Possible options for reuse and recycling of end-of-life waste glass from deconstruction projects

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Summary:

Construction and demolition waste accounts for 20-30% of the waste in Canadian landfills. Of this, glass makes up about 1%. This number is comparatively small, but represents an extremely recyclable material that frequently ends up in landfills simply because there is little to no infrastructure in place that can accept it. The most important thing is to establish this infrastructure, whether it be in current glass recycling facilities or a deconstruction hub. Until this happens, the opportunity to recycle the glass is lost. While the best option is to reuse, this is often difficult with the glass from deconstruction, which is largely constituted of windows. These single pane windows are not energy efficient and cannot be effectively used in their current state. Therefore, the best option is to recycle the glass. Many of these options involve crushing the glass into cullet or fine aggregates. Some fields in which glass can be recycled include soil applications, construction and road building, and art and decoration. Currently, there are no options for obtaining residual materials from the glass if it cannot be reused or recycled. While most of this glass will likely come from deconstruction projects in the future, there is also some that comes from renovation projects and new construction. A deconstruction hub would greatly increase the amount of glass that is recycled, when paired with proper education on the subject. It is also important to gain higher levels of participation in deconstruction, which could be achieved by providing incentives like tax credits, and by mandating waste diversion minimums.
Introduction

Every day, buildings are torn down to make space for new construction. Construction and demolition waste accounts for 20-30% of the waste in municipal landfills in Canada. Many areas have begun to use deconstruction as a means of diverting this waste from the landfill. Studies have shown that up to 90% of this waste can be diverted from the landfill when a structure is successfully deconstructed. Of the many types of materials used to make a typical structure, glass makes up a small percentage. A report prepared for Metro Vancouver found that glass was about 1% of the total waste from the construction and demolition stream, or approximately 9,560 tonnes/year. Glass also makes up about 3.5% of the total construction waste that comes from the building process. Renovations are yielding an increased amount of glass, as more and more homeowners are converting to more energy efficient windows. Even though this may seem to be a small or insignificant number, glass is extremely recyclable, and is something that need not take up any space in the landfill. Unfortunately, the infrastructure to recycle end of life glass is virtually non-existent in Vancouver. As a result, these materials frequently end up in the landfill, instead of being re-used or recycled. In a landfill, this glass will take up space forever, but if recycled, glass can be recycled an infinite number of times without losing its strength. This paper will present an in-depth analysis of the many options that exist to use this waste material in innovative and creative ways that will give it value and ensure that it does not end up in a landfill. It will also analyze what policies could be put in place to ensure a higher participation rate in deconstruction projects and waste diversion.

Deconstruction

When old houses are demolished to make way for new construction, materials are traditionally not sorted and salvaged. Deconstruction is the process of taking down a house, piece by piece, and sorting it so that materials can be salvaged, re-used and diverted from the landfill. This idea is still somewhat new in Vancouver, but in other cities, this method is being used to successfully reduce waste and increase sustainable construction. An excellent example can be found in Oregon, where the Rebuilding Center in Portland encourages reuse and recycling of building materials. The center is run by a non-profit organization, which brings in materials, sorts them, and then sells them to consumers. The center also offers a deconstruction service, as well as a furniture line made from salvaged materials.\(^4\) Portland also has a law in place that requires new construction to recycle 50-75% of construction debris depending on the total value of the construction being completed. However, this has been found to be difficult to enforce, and carries a somewhat small fine for infractions. A bigger incentive for home-buildings is the tax deduction they can receive from donating materials to the Rebuilding Center. The materials in the Rebuilding Center typically sell for 50-90% off retail price, offering an initial incentive, as well as the sustainability green factor that is increasingly important to today’s consumer. The deconstruction industry was steadily growing in the United States, until the economic downturn curbed some of the activity.\(^5\)

One of the key obstacles to deconstruction is time. Typically, people will get a demolition permit and a building permit on the same day, so they do not wish to waste any extra time taking down the pre-existing building slowly, but rather they are eager to get going with the


\(^5\) Ibid.
process of constructing the new building. Demolition typically takes one day, while the deconstruction process typically takes about 1-2 weeks to complete.\(^6\) Vancouver has already taken a step towards addressing this issue with the advance deconstruction permit. This new system gives homeowners a deconstruction permit two weeks in advance of the building permit, so that they have sufficient time to properly deconstruction the structure. The advanced permit is granted if they agree to divert at least 75% of the materials from the landfill. The permit also provides a discount for those materials that must be transported to the dump. Another obstacle to deconstruction is cost. However, a 2004 study found that reusing materials immediately in the new construction can make the process extremely cost-effective, even costing 30-50% less than demolition once the tax deductions and benefits are added in.\(^7\)

Another emerging idea is to design specifically for deconstruction. This is becoming increasingly popular, and it is often those who choose to deconstruct an old home who will re-build so that deconstruction in the future will be possible and easier. Designing a house with deconstruction in mind makes the new structure much more sustainable, because it also uses many of the salvaged materials that come from deconstruction processes. A 2012 study used a new online website called Sakura to measure the environmental benefits. Sakura shows how much energy and carbon can be saved by designing for deconstruction. Their results showed that carbon dioxide emissions are reduced at every stage of the buildings life cycle when that building has been designed for deconstruction.\(^8\) If sustainability is kept in mind throughout all of


\(^7\) Ibid, 40.

the phases of construction and eventual demolition, 20-30% of the waste that currently ends up in Canada’s landfills can be diverted.

