Practical 4D Construction Simulation Using Revit and Navisworks

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AUTODESK. UNIVERSITY

Timing

- 25 minutes – What and Why
- 25 minutes - Demonstrations
- 10 minutes - Q&A

About the speaker

Ken Flannigan

KONE Global BIM Solution Owner since 2016

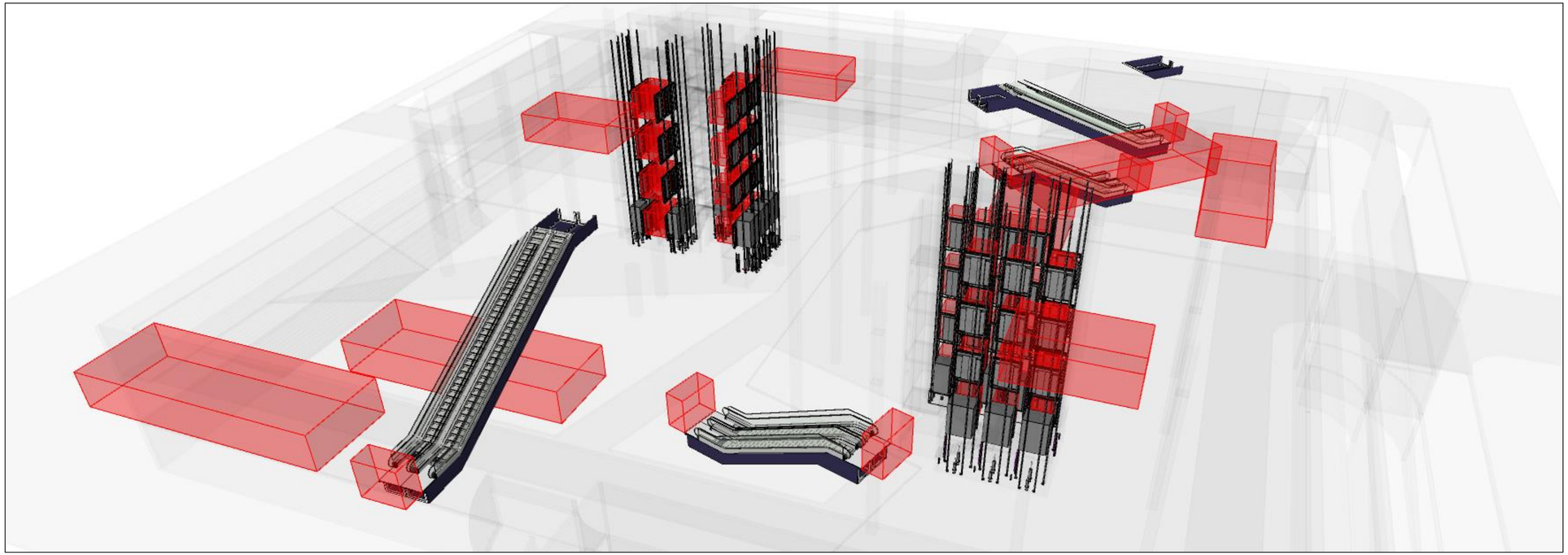
Live in Frisco, Texas

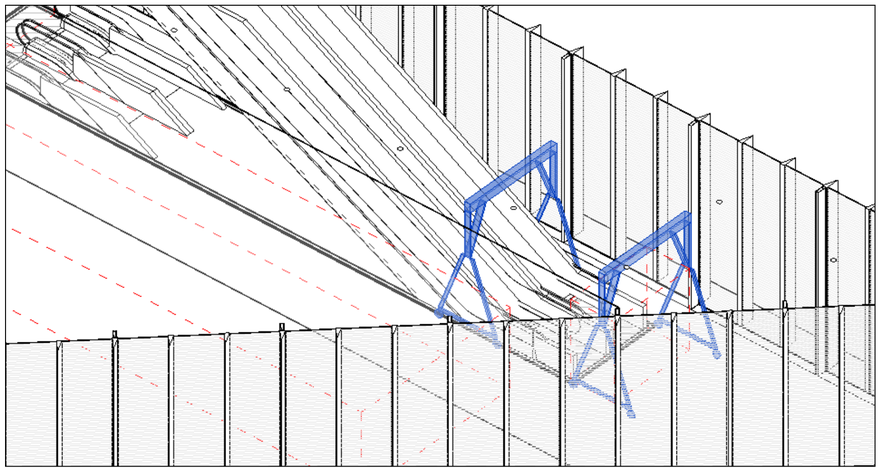
Started career in architecture, spent 10 years as consultant and trainer

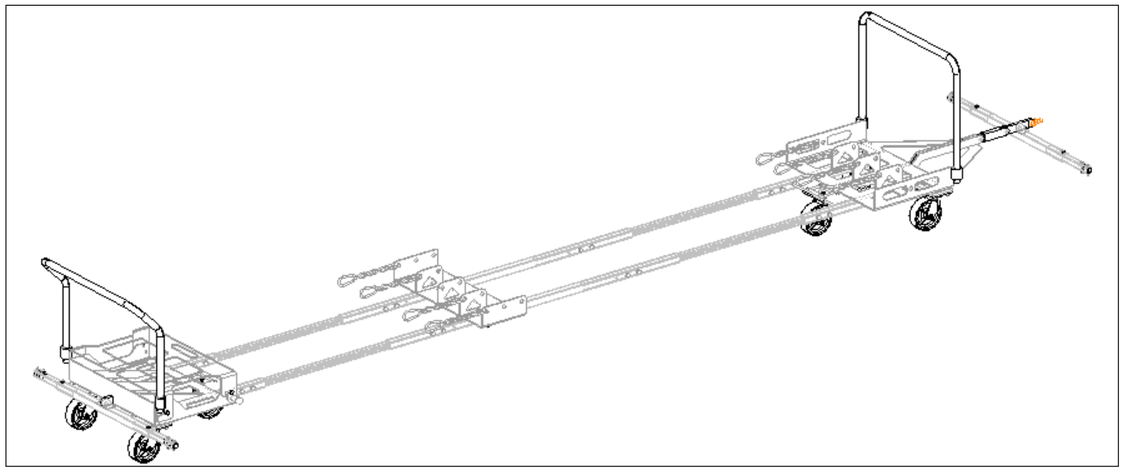
LEED AP


Today, most BIM coordination uses geometry in its final installed position.
What are we missing?

Construction Modeling and Simulation







90% of 4D use is:

“Hollywood BIM”

BIM deliverables, images, and animations made for entertainment purposes only. Also, NOT what we are interested in.

Photo credit goes here

https://commons.wikimedia.org/wiki/File:Aerial_Hollywood_Sign.jpg

We use “Hollywood BIM” too

Let’s remember back, how it all started…

The Year was 2008.

…The United Nations designated 2008 as the International Year of the Potato.

…The price of a movie ticket was $7.00

…Global stock prices plunged to record lows and the Dow Jones Industrial Average lost 33.8% of its value.

…The most popular song was Low by Flo Rida with T-Pain

We were just beginning our 3D coordination journey

We coordinated what we could, we modeled items outside of our scope to understand design and construction better

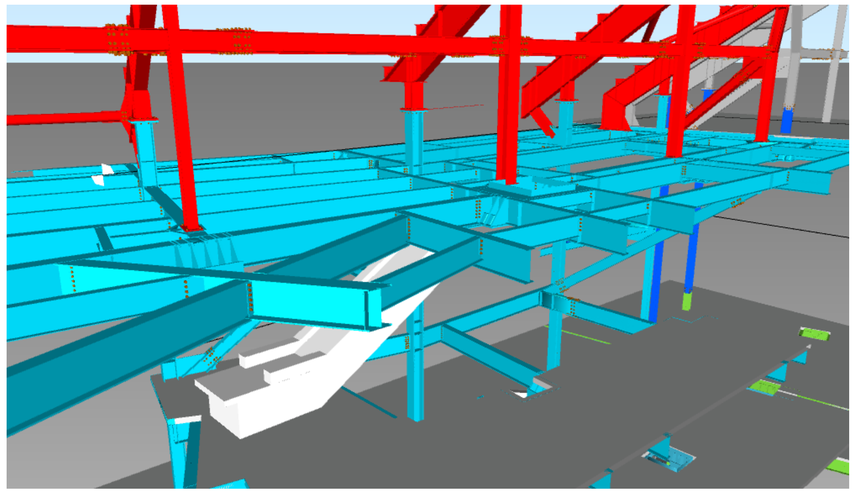
What are your problems?

Can we understand them better virtually?

Practical 4D Construction Simulation

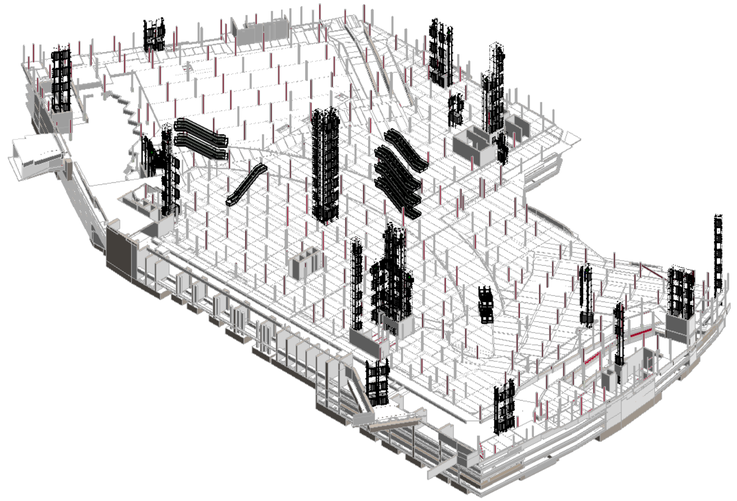
SITE LOGISTICS MODELING

3D models of clear work areas, material laydown areas, delivery and staging areas



EQUIPMENT ROUTING ANIMATION

Animation of an object that needs to be moved from a delivery or staging area into its installed position.

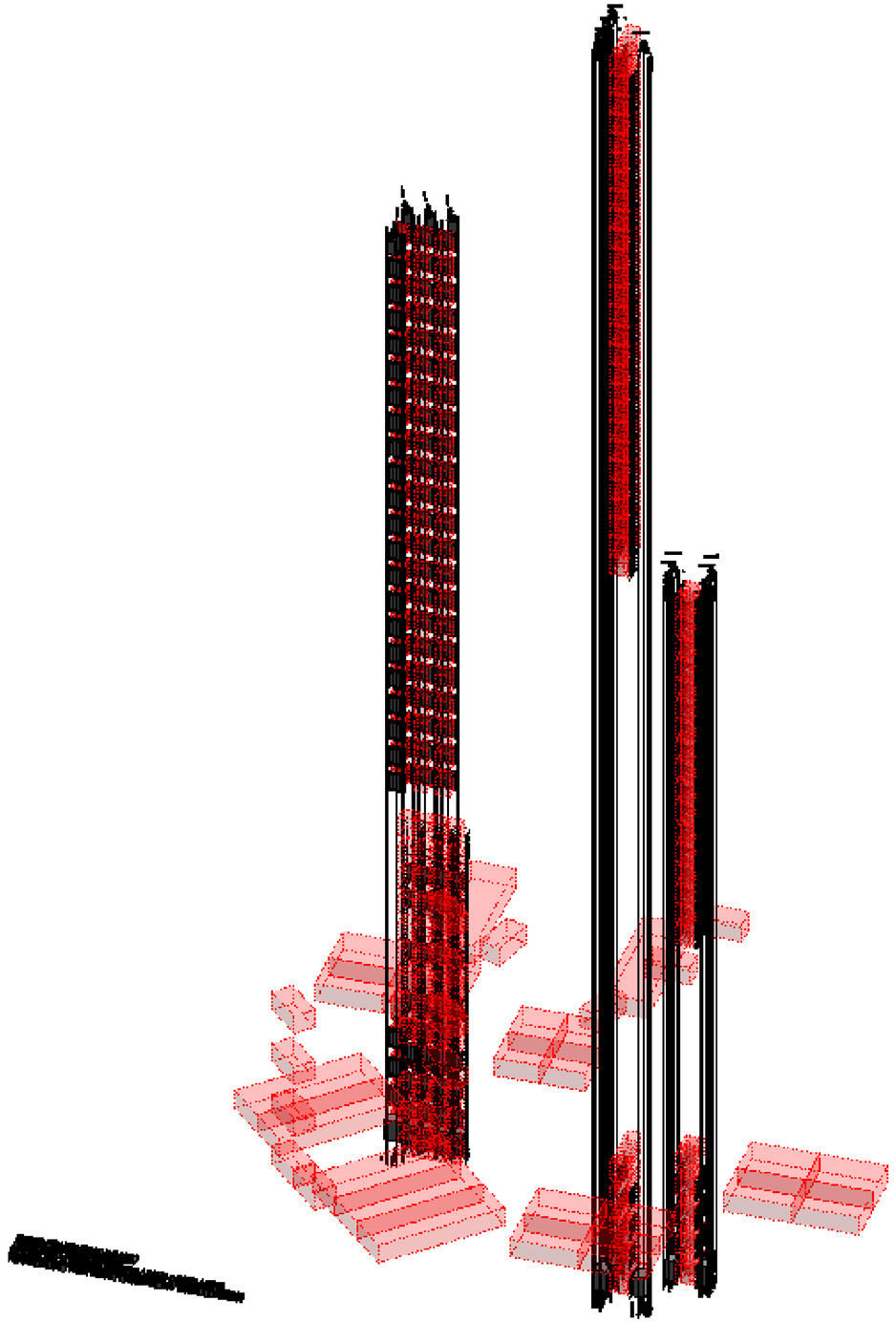


PROJECT TIMELINE SIMULATION

Animation showing building elements changing visual properties, usually color and transparency, during a series of tasks.

Site Logistics

- Improving communication of onsite material storage and clear work area requirements
- Coordinate equipment installation sequencing
- Communicate and optimize the space needed by multiple trades during construction



Site Logistics is usually communicated in a site readiness guide or checklist

Site Requirements Checklist

The following requirements must be completed prior to starting the escalator installation. Once all items have been completed and checked off, place your initials next to the check box for each item and fax the completed form to the local KONE Superintendent. Upon receipt of this form, your KONE representative will contact you to discuss and schedule an installation start date.

Contract number _____

Project name_____

General contractor name (print)_____

General contractor signature _____

If you have questions, contact your KONE representative.

KONE, Inc. Superintendent _____ Cell phone _____

Office phone _____ Fax _____

Safety and OSHA/Local code requirements

___ ☐ **Barricades:** Provide free-standing, removable barricades at top, bottom and the length of the wellway per OSHA 29 CFR 1926.502 and/or any applicable local codes. Barricades should allow 4-5 ft (1.5-2 meters) work space to escalator truss.

___ ☐ **Stair access:** Provide safe stairway access to all floors per OSHA 29.CFR1926.1052 and/or any applicable local codes.

___ ☐ **Work area:** Provide clear work area with OSHA and/or any applicable local code lighting, free of debris and tripping hazards.

Under no circumstances can other trades work in or around areas above the escalator installers and or escalator wellway while escalator installers are working in wellway.

General

___ ☐ **Hoisting method:** Coordinate with KONE representative the type of method to be used for setting trusses into wellways (crane, chain hoists, etc.) prior to shipment of material.

___ ☐ **Hoisting points:** Provide prearranged hoisting points capable of withstanding loads designated in KONE Final Layout Drawings.

___ ☐ **Work space:** Provide unloading/work area outside of building with space to splice trusses with forklifts.

___ ☐ **Access from unloading area:** Provide roll-able access from unloading area (smooth concrete with adequate room to maneuver truss around building structure, through doors, etc.).

___ ☐ **Three-phase power:** Install three-phase power with characteristics required in Final Layout Drawings, at each escalator/autowalk upper pit. Coordinate layout and location of disconnect with KONE representative after truss is set in wellway.

___ ☐ **Electrical equipment:** Install 110 volt, 20 amp GFCI dual gang receptacle and light fixture with switch located at upper and lower end of **each** escalator (each end of walk) per ASME A17.1/CSA B44; 6.1.7.1.2.) Coordinate location of receptacle, light fixture and light switch with KONE representative after truss is set in wellway.

___ ☐ **Storage space:** Provide clean, dry storage space near escalator wellway for easy access to parts/tools. Storage space is typically 60 feet x 20 feet (18 x 6 m) per escalator.

___ ☐ **Prohibited attachment:** Be aware that screwing/welding to truss angles and or pan is not permitted.

___ ☐ **Refuse disposal:** Provide refuse containers for crating and packaging.

___ ☐ **Lighting:** Provide task lighting in and around the escalator work area for a safe work environment.

___ ☐ **Demarcation lights circuit:** Escalator demarcation lights require a separate circuit and should be energized from Building Emergency Power Circuit.

___ ☐ **Optional circuitry:** Special options for the escalators (heating rods, handrail lighting, skirt lighting, remote monitoring, etc.) may require more circuits and/or work by others. Discuss this with your KONE representative prior to final design and procurement.

Pit

___ ☐ **Pit construction:** Construct pit to KONE final approved layouts.

___ ☐ Verify finished floor heights.

___ ☐ Verify pocket dimensions.

___ ☐ **Pit condition:** Provide clean, dry pit.

Wellway

___ ☐ **Wellway construction:** Construct wellway per KONE final approved layouts.

___ ☐ **Intermediate supports:** Construct intermediate supports per KONE final approved layouts.

___ ☐ **Reaction load evaluation:** Reaction loads of each escalator as shown on KONE final approved layouts must be evaluated by engineer of record.

___ ☐ **Pocket dimensions:** Nominal pocket depth and width must match dimensions on KONE final approved layouts.

___ ☐ **Penetrations:** Provide penetrations for piping separators, sumps and electrical lines in correct locations. (Coordinate with local KONE representative.)

___ ☐ **Ventilation:** Vent wellway per local building codes.

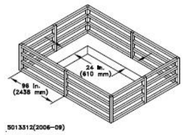
___ ☐ **Temporary structures:** Remove temporary supports and forming materials prior to KONE start date.

___ ☐ **Wellway condition:** Provide wellway that is clean and free of obstruction and debris.

Details for Site Requirements Checklist

Safety and OSHA/Local code requirements

___ ☐ **Barricades:** Provide free-standing, removable barricades at top, bottom and the length of the wellway per OSHA 29 CFR 1926.502 and/or any applicable local codes. Barricades should allow 4-5 ft (1.5-2 meters) work space to escalator truss.



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Under no circumstances can other trades work in or around areas above the escalator installers and or escalator wellway while escalator installers are working in wellway.

General

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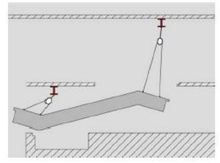
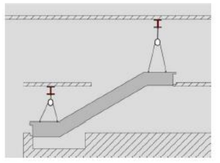
___ ☐ **Hoisting points:** Provide prearranged hoisting points capable of withstanding loads designated in KONE Final Layout Drawings.

- Hoisting points or beams capable of supporting the entire load of the escalator must be located above the escalator wellway.
- In cases where KONE uses an A frame to hoist the escalator, the contractor must provide a suitable anchorage point to anchor the A frame to the building floor.
- In cases where multiple escalators share a wellway, if the overhead hoisting member is required to support multiple units at one time, structural support members must be capable of supporting the gross load of all applicable escalators being hoisted.





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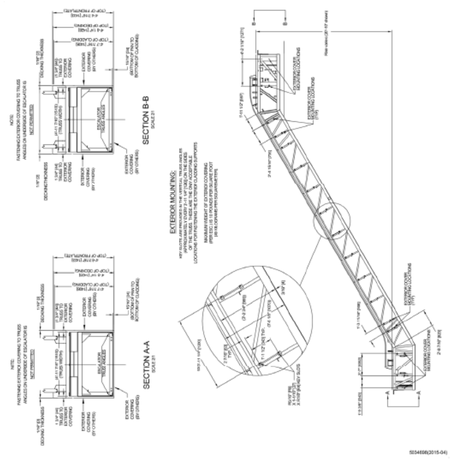
___ ☐ **Outer cladding:** See next page.



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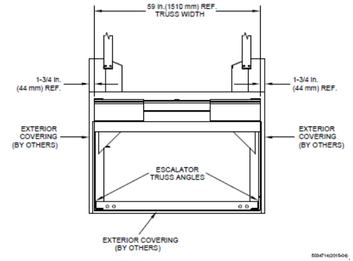

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What Does Site Logistics Modeling Enable?

PROJECT SEQUENCING DISCUSSION

Communicate the space needed during installation to help guide the sequence of construction / equipment installation

ONSITE MATERIAL STORAGE OPTIMIZATION

Placing onsite storage required areas in optimal locations may mean we spend less labor hours onsite.

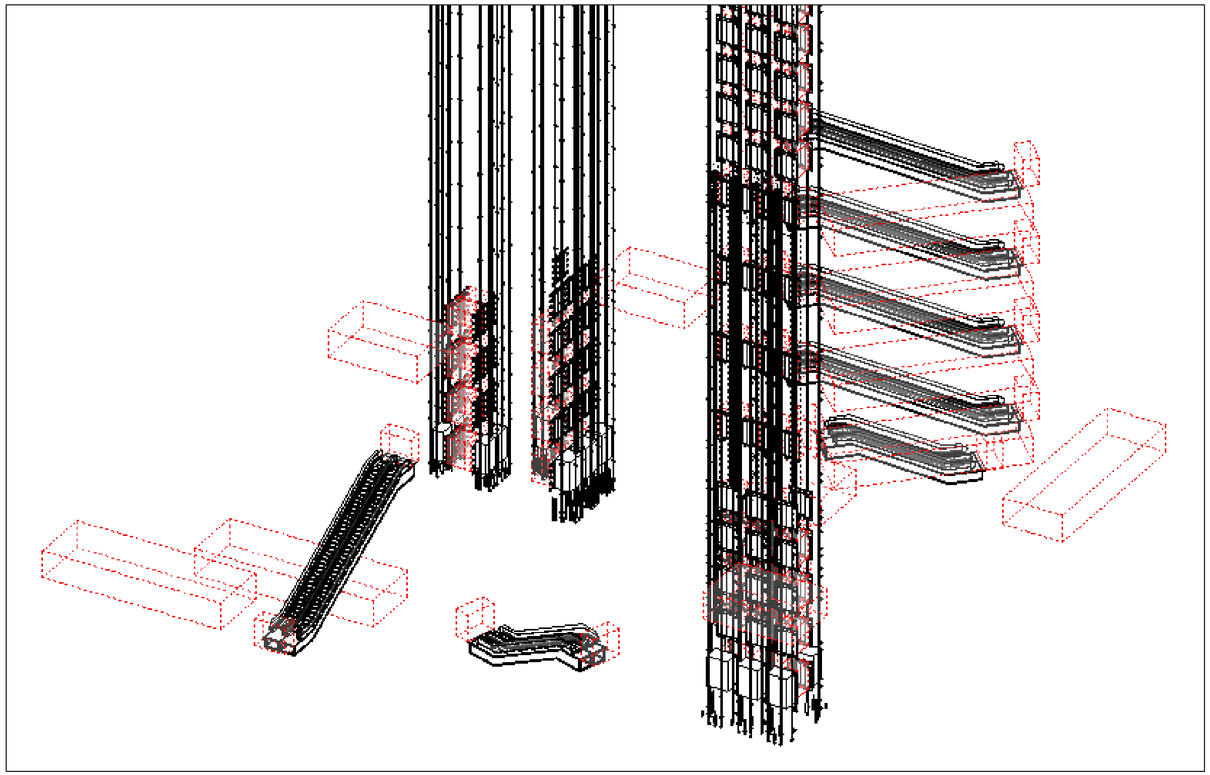
PLAN FOR MULTIPLE DELIVERIES

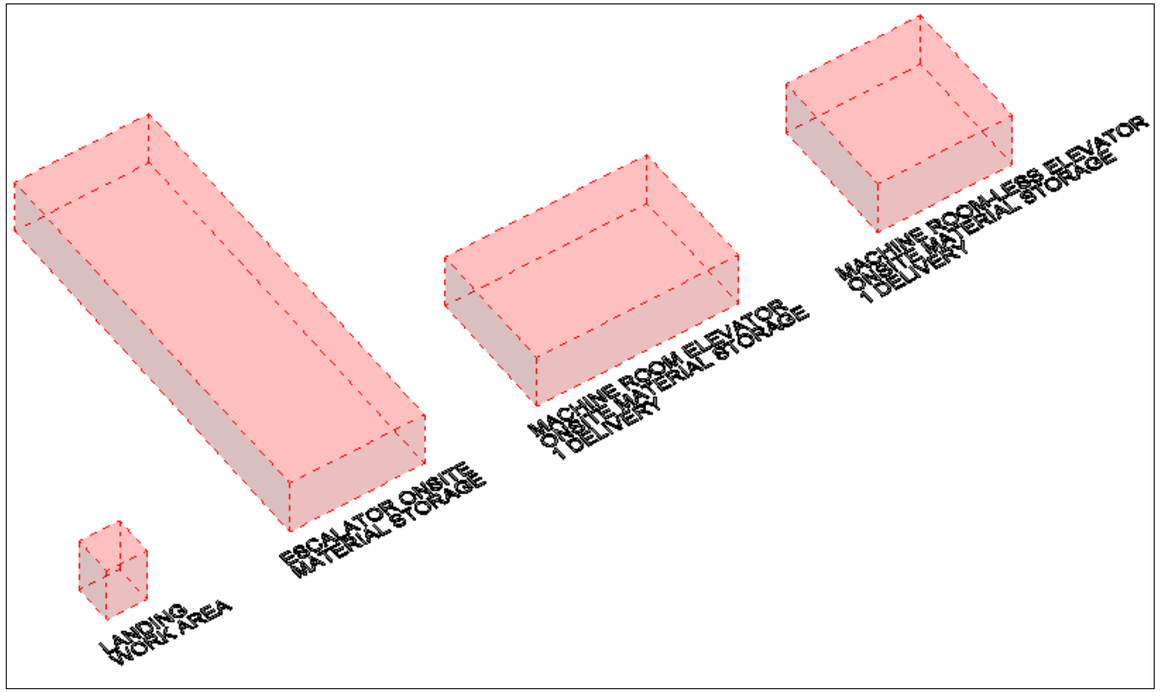
While we require a certain space per installation, we almost never get that space. Here we can use the 3D model to realistically plan for multiple deliveries.

