

Mass-Producing Freight Cars at Home

Robert Bowdidge



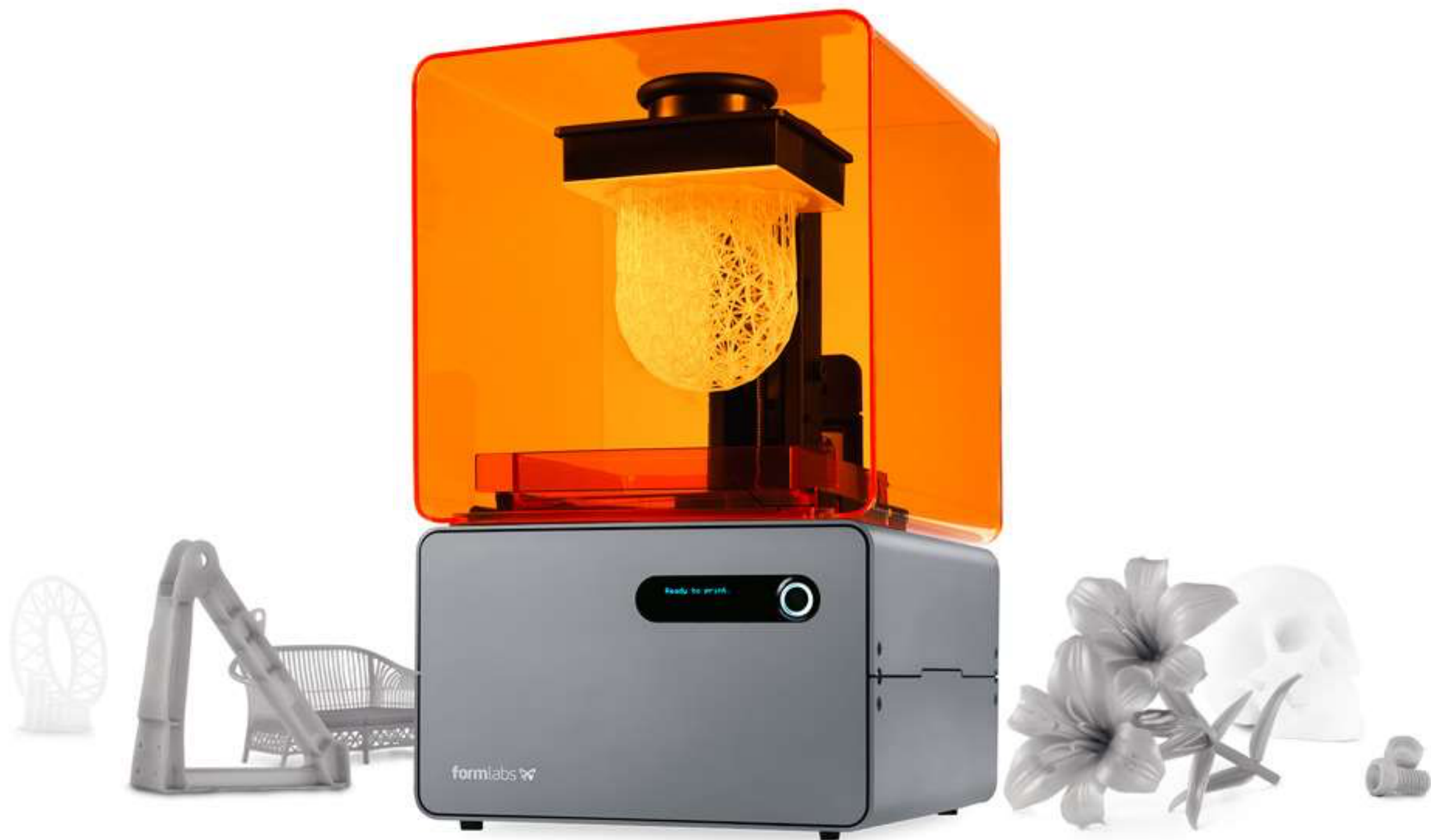




PACKING H
ION



LUMBER MILL



Levels of Effort

1 - 3 cars

Make one freight car.

5 - 10 cars

Make a few freight cars for me.

10 - 30 cars

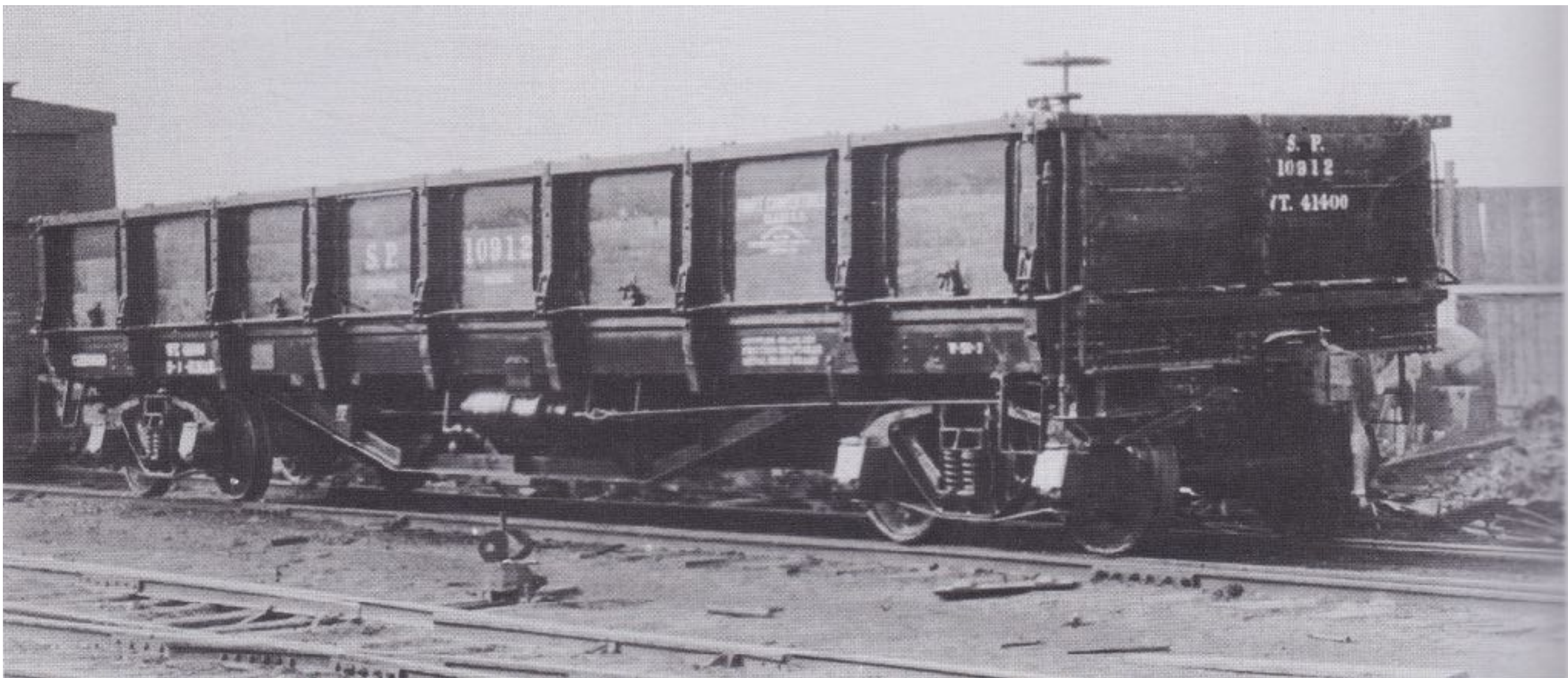
Make freight cars for friends.

30 - 100 cars

Sell freight cars.

What's Possible
on a Hobby Printer?

SP W-50-3 Gondola “Hart Convertible”



SP W-50-3 Gondola “Hart Convertible”





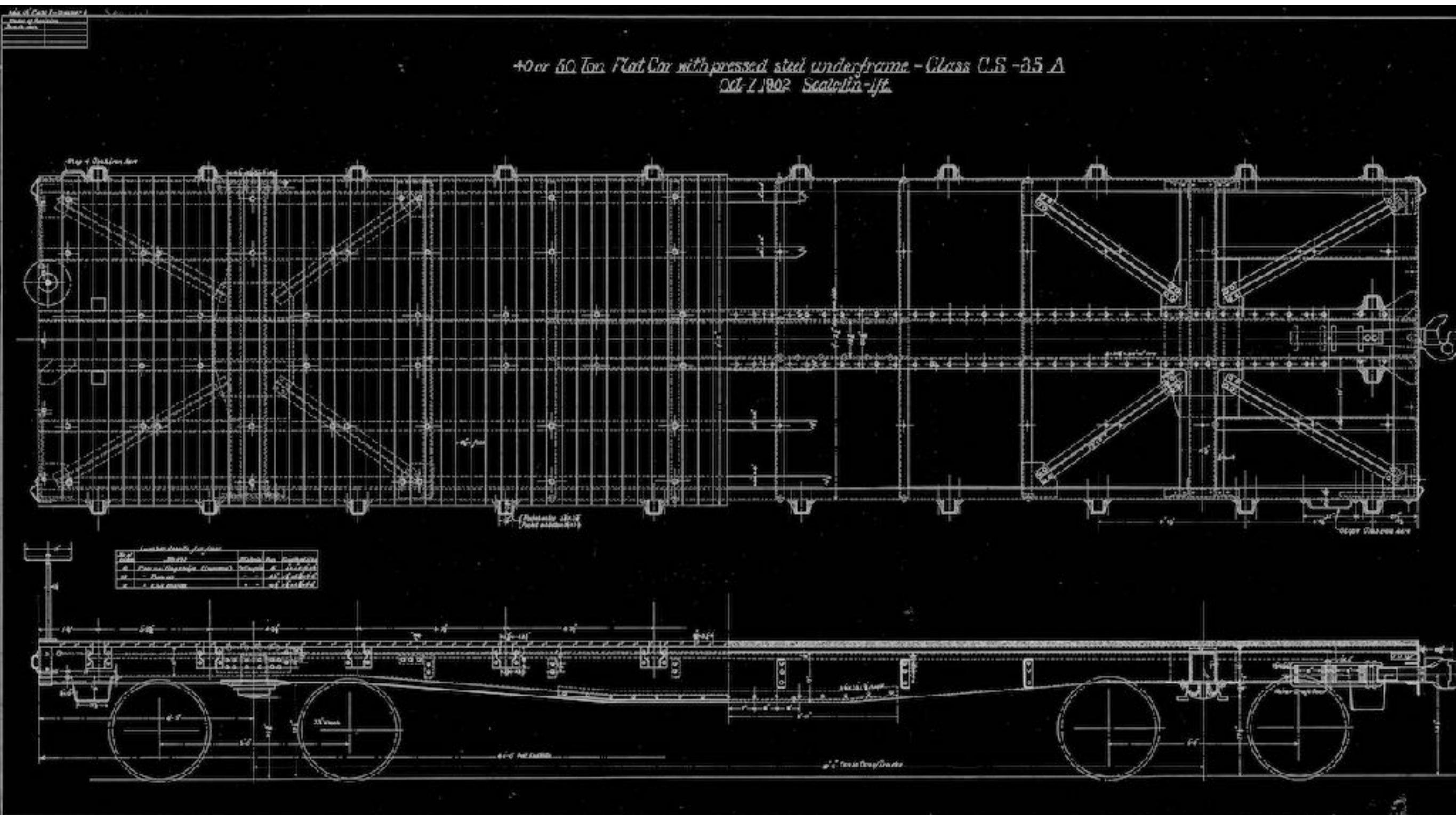
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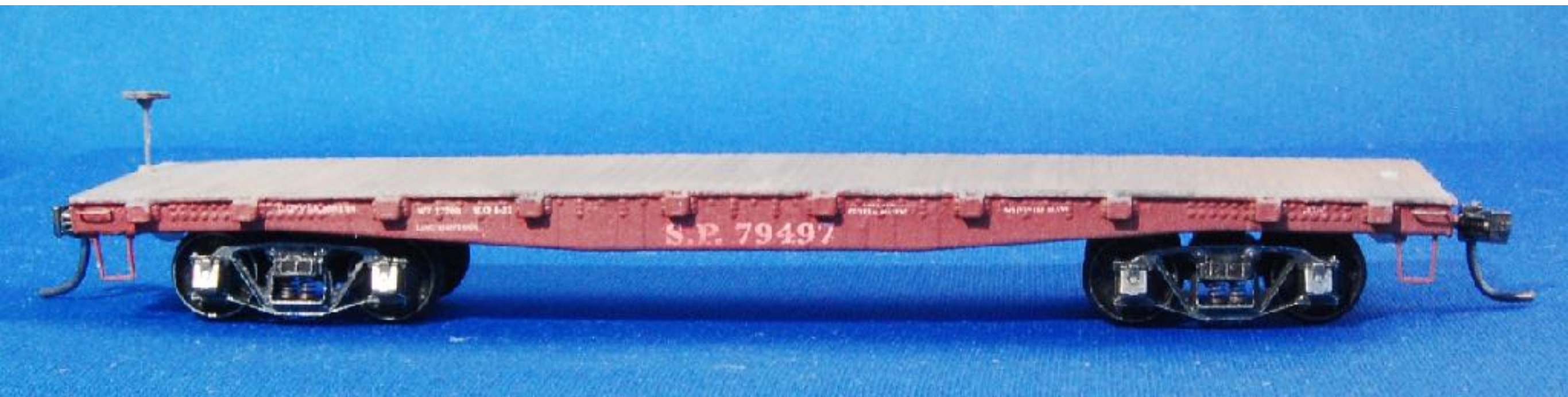
SP CS-35A Flat Car



SP CS-35A Flat Car



SP CS-35A Flat Car



SP “Battleship” Gondola



SP “Battleship” Gondola





N.P. 10924

N.P. 12389

PACIFIC RAILROAD

S.P. 10162

DRY CREEK MODELS

HO SCALE SOUTHERN PACIFIC W-50-3 BALLAST GONDOLA



WWW.DRYCREEKMODELS.COM / SAN JOSE, CA.

Y CREEK MODELS

HO SCALE KIT #101

SOUTHERN PACIFIC
W-50-3 BALLAST GONDOLA

AS BUILT (1912-1930)
HOPPER DOORS DOWN



DRY CREEK MODELS

HO SCALE KIT #100

SOUTHERN PACIFIC
W-50-3 BALLAST GONDOLA

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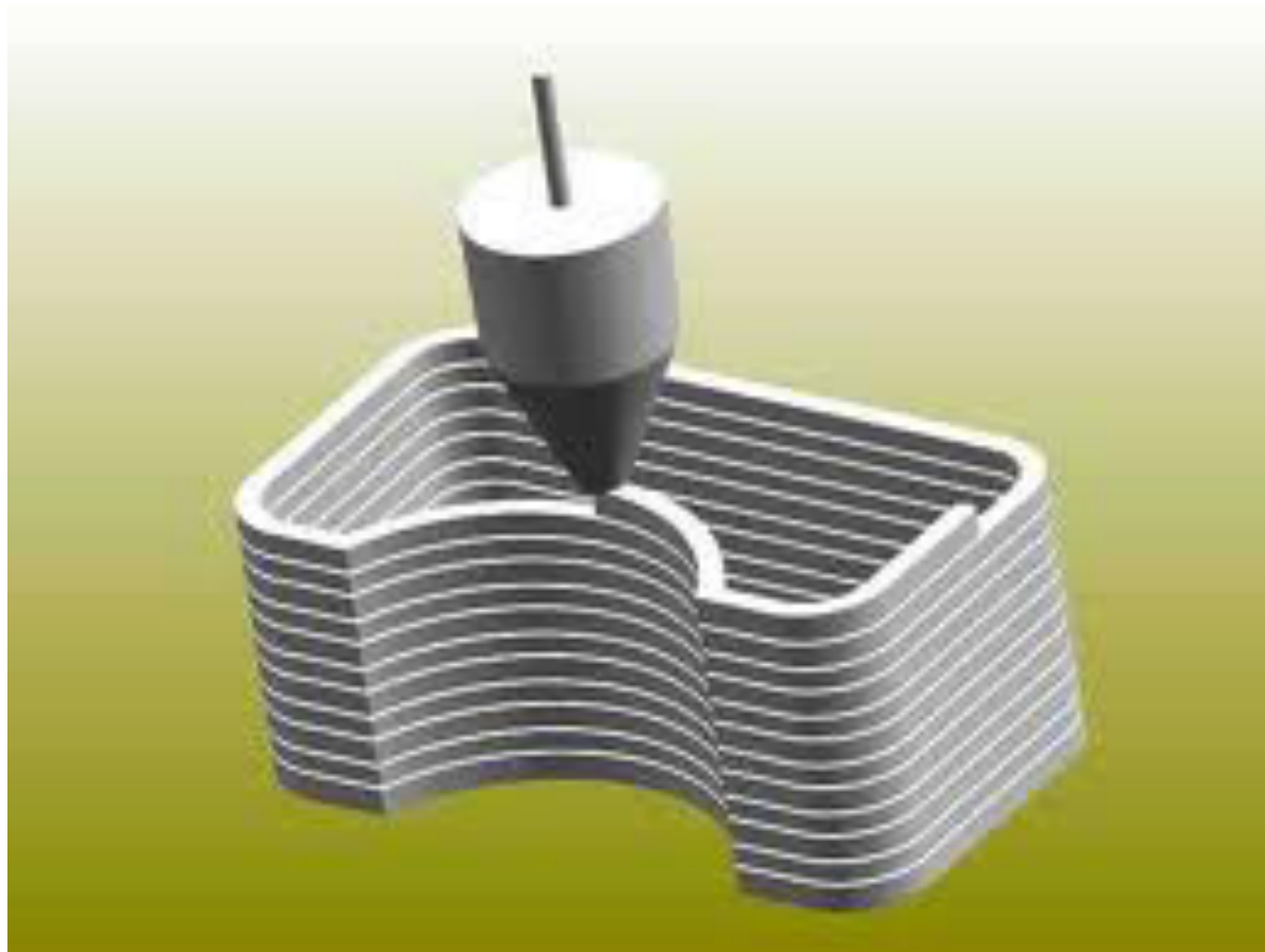
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How 3d Printing Works

- Several different kinds of printers - some only for industrial / commercial use, some hobby use.
- key points: all these printers have appeared because the patents expired, expect more of all of these
- Each printer type has its own strengths and weaknesses

