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Review on detailed analysis of building information modelling process (BIM) and implementation based on a case study

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Abstract
The study includes a review on the building information modelling process in terms of its necessity, application, structure and future scope. BIM with its integrated drawings make the complex projects easy to interpret in terms of various complex layouts incorporated together. The study shows major advantage of using BIM in terms of design customization and possibility of change at any stage of project. Changes made in the BIM drawings automatically reflected in the whole project. Building Information Modelling (BIM) has been an important topic of discussion for a long time, but as compared to its starting rise with the initial time frame, its growth have shown a decline. Now a days BIM has been used by mostly Architects and only a handful approximately 10% engineers use it. The reason for wide adaptation is the clarity of terms and flexibility of use. Apart from that there are some fields in which very less work has been done like cost estimates, quantities can be automatically calculated but integration of these with cost is a major objective for developers to achieve. Not much clarity regarding the use of BIM in pre-existing buildings is present. In this research, an attempt has been made to make the term clear firstly difference from CAD, the basic structure is clearly explained and some less explored fields are discussed. Among these fields are cost estimation from quantities and use of BIM for pre-existing building. In ending a small survey results have been represented to show the adaptation status of BIM in Facility Management.

Keywords: Building information modelling (BIM), infrastructure projects, cost estimation, facility management

1. Introduction
A set of some policies, techniques and technology interacts to generate a methodology to manage all the essential designs, drawings and data of a project in the digital form up to the project completion or throughout the life cycle of that project and this set is termed as Building Information Modelling (BIM) (H. Penttila 2006). BIM is generally misunderstood as an Architect's tool for building design but in reality, BIM is an integration of data obtained from various fields like electrical, plumbing, materials and all others which collaborate to form a complete project that may be for a building, a road or any other construction. The concept of BIM is not new as it was first introduced in mid 1980s under a term 'building model' by Simon Ruffle (1985), Robert Aish (1986) and later RUCAPS software developer's GMW Computers Limited referred it to be used at London's Heathrow Airport. However, the actual term comes into picture in 1992 as during the modelling of building information, it will be useful if the structure of a building model is based on the views of each and every individual participating in that building construction project as each person plays a different role in a project (e.g. plumber, electrician etc.) and always have different views on the project data as per their specific field (G.A. van Nederveen and F. P. Tolman 1992). However even after that it took 10 years to evolve the term clearly that too when Autodesk released a white paper titled "Building Information Modelling".
Those were the days when all the 3 major principle actors in the construction industry namely Architects, Engineers and Contractors used to work differently and independently. Those days are now passed because now for over almost 15 years there exists virtual information models like BIM that can collaborate these 3 principle actors to work in co-ordination with each other and achieve cost savings, time savings along with effective

management of all the construction system with minimum risks. The introduction of BIM to the Architect, Engineer and Construction (AEC) industry has produced drastic changes in the construction industry as BIM allows to build a digital model from the virtual models which can be analysed in 3D by the stakeholders. This 3D model can be prepared by the team members differently as per their field and all the information can be shared with each other in a common database. BIM solutions with the help of reserving and handling this information regarding the building as databases can seize, administer and present the data in user friendly way so that it can be mere for the building team members to analyse and use that data. As when the information is store as a database, it is easy to introduce any change in data and it can be automatically interpreted and used by the software throughout the life cycle of the project.

In this project, some field which does not get enough lime light like Cost Estimation, how to use BIM for existing buildings are explored and practical implementation of that is discussed. BIM has been a topic of discussion since its discovery but there are some components which BIM still have to explore and have to achieve perfection in already released fields. The main challenge of the BIM industry is to clearly explain what BIM is and what it can do as not much of the implementation of this is done which is also discussed that how much are using BIM and to what extent.

2. Building information model attributes - CAD v/s BIM:

The ambiguity over the difference in CAD and BIM should be made clear as this is one of the main reasons that BIM is not much popular in certain countries as contracts, architects are unable to predict the clear etymology of BIM. First of all, very basic thing is BIM is not CAD as CAD we can define as the replacement of our ancient pen and paper drawings, CAD shows the graphical representation of various building elements with the help of geometric elements like line, circle, arcs, shapes. CAD was good until we just have to show the basic drawings of simple buildings but when it comes to the relationship between various elements of some large building CAD fails to generate complex information regarding it.

