**CIVI 6711: Asset Management for Sustainable Civil Infrastructure**

GROUP PROJECT

Canada Pavilion, 1 Circuit Gilles Villeneuve: Shell, Interiors, Fire Protection, and Electrical

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# Executive Summary

On October 31, the crew was given permission to visit the location in order to evaluate it and visually inspect the assets connected to it for damage and condition. The crew was split into three smaller groups that will handle the Electrical and Fire safety, interior design, and shell disciplines, respectively.

**System assets owned:** The assets are broken down into three groups: Shell, Interior, and Services. They are further split into super structures, enclosures, and shell roofs. Interior, stairs, and interior finishes Electrical and fire safety services.

With a few exceptions of assets in sufficient and marginal condition, the state of the assets is described in depth in the inventory section, but as a general impression from the visit, the assets are mainly in good shape.

**Condition assessment rating:** Method for evaluating asset conditions: Each asset is graded from 1 (poor) to 5 (outstanding) (poor). Every system has an own, personalised rating scale. An asset's apparent age is determined via a condition-based adjustment. In order to assess each system's status, a System Condition Index is eventually computed.

**Assets' current state:** The calculations used to determine the shells' condition evaluation results in a system condition index of 0.10, which suggests that the condition of the shell is generally in excellent shape. Additionally, the service system condition index of 0.23 further supports the component's sound state. The overall condition is rated as good according to the system condition index

**Replacement value:** The condition rating was used to determine the component replacement cost. Using the rating scale, components received condition ratings. Any component receiving a rating of 1 or 2 was deemed to need replacement. We were able to determine the remaining time until the component must be replaced thanks to the Expected Service Life (ESL). The cost of a component was calculated by multiplying the unit cost by the number of units.

|  |  |  |
| --- | --- | --- |
| Types Of Components | Replacement Cost In 10 Year | Total Replacement Cost |
| Shell | 1364812.73 | 13156599 |
| Interiors | 67207.5 | 604947.75 |
| Services | 51085 | 223654 |

**Risk:** The risk factor for each asset was calculated using the numbers from POF and COF. POF was discovered with the use of a ratio between an asset's age and ESL. This figure served as the basis for the condition rating. The COF was determined based on the economic, environmental, and social factors. The component's COF and POF values provided the ROF value. ROF is used to determine the risk rating.

**Level of service:**  Shell, Interior, and Services are the three categories into which the assets are divided. With the use of ESL, the asset's present status may be determined. For instance, a component's present state allows for only a few functions. Based on the condition assessment, a plan of action is made to either replace the component or repair it. Level of Service is the name of this procedure.

**Life cycle funding requirements:** The ten-year capital plan provided a precise timeline for the following ten years, detailing when and how much it would cost to replace each component. Each component was marked up by 35%. To cover overhead, profit, and other unstated expenses, markup of 35% is applied.

# Background

Description of the building and systems

Originally consisting of 11.5 acres of green space, a lagoon, dykes, and canals, the former Canada Pavilion Arts Centre is situated on an irregularly shaped property in the southwest corner of Ile Notre Dame. The Canada Pavilion was a sizable complex of nine buildings and structures at the time. The only remaining portion of the lot's original design, in addition to the forested area and the artificial lake, is the center des Arts, which is the only structure on it now. Since 1978, the Grand-Prix de Montréal has taken place at I'lle Notre Dame, which is now a part of Parc Jean-Drapeau and is also home to Sainte-Hélène and Ronde islands. The Grand Prix de Montréal has been held at I'lle Notre Dame since 1978. A portion of the circuit surrounds the property. The Chemin des Floralies leads to the pavilion from the east side. It has two main facades, one looking out over the river and the other over the garden. The Jacques-Cartier Bridge, the Old Port of Montreal, the Cité du Havre, and the housing development Habitat '67 can all be seen from the latter. The Canada Pavilion Arts Centre structure is rectangular and features two porticoes, one of which projects and the other of which is set back. To accommodate the Société du parc Jean-needs Drapeau's and incorporate offices and other facilities, the west portico, which looks out over the city, has undergone internal remodeling. A vertical glass and steel curtain wall assemblage punctuates the façade‘s nearly uniform composition.

The structure was built between September 1966 and January 1967, expanded in 1970, and underwent additional changes from 1978 to 2003. The system was designed by Ashworth, Robbie, Vaughan & Williams-Shoeler, Barkham & Heaton, and Z.M. Stankiewicz, and it was primarily constructed for EXPO-67 (Ottawa). The government of Canada is listed as the document's original owner.

The structure combines non-combustible materials with flammable fixtures, such as wood siding and fabric ceilings. The system has three street facades and two floors. The building has sprinklers that protect a portion of it (boiler room and storage room for recycling materials). The structure is 5478 square meters in size.

The building's primary functions include meeting space for a performance hall, a banquet hall, a school, and a commercial center. In addition, the structure serves as a low-risk industrial facility with storage and a mechanical room.

La Toundra and The Buffet, restaurants in the Canada pavilion, provide guests with a distinctive aesthetic and culinary experiences at prices that work for all budgets. Additionally, there are two snack bars in the pavilion gardens. The restaurant La s a bar and built-in furnishings. The original kitchens that served the eateries are no longer there. There was only a service area and a kitchenette for staff members.

