LCA of New UBC Pharmacy Building
Life Cycle Assessment and Critical Review for a New Building at UBC in Vancouver, BC

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CIVL 498C

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PROVISIO

University of British Columbia

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Prepared for Rob Sianchuk and CIVL 498C

By Kevin Preston on 18 November 2013

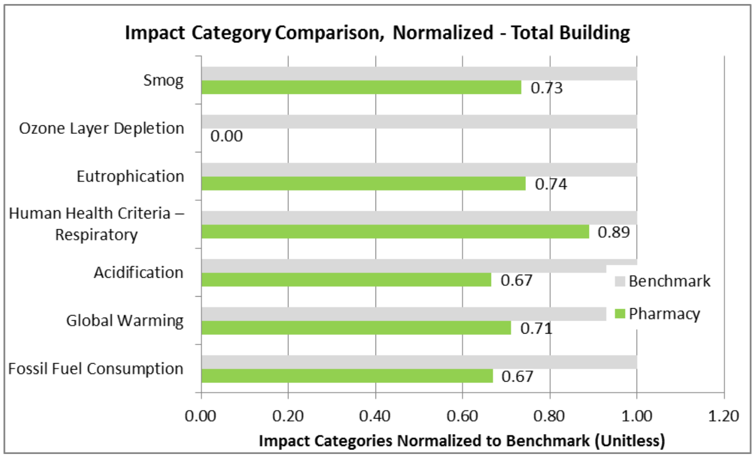
Executive Summary

The main purpose of this study is to evaluate the environmental impacts of the new building and to critically review the previous study done by Amiri and Hashemi. It also contributes to a benchmark study, against which new building projects can be compared. This report is intended for an all those who wish to know more about LCA at UBC, and in particular of the Pharmacy Building; next years' students; and for evaluation as the term project in CIVL 498C.

This project is undertaken at a high level of detail; the results are sorted into major element groups, which are entire classes of elements grouped together. The high level element groups are A11 Foundations, A21 Lowest Floor Construction, A22 Upper Floor Construction, A23 Roof Construction, A31 Walls Below Grade, A32 Walls Above Grade, and B11 Partitions. This is congruent with the CIQS MasterFormat.

Another element of scope is the limitation of the system boundary. For this project, the system boundary only considers the life cycle from cradle to gate; i.e. the process chain including extraction of raw materials, transportation, refining, transportation of refined materials, production into products, transportation to the construction site, and then construction. The use and the end-of-life stages are not considered. This limitation in scope reflects the time budget that the students are expected to put into the project.

One of the first tasks of this project was to sort the provided files into the major element groups. After being sorted, the model needed to be critically reviewed. It was found that almost no changes needed to be made, few changes could be made with the current level of acceptable accuracy, and those changes that could be made could not be made with the available resources. After the critical review, the results were interpreted and compared against the benchmarks set by the class.



The figure to the right shows the results of this assessment, normalized against the benchmarks, per unit of gross floor area. The New Pharmacy Building benefitted from economies of scale, modern technology, and leading environmental design standards to out-perform the average building of its class at UBC. To further explain, any green bar in that figure that exceeds 1.00 means that the corresponding impact category is that many times greater than the average academic building at UBC, per square meter of gross floor area. This figure shows that te building performed much better than its peers.

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List of Abbreviations

Several abbreviations were used in this report. For quick reference, please see them below:

CIQS: Canadian Institute of Quantity Surveyors

ISO: International Organization for Standardization

EPD: Environmental Product Declaration

GFA: Gross Floor Area, usually in square meters.

LCA: Life Cycle Assessment

LCI: Life Cycle Inventory

LCIA: Life Cycle Impact Assessment

LEED: Leaders in Energy and Environmental Design

PCR: Product Category Rule

UBC: University of British Columbia

1.0 General Information on the Assessment

Environmental performance of the New Pharmacy Building at UBC's Vancouver campus was re-analyzed and critically reviewed from September to November, 2013 by Kevin Preston, under the guidance of Rob Sianchuk, and using the LCA study completed by Helia Amiri and Mahshid Hashemi in April 2012. The work done for this report was intended to give the correct parts of study more authority, make corrections to the work, and provide additional interpretation to the LCA results.

Purpose of the assessment

The purposes of this study and the original study by Amiri and Hashemi are to evaluate the environmental impacts of the new building.[i] They also exist in the context of being part of a larger study at UBC, of which the intention is to create a baseline for the environmental performance of the academic buildings on campus. UBC plans to make their future buildings perform to better and better environmental performance standards, so this project gives UBC a tool to make planning better.

This is a life cycle assessment with an added critical review. The purpose of the critical review is to

- Review the study by Amiri and Hashemi.
- Confirm the correct information and adjust the incorrect information to increase the legitimacy of the study.
- Separate the data into MasterFormat categories to help standardize the project data for use in the larger project.

This LCA study is intended be a part of a much larger study, called the UBC LCA Database Project, which aims to collect LCA data about the buildings on campus to create a baseline for which future project can be compared.

This report is intended for an audience that includes all those who wish to know more about LCA at UBC, and in particular of the Pharmacy Building. It's also being prepared for next years' students as well, who will take the next step in this project. This report is also being prepared for the completion of course work for the CIVL 498C course.

This report is intended to be used next year by future LCA students. Because of this, accuracy is paramount and assumptions are clearly stated and explained. In spite of the need for accuracy, this project is still high level. The take-offs were done at a lower component element group level and grouped into major component groupings. For example, "Foundations" is one of the major element groups, and it contains all of the foundations. Those foundations can be broken down further into individual elements, and then further into material and work elements.

Identification of building

The New Pharmacy Building is six storeys above ground and two below, with a total floor area of 246,182 square feet, or 22,871 square meters. It is rectangular on the outside, with a flat roof and various overhangs, while the interior is full of angled walls and diagonal stairways. Inside the building, there are offices, classrooms, laboratories, lecture halls, a café, a museum, a pharmacy, and a data centre. The underground portion of the building extends beyond the main entrance, where it is covered by a plaza.

The building is in the health sciences region of the campus, located south of the hospital and the new Health Sciences Building. The address is 2405 Wesbrook Mall, Vancouver, BC V6T 1Z3. The project manager was Nick Maile, the architects were Saucier and Perrotte Architects & Hughes Condon Marler Architecs, and the construction was completed by Ledcor Construction.

The building is LEED Gold Certified, and has won the 2012 Canadian Architect Award of Excellence. Part of what makes it sustainable are its use of a high-efficiency irrigation system, its technical measures to reduce potable water use inside the building, the use of materials high in recycled content, and the diversion of 75% of waste from the landfill during construction.

It was opened on 18 September 2012 and had a budget at completion of $155 230 000[ii].

Other Assessment Information

Additional assessment information can be found in the table below.

Table 1. Additional Information for LCA Report

Client for Assessment	Completed as coursework in the civil engineering technical elective course CIVL 498C at the University of British Columbia.
Name and qualification of the assessor	Kevin Preston, Helia Amiri, Mahshid Hashemi, of the Department of Civil Engineering, Faculty of Applied Sciences
Impact Assessment method	Athena Impact Estimator for Buildings, Verion 4.2.0208 (Public Release)
Point of Assessment	This building was completed in 2012 and assessed in 2012.
Period of Validity	5 years.
Date of Assessment	Completed in April 2012
Verifier	Student work, study not verified.

2.0 General Information on the Object of Assessment

Functional Equivalent

According to the original report by Amiri and Hashemi, the functional units are as follows:

- “Per generic post-secondary academic building square meter constructed.
- Per specific post-secondary academic building square meter constructed.
- Per generic post-secondary academic building cubic meter constructed.
- Per dollar spent on the investment.”

This variety of units allows us to compare the studied buildings on campus with different purposes in mind. For example, when comparing the application for the design of a new lecture theatre as part of a new building, the theatre can be separated out and compared separately with other theatres. This allows designers to focus on aspects of the building during the detailed design to determine what is within acceptable parameters and what needs to be made greener.

Area measurements are important because area is the most useful parameter of buildings; floor space is used for everything done in a building. Cubic meters are useful because they indicate air space heating requirements and three-dimensional size.

The per-dollar spent measurement can be used in conjunction with the gross floor area unit to determine how much the university is willing to spend to reduce impacts. It allows the campus to quantify its environmental impact by dollar spent, which gives the decision-makers another tool to use to make sustainable decisions on campus; most importantly, the evaluation of new building proposals.

Table 2. Functional Equivalent Definition Template.

Aspect of Object of Assessment	**Description**
Building Type	Pharmaceutical Sciences Building – Institutional, academic, with service amenities.
Technical and functional requirements	Buildings at UBC must meet the requirements of the BC Building Code, the National Building Code of Canada, and UBC's Technical Guidelines. To highlight a few requirements from these: Buildings must be designed for a 100 year service life, and meet at least LEED Gold Certification.
Pattern of use	The building is designed to accommodate researchers, students, faculty, and staff, who are regular users of the basement and second to sixth floors. The main floor is used by students for studying, lecture space, and a café. Lectures tend to last for one to three hours, after which there is a flux in the use: students enter and leave all at once. The building is not likely used at night, except perhaps by researchers with ongoing experiments, or veterinary staff taking care of animals.
Required service life	The service life for all new buildings at UBC is set at 100 years.

Reference Study Period

The reference study period in EN 15978 specifies that we define the LCA study in terms of life cycle stages A through C and include Module D as well. This study focuses only on Module A, which includes

- A1 Raw Materials Supply
- A2 Transport (of raw materials)
- A3 Manufacturing
- A4 Transport (of manufactured products)
- A5 Construction Installation Process.

The study excludes Module B, the Use Stage; Module C, the End of Life Stage; and Module D, Supplementary Information beyond the Building Life Cycle. The exclusion is by choice; The scope is being limited in order to allow the authors to focus on getting the material quantities correct, rather than worry about all of the aspects.

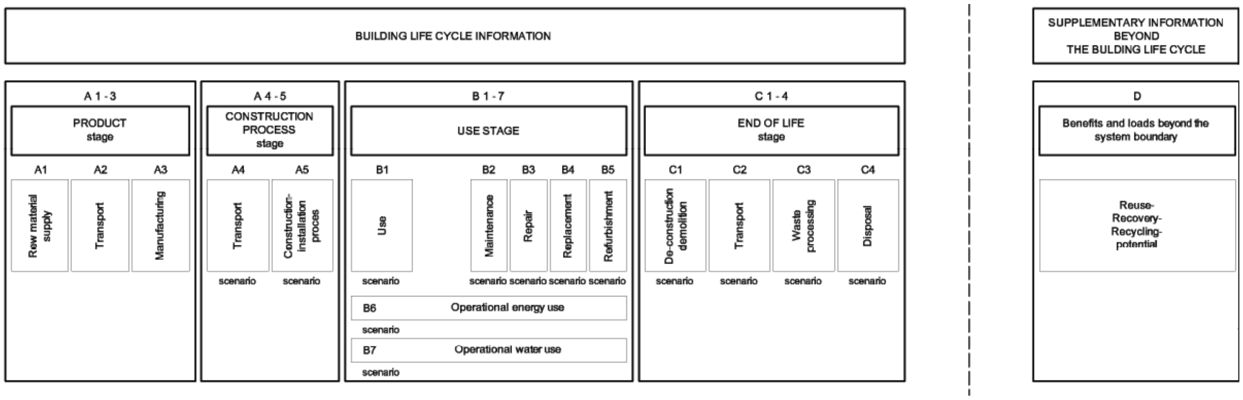


Figure 1. Display of modular information for the different stages of the building assessment

The required service life of all buildings at UBC is 100 years. This is written into the technical guidelines for architects and engineers.[iii]

Object of Assessment Scope

The building is six storeys high with two levels of basement. The construction site includes the frontage improvements, the creation of a berm across from the main entrance, and various landscaping improvements, but they are not part of the scope of the assessment. This assessment only includes everything within the building envelope. Excavations for footings and basements are not included because excavation is a highly variable process and can't be determined from the drawings. The plaza is included because it forms the roof of the interstitial basement.

The table below shows the space allocated to the seven major element groups. This data was developed by Amiri and Hashemi

Table 3. Building Definition Template.

CIVL 498C Level 3 Elements		Description	Quantity (Amount)	Units
A11	Foundations	Wall and column footings, pile caps, column pedestals, perimeter insulation, and crawl space walls. Also includes special foundations like piling, caissons, and rafts.	568	m^2
A21	Lowest Floor Construction	Slabs on grade, waterproofing, vapour barrier, insulation, and slab thickening below interior bearing walls.	1911	m^2
A22	Upper Floor Construction	Structural frame, suspended floors and decks, inclined and stepped floors, expansion joints, ramps and stairs, fireproofing, all columns and beams supporting the floor.	3548	m^2
A23	Roof Construction	Structural frame, suspended roof decks, firestopping, skylights, waterproofing, insulation, and all columns and beams supporting the roof.	6795	m^2
A31	Walls Below Grade	Exterior wall construction below grade and above lowest floor slab on grade, interior furring, wallboard, insulation and vapour barrier, windows and doors, structural components of walls below grade.	1351	m^2
A32	Walls Above Grade	Exterior wall construction, exterior finishing, framing, wallboard, insulation, vapour barriers, blockings, windows and doors, structural components of those walls, and curtain walls.	2616	m^2
B11	Partitions	Interior fixed partitions, wallboard, balustrades and railings, interior balconies, interior windows and glazing, movable partitions, structural partitions, all interior doors and finishings.	4524	m^2

3.0 Statement of Boundaries and Scenarios Used in the Assessment

System Boundary

For this project, the system boundary surrounds only Module A of EN 15798. Module A contains the Product and Construction Processes stages, shown in Figure 1. EN 15798 requires that we use A, B, C, and D, and that we describe any deviations from it.