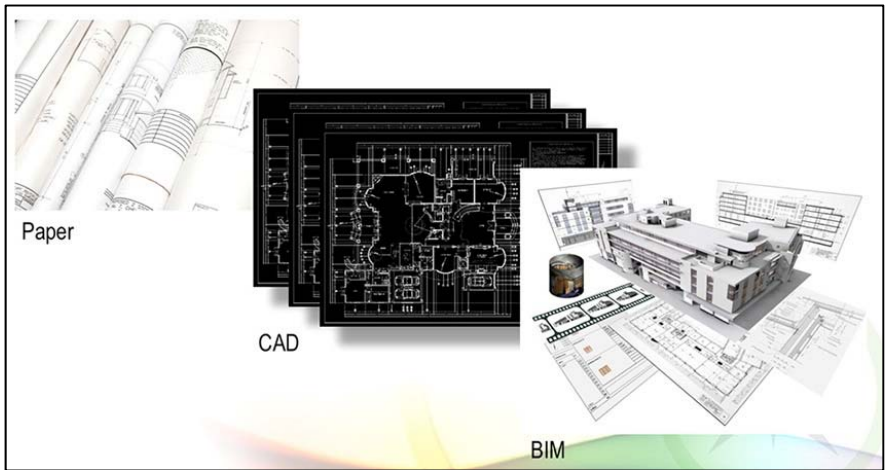

Fig 1: Evolution through ages

In CAD, all the views of the building (plans, sections & elevations) are to be drawn separately without any relationship whereas in BIM, a 3D parametric model is created from which we can generate all the important drawings for documentation like plans, sections and elevations. BIM can also be seen as an improvement over Object Oriented Computer Aided Drawing (OOCAD) as it is efficient enough to represent all the relationships between different elements of a project and all the complexities related to it. More over all the work done in BIM is in multi-dimension through which project can be better interpreted and explained to the owner in a better way who is neither Civil Engineer nor Architect and unable to actualize the project from drawings only.

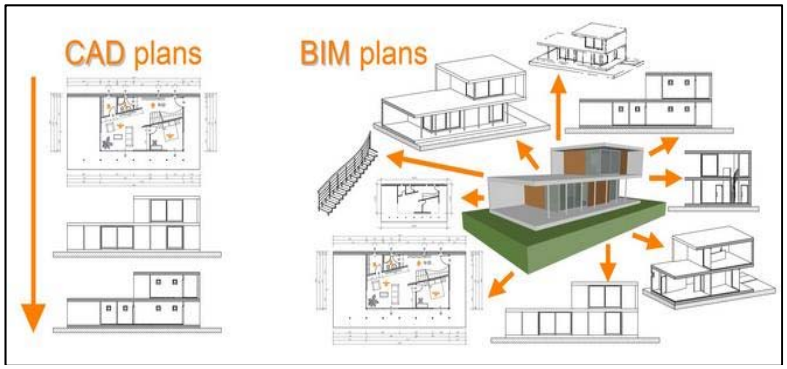

Fig 2: A plan in CAD and BIM

An analysis of the working hours in CAD and BIM has been done and results are published:

Table 1: Difference between efficiency of CAD and BIM

Task	CAD (hours)	BIM (hours)	Hours saved	Time savings
Schematic	190	90	100	53%
Design development	436	220	216	50%
Construction documents	1,023	815	208	20%
Checking and coordination	175	16	159	91%
Totals:	1,824	1,141	683	

2.1 Basic Structure: The basic structure of the BIM is just the collaboration of the design details of all the actors participating in the building construction. In this structure, input from every participant is taken and automatically recorded in the software for later use and the biggest benefit is that the change made in one drawing will reflect that change in all the design. It automatically upgrades the project and keeps the completed part also stored so that it can be put to later use.

