**Embodied & Construction Carbon**

Portland International Airport is planning a major renovation of the airport’s central terminal. The renovation will include demolition of existing retail areas and roof, and expansion of the building an additional 150’ west. Including new and renovated spaces, the project will affect 1,200,000 square feet. The project is currently in pre-construction, and the owner and design team are relying on your firm for cost and constructability feedback to shape their design.

The owner has a goal of reducing the embodied carbon associated with construction of the project by 20% compared to a baseline. Embodied carbon is the carbon emitted associated with the production and installation of building materials used to create the building. There is a $30 million carbon contingency for funding strategies to lower the total carbon associated with the project.

**Part I. Calculate Embodied Carbon Baseline**

**A. Carbon Associated with Building Materials**

The owner is asking for your assistance in setting the embodied carbon baseline for your project. Using a quantities of building materials prepared by your estimating group and a list of material carbon coefficients from your green building team (see supplementary documents “2019 PDX Estimate Quantities” and “2019 Carbon Coefficients”), create a baseline carbon footprint for the building materials used in your project. Identify the total carbon emissions associated with the building materials for the project in tons of CO2 as well as a graph or chart showing the breakdown between different building materials, and identify the gaps in the data where your green building team has not offered carbon coefficients.

**B. Carbon Associated with Worker Transportation**

The owner is also interested in carbon emissions due to worker commuting and wants to include this in the embodied carbon baseline. There are 1,000 craft workers onsite for the duration of the PDX T-Core Project, working 5 days per week. Their commuting distance, duration of work and means of transportation are provided in the supplementary excel document titled “Carbon Problem – Excel Supplementary Information”.

* The average gas fueled vehicle gets 24.3 MPG.
* The average Hybrid Electric Vehicle gets 44.4 MPG.
* There are 23.5 lbs CO2 emitted / gallon of gasoline burned.
* Assume the average carpool size is 2.17 passengers in an average gas fueled vehicle.
* Public transportation results in 60% less carbon emissions than the average gas fueled vehicle.
* Typical energy consumption for biking is 42.3 kcal/mile, with the average American diet producing 2.6 g CO2e\*/kcal. (CO2e stands for CO2 equivalent)

1. Calculate the emission factor (pounds of CO2 emitted/passenger mile) associated with each transportation type based on the given assumptions, rounding to the nearest thousandths.

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| --- | --- | --- | --- | --- | --- |
| **Means of Transportation** | Single Occupant Vehicle | Hybrid Electric Vehicle | Multiple Occupant Vehicle | Public Transportation | Bicycle |
| **Emission Factor (lbs CO2/ passenger mile)** |  |  |  |  |  |

1. Using the rounded emission factors calculated above, fill out the Dataset from tab 1 of the excel document and complete the Summary Table from tab 2, providing a breakdown based on means of transportation for count of worker, average commute distance, total miles traveled, emission factor, and total CO2 emissions (in tons), percentage of total trips and percentage of total emissions.

**Part II. Analysis of Embodied Carbon Reduction Strategies**

A. Material Optimization Strategies:

The design team has identified three potential ways for reducing embodied carbon associated with the project materials. The three options are:

1. **Using salvaged metal piles**. The project’s structural design includes 862 metal pipe piles. A project consultant has proposed using decommissioned oil pipeline piping instead of new material to reduce embodied carbon. Under the projects carbon accounting method, the carbon emissions related to the salvaged pile would be treated as zero.

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| --- | --- | --- |
|  | New Pile | Salvaged Pile |
| Cost Per Pile (material only) | $19,687 | $9,843 |
| Amount of Steel Per Pile (lbs) | 5,700 | 5,700 |

For this – we say 862 piles that includes micro piles and regular piles – which is fine but – the amount of steel per pile would be the same – should we ignore micropiles and just count the 386 piles or should we break out the calculation for both?

