SELCO Credit Union: a case study in quantifying the environmental impacts of design for deconstruction

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ABSTRACT:

Architect Daniel Herbert designed the SELCO Credit Union in Eugene, Oregon in 1972 to maximize the amount of material that could eventually be salvaged for re-use or recycling at the end of the life of the building. While there are no immediate plans to take the building down, this paper uses the current environmental value of the building material and current local building deconstruction and material recovery practices to conduct a speculative analysis of the environmental consequences of the architect's intention to design for eventual deconstruction.

To conduct this analysis, we asked and then investigated the following questions: 1) Based on international carbon and energy factors for each of the building materials, what is the environmental value in terms of embodied energy and carbon of the quantities of building materials used? 2) If the building were deconstructed today, what parts of the building could be diverted from the waste stream for direct reuse, what could be recycled into new materials, and what would be sent to landfills?

By categorizing quantities of building materials by degree of recovery and by cradle to gate carbon and energy impact, we estimated that more than one third of the embodied energy and about one third of the carbon embodied in the existing building could be recovered. Much of this savings can be attributed directly to three of the architect's decisions: 1) To build with a panelized plywood roof system, 2) To use uniformly sized concrete panels that can be disassembled, and 3) To use bolted trusses of high-value timber. We can conclude that if this case study building were deconstructed today that the architect's decision to design for deconstruction would result in measureable resource savings.

CONFERENCE THEME: On Measurement
KEYWORDS: deconstruction, construction, energy, carbon, lifecycle

INTRODUCTION

Materials that go into the construction of a building are almost always used just that once. When a building is conventionally deconstructed or demolished, its materials are landfilled or downcycled as scrap metal or fuel along with the energy, greenhouse gases, and other environmental impacts that are embodied in those construction materials. But when building materials are salvaged and reused, environmental savings can be measured in terms of the embodied environmental impacts of those materials as they substitute for equivalent measures of newly extracted and manufactured construction materials.

In the US, the amount of material that is salvaged for reuse or recycling at the end of the life of a building varies by project. To increase the amount of material that could eventually be recovered from the buildings they design, architects can plan for the recovery of construction materials by designing for the building's deconstruction into reusable, high value parts. In this study, we look at such a building to evaluate the potential impact of the architect's decision to design for maximum building material reclamation.

1. THE SELCO BUILDING

Eugene architect Daniel Herbert designed the SELCO Credit Union building in ways that he hoped would maximize the amount of material that would be recouped or recycled at the end of the life

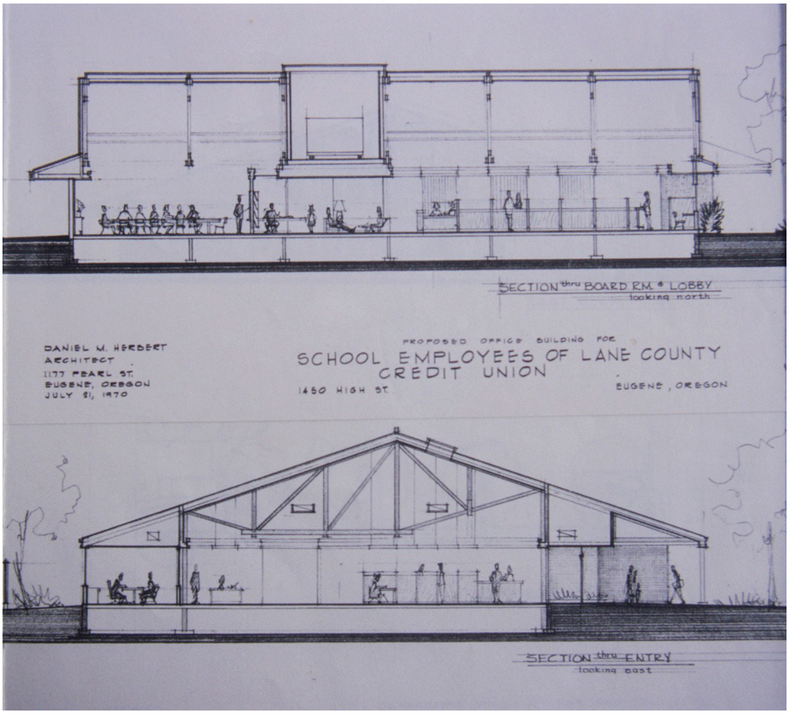

Figure 1: Architect's drawings of the 1972 SELCO Credit Union building. Source: Daniel Herbert