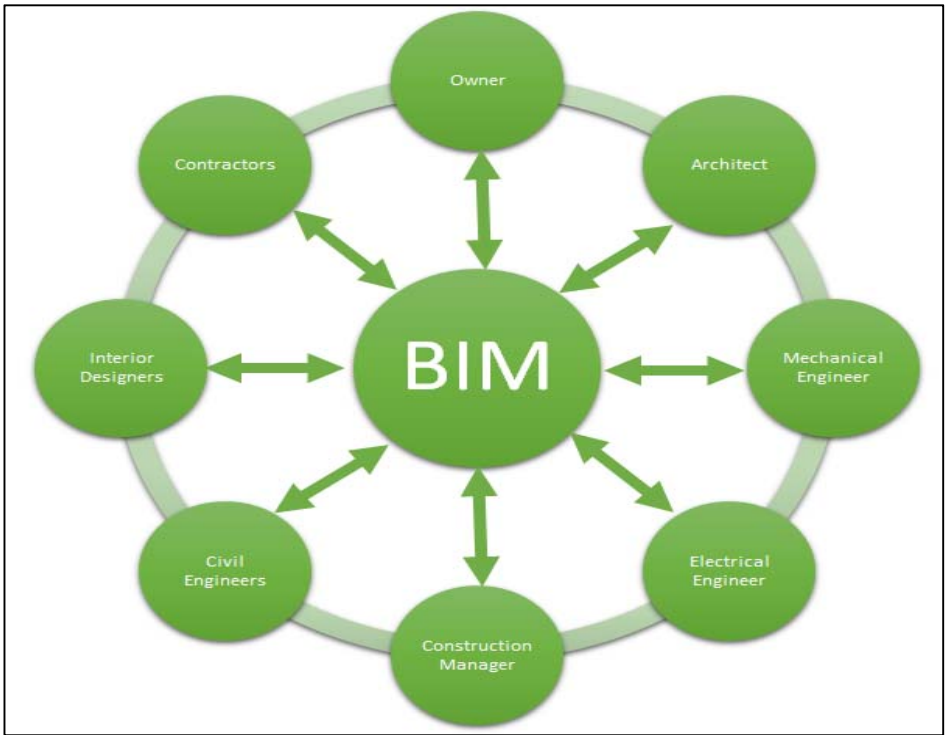

Fig 3: Basic Structure showing all BIM partners

2.2 Role of BIM Manager: As the demand of BIM is increasing day by day, the role of BIM managers is becoming crucial. They face many problems as they have to pitch the idea to the organizations and to bring all the stakeholders at the board in using BIM as key purpose of the construction manager is to save time, money and minimize risks which can be done with the help of BIM only so they have to take them on board first. BIM managers are always caught in the conflict to explain the long-term benefits of the software whereas some organizations which are only seeing short term benefits are not ready to spent as they want direct returns from their investment and it is genuine also if a businessman has to invest he will see only the investment returns and those returns in long terms benefits are to be explained by BIM managers clearly by describing long-term benefits of BIM and bringing all the stakeholders to the board.

2.3 Quantity Surveying in BIM: Quantity Surveying has been an integral part of construction industry since the days it has started but it has never come to mainstream. In earlier days, major work regarding project documentation, estimation, measurement, costing, drafting, bill of quantity(BOQ), tender preparation has been done by the Quantity Surveyors (QS) but they never come to limelight but later they realised that they have to enhance their role as more productive and efficient in measurement and management services and they adopted various software and techniques which proved very useful but with the changing

time they also have to change and be more persistent that can happen through BIM.

Already in United Kingdom, BIM is coming to limelight and clients expect their consulting QS to use BIM for cost effective and time efficient construction. This makes necessary for QS to understand and learn the potential of BIM and integrate BIM to their work. Several studies prove that architects are gaining much popularity over engineers and contracts in terms of BIM usage. All the direct costs like man, material, machinery and indirect costs are calculated by QS only and this estimate of cost is much needed for to find the budget and prepare the tender of any construction project. But the BIM has changed everything the way of design, documentation, analysis, construction, management of the construction industry as it unleashes dynamic ways of working and also it changes the way of production of cost estimates and plans as well. A very basic process how the estimation work is shown with the help of diagram as:

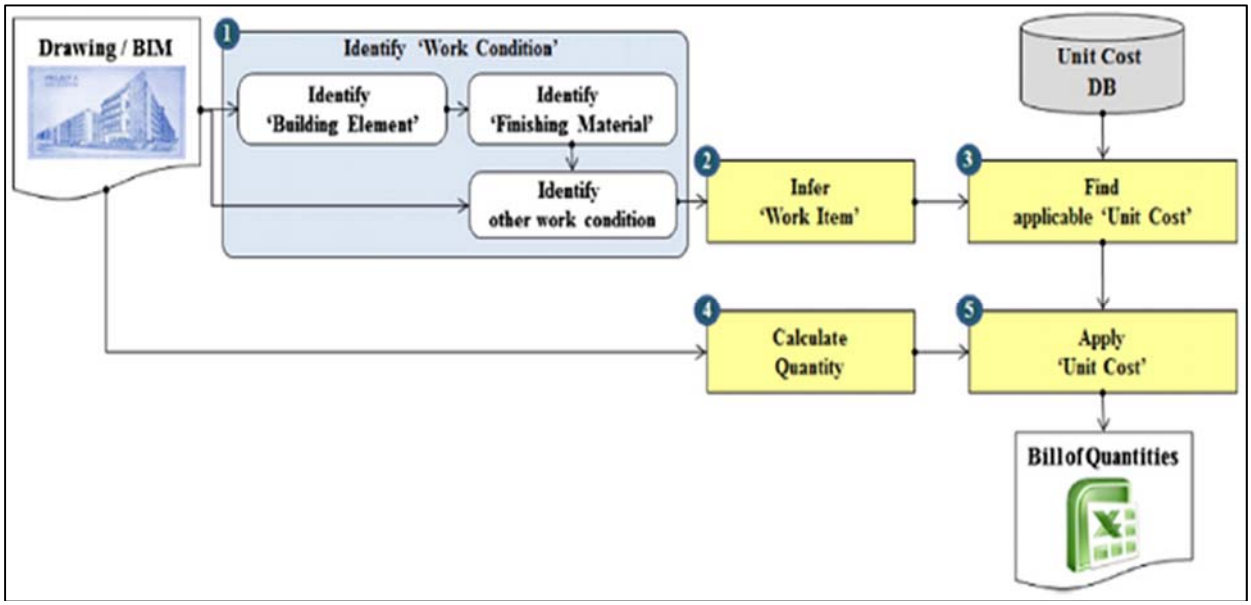

Fig 4: Basic Cost Estimation Process

2.4 Quantity Estimation Process based on BIM: Estimation of quantities on BIM becomes very easy due to its 3D representation/visualization. Early quantities of elements of project can be calculated at the initial stage, this can be basis of the calculation for later stage and helps in preparing accurate estimates. At each and every stage estimation of quantities can be done. As per Autodesk (2007), BIM does not do cost estimates but still several companies found it really useful as accurate quantities at each and every stage makes it easier for the QS to judge the budget of the project by integrating these quantities with their cost-database.

