Introduction

1.1 Background

Building Information Modeling (BIM) is one of the most promising developments in the architecture, engineering, and construction (AEC) industries. With BIM technology, one or more accurate virtual models of a building are constructed digitally. They support design through its phases, allowing better analysis and control than manual processes. When completed, these computer-generated models contain precise geometry and data needed to support the construction, fabrication, and procurement activities through which the building is realized. BIM also accommodates many of the functions needed to model the lifecycle of a building, providing the basis for new design and construction capabilities and changes in the roles and relationships among a project team. When adopted well, BIM facilitates a more integrated design and construction process that results in better quality buildings at lower cost and reduced project duration [1].

A strong need for a comprehensive tool which allows architects, engineers and contractors to simulate and visualize construction sequences as part of an interactive experience is arise. The 4D model provides the basis for a common language between all parties and a representation of the schedule itself [2].

Gantt chart technique for project planning has a long been popular technique, but it lack something to be desired when it comes to visualizing a project timeline, 4D model is the solution to it [3].

4D model is a 3D model attached to fourth dimension of time via a schedule, through the concept of 4D scheduling has been around over 20 years, it has not been popular due to some technical challenges associated with it. The continuous advancement in technology and emergence of building information modeling (BIM) has removed all challenges associated with 4D scheduling. With the

increasing success of BIM in the realm of designs, the adoption of 4D modeling is becoming the norm today [4].

1.2 Research Importance

The importance of developing a 4D model and reliable work plan has long been recognized by the industry. However, numerous construction projects are still plagued by delays and cost overruns, which can frequently be traced to ineffective identification and treatment of problems. First, when a construction method is not properly identified during scheduling, subsequent problems in the field are inevitable. Today's projects are becoming more and more technically complex and logistically challenging, which exposes construction operations to even more complex in the way of identification between stakeholders.

1.3 Problem Statement

The traditional scheduling methods, bar charts and Critical Path Method (CPM) which are widely used as a planning method, greatly limit our capability in modeling and resolving constraints during look-ahead scheduling [5].

These methods have long been blamed for their limitations in modeling and communicating between stakeholders. Thus, there is a need for a better understanding of constraints and conflicts in construction and a structured approach in identifying and modeling the schedule to ensure a constraint-free work plan, additionally to help a group of non-technical stakeholders visualize the scope of design, construction, safety and risk assessment in addition to the phasing of the total building program being funded [6].

1.4 Research Objectives

The aim of the current study is to assess the potential impact of adapting 4D modeling in the (AEC) industry in Sudan, with this context the objectives of the study were:

1. To gauge the level of awareness and understanding of the industry participates regarding the BIM and 4D modeling basics.

2. To determine the extent of use of the relevant software that supports the adapting of the concept of “BIM-4D” in the construction industry in Sudan.

3. To present an exercised model that can overcome the limitations of using traditional scheduling methods (bar charts, CPM) and Insure a group of stakeholders visualize the scope of design, construction method, safety and risk assessment.

The result of this study will be valuable to the industry practitioners in developing better practice and tools for construction management and look-ahead scheduling.

1.5 Research Methodology

The research methodology was two folds; first one a survey of the industry to gauge the understanding of the industry participants regarding the BIM & 4D modeling, the second fold was application through a real example to prove the potential benefits of moving from 2D & 3D scheduling to 4D scheduling.

Literature Review

2.1 Introduction:

The goals for a construction project will generally reflect the needs and wishes of the owner, since most building projects are initiated by an individual, a group of persons (company or organization), or a community. It is the task of the project team, the group of individuals working on the project, to understand and interpret these goals for the owner. The primary goal of all construction project team members needs to be project related and to help the owner achieve her or his goals and business plan, i.e., to improve education, health care, factory productivity, etc. The secondary goals such as improving project quality, increasing construction efficiency (in time or cost of the construction), improving project safety, or reducing construction risks become team goals that can add value to the project for the owner [6].

The individual and collective goals of project team members need to harmonize, and not conflict with the overall owner's goals; this will require collaboration on the part of all team members and enable the ultimate success of the team.
The use of building information modeling (BIM) as a tool may help in achieving the team's project goals. An interesting characteristic of the BIM process is that it tends to make the management process more transparent. The successful use of the BIM process will require a different psychological approach than most of the building design and construction industry which accustomed to [6].

The efforts required to implement the building information modeling approach successfully will develop directly into its greatest benefits, those of improving the four basic concepts of human interaction shown in Figure 2.1.
This industry will not merely change because of software and technology alone; the necessity for change is far more fundamental. All the contributors to the

planning, design, and construction of a project have to collaborate and work together to be able to produce the desired improvements.
Figure 2.1 illustrates the basic concepts of human action and interaction: visualization, understanding, communication, and collaboration. It is clear that all four of these concepts are interactively connected and both generate and reinforce one another.

The diagram also suggests, e.g., that the alternative routes to gain understanding (of a given subject) can be approached through visualization, communication, or collaboration. Each of the four concepts reinforces the other three.

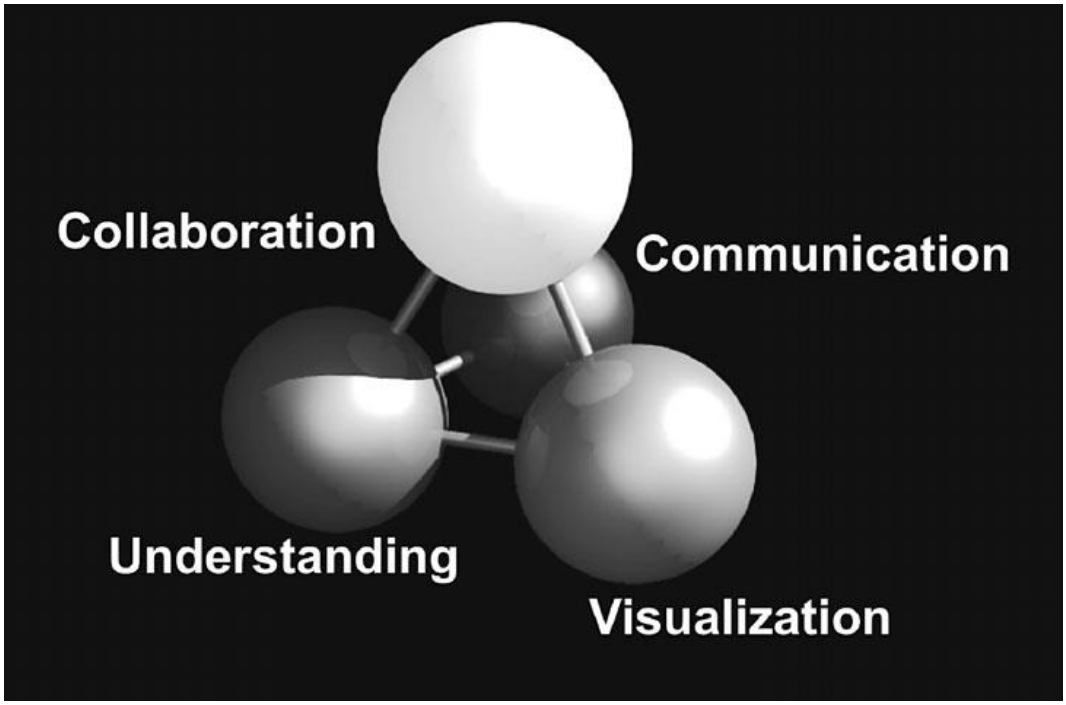


Figure 2.1: The interrelationship of the four concepts that form the basis for human action and interaction. [6]

2.2 History of project management and planning.

In 1917, one of the first fathers of project management, Henry Gantt, an American mechanical engineer created a scheduling diagram popularly called Gantt chart,

named after him. At that time it was a radical tool, and it became known worldwide in the 1920s. The Hoover Dam project, which started in 1931, was among the first beneficiaries of the Gantt chart. In fact, even until now. It has long been a popular technique for project planning.

In 1957, the Critical Path Method (CPM) was invented. Developed by the Dupont Corporation, CPM is used to estimate project duration and designed to address the complex method of shutting down as well as restarting chemical plants due to maintenance. The next year, the US Navy Special Projects Office designed PERT (Program Evaluation Review Technique) during the cold war. PERT is a method for analyzing the tasks involved in completing a project, especially the time needed to complete each task and identifying the minimum time needed to complete the total project.

Another milestone happened in 1962, when the United States Department of Defense created and mandated the Work Breakdown Structure (WBS) Approach for its projects. The WBS was later adopted by private enterprise businesses and remains a common project management tool.

In 1964, the first project management associated in the world, the International Project Management Association, was founded in Vienna. At present is has 120,000 members all over the world. Five years later, the Project Management Institute was launched as a nonprofit professional organization for the advancement of the profession, science, and practice of project management.

The rapid evolution and progress of computer technology resulted in the growth of some project management software businesses such as Oracle (1977), Artemis (1977), and Scitor Corporation (1979).

The modern history of project management software really took off in the Eighties and Nineties, when the information management sectors grew in leaps and bounds, especially with the advent of the personal computer and networking facilities. This

growth resulted in low-cost PCs that can do multi-tasking and efficiently managing complex project schedules. This allowed for the growth of project management techniques as well as software programs.

Examples of big projects done during this rapid growth of information technology include the England-France Channel project and the Space Shuttle Challenger project.

The rise of the Internet as well as related online developments led to the explosion of radical business practice ideas in the mid-1990s. The Internet has allowed people to instantly browse, track, and purchase products and services, resulting in making companies more efficient, productive, and client-oriented. Moreover, the Internet will be considered a major milestone in the history of project management software for allowing many software packages to have an Internet connectivity function.

But after all this methods lacks something to be desired when it comes to visualizing a project timeline. 4D model is the solution to it. 4D model is a 3D CAD model attached to the fourth dimension of time via a schedule.

With the information technology and project management evolving more than ever, expect the review of history of project management software in the future will be marked with even bigger challenges and the demand for increased speed-to-market when it comes to products and services [7].

2.3 History of 2D Drawing and its limitations.

Numerous standards have evolved with the development of construction drawings and specifications over the past few centuries. These two-dimensional (2D) drawings and written instructions, which allow a contractor to build what the owner, architect, and consultants have visualized, are the current “state of the industry.” Nevertheless they can also be the source of great misunderstanding, and

most persons involved in building construction will agree that the use of only drawings and specifications is an imperfect method of planning and building contemporary complex projects. The use of 2D instructions in a 3D world requires multiple translations, from the original conceptual visualization in the designer's head to all other persons who need to use, add to, or refine the documents. A 2D document (drawing) is used to communicate each exchange of information between persons; this 2D communication results in a 3D visualization with each transaction, and thus each step requires a translation in someone's head, until the resulting instructions finally need to be visualized correctly by the person constructing the project. These transitions between persons may let oversights and errors go undetected until it is too late to address them effectively.

Construction is almost always site-specific and rarely performed by the exact same project team. These variables complicate the preparations for a project and can create substantial challenges for the project team. A certain amount of learning needs to take place among the project team to establish working processes that take into account the specific project and the personal qualities of its team members. The repetitive nature of the information in a drawing set is another source of errors. The organization of the drawings for large projects can be complex, and as a project develops, it is likely that some of the changes are not "picked up" in all places affected in the documents.

Complex projects generally need to be documented by a large team of drafters and specifiers; they have the daunting task of visualizing and providing construction details for what the designers have in mind, and the builders have to realize. These characteristics of documentation are clearly a challenge to the communication skills of all the project team members.

With the advent of computers, many builders and designers saw their drafting load lightened because repetitive tasks could be automated. The essential nature of documentation did not change, however; the same drawings and specification paragraphs describing the project are still used. A light table (the backlight allows several layers of drawings on transparent paper to be overlaid and analyzed) is also still the primary tool to analyze interference between various building systems, using plan views where height is often difficult to discern. This process still leaves much to chance because it is a challenge to visualize the coordination properly, without the ability to verify it prior to the actual construction. Most construction projects thus have a large quantity of Requests for Information (RFIs) about the documents and a substantial amount of rework before all building components are coordinated during the actual construction.

It is difficult with a traditional construction documentation set to completely and accurately represent many of the complex structures built today.
In 2D drawings it is often the transitions between elements that are difficult to represent and easy to forget to design and document. An example is the transition between different cladding systems, particularly where special attention needs to be given to waterproofing.
It is often easy to imagine a project is represented completely without knowing what has been neglected, until the builder is ready to assemble it [1].

2.4- 4D Modeling

Though the concept of 4D scheduling has been around over 28 years, it has not been popular due to some technical challenges associated with it. The continuous advancement in technology and the emergence of Building Information Modeling (BIM) have removed all challenges associated with 4D scheduling. With the

increasing success of BIM in the realm of designs, the adoption of 4D modeling is becoming the norm today.

2.4.1- 4D Modeling Offers Significant Benefits over 3D Modeling:

4D model is a further development over 3D model. It challenges and changes many of the practices of conventional scheduling [8]. Some of the significant considerations are as follows:

- **Visualization of the Project:** 4D model enables the scheduler to view the entire construction site in a nutshell. The scheduler is able to move around, look outside, inside and under the building and verify the progress of project. It helps the scheduler to detect inconsistency and avoid visual incongruities in the representation.
- **Better Integration and Cost Estimation:**
  Integrating human resources, equipment and material resources with the BIM model, 4D scheduling helps to better schedule and cost estimate of the project. 4D BIM also monitors procurement status of project materials.
- **Conflict Detection and Resolution:** During design and construction phase, potential spatial conflicts may arise between building components. It is not easy to identify or predict these conflicts using 2D or 3D layouts, but 4D model identifies various issues related to space, schedule and sequencing, and resolve them ahead of the construction process.
- **Improved Time Management:** Integrated with BIM modeling, 4D scheduling helps the owner as well as project team to easily visualize time constraints and opportunities of improvement and investment in the project.
- **Maximization of Critical Resources:** 4D model allows the project team to evaluate various alternatives resources and scopes of work over a period of time to optimize the resources and labor accordingly.

2.4.2- 4D Project Planning with BIM

By adding the schedule date to the model components, project team improves the plan and integrates the communication among various divisions. With the progress of time, project team programmatically links schedule to BIM model to evaluate various construction options to make the optimum decision.

2.5 BIM planning

BIM project planning is based on fundamental BIM concepts and includes [9]

1. Determining the purpose for the BIM (set project and process goals).

2. Developing BIM specifications (choose processes, tools, and milestones for the work).

3. Developing implementation plan for the process (develop process strategies, select the team, and develop evaluation and adjustment methods).

The planning of a building information model is the preparation for the implementation of the BIM process.

The fundamental questions at this stage are as follows:

• What is the nature of the project?

• What is the nature of the project delivery method?

• What are the anticipated benefits of the simulation?

• What are the most critical anticipated difficulties (both project- and process-related)?

It is important to be explicit in defining all anticipated aspects of the project development, and to establish controls and methods for evaluating the results of the process.

The answers to these questions will become the basis for the specifications of the simulation; this is a critical and often underestimated aspect of this process!

It is tempting to focus on the more object-oriented (3D model), rather than the process oriented, aspects of the BIM specifications, even though it is ultimately the process that determines the requirements (characteristics) of the model objects. For example, if the exact size and location of concrete slab pours in a construction sequence is being studied, the slab sections will need to be modeled exactly as they are anticipated for the concrete pours, so that they can be properly represented in the construction sequence. This may require close collaboration between the modeler and the construction superintendent, and it could take several modeling sessions to optimize the pour sequence for the slab. If a cost estimate is desired, a deliberate choice of model components will have to be planned (with the appropriate level of detail) to represent the project in the cost estimate. In other words, it is more important to establish the various processes that need to be addressed first, before becoming distracted with the actual modeling itself.

The planning discussion is divided into three parts: first, the analysis of the purpose of the BIM, next, the development of the specifications required to achieve the desired results, and finally the implementation plan for the steps that are necessary to meet the chosen specifications [10].

Research Methodology

3.1 General:

The research methodology was two folds; first one a survey of the industry to gauge the understanding of the industry participants regarding the BIM & 4D modeling, the second fold was application through a real example to prove the potential benefits of moving from 2D & 3D scheduling to 4D scheduling.

There are various software programs dealing with BIM-4D concept like (Asta power project, Ceapoint, Synchro, Vico, Navisworks, etc.) the current study represent Navisworks manage as a tool of BIM-4D concept.

3.2 Research Contents:

A simple yet informative questionnaire was designed to be used as the main tool for data collection in the first part of the research. It comprised three parts: first part was general information about the participates, second part was general concept of BIM, and the third part was usage of (BIM) fourth dimension technique in construction projects at Sudan.

Questions were meant to be closed with a four point likest scale for respondent's feedback. The targeted participants included all the parties involved in the project

(A copy of the questionnaire is attached in appendix 2).

3.3 Sample Distribution:

After distribution and collection processes the returned questionnaires were 44 questionnaires by using Google Forms. The analysis and illustration the results of the data which was collected from the questionnaires, was done by using Google Forms also.

3.4 Autodesk Navisworks:

Over the years, the Navisworks interface has remained relatively unchanged until the 2011 release [11].

Autodesk introduced a new interface based on tabs and panels, all the while keeping some of the features from the previous versions.

With the Navisworks 2013 release, new tools have been added to take advantage of the native Revit files, Grid tools, and a new interface for the Clash Detective.

3.5 functions and tools of Navisworks [11]:

Navisworks software gives multi functions beside Adding fourth dimension (scope of study in this thesis) to the 3D model.

1. 4D Scheduling:

Simulate construction schedules and logistics in 4D to visually communicate and analyze project activities, and help reduce delays and sequencing problems.

The 4D scheduling features enable you to verify building or demolition viability by developing construction or demolition sequences that link model geometry to times and dates; import times, dates, and other task data from project management software to dynamically link schedules with project models; and set up planned and actual times to visualize deviations from the project schedule.

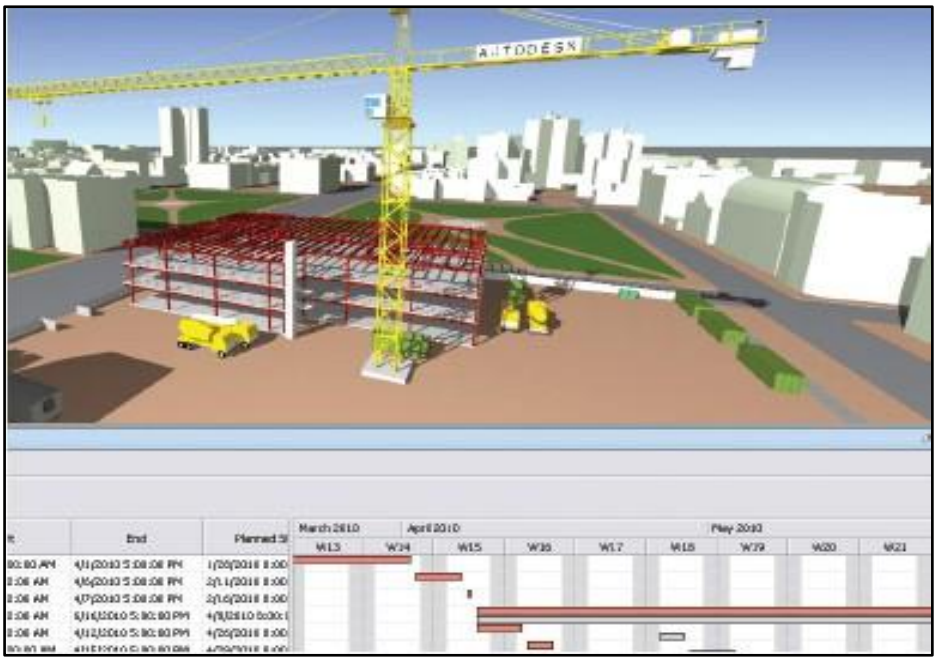


Figure 3.1: Simulate construction schedules.[11]

2. Collaboration Toolkit:

Communicate design intent and encourage teamwork with the ability to add markups to viewpoints with advanced redlining tools, comment on viewpoints with searchable notes, record animated walkthrough for real time playback, and stream large models and content, navigating the design as the model loads.

3. Clash and Interference Management:

Autodesk Navisworks Manage software provides the ability to manage and track clashes and interferences through to resolution. Reports of clash tests, including comments and screenshots, can be exported to communicate issues to the project team.

4. Clash and Interference Detection:

Anticipate and avoid potential problems before construction, reducing expensive delays and rework. Clash and interference detection features in Autodesk Navisworks Manage software enable user to perform clash tests against specified geometry to more easily find and resolve conflicts. Link clash tests to 4D simulations and object animations to analyze issues in space and time.

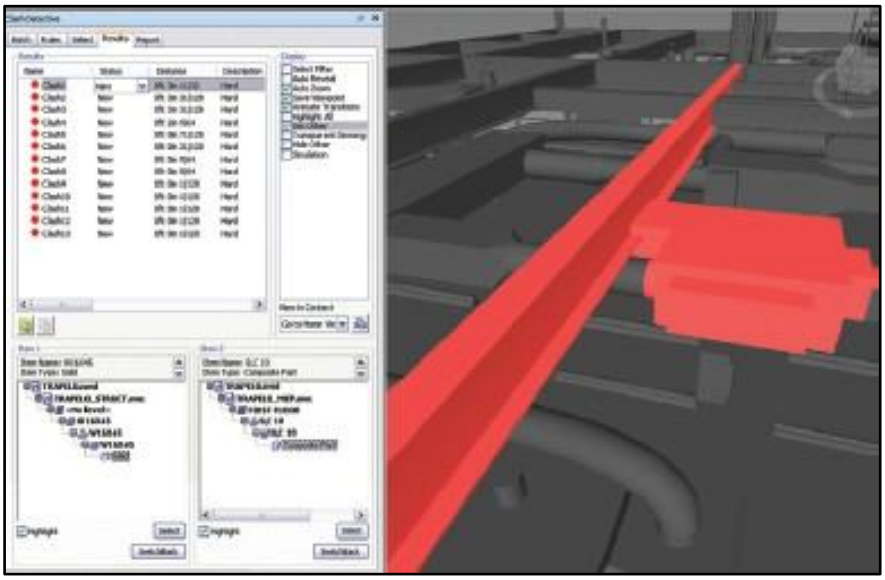


Figure 3.2: Clash Detection [11]

5. Object Animation:

The software's object animation features help you create animations of objects for clash and interference analysis. You can create interaction scripts that link animations to specific events, triggers, or key comments, and link animations to tasks in a 4D schedule for improved construction planning.

6. Photorealistic Visualization:

Use Autodesk Navisworks advanced visualization features to develop compelling 3D animations and imagery to present projects to stakeholders. Customize and configure every render aspect, including materials, lights, backgrounds, and rendering styles; use environment backgrounds to add real-world scenery; and choose from more than 1,000 built-in materials to create an accurate, photorealistic look.

Figure 3.3: Photorealistic visualization.[11]

7. Real Time Navigation:

Explore your integrated project model using advanced navigation tools that produce a realistic, real-time experience. Real-time navigation capabilities are included in all Autodesk Navisworks products.

8. Quantification: (from version Navisworks 2014)

Users can automatically make material estimates, labors cost plus indirect cost of projects estimate, measure areas and count building components.

3.6 The Products of Navisworks software:

The Autodesk Navisworks software family offers three products to provide project stakeholders with the right tools to help collaborate, coordinate, and communicate more effectively. Table 3.1 reviews the deference between three types.

- **Autodesk Navisworks Manage:**

Autodesk Navisworks Manage software is a comprehensive review solution for analysis, simulation, and coordination of project information. Multidisciplinary design data can be combined into a single integrated project model for interference management and clash detection.

Navisworks Manage helps design and construction professionals anticipate and avoid potential problems before construction. This is type of Navisworks software family chosen to be used in this research.

- **Autodesk Navisworks Simulate:**

Autodesk Navisworks Simulate software provides advanced tools for reviewing, analysis, simulation, and coordination of project information. Comprehensive 4D simulation, animation and photorealism capabilities enable the demonstration of design intent and simulation of construction to provide better insight and predictability. Real-time navigation combines with review toolsets to support collaboration among the project team.

- **Autodesk Navisworks Freedom:**

Autodesk Navisworks Freedom software is the free viewer for NWD and 3D DWF files. Navisworks Freedom extends the whole project view to all project stakeholders, helping to improve communication and collaboration.

Table (3.1): Deference between three products of Navisworks.[11]

	Autodesk Navisworks Manage	Autodesk Navisworks Simulate	Autodesk Navisworks Freedom
Project Viewing	●	●	●
Project Review	●	●	
Simulation and Analysis	●	●	
Coordination	●		

3.7 Navisworks file formats:

There are three types of Navisworks file formats:

- NWC: Exported files from CAD to Navisworks always saved as NWC, and NWC files are typically smaller than their original files.

- NWF: When we adding the time schedule to the model in Navisworks the new file saved as NWF file.
- NWD: This file content the geometry model with review markups, his space is larger than other files, separated from other files or original models and we can give it a password and specific period the file will not open after this period.

3.8 General features of Autodesk Navisworks:

(The source of all figures in section 3.7 from Navisworks manage 2014 software)
The land scape of Navisworks similar to other Autodesk software's land scape and this will be familiar with users those using some of Autodesk software's products. See figure 3.4.

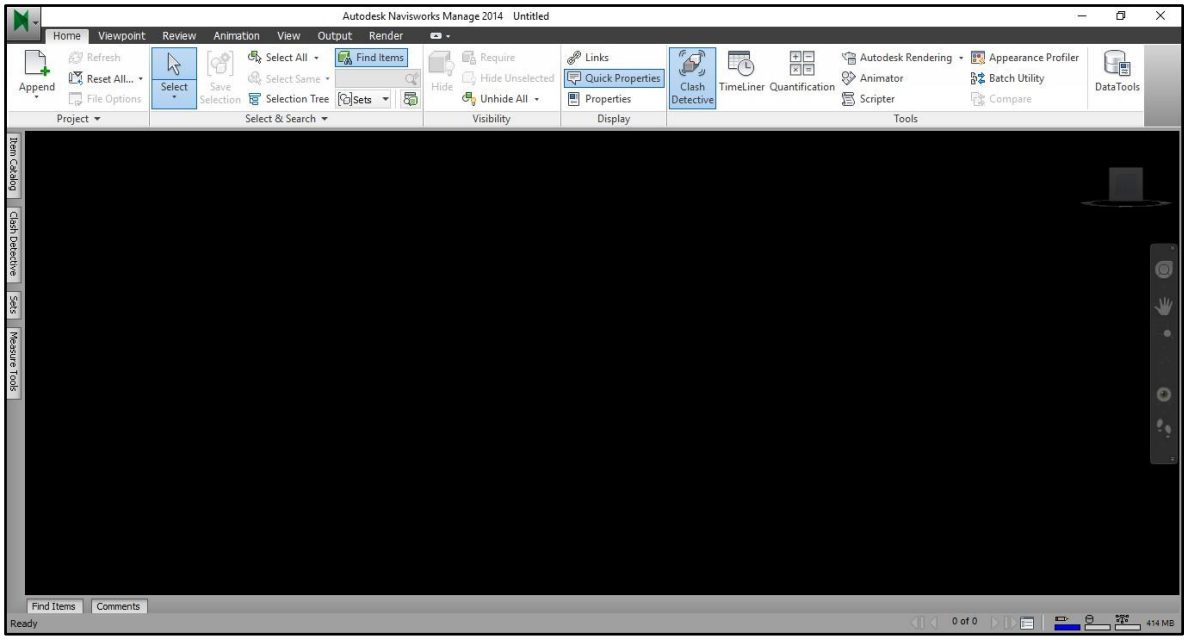


Figure 3.4: landscape of Navisworks Manage.

- **Application Menu: (The green N)**

A basic starting point within Navisworks, the Application menu, or green N, contains operations like New, Open, and Save. Several other useful operations that can be performed from here are shown in Figure 3.5.

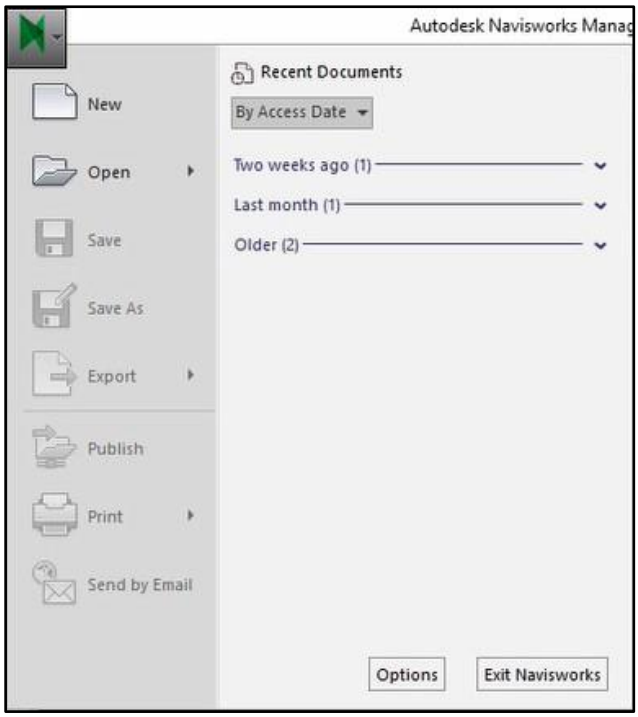


Figure 3.5: The green N, or Application menu

To preview the lists that included in "application menu" and there functions see appendix 1.

- **Quick Access Toolbar:**

The Quick Access toolbar, located adjacent to the Application menu, is a series of predefined operations. By default, you can find New, Open, Append, Merge, Save, Print, Refresh, Undo, and Redo.

The Quick Access toolbar is customizable. You can remove tools by right-clicking the item you wish to remove or by clicking the down arrow to the right of

the bar and clicking the option you wish to remove. You can add tools by selecting them from the tab and panel locations, right clicking, and then choosing Add to Quick Access Toolbar.

- **Tooltip:**

If you pause and hover your mouse cursor over any area in Navisworks, you get a tooltip, as shown here. Tooltips briefly explain the tool and may contain

information about shortcuts (such as pressing Ctrl+ A for Append). Also, if you leave your mouse in place a little longer, you will gain a longer explanation of the tool, the tooltip will expand into a definition from the help file.

