Industry in India is not purely process oriented as many players are involved in single project. Hence the collaboration level is not optimum because of which there exist issues that are avoidable.

BIM is highly useful in case of building involving critical design in shape and structural aspects. The high preference user advantage in BIM is that the designs are defined parametrically.ie. The objects are defined parametrically where a change in particular design of the object changes the design of the other dependant objects automatically. So there is no need of repetition of further changes to the dependant objects respectively. Each model has its own attributes and hence can be easily selected and ordered with their cost estimates, specification and quantities. It gives a clear understanding to the companies designing and implementing the projects. And also the quality of the building will also be high as there happens a clear understanding of the requirements without any ambiguity. As it is multi-functional, there is a great reduction/ saving in time and cost. BIM extends its use throughout the project life cycle, (1) Design and co-ordination,(2)Planning,(3)Implementation,(4)Construct ion-management,(5)project-management and(6) facility management. This wide application makes BIM more efficient tool for construction projects.

In India, projects are coming up with complex design and requirements. In case of airport terminal projects, many parties are involved and the effective

co-ordination between them is very important in achieving the project success.

Interface information is related to people, event, time and description of project interface during construction process. Traditional approach of tracking and managing interface was through face to face meeting and telephonic discussion which consumes time, and visualizing the real scenario is difficult in this case. BIM can be effectively used as a channel where issues can be addressed with high clarity to all the parties associated. The main advantage of the BIM is that interface information can be accessed easily and also after construction, these information can be made available for the operation team who take over the project after implementation and operate.

The efficiency difference between normal CAD and BIM applications for a particular project in different phases is shown in the table.

TASK	CAD(Hours)	BIM(Hours)	Hour saving	Time saving
Schematic	190	90	100	53%
Design development	436	220	216	50%
Construction Documents	1023	815	208	20%
Checking and Co-ordination	175	16	159	91%
Total	1824	1141	683	

Source: (Rick Rundel (7), 2007)

Project formwork of Airport terminal project in India

Airport projects are given high importance in recent years based on infrastructure development plans in India. Many stakeholders are coming forward to invest into Airport terminal projects. The main constraint in this sector is related to having a proper interface and communication between these stakeholders. As a result of which, the interest, influence of various stakeholders are not properly managed and there is a communication gap in delivering the requirements of these stakeholders at right time.

The main objective of a project is to fulfil the need and requirements of various stakeholders involved in development of projects. And to be more specific, high priority objective of any project is

1. Understanding of scope and requirements of project.
2. Effective and efficient planning
3. Completion of project within schedule and cost
4. Fulfilling the requirements of various stakeholders involved in a project.

The study is basically on adaptability of BIM for Airport Projects, we will consider various stakeholders involved in planning and execution phase and their requirements.

Various stakeholders involved in airport terminal construction but are not limited to ; client, Developer, Design consultant, MEP consultant, Landscape consultant, HVAC consultant, Interior developers, Main contractor and various sub-contractors. Most of the projects are fast tracked where planning and design stage occurs parallel with execution or construction stage. The level of clarity in design, resource requirements, developing schedule and execution of project required is high. BIM is one such technology where the interactions are handled in an integrated way and also clarity on design, resource requirements and schedule is high respectively.

In Design phase, the consultants develops a design based on requirements from project sponsor and will be followed by various revisions. Then once the design is accepted, it is fed into 3D software and the design is converted into 3D which is then collaborated with the schedule in BIM 4D. This process makes the consultant to understand the requirements very well and also makes them to eliminate the errors well in advance through clear visualization of design developed for the project. The effectiveness of BIM creates a better interface between client and the consultant during design phase.

Then the approved design is given to the main contractor for execution and this 4D model makes contractor more familiar about project requirements and the deadlines in a realistic way. Any potential constraints left out can be raised to design consultant which integrates the execution team with design team in an effective way. Through this 4D model, contractor understands the requirement and flow of work in an effective and efficient way. Based on the work flow, contractor can make more accurate resource requirements to meet the schedule. One of the major constraints in this process is that many contractors in India don't have necessary technical expertise to work on BIM. Because of this, BIM is utilized only by consultant for design and co-ordination and not effectively used during execution by contractors. This makes project team to eliminate errors, check validity of assumptions and constraints well before the execution of work. The early diagnosis of constraints helps the project team to plan in advance for the potential impact which may occur during later stages of execution.

