Sustainable Technology Park at California Polytechnic State University San Luis Obispo

Handbook of Guidelines : Ecology meets Technology

Sam Vigil
Professor of Environmental Engineering,
Civil and Environmental Engineering Department
Cal Poly - SLO

Renewable Materials and Construction Waste Management

RENEWABLE MATERIALS

The Technology Park can be a model of green building. Maximum use should be made of renewable and recycled construction materials. Examples of such materials include straw bale construction, compressed straw panels and the use of materials with high recycled content.

Straw Bale Technology - A local example of straw bale technology is currently under construction at the San Luis Obispo Botanical Garden (SLOBG) , located approximately 5 miles west of the Cal Poly campus on Highway 1 in the El Chorro Regional Park. The 3600 square foot Education Center is a showcase of sustainable construction techniques. It will be the first public LEED certified building in San Luis Obispo County. The Education Center includes passive solar design features, an on-grid photovoltaic system, an on-site wastewater treatment system, and water conservation features.

Figure 1 is a photo of the architectural model of the Education Center. More details on the center can be found on the website, www.slobg.org.

The straw bales provide thermal mass and insulation. They are also highly fire resistant. Technical information on straw bale construction can be found on the website of the Straw Building Association, http://www.strawbuilding.org/.

The Straw Bale Registry has links to virtually every straw bale building in the United States, including 75 in California, http://sbregistry.greenbuilder.com/. Notable among these buildings is the Claybourne and Churchill Winery, Wine Cellar Building, San Luis Obispo County, the first commercial straw bale building in California. The website contains a photo history of the construction process of the building, http://www.claibornechurch.com.

Figure 1 – San Luis Obispo Botanical Garden Education Center

Figure 2 – Interior View of Straw Bale Wine Cellar

Figure 3 – Exterior View of Straw Bale Wine Cellar

Compressed Straw Panels – Straw bale construction tends to be more expensive than standard construction practices. An alternative sustainable construction technique is the use of compressed straw panel board. One product, WOODSTALK fiberboard, is produced from wheat straw and polyurethane resin. The product can be used for flooring underlayments, door cores, and other non-structural uses where particleboard could be used. It is available nationally through building supply dealers. Information can be found at http://www.dow.com/bioprod/.

Compressed straw panels for structural uses are marketed by AgriBoard Inc. These panels can be used in similar applications to construction grade plywood. The product is produced in Texas and shipped FOB from the factory throughout the U. S. , www.agriboard.com . The product offers many of the characteristics of straw bale construction including thermal mass, fire resistance, and insulating properties.

Recycled Materials in Construction – There are many opportunities to use recycled-content building products (RCBP) in the construction of new buildings. The Construction Specifications Institute (CSI), has developed a system for identifying construction and building products called *CSI MasterFormat*, the construction industry's standard for formatting construction specifications. *CSI MasterFormat* has 16 Divisions. The Divisions, which include recycled materials, are given in Table 1.

Table 1 – *CSI MasterFormat* Division

Division	Products
2: Sitework	Sound Walls, Paving and Surfacing, Pavement Marking, Road Base, Sanitary Sewage, Walk, Road, and Parking Appurtenances
3: Concrete	Concrete Accessories, Concrete Materials, Concrete Reinforcement, Permanent Formwork
4: Masonry	Concrete Masonry Units
5: Metals	Cold Formed Metal Framing
6: Wood and Plastics	Board Paneling, Finish Carpentry, Plastic Lumber (Marine Applications), Plastic Lumber, Rough Carpentry, Structural Panels, Solid Polymer Fabrications
7: Thermal and Moisture Protection	Building Insulation, Shingles and Roofing Tiles, Siding
9: Finishes	Acoustical Ceiling Tiles, Carpet and Carpet Underlayment, Ceramic Tile, Gypsum Board, Painting Materials
10: Specialties	Toilet Compartments, Identifying Devices

After California Integrated Waste Management Board, "Designing With Vision… A Technical Manual for Material Choices in Sustainable Construction," Publication #431-99-009, Revised July 2000.

Table 2 describes the recycled products in each *CSI MasterFormat* Division.

