

Sample Pages

Real World
**Applications
of BIM in
Construction**

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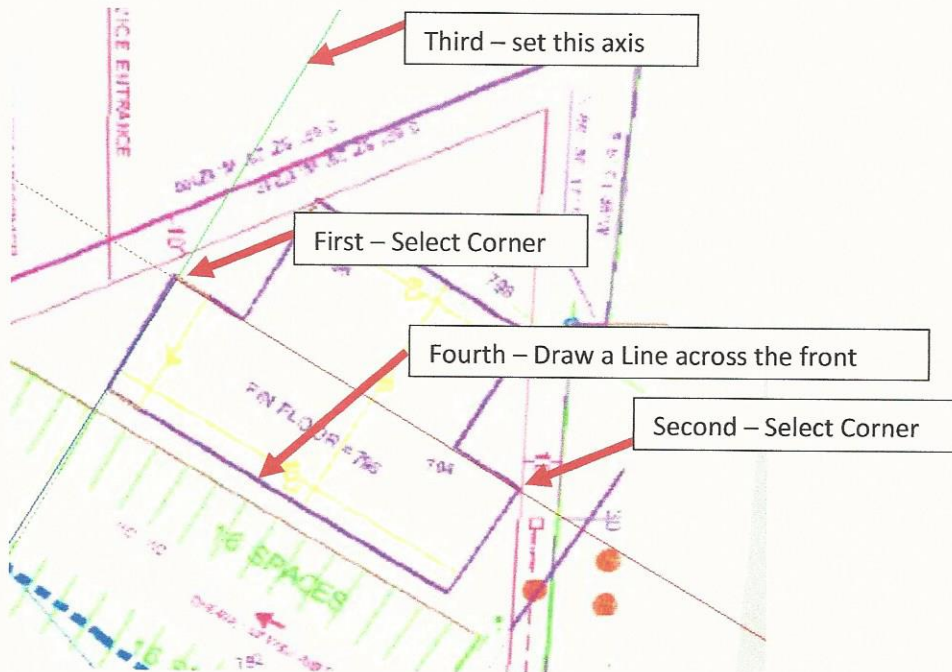
visually describes these items. SketchUp Make 2017 can be a helpful tool with regard to creating a site logistics plan and can even provide a 3D model with regard to this. The following example will show how this tool can be used.

All projects have “civil” site plans that are part of the construction/bid drawings and which show boundary lines of the property, the location of the building, elevations, the location of important utilities among other items. The following example will use a civil site plan called **SitePlan.jpeg** which is found on your CD/FLASH DRIVE or the course site in order to create a site logistics plan/drawing.

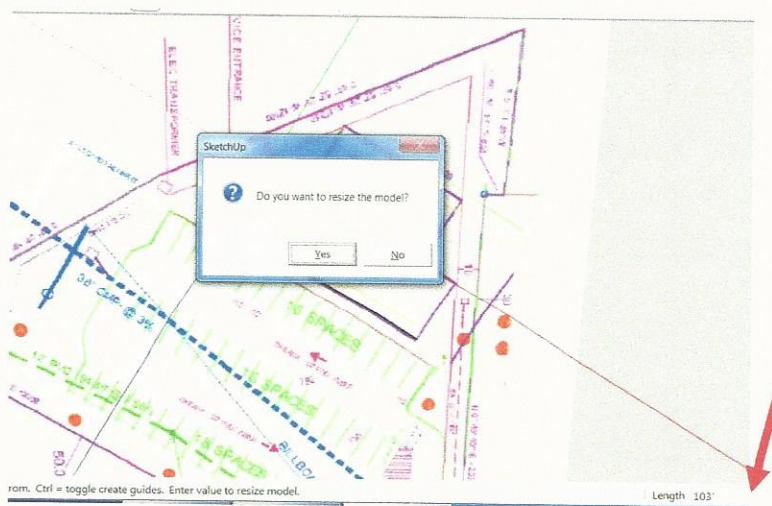
Open SketchUp Make and select an architectural template. Select and delete the “person” leaving only the three axes which intersect at the origin. Go to File and click on Import and choose the file named **SitePlan.jpeg** from the Section 2 folder on the CD/FLASH DRIVE. This will bring the image into SketchUp oriented into a plane. Click on the origin so that the image is anchored at this point. Go ahead and stretch it so that it fills a decent part of the screen and use the orbit tool so that you are looking at it “head on”.



Go ahead and place a building mass on the site as shown. Because the building is not oriented with the standard axes we will begin by moving the axes to the corner of the building. Go to the Tools menu and select Axes. Choose the corner of the building, then another corner to set one axis. Then click another point to set the second axis.

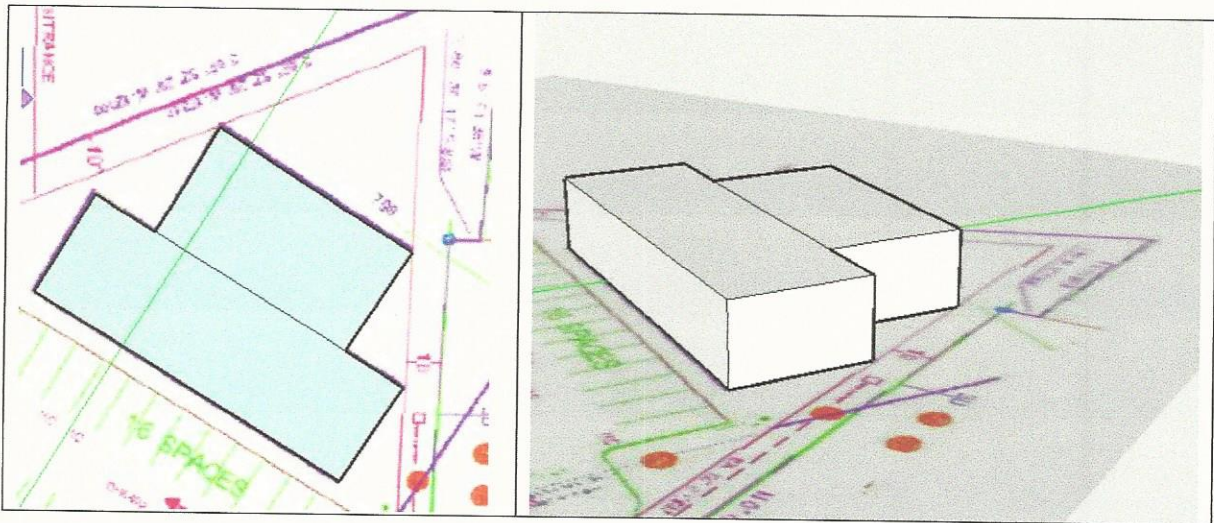


Next we will have to scale the imported site plan to be somewhat accurate as we begin to develop the site logistics plan. Remember the imported site plan is just an image file that is stretched. To do this we will choose a dimension that is shown on the site plan (for this we will choose the front building length which is 103 feet across the “front of the building”). Use the lines tool (i.e. the pencil) and draw a line. Next select the Tape Measure tool and then hit the Ctrl key once (this will remove the little “+” sign from the tool). Click on one end of the line and then click on the other end of the line. Type in 103’ (this should be displayed in the Length window). Then press Enter and the following should occur.

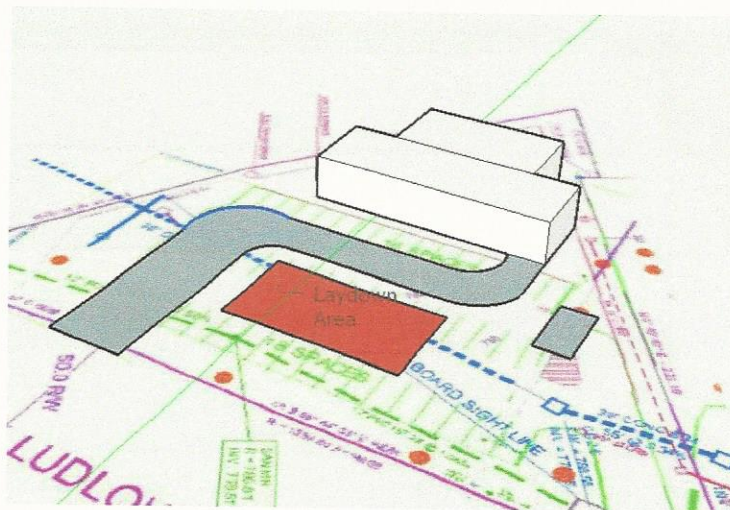


Click Yes. Because of the new scale your building may “disappear” but just go the Camera menu and click Zoom Extents. Go ahead and use the rectangle tool (twice) to draw the building mass and use the

Push/Pull tool to give it a 20 foot height. (If the axes get reset to the original just replace them as before).