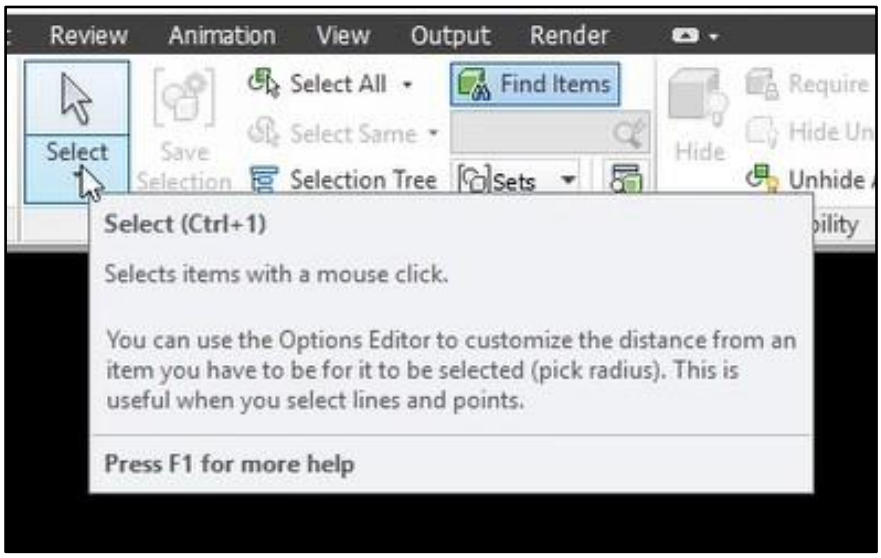


Figure 3.6 Tooltip

- **Navisworks Options:**

Options, or the Options Editor (sometimes referred to as Global Options), is used to adjust the program settings for Navisworks. The settings that you change here are retained across different Navisworks sessions. Settings can also be shared across a project team via the import/export feature (Figure 3.7).

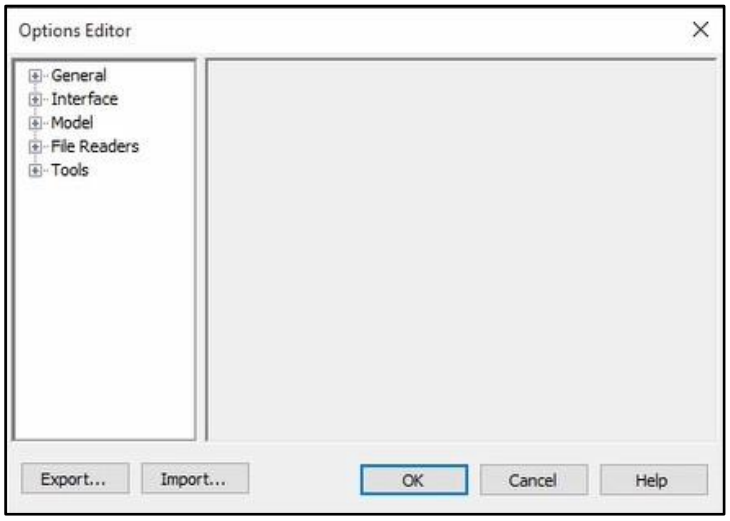


Figure 3.7 Options Editor

To preview the lists that included in "options editor" and there functions see appendix 1.

- **Exploring the Ribbon:**

The ribbon, located at the top of the user interface, is a palette that groups the entire Navisworks toolset into an easy to find and use location. The ribbon is divided into tabs, with each tab supporting a specific activity or task. Within each tab is a series of panels that contain the available tools.

While you are not able to add to or remove custom commands from the ribbon, you can customize the appearance and location of the panels using these methods:

- Right-click the tab or panel to open the context menu. From here, you can turn tabs or panels on or off.
- Left-click and hold a specific panel to move its location. You can change its location to a new place within the tab or drag it out into the workspace to make it more accessible. Panels may not be moved to other tabs.
- To reset the panel to its default position, right-click on an empty location on the panel and click Restore Default Ribbon.

Pushpins:

Any time a pushpin icon appears, you can click it to pin an item to the screen. This will allow the panel or palette to stay on top and remain open as you move to other tools in Navisworks.

Home:

The Home tab contains Project, Select & Search, Visibility, Display, and Tools panels (Figure 3.8 and Figure 3.9).

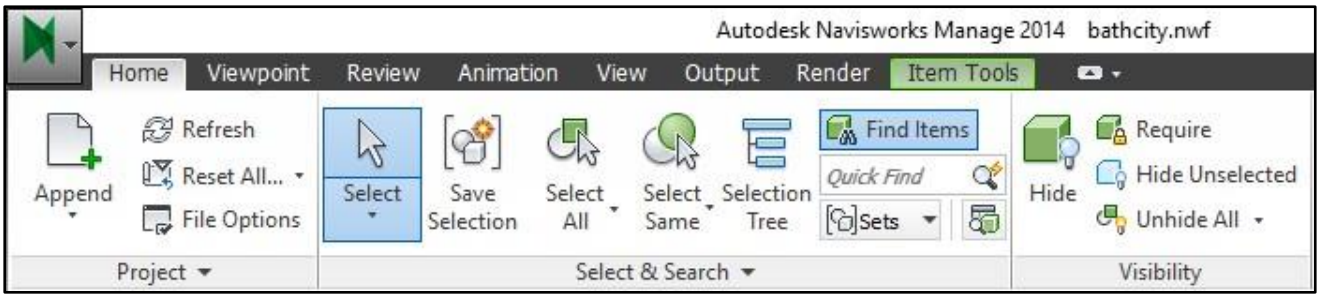


Figure 3.8 Home tab, showing additional tools enabled

To preview the panels that included in "Home" tab and there functions see appendix1.

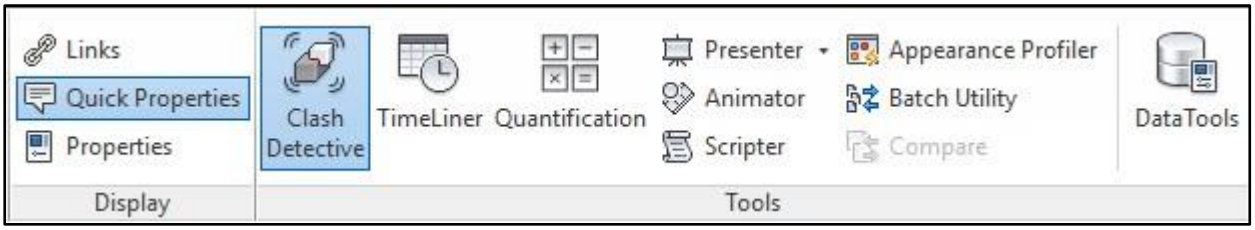


Figure 3.9 Home tab continued

Viewpoint:

The Viewpoint tab contains the Save, Load & Playback panel as well as the Camera, Navigate, Render Style, Sectioning, and Export panels (Figure 3.10 and Figure 3.11).

To preview the panels that included in "Home" tab and there functions see appendix1.

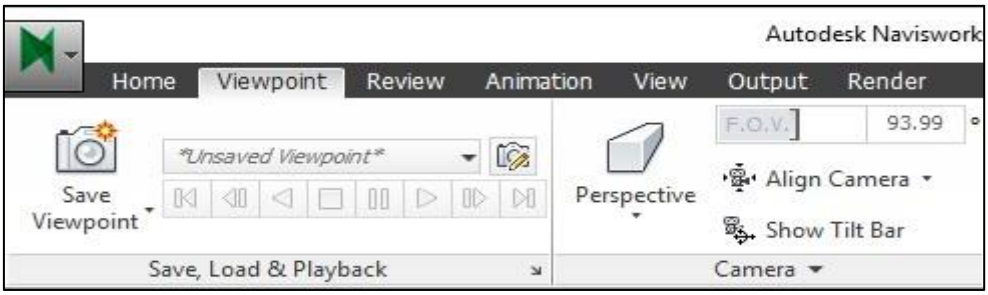


Figure 3.10 Viewpoint tab

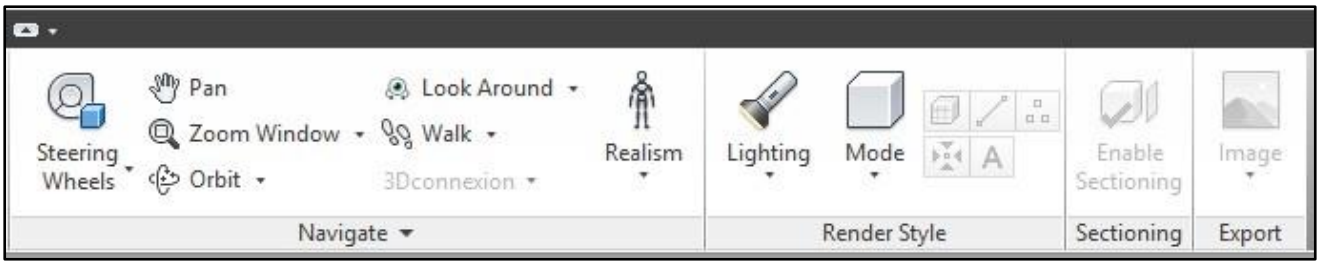


Figure 3.11 Viewpoint tab continued

Review:

The Review tab contains Measure, Redline, Tags, Comments, and Collaborate panels (Figure 3.12).

To preview the panels that included in "Review" tab and there functions see appendix 1.

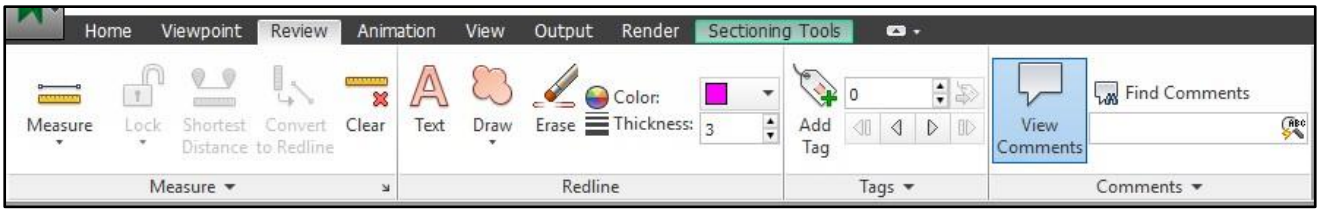


Figure 3.12 Review tab

Animation:

This tab contains the Create, Playback, Script, and Export panels (Figure 3.13).

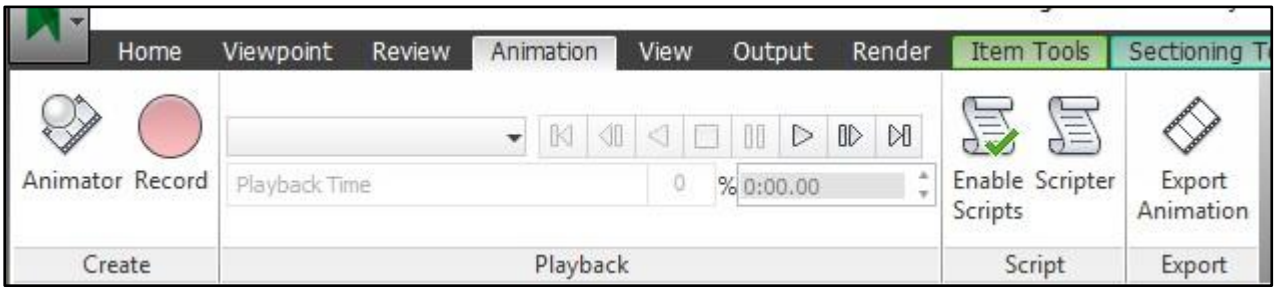


Figure 3.13 Animation tab

To preview the panels that included in "Animation" tab and there functions see appendix 1.

View:

The View tab contains Stereo, Navigation Aids, Grids & Levels, Scene View, and Workspace panels (Figure 3.14).

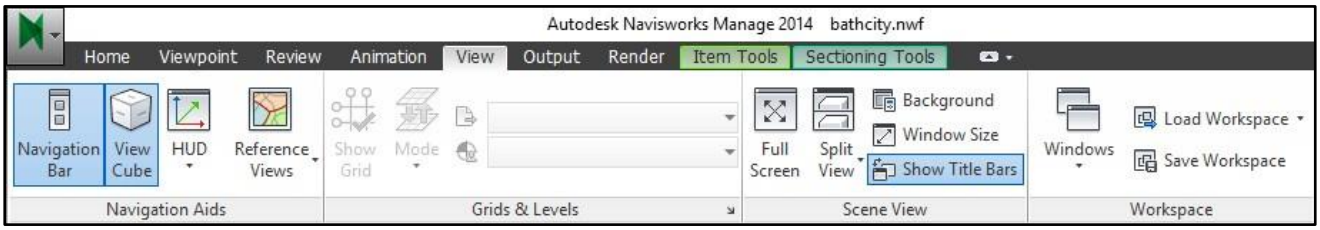


Figure 3.14 View tab

To preview the panels that included in "View" tab and there functions see appendix 1.

Output:

The Output tab contains Print, Send, Publish, Export Scene, Visuals, and Export Data panels (Figure 3.15 and Figure 3.16).

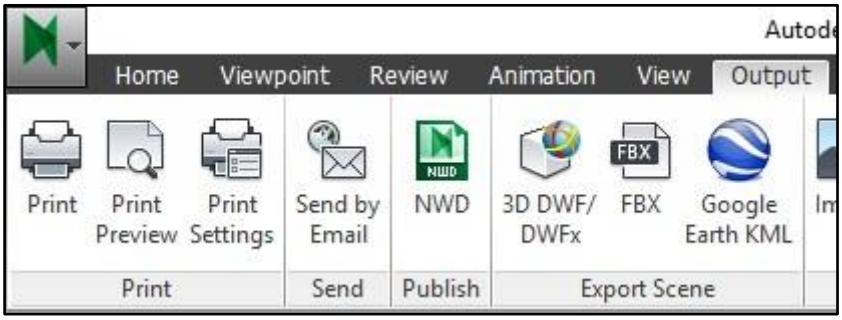


Figure 3.15 Output tab

Figure 3.16 Output tab continued

To preview the panels that included in "Output" tab and there functions see appendix1.

- **Status Bar, Performance Indicators, and Context Menus:**

Located in the bottom-right corner of the screen is the status bar, which contains four performance indicators that give you feedback on the performance of your computer and currently loaded Navisworks model (Figure 3.17).

Figure 3.17 Status bar

Pencil Bar: Indicates how much of the current view is drawn, that is, how much image dropout there is in the current view. When the progress bar is at 100 percent, the scene is completely drawn, with no dropout. The icon changes color when a redraw is in progress. While the scene is being drawn, the pencil changes to yellow. If there is too much data to handle and your computer cannot process this quickly enough for Navisworks, then the pencil changes to red, indicating dropout.

Disk Bar: Indicates how much of the current model is loaded from the local hard drive. When the progress bar is at 100 percent, the entire model, including geometry and property information, is loaded into memory. The icon changes color when a file load is in progress. While the data is being read, the disk changes to yellow. If there is too much data to handle and your machine cannot process it quickly enough for Navisworks, then the disk changes to red, indicating a potential problem.

Web Server Bar: Indicates how much of the current model is downloaded from a web server. When the progress bar is at 100 percent, the entire model has been downloaded. The icon changes color when a file load is in progress. While data is

being downloaded, the web server changes to yellow. If there is too much data to handle and your computer cannot process it quickly enough for Navisworks, then the web server changes to red, indicating a potential problem.

Memory Bar: Indicates the amount of system memory being utilized by Navisworks.

Navisworks uses a few context menus that contain various tools. These tools can help you save time once you master when and how to leverage them.

No Item Selected: This context menu (Figure 3.18) has a variety of tools that are found across various tabs and toolbars within Navisworks but that have been centralized for easy access. Access this menu by right-clicking in white space away from geometry. Once the menu is open, select your tool.

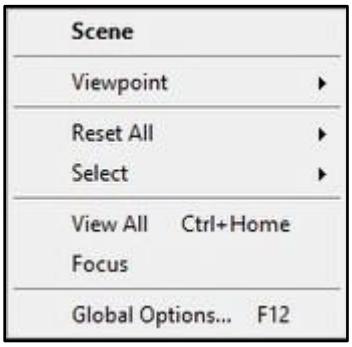


Figure 3.18 Context menu, with no items selected

With Item Selected: The With Item Selected context menu contains even more tools to help you along your way. Access this menu (Figure 3.19) by right-clicking once you've selected the geometry. If you right-click when no geometry is selected (right-clicking on the object instead of selecting it first), Navisworks will select that single piece of geometry and open this context menu as well, saving you the step of having to select the object first.

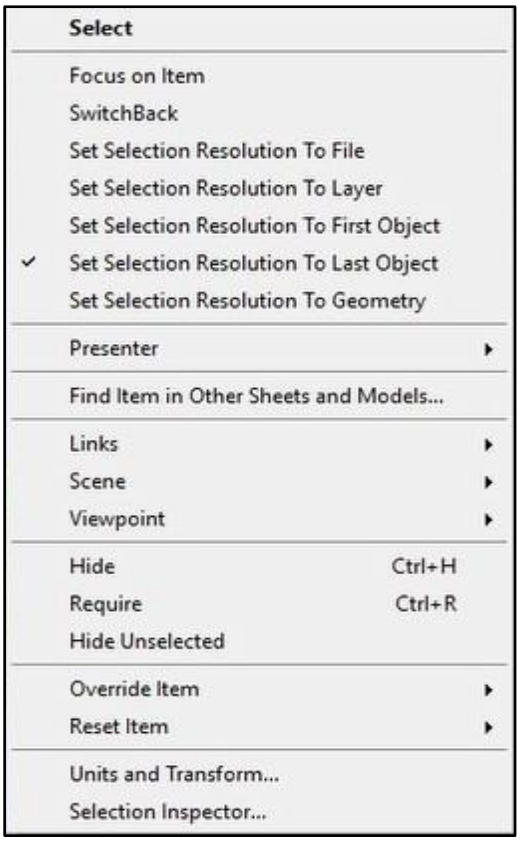


Figure 3.19 Context menu, with an item selected

- **The Bottom Line:**

Understand the ribbon: Knowing the locations of various tools within the Ribbon provides a good foundation for being able to quickly access items across the Navisworks interface.

Use the Measure and Redline tools: The Measure and Redline tools are useful in Navisworks throughout a project and having a basic understanding of these tools is essential.

3.9 Illustration on how to develop a 4D Model:

3.9.1 General information about the model:

The exercised model used for application was a simple tall building consists of 11 floors plus roof. Skeleton contains a flat slabs (18*30) m^2, circular columns, stairs and shear walls.

The roof deviates from suspended slab by 34.55 degree (2.88 degree for each floor). The module covered from outside by glasses and plastic cladding.

This research focusing on connecting between 3D model exported from Rivet software and schedule of construct this building to explain the procedure to doing that in Navisworks software. Refer to figure 3.20

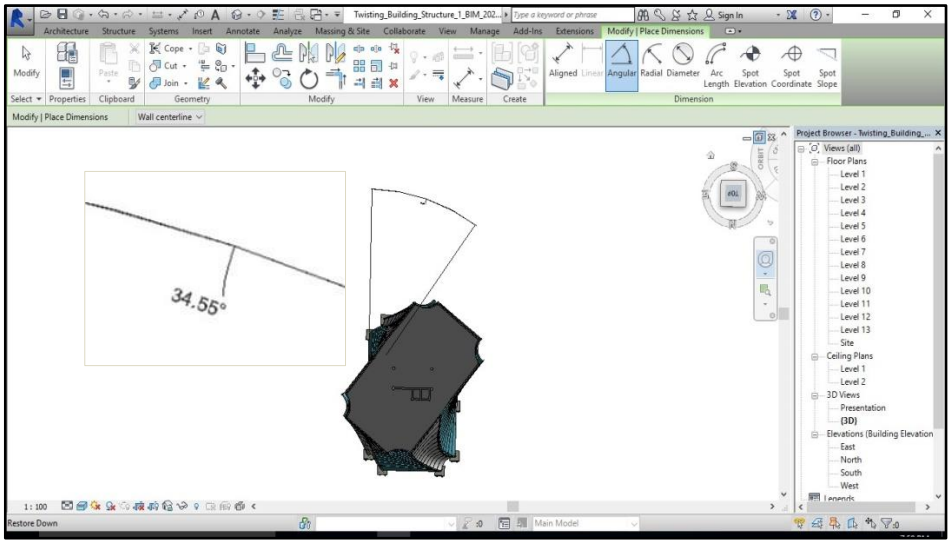


Figure 3.20 Three dimension model in Revit

- The source of figure from Revit 2014 software.

3.9.2 Transport the Model:

- **Export the Model from Revit software:**

From "**Add-In's**" tab in Revit software go to "**External**" panel and choose from **external tools** (Navisworks 2014) or any other version.

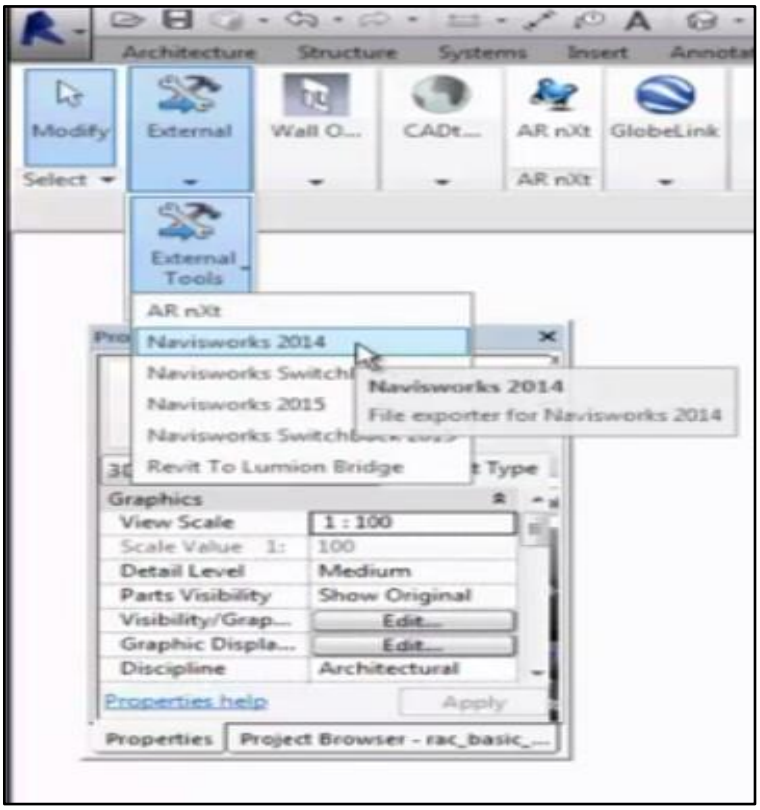


Figure 3.21 Exporting Model from Revit to Navisworks

(The source of figure from Revit 2014 software)

- Make sure to save the file as Navisworks (NWC) type
- Choose "Navisworks setting" to be sure the exporting will be for all model

not only the interface and that by choosing from "Export" ⟶ **Entire Project**.

- **Import the 3D model to Navisworks software:**

To Import the model in Navisworks software, From **Application Button**, go to **Open** and choose the naviswork file that was exported from Revit software.

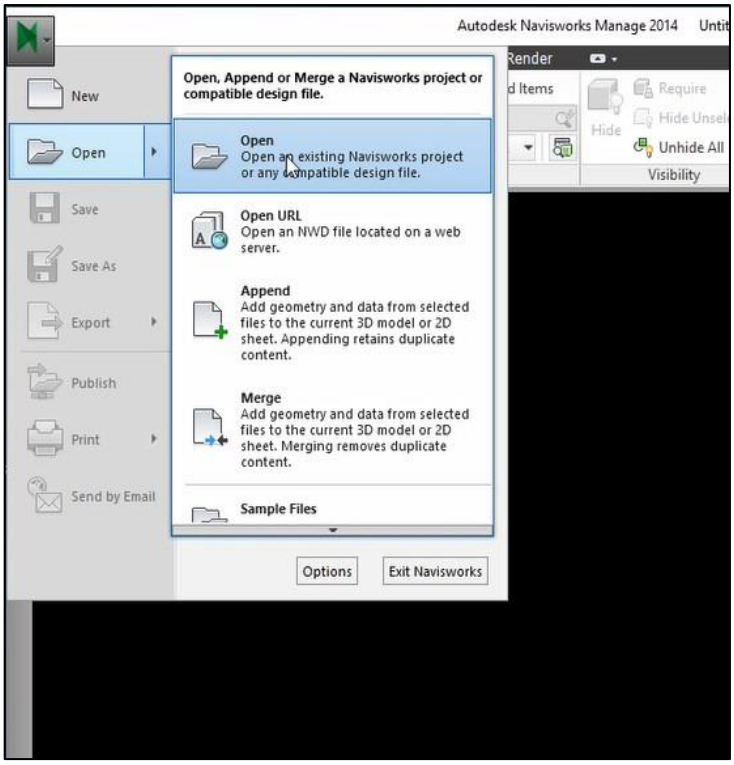


Figure 3.22 Importing Model to Navisworks

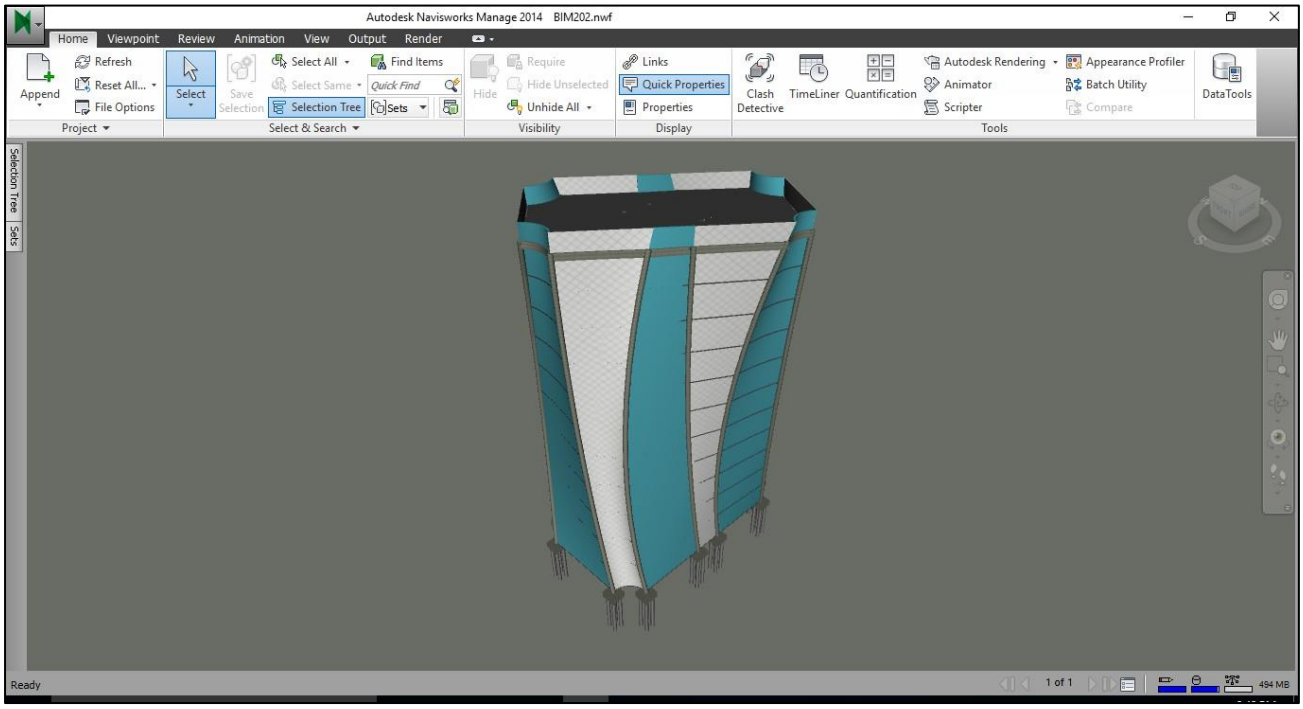


Figure 3.23 The imported Model in Navisworks interface

3.9.3 Identifying, grouping and sorting the model's elements:

In order to link between the 3D imported model and schedule tasks to make the simulation, you have to identify any group of components that shearing one task or activity in schedule.

For example if you have an activity named by "Construct the pile foundation" and you want to link this task with the structural 3D model, you must select the elements in model like piles and piles cap to set it as one group in set list, to attach between them in the simulation.

1. Selection Tree:

The selection tree is a window, which displays a variety of hierarchical views of the structure of the model, as defined by the CAD application in which the model was created.

To open the selection tree, From **Home** tab, go to **Select & search** panel and choose **Selection Tree**. 

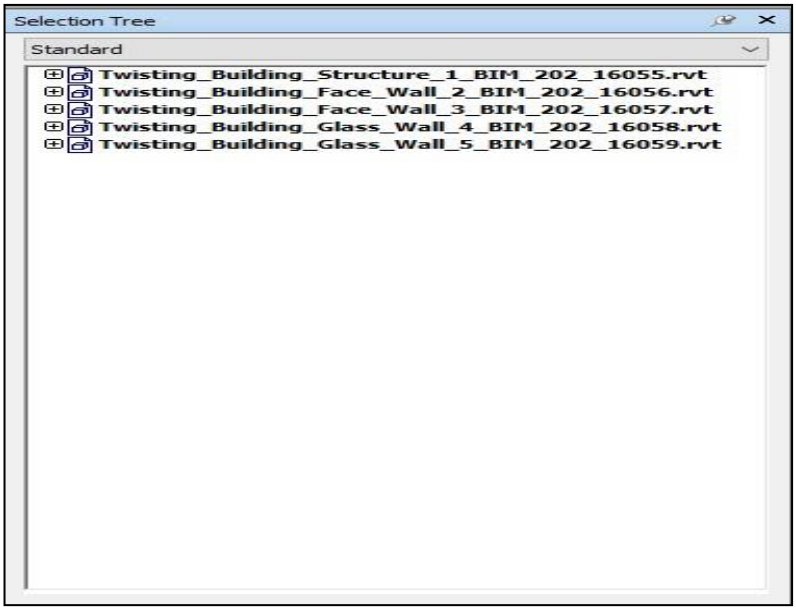


Figure 3.24 Selection tree for the exercised mode

Autodesk Navisworks uses this hierarchical structure to identify object-specific paths (from the file name down to a particular object).

Naming of items reflects the name from original CAD application wherever possible.

By default there are four options on the drop-down list:

• Standard: Displays the default tree hierarchy, including all instancing. The hierarchy can be sorted alphabetically.

• Compact: Displays a simplified version of the hierarchy on the Standard option, omitting various items. You can customize the level of complexity of this tree in the Options Editor.

• Properties: Displays the hierarchy based on the items' properties. This enables simple manual searching of the model by item property.

• Sets: Displays a list of selection and search sets. If no selection and search sets have been created, this option is not shown.

Note: The list of the items on the Sets option is exactly the same as the list on the Sets window.

2. Sets:

From the **Sets** window you can add, move and delete selection and search sets, and organize them into folders.

To open the **Sets** window, From **Home** tab, go to **Select & search** panel and choose **Sets.** 

Search and selection sets can be updated. You can modify your current selection in the

Scene View or the current search criteria, and change the contents of your set to reflect

this. You can drag and drop items from the Scene View and the Selection Tree into the Sets window to create new selection sets.