**For Option 1:**

1. Provide an estimate for cost impact, carbon reduction potential in metric tons and as a percentage of the baseline materials embodied carbon, and any risks or benefits from adopting these alternates
2. Provide the owner with a procurement plan that outlines who would be responsible for finding potential suppliers, the time required for procurement of salvaged material versus new material, how quality assurance could be maintained while using salvaged materials, and any other relevant factors for the owner to consider. Compare the risks and benefits to using new high recycled-content steel piles, which are widely available at a 15% cost premium.
3. **Using a hybrid timber/steel roof structure.**

As a carbon reduction strategy, the project is planning on using 1.5 million board feet (126,000 cubic feet) of glulam beams. The project would like to source the wood as close to the project site as possible. There are three potential suppliers. These suppliers have provided preliminary pricing.

**Canadian Glulam Manufacturer**

350 miles from job site

All wood sourced from British Columbia (within 450 miles per project)

Meets Canadian Government Forest Management Standards

Preliminary pricing (material only): $13 million

**Oregon Glulam Manufacturer**

71 miles from job site

All wood sourced within 100 miles of project

Not FSC - Managed to Oregon Forest Practices Act

Preliminary pricing (material only): $12.2 million

**Washington Glulam Manufacturer**

120 miles from job site

All wood sourced within 250 miles of project

Can provide FSC Mix Credit wood

Preliminary pricing (material only): $15 million for FSC Mix Credit wood, $12 million for standard

Note: Assume all suppliers use diesel trucks (2.5 lbs CO2/mile) to deliver one 1,200 cubic foot load of glulam beams.

Present the owner with the cost and transportation carbon impacts of each option. Given the projects goals for carbon reduction, give the owner your recommendation on whether FSC wood offers any advantages over the other sourcing options. The project may also pursue LEED v4 certification, so identify the impacts on relevant credits, given an expected LEED materials cost of $405 million, with $162 million of that qualifying as structure and enclosure.

1. **Using optimized concrete mixes.** Local concrete suppliers have provided information on the embodied carbon associated with different concrete mix designs (see supplementary document “2019 Alternate Concrete Mixes”). Based on the following concrete uses on the project, identify which if any of these mixes could be incorporated into the project.

|  |  |
| --- | --- |
| **Application** | **Minimum Required Strength (psi)** |
| Footings/Foundations | 8,000 |
| Slab on Grade | 8,000 |
| Shear Walls | 6,000 |
| Slab on Metal Deck | 3,000 |

Using the provided information above and the quantities from Part I.A, provide the owner with a comparison of both the lowest carbon and lowest cost combination of mixes. Clearly identify the potential carbon savings in total tons of CO2 and as a percentage reduction of the baseline carbon associated with concrete identified in Part I.A.

**B. Transportation Strategies**

In an effort to reduce transportation related carbon emissions, Skanska is investigating incentives to increase public transportation use for commuters. The PDX airport is part of the Metropolitan Area Express (MAX) Light Rail System, connecting neighboring cities of Gresham, Milwaukie, Beaverton and Hillsboro. MAX stops are easily accessed by TriMet buses or Portland streetcars. For $100 a month, riders can get unlimited access to the Max, TriMet and streetcars.

1. What percentage of regular car commuters would need to transfer to transit based commuting to achieve a 30% reduction in transportation emissions?
2. What would the total cost of this incentive be over the lifetime of the project? What is the cost per ton of CO2 reduced?
3. What other incentives could be given to encourage other lower impact transportation methods? What would the total cost and carbon reduction of these incentives be?
4. Beyond carbon impact, what risks or benefits could these incentives provide?

**Part III: Analysis and Strategies for Carbon Reduction**

1. For each strategy evaluated in Part II, identify the cost of carbon reduction (in $ / ton of C02).
2. What package of embodied carbon reduction strategies would you recommend? Defend your proposed solution in terms of ability to meet owner goal, total cost, effectiveness, impact on schedule and productivity, and any other factors you deem relevant.
3. Provide qualitative insights on the total amount of embodied carbon generated and averted by reduction strategies, providing sources for any complementary statistics used. This should provide context to the scale of construction related emissions on this project compared to other emission sources and industries.