

MATERIALS

Finishes

Interior Paint	111
Carpet	115
Wood Flooring and Alternatives	121
Linoleum	127
Vinyl Flooring	129
Ceramic and Stone Tile	131
Colored Concrete	135

Electrical

Lighting	139
Lighting Controls	145
Photovoltaics	149

Wood

Cabinetry and Millwork	155
Lumber and Alternatives	161

Exterior Envelope

Windows	167
---------	-----

Site

Paving (glossary of terms)	173
----------------------------	-----

Interior Paint

Traditional oil-based¹ and latex paint² contain harmful chemicals and compounds which offgas into the atmosphere, affecting the health of residents and workers, and producing ground level ozone. As the cost of paint is relatively inexpensive compared to the labor to apply it, "greener" paints can offer a significant way to reduce indoor air pollution at little or no extra cost. "Greener" paints have low or zero Volatile Organic Compounds (VOCs). Healthy paint formulas have improved substantially over the last several years so that low and no-VOC paint can perform as well as traditional paint. Most major manufacturers carry lines of low or zero-VOC paint whose cost is comparable to conventional mid to high quality paint. Some "natural paints" don't contain any petroleum products, instead using plant-based resins and chalk-based pigments. Recycled paint is yet another "green" option. LEED Credits can be obtained by using "greener" paints.³



No-VOC interior paint was used throughout the Drachma Housing Rehab Project in West Oakland.

Key Concepts

Durability and Ease of Maintenance

Careful preparation is critical to a long lasting paint job with any paint. All surfaces must be clean with visible peeling and cracking removed. When painting an older building, be sure to test for the presence of lead and use appropriate lead safe techniques and disposal methods for the prep work.⁴ Consider using high or semi-gloss paints for areas that will need washing, such as kitchens, bathrooms, and children's rooms.

For ease of maintenance, the owner may want to establish some type of standardization within and between buildings. In addition, extra supplies should be kept on hand and maintenance manuals should provide supplier information and specify type and location of each paint used.⁵

Indoor Air Quality

Conventional paints release VOCs, which are a major indoor air pollutant as well as serious smog contributor.⁶ VOCs are responsible for the distinctive smell of new paint, and commonly cause headaches and allergies. The American Lung Association reports that VOCs can produce a number of more serious health problems such as eye and skin irritation, lung and breathing problems, nausea, muscle weakness and liver and kidney damage.⁷ VOCs

important quote...

"Regardless of the color scheme, whenever I repaint a room, I paint the whole room - trim and walls - antique white semi gloss." - Maintenance staff

Paint components...

Paint consists of three basic components:

- **Pigment** gives the paint its color and sheen.
- **Binder** gives paint hardness, adhesion and resistance properties.
- **Solvent** determines a paint's viscosity and ease of application. It is also what gives paint its odor.

are typically ten times higher indoor than outdoors, and up to 1000 times higher after a new coat of paint. Traditional paints contain a high percentage of VOCs so that they will dry faster. However, most indoor and some outdoor projects can be done using low or no-VOC paints with equal performance.

While all household paints must meet EPA regulations, which call for no more than 250 grams per liter in latex and 380 grams per liter in oil-based paints, these limits are based primarily on reducing ozone formation in the outside air and not on healthy indoor air quality. Many green building experts recommend using paints with no more than 150 grams / liter of VOCs for non-flat paint, and no more than 50 grams / liter of VOCs for flat paint.⁸ The back of the paint can lists the VOC level, and greater detail about the paint should be available on the manufacturer's Material Safety Data Sheet (MSDS), often listed on their website.

Perhaps the greatest benefit from using low/no-VOC paint is when painting is performed in an occupied building. Therefore, maintenance staff should be educated about the benefits of low-VOC paint to encourage the ongoing use of such paints even after the building becomes occupied.

Recycling

Recycled content paint provides the environmental benefit of keeping existing paint from the landfill and avoiding the manufacture of new paint. Recycled paint is gathered from household paint collections and consolidated with similar colors to produce larger quantities. This process reduces color choice, and it is likely that recycled paint has a high VOC content.