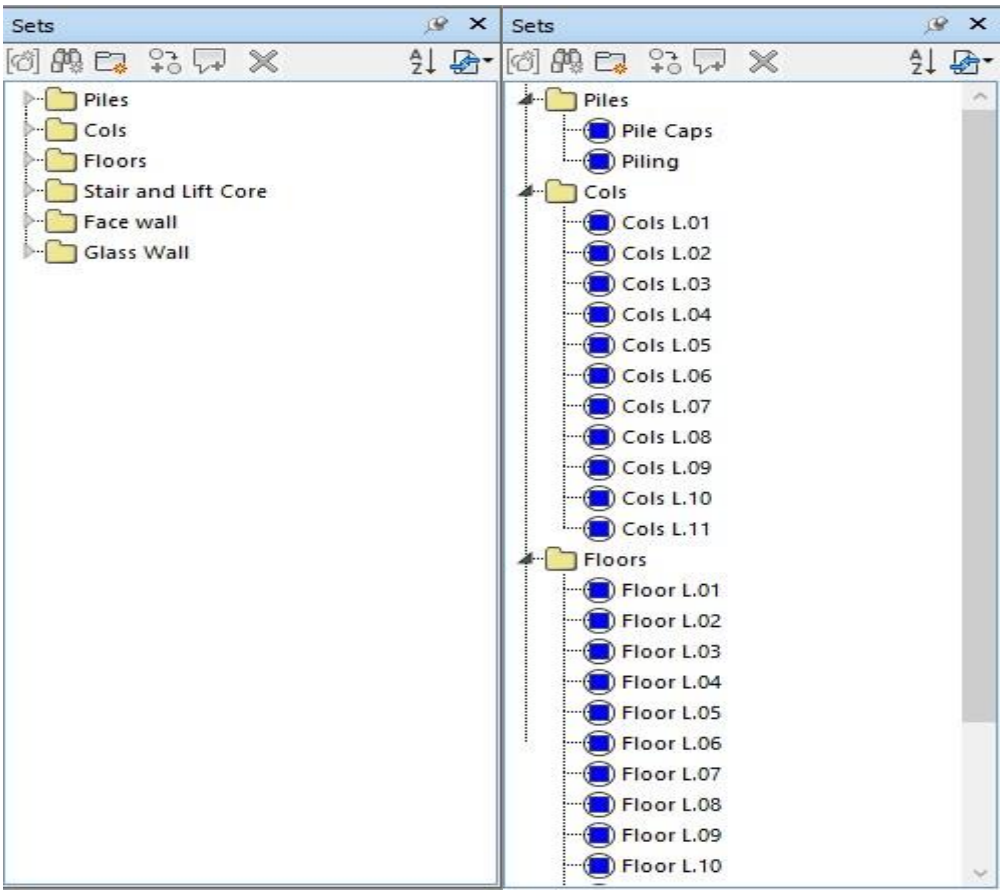


Figure 3.25 Sets window for the exercised mode

After arrange the elements for all building in **Sets** window, now you will be able to link between the elements in sets list with the opposite tasks in the project using time liner tool.

3.9.4 Project schedule:

You can make the project schedule in Navisworks or importing ready one from other scheduling software, for example Ms-project or primavera.

To make the project schedule in Navisworks use the tool of Timeliner.

➢ Time liner window:

The Time Liner window enables you to attach items in the model to project tasks, and simulate project schedules.

To open **Time liner** window, From **Home** tab, go to **Tools** panel and choose **Time liner.** 

There are four tabs in time liner window (Tasks, Data Sources, Configure and Simulate)

1. Tasks Tab:

The Tasks tab enables you to create and manage project tasks. It shows all of the tasks in your schedule, listed in a table format. You can use the scroll bars at the right and at the bottom of the tab to move through the task records.

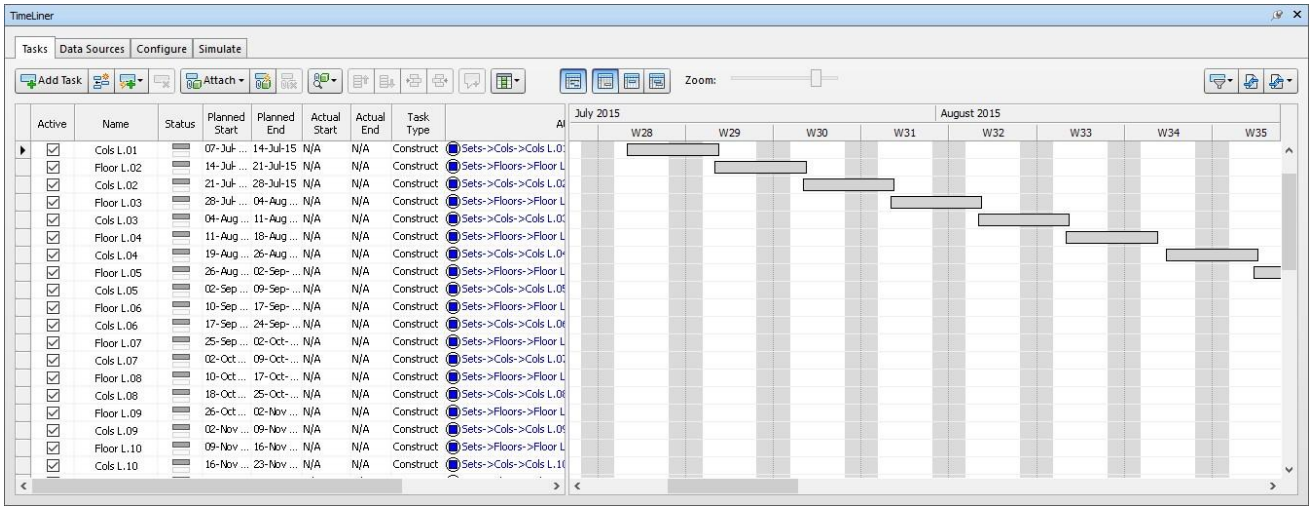


Figure 3.26 Tasks table window for the exercised model.

To preview the tabs that included in "Tasks" tab and there functions see appendix 1.

2. Data Sources:

The Data Sources tab enables you to import tasks from a third-party scheduling software, such as Microsoft Project, Asta, and Primavera. It shows all added data sources, listed in a table format.

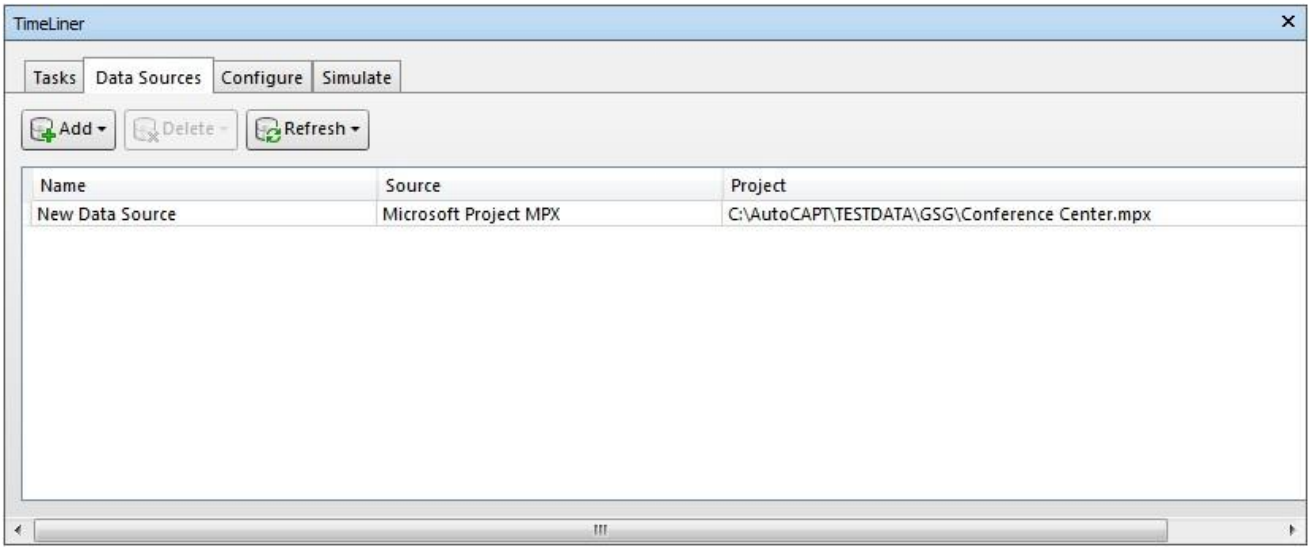


Figure 3.27 Data resource window for the exercised model.

The data sources are shown in a multi-column table. The columns show name, source (for example, Microsoft Project) and project (e.g. my_schedule.mpp). Any further columns (there may be none) identify the fields from the external schedule which specify the task type, unique id, start date and end date for each imported task.

You can move and resize columns, if necessary.

To preview the tabs that included in "Data Sources" tab and there functions see appendix 1.

3. Configure: The Configure tab allows you to set up the task parameters, such as task types, appearance definitions for tasks, and the default model appearance at the start of the simulation.

TimeLiner comes with three predefined task types:

• Construct: for tasks where the attached items are to be constructed. By default, during a simulation, the objects are highlighted in green at the start of the task and are reset to Model Appearance at the end of the task.

• Demolish: for tasks where the attached items are to be demolished. By default, during a simulation, the objects are highlighted in red at the start of the task and are hidden at the end of the task.

• Temporary: for tasks where the attached items are only temporary. By default, during a simulation, the objects are highlighted in yellow at the start of the task and are hidden at the end of the task.

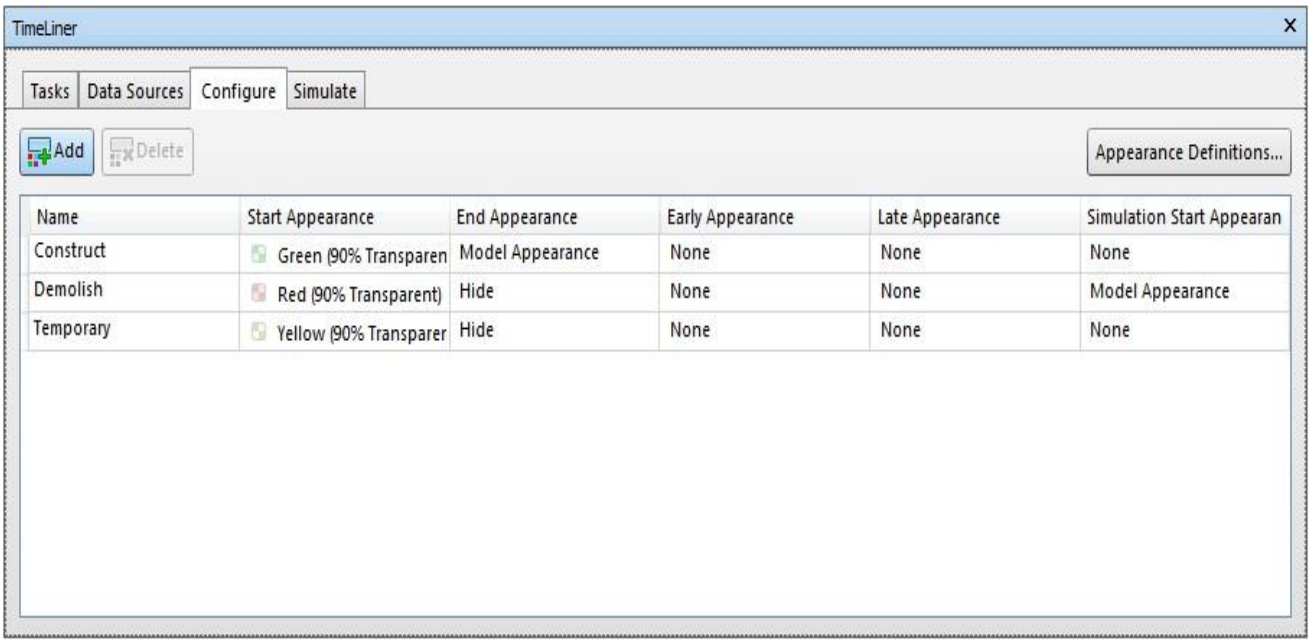


Figure 3.28 Configure window for the exercised model.

To preview detailed functions included in "Data Sources" tab see appendix 1.

4. Simulate tab: The Simulate tab enables you to simulate your Time Liner sequence throughout the duration of the project schedule.

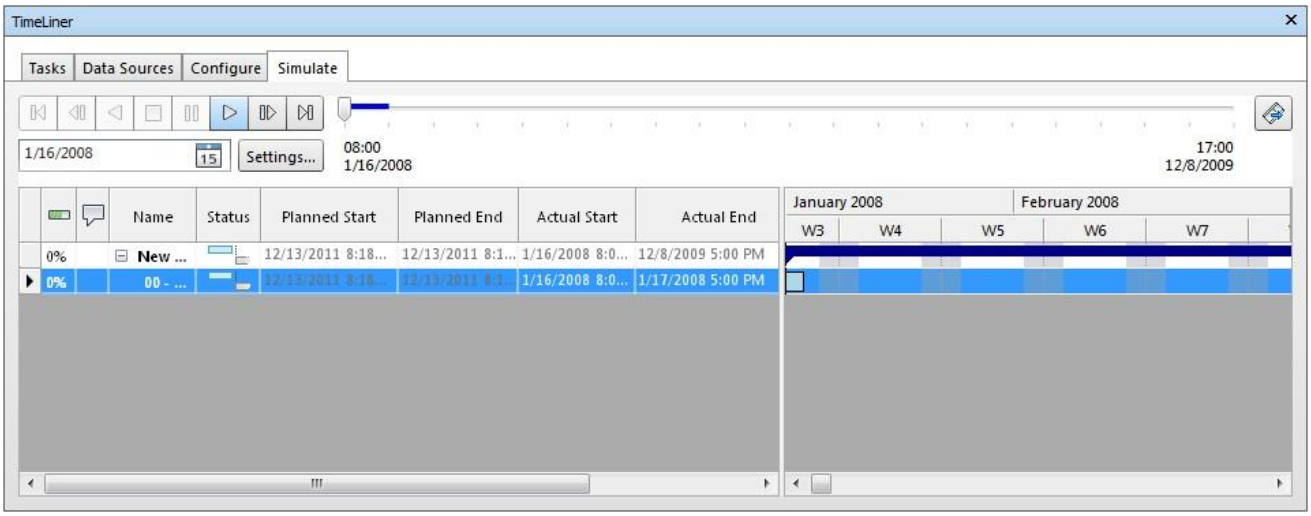


Figure 3.29 Simulate window for the exercised model.

To preview detailed functions included in "Simulate **tab**" tab see appendix 1.

3.9.5 Simulate the 4D model:

After you complete the scheduling and the attaching between the sets of elements with their opposite tasks you can make the simulation using same last tool "time liner" by the last fourth tab "simulate".

Simulation Settings Dialog Box:

The Settings button on the Simulate tab provides access to the Simulation Settings dialog box.

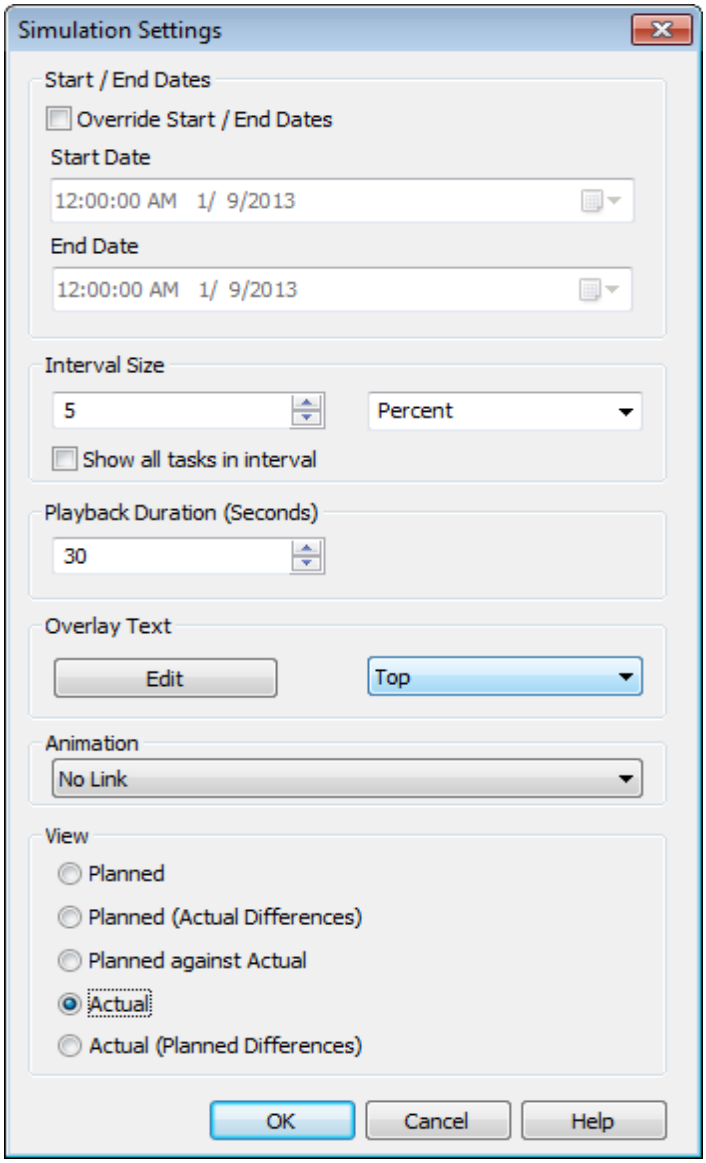


Figure 3.30 Simulation settings window

The final output from this process is simulation of construction processes sequence during the construction period

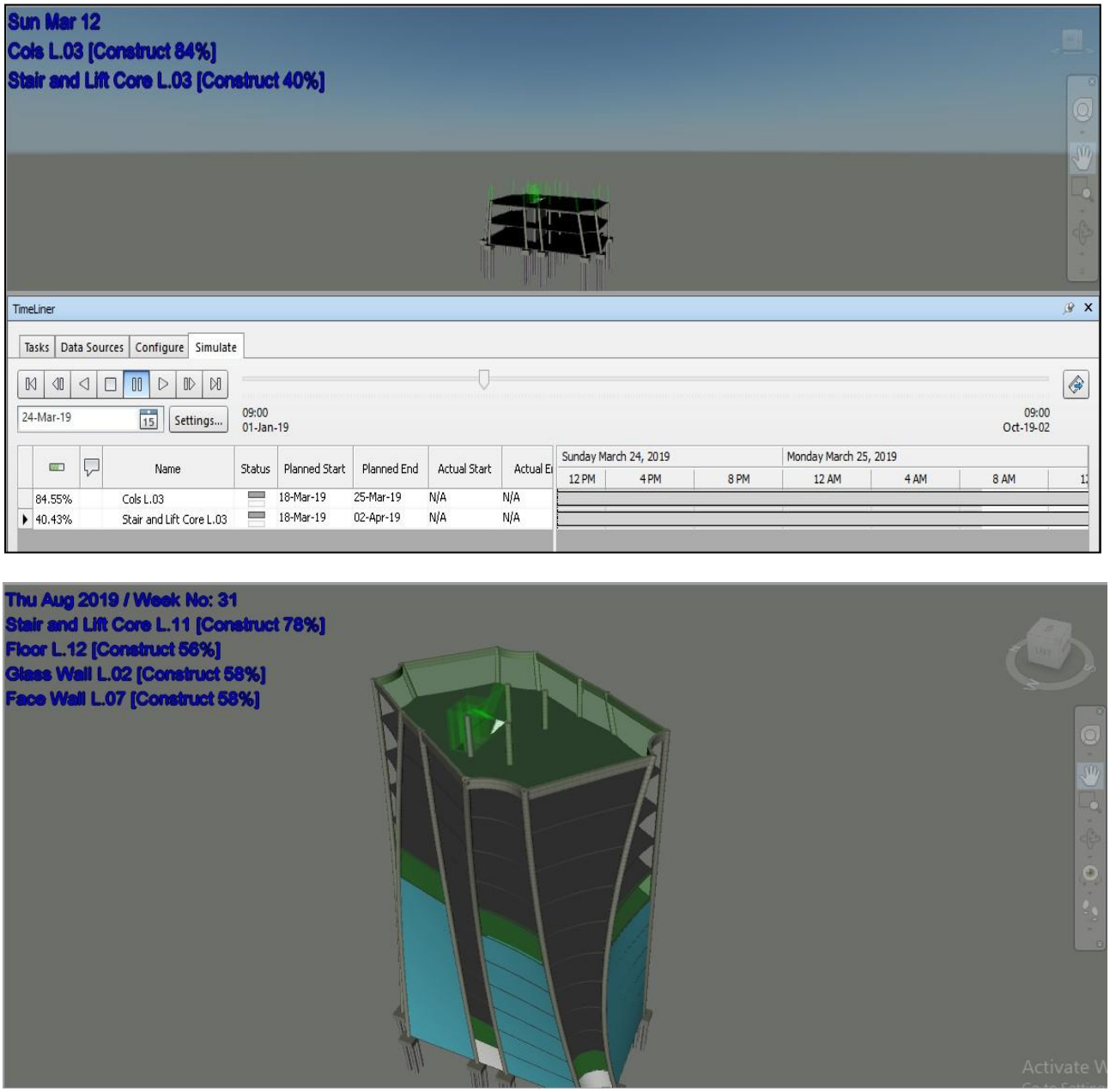


Figure 3.31 Simulation to construction processes

Results analysis and Discussion

4.1 Introduction:

This study is to examine the range of spreading in using software which supports the concept of "BIM-4D" in construction industry at Sudan and level of awareness among projects management stakeholders by role of applying 4D model in control the delaying and cost over runs in projects.

After distribution and collection processes the returned questionnaires were 44 questionnaires by using Google Forms. The analysis and illustration the results of the data which was collected from the questionnaires, was done by using Google Forms also.

4.2 Sample configuration:

A sample with size 44 respondents was randomly selected; it comprised participants with different education level as presented in table 4.1 and figure 4.1

Table 4.1 Respondent's education level

	Frequency	Percent %
Diploma	4	9.1
Bachelor	25	56.8
Master	13	29.5
Doctorate	2	4.6
Total	44	100

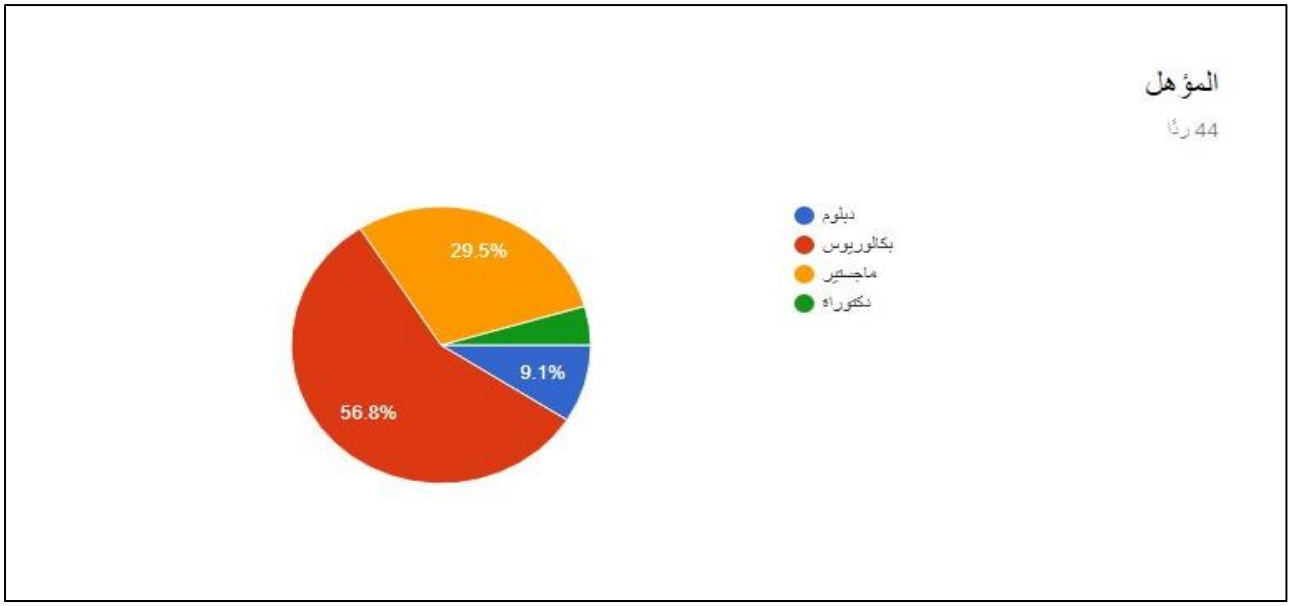


Figure 4.1 Respondent's education level

The presented results show that the above majority (56.8%) was Bachelor's degree then Master's degree (29.5%) which consider good indicator for targeted age from the selected sample.

Regarding their area of work, the sample was distributed in two main layers; Civil engineers representing (88.6%) of the sample, and Architecture engineers (11.4%). (Refer to table 4.2 and figure 4.2)

Table 4.2 Respondent's area of work

	Frequency	Percent %
Civil Engineer	39	88.6
Architect	5	11.4
Others	0	0
Total	44	100

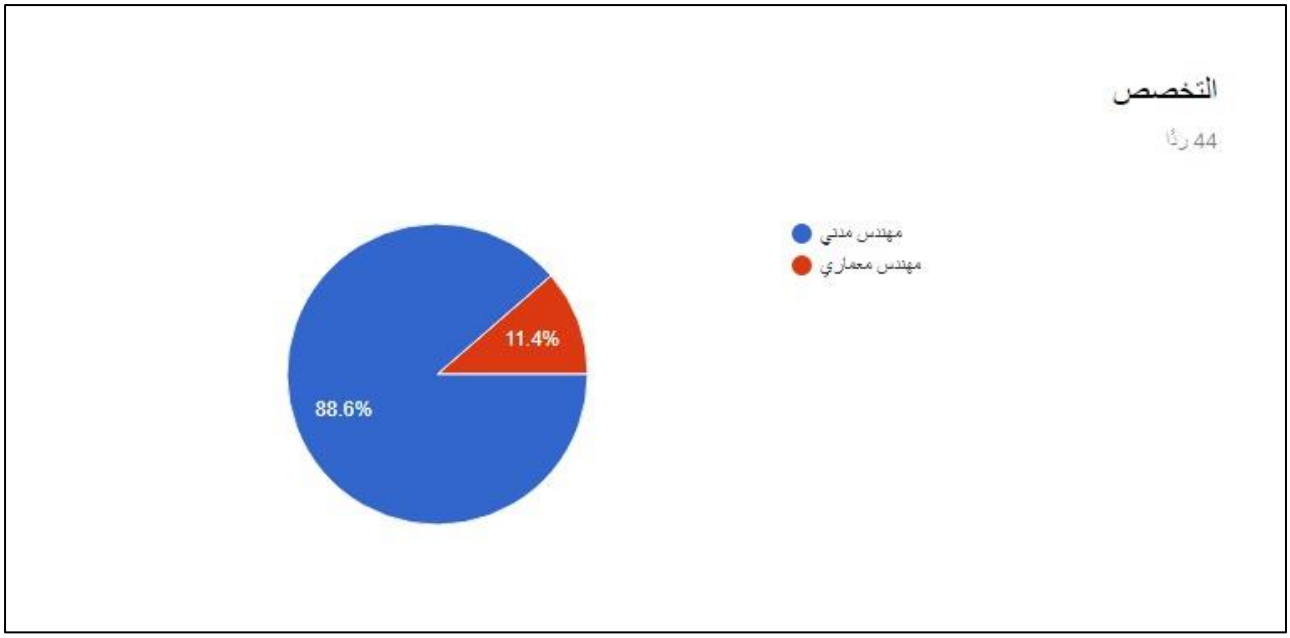


Figure 4.2 Respondent's specialties.

When asked to identify their position in their organizations, respondents were found to be distributed as directors (20.5%) while about a third (31.8%) were technical officers, (36.4%) were site engineers and (11.3%) were other positions. this results is matching with their experience ages.

(Refer to table 4.3 and figure 4.3)

Table 4.3 Respondent's position

	Frequency	Percent %
Director	9	20.5
Technical Office	14	31.8
Site Engineer	16	36.4
Other	5	11.3
Total	44	100

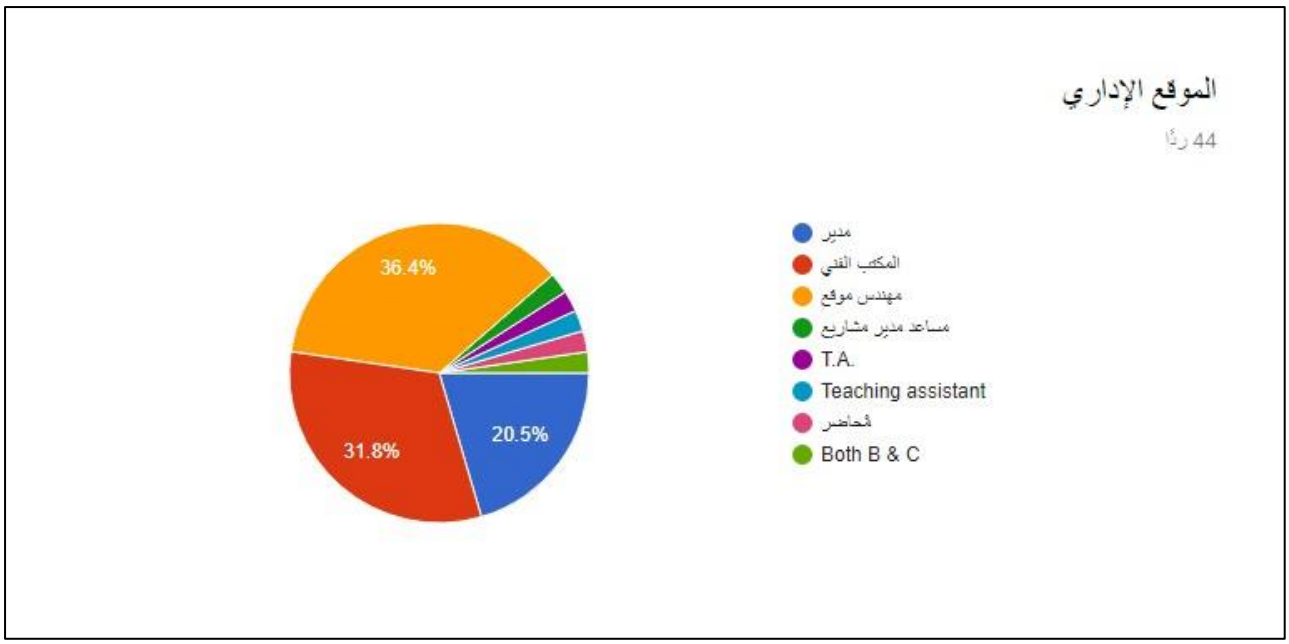


Figure 4.3 Respondent's position

A substantial majority (79.5%) of these participating was belong to Public sector, refer to table 4.4 and figure 4.4

Table 4.4 Sectors where respondent work for

	Frequency	Percent %
Public	35	79.5
Private	9	20.5
Total	44	100

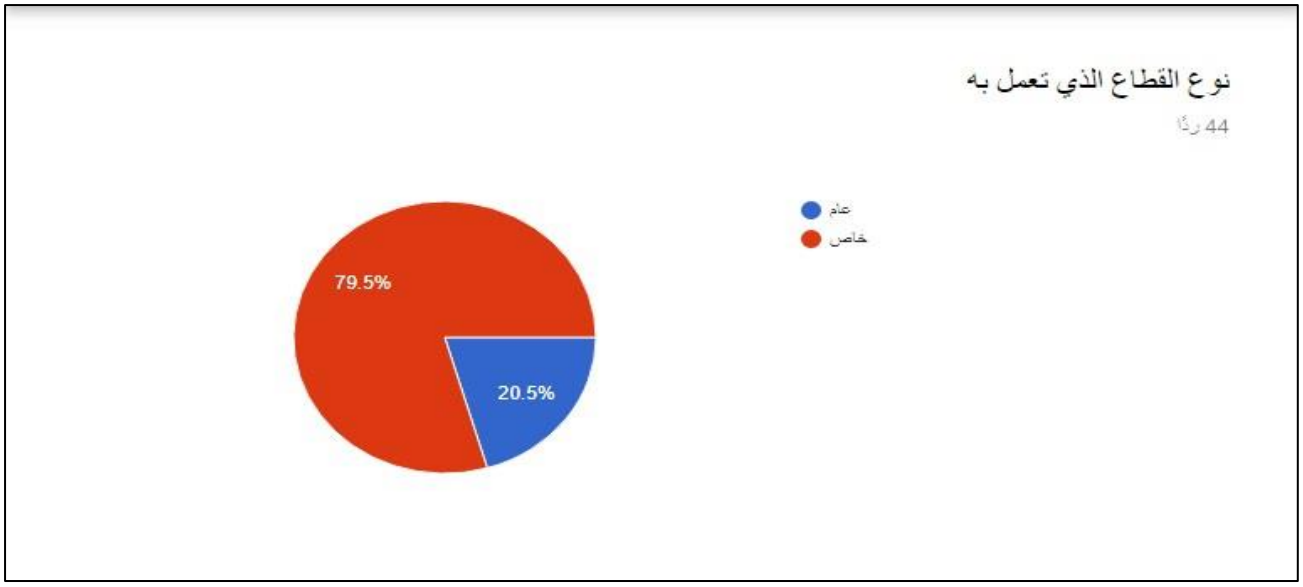


Figure 4.4 Sectors where respondent work for

With respect to their experience (54.5%) showed that their experience is almost less than 5 years, about a third (31.5%) have an experience from 6 to 10 years and for the remaining sample (14%) have more than 11 years of experience (refer to table 4.5 and figure 4.5).

Table 4.5 Respondent's years of experience

	Frequency	Percent %
0-5 years	24	54.5
6-10 years	14	31.5
11-15 years	5	11.4
More than 15 years	1	2.6
Total	44	100

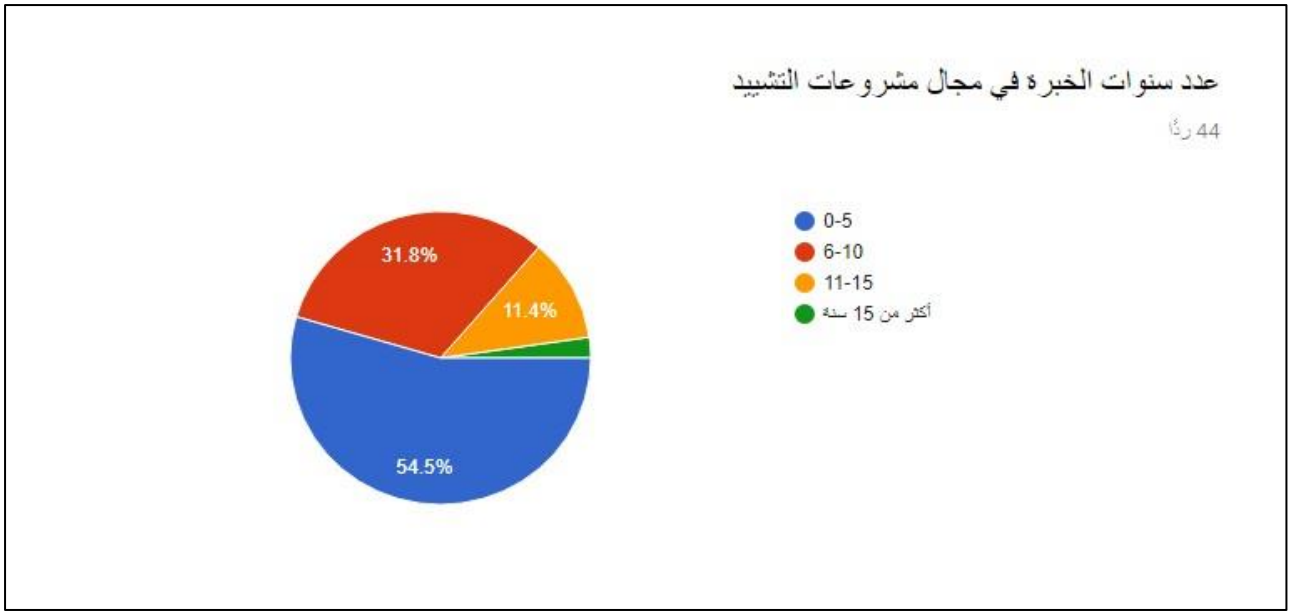


Figure 4.5 Respondent's years of experience

It thought that those who had the chance to practice abroad would have dealt with BIM concept in their works. Consequently, a question was included to check whether the respondents work abroad. The feedback presented in table 4.6 and figure 4.6 showed that above 2/3 (61.4%) of the respondent did not worked abroad, while a third were did it.

Table 4.6 Respondent's work in other countries except Sudan

	Frequency	Percent %
Yes	17	38.6
No	27	61.4
Total	44	100

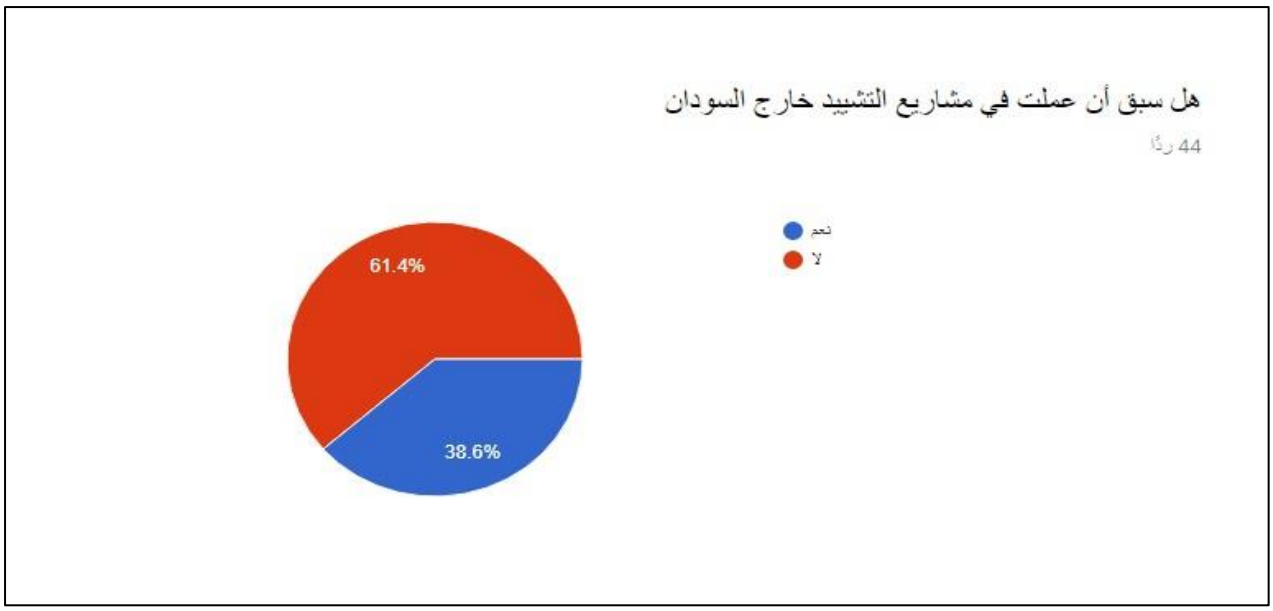


Figure 4.6 Respondent's work in other countries except Sudan

4.2.1 General concepts on Building Information Technology (BIM)

The main objective for this section is to gauge the level of awareness and understanding of the industry participates regarding the BIM basics.

Regarding the familiarity with concept of BIM (25%) showed that the respondents had a weak familiarity with BIM concept and (38.6%) had medium level (refer to table 4.7 and figure 4.7), so the results show that the above majority (68.6%) had a lack of Familiarity with BIM knowledge in Sudan.

Table 4.7 Level of Respondent's Familiarity with concept of BIM

	Frequency	Percent %
Weak	11	25
Medium	17	38.6
Good	8	18.2
Very Good	6	13.6
Excellent	2	4.6
Total	44	100

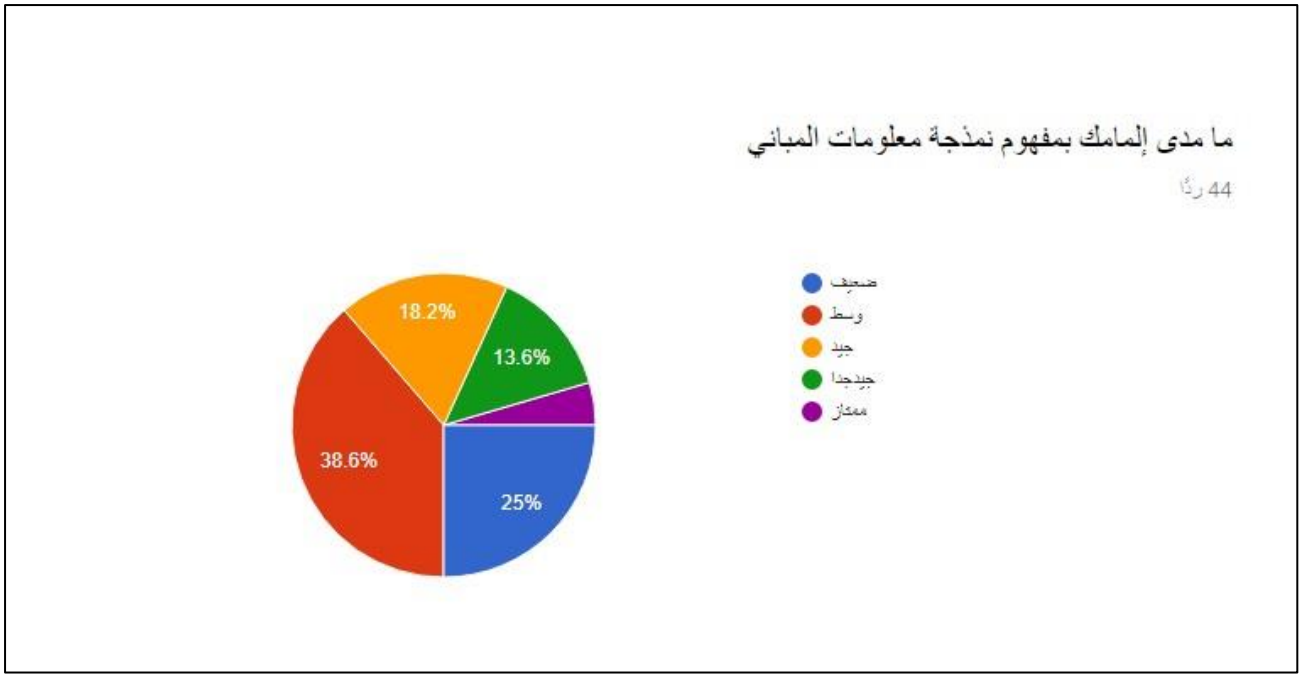


Figure 4.7 Level of Respondent's Familiarity with concept of BIM

A substantial majority (68.2%) of these respondents as showed in table 4.8 and figure 4.8 did not apply the BIM techniques in their works, so this is also indicator for weak spreading of BIM techniques in Sudan.

Table 4.8 Respondents whom applied the BIM techniques in their works

	Frequency	Percent %
Yes	14	31.8
No	30	68.2
Total	44	100

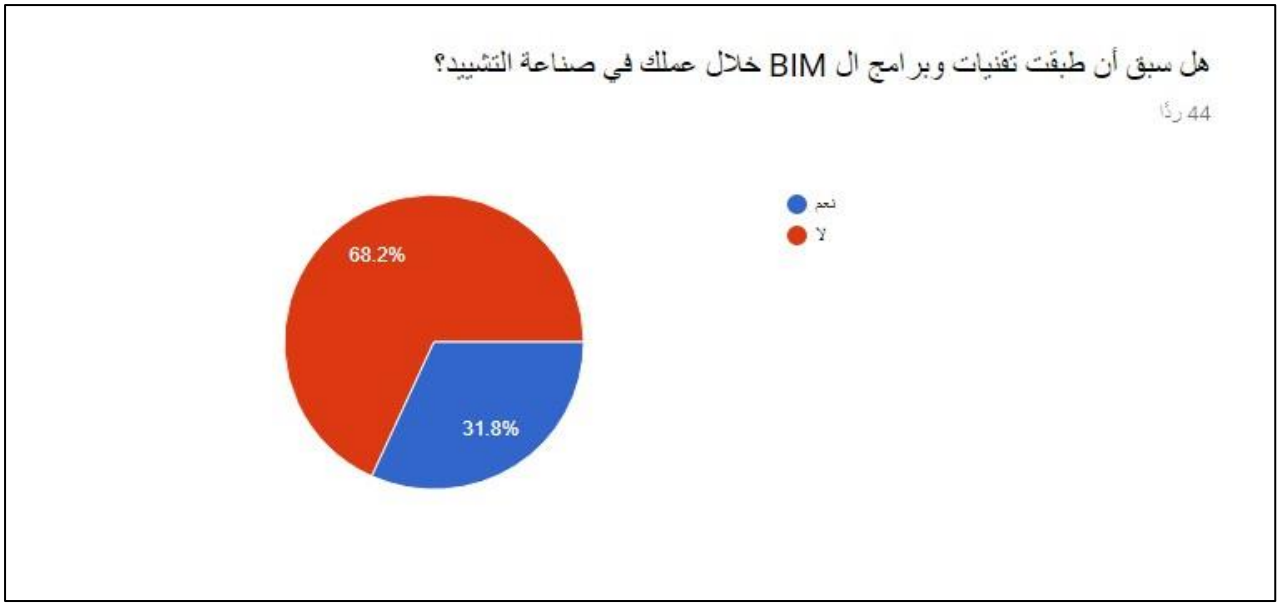


Figure 4.8 Respondents whom applied the BIM techniques in there works

Regarding their experience in applying BIM techniques, the weight average of the results showed in table 4.9 and figure 4.9 was “Medium”. This is also underscores the fact that applying of BIM techniques is weak in Sudan.

Table 4.9 Level of respondent’s experienced about applying BIM techniques in construction projects.

	Frequency	Percent %
Weak	15	34.1
Medium	15	34.1
Good	7	15.9
Very Good	5	11.4
Excellent	2	4.5
Total	44	100

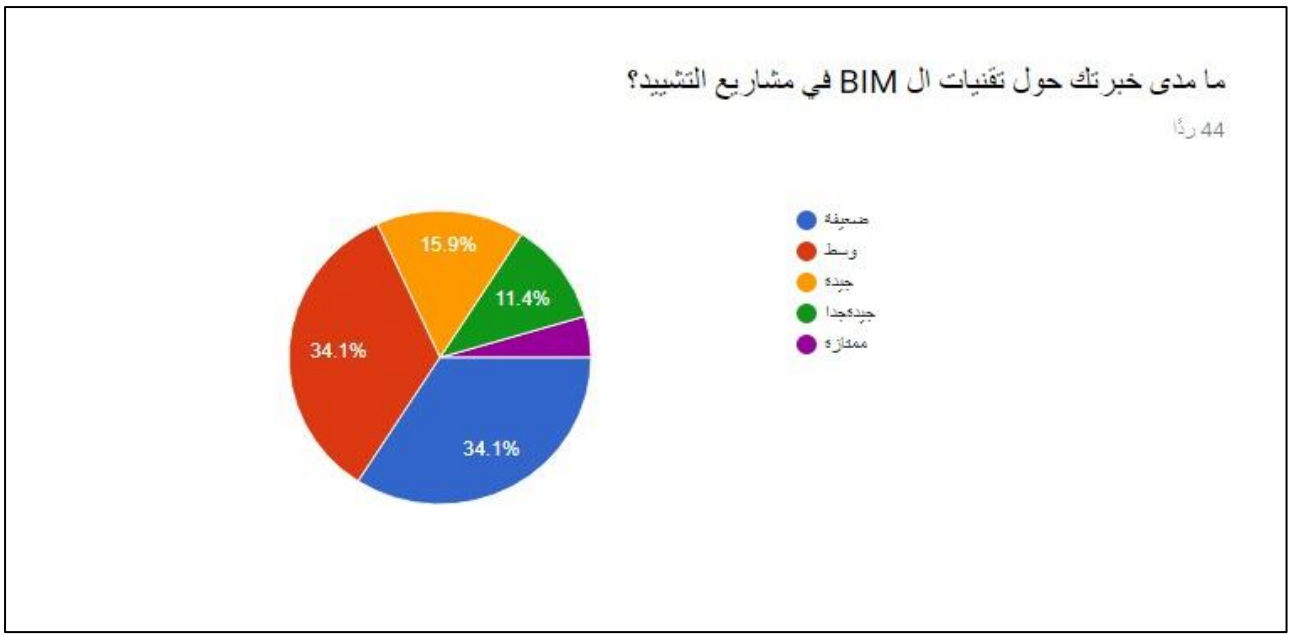


Figure 4.9 Level of respondents experienced about applying BIM techniques in construction projects.

In order to gauge the acceptability of respondents to BIM techniques a question was included, the results in table 4.10 and figure 4.10 showed that the weight average of results was “very good” to “Excellent”.

Table 4.10 Level of respondent’s interesting for knowing about BIM techniques in their works.

	Frequency	Percent %
Weak	2	4.2
Medium	1	2.7
Good	7	15.9
Very Good	10	22.7
Excellent	24	54.5
Total	44	100

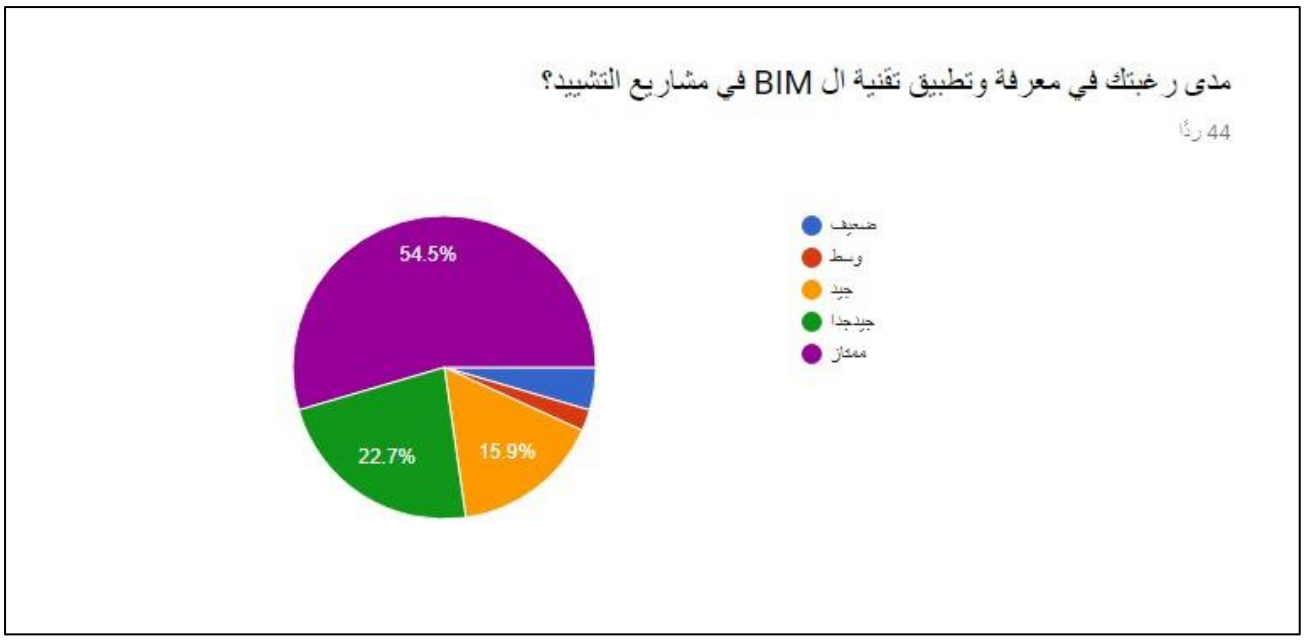


Figure 4.10 Level of respondent's interesting for knowing about BIM techniques in their works.

When asked the respondent about their opinion in importance and value of implementation the BIM's software in construction projects in Sudan, (50%) were strongly agreed with the concept, which is good indicator to acceptance of this technology.

(Refer to table 4.11 and figure 4.11)

Table 4.11 Respondent's opinion about importance and value of implementation the BIM's software in construction projects in Sudan.

	Frequency	Percent %
Strongly Agree	22	50
Agree	14	31.8
Likely	6	13.6
Disagree	2	4.6
Total	44	100

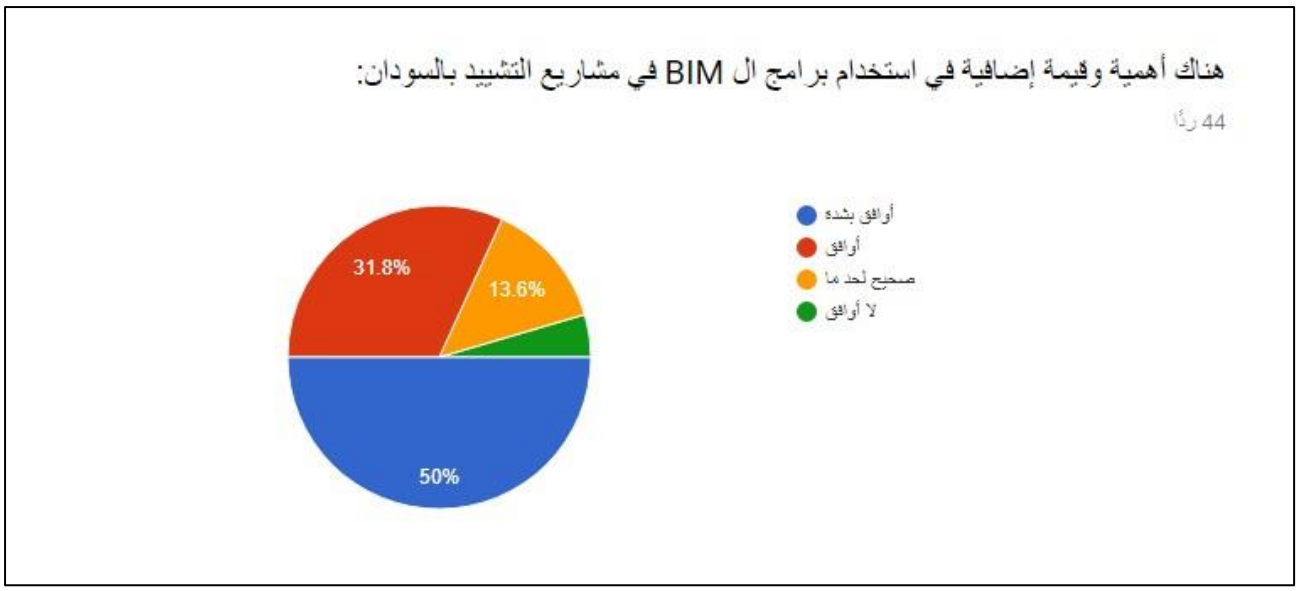


Figure 4.11 Respondent's opinion about importance and value of implementation the BIM's software in construction projects at Sudan.

4.2.2 Usage of (BIM) fourth dimension technique in construction projects in Sudan.

The main objective for this section is to gauge the level of understanding and usage of BIM fourth dimension technique in the construction industry in Sudan.

Table 4.12 Represent the respondent's opinion about the high level administrations in companies that working in AEC industry in Sudan accept the concept of applying BIM in their projects.

	Frequency	Percent %
Strongly Agree	2	4.5
Agree	14	31.8
Likely	19	43.2
Disagree	9	20.5
Total	44	100

The above Table 4.12 and the following Figure 4.12 present Respondent's opinion about whether the high level administrations in companies that working in AEC

industry accept the concept of applying BIM in their projects,the Weight average was conducted to the results and was going to “Agree” as shown in figure 4.17

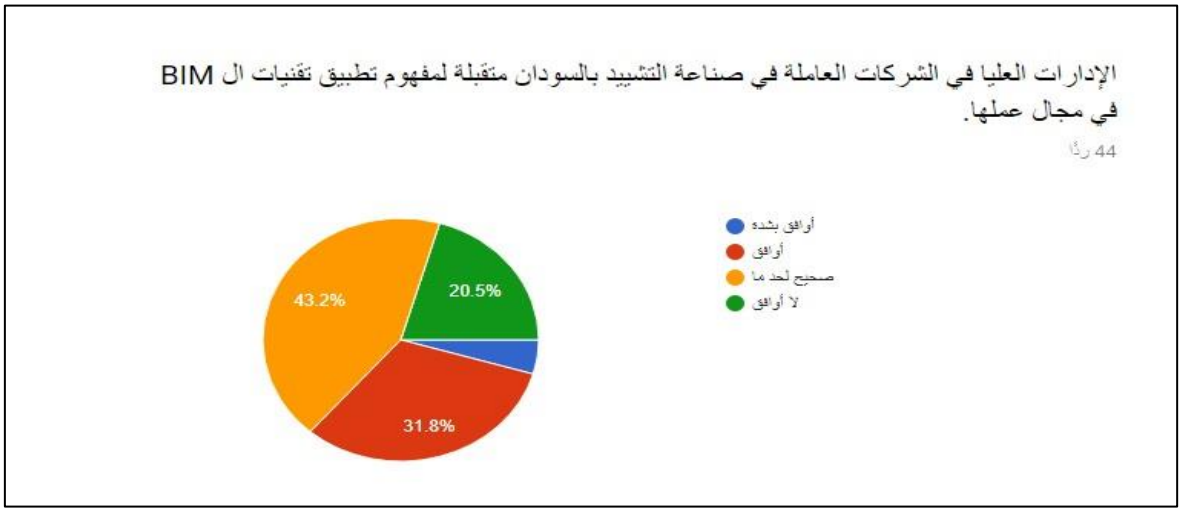


Figure 4.12 represent the respondent’s opinion about the high level administrations in companies that working in AEC industry in Sudan accept the concept of applying BIM in their projects.

Table 4.13 Represent the respondent’s opinion about the concept “the output from connection between the 3D model and schedule of the projects is simulation of construction scenario and its enhancing sharing knowledge between stakeholders”

	Frequency	Percent %
Strongly Agree	21	47.7
Agree	20	45.5
Likely	3	6.8
Disagree	0	0
Total	44	100

Regarding the respondent’s opinion about the concept “the output from connection between the 3D model and schedule of the projects is simulation of construction scenario and its enhancing sharing knowledge between stakeholders”, (47.7%) were strongly agreed the concept (refer to above table 4.13 and the following Figure 4.13) the weight average of Respondent’s opinion was 1.6 going to “Agree” as shown in figure 4.17

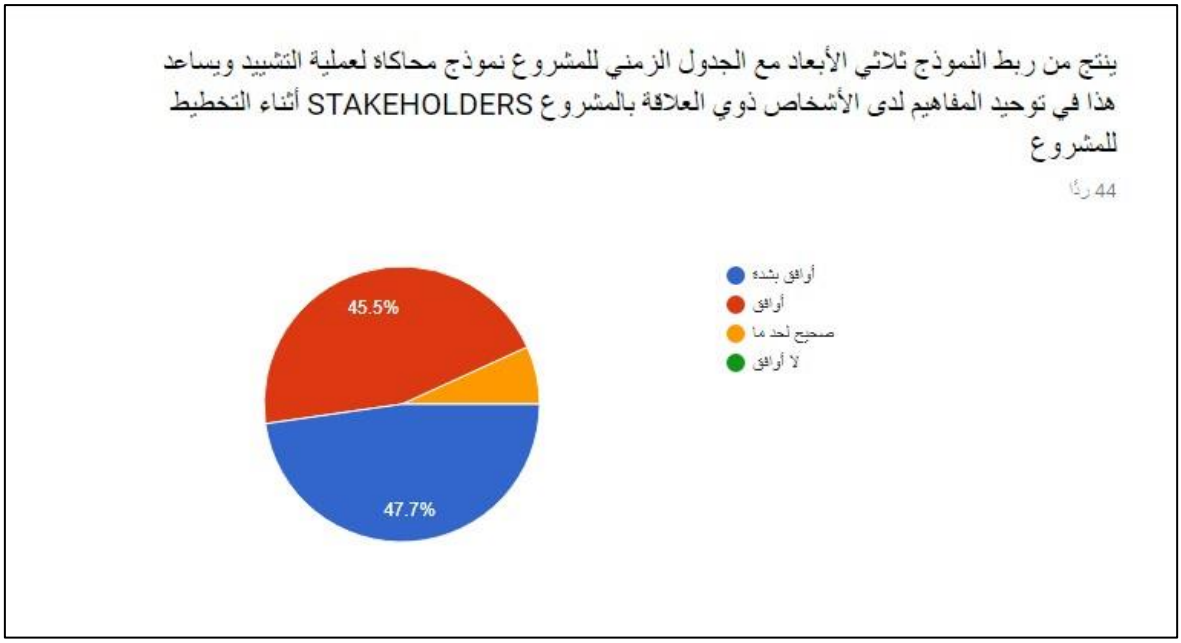


Figure 4.13 represent the respondent's opinion about the concept "the output from connection between the 3D model and schedule of the projects is simulation of construction scenario and its enhancing sharing knowledge between stakeholders"

To knowing which of BIM's Software used in construction market in Sudan a question was conducted, table 4.14 represent the answers and it is proof that the widely spreading of using "Revit & Primavera" software instead of other BIM's software in Sudan.

Table 4.14 Represent the respondent's chooses of which type of software that supports BIM-4D concept are used in their projects (multiple chosen was available)

Software	Frequency
Revit	29
Robot	8
AutoCAD	19
MS project	12
Navisworks	6
Primavera P6	28
Archicad	2

When asked the respondents about the concept “BIM-4D contributes by effectively manner in monitoring and controlling the cost and time of projects” (52.3%) agreed with the concept (see table 4.15 and figure 4.14) addition to that the weight average of Respondent’s opinion was done and also its going to “Agree” as shown in figure 4.17, so it’s good indicator for actuality of this concept.

