4D BIM modeling of Insulated Concrete Sandwich Panel Building

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Abstract

Unexpected disadvantages occur in construction industry due to deviation from planned schedule of a project. However, adjustment of these delays and deviation can be made by early assessment of the delays and deviation in the construction phase which is achieved by investigation of any possible delays and deviation that may occur and providing a planned schedule for the client. Adopting Building Information Modeling (BIM) in the construction industry can help in identifying and planning the different challenges faced by construction industry in phase of construction. This paper aims to develop BIM for the early planning, management and scheduling of construction of Concrete insulated sandwich panel building to avoid the wastage of time and resources during the construction phase. 3D model of Concrete insulated sandwich panel building is created in Autodesk Revit and the model is linked with MS Project scheduling using Naviswork Manage. 4D BIM modeling of the model is carried out which helps in identifying delays and reduce sequencing and delays problems.

Keywords: BIM, Resource management, Revit, Naviswork, MS Project, Sequencing, Planning.

1. BACKGROUND AND HISTORY

The demand for housing and industrial building all around the world in construction industry is increasing with time. These increasing demands is affecting the building material and the price to complete these constructions. These demands have given rise to the need of developing new construction methods and products. Researcher have worked continually to develop new products and material which has no effect on the environment and are considered to be sustainable. Sandwich panel is one of the products of the research which is being used in building construction since 1960s (Choi W et al. 2019).

Sandwich panel is a structural product consist of three layers, inner thick insulated Thermal core and two thin structural layers bonded to each side of insulted core. It can be differentiated from other structural product by various characteristic e.g. thermal insulation, light weight, high stiffness, water proof, high strength and ability to be modeled in different shapes and geometry. Due to these characteristics composite sandwich panel are increasingly considered in civil engineering structures. Also, Sandwich panel offer high flexibility, both in term of different constituent of material and geometry arrangement. To study the behavior of the sandwich panel researcher have performed various experimental and numerical studies.

Yury Solyaev et al. (2019) measured the thermal and mechanical performance of the foam-filled sandwich panel by studying sandwich panel models resting on elastic foundation. They find a new procedure of solution for stability of panel element under compression considering that the foam-filled is reinforced. They introduced Winkler moduli to describe the effect of foundation stiffness on the foam parameters. M Garrido et al. (2019) used Direct MultiSearch method to optimize the sandwich panel system for rehabilitation of building floors. The architectural model of sandwich panel was defined by them using 3 geometric variables, 8 objective functions and 14 variables related to material and concluded that for better performance high density and stiffer material should be used in the panels. H.R Tabatabaiefar et al. (2017) studies experimentally the mechanical properties of the sandwich panel whose inner core is constituent of mixed cement and polystyrene and outer layer is made of thin cement and find out the elastic modulus value and ultimate strength of sandwich panel in saturated and dry conditions and conclude that saturating the sandwich panel will reduce its total strength by 28% of its dry condition strength.

This paper presents the implementation of Building Information Modeling in the Construction of Concrete insulated sandwich panel building. BIM (Building Information Modeling) is a process of digital representation of physical and functional characteristic of a system. Traditional building design were mostly based on 2D drawings and 3D modeling but Building Information Modeling extends this beyond 3rd dimension. 4D BIM modeling of the building is achieved by using three different softwares, Revit, Navisworks and MS Project.

2. BIM TOOLS

The use of BIM had significantly increased in the field of design and construction. To solve different engineering challenges many construction companies especially AEC (architecture, engineering, construction) industry are using Building information modeling (BIM) software. BIM software not only fulfill design requirement but it also helps us in construction management. It is not only limited to 3D modeling but also include 4D (Time),5D(cost) and 6D

(Sustainability), 7D (Facility Management/ Operation and Maintenance). Using BIM more work can be carried out with smaller team, greater speed and high quality. BIM provide extensive information about complex structure, detect and solve errors before it occurs on the implementation stage. BIM tools help us to detect possible issues without wasting time and money. Most of the BIM products is built by Autodesk company like Navisworks, Infraworks, Revit etc.