Resources

"Greener" Paints fact sheet by Green Resource Center.
www.greenresourcecenter.org

GreenSeal is an independent non-profit that rates products that do not contain harmful solvents and verifies VOC limits.
www.greenseal.org

Scientific Certification Systems (SCS) verifies zero-VOC product claims of paint manufacturers. www.scs1.com

HUD Lead Paint Safety: A Field Guide for Painting, Home Maintenance and Renovation Work. www.hud.gov/offices/lead/training/LBPguide.pdf

"American Pride" latex paint is made from castor bean oil, using renewable materials and improving indoor air quality. "2003 Building Green Top-10 Products". www.buildinggreen.com/press/topten/top-10-list.cfm

1 Alkyd paint has replaced what we used to call oil-based paint. Alkyds are synthetic resins that are combined with vegetable oils such as linseed, soya, or tung, to produce clear resins. Alkyd paint has high levels of volatile organic compounds (VOCs), which are carbon-based chemicals that are able to rapidly evaporate.

2 Latex paint is thinned with water, and is the type of paint most commonly used in housing. Two common types of latex are vinyl acrylic latex (PVA) and acrylic latex. Latex paint is available in low and zero VOC.

3 LEED Credits: Materials and Resources Section, MR 4 Recycled Content (for recycled content paints), MR 6 Rapidly Renewable Materials (for milk and plant-based paints); and Indoor Environmental Quality Section, IEQ. 4.2 Low-Emitting Materials (paints).

4 See *HUD Technical Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*, www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm, as well the more user-friendly guide, *HUD Lead Paint Safety: A Field Guide for Painting, Home Maintenance and Renovation Work*. www.hud.gov/offices/lead/training/LBPguide.pdf

5 Extra supplies should include at least one un-opened can of each color of paint used. The can should be clearly marked with color, area where used, and date. The paint should be stored indoors in a dry location.

6 According to the Environmental Protection Agency, 9% of the airborne pollutants creating ground level ozone come from the VOCs in paint. Low and zero VOC paints have little or no smog-forming emissions ("Greener" Paints Factsheet, Green Resource Center, greenresourcecenter.org).

7 "Greener" Paints Factsheet, Green Resource Center, www.greenresourcecenter.org.

8 Green Seal requirements for low-VOC paints, <http://www.greenseal.org/standards/paints.htm>

MATERIALS

FINISHES

Guidelines for sustainable affordable housing

Carpet

Carpet is made by attaching yarns to a coarse fiber backing. The yarns can be made with natural or synthetic fibers. Likewise, the backing can be comprised of either natural materials (jute, for example) or synthetic components such as polypropylene. Natural fiber carpeting, though not without its environmental costs, is generally considered a more ecologically sensitive product as it is derived from renewable resources and requires less energy to produce than synthetic materials. However, natural carpet is typically more expensive, less readily available, and less durable than synthetic products and for these reasons, it is rarely used in affordable housing. Nylon fiber carpet with a synthetic backing is more commonly used for reasons of cost, durability, and moisture protection.

Carpet comes in two general types: level loop, which has a harder texture and is more durable; and cut pile which has a softer texture that may be appropriate for low traffic areas such as bedrooms in individual units. Combinations of loop and cut pile are also available.

In addition, there are various techniques for dyeing carpet. "Solution-dyed" carpet is generally the most preferable as color is added to the molten polymers from which the fibers are extruded. The color extends through the yarn, which ensures better color fastness and cleanability and reduces the likelihood of staining. When stains do occur, solution dyed carpet can better withstand the use of powerful cleaning agents, which may damage or cause fading in other types of dyed carpet. Other dyeing methods include: stock dyeing or color applied after the filaments are extruded but prior to spinning; yarn dyeing; piece or continuous dyeing; and printing where color is applied after the yarn has been tufted.¹



Hamid Hakimi

The nylon carpeting at the Oak Park Apartments in Oakland includes 50% recycled content (25% post consumer content) and can be picked up and recycled at the end of its effective life through a manufacturer sponsored recycling program.

environmental issue...

- ✓ Wall to wall synthetic floor covering may be one of the worst degraders of Indoor Air Quality. It can off-gas volatile organic compounds (VOCs), and trap dirt and other allergy causing contaminants.



3% of urban landfill volume is carpet

Key Concepts

Durability and Ease of Maintenance

When evaluating initial installation costs, carpet is generally the least expensive flooring option. However, most carpet wears quickly, is easily stained, and requires frequent replacement. It is considered a less durable solution than many hard flooring surfaces such as linoleum, tile, and even vinyl flooring. In addition, carpet is often replaced at unit "turnovers" when tenants leave a unit and before new residents move in. When such replacement occurs before the carpet is completely worn, the effective life span of the carpeting is further reduced and its associated "life cycle costs" increase. When weighing the costs of carpet, it is important to consider not only the initial purchase and installation price, but also the expense and timetable for replacement.