of the building.[1] He chose to span the open floor plan with large bolted timber trusses to optimize flexibility of the space over time and so that the roof framing might eventually be demounted and the timber saved. He specified precast, insulated panels for the walls that are doweled and mortared in place so that they would be easy to remove and to reuse. The roof framing and cladding is panelized and each panel is bracketed in place with the idea that the panels may be removed in whole pieces.

Nearly forty years later, the building is now operating as the Pacific Continental Bank. The current building looks a little different from the original version—the interior has been re-partitioned, the furnishings and carpet have been changed and the exterior that was originally cedar shingles is now painted board. But, the primary building systems remain the same. While there are no immediate plans to take this building down, in this paper we ask the speculative question: Given current practices in deconstruction and given the current environmental impact of equivalent replacement materials, how can we estimate the environmental impact of the architect's decision to design for deconstruction?

2. ESTIMATING ENVIRONMENTAL IMPACTS OF CONSTRUCTION MATERIAL

2.1. INTRODUCTION

There are environmental impacts associated with the raw material extraction and the manufacturing or production of all building materials. A complete lifecycle assessment or even a "cradle to gate" environmental impact study would include various indicators: total energy used in extraction, processing, and manufacturing, carbon emitted, water used, resulting human or environmental toxicity, acidification, or eutrophication. In this case study, we do not presume to do a true lifecycle assessment of these building materials. Instead, we estimate the environmental impact replacement cost of the SELCO building materials in terms of embodied energy primarily and embodied carbon secondarily to generate a working estimate of the potential environmental savings of recouping some of the materials at the end of the life of the building.

In this case and in environmental terms, the replacement cost of the building materials can be measured in terms of the current value of the materials. Each unit of building material salvaged from this building and reused elsewhere represents a unit of building material that will not have to be extracted and manufactured. As an illustration of this premise, imagine someone who is using a bowling ball that was manufactured decades ago and who, for some inexplicable reason, drops her ball into Lake Erie. That decision costs her the price of buying herself a new bowling ball. The price she originally paid for it is no longer important. In this study, we use the same reasoning to apply environmental value to used building materials. While each measure of material had some environmental cost associated with its original production, we are concerned now with the cost of replacing it and, by extension, with the environmental value of not having to replace it.

Figure 2: Installing prefabricated SELCO Credit Union building roof panels, 1972. Source: Daniel Herbert

2.2. METHODOLOGY

In this paper, we estimate the environmental value of the SELCO building materials by estimating the quantity and type of materials in the building and then associating those materials with factors derived from current global manufacturing processes for the embodied energy and carbon for comparable materials per unit of weight. To quantify the materials, we used original construction material lists from student projects that were conducted under the architect's direction in the 1970s, construction photos, and discussions with the architect.

For clarity and in order to focus on the architect's building-scale design decisions, this estimate includes only the structure and enclosure of the building itself. We include the dimensional lumber and plywood in the building structure and enclosure, the concrete in the panelized walls and foundation, the perimeter insulation in the concrete walls, gypsum board, dropped ceiling, and the exterior doors and windows. We do not include site materials including gutters and do not include interior partitions, doors or finish materials that are changed out over time. For clarity of the study boundary we also do not include building fixtures such as for plumbing, lighting or HVAC, furniture, fasteners, or the bank safe.

For embodied energy and carbon associated with the building materials, we used factors from the University of Bath International Carbon and Energy Database (ICE), except where as noted. We do have access to other more detailed libraries of LCA data for Europe, including for North America, but chose to use the ICE because of its accessibility to architecture students. While the ICE is based on data from the United Kingdom, a quick comparison with other sources showed us that geographical variation was statistically insignificant in the context of this study.

