LCA – Totem Park Residence

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Abstract

This study looks at the total environmental impact of the Totem Park residences located on the UBC Vancouver campus. The study aims to get an idea of what the total embodied impact of the building complex is. The goal and scope of an LCA must be clearly outlined in order to properly identify its uses and how it can be used by decision makers. The findings of the study showed that the reinforced concrete structural system contributed the most to the final environmental impact of the constructed buildings. An energy model was also constructed in order to compare the difference in operating energy of one of the residence buildings with its original insulation and window glazing, versus an upgraded insulation and windows. It was noted that the upgraded insulation shows a dramatic improvement on the operational efficiency.

Introduction

The Totem Park residence complex was built in 1963 making it one of the older residences on the UBC Vancouver campus. It has a total of 1163 beds in six different buildings as well as three social buildings and one large common building that includes a cafeteria, work out area, and other such amenities. The buildings have undergone a variety of renovations over the years, however these are outside the scope of this report.

Totem Park is constructed using primarily reinforced concrete. The exterior walls consist of concrete with a brick veneer. Interior walls are concrete blocks and cast in place concrete. Suspended concrete slabs make up the floors and roof. With all this concrete in the structure, it is anticipated that the total environmental impact of constructing it will be based largely on the concrete. It was also noted that the building envelope consists of very little insulation (only 1 inch thick) and is consequently very inefficient in the way of heating. Heating comes exclusively from steam that is piped in from the UBC central steam plant. The windows are all single glazed, and the common block has a very large portion of the building that is covered entirely by floor to ceiling glass – contributing to the overall inefficiency of the building's heating.

This report will show a Life Cycle Assessment (LCA) conducted on the entire complex (with a few omissions – see goal and scope section) with the intent of showing as much detail as is practically possible, given the software that was employed.

Goal of Study

This life cycle analysis (LCA) of the Totem Park residences at the University of British Columbia was carried out as an exploratory study to determine the environmental impact of the design of it's six buildings. This LCA of the Totem Park residence is also part of a series of twelve others being carried out simultaneously on respective buildings at UBC with the same goal and scope.

The main outcomes of this LCA study are the establishment of a materials inventory and environmental impact references for the Totem Park residences. An exemplary application of these references are in the assessment of potential future performance upgrades to the structure and envelope of the Totem Park residences. When this study is considered in conjunction with the twelve other UBC building LCA studies, further applications include the possibility of carrying out environmental performance comparisons across UBC buildings over time and between different materials, structural types and building functions. Furthermore, as demonstrated through these potential applications, this Totem Park residences LCA can be seen as an essential part of the formation of a powerful tool to help inform the decision making process of policy makers in establishing quantified sustainable development guidelines for future UBC construction, renovation and demolition projects.

The intended core audience of this LCA study are those involved in building development related policy making at UBC, such as the Sustainability Office, who are involved in creating policies and frameworks for sustainable development on campus. Other potential audiences include developers, architects, engineers and building owners involved in design planning, as well as external organizations such as governments, private industry and other universities whom may want to learn more or become engaged in performing similar LCA studies within their organizations.

Scope of Study

The product system being studied in this LCA are the structure, envelope and operational energy usage associated with space conditioning of the Totem Park residences on a square foot finished floor area of residence building basis. In order to focus on design related impacts, this LCA encompasses a cradle-to-gate scope that includes the raw material extraction, manufacturing of construction materials, and construction of the structure and envelope of the Totem Park residences, as well as associated transportation effects throughout.

Tools, Methodology and Data

Two main software tools are to be utilized to complete this LCA study; OnCenter's OnScreen TakeOff and the Athena Sustainable Materials Institute's Impact Estimator (IE) for buildings.

The study will first undertake the initial stage of a materials quantity takeoff, which involves performing linear, area and count measurements of the building's structure and envelope. To accomplish this, OnScreen TakeOff version 3.6.2.25 is used, which is a software tool designed to perform material takeoffs with increased accuracy and speed in order to enhance the bidding capacity of its users. Using imported digital plans, the program simplifies the calculation and measurement of the takeoff process, while reducing the error associated with these two activities. The measurements generated are formatted into the inputs required for the IE building LCA software to complete the takeoff process. These formatted inputs as well as their associated assumptions can be viewed in Annexes A and B respectively.

Using the formatted takeoff data, version 4.0.51 of the IE software, the only available software capable of meeting the requirements of this study, is used to generate a whole building LCA model for the Totem Park residences in the Vancouver region as an Multi-Unit Residential Rental building type. The IE software is designed to aid the building community in making more environmentally conscious material and design choices. The tool achieves this by applying a set of algorithms to the inputted takeoff data in order to complete the takeoff process and generate a bill of materials (BoM).

This BoM then utilizes the Athena Life Cycle Inventory (LCI) Database, version 4.6, in order to generate a cradle-to-grave LCI profile for the building. In this study, LCI profile results focus on the manufacturing and transportation of materials and their installation in to the initial structure and envelope assemblies. As this study is a cradle-to-gate assessment, the expected service life of the Totem Park residences is set to 1 year, which results in the maintenance, operating energy and end-of-life stages of the building's life cycle being left outside the scope of assessment.

