A BIM-BASED PROBLEM-SOLVING ANALYSIS OFCONSTRUCTION- RELATEDISSUESANDCLASHDETECTION

A.SheikFarid*,MuhammedSahalRoshanTK,AyishaSidiquaM.

Department of Civil Engineering, B.S.Abdur Rahman Crescent Institute ofScience&Technology,Chennai,India

Abstract: The construction industry is significantly more complicated than it wasin the past as a direct result of the high number of people engaged and theamount of documentation required. In the context of the Indian economy, themajorityofprojectsarestillbeingcarriedoutusingaconventionalmanner,whichresults in a great deal of difficulty during the execution phase. These difficultiesincludedelaysinconstruction,materialwaste,costoverruns,poorqualityof work,andtheidentificationofconfrontations.Theconventionalmethodsdonotconsider the spatial aspects of the building process, nor are they immediatelylinked to a model of the structure being constructed. BIM is a potential tool in thearchitecture,engineering,andconstruction(AEC)industrythatcanminimizesuchproblems and clashes in construction by making recommendations. Within thescope of this project, BIM is being utilized for the purpose of conducting ananalysis of a G+1 residential building. Autodesk REVIT 2022 for 3D modeling,schedulingusingAutodeskNavisworks,MicrosoftExcelforestimationandcosting, and Autodesk Navisworks for analysis of the structure. All of theseprograms were developed by Autodesk. The goal of the analysis is to find designflaws on the collaboration of structural and architectural models, detect clashesbased on techniques that detect clashes, evaluate the severity of the clashes,and manage residential building conflicts. The project's goal is to resolve theproblems and conflicts that have arisen during the construction process and toputthefindingsofthestudyintopractiseonanactiveproject.

Keywords: **AEC,BIM, Clashes,AutodeskNavisworks,Autodesk REVIT**

1. INTRODUCTION

BIM(BuildingInformationModeling)isadigitalrepresentationofthephysicalandfunctional characteristics of a building or infrastructure asset. It involves thecreationandmanagementofavirtualmodelofabuildingorinfrastructureproject,which contains all the relevant information required for the design, construction,andoperationoftheproject.

BIM is not just a software tool, but a collaborative process that involves allstakeholdersintheconstructionindustry,includingarchitects,engineers,

contractors, owners, and facility managers. BIM provides a platform for thesestakeholders to share information, coordinate their activities, and make informeddecisionsthroughoutthelifecycleofaproject(KumarandMukherjee2009).

2. BIM

BIM enables stakeholders to create a digital model of a building or infrastructureprojectthatisaccurate,reliable,andeasilyaccessible.Thisdigitalmodel containsinformation about the physical properties of the project, such as the size, shape,and location of building elements, as well as information about the functional andoperationalaspectsoftheproject,suchasheating,ventilation,andairconditioning(HVAC)systems,electricalsystems,andplumbingsystems(Rokooei.2015;Shaikhetal., 2016).

BIMiswidelyusedintheconstructionindustry,asithelpstoimprovecollaboration,reduceerrorsandrework,increaseefficiency,andlowercosts.Itisalsobecomingincreasinglyimportantintheoperationandmaintenanceofbuildings and infrastructure assets, as it provides a platform for the managementofbuilding dataand theoptimization of buildingperformance (Srimathi andUma,2017; PatilandKhandare,2017).

2.1 ClashDetection

Clash detection is one of the most important features of BIM, as it enables theidentificationofconflictsorclashesbetweenbuildingelementsbeforeconstructionbegins. Clash detection is the process of identifying and resolving clashes orcollisions between different building elements in a BIM model. In BIM, eachbuilding element is modeled as a 3D object with its own dimensions, properties,and attributes. When two or more building elements occupy the same space orintersectwitheachother,aclashoccurs(Langar,2017).Clashdetectionsoftwarecompares the geometry and spatial relationships of different building elements intheBIMmodeltoidentifypotentialclashesorcollisions.
Once clashes are identified, they can be resolved by adjusting the design of theaffectedelements.Thedesignteamcanworkcollaborativelytoreviewtheclashes, assess the impact of any necessary changes, and make adjustments tothe design accordingly. This process helps to avoid costly errors and rework thatwouldotherwisearise duringconstruction. Clashdetectioncanalso helptoidentify other issues, such as accessibility, constructability, and maintainabilityissues, which can be addressed before construction begins (Quan et al., 2020).By resolving clashes and other issues early in the design process, BIM helps toimprove the quality of construction, reduce costs, and ensure that projects aredeliveredontimeandwithinbudget(JoseandJacobe,2018,Goretal.,2018).

2.2 ClashDetectioninaNon-BIMandBIMBasedEnvironments

Inanon-BIMenvironment,clashdetectionistypicallydonemanuallybyreviewing2Ddrawingsandspecificationstoidentifypotentialconflicts.Thisprocesscanbetime-consuming and prone to errors, as it relies on the human ability to interpretandvisualize3Dspacefrom2Ddrawings(Shah,andVarghese,2019).