For Module A 1-3, the Product stage, the process inputs are raw materials and energy from their source locations. Outputs are the products, stored at the location where they are produced.

In Module A 4-6, the Construction Processes stage, the process inputs are those products produced in A 1-3, including transportation to site, and the outputs are waste and the building itself.

Product Stage

The product stage is that stage from raw material supply to manufacturing, including transportation of raw materials to manufacturing plants. The inputs at this stage are raw materials and energy, and the useful outputs are manufactured products. For example, a product such as a steel partition stud would have basic inputs of iron ore, coal, and energy. In addition, there are many ancillary inputs, such as diesel fuel for trucks delivering the massive material, the entire operation of the mines, the entire operation of the rail and trucking businesses, and the entire operation of the smelter. Outputs include the useful steel, but also wastes such as slag, emissions to air, water, and land, noise pollution, and heat. All of this information is included in the LCA via the Athena LCI database.

Extraction of raw materials, production, and transportation are accounted for by the Athena model by selecting “Vancouver” as the location. The choice of location calibrates the model to locally-collected data sets. The same is true for the collection and transport of wastes.

The manufacturing of products has different economics, standards, and trends in different parts of the country and the continent, and changes with time. Athena keeps up to date with these and uses the most recent data set. The location setting also helps the model calibrate to differences.

Energy produced across the continent is produced by different means depending on where it is; for example, BC and Quebec are well known for hydroelectric energy, while Ontario is better known for nuclear energy and Alberta for energy from fossil fuels. Canada’s utility crown corporations buy and sell energy to each other and to the companies in the USA as the price fluctuates with demand, so energy has an environmental consequence for those who produce it as well as those who buy it. Athena takes care of this with the location factor. This study does not consider the use phase, so energy plays a very small role.

Ancillary materials, packaging, and pre-products are considered in the same way as trends are considered by the model: by keeping up to date with such things and allowing users to download the latest models.

Waste disposal sites are located all over the continent, and not ever landfill site is the same: some are made with older technology, while others are simply governed by different standards, and still others experience higher amounts of one type of refuse compared to another. Each landfill site therefore has a different allocation to each environmental impact category. This is accounted for by choosing a location for the project.

Construction Stage

The construction stage starts with the transportation of products from their manufacturers to the construction site, and ends after those products have been installed on site. The construction process involves a lot of ancillary materials, such as formwork, packaging, and fuel, which get used in the placement of the products. For example, to make a concrete wall on the third floor, a crane might be needed to lift formwork to that floor, and then a concrete truck and a pump truck are used to pump the concrete into the forms. These large trucks use up a lot of energy and require water to wash them down. There are significant emissions to air, water, and land in the construction stage.

LCI data were collected by Athena for trucking fleets and railroad systems across the continent. These data are used in the Impact Estimator when the location is selected.

During the construction phase, different levels of effort tend to be taken by different contractors to divert wastes from the landfills, reduce the impacts of operations, and be more sustainable in general. The Athena Impact Estimator takes an average construction industry approach, which is a conservative assumption. Part of the reason for this is because Athena is a planning tool, made for use in the conceptual design when the contractor is not yet known. Because the Pharmacy Building is a LEED Gold project, the contractor had to use sustainable practices during the construction operation, which are not accounted for in the LCA.

4.0 Environmental Data

Data Sources

This project uses two databases for the impact estimate calculation. No additional data sources were sought, such as EPA documentation for alternative materials. The two databases are the Athena LCI Database and the US LCI Database.

The Athena LCI Database is managed by the Athena Sustainable Materials Institute, and has been developed since the ‘90s, as it began to grow out of research done by Forintek Canada Corporation in collaboration with two universities and representatives from building materials industries. ASMI was established in 1996 to separate itself from the lumber industry and gain total objectivity.

The US LCI Database is a project initiated in 2001 by the National Renewable Energy Laboratory. The database is maintained and developed by NREL, which is a US-based organization funded by a large number of stakeholder organizations.

Data Adjustments and Substitutions

Overall, the material types and properties were very accurate. The only way that they can be improved is by perusing the construction specifications and the LEED submission records, which are not available to me at this time. Some assumptions made for lack of data include

- Fly ash percentage in concrete was assumed to be “average”, because it’s not specified on the drawings.

- "Rigid insulation" was selected for walls and floors, but with no indication of type and thickness.
- There is one type of door in the model, and it is used to represent all doors. Doors can be wood, aluminum, or steel, so assuming one door is inaccurate, but inconsequential in the scale of the project.
- For steel stud walls, everything was assumed, from the spacing to the thickness, to what's included and the type of steel studs. Construction specifications would help to make this more accurate.
- A waterproof membrane is assumed to be the Athena input "polystyrene extruded". These are very different products: waterproof membrane is a dense, rubber material, while extruded polystyrene is insulating foam, aka Styrofoam.
- Galvanized Z-bars for the roof are included as extra materials. This excludes the construction operations and associated materials that go with it.

Another way that the data was adjusted was in the dimensions of the inputs. This was done because Athena requires specific inputs, such as length and width, and specific depths. If the object is not a rectangle, or has a depth different from the available input choices, then adjustments have to be made. One way to do this is to enter specific rectangular dimensions to keep the area, perimeter, and volume identical to the actual situation. Consider the two equations:

$$\begin{cases} A = w * l \\ P = 2 * (w + l) \end{cases}$$

Solving those expressions for width and length yields expressions for the inputs to Athena in terms of area A and perimeter P:

$$\begin{cases} w = \dfrac{P + \sqrt{P^2 - 16A}}{4} \\ l = \dfrac{A}{w} \end{cases}$$

Area and perimeter can be measured from the drawings, and then input into these formulas to get the appropriate Athena inputs. If volume needs to remain the same, then simply add the volume formula $V = w * l * d$ and the new variable d, depth. After solving the equations above for width and length, solve the volume equation for depth.

Data Quality

Data quality is defined by ISO 14044 as data of a good enough quality to enable the goal and scope to be met. Quality is often thought of as a pass or fail criterion in this context. For this project, the data quality can be evaluated by the following checklist, as guided by ISO 14044:

- ✓ The data are the most recent, available data and have been collected over a statistically significant period of time.
- ✓ The data come from the geographical regions relevant to the project.

- ✓ The data cover the same technology as what was used in reality.
- ✓ The data have low variance, and thus sufficient precision to yield accurate results.
- ✓ The measured data constitute a representative sample.
- ✓ The study methodologies for collecting data were applied consistently among studies.
- ✓ The data is reproducible.
- ✓ The data sources are available and reputable.
- ✓ Uncertainty is low enough, and specified.

Where there are gaps in data, those gaps have to be explained. Gaps in data are explained in the previous section and in the Inputs and Assumptions spreadsheet.

There are five types of uncertainty in data, summarized by the following table:

Table 4. The five types of data uncertainty.

Type	Description	Example
Data Uncertainty	Uncertainty aroused by the discrepancies between collection methodologies, allocation methods, or assumptions made by the collector.	Mass allocation vs. economic allocation. Outputs can be made to look more environmentally friendly by adjusting the allocation. Having two justifiable ways of allocation is a way of "fixing" the results.
Model Uncertainty	Uncertainty introduced by making assumptions during modelling	Linear vs. non-linear modeling, or extrapolating data when a relationship beyond the scope of data points is unclear.
Temporal Uncertainty	Uncertainty in the effects of a process over time, due to different methods and technologies put into place, or seasonal variations.	Sampling during the winter compared to the fall could give different results. Changes in equipment used at a plant would give different results, even if data has been collected for a sufficiently long time.
Spatial Uncertainty	Regional differences between factories, distribution of emissions, environmental sensitivity, or the like.	For example, a prevailing wind could cause air emissions on the North side of a city to be much worse than on the South side.
Variability Uncertainty	Uncertainty brought about by differences between factories and technologies that produce the same product.	Two steel producers could make the same beam, but the materials could come from different ends of the world.

5.0 List of Indicators Used for Assessment and Expression of Results

The Athena Impact Estimator for Buildings was used to prepare this assessment. There are seven impact categories to report on:

- Global Warming Potential
- Ozone Layer Depletion
- Eutrophication
- Acidification
- Smog

- Human Health – Respiratory
- Fossil Fuel Consumption

Global Warming Potential

Global warming potential is widely held by the CIVL 498C class as the most important. The category indicator for this is CO_2e, or carbon dioxide equivalent, as chosen by the Intergovernmental Panel on Climate Change. Carbon dioxide has the ability to absorb radiation reflected from the Earth's surface, preventing it from escaping into space. This gradually increases the temperature of the planet, leading to climate change and other effects.

Some of the major effects are the increased rate of melting of glaciers, increased precipitation, decreased precipitation, depletion of fresh water resources, increased populations of parasites such as the mountain pine beetle and killer bees. The depletion of alpine glaciers leads to the loss of fresh water, while the depletion of continental glaciers (i.e. ice caps) leads to rising sea levels and a disruption in the thermohaline circulation. Climate change has such a wide range of effects, but they are all rooted in the increase of greenhouse gases in the atmosphere.

Ozone Layer Depletion Potential

Ozone layer depletion was a big problem in the 1980s, after decades of chlorofluorocarbon (CFC) disposal had accumulated in the upper atmosphere. CFC is a catalyst in the reaction of ultraviolet radiation with ozone. The reaction breaks apart the ozone molecule into oxygen gas, while leaving the CFC as-is. The CFC molecule will eventually break down in the upper atmosphere.

The ozone layer was depleting until the emergency banning of CFC products in 1987 by the Montreal Protocol. Since then, more products have been phasing out, but not all nations are complying. In 2006, the ozone hole grew rapidly due to an unusually warm year, and set a record for the biggest ozone hole ever. Such holes in the ozone lead to increased ultraviolet radiation passing through the ozone layer, which leads to very dangerous human health effects, such as skin cancer, melanoma, cataracts, severe sunburns to humans and animals, damage to cyanobacteria, and damage to plants.

The indicator for ozone depletion potential is 10^{-11} kilograms of CFC equivalent. This characterization is chosen by the World Meteorological Organization.

Eutrophication Potential

Eutrophication is the change that a water body experiences as it increases in algae population. The change is often unnatural, and caused by an influx of nutrients such as carbon, nitrogen, and especially phosphorous.

The process of eutrophication begins with an influx of nutrients, which causes an algae bloom. Then, the algae die and rot, which depletes the oxygen in the water. The solid mass prevents spring and fall turnover, so oxygen-rich water can't reach the bottom of the water body. Now the bottom is permanently anoxic, and the process of stratification begins. Stratification is when this dying algae matter sinks to the anoxic layer year after year, slowly filling up the water body.

Anoxic conditions are highly acidic, as anaerobic bacteria produce hydrogen sulphide and iron reduces from the 3+ state to the 2+ state. This water is toxic to all life. If it is a source of drinking water, then it can't be used.

Eutrophication potential's category indicator is kilograms of nitrogen equivalent, as measured by the US Environmental Protection Agency.

Acidification Potential

Acidification is the decrease in pH of a region due to acid rain. Acid rain is caused by acid-forming gases in the atmosphere mixing with water vapour and rain water. The gases get into the rain, and the rain soaks into the land, causing acidification. Acidification can also be caused by the leaching of acids and metals into water bodies from industrial waste.

Acidification destroys ecosystems from the bottom of the food chain to the top. It is measured in kilograms of SO_2 equivalent, as characterized by the US EPA.

Smog Potential

Smog potential is an air emission's influence on the amount of smog produced in a populated area. One of the main contributors is ozone, formed photochemically in the troposphere. Smog is formed when nitrous oxides and volatile organic compounds are released into the air. High temperature and sunlight increases the rate of evaporation, which leads to increased smog during the summer and on hot, clear days.

Smog can also build up during atmospheric inversions, which is when a layer of fog forms and the air is prevented from mixing and moving around by convection. Smog builds up during an inversion because it is constantly being emitted. It persists despite the low temperature and high humidity, finally dissipating when the fog dissipates.

Smog is measured in kilograms of ozone equivalent, as characterized by the US EPA. It contributes to emphysema, bronchitis, and asthma, which are not only significant diseases, but can be epidemic in smoggy cities.

Human Health Criteria – Respiratory Effects

When we breathe in particulate matter, it gets stuck in our lungs. The smaller the particle, the deeper it can go, and the deeper it goes, the harder it is to get out. This criterion is categorized by kilograms of particulate matter equivalent to 2.5 microns in size, as designated by the US EPA.