When damaged, carpet can be difficult to patch or repair. Thus, even minor damage or staining can require the replacement of entire rooms of carpeting. One option for minimizing replacement costs is to specify **Carpet Tiles** instead of carpet rolls. Carpet tiles are made in the same manner as carpet but they are applied as individual tiles which can be selectively removed and replaced. This allows for smaller scale repairs and replacement of damaged, stained, or worn areas while permitting the continued use of the undamaged portions of the carpeted area. Replacement costs as well as waste generation is reduced.

Careful selection of locations for carpet installation may further reduce maintenance issues and cut down on replacement costs. Carpet is generally not recommended for high traffic areas such as hallways, lobbies, and community rooms, and should never be specified for areas which are potentially subject to heavy staining (such as trash rooms and adjoining areas) or significant moisture (such as laundry facilities). Carpeting on stairs is especially susceptible to rapid deterioration. Rubber treads are highly durable and, like carpet, will help to control noise.

Another option for high-traffic areas is to specify wood or linoleum for long-term maintenance and cleanliness, and employ area rugs or carpet runners for sound control and warmth.² The advantage of area rugs and runners is that they can be removed and cleaned periodically and then re-installed, thus avoiding the need to discard worn carpeting and purchase new.

When carpet is installed in areas subject to high use, level loop types are generally preferable as they will not show wear patterns as easily as cut pile carpeting. Some owners elect to use multiple colors of carpeting in high traffic areas. The border of the carpet contrasts with the center of the carpet. This can hide stains and allow for replacement of the high traffic center while allowing the border to remain intact.

specification tip...

Consider hard flooring such as wood or linoleum for long-term maintenance and cleanliness, with area rugs for sound control and warmth. The area rugs can be removed and cleaned periodically.

Indoor Air Quality

Wall to wall synthetic floor covering may be one of the worst degraders of Indoor Air Quality. Carpet is difficult to clean thoroughly and will tend to trap dust, dirt, fumes, mold, and other allergy-causing contaminants. If carpet becomes wet and is not dried thoroughly within 24 hours, it can support mold and mildew, causing unpleasant odors and possible allergic reactions.³ Carpet should be vacuumed regularly and cleaned every 12 to 18 months with a commercial grade carpet vacuum or HEPA vacuum (high efficiency particulate air filtered vacuum) to limit the accumulation of contaminants.

In addition to trapped contaminants, the dyes, adhesives and material content of carpet may "off-gas" volatile organic compounds (VOC's) for a period of days to months or even years after installation.⁴ Carpeting also has the ability to absorb VOC's from the environment (such as paint, cleaning products, smoke from cigarettes, building materials and furnishings) and slowly re-release them over time.⁵ The most intense off-gassing typically occurs during the first 48-72 hours after installation. Though often difficult to schedule, it can be a good idea to let carpeted spaces air out for several days before allowing tenants or residents to occupy them.

Increasingly, carpet products and adhesives are available which are less toxic and release fewer VOC's.⁶ Specifying carpet and pads with Carpet and Rug Institute's CRI Green Label will ensure that the product has met standards for low VOC emissions under CRI's Indoor Air Quality Testing Programs.⁷

Carpet removal is often performed in occupied buildings with little or no dust control measures. Carpet removal can significantly degrade IAQ if dust (including leaded dust) and allergens are allowed to migrate into occupied areas.⁸ Precautions should be taken during carpet removal to minimize the generation of dust ("safe work practices") and prevent the spread of dust to occupied areas ("containment").

Recycling

The removal and disposal of carpeting is a significant environmental issue. Synthetic carpet can take up to 100 years to decompose, and it is estimated that 3% of urban landfill volume is carpet. More than 2 million tons of carpeting are landfilled every year.⁹ One approach to mitigating the negative environmental effects of carpet use and disposal is to recycle carpet at the end of its effective life. Increasingly, programs are available which will pick up both used carpet and carpet pads and deliver them to a recycling center. These reclaimed carpet products serve as raw material either for new carpeting (known as "closed loop recycling") or for other products such as auto parts, plastic lumber, outdoor furniture, etc. (considered "downcycling" or "open loop recycling").