The IE then filters the LCA results through a set of characterization measures based on the mid-point impact assessment methodology developed by the US Environmental Protection Agency (US EPA), the Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI) version 2.2. In order to generate a complete environmental impact profile for the Totem Park residences, all of the available TRACI impact assessment categories available in the IE are included in this study, and are listed as;

- Global warming potential
- Acidification potential
- Eutrophication potential
- Ozone depletion potential
- Photochemical smog potential
- Human health respiratory effects potential
- Weighted raw resource use
- Primary energy consumption

Using the summary measure results, a sensitivity analysis is then conducted in order to reveal the effect of material changes on the impact profile of the Totem Park residences. Finally, using the UBC Residential Environmental Assessment Program (REAP) as a guide, this study then estimates the embodied energy involved in upgrading the insulation and window R-values to REAP standards and calculates the energy payback period of investing in a better performing envelope.

The primary sources of data for this LCA are the original architectural and structural drawings from when the Totem Park residences was initially constructed in 1963. The assemblies of the building that are modeled include the foundation, columns and beams, floors, walls and roofs, as well as the associated envelope and openings (ie. doors and windows) within each of these assemblies. The decision to omit other building components, such as flooring, electrical aspects, HVAC system, finishing and detailing, etc., are associated with the limitations of available data and the IE software, as well as to minimize the uncertainty of the model. In the analysis of these assemblies, some of the drawings lack sufficient material details, which necessitate the usage of assumptions to complete the modeling of the building in the IE software. Furthermore, there are inherent assumptions made by the IE software in order to generate the BoM and limitations to what it can model, which necessitated further assumptions to be made. These assumptions and limitation will be discussed further as they energy in the Building Model section and, as previously mentioned, all specific input related assumption are contained in the Input Assumptions document in Annex B.

Building Model – Takeoffs

Using the OnScreen software package, material takeoffs were performed. The Totem Park was split into three main building types: The residences, the social units and the common building. The residence building type is repeated six times, the social unit three times and the common building is unique. Takeoffs were performed in a methodical manner, going floor by floor with each building being its own typical unit. In order to obtain the entire bill of materials (BoM), each floor is simply multiplied by the respective number of times it is repeated. In this way, the takeoff data is conveniently organized, and one can easily isolate each individual floor from the rest of the site.

Challenges that made the process difficult were primarily due to the quality of the drawings. The drawings are hand made from the 1950's and 60's which were scanned into a computer and converted to .pdf format. Because they are hand drawn and quite old, the quality is very low and it was quite difficult to obtain much detailed information. This meant that certain assumptions had to be made such as wall and floor thicknesses and door/window details.

The building was modeled with a number of simplifying assumptions. Some of these assumptions apply to the entire park, these include:

- All residence and social floor loads are 75psf
- Floor loads for Common building are 100psf
- All roof loads are 45psf
- All concrete is assumed to be 3000psi strength
- All rebar is assumed to be #5 bar size
- All windows are the same size (3'x2')

A more detailed explanation of each assembly group can be found in Annex B.

Bill of Materials

The BoM represents the sum of all materials used to create the building. It is different from the input tables because it includes items taken from the materials database and is generated automatically from the EIE software. For example, joint compound and nails are both materials used in construction but were not specified in the material takeoffs, yet they are included in the BoM.

Table 1.1 – Bill of Materials

Material	Quantity	Unit
1/2" Gypsum Fibre Gypsum Board	86090.0945	m2
Aluminium	95.0063	Tonnes
Ballast (aggregate stone)	5934.0516	Kg
Cold Rolled Sheet	2.5718	Tonnes
Concrete 20 MPa (flyash av)	15825.5496	m3
Concrete 30 MPa (flyash av)	3527.5931	m3
Concrete Blocks	141192.5037	Blocks
EPDM membrane	3378.942	Kg
Expanded Polystyrene	229.425	m2 (25mm)
Extruded Polystyrene	49474.0214	m2 (25mm)
Galvanized Sheet	5.7484	Tonnes

Glazing Panel	37.7804	Tonnes
Joint Compound	85.9195	Tonnes
Mortar	819.8772	m3
Nails	107.935	Tonnes
Ontario (Standard) Brick	13368.4584	m2
Paper Tape	0.9861	Tonnes
PVC membrane	3637.756	Kg
Rebar, Rod, Light Sections	775.2878	Tonnes
Roofing Asphalt	5651.4777	Kg
Screws Nuts & Bolts	0.4417	Tonnes
Small Dimension Softwood Lumber, kiln-dried	23.6563	m3
Solvent Based Alkyd Paint	8176.4574	L
Standard Glazing	3151.1321	m2
Water Based Latex Paint	1185.3069	L
Welded Wire Mesh / Ladder Wire	5.5382	Tonnes

Some of the most important materials used in the construction of Totem Park are concrete, reinforcing steel, clay brick, concrete blocks and mortar. It is no surprise that concrete and steel are the most important, since all of the structures are made entirely of these materials. Reinforced concrete is very versatile in its uses and allows a high degree of flexibility in design. The biggest contribution to the total amount of concrete used comes from suspended slabs. There are nearly 200,000 square feet of suspended slabs in the residences alone. This is more than double the total concrete volume of the walls and slabs on grade for the entire park. The output of the EIE model will depend very heavily on the reinforced concrete. Steel reinforcing bars will play a very significant role as well. Even slabs on grade require a minimum reinforcing to protect against temperature cracking, and some assemblies such as footings and stairs will have a much higher steel content.

The accuracy of the figures shown is directly affected by the assumptions made such as slab thickness, wall thickness, beams and columns, etc. The Impact Estimator has a built in structural estimator that will estimate member dimensions based on the span of a beam or height of a column. These are rough estimates and are not considered exact. In addition, sometimes it is not possible to input the exact thickness of a wall or slab. For slabs on grade, the options are either 4” or 8”, and in this case the actual slabs were 6”. This will have an effect on the final result of the model, but it should still be within a reasonable range.

