Allard Hall LCA Study

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University of British Columbia

CIVL 498C

November 18, 2013

PROVISIO

This study has been completed by undergraduate students as part of their coursework at the University of British Columbia (UBC) and is also a contribution to a larger effort – the UBC LCA Project – which aims to support the development of the field of life cycle assessment (LCA).

The information and findings contained in this report have not been through a full critical review and should be considered preliminary.

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Executive Summary

This report is the final project for CIVL 498C, Life Cycle Analysis, which is being taken as a Civil Engineering fourth year technical elective. The subject of this report is Allard Hall, which is the building for the Faculty of Law on UBC Point Grey campus. Detailed information about Allard Hall is contained in this report. The life cycle analysis, as well as accompanying definitions and information, are detailed in this report. A life cycle assessment was performed previously for this building, also as a final project for a previous year of this class. For this project the previous LCA report and model was reorganized and modified where appropriate. To do this the take-off software On Screen Take-off, as well as the Athena Impact Estimator for Buildings software were used. Subsequent to the reassessment of the building, benchmarks for impact categories were created using LCA information from various other UBC buildings. The results of the reassessment of Allard Hall were then compared with the benchmarks, and the results were that Allard Hall had significantly lower impacts than the benchmarks. All of the information concerning the results of the LCA study on Allard Hall, as well as the comparison with the generated benchmarks are included in this report with accompanying figures.

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1.0 General Information on the Assessment

Purpose of the assessment

The general purpose of doing a building LCA is to determine the environmental performance of the building and its components, in a quantifiable manner. The purpose of this assessment is to organize a previously performed LCA on Allard Hall into CIQS standards, improve the previous LCA where possible, and compare the environmental performance of Allard Hall with benchmarks generated by improved LCA studies of other UBC buildings, which are carried out by peers.

Intended Use of Assessment

The intended use of this study is to compare the environmental performance of Allard Hall with other UBC buildings.

Reasons for Carrying out the Study

The reasons for carrying out this study are to organize the elements of Allard Hall into CIQS standards, assess the accuracy of the previous assessment, improve the previous assessment model where possible, create benchmarks for UBC buildings, compare results of Allard Hall assessment against benchmarks, and suggest things to consider when implementing LCA.

Intended Audience

There is a wide intended audience for this study. LCA students in future years are part of the intended audience. Just as this study uses the LCA study of Allard Hall performed by students in 2012 and improved LCA studies of other UBC buildings currently being performed by other students, in the future this study could be used by students to compare with other buildings or further improve the study. UBC Properties Trust Planners and policy makers are also part of the intended audience. This study, along with studies of other UBC buildings, can be used by them to determine what construction components have less of an environmental impact, which can inform policy decisions. Another part of the intended audience is the designers and contractors involved in UBC building projects, who can use this study, along with studies of other UBC buildings, to make informed decision on the construction components to use in their projects in order to minimize the environmental impact. Finally, the intended audience also includes the public since these reports will be make publicly available. The public can constitute other UBC students, faculty, administration, or anyone who is interested in LCA studies of UBC buildings.

Since the intended audience of this study is quite varied, is it important that the language and terminology used in this study be accessible to varying degrees of familiarity with LCA.

Comparative Assertions

This study of Allard Hall is in many ways a comparative assertion, since it uses LCA findings of other UBC buildings to create benchmarks to compare the results of this study against. The results of this study are being used to create benchmarks which other students are using to compare their buildings with. The results found in this study and presented in this report are intended to be used in the future to compare other buildings against.

Identification of building

Allard Hall is the main building for the University of British Columbia's (UBC) Faculty of Law. It is located on UBC's Point Grey campus, at 1822 East Mall, and was constructed in 14 months in order to open in September of 2011[1]. The building was designed by Diamond and Schmitt Architects in collaboration with CEI Architecture, the general contractor was ITC Construction group, and the property owner is the UBC Properties Trust. Allard Hall is a four-storey, 141,000 square foot building, which cost approximately $56M to construct in 2011[2]. The cost of construction for this building in 2013 Canadian dollars is $56.56MA major challenge in the structural design of this building was accommodating the weight of

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[1] . N.p.. Web. 19 Nov 2013. <http://en.wikipedia.org/wiki/Allard_Hall>.

[2] . N.p.. Web. 19 Nov 2013. <http://www.ubcproperties.com/portfolio_detail.php?category=Location&list=Vancouver&id=Allard Hall Faculty of Law Building>.

an extensive library collection. This was done successfully, and the building boasts a three-storey law library, as well as classroom space, meeting space, and large lecture halls. It was designed to meet LEED Gold standards and reduce energy consumption by 50%, through several sustainable features such as a Geo-exchange system[3].

Other Assessment Information

Table 1: Assessment Information

Client for Assessment	Completed as coursework in Civil Engineering technical elective course at the University of British Columbia.
Name and qualification of the assessor	First Author: Emma Brown, Undergraduate Civil Engineering Student Second Authors: Dominique Bram Guevarra, Eric Howie, Patti Shen
Impact Assessment method	Athena Impact Estimator for Buildings, Version 4.2.0208 TRACI version 2.2
Point of Assessment	Two years post-construction
Period of Validity	5 years.
Date of Assessment	Completed in December 2013.
Verifier	Student work, study not verified.

2.0 General Information on the Object of Assessment

Functional Equivalent

The functional units used in this study to normalize the results of the study are:

[3] . N.p.. Web. 19 Nov 2013. <http://www.ceiarchitecture.com/project/ubc-allard-hall-law-building/>.

- ***Per square metre** of institutional academic building constructed*

The functional unit of *m²* was selected because it can be used to directly compare the environmental impacts of Allard Hall with other buildings, particularly other UBC buildings.

Table 2 - Functional Equivalent Definition

Aspect of Object of Assessment	Description
Building Type	Institutional
Technical and functional requirements	LEED Gold, BCBC 2006, structural capacity to support a large library, Library, classrooms, office space, meeting rooms, large lecture halls, forums.
Pattern of use	-Business hours for administration staff, support staff, and faculty members -Business hours for classroom and lecture hall use -Extended business hours for library -All hours access for law students and law faculty -Daytime use on weekends and weekdays for general public -Special weekend use of forum auditorium for special events and lectures
Required service life	100 years[i]

Reference Study Period

The reference study period chosen for this assessment is one year. This is not equal to the service life required for UBC buildings, which is 100 years. EN 15978 stipulates that the default value for the reference study period should be the required service life of the building. There are several reasons why the reference study period for this assessment is not the service life of 100 years. The reference study period of one year only addresses the product and construction process stage of the building, which is Module A of EN 15978[4]. In order to make the scope of this assessment reasonable for the timeframe over which it was conducted (approximately 2.5 months), Modules B and C, the use and end of life stages of the building, were excluded. Module D is supplementary information, such as reuse, recycling, and recovery potential, and since it is outside of the system boundary, it is generally excluded[5]. A purpose of this study is to compare the environmental impacts with other UBC buildings; however, the time of construction and service life of the buildings on UBC campus vary greatly. Especially considering the relatively recent requirements of LEED Gold standards, which inherently has requirements for the building. In order to conduct the study in a manner that is conducive to comparison, the studies had to be normalized and a reference study period of one year, which only assesses the product and use stages, was chosen.

Object of Assessment Scope

An LCA study on a building should include the building, from its foundation to the external works enclosed within the area of the building's site, according to EN15978. This assessment of Allard Hall includes everything from its foundation to external works, except for interior finishes, fittings, mechanical systems and equipment, electrical components, and site work. The building components have been sorted using a modified version of the CIQS level 3 elements. These components were excluded in order to maintain a reasonable scope for this assessment. Furthermore, some of the components excluded from this study, such as mechanical systems, have changed significantly over the years; and therefore it would be difficult to compare the studies of various UBC buildings, which is in part what this assessment is intended for.

[4] . N.p.. Web. 19 Nov 2013. <http://www.coldstreamconsulting.com/services/life-cycle-analysis/whole-building-lca/en-15978-standard>.
[5] . N.p.. Web. 19 Nov 2013. <http://etool.net.au/eblog/environment/en-15978/>.

In essence this study is addressing the structure, envelope, and partition walls of Allard Hall. Allard Hall's foundation is comprised of pad and strip footings with slabs on grade, on both the basement level, which is not the full footprint of the building, and the ground level. The building's structural system is primarily concrete and consists of cast in place walls, beams, columns, and floor slabs. The building envelope is primarily curtain wall and the partition walls are mostly steel stud walls with a few concrete block walls.

Table. Building Definition Template.

Table 3 - Building Definition

CIVL 498C Level 3 Elements	Description	Quantity	Units
A11 Foundations	Concrete strip footings, concrete pad footings	2506.55	m^2
A21 Lowest Floor Construction	Concrete slabs on grade	2506.55	m^2
A22 Upper Floor Construction	Concrete columns and concrete beams from basement levels to level 4. Concrete suspended floor slab from levels 1 to 4.	9710.5	m^2
A23 Roof Construction	Concrete columns and beams on level 5. Concrete roof suspended slab. Steel joist roof.	7439.4	m^2
A31 Walls Below Grade	Concrete cast-in-place walls on basement level. Furring on all floors.	7542.2	m^2
A32 Walls Above Grade	Concrete cast-in-place walls on levels 1 to 5. All curtainwall.	6639.5	m^2

	Concrete block exterior partition walls.		
B11 Partitions	Steel stud partition walls on all floors. Concrete block interior partition walls.	9679	m^2

3.0 Statement of Boundaries and Scenarios Used in the Assessment

System Boundary

The only building life cycle module included in this study of Allard Hall is Module A. Modules B, C, and D have been excluded for reasons previously stated. Module A includes the product stage, involving raw material supply, transport, and manufacturing, as well as the construction process stage, involving transport and construction-installation process. These stages are described thoroughly in the following sections. The system boundary for this assessment is from the extraction of raw materials to when the building has been constructed and is ready for occupancy.

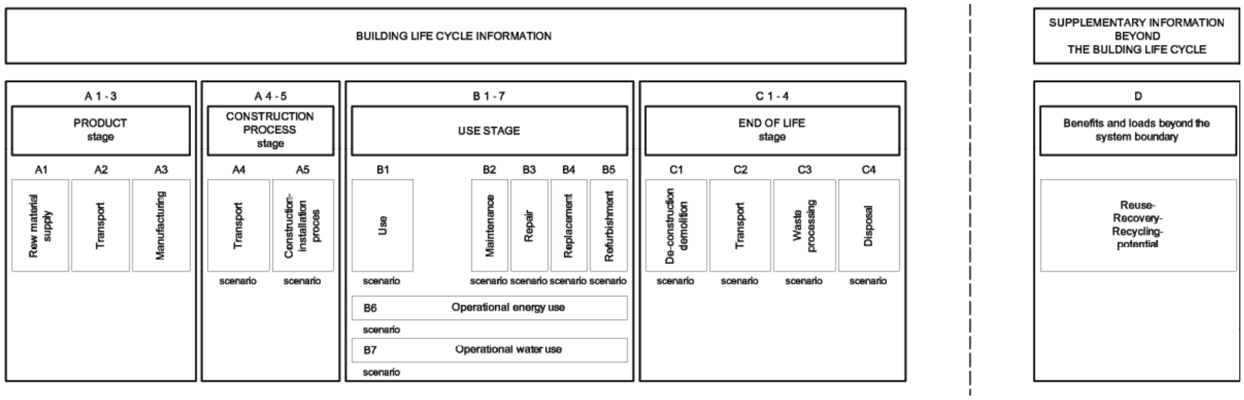

Figure 1 - Building Modules

Product Stage

The product stage of this LCA assessment takes into consideration the raw material supply, transport and manufacturing models prior to construction of the building. It is essentially considers the ‘cradle to gate’ processes for the building products and services that are reference flows for the construction stage. The Athena LCI Database was not developed from trade or government data sources, but it was developed from scratch using actual mill or engineering process models[6].