FDM - squirt plastic



Shapeways: layer by layer

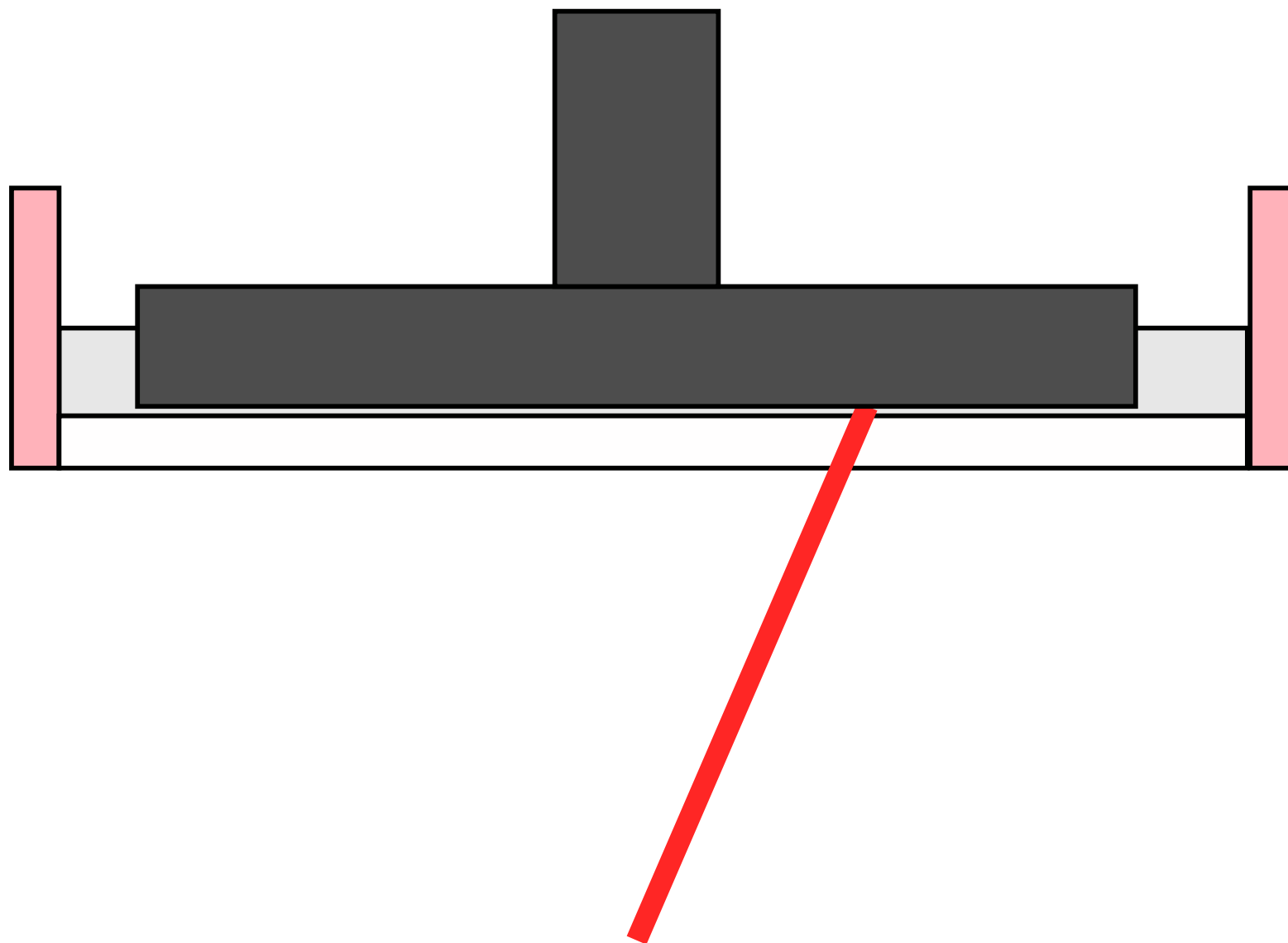
Wax

Final Part

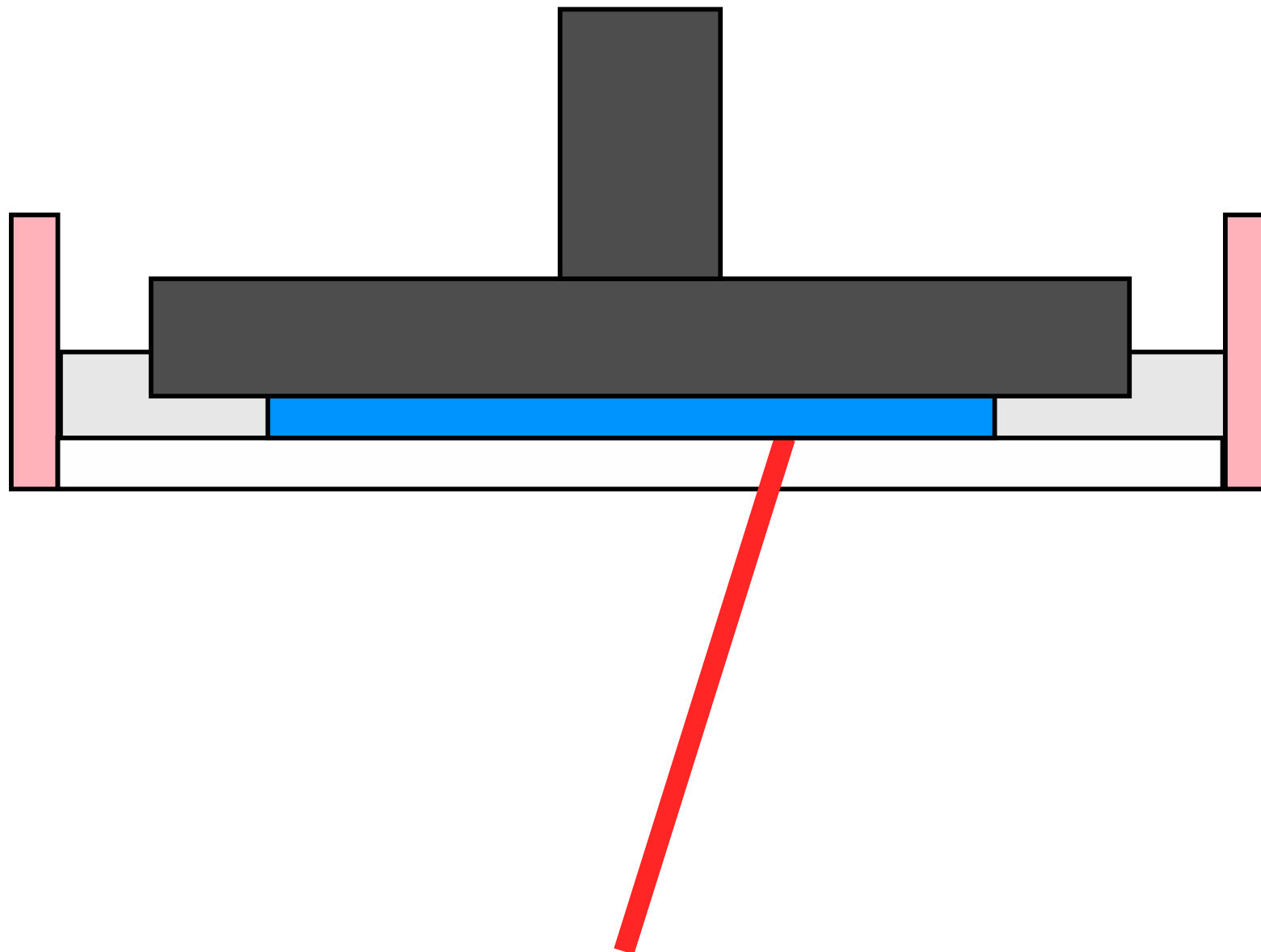
Wax



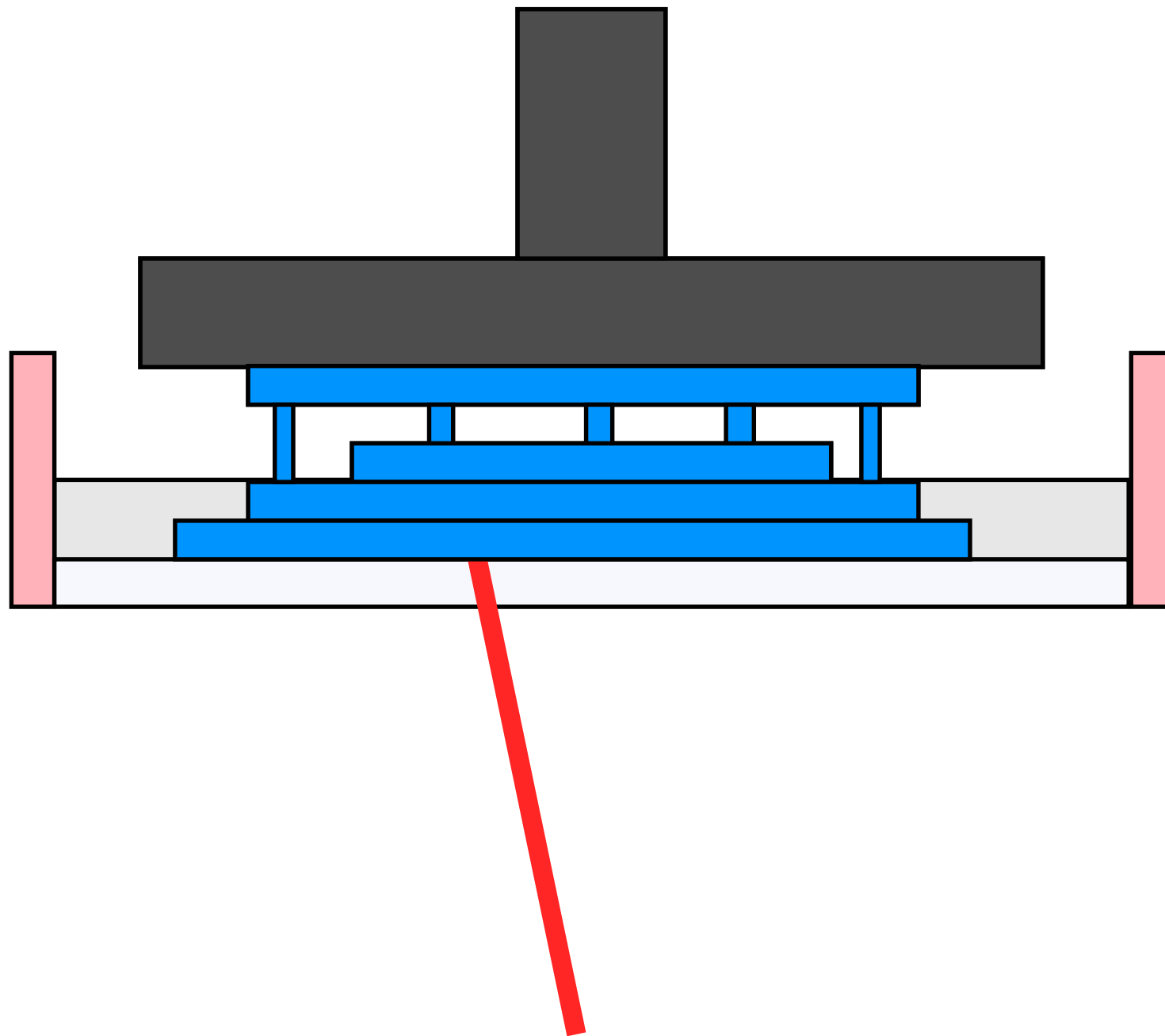
Liquid resin + light



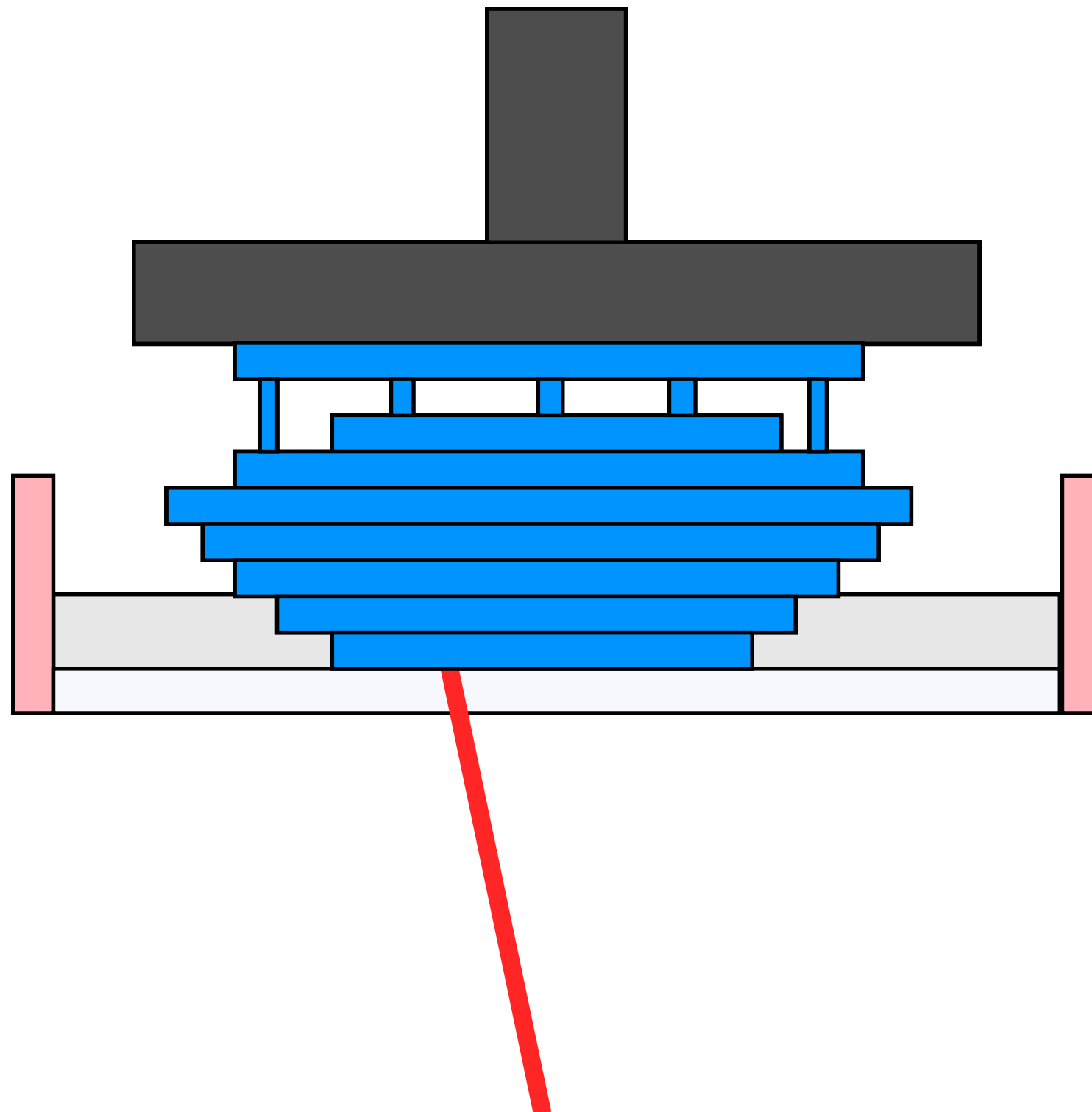
Liquid resin + light



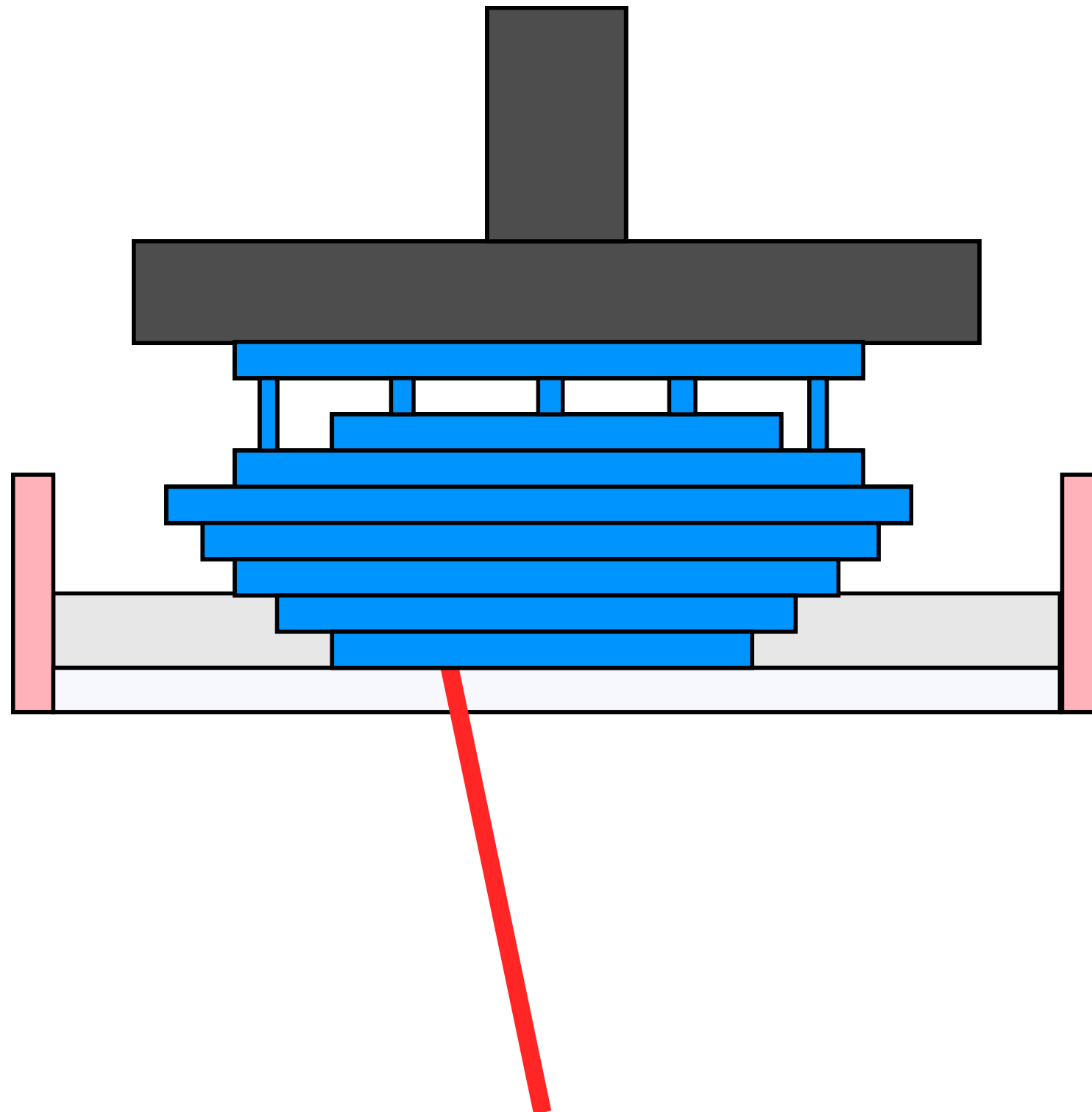
Liquid resin + light



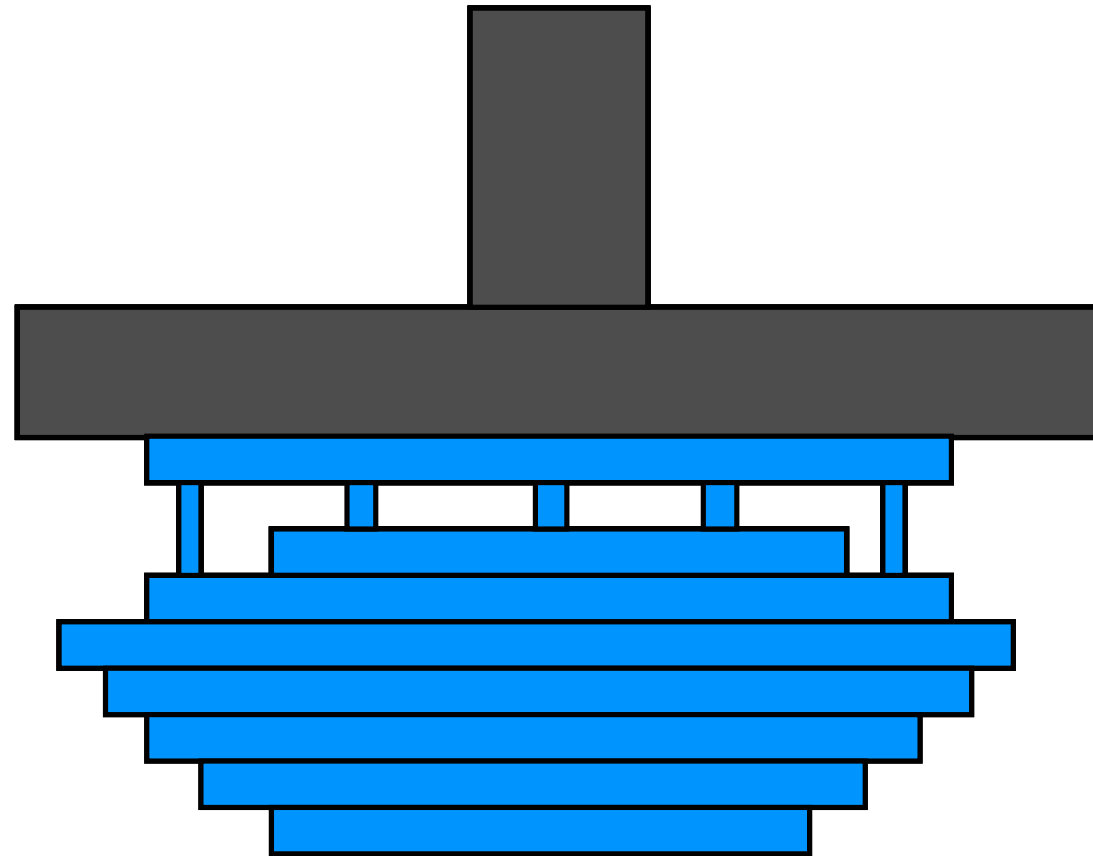
Liquid resin + light



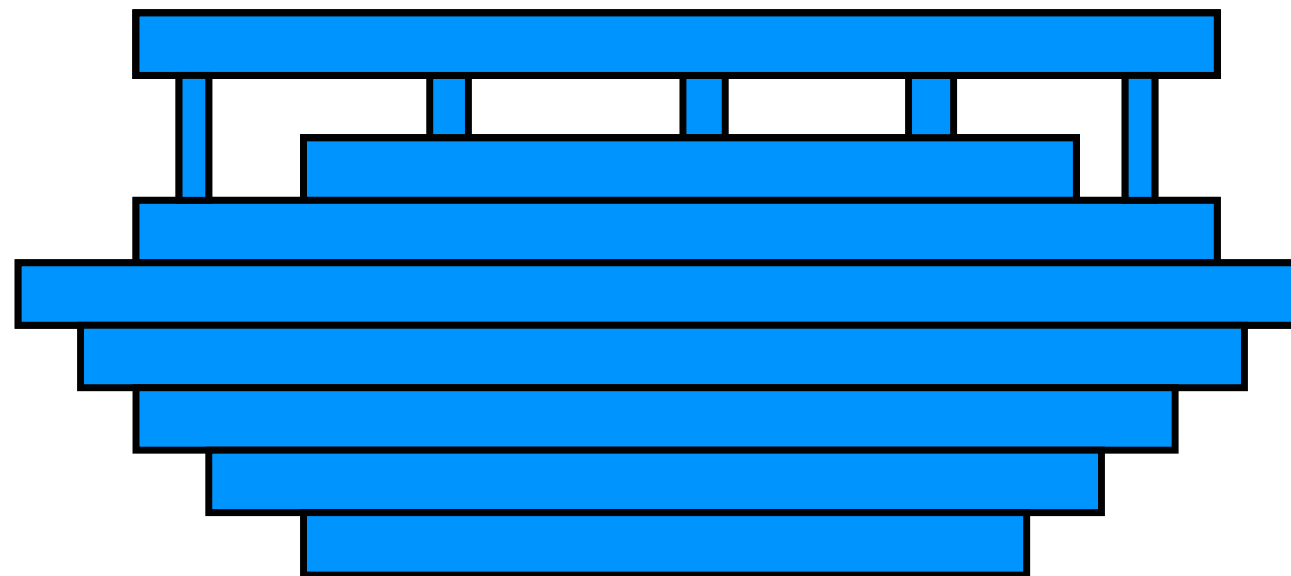
Liquid resin + light



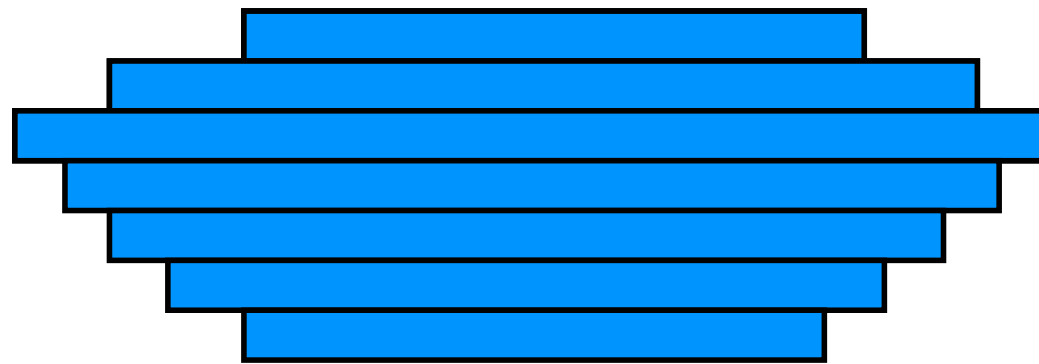
Liquid resin + light

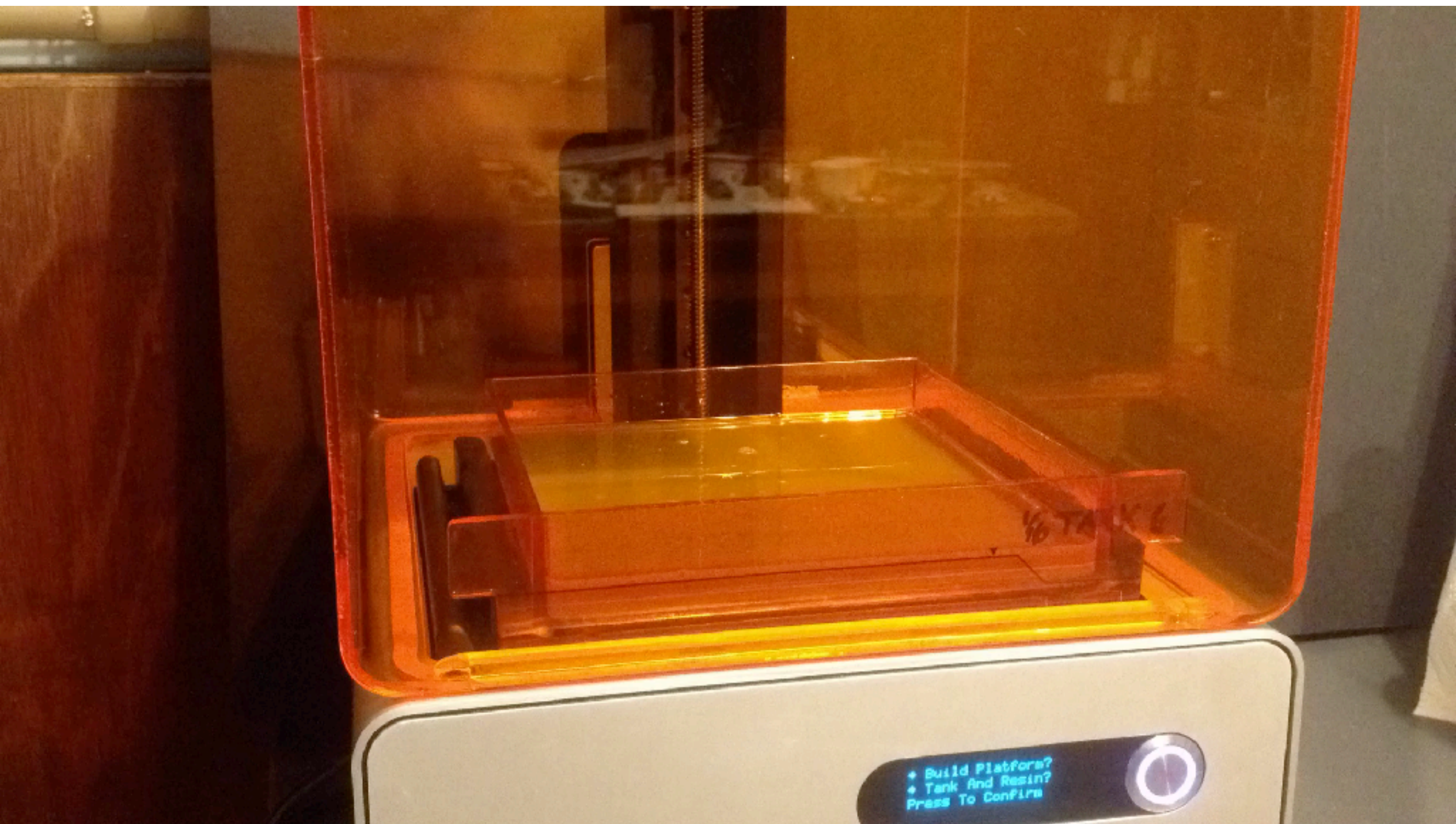


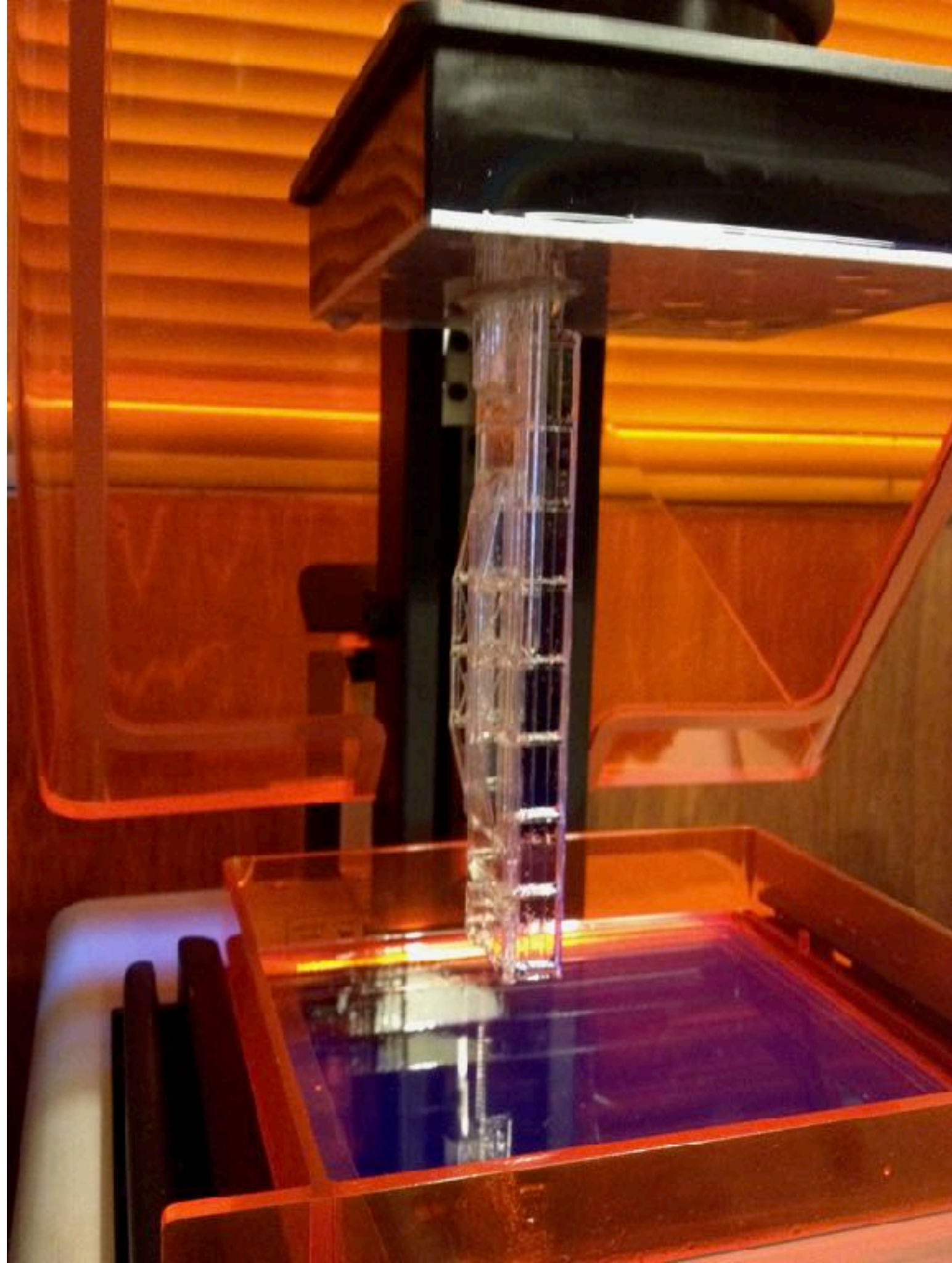
Liquid resin + light



Liquid resin + light





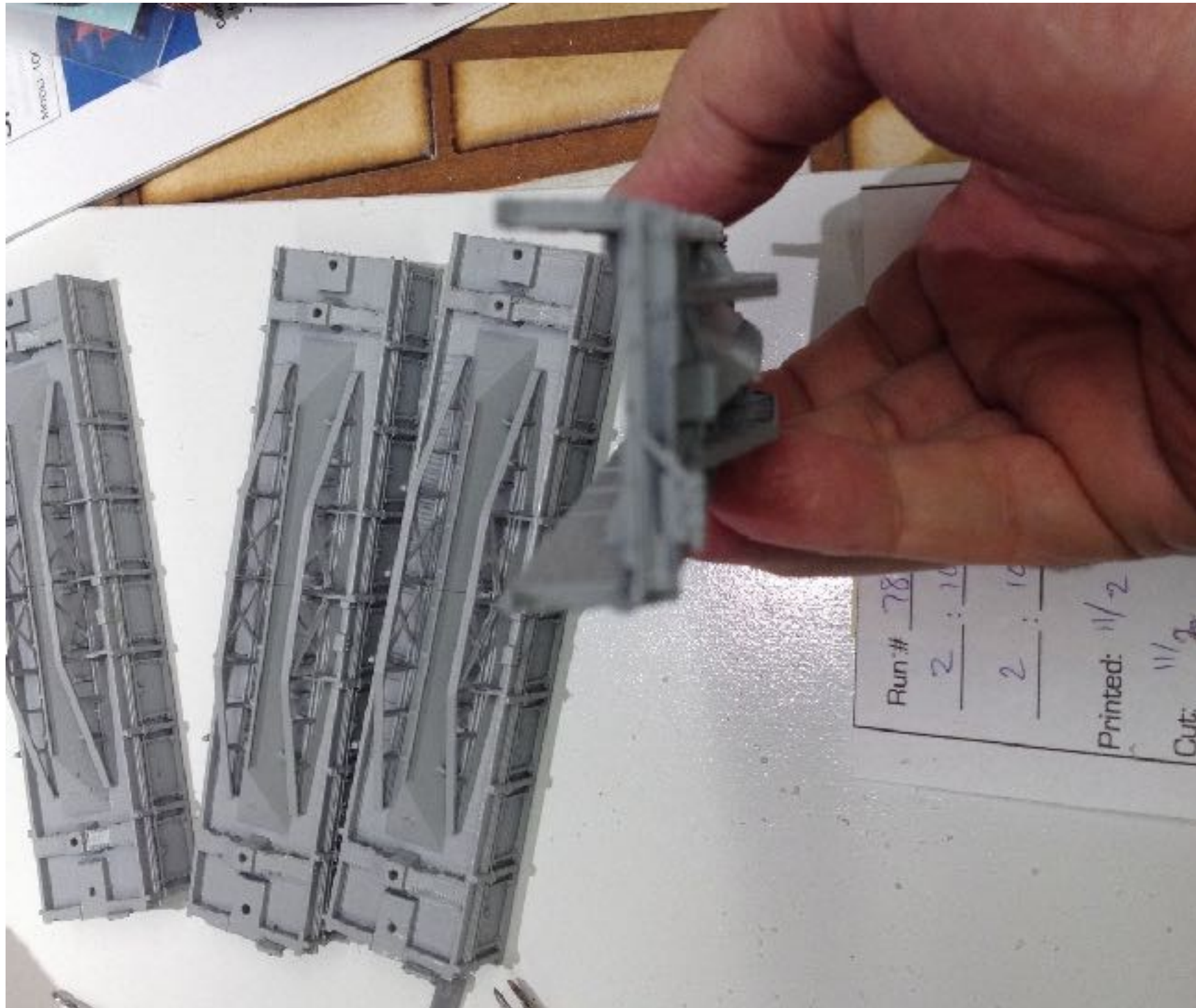




Remove Supports



Body done



And We're Done!