An Airport includes numerous facility elements which have to be constructed. Hence the interaction is complex in nature and integrated model of BIM makes it possible, effectively and efficiently. The work includes; civil works, MEP works, Landscape works,

Airport runway works, Air control tower works, other infrastructure facilities, modernised facilities, Interior works. As Airport terminal projects has complex works to be planned and executed(constructed), integrated approach of BIM -4D will facilitate better understanding of workflow, and for determining realistic timeline with negligible errors. The workflow co-ordination cycle makes it more efficient and effective which has been illustrated in Meynard International Airport project in subsequent part of this research.

And many Airport projects in India is executed in Build and operate type of contract-hence the developer or contractor takes responsibility of operation also. The main advantage of the BIM is that interface information can be accessed easily, and also after construction these information can be made available for the operation team who take over the project after implementation and operate. So, continuous flow of information in an effective manner is possible with BIM even in later stages of the project (during operation). This facilitates right approach during operation and maintenance.

Airport Terminal projects in India

There are no direct research works so far in finding out the construction problems of Aviation sector projects. However In any infrastructure project the major constraints will be the interface between the design and the construction team. In aviation sector also the following avoidable and controllable issues exists.

1. Design clarity during implementation
2. Lack of collaboration and Co-ordination between the design consultant and the contractors
3. Changes in design which involved additional time and cost
4. Lack of understanding the requirement as the design was critical and special in its own.
5. Lack of required Quality
6. Lack of clarity in assessing the resource requirement
7. Cost and Time overruns.
8. Interface Management

To understand the major construction difficulties, a recently completed airport expansion project at Chennai, India was analysed and the findings are incorporated in this work, in the coming pages. Also some of the major international airports which used BIM for construction are also studied and the details are being given below.

Challenges faced in construction-Chennai Airport Terminal

Area: 1, 33,462Sqm
Client: Airport Authority of India
Contractor: CCCL

The Chennai International Project has faced many challenges during execution stage due to unforeseen factors that caused hindrances during execution. Some of them are stated below and how BIM was an effective tool during execution or construction of airport terminal.

First, the Soil investigation was not proper and during execution they had to go with breaking hard rock stratum. Then, trusses designed for the project were very heavy. And as the intensity of erection work was not understood well, because of which there was an unsafe working condition (the crane which was there in the erection got collapsed). Here BIM plays a vital role, with which a proper layout plan for erection scheme can be laid and worked out with safety at its best.

Other notable point was there was limited working space which was not realised during planning stage- but later realised during execution stage. But with BIM it was possible to understand the working space requirements very well before execution begins. The most important challenge faced was reinforcement in case of columns/ piers. The reinforcement detailing given was very congested, and it was not practically possible to pour concrete as a result of which the reinforcement detailing of columns/piers were changed during execution-which caused a delay. But, BIM would have given a clear picture regarding the reinforcement detailing and would have avoided this delay in change of designs for practicality.

The other major problem faced was the underground cable and utility lines. Hence, excavation work was disturbed and caused delay. Same situation has been mitigated using BIM in other airport projects, and hence the delay would have been eliminated with use of underground utilities drawing in BIM. This will help in understanding the obstruction in planning stage and with no delay during execution stage. There was communication gap between client and the contractors. There was frequent change in requirements from clients as a result of which the design has to be modified which caused significant delay in execution of work. Using BIM, it is possible to control the later stage modification of designs as it gives a high level of clarity in terms of layout and design.

TEKLA Software was used for Chennai Airport terminal project which is BIM software. Eventhough

BIM was utilized for this airport terminal project; effectiveness was not as much when compared to projects executed in other developed countries. The reason is that BIM is not widely used in India for execution of Airport projects with complex design and workflow. The main aim of this paper is to stress on wide application of BIM in Airport projects with complex design and workflow in future. The effectiveness of BIM in various airport projects in other parts of the world is referred below in this paper.

The airports referred and studied were

1. San Diego International Airport's Terminal , United States
2. Maynard Holbrook Jackson Jr. International Terminal, United States
3. John Wayne Airport, United States.

SAN DIEGO International Airport's Terminal 2

Name of the Terminal - San Diego International Airport's Terminal 2
Capacity – 445,000 Sqft Expansion Areas
Other Features – 10 new jet gates, baggage system, ticketing system and shopping areas expanded.
And 1.5 million Sqft for parking and Aircraft apron respectively.
The project is stratified as "Air side" and "Land side" and different companies are involved in each part.
Air side – Joint venture among PCL, Turner and Flatiron construction companies with HNTB.
Land side – Joint venture between Sundt and Klewit.