Architectural, Engineering and Construction (AEC) industry has implemented 4D BIM in bunch of mega and small project and concluded positive effect of BIM on the construction. In 2013, BIM was implemented for the sustainable construction of the NeoBuild Innovation center (NIC) in Luxembourg. The building was designed to support research activities related to construction. 4D BIM modeling was implemented for sequencing issues and clash detection in early design stage of the building. HARBOR center is multi use building located in New York. In the construction of this center 4D synchro model was developed in its early design stage. The synchro model was aligned to the weekly schedule of the construction.

3. REVIT FAMILY

Revit is BIM software which has different features for architectural design, construction, structural Engineering and MEP (Mechanical, Electrical and Plumbing). Revit offers libraries of already made object that can be used in Modeling. All the elements that are add to Revit project are created with the help of families. All of these elements have different geometric, physical and thermal properties. There are two types of families use for modeling in Revit. System family and loadable family. system family are the build in family that cannot be created in, deleted from, loaded into, or saved out of the current project these are the predefined families. e.g. walls, roof, floors, stairs etc. loadable families can be created in Revit family builder or loaded in to the project from external source e.g. Doors, Windows, Columns.

4. METHODOLOGY

4.1 Concrete Insulated Sandwich Panel Family Creation

In order to create the section or basic element having properties of concrete insulated sandwich panel, the concept of composite section is used in Revit by creating family for wall and floor which consist of three layers, the middle layer is insulated thick thermal layer of thickness 4 inches and physical and thermal properties of insulation material Polystyrene are assigned to it from the material library. The outer layers are thin structure layers of thickness 2.5 inches each and structure material of Concrete of strength 3.5 ksi is assigned to them as shown in Figure (1).

Layers

EXTERIOR SIDE

	Function	Material	Thickness
1	**Core Boundary**	**Layers Above Wrap**	**0' 0"**
2	Structure [1]	Concrete	0' 2 1/2"
3	Thermal/Air Layer [3]	Polystyrene	0' 4"
4	Structure [1]	Concrete	0' 2 1/2"
5	**Core Boundary**	**Layers Below Wrap**	**0' 0"**

INTERIOR SIDE

Figure 1: Concrete Insulated Sandwich Panel Layers

4.2 Modeling in Autodesk Revit

BIM modeling of double story residential building for this paper is carried out in the Autodesk Revit 2017 using Concrete insulated sandwich panel in the walls, slabs and floors of the building. Revit automatically generate 3D view of a building when its 2D plan is drawn. Figure (2) shows 3D view of the building generated by Revit from 2D plane.

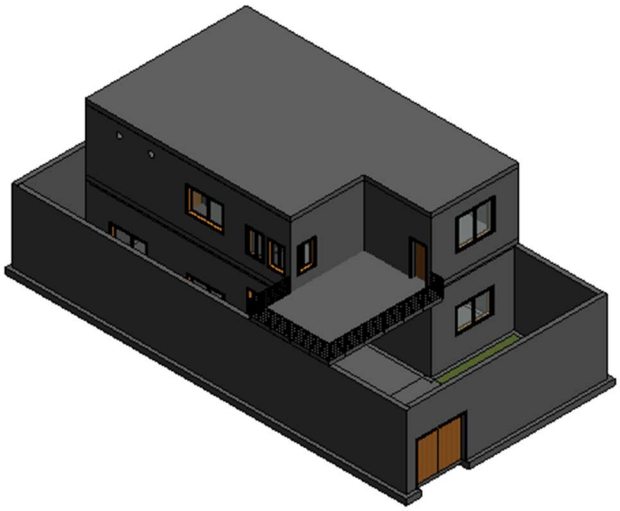

Figure 2: 3D view of Concrete Insulated Sandwich Panel Building

Elevation view of the building is also automatically generated in Revit and using the elevation view the height of different levels can be changed by dragging the level line or by changing its elevation value which will change the height of the objects attached to that specific level. Levels detail i.e. the height of single story and overall building are shown in Figure (3).