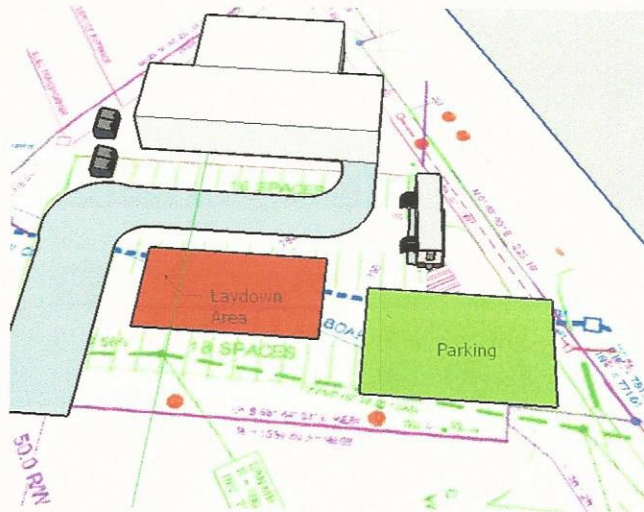


In this example we will place an access drive, laydown area, job trailer, dumpsters and temporary parking lot. Go ahead and place the access drive in from Ludlow Avenue using the Line tool. Make sure the Object that you draw to represent the drive is a closed form (Experiment with the Arcs tool for the curve if you like). Use the Rectangle tool to draw the laydown area that is 75' x 40' and use the Paint Bucket to select "Color" and choose a red. Under Tools select Text and Enter "Laydown Area". Next Place a 30' x 15' rectangle as shown this will be the site for a construction trailer. Use the Orbit tool and your plan should look similar to this:



Now go to the Window menu and choose 3D Warehouse and search for "construction trailer". You will have many choices. Choose "Download" and it will ask to load this into the model – say "yes". Place it on the pad you have drawn by clicking on the corner of the pad (experiment with the rotate and move tools to orient it as desired). Finally search the 3D warehouse for dumpsters and place two of these on the

opposite side of the building. Finally, use the Rectangle tool to draw a temporary parking that is 75' x 50' and use the Paint Bucket to select "Color" and choose a green. Under Tools select Text and Enter "Parking". It should look like this.



There are many other things you can do with the site logistics plan. Feel free to experiment – try out other items from the 3D warehouse, use the camera tool to walk through the site, and many other things.

text. Simply do that by hovering over the cell boundary and clicking and dragging when the expand symbol shows up. The quantity takeoff table should look like this:

The screenshot shows the Revit interface with a 'Wall Material Takeoff' table displayed. The table has three columns: A (Material: Area), B (Cost), and C (Family and Type). The data rows are as follows:

A	B	C
Material: Area	Cost	Family and Type
200 SF	0.00	Basic Wall: Generic - 8"
113 SF	0.00	Basic Wall: Generic - 8"
193 SF	0.00	Basic Wall: Generic - 8"
107 SF	0.00	Basic Wall: Generic - 8"

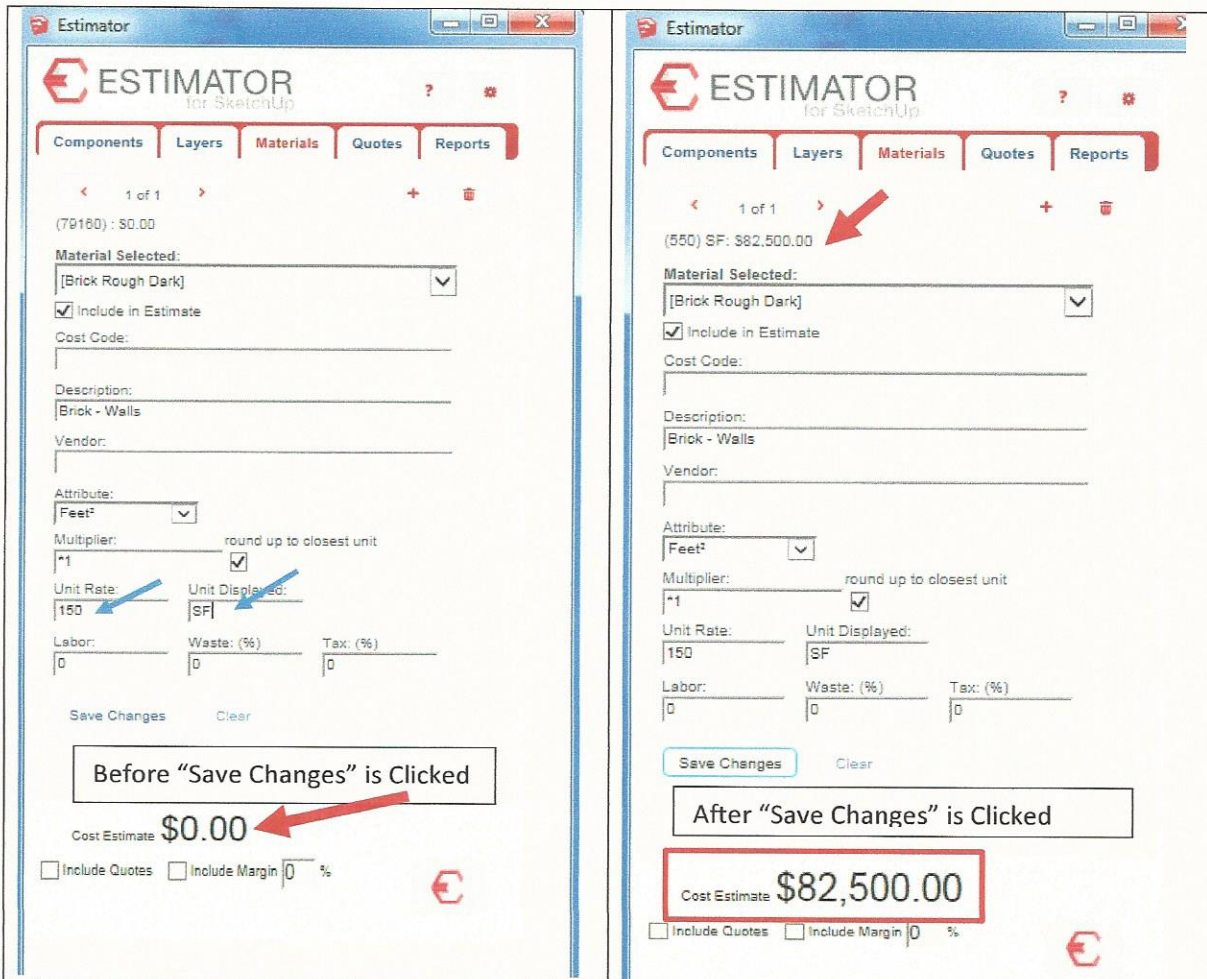
In the Project Browser on the left, 'Wall Material Takeoff' is highlighted in bold, and a red arrow points to it.

Notice that the Wall Material Takeoff is highlighted in the Project Browser as the takeoff table is shown in the display. If you would like to navigate back to any particular schedule or view of the model you can do that through the Project Browser. Go back to the 3D view by clicking on 3D in the Project Browser.

The screenshot shows the Revit software interface in 3D View. The 3D Viewport displays a 3D model of a rectangular structure. The Properties palette on the left shows the '3D View' section, with '3D View: {3D}' selected. A red arrow points to the '3D' option in the Project Browser on the left.

Click the red icon and the Estimator panel will open. Open up the **Estimator.skp** file located on the CD/FLASH DRIVE or course site. This file contains a simple Sketchup model of a model with four walls (brick) and a metal roof. Open Estimator and choose the Material tab.

Using the Selection arrow, select a wall (notice the Material Selected box says "Brick Rough Dark) and holding the Ctrl key select the other 3 walls. Under Description type in "Brick – Walls" and in the attributes box select "Feet²" from the menu. Enter in "150" for the Unit Rate and type in "SF" for the Unit Displayed.



Click "Save Changes". Notice the Cost Estimate changes to \$82, 500 based on a 550 SF of brick.

Repeat this by selecting both sides of the roof (remember to hold the Ctrl key down). Put in "Roof" for the Description. For the attributes box select "Feet²" from the menu. Enter in "75" for the Unit Rate and type in "SF" for the Unit Displayed. Click Save Changes. Did you get the following?