In a BIM environment, clash detection is automated using specialized softwarethat compares the 3D models of different building elements to identify potentialclashes.TheBIMmodelcontainsallthenecessaryinformationaboutthebuildi ngelements,includingtheirdimensions,location,andproperties,makingiteasiertoide ntify and resolve conflicts before construction begins (Rui,2019; Patil etal.,2020;Koshtietal.,2021).

In summary, using BIM for clash detection provides many benefits over a non-BIM environment, including greater accuracy, faster detection, collaboration, andcost savings (Hasan and Rasheed, 2019). The study aims to identify the clashesand issues of the buildingconstruction which affects the time, cost, energyconsumption,operationalmanagementandqualityoftheprojectbyusingBuildi ngInformationModeling.

Toidentifythepracticalconstraintsandtosuggestpropersolutionfortheexecution of construction project. To enhance the project performance and toproducebetteroutcomesusingBIMwhileexecutingtheconstructionproject.

3. METHODOLOGYFRAMEWORK

The methodological framework of this study describes that the step by stepprocedure of the tasks to be done in this project. Sufficient details are gatheredfrom various literatures regarding Building Information Modeling, application ofclash detection, scheduling, modelling and tracking. Autodesk AutoCAD 2022produce the various design detail drawings of the 2D plan with the base of theinitialsketchplan.These2DplansareimportedintoAutodeskRevit2022softwareto develop3Dmodelsof designdrawings.

In this study software used for clash detection process is Autodesk NavisworksManage 2022. After the creation of 3D models by Autodesk Revit 2022, it isnecessary to import the 3D model into Autodesk Navisworks Manage 2022 inordertoperformclashdetection.AproperWork-BreakdownStructureispreparedfortheentireproject accordingtothechainagesmarked.

The schedule of the project is made in Autodesk Navisworks Manage 2022software.TheschedulecanbeimportedintoAutodeskNavisworksManage2022 andviewedunderSelectionTreePaletteandallactivitiesarelinkedtothemodel.It incorporates time sensitive data into 3D models and controls the schedule atvariousstagesthroughouttheproject.Quantificationandestimationoftheprojectis done using Autodesk Navisworks Manage 2022 software. Energy analysis ofthe building and facility management process are done using Autodesk Revit2022. After the analysis the results are discussed and compared. The framing ofthemethodologicalprocessasshowninFigure1.
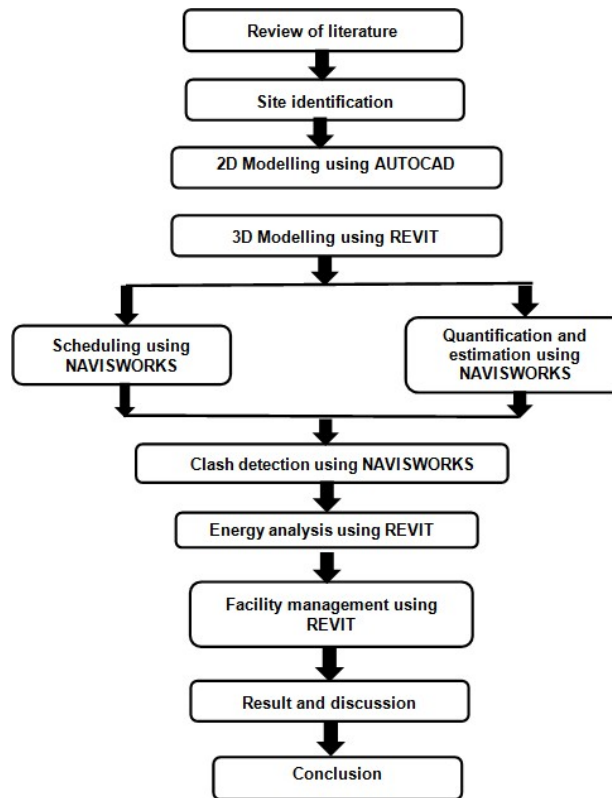
Figure1.METHODOLOGY

4. MODELLINGPROCESS

4.1 CREATING2DCADDETAILS

The plan of a G+1 residential building, which is a proposed project in Kerala istakenforstudy. Theareaofthis buildingisabout 1526sq.ft.Thehouseconsistsof two floors with the ground floor containing entrance hall, bedroom, bathroom,kitchen and the first floor contains bedroom, bathroom, balcony as shown inFigure2.

Figure2.2DCADDETAILS

4.2 BIM-BASED3DMODELING

The result of 3D modeling using the BIM software Revit 2022, which was done inaccordance with the manual for Autodesk Revit. This project's model creationprocess aims to create three-dimensional models from simple two-dimensionalsketches. In Autodesk Revit,Revit MEP (Mechanical,Electrical & PlumbingDesign) and Revit Architecture are built independently and then coordinated withoneanother.Eachsubjecthasitsownsetofmodel-makingtemplates.

