Solarpunk Building Materials

As we've said elsewhere, solarpunk buildings should use materials appropriate to their surroundings. Climate, weather (including rainy seasons, severe heat, long winters, etc), threats to the structure (such as insects and mold), and available materials should all be a factor, as should the needs of the community - perhaps importing an advanced material from further away will allow a structure to last and cause less harm than rebuilding it regularly.

The following is a far-from-exhaustive list of materials and building styles you may want to include depending on your setting:

Salvage

Few solarpunk stories seem to take place in 'clean slate' settings like space colonies (though some great ones absolutely do!), and if anything, a solarpunk society on earth would probably strive to preserve intact habitats and do less greenfield construction than our present day one. So it's likely existing buildings would see a fair bit of upkeep and modification, if only because they already exist and the resources to build them have already been spent.

But there are plenty of circumstances where maintaining a building or bringing it up to modern standards isn't worthwhile, and deconstruction makes more sense. Deconstructed (and even demolished!) buildings can yield all sorts of useful building materials, depending on the structure's condition at the time, and the care with which it's taken down. Generally this is a less cost-efficient source of materials than extraction from raw sources but part of that is because our current society has had a lot of time to iterate and improve on logging, mining, and other extractive fields - a solarpunk society might get equally good at deconstruction. And there are a few advantages: deconstruction sites/sources of salvaged material are almost guaranteed to be much closer to the places they'll be reused, and these materials are generally retrieved in a much more ready-to-use state. For example, dimensional lumber pulled from a stick-frame house might have some extra nails stuck in it, but it's already cut to size and will be easier to work down than a green tree, which must be cut down, transported, milled to rough dimensions, dried, possibly treated with preservatives, milled to final dimensions, and transported again.

Ideally, a deconstructed structure should provide every building material used in its construction, but realistically there are going to be limitations. Shingles (asphalt roofing shingles or wooden siding shingles) are going to be basically impossible to remove intact. Some forms of insulation (especially old stuff like newspaper, sawdust, or asbestos) won't be worth reusing and may even necessitate hazardous materials disposal. Horsehair plaster can be extremely fragile and probably wouldn't be worth reusing even if it survived removal, transportation and storage. Even modern sheetrock will be a pain to salvage. Some wood will be rotten or infested with ants, termites, or other insects. Wiring and plumbing will take a lot of inspection and some careful documentation of original use before it's considered safe to reuse, and many folks will be (not unreasonably,) reluctant to use reuse it even then. Even brick and concrete can be damaged by the elements.

That said, a tremendous amount of construction supplies, from doors and windows, to lumber and plywood can be obtained, saving both the materials and avoiding transportation and wasted space in a landfill. To get an idea of the sheer scope of materials, hardware, and *stuff* which might be salvaged, here's a few real life businesses which wholesale recovered materials:

- https://junkyardsnearme.net/building-material-salvage-yards-near-me/ - this one has some good

photos of salvage yards
- https://www.habitat.org/restores/find-donate-building-materials-habitat-restore
- https://www.rebuildgreen.net/services/salvage-and-material-resale
- https://www.seconduse.com/inventory/ - this appears to be an inventory of thousands of items from bowling alley parts to cabinet doors to light switch covers
- https://thereusepeople.org/shop/page/11/

Even concrete slabs can be cut up to produce new building materials or reused in creative ways! This is huge as concrete rubble accounts for 25-30% of solid waste in landfills.

Concrete rubble can also be reused in other ways, such as in landscaping. There's also a rich history of cobblestone buildings where concrete rubble may be a suitable replacement for stone.

Tangentially related: this article discusses salvaging earth which has been excavated to make room for foundations in urban construction for use in parks and similar.

Geopolymers

If you're looking for a drop-in replacement for Portland Cement (which is used to produce the vast majority of our built-up concrete environment) then you probably want Geopolymers. The concrete industry is a huge portion of human CO2 production today (around 8% total), due both to the release of CO2 from the chemical process of baking the limestone, and from burning fuel to produce the tremendous amounts of heat necessary for that reaction.

Geopolymer is a fairly new material/process which uses a different chemical reaction to turn a mix of powders and water into a solid block of stone. It's seen some real life use and a lot of testing, and appears to cover all the uses of concrete, and to actually surpass it in some areas. Further, it's almost carbon-neutral, and repurposes industrial waste as a primary ingredient.