Shopping for Green Carpet... Courtesy of Green Seal

- ✓ *Buy refurbished carpet whenever possible;*
- ✓ *Specify carpet with high overall recycled content;*
- ✓ *Ask whether environmental leasing or take-back programs are provided to ensure that the carpet will be replaced only as necessary and reused or recycled by the producer;*
- ✓ *Use carpet tiles where appropriate to extend the life of the installed floor covering;*
- ✓ *Buy carpet made from recyclable materials and likely to be easily accepted for recycling under existing programs. Carpet containing nylon 6 face fiber and vinyl-backed carpets are currently recyclable. No recycling programs currently exist for polyester carpet;*
- ✓ *Consider purchasing carpet made of wool or other natural fibers if your primary concern is the use of non-renewable resources.*

continued on next page...

Shopping for Green Guide continued...

Courtesy of Green Seal

- ✓ Buy carpet that is solution-dyed;
- ✓ Buy carpet that meets CRI Indoor Air Quality standards (Green Label program);
- ✓ Ensure that low VOC adhesives (CRI certified) are used during installation;
- ✓ Buy a carpet product that is consistent with the desired performance level, expected use pattern, and replacement schedule;
- ✓ Select an appropriate color for the carpet application. Light colors tend to get soiled easily and may require the frequent use of harsh cleaning chemicals and/or replacement.

www.greenseal.org

The recycling of carpet, however, continues to face many challenges, the most significant of which is the cost of collection, sorting, and transportation of used carpet to recycling centers. Some carpets are more easily recycled than others and some recycling centers will accept only certain types or brands of carpet. Currently, it is estimated that less than 5% of carpet is being recycled.¹⁰ Be sure to ask suppliers about recyclability of their products and the availability of programs which will pick up and/or accept worn carpeting for re-use.¹¹

Project sponsors can further support the recycling of carpet by specifying products with recycled content. Recycled content can refer to both "post industrial" waste (the use of carpet trimmings produced during the manufacturing process) and more importantly "post consumer" waste (carpeting which had been used in a commercial or residential application and then is reclaimed for integration into new carpet). Increasingly, carpet manufacturers are offering lines of carpet which include significant quantities of recycled content.

Other Design Considerations

Sound attenuation and Sense of Warmth: Carpet is known for its sound deadening qualities and warmth. These qualities may be particularly important when providing housing for populations accustomed to institutional settings. In residential applications in particular, carpet is valued for its buffering of noise between units.

Softness: Because carpet is soft underfoot and to the touch it is often considered an appropriate choice for flooring in childcare centers for infants and toddlers.

Accessibility: Exposed edges should be fastened to floor surfaces with trim along edge. Carpet with a pile height of over ½" must have a transition ramp between surfaces.

Installation: In general, direct glue down applications are more durable and are considered more appropriate for disabled and senior applications as they are less likely to bunch and create tripping hazards. However, tack-down applications limit the use of adhesives, thereby reducing the potential for VOC off-gassing. The method of carpet installation should not effect its ability to be recycled.

Rehabs & Carpet: Carpet is often favored in rehabs because it can be installed over existing, uneven subfloors.

1 Carpet and Rug Institute, www.carpet-rug.com

2 When using runners or area rugs, be sure to carefully tape or affix carpet edges to hard flooring so as to avoid creating a trip hazard.

3 For a description of methods for addressing water-damaged carpet, as well as repairing and restoring stained carpet, see "Partitions, Ceilings, Floors and Stairs," The Rehab Guide, Vol. 5, by U.S Department of Housing and Urban Development, www.huduser.org/publications/destech/rehabgds.html.

4 "Greener" Carpet, Green Resource Center, www.greenresourcecenter.org

5 The Rehab Guide, Vol. 5.

6 Green Seal is an independent, non-profit organization that strives to achieve a healthier and cleaner environment by identifying and promoting products and services that cause less toxic pollution and waste, conserve resources and habitats, and minimize global warming and ozone depletion. Green seal's standard for industrial adhesives calls for VOC levels of no more than 150 g/l for flooring adhesives. www.greenseal.org.

7 Carpet and Rug Institute, www.carpet-rug.com

8 Very high lead readings from "dust wipes" have been obtained from samples taken from floors after carpeting has been removed. Therefore, carpet removal in buildings constructed before 1978 should be performed in accordance with the protocols described in the HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, Chapter 11, www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm.