The project is implemented through Fast track construction system where construction of one part take off while the other is in design phase. As mentioned above there are variety of parties involved in the project and hence BIM was used to have better interface between the different companies and complete the project as per the requirement.

The PCL Company in charge has given the advantages of using BIM in this project in an article which will be highlighted below.

1. BIM makes paper less work flow. All the engineers were given tablets for the easy access of the design and drawings. Generally the cost of printouts and courier comes around six digits which can be saved using BIM.

2. BIM maximized the Quality of construction and also the rate of constructability feedback between the construction team and the design team. For instance the foundation of the underground baggage handling system was designed to have two levels of grade beam, one at top and other at bottom for the tunnel. The initial scheme had cost and schedule significance but the disadvantages reported for the scheme was extra excavation and also greater exposure to ground water infiltration. As a result of constructability feedback, the design team was able to change the initial design by eliminating at bottom level raising foundation on the existing grade on site. As a result of BIM processes, they are able have a positive impact on project, optimizing both the end product and the engineer's design and detailing time.

3. By modelling the area using BIM, floor to floor height was achieved lower than usual 14'6" compared to traditional 20' height respectively. Ducts, piping were located and modelled using x,y,z points instead of tape measure and drawings.

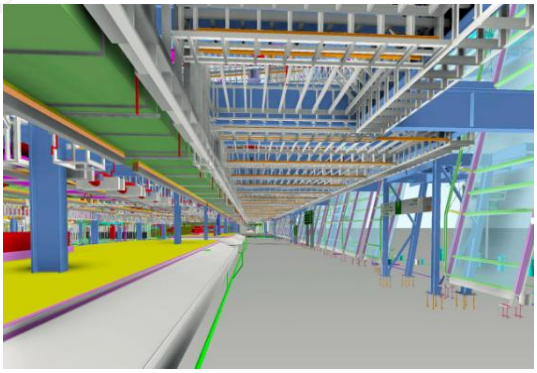

Fig: 1 3D View part of Terminal designed by HNTB Architectures
Source:
[11] San Diego Terminal development project - terminal 2 and airside expansion, <http://www.turnerconstruction.com/experience/project/22BB/san-diego-terminal-development-project-terminal-2-and-airside-expansion>,2012

Maynard Holbrook Jackson Jr. International terminal

Name of the Terminal - Maynard Holbrook Jackson Jr. International Terminal
Capacity –1.2 million Sqft areas

Other Features –Automated People Mover Connector from the existing Concourse E, a concrete Concourse Apron, a new Maynard H. Jackson Jr. Boulevard, elevated terminal roadways, an 1,100 space parking deck, and Long Term parking lots.

This Project also had joint venture between contracting firms and also variety of specialized design firms were involved for structural, mechanical, HVAC, Baggage system etc.

Contactor – Joint venture between Holder Construction Group LLC, Manhattan Construction Co., C. D. Moody Construction Co., and Hunt Construction Group Inc.
Architect - Atlanta Gateway Designers (AGD): JV between Gresham, Smith, & Partners and Duckett Design.

First the Architects and the design consultants are required to give only 2D drawings as per the contract but Holder constructions made it clear that 3D drawings are required, and the sub-contractors are also given with 3D modelling to understand the work better to achieve work at higher and best quality.

First work done was arriving at the milestones to be completed using BIM softwares and this milestone were given to all the companies involved in the project to create a good co-ordination between them. And the respective company should take care of completing their work according to milestone dates. This facilitated and made project to kick off on time. It is been reported that because of using BIM, in early stages of design and co-ordination, there was a huge saving in time and cost. More than that all the companies involved in the project understood their part clearly and also were working on to achieve their milestone.
The JV named HMMH utilized BIM for this project to achieve greater level of co-ordination between the companies of different work categories. And this co-ordination was at high level not only because of advanced technology BIM but also through weekly meeting where all the companies involved in the project come together and work on the cause and effects.
The work flow cycle is shown below.

Fig 3: Typical BIM coordination cycle

BIM makes paper less work flow. All the engineers were given tablets for the easy access of the design and drawings. And hence the extra cost involved in taking printouts was reduced to a greater extent. Coordination got improved as a result of using BIM for the project and also enabled the designers to visualize deviation and defects easily and also made the time for re-design faster.
Benefits observed such as the use of advanced technology (laser scanning), more sophisticated phasing and sequencing techniques, and most importantly the increase in visualization and coordination are highly notable and makes BIM an effective and efficient solution for construction projects having criticality.