Format	Extension	Version
Navisworks	.nwd .nwf .nwc	All
AutoCAD	.dwg .dxf	Up to AutoCAD 2014
MicroStation	.dgn .prp .prw	v7, v8
3D Studio	.3ds .prj	Up to Autodesk 3ds Max 8 2014
ACIS SAT	.sat .sab	All ASM SAT. Up to ACIS SAT v7
Catia	.model .session .exp .dlv3	V4, v5
CIS/2	.stp	STRUCTURAL_FRAME_SCHEMA
DWF/DWFX	.dwf .dwfx	All previous
FBX	.fbx	FBX SDK 2011 3.1
IFC	.ifc	IFC2X_PLATFORM, IFC2X_FINAL, IFC2X2_FINAL, IFC2X3
IGES	.igs .iges	All versions

Navisworks Manage® utilizes three “native” file formats – nwd, nwc and nwf. It is important that the construction manager know the difference between these three file types.

Navisworks File Types	Description
NWD	An NWD file serves as a published record of the model containing all model geometry together with other Navisworks data. You can think of an NWD file as a snapshot of the current state of the model. Compared to CAD files this file type is small which makes it ideal for transmitting – it is <u>recommended always to send this file type</u> for your assignments.
NWC	NWC files (“cache files”) are smaller than the original CAD files, and speed up your access. Anytime that work is performed using Navisworks Manage® a NWC file is produced. When you next open file or append file in Navisworks, the data is updated thus creating a new cache.
NWF	An NWF file contains links to the original native files (as seen on the Selection Tree) together with other data. It is basically a master file that links together all the original files that are used to create a consolidated model but it does not contain model geometry. Therefore these are files that should not be transmitted for assignments.

It should be noted that Revit® files can be directly opened in Navisworks Manage® but it can be a slow process depending on the complexity of the Revit® file. Exporting the Revit® file as a NWC file type, although not absolutely necessary, may improve the performance of the software depending on your computer and server. The process for exporting a rvt file from Revit® into Naviswork Manage is shown below:

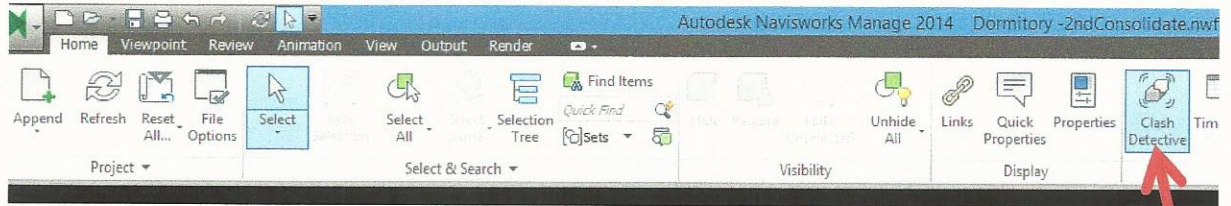
In Revit®:

4.4 Working with Files in Navisworks Manage® - Checking for Clashes

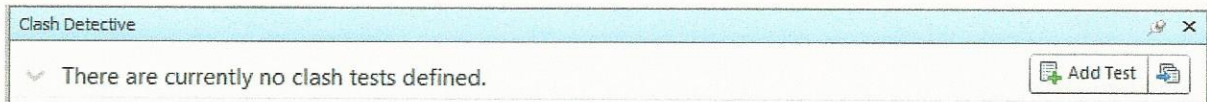
One of the primary tools found in Navisworks Manage® is the Clash Detective tool which allows the user to find where two objects intersect or clash. This tool is very important to the construction manager as it allows for clashes between systems (and sometimes within a system) to be found during various stages of design development. The file you will be working with is the **Section4-Consolidate.nwd** file you created earlier.

To check for clashes you begin by opening up the Clash Detective window by

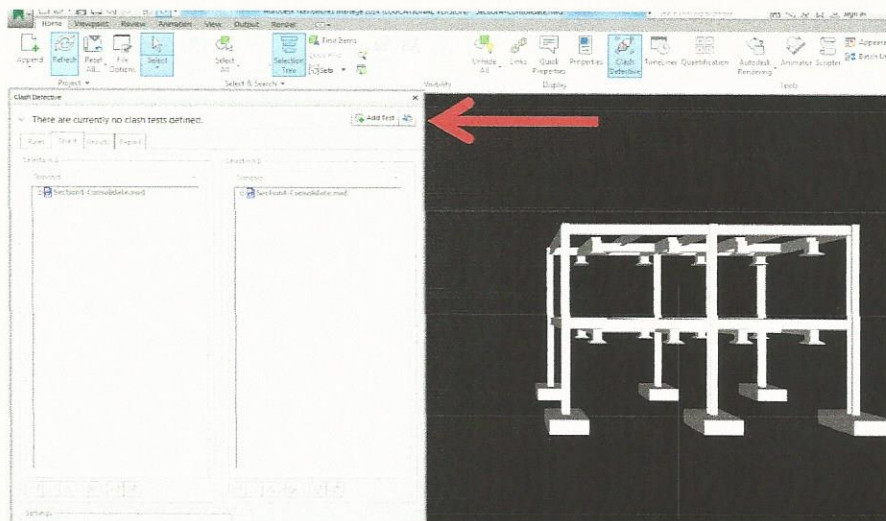
1. Clicking on the Clash Detective button which is found on the ribbon under the Home tab. This is shown below:

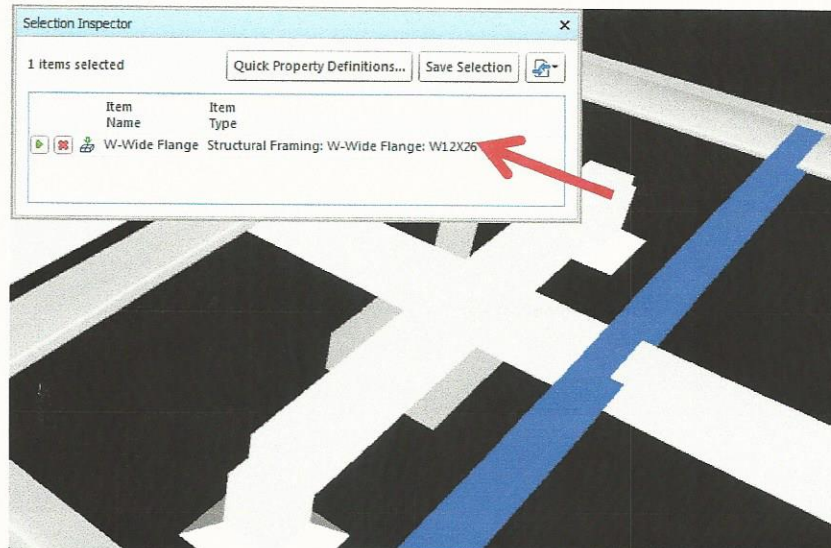


The Clash Detective window has two parts. The top part of the Clash Detective interface shows the name of the current test. In this case it says "There are no clash tests currently defined" because we are just getting started.



The bottom pane of the interface has four tabs – Rules, Select, Results, and Report. Currently the Select tab has been chosen. The Select tab allows you select the items that you wish to run by choosing an item out of Selection A and an item out of Selection B. Notice currently the **Section4-Consolidate.nwd** file looks something like this:

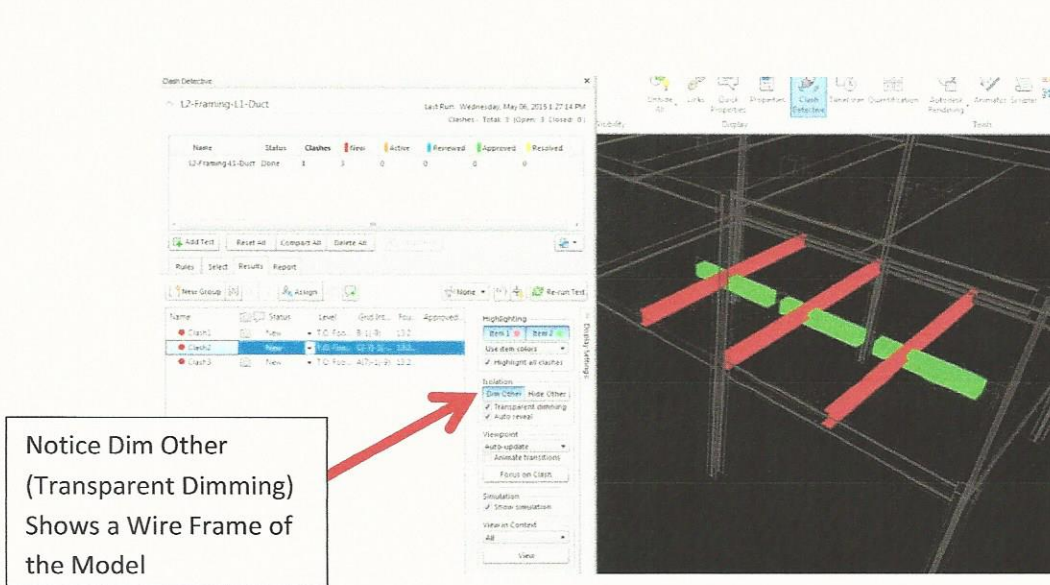




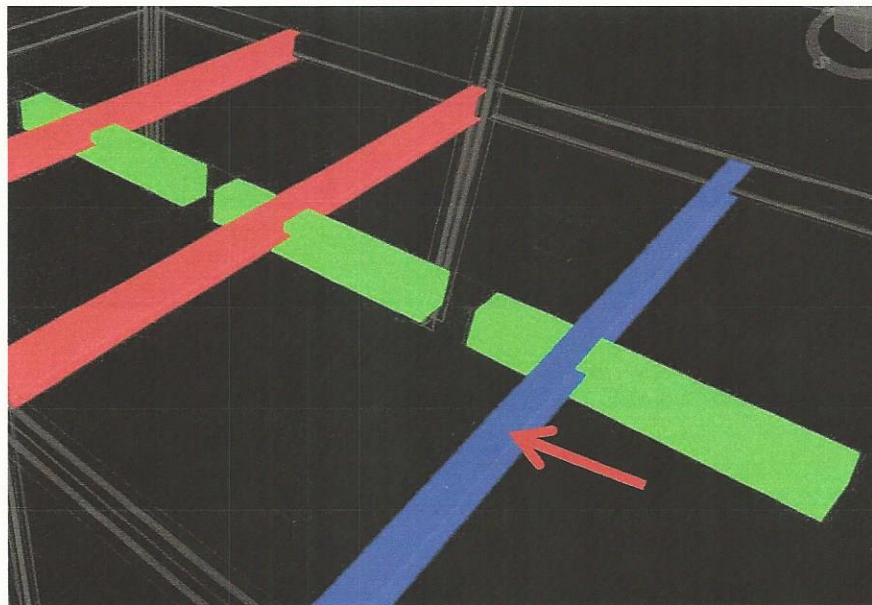
4.5 Working with Files in Navisworks Manage® – Clash Results

In the previous section we were introduced to the Results tab in the Clash Detective. You can toggle between the Select tab and the Results tab very easily. Looking at the Results tab for the L2-Framing-L1-Duct Clash test the bottom section of the Results interface will list the 3 clashes as we have already seen. Notice that each object in a particular clash is given a specific color. In this case the structural framing objects involved in clashes have a red color and the duct objects involved in clashes have a green color.

On the right side of the interface box you can click on the Display Settings if it is not already shown. It should look like this:



If you would like to identify an element in a clash you can click on it in the display area. It should be highlighted. You can then right click on it and choose "Selection Inspector". That will make a box visible that has more information about the element involved in the clash.



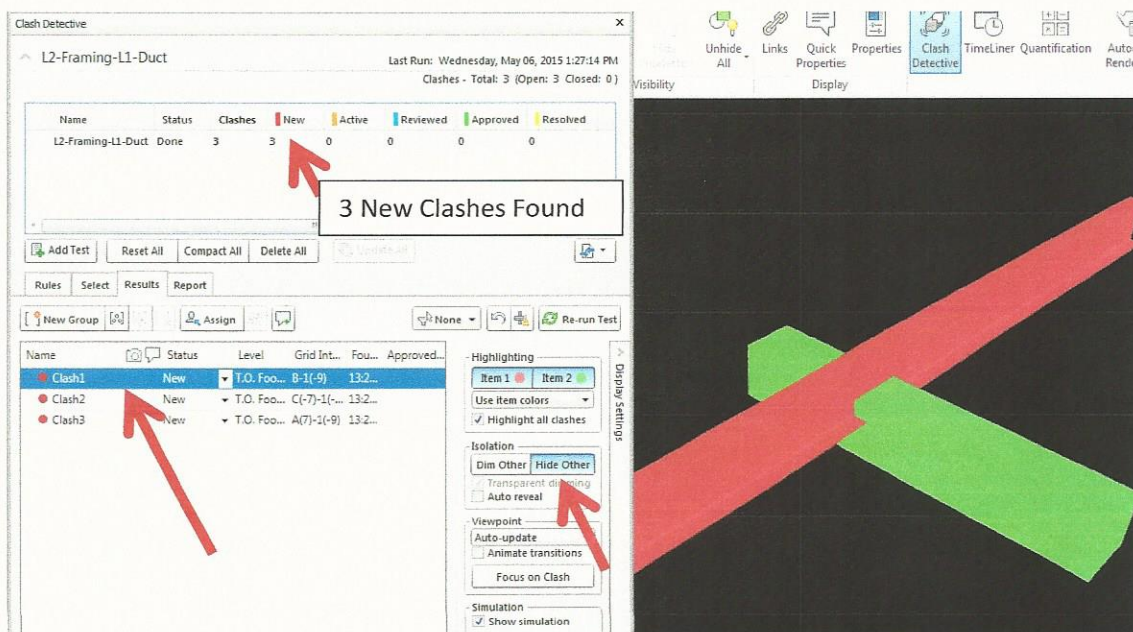
Here we can see the member is a W 12 x 26. Another way to do this is to select the "properties" button on the ribbon located to the left of the Clash Detective button.

- Click Run Test. This will initiate a test that looks for intersections between the subsets of Level 2 structural framing and Level 1 HVAC ductwork.

This test will come back with 3 hard clashes as shown in the top part of the Clash Detective interface as shown below. A hard clash is defined as an intersection of the geometry of the components being checked or an actual interference. You can get into the area of soft clashes where the space to work on a component or mechanical device is not large enough to allow for maintenance but that is a topic for more advanced coverage.

Notice that all clashes are considered a new clashes because presumably this is the first time we have run through this model looking at first floor structural framing and lower level duct. The other status boxes for clashes (i.e. active, reviewed, approved, resolved) will be discussed more in the next section.

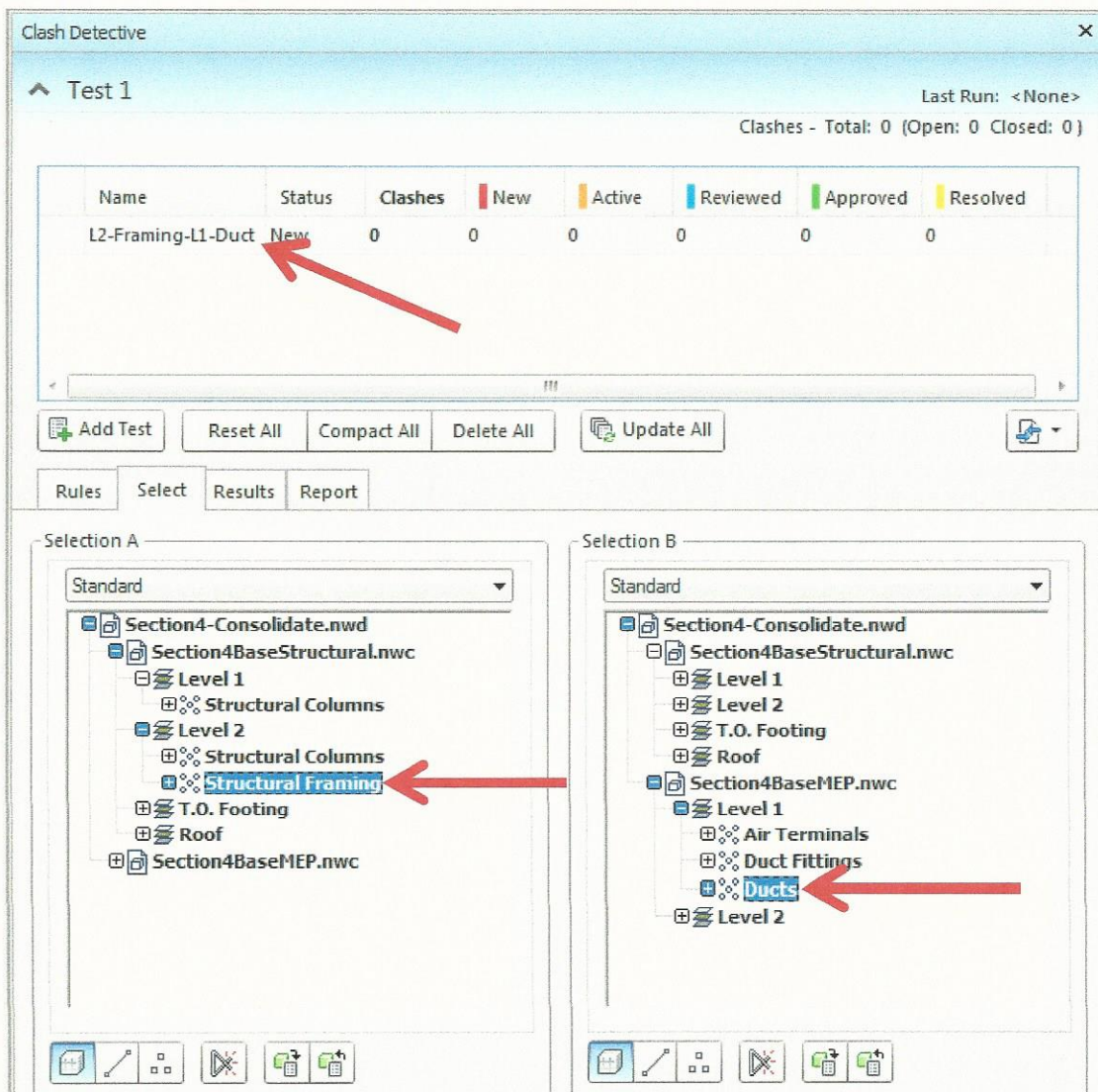
In the viewing area you can see the two items in Clash 1 that have been flagged. It might be worthwhile to investigate the “Dim Other” and “Hide Other” buttons at this point. Notice how the “Hide Other” blacks out everything except the clash while “Dim Other” shows a faint representation of the adjacent elements (either wire framed or as a grayed object depending if Transparent Dimming is chosen).

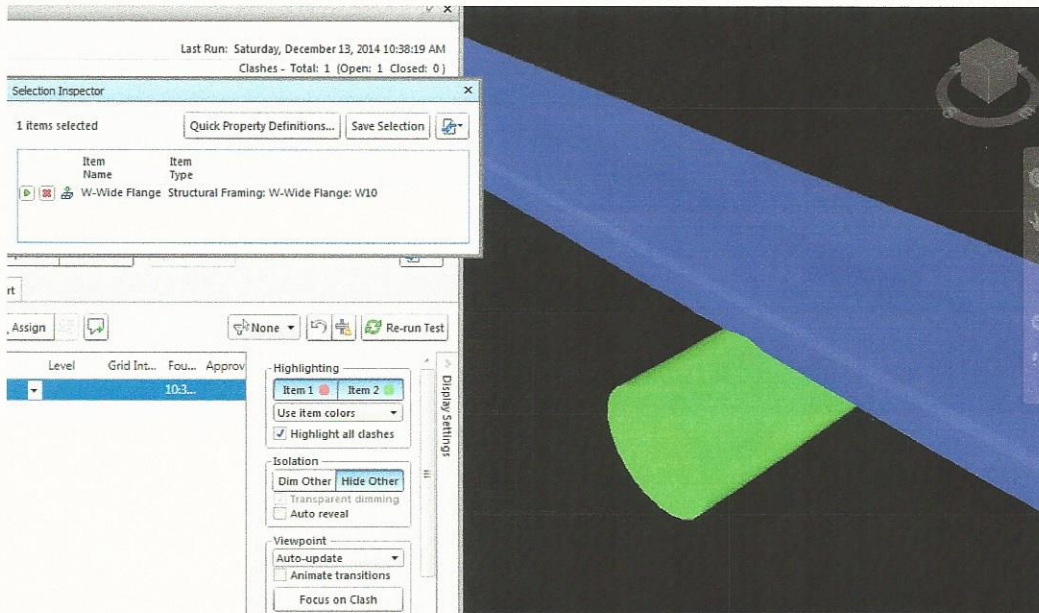


Notice also that each clash can be viewed individually by simply clicking on their respective name (Clash1, Clash 2, Clash 3). To gain perspective you can click on the display area and spin the wheel of your mouse to zoom out (you can push the wheel of your mouse to “pan” the display) on the 3 clashes found if the “Highlight all clashes” is checked on.

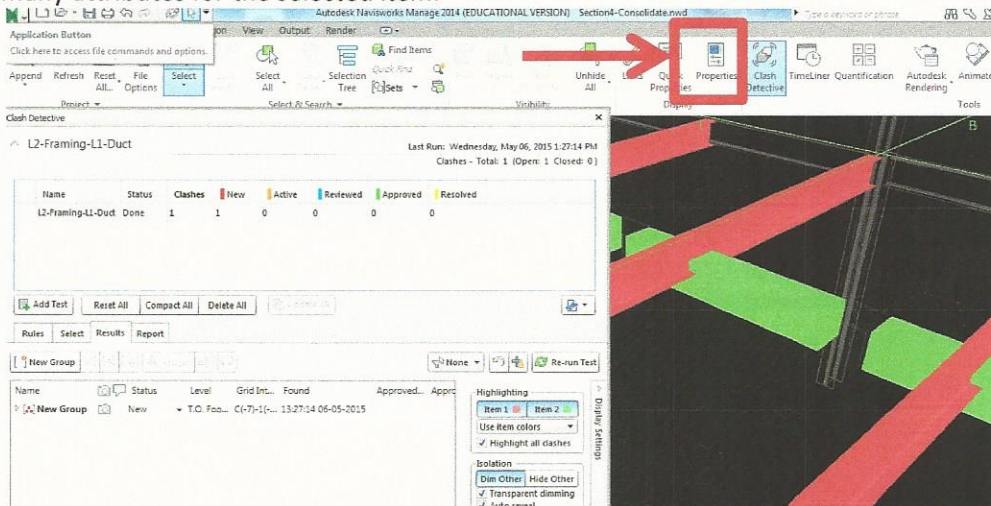
In this example a clash test will be performed between the first Floor Structural Framing and the Lower Level Ducts in the MEP model.

4. Go to the top pane and click where it says Test 1 and type in "L2-Framing-L1-Duct". This will be the new name for this test which will be a comparison of a portion of the Level 2 structural framing against the Level 1 HVAC ductwork.
5. Go to the bottom pane in the selection A column open up the **Section4BaseStructural** menu by clicking on the "+". Go down to the line that says "Level 2" and again expand the menu and click on Structural Framing. On the selection B side open up **Section4BaseMEP** menu by clicking on the "+". Go down to the line that says "Level 1" and again expand the menu and click on Ducts.





We also mentioned how useful it is to gain information on a member involved in a clash is the Properties button located next to the Clash Detective button. Once clicked, this will open up a panel that contains many attributes for the selected item.

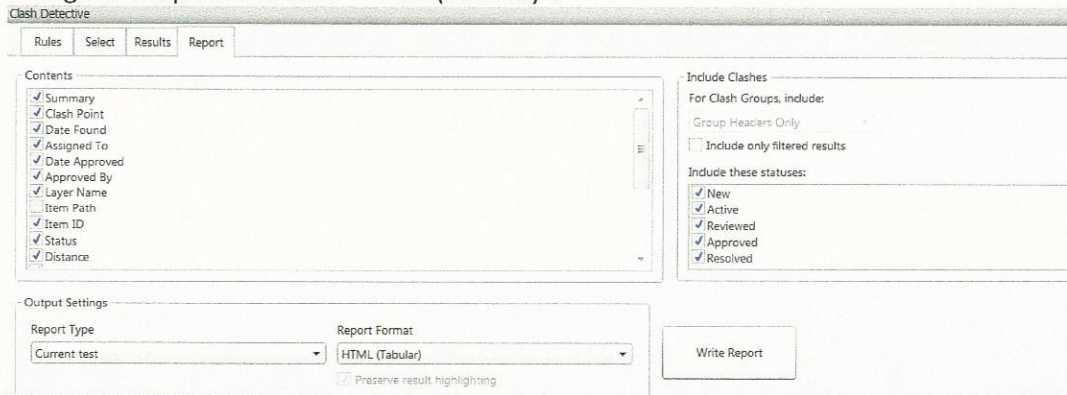


Knowing what items are actually clashing is very important as you move towards resolving that issue. A coordination meeting will have to be held on this part of the building between the construction manager, the MEP contractor and probably the structural engineer and/or architect to discuss the best way to resolve any clashes. In many cases, the structure of the building will be considered fixed as moving structural elements will be more difficult if the design has progressed beyond the schematic phase. Therefore, the clashes that are occurring between the structural framing and HVAC ductwork will likely be remedied by moving the ductwork. Among the various subcontractors, the HVAC system is probably the system that is hardest to relocate because of its size and scope. For instance, it is easier to re-locate sprinkler system (i.e. fire protection) components around HVAC ductwork than it is to move the ductwork to accommodate the sprinkler system. Although the hierarchy of systems can change

4.9 Navisworks Manage® – Reports in the Clash Detective

The last tab in the Clash Detective pane is called Results and this allows the user to configure how the clash information can be reported to other individuals. This might be a helpful method of formatting and consolidating clash information if the parties involved either cannot attend a coordination meeting or for keeping records of each stage. The information that is desired in the report can be clicked on or off and the type of report format selected. Please be aware the “Write Report” button is analogous to the familiar “Save As” button.

