SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Robert Crawford
FACULTY ADVISOR:	John Onyango, PhD
PROJECT PERIOD:	Summer 2022
PROJECT TITLE:	Life Cycle Assessments of Building Materials in Notre Dame Construction.
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**(X) Energy Conversion and Efficiency** **( ) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution** **( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Gather building dimensions	Found original blueprints, confirmed measurements with site visit and maps	95%
Determine building materials	Used original drawings to confirm materials and size but origins unknown	75%
Run life-cycle assessments	Need to renew SimaPro license to export relevant data	50%

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)
EXTERNAL AWARDS RECEIVED	(Sponsor, Project Title, PIs, Award Date, Award Amount)
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	(Event, Presentation Title, Presentation Date, Location)
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	(Purpose, Title, Date Received)
INTERNAL COLLABORATIONS FOSTERED	John Kuczmanski, Maintenance Supervisor, email correspondence and in-person meeting to find physical copies of building floor plans. Ginger Sigmon, Sustainable Energy Initiative, email correspondence and in-person meeting for information on building materials.
EXTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

RESEARCH EXPERIENCE

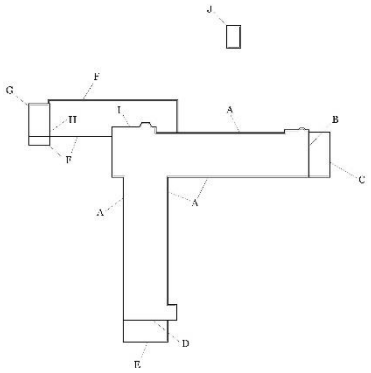
Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

There was a significant amount of leg work in the initial stages of this project, from reaching out to various departments on campus to find the correct drawings, to drawing up plans, to finding window dimensions, to running all of the various calculations, but once I had all of the necessary numbers using the SimaPro software was relatively easy. Professor Onyango was extremely helpful as was everyone else who I talked to along the way. The only problems I encountered were (1) the initial process of installing the SimaPro software was difficult since it does not run on Macs and (2) since I do not have a license right now I cannot export the most essential information for this project, but I should have a solution for this soon.

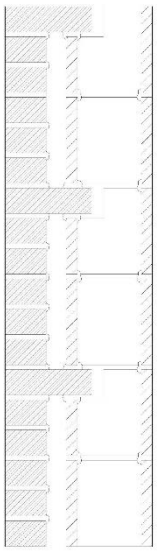
FINAL WRITTEN REPORT

(Please use the space below to describe your research project and objectives, any findings and results you can share, and graphs, charts, and other visuals to help us understand what you achieved as a result of this research experience.)

This research project was conducted in order to understand more about the energy implications of the various building materials used across Notre Dame's campus. Using Fisher Hall as the primary subject of my research, I began by locating the original blueprints of the building through Notre Dame's Department of Facilities Design and Operations. Using these documents, I was able to construct a working plan of the building with AutoCAD software, as seen at right.



Examining the original construction documents also showed the original construction materials used in the building, which were brick and CMU blocks, with a small cavity between (as seen below). Since original sourcing of these materials was unknown, separate tests were run to determine how changes in source location affected the overall life-cycle of each building material.



Approximate heights for each section of the building (labeled A–I) were determined using GIS mapping and the approximate volume for both brick and CMU within the building was calculated as shown below.

Wall Section	Area (sqft)	Height (ft)	Volume (cu ft)
A	135.77	38.58	5238.01
B	9.73	10.17	98.95
C	18.45	28.42	524.35
D	9.63	25.58	246.34
E	18.90	13.00	245.70
F	57.22	14.00	801.08
G	11.14	18.42	205.20
H	12.02	4.17	50.12
I	18.55	24.58	455.96
J	16.20	6.08	98.50
	Total Volume of Brick (cu ft) =		7964.20
	*without wall openings		

Wall Section	Area (sqft)	Height (ft)	Volume (cu ft)
A	286.99	38.58	11072.07
B	19.27	10.17	195.98
C	37.81	28.42	1074.56
D	19.06	25.58	487.55
E	38.76	13.00	503.88
F	118.51	14.00	1659.14
G	23.70	18.42	436.55
H	22.08	4.17	92.07
I	36.85	24.58	905.77
J	30.95	6.08	188.18
	Total Volume of CMU blocks* (cu ft) =		16615.76
	*without wall openings		