One thing to track is that geopolymers require a source of calcium aluminate. This can be Metakaolin (which would require mining) but there are a variety of industrial wastes which can provide this ingredient just sitting around poisoning huge swaths of land. Removing these waste heaps and safely containing them is absolutely something that should be done (for both the surrounding habitats and any neighboring people) but is often such a huge and expensive undertaking that it isn't done at all. Turning these waste products into a useful *input* for construction materials would enable Superfund-style cleanup and disposal with the safe disposal half of the work already guaranteed. It's a win-win.

Using them to produce geopolymers would be a win-win which produces our built environment while also providing containment for

- Blast Furnace Slag
- Electric Arc Furnace Slag
- Fly Ash
- Palm Oil Fuel Ash - left over from the burning of palm shells and husks and fibers in the production of palm oil (the industry has issues, but it seems like it could be done sustainably).
- Quartz mining tailings
- Sewage sludge
- Mineral wool waste -this compliments urban farming as mineral wool is a waste product of hydroponics, as well as used for housing insulation.

The base materials are very common on Earth and the number of possible sources are remarkable, with more or less levels of energy in processing.

The Differences:

Even if you haven't poured concrete yourself, you've probably noticed that for big construction projects, concrete is usually mixed at a factory a couple hours drive from the work site and delivered by caravans of cement trucks. This would change with Geopolymer. Compared to concrete geopolymer hardens very rapidly and so would often be mixed for use on-demand at the work location even at a relatively large volume. So you would have a pre-mix of the dry ingredients then an on-demand liquid mix of water, alkaline 'activator' (sodium silicate waterglass –usually pre-diluted with water as it's physically heavy and can be very viscous, but also shipped as a powder), and 'hardener' (sodium hydroxide). The fluids might be premixed together or added individually, the water content adjusted according the latent moisture in the aggregates and the work site (like traditional concrete geopolymer can be poured and cast underwater).

From a visual standpoint, there's probably not much to see with geopolymer production because of the simplicity. It's basically just a measured mixing process. And that work could be done in most any conventional industrial building or workshop. The huge roaring, rotary kilns used for Portland cement would be unnecessary, though some application of heat may be necessary depending on the source ingredients being prepared. This prep would probably be done near whatever heap of industrial waste is being used, because it's more efficient to transport refined materials than crude materials.

Why haven't we switched over already?

Some jobs have! The biggest real-world use I've found so far was an airport in Australia but the companies specializing in it have plenty of other projects to brag about.

The big difference is financial cost and inertia. Portland cement has been around for a long, long time, and the industry has had a lot of time to make improvements to their processes to drive down cost. It's also a known factor - civil engineers tend to appreciate consistency and Portland cement is a very well-understood material. They have entire books on its performance and limits in various conditions, and procedures for mixing, transporting, and pouring it in just about every circumstance you can imagine.

That institutional familiarity isn't there yet with geopolymers, so choosing to use it in a project probably feels like a risk.

That said, a solarpunk society is likely one that actually tracks its externalities and tries not to produce waste it can't account for, and once you factor in the true costs of Portland cement, the mining, the transportation, the CO2 production, geopolymers are a rather straightforward replacement.

Mass Timber Constriction

Mass timber is the name given to the various different types of engineered wood that can be used as structural building materials in place of steel and concrete. It's popular in solarpunk-adjacent spaces because it can be used to make modern skyscrapers and other big buildings with a far lower carbon footprint. This is partly because steel and concrete are CO2-heavy industries, and almost any alternative is an improvement there, but also because cutting down trees and using them to build buildings sequesters the carbon they captured from the atmosphere (at least for the lifetime of the building). This means that a mass timber building could even be carbon-negative if done correctly.

And that's kind of the theme with these buildings - if they're done right, they can be an absolutely awesome tool for mitigating the climate damage we're causing, and if done poorly, they can be incredibly environmentally damaging and possibly quite unsafe.

There are a ton of different configurations for which way the wood is arranged and fastened together to form these big structural beams and panels, and you can find lists of them here and here. The materials are usually made in factories and engineered to precise specifications and assembled onsite.