If we were to run the original clash test on the Section4-Consolidate.nwd model (finding 3 clashes between the Level 2 Structural Framing and the Level 1 Duct) and clicked on the report tab we could change the Report Format to “HTML (Tabular)”.



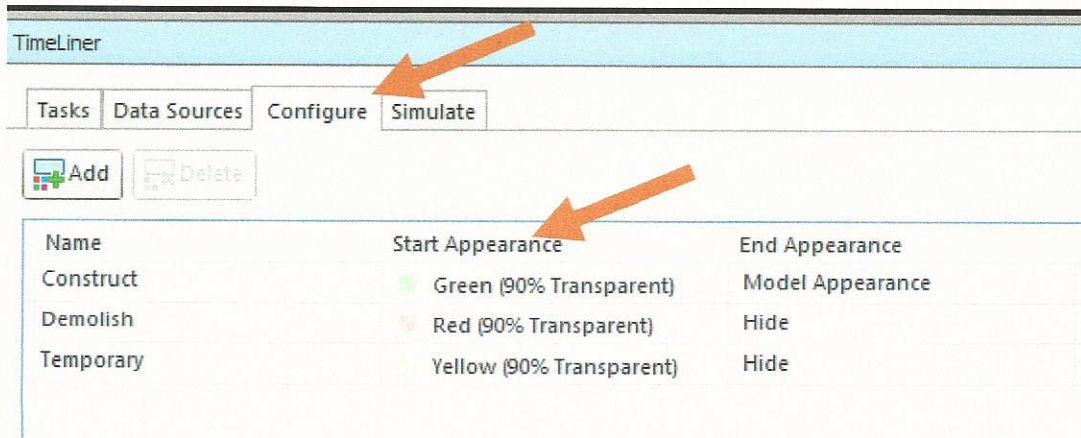
1. Click on “Write Report”. It will prompt you to the “Save As” where you can select a name (or use the default) and a location for the file. Click Save.
2. Go to that location. You should see a folder which has the clash images in it and an HTML file icon with the name associated with the report (I saved it as “Test 1”).



3. Click on that icon and the report should look like this:

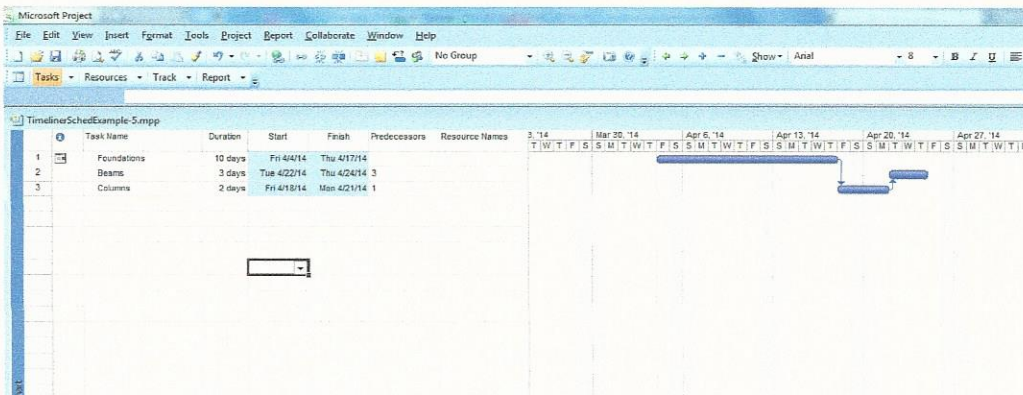
Test 1	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.003ft	3	3	0	0	0	0	Hard	OK

Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item 1				Item 2			
								Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type
	Clash1	New	-0.316	B-1 : T.O. Footing	Hard	2018/1/14 15:54	x:15.770, y:10.383, z:16.122	Element ID: 128663	Level 2	Steel ASTM A992	Solid	Element ID: 630293	Level 1	Rectangular Duct	Solid
	Clash2	New	-0.316	C-1 : T.O. Footing	Hard	2018/1/14 15:54	x:23.270, y:10.383, z:16.137	Element ID: 130393	Level 2	Steel ASTM A992	Solid	Element ID: 630292	Level 1	Rectangular Duct	Solid
	Clash3	New	-0.280	A-1 : T.O. Footing	Hard	2018/1/14 15:54	x:7.730, y:10.383, z:16.153	Element ID: 130520	Level 2	Steel ASTM A992	Solid	Element ID: 630294	Level 1	Rectangular Duct	Solid



5.3 Navisworks Manage® – Creating Timeliner Using a Linked Schedule

A second way to “timeline” a model in Navisworks is to link an actual construction schedule with it. Based on the previous model (with Footings, Columns, and Beams), a simple MS project schedule can be created. If you do not have experience with the MS Project scheduling software a simple schedule has been created for you and it is named **TimelinerSchedExample.mpp**. This file is found in the student CD/FLASH DRIVE or on the course site. This MS Project schedule has the same 3 activities (tasks) found in the **TimelinerSampleModel.nwc** file – footings, columns and beams. For this exercise each of these activities (tasks) will have durations as follows; foundation = 10 days, columns = 2 days, beams = 3 days. Each activity (task) will have its logical predecessor (i.e. footings precede column). The simple MS project schedule might look like this if you opened it in MS Project:



If you do not have access to MS project the file already exists in the Section 5 folder. The file name for the MS Project file is **TimelinerSchedExample.mpp**. Do the following:

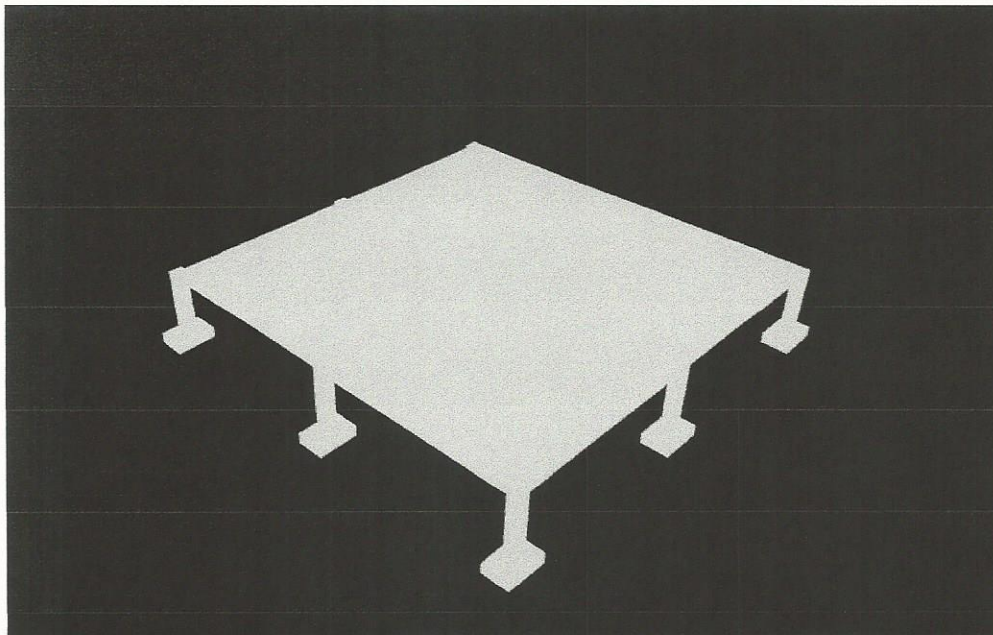
1. Close (without saving) Navisworks Manage

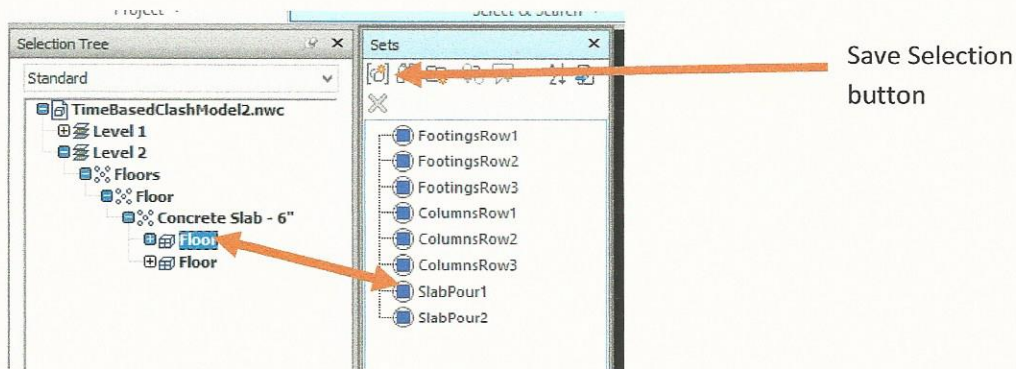
5.6 Navisworks Manage® – Identifying Time-Based Clashes Using Timeliner

It is easy to forget that clashes occur not only between objects that are constructed to “stay-in-place” but that clashes can occur between temporary elements that are needed to actually perform construction in the first place. There are items such as scaffolding, formwork, and equipment that are temporary elements that may have to be removed for other elements of construction to take place.