Particulate matter can be toxic, sharp, or strand-shaped. When it gets stuck in the alveoli and builds up, it blocks the movement of mucus, which reduces lung capacity and ultimately leads to breathing problems and death. It can cause or worsen asthma, heart disease, bronchitis, emphysema, and pneumonia.

Fossil Fuel Consumption

Fossil fuels are non-renewable. By using them, we are depleting a resource that future generations could otherwise use. Their use also contributes to global warming and air emissions that cause respiratory damage, smog, and acidification. Fossil fuel consumption is at the root of many of these indicators. It's measured in mega Joules (MJ), as categorized by the Athena Sustainable Materials Institute.

This category indicator includes all energy derived from fossil fuels, whether it is for transportation, electricity, or the production of goods.

6.0 Model Development

This project is focussed on taking the work done by the previous authors and converting it into the level 3 elements:

- A11 Foundations
- A21 Lowest Floor Construction
- A22 Upper Floor Construction
- A23 Roof Construction
- A31 Walls Below Grade
- A32 Walls Above Grade
- B11 Partitions

First, the take-off items had to be sorted into Level 3 Elements. The files sorted were the Inputs and Assumptions Spreadsheet, the On-Screen Takeoff file, and the Athena Impact Estimator file. After being sorted, the relevant areas and life cycle results were able to be reported. Before that could happen, though, the model needed to be critically reviewed. It was found that

- Almost no changes needed to be made
- Few changes could be made with the current level of acceptable accuracy
- Those changes that could be made could not be made with the available resources.

Differences in Gross Floor Areas Between Authors

Some of the challenges with model development were from matters of interpretation. The previous authors and I disagree on the allocation of gross floor area to categories. We had to find the gross floor area used in the building, and classify it into 11 categories, as shown in the table below.

Table 5. Differences in Measurement of Gross Floor Area

	Gross Floor Area (m2)		
Functional Area Type	**by Kevin Preston**	**by Amiri and Hashemi**	**Difference divided by average**
Classrooms	1498	2,460.59	48.63%
Offices/Office Spaces	4099	5,493.90	29.08%
Testing labs	7185	2,030.38	-111.87%
Library	0	287.18	200.00%
Study/Research/Prep/Computer lab rooms	0	6,170.61	200.00%
Storage rooms	524	38.15	-172.85%
Stairwells/Halls/ Atriums	8341	2,913.69	-96.45%
Washrooms/ Locker rooms	498	498.5	0.10%
Mechanical rooms	5086	2,225.00	-78.27%
Auditorium/ Lecture Halls	456	753	49.13%
Building Total	**27687**	**22871**	**-19.05%**

It was challenging to classify certain rooms in one category or another. For example, how do you categorize a museum, a café, a data centre, or an air locked corridor with these classifications? The challenges with these classifications are discussed below.

I accounted less area for classrooms, offices, study rooms, and libraries, but more to testing labs, corridors, and mechanical rooms.

There is no library; Amiri and Hashemi may be counting that space as the data centre in the basement or the museum on the second floor.

I accounted for much more storage. My storage number includes chemical storage and secure file storage, which may have been included by the other authors as office space or lab space. The washroom numbers are almost exactly the same.

This is because washrooms are clearly labeled on a drawing and there is nothing else like them. Perhaps laundry spaces are like washrooms, but we must have made the same assumptions.

I accounted for almost half the lecture hall space, which is possibly because lecture halls span multiple floors, and I only counted them once.

I had twice as much mechanical room space, in spite of excluding all exterior space on the roof. This is because every floor has several mechanical rooms. Plus, the data centre was counted as a mechanical room, and the basement had many mechanical things. Electrical rooms were counted as mechanical rooms, but they could have been counted as something else.

I accounted for vastly more hallway space. It is possible that a lot of the office and classroom space counted by the other authors included some of the hallway space that I counted towards this category.

It’s also interesting to note that the building floor area is different by about 20%. I made sure not to count void spaces, nor count exterior spaces, nor double-count spaces. What was counted here that’s not counted in the previous report, or what is missing there?

Reference Flows

A reference flow is a process that is normally thought of as an object. In this project, the reference flow is the New Pharmacy Building itself, which is a static, seemingly-unchanging monolith. However, it is the result of an enormous array of processes that continue to flow despite the unchanging nature of the building. Reference flows can be compared against each other. In the UBC LCA Project, all of the buildings are reference flows. When proposing a new building project, the bill of materials can be compared against the environmental impacts and the schedule of elemental spaces to get an idea of the parameters that the new building should fall between. Please see the bill of materials for the New Pharmacy Building below:

Table 8. Bill of Materials

Item	Quantity	Unit
5/8" Fire-Rated Type X Gypsum Board	51738.9	m2
5/8" Gypsum Fibre Gypsum Board	495.8	m2
5/8" Moisture Resistant Gypsum Board	3477.9	m2
6 mil Polyethylene	4173.2	m2
Air Barrier	3536.1	m2
Aluminum	109.1	Tonnes
Cedar Wood Bevel Siding	1356.2	m2
Cold Rolled Sheet	1.7	Tonnes
Commercial(26 ga.) Steel Cladding	3879.6	m2
Concrete 20 MPa (flyash av)	327.6	m3
Concrete 30 MPa (flyash av)	16025.7	m3
Concrete Blocks	22850.0	Blocks
EPDM membrane (black, 60 mil)	5390.7	kg
Extruded Polystyrene	12563.0	m2 (25mm)
FG Batt R11-15	86385.9	m2 (25mm)
Galvanized Sheet	28.4	Tonnes
Galvanized Studs	148.1	Tonnes
Glazing Panel	545.6	Tonnes
Hot Rolled Sheet	1.3	Tonnes
Joint Compound	55.6	Tonnes
Modified Bitumen membrane	90695.4	kg
Mortar	436.1	m3
Nails	4.7	Tonnes
Paper Tape	0.6	Tonnes
Polyiso Foam Board (unfaced)	16600.4	m2 (25mm)
Rebar, Rod, Light Sections	1428.5	Tonnes
Screws Nuts & Bolts	20.0	Tonnes
Small Dimension Softwood Lumber, kiln-dried	10.0	m3
Softwood Plywood	2259.9	m2 (9mm)
Solvent Based Alkyd Paint	50.3	L
Water Based Latex Paint	4638.0	L
Welded Wire Mesh / Ladder Wire	6.2	Tonnes
Wide Flange Sections	217.1	Tonnes

7.0 Communication of Assessment Results

Life Cycle Results

The results of the life cycle assessment are displayed in the tables and figures below. It was found that the upper floor construction contributed the most to all of the categories, and this is simply because it contains massively more material than the other sections. The building has one lowest floor, and then seven upper floors, and then the roof.

Table 6. Total Building Contribution to Impact Categories

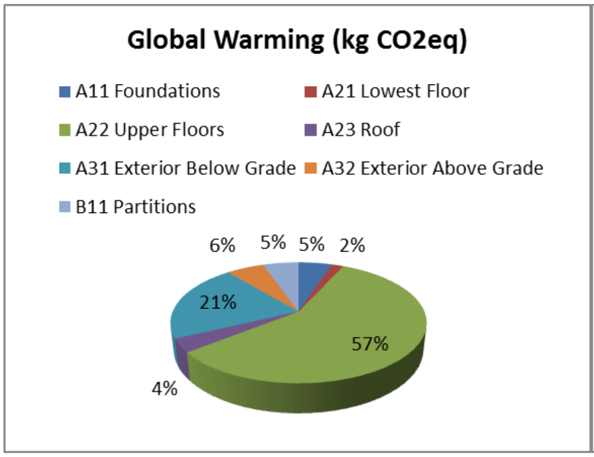
Total Building		
Fossil Fuel	170,604,833.58	(MJ)
Global Warming	15,895,786.97	(kg CO2eq)
Acidification	115,862.93	(moles of H+eq)
HH– Respiratory	55,660.65	(kg PM10eq)
Eutrophication	9,499.08	(kg Neq)
Ozone Layer	7.11E-02	(kg CFC-11eq)
Smog	1,999,890.93	(kg O3eq)

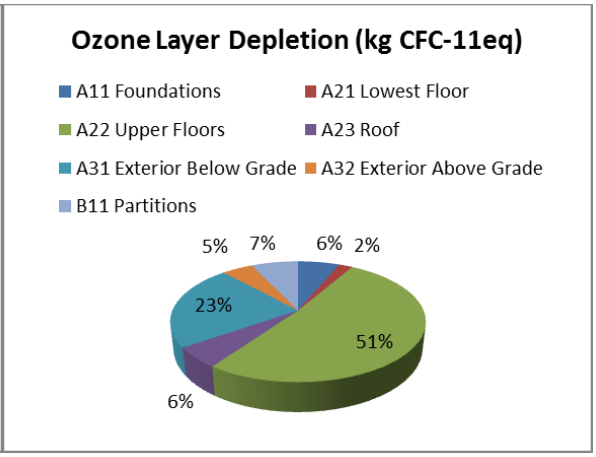
The total building results are tabulated above. The table shows the seven impact categories, with the building results from Athena Impact Estimator, in the category units specified by the professional organizations that determine them. A break-down of the same results into major element groups is below.

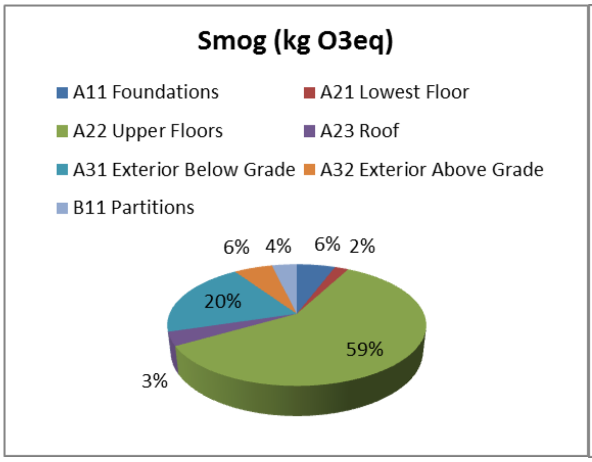
Table 7. Building Contributions to Impact Categories Broken Down by Major Element Group

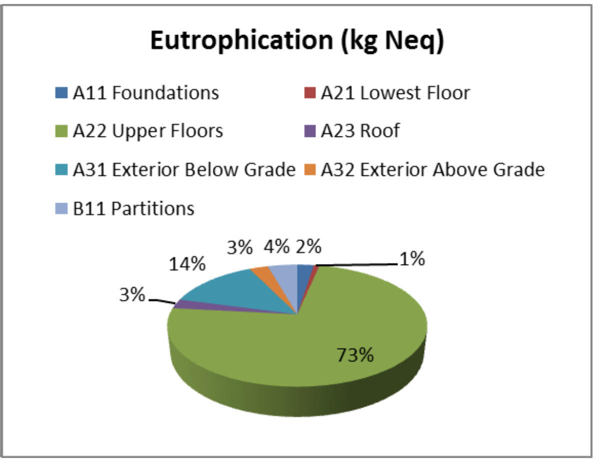
	Fossil Fuel Consumption	**Global Warming**	**Acidification**	**HH–Respiratory**	**Eutrophication**	**Ozone Layer Depletion**	**Smog**
	(MJ)	(kg CO2eq)	(moles of H+eq)	(kg PM10eq)	(kg Neq)	(kg CFC-11eq)	(kg O3eq)
A11 Foundations	5,521,593.99	808,385.96	5,207.14	1,950.51	232.67	4.46E-03	115,093.13
A21 Lowest Floor	1,968,694.78	278,225.99	1,815.19	643.26	81.20	1.48E-03	40,968.09
A22 Upper Floors	106,945,369.86	9,140,461.95	60,866.98	16,861.98	6,971.48	3.66E-02	1,177,332.87
A23 Roof	7,074,637.75	576,394.17	3,645.81	1,132.68	240.40	3.92E-03	72,663.08
A31 Exterior Below Grade	31,409,884.85	3,332,384.23	27,173.72	19,163.22	1,290.87	1.63E-02	404,188.62
A32 Exterior Above Grade	7,449,104.43	903,534.34	10,707.97	12,240.56	264.69	3.32E-03	115,304.77
B11 Partitions	10,235,547.91	856,400.33	6,446.12	3,668.43	417.77	5.03E-03	74,340.37

This data is also in pie form, shown below with percentages. It can be seen that the upper floor construction contributes the most to each category, with one exception: the Human Health – Respiratory category, in which the highest contribution is in A31 Exterior Below Grade. This is mainly because of a difference of materials used, because of the construction process, and because of comparable masses.