Summary measures

This section will discuss the findings of the LCA – that is, the environmental impact resulting from the construction of Totem Park. The summary measures shows data such as the total embodied energy, the global warming potential as well as a number of other impacts. Here we are viewing the data by the life cycle stages of the entire building. This is particularly useful if annual energy consumption data is available, as it would allow one to compare the embodied effects versus operating effects. Note that a simple energy model was conducted and will be discussed in a later section of this report.

Table 2.1 – Summary measures – by Life cycle stages

	Manufacturing			Construction			Total Effects
	Material	Transport	**Total**	Material	Transport	**Total**	
Primary Energy Consumption MJ	104590169	2447453	**107037622**	4285048	13566388	**17851436**	**12889057**
Weighted Resource Use kg	60145270	72439	**60217710**	196854	308753	**505607**	**60723317**
Global Warming Potential (kg CO2 eq / kg)	8821743	4369	**8826112**	290427	17677	**308104**	**9134216**
Acidification Potential (moles of H+ eq / kg)	2974251	1469	**2975720**	147635	5994	**153629**	**3129349**
HH Respiratory Effects Potential (kg PM2.5 eq / kg)	26007	2	**26009**	166	7	**173**	**26182**
Eutrophication Potential (kg N eq / kg)	168	0	**168**	0	0	**0**	**168**
Ozone Depletion Potential (kg CFC-11 eq / kg)	0	0	**0**	0	0	**0**	**0**
Smog Potential (kg NOx eq / kg)	39738	33	**39771**	3655	135	**3789**	**43560**

Sources of Uncertainty

There is a long list of assumptions inherent in the LCA process, and this report is not aimed at exploring an exhaustive list of these assumptions and their uncertainties. There are however several important points that should be considered. For example, the Impact Estimator takes the data from the LCI data associated with the BoM and references it against a non-regionalized version of the impact assessment methodology TRACI. The results are characterized and normalized so that similar pollutants can be expressed in the same units. The example of carbon dioxide (CO_2) equivalents can best illustrate this point - eventhough chemicals, such as methane, might have additional environmental interactions, when compared to carbon dioxide, the total impact is best described as a CO_2 equivalent. The chemicals are weighted according to the greenhouse effect of each chemical relative to carbon dioxide. The same process of weighting chemicals and impacts is used for the other impact categories (ie.

eutrophication, acidification, etc.). There is uncertainty in this process because there may be other important effects of the chemicals that are neglected when they are represented on equivalency scales. Interactions between chemicals and the natural environment may be more complex. They may also have a very short or very long life span. All of these difficulties contribute to the uncertainty of the impact assessment, and over LCA.

The impact of a given product varies from one company to another and from one region of the world to another. Differences in techniques, technologies, policies, resource availability, energy costs and a host of other inputs all play a role in determining the final impact of the product. For example, in third world countries, projects use a lot of labour and less machinery to get the job done – this may have a significant impact on the environmental impact of construction. For this reason, there are a number of databases from various parts of the world; each one is specific to the local and regional impacts of a given product or service. A concrete building in Vancouver will have inputs that are very different than the exact same building if constructed in Brazil. In addition, there is uncertainty regarding when and where the pollutants are released. They may be released slowly over a period or all at once. They may also be released in such a way as to facilitate dispersion over a wide area. For example transportation produces pollutants from trucks/ships etc all along the transportation route. These include air emissions as well as leaking fluids (lubricants, coolants etc) or solid materials such as blown out tires or broken parts. The same principle of uncertainty may apply to many of the outputs of the model – these exact details of when and where emissions are released to air, water and land are simply not known.

There are also a number of uncertainties inherent in the Impact Estimator. For example, the exact size of structural members such as beams, columns and suspended slabs are approximated automatically based on column height and span/bay sizes as well as live loads. This gives a pretty good rough estimate but may not represent the actual building precisely.

Sensitivity Analysis

The sensitivity analysis was carried out using a group of five materials. An extra 10% of each material was added to the Impact Estimator one at a time, recording the output after each change. The result shows what happens to the model when each material is adjusted by ±10% of its original BoM value. It should be noted that the IE takes into account construction waste factors. These construction waste factors did not seem to affect the sensitivity analysis in a significant way.

Table 3– Sensitivity - % Variance of output when selected materials are adjusted by 10%

	Concrete (%)	Rebar (%)	Brick (%)	Insulation (%)	Paint (%)
Energy (MJ)	2.49	1.43	0.33	0.16	0.15
Resource Use	8.67	0.88	0.68	0.63	0.65
Global Warming	4.72	0.84	0.44	0.11	0.32
Acidification	4.70	0.13	0.46	0.13	0.31
Respiratory Effects	4.62	0.59	0.45	0.30	0.31
Eutrophication	0.17	9.48	0.02	0.00	0.01
Ozone Depletion	8.65	0.59	0.59	0.59	0.58
Smog	5.36	0.28	0.37	0.59	0.08

As expected, concrete seemed to have the greatest affect on the output. This agrees with the observation that concrete is the most abundant material on the site. It also indicates that concrete is the single greatest polluter of all the materials. Interestingly, concrete did not have much of an effect on the eutrophication potential; in fact, the steel rebar had the greatest affect on eutrophication potential, the variance approached the maximum of 10% (which would mean that steel was the only material contributing to eutrophication potential)

Building Performance

Totem Park is a very old building complex, and as such was not expected to be very efficient. There have been a number of renovations over the years, and it is possible that the current state of the buildings is much better than its original efficiency, however these renovations are beyond the scope of this report. An upgrade that could be made in regards to operational efficiency is the addition of extra insulation and more thermally efficient windows. The use of a one inch rigid insulation is simply inadequate. In addition, the single glazed windows are extremely inefficient.