4.2.1 GeneratingthearchitecturalBIMmodels

Throughout the design, documentation, and construction phases, ArchitectureRevitinAutodeskenablesarchitectsandbuildingprofessionalstorecord, evaluate, and sustain vision. The build environment is the focus of the modelinganddetailing tool forarchitecturecalledRevit.Tocloselyreflecttheactualsituation, all displayed features, including footings, roofs, columns, doors, floors,windows and walls were produced by altering the 3D parametric models alreadyaccessibleinthelibraryofRevitwhichisshowninFigure3.
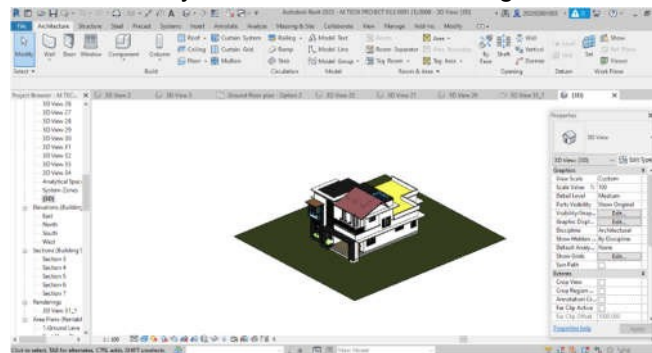

Figure3.REVITARCHITECTURERENDERINGIMAGE

4.2.2 MakingthemodelusingRevitMEP

Professionals that work in MEP engineering should use Revit MEP. Mechanical,Electrical, and Plumbing are the three engineering specialties that Revit MEPsupports.ToolsparticulartoRevitMEPmaybefoundunderthe"Systems"menu.Thesystemsinvolvedinmechanicalsystems,electricaldistributionsystems,andplumbing systems are covered by its tools. Without any visible direction from thestructural component of the home, the modeling is first carried out exclusivelyprimarily on the architectural component. The plumbing fittings were then addedto the architectural model. Since it was chosen to utilize the established nominalsizes from Revit, the plumbing diameters used in this work are approximations ofthosefoundintheactualdesign.Sincethiscomponentisunrelatedtotheconflictanalysis conducted in this work, the mechanical characteristics of the modelelements were not adjusted. Only lighting and electrical plug data were collectedfortheelectricalmodelusinga2Dsketch.Theplumbingmodelcombinessanitarypipe,pipefitting,andaplumbingfixtureshowninFigure4.

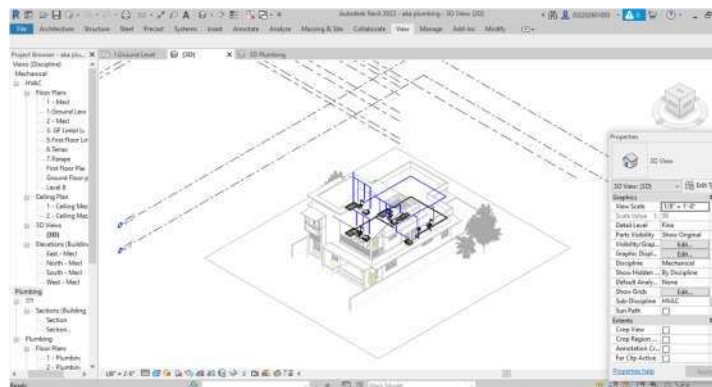**Figure4.REVITMEP3DVIEW**

4.2.3 Revitcoordination

Anybuilding'sconstructionrequirescooperationbetweenthearchitectural,structural, and MEP disciplines. Lack of cooperation would result in mistakesbrought on by misunderstanding, which would have major time, resource, andfinancialramifications.Renderedarchitecturemodel.

4.3 DEVELOPMENTOF4DBIM

Aimingtoeliminatedelaysandsequencingissues,the4DBIMtoolsimulatesandtracks constructionschedulesusingBIMtographicallycommunicateandevaluate project operations. Giving a project team a tool to use in order to keeptrack of project activity becomes very vital. Linking the elements in the buildingmodelwiththetasksandassociatingindividualelementsorgroupsofelementst oeach of the activities in the timeline are crucial steps in generating a 4D BIM oftheconstructionprocess,whichisshowninFigure5.
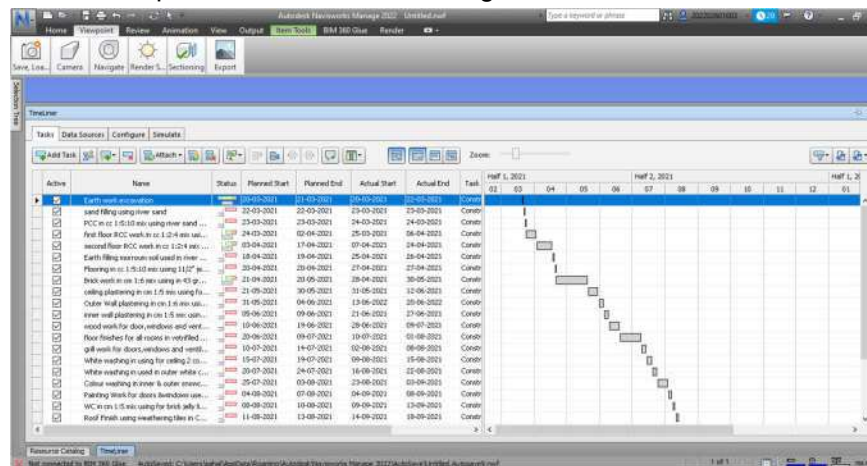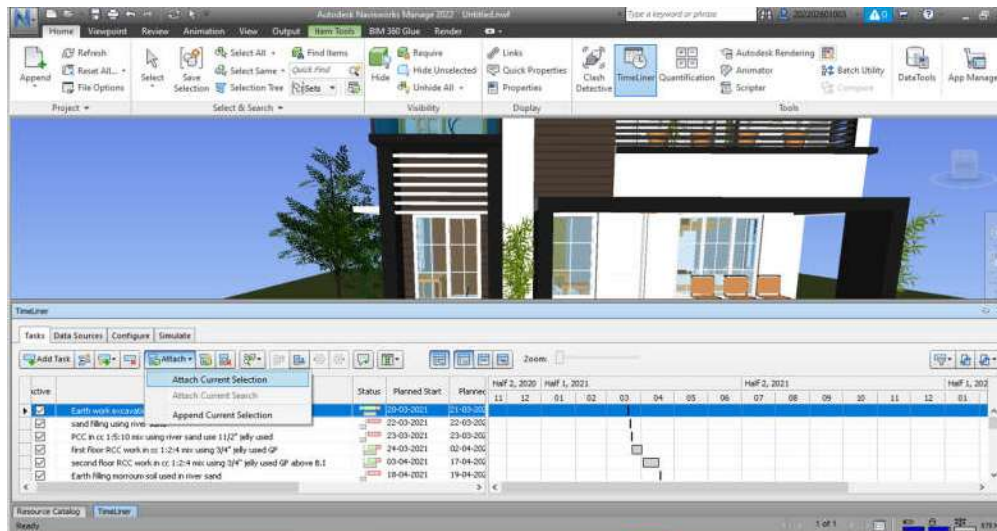