Table 2 – Recycled Product Descriptions

Division	Product Name	Product Description
2: Sitework	Sound Walls	Made from a variety of recycled materials, such as post-consumer plastic and crumb rubber from old tires.
	Paving and Surfacing	Recycled construction products for paving and surfacing include recycled asphalt concrete, modified asphalt, and rubberized asphalt.
	Paving and Surfacing	Recycled construction products for paving and surfacing include recycled asphalt concrete, modified asphalt, and rubberized asphalt.
	Pavement Marking	Glass beads made from 100 percent recycled-content glass are used to provide reflectivity for painted and thermoplastic traffic stripes and pavement markings for highway delineation.
	Road Base	Recycled aggregate base (or crushed miscellaneous base) is used under the wearing surface of a road or paved surface. The material is made from crushed demolition concrete and/or asphalt concrete.
	Sanitary Sewage	Septic tank system made from 75 percent high-density polyethylene (HDPE), and drainage and sewer pipes containing post-consumer and postindustrial plastic.
	Walk, Road, and Parking Appurtenances	Plastic parking stops, bollards, and speed bumps from post-consumer plastic.
3: Concrete	Concrete Accessories	Expansion joint filler made from post-consumer fiber and/or wood waste
	Concrete Materials	Fly ash, a coal combustion by-product that can be used as a replacement for up to 25 percent of the Portland cement in concrete foundations. Improves the durability and workability of concrete.
	Concrete Reinforcement	Steel reinforcement bars from pos-tconsumer scrap metal. 100% recycled content bars are available from Tamco, a California steel mill.
	Permanent Formwork	Molded insulating block-like forms are made from recycled polystyrene, cement and additives containing up to 80 percent post-consumer and postindustrial plastic.
4: Masonry	Concrete Masonry Units	Concrete masonry blocks made with recycled-content.
5: Metals	Cold Formed Metal Framing	Light gauge steel studs with about 28 percent recycled content
6: Wood and Plastics	Board Paneling	Decorative panels made from old newspapers.
	Finish Carpentry	Solid sawn redwood or fir exterior trim is available from re-milled salvaged lumber. Exterior trim is also being fabricated from rigid post-consumer polystyrene, which simulates natural wood.

Table 2 – Recycled Product Description (ongoing)

6: Wood and Plastics	Plastic Lumber (Marine Applications)	Marine products must be resistant to moisture damage, mechanical abrasion, chemical attack, and destruction by marine animals. Manufactured from inert secondary and post-consumer materials, including high-density polyethylene, scrap tires, crumb rubber, fiberglass and cement.
	Plastic Lumber	Plastic lumber products may contain post-consumer and/or post-industrial plastic and may be either a single plastic type or co-mingled plastics. Plastic lumber composites incorporate combinations of distinct material types, such as post-consumer plastic and postindustrial wood fiber or crumb rubber and post-consumer plastic.
	Rough Carpentry	Engineered wood products (EWP) use less wood for equal or greater load bearing characteristics. Examples of EWP are glulams, laminated trusses, I-joists, laminated veneer lumber and oriented strand board. Generally, these products are not recycled-content products but, rather, include materials recovered at timber mills.
	Structural Panels	The most common type of panel has an expanded polystyrene foam core faced with oriented strand board made from fast growing second growth trees. In some cases, the foam core is made from recycled polystyrene. Another type of structural panel uses Kraft paper in a honeycomb configuration (treated with phenolic resins) and facer material such as oriented strand board.
	Solid Polymer Fabrications	Countertops manufactured from post-consumer and post-industrial plastics.
7: Thermal and Moisture Protection	Building Insulation	Recycled building products are very common in weatherization products, such as cellulose made from old newspapers and fiberglass batt insulation. Fiberglass insulation sold in California is subject to minimum content law (requires a minimum of 30 percent post-consumer glass content).
	Shingles and Roofing Tiles	Products include sheet metal roofing, metal shingles, shakes and tile made from post-consumer aluminum and steel; cement composites, containing recovered materials, such as fly ash and wood fiber; roofing shingles made from post-consumer rubber, plastic and glass; recycled roofing products include roofing mats (walkway pads) and roof membranes made from post-consumer plastic; and roofing felt paper made from post-consumer paper.
	Siding	Engineered wood siding manufactured from wood waste using various binders, such as linseed oil; recycled-content vinyl siding that incorporates a substrate made from post-consumer plastic; wall panels manufactured from aluminum, steel or copper ranging between 35 percent to 95 percent post-consumer metal; siding manufactured from Portland cement composites that use silica cellulose fiber containing some post-consumer paper; solid sawn redwood or fir siding manufactured from re-milled salvaged lumber.