Embodied energy is a much harder question to answer. Clearly the use of reinforced concrete for the entire park was a practical choice at the time. It is a very versatile and practical material to use. It is not clear how the total impacts would change if the entire Park were to be built using a steel frame type construction. Steel is less often used in residential low rise construction simply because it cannot compete with concrete in terms of economics and ease of use. Timber frame generally has a lower impact compared to concrete but this was not practical for the residences because the building code limited conventional timber frame construction to four storeys at the time of construction, while the current buildings are six. Timber frame is also less practical for large assembly buildings where floor loads are high. The three social buildings would be the best choice to examine as they are only two storeys high and live loads are similar to the residences.

The following is a comparison of Totem Park as it was built, versus using timber frame construction for the three social buildings with the rest as is.

Table 4.1 – Environmental Effects with wood frame Social Buildings

	Savings			% Savings		
Material ID	walls	roof	floor	walls	roof	floor
Primary Energy Consumption MJ	2,272,916	1,296,348	1,021,815	2.3	16.5	8.2
Weighted Resource Use kg	2,240,462	1,328,801	1,061,970	7.4	19.8	8.9
Global Warming Potential (kg CO2 eq / kg)	490,486	247,480	203,554	3.7	19.0	9.4
Acidification Potential (moles of H+ eq / kg)	320,184	154,687	125,676	3.6	18.5	9.1
HH Respiratory Effects Potential (kg PM2.5 eq / kg)	235,923	118,786	95,479	3.6	18.3	8.9
Eutrophication Potential (kg N eq / kg)	8,195	4,960	3,824	2.1	16.5	8.1
Ozone Depletion Potential (kg CFC-11 eq / kg)	235,364	118,495	95,236	3.6	18.3	8.9
Smog Potential (kg NOx eq / kg)	236,871	119,120	95,785	3.6	18.3	8.9

The results show clearly that wood framed structures have a lower environmental impact than if concrete is used. This data must also be considered with other factors such as lumber prices versus concrete and functional benefits such as acoustics, durability and so on. It is difficult to say if going with timber framed social buildings would have been a better choice overall without knowing all of the constraints affecting the decision - but, based on the comparison shown, the timber frame is a better choice for these particular buildings.

Energy Consumption Model

Energy consumption was roughly estimated for one of the six storey residence buildings. Annual maximum, minimum and mean heat loss was calculated using the following equation:

$$Q = (1/R) \times A \times \Delta T$$

Where,

R = Calculated R-Value in $ft^2\ ^oF\ h/BTU$ (these are the Imperial units)

A = Assembly of interest ft^2

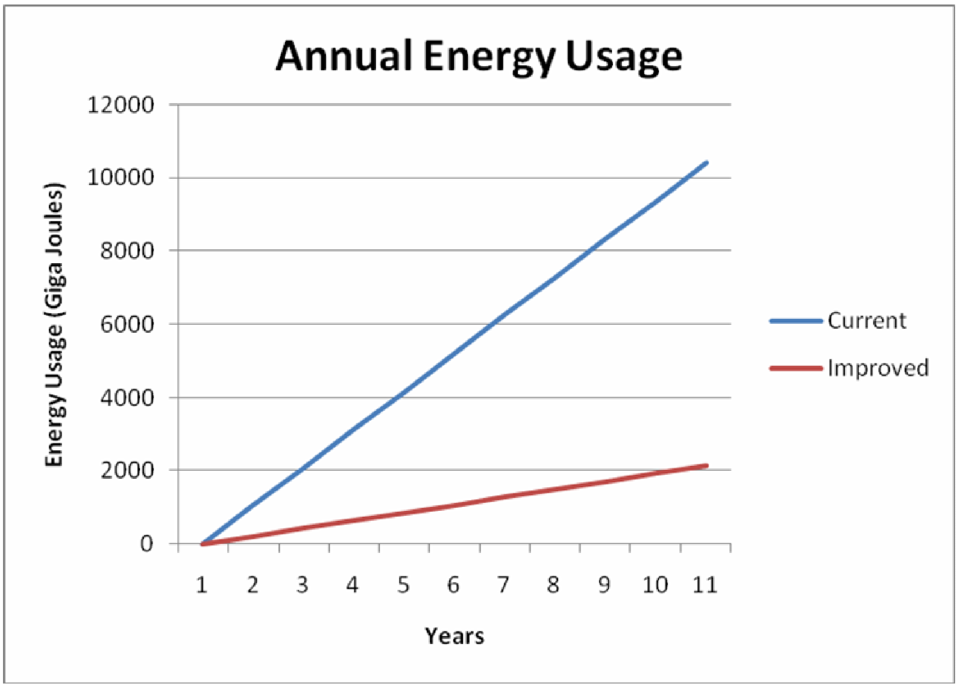
ΔT = Inside Temperature – Outside Temperature in °F (these values were obtained using historic weather data for Vancouver)