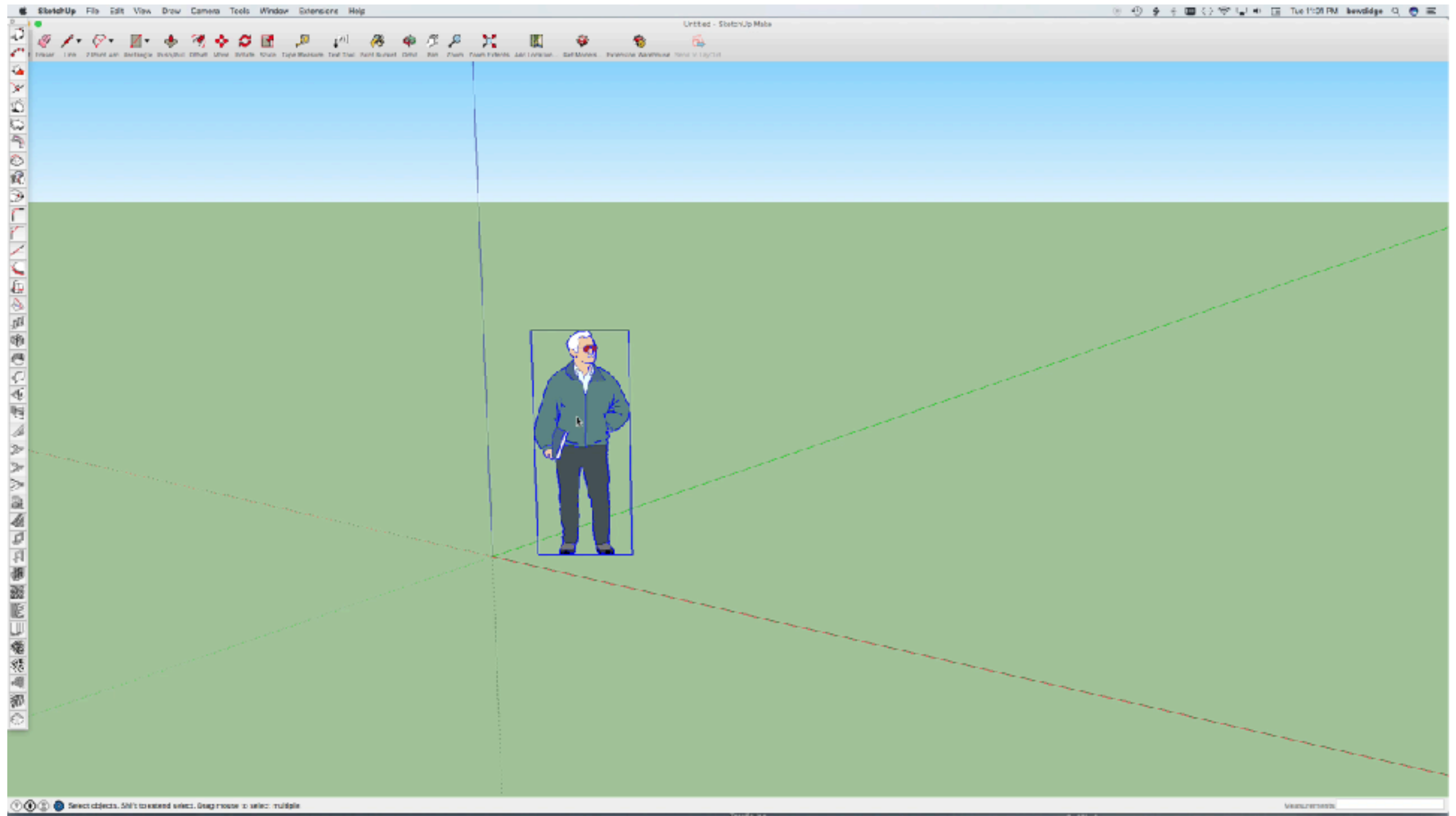


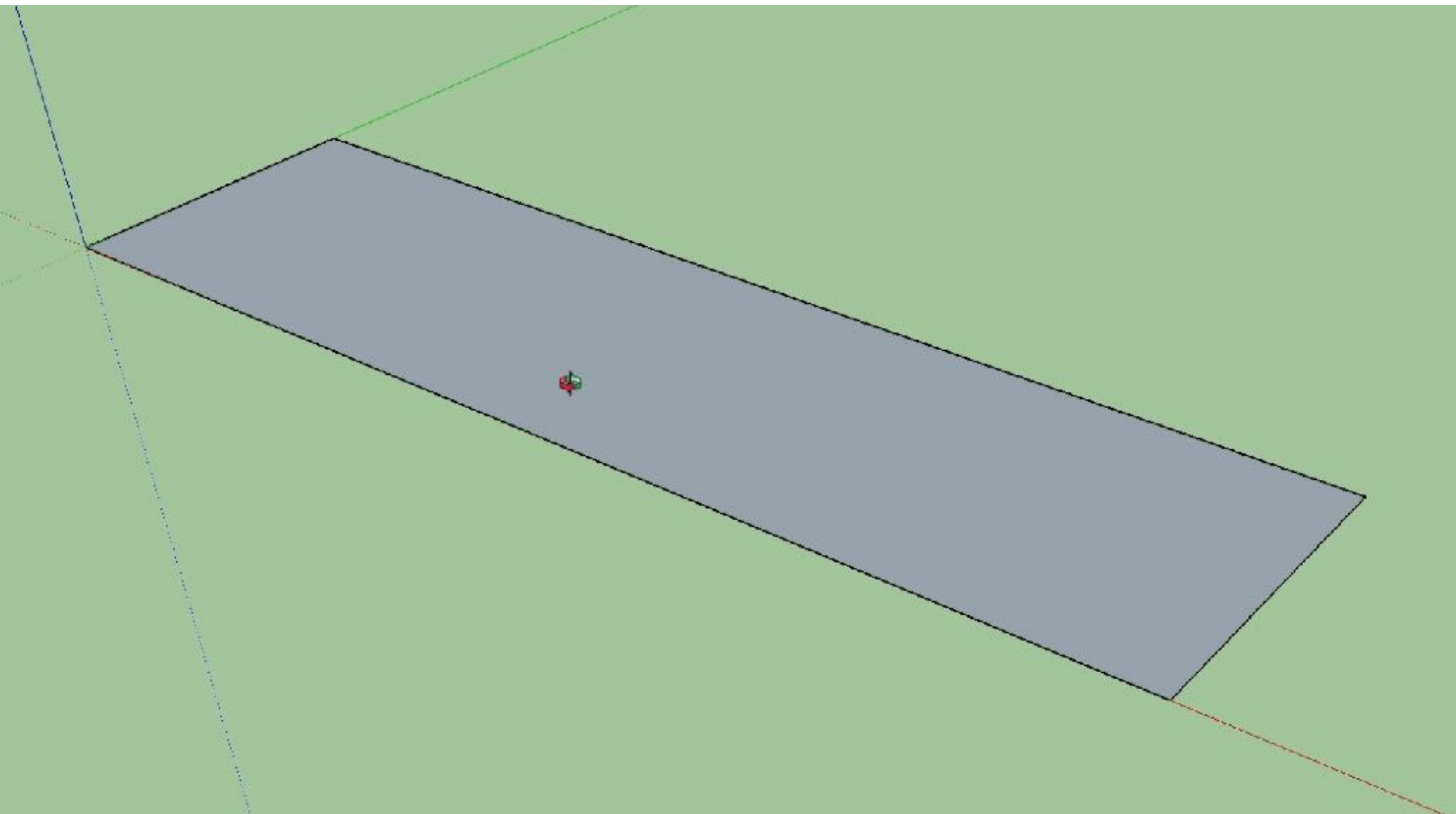
How we make one car

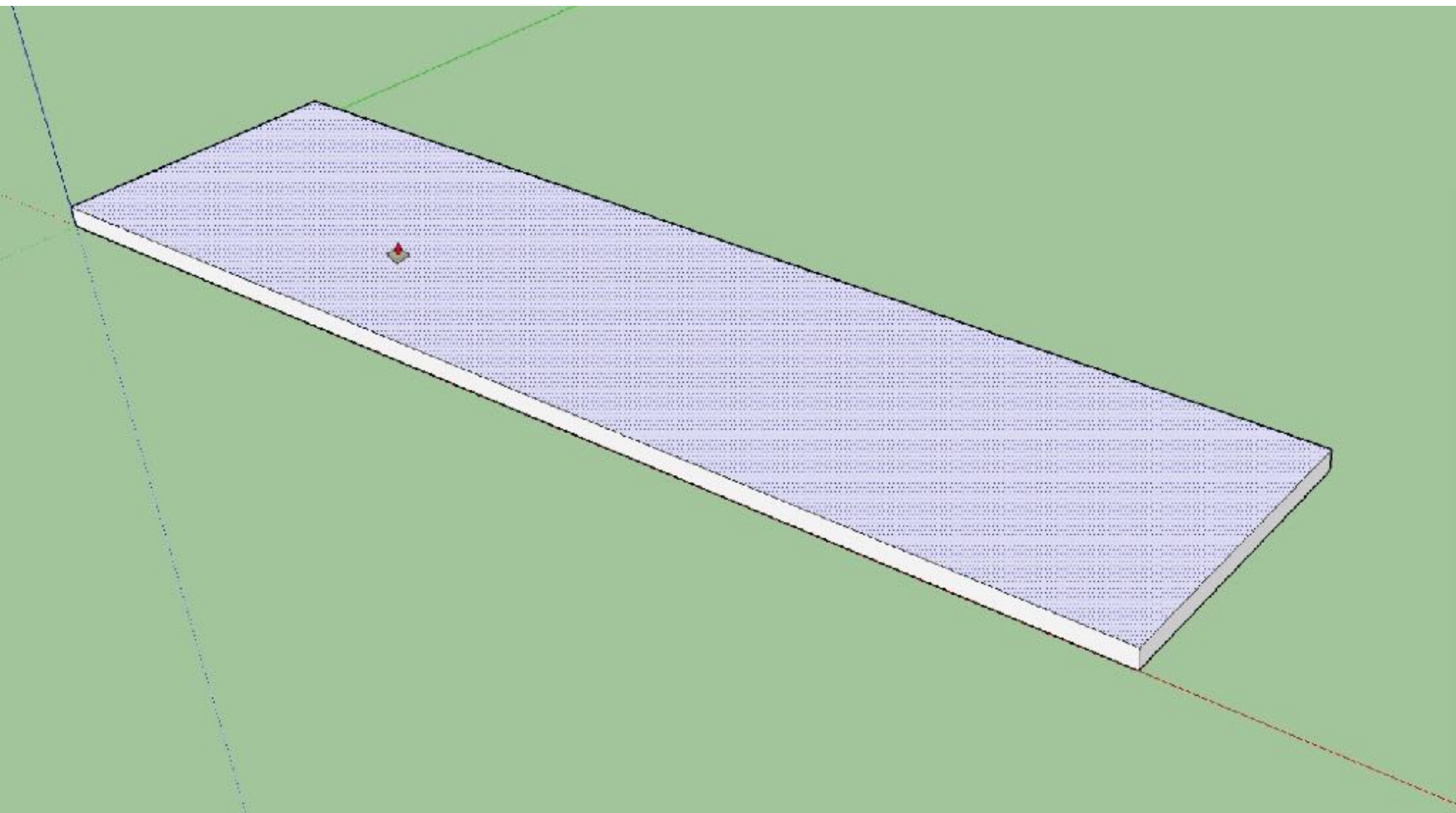
- Figure out what to build
- Create a 3d drawing describing the object.
 - correct thicknesses, holes, etc.
- Prepare for printing: facing, etc.
- Send to printer
- Clean up, finish.

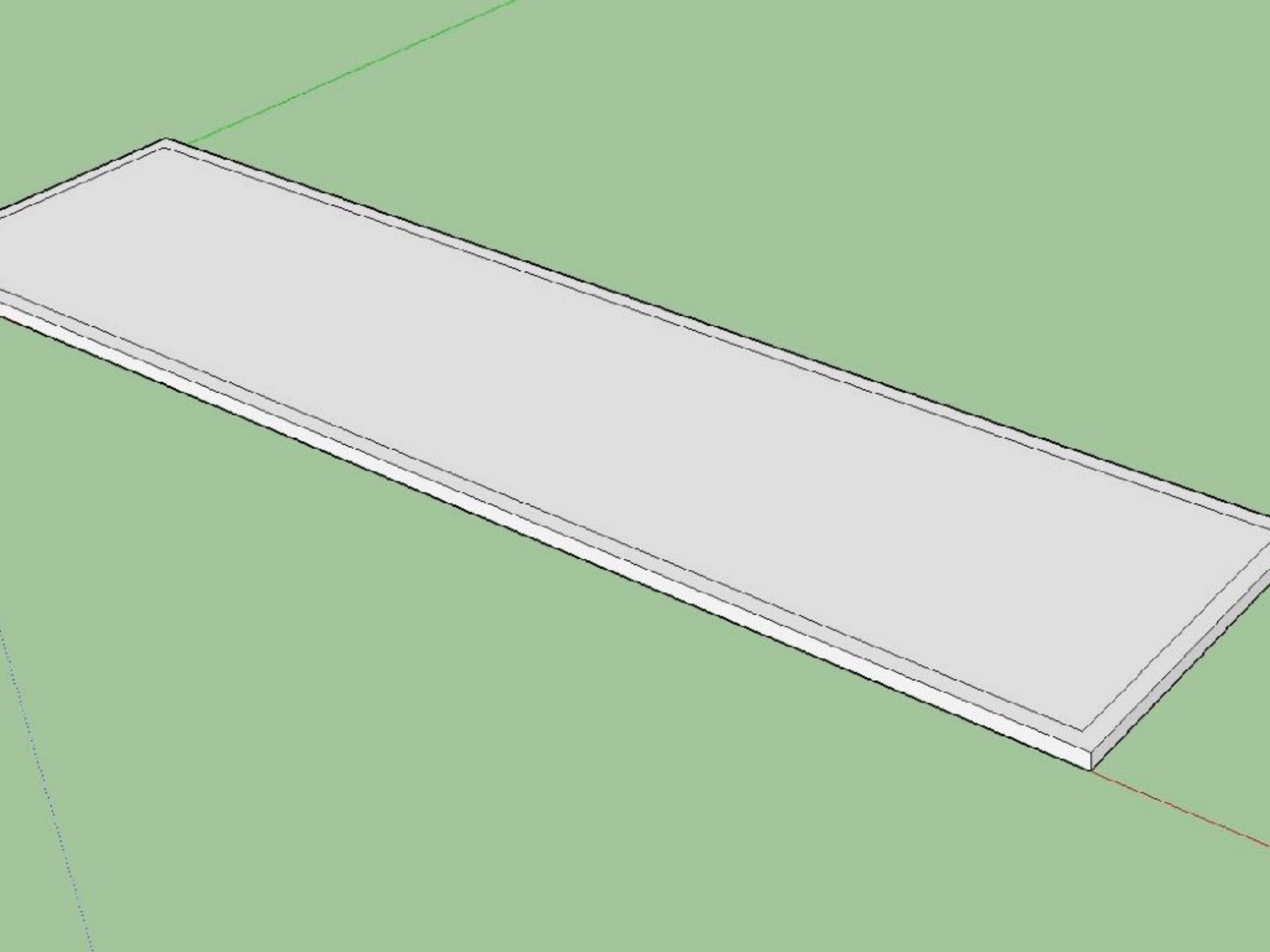
Creating 3D Model

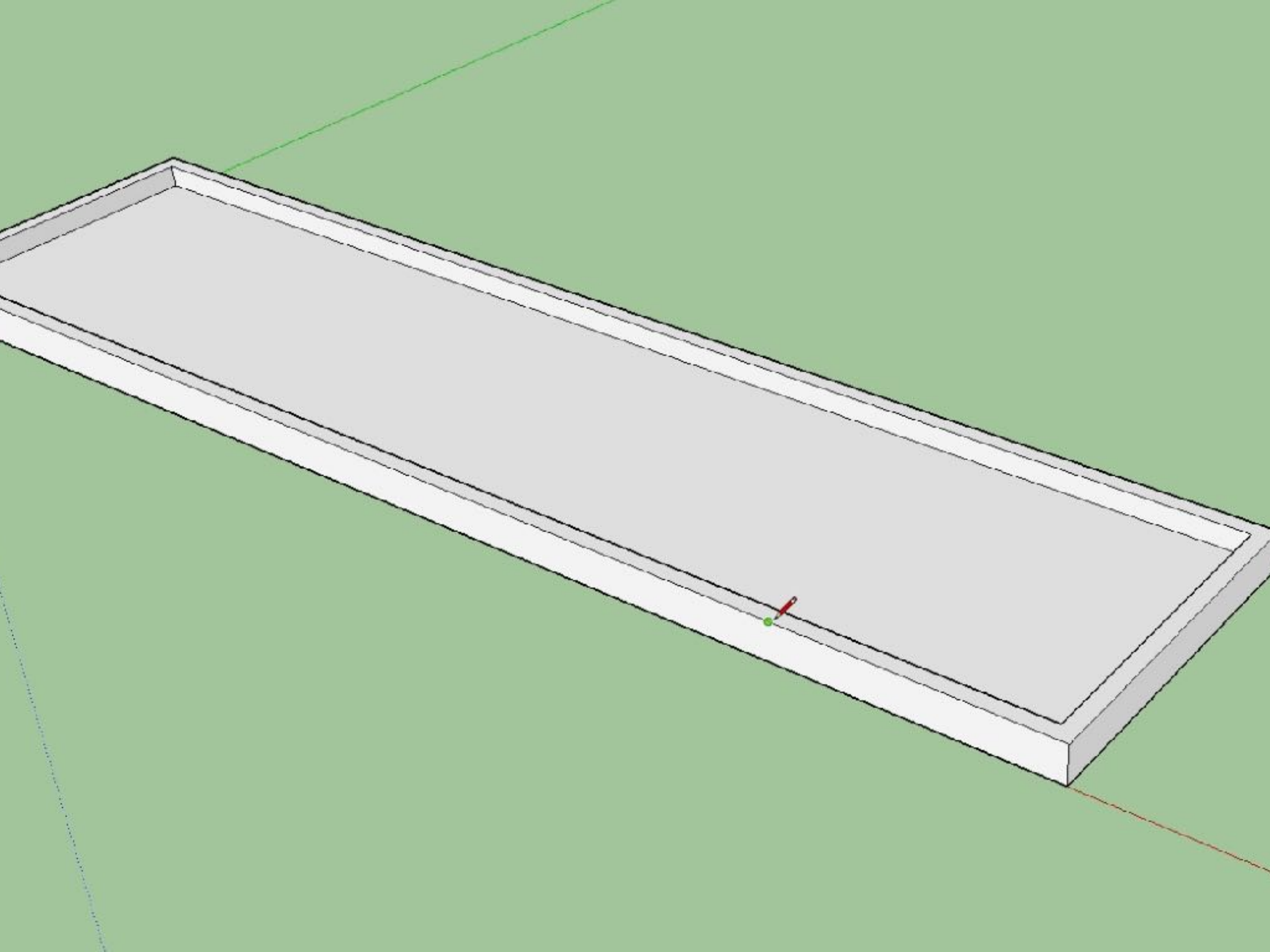
- I use SketchUp - free non-commercially (get plugin for STL)
- Works on idea of extruding shapes
- Plan to think at least a bit about what you're doing - can be hard to move sides out 2" if too narrow
- easy to use, but poor for intersecting round shapes (don't do locomotive cylinders)
- Work in actual size (and do lots of math), or do in scale size, then scale down.
- HO scale inches to actual mm = 0.292, O scale inches to actual mm=0.529