For the raw material supply, the Athena LCI Database uses information from regional product market analyses[7]. Data for raw material supply begins at the extraction of resources; the Athena LCI Database tracks the energy use, as well as emissions to air, land, and water per unit resource[8]. Activities such as reforestation and beneficiation are also considered in the data for this module.

[6] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.
[7] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.
[8] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.

For the transport module of the product stage, the Athena LCI Database uses weighted average transportation profiles based on distance, and takes into account difference in transportation based on region[9]. The database simplifies information by treating all offshore raw materials being produced in North America as though they obtained in North America. The transportation considered in this module is between the place of resource extraction and the mill or plant.

In the manufacturing module, which generally accounts for the largest part of embodied energy and emissions, the Athena LCI Database considers differences in recycled content based on region[10]. Furthermore, it includes resource extraction information and considers differences in manufacturing technology. In this database, this module begins with the delivery of the raw resources and ends with the finished product prepared for shipment.

Construction Stage

The construction stage of LCA encompasses the transportation and construction-installation process modules. In essence it measures the environmental impacts of the materials from the gate of the factory to the practical completion of the construction work.

The transportation module accounts for embodied energy and emissions of the construction materials from the factory or mill to the construction site. The Athena LCI Database accounts for variations in transportation based on location, and applies the typical transportation distances to the construction site within each city they are applied[11]. This is especially important for materials such as large dimension lumber, which can only be obtained from the British Columbia or the Pacific Northwest of the USA. This database

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[9] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.
[10] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.
[11] . N.p.. Web. 19 Nov 2013. <http://calculatelca.com/faqs/

treats all offshore products as if they were manufactured in North America[12]. This module also accounts for the transportation of construction equipment to and from the site.

The construction-installation process module takes account of the energy used to construct the elements of the building on site, for example from machines like cranes and mixers[13]. It also accounts for the waste generation, concrete formwork, and temporary heating and ventilation.

4.0 Environmental Data

Data Sources

This study uses the Athena LCI Database for material process data, as well as the US LCI Database for energy combustion and pre-combustion processes for electricity generation and transportation. The Athena LCI Database has been developed and is currently managed by the Athena Sustainable Materials Institute. The Athena LCI Database does not use data from trade or government sources, but instead was developed from the beginning from mill or engineering process models. This database is still growing and more than 2 million dollars have been invested in it. The US LCI Database was developed and is maintained by the National Renewable Energy Laboratory (NREL) and its partners. This database was developed and is maintained by NREL's High-Performance Buildings research group, who worked closely with industry partners and government stakeholders.

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[12] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.
[13] . N.p.. Web. 19 Nov 2013. <http://www.athenasmi.org/resources/about-lca/technical-details/>.

Data Adjustments and Substitutions

The Impact Estimator model that was created for the previous assessment of Allard Hall in 2012, as well as and the On-Screen Takeoff file used to created it, was checked for accuracy and validity. More detail about is provided about this in section 6.0 Model Development. The previous model of Allard Hall was found to be as accurate as possible, given the limitations of the Impact Estimator; therefore no data adjustments or substitutions were made.

Data Quality

The quality of the data is determined by its ability to satisfy the stated requirements. To describe data quality, there are five types of uncertainty, which are data uncertainty, model uncertainty, temporal uncertainty, spatial uncertainty, and variability between sources.

Data uncertainty is caused by variations in the values of measurements to derive the numerical values.

Model uncertainty arises due to simplifications of aspects of the model that cannot be properly modeled. This type of uncertainty is likely to occur frequently when buildings are modelled with the Impact Estimator, since there is limited choices of component inputs. For this assessment there is some model uncertainty, as several components, such as 250mm cast-in-place walls, were modeled in a simplified manner due to the limitations of the Impact Estimator.

Temporal uncertainty is due to variations of data over time. A possible source of temporal uncertainty in the Athena LCI Database and US LCI Database are the methods used in manufacturing new products, as these methods might change as new technology is developed.

Spatial uncertainty arises from fluctuations in the real world between geographical sites. The Athena LCI Database was compiled through surveys of different regions, which attempts to minimize the spatial uncertainty; however variability in the amount of data available for the various regions would cause spatial uncertainty. Furthermore, spatial uncertainty would arise when a building is assessed that is not located in one of the fifteen cities that the Impact Estimator allows one to choose from.

Variability between sources is caused by differences in sources of the inventoried system, such as variation in comparable technical processes.

5.0 List of Indicators Used for Assessment and Expression of Results

The impact assessment method used in this assessment and in the previous 2012 assessment on Allard Hall is the Athena Impact Estimator for Buildings (Version 4.2.0208). Athena uses the EPA Tool for Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI v 2.1, 2012). The impact categories used in this assessment are as follows:

- Global Warming Potential. The category indicator used is kg of CO_2 equivalent mass. There are many endpoint impacts for this category, one of which is aquatic ecosystems.
- Acidification potential for air. The category indicator used is moles of H+ equivalent mass. A possible endpoint impact of acidification are crops. Acidification can lead to increased aluminum in the soil solution, which can disrupt the cell wall structure of plants and inhibit their nutrient uptake[14].

[14] . N.p.. Web. 19 Nov 2013. <http://www.apis.ac.uk/overview/issues/overview_acidification.htm>.

- Human Health Criteria – Respiratory. The category indicator used is kg of PM 10 equivalent mass. An endpoint impact of this category are the cardiac and respiratory systems of humans[15].
- Eutrophication potential for air and water. The category indicator used is kg of N equivalent mass. Possible endpoint impact of this category are bodies of water.
- Smog potential for air. The category indicator used is kg of O_3 equivalent mass. Endpoint impacts of this category are plants and trees, as smog can cause growth loss, premature again, and decrease in pollen production for trees[16].
- Ozone depletion potential for air. The category indicator used is kg of CFC 11 equivalent. Some endpoint impacts of this category are marine life and agriculture. Plankton, which is the first vital step in the aquatic food chain, is threatened by increased UV radiation[17]. Some agriculturally grown plants, such as wheat, soybeans, rice, barley, oats, and many more, experience reduced photosynthesis, growth, and flowering due to increased UV radiation.
- Fossil fuel consumption. The category indicator used is MJ. An endpoint indicator of this category is air quality.

6.0 Model Development

The original model of Allard Hall was developed for the previous 2012 report. Structural drawings were used in conjunction with the take-off software OnScreen TakeOff, to

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[15] . N.p.. Web. 19 Nov 2013. <http://www.apis.ac.uk/overview/issues/overview_humanhealth.htm>.
[16] . N.p.. Web. 19 Nov 2013. <http://are.berkeley.edu/courses/EEP101/spring03/AllThatSmog/extern.html>.
[17] . N.p.. Web. 19 Nov 2013. <http://www.bcairquality.ca/101/ozone-depletion-impacts.html>.

determine the sizes of the various elements. An inputs and assumptions excel document was compiled contained all the quantities determined from OnScreen TakeOff, as well as any adjustments that were made to make the information compatible with the impact estimator software. In addition, any assumptions that were made in the process were detailed in the excel document. The adjusted quantities were then inputted into the Impact Estimator and results were generated. For this report and assessment, the previous model and data was used, sorted, and modified. The level 3 elements were sorted into CIQS format, in order to standardize the assessment process with other UBC buildings being assessed.

The next stage of this assessment involved checking the Impact Estimator model from the previous assessment of Allard Hall in 2012, as well as the associated OST files, for accuracy and validity. The scaling of the drawings on OST was checked and found to be accurate. The measurements determined from OST were checked as well. At first several measurements from the previous model appeared to be inaccurate; however, upon further inspection these values were confirmed as accurate. Due to the limitations of the Impact Estimator in selecting the type of assembly, for several components the dimensions were modified so that the model accurately represented the volume of concrete. Although these modifications create some inaccuracies and the resulting model does not precisely represent the actual building, upon further inspection it was determined that the modifications made create a model that is as accurate as possible given the limitations of the Impact Estimator. Other components that were checked include the material properties and component quantities. Initially it appeared that the quantities of the footings inputted into the Impact Estimator model was different than what was shown on the OST file. However, after observing the drawings more closely it became evident that the footings were accurately modeled in the Impact Estimator file, because footings are located on both the basement and ground level of Allard Hall, since the basement level is smaller than the building footprint. As the previous model of Allard Hall was found to be as accurate as possible after inspection, no changes were made and no new LCA information was substituted into the model. The details of the sorted Level 3 inputs and assumptions for this assessment of Allard Hall are provided in Annex D.

The Bill of Materials report produced by the Impact Estimator for the total building shown below:

Table 4 - Bill of Materials for Total Building

#15 Organic Felt	1674.764	m2
3 mil Polyethylene	2768.3392	m2
5/8" Fire-Rated Type X Gypsum Board	25704.0231	m2
5/8" Regular Gypsum Board	6511.9641	m2
Air Barrier	2768.3392	m2
Aluminum	38.4152	Tonnes
Cedar Wood Bevel Siding	536.579	m2
Cold Rolled Sheet	0.5129	Tonnes
Commercial(26 ga.) Steel Cladding	274.0212	m2
Concrete 20 MPa (flyash av)	292.0775	m3
Concrete 30 MPa (flyash av)	5692.5735	m3
Concrete Blocks	34717.3679	Blocks
Double Glazed No Coating Air	938.1353	m2
EPDM membrane (black, 60 mil)	2053.3982	kg
Expanded Polystyrene	14024.3277	m2 (25mm)
FG Batt R11-15	43466.9237	m2 (25mm)
Galvanized Sheet	8.3275	Tonnes
Galvanized Studs	119.7753	Tonnes
Glazing Panel	133.1374	Tonnes
Hollow Structural Steel	3.4291	Tonnes
Joint Compound	32.1521	Tonnes
Metric Modular (Modular) Brick	2151.7593	m2
Mortar	726.0972	m3
Nails	2.8096	Tonnes
Natural Stone	514.1651	m2
Paper Tape	0.369	Tonnes
Rebar, Rod, Light Sections	448.3175	Tonnes
Screws Nuts & Bolts	4.1944	Tonnes

Small Dimension Softwood Lumber, kiln-dried	7.5386	m3
Solvent Based Alkyd Paint	20.045	L
Water Based Latex Paint	766.3033	L
Welded Wire Mesh / Ladder Wire	2.5455	Tonnes

7.0 Communication of Assessment Results

Life Cycle Results

The following table summarizes the Impact Assessment results for Allard Hall.