Table 4.15 Represent the respondent’s opinion about the concept “BIM-4D contributes by effectively manner in monitoring and controlling the cost and time of projects”

	Frequency	Percent %
Deeply Agree	18	40.9
Agree	23	52.3
Likely	2	4.5
Disagree	1	2.3
Total	44	100

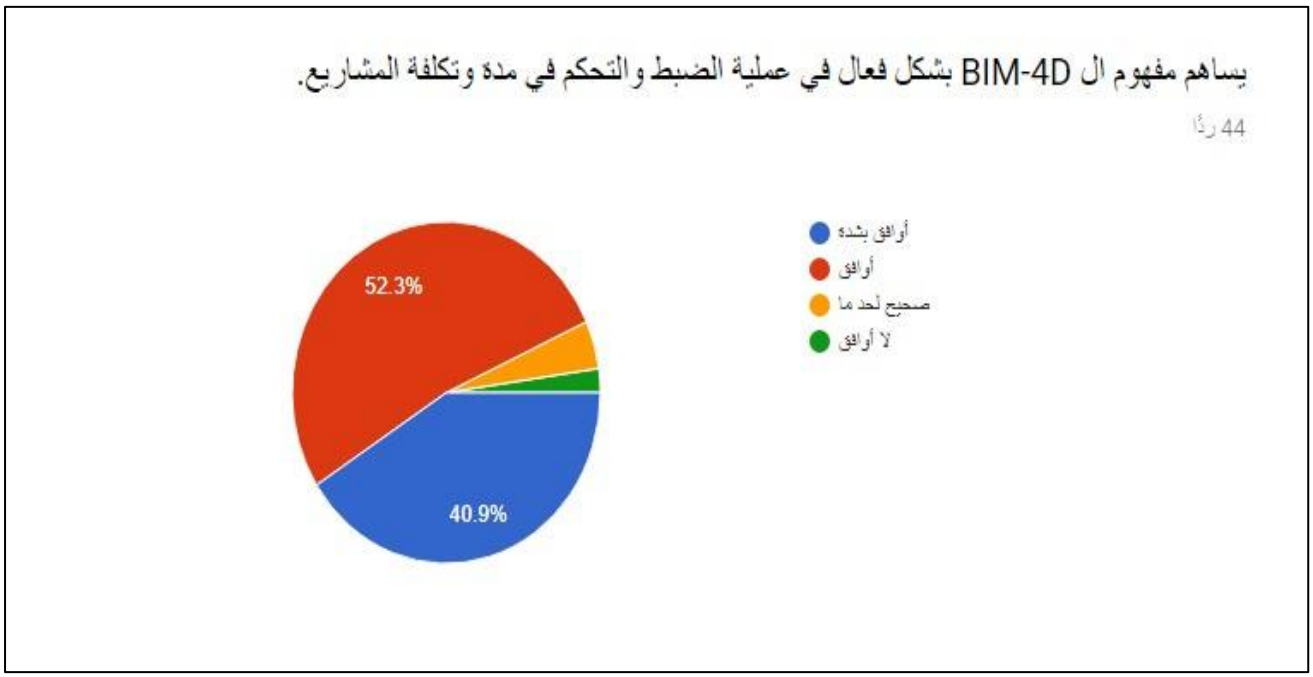


Figure 4.14 represent the respondent’s opinion about the concept “BIM-4D contributes by effectively manner in monitoring and controlling the cost and time of projects”

Finally when asked the participants about the concept “BIM-4D contributes in risk assessment processes during planning phase and decreasing the chances of happening during executing phase” (59.1%) voted by agreed for this concept (see table 4.16 and figure 4.15) also the weight average of Respondent’s opinion was going to “Agree” as shown in figure 4.17, also it’s good indicator for actuality of this concept.

Table 4.16 Represent the respondent’s opinion about the concept “BIM-4D contributes in risk assessment processes during planning phase and decreasing the chances of happening during executing phase”

	Frequency	Percent %
Deeply Agree	11	25
Agree	26	59.1
Likely	6	13.6
Disagree	1	2.3
Total	44	100

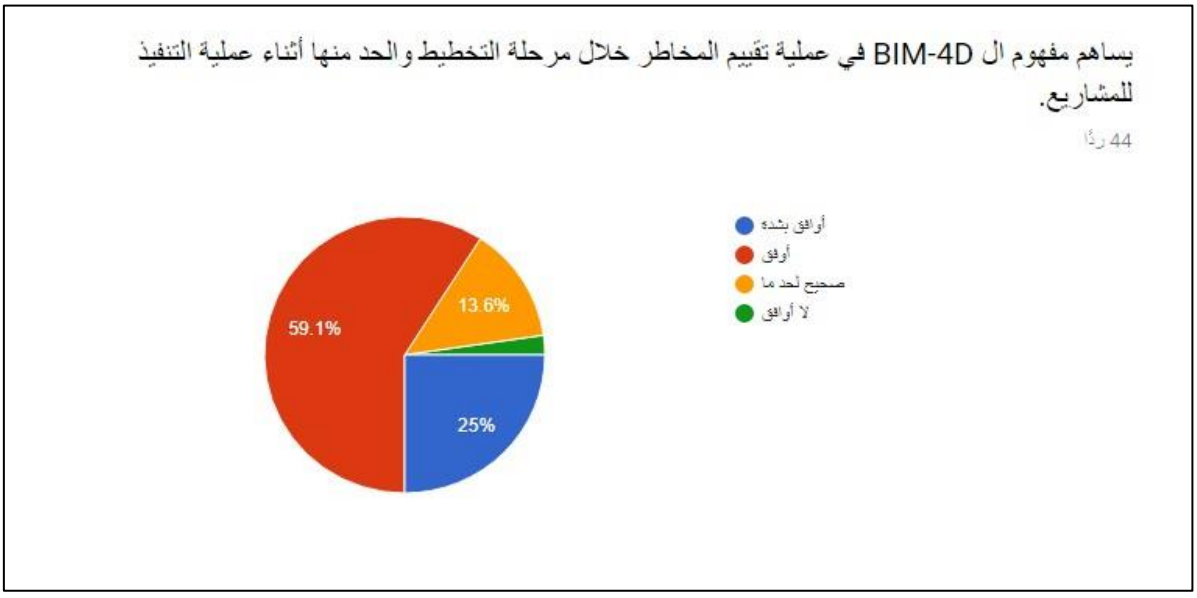


Figure 4.15 represent the respondent’s opinion about the concept “BIM-4D contributes in risk assessment processes during planning phase and decreasing the chances of happening during executing phase”

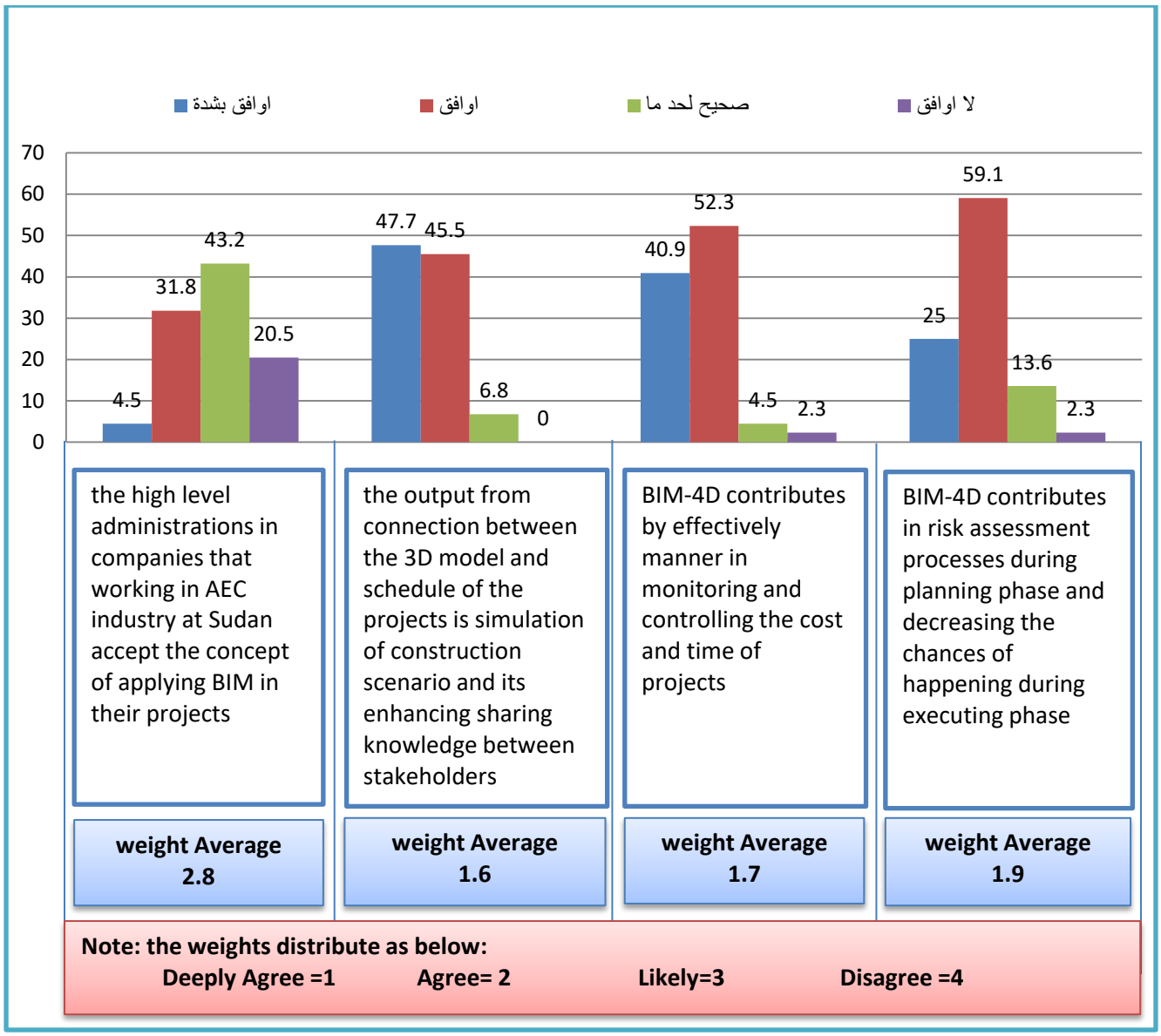


Figure 4.16 represent the weight average to respondent's opinion about part three questions

The above figure present the weights average for most important concepts in questionnaire, and the Major concept that the respondents was deeply agreed with it was "the output from connection between the 3D model and schedule of the projects is simulation of construction scenario and its enhancing sharing knowledge between stakeholders"

Conclusions and Recommendations

5.1 Preamble

This chapter will summarize the output from this research regarding BIM-4D concept and the effectiveness of using software which support this concept. “Navisworks manage 2014” was used as software where a simple case was presented and scheduled to illustrate the modeling process and the application for this research. Furthermore, present the conclusion of questionnaire results.

5.2 Conclusions

1- BIM-4D contributes by effectively manner in monitoring and controlling the cost and time of projects, and such it could be considered as a useful tool for project managers.

2- BIM-4D helps in risk assessment processes during the planning phase and as such it contributes to decreasing the chances of problems occurrence during the execution phase.

3- Navisworks software is considered a very good software, because it is connected to a number of same popular and commonly used software among Sudanese engineers.

4- Generally the spread of BIM concept is still weak among the engineers in the construction industry in Sudan, but conversely there is strong orientation from new graduate engineers and those have a medium level of experience (from 5 to 10 years) so this is a good indicator for future of this technology in Sudan.

5- The practical sample of 4D model provides the basis for a common language between all parties and a representation of the project schedule and component of construction model.

5.3 Recommendations

1- Increase the level of awareness of the projects participates by introducing regulations that necessitate the use of software and relevant packages in all the project stages.

2- Compulsion of contractors gradually to submit 4D- model with project's execution plan documents as a tool of quality assurance to insure the realistic of planned schedule and matching with the real construction processes.

3- Increase the researches and published papers in this topic with considering the nature of AEC industry in Sudan.

4- Educate the student at universities this is software to follow the growth of technologies in this discipline.

5.4 Proposed Future Studies

1- Building information modeling globally is new technology so it is necessary to concentration researches in this discipline.

2- To widen this research by considering the other three dimensions, fifth, sixth and seventh dimension (cost, integration BIM, operation)

3- To farther investigate the capabilities and functions of Navisworks as a useful software.

List of References

1/ Chuck Eastman etc. all. (2011)" BIM handbook: a guide to building information modeling for owners, managers, designers, engineers and contractors", USA.

2/ Singh V, Gu N, Wang X. 2011.A theoretical framework of a BIM-based multi-disciplinary collaboration platform. Automation in Construction

3/ Choi, B., Lee, H.-S., Park, M., Cho, Y.K., Kim, H., (2014). Framework for Work-Space Planning Using Four-Dimensional BIM in Construction Projects.

4/ Akcamete A, Akinci B, Garrett JH jr, 2010. Potential utilization of building models for planning maintenance activities. Proceedings of the International Conference on Computing in Civil and Building Engineering (ICCCBE), Nottingham, Britain.

5/ Kathleen McKinney, Kim, Fischer and Howard. "Interactive 4D-CAD" research paper, Stanford.

6/ Willem Kymmell, (2008). Building Information Modeling. Planning and managing construction projects with 4D CAD and simulation. The Mc Graw-Hill companies. USA.

7/ Duncan Haughey (2014) "A Brief History of Project Management", UK

8/ Krygiel E, Nies B, (2008). Green BIM: successful sustainable design with building information modeling. Indianapolis, Indiana: Wiley Publishing.

9/Julie Jupp, 2007. 4D BIM for Environmental Planning and Management, University of Technology Sydney, Ultimo, Australia.

10/ Koo, B., Fischer, M., (2000). Feasibility study of 4D CAD in commercial construction; pp. 251–260.

11/http;// www.Navesworks.com (Accessed Feb.2018).

Appendix 1

Represent to know Autodesk Navisworks:

The land scape of Navisworks similar to other Autodesk software's land scape and this will be familiar with users those using some of Autodesk software's products. See figure 1.

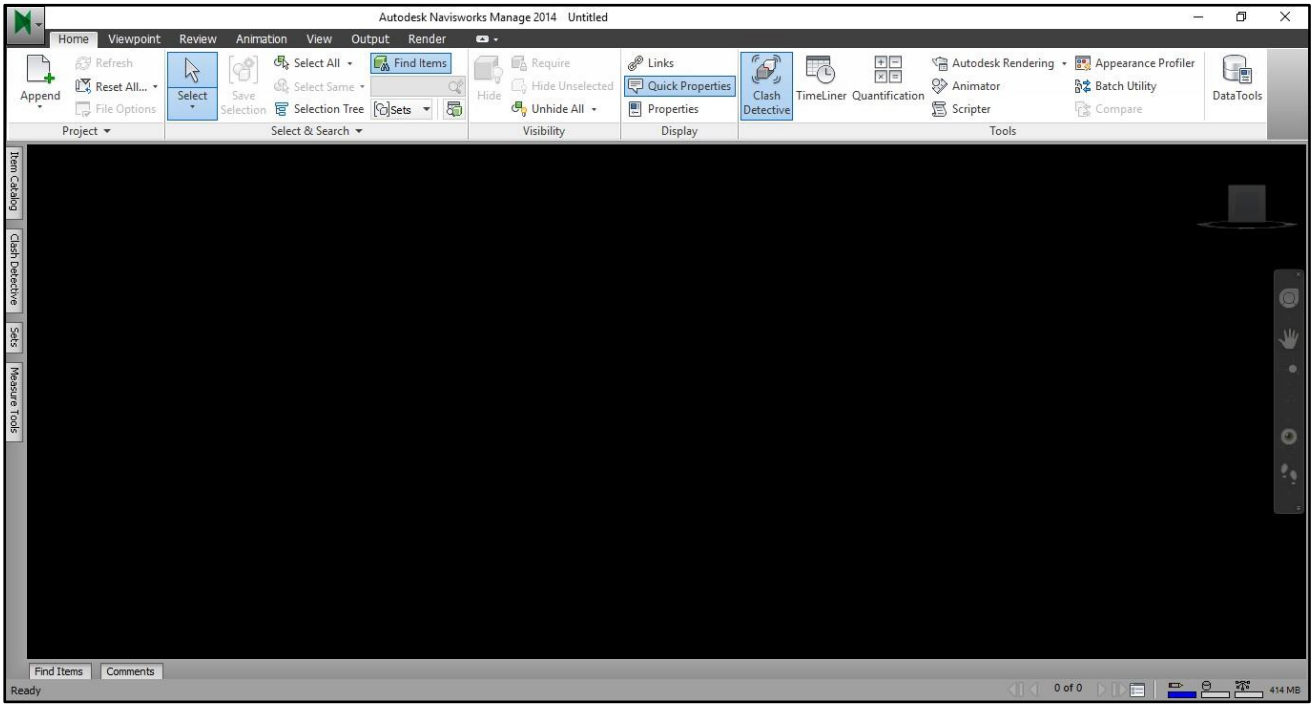


Figure 1: landscape of Navisworks Manage.

- **Application Menu: (The green N)**

A basic starting point within Navisworks, the Application menu, or green N, contains operations like New, Open, and Save. Several other useful operations that can be performed from here are shown in Figure 2.

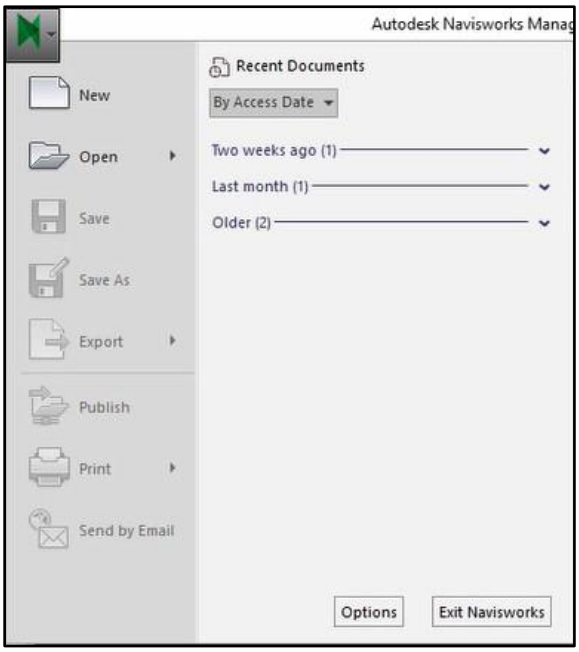


Figure 2: The green N, or Application menu

New: Closes the currently open file and opens a new file.

Open: Opens a new file (see Figure 3). Note that using Open while another file is already open will close that currently open file. You want to use Append and Merge to add additional files. Options include:

Open: Opens a new file while closing the currently open file.

Open URL: Opens a file from a URL, usually a website location.

Append: Appends additional files into already open files and merges duplicate geometry.

Merge: Merges a selected file into other files and adds only new information such as new geometry, new viewpoints, and new clashes.

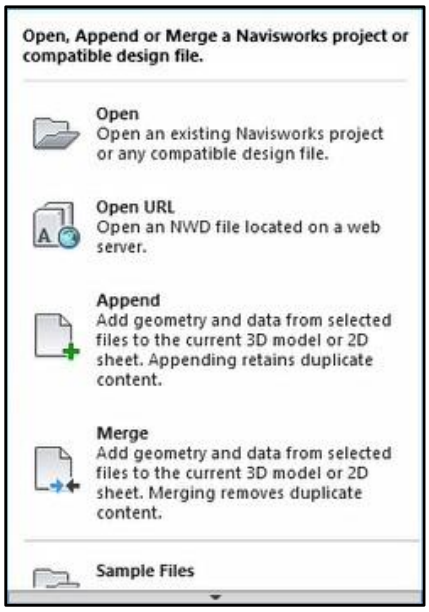


Figure 3 Additional Open operations

Save: Saves the current file.

Save As: Allows you to save the file in a different location or as a different file type (for example, as an NWD or NWF file). It allows you to save up to three versions back.

Export: Contains the Export operations (see Figure 4). Many of the other operations are located on the Output tab, explained later in this chapter.

Publish: Creates an NWD file. (An NWD file contains all model geometry together with Navisworks-specific data, such as review markups, viewpoints, or timeline sequence) also available on the Output tab.

Print: Contains Print, Print Preview, and Print Setup operations. also available on the Output tab.

Send by Email: Saves the current file as an NWD and uses your default email application to prepare an email to send. also available on the Output tab.

Recent Documents: This list shows all of the recently opened documents. You can control the order by Size, Access Date, Type, or Ordered List (default). Projects are only added to this list with the Normal view selected. If Classic view is used to

open a file, no project will be added to this list. All appended files will be added to this list when brought into a project.

Options: Opens the Options Editor. You can also access the Options Editor by using Ctrl+F12.

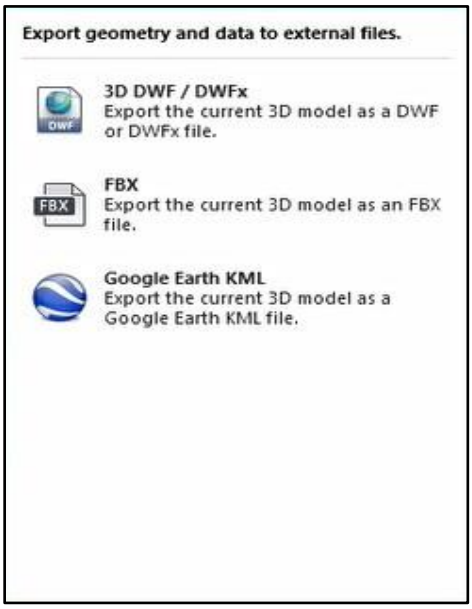


Figure 4 Export fly out

- **Quick Access Toolbar:**

The Quick Access toolbar, located  adjacent to the Application menu, is a series of predefined operations. By default, you can find New, Open, Append, Merge, Save, Print, Refresh, Undo, and Redo.

The Quick Access toolbar is customizable. You can remove tools by right-clicking the item you wish to remove or by clicking the down arrow to the right of the bar and clicking the option you wish to remove. You can add tools by selecting them from the tab and panel locations, right clicking, and then choosing Add to Quick Access Toolbar.

- **Tooltip:**

If you pause and hover your mouse cursor over any area in Navisworks, you get a tooltip, as shown here. Tooltips briefly explain the tool and may contain

information about shortcuts (such as pressing Ctrl+ A for Append). Also, if you leave your mouse in place a little longer, you will gain a longer explanation of the tool, the tooltip will expand into a definition from the help file.

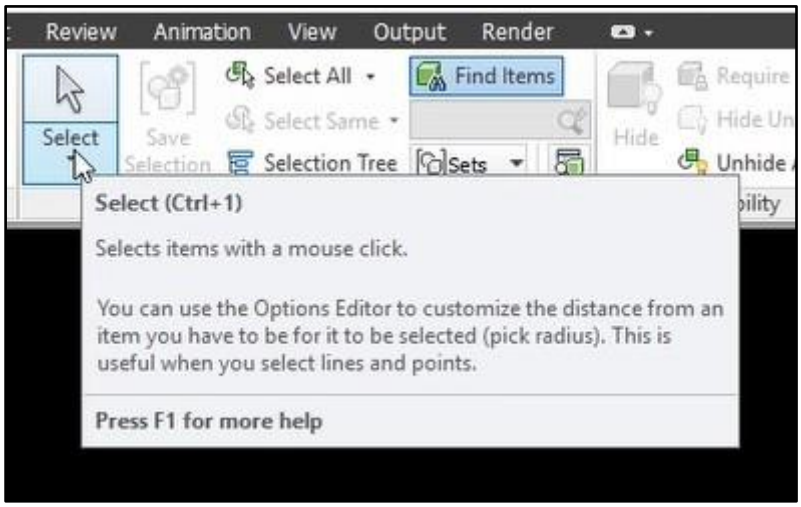


Figure 5 Tooltip

- **Navisworks Options:**

Options, or the Options Editor (sometimes referred to as Global Options), is used to adjust the program settings for Navisworks. The settings that you change here are retained across different Navisworks sessions. Settings can also be shared across a project team via the import/export feature (Figure 6).

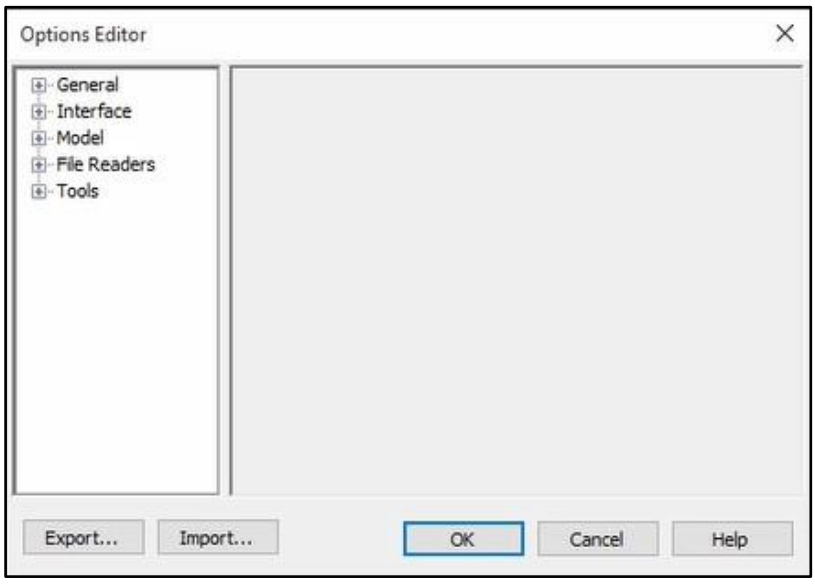


Figure 6 Options Editor

By looking at each page of the Options Editor:

GENERAL: Use the General settings (see Figure 7) to adjust the buffer size, file locations, number of recent file shortcuts you want Navisworks to store, and the Auto-Save options. Additional options include:

Undo: Specifies the amount of space Navisworks uses for undo/redo operations.

Locations: Enables the sharing of centralized project information for the project directory and site directory.

Environment: Specifies the maximum number of recently opened files for Navisworks to display. The default setting is 4 with a maximum of 16.

Auto-Save: Controls the settings for the Navisworks Auto-Save feature. From here, you can specify the save interval (30 minutes is recommended), the save location, and the number of save versions you want to maintain.

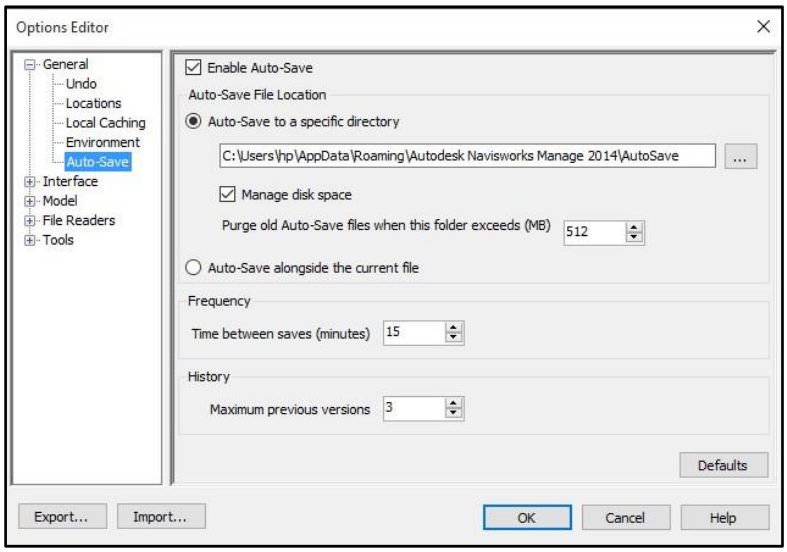


Figure 7 General options, with the Auto-Save settings shown

INTERFACE: Use the settings on the Interface page (see Figure 8) to customize the behavior of Navisworks.

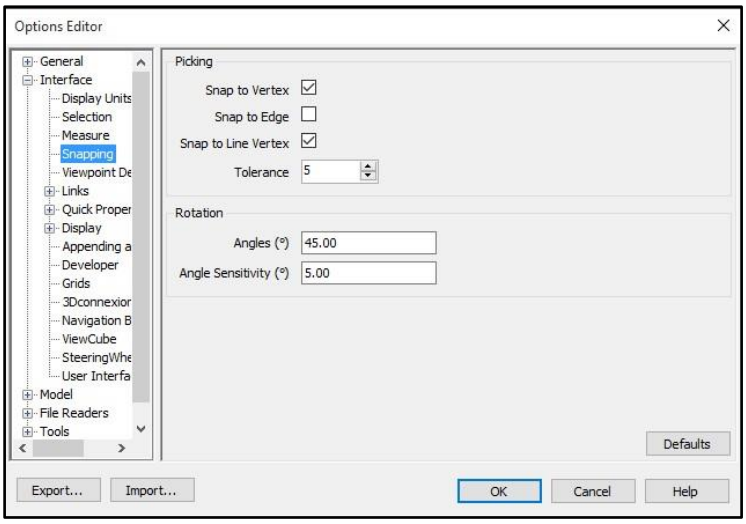


Figure 8 Interface options, with the Snapping options shown

Additional information includes:

Display Units: Changes the Navisworks display units, Meters are the default setting for new Navisworks files.

Selection: Configures the way geometry is selected and highlighted within Navisworks.

Pick Radius: Specifies the radius that an object has to be within to be selected.

Resolution: Specifies the level of selection. If you have problems selecting objects, you might try changing these settings.

Compact Tree: Specifies the level of detail to display on the Compact tab of the selection tree.

Highlight: Controls the Highlight settings. When the Enabled box is unchecked, selected items are no longer highlighted.

Measure: Use these options to adjust the settings for the Measure tools.

In 3D: Allows accurate measurements in 3D. This tool allows you to find the distance of 3D objects in a view. When 3D is not selected, Navisworks defaults to a 2D object defined by the points you select. In 3D changes the way the measurements are shown. If the measurement line is obscured by model geometry, it will be hidden when in 3D is selected.

Use Center Lines: With this check box selected, the Shortest Distance measurements snap to the center lines of the selected object. When Use Center Lines is not selected, the surface of the object is used.

Snapping: Enables snaps within Navisworks (Vertex, Edge, and Line Vertex). Enabling this tool is useful in conjunction with Measure tools.

Viewpoint Defaults: These options define the attributes that are saved with saved viewpoints.

Settings: Opens the Default Collision dialog box allow you to control settings from the Third Person Avatar. This dialog box can also be accessed from the Viewpoint tab under Edit Viewpoints.

Links: This page allows you to customize how links are displayed within Navisworks.

Quick Properties: Customizes the way Quick Properties are displayed. Use this page to set up additional Quick Properties categories or choose to hide Quick Properties using this tab.

Developer: Select this option if you want to enable the Geometry tab and the Transform tab within the Properties palette. This tab also enables the use of Hard Conservative clash tests.

Display: Adjusts display performance.

Occlusion Culling: Select this check box to enable or disable the Culling feature. Enabling Culling means that Navisworks draws only visible objects and ignores other objects.

Grids: grids allow you to change the options for the Grids and Levels tool found on the View tab. Here, you can change options such as color, font size, and grid transparency (X-Ray mode).

3Dconnexion: Controls the settings for a 3D mouse or motion controller mouse, often referred to as a space mouse (including speed). A space mouse can be used as an alternative (or in addition) to the mouse to move around the scene view.

Navigation Bar: Used for customizing the Navigation Bar and legacy navigation tools.

View Cube: Customizes the behavior of the View Cube tool.