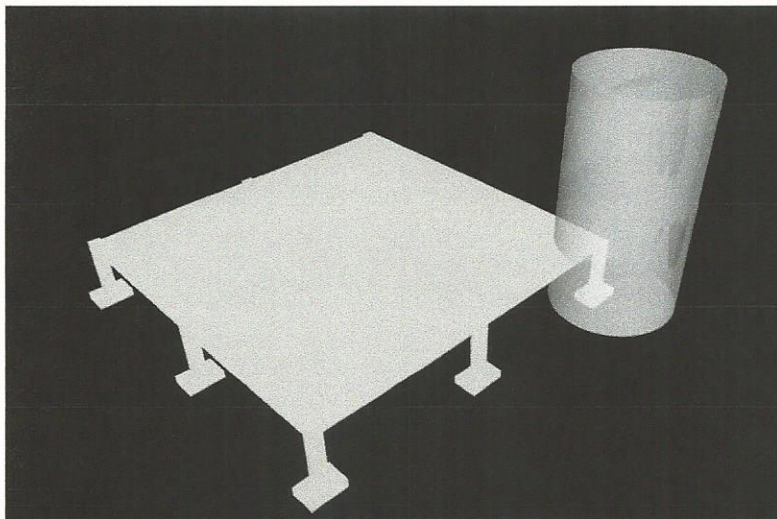
Although the tower crane does not remain in place forever, a construction manager would have to consider its location, height and swing radius relative to the construction of the building frame. Although it seems obvious, a temporary item (like a tower crane) should not interfere with the construction process by clashing with building components. Construction managers and contractors must be able to anticipate conflicts and interferences that could arise through the placement and scheduling of temporary items. The Timeliner tool can be used in conjunction with the Clash Detective tool so that temporary items, such as equipment, can be compared to the building model to check for time-based or “soft” clashes. Identification of a time-based clash will alert the construction manager to the need of adjusting the location or scheduling of the temporary item.

The following example will demonstrate how the Timeliner and Clash Detective tools can be used together to help a construction manager coordinate the timing of activities on a project. Using Navisworks Manage®, the first step is to open the Section 5 folder on the Course site or on the student CD/FLASH DRIVE and find a file named **TimeBasedClashModel2.nwc**. You should see the following on your display area in Navisworks.

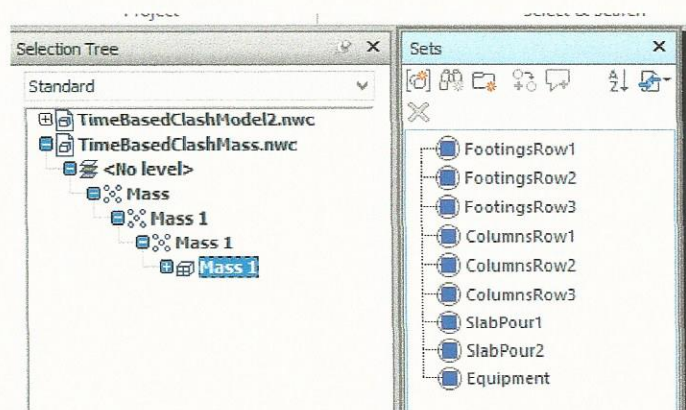




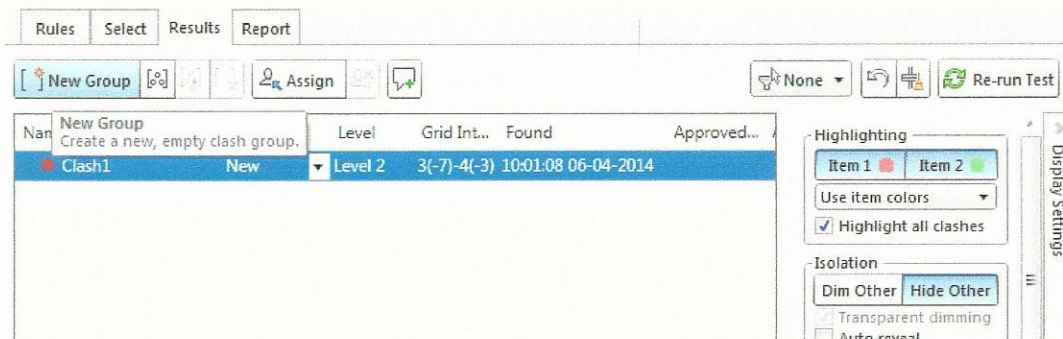
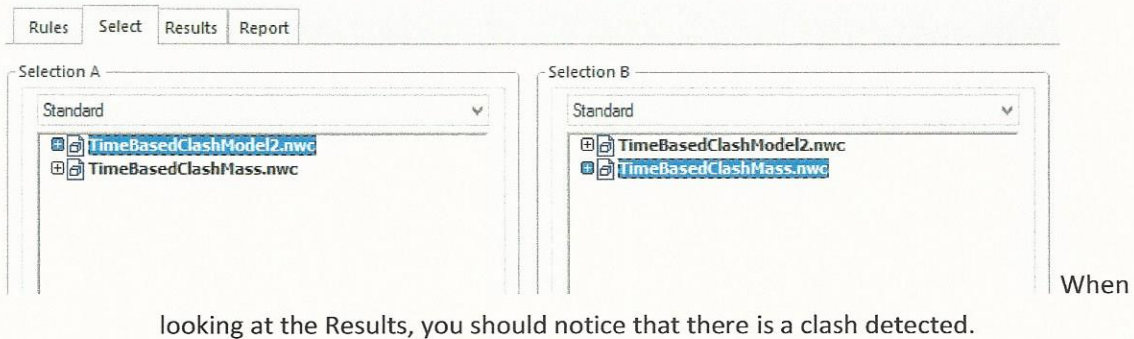
Once the Sets for the model have been completed, use the Append button and append a file named **TimeBasedClashMass.nwc**. The cylindrical mass is representing the zone of operation for a crane. Once this is appended the display should look as follows (you may have to click the "Home" icon above the View Cube).



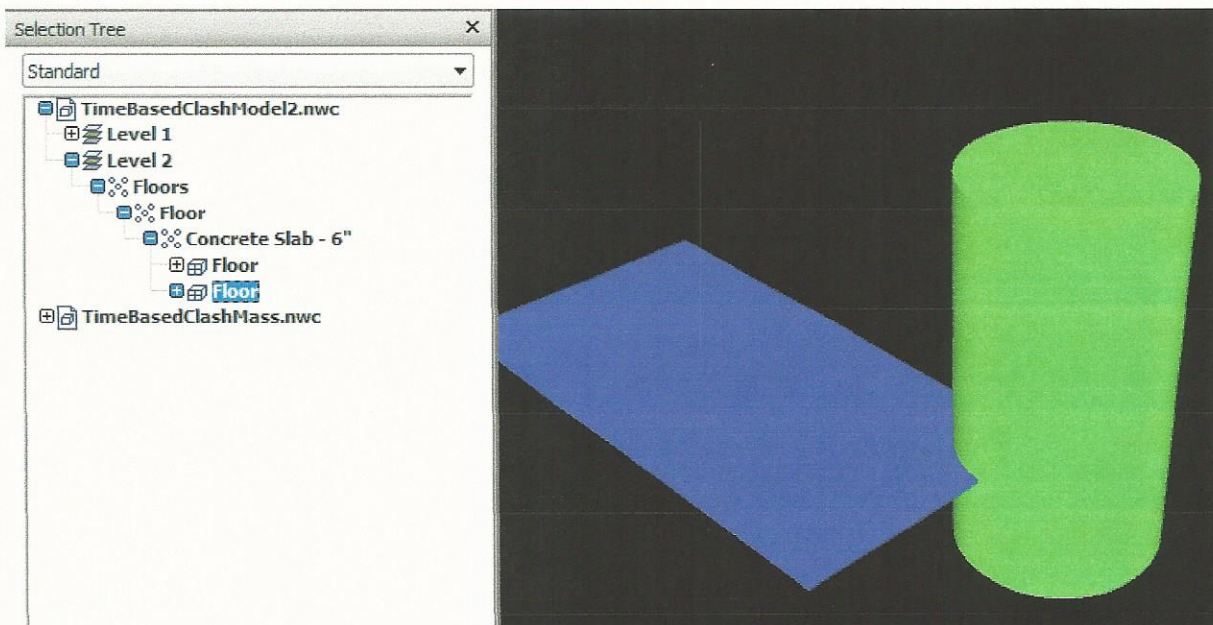
Select the cylinder mass and add it to the Sets, you can call it Equipment. Now your Sets pane should look as follows:

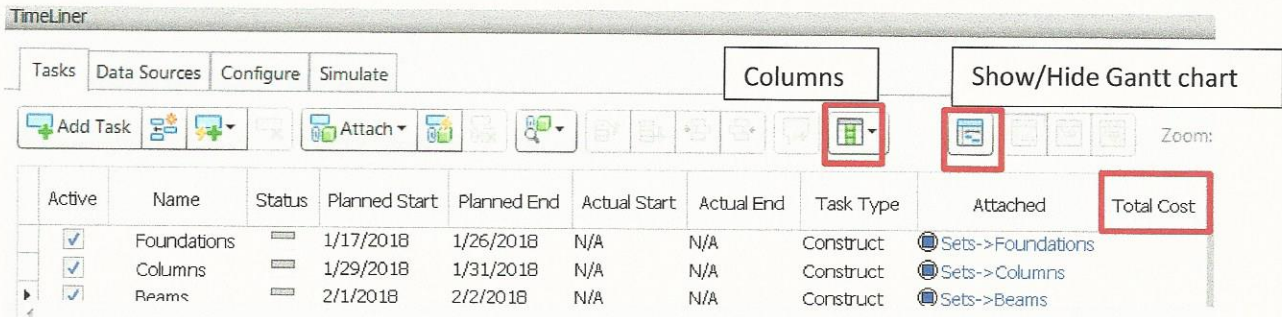


Open the Clash Detective, and click the Add Test (you can leave it titled Test 1). Run a clash test comparing the model to the mass. The selection panes would look as follows:



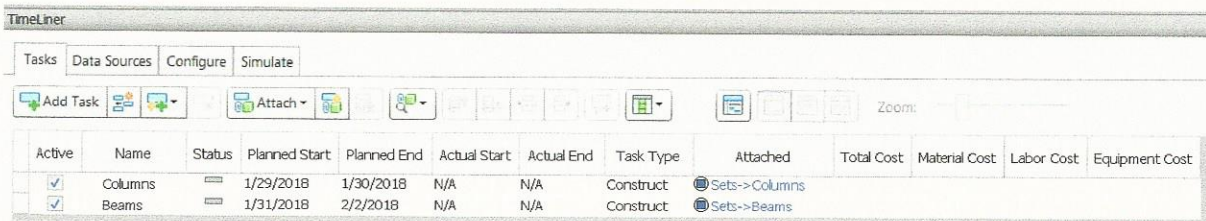
The mass is interfering with the slab (which seems fairly obvious). You can see from the Selection Tree that the slab interfering with the mass is second element listed (which is Slab Pour 2).





You can treat the Total Cost Column as if you were a Cost from a Schedule of Values. It is usually considered to be in some manner made up of Labor, Material, Equipment and/or Subcontractor Cost. Go ahead and Show the Material, Labor and Equipment Cost Columns.

2. Click on the Columns button and click on "Choose Columns. Then "check-on" Labor, Material and Equipment Cost. Then click "OK". You should now see the following:



3. Enter the following material, labor and equipment costs values for each task (the total cost will add these automatically). Notice that the Total Cost is just a sum of the various components.

The screenshot shows a detailed cost breakdown table for the selected tasks. The table has the following columns: Attached, Total Cost, Material Cost, Labor Cost, and Equipment Cost. The data is as follows:

Attached	Total Cost	Material Cost	Labor Cost	Equipment Cost
Sets->Foundations	40,000.00	20,000.00	15,000.00	5,000.00
Sets->Columns	35,000.00	12,000.00	15,000.00	8,000.00
Sets->Beams	25,000.00	10,000.00	10,000.00	5,000.00

4. Toggle the Show/Hide Gantt button again

So far, when you ran the Timeliner simulation, you may have noticed that the simulation had some time and date information scrolling across the screen. That is part of the "Settings" button that is under the "Simulate" tab.

Once you open up the report you should see the following:

Test 1										Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
										0.00ft	1	0	1	0	0	0	Hard	OK

Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Clash Point	Item 1			Item 2			Task				
								Item ID	Layer	Item Name	Item Type	Item ID	Layer	Item Name	Item Type	Name	Start	End
	Clash1	Active	-2.37	3-4 : Level 2	Hard	2015/4/7 15:26.25	x:76.32, y:45.33, z:10.00	Element ID: 130725	Level 2	Concrete, Cast-in-Place gray	Solid	Element ID: 130532	<No level>	Default Form	Solid	Equipment	2015/4/17 09:0.0	2015/4/17 17:0.0

Notice the report lists items such as clash location and items but what is of primary interest is the last part of the report which shown that the Equipment task was involved in the clash starting on a date and ending on a day (the actual dates are not important to us in this example). You can obviously see from the image and the other information that the clash is with the equipment mass. It occurs as the equipment is “installed and ends when the equipment is removed. To remedy this, the equipment (i.e. the mass) can be relocated, re-scheduled or perhaps the sequence of constructed elements could be changed. What would happen if the dates for SlabPour1 and SlabPour2 were switched?

5.7 5D BIM Using Timeliner

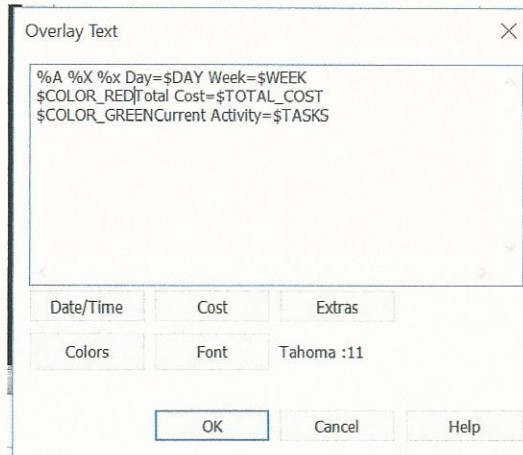
The world of three-dimensional models can be linked with the time and logic of various tasks as we have already seen with the Timeliner tool in Navisworks Manage to provide what many people call 4D BIM. The Timeliner tool can extend this into another dimension – cost – as an example of what many refer to as 5D BIM.

Cost can be assigned to a task in the TimeLiner tool by manually entering a cost in the task pane of the tool. The most basic cost to track is “Total Cost” but you can also input other costs such as material, labor, equipment, and subcontractor. Costs could also be imported from a scheduling software but that is beyond the scope of this introduction.

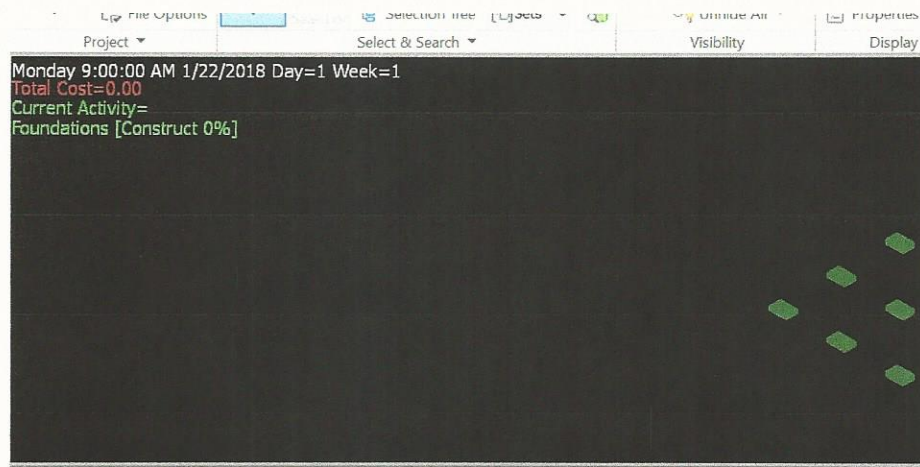
Go to the course site or CD/Flash Drive and open the file named **Timeliner5DSample.nwd**. This is a simple building frame with three tasks – Foundations, Beams, and Columns which have model elements grouped into Sets and those Sets attached to the Timeliner so the a Simulation will run. Go ahead play the Simulation.

Now we are going to add cost values to the model.

1. Go to the Timeliner pane and click the Show/Hide Gantt Chart button. This reveals The Total Cost column just in case you didn't see it.



9. Click “OK” in the settings tab. Your Timeliner should look like this:



Go ahead and run the simulation. The cost and schedule are being integrated with the model which is the definition of 5D BIM. This can give the viewer a combination of information that allows them to better visualize the progress and resources needed at various stages of the project.