9 Choose Green Report: Carpet, Green Seal, www.greenseal.org

10 California Integrated Waste Management Board, C & D Recycling Program, www.ciwmb.ca.gov.

11 See www.ciwmb.ca.gov/condemo/factsheets/carpet.htm for more information, including a list of recycling centers in California.

MATERIALS

FINISHES

Guidelines for sustainable affordable housing

Wood Flooring and Alternatives

Wood flooring is praised for its aesthetics, warmth, durability and ease of maintenance. Though often considered too expensive for affordable housing, it can be an appropriate flooring choice for community spaces, hallways and common areas. It is available in a variety of wood types, including oak, pine, and maple, and comes in strips (1-1/2" to 3-1/4" widths), planks (3" to 18" widths) or tiles/parquet. Wood flooring can either be "solid" where the wood grain extends through the depth of the plank, or "engineered" where layers of wood are glued together with the grain of each layer running in a different direction. Engineered wood products are advantageous in that they can make use of smaller pieces of wood (thus helping to preserve larger, old-growth trees) and are generally considered to be more dimensionally stable than solid wood flooring. However, the adhesives used in the plank's assembly should be evaluated carefully to minimize the off-gassing of harmful VOC's. In addition, engineered wood flooring may have a shorter lifespan because the depth of the top veneer may permit fewer sanding/refinishing cycles.

The use of wood as a construction material has come under greater scrutiny in recent years. Though it is a common and essential part of standard construction practice in the U.S. (most low-rise and smaller scale buildings in the U.S. are wood-framed), wood, and its extraction through logging, contributes to a variety of environmental problems, such as loss of wildlife habitat, soil degradation and erosion.

Because of the negative environmental impacts associated with traditional logging practices, many project sponsors have begun to look for alternatives to standard wood products. For example, wood products certified by the Forest Stewardship Council (FSC) are increasingly available (see Section 3, Lumber and Alternatives).¹ The FSC oversees a process of certification which recognizes wood derived from sustainably managed forests. Unfortunately, certified wood products tend to be more expensive than typical wood products



Cork flooring at 555 Ellis Street in San Francisco provides an attractive, durable surface for the community room

specification tip...

Wood, cork, and bamboo flooring contribute to good indoor air quality as they are easy to clean and maintain free of many of the contaminants which can become embedded in carpeting. However, adhesives and sealants used in the manufacture and installation of the products can off-gas harmful VOC's, especially soon after installation. In general, factory applied sealants will off-gas less. Be sure to specify water-based low-VOC adhesives and sealants when choosing wood, cork, and bamboo flooring.

and often they are not as readily available. As the market grows for certified wood and wood products, their price will undoubtedly become increasingly competitive and their availability will increase.

Other alternatives to wood flooring include cork and bamboo. Both products offer many of the advantages of wood: a strong aesthetic, sense of warmth, high durability, and ease of maintenance. In addition, both are manufactured from what are considered to be "rapidly renewable" resources. Bamboo, a type of grass, reaches maturity in just three to seven years (as opposed to 120 years for an oak tree), and cork, which is derived from the outer bark of oak trees, can be harvested every nine to ten years. Though labeled "alternative" products, both materials are being used in affordable housing and have a strong track record of success.

Bamboo: Bamboo is a woody, tall, tropical grass with strong hollow stems which can be used for building products. Recently it has been manufactured as flooring to compete with hardwood flooring. Its looks compare to hardwood floors, with two color choices: natural golden, or a darker, cherry color. It is available as single ply vertical grain, as 2-3 ply horizontal grain or in cross-laminated products. Some products are available with bevels to emphasize individual planks. Initial cost is generally considered to be as high as that for hardwood flooring, which may make it unaffordable. However, like wood, its durability and low maintenance make it's life cycle costs very favorable.²

Cork Flooring: Cork comes from the outer bark of the oak tree. It is removed from the tree and combined with binders which hold the cork granules together. A natural product, it can be harvested approximately every 10 years. It typically comes in tile form and in shades of light, medium and dark. Cork provides thermal and acoustical insulation, is resistant to moisture damage and decay, and is soft underfoot. Its cost is comparable to high quality vinyl flooring but it has a life-expectance of four to five times that of vinyl.³