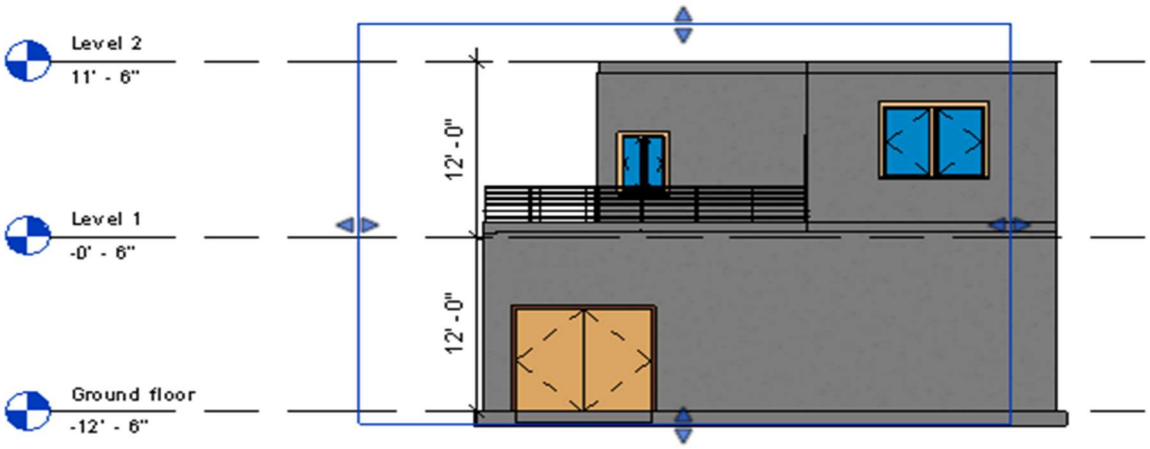

Figure 3: Elevation View of Residential Building

4.3 Linking with MS project

After 3D modeling of the sandwich panel building. Planning and resource management of that building is carried out in MS Project. Estimated duration and various requires resources are assigned to the different tasks and its scheduling is carried out to obtain its Gantt Chart as shown in Figure (4) and (5).

Task Mode	Task Name	Duration	Start	Finish	Predecessors
	Foundation	5 days?	Tue 23/04/19	Mon 29/04/1	
	GF-Sandwich Panel Wall	8 days?	Tue 30/04/19	Thu 09/05/19	2
	Stairs	4 days?	Fri 10/05/19	Wed 15/05/1	3
	GF-Sandwich Panel Slab	2 days?	Thu 16/05/19	Fri 17/05/19	4,3
	1F-Sandwich Panel Wall	9 days?	Mon 20/05/19	Thu 30/05/19	5
	1F-Sandwich Panel Slab	3 days?	Fri 31/05/19	Tue 04/06/19	6
	Floors	4 days?	Mon 20/05/1	Thu 23/05/19	5,3
	Windows	5 days?	Fri 31/05/19	Thu 06/06/19	6,3
	Doors	5 days?	Fri 31/05/19	Thu 06/06/19	6,3
	Boundry Wall	2 days?	Tue 23/04/19	Wed 24/04/1	