2.5 Cost Estimation Process: The automatic calculation of area, volume, quantities is not enough as it does not produce our prime need i.e. Cost Estimate. So, Autodesk (2007) and Eastman *et al*. (2011) [7] has given some ways for BIM based estimation of cost which we cannot say are best alternates but are better than nothing and are described as:

- Export the quantities of building elements in estimation software: As we have already discussed that importing and exporting file is not a big issue at all in BIM hence, quantity estimation files can be exported in the MS Excel spreadsheet for the QS to perform the calculations by integrating the file with his pricing file. Hardin (2009) raises the point that how this estimate will be updated for the changes in project as there is no integration so that the data will be automatically updated like other systems due to any change in project file. On this Autodesk suggested that the simplicity of data exchange of BIM with other software makes it easy to export data at any time, a model can be pre-pared in MS Excel so that every time data is exported on changes it automatically updates the file.
- Directly bridging the BIM tool with estimation software: The measurement rules can be defined by the QS for the automatic generation of the quantities required for the cost estimation of the present model and then the cost data can be mapped to the relevant building components. As Autodesk (2007) and Eastman *et al*. (2011) [7] have discussed all this can be done using the plug-ins which can be done by linking BIM estimation software like Tocoman iLink with Revit (a design tool of BIM).
- By using qualification tools of BIM: Several other software like Autodesk Quantity Take Off, Exactal CostX, Bentley ConstrucSim and Vico Office suite Estimator can be used to transfer BIM quantity models and they have both automatic extraction as well as manual copying features. An example how it is done is shown:

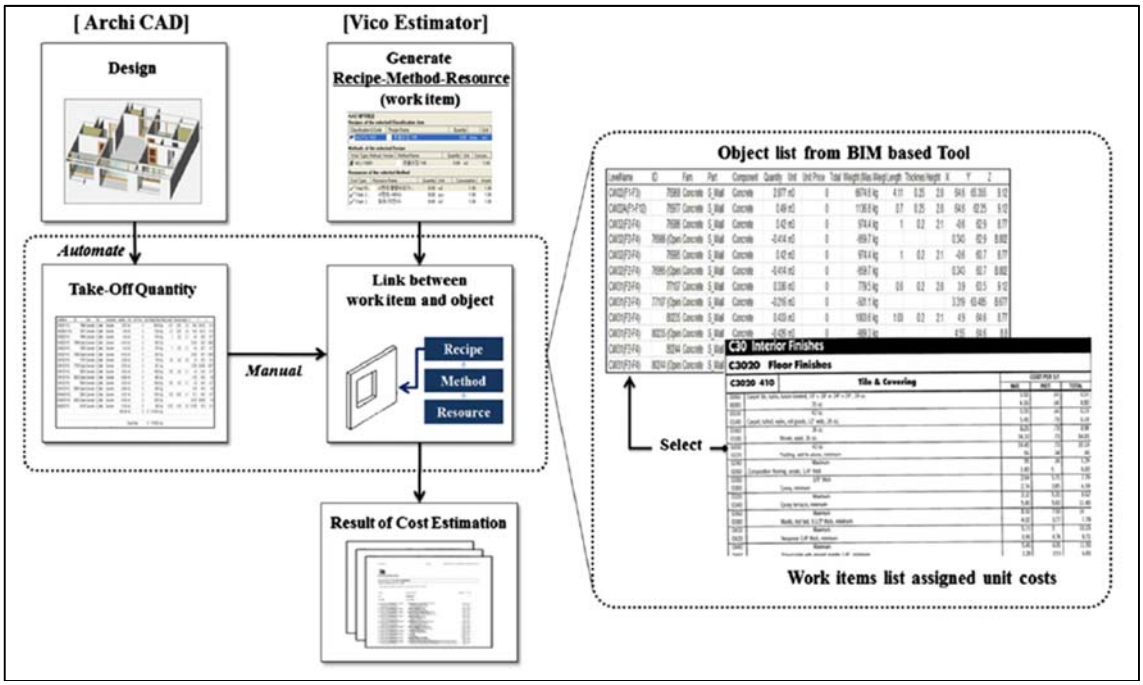

Fig.5 Estimation done in Vico Office Suite Estimator

2.6 BIM for Existing Buildings: As we have already discussed that how BIM can be useful for the construction industry in construction of new buildings but now we have to see how much BIM can help us to increase the Life Cycle of already existing buildings mainly of complex buildings. Generally, buildings are very different in terms of usage like building may be commercial, residential etc., in terms of age of the structure like heritage, existing or new, in terms of ownership like public, private, public-private etc. The application of BIM is influenced by certain factors like differing site conditions, degree of detail, the various structural factors like design and construction, management aspects like maintenance, demolition and reconstruction as per requirements of the client or firm. Since the introduction of many updated features like Construction Operation Building Information Exchange (COBie), now BIM can store maintenance features also but as we know applying BIM in existing buildings is a difficult task as their documentation is very different from the BIM. Some technical issues which we are going to face in Building's Life Cycle (LC) are:

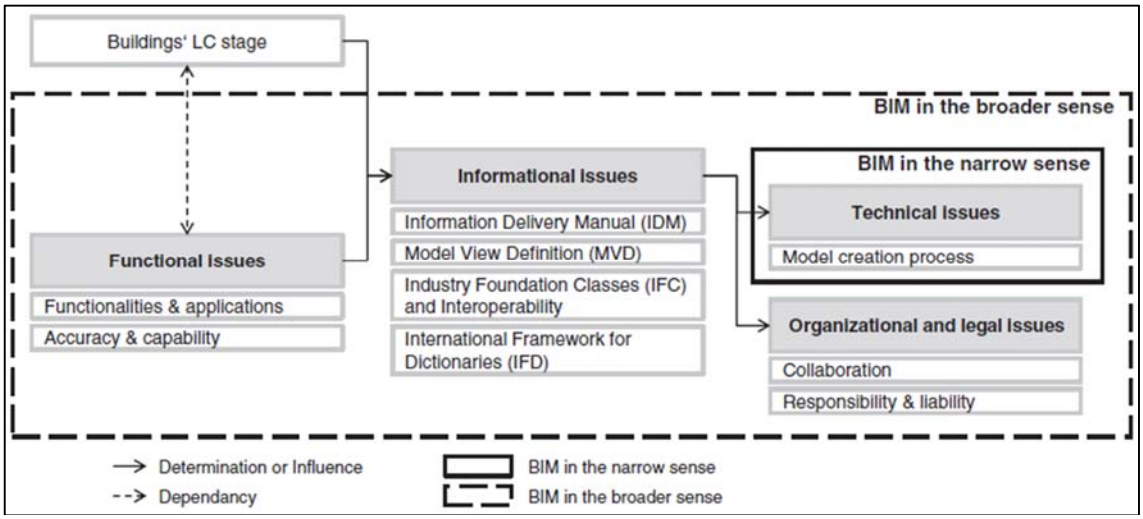

Fig 6: Relation of Building's LC with various issues considered

The creation of BIM model for existing and new construction is same up to production of model and maintenance of existing building can be done through BIM if the documentation of old construction is present but in countries like Europe where most of the construction happen before 1990 which do not even have construction documentation, it becomes difficult to make their maintenance plans through BIM. For old building cases, BIM can work in two phases either it can update the old plans or can create the new plans. So, for countries like Europe wholly new plans have to be made. The model applicable for the New and Old Construction is:

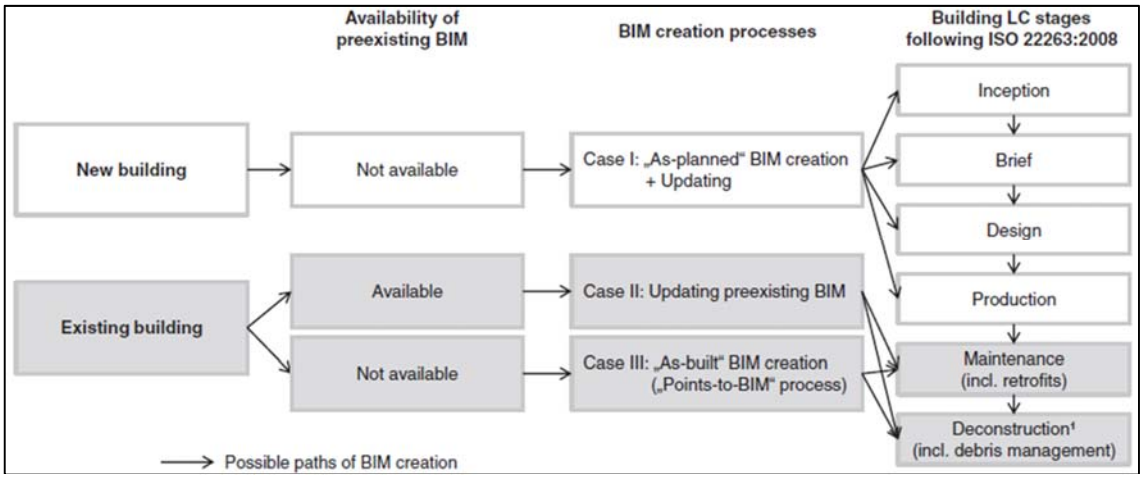

Fig 7: Model creation process of New and Existing buildings depending on available, updated & new plans

The Fig.8 clearly explains real time 3 cases through which BIM can be used at all. The most important case among these is Case 3 where we have to create the whole plan to execute BIM in pre-existing building.