Figure5.SCHEDULEOFPROJECT

4.3.1 Integrationof3Dmodelwithschedule

This includes three steps; developing selection sets, linking project activities withthe selection sets as shown in Figure 6, linking the 3D models with its timeassociations.

Figure6.LINKINGTASKSWITH3DMODEL

To fit the timetable, Navisworks configuration and linking parameters (such asstart dates, finish dates, interval size, and playback length) need be changed.Thisproducesthefirst4Dmodel.

The benefits of 4D modeling were recognized after the scheduling activities andmodel components were connected. The timetable is automatically adjusted ifthere are any changes to the plan. The projected development of the virtualproject construction was displayed right away in the model as soon as the "timeliner"waschosenforacertainday.Throughavisualmedium,thesimulationaidsin comprehendingtheflowofbuildingactivity.

4.3.2 ConflictDetectionAnalysisForBimBasedDesigns

Every significant design incompatibility must be addressed and evaluated againduringtheconflictanalysisprocess,alteringandupdatingsolutionsasnecessary to reach the required degree of coordination. The three selected componentswere made into 3D models and evaluated in Navisworks for any conflicts thatcould exist between them. Typically, the conflicts that were discovered

throughdetectionwereremoved.Becausethissoftwarecanidentifycollisionsinrealtim eduringthedesignphase,itprovidesBIMstakeholderswithaveryeffectivewaytoenha nce coordination between various building systems and ultimately preventtheneedforexpensivefixesafterdrawingcompletionandduringtheconstructio nphase(Savitrietal.,2020).

Collision detection may be done once each discipline has contributed to the BIMmodel.Thisprocedureentailslookingforthingsfromotherdisciplinesthatcompete withoneanother,thatis,elementsthatshareaplacephysicallyorthat

haveconflictingspecifications.The"select"optionisusedtoselectvariousmodelcomp onentsthatcanclashwithoneanother.

TheClashDetectivetoolcontinuouslyupdatesthestateoftheclasheswhentheyare found and shown inside the "Results" page of Navisworks Manage sinceNavisworks manage dynamically assigns a status to each clash for usage in thefuture,whichisshowninFigure7.
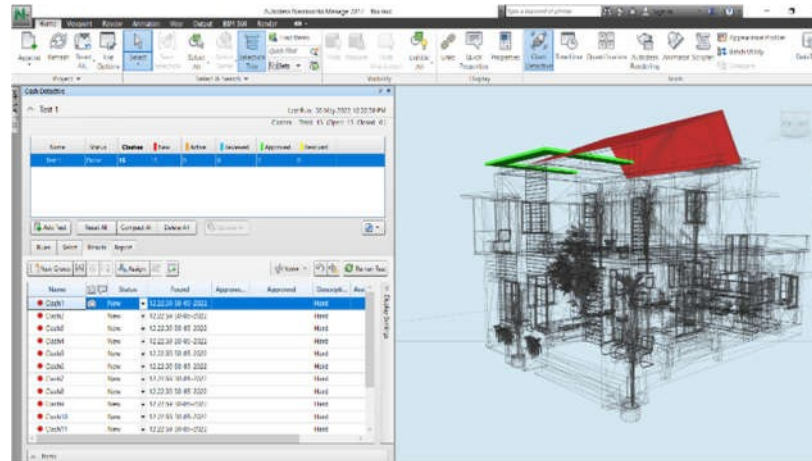
Figure7.CLASHDETECTIVESHOWINGTHERESULTTAB
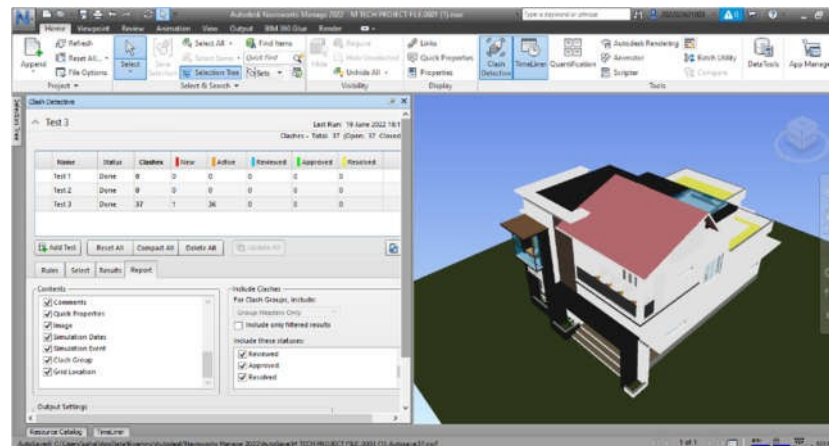
Figure8.CLASHDETECTIVESHOWINGTHE'REPORT'TAB