Heat loss was then multiplied by the number of hours in each month and converted to the appropriate SI units (Joules). This calculation was performed using the buildings actual insulation and window information, and then repeated using upgraded insulation and windows. The following table shows the average R-value of the existing versus proposed insulation/windows:

Table 4.2 – R-Value of Current vs. Improved

		R-Value (ft2.degF.h/BTU)	
	Area (ft2)	'Current' Building	'Improved' Building
Exterior Wall	22837.5	5	20
Window	1194	0.91	2.81
Roof	6332	5	40
Weighted Average	30363.5	4.84	23.49

Figure 4.1 – Energy comparison



The slope of the lines represents the annual operating energy usage, where the red line represents a much lower annual cost. Interestingly, the embodied energy of the insulation and windows was included in both scenarios, but was so low compared to the operating energy that it does not show up on the graph. If embodied energy of the entire building had been included, both lines would simply be shifted upward by the same amount. It should be noted that this is actually a very simple comparison and does not take into account the full environmental impacts of each design. If for example, this type of insulation produces a highly toxic form of pollution, the total environmental effects of making more insulation could potentially be greater than simply using less insulation and more operating energy. This could be especially true in British Columbia where most electricity comes from hydro electric plants where pollution related to energy generation is minimal, thus making the impacts of energy saving materials relatively more prevalent.

The energy savings “payback” period is less than one year, however, this does not represent the economic payback. An economic payback analysis would be the most useful since most decisions are made based on return on investment. The economic analysis is beyond the scope of the report, but it is recommended for further study of the building.

Conclusion

The environmental impacts of constructing the original buildings are heavily dependent on the reinforced concrete. This is expected for a group of buildings of this size. It is not practical to build six storey residences using timber frames, and steel is often too expensive and/or there are few contractors with the expertise to do it quickly and safely. This is likely why reinforced concrete was chosen to begin with. Its availability and workability make it a favorite for engineers and contractors alike. As it was shown in the report, it may have been beneficial to build the social buildings using timber frame construction. This would have reduced the total environmental impact of the park by a significant factor.

The Totem Park residence complex is also very old and in need of some efficiency upgrades if they haven’t already been done since it’s initial construction. It may be of significant economic benefit over the long term to invest in some insulation upgrades as well as windows. Further analysis in this regard is recommended.

ANNEX A – Impact Estimator Input Tables

Inputs for the Common Block - Totem Park

General Description					
	Project Name		Totem Park		
	Project Location		Vancouver		
	Gross square footage of entire site		309021.29		
	Building Life Expectancy		1 years		
	Building Type		Institutional		
	Operating Energy Consumption		-TBA-		
Assembly Group	**Assembly Type**	**Assembly Name**	**Input Fields**	**Input Values**	
				Known/Measured	EIE Inputs
1 Foundation					
	1.1 Concrete Slab on Grade				
		1.1.1 - Unfinished slab on grade			
			Length (ft)	65	0
			Width (ft)	65	0
			Thickness (in)	4	
			Concrete (psi)	-	3000
			Concrete flyash %	-	average
	1.2 Concrete Footing				
		1.2.2 - Continuous footing			
			Length (ft)	715	715
			Width (ft)	4	4
			Thickness (in)	10	10
			Concrete (psi)		
			Concrete flyash %	average	
			Rebar	-	#4
		1.2.3 - Continuous			

		footing (Conc. Stairs)			
			Length (ft)	137	137
			Width (ft)	12	12
			Thickness (in)	8	8
			Concrete (psi)		
			Concrete flyash %	average	
			Rebar	-	#4
		1.2.4 - Spread Footing			
			Count	35	1
			Width (ft) - Square	4	140' x 4'
			Thickness (in)	12	12
			Concrete (psi)		
			Concrete flyash %	average	average
			Rebar	#4	#4
2 Custom Wall					
	2.1 Concrete Block Wall				
		2.1.1 - 8" Block wall			
			Wall Type	Interior	-
			Length (ft)	16	0
			Height (ft)	14	0
		Envelope	Category	Gypsum board	-
			Material	Gysum Regular 1/2"	-
			Thickness	-	-
		2.1.2 - 6" Block wall			
			Wall Type	Interior	Interior
			Length (ft)	1733	1820.43
			Height (ft)	14	14
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Number of Doors	12	12
		2.1.3 - 6" Block wall			
			Wall Type	Interior	-
			Length (ft)	100	0

	Envelope	Height (ft)	10	0
		Category	Gypsum board	-
		Material	Gysum Regular 1/2"	-
		Thickness	-	-
2.2 Cast-in-Place				
	2.2.1 - Interior Concrete wall 10'			
		Length (ft)	9	0
		Height (ft)	10	0
		Thickness (in)	6	0
		Concrete (psi)	-	0
		Concrete flyash %	-	-
		Rebar	-	-
	Envelope	Envelope Category	Gypsum board	-
		Envelope Material	Gysum Regular 1/2"	-
		Thickness	-	-
	2.2.2 - Interior Concrete wall 14'			
		Length (ft)	164	170.43
		Height (ft)	14	14
		Thickness (in)	6	8
		Concrete (psi)	-	0
		Concrete flyash %	-	Average
		Rebar	-	5
	Envelope	Envelope Category	Gypsum board	Gypsum board
		Envelope Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	-
		Number of Doors	13	
		Door Type	Wood, Solid core	
2.3 Glass Curtain Wall				
	2.3.1 - Floor to ceiling glass wall			
		Wall Type	Exterior	Exterior
		Length (ft)	785	785
		Height (ft)	14	14
		Glazing panel width (ft)	3	-
		Thickness (in)	0.5	-