Advantages:

- When it's harvested sustainably (and ideally locally to reduce CO2 released in transportation, and when the manufacturing process is efficient) mass timber is carbon negative. But even if it only breaks even it'd still be an improvement over concrete and steel.
- Mass timber is lighter than traditional construction materials - this is great because the heavier the building, the deeper its foundation has to be. By reducing the weight of the building the designers can use even less concrete for the foundation. This example apparently weighs a fifth of a concrete building of its size, reducing the number of deliveries required during construction by 80 per cent (and allowing it to be bigger than it could have been due to a weight limit on the site).
- The wood structure can be constructed at a quicker speed compared to concrete- or steel-framed buildings of similar size. This also provides a cost-savings on the financial side, as that's fewer person-hours spent driving and building.
- Overall cost - these buildings are often actually cheaper to make than an equivalent concrete one, despite mass timber being a fairly new industry.
- Timber is easy to cut and to build with, so the buildings are generally easier to adapt. This *may* make them last longer by making it easier to change/improve them than to replace them.
- Looks awesome - many of these buildings are genuinely impressive, with huge open spaces and interesting uses of the structural elements and natural wood making excellent use of the materials. Solarpunk isn't just aesthetics but good aesthetics certainly don't hurt.

Disadvantages / things to account for in your setting:

- The carbon-negative potential of the timber can be offset by a few things:
  - The other materials used in construction can offset the carbon savings of the wood if they're not chosen carefully.
  - The carbon footprint of mass timber is impacted by how and from where the wood was sourced and transported. Poor timber harvesting practices can be incredibly destructive and release tremendous amounts of carbon from forests.
  - If the wood used in a building's construction ends up in a landfill, it is likely to be incinerated or left to decompose, with its sequestered carbon released back into the atmosphere – cancelling out the carbon benefits. Because so few mass-timber buildings have been constructed – let alone demolished – researchers are also unable to reliably forecast what will happen to engineered timbers at end of their life and what emissions this would entail. Salvage and deconstruction could play a huge role here in keeping this carbon sequestered by reusing these structural timber elements.
- Deforestation - humans are already erasing huge swaths of wild forest habitats from the earth - an increase in demand driven by a transition to mass timber could be disastrous, especially under capitalism (which ignores externalities and optimizes for the cheapest option) or when otherwise poorly managed.
- Fire risk - these buildings can be very safe, but steel and concrete don't burn, and, under the right circumstances, wood certainly does. This means that the actual structure of the building

can become fuel for a fire and that's something that has to be accounted for in the design. It seems likely that there's at least one of these buildings out there slapped together by architects who didn't bother to understand the differences in design required by their change in materials, just waiting to go up like a match, kill a bunch of people, and Hindenburg the entire concept of mass timber.

Mycelium

There have been several interesting projects looking to turn fungus mycelium into a building material.

Sometimes this is a process of compressing and baking it into mycoblocks (large, solid brown slabs of oyster mushroom waste and invasive encroacher bush substrate), and sometimes it's a process of growing pieces of the house in big forms.

Mycelium has some appeal for solarpunk folks because it's a natural, sometimes carbon-negative building material which can be grown from organic waste products (like sawdust, or plant waste from agriculture) with a bit of mystique from mushrooms.

There are some challenges with producing consistent mycelium products, and there seems to be a bit of a search to see what mycelium will be useful for.

Mycelium construction materials aren't a drop-in replacement for concrete or brick - though they're strong for their weight they're quite a bit weaker in the same volume. They might be a closer fit for foamed concrete or clay brick.

Most of the materials are biodegradable and also appear to not be waterproof without special coatings - this isn't unique (we build houses out of wood, after all) but it's something of an issue given that mycelium tends to be softer and its limits and performance in different climates is less well understood.

Mycelium provides good thermal insulation so there are some projects looking to use them to produce insulation, including to replace expanded polystyrene. This might be the easiest drop-in replacement to start out with.

This project is looking at using Trametes versicolor, a wood-rotting fungus known as turkey tail, to break down [[https://en.wikipedia.org/wiki/Oriented_strand_board|Oriented strand board (OSB) with the goal of using the fungal mycelium as insulation. For more information on mycoremediation

For now, it seems like this stuff is a little further out and we have less of an idea how we'll eventually use it. One thing I've noticed is that mycelium as a building material tends to show up in lots of showcase projects, student demos, and temporary outdoor pavilions, but I've had some trouble finding finished examples like with Mass Timber and Geopolymers.