In this project, total of 12 clashes are detected in this clash test. Each of theclashes are reviewed and resolved by using element ID exported into clashreport.TheclashassignedarevisibleononceopenitandpastetheelementIDin'S elect by ID' tab in Revit. To locate each conflict, you may choose it, and youcanalsonameeachoneseparately.Thecorrectedfileisproducedin'nwf'formatfro m Revit Architecture. After making the adjustments, Navisworks is openedoncemoretolookforconflicts.BothatextfileandanHTMLfilemaybeexportedfr omtheconflictreport.

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4.4 Developmentof5DBIM

5DBIMisusedtocreateavirtualmodelofabuildingorinfrastructureprojectthatincludesi nformationaboutthetimeandcostofconstruction.Thedevelopmentof5D BIM was a natural progression from the earlier versions of BIM. As the use ofBIMbecamemorewidespread,stakeholdersintheconstructionindustrybegantorec ognizethepotentialforaddingtimeandcostinformationtothemodel.Thisledtothedevel opmentof5DBIM,whichallowsstakeholderstosimulatetheconstruction process and estimate the cost of the project before constructionbegins(Hamledarietal.,2018).

To develop a 5D BIM model, the construction schedule and cost estimate areintegrated into the 3D BIM model. The model is then used to simulate theconstructionprocess,allowingstakeholderstoidentifypotentialissuesandconflict s before construction begins. This helps to reduce delays, change orders,and cost overruns during construction (Bakhshi et al., 2018).. The use of 5D BIMhasmanybenefitsforstakeholdersin

theconstructionindustry.Ithelpstoimprovecommunicationandcollaborationbetwee ndifferentstakeholders,reduces errors and rework during construction, and helps to ensure that projectsare delivered on time and within budget. It also helps to improve the quality ofconstruction, as stakeholders can identify and resolve issues before constructionbegins(Bakhshiet al.,2018,Kulkarni&Kamdi,2021).

In summary, the development of 5D BIM has been an important step in theevolution of BIM, as it has added the element of time and cost to the model. 5DBIM is a powerful tool that can help stakeholders in the construction industry toplanandmanageconstructionprojectsmoreeffectively,resultingincostsavings,imp rovedquality,andbetterproject outcomes.

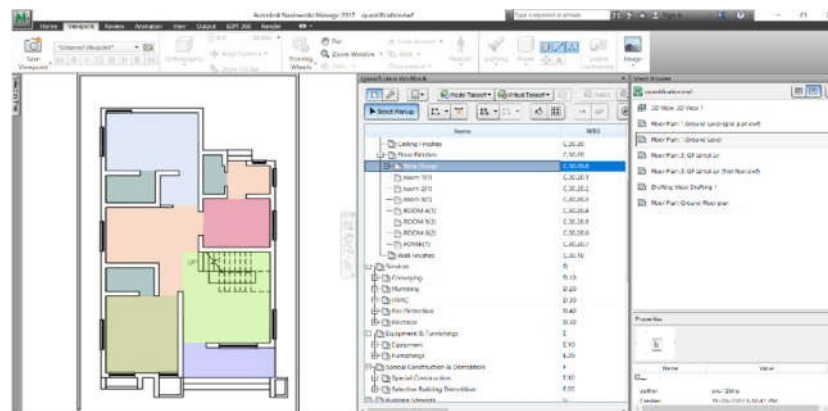**Figure9.QUANTIFICATIONUSINGNAVISWORKS**

4.5 Developmentof6DBIM

6D BIM is an extension of 5D BIM that adds the element of sustainability andlifecycle management to the model. It is also known as "BIM with Sustainability"or "BIM for Facility Management". The development of 6D BIM was driven by theneed for a more sustainable approach to building design and construction.

Thegoalof6DBIMistoprovideacomprehensiveviewofthebuilding'slifecycle,fromdes ignandconstructiontooperationandmaintenance,andultimately,decommissioning.