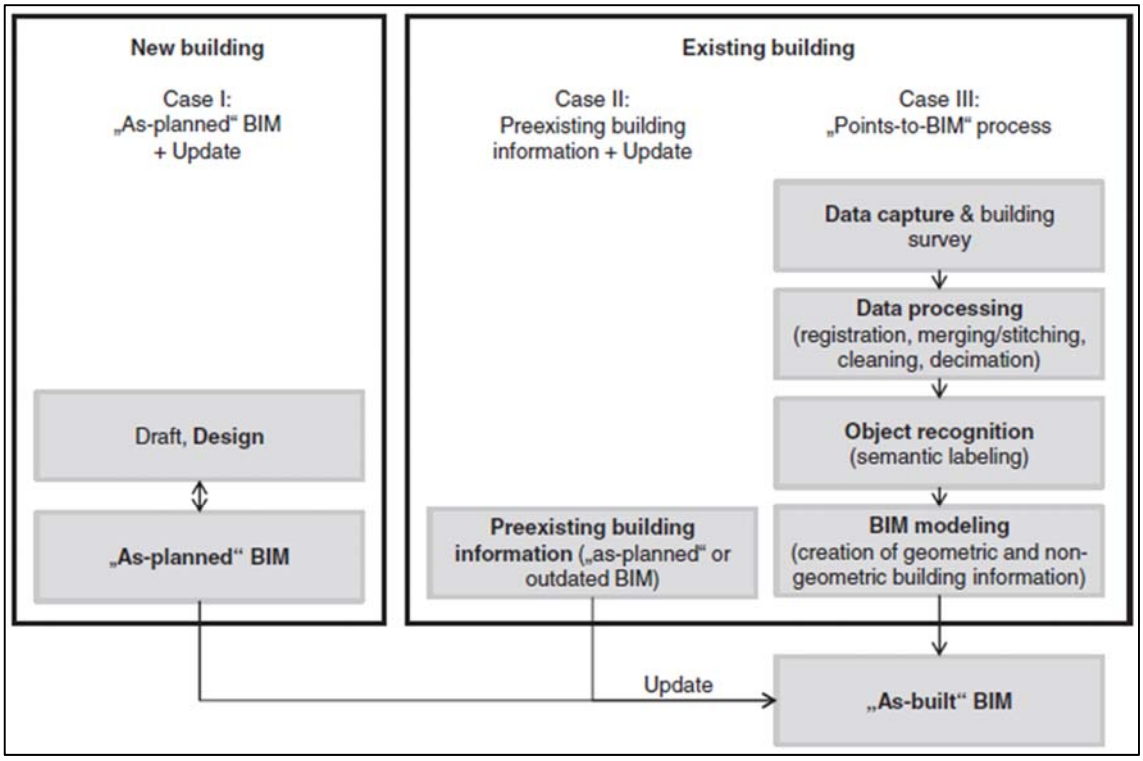

Fig 8: Actual Model creation process of New and Existing buildings

3. Case Study: In BITS Pilani, Pilani Campus largest single infrastructural plan worth ₹400 crores under the name Parivartan is going on which aims in making BITS Pilani among the top collages in Asia. In the first phase of this project New Academic Building (NAB) has been constructed with the huge investment. The company awarded the contract did not implement BIM during any phase of the project. This produced devastation results as major problems occur after the construction. Firstly, Water Drainage System has not been plotted of the old system and new building just created which results in water logging during heavy rainfall. Also, water leakage problems are very common site at each and every room along with the cracks on majority of the walls of the NAB. It is not concluded that with the implementation of BIM it can be controlled but it is sure that at least drainage problems could have been sorted out. Result is that the company awarded the contract has been dismissed from the future work in other BITS campuses. Now the other work has been awarded to other contractor and consultants are playing major part in design and construction but still they have not implemented BIM. So here too many problems they are facing like cracks starts coming during the construction itself. The old drawings if not there then it can be again drawn with the help of people staying in the campus from a long period as they may be knowing the majority of the details. In the construction phase only they are facing too many problems if right

amount of time has been invested all the previous, present and the problems to come in near future can be avoided.