	Door Opening	Stud Type	Aluminum	Aluminum
		Number of Doors	50	50
		Door Type	Glass	Metal, 80% glazing
2.4 Brick Wall				
	2.4.1 - Exterior Brick Veneer, Cast in Place Concrete			
	Envelope	Length (ft)	498	748.85
		Height (ft)	14.75	14.75
		Thickness (in)	6	6
		Concrete (psi)	-	3000
		Concrete flyash %	-	Average
		Rebar	-	#5
		Envelope Category	Gypsum board	Gypsum board
		Envelope Material	Gypsum Regular 1/2"	Gypsum Regular 1/2"
		Insulation	1" Rigid	1" Rigid
		Number of Doors	8	10
		Door Type	Metal, Solid core	Metal, Solid core
		Overhead Door (10'x10')	1	1
		Number of Windows	4	4
		Window size	3'x4'	3'x4'
	2.4.2 - Exterior Brick Veneer, Cast in Place Concrete			
		Length (ft)	370	0
		Height (ft)	10	0
		Thickness (in)	6	0
		Concrete (psi)	-	-
		Concrete flyash %	-	-
		Rebar	-	-
	Envelope	Envelope Category	Gypsum board	-
		Envelope Material	Gypsum Regular 1/2"	-
		Insulation	1" Rigid	-
		Number of Doors	2	-
		Door Type	Metal, Solid core	-
3 Mixed				

Columns and Beams					
	3.1 Concrete Column and Concrete Beam				
		3.1.1 - Interior Beams/Columns			
			Number of Beams	188	188
			Number of Columns	122	122
			Floor to floor height (ft)	14	14
			Bay sizes (ft)	20	20
			Supported span	20	20
			Live load (psf)	100	100
		3.1.2 - Exterior Balcony area			
			Number of Beams	19	19
			Number of Columns	19	19
			Floor to floor height (ft)	14	14
			Bay sizes (ft)	11	11
			Supported span	20	20
			Live load (psf)	100	100
4 Roofs					
	4.1 Suspended Slab				
		4.1.1 - Gravel Roof			
			Roof Width (ft)	151	151
			Span (ft)	151	151
			Concrete (psi)	4000	4000
			Concrete flyash %	average	average
			Live load (psf)	45	45
		Envelope	Category	Gravel roof	Gravel roof
			Material	1" Rigid insulation	1" Rigid insulation
			Thickness (in)	3	3
5 Floors					
	5.1 Suspended Slab				
		5.1.1 - Finished Floor			
			Floor Width (ft)	137.5	590.8

			Span (ft)	137.5	32
			Concrete (psi)	3000	3000
			Concrete flyash %	average	average
			Live load (psf)	100	100
	5.2 Concrete slab on grade				
		5.2.1 - Finished Floor - Slab on Grade			
			Floor Width (ft)	136.5	201.5
			Floor Length (ft)	136.5	201.5
			Thickness (in)	6	8
			Topping	Included	not Included
6 Ceilings					
	6.1 Ceilings				
		Suspended Ceiling tiles			
			Area (SF)	21746	0
		Plaster ceiling			
			Area (SF)	17426	0
7 Extra Basic Materials					
	7.1 Concrete				
		7.1.1 - Concrete Railing			
			Height (ft)	3	3
			Length (ft)	421	421
			Thickness (ft)	0.5	0.5
			Total Volume (m^3)	17.90	17.90
		7.1.2 - Concrete Balcony thingy			
			Height (ft)	4	4
			Length (ft)	489	489
			Thickness (ft)	0.75	0.75
			Total Volume (m^3)	41.57	41.57
		7.1.3 - Total Concrete by Volume			
			Total for Common building (m3)	59.47	59.47
	7.2 Extra Material Other				
		7.2.1 - Collapsible partition wall -			

	Accordian type			
		Length (ft)	128	0
		Height (ft)	13	0

Inputs for the Residence Units - Totem Park

Assembly Group	Assembly Type	Assembly Name	Input field	Measured Quantities per building	EIE Input Values	
					Per building	*6 Buildings
1 - Footings						
	1.1 - Concrete Strip Footings					
		1.1.1 - Footings	Length (ft)	1,118	1,118	6708
			Width (ft)	4'	4'	4'
			Thickness (in)	18"	18"	18"
			Rebar	#5		
	1.2 - Slab on Grade					
		1.2.1 - Slab on Grade	Length (ft)	24	24	58.79
			Width (ft)	24	24	58.79
			Thickness (in)	6"	4"	4"
	1.3 - Stairs					
		1.3.1 - Concrete stairs	Length (ft)	120	120	720
			Width (ft)	4'	4'	4'
			Thickness (in)	10"	10"	10"
			Rebar	#5	#5	#5
2 - Floors						
	2.1 - Suspended Floors					
		2.1.1 - Finished, Suspended floor	Width (ft)	1,647	1,647	9882
			Average Span (ft)	20	20	20
			Thickness (in)	6"	Unknown	Unknown
			Load (psf)	Unknown	75	75
3 - Custom Wall						
	3.1 - Brick Walls					
		3.1.2 - 8' 9" Exterior Brick wall	Length (ft)	2,610	2,610	15660
			Height (ft)	8'9"	8'9"	8'9"
			Type	Concrete	Concrete	
			Envelope	Brick	Ontario Brick	
			Insulation	1" rigid	1" Extruded Poly	
			Doors	Unknown	Metal with 50% glazing	