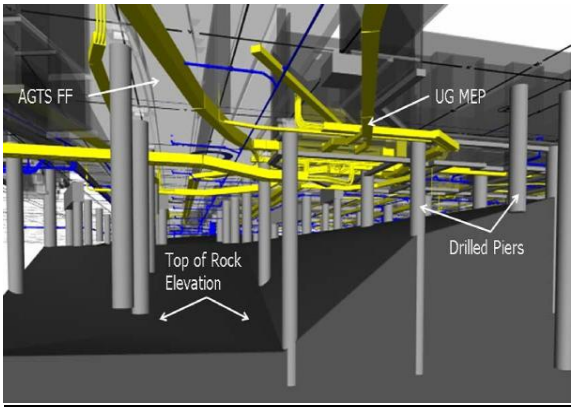

Fig 4 BIM Model showing foundation and pile location
Source:
[10] Maynard Holbrook Jackson Jr. International Terminal, <http://bim.arch.gatech.edu/data/reference/KFordAtlantaairportCaseStudy.pdf>, 2009.

John Wayne Airport

Name of the Terminal – John Wayne Airport Terminal
Capacity – 282,000 Sqft Expansions

Other Features –are expansion to an operating Airport terminal, long spanning metal roof, etc.

This project had a complex feature and challenging task of installing barrel vaulted roof on terminal c concourse. In order to reduce deviation and defects in field, BIM was used for this project. This virtual model helped in identifying any clash or overlap prior to implementation of the structures. As this overlap may cause issues in advancement of construction which was avoided using BIM effectively. This improved the co-ordination and also made construction rate faster without any delay as the potential delays are analysed well ahead using the virtual model of the structures.
There are many numbers of projects that use BIM effectively not only in Airport projects but wide variety of infrastructure projects.

Potential growth in utilization of BIM in construction airport terminal projects in India

A Technology Rating Index (TRI) is developed to analyse the potential growth in utilization of BIM technology in Indian construction industry very specific to Airport terminal projects. This rating was developed to indicate the level of importance in industry that BIM can be effectively used for fore coming airport terminal projects which beneficial throughout the life cycle of a project.
The factors that make utilization of BIM effective and efficient are listed and are rated on scale of 1 to 5 and then multiplied with factor weight-age. The score were listed and the summation of scores of all factors is the index of BIM.
The weightage given to the factors are on the basis of general factors and its contribution in an airport project, the rating is based on the inference from study of various airport projects which utilized BIM and its effectiveness respectively. For e.g.: If you consider factor- level of visualization (4), rating of 4 out of 5 is given based on the study of various airport project where it is mentioned by the project team that they were able to co-ordinate and identify potential constraints earlier during planning and designing, clarity on designs, clarity on workflow. Likewise, all the factors mentioned below are rated on basis of study of various airport projects and benefits which were addressed by the project team as a result of utilizing BIM in the projects.

Factors	Weightage	Rating					Factor Score
		1	2	3	4	5	
Fast track construction method	0.15				4		0.6
Interface management	0.15					5	0.75
Ripple effect	0.05			3			0.15
Level of visualisation	0.1				4		0.4
Forecast of resource requirements	0.1			3			0.3
Re design process	0.05			3			0.15
Clarity during implementation	0.05				4		0.2
Design error and changes	0.05			3			0.15
Data base management	0.05			3			0.15
Complex structure and design	0.1			3			0.3
Level of Quality during implementation	0.15				4		0.6
	1						**3.75**

The rating index for utilizing BIM in Indian construction industry considering the major factors is 3.75 out of 5 which is showing a positive rating. This score as of now indicates a positive sign but when BIM is effectively utilized for airport projects with proper customization as per Indian conditions of work flow, the rating can increase and can also become an effective tool for efficient and effective project management. More customization can be made possible only when BIM is used extensively in Airport projects which will result in continuous improvement of technology itself and lead to better performance.

Conclusion and future works

This study mainly focused on some construction aspects of Aviation projects and described the importance of using Building Information Modelling by taking example of some Airport projects completed in United States. Even though BIM is sparingly used in infrastructure sector, as airport terminals can be more or less categorised into building sector, the usability of BIM in airport sector can address many of the prevailing construction issues in this sector. Even though the construction industry is aware of BIM technology, it is still in the Research and engineering stage. Future studies in this area can include adopting of BIM for a new Greenfield Airport terminal throughout its life cycle and analysing the project performance and widely starting to use this in the forthcoming airports.

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