Global Warming (kg CO2eq)


Ozone Layer Depletion (kg CFC-11eq)


Smog (kg O3eq)


Eutrophication (kg Neq)

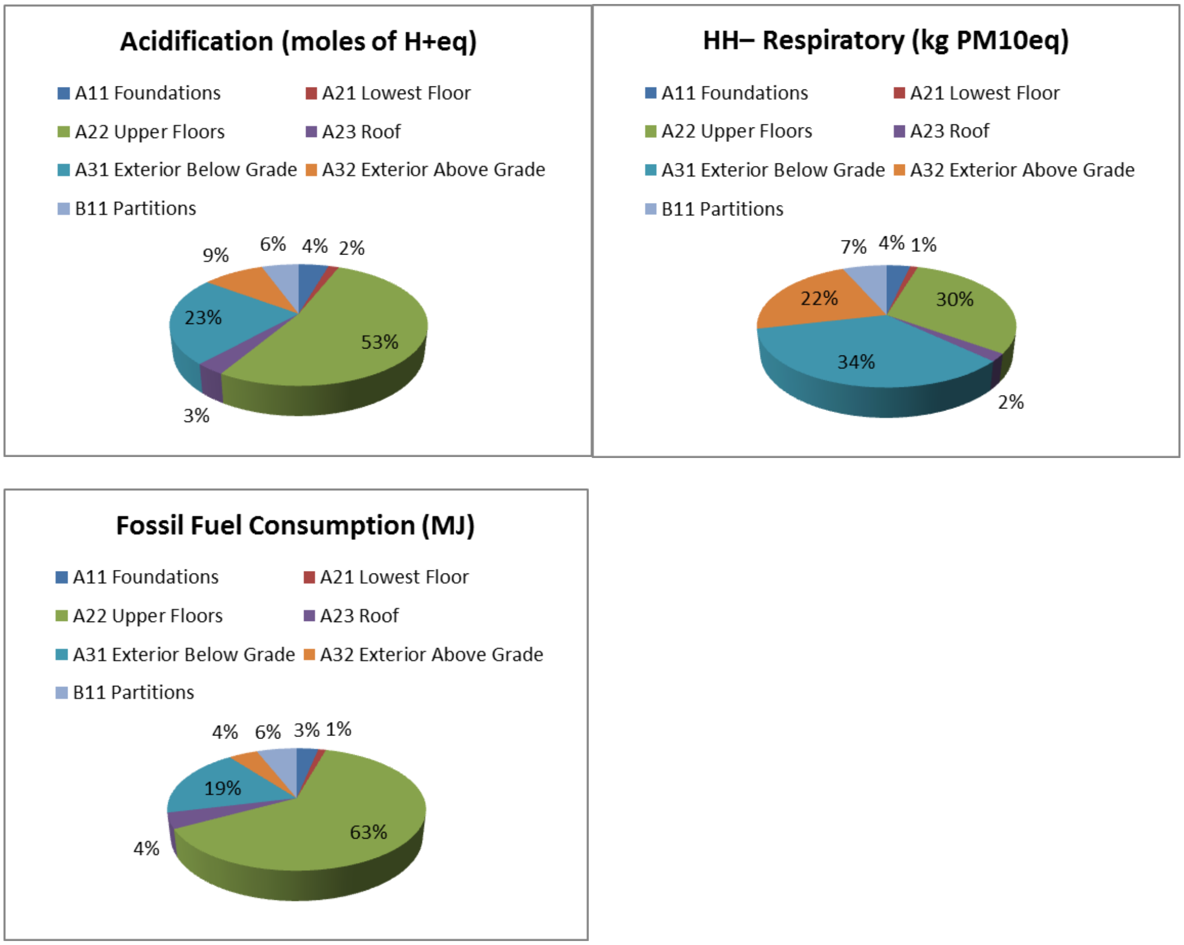


Figure 2. Pie charts showing the proportions of contributions to the impact categories for the Pharmacy Building.

These pie charts show the seven impact categories, starting at the top with A11 Foundations, and moving clockwise in the pie and in the reading direction in the legend, to A21 Lowest Floor and then A22 Upper Floors, which is the biggest slice in most cases.

For further information about the study, please consult the annexes:

- Annex A – Interpretation of Assessment Results: Describes how the concept of benchmarking in LCA adds to the interpretation of the results.
- Annex B – Recommendations for LCA Use: Things to consider when using LCA in building design.
- Annex C – Author Reflection: This author’s personal reflection on LCA and the CIVL 498C course. (Not related to this section, but still very important.)
- Annex D – Impact Estimator Inputs and Assumptions: Tables showing the actual inputs and assumptions used in the model.

Annex A - Interpretation of Assessment Results

First, the benchmark development concept will be discussed, and then its application to UBC academic buildings.

Benchmark Development

A benchmark is a standard point of reference, against which things can be compared. In LCA, this means performing many LCA studies for similar buildings and compiling the results. This involves further categorization along various axes; for academic buildings at UBC, this could include:

- Building faculty: Arts, Science, Engineering, Business, etc. This is relevant because each faculty has different requirements for room sizes, types of facilities, and architectural styles.
- LEED Certification: LEED Certified, LEED Silver, LEED Gold, LEED Platinum, and Living Building Challenge. It is important to be able to compare buildings at the same standard.
- Amenities: Gyms, cafés, shops, club space, etc. If a building contains amenities, it will change the function of the building, so amenities are important to note.
- Building size – number of floors, gross floor area, and length-width-height aspect ratio. This is important because economies of scale drastically affect the building performance. Aspect ratio affects the energy use requirements.

Benchmarking is not only useful when comparing similar things, but it can also be useful for extrapolation. For example, a new building at the Simon Fraser University might be built with high LEED standards, and comparable to UBC buildings of the same size and function. Although it's at a different university, it can still be compared because it's in the same geographical region, albeit at a higher altitude and for a different client.

In order for benchmarks to be usable, they must be made to the same standard. In the UBC LCA Project, that standard is ISO 14044, which outlines the standards by which an LCA report should be written. It's very important to have the same goal and scope among all of the projects because that's what makes it fundamentally comparable. For example, this project excludes the use and end of life stages. If a project for a similar building used those stages, then it would look a lot worse. They wouldn't be comparable.

Another important difference between buildings is their function. For example, the Pharmacy Building is full of testing labs, chemical storage, air locks, and offices. Although it has two lecture theatres, those theatres take up less than 10% of the building. Compare this to another academic building: the Buchanan Building. Buchanan's main purpose is for lectures and classes. It has classrooms and offices, but no testing facilities. It serves a very different function than the New Pharmacy Building. To compare them as similar buildings is possible, as long as one keeps in mind those inherent differences.

UBC Academic Building Benchmark

Benchmarks were developed using the academic buildings, including the Pharmacy Building. The benchmark is shown in the figure below in grey and the Pharmacy Building is shown in Green. Note that the units are different, by orders of magnitude, from the standard. This was done for visualization only.

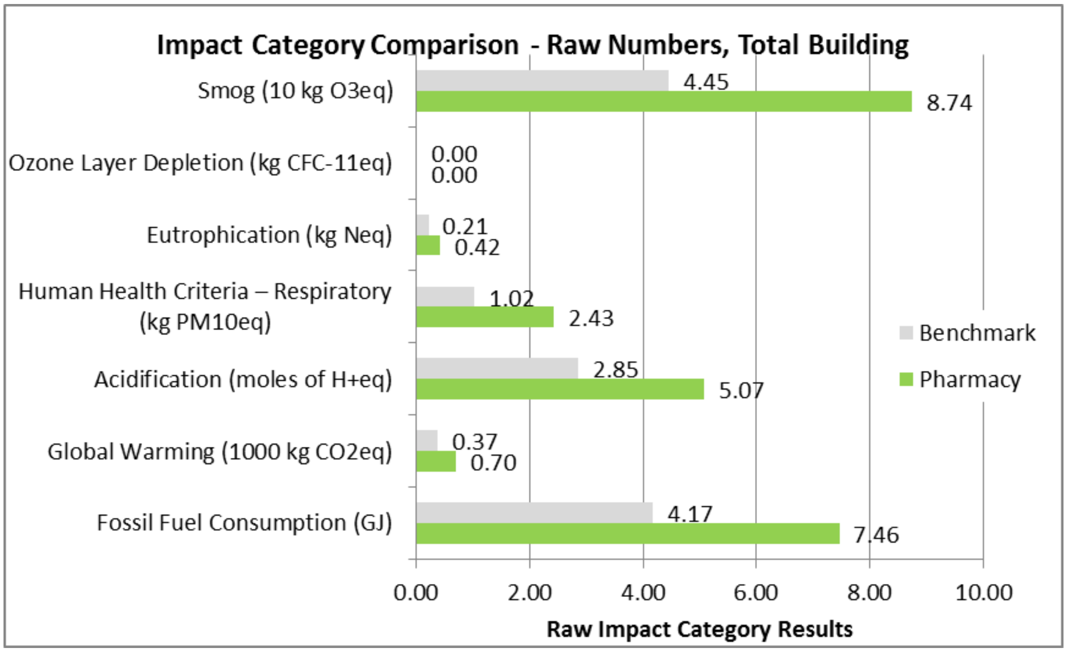


Figure A-1. Impact Category Comparison for Total Building, Showing Raw Numbers

As shown above, the Pharmacy Building has a much higher impact than the average building on campus. That's because the building is much larger than the average building. Specifically, it is 22,871 square meters compared to the average of 8,544 square meters. For comparisons, it's better to show the impacts by square meter. In the figure below, each impact category is converted to per-square meter, and then divided by the benchmark's per-square meter result.

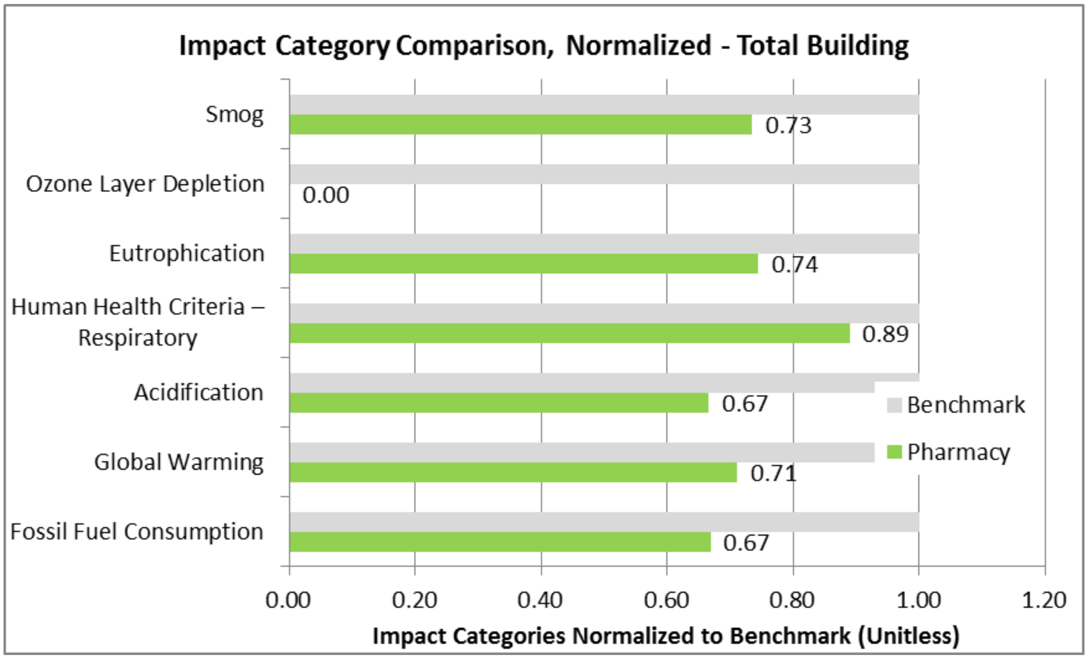


Figure A-2. Impact Category Comparison, Normalized to Benchmark

As shown in the figure above, the Pharmacy Building performs better than the average academic building at UBC. The ozone layer depletion category is zero, because zero was obtained.

In the figure below, the building cost is compared with a single impact category: global warming potential. Note that this uses the totals rather than the per-square meter numbers.

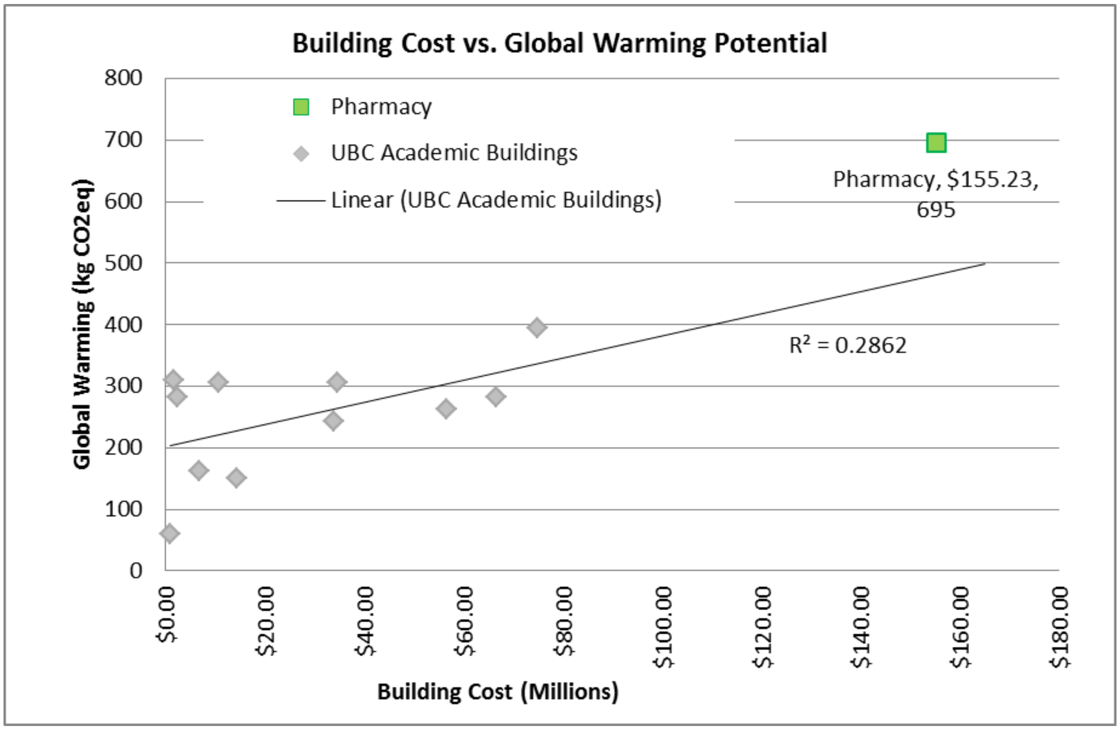


Figure A-3. Building Cost vs. Global Warming Potential

As shown in the chart above, the New Pharmacy Building is vastly more expensive than other buildings and has a much higher global warming potential. The linear regression extended out to the pharmacy building vaguely shows where the building should plot; however, the R^2 is only 0.29, which is far from statistically significant.

Annex B - Recommendations for LCA Use

This LCA should be used for comparisons of academic buildings at the UBC campus. This section discusses the considerations for using this LCA in any other purpose.

Scope Limitation

The first limitation for using this LCA is that it was developed using only Module A of EN 15978. Because Modules B, C, and D are excluded, any comparison should also exclude those modules. The more modules an LCA includes, the higher the environmental impact. In the future, this LCA will be expanded to include those modules, because they are important for accuracy and completeness.

Applications in Design

In the conceptual design stage, many different ideas are tested against each other. Some ideas are touted as “green” or “greener than Option X”. LCA is a way of proving and quantifying those claims.

Data Issues

Technology is changing all of the time; new materials are being produced, new products are getting environmental performance data, and their preceding processes are changing. Companies start up and die out all of the time, so producers are always changing. Transportation changes modes, types, and distances as global economics change. All of this data has to be kept up to date, or else the model becomes outdated. In addition, from the time the conceptual design is formalized to the time it gets built, this change is still going on. As such, LCA reports are estimates at best.

When new materials are being proposed at the conceptual design stage, they might not be in Athena yet. If that’s the case, then the performance has to be measured outside of Athena. To do this:

1. Model a similar element in Athena Impact Estimator for Buildings, and then export to Excel all impact categories in a report. Call this Table 1.
2. Export the bill of materials for that element, and then model the same element in the Extra Materials section. This excludes construction work, so you will need to play with the numbers to get the two elements to match. Export this Extra Materials data to Excel and pasted it underneath Table 1. Call this Table 2.
3. Find an EPD (Environmental Product Declaration) for the product that you are trying to model. Copy the format of Table 2 and clear the data, then enter the EPD’s data in each impact category. Make sure that the data you input is unitary. Call this Table 3.
4. Copy Table 1 underneath Table 3 and call it Table 4. The values for this table are equal to Table 1’s values, plus the unitary values of Table 3 multiplied by the quantities that make up Table 2.

After data has been exported from Athena for the result for the full building, apply the changes made here to that data.

Issues in Application

Each client has a different understanding, or valuation, or prioritization, of the impact categories. For example, one client might be morally concerned with global warming, and unconcerned about the others; another client might have a financial interest in reducing their smog-causing air emissions due to environmental monitoring and fines.

Additionally, the Impact Estimator gives out numbers, or quantities of chemical equivalents, which are somewhat intangible. This reinforces the need to have a benchmark. Clients are more interested in being greener than their competitors, rather than choosing an option that has an array of intangible numbers that are lower than some other set of intangible numbers.

Using LCA at UBC

It's very easy to use LCA at UBC. Right now, we have a very good approximate benchmark for buildings at UBC, similar to the scatter plot in Figure A-3. That figure has only one impact category out of seven showing, and by million dollars rather than gross floor area. For a full comparison, see the two figures at the end of this section. The figures show all of the "axes", or environmental impact categories, in bar chart form. The comparison has to be made between buildings; this "forest of bars" against another, and then by specifics.

There is a relationship between size and cost; generally, the larger the building, the more expensive it is. It tends to follow roughly a fractional exponential curve as economies of scale kick in. For example, doubling the size of a small building could quadruple the cost, while doubling the size of a large building could only double the cost. The relationship between impact categories, cost, and size, is much more linear. Construction operations can benefit from economies of scale, which in turn reduces the impact at larger scales. In general, it can be expected that the impact categories are somewhat linear with size and a fractional exponential with cost.

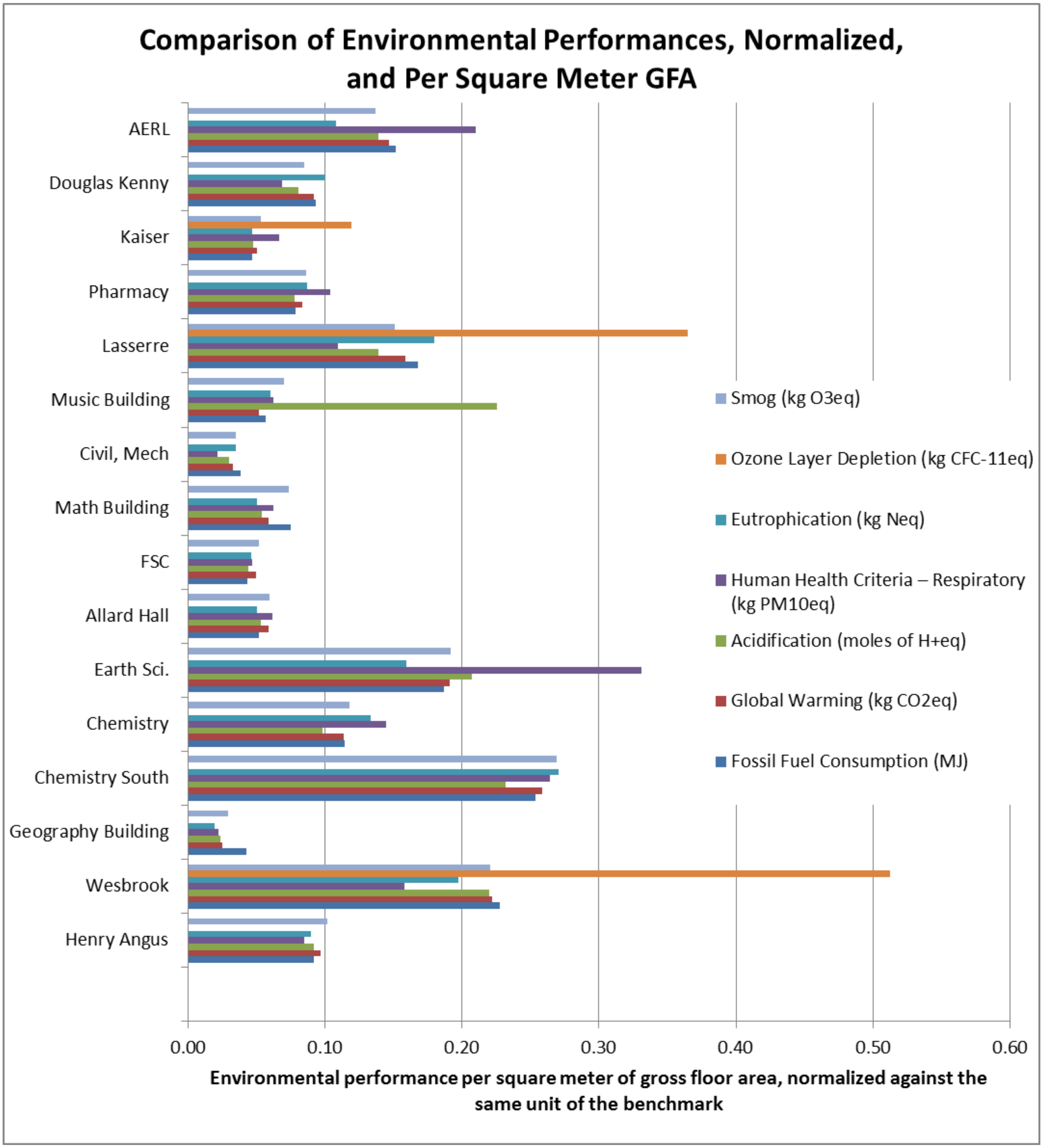


Figure B-1. Comparison of Environmental Performances, Normalized, and per Square Meter GFA

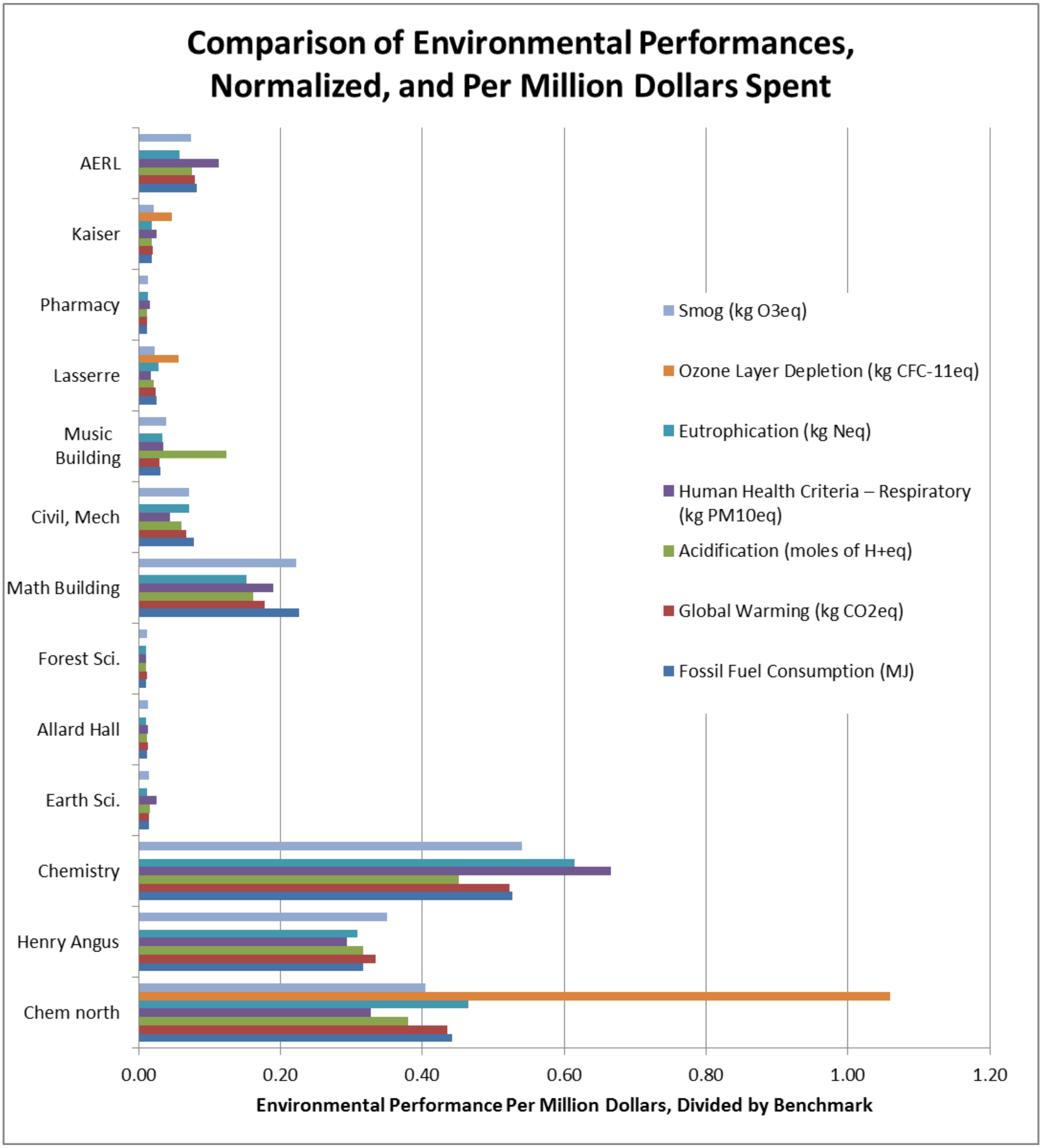


Figure B-2. Comparison of Environmental Performances, Normalized, and per Million Dollars Spent

Annex C - Author Reflection

This annex is my own personal reflection. As such, I allow myself to write informally and more candidly. First, the banal details, and then my personal background, and then my review of the course:

This course ran from September to November, 2013, and is called CIVL 498C – Life Cycle Assessment. It was taken at the University of British Columbia in Vancouver as a three credit elective for my final year in the Bachelor of Applied Science in Civil Engineering Degree program.