The glass coming from construction and demolition waste is largely from windows. The glass used in windows is largely soda-lime glass, which is the very same glass used to make bottles, jars and other glass items we commonly use and recycle, with only a few minor chemical differences. Since the chemical composition is slightly different, these glass types do need to be separated and sorted, which means that window glass cannot be recycled with glass bottles and other common glass recyclables. The four main chemicals used in the composition of this glass include SiO₂ (73%), Na₂O (14%), CaO (9%), and MgO (4%). Throwing a glass bottle into the garbage is highly frowned upon in Vancouver today, and yet glass windows with almost identical composition are thrown away on a daily basis simply because there is no infrastructure in place that allows these materials to be recycled. As a part of its Zero Waste Management Program, the city of Vancouver implements a system of 5 R’s: Reduce, Reuse, Recycle, Recover and Residuals. I will go through each of these options in detail and discuss the possibilities in each of the 3 middle categories on the pyramid. Reduce is something that must take place before the scope of this project, in the actual manufacturing of the glass. Hopefully, with these recommendations, we can ensure as little as possible will end up in the residuals category at the landfill.

![Figure 1 - The 5 R's of Waste Management. Source: Trash Talk](image-url)
Reuse

Unfortunately, the glass coming from deconstruction is largely from windows, and these windows are usually not reusable in their pre-existing form, because the single-pane windows typically found in the houses being demolished are not energy efficient. Reuse of these windows can only occur when the windows are not a part of the envelope of the house. They can theoretically be used as indoor windows within the house, where they will not allow heat to escape to the outside. There are also some creative re-uses for windows in their current form, including greenhouses. Reuse is in theory a better option than recycling, because it leaves the glass in its current form without requiring any re-manufacturing or energy used to recycle the glass. However, most of the ways in which glass can be repurposed will fall under the recycle category.

A creative greenhouse made completely from salvaged materials is displayed in Figure 2.

Recycle

Below, I have broken down some of the possible recycling options for glass into different categories. These are only some of the many options for recycling glass, which had considerable
research backing. Many of the options found in the body of literature on the topic involved different kinds of glass, so more research will certainly be needed to test the effectiveness of construction and demolition waste glass in these options.

Landscaping and Soil Applications

A 2012 study attempted to assess whether glass could be used as an aggregate in problematic soil applications. In areas of high erosion and other problematic areas, sand is often used as a base to prevent the soil from eroding away. The researchers here used pulverized glass fibre instead of glass, to see if it could successfully be used as a replacement. The glass used in the study was largely glass from e-waste, such as computer screens and TVs. The results were favorable, finding that the glass fibers improved friction between the soil particles, which improved cohesion value of the soil, and also made it more resistant to horizontal sheering forces. The glass fibers that were used are non-biodegradable, so the favorable effects on the soil will not wear off, and this method provides a more sustainable way of disposing of this material than sending it to a landfill.9 The article did not explore the possible environmental effects of using this material, and they do suggest that more study and field tests are needed before this can be fully approved. The early research seems to show promise though, and if this glass can be used as opposed to sand, it provides an outlet for these materials that would otherwise end up in a landfill, and perhaps prevents sand from being removed from ecosystems and environments that need it there. The type of glass they used in their experiment is potentially more environmentally harmful because the e-waste glass contains more chemicals and heavy metals than soda-lime glass used to make windows. It seems that recycled glass from house

deconstruction could be used in this way as well, but more research is needed before that can be ascertained.

Glass can also be made into decorative and useful landscaping tools. A company in San Francisco uses glass to make decoration for gardens, which can help with drainage and add aesthetic value (see Figure 3).

**Figure 3 - A sample of the recycled glass landscape design tools.**
Source: Building RESources

**Art and Decoration**

A recent design trend provides an excellent outlet for glass waste. Glass tiles are becoming increasingly popular, and many companies are making use of recycled glass to make these tiles. This is great way to add value to the glass, and can also bring awareness to the sustainability when placed in high traffic areas. The tiles can be used as floors, walls, or countertops, and are highly durable. A popular kind of these tiles is glass terrazzo, which is made from crushed glass combined with an epoxy resin. There are several other options of different kinds of tile that can be made from recycled glass. Poured glass is very energy-intensive and requires clarity, so it is also labor intensive and requires sorting and cleaning. Sintered glass requires glass to be clean, because any contaminants can create flaws in the final product. Glass terrazzo is ground after curing to expose the glass pieces and provide a nice look.

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This method is generally thought to be the best method for making tiles with crushed glass. However, these require sealer to be maintained, or else the tile can stain. There is a company in Burnaby that makes these tiles from recycled glass, and they have displays in high profile areas like the Vancouver Convention Center and Vancouver International Airport. A mosaic made from these tiles in the Vancouver Convention Center can be seen in Figure 4.

