INVESTIGATION AND MANAGEMENT OF CLASHES ARISING DURING CLASH DETECTION

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Abstract - *In any construction project, design drawings are usually developed by different teams like structural, architectural and mechanical, electrical and plumbing (MEP). Hence when these drawings are integrated there are high chances of occurrence of clashes between various components like structural element colliding with any MEP component. Conventional method of resolving clashes by overlapping the drawings and manually coordinating between the different departments is a chaotic and time-consuming process. The efficiency of this process is low and can even lead to conflicts between different departments. These clashes if not resolved prior to the construction can lead to reworks in site which results in time and cost overruns. This can be effectively overcome by using clash detection tool in Autodesk Naviswork software which is a part of Building Information Modelling (BIM) wherein the clashes are identified from the models in no time. The clash detection tool facilitates the identification of clashes between different components, for example between structural element and architectural element, between structural element and mechanical duct, between architectural element and fire duct etc. Clash detection test usually identifies a large number of relevant and non-relevant clashes. Amongst these, the relevant clashes nee d to be resolved prior to construction so as to avoid rework during construction and the non- relevant clashes can be dealt with in site during construction. Once the relevant clashes are obtained, they have to be notified to different departments for resolution. Better management of clashes is crucial to the speedy completion of resolution of clashes. Many challenges are faced during management of these clashes. Different case examples are studied and analyzed to obtain the challenges involved and the methods used to resolve these challenges. In this study, a method of codifying clashes is presented for effective and efficient management of clashes. This method is validated on a sample project of Kannur Airport and is recognized as a better method for the segregation of clashes. Relevant suggestions are proposed to improve the efficiency of the process of clash detection and resolution.*

1. INTRODUCTION

Designing and preparation of construction drawings is one of the first step in any construction project. Construction drawings are prepared by various departments like structural, architectural and mechanical, electrical and plumbing (MEP). Therefore, when these drawings are combined, there are high chances of clashes between parts of structural component like column colliding with MEP component like mechanical duct. Conventional method of resolving clashes by overlapping the drawings and manually coordinating between the different departments is a very hectic and time-consuming process. The efficiency of this process is also low and can even lea d to conflicts between different departments. These clashes if not resolved prior to the construction can lead to reworks in site which results in time and cost overruns.

A better Project management leads any project to its optimum output. Building Information Modelling (BIMs) is a project management tool that can support owners, designers, and builders in their creation and coordination of the design of building systems and planning of construction work, in their processes for fabrication and building, and in their processes for operating and maintaining, as well as decommissioning their facilities.

Hence the issue of clashing can be effectively overcome by using clash detection tool in BIM wherein the clashes are identified from the models in no time. The clash detection tool facilitates the identification of clashes between any components, for example between structural element and architectural element, between structural element and mechanical duct, between architectural element and fire duct etc. Clash detection test usually identifies a large number of relevant and non- relevant clashes. Clash management includes two procedures: detecting clashes and resolving clashes. To improve the quality of clash detection, this study device a method on how to group high volume of clashes. Amongst these, the relevant clashes need to be resolved prior to avoid rework during construction and the non-relevant clashes can be dealt with in site during construction.

Also, the occurrence of large volume of clashes obtai ned after developing these 3D models have posed a challenge to the construction professionals. The methods employed for the management of clashes are time consuming and cumbersome. So, it is high time that a method is devised to handle this army of clashes efficiently. This study is done to find a way to effectively utilise clash detection and overcome various challenges due to clash detection in order to enhance the efficiency of clash management.

1.1 Problem Defenition

When clash detection test is done on a 3D model, there is a probability of occurrence of a large number of clashes, usually in thousands. This outcome includes many irrelevant clashes which has no substantial influence on the project or that can be solved in the subsequent design or construction phase. The identified relevant clashes should be communicated to the structural, architectural or the services team (Mechanical, Electrical, and Plumbing) to make necessary changes. This process of detection of clash, subsequent grouping into relevant and irrelevant clashes, communication of the identified relevant clashes to the concerned team, decision making as to how to deal with the clash and final testing if the clashes have been resolved is a time consuming and cumbersome process that takes seve ral months. This has to ideally start two to three months before the start of the project. To improve the efficiency of the grouping of clashes to identify relevant clashes and provide effective coordination and communication among project team members is the essence of the study.