3.1 BIM Implementation Status: An online survey has been created by the researchers to target professionals in every field of construction to know various factors like awareness level, experience and interest in BIM applications weather they know or not about BIM and if they know how much they know and how much they have worked in BIM and how much they want to know more and if they are not aware whether they want to learn or not. The respondents of this survey are chosen with utmost care so that only from the real institutes data can be collected. The data collected from different institutes is shown:

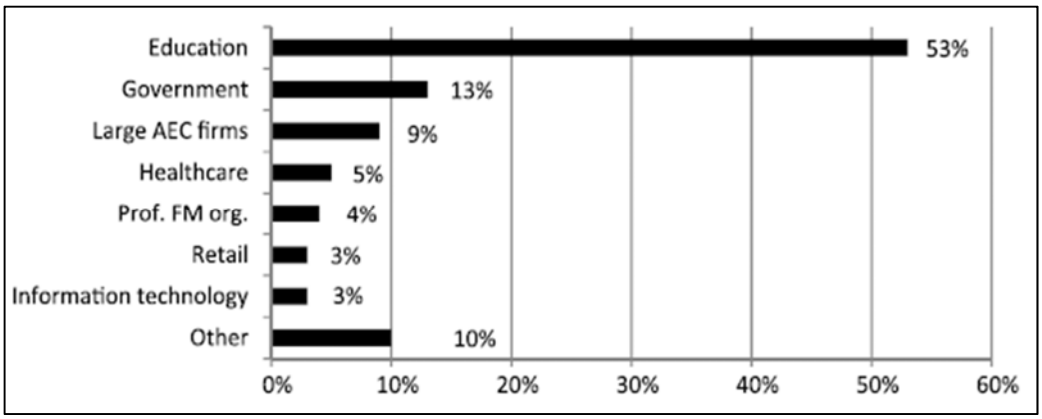

Fig 9: Chosen Respondent Institutions for Survey

The function of various institutes is also recorded like the field in which they are working:

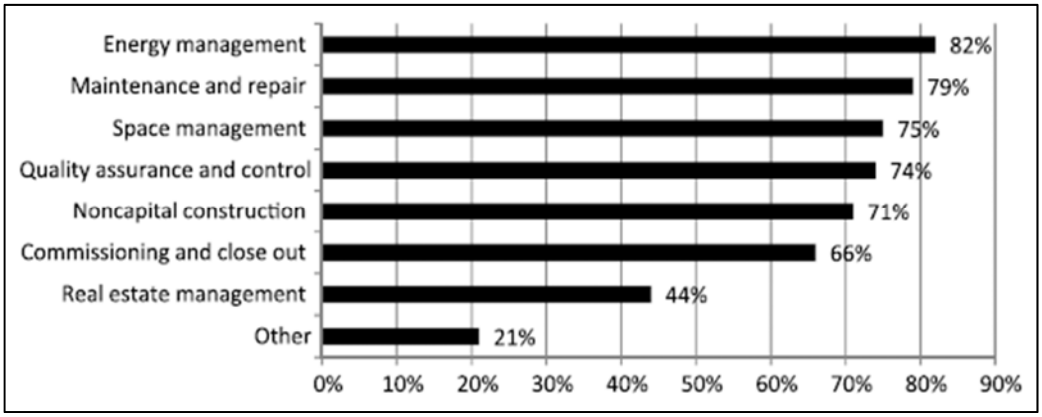

Fig.10 Function of Chosen Institutes

The various stages are also looked into which BIM has already been implemented and has more potential to further implement:

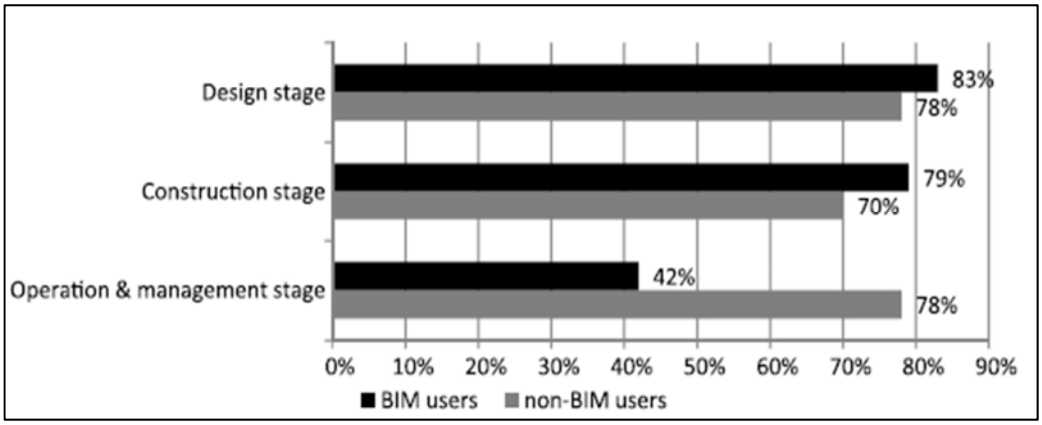

Fig 11: Projects in which BIM is used and planned to be used

The responses that are most important which still do not use BIM or are planning to do so. This will give us the number and direction towards which we have to target:

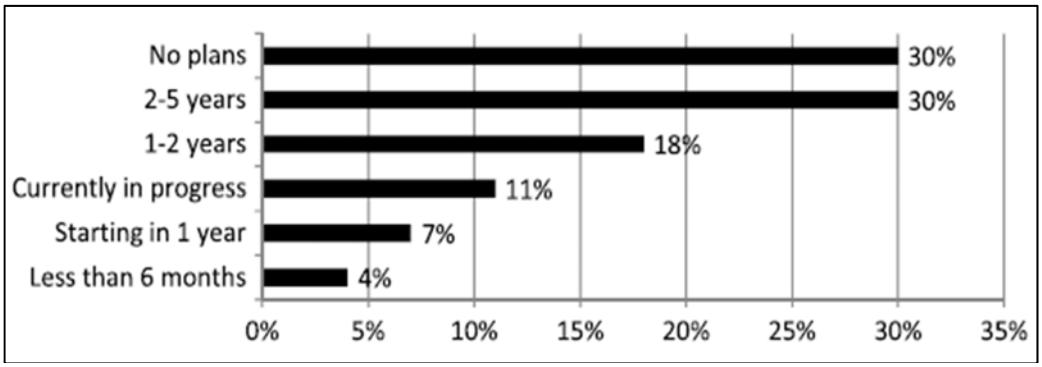

Fig 12: Non BIM users planning to do so

In the last stage, areas are seen in which there is potential to use BIM as Facility Management. Facility Management is not a new terms as it is also a part of construction industry in a way how the manage the facility provided. So, the potential can be seen but need speedy implementation for better results.

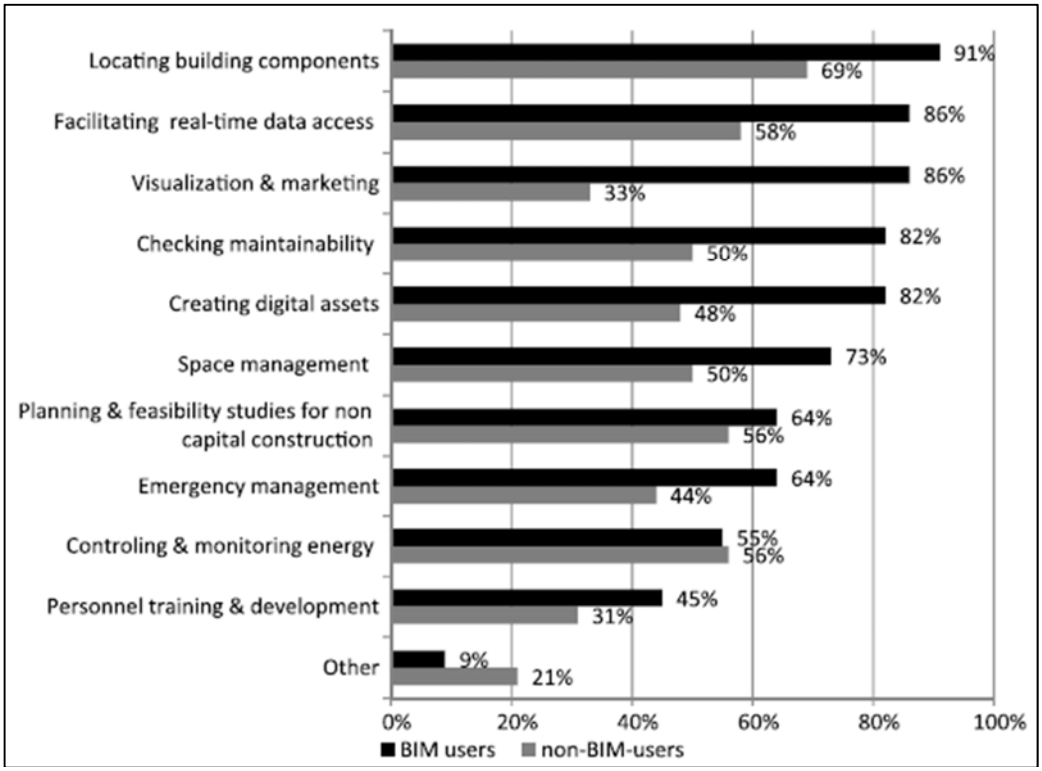

Fig 13: Potential Facility Management areas in which BIM can be used

4. Conclusion & Discussions: It can be said that BIM is a very powerful and effective tool which should be adopted by construction industry at least in new constructions. It is little bit difficult to implement BIM in old buildings but if efforts are made it can also be done. The most important thing concluded from this study is that contractors and engineers should be made aware and make realise the simplicity and usefulness of BIM. It should be specifically told that once BIM designs are made they can be used for lifetime for a building and a major advantage is that the designs can be change at any point of time without worrying about the other drawings. Initially contractors, engineers and architects used to work separately that culture can no longer be lasted as at each and every stage they have to share information to complete the building design. The main need of BIM is there in renovation projects as they eat up the most of the budget of any nation. Hopefully this study will be able to clear some aspects for users as well as developers to make the world a better place in terms of infrastructure quality. There is a lot what can be done in BIM. The future of the construction industry is BIM as it makes so much easy to program the implementation of construction project. There are lot of software integrated with BIM now a day to provide best facilities in every term and the best part that the mistakes that happened due to drawing the different components separately are completely removed.

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