Table 5 - Allard Hall LCA Results

	Life Cycle Stage	Process	Level 3 Element							Building Total
			A11 Foundation	A21 Lower Floor Construction	A22 Upper Floor Construction	A23 Roof	A31 Walls Below Grade	A32 Walls Above Grade	B11 Partitions	
Fossil Fuels (MJ)	Manufacturing	Material	436827	436827	8268600	2836147	1459957	8767689	25179094	26650617
		Transportation	37248	37248	406143	87490	88023	237353	130841	118946336
		Total	474075	474075	8674780	2923637	1547980	9005041	2648750	27840081
	Construction	Construction-Installation Process	101920	101920	798414	167920	164692	565325	156752	2142664
		Transportation	57142	57143	437860	163322	105222	824305	132289	1967701
		Total	159063	159063	1236274	331242	269914	1389630	289041	4110365
	Assembly Total		63313	633138	9911054	3254879	1817894	10394671	2937791	31950446
Global Warming (kg CO2eq)	Manufacturing	Material	66103	66103	820115	261458	159377	918274	180994	2798308
		Transportation	2237.8	2237.8	24702	4968.2	5108.4	14504	7612.1	70899
		Total	68340	68341	844817	266426	164485	932778	188606	2869207
	Construction	Construction-Installation Process	8554.4	8554.5	72150	14792	14768	59453	12635	206900
		Transportation	4209.9	4209.9	33360	7607.4	6968.0	62678	8312.0	141989
		Total	12764.5	12764	105510	22399	21736	122131	20947	348889
	Assembly Total		81105	81105	950327	288825	186221	1054909	209553	3218097
A	Manufactur	Material	434.28	434.28	5438.9	1292.8	969.13	8091.2	1140.2	19924.4

	ing	Transportation	13.928	13.928	152.24	31.743	31.897	89.972	44.282	440.51
		Total	448.21	448.21	5591.1	1324.5	1001.0	8181.1	1184.5	20365
	Construction	Construction-Installation Process	61.291	61.291	577.55	109.59	107.37	423.01	85.636	1518.2
		Transportation	20.317	20.317	156.01	57.233	37.225	293.37	46.537	698.91
		Total	81.608	81.608	733.56	166.82	144.59	716.38	132.17	2217.2
	Assembly Total		529.82	529.82	6324.7	1491.3	1145.6	8897.5	1316.7	22582
Human Health – Respiratory (kg	Manufacturing	Material	184.30	184.30	1794.2	372.29	319.68	5179.6	202.11	9075.5
		Transportation	0.39076	0.390759	4.2840	0.88372	0.8941	2.5268	1.2689	12.365
		Total	184.69	184.69	1798.49	373.18	320.57	5182.1	203.38	9087.8
	Construction	Construction-Installation Process	9.5890	9.5889	92.450	16.848	16.723	100.74	16.290	304.10
		Transportation	0.61981	0.61981	4.8155	1.5153	1.0952	9.0520	1.3476	21.168
		Total	10.209	10.209	97.266	18.364	17.819	109.80	17.637	325.26
	Assembly Total		194.89	194.89	1895.8	391.54	338.39	5291.9	221.02	9413.1
Eutrophication (kg Neq)	Manufacturing	Material	19.760	19.759	559.90	149.44	73.561	367.16	99.797	1377.8
		Transportation	0.97417	0.97417	10.658	2.2150	2.2303	6.2949	3.1173	30.815
		Total	20.734	20.734	570.56	151.66	75.792	373.45	102.91	1408.63
	Construction	Construction-Installation Process	3.4366	3.4366	35.031	6.9521	6.4125	21.026	5.4508	85.118
		Transportation	1.4589	1.4589	11.245	3.9347	2.6423	21.143	3.2870	50.068
		Total	4.8954	4.8954	46.275	10.887	9.0548	42.169	8.7377	135.19
	Assembly Total		25.63	25.63	616.84	162.55	84.85	415.62	111.65	1543.8
Ozone Layer (kg CFC-11eq)	Manufacturing	Material	0.0003769	0.0003769	0.0040196	0.000712	0.000703	0.00451	0.001557	0.01425
		Transportation	9.1120E-08	9.119E-08	1.006E-06	2.031E-07	2.083E-07	5.91E-07	3.087E-07	2.889E-06
		Total	0.0003770	0.00037699	0.0040206	0.0007126	0.0007032	0.00451	0.001557	0.01425
	Construction	Construction-Installation Process	1.884E-05	1.884E-05	0.00020133	3.565E-05	3.705E-05	0.000244	6.796E-05	0.0007241
		Transportation	1.68E-07	1.680E-07	1.331E-06	3.076E-07	2.789E-07	2.49E-06	3.33E-07	5.669E-06
		Total	1.901E-05	1.901E-05	0.0002026	3.596E-05	3.733E-05	0.0002468	6.829E-05	0.000729
	Assembly Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Smog (kg	Manufacturing	Material	8989.155041	8989.2	100581	20099	16502	106331	9301.5	315670
		Transportation	493.1131722	493.11	5389.9	1124.0	1129.3	3185.4	1567.5	15596
		Total	9482.268	9482.3	105971	21223	17631	109517	10869	331266

			213							
	Construction	Construction-Installation Process	1890.852777	1890.9	17236	3219.7	2875.2	10521	889.19	40343
		Transportation	718.4214696	718.42	5516.8	2023.3	1316.2	10374	1645.6	24714
		Total	2609.274247	2609.3	22752	5242.9	4191.5	20895	2534.74	65057
	Assembly Total		12,091.54	12091	128724	26466	21823	130412	13404	396323

Several hotspots were identified for each level 3 elements for the global warming impact category. For element A11, Footing_F5 contributed to 54.42% of the total global warming impact. For element A21, SOG_100mm_Interior contributed 70.27% of the total, and for element A23, Roof_Concrete Suspended Slab_4.8LL contributed 43.75%. For element A31, 1.1.1 Wall_Cast-in-Place_200mm_Basement contributed to 42.39% of the total. For element A32, 1.2.17 Exterior_Partition_W1_Main contributed to 23.70% of the total. And for element B11, 1.2.5 Interior_Partition_P2_Main contributed to 46.76%.

Subsequent to this section are several Annexes that provide information that is not part of the EN 15978 requirements. Annex A contains further interpretation of the assessment results. Annex B contains recommendations for LCA use. Annex C contains a reflection of the study. And finally, Annex D contains the Impact Estimator inputs and assumptions.

Annex A - Interpretation of Assessment Results

Benchmark Development

A benchmark is a standard or point of reference against which things can be compared. In order to create benchmarks for LCA, environmental impact data from various LCA studies must be collected. These LCA assessments must have a similar reference study period, must use the similar impact assessment methods, and must have the same functional units. Using the same functional units and presenting benchmarks as *environmental impact/functional unit* is essential, otherwise the data from the LCA studies is incompatible and cannot be used to make benchmarks. Moreover, the goal and scope, as well as the model development of the LCA studies to be used to make benchmarks must be the same, or at least very similar. Benchmarks can be created for a variety of unifying characteristics, such as region, use of building, type of building construction, classification of building, and many more. It is inevitable that the building process will have environmental impacts, and LCA assessments are beneficial in that they make the audience aware of what the environmental impacts are; however, without benchmarks to compare against, it is impossible to determine if the building under assessment has a higher or lower environmental impact than average. Furthermore, benchmarks allow the overall comparison of environmental impacts of different building regions, or different building types, or different building categories.

UBC Academic Building Benchmark

Benchmarks were created from the seventeen UBC building assessed. The benchmarks were created from information on the GoogleDrive taken at 2pm on Sunday, November 17, 2013. The results of this study on Allard Hall are compared against the benchmarks in the following figures.

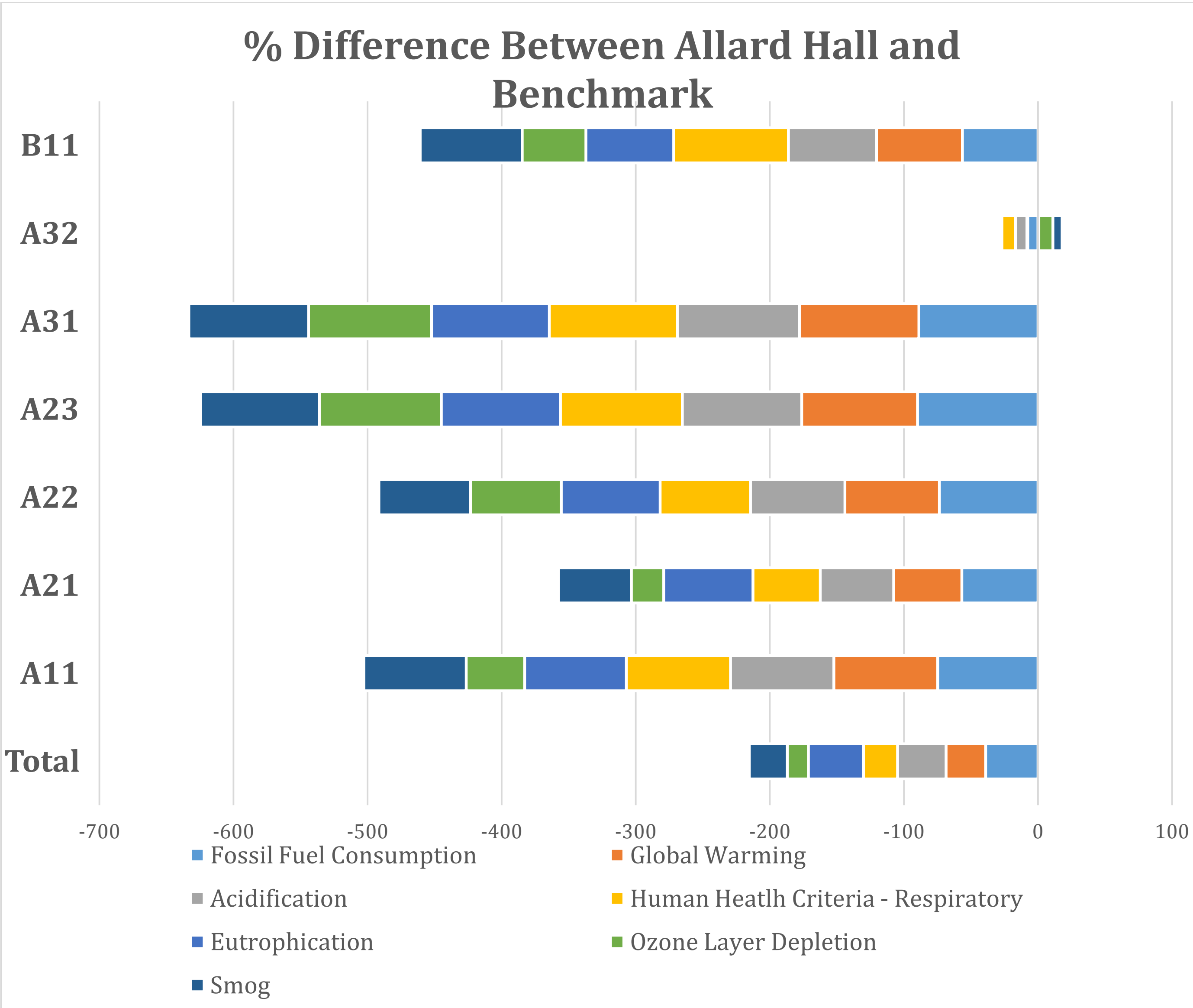

Figure 2 - All Impact Categories, % Difference

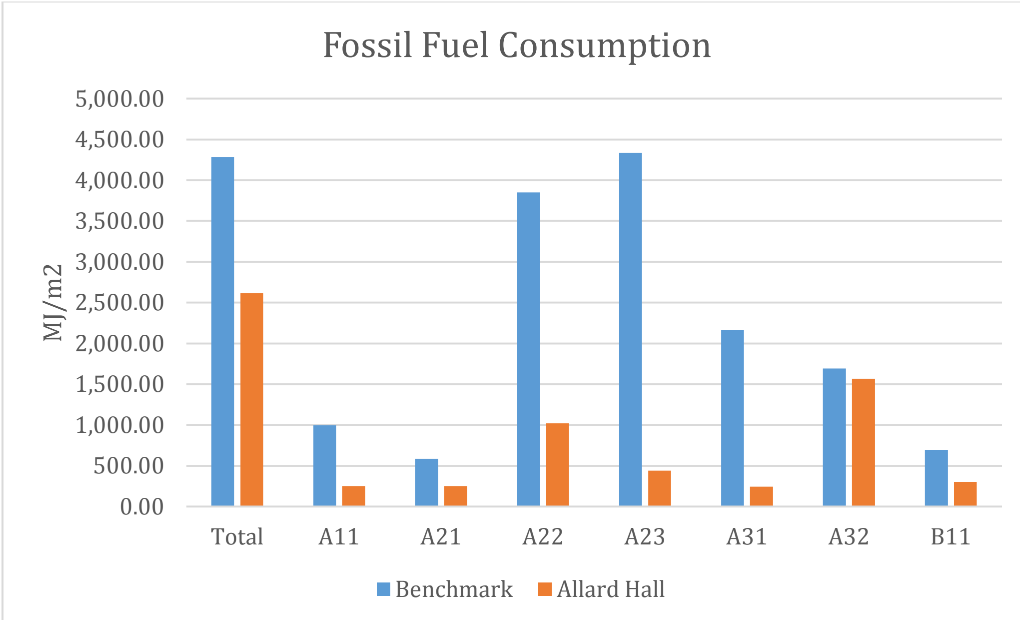

Figure 3 - Fossil Fuel Consumption

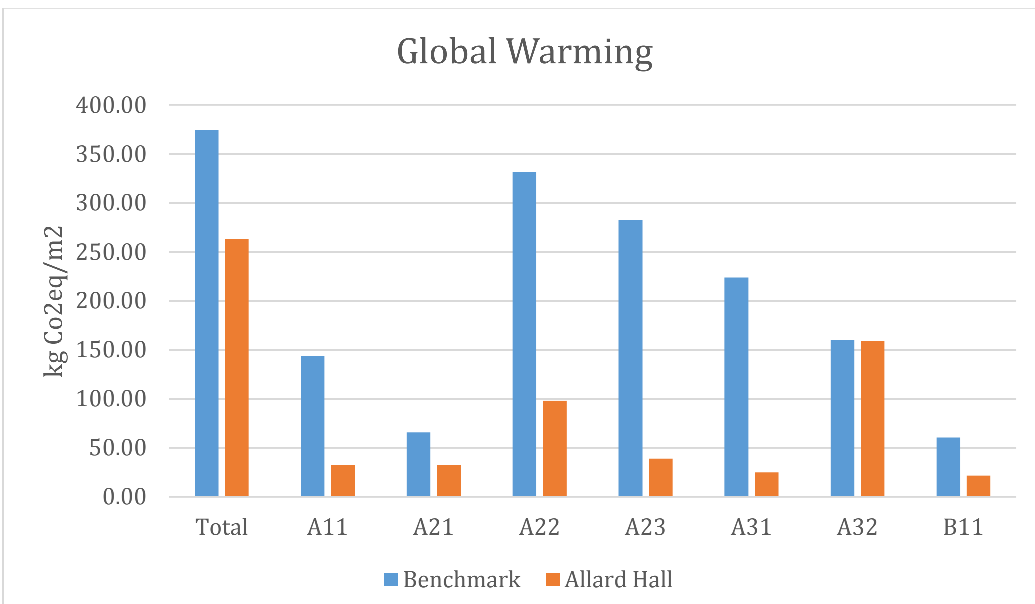

Figure 4 - Global Warming

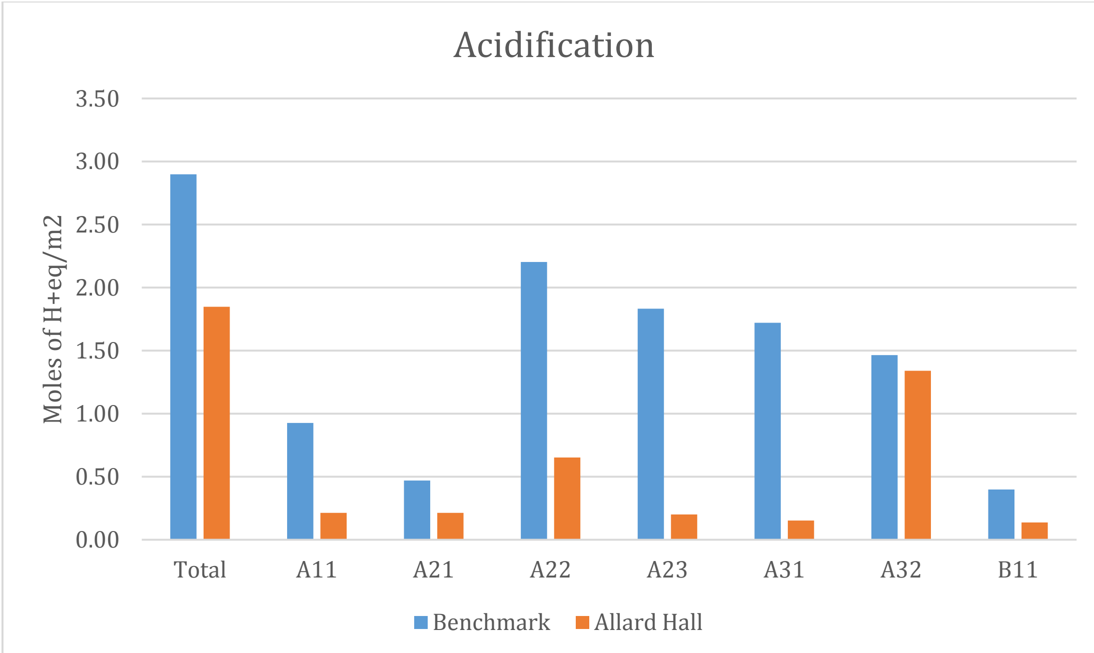

Figure 5 - Acidification

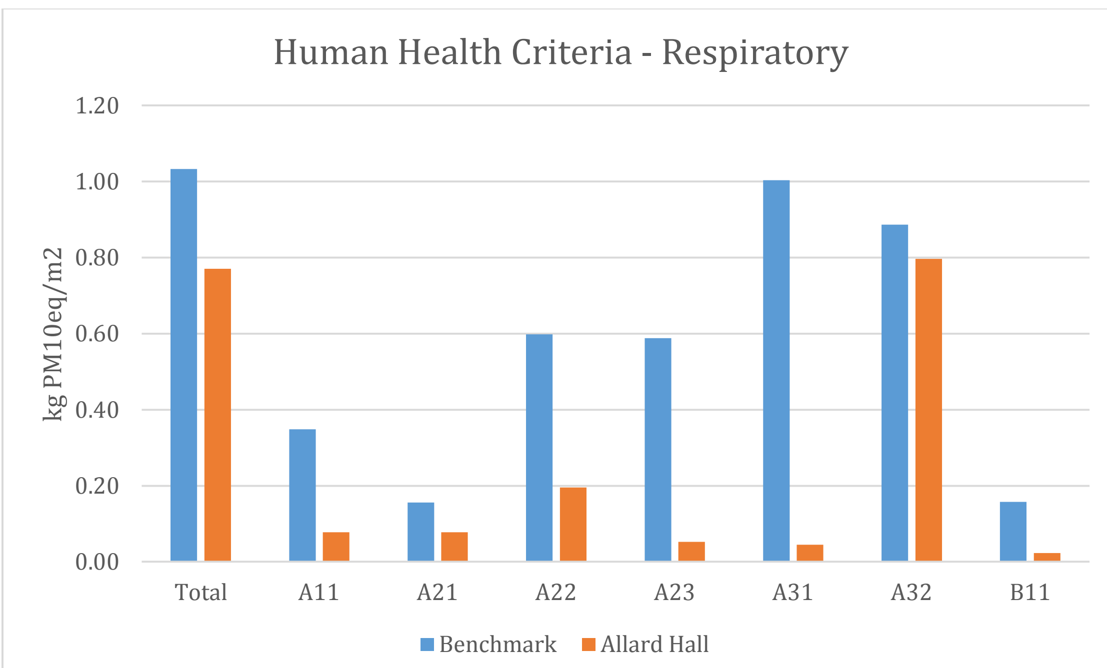

Figure 6 - Human Health Criteria - Respiratory

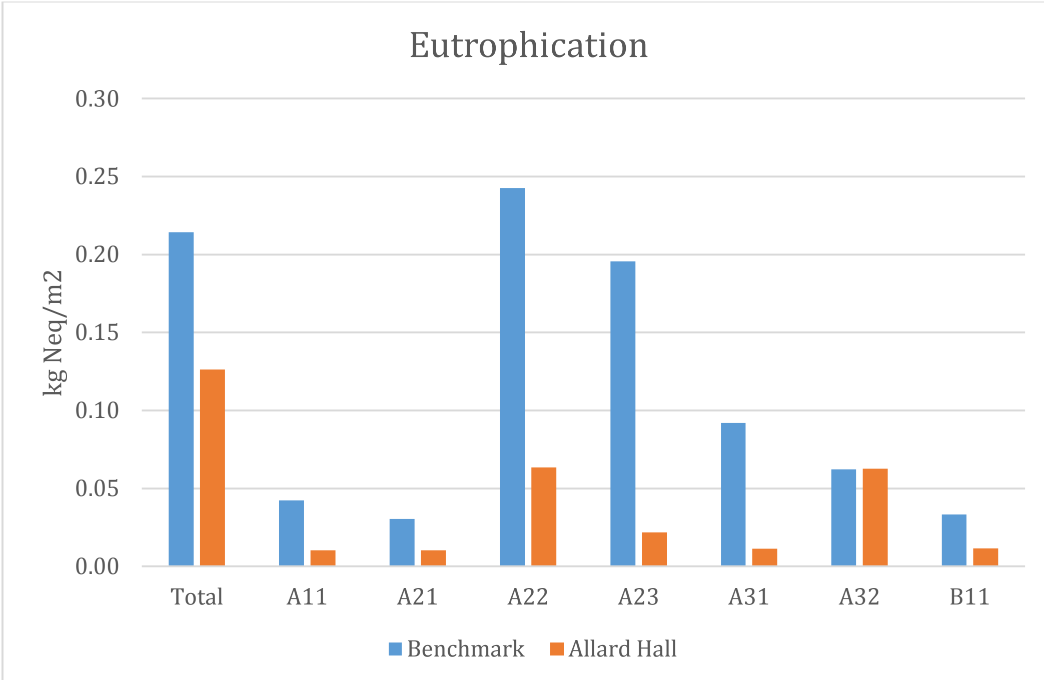

Figure 7 - Eutrophication

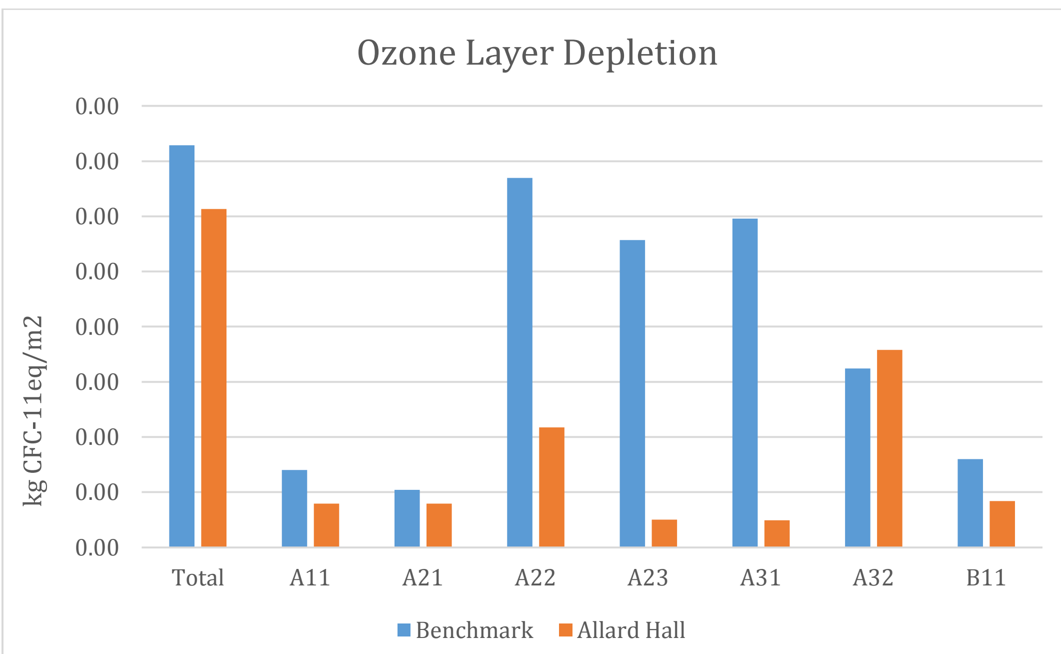

Figure 8 - Ozone Layer Depletion

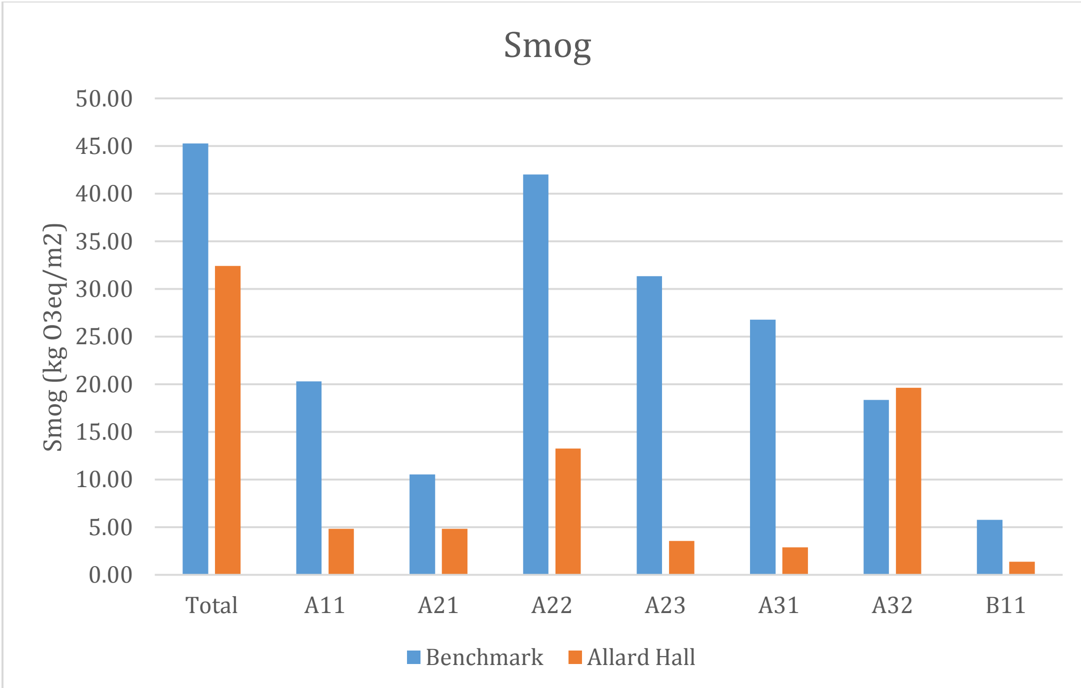

Figure 9 - Smog

Allard Hall had lower values for all the impact categories when compared to the benchmark values.

The following is a scatter plot of total cost of construction in 2013 Canadian dollars versus global warming potential for the UBC buildings used to create the benchmarks.

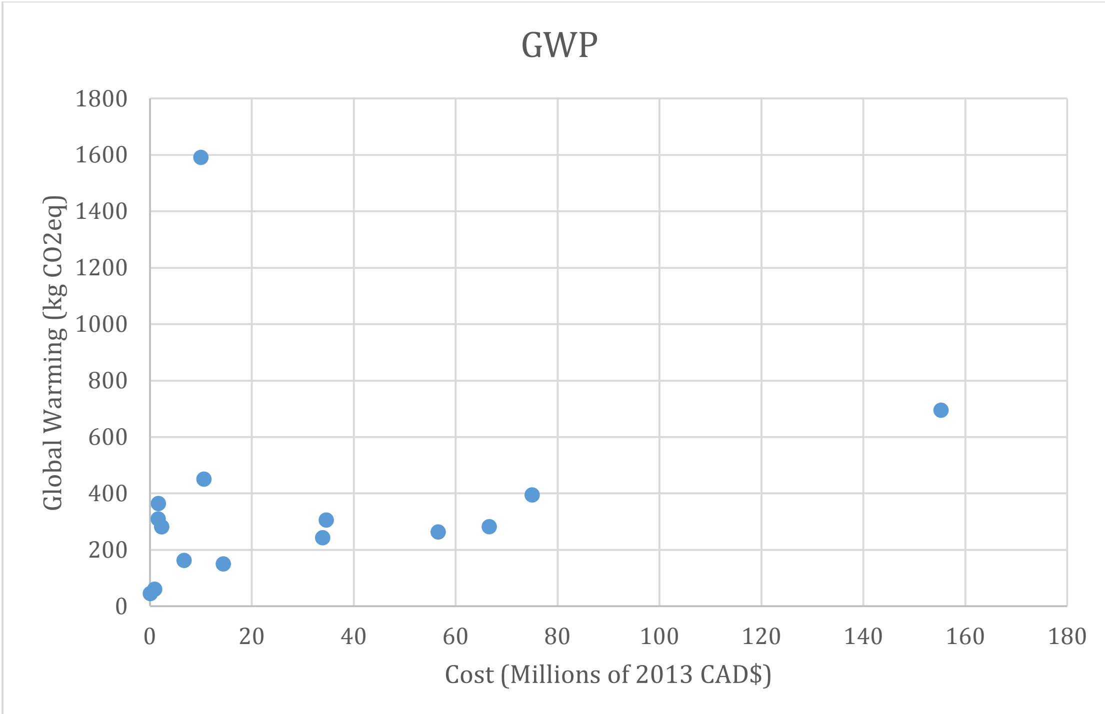

Figure 10 - Cost versus Global Warming

The above figure of building cost versus global warming is inaccurate and imprecise in many ways. The values for cost were intended to be in 2013 Canadian dollars; however the cost calculations were all done separately by different students and taken from a common information drive, it was impossible to know at the time of data extraction if the cost values had been inflated to 2013 dollars. Furthermore, since the cost calculations were done by individual students, it is difficult to verify if the calculations were done in a congruent and accurate manner.

Annex B - Recommendations for LCA Use

Life cycle analysis can be a powerful tool to use in the design stage of a building. It can be utilized to inform designers and planners of the potential impacts that their building designs would have on the environment. It can be used for building designers and planners to explore many different options for building components and accurately compare them based on the impact categories of LCA results. In order for LCA to become more widely used in building design and appropriate for various types of projects, there are several things that should be considered. Constant development and maintenance of LCI databases, to improve the quality and variety of products involved, should be undertaken. The development of benchmarks for buildings groups by categories such as geographical region, use, classification, and construction would help LCA become a more powerful design tool. Furthermore, life cycle modules beyond product and construction stages should be considered for buildings, and benchmarks should be created for these stages as well. In order for benchmarks to be created, normalization methods will need to be developed to make the comparison valid for buildings with different uses and service lives. In efforts to operationalize LCA in building design, it is important to consider how the impact categories should be prioritized. Many professionals have differing opinions concerning which impact categories are most important, and which should be minimized the most. Although it is unlikely to have all professionals involved come to a consensus concerning the prioritization of impact categories, it is important to explicitly outline how the LCA results will be used and how the impact categories are prioritized. The steps and considerations outlined above should be used when attempting to operationalize LCA methods, data and their use in practice at UBC.

Annex C - Author Reflection

Prior to this class, I had only been exposed to LCA briefly in CIVL 200. Sustainability is a topic that has been integrated into a large number of the classes I have previously taken.

This course, CIVL 498C, covered the entire LCA process, from the history of LCA to the practice of LCA, as well as related topics such as social LCA and LCC.

What interested me about this course is drive to move towards more sustainable building practices, and the methods that can be used to assess the impacts of construction projects. Although this project has been time consuming and using the software has been at times been frustrating, the overall experience of looking in such detail at an LCA study has been rewarding. However, a large portion of this project hinged on the quality of work of the previous study of the building.

Graduate Attribute			
Name	Description	Select the content code most appropriate for each attribute from the dropdown menue	Comments on which of the CEAB graduate attributes you believe you had to demonstrate during your final project experience.

1	Knowledge Base	Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	N/A = not applicable	During this project I did not need to demonstrate compentancy in mathematics, natural sciences, engineering funcamentals (other than knowledge of construction practices), or specialized engineering knowledge.