3D/4D CONSTRUCTION SITE SPACE PLAN

If all trades are modeling their construction-time space requirements, there is an opportunity to computationally solve for an optimized sequence the same way generative design tools allow for early design optimization

What Does a Site Logistics Model Look Like?





Site Logistics in Revit and Navisworks

REVIT

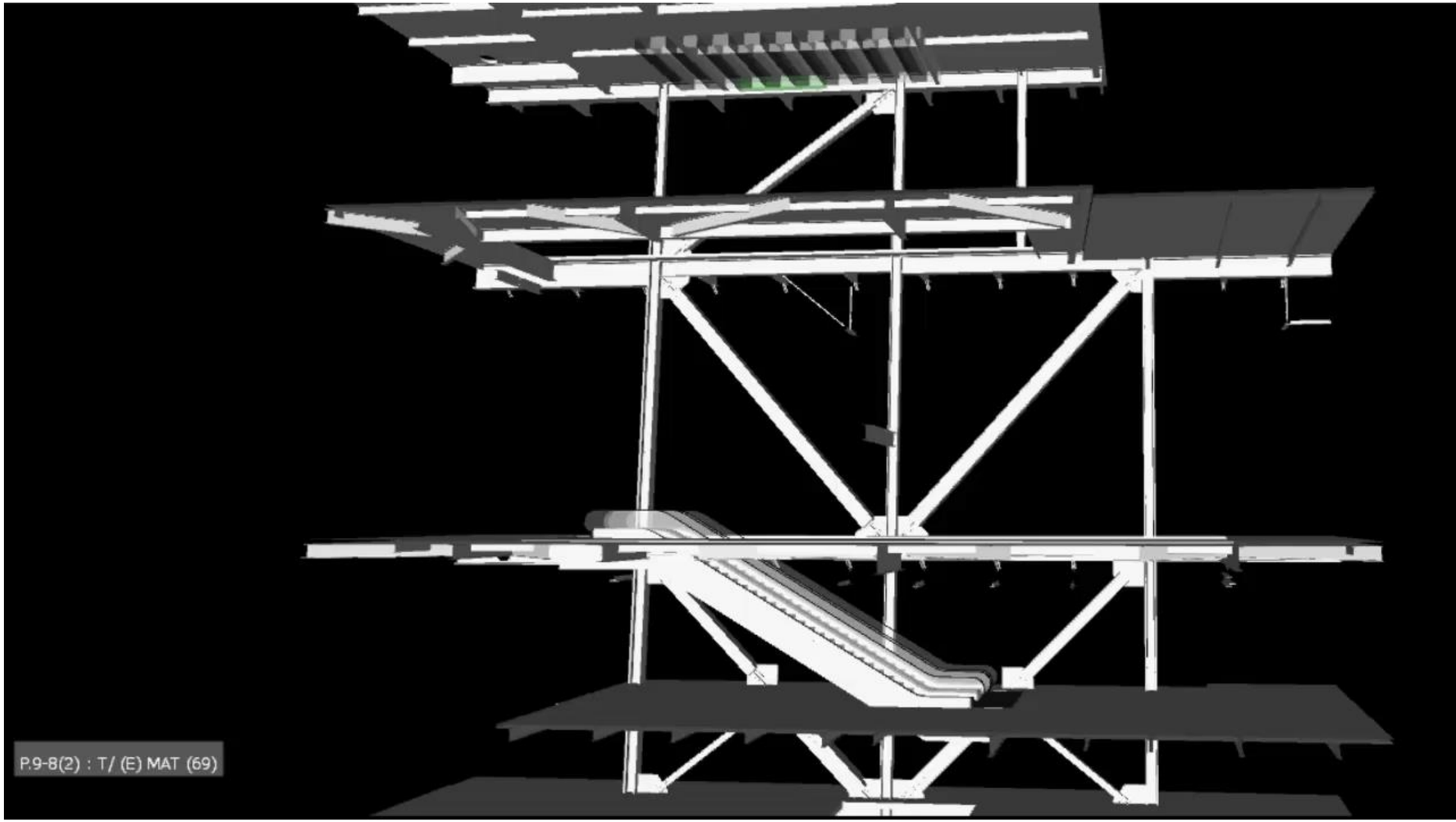
1. Link Equipment models and architectural/structural models
2. Copy important levels and Acquire Coordinates
3. Place the site logistics components on each level, as required
4. Hide Linked models and export 4D Site Logistics model to desired format (DWF)

NAVISWORKS

1. Append the site logistics model exported from Revit, we use DWF or IFC.
2. Isolate building floors with site logistics using sectioning tools.
3. Save Viewpoint(s)
4. If necessary, select the object and use the Item tools to Move, Rotate, or Scale
5. Screen capture or export image formats.

Equipment Routing

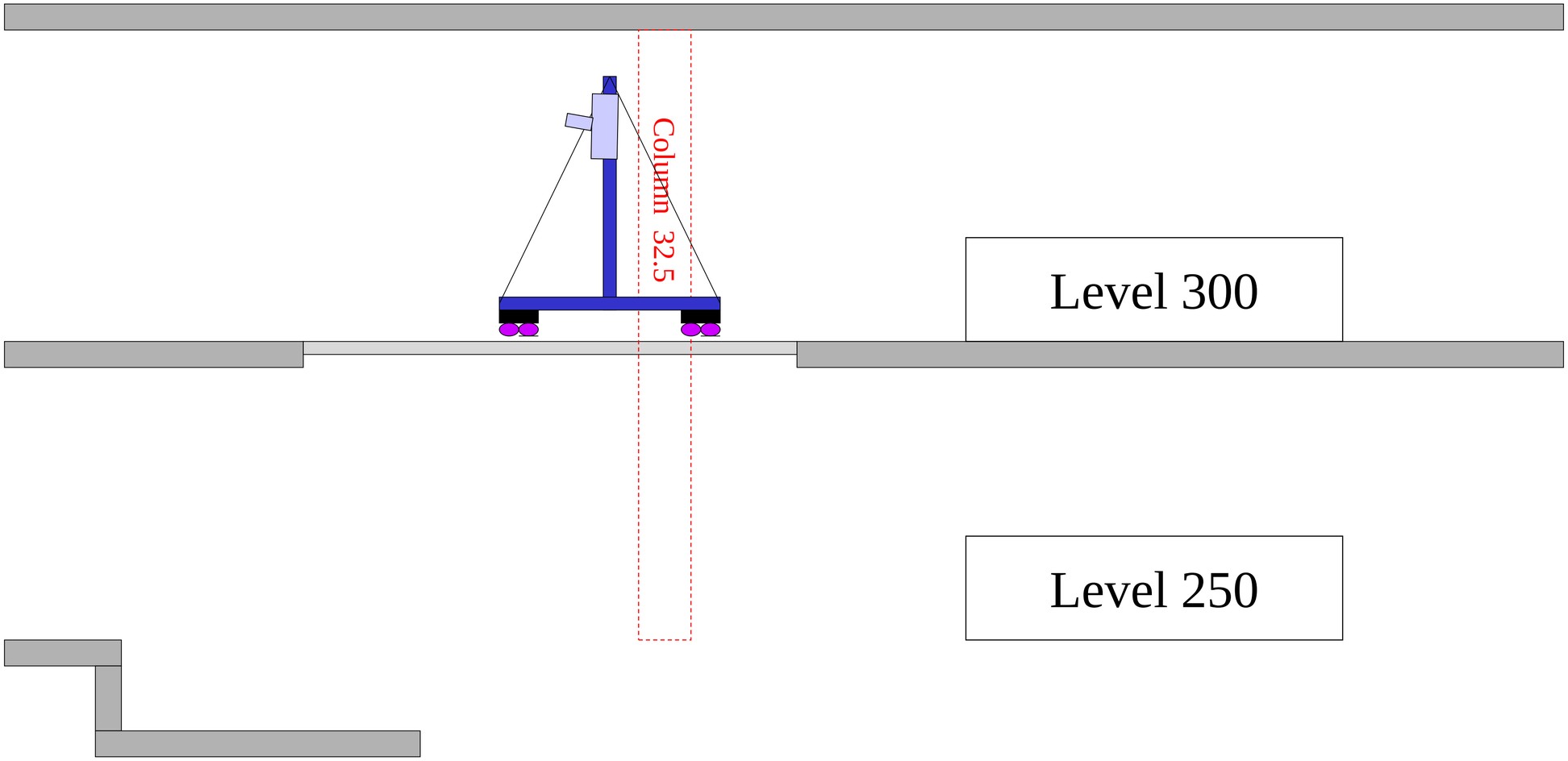
- Improve installation planning by animating the path and associated equipment and rigging



The way it was done before,

Rig & Hoist

- **Installation with rolling A-frames:**



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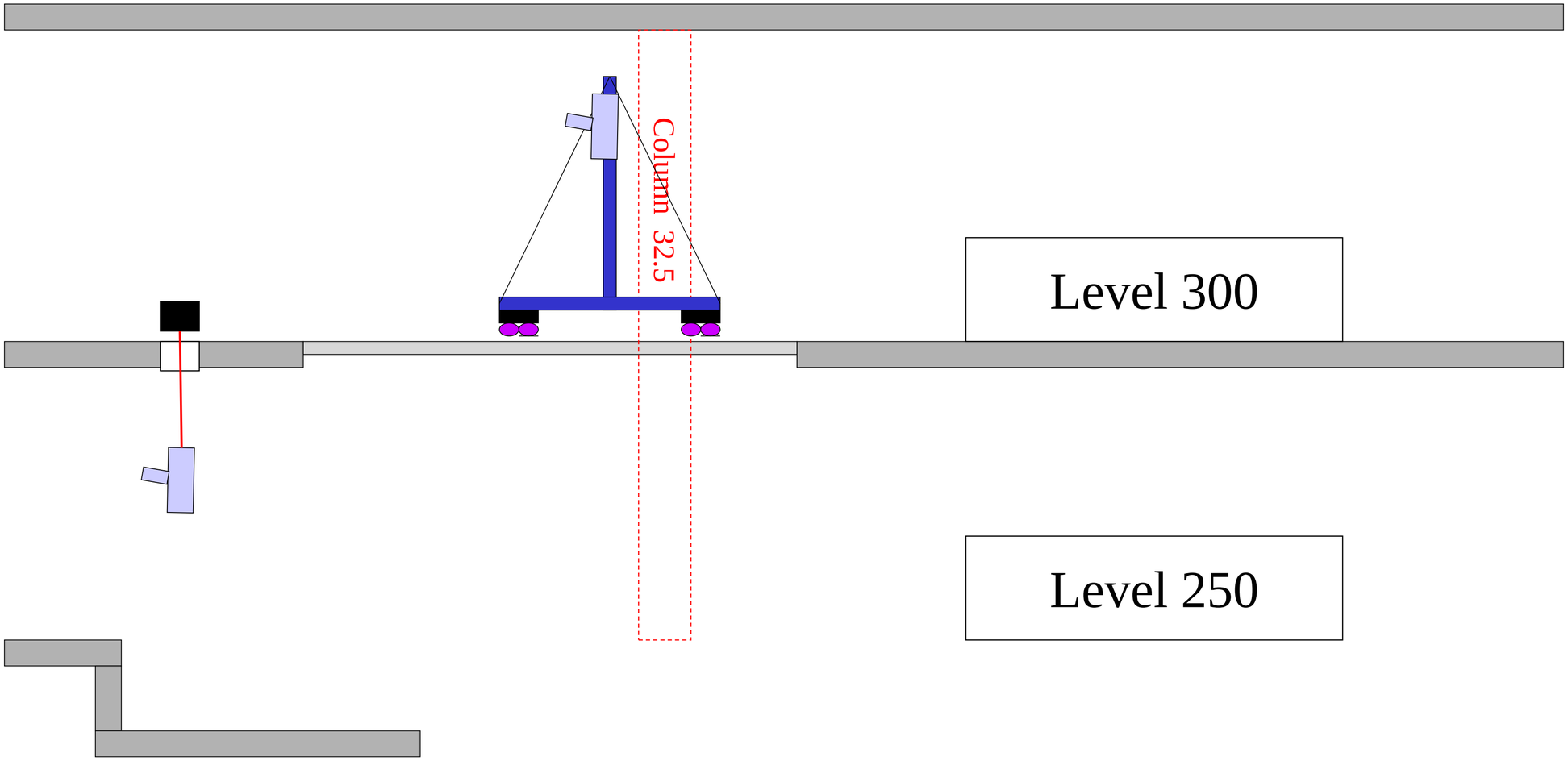

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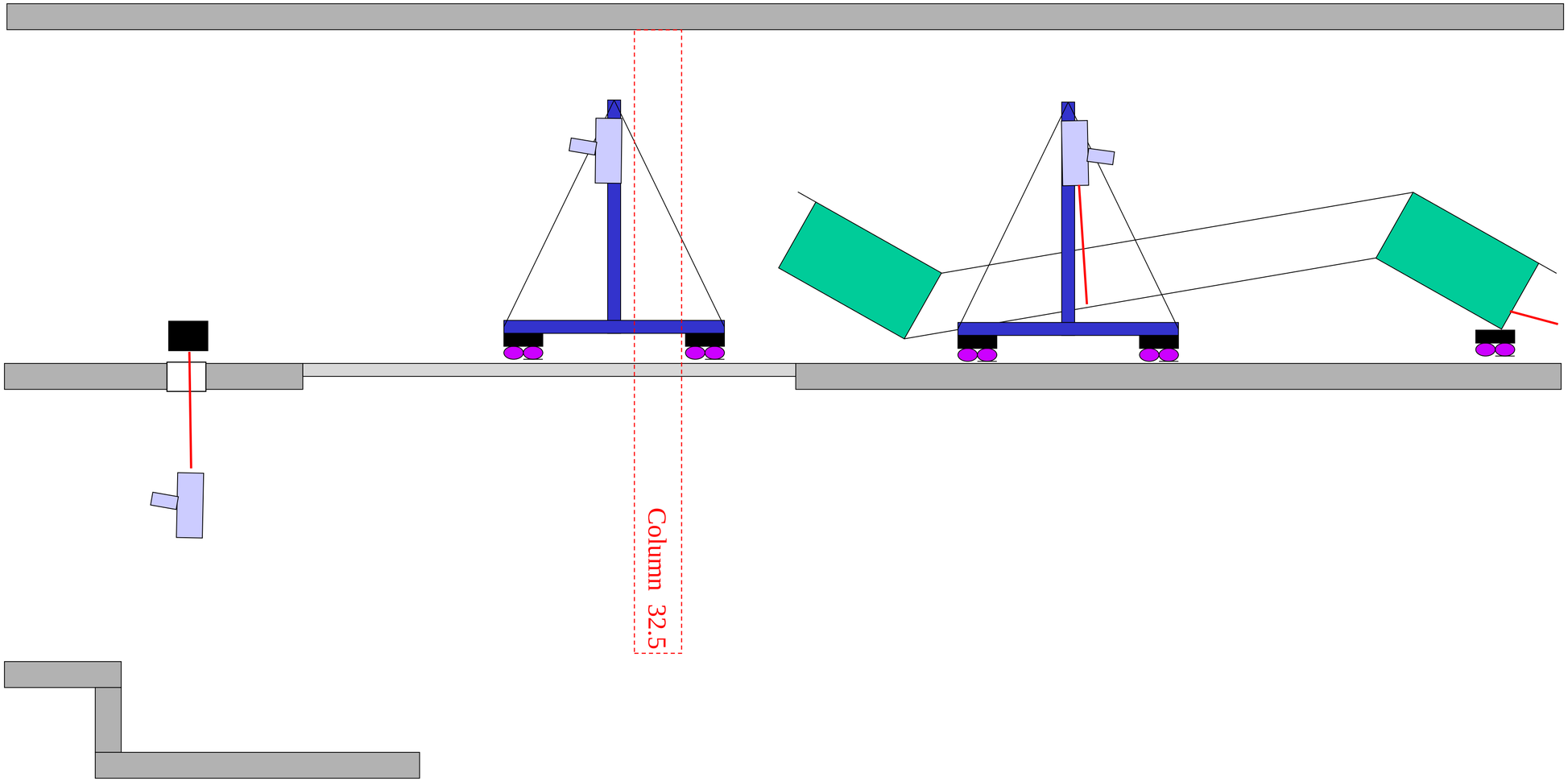

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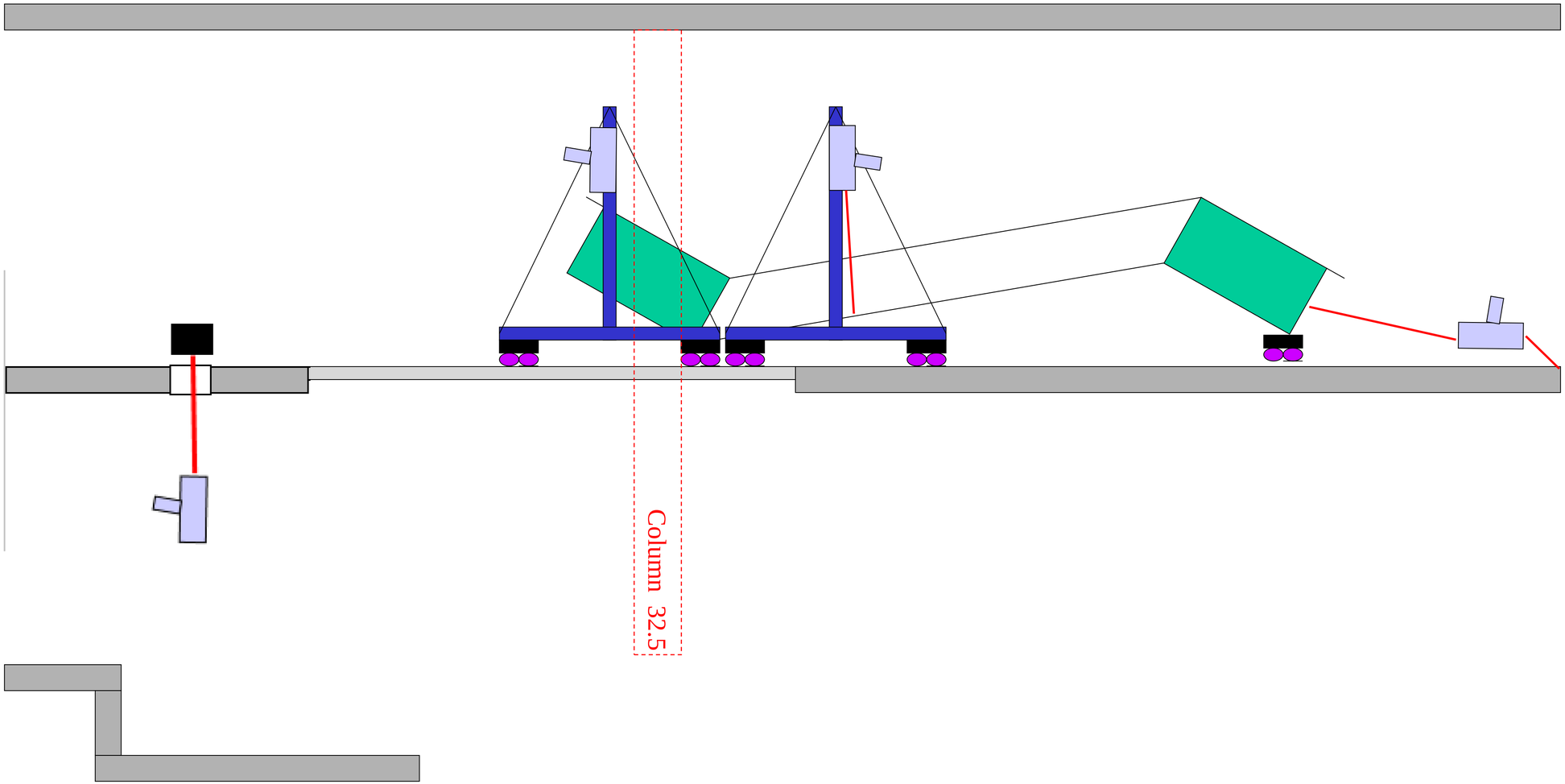