1.2 Scope of Study

The use of BIM has increased during recent years, clash detection being an important tool widely used. Clash resolution prior to start of a project improves coordination among structural team, architectural team, services team and the workers. Clash detection and resolution are crucial to improve the overall efficiency of the project. This thesis is done to find a way to effectively utilise clash detection and overcome various challenges due to clash detection in order to optimize the project.

The study aims to identify a suitable method to handle large volume of clashes by grouping them into relevant and irrelevant clashes. The identified relevant clashes need to be communicated to the concerned team with more efficiency to help them identify the details of clashes with more accuracy and ease. This facilitates the clash management process.

1.3 Objective of Study

- To study and analyse cases related to cost and time variations in projects where clash detection techniques are used.
- To identify a method to manage high volume of clashes.
- To implement the identified method to a project and understand the importance of eliminating non-significant clashes.

2. CLASH DETECTION

Shyamkant and Pataskar (2017) summarized that a clash takes place when elements of different models occupy the same space. It entails overlaying of drawing to check if there are any conflicts. With BIM though, this technique is improved, as BIM brings automation to clash detection. Clash detection enable effective identification, inspection and reporting of conflicts in a project model. It is used for checking completed/ongoing projects and decreases the risk of human error during model inspections. Clash detection is essential because different models (structural, MEP, etc) are integrated into one master BIM model. Clashes are usually classified according to tolerance level between the colliding components, viz.

- Soft Clash (Clearance)

It refers to components that are nearer than a particular distance (a minimum clearance) from each other or in other words it refers to a item that occupy an area that may affect the movement of another item or person.

- Hard Clash

It refers to a building component that physically yet accidently penetrating some other building component; that is, two (or more) components that occupy same physical space in the model.

- 4D/Workflow Clash

Clashes resulting from scheduling clashes of interdisciplinary activities which affects the scheduled duration and the cost of the project.

Features of Clash Detection include:

- Clash detection helps in efficient recognition, investigation and reporting of interferences in a building model.
- It is used for checking completed/ongoing work and decrease the risk of human error during model testing.
- Clash detection is required because numerous models (structural, MEP, etc) are incorporated into one master BIM model.
- With clash detection, mistakes which generally would have been located at thesite (which affect cost and schedule when corrected at that stage) can now be discovered in the workplace.
- Navisworks can even make clash detection possible for item within items (a reinforcement steel completely immersed inside a concrete wall).

2.2. Need for Clash Detection

Akponeware and Adamu (2017) found that contemporary design practice and construction delivery has historically suffered from terrible coordination and irregularities in the way that different department teams manage, operate and communicate project lifecycle data. After each of the disciplines (structural engineering, Architectural, MEP engineering, environmental engineering, etc.) have finished their work, clash detection is done. Detecting these inconsistencies is important, as they would badly affect the construction process, inflicting delays, design revisions, materials price and a cascade of problems and cost overruns.

Raut and Valunjkar (2017) also found that within last couple of years, the complication of modern day construction projects has increased drastically and there's no great improvement in productivity. Traditionally the productivity of construction industry has been much lower than that of other industries due to lack of ability to adopt new changes technology. The productivity of other industries such as automobile industry has increased steadily over the years by adopting new modified methods, technique and technology. Indian construction is not yet up to the world standards. It is not making use of the true potential of BIM tools. Most of the architectural and engineering firms in India still use 2D Computer-Aided Design i.e. CAD drawings. Due to the failure of traditional difficult method of detecting clashes using two - dimensional methods, it's miles important to bring about a new manner of running and thinking in the creation within the construction industry so that it calls for implanting modern generation like BIM to enhance the clash detection techniques in preference to traditional technique.

2.3 Various softwares Used for Clash Detection

2.3.1 Solibri Model Checker

Solibri Model Checker was one of the only software available for checking the model. It was one of the few applications that were developed specifically to work with the IFC file format, actually. It was developed before BIM was officially brought into AEC/FM industry. The checking of Solibri is executed on the basis of rules grouped into related "rule sets". One of most obvious convenience of Solibri Model Checker is that it can be viewed in the original BIM authoring software, letting them to be fixed with difficulty and faster.