2	Problem Analysis	An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.	N/A = not applicable	In this project I did not need to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantatiated conclusions.
3	Investigation	An ability to conduct investigations of complex problems by methods that include	DA = developed & applied	This project involved some investigation, but not into very complex problems.

		appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.		Experiments were not used in this project. Analysis and interpretation was heavily used in this project. Synthesis of information in order to reach valid conclusions was also involved in this report.
4	Design	An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.	N/A = not applicable	This project did not involve any design work.

5	Use fo Engineering Tools	An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.	DA = developed & applied	If one considers microsoft excel, OST, and Athena engineering tools, then engineering tools were used in this project.
6	Individual and Team Work	An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.	N/A = not applicable	This project did not involve any team work.
7	Communication	An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading,	DA = developed & applied	Communication was used in this project, in the form of a written report.

		writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.	
8	Professionalism	An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.	

9	Impact of Engineering on Society and the Environment	An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.	DA = developed & applied	To some extent this category is applicable to this project.
10	Ethics and Equity	An ability to apply professional ethics, accountability, and equity.	DA = developed & applied	I had to apply ethics and accountability in this project, in information gathering, proper citation, not

				plagarising, and managing time in an efficient manner.
11	Economics and Project Management	An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.	N/A = not applicable	Other than a basic calculation of 2013 building cost using inflation rates, this project did ot incorporate economic or business practices.
12	Life-long Learning	An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.	DA = developed & applied	This project required a significant amount of investigation, which encourages life-long learning.

Annex D – Impact Estimator Inputs and Assumptions

Element	Quantity	Units	Assembly Type	Assembly Name	Input Fields	Known/ Measured Info	IE Inputs
A11 Foundations	26980 2507	ft^2 m^2	Concrete Footing	1.2.1 Footing_F1	Length (ft)	49.2	49.2
					Width (ft)	4.9	4.9
					Thickness (in)	17.7	17.7
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#5	#5
				1.2.2 Footing_F2	Length (ft)	70.85	70.85
					Width (ft)	5.90	5.90
					Thickness (in)	19.68	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#5	#5
				1.2.3. Footing_F3	Length (ft)	52.48	57.73
					Width (ft)	6.56	6.56
					Thickness (in)	21.65	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#6	#6
				1.2.4 Footing_F4	Length (ft)	135.79	176.53
					Width (ft)	7.54	7.54
					Thickness (in)	25.58	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#6	#6
				1.2.5 Footing_F5	Length (ft)	9.84	16.73
					Width (ft)	9.84	9.84
					Thickness (in)	33.46	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#8	#6
				1.2.6	Length (ft)	17.71	17.71

		Footing_F6	Width (ft)	2.95	2.95
			Thickness (in)	9.84	9.84
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#4	#4
		1.2.7 Footing_SF1	Length (ft)	555.39	555.39
			Width (ft)	1.97	1.97
			Thickness (in)	9.84	9.84
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.8 Footing_SF2	Length (ft)	420.43	462.47
			Width (ft)	6.56	6.56
			Thickness (in)	21.65	19.68
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#8	#6
		1.2.9 Footing_SF3	Length (ft)	54.15	70.39
			Width (ft)	8.20	8.20
			Thickness (in)	25.58	19.68
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#8	#6
		1.2.10 Footing_SF4	Length (ft)	57.72	57.72
			Width (ft)	4.92	4.92
			Thickness (in)	13.78	13.78
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#6	#6
		1.2.11 Footing_1500mm_LowerFloor	Length (ft)	54.42	163.26
			Width (ft)	21.33	21.33
			Thickness (in)	59.04	19.68
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#10	#6
		1.2.12 Footing_250mm_LowerFloor	Length (ft)	3.28	3.28
			Width (ft)	3.94	3.94
			Thickness (in)	9.84	9.84
			Concrete (psi)	4351	4000
			Concrete flyash %	-	average
			Rebar	#4	#5