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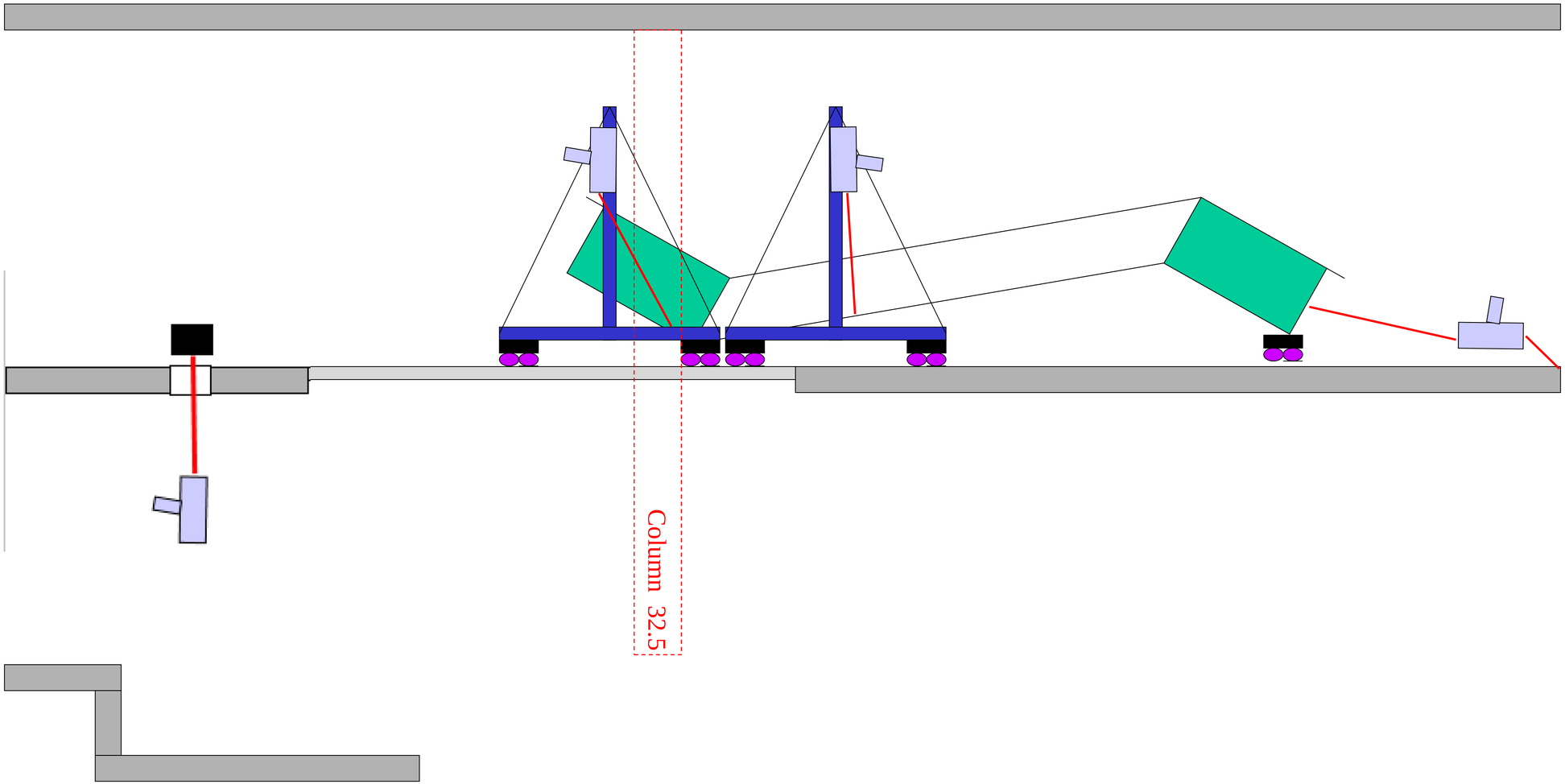

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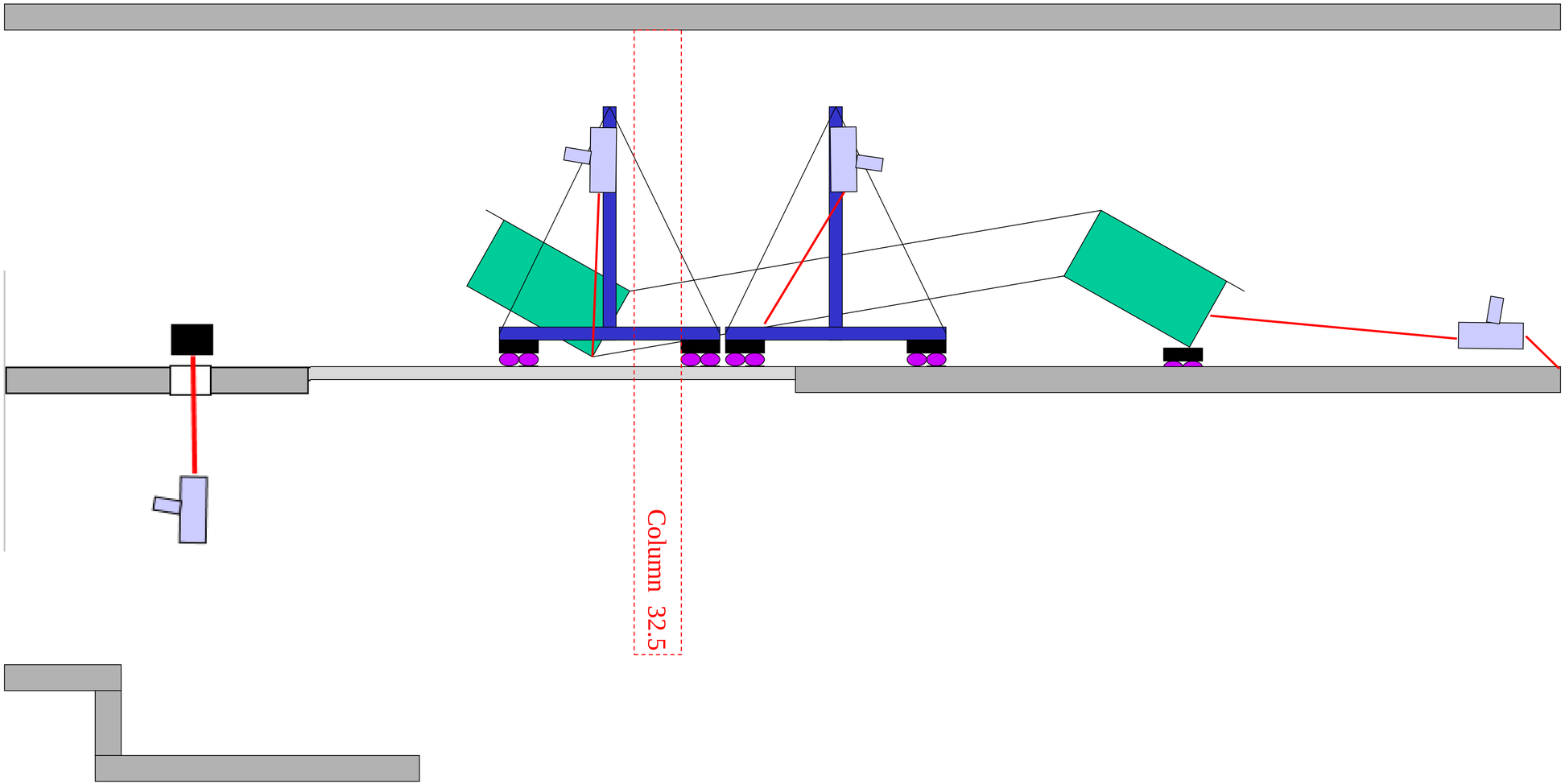

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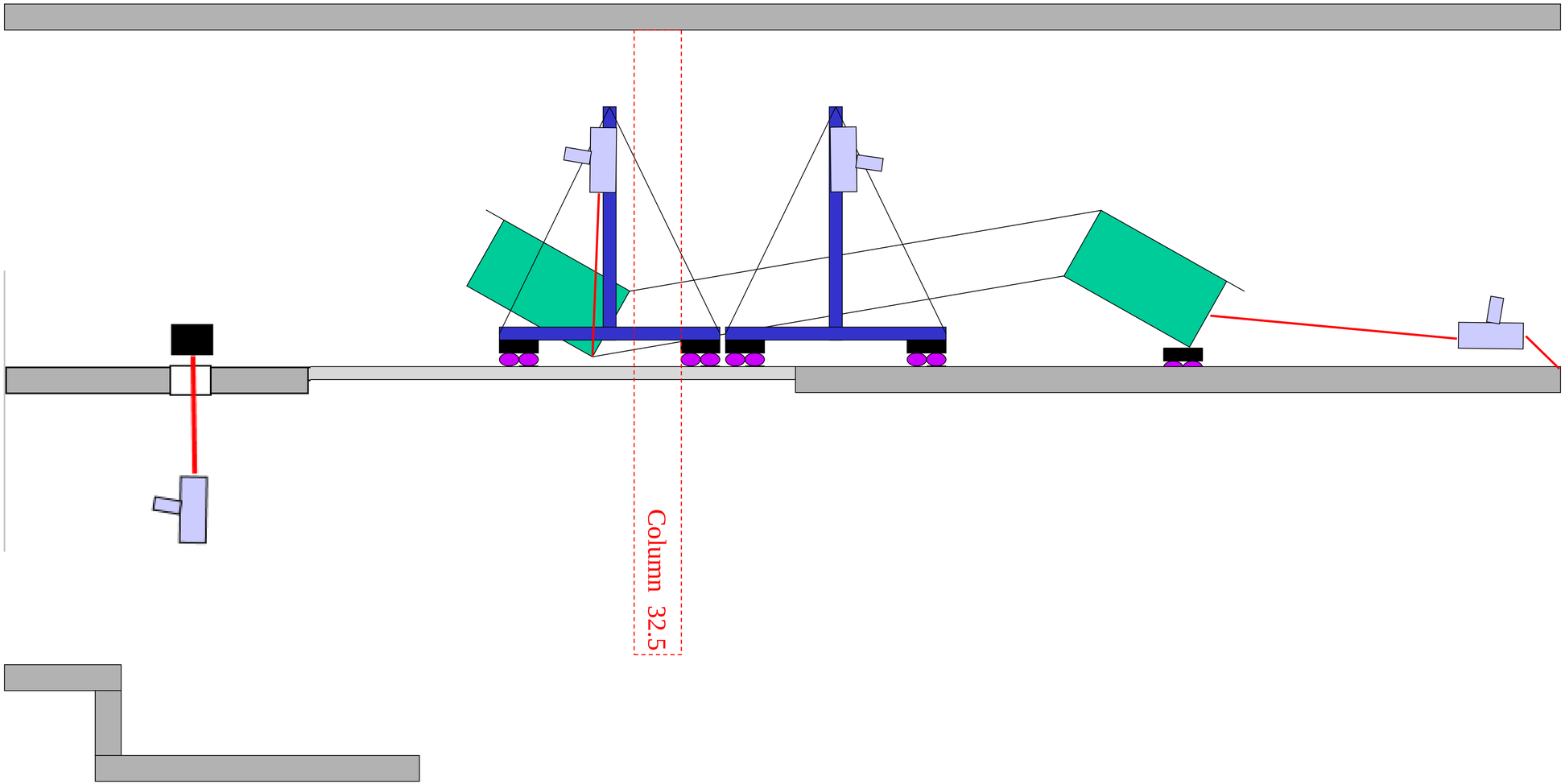

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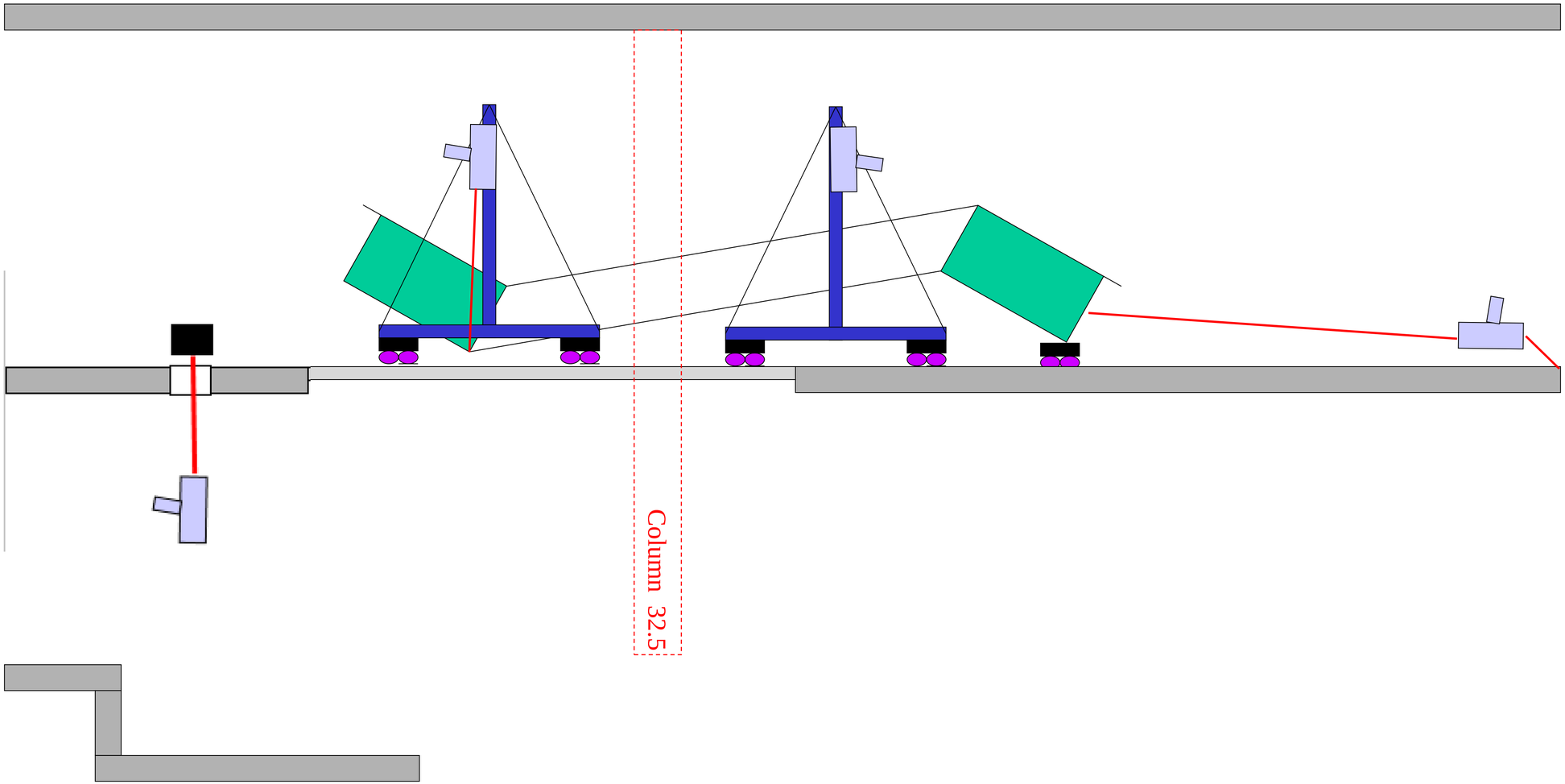

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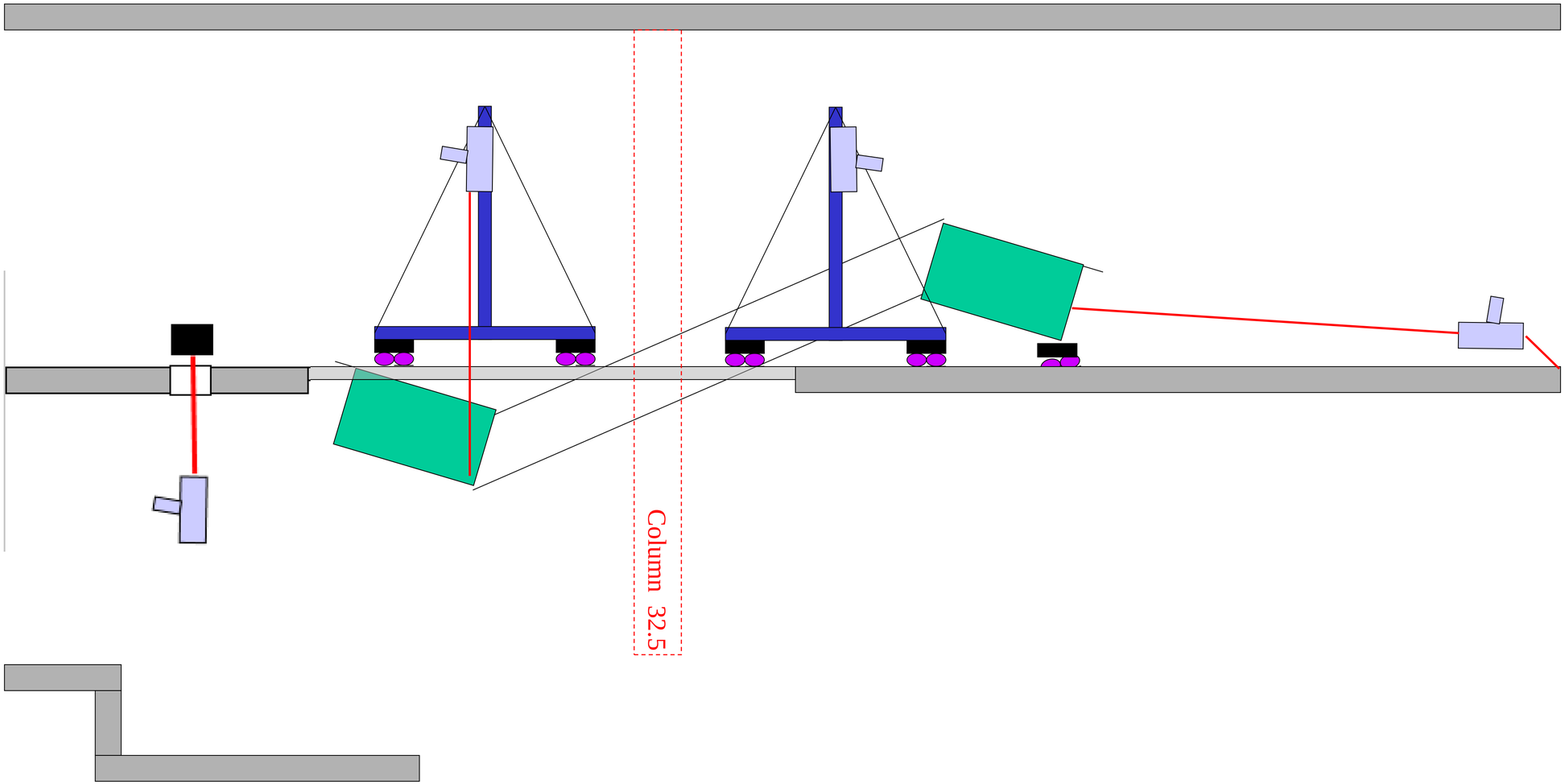

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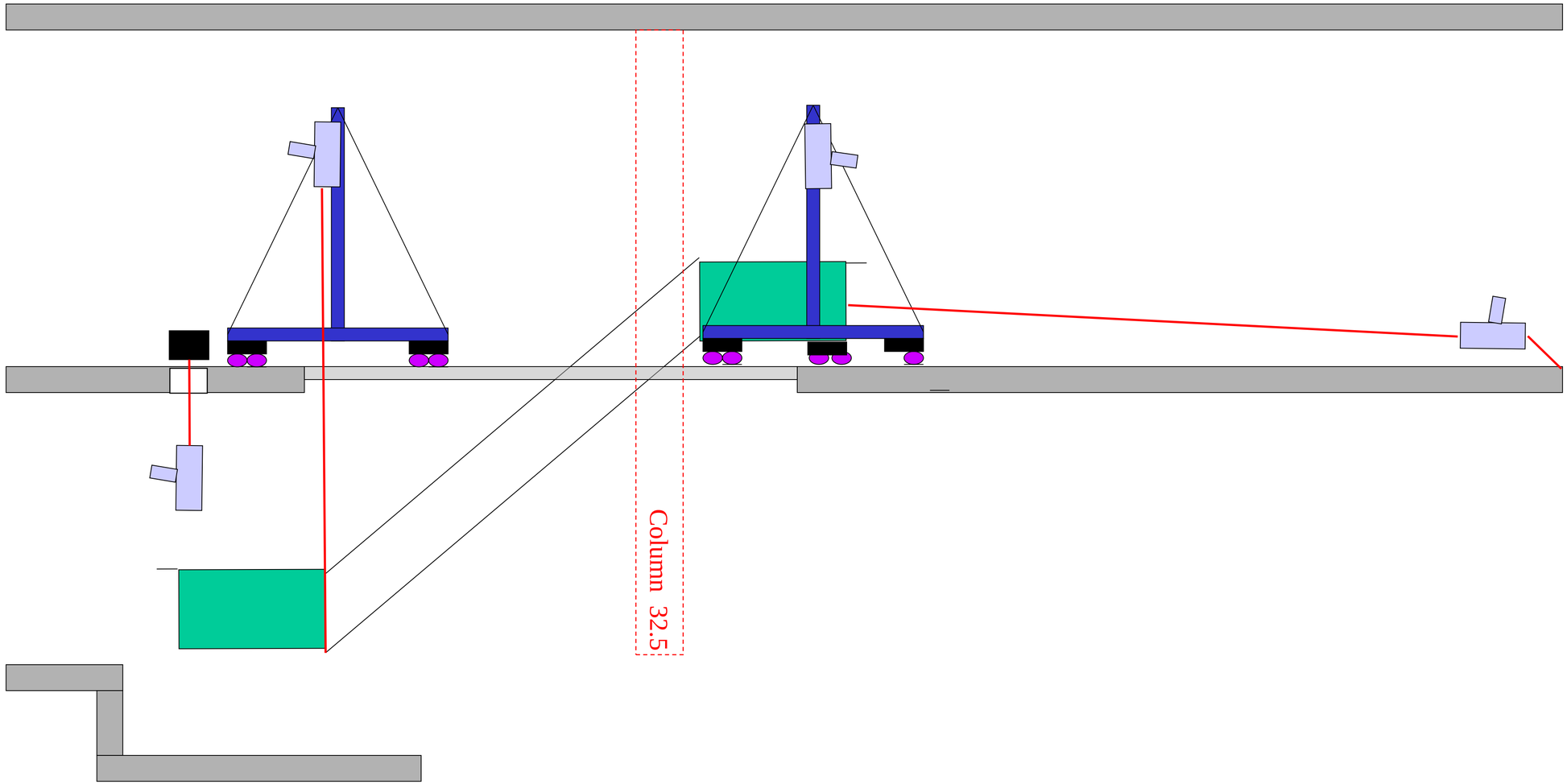