2.3.2 Autodesk Naviswork

Raut and Valunjkar (2017) concluded that Autodesk Navisworks product facilitates architecture, structural engineerings, and construction teams to develop higher control over the final results of their projects. Navisworks application enables the user to interrogate and utilize this information throughout the design, build, and operation stages without the need for a design application.

Berdeja (2014) also found that Navisworks is a coordination application from Autodesk and mostly used project review application amongst BIM users. The present clash detective features is of exquisite assist in clash analysis and undertaking project coordination. Contrary to Tekla BIMsight, Navisworks permits the clashing of different disciplines inside the same model and, therefore, there is no need to keep them as separate files. Revit produces files can be open in Navisworks, because they are both Autodesk products. Navisworks features the Switchback capability that when enabled opens the Revit model immediately focusing the conflicted elements, thus resulting in quickly resolving the problem.

Afterwards, the up to date Revit file is saved, contemplating that the previous file must be overwritten or deleted. In this way Navisworks model can be updated by just refreshing the model. The potential to add and update data between Revit and Navisworks software with the Switchback function is one of the advantages when using these BIM tools together. This can create an iterative and efficient workflow that comes a few steps closer to resembling what the BIM methodology really is about.

2.3.3 Bentley Interference Manager

Bentley Interference Manager is a software for the detection, evaluation and management of component conflicts in three dimensional models. It can be used with designs created in a wide range of commercial software and provides review reporting for each clash. It also help tracking and coordinating resolutions for potential design problems. This shows the versatility of the software.

2.4 Causes of Clashes

Akponeware and Adamu (2017) found the causes of clashes as follows:

- Isolated working was the prime cause of high occurrences of clashes linked to mechanical, electrical and plumbing (MEP) 3D BIM systems.
- Poor coordination between multi-disciplinary teams that manage and exchange project lifecycle data.
- Non-BIM specific training (or the professional qualifications) received by the design practitioners.
- Use of wrong or low level of detail.
- Design uncertainty and complexity leading to errors.
- Failing of design rules.
- Lower accuracy arising due to nearing deadline.
- 3D model objects exceeding allowable clearance.
- Use of 2D instead of 3D models for developing the design.
- Lack of experts.

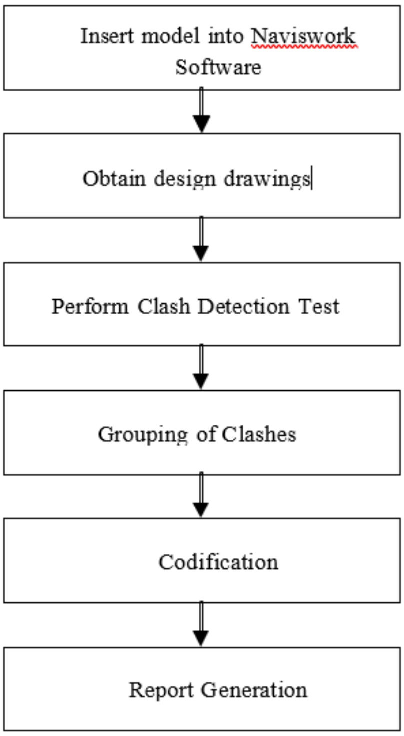
3. VALIDATION USING CASE EXAMPLE

3.1 Kannur Airport

The method identified from the study is tried to be implemented in a sample project which has architectural, structural and MEP components. The project selected here is the Kannur airport Model. The identified method for the management of clashes is followed in this project. The detailed steps in which the method is implemented and the final groups of clashes obtained from the analysis is explained below. The procedure followed for the notification of clashes to concerned parties is also explained.

Figure 3.1: Kannur Airport Model

3.2 Process Flow



Step 1: Obtaining the design drawings

Obtaining the design drawings from architectural, structural and MEP (Mechanical, Electrical and Plumbing) teams well ahead of the start of clash detection process. In case of the model of Kannur airport on which we performed clash detection, these design drawings were not separately provided. So individual sets were created separating the structural, architectural and MEP components of the model. Elements containing various structural, architectural and MEP components was searched and saved into sets as shown in figure 3.2.