				1.2.13 Footing_400mm_GroundFloor	Length (ft)	40.10	40.10
					Width (ft)	52.48	52.48
					Thickness (in)	15.74	15.74
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#6	#6
				1.2.14 Footing_750mm_GroundFloor	Length (ft)	48.25	48.25
					Width (ft)	9.84	9.84
					Thickness (in)	19.68	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#8	#6
				1.2.15 Footing_400mm_GroundFloor	Length (ft)	8.20	8.20
					Width (ft)	4.92	4.92
					Thickness (in)	15.74	15.74
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#5	#5
				1.2.16 Footing_500mm_GroundFloor	Length (ft)	14.76	14.76
					Width (ft)	4.92	4.92
					Thickness (in)	19.68	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#6	#6
				1.2.17 Footing_1500mm_GroundFloor	Length (ft)	56.25	168.75
					Width (ft)	6.56	6.56
					Thickness (in)	59.04	19.68
					Concrete (psi)	4351	4000
					Concrete flyash %	-	average
					Rebar	#8	#6
A21 Lowest Floor Construction	26980 2506	ft^2 m^2	Concrete Slab on Grade	1.1.1 SOG_100mm_Exterior	Length (ft)	57.78	57.78
					Width (ft)	57.78	57.78
					Thickness (in)	4	4
					Concrete (psi)	4000	4000
					Concrete flyash %	-	Average
				1.1.2 SOG_100mm_Interior	Length (ft)	154.98	154.98
					Width (ft)	154.98	154.98

					Thickness (in)	4	**4**
					Concrete (psi)	3000	3000
					Concrete flyash %	-	Average
				1.1.3 SOG_200mm_Interior	Length (ft)	54.42	54.42
					Width (ft)	54.42	54.42
					Thickness (in)	8	**8**
					Concrete (psi)	3000	3000
					Concrete flyash %	-	Average
A22 Upper Floor Construction	104522	ft^2	Concrete Column	3.1.1 Column_Concrete_Beam_N/A_Lowerlevel			
	9710	m^2			Number of Beams	0	0
					Number of Columns	6	6
					Column Height(ft)	0.00	0.00
					Bay sizes (ft)	19.68	19.68
					Supported span (ft)	19.68	19.68
					Supported Area(ft2)	387.30	388.00
					Live load (psf)	0.00	0
				3.1.2 Column_Concrete_Beam_Concrete_GroundLevel			
					Number of Beams	20	20
					Number of Columns	43	43
					Column Height(ft)	13.12	13.12
					Bay sizes (ft)	19.68	19.68
					Supported span (ft)	19.68	19.68
					Supported Area(ft2)	387.30	388.00
					Live load (psf)	0.00	0
				3.1.3 Column_Concrete_Beam_Concrete			

		_Level2			
			Number of Beams	11	11
			Number of Columns	64	64
			Column Height(ft)	13.12	13.12
			Bay sizes (ft)	19.68	19.68
			Supported span (ft)	19.68	19.68
			Supported Area(ft2)	387.30	388.00
			Live load (psf)	0.00	0
		3.1.4 Column_Concrete_Beam_Concrete_Level3			
			Number of Beams	8	8
			Number of Columns	83	83
			Column Height(ft)	13.12	13.12
			Bay sizes (ft)	19.68	19.68
			Supported span (ft)	19.68	19.68
			Supported Area(ft2)	387.30	388.00
			Live load (psf)	0.00	0
		3.1.5 Column_Concrete_Beam_Concrete_Level4			
			Number of Beams	13	13
			Number of Columns	87	87
			Column Height(ft)	13.12	13.12
			Bay sizes (ft)	19.68	19.68
			Supported span (ft)	19.68	19.68
			Supported Area(ft2)	387.30	388.00
			Live load (psf)	0.00	0
	Concrete Suspended Slab	4.1.2 Floor_Concrete Suspended Slab_3.6LL			

				Roof Width (ft)	2618.43	2618.4
				Span (ft)	18.403	18.403
				Concrete (psi)	4000	4000
				Concrete flyash %	-	Average
				Live Load (psf)	75	75
			4.1.3 Floor _Concrete Suspended Slab_4.8LL			
				Roof Width (ft)	2965.05	2965.05
				Span (ft)	19	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	Average
				Live Load (psf)	100	100
A23 Roof Construction	80080 7439	ft^2 m^2	Concrete Suspended Slab	5.1.1 Roof _Concrete Suspended Slab_2.4LL		
				Roof Width (ft)	1280.568	1280.5
				Span (ft)	18.542	18.542
				Concrete (psi)	4000	4000
				Concrete flyash %	-	Average
				Live Load (psf)	50	50
			Steel Joist Roof	5.2.1 Roof_Steel Joist Roof		
				Roof Width (ft)	3122.83	3122.83
				Span (ft)	18.04	18.04
				Decking Type	-	None
				Decking Thickness (in)	1.5	0.75
				Steel Gauge	-	18
				Joist Type	7/8 x 10	1 5/8 x 10
				Joist Spacing	28	24
				3.1.4 Column_Hollow Structural Steel_Beam _N/A_Level 5		
				Number of Beams	7	7

				Number of Columns	31	31
				Column Height(ft)	0.00	0
				Bay sizes (ft)	19.68	19.68
				Supported span (ft)	19.68	19.68
				Supported Area(ft2)	387.30	388.00
				Live load (psf)	0.00	0
A31 Walls Below Grade	81183 ft^2 7542 m^2	Cast-in-Place	2.1.1 Wall_Cast-in-Place_200mm_Basement			
				Length (ft)	863.00	863.00
				Height (ft)	13.70	13.70
				Thickness (in)	7.87	8
				Concrete (psi)	-	4000
				Concrete flyash %	-	average
				Rebar	#15M	#5
			2.1.2 Wall_Cast-in-Place_300mm_Basement			
				Length (ft)	233.00	233.00
				Height (ft)	13.70	13.70
				Thickness (in)	11.81	11.81
				Concrete (psi)	-	4000
				Concrete flyash %	-	average
				Rebar	#15M	#5
			2.1.3 Wall_Cast-in-Place_400mm_Basement			
				Length (ft)	41.00	54.68
				Height (ft)	13.70	13.70
				Thickness (in)	15.75	11.81
				Concrete (psi)	-	4000
				Concrete flyash %	-	average
				Rebar	#15M	#5
			Opening	Type	Door	Door
				Number	1	1.000

			Material	Hollow Metal	Steel Interior Door
		2.1.4 Wall_Cast-in-Place_450mm_Basement			
			Length (ft)	72.00	108.03
			Height (ft)	13.70	13.70
			Thickness (in)	17.72	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		Opening	Type	Door	Door
			Number	1	1
			Material	Wood	Hollow Core Wood Interior Door
		2.1.5 Wall_Cast-in-Place_600mm_Basement			
			Length (ft)	15.00	30.00
			Height (ft)	13.70	13.70
			Thickness (in)	23.62	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		2.1.6 Wall_Cast-in-Place_1000mm_Basement			
			Length (ft)	7.00	23.34
			Height (ft)	13.70	13.70
			Thickness (in)	39.37	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
	Furring	2.3.1 Furring_F1_Basement			

			Length (ft)	299.00	299.00
			Height (ft)	13.70	13.70
			Wall Type		Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1" metal furring system	1 5/8 x 3 5/8
			Stud Spacing (in)	16	24
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm regular	Gypsum Regular 5/8"
			Material/Number	-	-
		Opening	Type	Door	Door
			Number	5	5
			Material	Hollow Metal	Steel Interior Door
		2.3.2 Furring_F3_ Basement			
			Length (ft)	126.00	126.00
			Height (ft)	13.70	13.70
			Wall Type		Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	2 1/2	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm regular	Gypsum Regular 5/8"
			Material/Number	-	-
		2.3.3 Furring_F1_ Main			
			Length (ft)	362.00	362.00
			Height (ft)	12.47	12.47
			Wall Type		Non Load Bearing

			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1" metal furring system	1 5/8 x 3 5/8
			Stud Spacing (in)	16	24
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm regular	Gypsum Regular 5/8"
			Material/Number	-	-
		Opening	Type	Door	Door
			Number	1	1
			Material	Hollow Metal	Steel Interior Door
		2.3.4 Furring_F3_Main			
			Length (ft)	3,599.00	3,599.00
			Height (ft)	12.47	12.47
			Wall Type		Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	2 1/2	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm regular	Gypsum Regular 5/8"
			Material/Number	-	-
		Opening	Type	Door	Door
			Number	5	5
			Material	Wood	Hollow Core Wood Interior Door
		2.3.5 Furring_F4_Main			
			Length (ft)	730.00	730.00
			Height (ft)	12.47	12.47

					Wall Type		Non Load Bearing
					Stud Weight	-	Light (25Ga)
					Sheathing Type	none	none
					Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
					Stud Spacing (in)	16	16
				Envelope	Category	Gypsum Board	Gypsum Board
					Material/Number	16mm regular	Gypsum Regular 5/8"
					Material/Number	-	-
				Opening	Type	Door	Door
					Number	21	21
					Material	Wood	Hollow Core Wood Interior Door
A32 Walls Above Grade	71467	ft^2	Cast-in-Place	2.1.7 Wall_Cast-in-Place_200mm_Main			
	6639	m^2		(see assumptions)	Length (ft)	619.00	430.00
					Height (ft)	12.47	12.47
					Thickness (in)	7.87	8
					Concrete (psi)	-	4000
					Concrete flyash %	-	average
					Rebar	#15M	#5
				2.1.8 Wall_Cast-in-Place_300mm_Main			
					Length (ft)	855.00	855.00
					Height (ft)	12.47	12.47
					Thickness (in)	11.81	11.81
					Concrete (psi)	-	4000
					Concrete flyash %	-	average
					Rebar	#15M	#5
				2.1.9 Wall_Cast-in-Place_400m			

m_Main			
	Length (ft)	166.00	221.38
	Height (ft)	12.47	12.47
	Thickness (in)	15.75	11.81
	Concrete (psi)	-	4000
	Concrete flyash %	-	average
	Rebar	#15M	#5
Opening	Type	Door	Door
	Number	4	4
	Material	Wood	Hollow Core Wood Interior Door
2.1.10 Wall_Cast-in-Place_450mm_Main			
	Length (ft)	289.00	433.62
	Height (ft)	12.47	12.47
	Thickness (in)	17.72	11.81
	Concrete (psi)	-	4000
	Concrete flyash %	-	average
	Rebar	#15M	#5
Opening	Type	Door	Door
	Number	5	5
	Material	Wood	Hollow Core Wood Interior Door
2.1.11 Wall_Cast-in-Place_600mm_Main			
	Length (ft)	57.00	114.00
	Height (ft)	12.47	12.47
	Thickness (in)	23.62	11.81
	Concrete (psi)	-	4000
	Concrete flyash %	-	average
	Rebar	#15M	#5
2.1.12 Wall_Cast-in-Place_1000mm_Main			

			Length (ft)	28.00	93.34
			Height (ft)	12.47	12.47
			Thickness (in)	39.37	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		2.1.13 Wall_Cast-in-Place_300mm_5thFloor			
			Length (ft)	19.00	19.00
			Height (ft)	16.40	16.40
			Thickness (in)	11.81	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		2.1.14 Wall_Cast-in-Place_400mm_5thFloor			
			Length (ft)	29.00	38.67
			Height (ft)	16.40	16.40
			Thickness (in)	15.75	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		Opening	Type	Door	Door
			Number	1	1
			Material	Hollow Metal	Steel Interior Door
		2.1.15 Wall_Cast-in-Place_450mm_5thFloor			
			Length (ft)	63.00	94.53
			Height (ft)	16.40	16.40
			Thickness (in)	17.72	11.81
			Concrete (psi)	-	4000
			Concrete flyash %	-	average
			Rebar	#15M	#5
		Opening	Type	Door	Door
			Number	1	1

Curtain Walls		Material	Hollow Metal	Steel Interior Door
	2.4.1 Curtain_Wall_FM2_600_lounge			
		Length (ft)	73.00	73.00
		Height (ft)	13.12	13.12
		Wall Type	Curtain	Curtain
		Percent viewable glazing	85	85
		Percent spandrel panel	15	15
		Insulation thickness (mm)	125	125
		Spandrel panel type	glass	Opaque Glass Panel Spandrel
	Opening	Type	Door	Door
		Number	2	2
		Material	Glass	Aluminum Exterior Door, 80% Glazing
	2.4.2 Curtain_Wall_FM2_800_lounge			
		Length (ft)	94.00	94.00
		Height (ft)	13.12	13.12
		Wall Type	Curtain	Curtain
		Percent viewable glazing	80	80
		Percent spandrel panel	20	20
		Insulation thickness (mm)	125	125
		Spandrel panel type	glass	Aluminum Exterior Door, 80% Glazing
	2.4.3 Curtain_Wall_FM2_0_lounge			