Key Concepts

Durability and Ease of Maintenance

Wood, cork and bamboo are all considered to be very durable products with anticipated life-spans of 40 years or more. Wood and bamboo can be sanded and refinished periodically to regain their original appearance, though the number of refinishing cycles will depend on the plank construction and depth and direction of finish grain.⁴ Scratched cork flooring can be buffed and resealed, preferably with a low-VOC polyurethane sealer. Unlike sheet products such as vinyl and linoleum, wood, cork and bamboo are less prone to damage by cutting and burning, and if damage does occur, they can typically be repaired through sanding, buffing and resealing. Cork has "memory" and will spring back from compression, though it can be punctured by sharp objects or furniture. Because of the repairability of these flooring products, replacement of the entire floor is rarely necessary thus increasing the life span of the original material and reducing waste generation and replacement costs.⁵

Wood, cork and bamboo can be easily maintained by sweeping or cleaning with a damp mop and mild detergent. Each product should be sealed according to manufacturer's recommendations and many manufacturers produce specially formulated cleaning products for their flooring. However, the use of wood, cork and bamboo in areas susceptible to high levels of moisture should be considered carefully. HUD's *Rehab Guide* reports that most problems with wood flooring are related to lack of routine maintenance or exposure to high levels of moisture or extreme changes in moisture content.⁶ Excessive water can seep between boards and into small cracks, causing deterioration of finishes and cupping, crowning or buckling of wood. Similar issues are likely to arise with bamboo and cork floor. It has been reported that wood flooring in the vicinity of existing steam radiator systems can tend to swell. Generally, these products are not recommended for high moisture areas such as communal kitchens and communal bathrooms.

Indoor Air Quality: Hard surfaces such as wood, cork and bamboo are easier to maintain free of dust, mold, and other allergy-causing agents than are softer flooring types such as carpet. For example, contaminants which can be trapped in the fibers of carpet are easily cleaned from the surface of hard-flooring products through routine mopping, dusting and vacuuming. However, adhesives and binders are used in the manufacture of engineered wood flooring, bamboo flooring and cork, and these can include harmful chemicals such as formaldehyde. In addition, all wood flooring and alternatives are sealed with a finish coat that may also off-gas VOC's. While factory applied sealers, or water based finishes will reduce off-gassing, project sponsors

should consider low-VOC and formaldehyde-free adhesives, surface finishing products, and subfloor materials where available.

Other Design Considerations

Installation: Wood and bamboo are available in glue-down, nail-down and floated applications. The moisture content of subfloor surface should be measured prior to installation as excessive moisture will inhibit effectiveness of adhesives in glue-down applications, and may cause warping, cupping or cracking in the product once installed. Wood, bamboo and cork may require more preparation of the subfloor than is typically needed for carpet⁷ and may necessitate more lead time as the products should acclimate to their environment prior to installation.

Finishing: Bamboo and wood flooring is available as pre-finished and site-finished strips, planks, and tiles. Both pre-finished and site-finished types can be refinished over time. Common finishes include: water based urethanes, oil-modified urethanes, moisture cured urethanes, swedish finishes, oil finishes, and waxes. In general, water based urethanes are preferable because they provide good durability and contain fewer VOC's than other finishes. In contrast, conventional solvent-based wood finishes can off-gas for months. If solvent-based finishes are used, the floor could be left to off-gas, preferably for 3-4 weeks prior to occupancy.⁸ Finally, a low-gloss finish such as satin will tend to hide scratches and other surface damage better than high-gloss finishes.⁹

Rehabs: When removing carpeting or other flooring material as part of a building rehabilitation, consider the possibility of finishing the existing subflooring with an appropriate low-VOC polyurethane finish. It may provide an attractive flooring without the need for investing in additional finish materials.

Sound: In high traffic areas or on stairs, wood and bamboo can be "loud" as footfalls will reverberate off the hard surface. Cork is generally considered to be better at sound attenuation.

1 The Forest Stewardship Council website, www.fscus.org/buying_and_selling/index.html, allows you to search a database for available FSC certified wood products, including wood flooring. Bay Area suppliers are available.

2 For additional information, see "Bamboo Flooring," Green Resource Center, at www.greenresourcecenter.org; "Bamboo Flooring," California Integrated Waste Management Board, Publication #433-03-017, August 2003, at www.ciwmb.ca.gov/publications/greenbuilding/43303017.pdf.