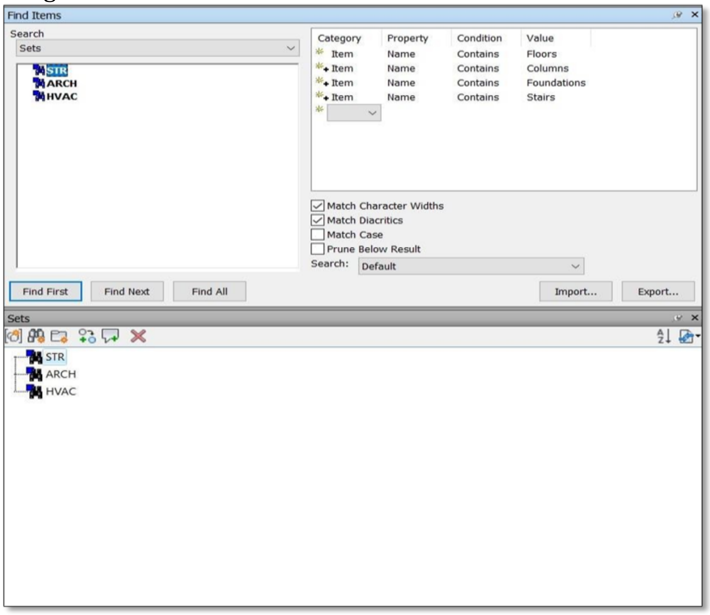


Figure 3.2: Finding items and sets creation

Step 2: Perform clash detection test

After obtaining those individual models or creation of separate sets, clash detection test was conducted between the Structural components versus MEP components and Architectural components versus MEP components which resulted in 91 and 869 clashes respectively. Compared to the thousands of clashes usually arising, this amounts only to very few clashes. Clash detection tests between structural and architectural components are not feasible and is not being carried out in the industry during clash detection. The tests that are conducted in this model and the results obtained are shown in figure 3.3.

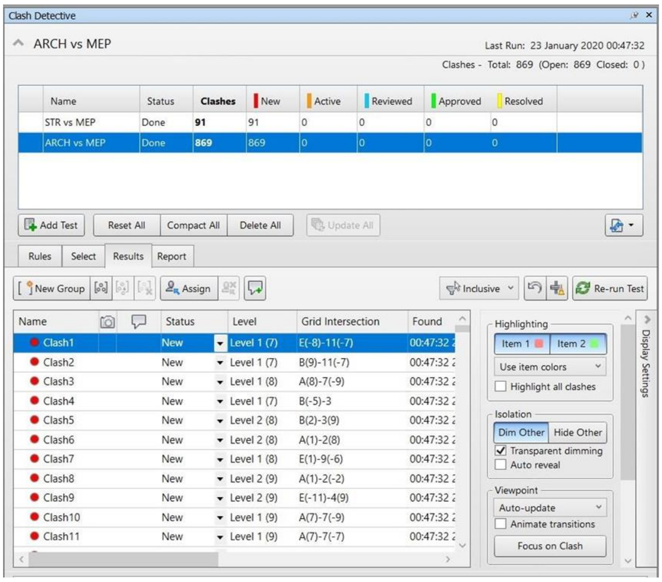


Figure 3.3: Clash detection tests

Step 3: Grouping of clashes

This is the step were the large number of clashes that was obtained were grouped into main two groups viz. clashes to be reviewed or 'issues' and clashes that are approved or 'approvable'. Approvable refers to clashes which does not require immediate attention or resolution i.e. they are resolved directly at construction sites. Issues refers to the clashes which require immediate attention and are to be solved before the start of construction activities.