	Length (ft)	104.00	104.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	100	100
	Percent spandrel panel	0	0
	Insulation thickness	-	-
	Spandrel panel type	-	-
2.4.4 Curtain_Wall_FM2_1500_lounge			
	Length (ft)	104.00	104.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	62	62
	Percent spandrel panel	38	38
	Insulation thickness (mm)	125	125
	Spandrel panel type	glass	Opaque Glass Panel Spandrel
2.4.5 Curtain_Wall_Glass_forum			
	Length (ft)	109.00	109.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	100	100
	Percent spandrel panel	0	0
Envelope	Insulation thickness	-	-
	Spandrel panel type	-	-
Opening	Type	Door	Door
	Number	2	2
	Material	Glass	Aluminum Exterior Door, 80%

			Glazing
2.4.6 Curtain_Wall_FM2_1200_southwest			
	Length (ft)	182.00	182.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	70	70
	Percent spandrel panel	30	30
	Insulation thickness (mm)	125	125
	Spandrel panel type	glass	Opaque Glass Panel Spandrel
2.4.7 Curtain_Wall_FM2_2000			
	Length (ft)	309.00	309.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	50	50
	Percent spandrel panel	50	50
	Insulation thickness (mm)	125	125
	Spandrel panel type	glass	Opaque Glass Panel Spandrel
2.4.8 Curtain_Wall_FM2_Terrace			
	Length (ft)	129.00	129.00
	Height (ft)	13.12	13.12
	Wall Type	Curtain	Curtain
	Percent viewable glazing	100	100
	Percent spandrel panel	0	0
	Insulation thickness	-	-
	Spandrel panel type	-	-

2.2.17 Exterior_Partition_W1_Main			
	Length (ft)	1,159.00	1,159.00
	Height (ft)	13.12	13.12
	Wall Type	Concrete Block	Concrete Block
	Reinforcement	-	#4
Envelope	Category	Cladding	Cladding
	Material	Brick (modular metric)	Brick (modular metric)
Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
	Material	Air Barrier	Air Barrier
Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
	Material	Vapour Retarder Membrane	Polyethylene 3 mil
Envelope	Category	Insulation	Insulation
	Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
	Thickness	125	125
Opening	Type	Window	Window
	Number	75	75
	Total Area (ft²)	2743.800	2743.800
	Frame Type	-	Aluminum Frame
	Glazing Type	-	Standard Glazing
	Fixed / Operable	Fixed	Fixed
2.2.18 Exterior_Partition_W1.1_Main			
	Length (ft)	109.00	109.00
	Height (ft)	13.12	12.47

		Wall Type	See 1.1.7	
		Reinforcement	See 1.1.7	
	Envelope	Category	Cladding	Cladding
		Material	Brick (modular metric)	Brick (modular metric)
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour Retarder Membrane	Polyethylene 3 mil
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	125	125
	2.2.19 Exterior_Partition_W2_Main			
		Length (ft)	58.00	58.00
		Height (ft)	13.12	13.12
		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
	Envelope	Category	Cladding	Cladding
		Material	12mm prefinished wood	Wood Bevel Siding - Cedar
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour	Polyethy

			Retarder Membrane	lene 3 mil
	Envelope	Category Material	Insulation semi-rigid, flexible (polyurethane?)	Insulation Polystyrene Expanded
		Thickness (mm)	125	125
	2.2.20 Exterior_Partition_W3_5thFloor			
		Length (ft)	188.00	188.00
		Height (ft)	16.40	16.40
		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
	Envelope	Category Material	Cladding 32mm stone veneer	Cladding Natural stone
	Envelope	Category Material	Air and Vapour Barrier Air Barrier	Air and Vapour Barrier Air Barrier
	Envelope	Category Material	Air and Vapour Barrier Vapour Retarder Membrane	Air and Vapour Barrier Polyethylene 3 mil
	Envelope	Category Material	Insulation semi-rigid, flexible (polyurethane?)	Insulation Polystyrene Expanded
		Thickness (mm)	125	125
	2.2.21 Exterior_Partition_W3.1_5thFloor			
		Length (ft)	80.00	80.00
		Height (ft)	16.40	12.47

		Wall Type	See 1.1.7	
		Reinforcement	See 1.1.7	
	Envelope	Category	Cladding	Cladding
		Material	32mm stone veneer	Natural stone
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour Retarder Membrane	Polyethylene 3 mil
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	125	125
	Opening	Type	Door	Door
		Number	4	4.000
		Material	Hollow Metal	Steel Exterior Door
	2.2.22 Exterior_Partition_W4_5thFloor			
		Length (ft)	109.00	109.00
		Height (ft)	16.40	16.40
		Wall Type	Steel z-girts	Non Load Bearing
		Stud Weight	Heavy (20ga)	Heavy (20ga)
		Sheathing Type	none	none
		Stud Thickness	200mm	1 5/8 x 8in
		Stud Spacing	600mm	24in
	Envelope	Category	Cladding	Cladding
		Material	prefinish	commer

			ed metal cladding	cial - 26ga
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	100	100
	2.2.24 Special_Exterior_Partition_W1_3400			
		Length (ft)	181.00	181.00
		Height (ft)	11.15	11.15
		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
	Envelope	Category	Cladding	Cladding
		Material	Brick (modular metric)	Brick (modular metric)
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour Retarder Membrane	Polyethylene 3 mil
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	125	125
	Opening	Type	Window	Window
		Number	11	11
		Total Area (ft²)	223.700	223.700
		Frame Type	XXX	Aluminum Frame
		Glazing Type	XXX	Standar

				d Glazing
		Fixed / Operable	Fixed	Fixed
	Opening	Type	Door	Door
		Number	2	2
		Material	Glass	Aluminum Exterior Door, 80% Glazing
	2.2.25 Special_Exterior_Partition_W3_600			
	Envelope	Length (ft)	642.00	642.00
		Height (ft)	1.97	1.97
		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
		Category	Cladding	Cladding
		Material	32mm stone veneer	Natural stone
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour Retarder Membrane	Polyethylene 3 mil
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	125	125
	2.2.26 Special_Exterior_Partition_W1_50-50			
		Length (ft)	286.00	286.00
		Height (ft)	13.12	13.12

		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
	Envelope	Category	Cladding	Cladding
		Material	Brick (modular metric)	Brick (modular metric)
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Air Barrier	Air Barrier
	Envelope	Category	Air and Vapour Barrier	Air and Vapour Barrier
		Material	Vapour Retarder Membrane	Polyethylene 3 mil
	Envelope	Category	Insulation	Insulation
		Material	semi-rigid, flexible (polyurethane?)	Polystyrene Expanded
		Thickness (mm)	125	125
	Opening	Type	Window	Window
		Number	170	170
		Total Area (ft²)	1875.900	1875.900
		Frame Type	XXX	Aluminum Frame
		Glazing Type	XXX	Standard Glazing
		Fixed / Operable	Fixed	Fixed
	2.2.27 Special_Exterior_Partition_W1_800			
		Length (ft)	724.00	724.00
		Height (ft)	2.62	2.62
		Wall Type	Concrete Block	Concrete Block
		Reinforcement	-	#4
	Envelope	Category	Cladding	Cladding
		Material	Brick (modula	Brick (modula

		r metric)	r metric)
Envelope	Category Material	Air and Vapour Barrier Air Barrier	Air and Vapour Barrier Air Barrier
Envelope	Category Material	Air and Vapour Barrier Vapour Retarder Membrane	Air and Vapour Barrier Polyethylene 3 mil
Envelope	Category Material Thickness (mm)	Insulation semi-rigid, flexible (polyurethane?) 125	Insulation Polystyrene Expanded 125
Opening	Type Number Material	Door 2 Glass	Door 2 Aluminum Exterior Door, 80% Glazing
2.2.28 Special_Exterior_Partition_FM2_3200			
	Length (ft)	724.00	724.00
	Height (ft)	10.50	10.50
	Wall Type	Curtain	Curtain
	Percent viewable glazing	50	50
	Percent spandrel panel	50	50
	Insulation thickness (mm)	125	125
	Spandrel panel type	glass	Opaque Glass Spandrel Panel
2.2.29 Special_Exterior_Partition_FM2_3400			

					Length (ft)	461.00	461.00
					Height (ft)	11.15	11.15
					Wall Type	Curtain	Curtain
					Percent viewable glazing	50	50
					Percent spandrel panel	50	50
					Insulation thickness (mm)	125	125
					Spandrel panel type	glass	Opaque Glass Spandrel Panel
B11 Partitions	104185	ft^2	Partition Walls	2.2.1 Interior_Partition_P1_Basement			
	9679	m^2			Length (ft)	30.00	30.00
					Height (ft)	13.70	13.70
					Wall Type	-	Non Load Bearing
					Stud Weight	-	Light (25Ga)
					Sheathing Type	none	none
					Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
					Stud Spacing (in)	16	16
				Envelope	Category	Gypsum Board	Gypsum Board
					Material/Number	16mm type X / 2	Gypsum Fire Rated Type X 5/8"
					Material/Number	-	
				Envelope	Category	Insulation	Insulation
					Material	Batt Insulation	Fiberglass Batt
					Thickness (mm)	92	92
				Opening	Type	Door	Door
					Number	1	1
					Material	Hollow Metal	Steel Interior Door
				2.2.2 Interior_Partition_P2_Basement			

			Length (ft)	149.00	149.00
			Height (ft)	13.70	13.70
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm type X / 3	Gypsum Fire Rated Type X 5/8"
			Material/Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	6	6
			Material	Wood	Hollow Core Wood Interior Door
		2.2.3 Interior_Partition_P4_Basement			
			Length (ft)	75.00	75.00
			Height (ft)	13.70	13.70
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	(2x) 1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm	Gypsum

			Material / Number	type X / 2 -	Fire Rated Type X 5/8"
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	184	184
		2.2.4 Interior_Partition_P1_Main			
			Length (ft)	1,050.00	1,050.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm type X / 2	Gypsum Fire Rated Type X 5/8"
			Material/Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	47	47
			Material	Wood	Hollow Core Wood Interior Door
		2.2.5 Interior_Partition_P2_Main			

			Length (ft)	4,869.00	4,869.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm type X / 3	Gypsum Fire Rated Type X 5/8"
			Material/Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	197	197
			Material	Wood	Hollow Core Wood Interior Door
		2.2.6 Interior_Partition_P3_Main			
			Length (ft)	349.00	349.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm type X /	Gypsum Fire

			Material/Number	1 16mm Fire Code C / 2	Rated Type X 5/8" Gypsum Fire Rated Type X 5/8"
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	3	3
			Material	Wood	Hollow Core Wood Interior Door
		2.2.7 Interior_Partition_P4_Main			
			Length (ft)	387.00	387.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm type X / 2	Gypsum Fire Rated Type X 5/8"
			Material / Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	184	184
		Opening	Type	Door	Door
			Number	8	8

			Material	Wood	Hollow Core Wood Interior Door
		2.2.8 Interior_Partition_P5_Main			
			Length (ft)	146.00	146.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm Fire Code C / 2	Gypsum Fire Rated Type X 5/8"
			Material / Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	4	4
			Material	Wood	Hollow Core Wood Interior Door
		2.2.9 Interior_Partition_P6_Main			
			Length (ft)	256.00	256.00
			Height (ft)	12.47	12.47
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)

			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	24	24
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm Fire Code C / 1	Gypsum Fire Rated Type X 5/8"
			Material / Number	25mm for elevator, fire resistant	Gypsum Fire Rated Type X 5/8"
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	64	64
		2.2.10 Interior_Partition_P9_Main			
			Length (ft)	148.00	
			Height (ft)	12.47	
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 6	1 5/8 x 6
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm Type X / 2	Gypsum Fire Rated Type X 5/8"
			Material / Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	152	152
		Opening	Type	Door	Door