## Shell

The total built-up area of this two-story structure is 58,968 square feet. The superstructure comprises aluminum-framed windows, brown steel and aluminum doors, wooden facing, exterior bronze glass walls, and a roofing system made of fire-resistant materials and translucent canvas panels. This shell construction needs to be renovated.

This building's foundation is made of a concrete slab, while the bottom level is made of a concrete structure covered in brick walls. Except for a few minor repairs for cracks and spalls at certain spots, the outside surface is in generally good shape. In addition, the steel columns have signs of corrosion. Wood cladding requires a little additional attention.

The roof was redone in 2016. A concrete slab with a flat membrane serves as the roof. The roof has many provisions for housing the HVAC and other ventilation systems. The facade is covered with white steel panels. There are several types of skylights available for natural illumination. There is one roof hatch for accessing the roof. There isn't a stairway outside.

Benefits of the Asset management plan (AMP)

1. The asset management plan can also identify the components for which refurbishment and minor repairs can be done to extend their useful lives.
2. It offers a rough estimate of the entire asset’s worth, which is helpful for various reasons.
3. It aids in planning the price of replacing assets when their useful lives are up.

Challenges of Asset Management Plan (AMP)

1. An AMP involves a significant quantity of data that must be managed and included during the preparation phases and at regular intervals to guarantee the data's authenticity.
2. It isn’t easy to estimate the service life of interior components since the precise date of installation is still being determined.

## Interior

The Canada Pavilion structure has two levels on the inside. The interior partitions are glazed with oak panels and rubber board. The inside doors are composed of wood panels; some doors originally in 1967 remain, while a few others were recently replaced. The floor's foundation is simple cement concrete. Some base bulging has been noted, which might be due to damp soil beneath the structure. In most parts, the flooring is covered with parquet tiles. The floor is covered with vinyl tiles, oak wood, and ceramic tiles in some areas, such as the bar and kitchen.

An H-section steel column supports the building's ceiling. The ceiling is comprised of fire-resistant transparent canvas panels mounted on wood panels. The hanging panels are 2X4 in size. The translucent canvas panels, which resemble lanterns, conceal fluorescent illumination. The partitions in the main reception and conference room are composed of Gypsum boards. The floors have the original timber flooring from 1967, with a carpet runner. This section's doors are all double-carved wooden doors. The conference room's ceiling is built of wooden panels. The welcome area features original, built-in loose furniture and a steel staircase.

The theatre's frames are built of steel. The flooring is wood and requires immediate maintenance since the floors have begun to cave in where the column is present due to tension from the column and age. The ceilings and walls are built of precast concrete panels and concrete blocks.

Benefits of the Asset management plan (AMP)

1. A solid asset management strategy may identify interior components that have outlived their useful service life and must be replaced.
2. The plan can also aid in planning capital expenditures for future replacements and repairs.
3. A well-updated AMP provides the remaining usable life of assets, allowing for prompt replacement and reducing asset downtime.

Challenges of Asset Management Plan (AMP)

1. To ensure the validity of the data, an AMP involves a significant amount of data that must be handled and incorporated during the preparation phases and at regular intervals.
2. The high ceiling of the interior makes it impossible to judge the remaining service life of the suspended ceilings.

## Services (Fire Protection and Electrical)

High- and low-tension distribution, lighting equipment, telephone systems, television systems, LANs, security systems, emergency lights, and more are electrical assets. Many of the electrical assets were installed in 2014. Most of the assets are in good shape and provide the desired level of service. The building contains a variety of glass panels and skylights, which decrease the use of lighting throughout the day. The building's primary distribution system is in good shape and has yet to reach the end of its useful life.

The central fire alarm panel, fire detection, and signaling devices appear to be up to their useful life. The current fire alarm wire seems to be in good condition. A new fire alarm system was just installed. Automated sprinklers protect only a tiny portion of the building's ground level. The building's roof is made of fire-resistant materials. There are now portable fire extinguishers within the structure.

Benefits of the Asset management plan (AMP)

1. A solid asset management strategy may identify any service components that have outlived their useful service life and must be replaced.
2. A well-updated AMP provides the remaining usable life of assets, allowing for prompt replacement and reducing asset downtime.
3. The plan can also aid in planning capital expenditures for future replacements and repairs.

Challenges of Asset Management Plan (AMP)

1. It isn’t easy to estimate the estimated service life of interior components since the precise date of installation needs to be clarified.
2. It is a time-consuming procedure that requires the assistance of expert asset management specialists.
3. The ratings of assets in condition assessment are subjective; the evaluation's correctness and validity depend on an AM professional's expertise and interpretation. Several biases may also be present in the ratings.

# Asset Hierarchy

## Description of the Hierarchy system

Hierarchy is produced when an element appears more significant than other elements in the design. Scale is typically used in architectural design and construction to highlight a specific element or component of a building. Through its classification of building elements and associated site work, the UNIFORMAT II ASTM E1557 Standard provides a typical structure connecting the building program, specifications, and estimates. Through its incorporation into the design process, all project participants' communications and coordination are better, the design is completed more quickly, and productivity is significantly raised.

ASTM Uniformat II Classification gives a hierarchy that allows project managers or cost estimators to work on different levels: aggregation and summarization. Moreover, it provides cost control and schematic phase preliminary project descriptions. This framework accommodates unlisted items based on the judgment of building professionals. At the same time, the selected item significantly influences project cost, high frequency of occurrence, and distinctive. A professional appraisal is used to place elements where building professionals in current practice usually look for such items in a classification.

ASTM Uniformat II Classification classifies building components into four levels; like the tree branching method, the element becomes more detailed with information such as material and cost, looking from Level 1 to Level 4.

Level 1: contains significant elements such as the shell, interior, and services.

Level 2: contains superstructure, Exterior Closure, and Roofing, for instance, are components of the Shell.

Level 3 contains exterior walls, windows, and doors, all examples of outer closure.

Level 4: contains common foundation sub-elements, including insulation, perimeter drainage, wall foundations, and column foundations.

Table 1 Asset hierarchy

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Level 1 | Level 2 | Level 3 | Level 4 | ESL |
| B Shell | B10 Superstructure | B1010  Floor Construction | B1012 Upper Floors Construction | 100 |
| B1013 Balcony Floors Construction | 100 |
| B1014 Ramps | 100 |
| B1019 Other Floor Construction | 100 |
| B1020  Roof Construction | B1021 Flat Roof Construction | 60 |
| B1022 Pitched Roof Construction | 100 |
| B20 Exterior Enclosure | B2010 Exterior Walls | B2011 Exterior Wall Construction | 100 |
| B2015 Balcony Walls & Handrails | 15 |
| B2016 Exterior Soffits" | 20 |
| B2020  Exterior Windows | B2021 Windows | 35 |
| B2022 Curtain Walls | 75 |
| B2030 Exterior Doors | B2034 Overhead Doors | 25 |
| B2039 Other Doors & Entrances" | 30 |
| B30 Roofing | B3010 Roof Covering | B3011 Roof Finishes | 50 |
| B3013 Roof Insulation & Fill | 50 |
| B3016 Gutters and Downspouts" | 20 |
| B3020 Roof Openings | B3021 Glazed Roof Openings | 75 |
| B3022 Roof Hatches | 75 |
| B3023 Gravity Roof Ventilators" | 20 |
| C Interiors | C10 Interior Construction | C1010 Partitions | C1011 Fixed Partitions | 14 |
| C1014 Site-Built Toilet Partitions | 40 |
| C1015 Site-Built Compartments Cubicles | 40 |
| C1016 Interior Balustrades and Screens | 20 |
| C1017 Interior Windows & Storefronts" | 20 |
| C1020 Interior Doors | C1021 Interior Doors | 40 |
|  | C1022 Interior Door Frames | 40 |
|  | C1023 Interior Door Hardware | 20 |
|  | C1027 Door Painting & Decoration" | 24 |
|  | C1031 Fabricated Toilet Partitions | 20 |
| C1030 Fittings | C1032 Fabricated Compartments & Cubicles | 20 |
|  | C1033 Storage Shelving and Lockers | 30 |
|  | C1036 Closet Specialties | 20 |
| C20 Stairs | C2010  Stair Construction | C2011 Regular Stairs | 100 |
| C2014 Stair Handrails and Balustrades | 20 |
| C2020 Stair Finishes | C2021 Stair, Tread, and Landing Finishes | 100 |
| C2022 Stair Soffit Finishes | 100 |
| C30 Interior Finishes | D3010 Energy Supply | D3011 Oil Supply System | 20 |
| D3012 Gas Supply System | 50 |
| D3015 Hot Water Supply System | 20 |
| D3020 Heat Generating Systems | D3021 Boilers | 30 |
| D3024 Insulation | 20 |
| D3030  Cooling Generating Systems | D3032 Direct Expansion Systems | 15 |
| D Services | D40 Fire Protection | D4020 Standpipes | D4021 Standpipe Water Supply | 20 |
| D4022 Pumping Equipment | 20 |
| D4023 Standpipe Equipment | 20 |
| D4024 Fire Hose Equipment | 75 |
| D4030 Fire Protection Specialties | D4031 Fire Extinguishers | 20 |
| D50 Electrical | D5010 Electrical Service & Distribution | D5012 Low Tension Service & Dist. | 50 |
| D5020 Lighting & Branch Wiring | D5021 Branch Wiring Devices | 20 |
| D5022 Lighting Equipment | 15 |
|  | D5033 Telephone Systems | 20 |
|  | D5035 Television Systems | 20 |
| D5030 Communications & Security | D5037 Fire Alarm Systems | 20 |
|  | D5038 Security and Detection Systems | 20 |
|  | D5039 Local Area Networks | 15 |
| D5090 Other Electrical System | D5091 Grounding Systems | 20 |
| D5092 Emergency Light & Power Systems | 20 |
| D5094 Other Special Systems & Devices | 18 |
| D5095 General Construction Items (Elect.) | 20 |

# Condition Assessment Rating Scale by Component – (UNIFORMAT level 4)

The building's components are rated to reflect the facility's use and safety. Our group concluded to create three different rating scales. Those grading scales will decide the element’s physical state during the visit and making the inventory. The building condition assessment report results will outline any urgent or long-term repairs needed, along with an estimated cost. A review of the building's condition will gauge how well the following are performing. This strategy will enable us to find what needs to be updated, rectified, or altered as soon as possible to meet the criteria. The team can also forecast how long the systems and parts of the structure will last.

1. The Shell System consists of the following components: the floor, the roof, the exterior walls, the exterior windows, the exterior doors, the roof coverings, and the roof opening.
2. Interiors consist of interior finishes, stairs, and interior construction.

Services include electrical and fire protection.

## Condition assessments rating for All system

Description of each system for condition rating.

|  |  |  |  |
| --- | --- | --- | --- |
| **Rating** | **Condition** | **System** | **Description** |
| 5 | Excellent | Shell | New, flawless, and performing as anticipated. |
|  |  | Interior | The item is new or close to being unique and has no noticeable faults. |
|  |  | Services | Fully operational, in brand-new condition, and free of any other types of defects. |
| 4 | Very Good | Shell | Excellent condition with only minor defects but functioning as the new one. |
|  |  | Interior | An item in good functioning order but not brand new might have some marginally damaged components. |
|  |  | Services | Providing the degree of service expected, but no longer in new condition, it’s possible to have minor problems. |
| 3 | Good | Shell | Good condition with significant flaws and still workable for a few years. |
|  |  | Interior | Components that have mildly deteriorated or have flaws but have not yet lost their utility. But it requires considerable remodeling work. |
|  |  | Services | Leaks and corrosion are among the operational and functional problems; Leaks, breakdowns, and other issues can be resolved through repair. |
| 2 | Average | Shell | Defects that are serious and significant, not working as planned, require immediate fixes. |
|  |  | Interior | Defective or aged components must be replaced since they have outlived their usefulness. |
|  |  | Services | Some leaks and other types of damage are encountered; even with repair or maintenance, the harm can only be stopped for a brief period, and if necessary, replacement is done. |
| 1 | Poor | Shell | Unserviceable Not functioning needs to be replaced. |
|  |  | Interior | Components that need immediate repair are severely damaged or have reached the end of their useful lives. |
|  |  | Services | Damage is at its peak, where it can no longer be repaired and must be replaced immediately to prevent future harm to other parts or components. |

# QA/QC procedure

To create an interim asset management plan, quality assurance and quality control entail a procedure for evaluating the existing state of the assets and observation for a specific purchase. This technique was carried out by six people, each of whom assessed one specific system—the interior, shell, fire, and electrical plan—in turn. One person from each group prepared the asset inventory using Uniformat II and verified the building's assets. At the same time, the other team member evaluated the asset's state and looked at its existing quality. Below inspected points are kept in mind during observation.

1. To get consistent results, an appropriate table with the asset inventory listed according to Unformat II for each system is developed.
2. Following Unformat II, each specific item has a unique element ID allocated to it and used across all three systems.
3. To assess the state of each asset and specific system, pictures of the asset were taken.
4. Depending on the system's operation and the deficiencies that were present during the observation, a unique condition rating scale, ranging from 1 to 5, was assigned to each design.
5. Apparent age of each asset is determined using a condition rating scale, and using the remaining useful life of each asset was calculated.
6. Based on the visual observation, each asset's features and deficiency descriptions were described.
7. All the references for expected service life and unit costs were assigned.
8. Asset condition rating of 2 or less is considered for differed maintenance or replacement.
9. Each system was assigned an individual system condition indices brief for their condition rating from 1 to 5.

# Asset Inventory

A building's physical assets are listed in its asset inventory. This covers the building's equipment, furnishings, and other property. Each asset's description, element ID, and status are all listed in this inventory. All the assets are listed based on the category of the group, i.e., shell, interior and, fire protection & electrical. Assets are identified up to level 4 based on Uniformat II.

Chart

Description automatically generated

Graph 1 Number of an asset in each system

Following are the assets identified during the building inspection in a significant group element.

## Major Group Element: B SHELL

Flooring is wooden with carpet at almost every part of the building. In Some features, carpet is laid in office spaces. There is a wooden floor balcony with metal handrails in one south part of the building. A wooden ramp covered with carpet is located at the southeast part of the building. Some exterior and interior walls are made of unreinforced masonry blocks. At the same time, some part of the outer curtain walls consists of bronze glass on a steel frame, including the main door. Exterior soffits are made of aluminum. For the garage, an overhead steel door is installed, and other entrances to the building are the glazed door with steel frames. A flat concrete membrane is used on the roof, and white steel panels with pyramid exterior cladding are on the periphery. Roof openings are found at several places for better lighting, one access is provided to the roof with a roof hatch, and gravity ventilators are provided for air circulation on the roof floor.

A picture containing tree, outdoor, building, porch

Description automatically generated

Figure 1 Exterior part of the building

## Major Group Element: C INTERIORS

Most of the partitions of the main reception and conference room are gypsum walls. Other divisions are of plywood. While facility recently built some site-built compartment cubicles with timber and glass glazing. It also includes an interior fence and a fixed glass window with proper lighting. The fabricated toilet partition and its compartments, including storage shelving and lockers, are made of coated metal provided at different locations in the building. Interior doors are wooden doors and painted with green paint on some doors. Locks and other hardware, such as door hinges, are installed, but some doors do not have locks. The Interior hatch is in the main electrical room. The metal door is used in the cash deposit room for security reasons. The wooden closet used for storage is located in a different part of the building. The building includes a hot water and gas supply system, a boiler system, and a cooling generating system.