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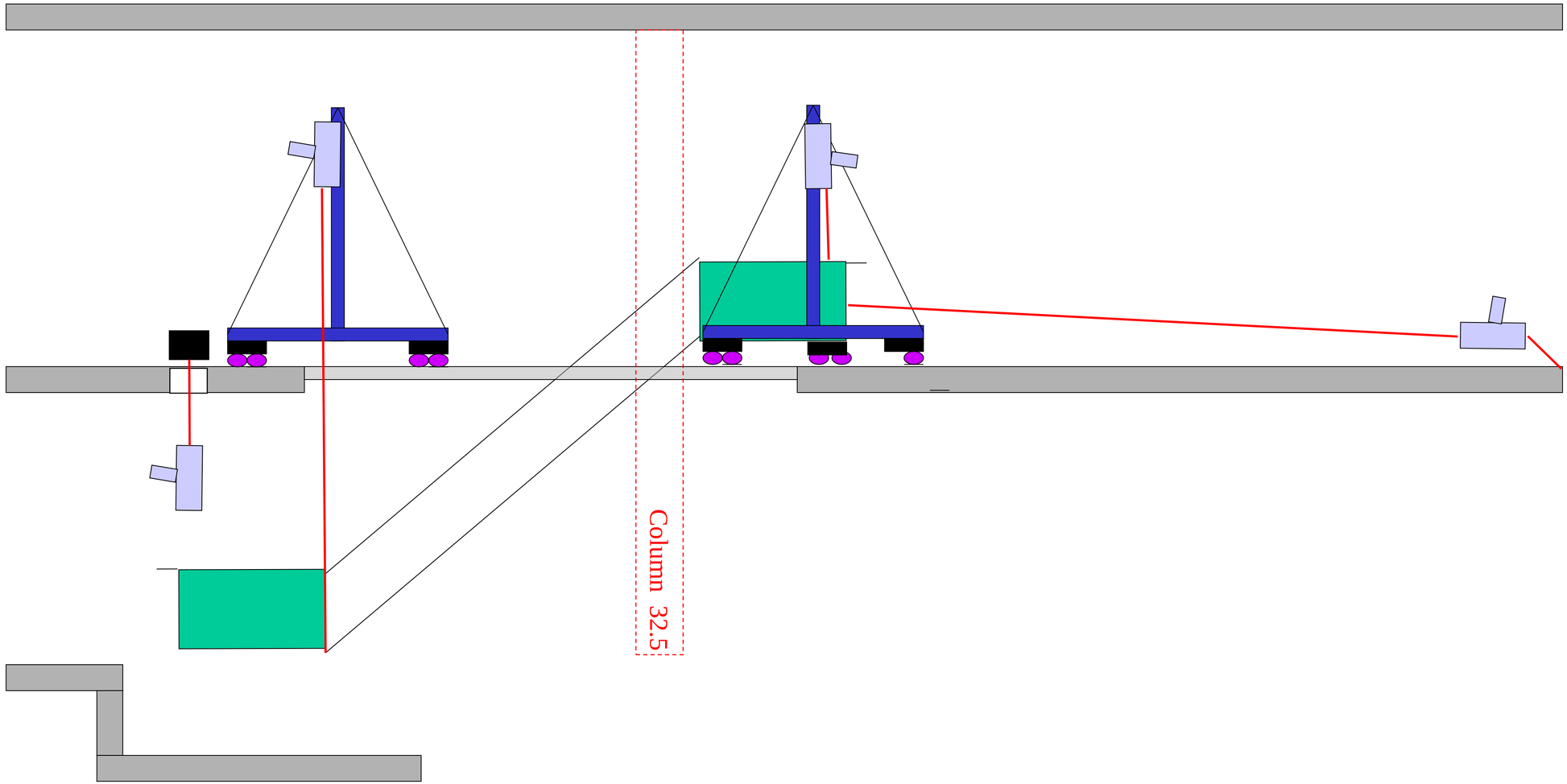

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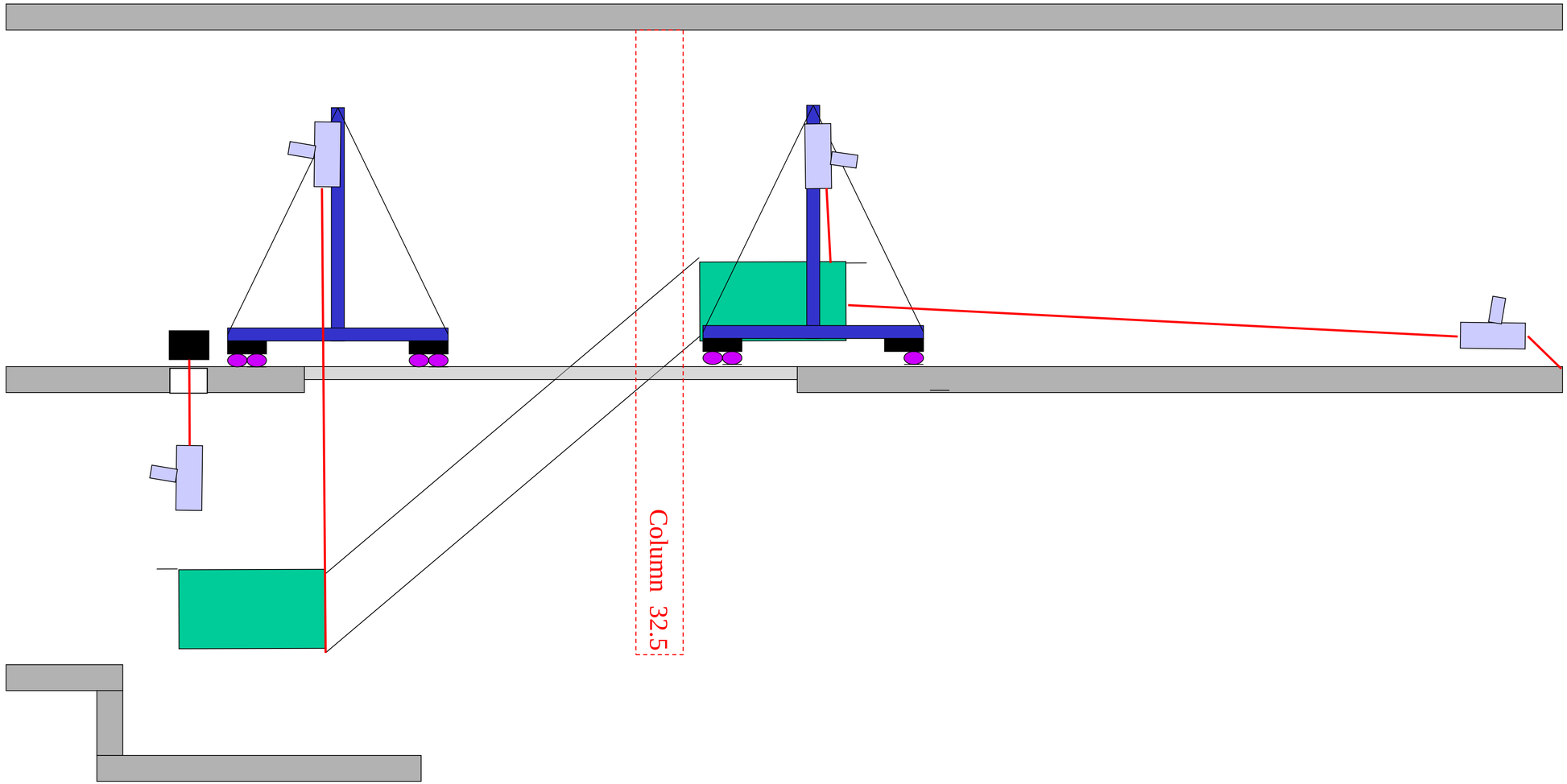

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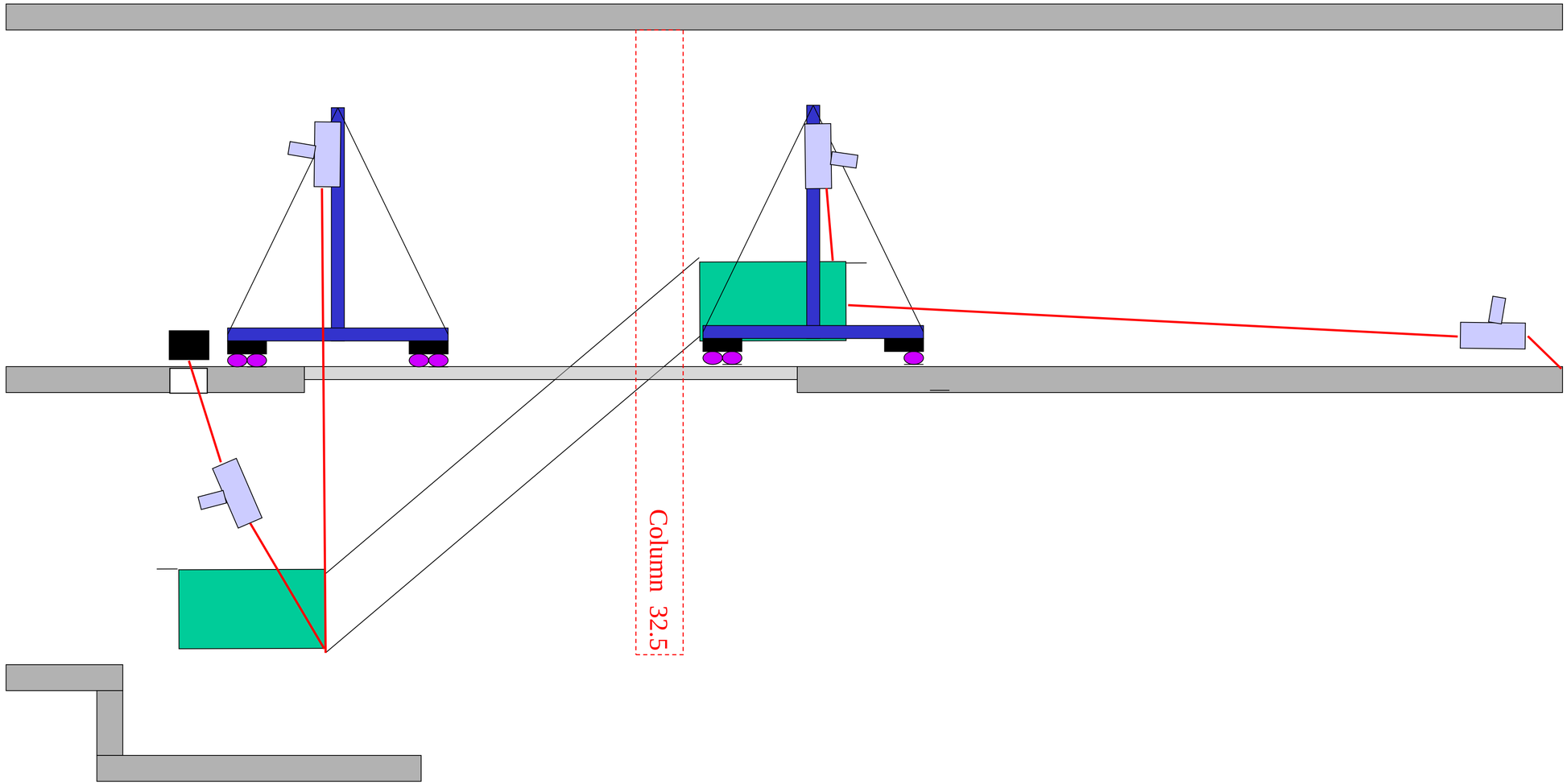

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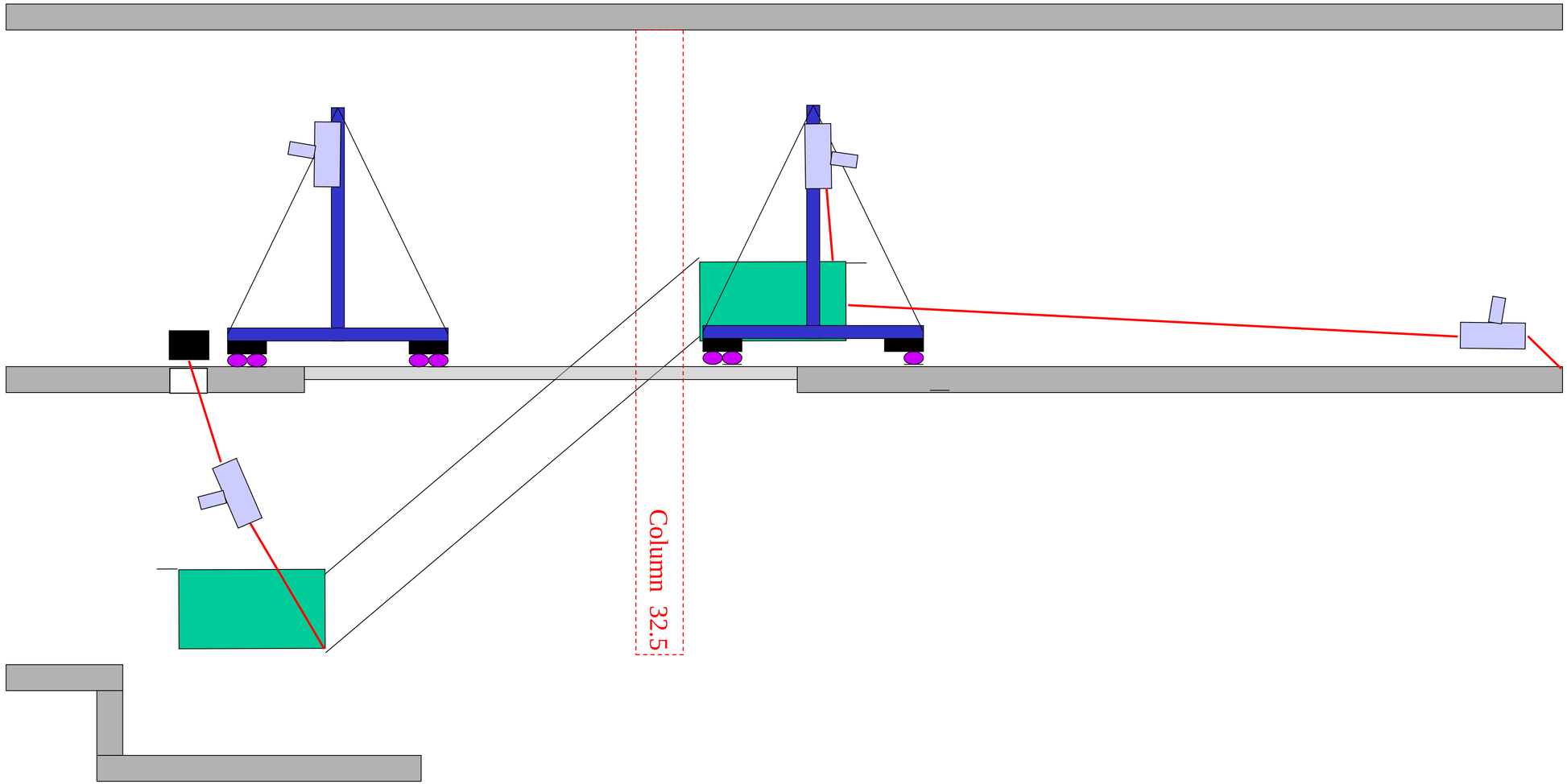

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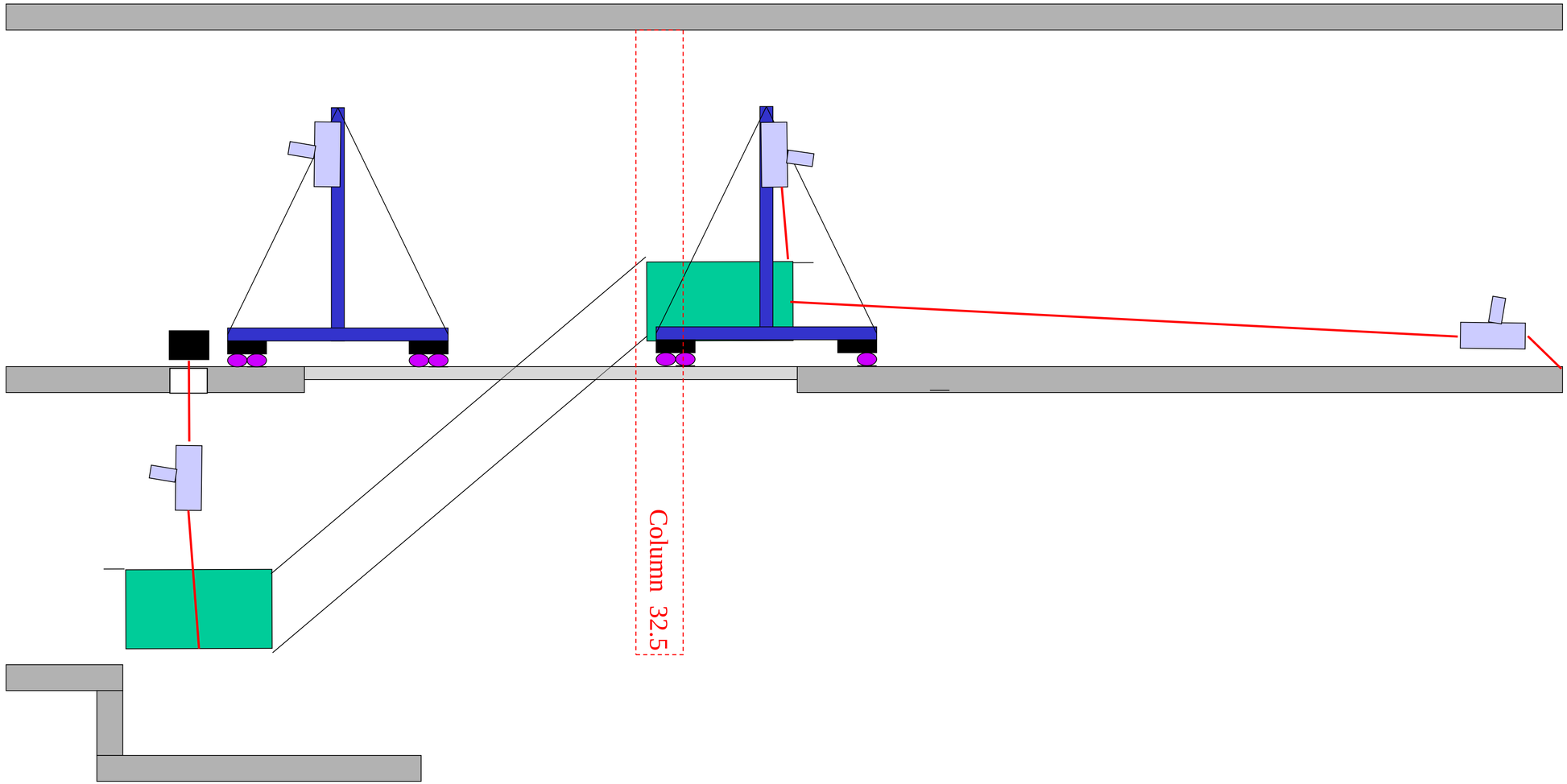

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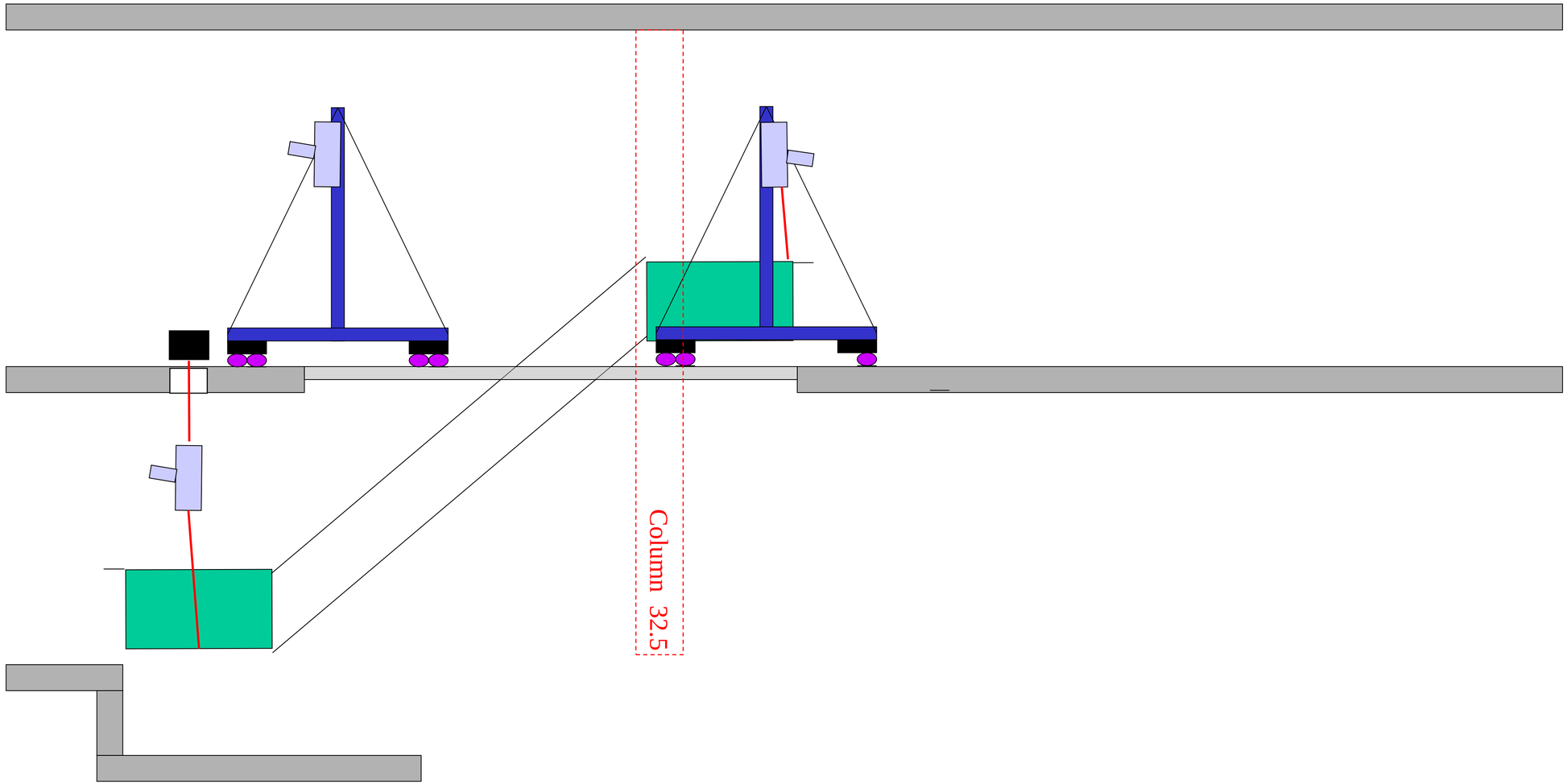

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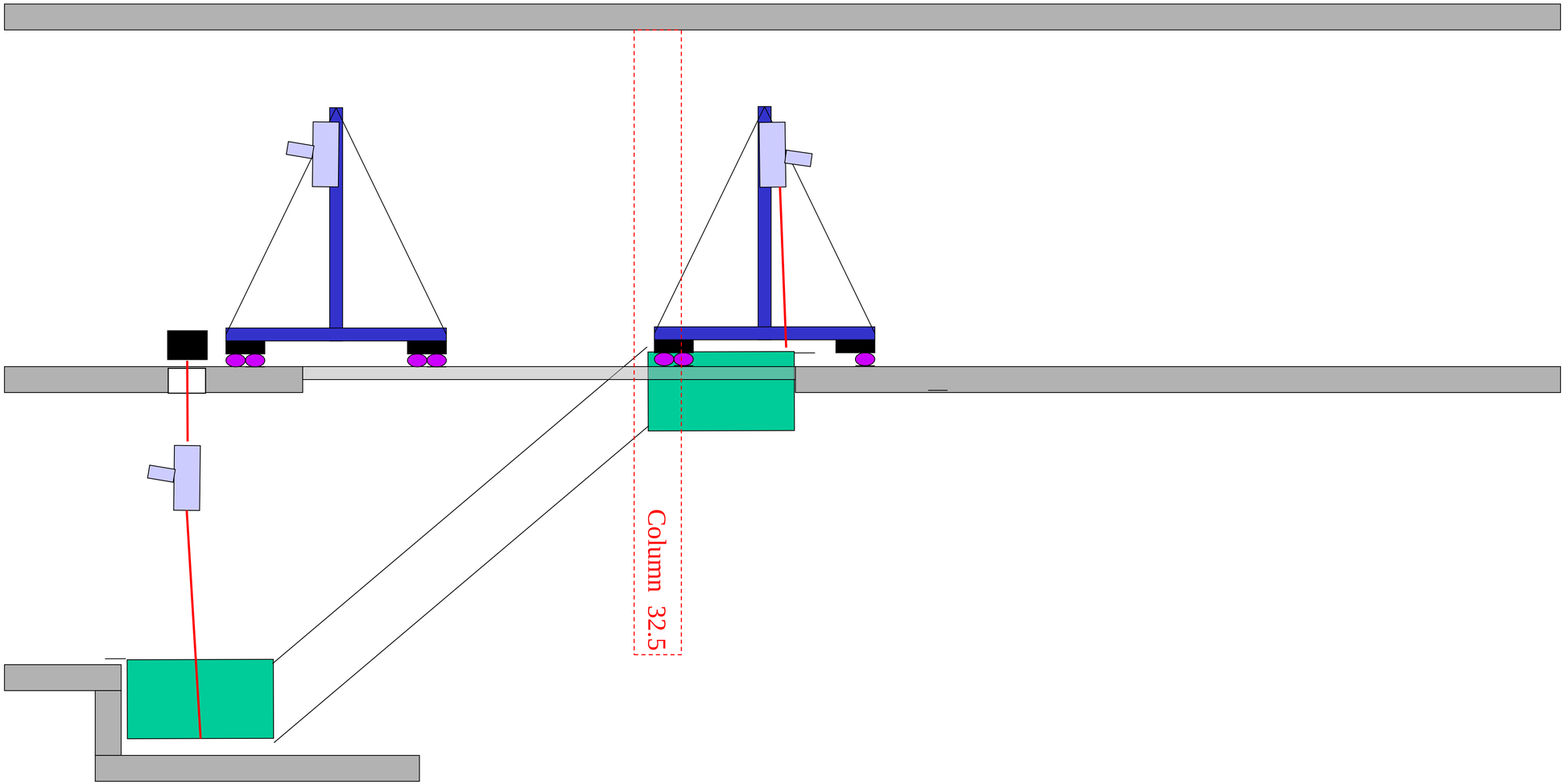