Steering Wheels: Customizes the behavior of the Steering Wheels tool.

User Interface: Used to switch between Standard (ribbon) and Classic (toolbars) interface mode.

MODEL:

Use the Model settings (see Figure 9) to optimize the performance of Navisworks and to customize parameters for NWD and NWC files.

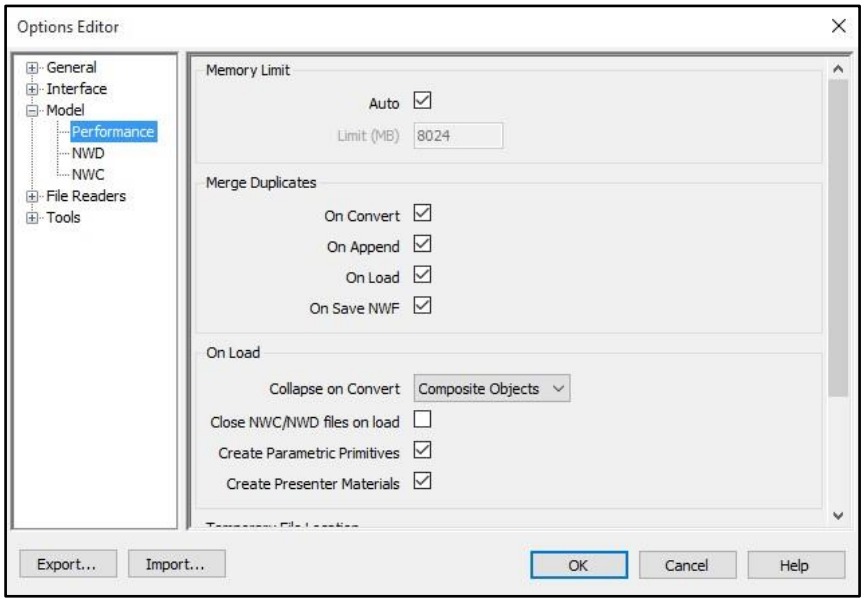


Figure 9 Model options, with Performance options shown

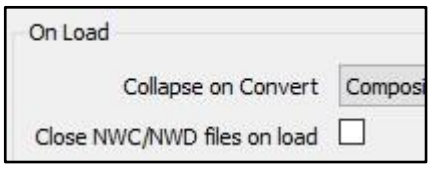
Additional options include:

Performance: Optimizes the performance of Navisworks.

Memory Limit: Specifies the amount of physical memory that Navisworks uses.

Merge Duplicates: Allows you to control how and when information is merged into Navisworks.

On Load: Optimizes the performance of Navisworks when loading files into Navisworks.



- **Collapse on Convert:** Collapses the tree structure.

- **Close NWC/NWD Files on Load:** Controls whether or not the NWC/NWD files are locked for editing. When this box is unchecked, the files will be locked for editing. Checked means that these files are closed once loaded into memory and can be edited.
- **Create Parametric Primitives:** Improves speed and performance by using parametric objects.
- **Create Presenter Materials:** Allows you to create and use materials when an NWC file is loaded.

NWD: Enables and disables geometry compression for the NWD file format.

NWC: Use this page to manage the file options for the NWC file format.

Caching: With these boxes checked, Navisworks creates and saves to a cache file, or NWC. This is a recommended setting because NWC files are typically smaller than their original files.

The Close NWC/NWD Files on Load Option:

Depending on your workflow and what your needs are, you should give this check box careful consideration.

If you leave Close NWC/NWD Files on Load unchecked, you will not be able to update your NWC/NWD fi les on the fly. In other words, if you are working on an active project (coordination meetings, for example) and find yourself updating fi les often, you would have to close Navisworks in order to update the NWC/NWD fi les loaded in the project. With this box checked, you can modify your files during the project.

FILE READERS:

Use the File Readers settings (see Figure 10) to configure the file readers required to open native CAD, BIM, and scanning application file formats in Navisworks.

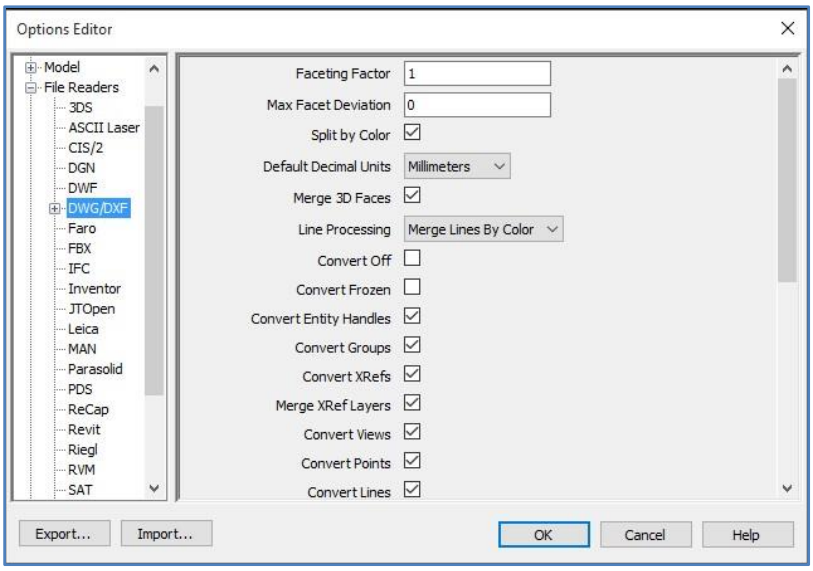


Figure 10 File Readers page, with options for DWG/DXF shown

DWG/DXF: Adjust options for the DWG/DXF file reader.

Merge 3D Faces: Allows the file reader to merge the 3D faces of DWG/DXF objects into a single item in the selection tree. This helps to lessen the number of items selected.

DWG Loader Version: Allows Navisworks to select which version of the Autodesk object enablers to use when loading a DWG file. If the DWG Loader Version needs to change, Navisworks must be restarted for this setting to take effect.

Advanced Use the Convert Object Properties dialog box (click Advanced to open this dialog) to select third-party applications for the file reader to read additional options from (Figure 11).

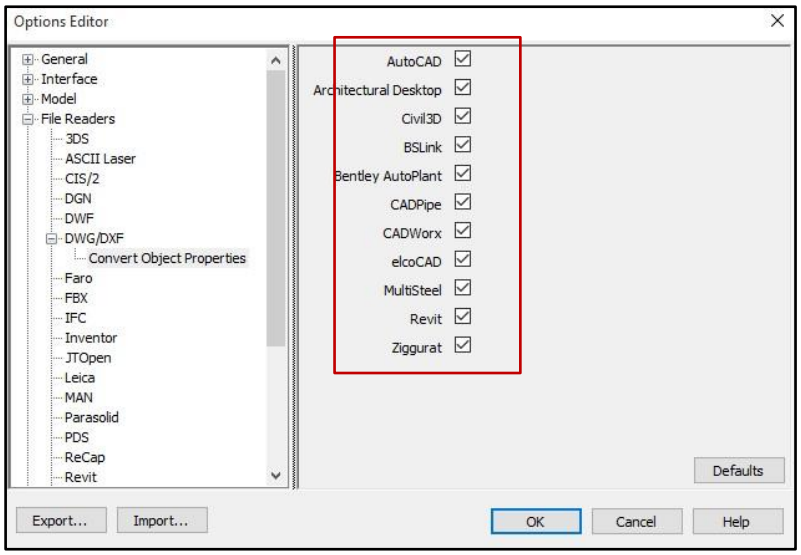


Figure 11 Convert Object Properties dialog box

All other file readers adjust the options for the file type they are associated with.

TOOLS: Use the Tools settings (see Figure 12) to adjust the options for Clash Detective, Presenter, time liner, Scripter, and Animator.

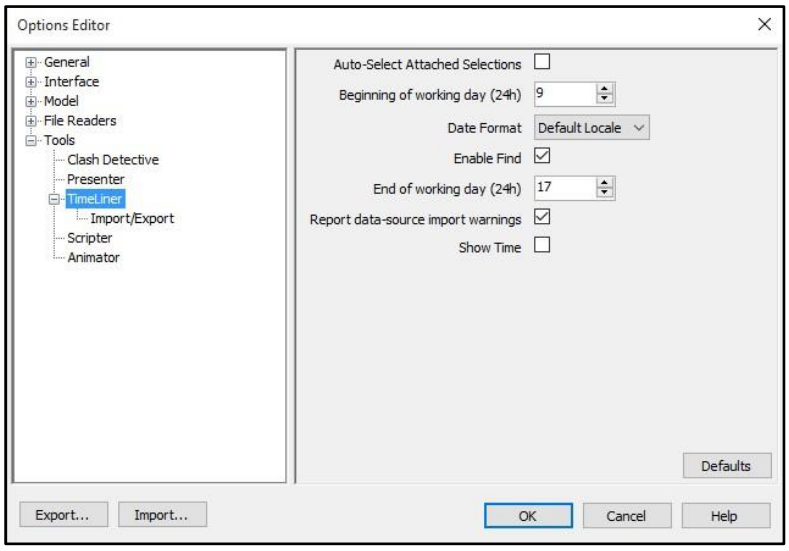


Figure 12 Tools options, with settings for Time liner shown

Options include:

Clash Detective: Customizes Clash Detective options.

Presenter: Customizes Presenter options.

Profile: You can adjust Presenter profiles to reflect your level of comfort or knowledge. The Basic setting is the Navisworks default and has a limited editing

functionality. Standard has some advanced Presenter features. Advanced gives you access to such features as extra materials, lights, and render styles.

Interactive Materials: When this check box is cleared; materials are not displayed during navigation. This decreases the load on the video card and can improve performance.

Interactive Lighting: When this check box is cleared; lights are not displayed during navigation. This decreases the load on the video card and can improve performance.

Time liner: Customizes Time liner options.

Auto Select Attached Selections: When enabled, automatically selects attached objects in Time liner.

Display Synchronization Errors: When enabled; indicates that error messages will display when synchronizing tasks from eternal links in Time liner.

CSV File: Read and Write Encoding: Specifies the file format of the imported or exported CSV file.

Scripter: Use these options to customize the Scripter settings.

Animator: A check box indicates whether or not a manual entry is shown in the Animator.

IMPORT AND EXPORT:

These settings allow you to export the current Options settings into an Options XML file; you can choose which categories are exported. These items may also be imported using the Import feature.

From a workflow perspective, it may be useful to save individual files for each category (General, Interface, and so forth) per project. This way, specific settings are retained as needed and can be shared among users quickly and easily.

- **Exploring the Ribbon:**

The ribbon, located at the top of the user interface, is a palette that groups the entire Navisworks toolset into an easy to find and use location. The ribbon is divided into

tabs, with each tab supporting a specific activity or task. Within each tab is a series of panels that contain the available tools.

While you are not able to add to or remove custom commands from the ribbon, you can customize the appearance and location of the panels using these methods:

- Right-click the tab or panel to open the context menu. From here, you can turn tabs or panels on or off.
- Left-click and hold a specific panel to move its location. You can change its location to a new place within the tab or drag it out into the workspace to make it more accessible. Panels may not be moved to other tabs.
- To reset the panel to its default position, right-click on an empty location on the panel and click Restore Default Ribbon.

Pushpins: Any time a pushpin icon appears, you can click it to pin an item to the screen. This will allow the panel or palette to stay on top and remain open as you move to other tools in Navisworks.

Home: The Home tab contains Project, Select & Search, Visibility, Display, and Tools panels (Figure 13 and Figure 15).

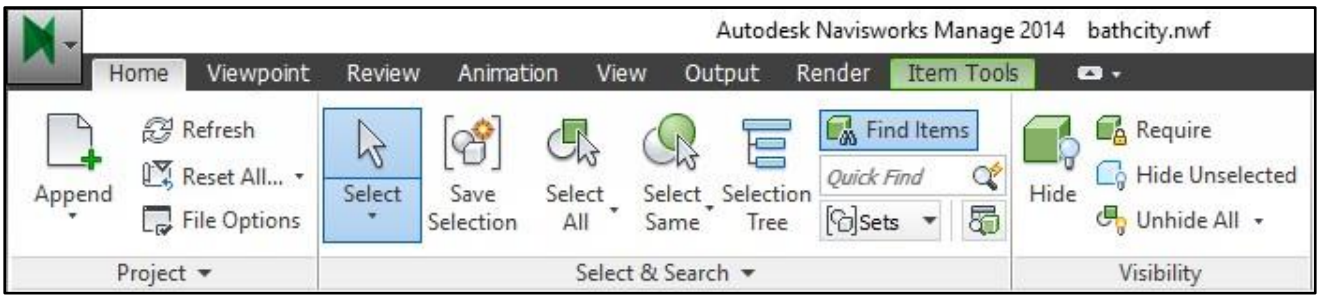


Figure 13 Home tab, showing additional tools enabled

PROJECT:

Append: Appends, or combines, files. The drop-down also contains Merge.

Refresh: To ensure that you are working with the most current information, Navisworks contains a Refresh feature.

Reset All: Uses the various tools to reset changes applied in Navisworks.

Appearance: Returns all color and transparency overrides to their original state.

Transforms: Resets all Transforms overrides to their original state.

Links: Resets all links applied to their original state. Deletes all links made in Navisworks and retains only links inherited from the original files.

File Options: This dialog box (see Figure 14) controls the appearance of the model as well as the speed of navigation around it. Changes made in this dialog box are for the current session only, and options are returned to the defaults when the model is closed.

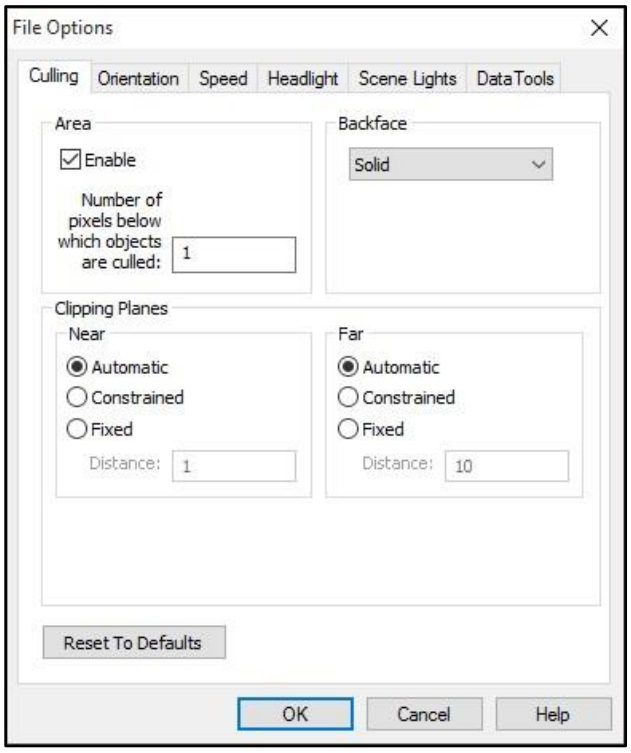


Figure 14 File Options dialog box

Culling: Use this tab to adjust geometry culling (that is, the ability to navigate large areas) in the open Navisworks file.

Orientation: Use this tab to adjust the real-world orientation of your model.

Speed: Use this tab to adjust the frame rate speed to reduce the amount of dropout during navigation.

Headlight: Use this tab to change the intensity of the scene's ambient light and headlight for Headlight mode. This setting is useful to customize the lighting as you navigate.

Scene Lights: Use this tab to change the intensity of the scene's ambient light for Scene Lights mode. This setting is useful to define a different lighting scheme as you navigate the model.

Data Tools: Use this tab to create and manage links between open Navisworks files and external databases. You will not likely use this setting often.

Scene Statistics: An extremely useful tool, Scene Statistics lists all of the files contributing to aggregated elements, or the "scene." It also shows the various graphic elements that help to make up the scene. Use Scene Statistics when an object enabler appears to be missing or when certain objects are not showing up properly.

SELECT & SEARCH:

Select: Allows you to select objects with your mouse. Also available within the drop-down list is Select Box, which allows you to select all items within a defined box.

Select All: Selects all objects within the model.

Select None: Deselects the current selection. Pressing the Esc key has the same function.

Invert Selection: Deselects the currently selected items and selects the currently unselected items. In short, it selects the opposite of what you had selected.

Save Selection: Saves the currently selected objects as a selection set and opens the Sets window. The set can then be renamed and modified.

Select Same: Allows you to select multiple instances of the selected item or group of items. Also opens to the Select Same drop-down for additional selection criteria and options.

Selection Tree: Toggles the selection tree on and off. The selection tree is a palette that displays a variety of categorized views of the structure of the model depending on the loaded model.

Find Items: Toggles the Find Items palette on and off.

Quick Find: A simplified version of Find Items, Quick Find allows you to search the scene using the Quick Find dialog box.

Sets: Displays a list of defined search and selection sets. You can access the Sets palette from this drop-down.

Selection Inspector: Displays a list of all selected objects showing their Quick Properties information. Quick Properties information can be customized in the Options Editor.

VISIBILITY:

Hide: Hides selected items from display. You can select multiple items to hide them and at different intervals. The items also appear grayed out in the selection tree to represent hidden.

Require: Forces an item to remain visible regardless of performance settings, such as culling. When an item is set to Required, it will appear red in the selection tree. Required items can still be hidden; the required setting is mainly to help ensure that items will not be dropped from view when you have to change your performance settings.

Hide Unselected: Hides all items except those that are currently selected. This tool is useful when you're trying to build a selection set and ensure the items that you have selected.

Unhide All: Reveals all hidden items in the scene. The drop-down also contains Unrequire all, which sets required items back to optional.

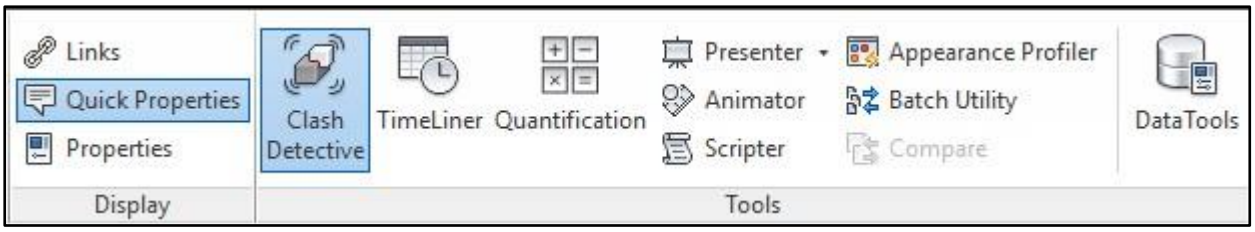


Figure 15 Home tab continued

DISPLAY:

Links: Displays or hides links. Several types of links display in Navisworks: Hyperlink, Label, Viewpoints, Clash Detective, TimeLiner, Sets, Redline tags, and user-defined links. You can use the Options Editor to toggle the display of each of the link categories and also to control their appearance.

Quick Properties: When enabled, Quick Properties displays brief information about the object in a tooltip type of display. You can edit the type of information that is displayed in the Options Editor.

Properties: Toggles the Properties palette on and off. The Properties palette displays available properties for a selected item. If more than one item is selected, the Properties palette will display only the total number of selected items and no additional property information.

TOOLS:

Clash Detective: Toggles the Clash Detective palette on and off. Clash Detective enables you to interactively search your model for clashes or interferences.

TimeLiner: Toggles the TimeLiner palette on and off. TimeLiner allows you to create 4D simulations of your project, linking time with modeled objects.

Presenter: Toggles the Presenter palette on and off. Presenter allows you to apply materials and lighting to your model to aid in creating renderings.

Animator: Toggles the Animator palette on and off. Animator allows you to animate objects to bring realism to your project.

Scripter: Toggles the Scripter palette on and off. Scripter adds interactivity to your animated objects.

Batch Utility: Opens the Batch Utility dialog box. From here, you can create a list of all design files, append multiple design files into a single NWD or NWF file, and convert multiple design files into individual NWDs.

Appearance Profiler: Toggles the Appearance Profile palette on and off. This tool lets

you create custom appearance profiles for items based on properties or sets (Search and Selection). Then you can use the appearance profiles to essentially color-code the objects in your model to help identify or differentiate status or type.

Compare: Opens the Compare dialog box. You can look for differences between any two items selected in the model. These items can be files, layers, instances, groups, or geometry.

Data Tools: Opens the Data Tools dialog box. From here, you can connect Navisworks to external databases and create links to objects within the model.

Viewpoint: The Viewpoint tab contains the Save, Load & Playback panel as well as the Camera, Navigate, Render Style, Sectioning, and Export panels (Figure 16 and Figure 17).

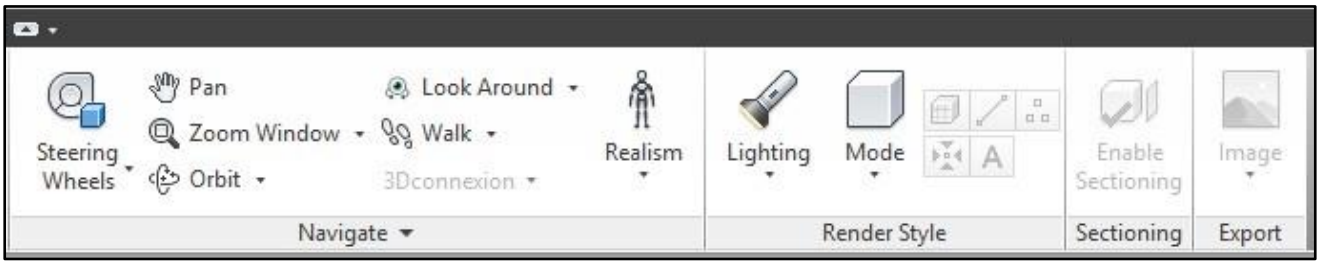


Figure 16 Viewpoint tab

SAVE, LOAD & PLAYBACK:

Save Viewpoint: Saves a viewpoint of the current view. The saved viewpoint retains the properties and attributes of the current view when the Save Attributes setting in the Options is selected. There is also a Record feature to record your actions (Walk, Fly, Zoom, and other actions in Navisworks). The recording is saved in the Saved Viewpoints window.

Animation Controls: See “Playback” in the section “Animation.”

Edit Viewpoint: Opens the Edit Viewpoint dialog box. This dialog box allows you to edit any viewpoints attributes, including camera position, field of view, speed of motion, and saved attributes. The Collision dialog box is located within the Edit Viewpoint dialog box, allowing you to adjust collision settings for the current viewpoint.

Saved Viewpoints Dialog Launcher: toggles the saved viewpoints palette.

CAMERA:

Perspective: Allows you to choose between Orthographic or Perspective mode. Walk and Fly navigation tools are not available in Orthographic mode. Tip: If the view becomes distorted when you switch between modes, undo the switch, use the Focus tool, and then switch modes.

Field Of View (F.O.V.): Defines the area of the scene that the camera can view. The lower the number, the narrower the camera angle or the closer you are to the object being viewed. You can you edit existing or saved Field Of View settings using the Edit Viewpoint dialog box. The higher the number is, the more distorted the model looks.

Align Camera: Opens the Align Camera drop-down, which allows you to use these tools to align the camera to the chosen axis:

Align X Aligns the camera to the x-axis.

Align Y Aligns the camera to the y-axis.

Align Z Aligns the camera to the z-axis.

Straighten: A useful tool to straighten the view when you find yourself askew, which can often occur when using some of the navigation tools such as Fly and Orbit. It works only when the view is within 13 degrees of a face of the View Cube.

Show Tilt Bar: Toggles the Tilt Bar off and on. Tilt adjusts the vertical angle of the camera.

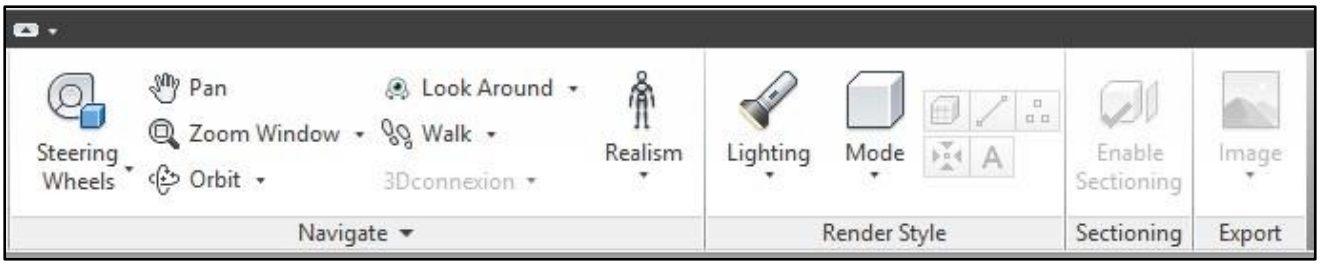


Figure 17 Viewpoint tab continued

NAVIGATE:

Navigate Tools: Included on the Viewpoint tab are Navigation tools to help to move around the model. Here, you can find tools for Pan, Zoom Window, Orbit, Look Around, Walk, and Steering Wheels. Most of these tools can also be found on the Navigation Bar.

Realism: Toggles the Realism settings on and off for the following options. (Figure 3.21) shows one result of working with Realism settings: a construction worker avatar in a crouching position.

Collision: Enabling Collision allows you to navigate the model with mass. As you interact with the model and come into contact with objects like doors or columns, you stop or are unable to pass through that object. You can change or customize the size of the Collision Volume to reflect the needs of the user or collision requirements. Collision can only be used with the Walk and Fly tools.

Gravity: This tool gives you the appearance of weight. When you are using the Walk tool and you begin to move, you will "fall" until you reach a surface. Gravity works best when Collision is also active so that when a surface is contacted, the falling stops. Use Gravity in conjunction with Collision to walk up or down stairs. Gravity can only be used with the Walk tools. If Gravity is selected, Collision is automatically turned on. You cannot have Gravity without Collision.

Crouch: with Crouch activated, you will automatically crouch under any objects that you cannot freely walk under at the specified avatar height. This can be useful for checking clearance heights under pipes and other equipment.

Third Person: When Third Person is active, it turns on Third Person view, or an avatar, which you can use as a representation of yourself while navigating the model. Third

Person has other added benefits like working with Gravity, Collision, and Crouch.

When you're using the avatar for Collision, it will turn red when it approaches another item. Also, you can customize Third Person by changing the avatar selection and dimensions.

Linear Speed: Sets the linear speed, which is the speed the Walk and Fly tools use when navigating through the model. The 5-10 ft/sec range is ideal for an average walking pace.

This is a temporary setting specific to the view. If you change views, this setting will go back to the project default.

Angular Speed: Sets the angular speed, which is the speed at which the Walk and Fly tools turn when navigating through the model. The 45-60 deg/sec range is ideal for an average walking pace.

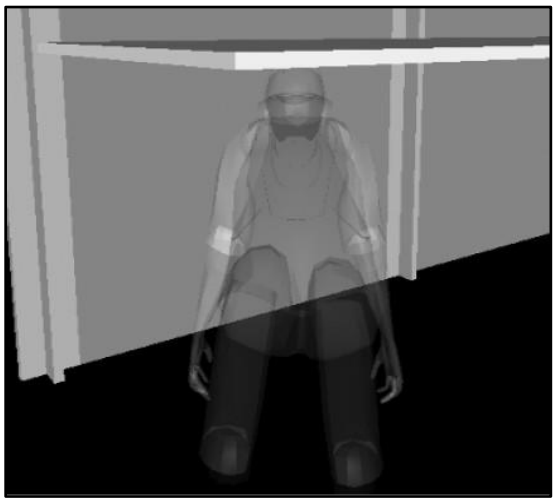
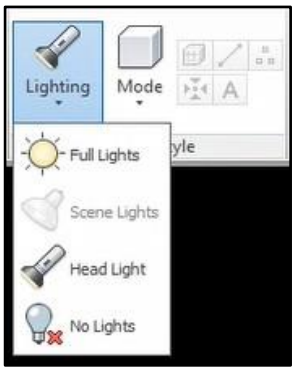


Figure 3.18 Third Person with Gravity, Collision, and Crouch enabled

RENDER STYLE:

Lighting: Changes the Lighting mode within Navisworks to control how the 3D scene lighting is displayed.

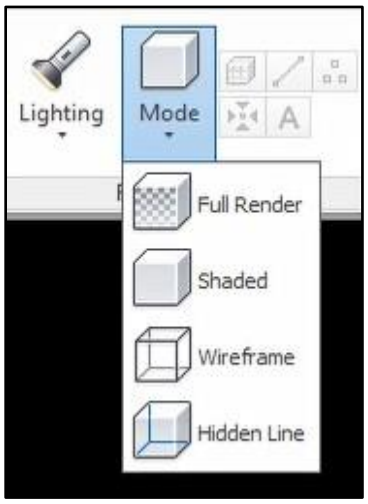
- ✓ **Full Lights:** Uses the highest quality lighting available. Controlled by Presenter.



- ✓ **Scene Lights:** Uses the lights supplied with the appended files. If no lights are added, Navisworks will add two opposing lights. You can change the ambient lighting options using the File Options tool.
- ✓ **Headlights:** Uses a light that comes from the camera location. You can change the ambient lighting option using the File Options tool.
- ✓ **No Lights:** does not use any lights in the view; geometry is rendered with flat lights.

Mode:

The Mode drop-down controls the options for displaying the scene geometry rendering and the level of materials to display.



Full Render: in Full Render mode, the model is shown with materials and textures along with edges and smooth shading.

Shaded: The model is shown with additional edges and smooth shading. Materials and textures are not included in this mode.

Wireframe: The model is shown in Wireframe mode only. Materials and textures are not included in this mode.

Hidden Line: The model is shown in Wireframe mode but only outline and facet edges are displayed; this hides additional lines over Wireframe mode. Materials and textures are not included in this mode.

Surfaces: toggles 3D surface geometry on and off.

Lines: toggles on and off the 2D lines that come from an appended file.

Points: toggles on and off the points that come from appended files. When you are inserting point cloud or laser scan data, it may be necessary to have the points enabled.

Snap Points: Toggles on and off the rendering of snap points within the model.

Text: Toggles on and off 2D or 3D text that comes from appended files.

Using a combination of these tools when bringing in an AutoCAD file or other vector-based file types helps to clean up the scene in Navisworks and create a display of only 3D geometry.

SECTIONING:

Enable Sectioning:

Opens the Sectioning Tools tab (Figure 19). The Sectioning tools allow you to create cross-sections of your model. Sections can enabled and disabled as needed.

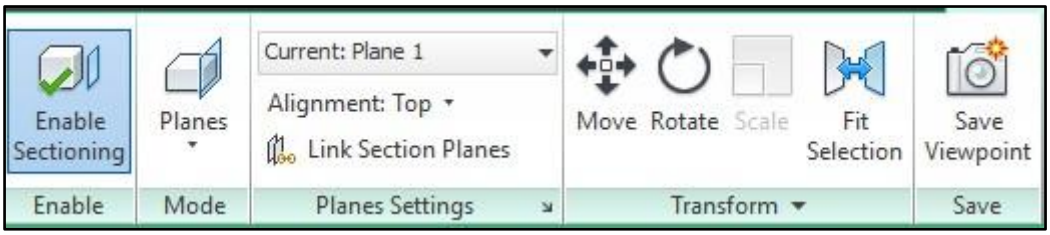


Figure 19 Sectioning Tools tab

EXPORT:

Image: Saves an image file of the current view.