Table 2 – Recycled Product Description (ongoing)

8: Doors and Windows	Doors Windows/ Skylights	Windowsills and door jams manufactured from rigid post-consumer; door rails and windowsills manufactured from a post-consumer plastic composite substrate; windows and skylights fabricated from post-consumer aluminum, plastic and postindustrial glass; door moldings manufactured from densified polystyrene.
9: Finishes	Acoustical Ceiling Tiles	Acoustical ceiling tiles made from post-consumer materials including old newsprint and mineral wool.
	Carpet and Carpet Underlayment	Carpet is made from recycled plastic beverage bottles (PET). Carpet padding is made from tire scrap, post-consumer plastic or post-industrial fiber and from scraps from furniture and car seat manufacturers and carpet layers. Broadloom and carpet tiles are available in level loop and open weave fiber configurations.
	Ceramic Tile	Floor tiles manufactured from post-consumer recycled glass, post industrial grinding paste from the computer industry, and post-industrial mining waste from the sand and gravel industry. The tile is available in a variety of hues and tones.
	Gypsum Board	Wallboard from post-consumer paper facing and backing and post-consumer and/or post-industrial gypsum is available at about the same cost as virgin wallboard products.
	Painting Materials	A variety of recycled paints are made from remanufactured paint from municipal paint recycling programs. (San Luis Paints has a locally manufactured product)
10: Specialties	Toilet Compartments	Floor mounted overhead braced or ceiling mounted toilet compartment partitions made from recycled, high-density polyethylene are readily available on the market.
	Identifying Devices	Plastic signs are available from post-consumer plastic for indoor and exterior applications.

After California Integrated Waste Management Board, "Designing With Vision… A Technical Manual for Material Choices in Sustainable Construction," Publication #431-99-009, Revised July 2000.

The California Integrated Waste Management Board (CIWMB) has identified hundreds of vendors for these recycled building products. They are listed in *CSI MasterFormat* Division order in Chapter 6 of "*Designing With Vision…A Technical Manual for Material Choices in Sustainable Construction,"* Publication #431-99-009, Revised July 2000, available for downloading at:

http://www.ciwmb.ca.gov/Greenbuilding/Pubs.htm

More information on the use of recycled construction materials can be found on the CIWMB Green Building website:

http://www.ciwmb.ca.gov/GreenBuilding/Toolkit.htm

Case Study – Monterey County Regional Waste Management District – One of the best examples in California of the use of recycled construction materials is the Education Building at the Monterey County Regional Waste Management District (MCRWMD) site in Seaside, California. The site houses a Materials Recovery Facility, compost system, and landfill with energy recovery. The Education Building serves as both the administrative headquarters of the site and as a public education and outreach center. The building was constructed using as many recycled building products as possible as listed in Table 3.

Figure 4 – Education Building at the Monterey County Regional Waste Management District

Figure 5 – Recycled Building Materials Display at the MCRWMD Education Building

Table 3 – Recycled Materials in the MCRWMD Education Building

Fiberglass Insulation
Linoleum
Carpeting
Ceramic/Glass Tile
Oriented Strand Board Panels
Wood Composite Truss Joists
Plastic Restroom Partitions
Newspaper Based Wall Paneling
Recycled Content Roofing Shakes
Recycled Parking Lot Road Base
Recycled Plastic Parking Stops
Green Waste Compost on Landscaping
Recycled Plastic Benches

The recycled materials used in the Education Building are highlighted in a permanent display as part of the public outreach mission of the District. A similar display and outreach program should be part of the Technology Park.

References – Renewable Materials

Agriboard Industries, compressed straw structural panels.
www.agriboard.com

California Integrated Waste Management Board, "*Designing With Vision… A Technical Manual for Material Choices in Sustainable Construction,"* Publication #431-99-009, Revised July 2000. Available for downloading in four parts from: http://www.ciwmb.ca.gov/Greenbuilding/Pubs.htm

California Integrated Waste Management Board, Green Building Toolkit
http://www.ciwmb.ca.gov/GreenBuilding/Toolkit.htm

California Straw Building Association, technical and standards information for straw bale buildings.
http://www.strawbuilding.org/

Claybourne and Church Winery, Straw Bale Wine Cellar Building.
http://www.claibornechurchill.com/

Dow BioProducts, Ltd., WOODSTALK fiberboard products.
http://www.dow.com/bioprod/

Straw Bale Registry, listing of numerous straw bale buildings throughout the United States.
http://sbregistry.greenbuilder.com/

CONSTRUCTION WASTE MANAGEMENT

According to sampling of solid waste disposed in California in the 1999 statewide waste characterization study, construction and demolition (C&D) waste materials account for almost 12 percent of the solid waste stream. C&D materials can include lumber, paper, cardboard, metals, masonry (brick, concrete, etc.), carpet, plastic, pipe (plastic, metal, and clay), drywall, rocks, dirt, and green waste related to land development.