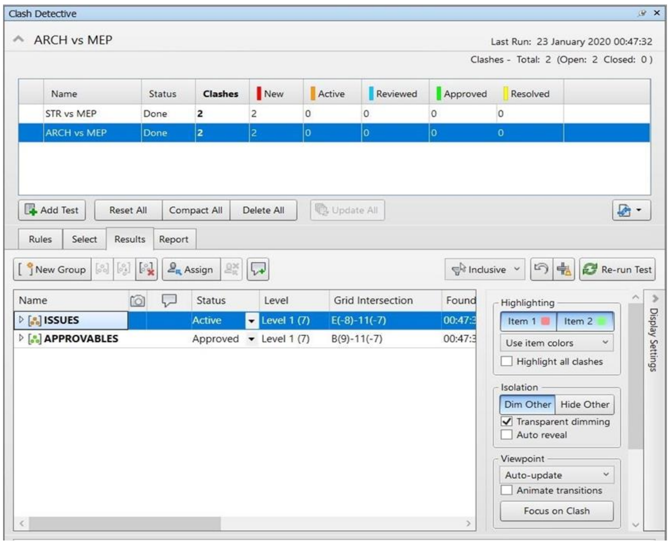


Figure 3.4: Clash classification into issues and approvable

Step 4: Codification

This is the main and integral part of handling the clashes and effectively communicating to different contractors, sub-contractors and other parties involved. In order to rectify the clashes which are grouped as issues, contractors and sub - contractors must understand the nature and area of clash where it occurred. Grouping of clashes helps to organize the large amount of clashes formed, based on the required criteria. Codification refers to grouping individual clashes of similar components occurring at similar area under a standard code. So for the purpose of codification the entire model was divided into 4 zones viz. A, B, C and D. It was done for easy identification of clashes of any particular region.

Consider an example of the code that is developed and used in this model.

0.01_001.FSvsMD_L2_B

- 0.01 refers that structural components are involved in this group of clash.
- Similarly 1.01 refers that architectural components are involved in it.
- 001 gives the count of clash groups that are present after codification.
- FSvsMD – This part gives the abbreviated names of the components that are clashing. In this case, floor slab clashes with mechanical ducts.
- L2 refers to the level 2 of the building model.
- B refers to the zone B.

Various abbreviations that are used for codification

Abbreviations	Expanded form
FS	Floor Slab
MD	Mechanical Duct
SC	Structural Column
FNS	Foundation Slab
DR	Door
WN	Window
BW	Basic Wall
AT	Air Terminals
PF	Pipe Fittings
DF	Duct Fittings
HP	Heating Pipe
RP	Refrigerant Pipe
CP	Condensate Pipe
ME	Mechanical Equipment
DA	Duct Accessories
PA	Pipe Accessories
L1	Level 1
L2	Level 2
L3	Level 3

After grouping the clashes as per the codes, it was found that the number of clashes was reduced considerably. The resolution of these clashes will now take much lesser time as similar clashes were grouped together.
The total number of clashes was now reduced from 81 to just 10 groups and from 869 to 72 groups including the approvable group. Figure 3.5 shows the reduced number of clashes and the codes given for similar groups of clashes.

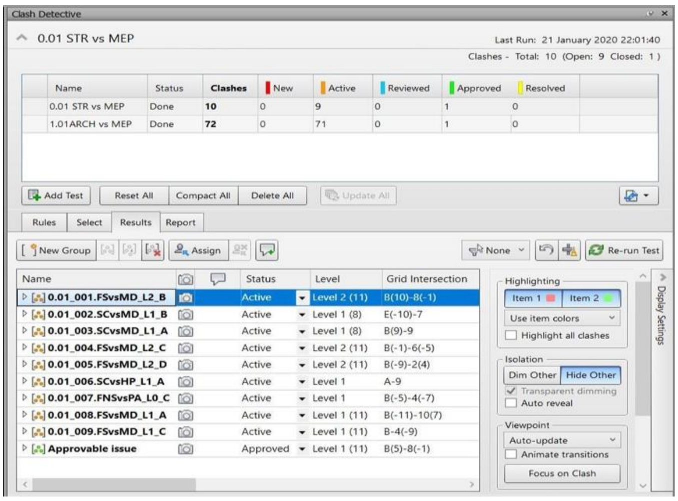


Figure 3.5: Reduced clashes after codification

Step 5: Report Generation

Report can be generated in various formats like XML, HTML, Text and as viewpoints. Here the report format adopted is as viewpoints. Thus the coded groups are visible as saved viewpoints as shown in figure 3.6.