Rendered Image saves a rendered image of the current view.

Piranasi EPix Saves a Piranasi EPix file of the current view.

Review: The Review tab contains Measure, Redline, Tags, Comments, and Collaborate panels (Figure 20).

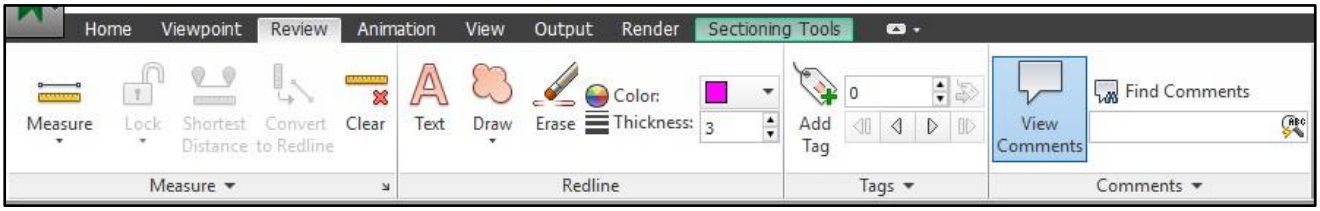


Figure 20 Review tab

MEASURE:

Measure:

Navisworks has tools that allow you to measure between points, calculate area, and convert measurements to redlines. The Measure tools are independent of Navigation tools. if you activate the Navigation tools (walk, fly, orbit, pan), you will have to go back to your Measure tools after using any of the Navigation tools. However, you can use the mouse tools for navigation (mouse orbit, pan and zoom) without affecting the Measure tools. Using the mouse tools can help you to also move to better align your measurement. Use right-click or the Esc key to cancel any of the Measure tools. to clear the screen of the measurement after placement, use Clean as explained below.

Point to Point: Measures the distance between two points.

Point to Multiple Points: measures the distance between a starting point or base point and any number of additional selected points.

Point Line: Measures consecutive linear distances.

Accumulate: Measures the total length of nonconsecutive linear measurements (keeps a running total of the linear measurements) until cleared or canceled.

Angle: Measures the angular distance as defined by three selected points.

Area: Measures the area of selected points.

Shortest Distance: Measures the shortest distance between two selected objects (two objects must be selected; use the Ctrl key to select the objects as needed).

Convert To Redline: Clears the measurement and converts it to a redline. The redline will be saved as part of the active viewpoint. If no viewpoint is selected, the Convert to Redline tool will create a new viewpoint automatically.

Clear: Clears the current measurement from the screen.

Transform Selected Items: Moves or rotates the currently selected object the distance specified by a measuring tool. Use Transform Selected Items to move the object in the direction that you specified. For example, if you selected the bottom of an object and then the top of an object with a measuring tool, your object will be

moved up. Keep in mind that this is not a temporary transform that can be reset by using Reset Transform, but that it affects the file units and transforms; this is a permanent change to the object.

Moving an Incorrect Element:

Learning to use the Measure Transform tool can sometimes mean the difference between a project moving smoothly and a project with additional conflicts because of

a misplaced appended item. There are times during an Append or Merge operation when objects could be improperly aligned, even given the best efforts of the project team. There is good news, though; all items in Navisworks can be moved. In most cases, entire file sets are selected and transformed to a new location. (see figure 21)

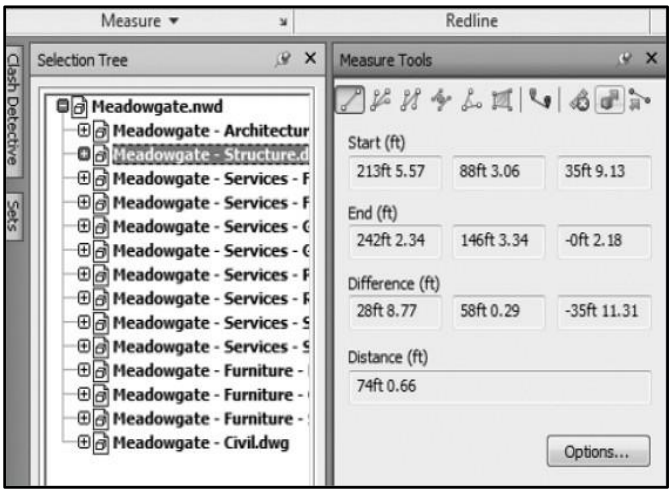


Figure 21 Measure Transform tool

Using the Measure Transform tool in conjunction with the selection tree lets you specify a distance to relocate the object. It helps to know a good reference or common location between the items when selecting your points. Another good idea is to have your snaps enabled when using the Measure Transform tool to help with selecting points.

REDLINE:

Draw:

Allows you to add redline shapes and text notes to your model. Redlines can only be added to a saved viewpoint or to a clash, which has a saved viewpoint. If there are no saved viewpoints, adding a tag will automatically create and save a viewpoint for you. Otherwise, you will receive an error, and you'll have to save a viewpoint before adding any redlines.

Color: Allows you to change the color of redlines.

Thickness: Changes the line thickness of the redlines being added; 9 is the maximum thickness.

TAGS:

Add Tag:

Inserts a tag into your model. If you have a viewpoint selected, the tag will be created within that viewpoint; otherwise, the tag will create its own viewpoint.

Tag ID: Allows you to enter the tag ID or number to use with Go to Tag.

Go to Tag: once you enter the desired number, you can use the Go to Tag tool to take you to the tag.

Tag Selection: Scrolls through the tag and its associated viewpoints.

Renumber Tag IDs: Used to renumber the tag IDs; removes duplicates. This tool is useful when you're appending or merging fi les that may have existing tag IDs.

COMMENTS:

View Comments:

Toggles the comments palette on and off. From here, you can manage the comments created throughout the model.

Find Comments: Opens the Find Comments palette. You can search through both

comments and tags for text, author, comment ID, status, comment, and date modified.

Renumber Comment IDs: Used to renumber the comment IDs; removes duplicates. This tool is useful when you're appending or merging fi les that may have existing comment IDs.

COLLABORATE:

Collaborate: Enables a collaboration session using Windows NetMeeting.

Drive: Enables the user to become the driver of a remote computer.

Refresh: Shares model updates with each member of the team.

Animation:

This tab contains the Create, Playback, Script, and Export panels (Figure 22).

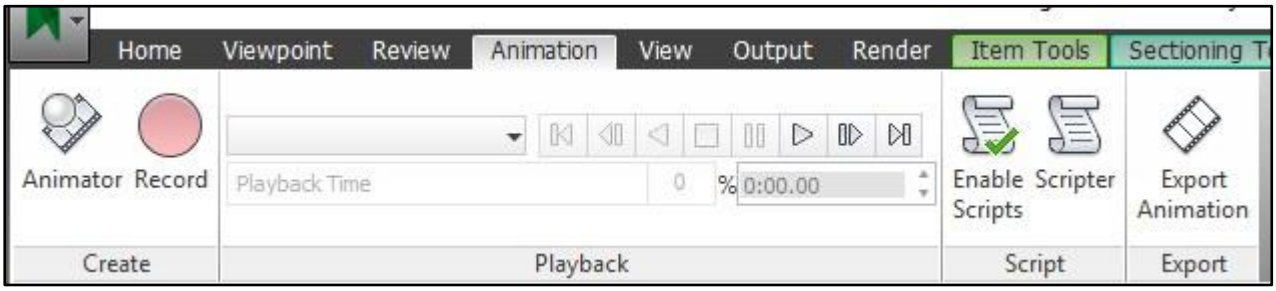


Figure 22 Animation tab

CREATE:

Animator:

Toggles the animator palette on and off (same as the animator located on the home tab). Animator allows for the animation of objects to bring realism to your project.

Record: Begins to record your actions (Walk, Fly, Zoom, and other actions in Navisworks).

The recording is saved as an animation in saved viewpoints that you can later edit or add to as needed.

PLAYBACK:

After an animation has been created, you gain access to the Playback tools. From the dropdown, select the animation that you wish to play, and use the tools available to play the animation.

You can also use the slide at the bottom of Playback to manually change the display of the playback.

SCRIPT:

Enable Scripts:

Enables and disables scripts. Once a script has been created, it has to be enabled before the action created can be utilized. For example, if you created a script to operate a door on approach, enabling scripts will allow this to occur.

Scripter: Toggles the Scripter palette on and off (same as the Scripter located on the Home tab). The Scripter adds interactivity to your animated objects.

EXPORT:

Export Animation: Exports the current animation.

View: The View tab contains Stereo, Navigation Aids, Grids & Levels, Scene View, and Workspace panels (Figure 23).

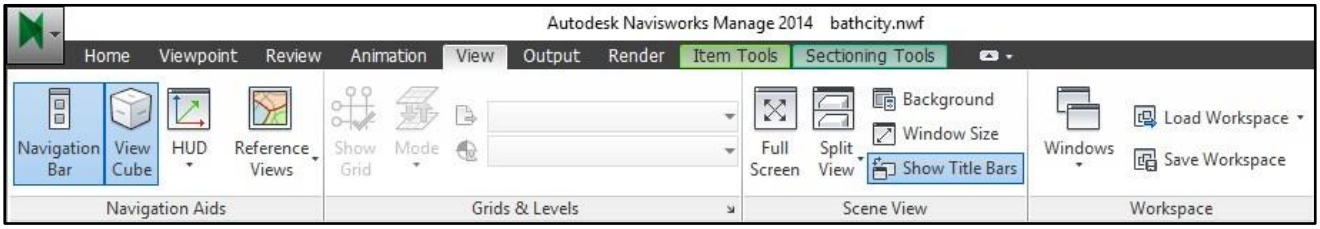


Figure 23 View tab

STEREO:

Enable Stereo: Stereo, or stereoscopic viewing, allows you to view the 3D model through stereo-enabled hardware (i.e., in true 3D), including active and passive stereo viewing glasses. This option is only available if you have the required hardware as well as the correct driver and display settings.

NAVIGATION AIDS:

Navigation Bar: Toggles the Navigation Bar on and off. Contains View Cube, Steering Wheels, Pan, Zoom, Orbit, Look, Walk, and Fly tools.

View Cube: Toggles the View Cube on and off. The View Cube allows you to switch between views of your model. Use View Cube to set a Home view that you can easily get back as you navigate around your model.

HUD: In Head Up Display, or HUD for short, the x-, y-, and z-axes, the position readout, and the grids display on and off. All of the HUDs are displayed in the lower-left corner of the screen.

XYZ Axes: As you can see in Figure 24, this option shows the X, Y, Z visual orientation of the camera (or the Third Person position if Third Person has been enabled).

Position Readout: As you can see in Figure 24, this option shows the X, Y, Z textual position of the camera (or the Third Person position if Third Person has been enabled).

Grids: Displays the Grid location HUD, as shown in Figure 24. With the Grid HUD turned on, you can see your level as well as the grid reference.

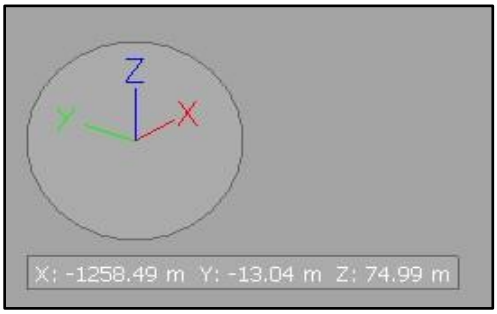


Figure 24: XYZ axes, position readout, and grids

Reference Views: toggles the Plan and Section views on and off. Both reference views allow you to gain perspective and location within your model, especially in large models. To use this feature, drag the white triangle to move yourself around. Additional tools are available on the context menu to aid in navigation.

GRIDS & LEVELS:

Show Grid: Toggles the grid on or off.

Mode: Allows you to change how the grid is displayed in Navisworks. Choose from Fixed, Below, Above, or Above And Below.

File: Permits you to choose the active file and change settings for the grids as needed.

Level: Controls the default level based on the active file.

SCENE VIEW:

Full Screen: Clears away all tabs and palettes and displays Navisworks in Full Screen mode. Press F11 to exit Full Screen mode and return to your tools.

Split View: Allows you to add horizontal and vertical screen splits. Each view can be set to represent a different view of the model. Only one view can be active at a time.

Background: Opens the Background Settings dialog box, which allows you to change the background color and scheme.

Window Size: Opens the Window Size dialog box, which allows you change the size of the Navisworks canvas. If you change the size and want to return to the default, change back to Use View.

Show Title Bars: Show or hides the title bars on secondary display view windows.

WORKSPACE:

Windows: Serves as a central list all of the palettes and toggles them on and off.

Load Workspace: Workspaces retain information about which windows are open, their positions, and the size of the application window. The Load Workspaces drop-down contains predefined workspaces as well as any custom workspaces. Workspaces do not maintain changes to the ribbon but do include changes made to the Quick Access toolbar.

Safe Mode Opens the workspace with minimal features.

Navisworks Minimal: Loads the workspace with the fewest tools and most space in the scene.

Navisworks Standard: Loads the workspace with the most commonly used tools and palettes.

Navisworks Extended: Opens the workspace with the most tools. This workspace is recommended for advanced users.

More Workspaces: Opens previously saved workspaces.

Save Workspace: Saves the current workspace as an XML file.

Output:

The Output tab contains Print, Send, Publish, Export Scene, Visuals, and Export Data panels (Figure 25 and Figure 27).

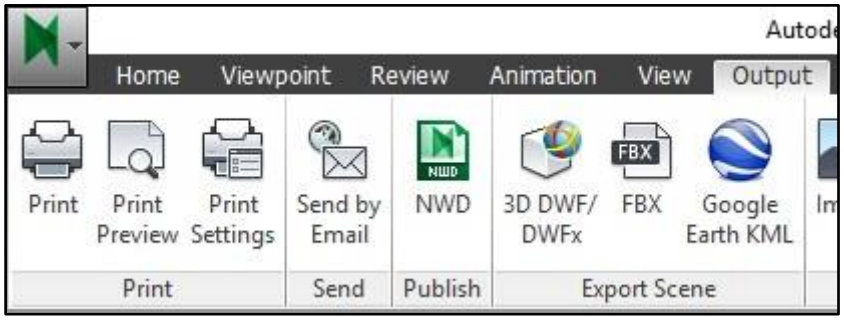


Figure 25 Output tab

PRINT:

Print: Sends the current view to a printer.

Print Preview: Creates a preview of the view to be printed.

Print Settings: Allows you to specify the printer settings.

SEND:

Send By Email: Saves the current file and uses your default email application to prepare an email to send. It can be used to send either an NWF or NWD file, but an NWD file is considerably larger. Make sure the file size meets the requirements of the email provider.

PUBLISH:

NWD: Creates an NWD file (NWD is a file that contains all model geometry together with Navisworks-specific data, such as review markups, viewpoints, or timeline sequence). You can also set options such as May Be Re-saved or set the file to expire within a certain timeframe (Figure 26).

When using Publish to create an NWD file, you can't save to previous versions of Navisworks, but you have access to all the other features and functions of Publish. If you need to create an NWD file for an older version of Navisworks, you will have to use Save As instead.

The downside is that you will no longer have access to the Publish options.

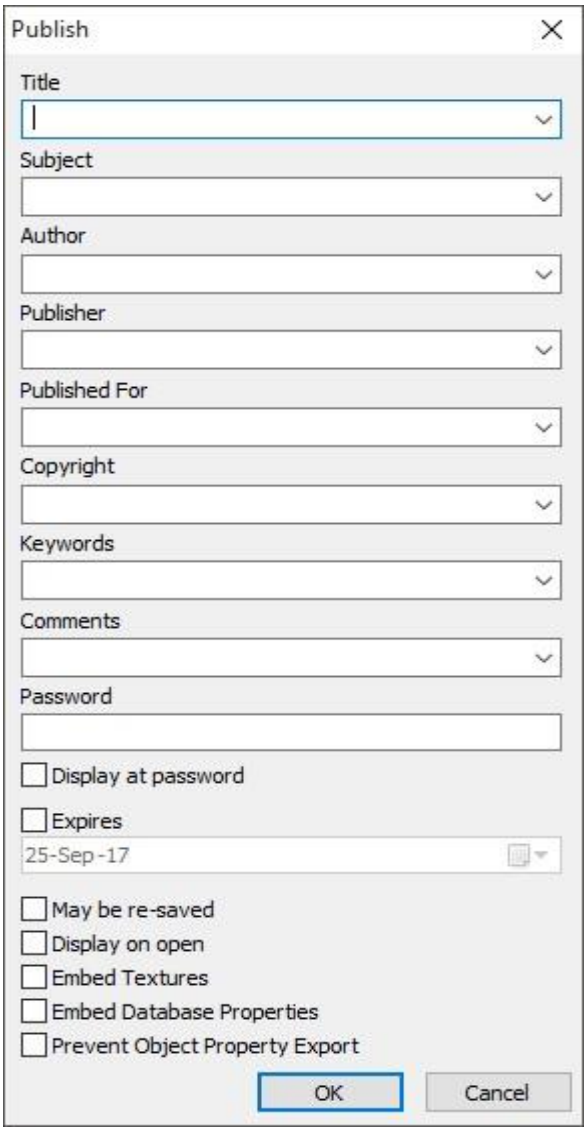


Figure 26 Publish dialog box

EXPORT SCENE:

3D DWF: Exports all materials and geometry into a 3D DWF file.

FBX: Exports an FBX file out of Navisworks. allows you to include things like lights, cameras, and textures in your export.

Google Earth KML: Google Earth KML files can be exported from Navisworks. The exporter creates a compressed KML file with the extension .kmz.

VISUALS:

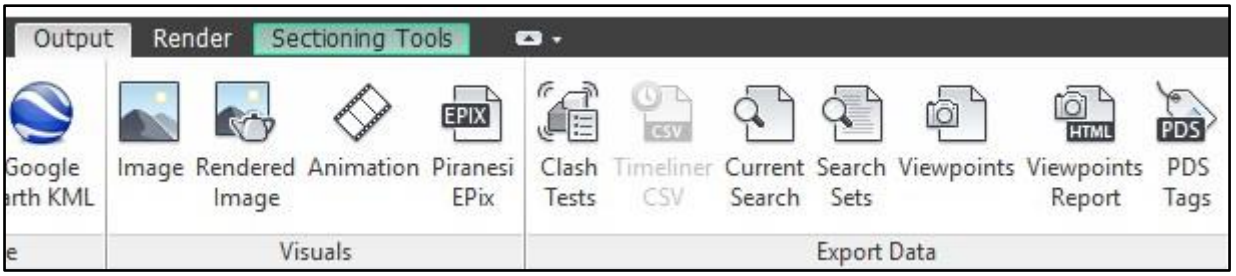


Figure 3.27 Output tab continued

Image: Opens the export image dialog box. This dialog box allows you to export an image of the current scene.

Rendered Image: Opens the rendered image dialog box, which allows you to export a rendered image.

Animation: Opens the Animation Export dialog box. You can choose from Source, Renderer, Output Type, and Size.

Piranesi EPix: Exports an EPX file for rendering in Piranesi from Informatix.

EXPORT DATA:

Clash Tests: Exports the settings for all of the clash tests created in Clash Detective into an XML file.

Timeliner CSV: Exports the current Timeliner tasks into a CSV file.

Current Search: Saved Find Items criteria can be exported from Navisworks into an XML file and imported into other sessions of Navisworks.

Search Sets: Saved search sets can be exported from Navisworks into an XML file and imported into other sessions of Navisworks.

Viewpoints: Exports all of the viewpoints into an XML file. This is a text-based XML file and the images are not exported. This file contains all associated data, including camera positions, sections, hidden items, material overrides, redlines, comments, tags, and collision detection settings. The XML file can be imported into other Navisworks files, and it creates all the views from the original project.

Viewpoints Report: Creates an HTML file or report of JPEG files of all saved viewpoints.

The report contains camera position, comments, and other associated data. If you have created an animation, the report will also include the animation frames as individual images as part of the report.

PDS Tags: Exports all PDS tag data from the model into a TAG file.

Status Bar, Performance Indicators, and Context Menus:

Located in the bottom-right corner of the screen is the status bar, which contains four performance indicators that give you feedback on the performance of your computer and currently loaded Navisworks model (Figure 28).

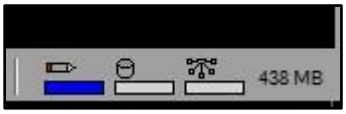


Figure 28 Status bar

Pencil Bar: Indicates how much of the current view is drawn, that is, how much image dropout there is in the current view. When the progress bar is at 100 percent, the scene is completely drawn, with no dropout. The icon changes color when a redraw is in progress. While the scene is being drawn, the pencil changes to yellow. If there is too much data to handle and your computer cannot process this quickly enough for Navisworks, then the pencil changes to red, indicating dropout.

Disk Bar: Indicates how much of the current model is loaded from the local hard drive. When the progress bar is at 100 percent, the entire model, including geometry and property information, is loaded into memory. The icon changes color when a file load is in progress. While the data is being read, the disk changes to yellow. If there is too much data to handle and your machine cannot process it quickly enough for Navisworks, then the disk changes to red, indicating a potential problem.

Web Server Bar: Indicates how much of the current model is downloaded from a web server. When the progress bar is at 100 percent, the entire model has been downloaded. The icon changes color when a file load is in progress. While data is being downloaded, the web server changes to yellow. If there is too much data to handle and your computer cannot process it quickly enough for Navisworks, then the web server changes to red, indicating a potential problem.

Memory Bar: Indicates the amount of system memory being utilized by Navisworks.

Navisworks uses a few context menus that contain various tools. These tools can help you save time once you master when and how to leverage them.

No Item Selected: This context menu (Figure 29) has a variety of tools that are found across various tabs and toolbars within Navisworks but that have been centralized for easy access. Access this menu by right-clicking in white space away from geometry. Once the menu is open, select your tool.

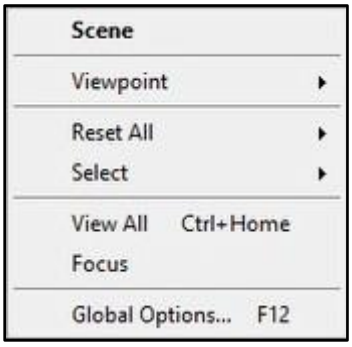


Figure 29 Context menu, with no items selected

With Item Selected: The With Item Selected context menu contains even more tools to help you along your way. Access this menu (Figure 30) by right-clicking once you've selected the geometry. If you right-click when no geometry is selected (right-clicking on the object instead of selecting it first), Navisworks will select that single piece of geometry and open this context menu as well, saving you the step of having to select the object first.

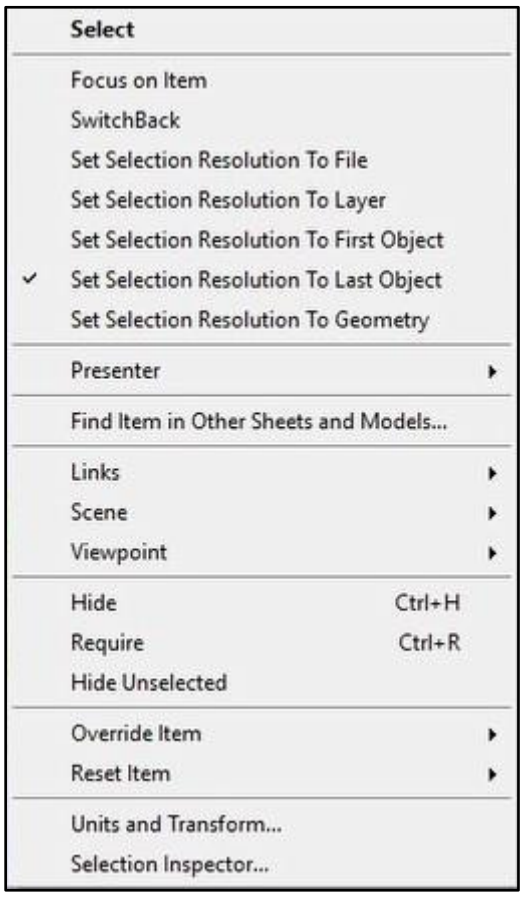


Figure 30 Context menu, with an item selected

The Bottom Line:

Understand the ribbon: Knowing the locations of various tools within the Ribbon provides a good foundation for being able to quickly access items across the Navisworks interface.

Use the Measure and Redline tools: The Measure and Redline tools are useful in Navisworks throughout a project, and having a basic understanding of these tools is essential.

➢ TimeLiner Tool:-

Timeliner tool used in linking models with an external construction schedule for visual time and cost based planning.

There is four tabs included in timeliner:

1- Task:

The Task view:

The tasks are shown in a multi-column table, which provides some flexibility in how records are displayed. You can:

• Move or resize columns

• Sort column data in ascending or descending order

• Add new user columns to the default column set

Tip: You can move between entries with the keyboard. Simply select a task, and use Tab and SHIFT + Tab keyboard keys to move forwards and backwards between fields. The keyboard can then be used to edit and set each entry where necessary.

The Task Hierarchy

Autodesk Navisworks TimeLiner supports a hierarchical task structure, as imported from a data source, for example Microsoft Project. The hierarchy can be expanded or contracted by clicking on the plus or minus sign, respectively, to the left of the task.

The Status Icons

Each task has its own status identified by an icon. Two separate bars are drawn for each task, showing planned against actual relationships. The color is used to

differentiate the early (blue), on-time (green), late (red), and planned (gray) portions of the task. Dots mark the planned start and end dates.

Placing the mouse pointer over a Status icon shows a tooltip explaining the task status.

Finished before planned start.

Early start, early finish.

Early start, on-time finish.

Early start, late finish.

On-time start, early finish.

On-time start, on-time finish.

On-time start, late finish.

Late start, early finish.

Late start, on-time finish.

Late start, late finish.

Started after planned finish.

No comparison.

The Active Check Box

The check box in the Active column enables you to turn a task on/off. If a task is turned off, then it will not appear in the simulation. For hierarchical tasks, turning off the parent task will automatically turn off all child tasks.

The Context Menus

Right-clicking within the tasks area on the tab, opens a context menu that enables you to work with tasks in your schedule.

• Copy Date/Time: copies date/time values in the selected field. This option is only available when you right-click one of the date fields (for example, Planned Start).

Note: Currently, you cannot use the CTRL + C keyboard shortcut to copy date/time values.

• Paste Date/Time: pastes date/time values. To access this option you need to right-click one of the date fields. Also, this option is not available unless a valid date/time has been previously copied.

Note: Currently, you cannot use the CTRL + V keyboard shortcut to copy date/time values.

•Enable Planned Dates: Simulate Planned Dates for the selected task. This option is available when you right-click the Planned Start or the Planned End field.

•Enable Actual Dates: Simulate Actual Dates for the selected task. This option is available when you right-click the Actual Start or the Actual End field.

•Dates: Enables you to simulate actual and planned dates for the selected task. If no dates are enabled for the task, then it will not appear in the simulation.

•Add Task: adds a new task to the schedule. This option is available when you right-click in an area of the task view below any current tasks.

• Attach Current Selection: attaches the currently selected items in the scene to the selected tasks.

• Attach Current Search: attaches all items selected by the current Search to the selected tasks.

• Attach Set: attaches all items contained within a Selection Set, to the selected tasks. When you choose this option a list of all Selection and Search Sets saved in the current scene is displayed. Choose the Selection or Search Set you wish to attach to the tasks.

• Append Current Selection: appends the currently selected items in the scene to the items already attached to the selected tasks.

Note: See Select Objects for more information on how to select items in Autodesk Navisworks.

• Clear Attachment: removes the attachment from this task.

• Add Comment: adds a comment to the task.

• Fill Down: sets the Task Type of all currently selected tasks in the Tasks view to match that of the task that is currently 'in focus'.

• Insert Task: inserts a new task above the one currently selected in the Task view.

• Delete Task: deletes the task currently selected in the Task view.

• Auto-Add Tasks: automatically adds a task for every topmost layer, top-most item, or every search and selection set.

• Find: finds items in a schedule based on the search criteria that you select in the Find menu. This option can be turned on/off in the Options Editor (Tools TimeLiner Enable Find check box).

You can use multi-selection (i.e. holding down SHIFT or CTRL) to perform most commands on several tasks at once. For example, should you need to delete all tasks, select the first task, then hold down SHIFT and select the last task, then press Delete.

Task Buttons:

Add Task 

The Add Task button adds a new task as the bottom of the tasks list.

Insert Task 

The Insert Task button inserts a new task above the one currently selected in the task view.

Auto-Add Tasks 

The Auto-Add Tasks button automatically adds a task for every top most layer, top most items, or every search and selection set.

Delete Task 

The Delete Task button deletes the tasks currently selected in the Task view.

Attach 

The Attach button enables you to:

- Attach Current Selection: attaches the currently selected items in the scene to the selected tasks.
- Attach Current Search: attaches all items selected by the current Search to the selected tasks.
- Append Current Selection: appends the currently selected items in the scene to the items already attached to the selected tasks.

Auto-Attach Using Rules 

The Auto-Attach Using Rules button opens the TimeLiner Rules Dialog Box where you can create, edit and apply rules for automatically attaching model geometry to tasks.

Clear Attachment 

The Clear Attachment button detaches the model geometry from the selected tasks.

Find Items 

The Find Items button enables you to find items in a schedule based on the search criteria that you select from the drop-down list. This option can be turned on/off in the Options Editor (Tools ➤ TimeLiner ➤ Enable Find check box).

Move Up 

The Move Up button moves the selected tasks up the task list. Tasks can only move with their current level of hierarchy.

Move Down 

The Move Down button moves the selected tasks down the task list. Tasks can only move with their current level of hierarchy.

Indent 

The Indent button indents the selected tasks by one level in the task hierarchy.

Outdent 

The Outdent button outdents the selected tasks by one level in the task hierarchy.

Add Comment 

The Add Comment button adds a comment to the task.

Columns 

The Columns button enables you choose one of three pre-defined column sets to display in the Tasks view; Basic, Standard or Extended. Alternatively you can create a customized column set in the Choose TimeLiner Columns Dialog Box by

clicking Choose Columns, then selecting Custom when you have set up your preferred column set.

Filter by Status 

The Filter by Status button enables you to filter tasks based on their status. Filtering a task temporarily hides the task from the Task and Gantt Chart views, but does not make any changes to the underlying data structure.

Export Schedule 

The Export Schedule button enables you export a TimeLiner schedule as a CSV or Microsoft Project XML file.

The Gant Chart veiw:

The Gantt Chart displays a colored bar chart illustrating your project status.

Each task takes up one row. The horizontal axis represents the time span of the project, broken down into increments (such as days, weeks, months, and years) and the vertical axis represents the project tasks.

Tasks can run sequentially, in parallel, or overlapping.

You can drag a task to different dates, or click and drag on either end of the task to extend or shorten its duration. Any changes are automatically updated in the Task view.

Gant Chart Button:

The Display Dates

The Display Dates drop-down enables you to switch between Actual, Planned, and Planned vs. Actual Gantt charts.