A picture containing indoor, ceiling

Description automatically generated

Figure 2 Interior part of the building

## Major Group Element: D SERVICES

For fire safety and protection of the building, the facility installed several standpipe water supplies with pumping and standpipe equipment at several parts of the building for a fire hazard. Central fire hose also installed a central fire hose system with a cabinet several times. The individual fire extinguishers' cylinders. They were also placed for safety purposes. All these fire safety systems are tested every year.

A fire extinguisher and a fire extinguisher

Description automatically generated with medium confidence

Figure 3 Fire protection system

The entire building’s electricity is controlled from the main electrical room on the southwest part of the building. This room includes all the main electrical stuff, which provides for Single Phase, 120/240 V, 200 A, 3 Phase, 120/208 V, 1200 A, Main lugs, 120/208 V, 225 amp, NQOD, as well as general electrical circuits and panels. A grounding system is installed on the roof. Branch wiring inside the building is exposed. Fluorescent lighting is installed at the office and main reception area. Intercom telephones are used for internal communication. Security cameras, motion detectors, and fire alarm systems are installed at several places for the safety and security of the building.

A picture containing indoor, toilet

Description automatically generated

Figure 4 Electrical system

The following graph shows the assets' materialistic characteristics, such as Aluminum, brass, coated metal, concrete, copper, fabric, glass, marble, steel, wood, etc.

Chart, bar chart

Description automatically generated

Graph 2 Assets according to their material

# State of the Assets

The **Expected Service Life**, or "**ESL**," is the average years that an item, component, or system (in a building or property improvement) is expected to work after installation and normal maintenance. The uniformat is used to determine the building's expected service life. The **Remaining Useful Life** of an asset estimates how many years it will be profitable. A helpful life estimate is used to evaluate how long an item will be in usable condition.

## Shell

The building's top and balcony floors are in bad shape and must be rebuilt as soon as possible. The incline stairs in the bar area are in good condition and will survive for a long time, although upkeep might be improved. The roof of the building and the roof components are in great shape. There is just one asset with a rating of 1. There are three assets with a grade of 2. There are four assets with a rate of 3. There are eight assets with a rating of 4. There are three assets with a rating of 5. Overall, the shell is in good shape and will last many years.



Figure 5 Shell elements

Chart 1 depicts the estimated service life, apparent age, and remaining useful life of shell assets. Furthermore, Chart 2 illustrates the condition rating for each asset of the shell.

Graphical user interface, chart

Description automatically generated

Graph 3 Condition Rating for shell

## Interior

The building's interior appears to be perfect. According to the ratings assigned to the assets, most of them fall within ratings 4 and 5. Two assets come under rating 1, and five falls under rating 2. Two assets have a rating of 3. There are 13 assets classified as rating 4 and 3 classified as rating 5.

A picture containing indoor, wooden, wood

Description automatically generated

Figure 6 Interior elements condition

Chart 1 depicts the information about the Estimated service life, apparent age, and remaining useful life of the Interior asset. Furthermore, Chart 2 illustrates the condition rating for each asset of the Interior.

Graphical user interface, chart

Description automatically generated

Graph 4 Condition Rating for Interior

## Services

The building's fire protection and electrical systems look to be flawless. The bulk of the assets have ratings of 4 or 5, according to the ratings awarded. There is one asset with a rating of 1 and two with a rating of 2. There are three assets with a 3 grade. There are eight assets with a rating of 4 and six with a rating of 5. Sprinklers might have been included as a conventional fire protection feature. The structure does not meet basic fire protection regulations.



Figure 7 Fire safety and electrical equipment

Chart 1 depicts the estimated service life, apparent age, and remaining useful life of the Services asset. Furthermore, Chart 2 illustrates the condition rating for each asset or Service.

Graphical user interface

Description automatically generated

Graph 5 Condition Rating for services

## SCI (System Condition Index)

The system replacement cost for SHELL is 0.41. The system replacement cost for INTERIORS is 0.09. The system replacement cost for SERVICES is 0.26.

SCI is the ratio of the preferred maintenance of the system to the total replacement value of that system.

Table 5 System condition Index

|  |  |
| --- | --- |
| System | SCI |
| SHELL | 0.10 |
| INTERIORS | 0.11 |
| SERVICES | 0.23 |

The bar chart shows the weightage of SCI value by each structural group.

Graph 6 The weightage of SCI value by each structural group

Graph 7 System condition Index chart

# Life Cycle Costs

## Description Of Unit Costs (According to Asset Hierarchy)

A unit cost is an overall cost incurred by the company to create, hold, and sell one unit of a specific good or service. The cost of goods sold, and unit costs are interchangeable terms (COGS). All fixed and variable costs related to creating a good or service are included in this accounting metric.

If the unit is each, the unit cost is calculated directly for each team; however, if the unit is square feet or linear feet, we must multiply the unit cost by the quantity to determine the overall cost.

Evaluate this structure; we used a variety of references, including RS means and Fixers, to establish unit costs for each piece. Also, from the official website of Canada's online sources.

The unit cost of any asset varies depending on its nature (Appendix)

Briefly, it would state that all unit costs of all the asset management elements are divided into three primary groups: "Square feet, Linear Foot, Each Unit, Meter square."

In the shell system, we must determine the area for many elements. Hence, most of the details have units of square feet and linear feet. As opposed to this, each unit is used to measure items like roof openings, hatches, gravity ventilator-pitched roofs, and windows. But, based on its type and how the market values it, each asset has a range of cost units.

The interior of a house is typically measured in square feet, but some parts of the interior are measured in linear feet, such as fixed partitions, painting finishes, etc.

Most building services are available and measured in each unit so they can be easily compared, which allows for quick and accurate decision-making regarding choosing the best service for a particular building.

Table 6 Unit and notations

|  |  |
| --- | --- |
| Units | Notation |
| Each Unit | EA |
| Linear Feet | LF |
| Square meter | m2 |
| Square feet | Sf |

The websites, RS means, and structural drawings provide the necessary details when constructing a building. However, it is essential to remember that these are just tools and that the workers are the most critical aspect of construction.

## Markups

The total markup percentage includes the contingency for uncertain construction costs, the contractor's overhead, and profit.

Table 7 Markup costs

|  |  |
| --- | --- |
| Markup (Additional Cost )- | Percentage |
| Contingency of uncertainty | 10% |
| Construction contingency | 10% |
| General contractor overhead | 5% |
| General contractor adm and profit | 10% |
| Total Markup Percentage | 35% |

## Total Asset replacement value

From the total replacement value, which is $13985200.75, the value shell system contains $13156599, while the Interior has a value of $604947.75, and lastly, Services contributed $223654 in total cost.

After five years, the components must replace three parts: the shell, the interiors, and the services. The replacement cost for the shell is $1364812.73, the replacement cost for the interiors is $67207.5, and the replacement cost for the services is $1483105.23. The total replacement cost for all three components is $2002192.

Here, we observe that most of the contribution to the system’s replacement came from the shell.

Table 8 Total Asset replacement values

|  |  |  |
| --- | --- | --- |
| Types Of Components | Replacement Cost In 10 Year | Total Replacement Cost |
| Shell | 1364812.73 | 13156599 |
| Interiors | 67207.5 | 604947.75 |
| Services | 51085 | 223654 |
| Total | 1483105.23 | 13985200.75 |
| Total Cost Markups (35%) | 2002192.061 | 18880021.01 |

Graph 8 Total Asset replacement value

Table 9 Replacement cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Replacement cost | | | | |
|  | Shell | Interior | Services | Total |
| 2022 | 1360620 | 22387.5 | 35500 | 1418507.5 |
| 2023 | 0 | 0 | 0 | 0 |
| 2024 | 0 | 0 | 0 | 0 |
| 2025 | 0 | 7065 | 0 | 7065 |
| 2026 | 0 | 0 | 0 | 0 |
| 2027 | 0 | 24000 | 0 | 24000 |
| 2028 | 2513.9 | 0 | 0 | 2513.9 |
| 2029 | 0 | 13755 | 0 | 13755 |
| 2030 | 0 | 0 | 0 | 0 |
| 2031 | 1678.83 | 0 | 15585 | 17263.83 |
| Total | 1364812.73 | 67207.5 | 51085 | 1483105.23 |
| Markup (35%) | 1842497.186 | 90730.13 | 68964.8 | 2002192.061 |

Replacement of all assets with a remaining useful life of fewer than 10 years is taken into account in a 10-year capital plan. When replacing specific assets, we take into account their entire cost.

Estimated future expenses are converted to present-worth terms using the discount rate, often known as the time value of money. The Interest rate of 5%, with an inflation rate of 2% and a discount rate of 3% is considered while calculating the total present worth of the replacement value.

Markups: We took into account a 35% markup, which included general contractor overhead, construction contingency, general contractor profit, and general contractor adm.

The following table displays the TPWC replacement cost forecast for the next ten years.

Table 10 Replacement cost in TPWC

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Replacement cost in TPWC | | | | |
|  | Shell | Interior | Services | Total |
| 2022 | 1360620 | 22387.5 | 35500 | 1418507.5 |
| 2023 | 0 | 0 | 0 | 0 |
| 2024 | 0 | 0 | 0 | 0 |
| 2025 | 0 | 6465.48 | 0 | 6465.47582 |
| 2026 | 0 | 0 | 0 | 0 |
| 2027 | 0 | 20702.6 | 0 | 20702.6108 |
| 2028 | 2105.35167 | 0 | 0 | 2105.35167 |
| 2029 | 0 | 11184.1 | 0 | 11184.0737 |
| 2030 | 0 | 0 | 0 | 0 |
| 2031 | 1286.6834 | 0 | 11944.6 | 13231.2882 |
| Total | 1364012.035 | 60739.66 | 47444.6 | 1472196.3 |
| Markup (35%) | 1841416.247 | 81998.54 | 64050.22 | 1987465.005 |

# Required Levels of Service

selection of applicable levels of service - at least 5 customer levels of service and 10 technical levels of service (1.0)  
current levels if monitored, required levels (1.0)  
strategies for measuring and improving them (0.5)

Maximum score 2.5

## Summary of critical levels of service

### Customer Level of Service

1. Customer Respect: Treat all customers with respect, regardless of their background, language, or beliefs.
2. Responsiveness: Answering customer questions and concerns promptly.
3. Quality: Providing customers with quality products and services.
4. Accessibility: Ensuring customers can easily access the public building and its services.
5. Safety: Ensure all customers feel safe and secure when visiting the public building.
6. Communication: Communicating openly and clearly with customers.
7. Flexibility: Adapting to different customer needs and expectations.
8. Problem-solving: Quickly and efficiently solving any customer-related issues.
9. Listening: Taking the time to listen to customer feedback and opinions.
10. Appreciation: Showing gratitude and appreciation to customers.

### Technical Level of Service

1. HVAC System Maintenance: Ensuring the HVAC system is regularly maintained and that any repairs or replacements are completed promptly to ensure a comfortable environment.
2. Fire and Life Safety: Ensuring that all fire and life safety systems are in proper working order, including fire alarms, smoke detectors, sprinkler systems, and fire suppression systems.
3. Building Automation: Installing and maintaining building automation systems for climate control, lighting, and security.
4. Structural Integrity: Ensuring the building is structurally sound and free of any safety hazards.
5. Accessibility: Ensuring the building is accessible to people with disabilities.
6. Plumbing: Ensuring that all plumbing systems are in proper working order and that any repairs or replacements are completed promptly.
7. Electrical: Ensuring that all electrical systems are in proper working order and that any repairs or replacements are completed promptly.
8. Elevators and Escalators: Ensuring that all elevators and escalators are in proper working order and that any repairs or replacements are completed promptly.
9. Lighting: Ensuring that all lighting systems are in proper working order and that any repairs or replacements are completed promptly.
10. Grounds Maintenance: Ensuring the grounds surrounding the building are regularly maintained and free of any safety hazards.

# Risk of Failure

## Consequence of Failure Framework

Flowchart 1 Consequences of failure

## Description of the AHP process and AHP results

The relevance level of the paired consequences of failure comparison for the economic, environmental, and social components is displayed in the following tables.

|  |  |
| --- | --- |
| **Ratio** | **Importance** |
| 1 | Equally Important |
| 1.5 | Moderately more important |
| 3 | Strongly more important |
| 4.5 | Very strongly more Important |
| 6 | Extremely more Important |

By giving each consequence a score for its impact and comparing it to the others in pairs, a pairwise comparison for each consequence was performed. To obtain the most accurate result from the following comparison criteria, the survey result shown in the illustration was checked for consistency.

### Pairwise comparison (Structure)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pair-wise Comparison for Consequences** | | | | |
|  | **Economic** | **Environmental** | **Social** | **Sum** |
| **Economic** | 1.00000 | 1.50000 | 3.00000 | 5.50000 |
| **Environmental** | 0.66667 | 1.00000 | 3.00000 | 4.66667 |
| **Social** | 0.33333 | 0.33333 | 1.00000 | 1.66667 |
| **Total** |  |  |  | **11.83333** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Economic | Environmental | Social | Weighting |
| Economic | 0.5000 | 0.5294 | 0.4286 | 49% |
| Environmental | 0.3333 | 0.3529 | 0.4286 | 37% |
| Social | 0.1667 | 0.1176 | 0.1429 | 14% |
| Total |  |  |  | 100% |

Consistency Check, CR = 0.015788< 0.10

### Pairwise comparison (Economic)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pair-wise Comparison for Consequences** | | | | |
|  | Use Of Material | Labor Costs | Cost To Replace | Sum |
| Use Of Material | 1.00000 | 3.00000 | 3.00000 | 7.00000 |
| Labor Costs | 0.33333 | 1.00000 | 2.00000 | 3.33333 |
| Cost To Replace | 0.33333 | 0.50000 | 1.00000 | 1.83333 |
| Total |  |  |  | 12.16667 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Use Of Material | Labor Costs | Cost To Replace | Weighting |
| Use Of Material | 0.6000 | 0.6667 | 0.5000 | 59% |
| Labor Costs | 0.2000 | 0.2222 | 0.3333 | 25% |
| Cost To Replace | 0.2000 | 0.1111 | 0.1667 | 16% |
| Total |  |  |  | 100% |

Consistency Check, CR = 0.046469276912< 0.10

### Pairwise comparison (Environmental)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pair-wise Comparison for Consequences** | | | | |
|  | Waste generation | Energy Consumption | Fire safety | Sum |
| Waste generation | 1.00000 | 3.50000 | 4.00000 | 8.50000 |
| Energy Consumption | 0.28571 | 1.00000 | 3.00000 | 4.28571 |
| Fire safety | 0.25000 | 0.33333 | 1.00000 | 1.58333 |
| Total |  |  |  | 14.36905 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Waste generation | Energy Consumption | Fire safety | Weighting |
| Waste generation | 0.6512 | 0.7241 | 0.5000 | 63% |
| Energy Consumption | 0.1860 | 0.2069 | 0.3750 | 26% |
| Fire safety | 0.1628 | 0.0690 | 0.1250 | 12% |
| Total |  |  |  | 100% |

Consistency Check, CR = 0.091169277776< 0.10

### Pairwise comparison (Social)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pair-wise Comparison for Consequences** | | | | |
|  | Customer reviews | Comfortable space | Accessibility | Sum |
| Customer reviews | 1.00000 | 1.25000 | 1.50000 | 3.75000 |
| Comfortable space | 0.80000 | 1.00000 | 1.60000 | 3.40000 |
| Accessibility | 0.66667 | 0.62500 | 1.00000 | 2.29167 |
| Total |  |  |  | 9.44167 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Customer reviews | Comfortable space | Accessibility | Weighting |
| Customer reviews | 0.4054 | 0.4348 | 0.3659 | 40% |
| Comfortable space | 0.3243 | 0.3478 | 0.3902 | 35% |
| Accessibility | 0.2703 | 0.2174 | 0.2439 | 24% |
| Total |  |  |  | 100% |

Consistency Check, CR = 0.007934326114< 0.10

## Description of highest CoF assets and CoF graph

Consequences of Failure (CoF) refers to the negative outcome that results from improper asset management. The probability that the worst-case scenario will materialize if a system or asset fails is indicated by the highest consequence of the failure (CoF) rate. It is frequently used to evaluate the risk associated with a system or asset and is commonly expressed as the probability that the worst possible outcome will materialize within a specific time frame. Decisions about asset management, maintenance, and the purchase of new assets are informed by CoF rates.

The building contains sixty components, all of which need quick repair. It is obvious that Roof finishes have the lowest failure risk and Gas supply systems have the greatest. Based on economic, environmental, and societal aspects as well as the COF, POF, and ROF values, we have come to a conclusion regarding the risk assessment for the individual components. Impact values for COF are set at 25, 50, 75, and 100 for various levels of impact. A risk scatter graph between POF and COF has been drawn. Where the COF value is calculated based on the weighing distribution of economic, social and environmental factors on each assets.

|  |  |
| --- | --- |
| Impact score for COF | |
| Low | 25 |
| Medium | 50 |
| High | 75 |
| Very High | 100 |

**Probability of failure (POF)**

The probability of an asset failing to fulfil its intended purpose is measured by the POF. It is based on the asset's present condition and anticipated future performance.

|  |  |
| --- | --- |
| Age vs. ESL | |
| Value | Score |
| 0%-25% | 10 |
| 25%-50% | 40 |
| 50%-75% | 90 |
| 75%+ | 100 |

The probability of failure is calculated based upon the weighing distribution considered, i.e. which is 60% of the condition rating score and 40% of the age vs ESL score, which finally resulted in probability of failure(PoF).

|  |  |
| --- | --- |
| Rating (1 - 5) | Score |
| 1 - Poor | 100 |
| 2 - Marginal | 75 |
| 3 - Adequate | 50 |
| 4 - Good | 25 |
| 5 - Excellent | 0 |

**Description of highest risk assets and risk graph**

The possibility that an asset won't function as intended or will stop working altogether is known as the risk of failure (RoF). Regular asset upkeep, examinations, and testing may help determine the risk of failure.

The RoF value is calculated based on the 50% of Probability of failure and 50% of consequences of failure weighing.

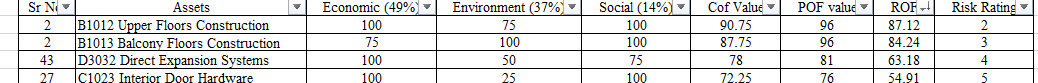
|  |  |
| --- | --- |
| Age Vs. ESL | |
| Value | Score |
| 0% - 25% | 10 |
| 25% - 50% | 40 |
| 50% - 75% | 90 |
| 75%-100% | 100 |



|  |  |
| --- | --- |
| Rating | Score |
| 1-poor | 100 |
| 2-marginal | 75 |
| 3-adequate | 50 |
| 4-good | 25 |
| 5-excellent | 0 |



Nirav add three to four highest risk assets and it’s condition from moodle description



The graph illustrates the RoF value of each asset from highest to lowest and the risk rating numbering from 1 to 60.

**The risk scattered graph plots the POF vs COF values of each assets.**

# Capital Investment Strategy – lifecycle funding requirements for ten years and average annual reinvestment based on the 10-year analysis

This table outlines the financial information for a given budget in the year. The interest rate is 5%, the discount rate is 3% and the inflation rate is 2%. The budget for each year is 150000$.

|  |  |
| --- | --- |
| Interest rate | 0.05 |
| Discount Rate | 0.03 |
| Inflation | 0.02 |
| Current Year | 2022 |
| Budget | 150000 |

We established the ROF rating based on the Risk of Failure (ROF) value, starting with one and going down to the lowest Risk of Failure numbers. Each year, a budget allocation of $150,000 is provided. The budget allocation is utilized to replace the assets after taking into account their risk assessment system. Everywhere it was necessary, we also took into account if we could restore the asset for less money.



The total present value cost for the replacement of some of the assets that must be replaced in the next ten years, considering the budget and the risk of failure rating system, is $ 1,564,964. For a period of ten years, the average yearly reinvestment is $156 496.41. Additionally, we estimated the equivalent uniform annual cost (EUAC) using a 5% interest rate and came up with a result of $202,670.

|  |  |
| --- | --- |
| TPWC | $ 1,564,964 |
| AARI | $ 156,496.41 |
| EUAC | ($202,670.01) |

The financing needed for each year, taking into account the years 2022 through 2031, is shown in the charts above, along with the total amount to be spent on assets.

# Future Recommendations

## Shell and Interior

Most of the shell and interior elements are in good condition and can be maintained regularly during major events and peak seasons. Primary replacement of floor in theater room is required.

## For services

Electrical wiring needs to be concealed near administrative areas and cafeteria areas.

The grounding wire must be repaired on the terrace floor where it broke.

The main electrical room should be adequately managed, and regular maintenance is required.

Fire safety Equipment is in good condition and can be maintained and monitored regularly.

# References

# APPENDIX

The attached Excel Workbook mentions each system's asset hierarchy, inventory, and SCI. In which deficiency description and observation of each element are described.