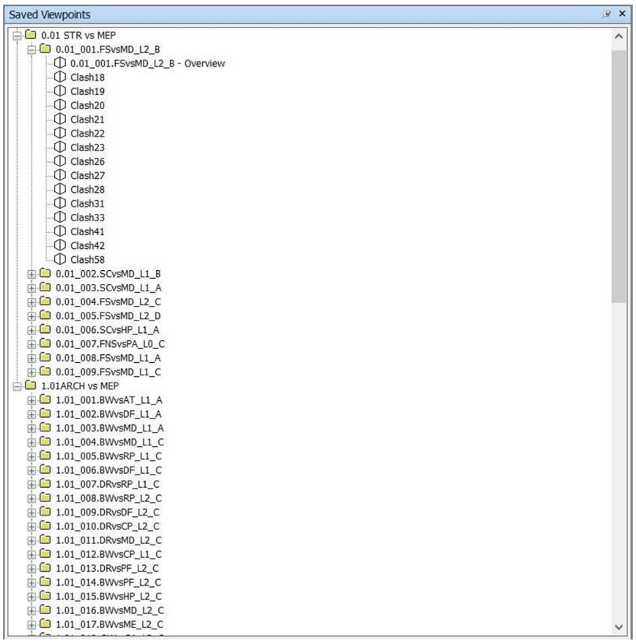


Figure 3.6: Saved Viewpoints

The report generated is then transferred to the contractors or sub -contractors of concerned discipline for correction through BIM track or BIM 360 docs or other similar software. These are web-based management and collaboration platform that helps in connecting the entire project team. It provides a central hub for all coordination information from design to construction. The status of the clashes that need correction can be viewed in the collaborating software.

The clash report from Navisworks is fed into the collaborating software by publishing it with the name of concerned discipline.

Once these clashes are added into the software, it will have the status as 'open'. The corresponding party will update their model with required changes. The status during this time period will be 'in progress'. When the model is updated with required changes, it will be marked for review with the status as 'ready for review'. Once the review is completed the status of the clash report will be changed to 'closed'.

4. LIMITATIONS AND RECOMMENDATIONS

4.1 Limitation of the Study

The study covers mainly on the clash detection process after design before construction and does not focus much on the clash detection after the commencement of construction. The identified method is tried only on one sample project, hence this cannot be considered as a unified solution for all kinds of projects. Further the method could not be tried on a live project due to practical difficulties. Hence there is a chance for future work in these areas.

4.2 Recommendation

Conventionally after clash detection each clash is individually studied and sent to each stakeholder to resolution of clashes. This process is time consuming as large number of clashes are encountered. It would be better if clashes are grouped and
avoid insignificant through various method such as applying rules.

This grouping can be done by developing a software. Since each disci pline have their own model, it is easy to group clashes between different disciples such as Structural vs. MEP. If this grouped clash is directly linked to cloud services such as BIM Track, the clashes can be directly communicated with different stakehol der and only the clashes that are concerned with each disciple will be available to them. So, clashes can be easily handled. After resolving the clashes, the data is fed into the cloud service where we can make recommend change in the original model using this data. The cloud service data can be fed into Navisworks where it points out the clash with recommendation (Recommendations are shown in dialogue box). Using switch back from Navisworks the clashes is pointed out in REVIT where the changes can be made.

CONCLUSION

This study was done to find a method to manage clashes effectively so as to save time and prevent reworks in site. From the literature review, we could understand that relevant clashes should be resolved prior to construction and non-relevant clashes can be dealt with on site. Also, it was clear from this review that there should be a method to convey these clashes effectively to relevant stakeholders. This study has brought out a method to overcome the challenges by effectively segregating the army of clashes as relevant and non-relevant clashes. The relevant clashes are codified so as to effectively notify the clashes to the concerned departments. The identified method is applied on a sample project, Kannur Airport, to determine its applicability in improving the efficiency of clash detection.