3 For additional information, see "Cork Flooring" Green Resource Center, www.greenresourcecenter.org

4 "For hardwood floors, the National Oak Flooring Manufacturers Association estimates that a typical sanding will remove between 1/64" and 1/32" of wood. Tongue and groove, 3/4" oak flooring has 19/64" above the tongue. Therefore a floor could theoretically be sanded and finished 6-10 times or more before the top of the groove is weakened. Under normal conditions, refinishing occurs at approximately 15 year intervals. This suggests that hardwood flooring, if not abused, can last as long as the structure." HUD's The Rehab Guide, "Partitions, Ceilings, Floors and Stairs" Vol. 5, p. 29.

5 For a thorough review of wood flooring repair strategies, see HUD's The Rehab Guide , "Partitions, Ceilings, Floors and Stairs" Vol. 5

6 The Rehab Guide, p. 29

7 Hard surfaces such as wood flooring and alternatives typically require a much "flatter" subfloor than does carpeting. This can sometimes be difficult to achieve in rehabs without significant preparation, such as overlaying the existing subfloor with gypcrete or OSB.

8 "Indoor Air Quality/Finishes" Green Building Guidelines, Alameda County Waste Management Authority, p. 38.

MATERIALS

FINISHES

Guidelines for sustainable affordable housing

Linoleum

Linoleum is a natural flooring product made from chemically benign, commonly available, and renewable resources such as linseed oil, pine rosin, cork and jute. It comes in sheets and in tiles, and can also be used for countertops and desktops in addition to its more common use as a floor finish. In recent years the product has been re-gaining popularity as an alternative to vinyl flooring because of its longer life span, greater durability, biodegradability, and wide variety of colors and styles.

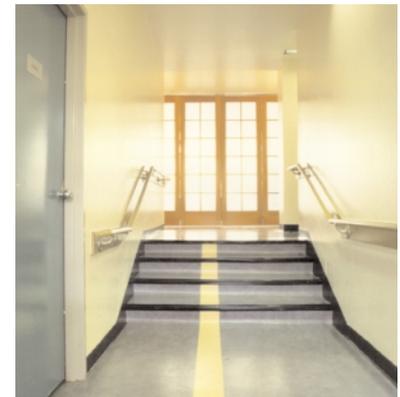
Though linoleum is considered a responsible choice for flooring from an environmental standpoint, it should be noted that all linoleum is currently manufactured in Europe and thus a considerable amount of energy is consumed in its transport to the US. However, because relatively little energy is expended during its manufacture, the total amount of energy used in production and transportation is considered lower than for most other laminate or hard flooring surfaces.

Key Concepts

Durability and Ease of Maintenance

The durability of linoleum compares to that of more expensive materials like ceramic tile, and typically far exceeds the expected lifespan of vinyl flooring. Properly maintained, linoleum has a life expectancy of 30 to 40 years. Thus, while linoleum is generally more expensive to install than vinyl, this higher initial cost can be recaptured over time in maintenance and replacement savings ("life cycle cost analysis"). The durability and lifespan of linoleum, as is the case for any finish product, will depend in large measure on its appropriate installation. Linoleum is more complicated to install than most vinyl products. Only manufacturer-certified installers should be used.

Linoleum is relatively easy to clean and maintain. Linoleum can be finished with a manufacturer's recommended low VOC polyurethane sealant in order to ensure durability, though sealing linoleum is not required. The surface can be cleaned with a wet mop, or with a reusable electrostatic cloth which picks up dirt and dust. Linoleum holds up very well to spills, stains, and nicks and should not stain if burned. Scratches or cuts can be sanded down and filled in a manner similar to wood flooring. Linoleum gets stronger with age and stretches over time making seams tighter rather than pulling them apart (installers should account for this stretching). For these reasons, it is



Linoleum comes in a wide variety of colors and can be installed in different patterns. It is a durable, easy to maintain floor finish made from renewable resources

preferred use...

- ✓ high traffic areas such as hallways, any areas where wood floors would be used

discouraged use...

- ✗ areas where standing water can occur, such as bathrooms

environmental issues...

- ✓ unlike sheet vinyl and other synthetic products, linoleum is biodegradable
- ✓ linoleum is very durable and has a long life expectancy
- ✓ linoleum is considered a rapidly renewable resource
- ✗ most linoleum is manufactured in Europe and requires shipping to the US

considered a great flooring product for high traffic areas such as hallways and community rooms, as well as in kitchen areas in individual units. It is generally not recommended for bathrooms or communal kitchens since linoleum can degrade over time when subject to continuous moisture or standing water.