At the same time, it should be noted that these numbers do not account for transportation to the site from the manufacturing plant and that there are regional differences in the amount of energy and carbon embodied in certain materials, especially due to different fuel splits for manufacturing processes in different regions. For example, we assume lower carbon emissions per unit of energy produced in the northwestern US in general. But, we cannot assume in this case that replacement building materials would be manufactured in this region.

2.3. FINDINGS

In compiling the construction material and their associated carbon and energy, we estimated that the cast-in-place and precast concrete make up the majority of the building by weight (79% of the total) but in terms of embodied energy, we estimate that the energy associated with the aluminum in the ceiling grid and exterior doors and windows (43%) is more significant than that of the concrete (23%). The energy associated with the dimensional lumber is roughly equivalent to that of the concrete. This is probably heavily influenced by the amount of energy used in the extraction, refinement and manufacturing for aluminum extrusions in door, window, and ceiling systems.

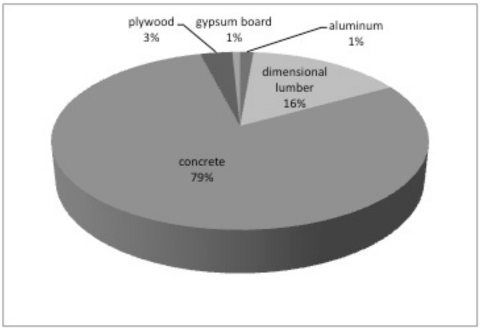

Figure 3: Distribution of Building Materials by Weight.

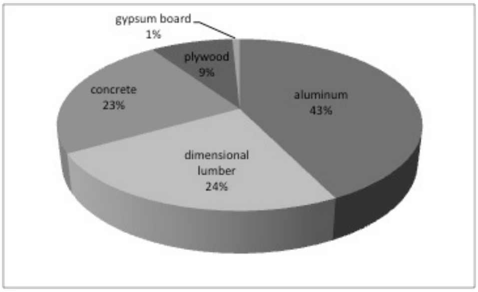

Figure 4: Distribution of Total Building Material (replacement) Embodied Energy.

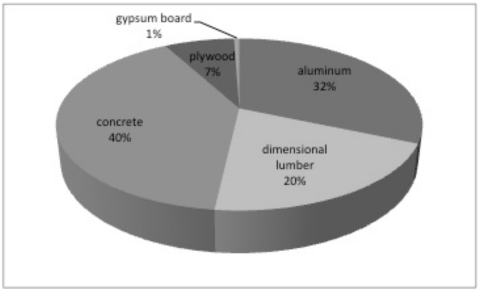

Figure 5: Distribution of Total Building Material (replacement) Embodied Carbon.

In the current environmental context, it is important to look also at the greenhouse gas emissions generated by different energy sources. In this analysis we also include the associated embodied carbon emissions for each of these materials. Because there are different fuel types with different levels of emissions associated with different building material manufacturing processes, the estimates of embodied carbon do not follow those of the embodied energy directly. In fact, this difference would vary depending on the manufacturing region.

In this case, there are proportionally more carbon emissions associated with the concrete products in the SELCO building than in any other material category (40%) followed by that of the aluminum (32%). This appears to be due to the higher level of coal (and so proportionally higher level of carbon emissions) used globally in the manufacture of portland cement compared to emissions from the generation of electrical energy used for the production of aluminum building products.

If the materials of the SELCO building were manufactured today, we estimate that they would represent about 3,350,000 MJ of energy. To translate this very roughly into more tangible terms, this is more or less the amount of energy required to make a roundtrip from Seattle to Miami in a station wagon one hundred times.2 The total carbon emissions associated with the construction materials, 235,000 kg or 235 metric tons, are approximately equivalent to the amount of carbon that 5 acres of US pine forests could sequester in 40 years (EPA).

3. SPECULATIVE DECONSTRUCTION

3.1. INTRODUCTION

The environmental cost of disposing of single-use building material is large. The US Environmental Protection Agency (EPA) estimated that in 2003, 154 million metric tons (170 million tons) of building related construction and demolition material was produced. In US terms, this represents 1.45 kg (3.2 lbs) of C&D waste per person per day. (Guy). It should be noted that construction and demolition (C&D) waste—scraps, packaging and unused material from new construction and the waste from whole building demolition—are typically measured together but that it is generally understood that demolition waste in the US typically makes up 90% of C&D waste.

If the SELCO bank building were deconstructed today, how much C&D waste would be produced? How much of the building material might be salvaged for recycling or use? What are the environmental savings associated with reclaiming that material? There are three scenarios that we can imagine for the end of the life of this building: 1) In the most extreme case, the building and its material could be entirely demolished and landfilled. This classic “wrecking ball” scenario is extremely unlikely because of the local cost of dumping. In the increasingly rare locations where there are minimal or no disposal fees, it might be easiest and cheapest to do this. In the City of Eugene, the cost of whole dumping is prohibitive enough to warrant some material reclamation (Filip). In scenario 2): If no attempt were made at on-site deconstruction and material recovery, most of the building materials would be transferred in roll–off containers to a local material recovery facility (MRF) where a portion of materials with some easily recoverable value would be separated—first the scrap metal for sale to a foundry, then the lumber for hog fuel (biomass). The remainder of the material would be sent to a dry construction landfill. Our local MRF Ecosort, currently aims to reclaim 25-30% of each container, the percentage required to receive a discounted tipping fee at the landfill for the remainder of the demolition waste (Ritz). In this paper we focus on the final scenario 3): If some labor were invested in deconstructing the building, what is the *maximum* amount of material that could be salvaged for recycling and/or reuse? While in current economic conditions here, this would require additional investment in the cost of labor, this is not unlikely in the increasing number of jurisdictions where the disposal of construction waste in landfills is very expensive or prohibited and is a very conceivable future scenario for the City of Eugene.

3.2. METHODOLOGY

In order to estimate which materials would be reused, recycled, and wasted in scenario #3, we relied on our own familiarity with construction details and on the expertise of Julie Daniels, executive director at BRING, a Springfield, Oregon organization that resells salvaged building materials and that was licensed as a deconstruction contractor. We asked Daniels to help us speculate on the deconstruction of the SELCO building and to determine which materials could practically be salvaged for reuse, which could be recycled, and which would be irrecoverable.

By referring back to the embodied energy and carbon we associate with each group of materials, we are able to estimate, in degrees, the energy and carbon associated with the landfilled, recycled, and reclaimed material. This methodology is most useful for understanding the significance of the reclaimed and landfilled material.

In the case of the reclaimed building materials, this represents a savings—the amount of energy not consumed and carbon not emitted as these materials displace other materials that would otherwise be produced. In the case of the landfilled material, these quantities of energy and carbon represent a dead end loss—a lost opportunity quantified in the amount of energy and carbon that will be consumed and emitted as these materials are replaced in the building materials stream.

It is difficult, if not impossible in this case, to estimate the amount of energy and carbon emissions saved in the recycling of building parts because it is unclear how much of those two embodied impacts would be recovered in the process of recycling. For example, the aluminum doorframes sent to the foundry mean that nearly that much less bauxite will be extracted to make new extrusions. At the same time, a notable amount of energy will be used to process the recycled aluminum. In this study we do not attempt to quantify the energy and carbon savings from recycling.

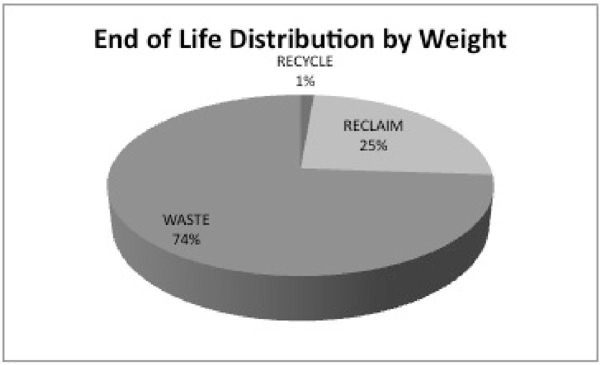

Figure 6: End of Life Distribution by Weight

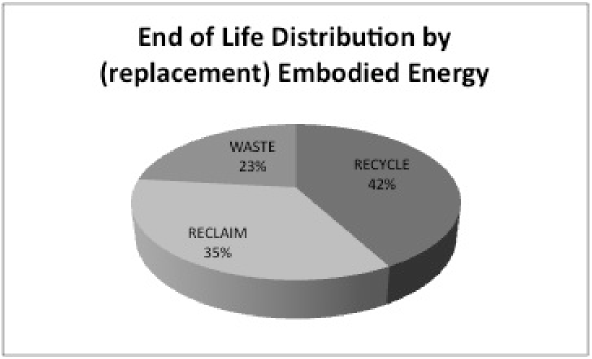

Figure 7: End of Life Distribution by Embodied Energy

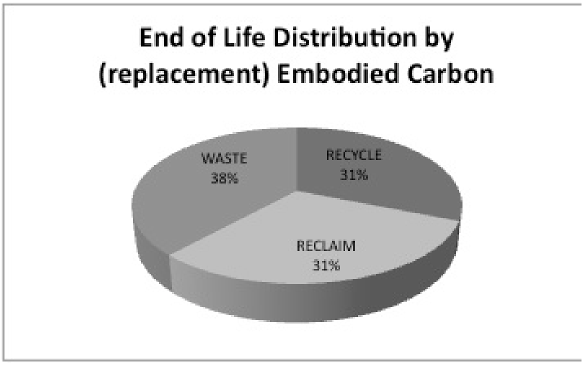

Figure 8: End of Life Distribution by Embodied Carbon

3.3. FINDINGS

According to Daniels, a significant portion of the building materials would be irrecoverable: the poured-in-place concrete, gypsum board, glass windowpanes, and acoustical panels would go to the C&D landfill. Three noteworthy building components might be able to be sold whole directly from the site for reuse: the bolted timber trusses, the roof panels, and the concrete precast panels. This depends on an interested buyer but Daniels speculated that this would be quite likely. Generally, lumber and plywood could be reclaimed for reuse or for resale at the BRING store. The aluminum door and window frames and ceiling grid would be resold to a foundry for recycling.

In our estimate, the material designated for reclamation represents 35% of the total embodied energy of the project. Of this material, the dimensional lumber, plywood sheathing and the concrete panels represent the largest amount of embodied energy and savings; the lumber has a replacement value of 23% of the total embodied energy of the project. It is interesting to note that the three major decisions in designing for deconstruction—the trusses, the wall panels, and the panelized roof system make up more than half of the reclaimed material in terms of embodied energy and carbon.

The material designated for landfill represents only 23% of the project total in terms of replacement embodied energy. This is almost entirely the poured-in-place concrete for the foundation. The broken up concrete would probably go directly to the C&D landfill but would be set aside for use in earthworks for the landfill or for use later as roadbed. While this is still a form of salvage and re-use, we do not count the embodied energy from the material as reclaimed because it does not act as a substitute for newly poured concrete.

The material designated for recycling represents a replacement value of 42% of the project total in terms of embodied energy—the largest fraction because of the large amount of embodied energy in aluminum materials. But, as noted in the methodology, this number does not translate directly into savings or loss of the environmental value of the materials.

CONCLUSION

While the most obvious savings in terms of material investment is to continue to use the building as it stands rather than to replace it, these estimates quantify significant environmental savings that could result from the architect's decision to design the SELCO Credit Union building for eventual deconstruction, particularly in terms of the building's roof panels, trusses, and panelized walls.

These findings also show that in considering the lifecycle embodied energy and carbon in the design of a building that two categories of materials should be used only with cautious consideration: 1) high impact materials such as concrete and aluminum and 2) materials that have no chance of reclamation such as poured in place concrete and gypsum board.

In the future, it would be useful to compare a building such as this one that is designed for deconstruction with a comparable building that is designed conventionally to generate a case study per square foot comparison of the environmental impacts of the materials themselves along with a similar comparison of end of life scenarios. Does a building that is designed for deconstruction have a higher per square foot embodied energy in the initial construction? Are there whole, reclaimable materials in a (hypothetical) conventionally constructed building?

ACKNOWLEDGEMENTS

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ENDNOTES

[1] The SELCO Credit Union, 1450 High Street, Eugene, Oregon, completed in 1972. The building now houses a branch of the Pacific Continental Bank.