			Number	4	4
			Material	Wood	Hollow Core Wood Interior Door
		2.2.11 Interior_Partition_P10_Main			
			Length (ft)	84.00	
			Height (ft)	12.47	
			Wall Type	-	Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 6	1 5/8 x 6
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm Type X / 3	Gypsum Fire Rated Type X 5/8"
			Material / Number	-	
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	152	152
		Opening	Type	Door	Door
			Number	2	2
			Material	Wood	Hollow Core Wood Interior Door
		2.2.12 Interior_Partition_P3_5th Floor			
			Length (ft)	48.00	
			Height (ft)	16.40	
			Wall Type	-	Non Load Bearing

			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material/Number	16mm type X / 1	Gypsum Fire Rated Type X 5/8"
			Material/Number	16mm Fire Code C / 2	Gypsum Fire Rated Type X 5/8"
		Envelope	Category	Insulation	Insulation
			Material	Batt Insulation	Fiberglass Batt
			Thickness (mm)	92	92
		Opening	Type	Door	Door
			Number	5	5
			Material	Hollow Metal	Steel Interior Door
		2.2.13 Interior_Partition_P5_5th Floor			
			Length (ft)	49.00	
			Height (ft)	16.40	
			Wall Type		Non Load Bearing
			Stud Weight	-	Light (25Ga)
			Sheathing Type	none	none
			Stud Thickness (in)	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing (in)	16	16
		Envelope	Category	Gypsum Board	Gypsum Board
			Material / Number	16mm Fire Code C / 2	Gypsum Fire Rated Type X 5/8"
			Material / Number	-	

	Envelope	Category	Insulation	Insulation
		Material	Batt Insulation	Fiberglass Batt
		Thickness (mm)	92	92
	Opening	Type	Door	Door
		Number	1	1
		Material	Hollow Metal	Steel Interior Door
	2.2.14 Interior_Partition_P6_5th Floor			
		Length (ft)	10.00	
		Height (ft)	16.40	
		Wall Type	-	Non Load Bearing
		Stud Weight	-	Light (25Ga)
		Sheathing Type	none	none
		Stud Thickness (in)	1 5/8 x 2 1/2	1 5/8 x 3 5/8
		Stud Spacing (in)	24	24
	Envelope	Category	Gypsum Board	Gypsum Board
		Material / Number	16mm Fire Code C / 1	Gypsum Fire Rated Type X 5/8"
		Material / Number	25mm for elevator, fire resistant	Gypsum Fire Rated Type X 5/8"
	Envelope	Category	Insulation	Insulation
		Material	Batt Insulation	Fiberglass Batt
		Thickness (mm)	64	64
	2.2.15 Interior_Partition_P23_Basement			
		Length (ft)	245.00	245.00
		Height (ft)	13.70	13.70
		Wall Type	Concrete Block	Concrete Block

			Reinforcement	-	#4
		Opening	Type	Door	Door
			Number	12	12
			Material	Hollow Metal	Steel Interior Door
		2.2.16 Interior_Partition_P23_Main			
			Length (ft)	37.00	37.00
			Height (ft)	12.47	12.47
			Wall Type	Concrete Block	Concrete Block
			Reinforcement	-	#4
		Opening	Type	Door	Door
			Number	2	2
			Material	Hollow Metal	Steel Interior Door
	Special Interior Walls	2.5.1 Forum_Sliding_Doors			
		(extra materials input used) (converted to square feet)	Length (ft)	127.00	(1249.68 sf)
			Height (ft)	9.84	
			Wall Type	Solid Wood Panel	Cedar Wood Bevel Siding
		2.5.2 Forum_Wood_Panel_Balcony			
		(extra materials input used) (converted to square feet)	Length (ft)	54.00	(177.12 sf)
			Height (ft)	3.28	
			Wall Type	2 wood panels	Cedar Wood Bevel Siding
		2.5.3 Forum_Concrete_Balcony			
			Length (ft)	84.00	84.00

			Height (ft)	3.28	3.28
			Thickness (mm)	300.00	300.00
			Wall Type	Concrete	Typical Concrete Values
		2.5.4 Library_Glass_Wall			
		(extra materials input used) (converted to square feet)	Length (ft)	58.00	(464 sf)
			Height (ft)	8.00	
			Wall Type	Glass	Standard Glazing
		2.5.5 Glass_Guard			
		(extra materials input used) (converted to square feet)	Length (ft)	1,191.00	1,137.70
			Panel Height (ft)	2.79	2.79
			Panel Width (ft)	4.27	
			Panel gap (ft)	0.20	(3174 sf)
			Wall Type	Glass	Standard Glazing

Element	Assembly	Assembly Type	Assembly Name	Modeling Assuption*
A11 Foundations	Foundation	Footings		All footings with width larger than 500 mm are assumed to have width equal to 500mm (19.68in.)
				All footing concrete has average fly ash content
				Rebar sizes are assumed as follows: 10M→#4 15M→#5 20M→#6 Rebar sizes larger than

				20M will be assumed to be #6.
				All measurements in IE are in emperial form
A21 Lower Floor Construction	Foundation	Concrete Slabs On Grade		The strength of the slabs on grade are dependant on being interior or exterior. These are denoted as 20 Mpa for Interior and 32 Mpa for Exterior and are taken in the Impact estimator as 3000psi and 4000psi respectively.
				All Slabs on Grade are assumed to have average content of fly ash.
				All measurements in IE are in imperial form
				All measurements taken using on screen take off for slabs do not overlap with footings and walls, but do overlap columns and beams.
	Columns and Beams			Columns and Beams are not summarized as individual structural components. Instead, a set of beam, column and floor intesection is analyzed in the Impact Estimator
				Aeras of each floor are measured based on Onscreen Takeoff.
				All columns and beams concrete has average fly ash content
				Bay sizes and span sized are assumed to be 6m based on their location on the grids in the structural drawings.

					Live load of each floor calculated as an average of the load design of that floor. Exact results are approximated later for input data.
A22 Upper Floor Construction	Columns and Beams				Columns and Beams are not summarized as individual structural components. Instead, a set of beam, column and floor intesection is analyzed in the Impact Estimator
					Aeras of each floor are measured based on Onscreen Takeoff.
					All columns and beams concrete has average fly ash content
					Bay sizes and span sized are assumed to be 6m based on their location on the grids in the structural drawings.
					Live load of each floor calculated as an average of the load design of that floor. Exact results are approximated later for input data.
	Floors	Concrete Suspended Slab			All Slabs are noted to be 30Mpa, which is rounded to 4000 psi
					All Slabs on Grade are assumed to have average content of fly ash. All measurements in IE are in imperial form All measurements taken using on screen take off for slabs do not overlap with footings and walls, but do

				overlap columns and beams. All spans lengths noted are found using a weighted average calculation. This calculation used the spans observed and averaged the values based on the area these were found. For details of these calculations, please refer to below.
			4.1.2 Floor _Concrete Suspended Slab_3.6LL	The live load of 3.6KN was used for all classroom and office areas as noted on the structural drawings provided
			4.1.3 Floor _Concrete Suspended Slab_4.8LL	A live load of 4.8KN was used for all library areas and other high load areas as noted on the structural drawings provided. Because 4.8KN is the highest live load analysed by IE, this includes Live Loads of 7.2 and 9.8, also noted in the plans.
A23 Roof	Roof	Concrete Suspended Slab		All Slabs are noted to be 30Mpa, which is rounded to 4000 psi
				All Slabs on Grade are assumed to have average content of fly ash. All measurements in IE are in imperial form All measurements taken using on screen take off for slabs do not overlap with footings and walls, but do overlap columns and beams.

				All spans lengths noted are found using a weighted average calculation. This calculation used the spans observed and averaged the values based on the area these were found. For details of these calculations, please refer to below.
			5.1.1 Roof _Concrete Suspended Slab_2.4LL	The live load of 2.4KN was used for all roof areas as noted on the structural drawings provided
		Steel Joist Roof		All measurements in IE are in imperial form All spans lengths noted are found using a weighted average calculation. This calculation used the spans observed and averaged the values based on the area these were found. For details of these calculations, please refer to below.
			5.2.1 Roof_Steel Joist Roof	The Joist Size as approximated to be W250X22 based on its description in the drawings
				Deck Thicness was listed as 38mm, but used 19mm in IE due to limitations. All other factors were not provided and were assumed based on typical industry standards
A31 Walls Below Grade	Walls	Cast In Place		All walls taken as 30MPA (4350psi). Actual walls were between either 25, 30, or 40. In order to

				balance out and be conservative, 30 was chosen.
			2.1.1 Wall_Cast-in-Place_200mm_Basement	Flyash percentage not specified, "average" used.
				Slab depth was taken as 200mm (0.656ft) in all locations. Reasonable considering that a majority of the slabs are 200mm and the difference between 200mm and 225mm is negligible
				All reinforcement taken as #15M. Most reinforcement is actually 10M, with very few 20M bars in the larger shear walls.
				Lengths adjusted and 12in. thickness used for impact estimator to achieve equivalen volumes. This may create an overestimation for formwork but is necessary to not underestimate concrete.
		Furring		
			2.3.5 Furring_F4_Main	Section on first floor drawing has 11ft of "F5." Doesn't exist in schedule, assumed it was F4 (similar to other furring in the area).
A32 Walls Above Grade	Walls	Cast In Place		All walls taken as 30MPA (4350psi). Actual walls were between either 25, 30, or 40. In order to balance out and be conservative, 30 was chosen.
				Flyash percentage not specified, "average" used.
				Slab depth was taken as 200mm (0.656ft) in all locations. Reasonable considering

				that a majority of the slabs are 200mm and the difference between 200mm and 225mm is negligible
				All reinforcement taken as #15M. Most reinforcement is actually 10M, with very few 20M bars in the larger shear walls.
				Lengths adjusted and 12in. thickness used for impact estimator to achieve equivalen volumes. This may create an overestimation for formwork but is necessary to not underestimate concrete.
			2.1.7 Wall_Cast-in-Place_200mm_Main	"Main" refers to the 1st to 4th floor, which share similar wall heights and other characteristics.
B11 Partitions	Walls	Partition Walls		
			2.2.1 Interior_Partition_P1_Basement (and all other steel stud partition walls unless stated)	Stud thickness unknown, taken as 25Ga. Insulation type unknown, referred to only as Batt Insulation. "Fiberglass Batt" used. Gypsum board 16mm Type X and 16mm Fire code C both taken as "Gypsum Fire Rated Type X 5/8"
			2.2.16 Exterior_Partition_W1_Main (and all other concrete block walls)	Reinforcement unknown, taken as 10M (lowest value allowed by impact estimator). Insulation type unknown, referred to only as semi-rigid insulation. "Polystyrene Expanded" used. Air and water barrier unknown. "Polyethylene 3 mil" used. Glazing type unknown. "Standard Glazing" used.

			2.2.17 Exterior_Partition_W1.1_Main 2.2.21 Exterior_Partition_W3.1_5thFloor	Cladding exists over previously counted structural walls. No assembly used, only envelope.
			2.2.18 Exterior_Partition_W1.1_Main	In order to add cladding without a wall, part of the length of 2.1.7 was removed and added to 2.2.18 to balance out the amount of concrete used.
			2.2.21 Exterior_Partition_W3.1_5thFloor	In order to add cladding without a wall, part of the length of 2.1.7 was removed and added to 2.2.18 to balance out the amount of concrete used. Note, the presence of doors and height differential will make numbers slightly inaccurate.
			2.3.1 Furring_F1_Basement	22mm furring system used and smallest steel stud available is 92mm. Studs placed at 600mm spacing to compensate.
		Special Interior Walls		
			2.5.1 Forum_Sliding_Doors 2.5.2 Forum_Wood_Panel_Balcony	Type of wood unknown and no applicable input exists. Extra material "cedar wood bevel siding" used.
			2.5.4 Library_Glass_Wall 2.5.5 Glass_Guard	Type of glass paneling unknown, extra material "standard glazing" used.

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