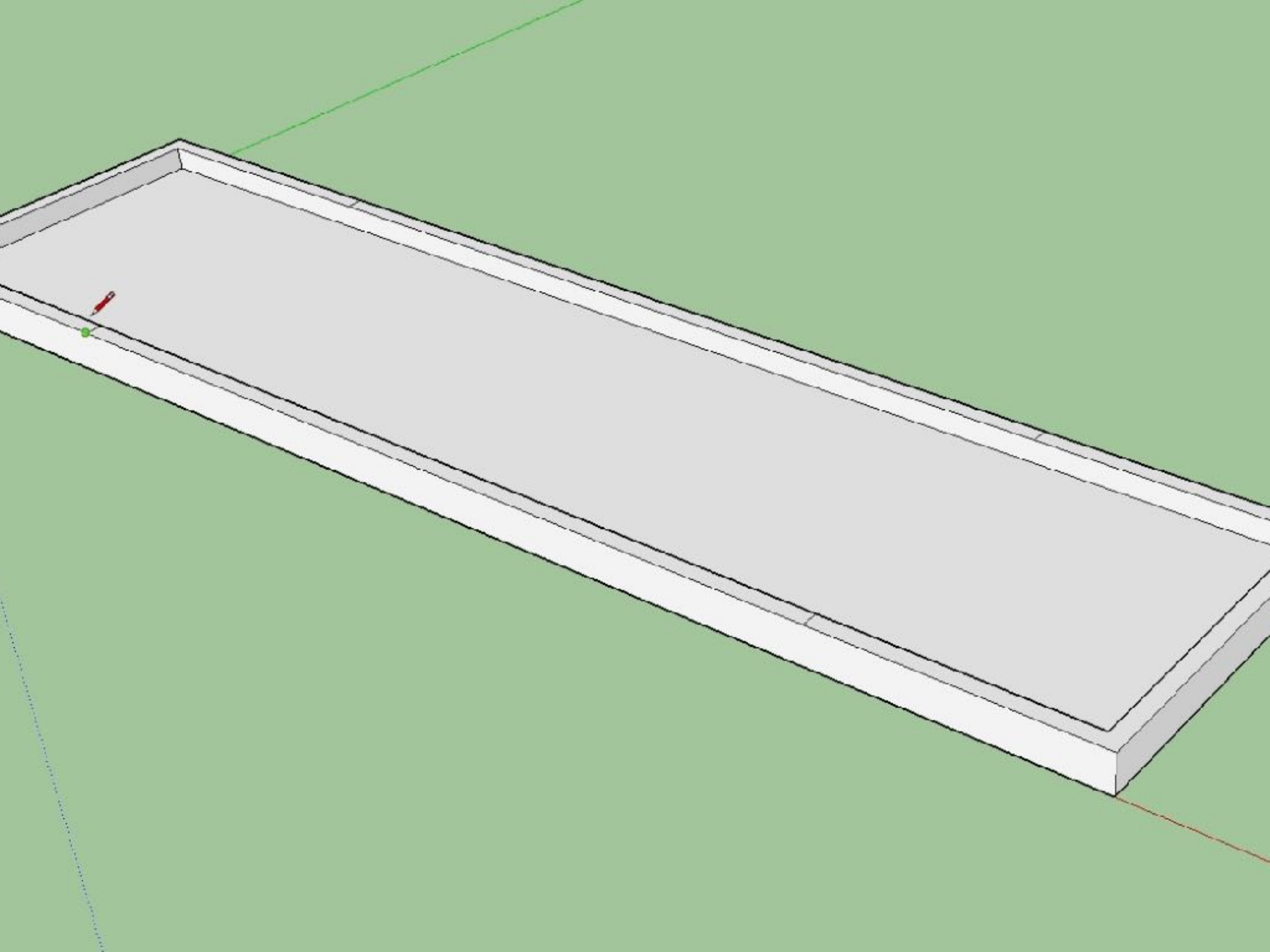


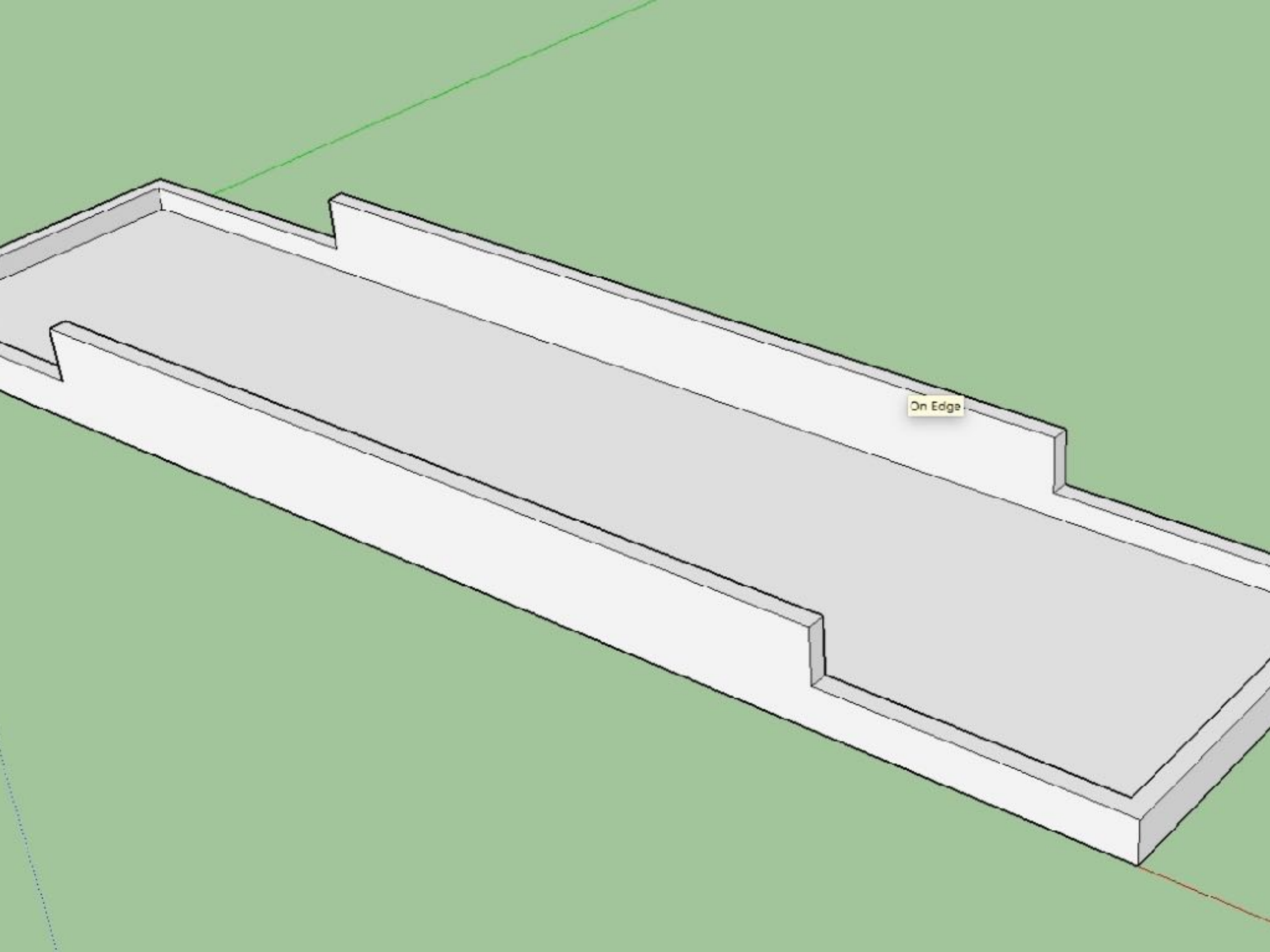




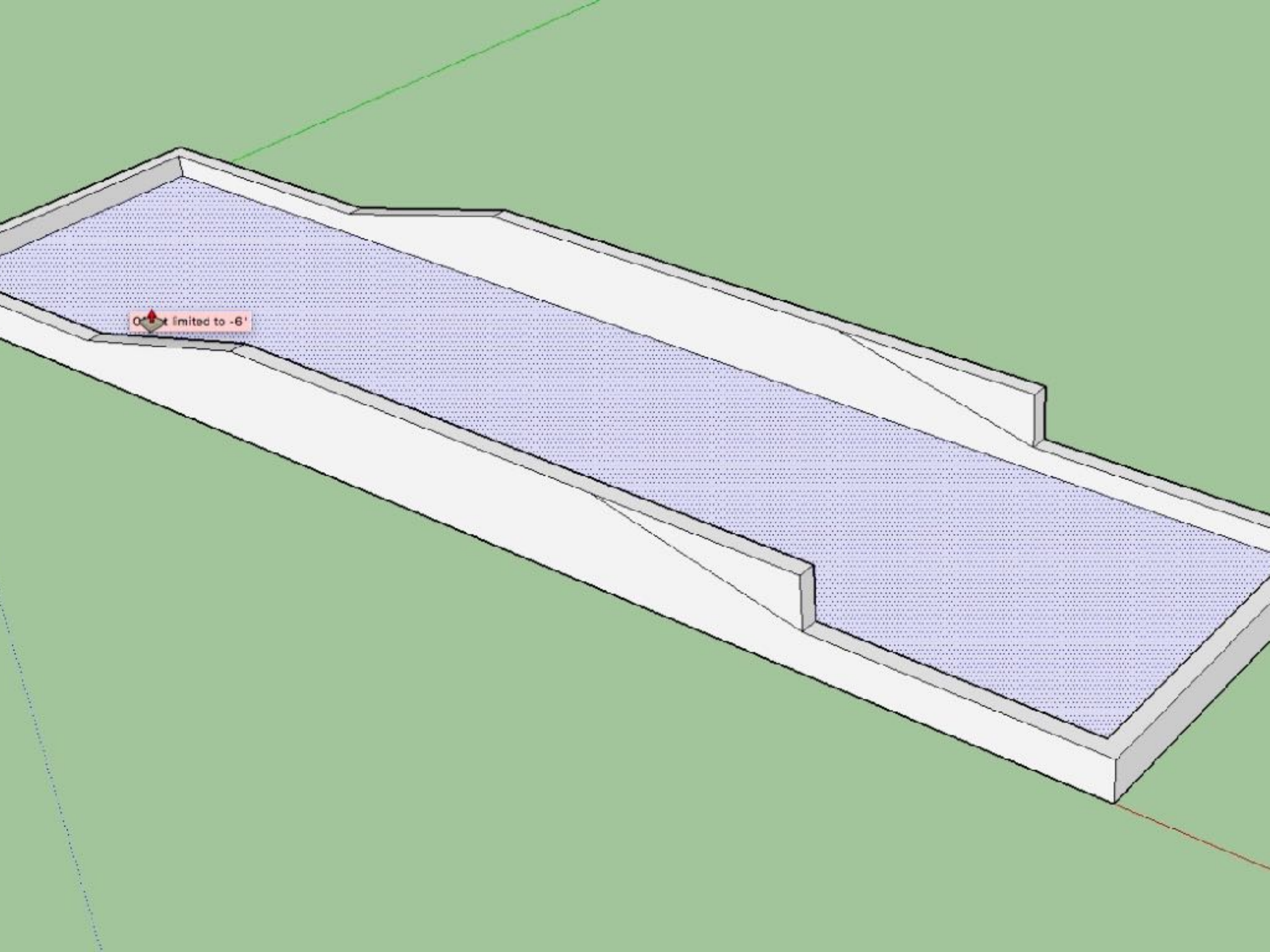




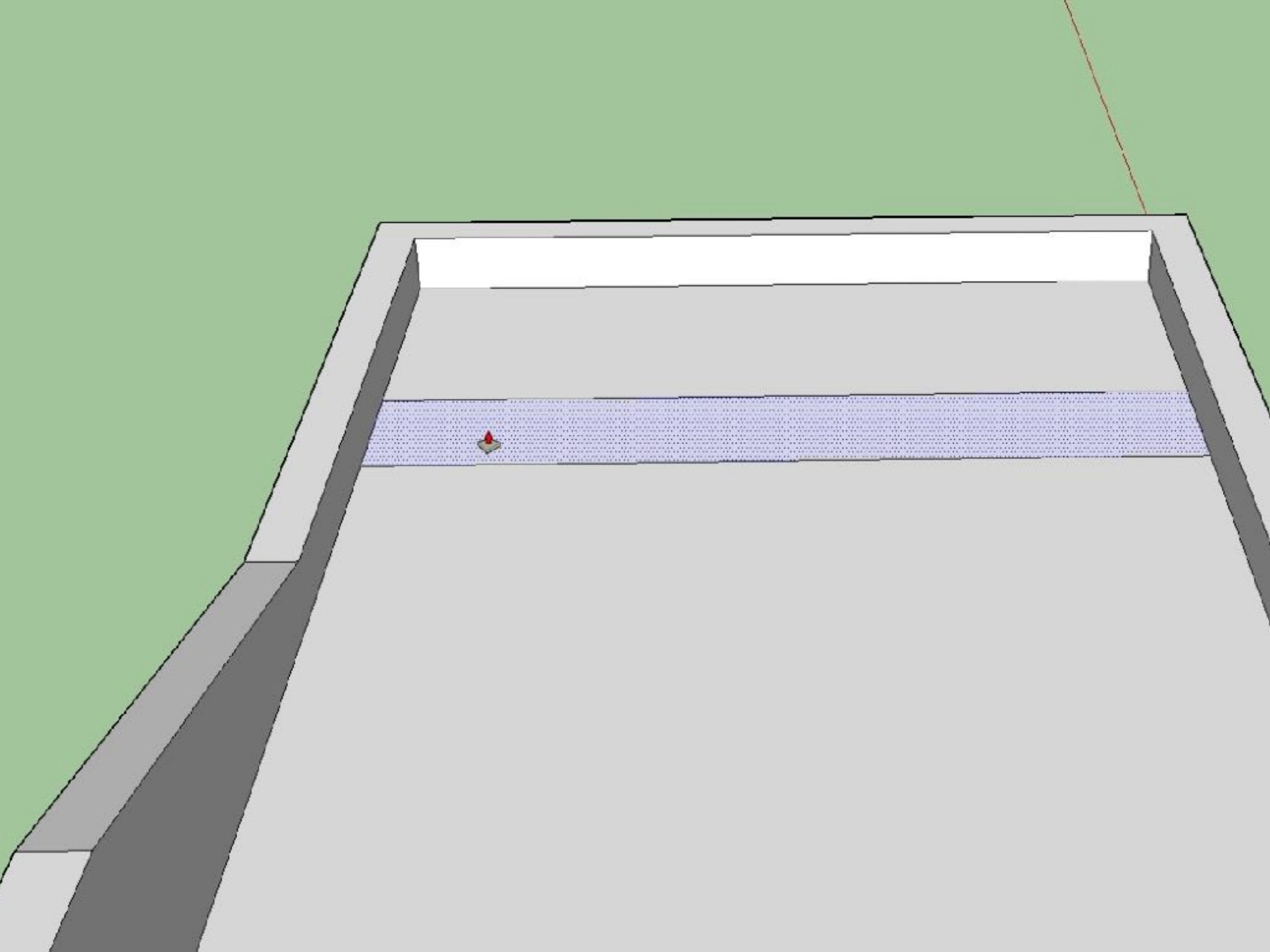


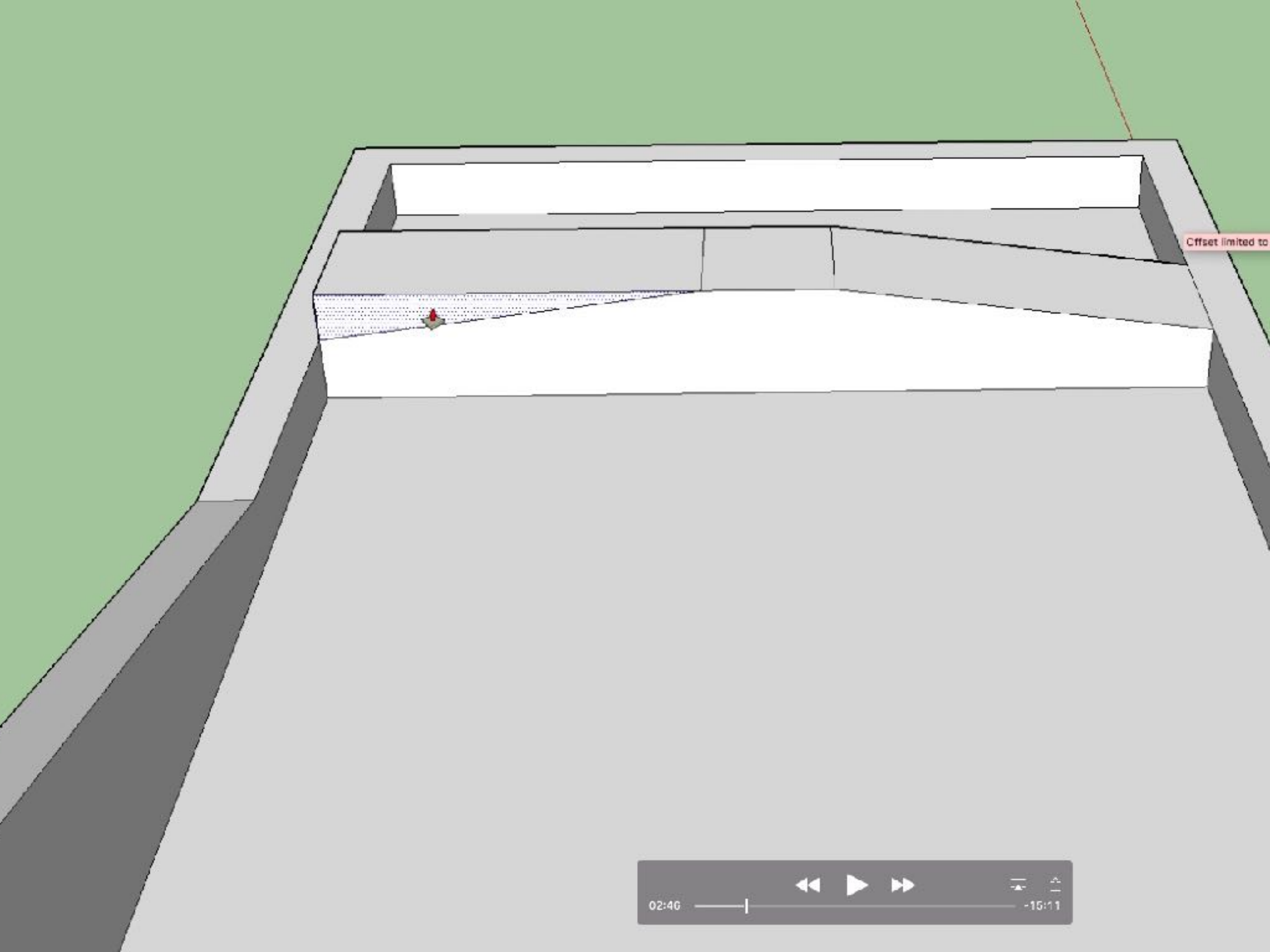


On Edge

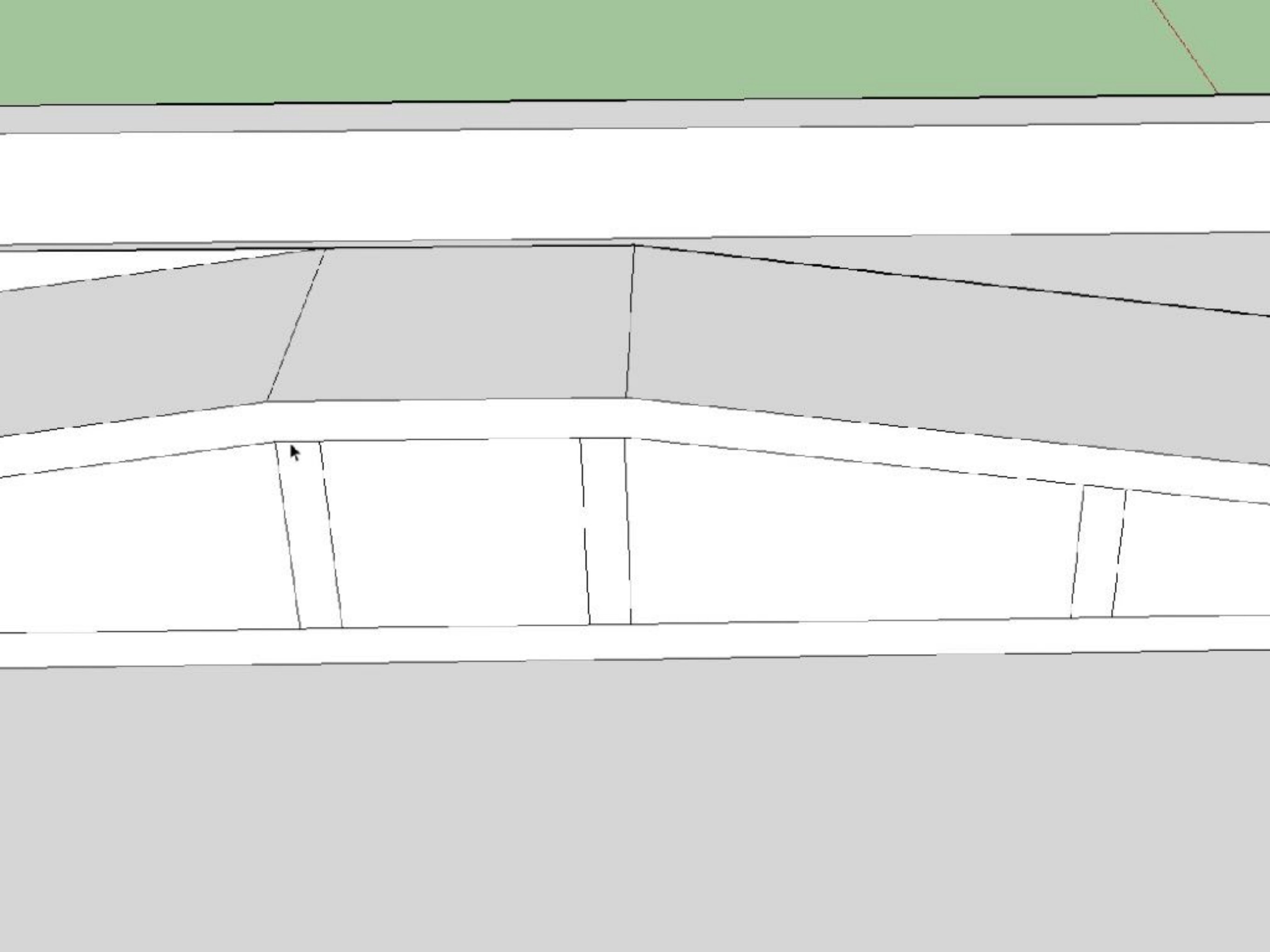


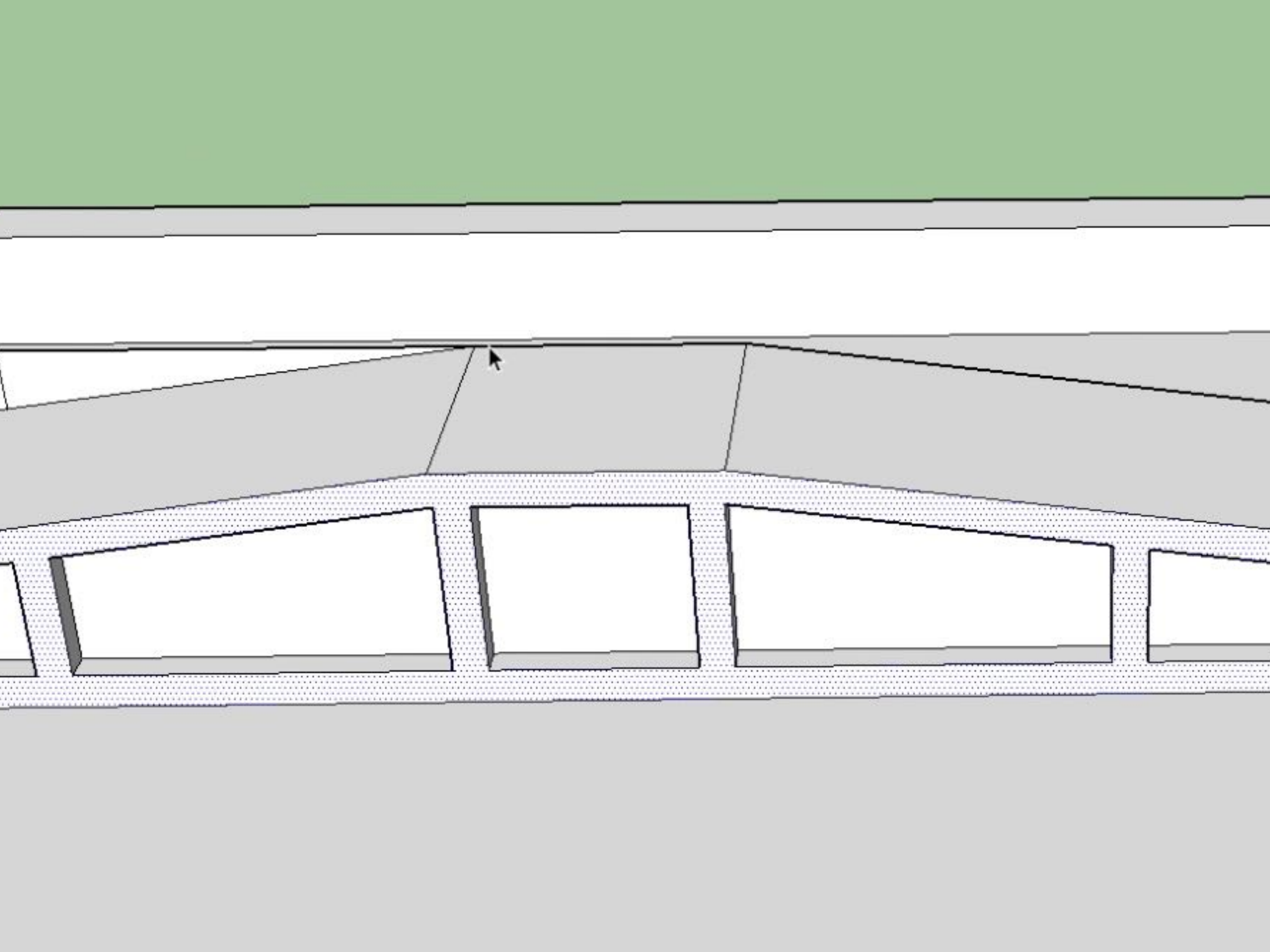
Offset limited to -6'

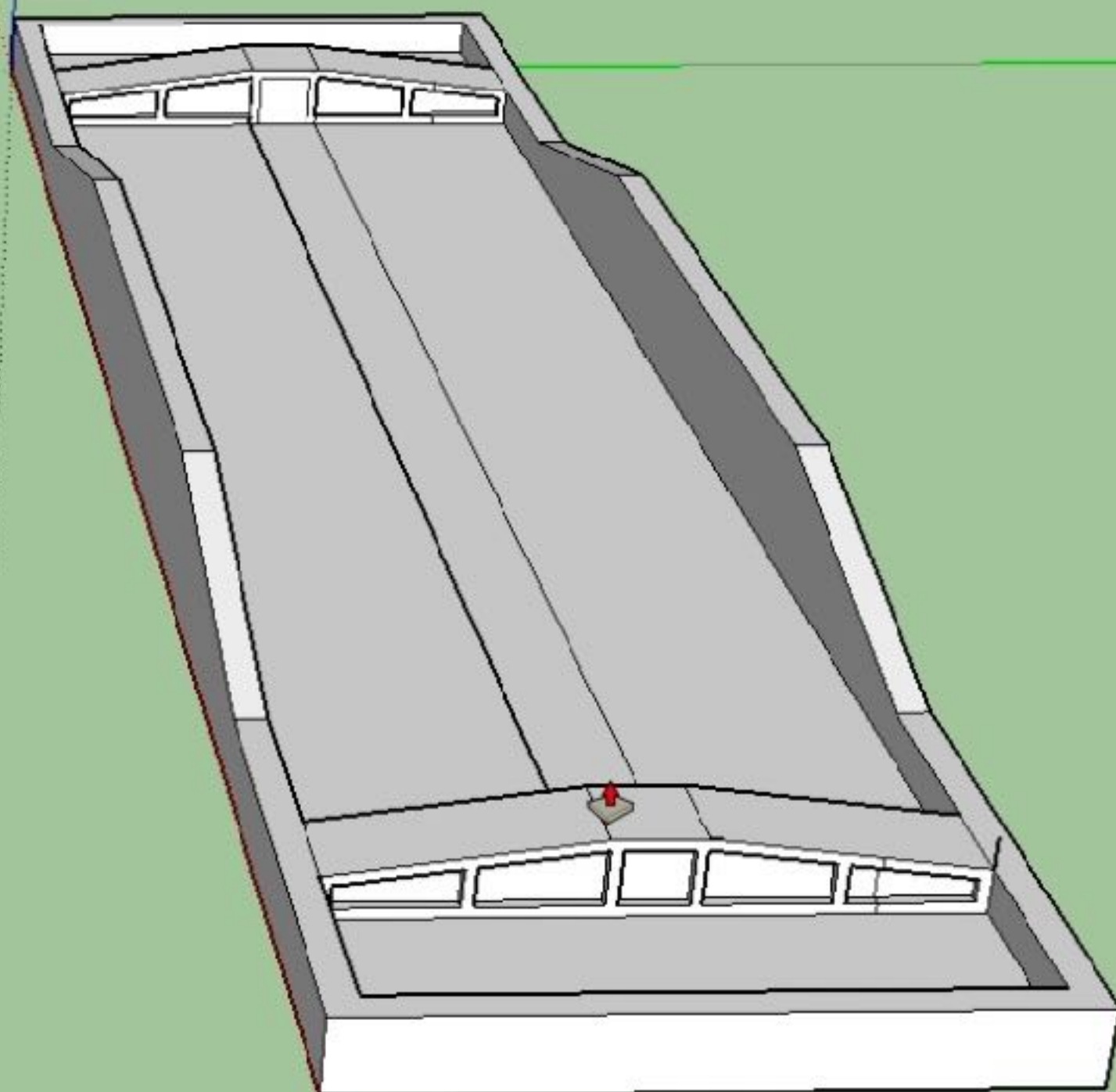


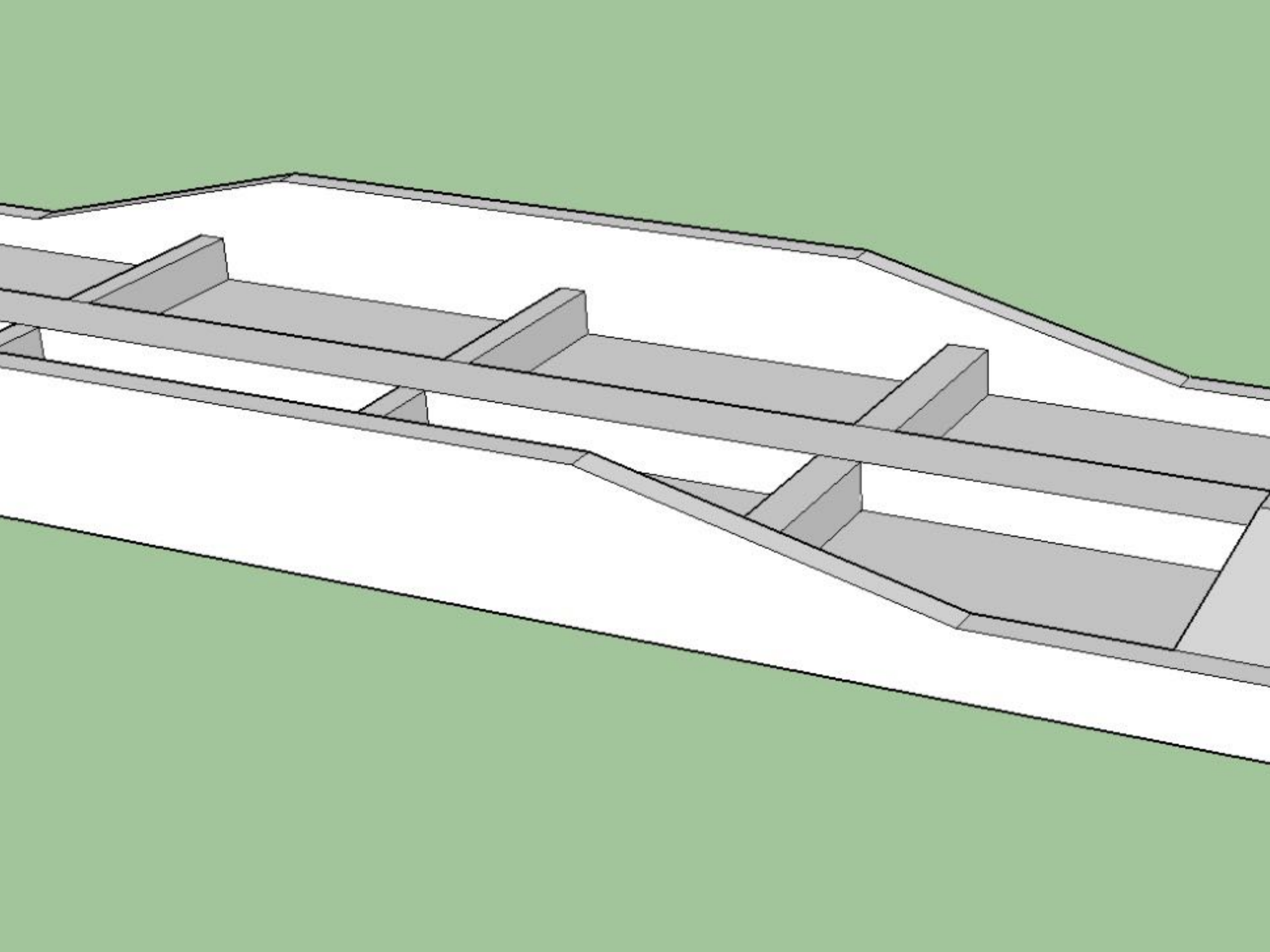


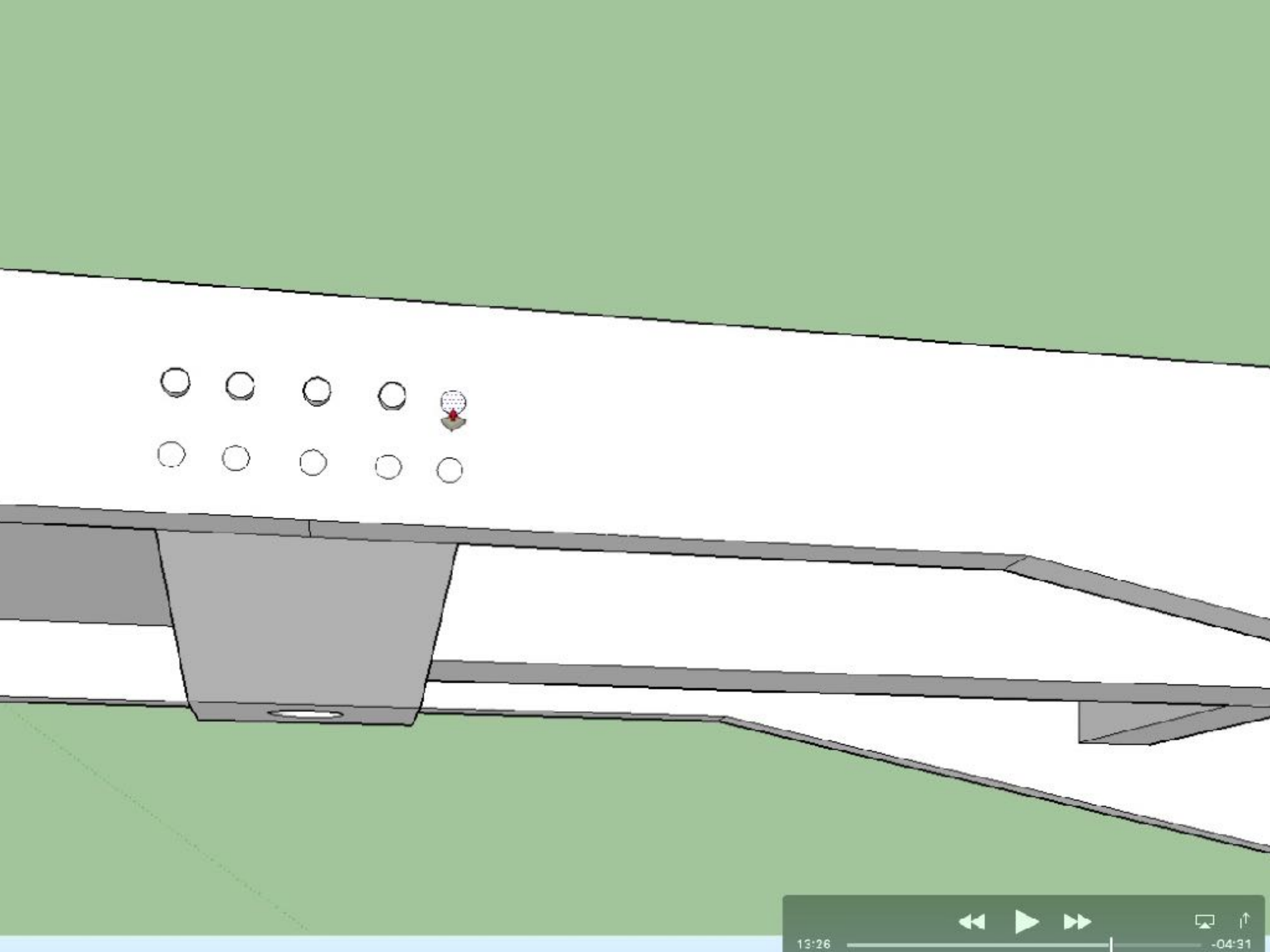
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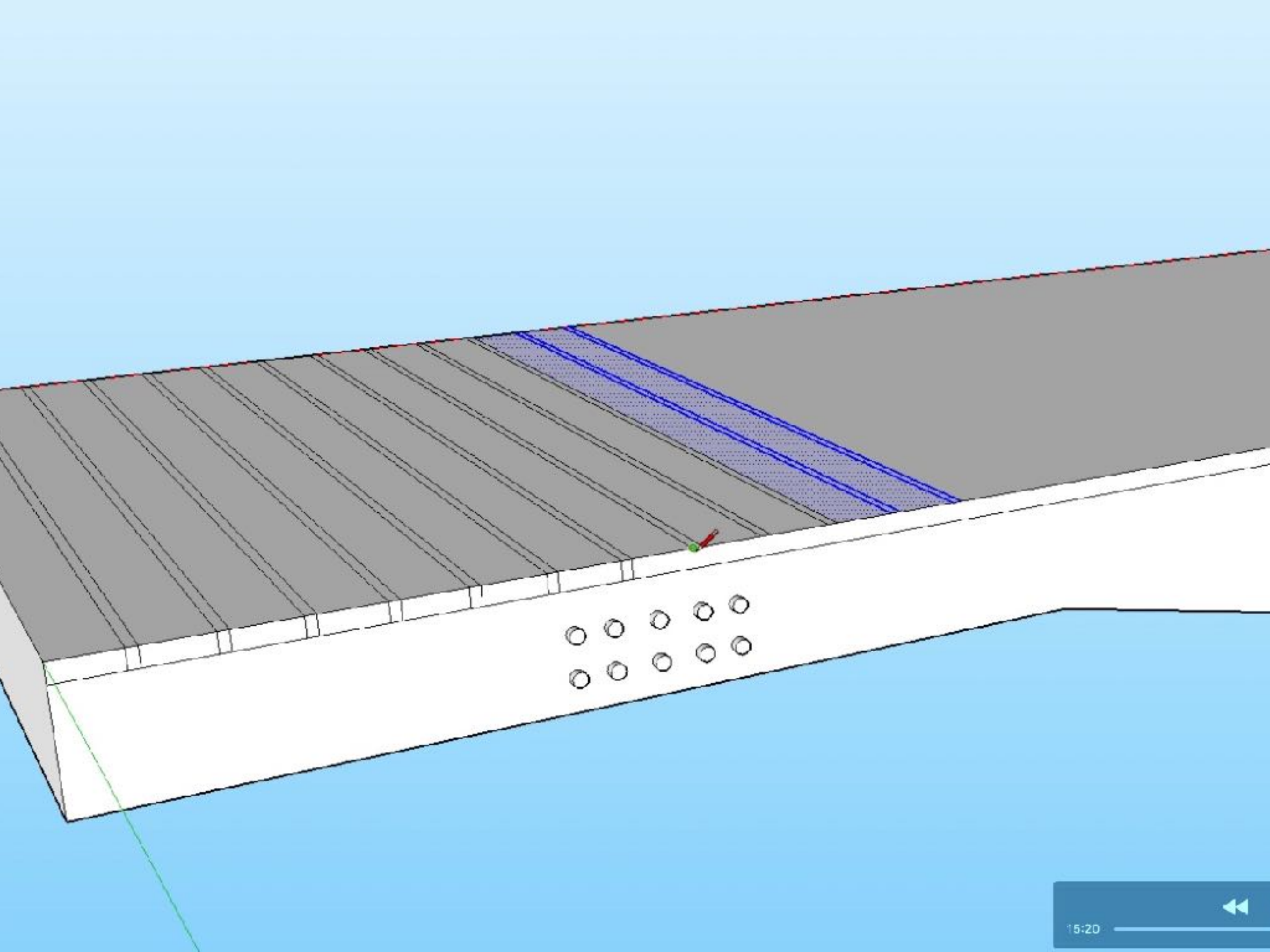


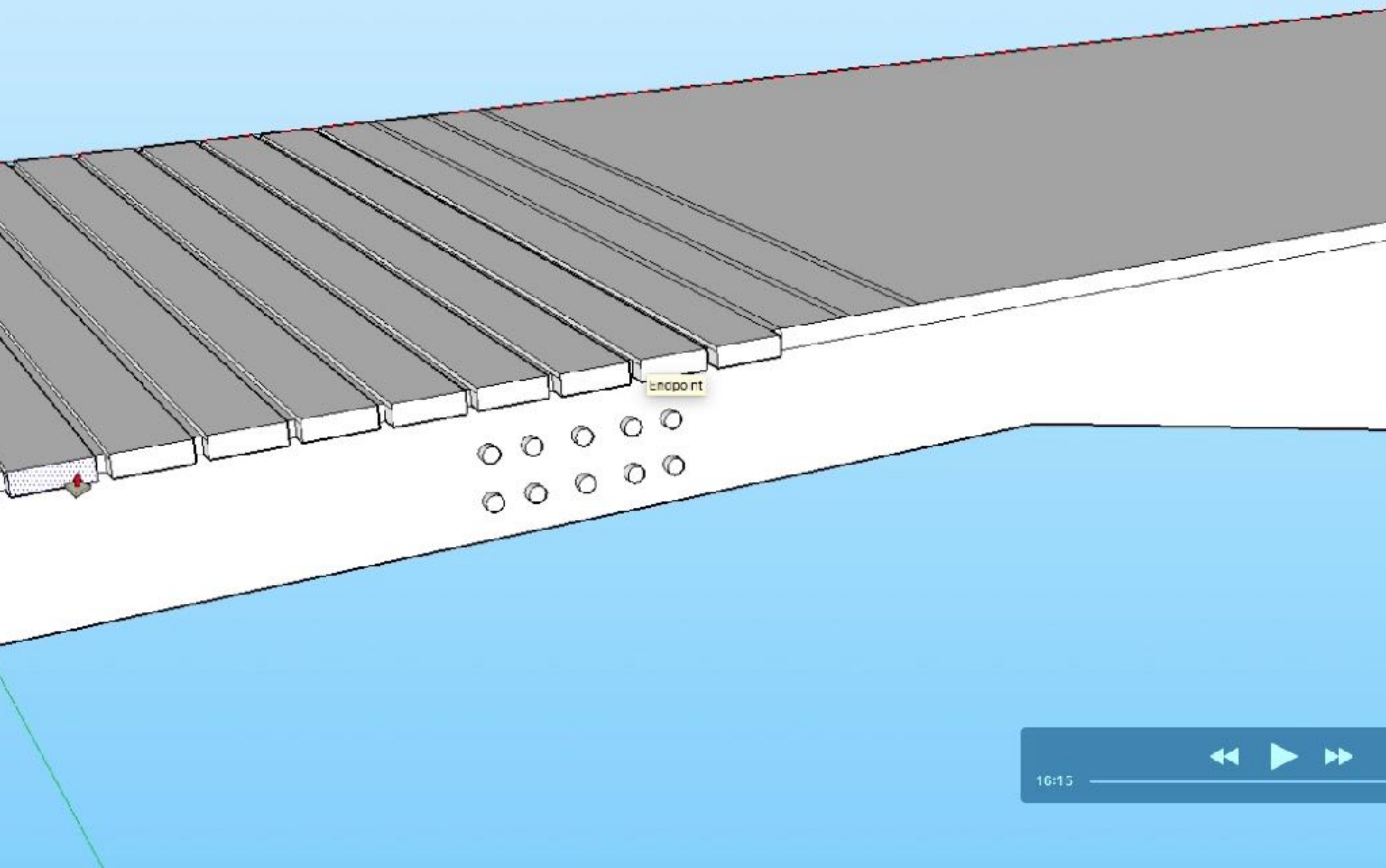


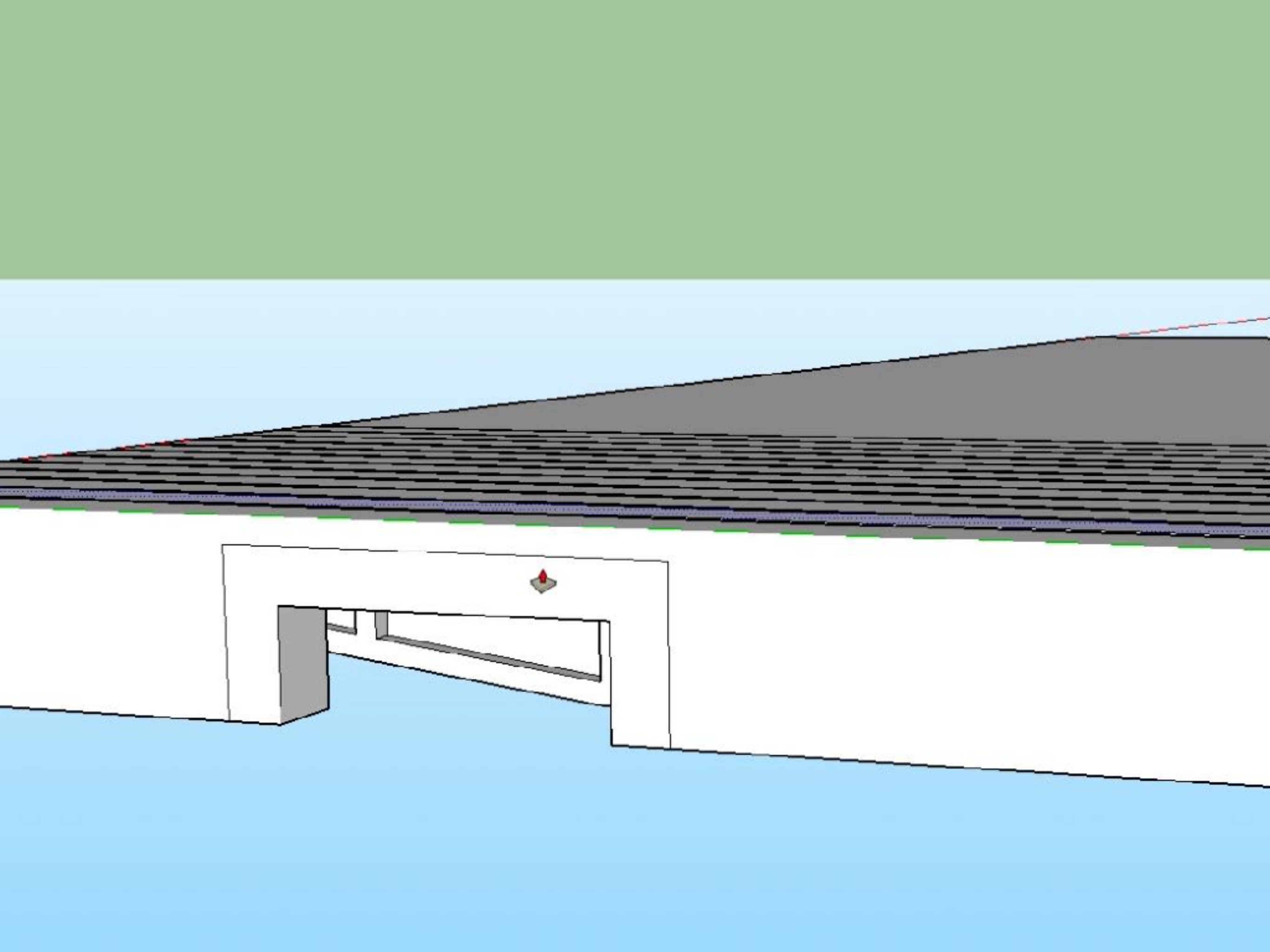


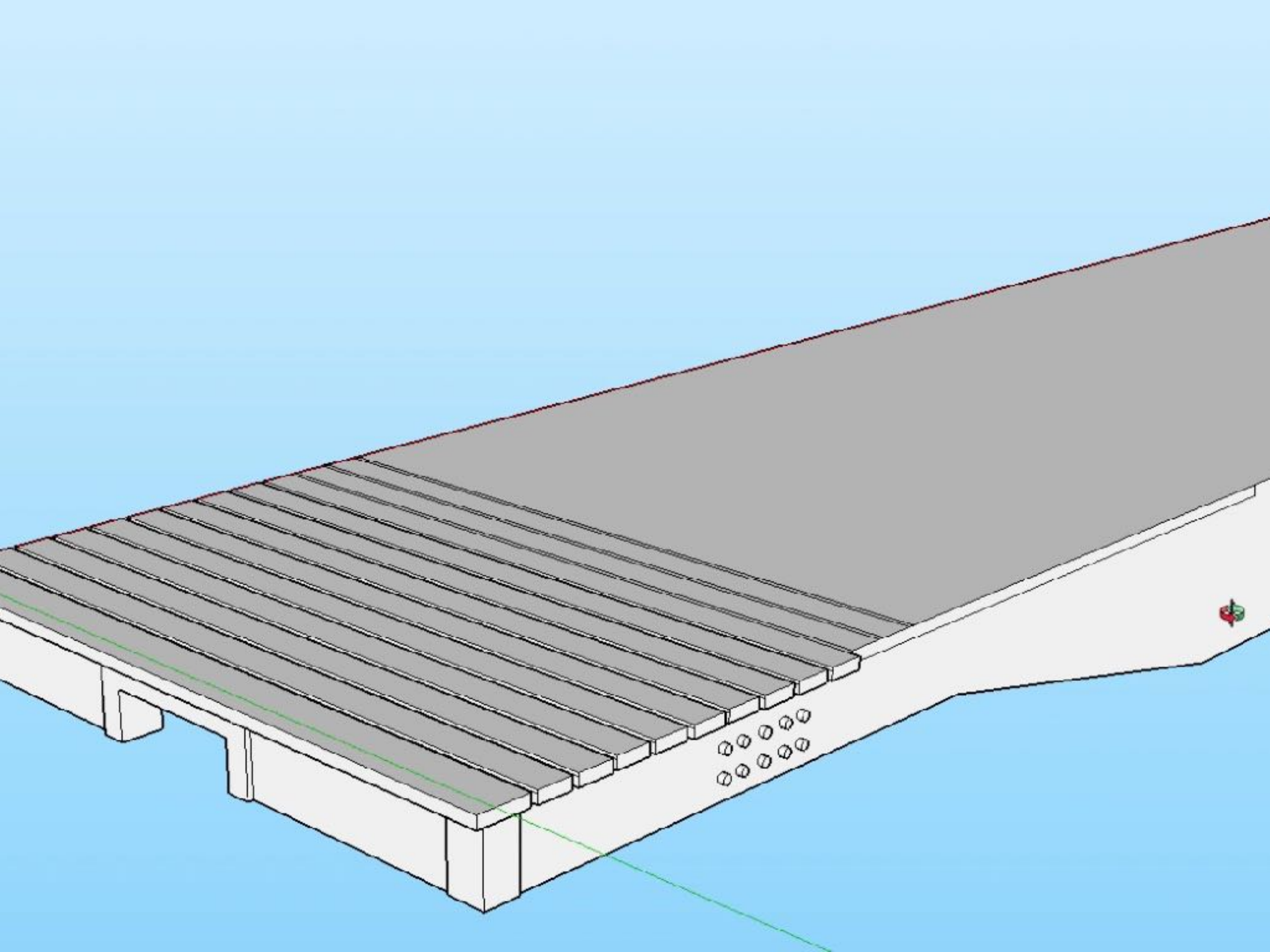




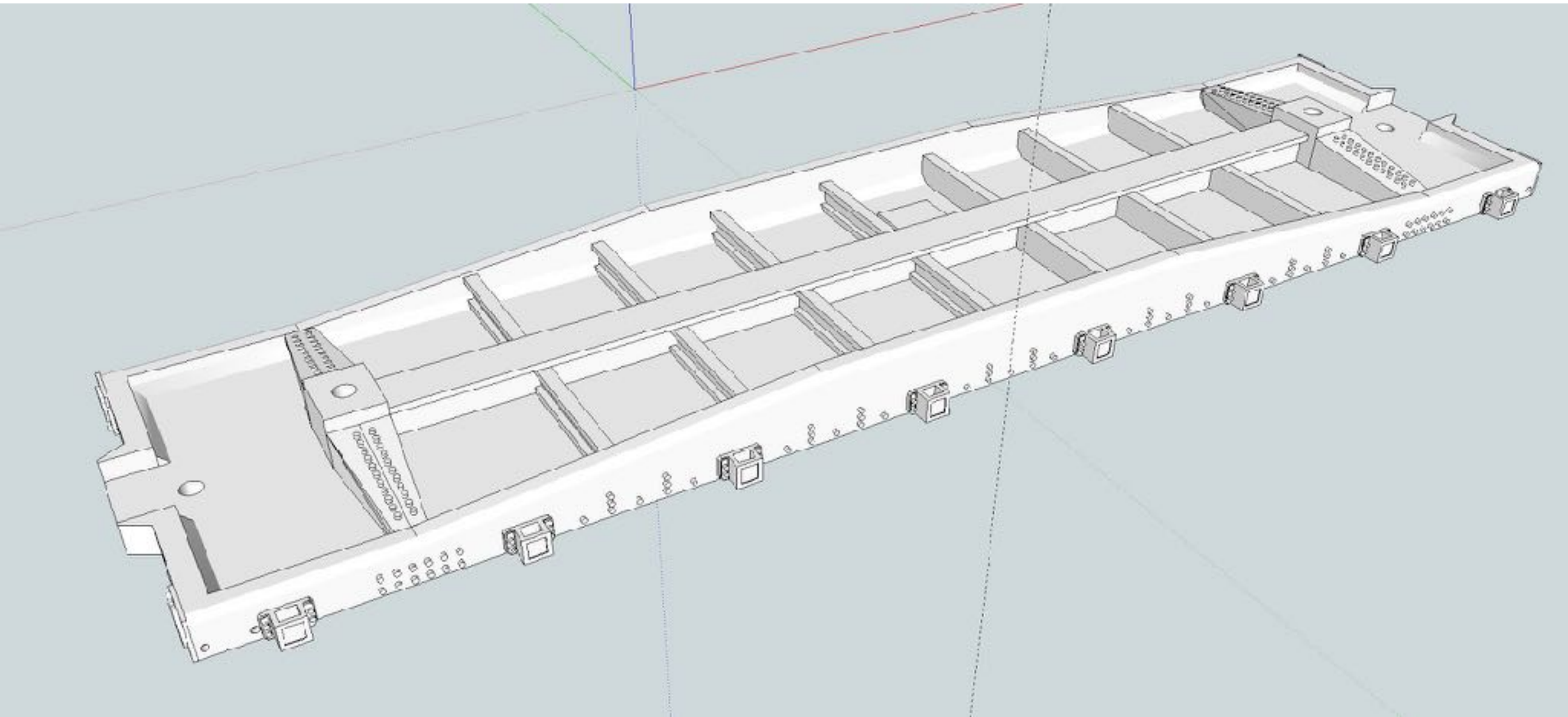






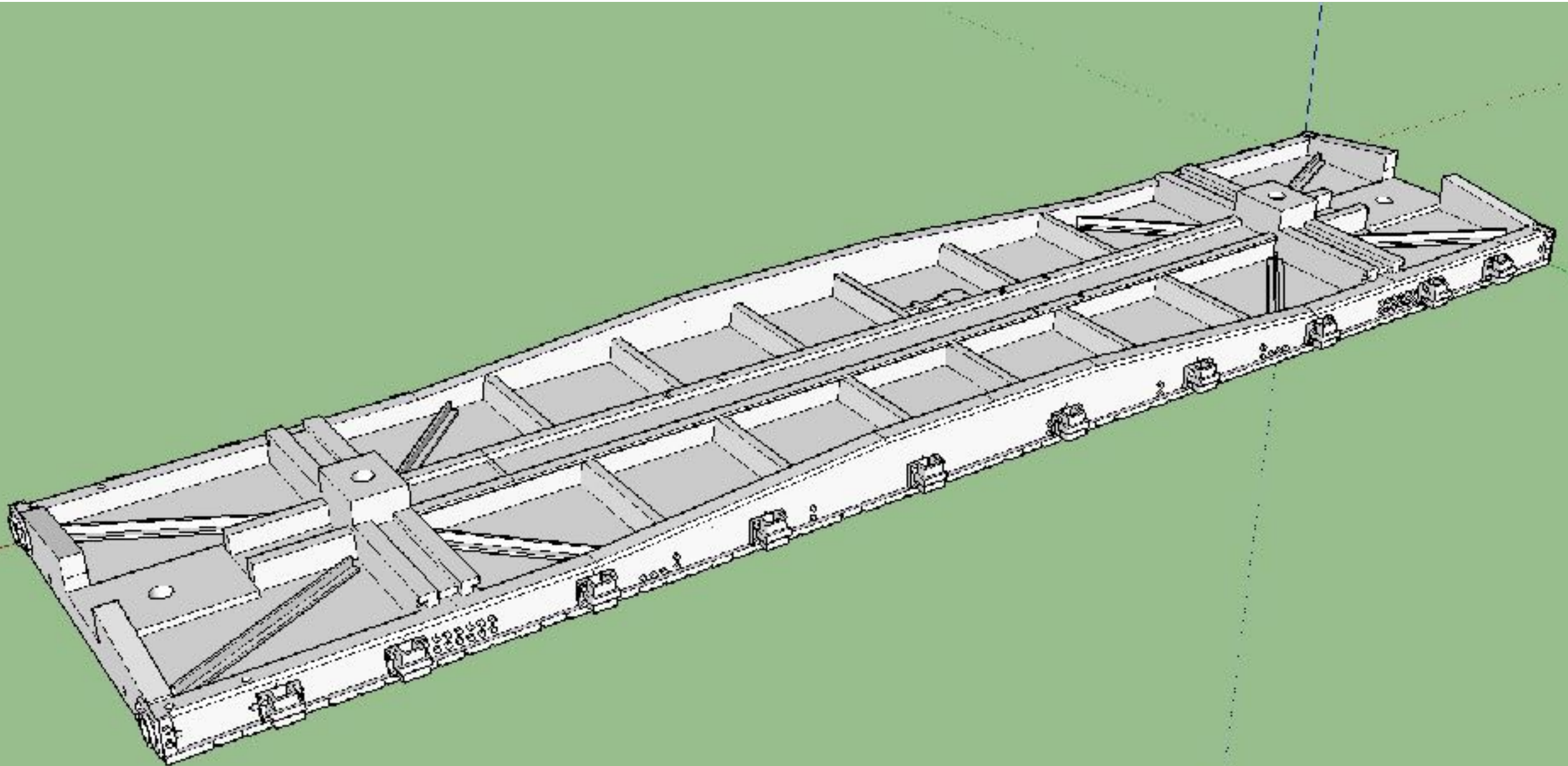


SP CS-35 36' Flat Car



(SketchUp file at thingiverse.com/bowdidge/designs)