Northern side	Quantity	Width (ft)	Height (ft)	Brick depth (ft)	Volume (cu ft)
Standard, 4 panes	23	11.5	5	0.302083333	399.51
Standard, 3 panes	3	7.5	5	0.302083333	33.98
Bay windows, small	4	1	4	0.302083333	4.83
Bay windows, large	9	2.5	5	0.302083333	33.98
Entrance, eastern window	1	17	8	0.302083333	41.08
Entrance, door	1	6	10	0.302083333	18.12
Entrance, northern window	1	12	8	0.302083333	29.00
Chapel windows, standard	4	4	5	0.302083333	24.17
Chapel window, decorative	1	3	15	0.302083333	13.59
Western side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Chapel windows, tall	2	3	6.5	0.302083333	11.78
Chapel windows, small	1	2.5	5	0.302083333	3.78
Chapel door	1	4	7.5	0.302083333	9.06
Chapel window, standard	1	4	5	0.302083333	6.04
Stairwell windows	2	1.5	5	0.302083333	4.53
Long, 4 panes	4	17	5	0.302083333	102.71
Long, 4 panes, short	1	17	3	0.302083333	15.41
Standard, 1 pane	5	3	5	0.302083333	22.66
Standard, 4 panes	20	11.5	5	0.302083333	347.40
Standard, 3 panes	4	7.5	5	0.302083333	45.31
Standard, 4 panes, basement	6	11.5	8	0.302083333	166.75
Skinny, 1 pane	4	1.5	5	0.302083333	9.06
Standard, 1 pane	1	3	5	0.302083333	4.53
Southern side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Standard, 1 pane	3	3	5	0.302083333	13.59
Standard, 3 panes	2	7.5	5	0.302083333	22.66
Standard, 4 panes	23	11.5	5	0.302083333	399.51
Skinny, 1 pane	4	2.5	5	0.302083333	15.10
Standard, 1 pane	3	3	5	0.302083333	13.59
Door	1	5	7	0.302083333	10.57
Eastern side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Standard, 1 pane	1	3	5	0.302083333	4.53
Skinny, 1 pane	3	2.5	5	0.302083333	11.33
Door	1	6.5	7.5	0.302083333	14.73
Standard, 4 panes	20	11.5	5	0.302083333	347.40
Skinny, 1 pane	4	2.5	5	0.302083333	15.10
Door	1	6.5	7.5	0.302083333	14.73
Standard, 1 pane	3	3	5	0.302083333	13.59
		Total volume of bricks displaced by openings =			2243.72

Northern side	Quantity	Width (ft)	Height (ft)	Brick depth (ft)	Volume (cu ft)
Standard, 4 panes	23	11.5	5	0.63541667	840.34
Standard, 3 panes	3	7.5	5	0.63541667	71.48
Bay windows, small	4	1	4	0.63541667	10.17
Bay windows, large	9	2.5	5	0.63541667	71.48
Entrance, eastern window	1	17	8	0.63541667	86.42
Entrance, door	1	6	10	0.63541667	38.13
Entrance, northern window	1	12	8	0.63541667	61.00
Chapel windows, standard	4	4	5	0.63541667	50.83
Chapel window, decorative	1	3	15	0.63541667	28.59
Western side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Chapel windows, tall	2	3	6.5	0.63541667	24.78
Chapel windows, small	1	2.5	5	0.63541667	7.94
Chapel door	1	4	7.5	0.63541667	19.06
Chapel window, standard	1	4	5	0.63541667	12.71
Stairwell windows	2	1.5	5	0.63541667	9.53
Long, 4 panes	4	17	5	0.63541667	216.04
Long, 4 panes, short	1	17	3	0.63541667	32.41
Standard, 1 pane	5	3	5	0.63541667	47.66
Standard, 4 panes	20	11.5	5	0.63541667	730.73
Standard, 3 panes	4	7.5	5	0.63541667	95.31
Standard, 4 panes, basement	6	11.5	8	0.63541667	350.75
Skinny, 1 pane	4	1.5	5	0.63541667	19.06
Standard, 1 pane	1	3	5	0.63541667	9.53
Southern side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Standard, 1 pane	3	3	5	0.63541667	28.59
Standard, 3 panes	2	7.5	5	0.63541667	47.66
Standard, 4 panes	23	11.5	5	0.63541667	840.34
Skinny, 1 pane	4	2.5	5	0.63541667	31.77
Standard, 1 pane	3	3	5	0.63541667	28.59
Door	1	5	7	0.63541667	22.24
Eastern side	**Quantity**	**Width (ft)**	**Height (ft)**	**Brick depth (ft)**	**Volume (cu ft)**
Standard, 1 pane	1	3	5	0.63541667	9.53
Skinny, 1 pane	3	2.5	5	0.63541667	23.83
Door	1	6.5	7.5	0.63541667	30.98
Standard, 4 panes	20	11.5	5	0.63541667	730.73
Skinny, 1 pane	4	2.5	5	0.63541667	31.77
Door	1	6.5	7.5	0.63541667	30.98
Standard, 1 pane	3	3	5	0.63541667	28.59
		Total volume of CMU blocks displaced by openings =			4719.56

Material	Calculated volume	Opening Displacement	Total (cu ft)
Brick	7964.20	2243.72	5720.48
CMU	16615.76	4719.56	11896.20

Unfortunately, Notre Dame's licenses that I used to run the SimaPro software expired on Jan 1, 2023. I was able to run tests last semester but do not have exported images to show the full results. I am currently working on renewing these licenses so that I can retrieve the relevant data and charts for this project.