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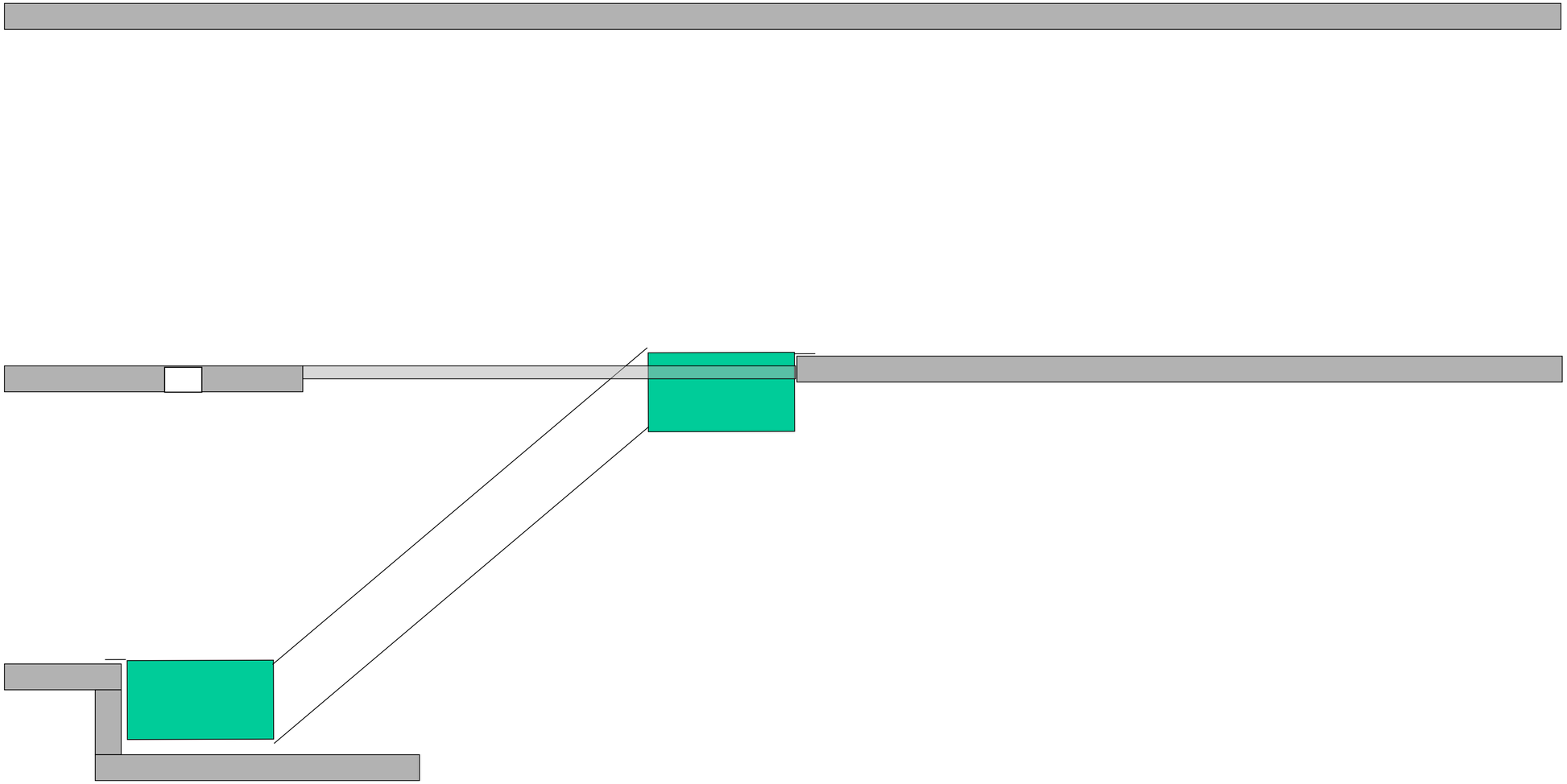

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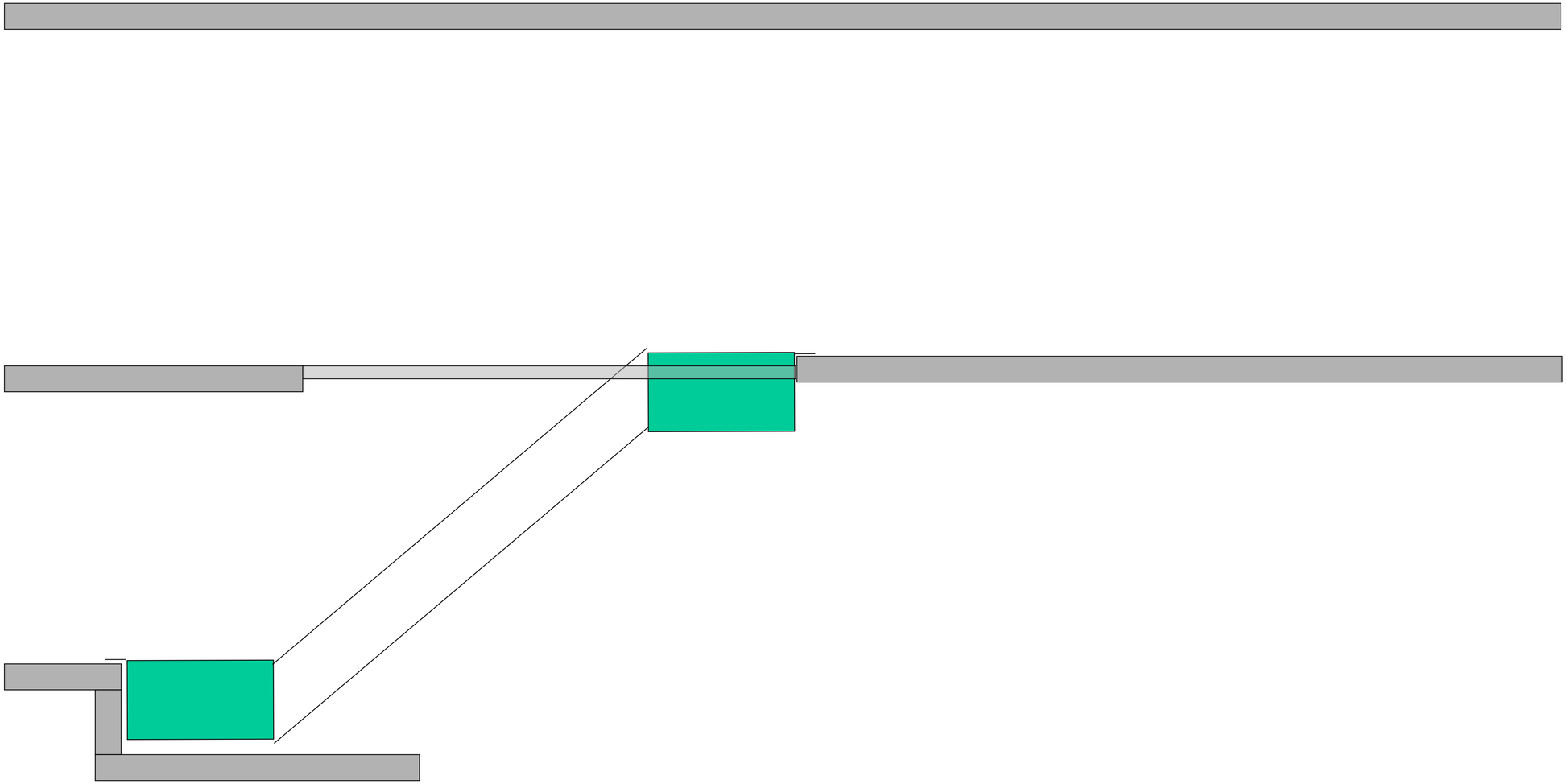

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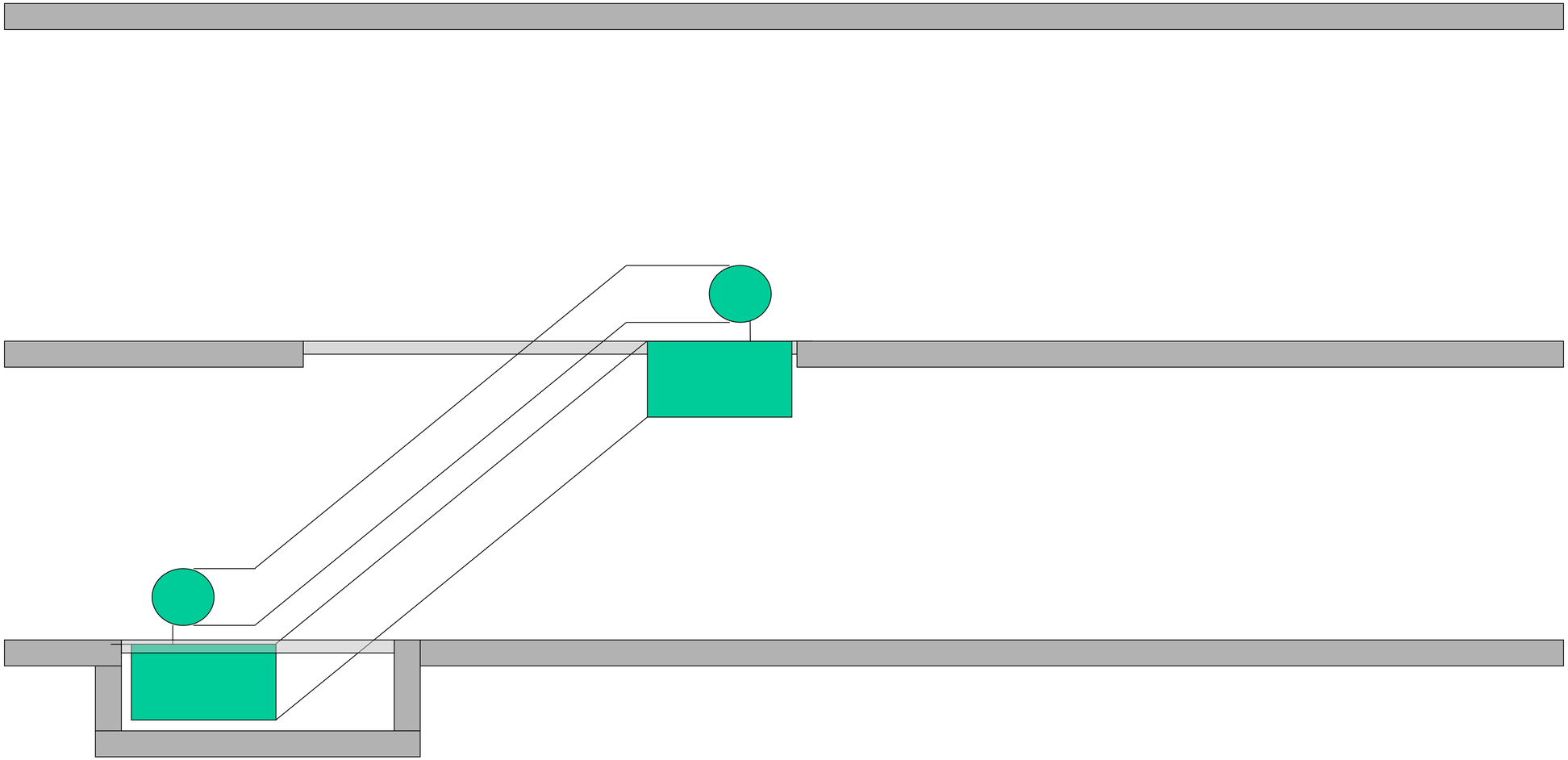
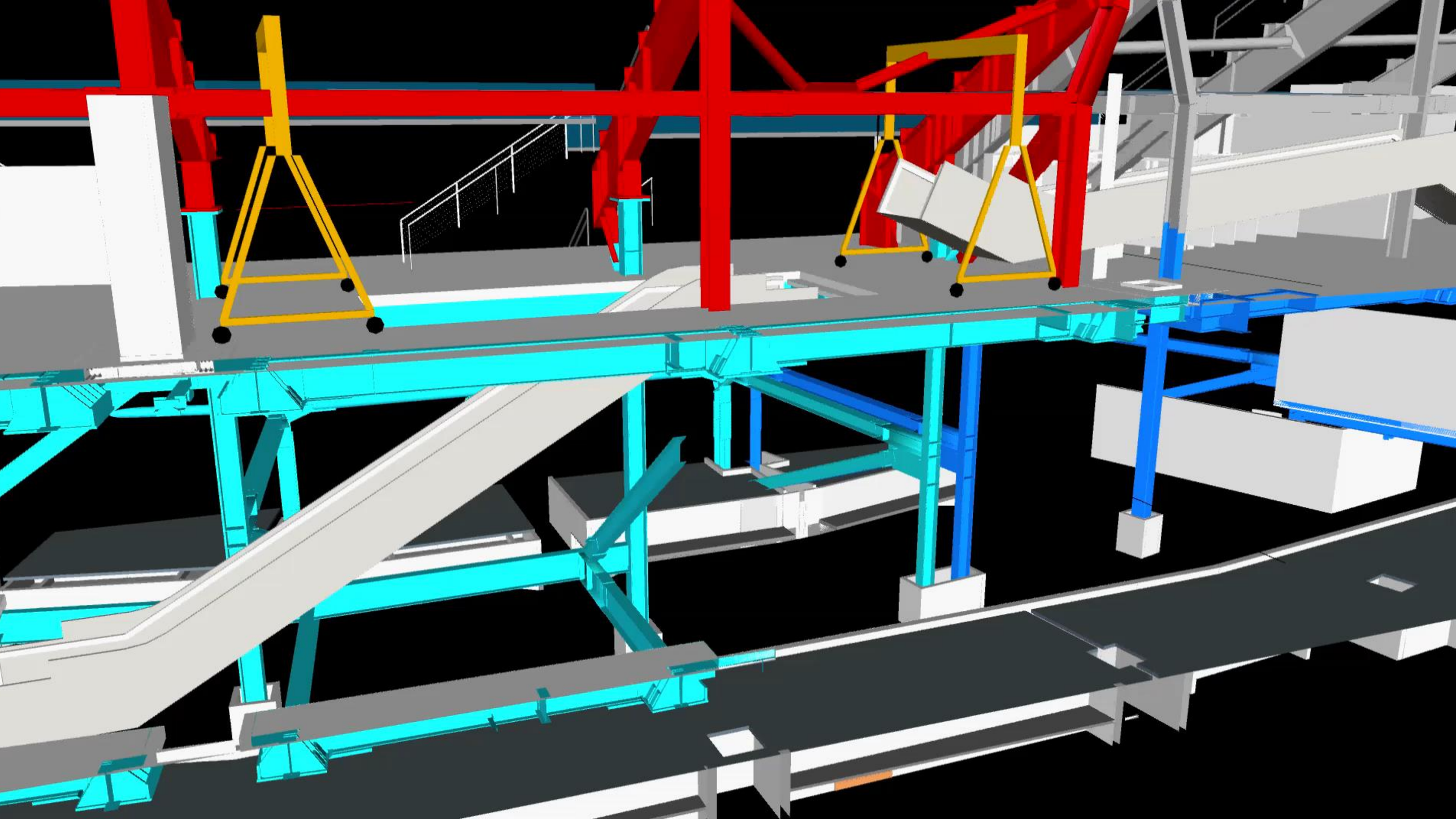


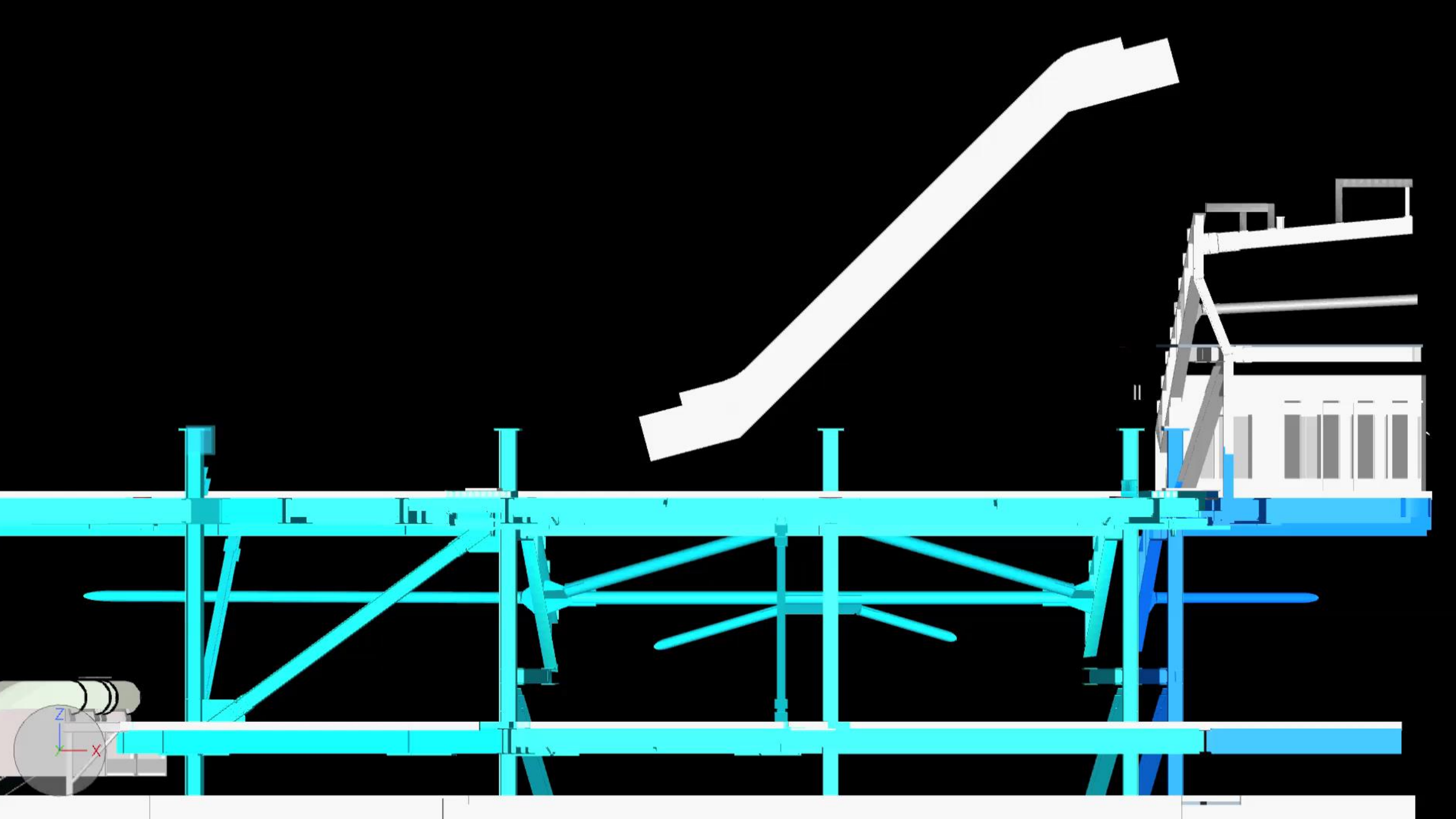
Good Luck

When You Use 3D To Simulate That Solution:



Let’s Simulate A Better Plan…

Option1: Single truss installation if sequenced before upper steel is erected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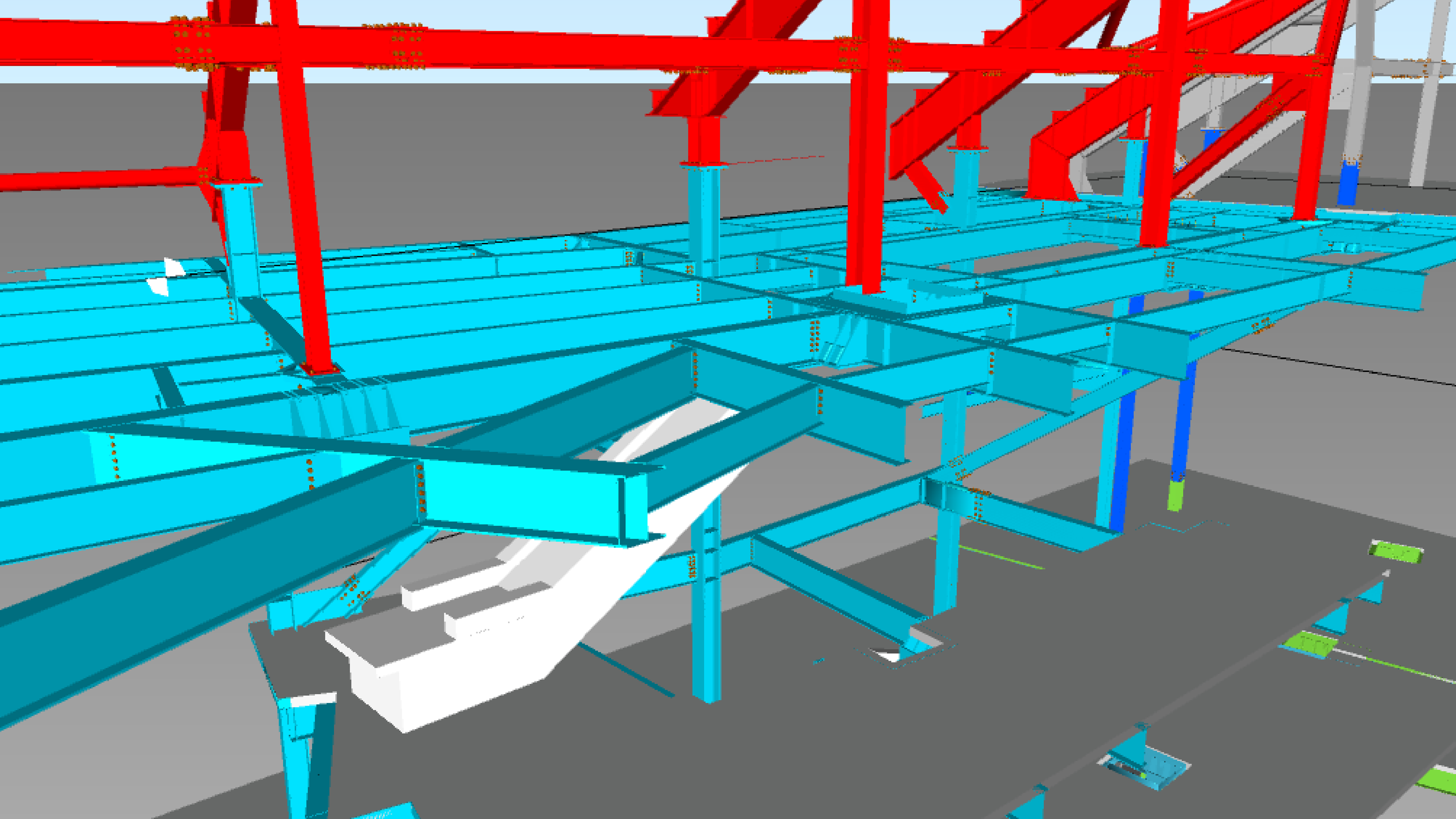
OR…

Option 2: Split truss installation if sequenced after upper steel (red) is erected



Equipment Routing in Revit and Navisworks

REVIT

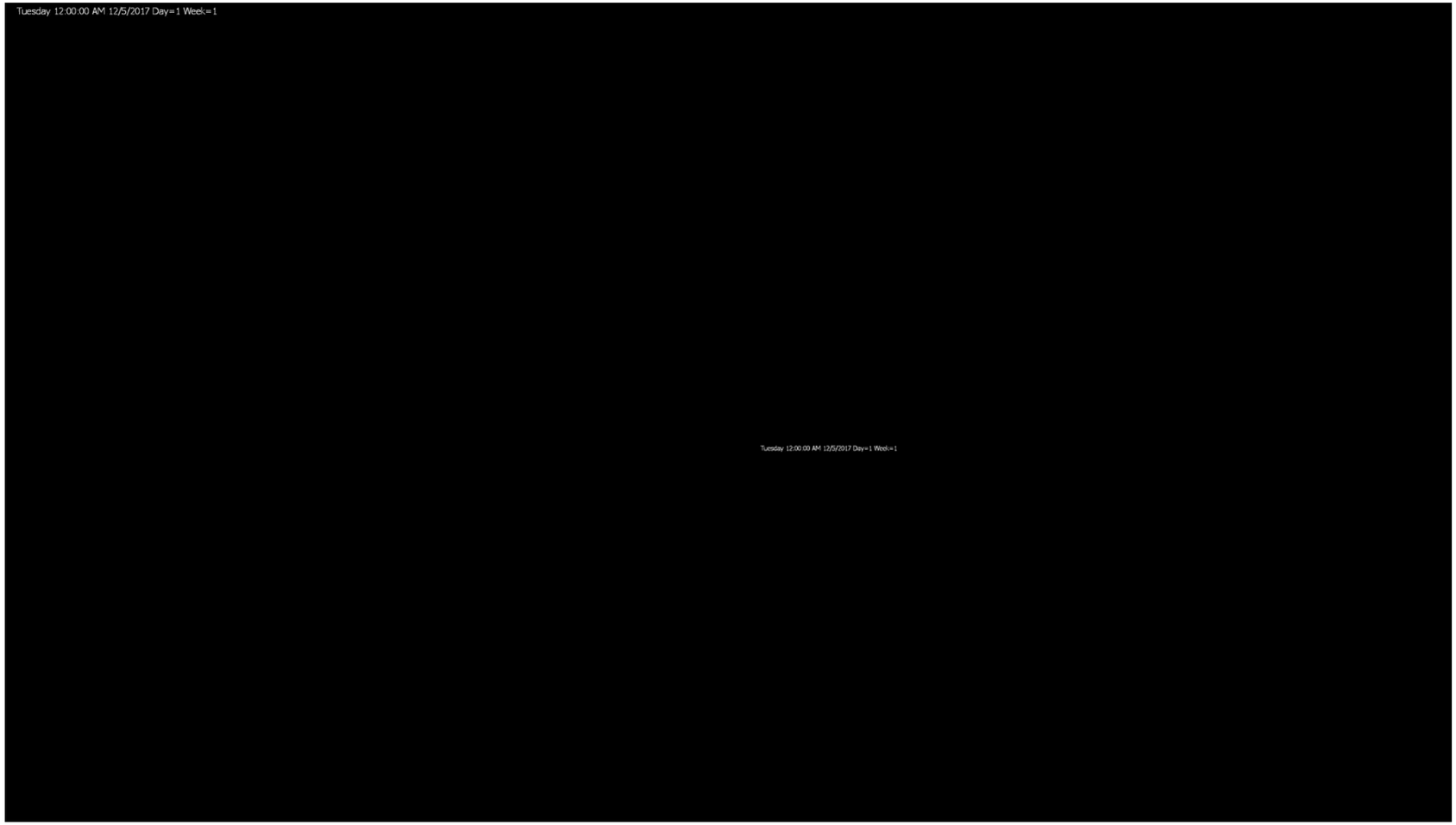
1. Use the Site logistics model as a starting point, if available.
2. Insert onsite construction equipment to be used in routing
3. If adding rigging elements to an item, use an In-Place model to generate a simplified version of the crane rigging, as necessary to more completely represent the size of the routed equipment.

NAVISWORKS

1. Move the time bar to the starting keyframe (~40 seconds in)
2. Capture a key frame – this represents the end of the animation
3. Move the time bar earlier (2-5 seconds) so now we are at the time 35 – 38 seconds
4. Choose one or more transform and move the equipment animation set to the condition representing the culmination of movement and/or visibility changes from the previous key frame.
5. Capture a key frame.
6. Repeat steps 3-5 until the position and/or visibility of the equipment animation set is in its starting position.
7. Play the animation and re-positon each keyframe to achieve a pleasant speed.

Timeline Simulation

- Animation of the overall construction process and can/should include site logistics geometry and equipment routing animations.



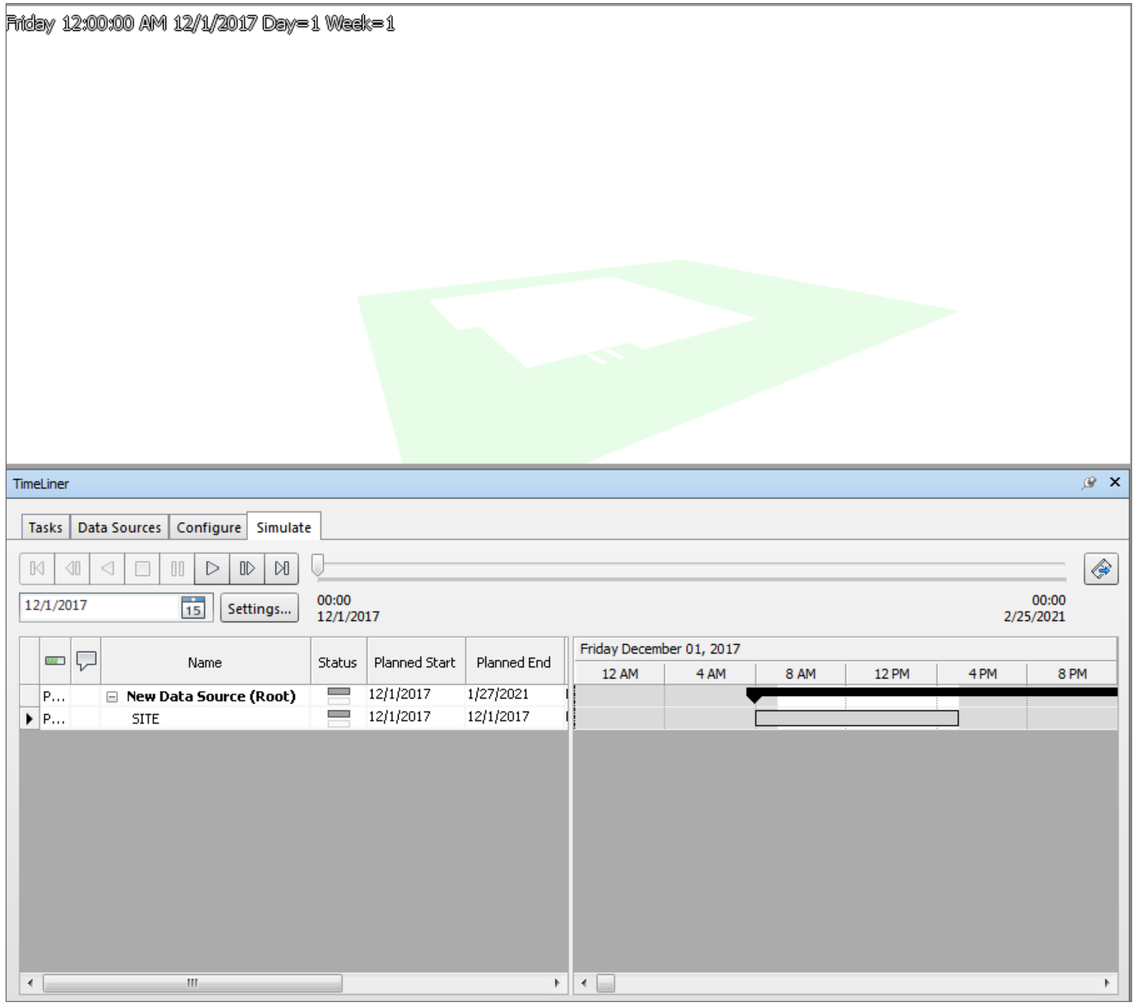
Practical Timeline Simulation

WHAT IT IS

- High level tasks representing major milestones
- Site logistics components appear as temporary tasks
- Model Text geometry representing milestones not easily communicated through equipment model geometry

WHAT IT IS NOT

- Minute-by-minute work plan that we may use internally to measure performance of an installation team
- Photorealistic animations of all elements on a construction site.



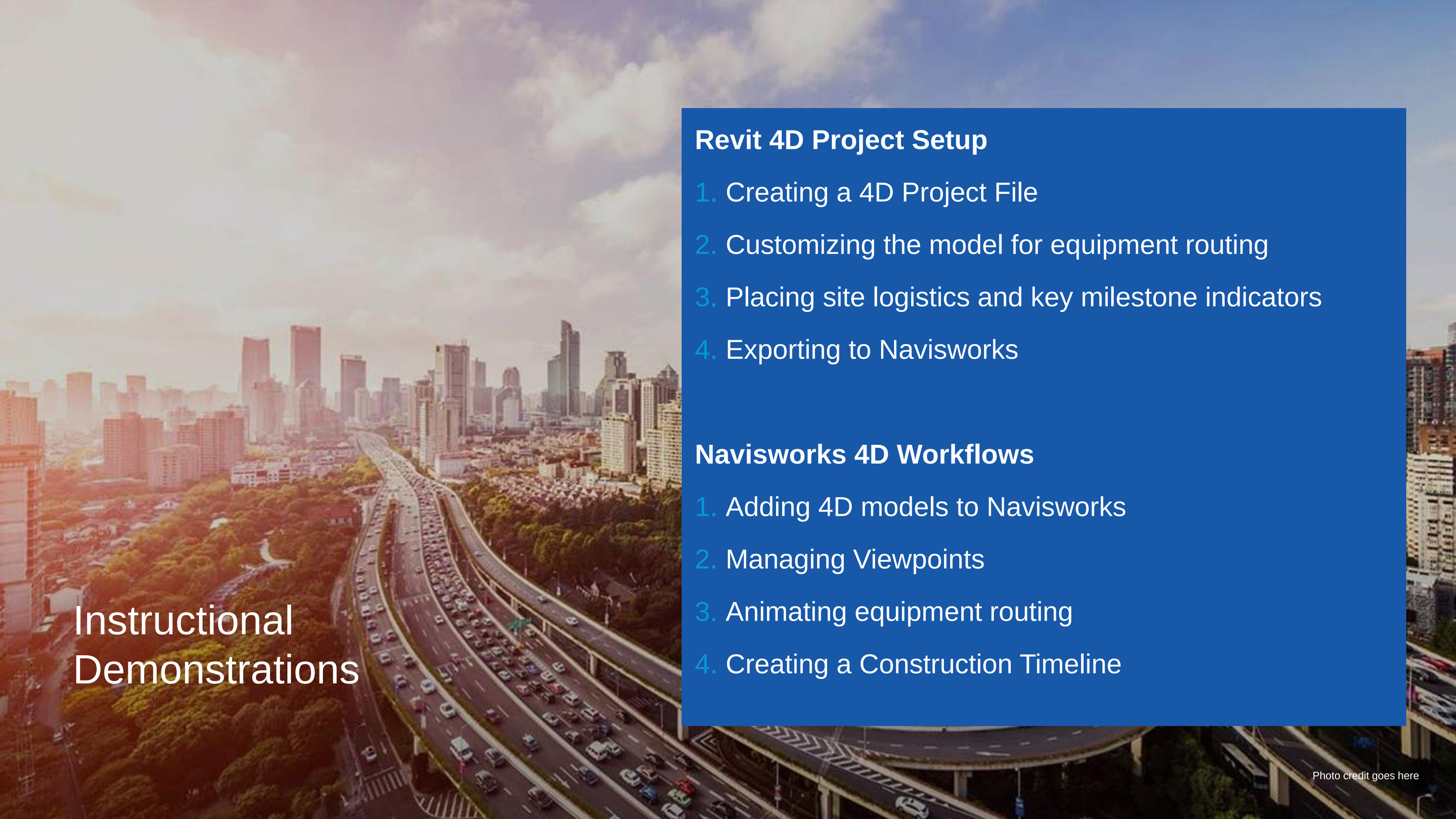
Timeline Simulation in Revit and Navisworks

REVIT

1. Working in a 4D template, use model text based component to add notes to the 4D model
2. Position the model text component outside of the building model in an easily viewed area from the standard isometric views.

NAVISWORKS

1. Create tasks
2. Add start /End dates
3. Set the Task type:
    a) Construct – For equipment elements to be installed
    b) Temporary – For site logistics geometry only used during construction
4. Attach selection and animation
5. Simulate to customize, preview and export the animation



Instructional Demonstrations

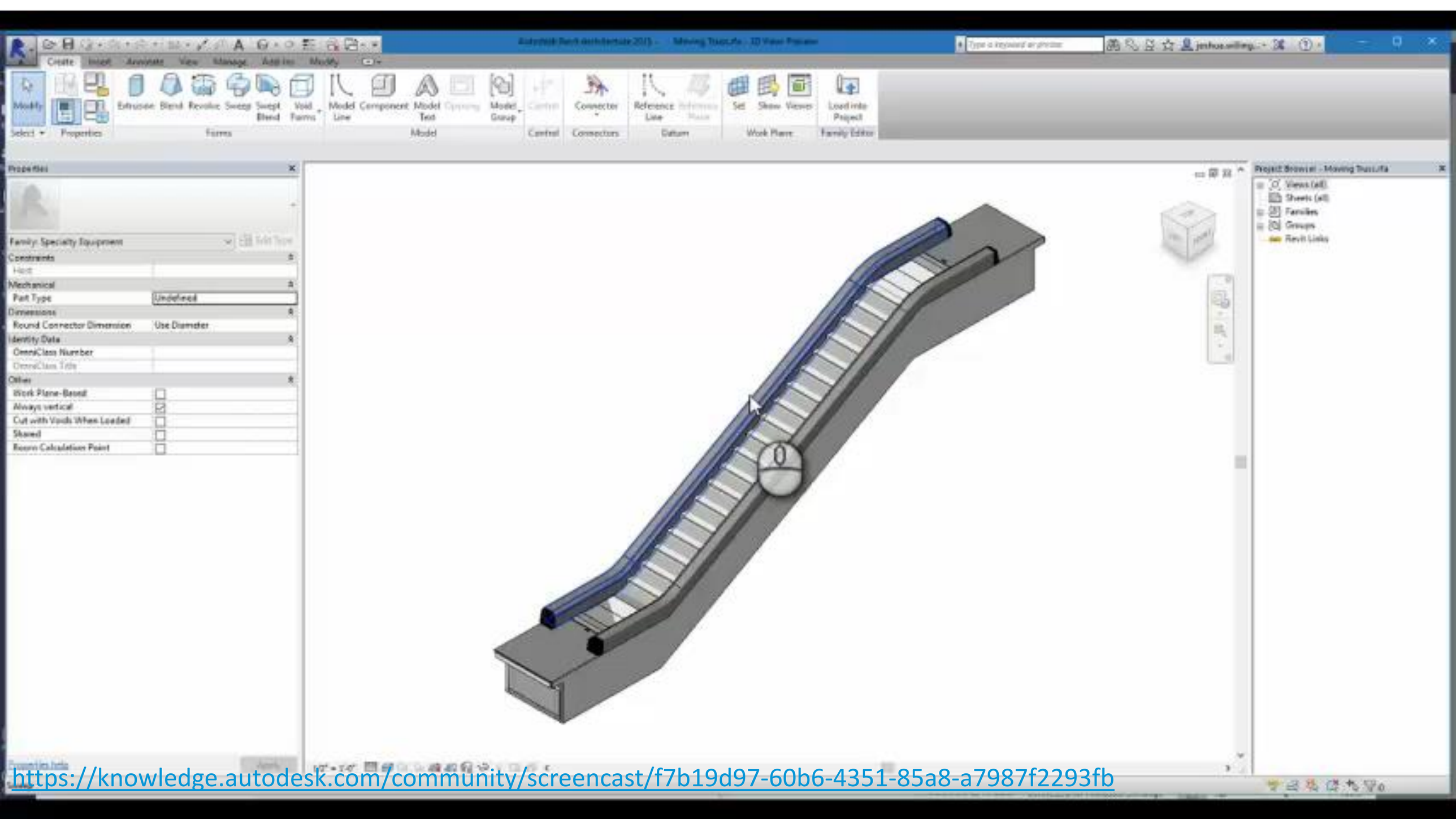
Revit 4D Project Setup

1. Creating a 4D Project File
2. Customizing the model for equipment routing
3. Placing site logistics and key milestone indicators
4. Exporting to Navisworks

Navisworks 4D Workflows

1. Adding 4D models to Navisworks
2. Managing Viewpoints
3. Animating equipment routing
4. Creating a Construction Timeline

Photo credit goes here



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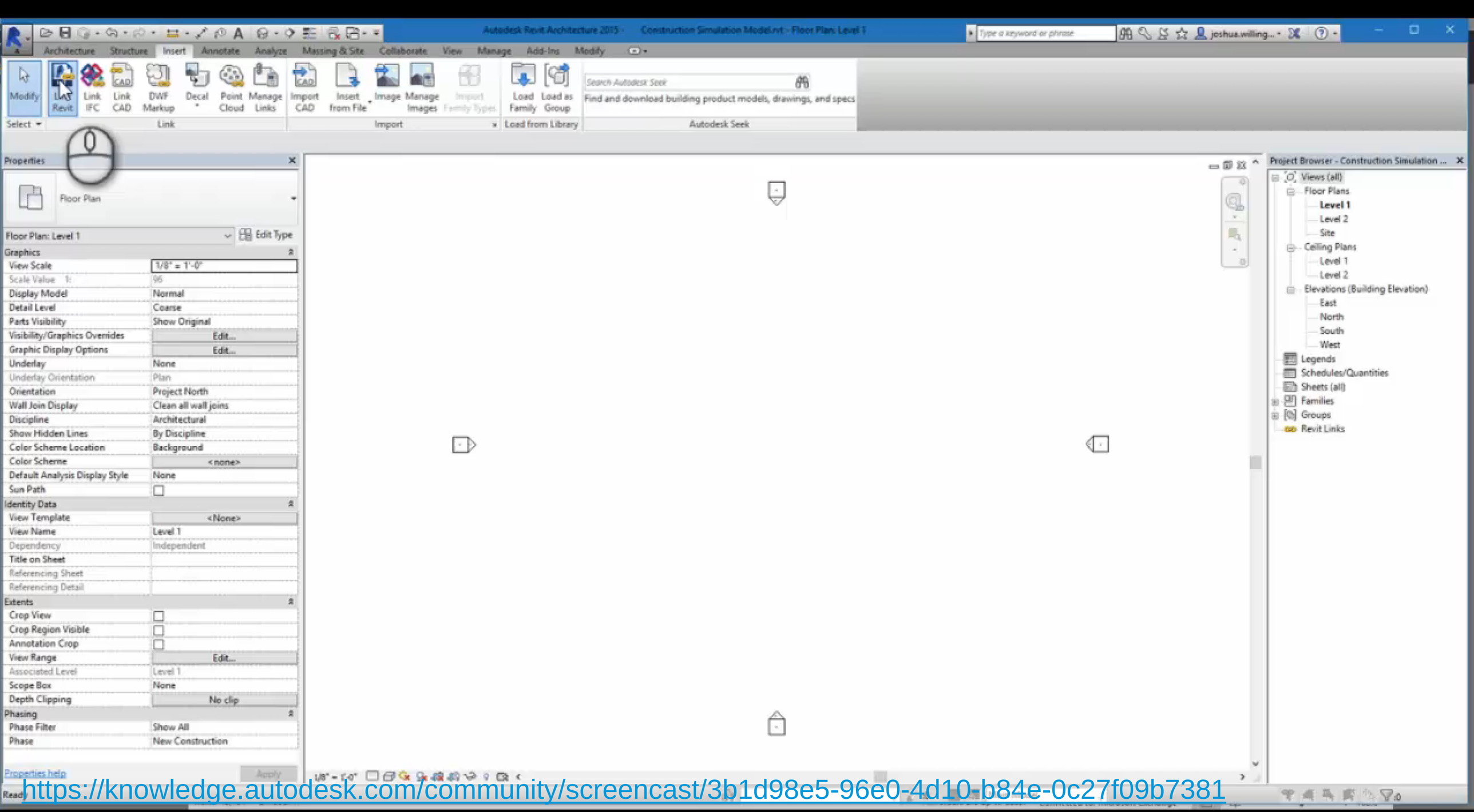

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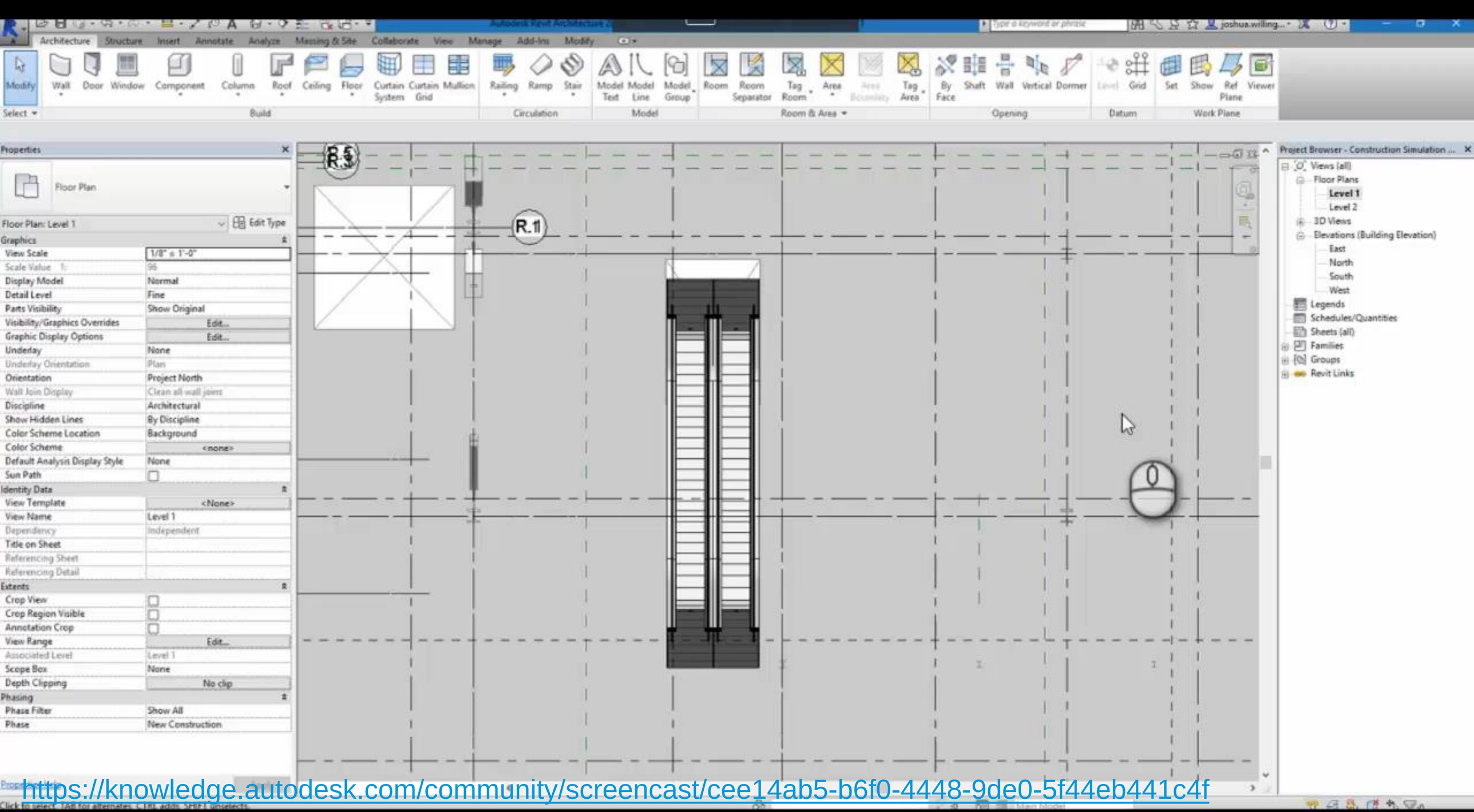