SP CS-35A 40' Flat Car



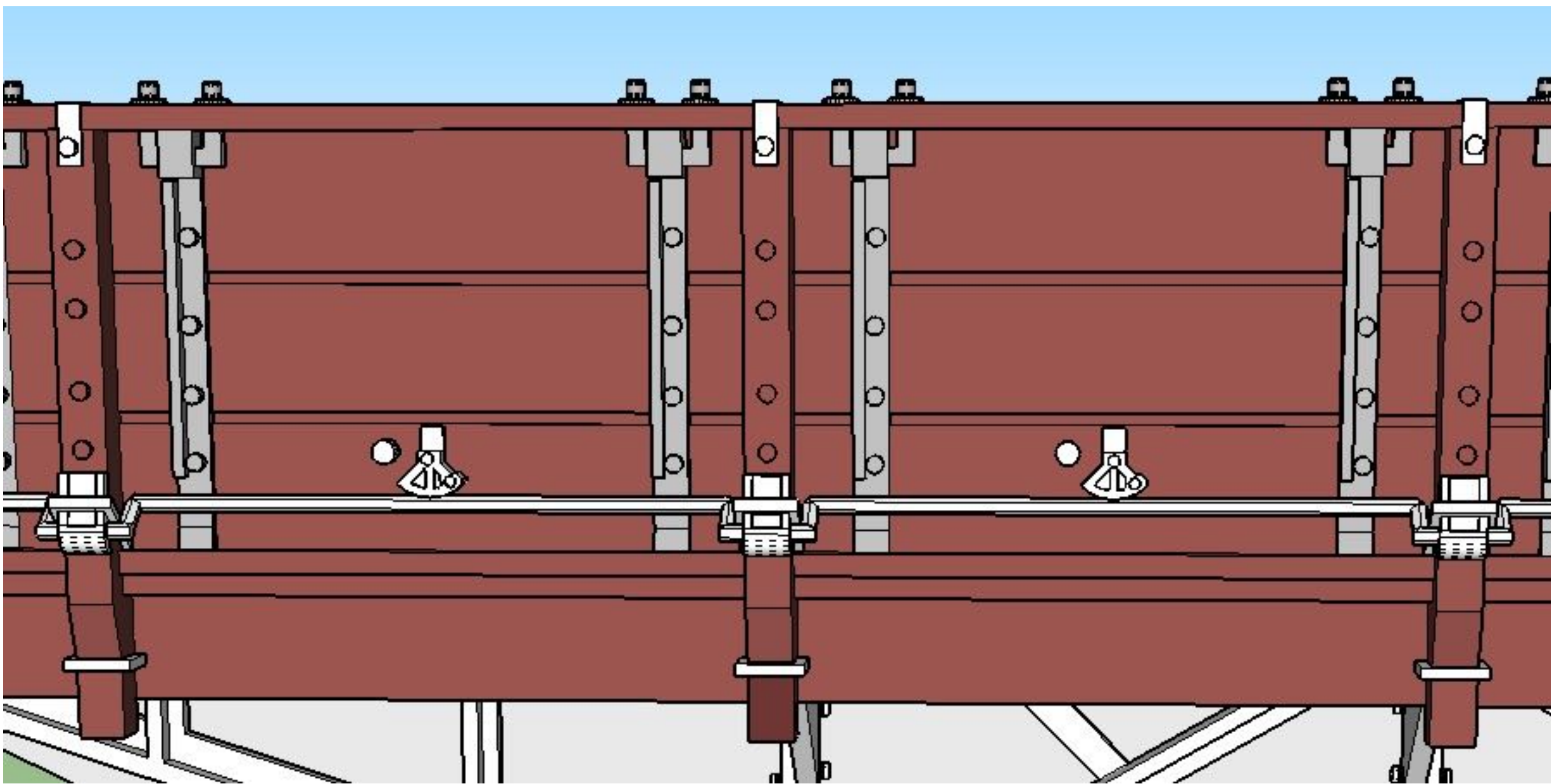
What's Easy in 3d Printing

- Choose models that you can't get otherwise
 - Can't be made from molds
 - Repeated, tedious details
 - Complex, difficult to assemble