		Number of Doors	7	7	42
		Number of Windows	199	199	1194
		Window area	1,602	1,602	9612
		Window Type	Aluminum, Operable	Aluminum, Operable	
3.2 - Cast In Place					
	3.2.2 - Interior Concrete wall - 8' 9"	Length (ft)	3,986	3,986	23916
		Height (ft)	8'9"	8'9"	8'9"
		Type	concrete	concrete	
		Envelope	Gypsum and paint	Gypsum and paint	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	wood, hollow core	wood, hollow core	
		Number of Doors	110	110	660
3.3 - Concrete Block					
	3.3.1 - 6" block wall - 8' 9"	Length (ft)	1,468	1,468	8808
		Height (ft)	8'9"	8'9"	8'9"
		Type	Concrete Block	Concrete Block	
		Envelope	Gypsum and paint	Gypsum and paint	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	wood, hollow core	wood, hollow core	
		Number of Doors	110	110	660
	3.3.2 - 6" block wall - 10'	Length (ft)	326	326	1956
		Height (ft)	10'	10'	10'
		Type	Concrete Block	Concrete Block	
		Envelope	Gypsum and paint	Gypsum and paint	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	none	none	
4 - Roof					
4.1 Flat Roof System					
	8.1.1 - Gravel / Bitumen	Average Span (ft)	32	32	32
		Width (ft)	198	198	1187.4
		Insulation	1" rigid	1" Extruded Poly	
		Envelope	Gravel,	Asphalt, aggregate, PVC	

				Bitumen	membrane	
5 - Extra Materials						
	5.1 - Parapet wall					
		5.1.1 - Parapet wall	Length (ft)	508	508	3048
			Height (ft)	1.5	1.5	1.5
			Thickness (in)	8	8	8
			Envelope	none	none	none
			Volume of concrete (m^3)			86.38
	5.2 - Suspended Ceiling					
		5.2.1 - Suspended acoustic tile	Area (sq. ft)	33,242	-	-
			Thickness (in)	0.5	-	-
			Type	Fiberboard	-	-

Inputs for the Social Units - Totem Park

Assembly Group	**Assembly Type**	**Assembly Name**	**Assembly Description (Dimensions)**	**Measured Quantities Per building**	**Actual EIE Inputs**	
					Inputs per Building	*3 Buildings
1 - Footings						
	1.1 - Concrete Strip Footings					
		1.1.1 - Footings	Length (ft)	857	857	2571
			Width (ft)	4'	4'	4'
			Thickness (in)	12"	12"	12"
			Rebar	#5	#5	#5
	1.2 - Slab on Grade					
		1.2.1 - Slab on Grade	Length (ft)	85.5	85.5	148.09
			Width (ft)	85.5	85.5	148.09
			Thickness (in)	6"	4"	4"
	1.3 - Stairs					
		1.3.1 - Concrete stairs	Length (ft)	60	60	180
			Width (ft)	4'	4'	4'
			Thickness (in)	10"	10"	10"
			Rebar	#5	#5	#5
2 - Floors						
	2.1 - Suspended Floors					
		2.1.1 - Finished,	Width (ft)	442	442	1324.65

	Suspended floor				
		Average Span (ft)	20	20	20
		Thickness (in)	6"	Unknown	
		Load (psf)	Unknown	75	75
3 - Custom Wall					
3.1 - Brick Walls					
	3.1.2 - 8' 9" Exterior Brick wall	Length (ft)	941	941	2823
		Height (ft)	8'9"	8'9"	8'9"
		Type	Concrete	Concrete	
		Envelope	Brick	Ontario Brick	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	Unknown	Metal with 50% glazing	
		Number of Doors	21	21	63
		Number of Windows	32	32	96
		Window area	192	192	576
		Window Type	Aluminum, Operable	Aluminum, Operable	
3.2 - Cast In Place					
	3.2.2 - Interior Concrete wall - 8' 9"	Length (ft)	940	940	2820
		Height (ft)	8'9"	8'9"	8'9"
		Type	concrete	concrete	
		Envelope	Gypsum and paint	Gypsum and paint	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	wood, hollow core	wood, hollow core	
		Number of Doors	40	40	120
	3.2.3 - Basement Wall	Length (ft)	692	692	2,076
		Height (ft)	10	10	10
		Type	Concrete	concrete	
		Envelope	Gypsum and paint	Gypsum and paint	
		Insulation	1" rigid	1" Extruded Poly	
		Doors	none	none	
3.3 - Concrete Block					
	3.3.1 - 6" block wall - 8' 9"	Length (ft)	196	196	588
		Height (ft)	8'9"	8'9"	8'9"
		Type	Concrete Block	Concrete Block	
		Envelope	Gypsum and paint	Gypsum and paint	