To develop a 6D BIM model, the 5D BIM model is further enhanced with data onthebuilding'senergyconsumption,waterusage,andotherenvironmentalfactors.T his information is used to assess the building's sustainability and to identifyopportunities for energy and resource savings. The use of 6D BIM has manybenefitsforbuildingownersandoperators.Ithelpstooptimizebuildingperforman ce and reduce operating costs by identifying areas for energy andresourcesavings(Wangetal.,2022;Shin&Park,2023).Italsohelpstoimprovethe building's overall sustainability and environmental impact, which is becomingincreasingly important as the construction industry strives to reduce its carbonfootprint.

Inaddition,6DBIMcanbeusedtoimprovethemaintenanceandoperationofthebuilding by providing accurate and up-to-date information about the building'ssystems and components (Chen et al., 2023). This information can be used toschedulemaintenancetasks,orderreplacementparts,andplanforfutureupgrades.

In summary, the development of 6D BIM has been an important step in theevolution of BIM, as it has added the element of sustainability and lifecyclemanagement to the model. 6D BIM is a powerful tool that can help buildingowners and operators to optimize building performance, reduce operating costs,andimprovethebuilding'soverallsustainabilityandenvironmentalimpact.

4.6 7DBIM

7D BIM is an extension of 6D BIM that adds the element of operational andfacility management to the model. It is also known as "BIM with Operations andMaintenance" or "BIM for Asset Management". The development of 7D BIM wasdriven by the need to improve the management and maintenance of buildingassetsovertheirentirelifecycle.Thegoalof7DBIMistoprovideacomprehensiv e view of the building's lifecycle, from design and construction tooperation, maintenance, and ultimately, decommissioning. To develop a 7D BIMmodel,the6DBIMmodelisfurtherenhancedwithdataonthebuilding'soperational andmaintenanceactivities.Thisincludesinformationonassetcondition,equipmentm aintenanceschedules,andrepairhistory.Thisinformationis used to develop a comprehensive asset management plan that supports thebuilding'slong-termoperationandmaintenance.

The use of 7D BIM has many benefits for building owners and operators. It helpsto optimize building performance and reduce operating costs by providing acompleteviewofassetconditionandmaintenanceneeds.It alsohelpstoextend

the useful life of building assets, reducing the need for costly replacements. Inaddition,7DBIMcanbeusedtoimprovetheplanningandexecutionofmaintenanceactivitiesbyprovidingaccurateandup-to-dateinformationaboutthebuilding's systems and components. This information can be used to schedulemaintenance tasks, order replacement parts, and plan for future upgrades(Salvietal.,2022).

In summary, the development of 7D BIM has been an important step in theevolutionofBIM,asithasaddedtheelementofoperationalandfacilitymanagement to the model. 7D BIM is a powerful tool that can help buildingowners and operators to optimize building performance, reduce operating costs,andextendtheusefullifeofbuildingassets.

5. RESULTANDDISCUSSION

5.1   DESIGNCONFLICTDETECTIONRESULTS

In this study there are 12 clashes are detected by conducting the clash detectiontest. Each clash was grouped by category and resolved by using element ID ofthat clashing member. These element ID was copied from the clash report andthat ID was pasted in the Revit to locate the member where the clash wasoccurred,finallyitisresolvedbychangingtheelements,whichisshowninFigure10, clashpointsanddisplacementsaregiveninTable1.
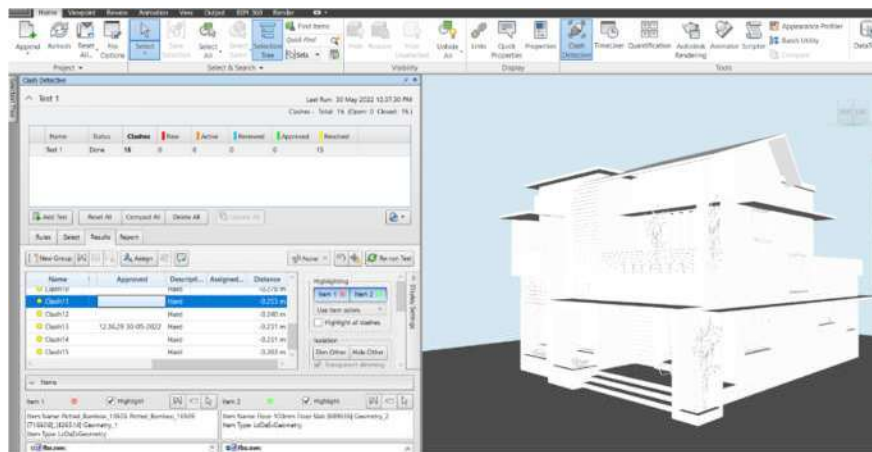

**Figure10.RESOLVEDCLASHDETECTIONRESULT**

Table1CLASHPOINTSANDDISPLACEMENTS

No	Clashes	Displacementinmeter
1	WallvsSunshade	0.469
2	ColumnvsSunshade	0.300
3	WallvsRoof	0.278

4	FloorvsStep	0.160
5	RoofvsWall	0.210
6	FloorvsColumn	0.150
7	WallvsRail	0.180
8	RoofvsWall	0.320
9	RailvsWall	0.230
10	StairvsRail	0.364
11	WallvsFloor	0.180
12	FloorvsDoor	0.120

The Quantity take off details for structural elements and construction materialslike bricks, cement, and sand has been calculated and the quantity units werecompared in materials wise are shown in Figure11. As a result it helps to reducethematerialconsumptionandwastages.
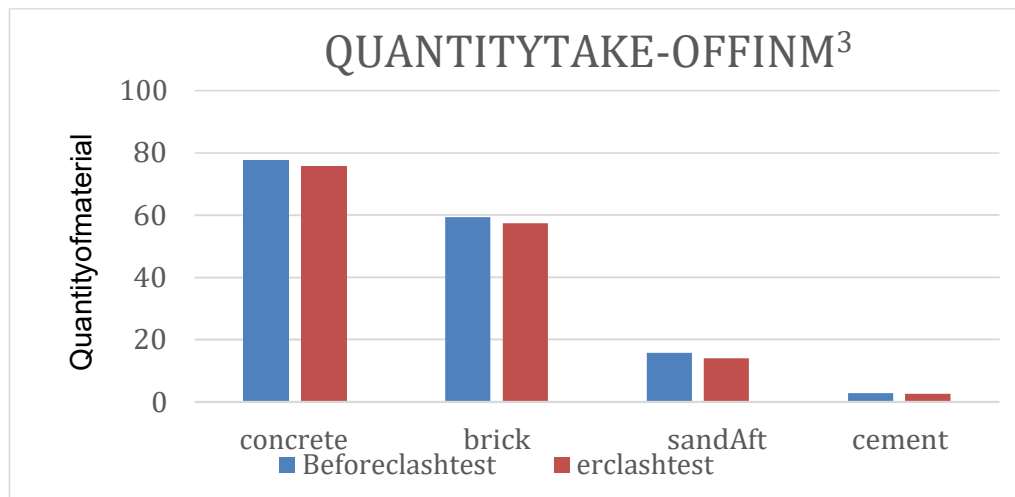
Figure11.COMPARISONCHARTOFQUANTITYTAKEOFFOFMATERIALS

5.2 SCHEDULINGUSINGBIM

By proper scheduling using BIM it is found that there is saving of duration of theproject by 40 days which was about 20 percentage of the actual duration of theproject. Scheduling is given in Figure12. Activities using start to start relationshipisshowninTable2.
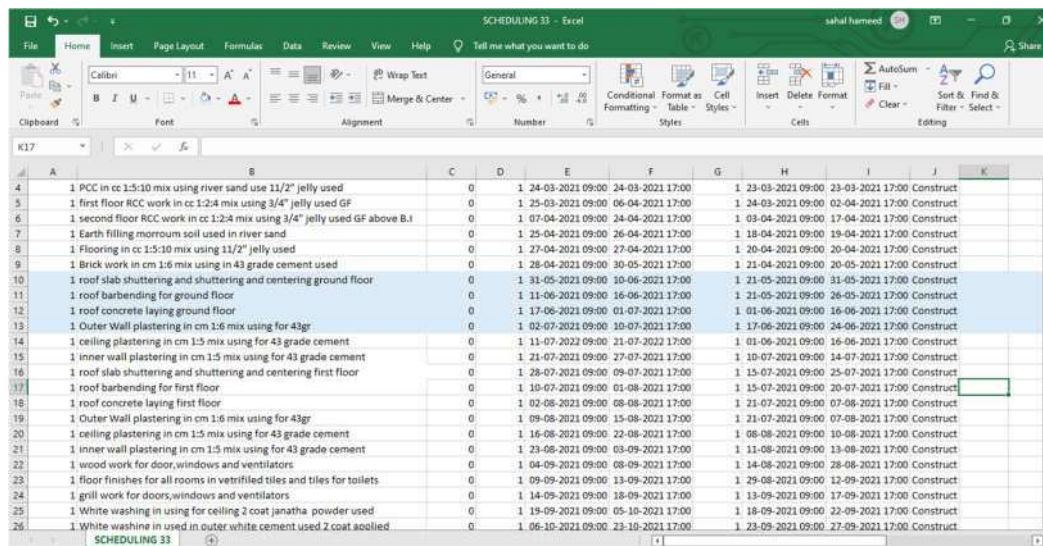
Figure12.SCHEDULINGEXPORTEDTOEXCEL

Table2ACTIVITIESUSINGSTARTTOSTARTRELATIONSHIP

Activity code	Activityname	Actualduration ofconstruction (Days)	Activitiesusingstarttostartrelationship (Days)	Time saved(Days)
(a)	Roofslabshutteringandcenteringofgroundfloor	10	(a)➔(b)	10
(b)	Barbending of roof slabgroundfloor	10		
(c)	Roof slab concretelaying groundfloor	15	(c)➔(d)	10
(d)	Outerwallplastering Groundfloor	10		
(e)	Roofslabshutteringandcenteringoffirst floor	10	(e)➔(f)	10
(f)	Barbending of roof slabfirstfloor	10		
(g)	Roof slab concretelaying offirstfloor	15	(g)➔(h)	10
(h)	Outerwallplastering Firstfloor	10		
Total				40

5.3 QUANTIFICATIONANDESTIMATIONRESULTS

Inthisprojecttheactualcostofconstructionwasabout3250000rupees,whilebyestimating the cost using BIM it is found that the total cost of construction wasabout3000000rupees,byreducingthedurationoftheprojectby40dayshere

the labour charge of 40 days work was saved which is 320000 rupees, which isshown in table 5.3, these labour charges are major reason for the cost overrun.By estimating using BIM it was comes to know that there is a saving of 320000rupeeswhichisabout10percentageoftheactualcostofconstruction(Ziyuetal., 2019).

5.4 ENERGYEVALUATIONRESULTS

For the analysis we need divide the whole building into different zones by usingspacers. By giving materials which are less heat absorbing for construction willreducetheoverallenergyconsumption.Themajortypematerialswhichareusedin construction of walls in buildings, their heat transfer coefficient and thermalresistancearegivenbelowin Table3.

Table3.HEATPROPERTIESOFWALLMATERIALS

Material	Heat TransferCoefficient (HTC)in(W/m^2.K)	ThermalResi stancein(m^2. K/W)
Concretemasonry	0.3815	2.6212
Commonbrick	2.5116	0,3981
Metalsheetingrails	0.1895	5.2757
Concretecastin-situ	3.4867	0.2868
Infiltrationbarriers	0.7698	1.2990

Byanalyzingthisresidentialbuildingitisfoundthattotalannualenergyconsumption is about 48,024 Kw-h, from this 40,194 kw-h is used for cooling,3,361 kw-h is used for interior lighting and 4,369 kw-h is used inter equipmentandthemonthlyenergyconsumption.

5.5 OPERATIONOFFACILITYMANAGEMENT

Itisthe7thdimensionalanalysisoftheproject,facilitymanagementiscompletely data based approach, here we can give the complete data of all theelectricalitems,thebathroomaccessories,electricalequipmentandotherinstallati ons by giving these details it will get saved on the that model data base.By doing facility management here the complete quantity takeoff and estimate ofpipes and scheduling of the plumbing fixture are done. Details of the accessoriesaregivenintheFigure13.
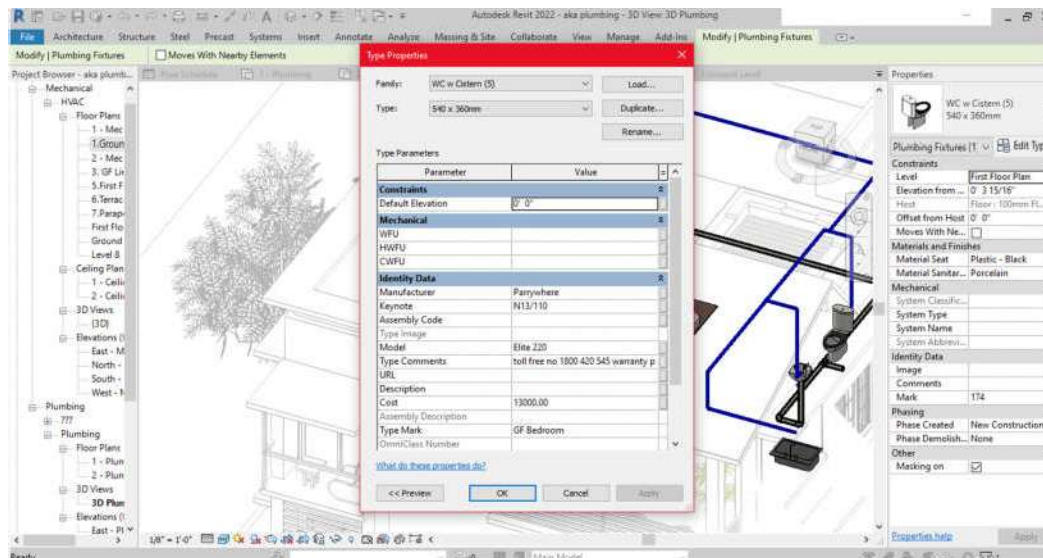
Figure13.DETAILSOFPLUMBINGACCESSORIES

6. CONCLUSION

4DBIMimprovestheabilitytomonitorandcontroltheconstructionandtotherebyidentify and resolve clashes more quickly, thereby reducing claims. 20 % of theduration of the project is saved in scheduling using BIM.10 % of the cost ofconstruction is also saved by using BIM for scheduling and cost estimation. Alltheclashesinthebuildingaredetectedandithelpedforsavingthematerialsandtime for construction, it made the design error free. Total energy consumption iscalculated and recommendation for reducing the energy consumption are given.Points for minimum lighting and maximum lighting are identified. Solar study ofthe building is done, interior lighting and sun orientation are analyzed. Position

ofventilationsaresuggested.Facilitymanagementfortoiletandkitchenaccessoriesar egiven.Operationalandmaintenancetimeissavedusingfacilitymanagement.Plumbi ngscheduleandplumbingfixturearedoneusingfacilitymanagement.

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