I am a "fourth-year" student in the civil engineering degree at UBC. I'm also a transfer student. I started this journey at BCIT by taking the Diploma of Technology in Civil Engineering. After that two-year diploma, I worked for two years as a Civil Design Technologist, designing transportation infrastructure and performing traffic studies under the direction of an engineer. After that, I took a Certificate in Advanced Project Management from Langara College because I had noticed that everyone in the engineering office was some sort of project manager; the competency is important. Immediately following the certificate, I moved to Saanich and attended Camosun College for the Advanced Diploma in Civil Engineering Bridge, which is a bridging program that, when paired with my diploma from BCIT, allowed me to go directly into third year at UBC. Thus, although this is my "fourth year", it is not my fourth year on this path of education.

My previous exposure to sustainability and LCA has been exclusively through courses taken at my schools. I have other experience, though: I have been involved with Scouts Canada for more than half of my life, during which I learned a lot about camping and nature. I can identify and use many of our native plants. I'm very fascinated with the natural world. It is what keeps me interested in LCA.

I've been especially interested in the LCA of currency; in particular, when I spend a dollar, what is the environmental impact? How does it relate to my lifestyle? When I receive income from the government or from an employer, how much of their impacts do I inherit? Also, because currency flows in loops through the economy, where do you set the system boundary?

In order to avoid an extensive discussion of the CEAB Graduate Attributes, I will pick the top two that I demonstrated, and use examples in the dialogue.

The first CEAB Graduate Attribute to discuss is Investigation.

> *"Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions."*

I have brought a lot of investigative experience with me into this course and have used it at various times. For example, when investigating the service life, I had to figure out where I could find that data. Since UBC is not part of the City of Vancouver, it must be governed by some other body. That body is the university itself, so their design criteria must be available through them. I found the criteria online at www.technicalguidelines.ubc.ca, and a search of those guidelines yielded several documents that discuss service life. There are four that require a service life of 100 years: metals, wood, concrete, and masonry. These are also the four main structural building materials. It follows, then, that the service life of buildings at UBC is 100 years.

Another example of investigative skills demonstrated is in the use of the ISO 14044. Codes can be extraordinarily long, technical, and confusing, but with the right mindset, they can be mastered. I skimmed through it with a highlighter, keeping a few questions in mind, and marked relevant sections. After skimming through the document, I went back to those sections and used them in conjunction to figure out what my answer would be. By skimming that code that one time, I was able to go back to it another time to find an answer, and do it faster. This is a skill I learned in a law class at BCIT, and developed it further in this course.

The second of the top two CEAB skills to demonstrate is communication.

> *"Communication: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, 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."*

This entire report is an example of my communication skills. From tables and figures sandwiched by explanation to the discussion of impact categories, I have demonstrated the appropriate skill and tact that an engineer should have. I developed this skill while working at the design firm after graduating from BCIT. Transportation engineering is all about governance, or the balancing of needs; the client wants a cheap system, the users want an efficient system, and engineering ethics maintains that it has to be a safe system. These are all competing priorities, and when the report is written, the engineer has to be aware that what is written can be interpreted differently by those different stakeholder groups.

References for This Report

[i] Life Cycle Assessment of UBC Faculty of Pharmaceutical Sciences Building: CIVL 498E Final Report. Helia Amiri & Mahshid Hashemi. UBC 2012.

[ii] UBC Public Affairs (18 September 2012). *UBC Opens New $133M Pharmaceutical Sciences Building*. Retrieved from http://www.publicaffairs.ubc.ca/2012/09/18/ubc-opens-new-133m-pharmaceutical-sciences-building/

[iii] UBC (2013). *UBC Technical Guidelines.* www.technicalguidelines.ubc.ca

Annex D – Impact Estimator Inputs and Assumptions

Inputs

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
A11 Foundations		1.2 Concrete Footing				
			1.2.1 Footing_F5			
				Length (ft)	54.9	54.9
				Width (ft)	6.1	6.97
				Thickness (in)	21.7	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#6	#6
			1.2.2 Footing_F8			
				Length (ft)	14.4	14.4
				Width (ft)	7.2	9.70
				Thickness (in)	25.6	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#6	#6
			1.2.3. Footing_F3			
				Length (ft)	19.2	19.2
				Width (ft)	4.8	4.8
				Thickness (in)	17.7	17.7
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5 & 6	#6
			1.2.4 Footing_F4			
				Length (ft)	59.4	59.4
				Width (ft)	4.1	4.1
				Thickness (in)	13.8	13.8
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
			1.2.5 Footing_F1			
				Length (ft)	18.8	18.8
				Width (ft)	9.4	15.58
				Thickness (in)	31.5	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#7	#6
			1.2.6 Footing_F2			
				Length (ft)	34	34
				Width (ft)	8.5	12.35
				Thickness (in)	27.6	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#7	#6
			1.2.7 Footing_F7			
				Length (ft)	14.8	14.8
				Width (ft)	5.4	5.4
				Thickness (in)	17.7	17.7
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5 & 6	#6
			1.2.8 Footing_F6			
				Length (ft)	13.1	13.1
				Width (ft)	6.6	8.20
				Thickness (in)	23.6	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#6	#6
			1.2.9 Footing_F10			
				Length (ft)	12.8	12.8
				Width (ft)	6.4	7.31
				Thickness (in)	21.7	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
			1.2.10 Footing_F9			
				Length (ft)	5.4	5.4
				Width (ft)	4.1	4.1
				Thickness (in)	17.7	17.7
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
			1.2.11 Footing_SF1			
				Length (ft)	315.23	315.23
				Width (ft)	2	2
				Thickness (in)	9.8	9.8
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
			1.2.12 Footing_SF2			
				Length (ft)	31.38	31.38

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Width (ft)	2.6	2.6
				Thickness (in)	9.8	9.8
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
			1.2.13 Footing_1400mm_LeftBasement			
				Length (ft)	52.73	52.73
				Width (ft)	52.73	152.97
				Thickness (in)	55.12	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#7	#6
			1.2.14 Footing_700mm_SmallLeftBasement			
				Length (ft)	18.41	18.41
				Width (ft)	18.41	26.71
				Thickness (in)	27.56	19
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#7	#6
			1.2.15 Stairs_Concrete_TotalLength			
				Length (ft)	207.03	207.03
				Width (ft)	3.67	3.67
				Thickness (in)	14	14
				Concrete (psi)	4000	4000
				Concrete flyash %	-	average
				Rebar	#5	#5
A21 Lowest Floor Construction	1 Foundation					
		1.1 Concrete Slab-on-Grade				
			1.1.1 SOG_125mm			
				Length (ft)	116.08	116.08
				Width (ft)	116.08	116.08
				Thickness (in)	4.9	4
				Concrete (psi)	3000	3000
				Concrete flyash %	-	average
			1.1.2 SOG_200mm			
				Length (ft)	56.86	56.86
				Width (ft)	56.86	56.86
				Thickness (in)	9.8	8
				Concrete (psi)	3000	3000
				Concrete flyash %	-	average
			1.1.3 SOG_150mm			
				Length (ft)	61.90	61.90
				Width (ft)	61.90	61.90
				Thickness (in)	4.9	4
				Concrete (psi)	3000	3000
				Concrete flyash %	-	average
A22 Upper Foor Construction	3 Columns and Beams					
		3.1 Concrete Column				
			3.1.1 Column_Concrete_Beam_N/A_Basement			
				Number of Beams	0	0
				Number of Columns	6	6
				Floor to floor height (ft)	12	12
				Bay sizes (ft)	16.17	16.17
				Supported span (ft)	16.17	16.17
				Live load (psf)	-	75
			3.1.2 Column_Concrete_Beam_N/A_GroundLevel			
				Number of Beams	0	0
				Number of Columns	38	38
				Floor to floor height (ft)	12	12
				Bay sizes (ft)	17.35	17.35
				Supported span (ft)	17.35	17.35
				Live load (psf)	-	75
			3.1.3 Column_Concrete_Beam_N/A_Level2			
				Number of Beams	0	0
				Number of Columns	41	41
				Floor to floor height (ft)	12	12
				Bay sizes (ft)	17.92	17.92
				Supported span (ft)	17.92	17.92
				Live load (psf)	-	75
			3.1.4 Column_Concrete_Beam_N/A_Level3			
				Number of Beams	0	0
				Number of Columns	45	45
				Floor to floor height (ft)	12	12
				Bay sizes (ft)	17.1	17.1
				Supported span (ft)	17.1	17.1
				Live load (psf)	-	75
	4 Floors					
		4.1 Concrete Suspended Slab				
			4.1.1 Floor_ConcreteSuspendedSlab_200mm			
				Floor Width (ft)	1271.28	1271.28
				Span (ft)	30	30
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Life load (psf)	-	75
	6 Extra Basic Materials					
		6.1 Steel				
			6.1.1 XBM_Columns_HSS_(Total Sum)			
				Hollow Structural Steel (To	-	13.02
A23 Roof Construction	5 Roof					
		5.1 Concrete Suspended Slab				
			5.1.1 Roof_ConcreteSuspendedSlab_200mm			
			Envelope	Roof Width (ft)	379.37	379.37
				Span (ft)	30	30
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Life load (psf)	-	75
				Category	Roof Envelopes	Roof Envelopes
				Material	Standard Modified Bitumen Membrane 2 ply	Standard Modified Bitumen Membrane 2 ply
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Polyisocyanurate Foam	Polyisocyanurate Foam
				Thickness	3.93	3.93
				Category	Vapour Barrier	Vapour Barrier
				Material	-	Polyethylene 6 mil
				Thickness	-	-
		5.2 Steel Joist Roof				
			5.2.1 Roof_SteelJoist_Penthouse			
			Envelope	Roof Width (ft)	3554.22	3554.22
				Roof Length (ft)	17.35	17.35
				Decking Type	Dens Deck Roof Board	-
				Decking Thickness	5/8	5/8
				Steel Gauge	-	18
				Joist Type	-	1 5/8 x 6
				Joist Spacing	-	16
				Category	Roof Envelopes	Roof Envelopes
				Material	Standard Modified Bitumen Membrane 2 ply	Standard Modified Bitumen Membrane 2 ply
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Dens-GlassGoldSheathing	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Polyisocyanurate Foam	Polyisocyanurate Foam
				Thickness	3.93	3.93
				Category	Vapour Barrier	Vapour Barrier
				Material	-	Polyethylene 6 mil
				Thickness	-	-
			3.1.5 Column_Concrete_Beam_N/A_Level4			
				Number of Beams	0	0
				Number of Columns	45	45
				Floor to floor height (ft)	12	12
				Bay sizes (ft)	17.1	17.1
				Supported span (ft)	17.1	17.1
				Live load (psf)	-	75
A31 Walls Below Grade						
		2.1 Cast In Place				
			2.1.1 Wall_Cast-in-Place_150mm			
				Length (ft)	27.3	20.48
				Height (ft)	12	12
				Thickness (in)	6	8
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			2.1.2 Wall_Cast-in-Place_W1_200mm			
			Envelope	Length (ft)	331.87	331.87
				Height (ft)	12	12
				Thickness (in)	8	8
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
				Category	Insulation	Insulation
				Material	Rigid Insulation	Polystyrene Extruded
				Thickness	1.5"	1.5"
			2.1.3 Wall_Cast-In-Place_W3_200mm			
			Envelope	Length (ft)	394.48	394.48
				Height (ft)	12	12
				Thickness (in)	8	8
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
				Category	Cladding	Cladding
				Material	Brick - Modular (metric)	Brick - Modular (metric)
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Polystyrene Extruded	Polystyrene Extruded
				Thickness	2.64"	2.64"
				Category	Vapour Barrier	Vapour Barrier
				Material	-	Polyethylene 6 mil

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Thickness	-	-
			2.1.4 Wall_Cast-in-Place_Elevator_200mm			
				Length (ft)	30.87	30.87
				Height (ft)	63.33	63.33
				Thickness (in)	8	8
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			2.1.5 Wall_Cast-in-Place_NoEnv_200mm			
				Length (ft)	24.5	24.5
				Height (ft)	12	12
				Thickness (in)	8	8
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			2.1.6 Wall_Cast-in-Place_250mm			
				Length (ft)	38.83	32.36
				Height (ft)	12	12
				Thickness (in)	10	12
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			2.1.7 Wall_Cast-in-Place_300mm			
				Length (ft)	12.24	10.2
				Height (ft)	12	12
				Thickness (in)	12	12
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			2.1.8 Wall_Cast-in-Place_W1_400mm			
				Length (ft)	218.49	291.32
				Height (ft)	12	12
				Thickness (in)	16	12
				Concrete (psi)	3500	4000
				Concrete flyash %	-	average
				Rebar	#4	#5
			Envelope	Category	Insulation	Insulation
				Material	Polystyrene Extruded	Polystyrene Extruded
				Thickness	1.5"	1.5"
A32 Walls Above Grade	2 Walls					
		2.3 Curtain Wall				
			2.3.1 Wall_CurtainWall_AllGlazing			
				Length (ft)	818.59	818.59
				Height (ft)	12	12
				Percent Viewable Glazing	100	100
				Percent Spandrel Panel	0	0
				Thickness of Insulation (in)	2.64"	2.64"
				Spandrel Type (Metal/Glas	Metal	Metal
			Door Opening	Number of Doors	16	16
				Door Type	-	Aluminum Exterior Door, 80% glazing
			2.3.2 Wall_CurtainWall_MetalSpandrel			
				Length (ft)	737	737
				Height (ft)	12	12
				Percent Viewable Glazing	75	75
				Percent Spandrel Panel	25	25
				Thickness of Insulation (in)	2.64"	2.64"
				Spandrel Type (Metal/Glas	Metal	Metal
			Door Opening	Number of Doors	1	1
				Door Type	-	Aluminum Exterior Door, 80% glazing
			2.3.3 Wall_CurtainWall_TypeSF1			
				Length (ft)	788.29	788.29
				Height (ft)	12	12
				Percent Viewable Glazing	-	99
				Percent Spandrel Panel	-	1
				Thickness of Insulation (in)	-	0.1
				Spandrel Type (Metal/Glas	Metal	Metal
			Door Opening	Number of Doors	16	16
				Door Type	-	Steel Interior Door, 50% glazing
B11 Partitions			2.2.3 Wall_ConcreteBlock_P2_Partition			
				Length (ft)	68.4	68.4
				Height (ft)	12	12
				Rebar	#4	#4
			Door Opening	Number of Doors	3	3
				Door Type	-	Steel Interior Door, 50% glazing
		2.4 Steel Stud				
			2.4.1 Wall_SteelStud_Type29			
				Length (ft)	310.49	310.49
				Height (ft)	3.42	3.42
				Sheathing Type	-	None
				Stud Spacing	-	24oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	-	1 5/8 x 3 5/8
			Envelope	Category	-	Gypsum Board
				Material	-	Gypsum Regular 5/8"
				Thickness	-	-

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Category	-	Gypsum Board
				Material	-	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.2 Wall_SteelStud_W2			
			Envelope	Length (ft)	17.25	17.25
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	-	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	6"	6"
				Category	Vapour Barrier	Vapour Barrier
				Material	Polyethylene 6 mil	Polyethylene 6 mil
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.3 Wall_SteelStud_W5			
				Length (ft)	710.42	710.42
				Height (ft)	12	12
				Sheathing Type	Dens-GlassGoldSheathing	None
				Stud Spacing	-	16oc
				Stud Weight	-	Heavy (20Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Window Opening	Number of Windows	128	128
				Total Window Area (ft2)	2151.68	2151.68
				Frame Type	Fixed, Aluminum Frame	Fixed, Aluminum Frame
				Glazing Type	-	Low E Tin Glazing
			Envelope	Category	Cladding	Cladding
				Material	Brick - Modular (metric)	Brick - Modular (metric)
				Thickness	-	-
				Category	Insulation	Insulation
				Material	CavityMateUltra	Polystyrene Extruded
				Thickness	2.64"	2.64"
				Category	Vapour Barrier	Vapour Barrier
				Material		Polyethylene 6 mil
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Dens-GlassGoldSheathing	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
			2.4.4 Wall_SteelStud_W5_SteelCladding-Add-in_Length			
			Envelope	Length (ft)	175.58	175.58
				Height (ft)	3.83	3.83
				Sheathing Type	Dens-GlassGoldSheathing	None
				Stud Spacing	-	16oc
				Stud Weight	-	Heavy (20Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
				Category	Cladding	Cladding
				Material	Steel Cladding - Commercial (26 ga.)	Steel Cladding - Commercial (26 ga.)
				Thickness	-	-
				Category	Insulation	Insulation
				Material	CavityMateUltra	Polystyrene Extruded
				Thickness	2.64"	2.64"
				Category	Vapour Barrier	Vapour Barrier
				Material		Polyethylene 6 mil
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Dens-GlassGoldSheathing	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
			2.4.5 Wall_SteelStud_P3_Partition			
			Envelope	Length (ft)	498.24	249.12
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 1 13/16	1 5/8 x 3 5/8
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	-	Gypsum Board
				Material	-	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.6 Wall_SteelStud_P4_Partition			
				Length (ft)	615.47	615.47
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Stud Thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Door Opening	Number of Doors	60	60
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.7 Wall_SteelStud_P5_Partition			
				Length (ft)	306.63	306.63
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Door Opening	Number of Doors	16	16
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.8 Wall_SteelStud_P6_Partition			
				Length (ft)	1039.14	1039.14
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Door Opening	Number of Doors	23	23
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
			2.4.9 Wall_SteelStud_P7_Partition			
				Length (ft)	233.73	233.73
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Door Opening	Number of Doors	13	13
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Moisture Resistant 5/8"	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Moisture Resistant 5/8"	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
			2.4.10 Wall_SteelStud_P8_Partition			
				Length (ft)	179.49	179.49
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Door Opening	Number of Doors	7	7
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Moisture Resistant 5/8"	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt

Level 3 Grouping	Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
					Known/Measured	IE Inputs
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Moisture Resistant 5/8"	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
			2.4.11 Wall_SteelStud_P9_Partition			
				Length (ft)	157.67	157.67
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Door Opening	Number of Doors	3	3
				Door Type	-	Steel Interior Door, 50% glazing
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 5/8"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	3.62
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Moisture Resistant 5/8"	Gypsum Moisture Resistant 5/8"
				Thickness	-	-
			2.4.12 Wall_SteelStud_P10_Partition			
				Length (ft)	13.67	41.01
				Height (ft)	12	12
				Sheathing Type	None	None
				Stud Spacing	16 oc	16oc
				Stud Weight	-	Light (25Ga)
				Stud Thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Envelope	Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 1/2"
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Fiberglass Batt	Fiberglass Batt
				Thickness	3.62	1.36
				Category	Gypsum Board	Gypsum Board
				Material	Gypsum Regular 5/8"	Gypsum Regular 1/2"
				Thickness	-	-
		2.2 Concrete Block Wall				
			2.2.1 Wall_ConcreteBlock_W4_200mm			
				Length (ft)	12.92	12.92
				Height (ft)	12	12
				Rebar	#4	#4
			Envelope	Category	Cladding	Cladding
				Material	Brick - Modular (metric)	Brick - Modular (metric)
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Polystyrene Extruded	Polystyrene Extruded
				Thickness	2.64"	2.64"
				Category	Vapour Barrier	Vapour Barrier
				Material		Polyethylene 6 mil
				Thickness	-	-
			2.2.2 Wall_ConcreteBlock_W4_200mm_ShortBrickAddIn_Length			
				Length (ft)	186.01	186.01
				Height (ft)	3.58	3.58
				Rebar	#4	#4
			Envelope	Category	Cladding	Cladding
				Material	Brick - Modular (metric)	Brick - Modular (metric)
				Thickness	-	-
				Category	Insulation	Insulation
				Material	Polystyrene Extruded	Polystyrene Extruded
				Thickness	2.64"	2.64"
				Category	Vapour Barrier	Vapour Barrier
				Material		Polyethylene 6 mil
				Thickness	-	-

Assumptions

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
1 Foundation	The Impact Estimator, SOG inputs are limited to being either a 100mm or 200mm thickness. Since the actual SOG thicknesses for the Pharmacy building were not exactly 100mm or 200mm thick, the areas measured in OnScreen required calculations to adjust the areas to accommodate this limitation. The Impact Estimator limits the thickness of footings to be between 190mm and 500mm thick. As there are a number of cases where footing thicknesses exceed 500mm, their widths were increased accordingly to maintain the same volume of footing while accommodating this limitation. Lastly, the concrete stairs were modelled as footings. All stairs had the same thickness and width, so the total area of stair was measured and were combined into a single input.		
	1.1 Concrete Slab-on-Grade		
		1.1.1 SOG_125mm	As the SOG is not a simple rectangle, the area is messured rather than length and width. However, the area of this slab had to be adjusted so that the thickness fit into the 200mm thickness specified in the Impact Estimator. The following calculation was done in order to determine appropriate Length and Width (in mm) inputs for this slab; = sqrt[((Measured Slab Area) x (Actual Slab Thickness))/(200)] = sqrt[(5520x 150)/(200)] = 58736.7mm
	1.2 Concrete Footing		
		1.2.1 Footing_F1	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.2 Footing_F2	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.5 Footing_F3	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.6 Footing_F4	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.8 Footing_F5	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.8 Footing_F6	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.8 Footing_F7	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.8 Footing_F8	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm)
		1.2.10 Footing_F10	The number of this type of footing is counted and will be modeled in IE as one imput. The width of this Foundation was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 500mm. The measured width was maintained, thicknesses were set at 500mm and the length were increased using the following calculations; Length (m)= (Counted number of foundations)*Volume (m3)/(Width(m)*500/1000) Total length(mm)=Number*Length (mm) Since the rebar is not specified, it has been assumed to be #20.
		1.2.13 Foundation Slab_GS 300	There are three foundations of this type. Each one has different width and length. In order to have it as one imput into IE, the width was assumed to be 3m.Considering the constant Area, the length is calculated. Length (m)= Total Area (m2)/(3)

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
		1.2.16 Foundation Slab_GS 1350	There are five foundations of this type. Each one has different width and length. In order to have it as one imput into IE, the width was assumed to be 16m and the thickness to be 500mm.Considering the constant Volume, the length is calculated. Length (m)= Total Area (m2)*(1350/1000)/(16*500/1000)
		1.2.17 Foundation Slab_GS 1600	There are five foundations of this type. Each one has different width and length. In order to have it as one imput into IE, the width was assumed to be 14.5m and the thickness to be 500mm.Considering the constant Volume, the length is calculated. Length (m)= Total Area (m2)*(1600/1000)/(14.5*500/1000)
		1.2.22 Foundation_Retaining Wall_250	Looking at Structural Drawings, S604, there are two types of this foundation type. Based on the measurements, Type 2 is selected.
		1.2.23 Stepped Footing	The Cross Section of the footings are measured in On Screen take-off. Having the width=450mm, the volume is calculated. Assuming the constant volume, width=0.450m and depth to be equal to 500mm, length is calculated. Length (m)= Total Area (m2)*(450/1000)/((500/1000)*0.450)
		1.2.24 Concrete stairs	Concrete stairs are modeled in IE as footings. The volume of concrete is extracted from On Screen take off and assuming the width to be 250mm and length to be 3.5m, the length is calculated.
2 Walls			
	The length of the concrete cast-in-place walls needed adjusting to accommodate the wall thickness limitation in the Impact Estimator. It was assumed that interior steel stud walls were light gauge (25Ga) and exterior steel stud walls were heavy gauge (20Ga). Based on the Doors used on interior walls, all the door type has been assumed to be Hollow core wood interior door which is the closest surrogate to the doors used in this building.		
	2.1 Cast In Place		
		2.1.1 Wall_Cast-in-Place_W1	This wall was reduced by a factor in order to fit the 200mm and 300mm thickness limitation of the Impact Estimator. This was done by reducing the length of the wall and keeping the thickness and volume constant. From Architectural drawings, W1 was divided into 11 different walls (Wall 01 to Wall 11) in Structural drawings with varying thickness. Thickness, reinforcement and rebar were found from the Structural drawings.
		2.1.2 2.1.2 Wall_Cast-in-Place_W4	This wall was reduced by a factor in order to fit the 300mm thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/300]
		2.1.3 Wall_Cast-In-Place_W10	This wall was reduced by a factor in order to fit the 200mm thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/200]
		2.1.4 Wall_Cast-in-Place_W11	This wall has a layer of waterproof membrane insulation. The only waterproof insulation option available in Imapct Estimator is Polystyrene Extruded. Thus, it was assumed to be Polystyrene Extruded.
		2.1.5 Wall_Cast-in-Place_W12	This wall was reduced by a factor in order to fit the 300mm thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/300] This wall has a layer of waterproof membrane insulation. The only waterproof insulation option available in Imapct Estimator is Polystyrene Extruded. Thus, it was assumed to be Polystyrene Extruded.
		2.1.6 Wall_Cast-in-Place_W13	This wall was reduced by a factor in order to fit the 200mm thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/200]
	2.2 Metal Clad Wall		
		2.2.1 Metal Clad Wall_W40	Research shows that Dens Glass Gold Sheathing is essentially a fiberglass covered gypsum board that is also reinforced with glass fibers. This combination provides a product that is dimensionally stable, resistant to moisture and mold as well as fire. This material is not an option in the Impact Estimator, so a surrogate of 5/8" Moisture Resistant Gypsum was used in it's place. Since Galvanized Steel Z Bar is not an option under Wall Assembly, it has been categorized under Extra Basic Material as Galvanized Sheet. This wall is sitting on concrete walls; therefore, there is nothing as steel stud or Metall cladding defined in the characteristics of the wall. As there should be a wall type defined in IE, steel stud is defined for this wall.
		2.2.2 Zinc Clad Wall_W41	Research shows that Dens Glass Gold Sheathing is essentially a fiberglass covered gypsum board that is also reinforced with glass fibers. This combination provides a product that is dimensionally stable, resistant to moisture and mold as well as fire. This material is not an option in the Impact Estimator, so a surrogate of 5/8" Moisture Resistant Gypsum was used in it's place. Since Galvanized Steel Z Bar is not an option under Wall Assembly, it has been categorized under Extra Basic Material as Galvanized Sheet. This wall is sitting on concrete walls; therefore, there is nothing as steel stud or Metall cladding defined in the characteristics of the wall. As there should be a wall type defined in IE, steel stud is defined for this wall. Based on the conversation with contractor: there were two types of Zinc used for this project which their finishing method were different. and Type B is a way to distinguish them and it is modeled as Extra Basic Material.
	2.3 MASONRY PARTITION WALL		
		2.3.1 MASONRY PARTITION WALL_P1	According to wall types on page 3 of architectural map, P1 has an unknown rebar. Thus, it has been assumed to have the minimum rebar of #10.
		2.3.2 MASONRY PARTITION WALL_P2	According to wall types on page 3 of architectural map, P1 has an unknown rebar. Thus, it has been assumed to have the minimum rebar of #10.
		2.3.3 MASONRY PARTITION WALL_P3	According to wall types on page 3 of architectural map, P1 has an unknown rebar. Thus, it has been assumed to have the minimum rebar of #10.
	2.4 Steel Stud		

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
		2.4.1 Wall_SteelStud_TypeP10	Mineral fiber insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.2 Wall_SteelStud_TypeP15	For this type of wall the stud sapcing is 610mm OC. Since there are only two available options in the Impact Estimator, 400 OC and 600 OC, it was assumed to be 600 OC as it is closer to its actual stud spacing. For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 100 C-HStud is not an option in the Impact Estimator.
		2.4.3 Wall_SteelStud_TypeP16	For this type of wall the stud sapcing is 610mm OC. Since there are only two available options in the Impact Estimator, 400 OC and 600 OC, it was assumed to be 600 OC as it is closer to its actual stud spacing. For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 64 C-HStud is not an option in the Impact Estimator. Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate. ******This wall is included in the wall types; however no walls of this type were found in the drawings.
		2.4.4 Wall_SteelStud_TypeP17	For this type of wall the stud sapcing is 610mm OC. Since there are only two available options in the Impact Estimator, 400 OC and 600 OC, it was assumed to be 600 OC as it is closer to its actual stud spacing. For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 100 C-HStud is not an option in the Impact Estimator. Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.5 Wall_SteelStud_TypeP18	For this type of wall the stud sapcing is 610mm OC. Since there are only two available options in the Impact Estimator, 400 OC and 600 OC, it was assumed to be 600 OC as it is closer to its actual stud spacing. For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 64 C-HStud is not an option in the Impact Estimator.
		2.4.6 Wall_SteelStud_TypeP20	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 92 C-HStud is not an option in the Impact Estimator. Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.7 Wall_SteelStud_TypeP21	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 152mm 25 GAU Stud is not an option in the Impact Estimator. Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.8 Wall_SteelStud_TypeP22	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.9 Wall_SteelStud_TypeP23	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.10 Wall_SteelStud_TypeP24	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.11 Wall_SteelStud_TypeP25	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.12 Wall_SteelStud_TypeP26	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.13 Wall_SteelStud_TypeP27	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.14 Wall_SteelStud_TypeP28	Acoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.15 Wall_SteelStud_TypeP29	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate. Gypsum mould resistance 5/8" wan not available in the Impact Estimator. Therefore, Gypsum moister resistance 5/8" was selected as the closest surrogate.
		2.4.21 Wall_SteelStud_TypeP40	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 22mm Steel Hat Channel is not an option in the Impact Estimator.
		2.4.22 Wall_SteelStud_TypeP41	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 38mm Steel Hat Channel is not an option in the Impact Estimator.
		2.4.25 Wall_SteelStud_TypeP44	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.26 Wall_SteelStud_TypeP45	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.27 Wall_SteelStud_TypeP46	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 50mm Z Girt is not an option in the Impact Estimator.
		2.4.28 Wall_SteelStud_TypeP47	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 64mm stud is not an option in the Impact Estimator.
		2.4.29 Wall_SteelStud_TypeP48	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 50mm Z Girt is not an option in the Impact Estimator.
		2.4.30 Wall_SteelStud_TypeP50	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 38mm Steel Hat Channel is not an option in the Impact Estimator. The Wood Cladding was not an option in the Impact Estimator so Wood Bevel Siding-Cedar was selected as the closest surrogate.

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
		2.4.31 Wall_SteelStud_TypeP51	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X152 as 50mm Z Girt is not an option in the Impact Estimator. The Wood Cladding was not an option in the Impact Estimator so Wood Bevel Siding-Cedar was selected as the closest surrogate.
		2.4.32 Wall_SteelStud_TypeP52	The Wood Cladding was not an option in the Impact Estimator so Wood Bevel Siding-Cedar was selected as the closest surrogate.
		2.4.33 Wall_Steel_TypeP55	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 22mm Steel Hat Channel is not an option in the Impact Estimator. Steel sheet is modeled as Extra Basic Material.
		2.4.34 Wall_Steel_TypeP56	Steel sheet is modeled as Extra Basic Material.
		2.4.35 Wall_Steel_TypeP57	For stud thickness, we have choices of 39X92, 39X152 and 39X203, and it was assumed to be 39X92 as 22mm Steel Hat Channel is not an option in the Impact Estimator. Alucaband is a composite panel consisting of two aluminium cover sheets and a plastic core. Based om its functionaloty, the closest surrogate is the Steel Cladding-Commercial(26ga) in the Impact estimator.
		2.4.37 Wall_SteelStud_TypeP59	Steel sheet is modeled as Extra Basic Material.
		2.4.38 Wall_SteelStud_TypeP60	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate. Gypsum mould resistance 5/8" wan not available in the Impact Estimator. Therefore, Gypsum moister resistance 5/8" was selected as the closest surrogate.
		2.4.39 Wall_SteelStud_TypeP61	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.40 Wall_SteelStud_TypeP62	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
		2.4.41 Wall_SteelStud_TypeP63	Accoustic Batt insulation was not available in the Impact Estimator so Fiberglass Batt was selected as the closest surrogate.
	2.5 Curtain Wall		
		2.5.1 Wall_CurtainWall_Interior	Aluminum Door with 50% glazing was the closest estimtation to the observed doors in this wall.
		2.5.2 Wall_CurtainWall_BlackGlass	Aluminum Door with 50% glazing was the closest estimtation to the observed doors in this wall.
		2.5.3 Wall_CurtainWall_Exterior	Aluminum Door with 80% glazing was the closest estimtation to the observed doors in this wall.
3 Columns and Beams	The Impact Estimator calculates the sizing of beams and columns based on the number of beams, number of columns, floor to floor height, bay size, supported span and live load. The available range for bay size in the Impact Estimator is between 3.05m and 12.2m, in cases that the actual value of bay size is greater than this range, it has been assumed to be 12.2m.		
	3.1 Concrete Column		
		3.1.1 Column_Concrete_Beam_Level 1 ins	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns In IE the supported area must be greater than or equal to Bay sizeX Supported span; therefore the supported area was assumed to be equal to Bay sizeX Supported span
		3.1.2 Column_Concrete_Beam_Level 1	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns
		3.1.3 Column_Concrete_Beam_Level 2	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns In IE the supported area must be greater than or equal to Bay sizeX Supported span; therefore the supported area was assumed to be equal to Bay sizeX Supported span
		3.1.4 Column_Concrete_Beam_Level 3	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)]
		3.1.5 Column_Concrete_Beam_Level 4	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns
		3.1.6 Column_Concrete_Beam_Level 5	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)]
		3.1.7 Column_Concrete_Beam_Level 6	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
		3.1.8 Column_Concrete_Beam_Roof	Because of the variability of bay and span sizes, they were calculated using the following calculation; Bay size= Total Length of beam/ Number of Beams Supported Span= sqrt[(Measured Supported Floor Area) / (Number of Columns)] Supported Area= Floor Area/Number of columns The minimum acceptable live load in the Impact Estimator is 2.4 kPa. Thus, the live load has been assumed to be 2.4 kPa instead of the actual value of 1.8 kPa.
4 Floors			
	4.1. Concrete Suspended Slab		
		4.1.1 Floor_Level 01_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated.
		4.1.2 Floor_Level 01_12 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated. The max load that is accepted by IE is 4.8kpa; however, the live load in this are is 12kpa. The live load is assumed to be 4.8kpa.
		4.1.3 Floor_Level 02_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated.
		4.1.4 Floor_Level 03_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated.
		4.1.5 Floor_Level 04_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is 97m the floor width is calculated.
		4.1.6 Floor_Level 04_10.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span and the floor width are equal,the following formula is used to calculate them. Span(m)=floor width(m)=sqrt(area(m2)) The max load that is accepted by IE is 4.8kpa; however, the live load in this are is 10.8kpa. The live load is assumed to be 4.8kpa.
		4.1.7 Floor_Level 04_11.6 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span and the floor width are equal,the following formula is used to calculate them. Span(m)=floor width(m)=sqrt(area(m2)) The max load that is accepted by IE is 4.8kpa; however, the live load in this are is 11.6kpa. The live load is assumed to be 4.8kpa.
		4.1.8 Floor_Level 05_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is 97m the floor width is calculated.
		4.1.9 Floor_Level 05_11.6 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated. The max load that is accepted by IE is 4.8kpa; however, the live load in this are is 11.6kpa. The live load is assumed to be 4.8kpa.
		4.1.10 Floor_Level 06_4.8 kpa	TThe shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (9.75m), the floor width is calculated.
		4.1.11 Floor_Level 06_11.6 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span and the floor width are equal,the following formula is used to calculate them. Span(m)=floor width(m)=sqrt(area(m2)) The max load that is accepted by IE is 4.8kpa; however, the live load in this are is 11.6kpa. The live load is assumed to be 4.8kpa.
	4.2 Steel Joist		
		4.2.1 Floor_Level 01 interstitial_4.8 kpa	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is the maximum acceptable value in the Impact Estimator (5.5m), the floor width is calculated. The steel joist doesn't have concrete in its assembly, therefore the concrete topping is modeled as Extra Basic Material.
5 Roof			
	5.1 Concrete Suspended Slab		
		5.1.1 Roof_R10_Built up Roof	The shape of the plan is not a simple rectangle, having the area from On screen takeoff and assuming the span is 40m the length is calculate. Research showed that SBS Self-Adhering Base/Ply Sheet is a durable, modified bitumen membrane designed and manufactured to meet industry and code requirements, therefore, on IE the material is set to Standard Modified Bitumen Membrane 2 ply which is assumed to be the most closest one and the thickness had to be adjusted with the minimum aceptable for IE. In addition, Protection Board is an extruded polystyrene foam insulation therefore, Polystyrene Extruded was slected on IE. research also shows that Polyisocyanurate insulation boardsare typically produced as a foam and used as rigid thermal insulation. The min load that is accepted by IE is 2.4kpa; however, the live load in this are is 1.8kpa. The live load is assumed to be 4.8kpa.
6 Extra Basic material			
	6.1. Steel Joist		
		6.1.1 Floor_Level 01 interstitial_XBM	The concrete topping in the steel joist roof is modeled in Extra basic material. 30MPa with average flyash is chosen for this purpose. Having the area and 40mm thickness, the volume is calculated.
	6.2 Metal Clad Wall		
		6.2.1. Metal Clad Wall_W40_XBM	Galvanized Steel Z Bar (16ga) is modeled as galvanized sheet. 16 gauge is equal to 1.5mm. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated
		6.2.2. Metal Clad Wall_W41_XBM	Galvanized Steel Z Bar (16ga) is modeled as galvanized sheet. 16 gauge is equal to 1.5mm. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated
		6.2.3. Metal Clad Wall_W41_XBM	As Zinc is not included in the IE, the zinc sheet is modeled as hot rolled sheet with the density of zinc (7140kg/m3). Having the volume and density the wegth is calculated
	6.3 Wall_Steel Stud		
		6.3.1. Wall_Steel_TypeP55 level 02_XBM	Based on the research cold rolled sheet is lighter with more strength and for fabricating thin sheets cold rolled sheet is used.Therefore, Sheet steel is modeled as Cold rolled sheet. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated
		6.3.2. Wall_Steel_TypeP56 level -01 ins_XBM	Based on the research cold rolled sheet is lighter with more strength and for fabricating thin sheets cold rolled sheet is used.Therefore, Sheet steel is modeled as Cold rolled sheet. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated
		6.3.3. Wall_Steel_TypeP56 level 04_XBM	Based on the research cold rolled sheet is lighter with more strength and for fabricating thin sheets cold rolled sheet is used.Therefore, Sheet steel is modeled as Cold rolled sheet. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated
		6.3.4. Wall_SteelStud_TypeP59 level 01_XBM	Based on the research cold rolled sheet is lighter with more strength and for fabricating thin sheets cold rolled sheet is used.Therefore, Sheet steel is modeled as Cold rolled sheet. Having the volume of the sheet and considering the density equal to 7850 kg/m3, the weight is calculated