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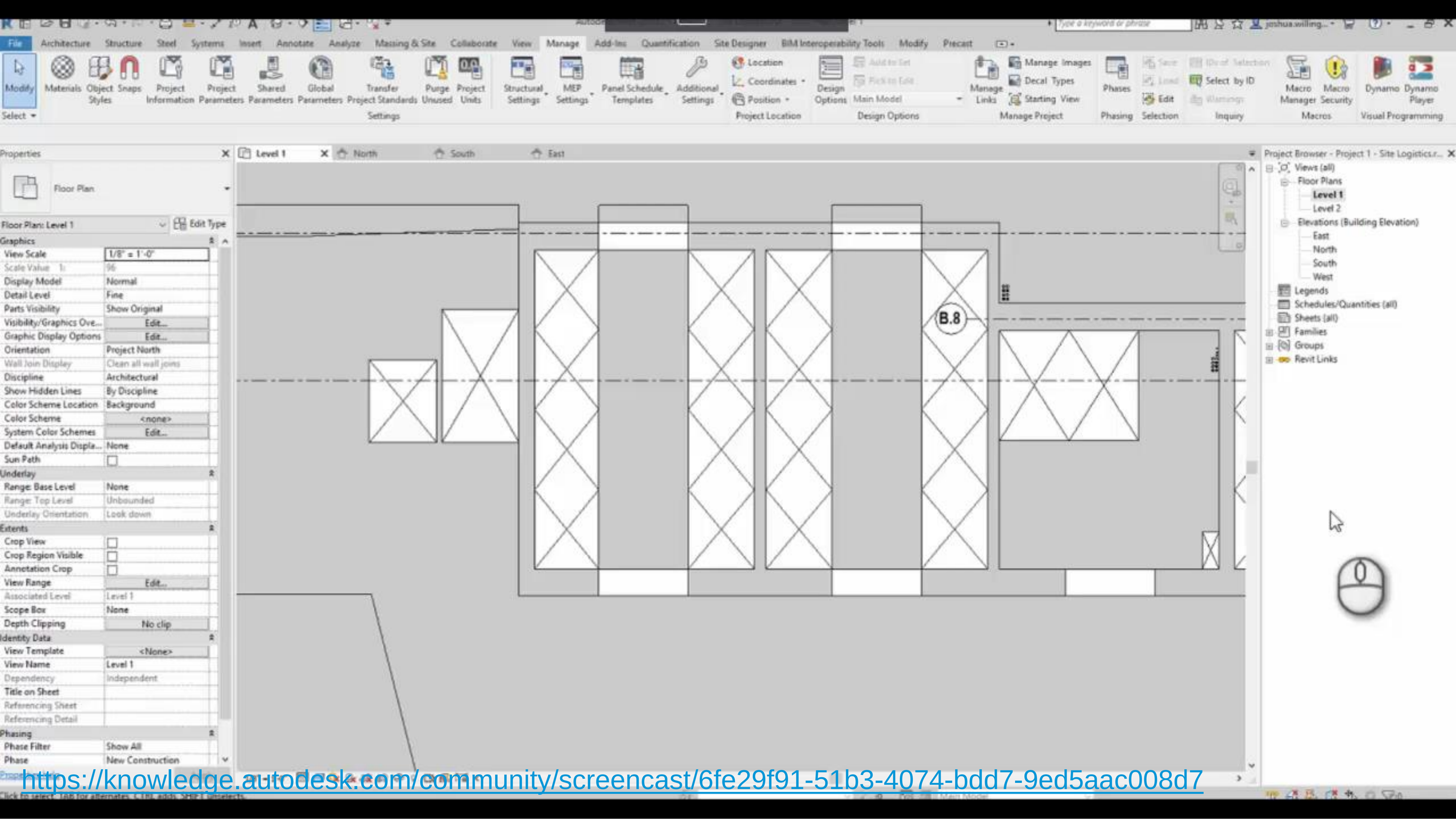

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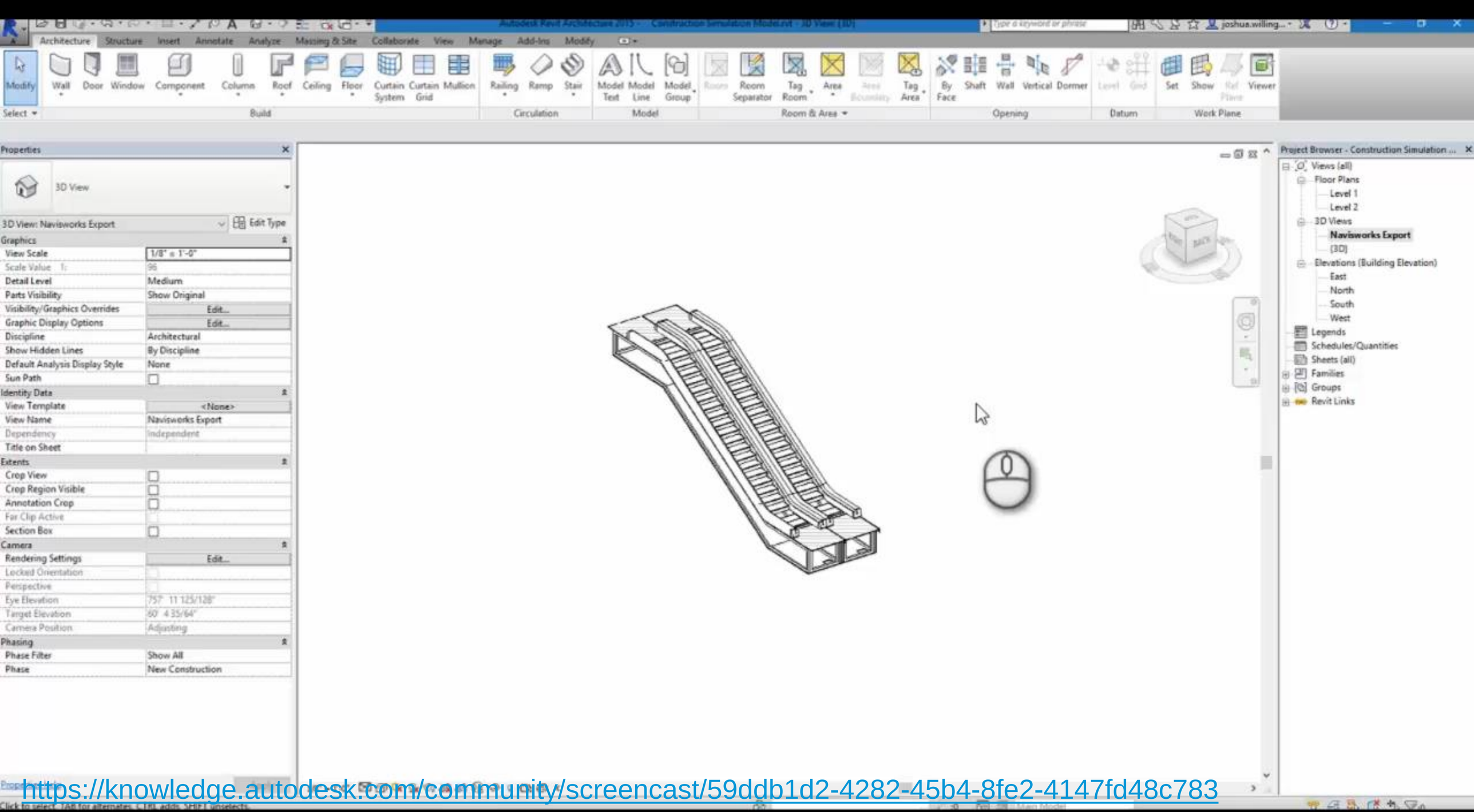

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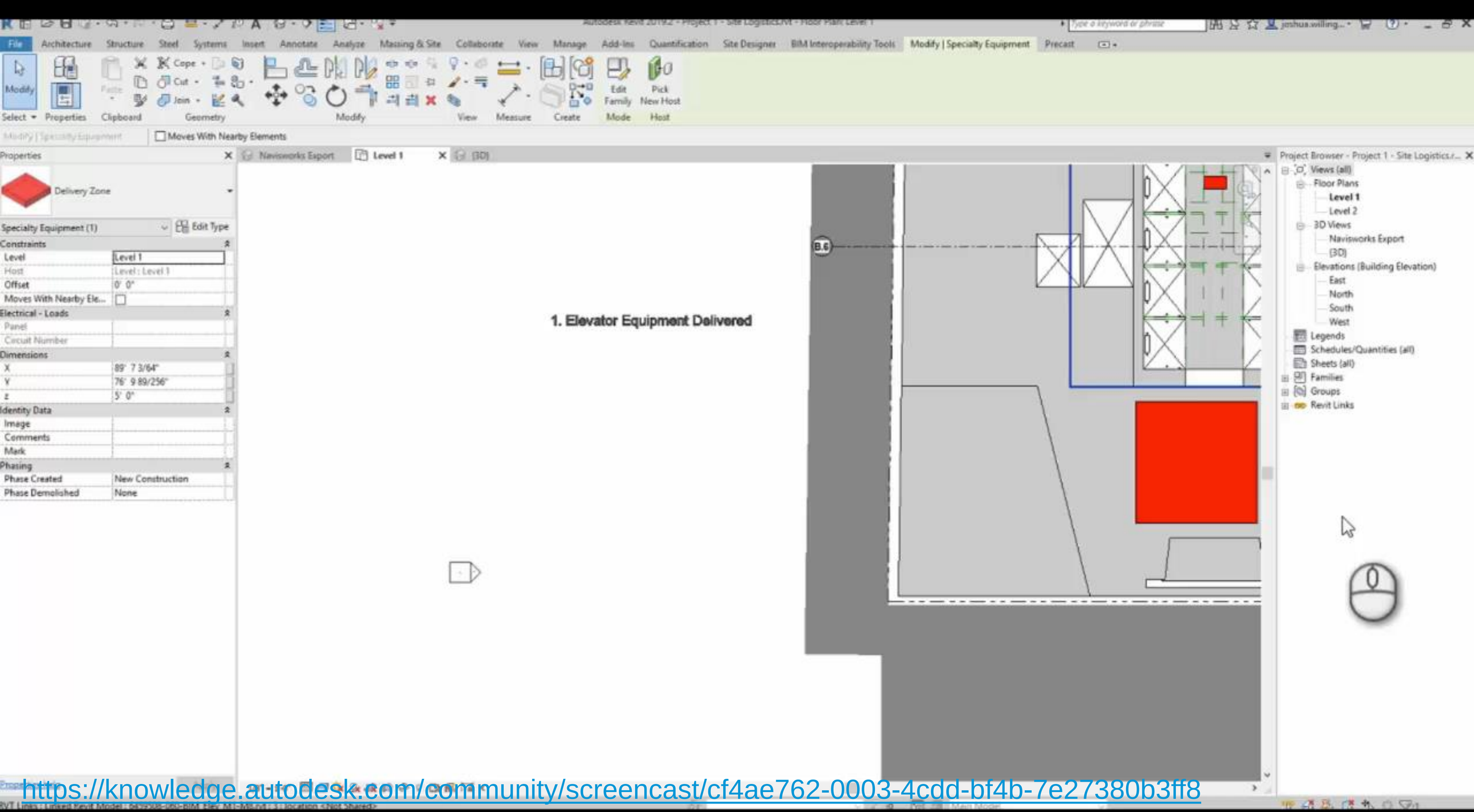

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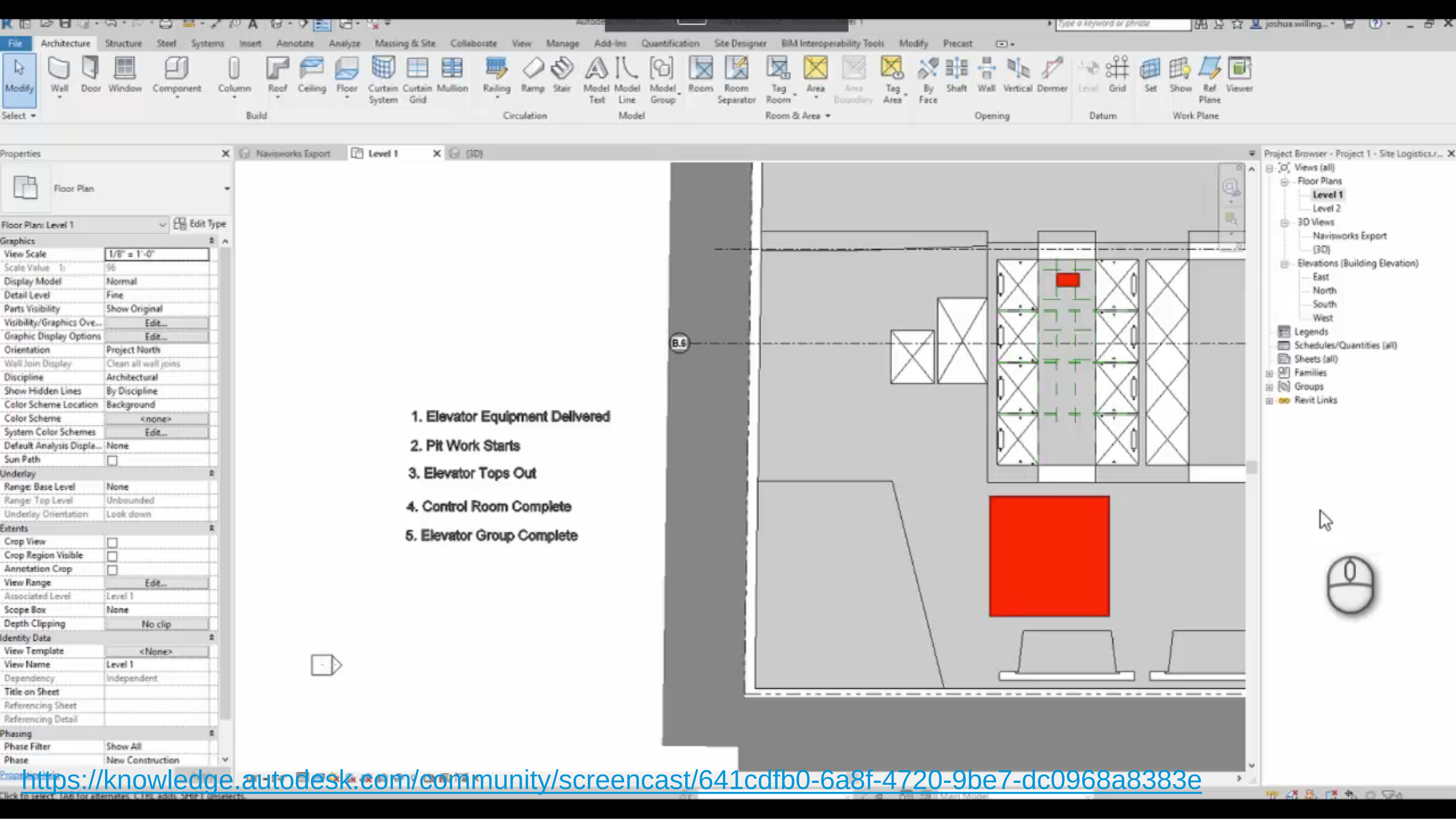

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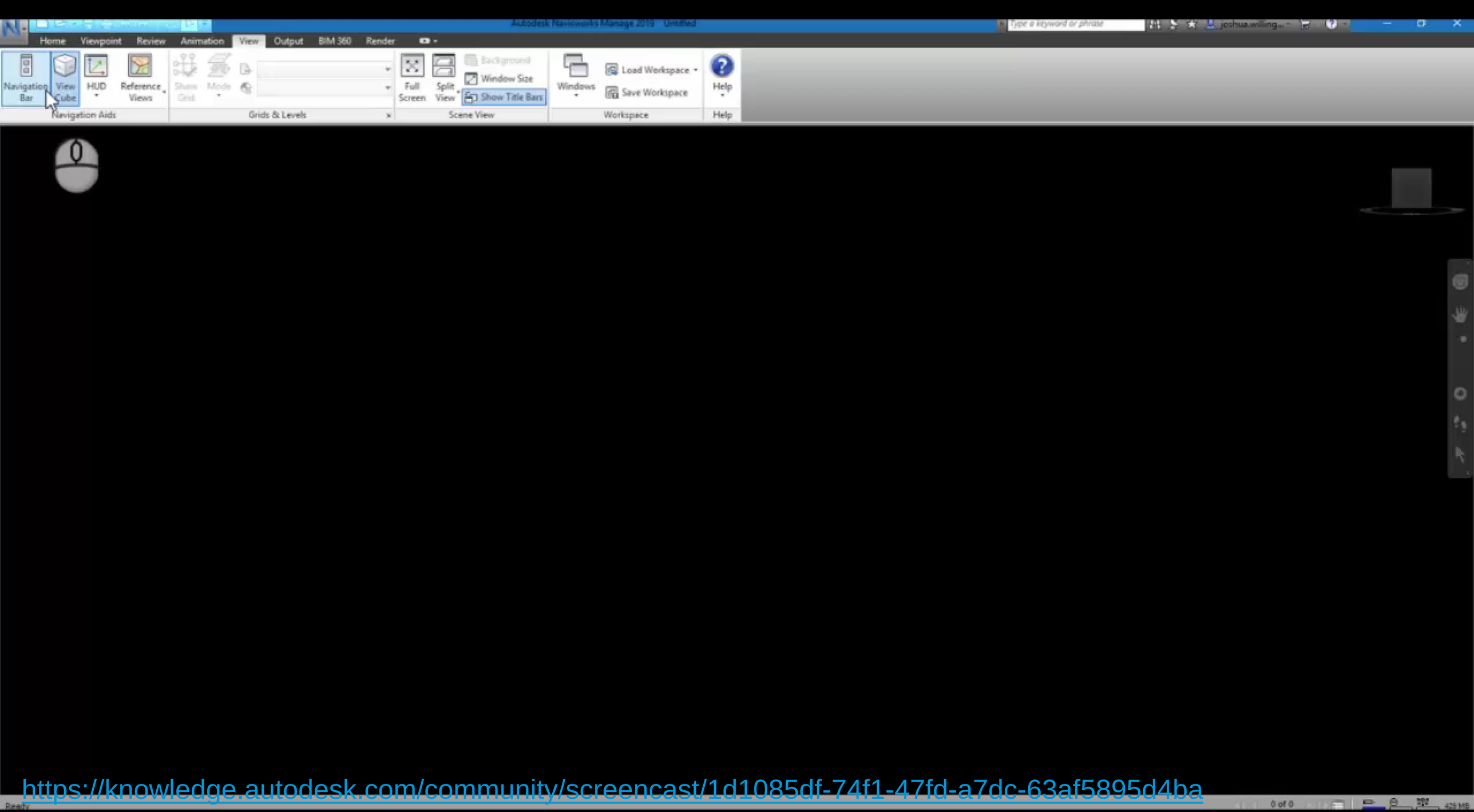

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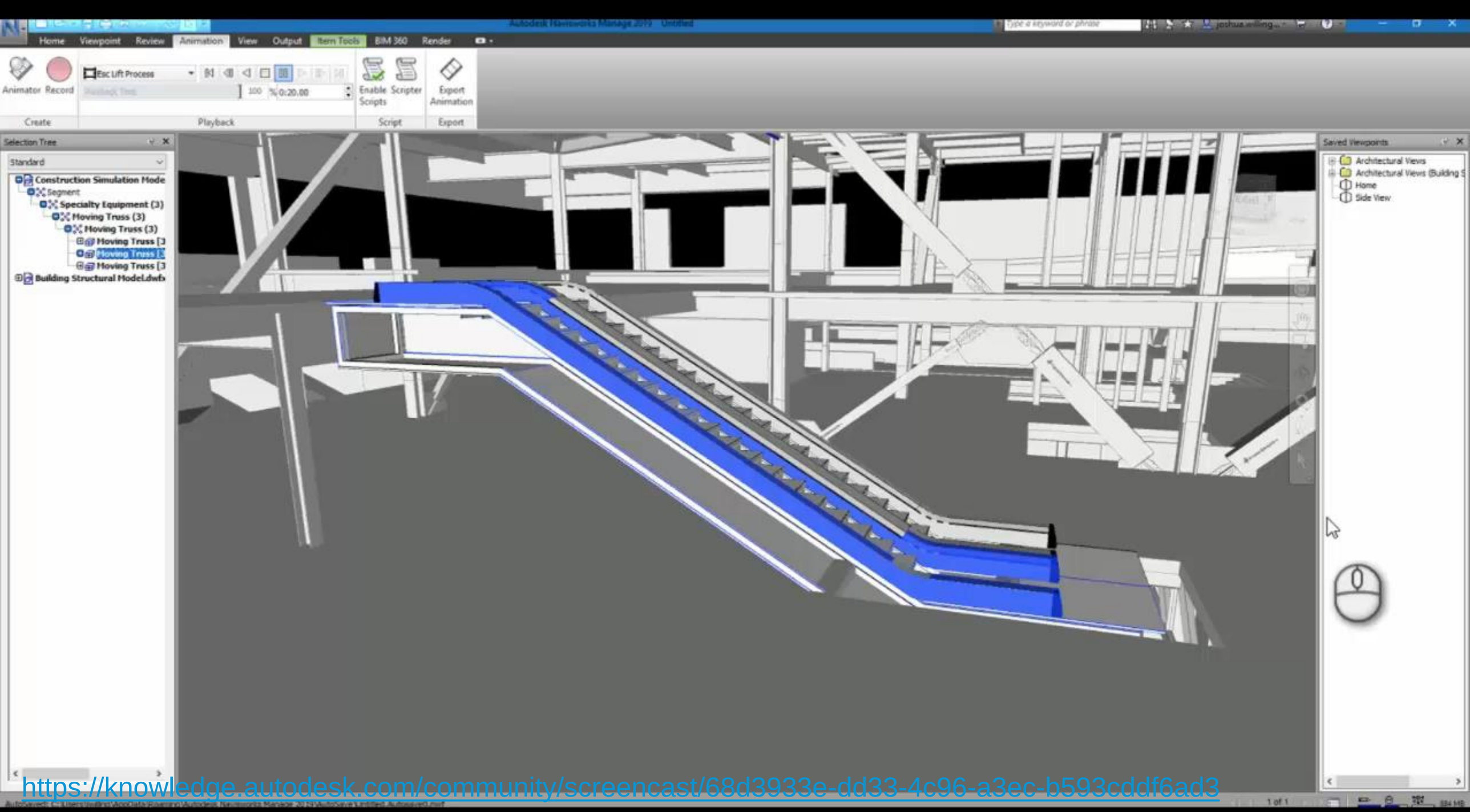