As required by the California Integrated Waste Management Act, all California cities and counties must have reduced solid wastes deposited in landfills 50% by the year 2000. San Luis Obispo County has met this goal but must constantly monitor waste disposal to keep the percentage of waste reduction at the 50% or higher level.

The City of San Luis Obispo and the County of San Luis Obispo have passed ordinances requiring C&D recycling. Cal Poly is not bound by these regulations but has recently voluntarily adopted the city regulations on new dormitory construction. The city regulations require that a Recycling Plan be prepared as part of the Building Permit process (note: Cal Poly is not required to obtain city building permits). The Recycling Plan includes the following elements:

1. The estimated volume or weight of project construction and demolition debris, by materials type, to be generated;
2. The maximum volume or weight of such materials that can feasibly be diverted via reuse or recycling;
3. The vendor or facility that the applicant proposes to use to collect or receive that material; and
4. The estimated volume or weight of construction and demolition debris that will be landfilled.

To assist in estimating volumes and weights of construction waste, Table 4 provides estimating factors based on project square footage, and Table 5 provides conversion factors.

Table 5 – Conversion Factors for Construction Waste

Waste	lb/yd³	yd³/ton
Mixed Waste	350	5.7
Inerts	1400	1.4
Drywall	500	4.0
Metals	150	13.3
Lumber	300	6.7
Cardboard	100	20.0

The County Integrated Waste Management Authority (IWMA) which monitors waste disposal and provides recycling information to the public has developed a list of certified construction waste recyclers. Table 6 lists all of recyclers listed on the IWMA website:

http://www.iwma.com/directory-aj/construction.html

Additional C&D recyclers state-wide can be found on the CIWMB website:

http://www.ciwmb.ca.gov/ConDemo/Recyclers/

After the project is completed, the contractors building the Technology Park will be required to document the volume or weight of construction waste leaving the site and provide receipts proving that the wastes were recycled. The target recycling rate is at least 50%.

Construction waste can either be separated at the site and transported by the contractor to a recycling center or as is more common, subcontract waste processing to a certified roll-off company who will provide a drop-off bin for mixed construction waste and transport the waste to there own recycling facility.

Contractors should contact the City of San Luis Obispo Building Department and the County Integrated Waste Management Authority for the latest regulations and list of certified recyclers.

Table 4 – Construction Waste Estimates – Pounds/Square Foot Constructed

Project Type	lb/ft²	Project Type	lb/ft²
Commercial Additions	27	Multi-Family New Const.	9.5
Commercial Demolition	21	Single Family Addition	33
Commercial New Const.	13	Single Family Demo	83
Commercial T& I	10	Single Family Custom	7.5
Multi-Family Addition	4.5	Single Family Tract	3.2
Multi-Family Demo	16	Single Family Remodel	39

Table 6 – Construction Waste Recyclers – San Luis Obispo Area (February 2005)

Gator Crushing & Recycling
2363 Willow Road (Highway 1)
Nipomo 995-1097
Accepts porcelain toilets, concrete, asphalt, rock and brick.
Open M-F 8-4

Heilman's Salvage and Metals
6450 Rocky Canyon Road
Atascadero 466-4893
Recycles all metal and electrical wiring.
Open W-Sat 9-5

Pacific Coast Lumber
40 Zaca Lane
San Luis Obispo 543-5533
Accepts wood and trees.
Open M-F 8-5, Sat 9-1

R&R Rolloff Service
P. O. Box 6332
Arroyo Grande 343-5595
Recycles all construction debris (toilets, wood, concrete, asphalt, glass, metal, cardboard, etc.). Call to request rolloff bin.
Open M-F 7-5

R. Burke Corporation
865 Capitolio Way
San Luis Obispo 543-8568
Accepts porcelain toilets, broken concrete, asphalt, rock and brick. Please call for more information.
Open M-F 8-4

San Benito County:
Zanker Road Landfill
Contact: Mike Gross
Facility location: Gilroy, California (408) 263-2384
Accepts asphalt shingles for recycling. Call for price info
www.z-best.com

After San Luis Obispo County Integrated Waste Management Authority http://www.iwma.com/directory-aj/construction.html

References – Construction Waste Management

San Luis Obispo County Integrated Waste Management Authority, directory of local construction waste recycling facilities.
http://www.iwma.com/directory-aj/construction.html

California Integrated Waste Management Board, C&D Debris Recyclers Database
http://www.ciwmb.ca.gov/ConDemo/Recyclers/