Regional Options

The rest of these materials/processes are going to be much more regional - a material that's easy to make and lasts a long time in a hot dry climate might not make sense in a place with monsoons, etc, so consider the climate, weather, available materials, and other conditions in your setting as you look through these.

Cob

Cob is the British term for a traditional building material/method which has been used for thousands of years and was invented independently by people on multiple continents. It involves creating a mix of clay, sand, water, and straw or other fiber, and building it up and shaping it into a structure in multiple layers. It's a cheap, low-carbon construction method which can build comfortable homes out of local (often even local to the build site!) materials. Cob lost popularity in many regions during industrialization, but has seen a resurgence in popularity recently with earthship, owner-built, and permiculture/self sufficiency movements.

The flowing, sculptural shapes of the buildings, gives them a fantastical, sometimes fairy-tale vibe, and they're often decorated with bas reliefs, mosaics, or other artwork. And cob is used for more than just walls - people sculpt in all kinds of clever nooks and shelves, stairways, seating and even fire places and stoves. This extreme customization is an excellent rejection of the resale value pressure to treat our homes as products, best kept generic and free of any permanent personalization.

Modern 'Oregon' cob is a more tightly-controlled mix of materials allowing for thinner, stronger designs than historical cob buildings (which were generally just built out of what was on-hand) tended to use.

Cob has a few advantages and disadvantage:

Advantages:

- It's cheap - entire houses can sometimes be built for thousands to low tens of thousands of dollars.
- It's low carbon and uses very few refined materials. Most cob homes use rubble foundations, wood for spans and floors, and locally-sourced clay, sand, and plant fiber for the main structure. The most 'normal' part of the structure is likely the roof.
- Cob itself is fireproof and is often used to make ovens - by contrast, many modern construction materials (plastic siding, EIFS foam, foam insulation) are petroleum based and burn quite readily. (Even synthetic materials used for interiors are comparatively flammable).
- Anecdotal evidence and recent testing show cob walls are highly resistant to earthquakes. Unlike cement which tends to shake apart in an earthquake, lumps of cob are woven together in the building process to form one large mass reinforced by fiber. Also, unlike cement, cob is easily repaired with the same material it was built from, and if torn down, there is no waste to be disposed of — only earth that can be returned to the ground or soaked in water and reused to build another room or house.

Disadvantages:

- Cob isn't a great fit for every region. It does not have a very high insulation value per thickness and most of its temperature regulation benefits are done via its mass. This is great for places where the temperature swings between hot days and cold nights, but if it's freezing outside day and night for months or perpetually hot and humid, this mass and inertia may work against you as you try to maintain a comfortable temperature indoors. You can find more discussion on where cob makes sense and how to account for local conditions here.
  - In particularly cold, wet regions, cob is sometimes used for interior walls and structures, while more 'normal' insulated walls are used on the exterior. Cob is a popular way to build thermal mass heaters and rocket mass heaters.
- Many regions have strict building codes written around modern construction practices. Cob

buildings generally aren't included in these regulations and may be specifically excluded, leading to time and money wasted changing the codes and educating lawmakers, awkward workarounds like only building small 'accessory' buildings, or just building illegally.
- Cob is a natural material and where used outside, will need upkeep and maintenance, especially in wet areas as rain can wash it away. Many designs call for large, overhanging roofs and special coatings to protect it (and some, like lime, may take more CO2 to produce than expected). There are some other interesting ways to waterproof it.

Salvage in cob buildings:

There are some interesting opportunities for salvage in a cob structure. The foundation is often a trench filled with 'rubble' - this is usually fieldstone but there's no reason it couldn't be actual broken up concrete, which would otherwise end up in a landfill.

The process of sculpting cob and general reliance on flowing curves and irregular shapes allows for some more creativity in where parts are sourced. Car windows often have curved irregular shapes which would be annoying to frame into a wood building but would be fairly easy in cob.

Perhaps the most famous examples of reuse in cob buildings and earthships are the colorful glass bottles often used to let in light.

More info:

Sometimes seeing real life discussions between people using a solarpunk practice can provide some perspective and ideas - here's a handful of forum threads on cob construction:
https://permies.com/f/76/cob