Figure 4: Building Tasks in MS Project

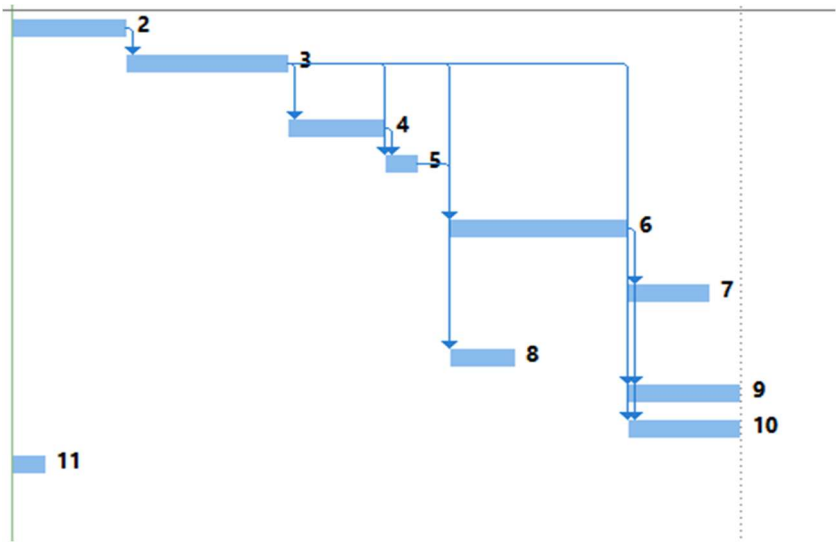

Figure 5: Gantt Chart for Sandwich Panel Building

Navisworks Manage is used as a medium for linking the 3D model and the planning in MS Project. First the 3D model from Revit is inserted to the Naviswork then MS project scheduling is inserted into the Naviswork Manage using Timeliner Feature. Components of the model are attached to its corresponding task which able the model for 4D simulation which give rise to the sequence of building of the model

5. RESULT AND DISCUSSION:

After linking of the model and its planning in MS project. The 4D simulation is run to develop animation which represent the construction work which is in progress or finished by change in visual behavior of the building model. The light green color represents the initial stage of construction of specific building component while the color changes to its material color when the construction of that component is complete i.e. at final stage. These colors can be assigned to every element of the building differently by creating new category of visual behavior for the component. Figure (6) and (7) shows the initial and final stage of the building components construction by light green color and material own color respectively.

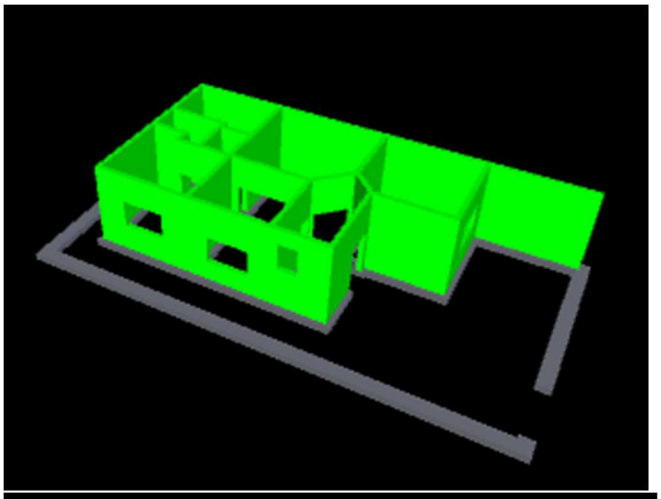

Figure 6: 4D simulation of Ground Floor

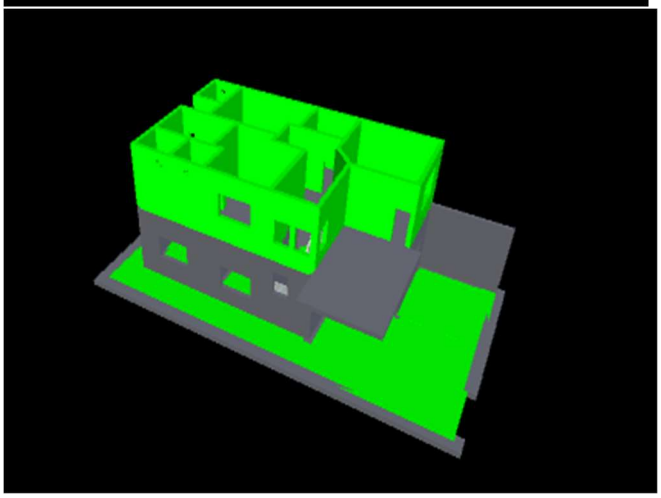

Figure 7: 4D simulation of 1st floor

6. CONCLUSION AND RECOMMENDATION

Once the model components and the scheduling are linked the advantages of 4D BIM are realized that it helps in Understanding the construction work flow through visual medium. Construction work flow consists of major activities such as Foundation construction, wall construction, slab construction etc.

It is concluded that 4D BIM visualize safety by identifying the shortcoming and by detection of possible delays that may happen during construction phase.

It is concluded that the real benefits of the 4D BIM modelling will not be obtained until the model is authored in coordination of project planning activities.

The significant weakness of the Naviswork was identified that its visualization time scale count is one calendar day which is too long time for simple residential building construction.

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