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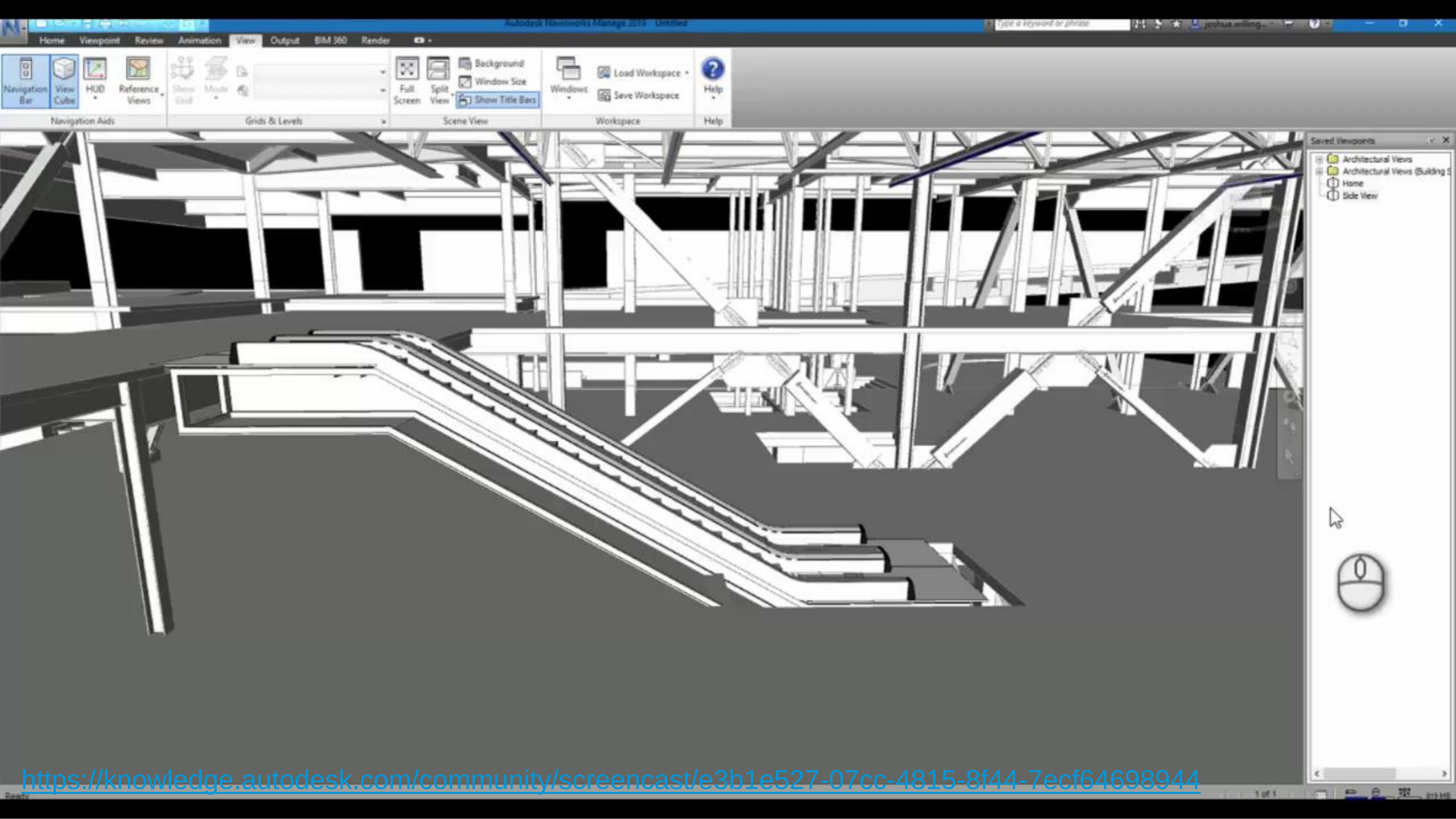

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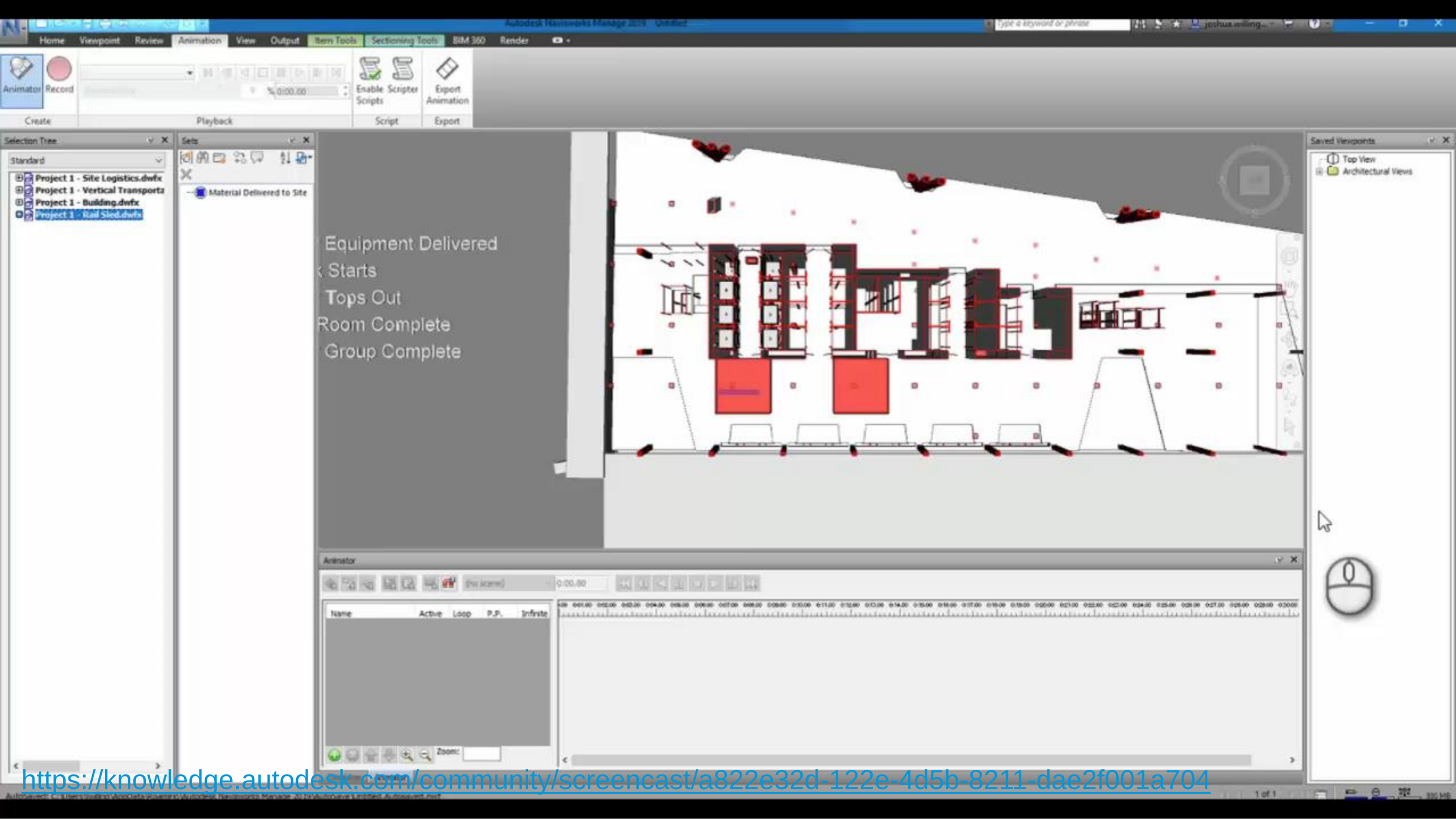

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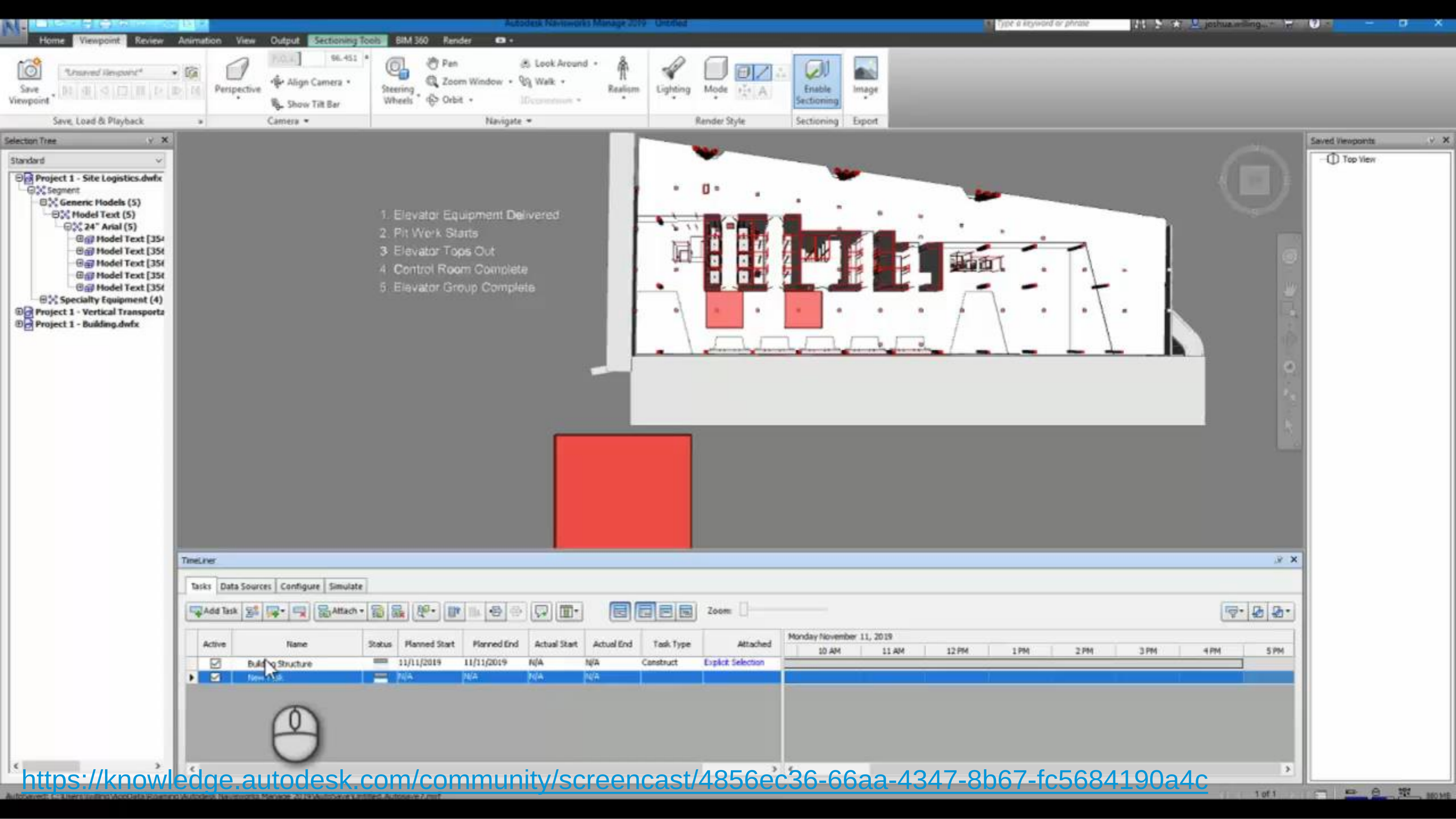

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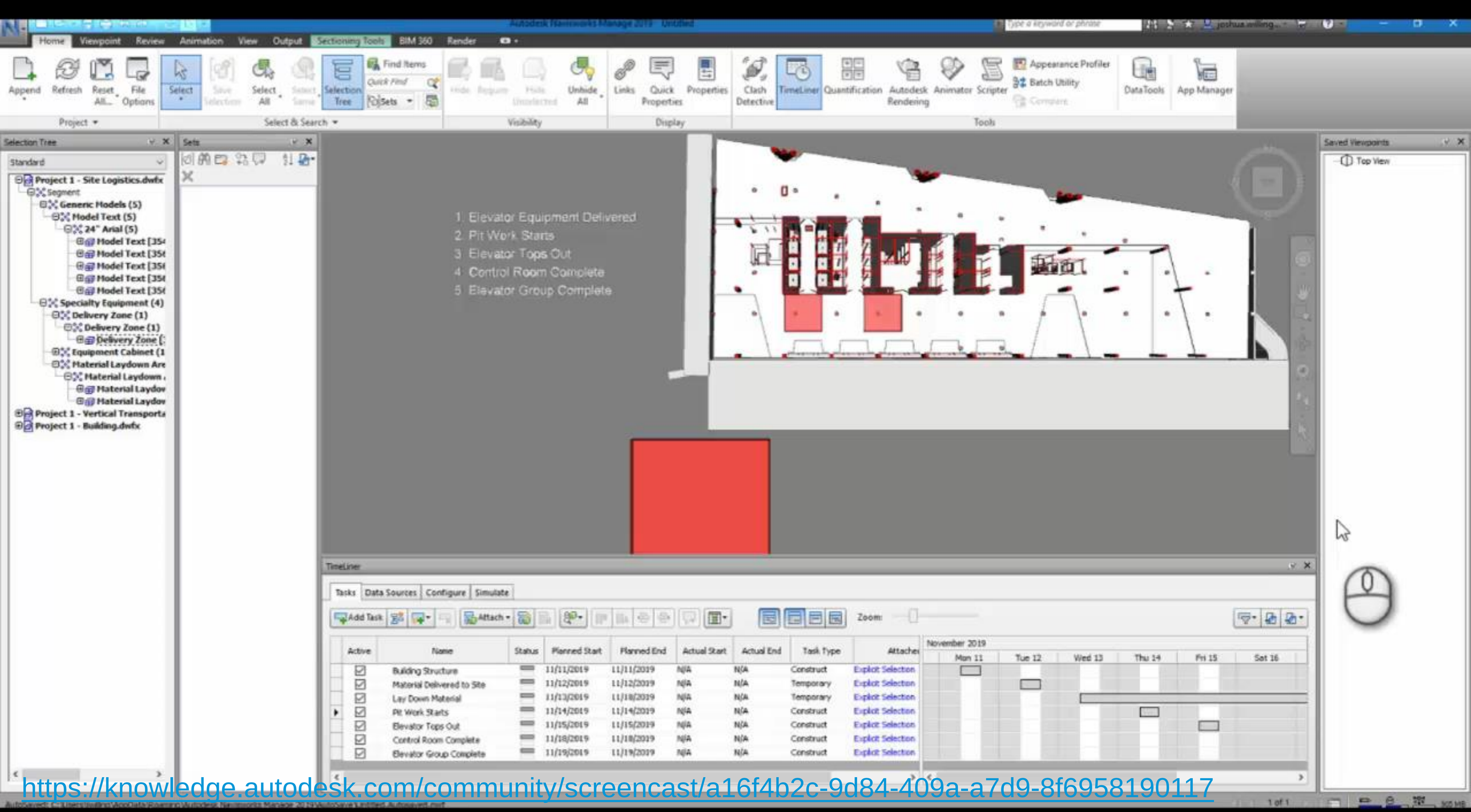

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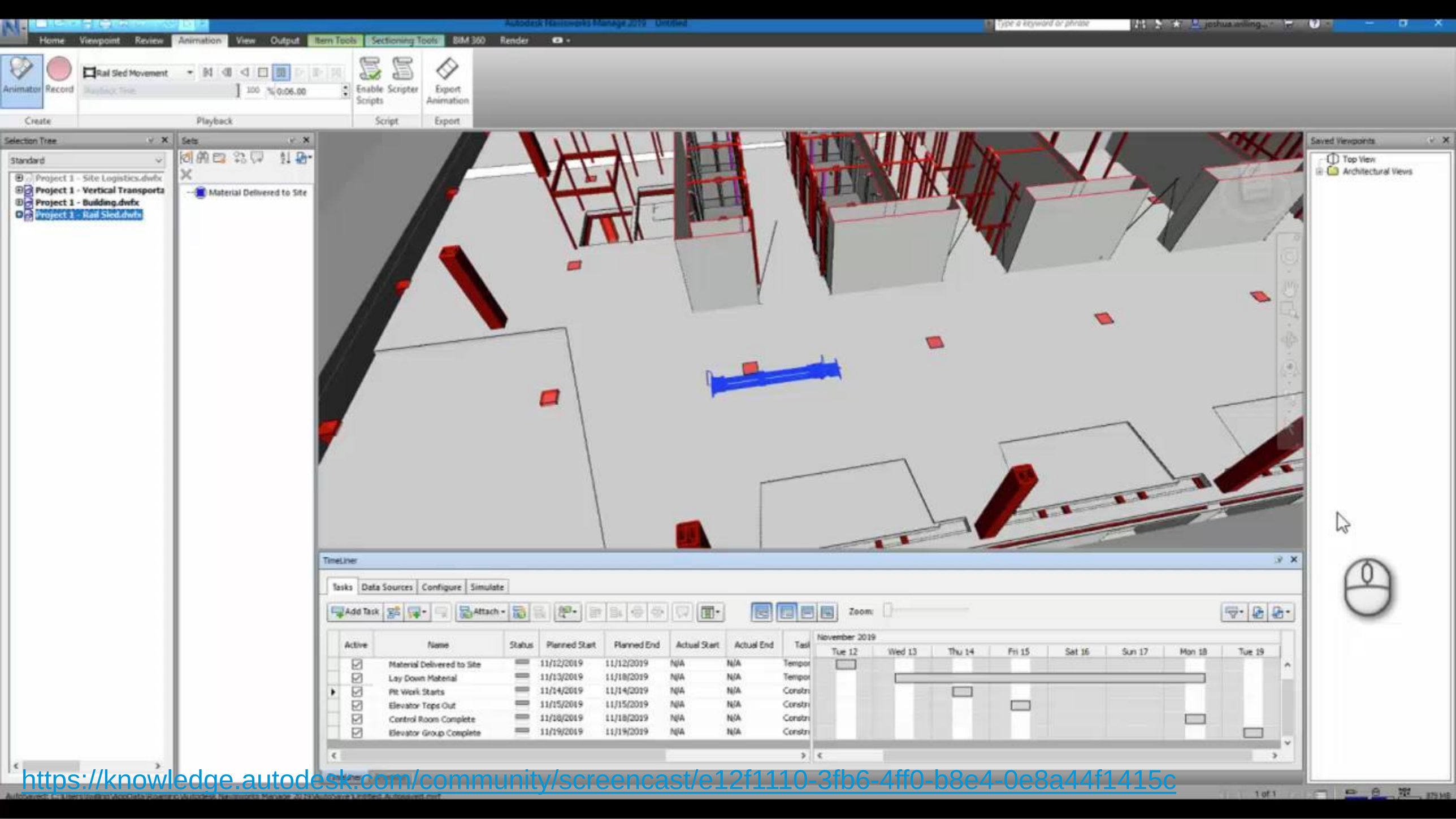

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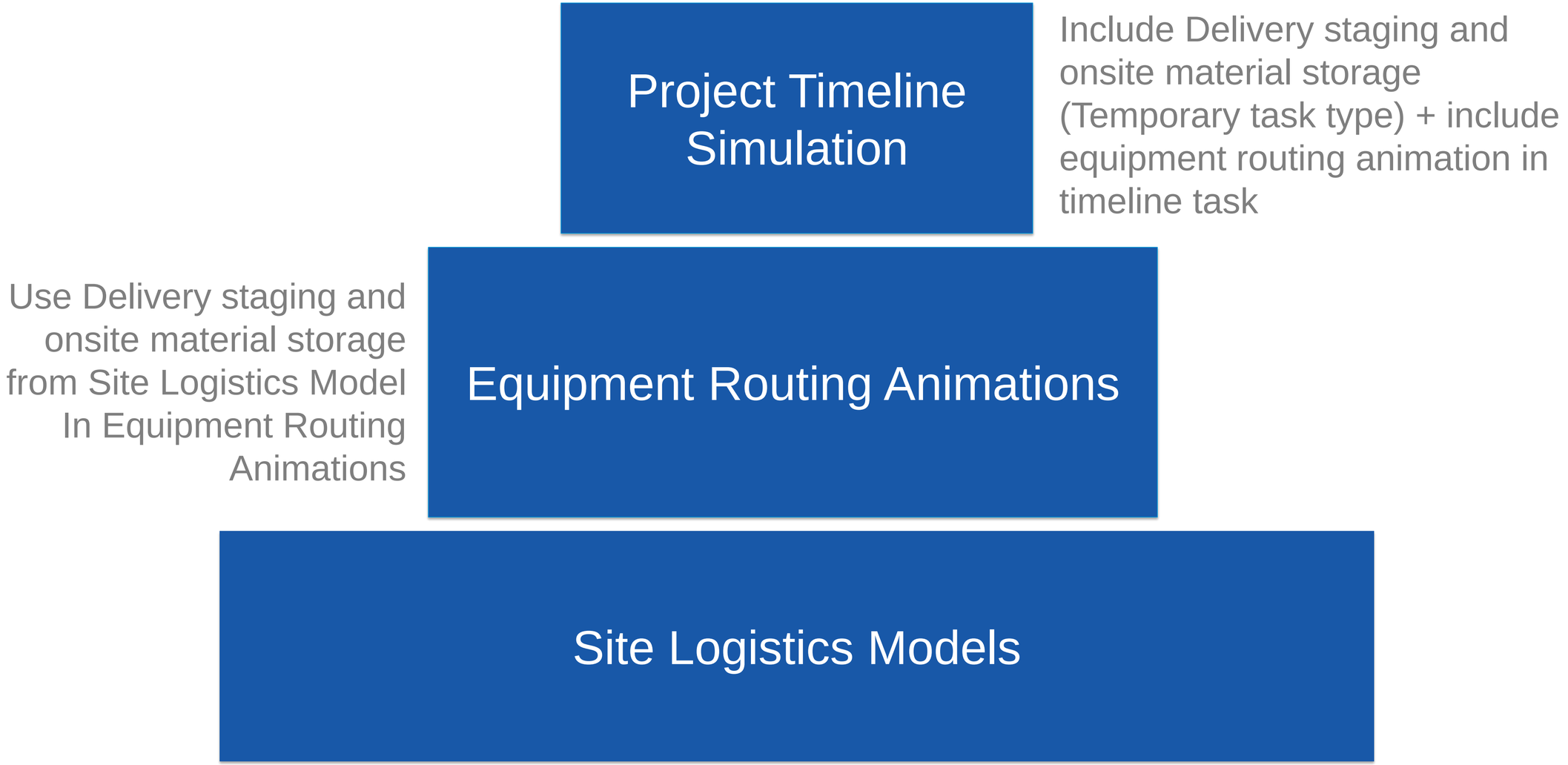
Practical 4D – Building The Digital Construction Site



What’s Next?

4D Construction Digital Twin

Simulative Planning

- Space planning the construction site
- Starts with Site logistics modeling
- Computational solving similar to building program optimization

Real-time feedback

- 3D virtual model container for vast and growing sensor data
- Reality capture provide spatial progress data to update/compare 3D virtual model
- Foundation of operational digital twin

Parting Thoughts

Expect BIM Coordination from elevator/escalator contractor

Consider value of all trades modeling construction-time requirements

Include 4D project requirements for specific use cases (e.g. large equipment routing)

Thank you.

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