			Insulation	1" rigid	1" Extruded Poly	
			Doors	wood, hollow core	wood, hollow core	
			Number of Doors	9	9	27
		3.3.2 - 6" block wall - 10'	Length (ft)	255	255	765
			Height (ft)	10'	10'	10'
			Type	Concrete Block	Concrete Block	
			Envelope	Gypsum and paint	Gypsum and paint	
			Insulation	1" rigid	1" Extruded Poly	
			Doors	none	none	
		3.3.2 - 8" block wall - 10'	Length (ft)	142	142	426
			Height (ft)	10	10	10
			Type	Concrete Block	Concrete Block	
			Envelope	Gypsum and paint	Gypsum and paint	
			Insulation	1" rigid	1" Extruded Poly	
			Doors	none	none	
4 - Roof						
	4.1 Flat Roof System					
		4.1.1 - Gravel / Bitumen	Average Span (ft)	32	32	32
			Width (ft)	182	182	547.2
			Insulation	1" rigid	1" Extruded Poly	
			Envelope	Gravel, Bitumen	Asphalt, aggregate, PVC membrane	
5 - Mixed Columns and Beams						
	5.1 - Concrete Columns					
		5.1.1 - Columns	Number of Columns	16	16	48
			Height (ft)	10	10	10
			Number of Beams	8	8	24
			Span (ft)	20	20	20
			Bay size (ft)	20	20	20
			Supported Load (psf)	45	45	45
			Beam Type	Concrete	Concrete	
6 - Extra Materials						
	6.1 - Parapet wall					
		6.1.1 - Parapet wall	Length (ft)	390	390	1170
			Height (ft)	1.5	1.5	1.5

		Thickness (in)	8	8	8
		Envelope	none	none	none
		Volume of concrete (m^3)		11.05	33.16
6.2 - Suspended Ceiling					
	6.2.1 - Suspended acoustic tile	Area (sq. ft)	14,558	-	-
		Thickness (in)	0.5	-	-
		Type	Fiberboard	-	-
	6.2.2 - Concrete Fireplace	Approx Vol. Of concrete (m^3)	0.68	1.36	4.08
		Quantity	2	2	6
	6.2.3 - Conc. Balcony railing	Length (ft)	156	156	468
		Height (ft)	4	4	4
		Thickness (in)	8	8	8
		Total Volume (m^3)		11.79	35.37

ANNEX B – Impact Estimator Imput Assumptions Documents

Assumptions for the Common Building - Applicable to all three building types

1 Foundation

1.1 Concrete Slab on Grade

1.1.1 - Unfinished slab on grade

This section was combined with section 5.2.1 - Finished floor Slab on Grade

1.2 Concrete Footing

1.2.2 - Continuous footing

Rebar type may vary, actual rebar details were not available

Concrete strength was not available. Assume 3000psi

1.2.3 - Continuous footing (Conc. Stairs)

Stairs are modeled as a continuous footing in order to best match reinforcing

Actual Rebar details were not available and may vary

1.2.4 - Spread Footing

Spread footings are modeled as continurous strip footings of equivalent width and length

Rebar type may vary, actual rebar details were not available

2 Custom Wall

2.1 Concrete Block Wall

2.1.1 - 8" Block wall

Rebar type may vary, actual rebar details were not available

2.1.2 - 6" Block wall

6" concrete blocks were modeled as 8" blocks since there is no option to change it

2.1.3 - 6" Block wall

This section was included in section 2.1.2 - 14' x 6" block walls

2.2 Cast-in-Place

2.2.1 - Interior Concrete wall 10'

This section was included in section 2.2.2 - Interior Concrete wall 14'

2.2.2 - Interior Concrete wall 14'

These are load bearing walls and might not be accurately reinforced in the model

Envelope consists of gypsum and paint on both sides of the wall
Door information was unreadable. Assumed hollow core wood for interior

2.3 Glass Curtain Wall

2.3.1 - Floor to ceiling glass wall

The model requires a thickness of insulation to be used. 0.001" was assumed

2.4 Brick Wall

2.4.1 - Exterior Brick Veneer, Cast in Place Concrete

Brick type was modeled as Ontario standard brick
Insulation type was not available beyond 1" rigid - Extruded Polystyrene was assumed

Door information was unreadable. Assumed metal with solid core

2.4.2 - Exterior Brick Veneer, Cast in Place Concrete

This section was added to section 2.4.1 - Exterior Brick 14.75'

3 Mixed Columns and Beams

3.1 Concrete Column and Concrete Beam

3.1.1 - Interior Beams/Columns

All Columns and Beams are approximated by the model. Actual sizes and reinforcing information was not available

3.1.2 - Exterior Balcony area

All Columns and Beams are approximated by the model. Actual sizes and reinforcing information was not available

Live loads assumed to be 75psf

4 Roofs

4.1 Suspended Slab

4.1.1 - Gravel Roof

Roof assembly was assumed to be stone aggregate with asphalt, a 1" layer of extruded polystyrene and a PVC membrane

Live loads assumed to be 45psf

Average span of suspended concrete assumed 20'

5 Floors

5.1 Suspended Slab

5.1.1 - Finished Floor

Average span of suspended concrete assumed 20'

All floor finishes omited
Actual thickness was not modeled. The model approximates thickness based on span and load
Actual Rebar information was not available. Model approximates this data

5.2 Concrete slab on grade

5.2.1 - Finished Floor - Slab on Grade

Rebar type may vary, actual rebar details were not available
All floor finishes omitted
Actual thickness was 6” but model uses 4”

6 Ceilings

6.1 Ceilings

6.1.1 - Suspended Ceiling tiles

This section was omited from the model

6.1.2 - Plaster ceiling

This section was omited from the model

7 Extra Basic Materials

7.1 Concrete

7.1.1 - Concrete Railing

An average thickness was assumed, and the volume of concrete calculated based on height and length

7.1.2 - Concrete Balcony thingy

Volume of concrete was calculated, rebar was assumed to be zero

7.1.3 - Total Concrete by Volume

This represent the sum of section 7

7.2 Extra Material Other

7.2.1 - Collapsible partition wall - Accordian type

This section was omited from the model