Recycled glass is also frequently up-cycled through art projects or jewelry makers. Glass material comes in handy for these artists, and using this waste material in art is a great way to potentially add value to what was once waste.

*Construction and Road Building*

Glass has long been used as an aggregate in concrete used for new buildings and roads. Global cement production is about 2.8 billion tons per year, and will likely increase, so if glass can successfully be used, it will create an outlet for this glass to be recycled rather than landfilled. A 2012 study examined the feasibility of using crushed glass waste to replace cement

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in mortar, and therefore use fewer materials, and whether the resulting material is as strong as the original material would be if it were made in the conventional manner. In the experiment, 3 types of mortar were created: one control with 100% cement, and then mixes with 10 and 20% crushed glass waste powder. The strength of the mortar was encouraging, and equivalent to the control group, meaning that this could be an effective use for preventing glass waste from entering the landfill.\(^\text{13}\) Glass can also be used in concrete in a more decorative style, using large chunks of recycled glass that show up in the finished building.

Another study identified a key barrier in glass recycling in road applications to be lack of knowledge about potential harmful effects on the environment. Their study attempted to assess the environmental effects of fine and medium recycled crushed glass to find out if this sustainable option is really safe to use on future projects. The glass used included bottle glass and window glass, essentially anything that could not be utilized in typical reworking of glass into new glass bottles. The workability was found to be equal to or superior to that of the road application that utilized typical aggregates. They also examined the potential environmental risks including groundwater contamination. They concluded that they found satisfactory evidence that there are no environmental, health or safety risks.\(^\text{14}\) They also did tests to determine whether road-workers would more susceptible to cuts and injuries, or breathing in contaminants when using glass aggregate roads, and found that there was no more risk than was involved with using natural rock aggregate.\(^\text{15}\) This is important research because many studies have examined the effectiveness of the aggregate, but few have studied the environmental consequences or risks. That extra step is hugely important, and further research in this area will

\(^{13}\) Matos and Sousa-Cotinho, “Glass powder as cement replacement”, 410.


\(^{15}\) Disfani, et al., “Environmental Risks”, 177.
hopefully lead to increased use of recycled glass in road applications and cement production. This study was one of the first of its kind, so clearly more research in the area is needed so that we can be sure the conclusions and results are accurate.

There are many more possibilities for using recycled glass in other products, from fiberglass, to linoleum, to roofing. These options have not been researched thus far, and therefore, further research is needed to expand the horizons of possibility for recycling glass waste.

Recover

When reuse and recycling are not possible, an attempt is made to recover the resources that went into creating the waste material in the first place. In the case of glass this may not be possible. Since glass involves a chemical reaction and high heats, which change the materials into the glass, it may not be possible to break down the glass into these individual materials. Perhaps by heating to different melting points, it may be possible to separate the glass into its original components. If this is the case in the future, there could be a whole host of opportunities. The main ingredient in soda-lime glass is silicon dioxide, or silica, which has a wide range of uses from food production to telecommunications and toothpaste.

Recommendations:

To ensure that construction and demolition waste glass is diverted from the landfill, it is clear that some sort of infrastructure is needed. Through my research, I have found very few
companies in the greater Vancouver area that accepted salvaged glass waste. A dedicated center for glass waste recycling would not likely not see a large enough volume of materials, so a deconstruction hub would be ideal. An operating deconstruction center such as the one in Portland, Oregon would have a tremendous impact in reducing the amount of glass and other construction and demolition waste that ends up in the landfill. There are a few deconstruction companies on Vancouver Island who accept and then re-sell salvaged materials. In the lower mainland, we can look to Restore in Burnaby as a good example. They accept all salvaged materials, but unlike the Portland center, they are unable to offer tax credits as incentives. It also seems that more education is necessary to raise awareness of the deconstruction process and how much of an impact it can have on the environment. Even if the mandated diversion minimums and deconstruction laws in Portland have not been entirely enforceable, they still raise awareness, and perhaps the threat of a fine is enough to ensure that more people divert materials from the landfill. The fact that window glass is virtually the exact same composition as bottle glass means that it could be diverted from the landfill if only the proper infrastructure was in place, and people knew about it. While the advance deconstruction permit does provide some benefits, more people might be encouraged to pursue deconstruction if there were additional incentives like the tax credits offered in Portland.

Conclusion

There are so many options for recycling waste glass materials that there is really no excuse for them ending up in the landfill. Although the percentage of total waste is small, glass could be reused efficiently and effectively in many operations if the proper infrastructure existed.
Future research is still needed in some areas, but as deconstruction continues to develop in Vancouver, I am hopeful that much of this glass will be diverted from landfills in the future. It is essential that the infrastructure to support this glass waste recycling is created, for until that happens, the glass waste will likely to continue to go to the landfill. Higher levels of participation are also necessary to ensure that as much of the glass waste as possible is diverted from the landfill. This could be achieved with incentives, or mandated levels of waste diversion. Ultimately, more awareness is needed on the issue of deconstruction, so that there is more glass to be used for all of these reuse and recycling options.
References:


