FACADE OPTIMIZATION

VERNIER SCIENCE CENTER [SB1]

Portland State University + Bora Architecture
ARCH 560 | Fall 2021
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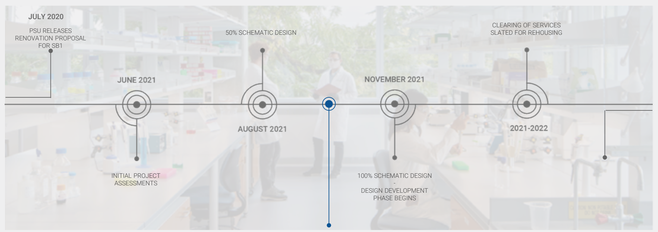
PROJECT OVERVIEW

As part of Bora's renovation of Portland State's Science Building One [SB1], we have been tasked with helping research how to optimize the building envelope through multiple methods, including optimizing daylighting and maximizing insulation, while staying within budget.

The PSU team has worked with the BORA team to expand an existing Thermal Flux Calculator to include all four facades of the Existing condition, the Schematic Design, and an Optimized version based on our own design. This calculator is used to determine the best wall-to-glazing ratio to increase the thermal efficiency of the envelope without compromising the visual experience.

We focused much of our attention on the north and south facades of the building where the abundance of existing glazing allows for the biggest opportunity to increase the thermal efficiency of the building's envelope. There was a focus on creating an envelope that allows for more daylighting, insulation, and limits solar heat gain through the addition of planters and plants. In regards to glazing, we are looked at glazing goals (<6000 SF), window-wall ratio (<40%), and total heat transfer (<2000 BTUs). In addition to that research, we also looked into some products that were used on the existing east and west facades to try to estimate their R-value for the calculator.

PROJECT TIMELINE



BORA

SOUTH ELEVATION

RESEARCH METHODOLOGY

The project started by analyzing Science Building One's existing facade through the lens of a simple but effective Thermal Flux Calculator provided by the Bora team using Excel. Initial studies split each facade into independent sections. The section of the South Facade [as provided by BORA] of the Excel Worksheet includes:

First Floor Storefront
Ribbon Windows
Spandrel
Floor Slabs
Roof Edge
Pedestal

Over the course of several weeks, adjustments were made to the calculator to reflect more specific building materials and their respective R-values, as well as to consolidate all of the facades into a single calculator that would allow the user to easily compare the total heat transfer of the different facades. The PSU team utilized AutoCAD, Revit, and Rhino to calculate the square footage for different building elements.

South Facade	Facade Area	Q (# stories)	SF	Adjusted area	R-value	U-value	UA	UA Adjusted	
First floor storefront	2,816	1	2,816	2,816		0.26	732	732	30%
Ribbon Windows	1,105	4	4,420	4,420		0.26	1149	1149	47%
Spandrel	301	4	1,204	1,204	20	0.05	60	60	2%
Slab edges	679	4	2,716	2,716	13	0.08	209	209	9%
Roof - edge	847	1	847	847	13	0.08	65	65	3%
Pedestal	2,800	1	2800	2,800	13	0.08	215	215	9%
	8,548		14,803	14,803			2431	2431	
							BTUs		
						Total Glazing UA	1881	1881	
						Glazing heat transfer	77%	77%	
							(per hour per delta T)		
	7,236								

	As is	Adjusted	Reduction	Goal
Total Glazing	7,236	7,236	0%	<6,000
WWR	49%	49%	0%	<40%
Glazing heat transfer (of total)	77%	77%	0%	<66%
Total heat transfer	2,431	2,431	0%	<2,000

INITIAL THERMAL FLUX CALCULATOR FOR THE SOUTH FACADE

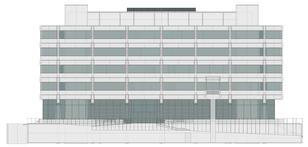
Existing	North	East	South	West	SF	R-Value	U-Value	UA	% of Total
First Floor Windows	1,878	131	1,908	131	3,918	1	1.00	3,918	26%
Ribbon Windows	4,176	0	4,176	0	8,352	1	1.00	8,352	55%
Glasweld Panels	2,112	2,592	2,112	2,592	9,408	5.5	0.18	1,711	11%
Walls	565	565	559	565	2,254	6	0.17	376	2%
Slab Edge	2,665	1,186	2,665	1,186	7,702	13	0.08	592	4%
Roof Edge	655	296	655	296	1,902	13	0.08	148	1%
Pedestal (Above Grade)	1,090	868	815	0	2,773	13	0.08	213	1%
	13,141	5,638	12,890	4,770	36,309			15,309	
							BTUs		
						Total Glazing UA	12,270		
						Glazing Heat Transfer	80%		
							(per hour per delta T)		

Entire Building	Existing
Total Glazing	12,270
WWR	34%
Glazing Heat Transfer (of total)	80%
Total Heat Transfer	15,309

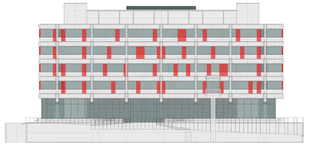
UPDATED CALCULATOR FOR ALL OF THE EXISTING FACADES

FINDINGS

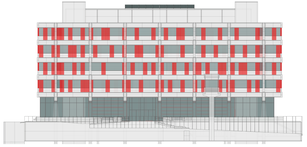
After fine-tuning the Thermal Flux Calculator we were able to use to it quickly evaluate and compare the thermal performance of various design options. The calculator quickly confirmed that the weakest performing aspect of the facades were the windows, so we knew that future design iterations needed to explore ways in which to add solid elements to the structure without sacrificing access to daylighting and external views. We proposed two different options in which we added solid panels to portions of the north and south facades where the interior walls meet the exterior walls. This allowed us to add more opportunities for insulation, while preserving daylight within the building.



50% SCHEMATIC DESIGN



OPTIMIZED FACADE A



OPTIMIZED FACADE B

OPTIMIZED FACADE B

Optimized Facade B	North	East	South	West	SF	R-Value	U-Value	UA	% of Total
First Floor Storefront	2,391	1,037	2,391	1,037	6,856	4	0.25	1,714	35%
Windows	2,430	504	2,484	489	5,907	4	0.25	1,477	31%
Walls	2,567	2,235	2,567	2,250	9,619	20	0.05	481	10%
Panels	1,746	0	1,692	0	3,438	20	0.05	172	4%
Slab Edge	3,320	1,482	3,320	1,482	9,604	13	0.08	739	15%
Pedestal Glazing	40	130	40	0	210	4	0.25	53	1%
Pedestal (Above Grade)	1,090	868	815	0	2,563	13	0.08	197	4%
	13,584	6,256	13,309	5,258	38,197			4,832	
							BTUs		
						Total Glazing UA	3,243		
						Glazing Heat Transfer	67%		
							(per hour per delta T)		

	50% SD	Optimized B	% Change	Goal
Total Glazing	15,961	12,763	20%	<15,250
WWR	42%	33%	8%	<40%
Glazing Heat Transfer (of total)	74%	67%	7%	<66%
Total Heat Transfer	5,472	4,832	12%	<6350

The proposal for Optimized Facade B would add roughly 3,400 SF of solid, insulated panels to the north and south facades. The additon of the these panels would reduce the total glazing by 20%, resulting in a 12% reduction in total heat transfer. The initial monetary savings of using panels over windows is negligible, but the building would be significantly more efficient in the long run.

REFLECTION

After using the Thermal Flux Calculator to analyze Science Building One's existing façade and our proposal we were able to get a clearer picture of how poorly the existing building is performing. SB1 currently has a total heat transfer of approximately 15,000 BTUs, while Optimized Façade B, which has roughly the same percentage of glazing and WWR, has a total heat transfer of approximately 4,800 BTUs. We attribute this significant reduction to the addition of better insulation and the proposed replacement of the building's single pane windows. Interestingly, despite the reduction in total heat transfer, the glazing in Optimized Façade B still accounts for 67% of the total heat transfer, compared to 80% for the existing building. We believe that this can be attributed to the significant upgrade in R-value for the solid wall portion of the building, which means that even though the windows have a better U-value, they're still accounting for a larger proportion of total heat loss.

Going forward, we think that adding solid panels to the façade of Science Building One would be an upgrade thermally and aesthetically. We were also pleased with how simple the Thermal Flux Calculator was to use to compare different design proposals, and we are confident that it could be repurposed to use for different buildings with minimal adjustments.