Make In One Piece



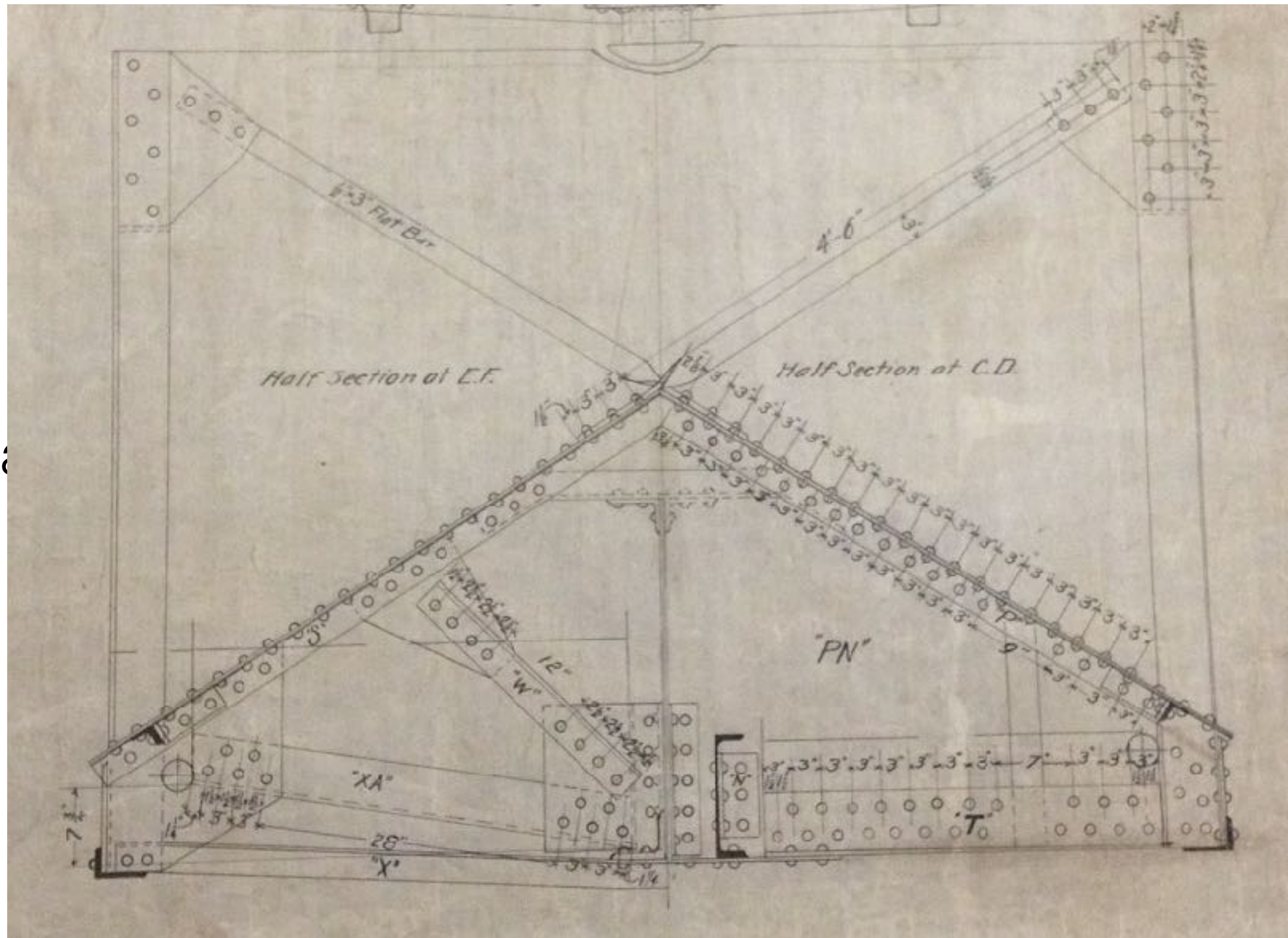
Find Repeated Parts

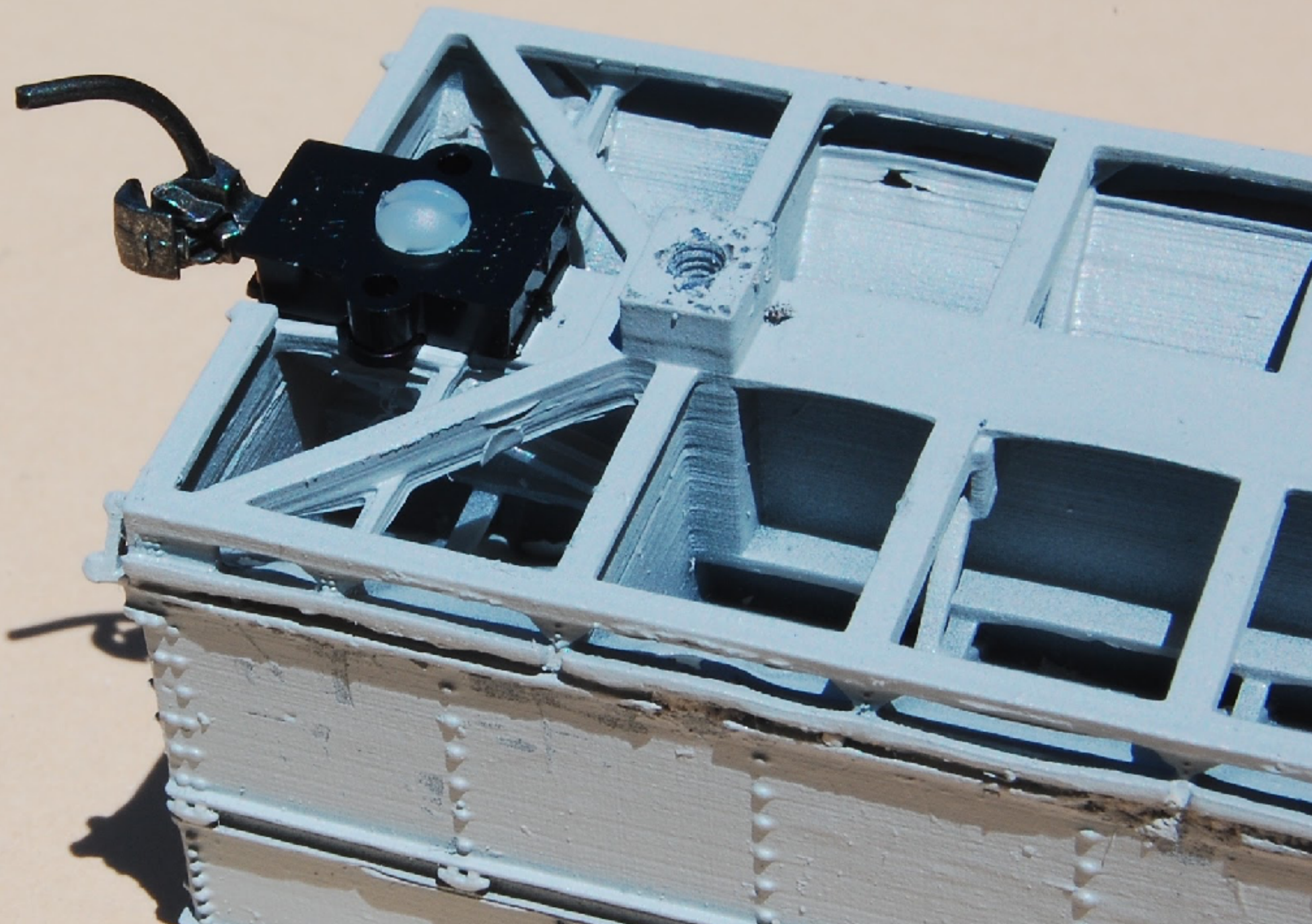


Use Floating Details

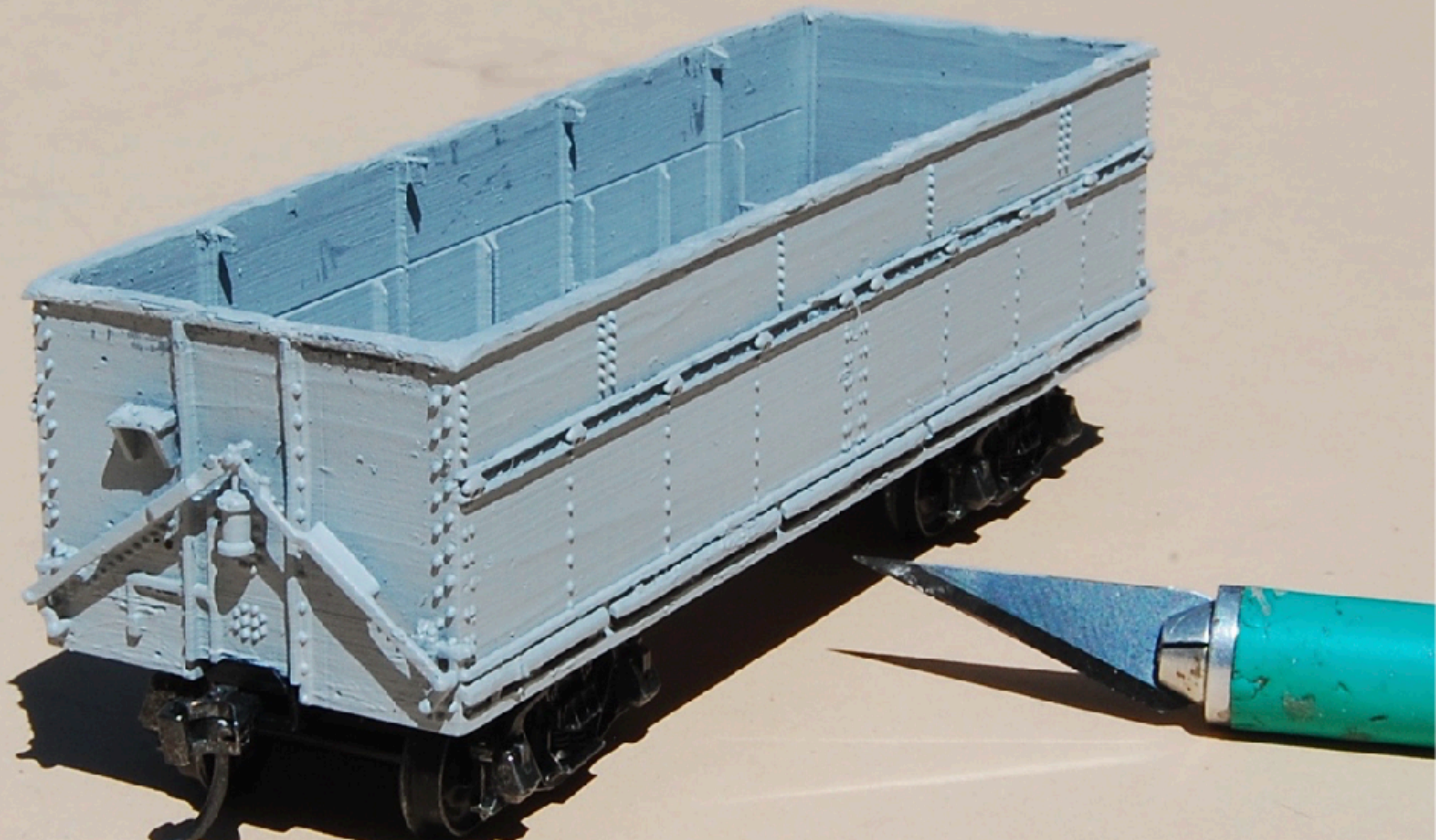


Add All the Detail





Detail on all sides

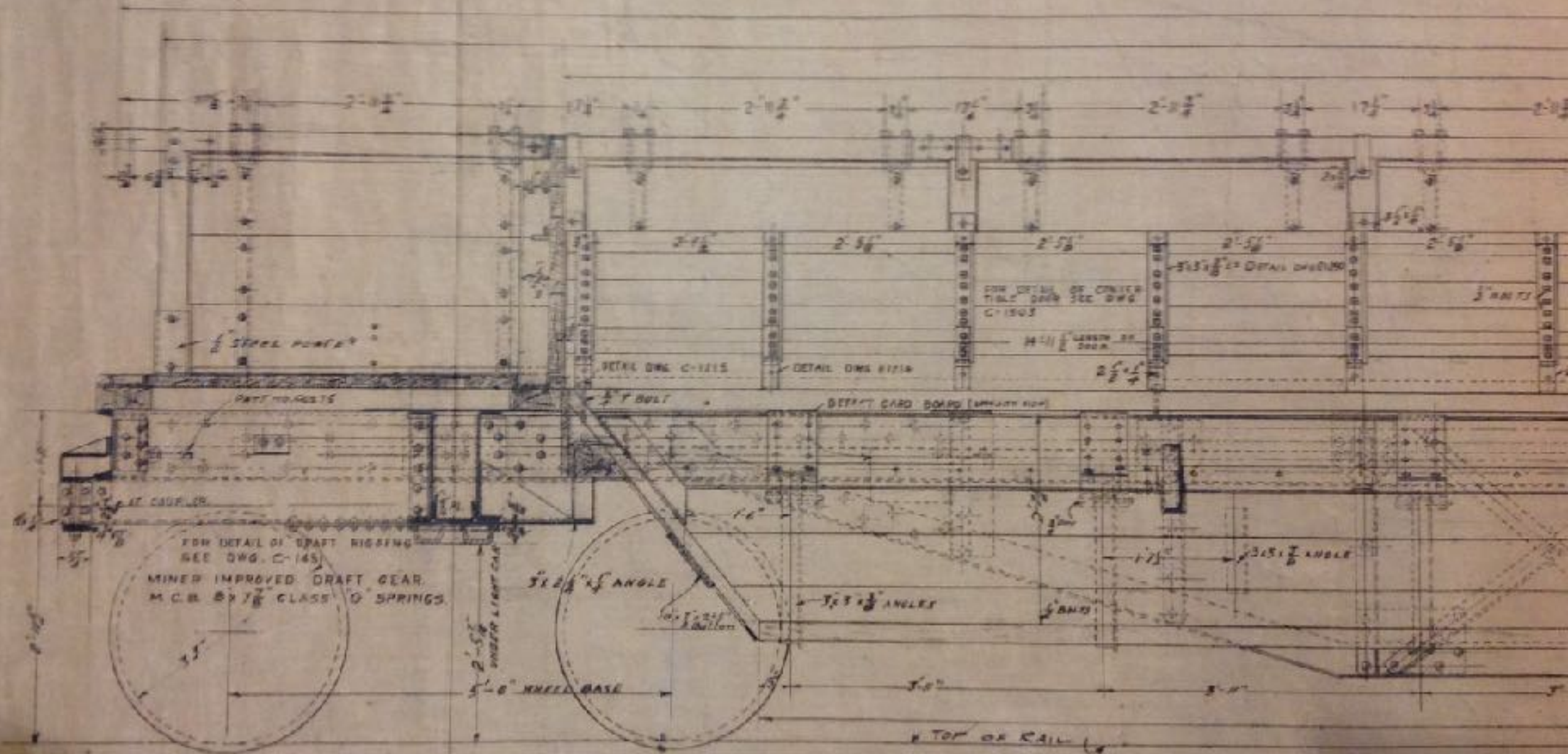


Throw On More Details

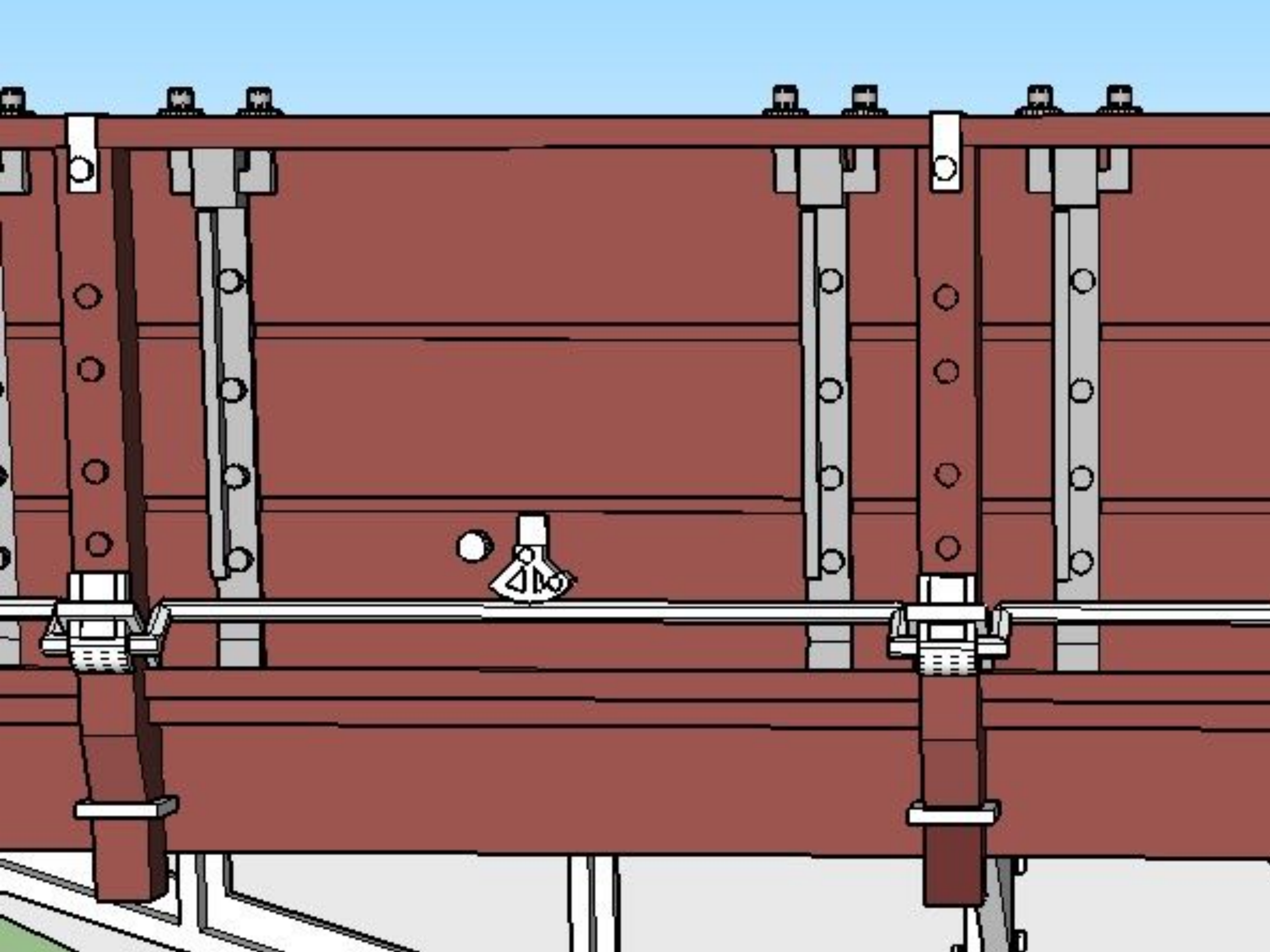


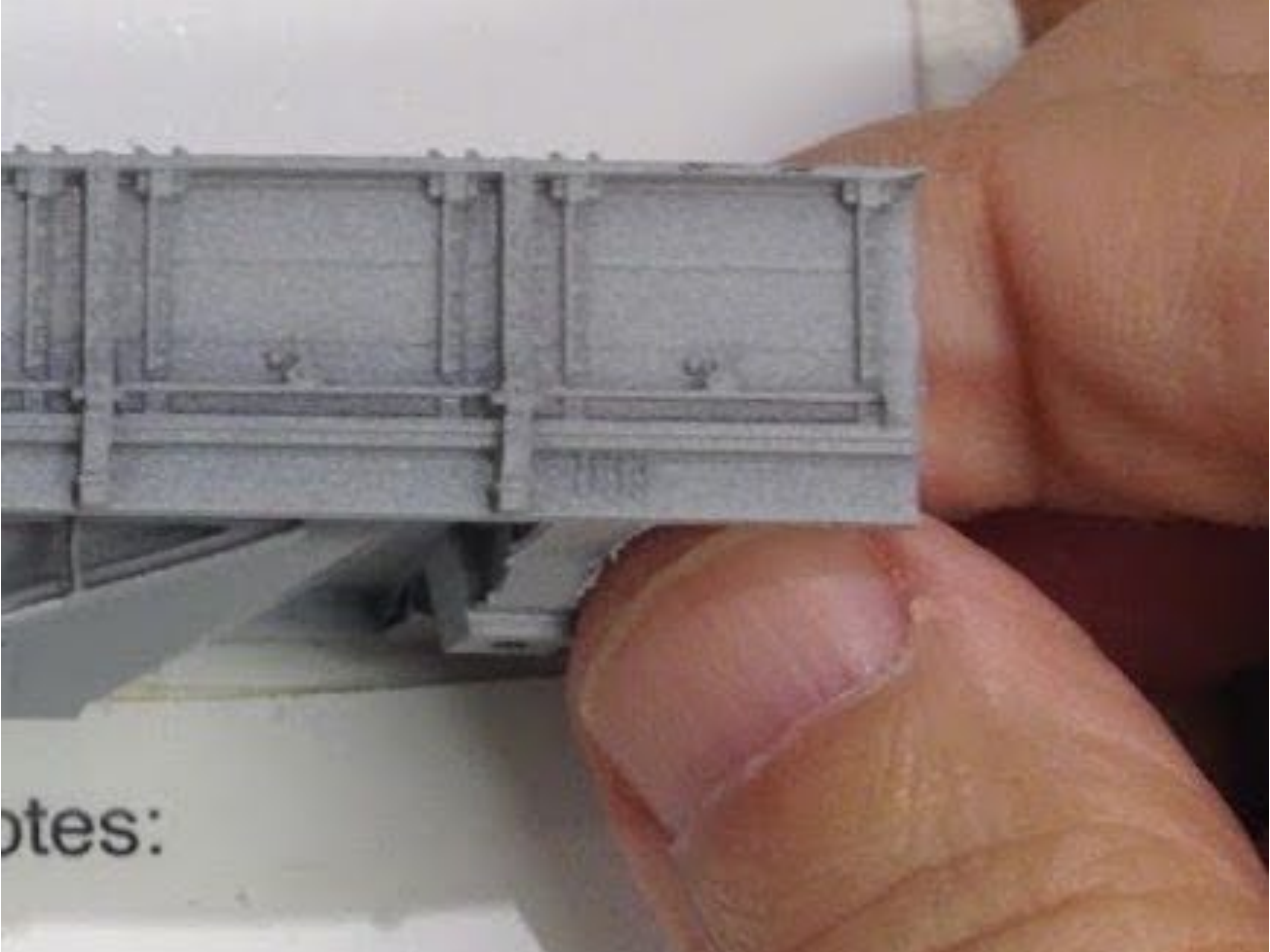
SECTION AND PLAN OF UNDERFRAME

41' 6" LENGTH OVER



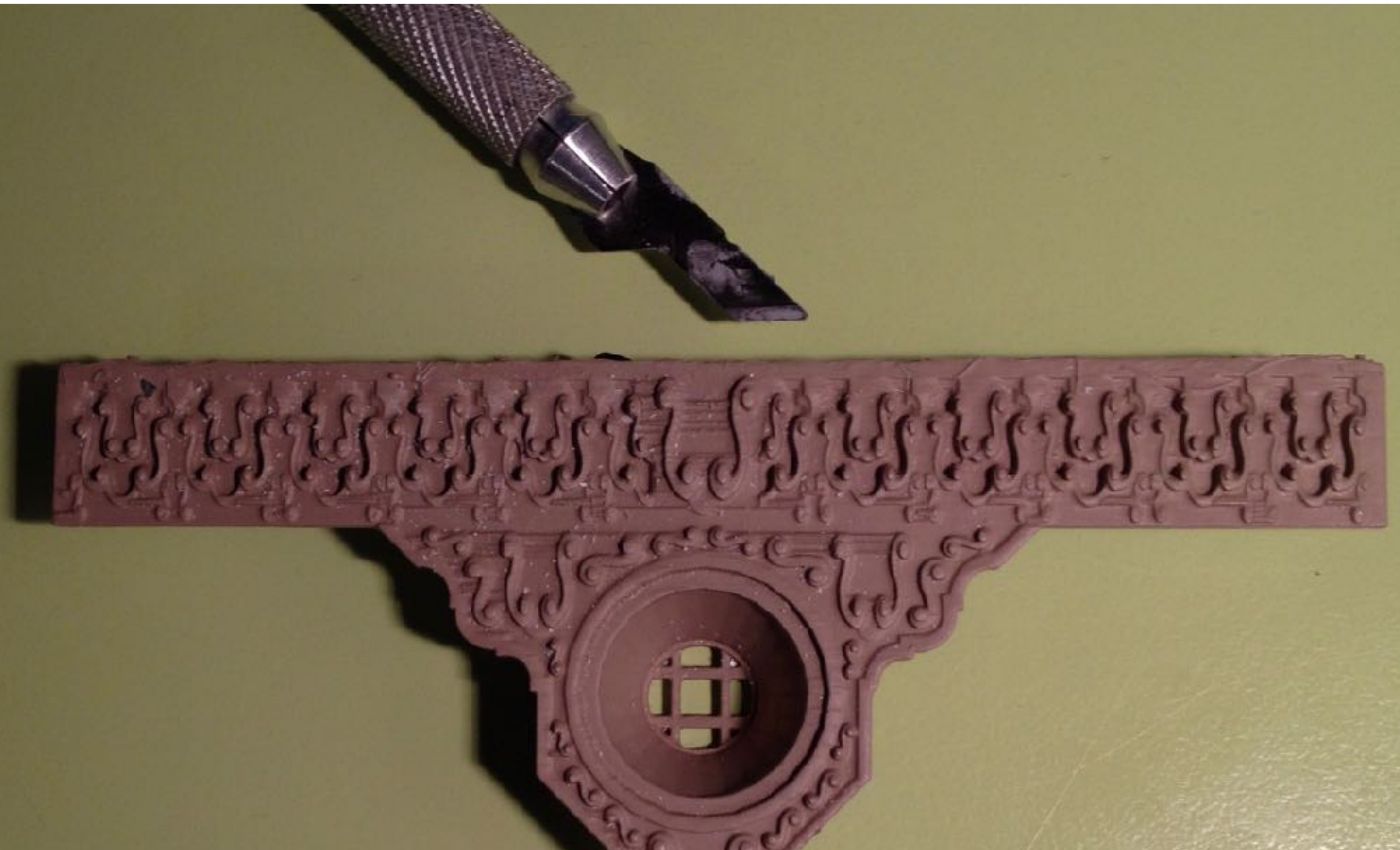
HALF LONGITUDINAL SECTION



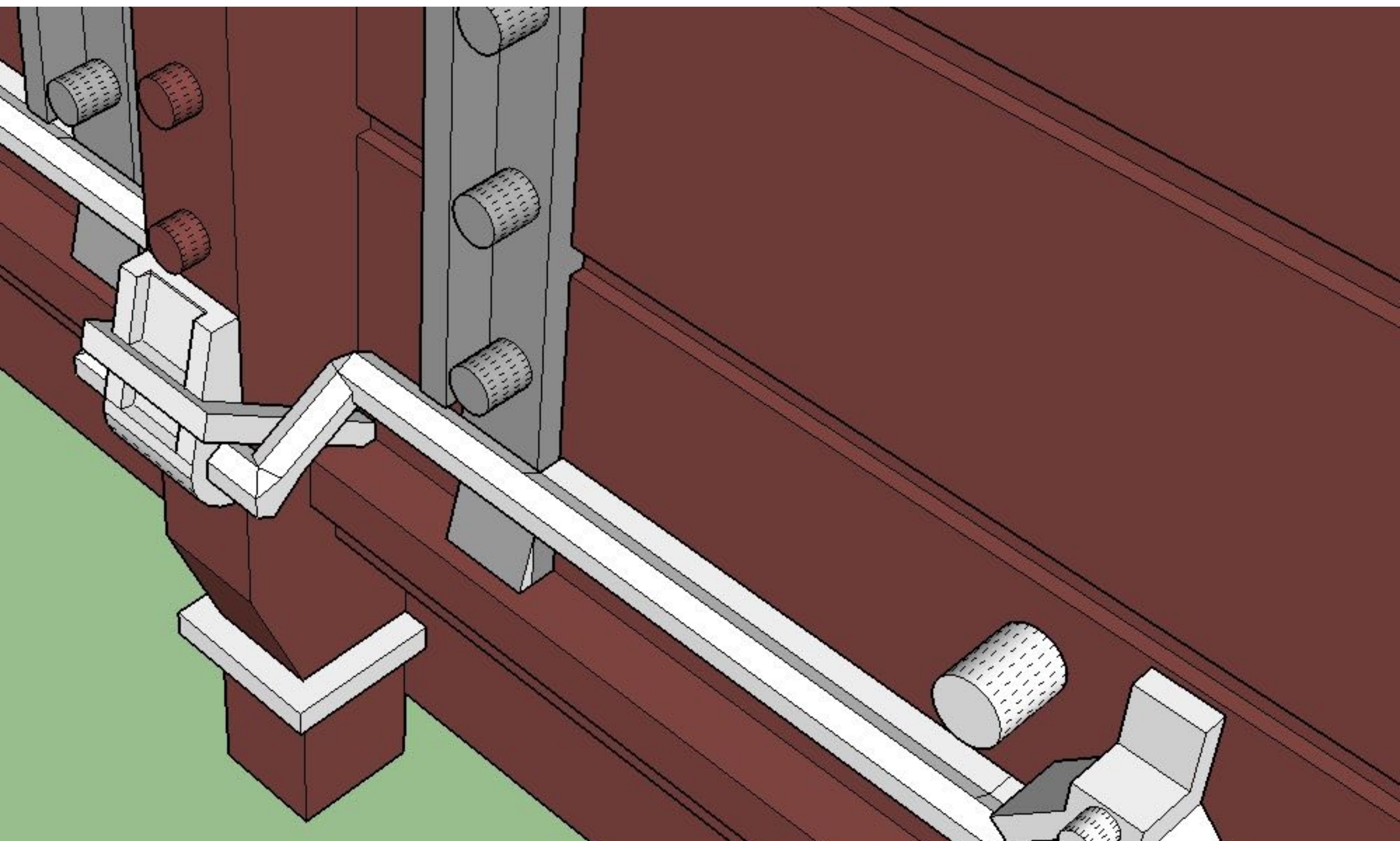


otes:

Emboss for Texture



Undercut details



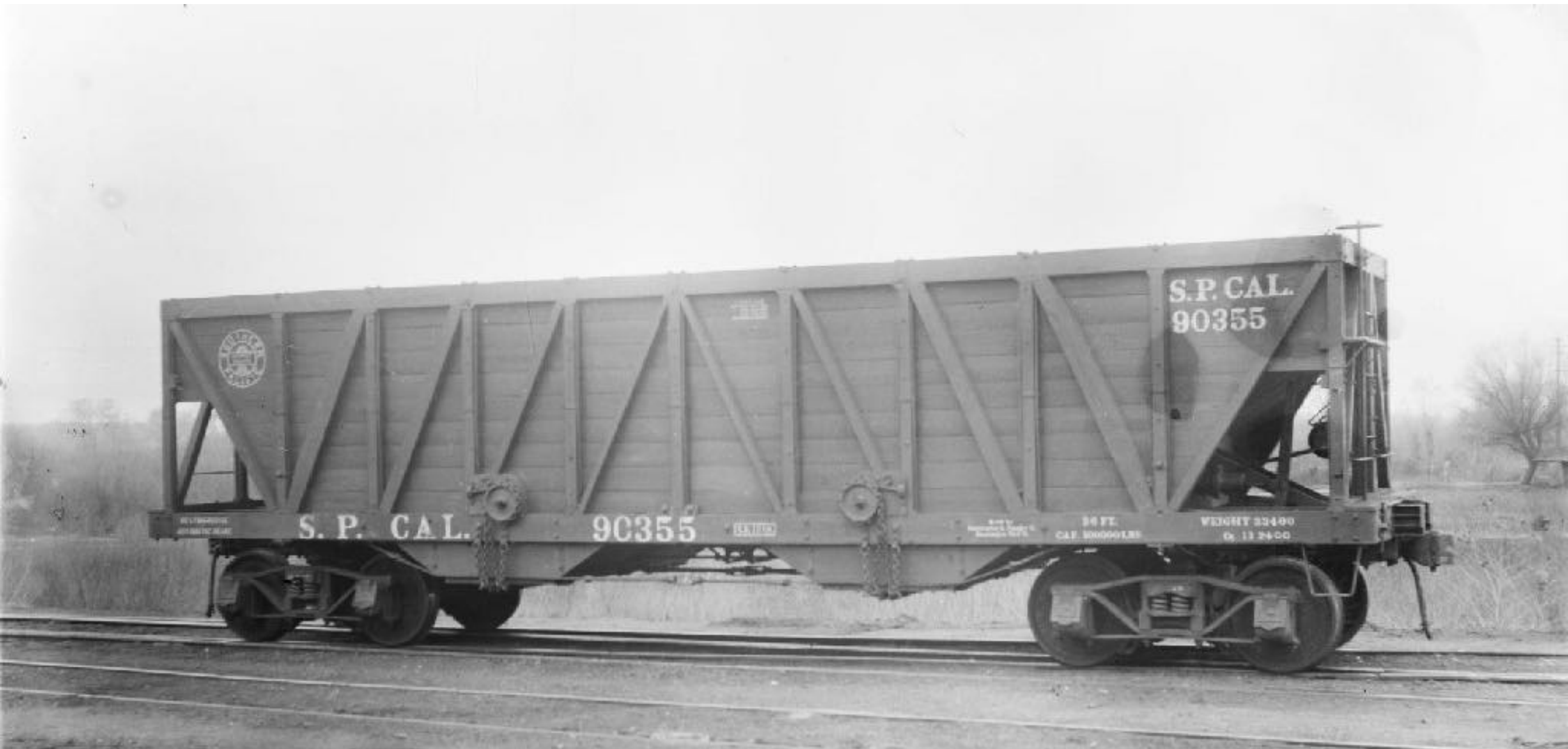
Make Multiple Variants



What's Hard in 3D Printing

- Surface still a bit rough - better for wood than metal
- Plain flat surfaces easier to add with styrene sheet
- Warping an issue with thinner pieces
- Requires effort of resin kit to finish
- Size limits on printers, cost of Shapeways

Good Cars To Make



Good Cars To Make

Garth Groff photo, wplives.org



Design Guidelines

Measurement	Form One (HO scale)	Formlabs (inches)	Shapeways FUD (inches)
Minimum wall thickness	2"	0.015"	0.02"
Minimum unsupported wall	2"	0.023"	0.023"
Minimum thickness for handling	4"		
Minimum unsupported overhang		.0.040	
Maximum span		0.087"	0.082"
Minimum wire width	1"	0.012"	0.023"
Minimum unsupported wire		0.060"	0.060"
Minimum embossed detail	.75"	0.003"	0.006"
Minimum engraved detail	.50"	0.013"	0.015"
Minimum hole diameter	6" (clean), 2" (pilot hole)	0.023"	0.019"

Levels of Effort

1 - 3 cars

Make one freight car.

5 - 10 cars

Make a few freight cars for me.

10 - 30 cars

Make freight cars for friends.

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Sell freight cars.

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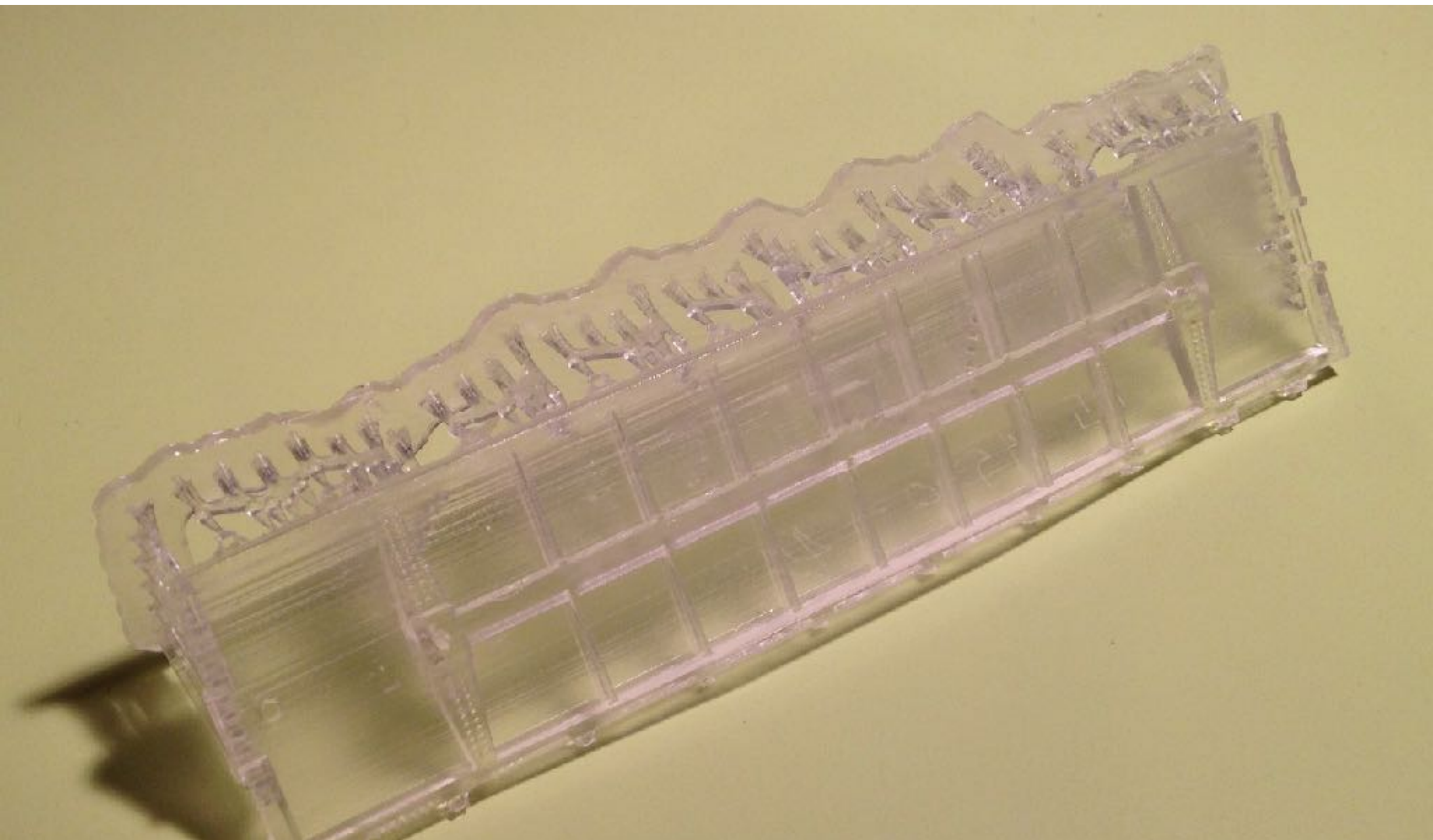
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Tweaking the design

- Speed: print more than one, change orientation
- Yield: fix details and support structures to get more good models.
- Cost: adjust design to cut material, support structure
- Usability: weight, coupler height, truck height, turning radius

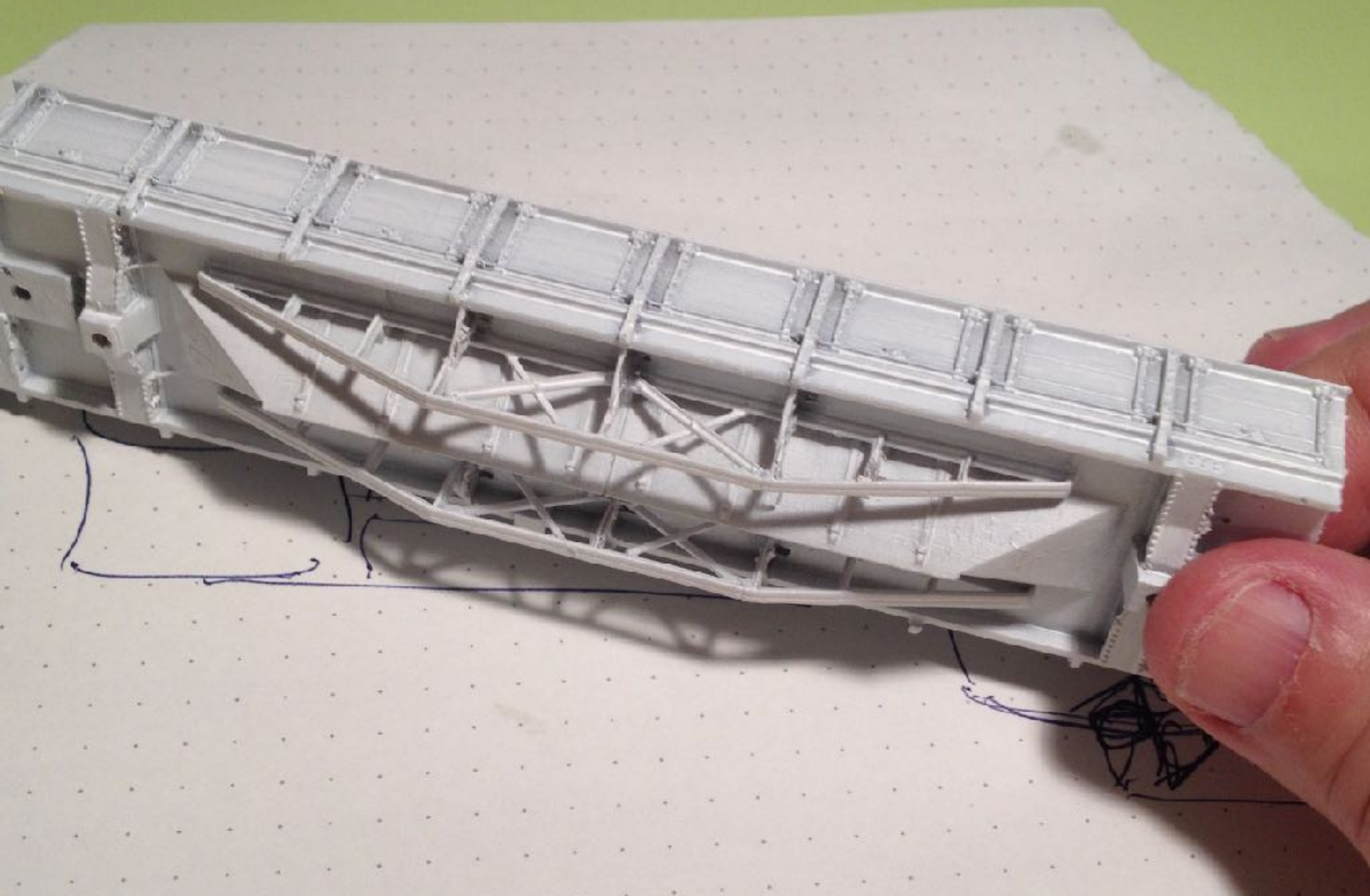
Speed





Yield

- Why are details like vertical posts printing badly?
- What areas are hard to trim?
- How do I cure the models? How do I fight warping?