Show/Hide Gantt Chart 

Click the Show/Hide Gantt Chart button to show or hide the Gantt chart.

Show Planned Dates 

Click the Show Planned Dates button to show Planned Dates in the Gantt chart.

Show Actual Dates 

Click the Show Actual Dates button to show Actual Dates in the Gantt chart.

Show Planned vs. Actual Dates 

Click the Show Planned vs. Actual Dates button to show Planned vs. Actual Dates in the Gantt chart.

The Zoom Slider

The Zoom slider enables you to adjust the resolution of the displayed Gantt chart. The utmost left position selects the smallest available increment in the timeline (for example, days); the utmost right position selects the largest available increment in the timeline (for example, years).

Filter by Status 

The Filter by Status button enables you to filter tasks based on their status. Filtering a task temporarily hides the task from the Task and Gantt Chart views, but does not make any changes to the underlying data structure.

Export Schedule 

The Export Schedule button enables you export a TimeLiner schedule as a CSV or Microsoft Project XML file.

2- Data Source Tab:

The Data Source Button:

Add

Creates a new connection to an external project file. Clicking this button displays a menu listing all project sources that may be connected to on the current machine.

See Supported Scheduling Software for more information on which sources are available.

Delete

Deletes the currently selected data source. If you have refreshed the data source before you deleted it, any tasks and data read from the data source will remain on the Tasks tab.

Refresh

Displays the Refresh from Data Source Dialog Box where you can refresh the selected data sources.

The Context Menus:

Right-clicking within the data source area on the tab opens a context menu that enables you to manage data sources.

• Rebuild Task Hierarchy: reads all of the tasks and associated data (as defined in the Field Selector Dialog Box) from the selected data sources and adds these to the Tasks tab. Choose this option also to synchronize with the selected project file when new tasks have been added to the project file. This will rebuild the task hierarchy in TimeLiner, containing all of the latest tasks and data.

• Synchronize: Updates all existing tasks in the Tasks tab, with the latest associated data from the selected data sources (for example, Start and End dates).

• Delete: deletes the currently selected data source. If you have refreshed the data source before you deleted it, any tasks and data read from the data source will remain on the Tasks tab.

• Edit: enables you to edit the selected data source. This will display the Field Selector Dialog Box, from which you can define new fields or re-define existing ones.

•Refresh: displays the Refresh from Data Source Dialog Box where you can refresh the selected data source.

•Rename: enables you to rename the data source to something more appropriate. When the text field becomes highlighted, enter the new name, then press Enter to save it.

Note: Tasks in the data source will be ignored if they do not include both start and end dates, with the start date being less than or equal to the end date.

3- Configure Tab:

Add: Adds a new task type.

Delete: Deletes the selected task type.

Appearance Definitions

Use this dialog box to customize the default task types, or create new ones, as necessary. To access it, click the Appearance Definitions button on the Configure tab.

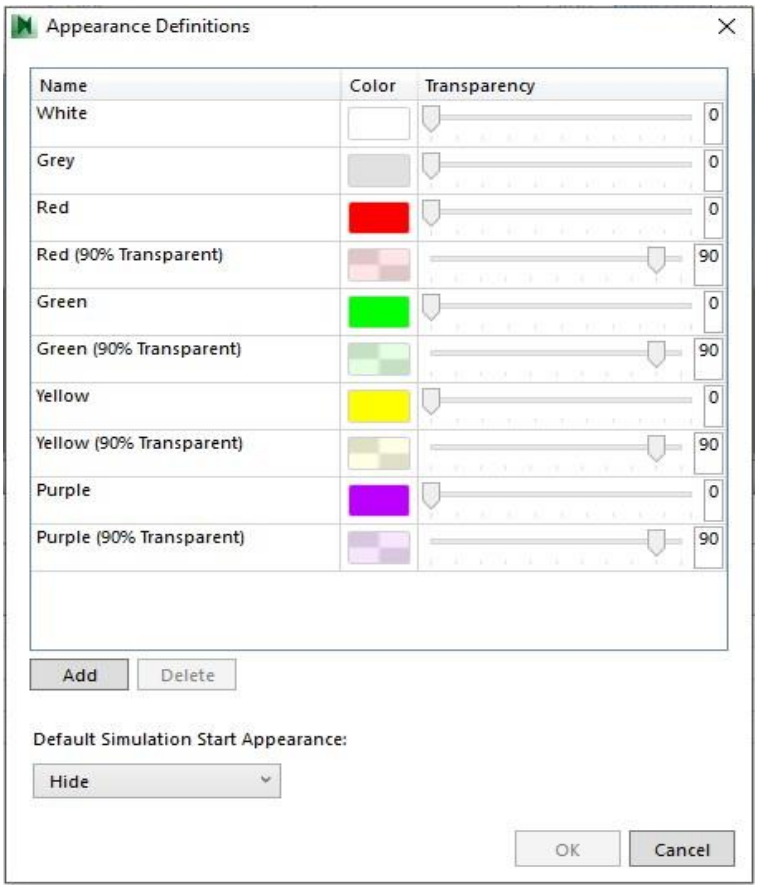


Figure 31 Appearance Definitions window

TimeLiner comes with a set of ten predefined appearance definitions that you can use to configure the task types. Appearances define a level of transparency and a color.

Name: Specifies the appearance definition name. Click on the name to change it as required.

Color: Specifies the appearance definition color. Click on the color to change it as required.

Transparency: Specifies the appearance definition transparency. Use the slider or enter a value to change the transparency as required.

Add: Click to add an appearance definition.

Delete: Click to delete the currently selected appearance definition.

Default Simulation Start Appearance: This drop-down box specifies a default appearance to apply to all objects in the model at the start of the simulation. The default is Hide, which is ideal for simulating most construction sequences.

4- Simulate Tab:

The Simulate tab enables you to simulate your TimeLiner sequence throughout the duration of the project schedule.

The playback controls:

Use the standard VCR buttons to step and play forwards and backwards through the simulation:

Rewind  will rewind the simulation back to the beginning.

Step Back  will step back a single step size.

Reverse Play  will play the simulation backwards.

Pause will pause the simulation at the time you press it at. You can then look around and interrogate the model, or step forwards and backwards through the simulation. To continue playing from where you paused, just press Play again.

Stop will stop the simulation playing and rewind back to the beginning.

Play will play the simulation from the currently selected time.

Step Forwards will step forwards a single step size.

Forward will fast forward the simulation to the end.

You can use the Simulation Position slider to quickly move forwards and backwards through the simulation. Full left is at the beginning and full right is at the end.

The Date/Time box next to the VCR buttons shows the point in time through the simulation. You can click on the drop-down icon to the right of the date to display a calendar, from which you can select a date to 'jump' to.

Simulation Settings Dialog Box:

The Settings button on the Simulate tab provides access to the Simulation Settings dialog box.

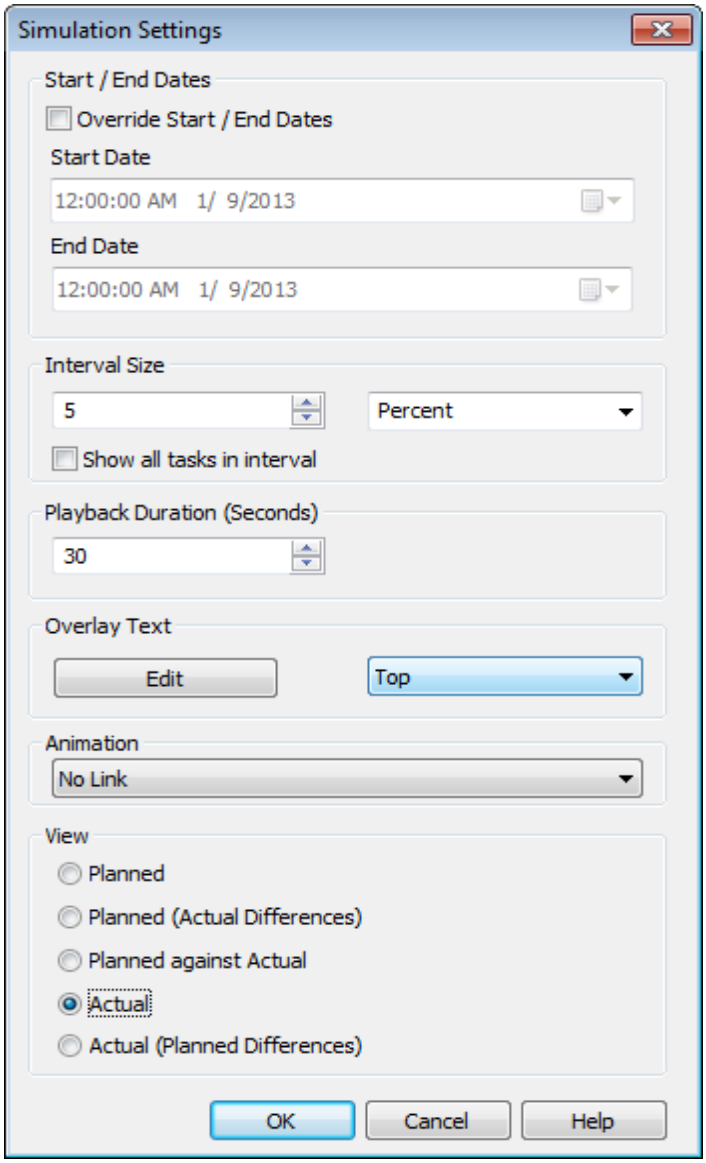


Figure 32 Simulation settings window

It is possible to override the Start and End dates that the simulation runs between. Selecting the Override Start/End Dates check box enables the date boxes and allows you to choose the start and end dates. By doing this, you can simulate a small sub-section of the overall project. The dates will be shown on the Simulate tab. These dates will also be used when exporting animations.

You can define the Interval Size to use when stepping through the simulation using the playback controls. The interval size can be set either as a percentage of the overall simulation duration or to an absolute number of days or weeks, and so on.

Use the drop-down list to select the interval unit, then use the Up and Down arrow buttons to increase or decrease the interval size.

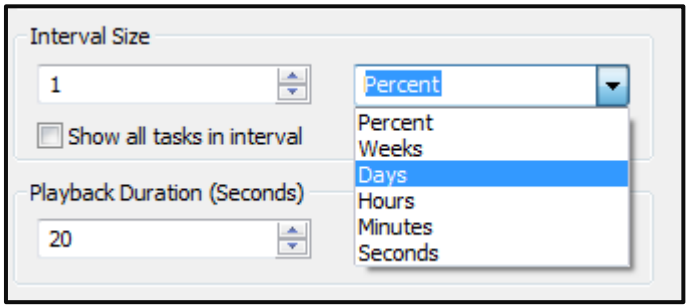


Figure 33 Interval size in Simulation settings window

It is also possible to highlight all the tasks that are being worked on during the interval. By selecting the Show All Tasks in Interval check box, and, for example, setting the Interval Size to 5 Days, all tasks being worked on during those 5 days will be set to their Start Appearance in the Scene View, including those that begin and end within the bounds of the interval. The Simulation slider will show this by drawing a blue line under the slider. If this check box is clear, tasks that begin and end within the bounds of the interval will not be highlighted in this manner, and will need to overlap with the current date in order to be highlighted in the Scene View.

You can define the overall Playback Duration for the complete simulation (the time needed to play it through from start to finish). Use the Up and Down arrow buttons to increase or decrease the duration (in seconds). You may also enter a duration directly into this field. You can define whether the current simulation date should be overlaid in the Scene View, and if so whether it should appear at the top or bottom of the screen. From the drop-down, choose from None (to display no overlay text), Top (to display the text at the top of the window), or Bottom (to display the text at the bottom of the window).

You can Edit the information displayed in the overlay text using the Overlay Text Dialog Box. This dialog box also makes it possible to alter the Font Type, Style and Size by clicking on the contained Font button.

You can add animation to an entire schedule, so that during the TimeLiner sequence playback, Autodesk Navisworks will also play the specified viewpoint animation or camera.

The following options can be selected in the Animation field:

- No Link: no viewpoint animation or camera animation will be played.
- Saved Viewpoints Animation: links your schedule to the currently selected viewpoint or viewpoint animation.
- Scene X - Camera: links your schedule to a camera animation in the selected animation scene.

You can pre-record suitable animations for use with the TimeLiner simulation. Using animation also affects the Animation Export.

View area: Each view will playback the schedule depicting Planned and Actual relationships:

- **Actual**. Choose this view to simulate the Actual schedule only (that is, only use the Actual Start and Actual End dates).
- **Actual (Planned Differences)**. Choose this view to simulate the Actual schedule against the Planned schedule. This view will only highlight the items attached to the task over the Actual date range (that is, between Actual Start and Actual End. See diagram below for graphical representation). For time periods where the Actual dates are within the Planned dates (on schedule), the items attached to the task will be displayed in the Task Type Start Appearance. For time periods where the Actual dates are early, or late in comparison to the

Planned dates (there is a variance), then the items attached to the task will be displayed in the Task Type Early or Late Appearance, respectively.

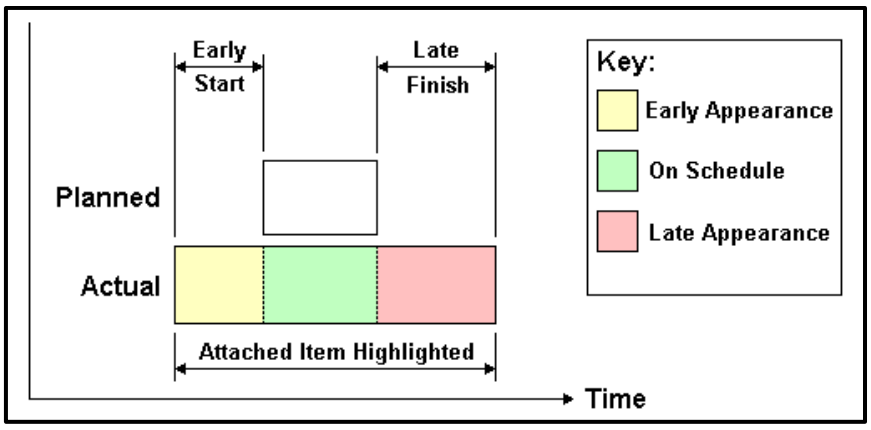


Figure 34 graphical representation for Actual (Planned Differences) Actual dates are early

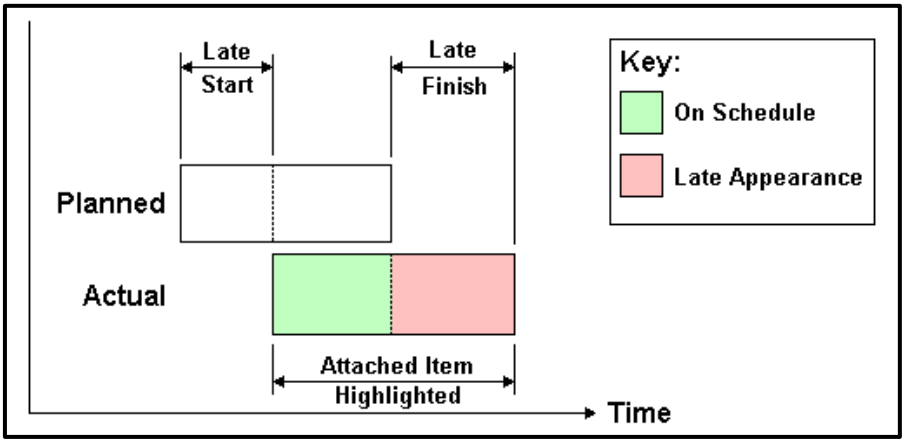


Figure 35 graphical representation for Actual (Planned Differences) Actual dates are late

- **Planned**. Choose this view to simulate the Planned schedule only (that is, only use the Planned Start and Planned End dates).
- **Planned (Actual Differences).** Choose this view to simulate the Actual schedule against the Planned schedule. This view will only highlight the items attached to the task over the Planned date range (that is, between Planned Start and Planned End. See diagram below for graphical representation). For time

periods where the Actual dates are within the Planned dates (on schedule), the items attached to the task will be displayed in the Task Type Start Appearance. For time periods where the Actual dates are early, or late in comparison to the Planned dates (there is a variance), then the items attached to the task will be displayed in the Task Type Early or Late Appearance, respectively.

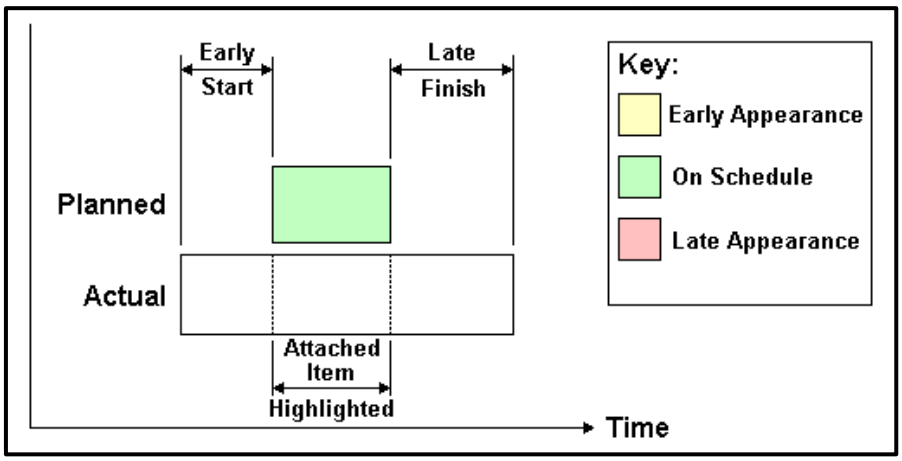


Figure 36 graphical representation for Actual Planned (Actual Differences) Actual dates are early

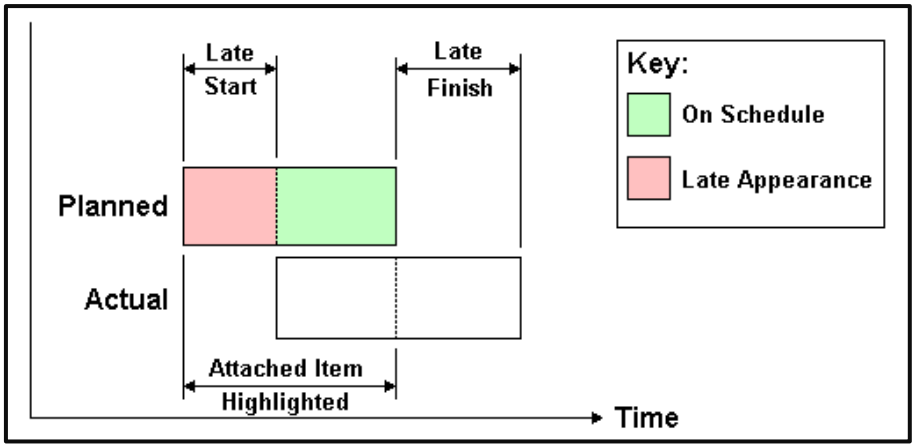


Figure 37 graphical representation for Actual Planned (Actual Differences) Actual dates are late

- **Planned Against Actual.** Choose this view to simulate the Actual schedule against the Planned schedule. This will highlight the items attached to the task

over the entire Planned and Actual date range (that is, between the earliest of Actual and Planned Start dates and the latest of Actual and PlannedEnd dates. See diagrams below for graphical representation). For time periods where the Actual dates are within the Planned dates (on schedule), the items attached to the task will be displayed in the Task Type Start Appearance. For time periods where the Actual dates are early, or late in comparison to the Planned dates (there is a variance), then the items attached to the task will be displayed in the Task Type Early or Late Appearance, respectively.

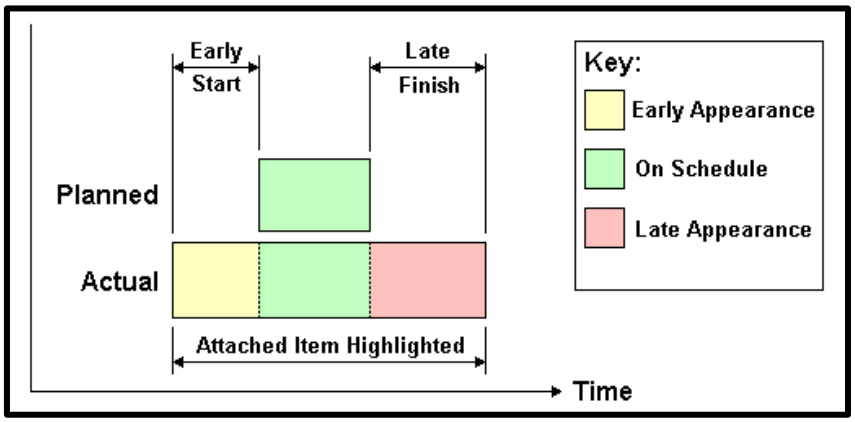


Figure 38 graphical representation for Planned Against Actual. Actual dates are early

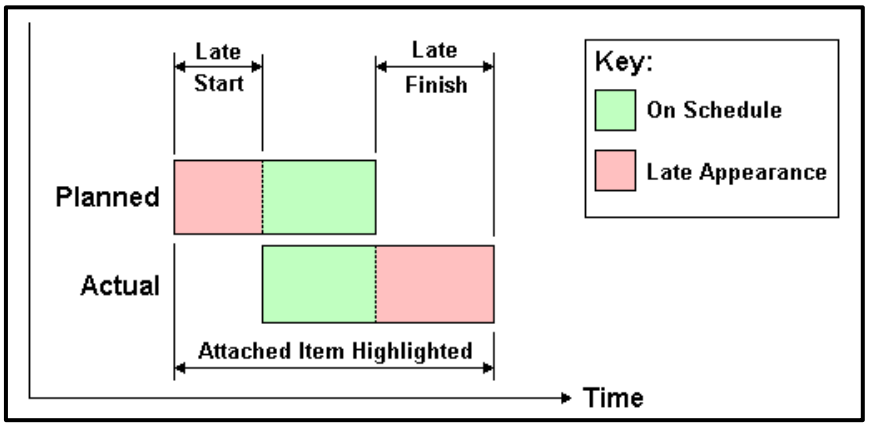


Figure 39 graphical representation for Planned Against Actual. Actual dates are late.

The Export Animation Button:

The Export Animation button  opens the Animation Export Dialog Box that enables you to export a TimeLiner animation to an AVI file or a sequence of image files.

The Task View:

All active tasks are show in a multi-column table. You can move and resize table columns, if necessary.

You can view the current simulation time for each of the active tasks, and how close to completion they are (Progress is displayed as a percentage). The Status of each active task is also displayed as an icon. For simulations where Planned and Actual dates are available, the status provides a visual representation as to whether there is any variance between the planned and actual dates.

The Gantt Chart view:

The Gantt Chart displays a colored bar chart illustrating your project status. Each task takes up one row. The horizontal axis represents the time span of the project, broken down into increments (such as days, weeks, months, and years) and the vertical axis represents the project tasks. Tasks can run sequentially, in parallel, or overlapping.

The visible range (zoom) level is determined by the Interval Size options in the Simulation Settings dialog.

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Appendix 2

Sudan University of Science and Technology

College of Graduate Studies

Questionnaire

Dear respondent,

This questionnaire is for academic purpose only. It is designed as one of the tools for collecting data concerning the subject matter. Please answer the questions laid down to the best of your knowledge; Be insured that this information will be confidential and used for academic purpose only as indicated above. It takes approximately 15 minutes to answer the questionnaire.

Thank you.

Part One - A: General Information

Please choose the appropriate choice by putting (√)

1. **Respondent's Gender, Specialty and Educational Qualifications:**

Education level: ☐ Diploma ☐ Bachelor ☐ Master ☐ Doctorate

Specialty: ☐ Civil Engineer ☐ Architect ☐ Other

Gender: ☐ Male ☐ Female

2. **The position of the respondent:**

☐ Director ☐ Deputy Director

☐ Project Manager ☐ Site/ Office Engineer

3. **The sector type you work for:**

☐ Public ☐ Private ☐ Other

4. **Years of experience in construction projects:**

☐ 0 – 5 ☐ 5 – 10 ☐ 10 – 15 ☐ More than 15

5. **Have you ever worked in construction projects outside Sudan?**

☐ Yes ☐ No

Part Two: General concepts of Building Information Modeling (BIM)

Note: Building Information Modeling (BIM) concept is collect of whole information related with a building in one model, allow to all whose involved in design, Build and operate the building for working on central model, helps to coordinate and control the intersections in-between them.

1. **Your level of familiarity with BIM concept.**

   Weak ☐ Medium ☐ Good ☐ Very good ☐ Excellent ☐

2. **Have you ever applied BIM technics during your work in construction projects?**

   ☐ Yes ☐ No

3. **Your experience with BIM technics in construction projects.**

   Weak ☐ Medium ☐ Good ☐ Very good ☐ Excellent ☐

4. **How much do you want to know the concepts BIM in construction projects?**

   Weak ☐ Medium ☐ Good ☐ Very good ☐ Excellent ☐

5. **It is important to use BIM software to manage the construction projects in Sudan:**

   ☐ Strongly Agree ☐ Agree ☒ Somewhat ☐ Disagree

Part Three: Usage of (BIM) fourth dimension technique in construction projects at Sudan.

Note: Fourth dimension mean the output from connect 3D model with time dimension of project, by using software to connect between 3D model and schedule.

1. **The high level administrations in companies that working in AEC industry at Sudan accept the concept of applying BIM in their projects.**

☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

2. **Which type of software that supports BIM-4D concept is used in your projects?**

(You can tick more than one)

☐ AutoCAD ☐ Primavera ☐ Rivet

☐ MS. Project ☐ Navisworks ☐ Others

In case of choose other please mention it ……..

3. **The output from connect between the 3D model and schedule of the projects is simulation of construction scenario and its enhancing sharing knowledge between stakeholders during planning phase.**

☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

4. **BIM-4D contributes by effectively manner in monitoring and controlling the cost and time of projects**

☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

5. **BIM-4D contributes in risk assessment processes during planning phase and decreasing the chances of issues happening during executing phase**

☐ Strongly Agree ☐ Agree ☐ Somewhat ☐ Disagree

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Appendix 3

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

إستبيان

هذا الإستبيان لغرض أكاديمي فقط، وهو مصمم بإعتباره أحد أدوات جع البيانات المتعلقة بالدراسة، وذلك للحصول على درجة الماجستير في الهندسة المدنية (هندسة التشييد). الرجاء الإجابة على الأسئلة المحددة بأفضل ما لديك من معرفة. ثق تماماً أن هذه المعلومات ستكون سرية وإستخدامها لأغراض أكاديمية بحتة كما هو مبين أعلاه.

عنوان الرسالة : نمذجة معلومات المباني BIM

(الربط بين النموذج ثلاثي الابعاد والجدول الزمني لإنشاء نظام البعد الرابع)

الجزء الأول: معلومات عامة

الرجاء وضع علامة (√) لتحديد الخيار المناسب.

1. **المؤهلات العلمية، التخصص والنوع:**

المستوى التعليمي: ☐ دبلوم ☐ بكالوريوس ☐ ماجستير ☐ دكتوراة

التخصص: ☐ مهندس مدني ☐ مهندس معماري ☐ أخرى .....

النوع: ☐ ذكر ☐ أنثى

2. **الموقع الإداري:** ☐ مدير ☐ نائب المدير

☐ مدير مشروع ☐ مهندس موقع/ مكتب

3. **نوع القطاع الذي تعمل به:**

☐ عام ☐ خاص ☐ أخرى .....

4. **عدد سنوات الخبرة في مجال المشروعات:**

☐ 0 - 5 ☐ 5 - 10 ☐ 10 - 15 ☐ أكثر من 15

5. **هل سبق لك أن عملت في مشاريع التشييد خارج السودان؟**

نعم ☐ لا ☐

الجزء الثاني: مفاهيم عامة عن نمذجة معلومات المباني (BIM)

ملحوظة: مفهوم ال Building Information Modeling (BIM) هو نمذجة كل المعلومات المتعلقة بالمبنى في نموذج واحد يسمح لكل المشاركين في تصميم وتنفيذ وتشغيل المبنى بالعمل على نموذج مركزي يساعد في التنسيق والتحكم في التقاطعات في مابينهم.

1. **مامدى المامك بمفهوم نمذجة معلومات المباني (BIM)؟**

ضعيف ☐ وسط ☐ جيد ☐ جيد جداً ☐ ممتاز ☐

2. **هل سبق أن طبقت تقنيات وبرامج ال (BIM) خلال عملك في صناعة التشييد؟**

نعم ☐ لا ☐

3. **ما مدى خبرتك حول تقنيات ال (BIM) في مشاريع التشييد:**

ضعيف ☐ وسط ☐ جيد ☐ جيد جداً ☐ ممتاز ☐

4. **مدى رغبتك في معرفة مفاهيم ال (BIM) في مشاريع التشييد:**

ضعيف ☐ وسط ☐ جيد ☐ جيد جداً ☐ ممتاز ☐

5. **هنالك أهمية في إستخدام برامج ال (BIM) في ادارة مشاريع التشييد بالسودان:**

أوافق بشدة ☐ أوافق ☐ صحيح لحد ما ☐ لا أوافق ☐

الجزء الثالث: استخدام البعد الرابع من ال BIM في صناعة التشييد بالسودان

ملحوظة : يقصد بالبعد الرابع هو المنتج من ربط النموذج ثلاثي الابعاد بالبعد الزمني للمشروع باستخدام برنامج يربط مابين المخطط الزمني للمشروع والنموذج ثلاثي الابعاد.

1. **الإدارات العليا في الشركات العاملة في صناعة التشييد بالسودان متقبلة لمفهوم تطبيق تقنيات ال BIM في مجال عملها:**

☐ أوافق بشدة ☐ أوافق ☐ صحيح لحد ما ☐ لا أوافق

2. **أي نوع من البرامج الداعمة لمفهوم البعد الرابع من تقنية ال (BIM) مستخدم لديكم ؟** (يمكن إختيار أكثر من خيار)

☐ AutoCAD ☐ Primavera ☐ Rivet

☐ Navisworks ☐ MS. Project ☐ Others

في حالة اختيار (Others) اذكرها .....

3. **ينتج من ربط النموذج ثلاثي الابعاد مع الجدول الزمني للمشروع نموذج محاكاة لعملية التشييد ويساعد هذا في توحيد المفاهيم لدى الاشخاص ذوي العلاقة بالمشروع (Stakeholders) اثناء التخطيط للمشروع:**

☐ أوافق بشدة ☐ أوافق ☐ صحيح لحد ما ☐ لا أوافق

4. **يساهم مفهوم ال BIM-4D بشكل مباشر وفعال في عملية الضبط والتحكم في مدة وتكلفة المشاريع :**

☐ أوافق بشدة ☐ أوافق ☐ صحيح لحد ما ☐ لا أوافق

5. **يساهم مفهوم ال BIM-4D في عملية تقييم المخاطر خلال مرحلة التخطيط والحد منها اثناء عملية التنفيذ للمشاريع :**

☐ أوافق بشدة ☐ أوافق ☐ صحيح لحد ما ☐ لا أوافق