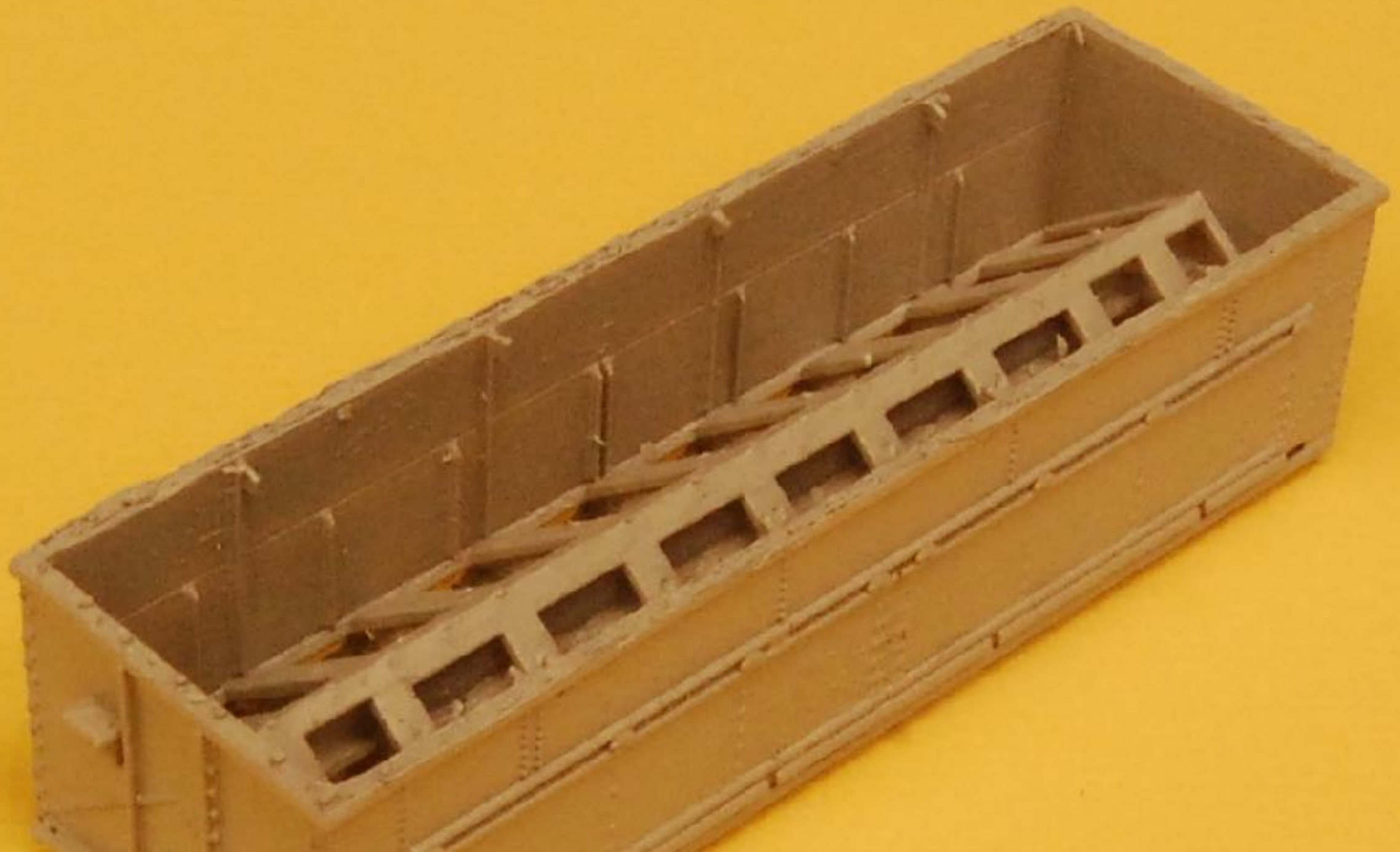




Minimize support structure



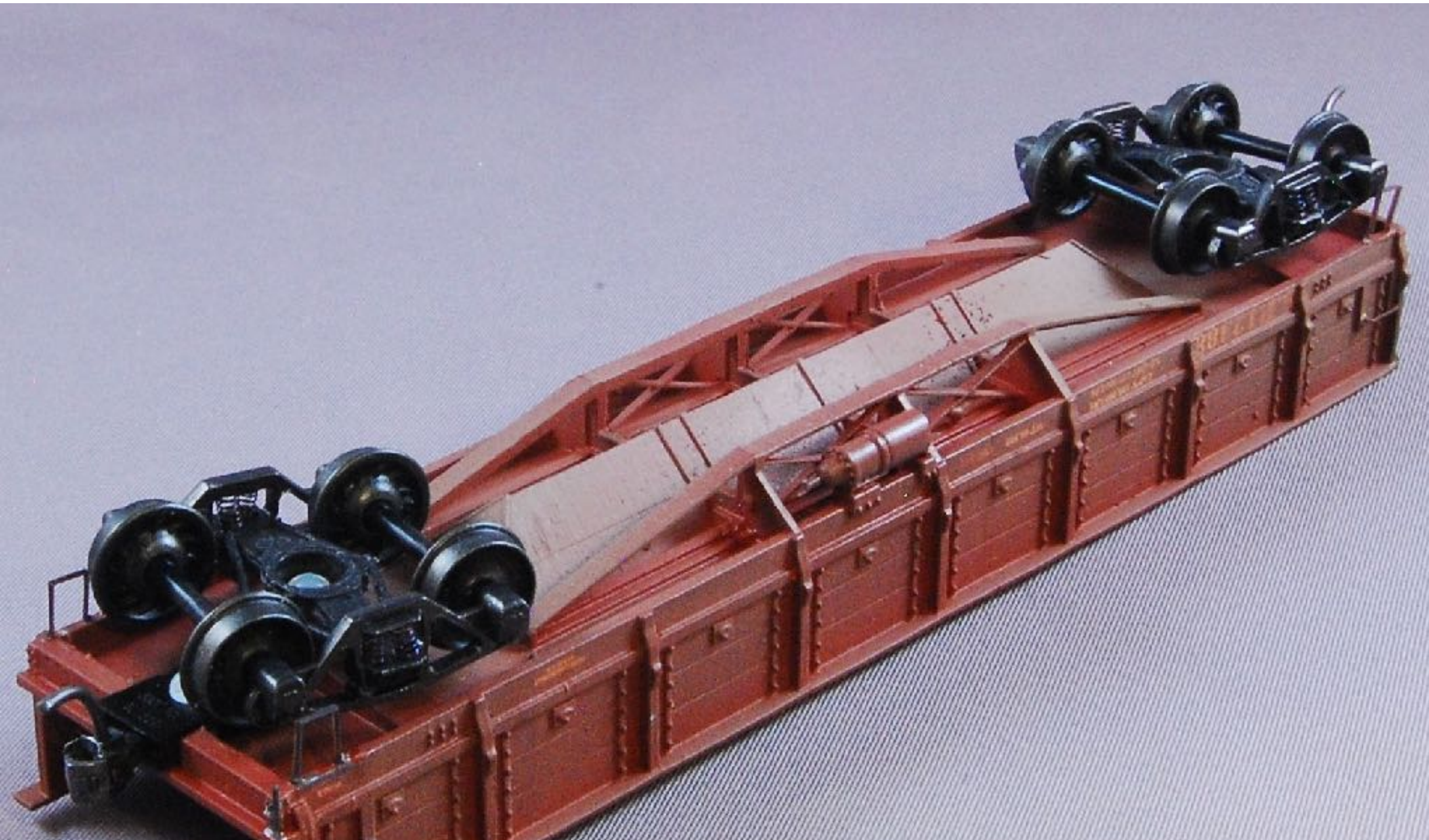
Don't Print Big Flat Areas



Weight



Weight



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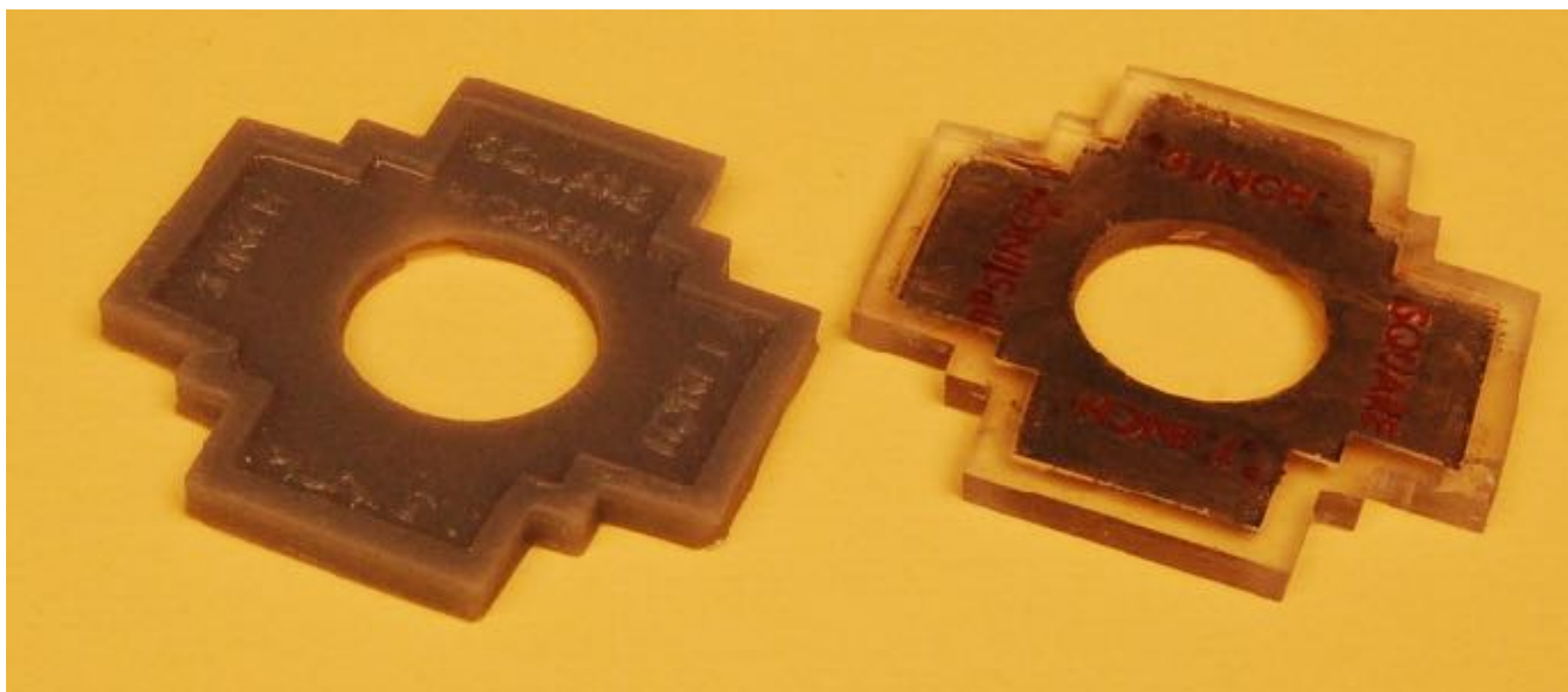
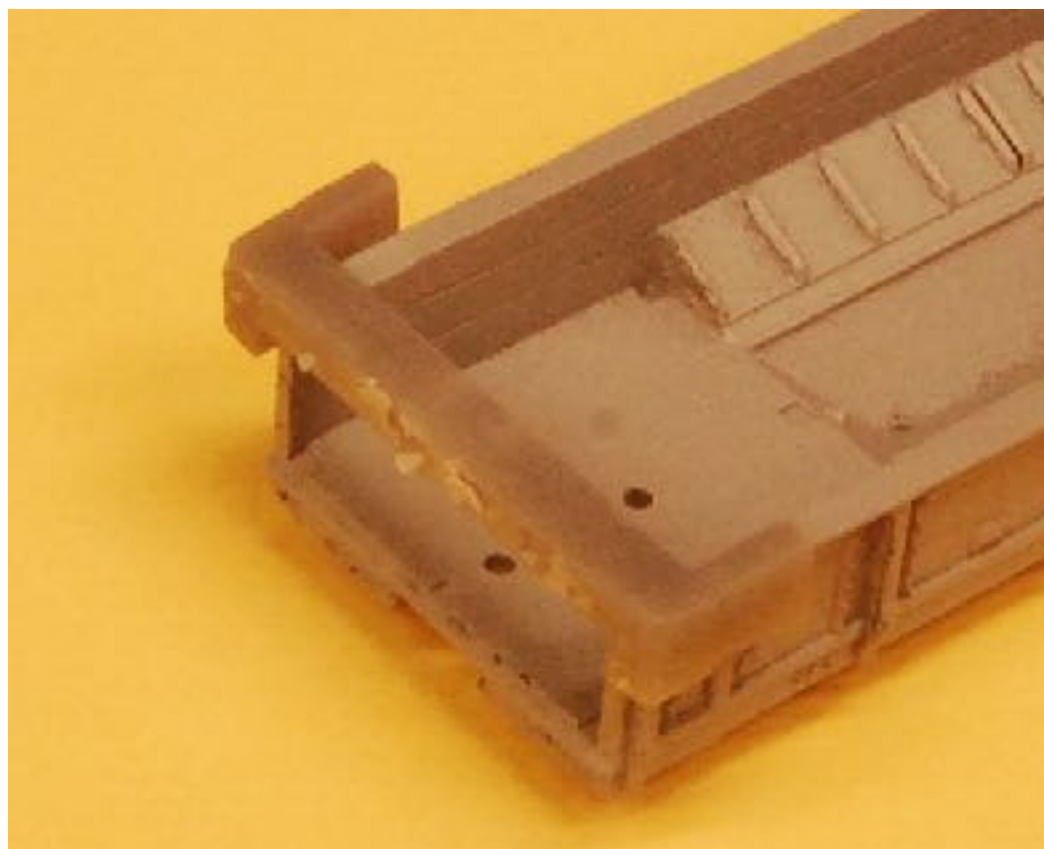
Sell freight cars.

In real manufacturing,
making fifty is a test run.

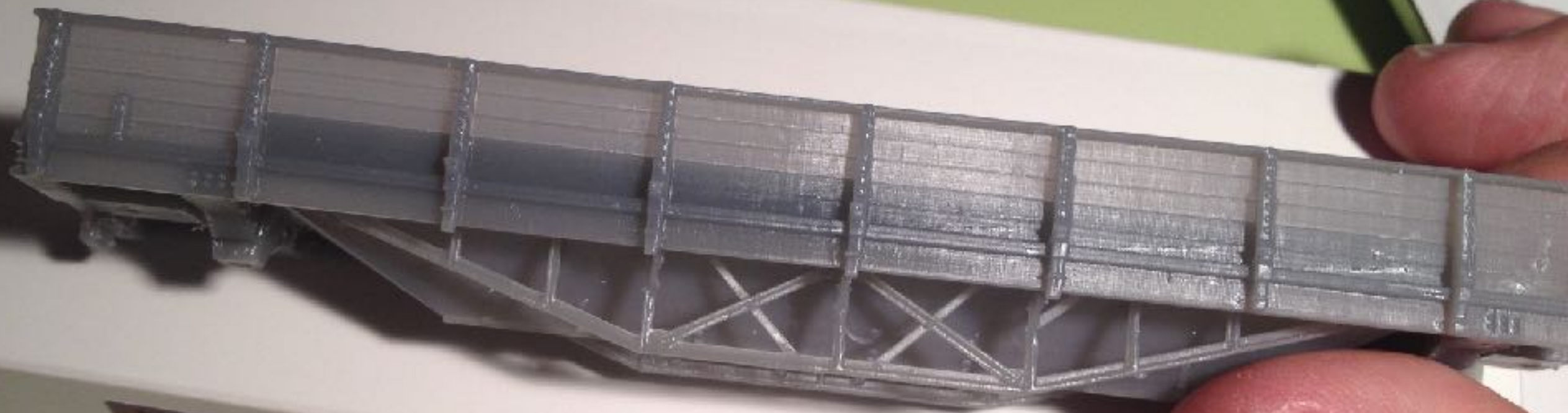
For me, that's next year's
sales.

Mass-Producing

- Quick decisions
- Comparing several prints
- Go / No-Go Gauges
- Records, checklists, photos
- Fixing almost good enough models



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Hart Gondola Inspection

Quick Inspection:

- ☐ All holes drilled and tapped.
- ☐ Look over entire model for any obvious debris or damage.
- ☐ **Reject or rework for obvious damage.**
- ☐ Clean any easily-removable flakes.

Check sides:

- ☐ Check most brackets for door rods ok.
- ☐ Check all side posts are whole.
- ☐ If more than a few posts are hollowed out, reject.

Check underside:

- ☐ Check that truss is complete, and vertical posts exist.
- ☐ Check that gussets are whole (ok to have holes in 1-2). **OK to fill holes with resin.**

Run # 51
110 : 2

Notes: *1 broke during assembly*

Printed: 3/10 Cured: 3/11
Cut: 3/11 Painted: 5/1
Drilled: 3/11 Tapped: 3/16
Inspected: 3/16

3/23

Drilled: 3/23 Tapped: 3/23
Inspected:

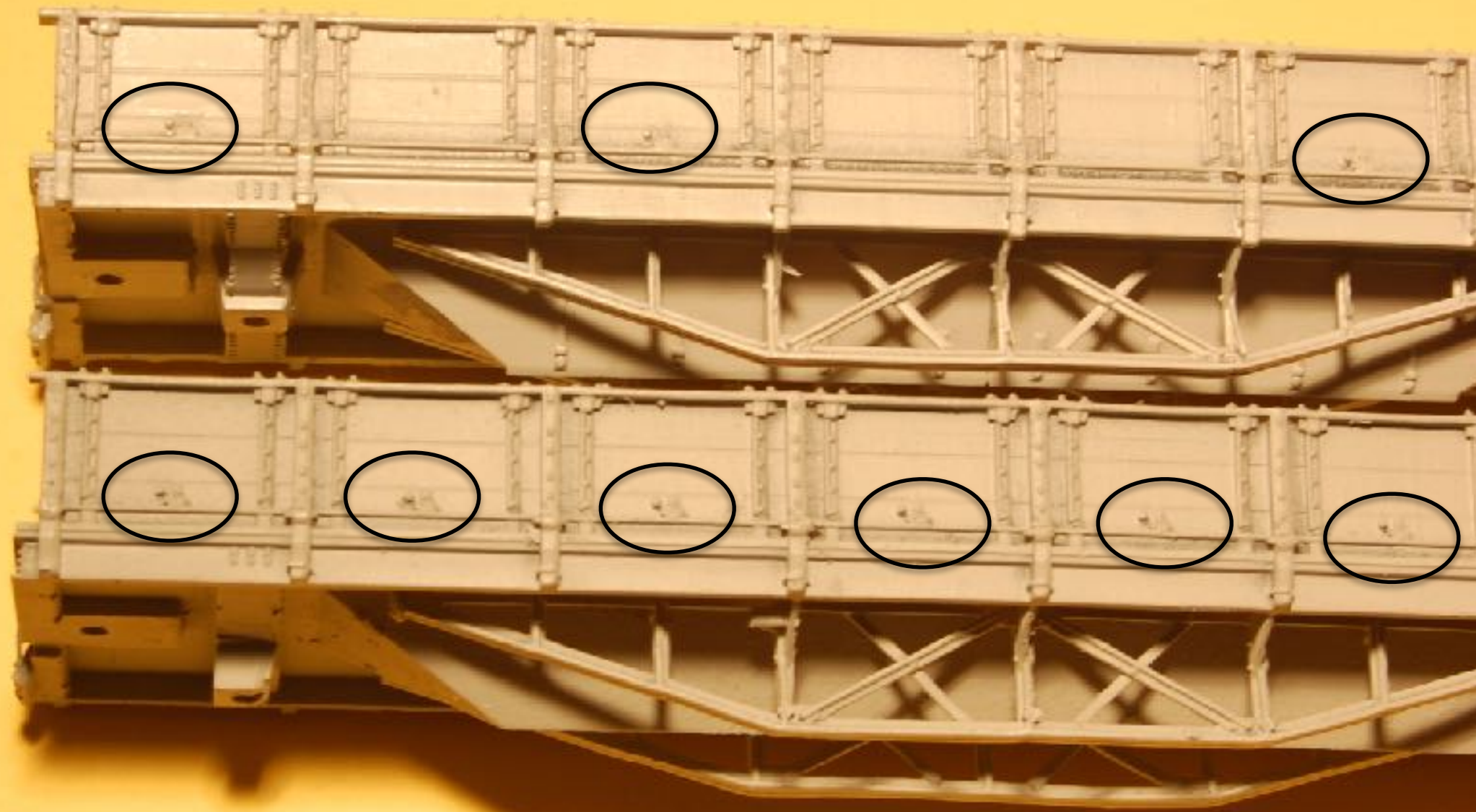
It's trivial to change a design. When to stop?

- Changes in model affect instructions
- Changes in model, support structure, orientation affect reliability
- Do you still sell older versions?
- Do you know which are the older versions?

What's the Difference?



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Let's Talk About Money

- What's a reasonable price?
- What's the cost per car?
- What are the other costs?
- What's the real yield?

Price?

- CN narrow gauge gondola on Shapeways: \$170
- Shapeways (40' car, no markup): \$60-\$70
- Resin kit: \$35-40

Prices

Sale Price		\$35
Cost of resin	25 ml, 15¢/ml	\$3.75
Depreciation of machine	assume 1000 cars	\$3.00
<i>Details</i>	Retail	<i>\$4.50</i>
Decals		75¢
Labor (manufacturing)	15 min @ \$30/hr	\$7.50
Labor (packing)	10 min @ \$30/hr	\$6.00
Packaging		65¢
Total		\$26.15

Material Cost

- Typical car: 18 cm^3 / 25 cm^3 with support
- Formlabs resin: \$3.75 (15¢ / cc)
- Shapeways: \$68 (\$5.00 + 3.49 / cc)
 - Includes labor, material, website, shipping.

Parts

- Additional parts - wire for grab irons, screws, detail parts, decals - big risk for small manufacturers
- Buy wholesale: minimum number,
- Buy retail: high prices
- If I run out, production stops
- For small runs and testing a concept, this is a big risk

What to Do About Parts?

- Wire, grab irons, brake wheel, steps: Don't furnish.
- Decals: Harder to find. Custom-print these.
- Screws, etc. Buy them. (Sometimes local!)
- Detail parts? If only I had a magic factory...



Making Detail Parts



Assumption: material was major cost.

Reality: Labor dominated

- Tending printer
- Rinsing models
- Trimming off supports
- Drilling, tapping, cleaning up, inspecting
- Distinguishing good from bad
- Part of Shapeways cost is all of this.

Assumption: Print on Demand

- Challenges
 - identifying good cars, cleanup
 - getting together parts
 - getting into rhythm for wrapping, packaging

Assumption: Cost Per Model Dominated

- Reality: One-off Costs dominated
 - building and photographing pilot models
 - finding boxes and packaging
 - figuring out how to wrap
 - instructions

The Box



And If
the
Printer
Fails...



How Did It Go?

- Sold around 60 cars, mostly “as-built” version.
- Announcements: friendly blog, mailing lists, word of mouth
- Most sales from friendly blog, dealer queries.
- Plan: regularly release new cars
- Reality: printer problems, new day job

So should you do this?

Fun Only?

- Want to make a fleet for friends and kindred spirits?

Do it.

- Choose cars that folks can't get any other way.
- Find ways to get friends to help with labor
- If too much work, then go to Shapeways.

Commercially?

- Possible, but not a route to easy money
 - Labor and yield are the two biggest challenges
 - Print a bunch in bulk and sell as you can
 - Regularly release designs to amortize startup costs
 - Tweak design, process to minimize your effort
 - Fall back to Shapeways when it gets annoying.

More Info?

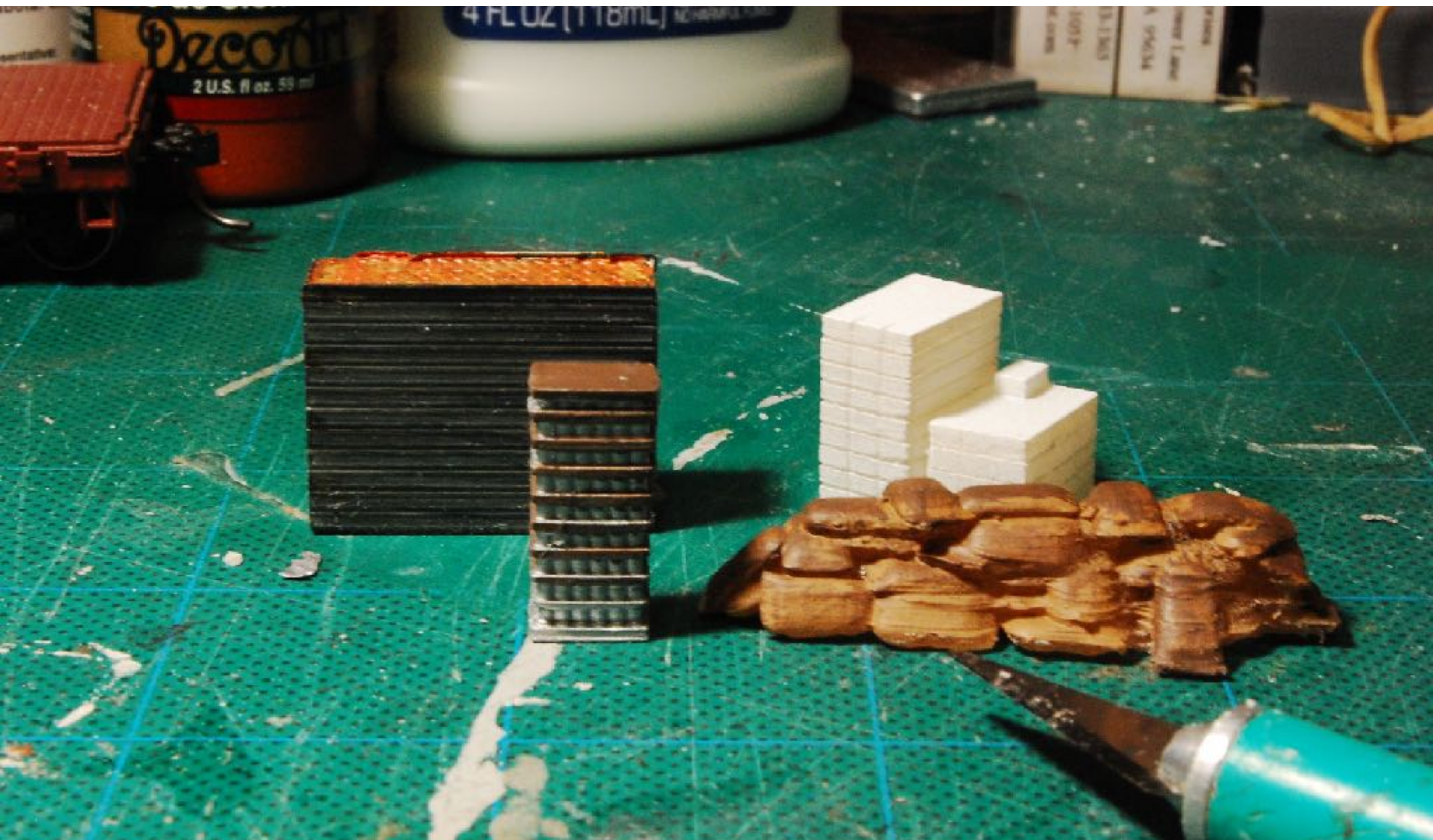
- Jack Burgess's 3d printing talk: Saturday, 10:30 a.m.
- Sample SketchUp design: CS-35 flat car @ thingiverse.com
- See these slides at vasonabbranch.com/3dprinting
- Follow progress at vasonabbranch.blogspot.com
- Send questions to rbowdidge@mac.com

Best Use for 3D Printing?

Structure Detail



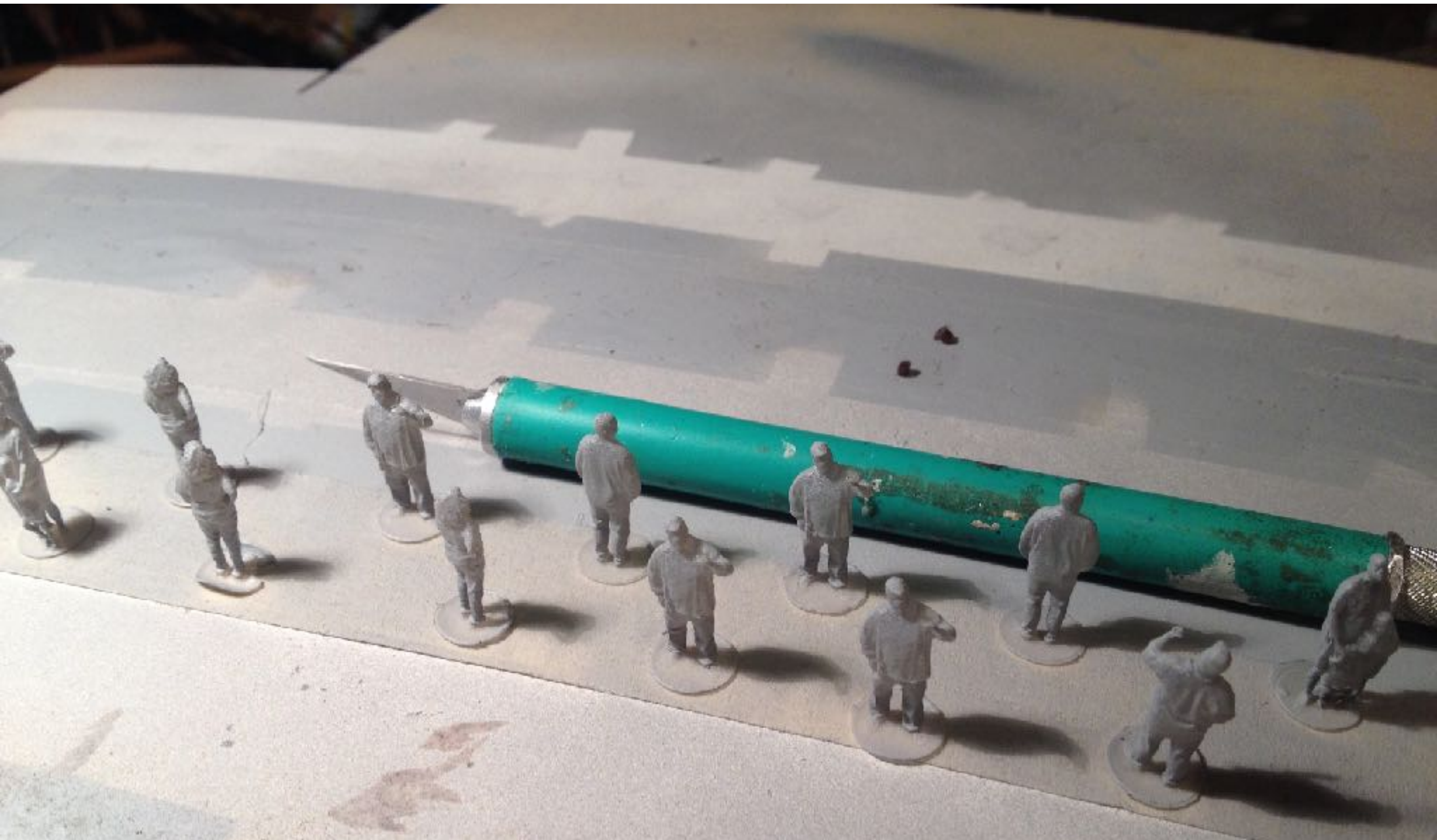
Clutter



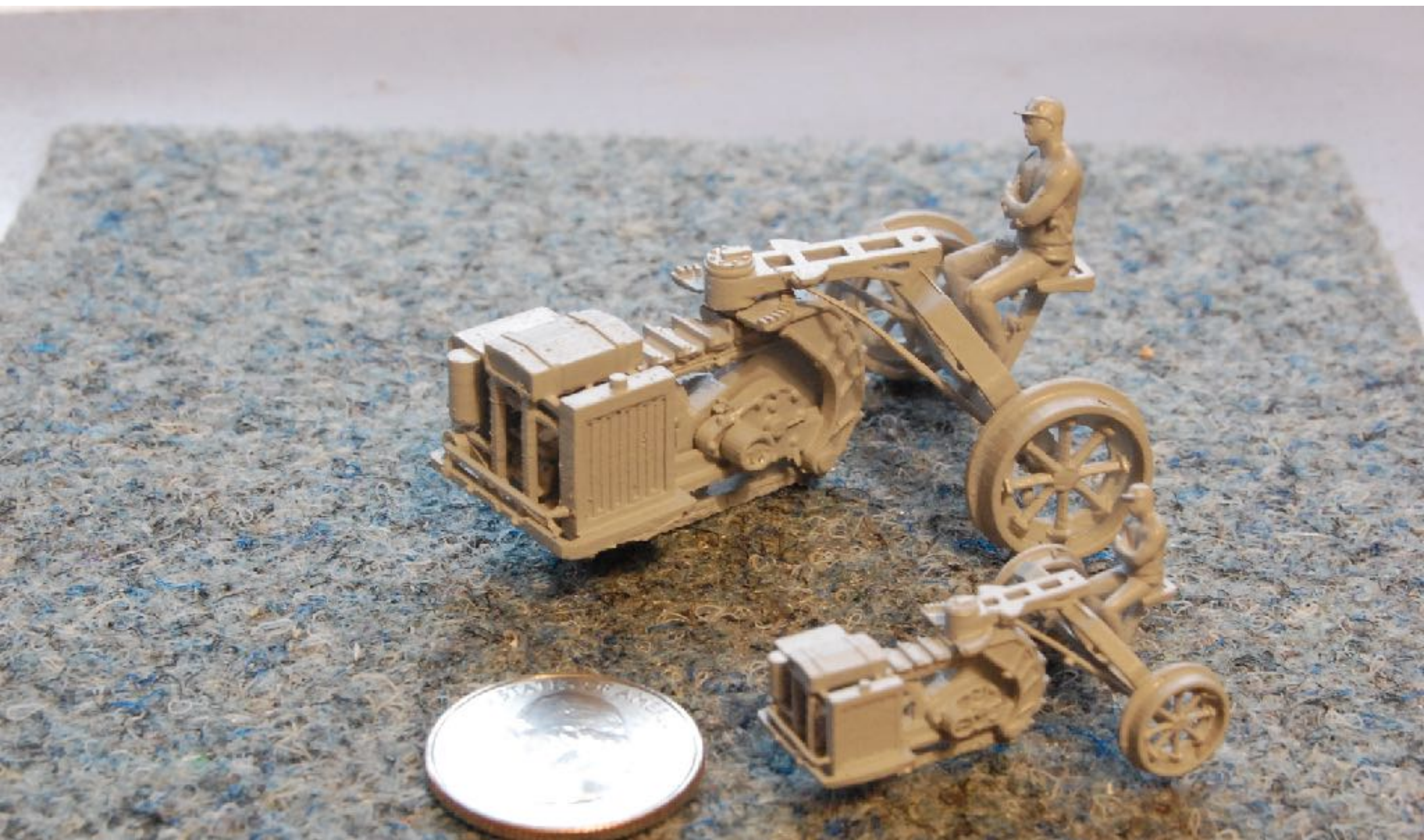
Odd Structural Parts



Figures



Vehicles



Set Dressing



More Figures



Freight Car Ideas?

Other Scales

- Basics of model depend on scale
 - robust enough for handling, not too chunky
 - some details don't match printer's capabilities
 - bolsters, coupler pads, clearances need to be changed