Indoor Air Quality

Linoleum is easier to maintain free of dust, mold, and other allergy-causing agents than are softer flooring types such as carpet. Linseed oil, a component of linoleum, naturally kills bacteria and mold, making linoleum a good choice for kitchens and play areas for children. It does not emit harmful volatile organic compounds (VOC's) as do vinyl flooring products, and low-VOC sealers and adhesives are commonly available. However, the linseed oil used in linoleum's manufacture will off-gas initially and this can affect people with chemical sensitivities (others may find the odor somewhat unpleasant). Where possible, it is a good idea to allow linoleum to "air-out" for a few days before the unit is occupied.

Other Design Considerations**Installation**

Since linoleum is more difficult to install than most vinyl flooring products, only certified installers should be used. Linoleum should be allowed to acclimate to the environment in which it will be installed for at least one week prior to installation. A smooth substrate is very important as any irregularities in the subfloor will telegraph through the finish floor. If installing in an existing building with an irregular surface, it may be necessary to first cover the existing surface with ¼" plywood. Linoleum can be installed over a slab or gypcrete, but the subsurface must be tested for water content. If it is too wet, the linoleum may buckle.

Full glue down application with water-based low-VOC adhesives is recommended. Be sure to use adhesives specifically manufactured for linoleum as opposed to glues made for other sheet products such as vinyl. Linoleum expands and will form bubbles unless fully glued down in place. Heat sealed seams should be specified in damp areas to prohibit water intrusion, though be aware that the heat welding will create a visible seam. Glued seams, by contrast, are virtually invisible.

Design: A large variety of colors and textures are available, and linoleum is available in tile and sheet goods approximately 6' in width.

Resources

Green Resource Center, "Natural Linoleum Flooring"
<http://www.greenresourcecenter.org/MaterialsSheets/NaturalLinoleum.html>

Vinyl Flooring

Vinyl flooring is comprised of polyvinyl chloride ("PVC"), resins, pigments, and inert fillers. There are two common types of vinyl flooring: sheet vinyl and vinyl tiles. Vinyl tiles, in turn, come in two varieties: vinyl composition tiles, or VCT, which are comprised of vinyl and other fillers and additives, and solid vinyl tiles which have a higher vinyl content and tend to wear longer.

Key Concepts

Durability and Ease of Maintenance

Vinyl flooring is considered an inexpensive and relatively durable flooring material and for this reason is commonly found in affordable housing. Wear and durability, however, will vary according to the type of flooring and quality. In general, commercial grade flooring should be specified for multi-family housing. Vinyl composition tiles are generally the least expensive vinyl option but they are brittle and can crack if subject to heavy or point loads. Solid vinyl tiles are more flexible, more resistant to point loads, and because the wear layer extends through the depth of the tile, they will maintain their finish and color pattern for a longer period of time. If vinyl flooring is specified, sheet vinyl is recommended for all areas where standing water may be an issue, such as bathrooms.

Vinyl flooring typically represents a low initial cost. However, in high use areas such as common bathrooms, hallways, lobbies, common rooms, etc. vinyl products may wear quickly and require frequent replacement, thus increasing the associated "life cycle costs". Vinyl becomes brittle as it ages and is thus more susceptible to cracking over time. Its anticipated life span varies tremendously depending on product and grade. High performance commercial vinyl has warranties of 15 years or longer. These products are sometimes reinforced with quartz or other additives to improve durability. Most vinyl flooring products, however, will have a lower anticipated lifespan than other hard flooring products such as ceramic tile.

Non-porous sheet goods and tiles are relatively easy to maintain and vinyl flooring is no exception. However, sheet vinyl tends to scratch easily, shows cigarette burns and is difficult to repair.¹ Tile products offer the advantage of selective replacement so that when damage occurs, individual tiles can be removed and replaced. For longer wear, ensure that the substrate is smooth and even. Any depressions, holes or cracks should be filled and patched and any protrusions should be removed and the surface sanded smooth. Irregularities in the substrate can cause cracking of the tiles. Also, use of excessive amounts of water for cleaning may lead to the separation of the seams and the exposure of the subfloor to potential water damage.



The Vinyl Composition Tile used at the Janice Mirikitani Family Youth and Childcare Center was slated to be discarded but instead was salvaged and arranged into a random decorative pattern.

environmental issue...

- ✘ Production of vinyl flooring has shown to be hazardous to workers during manufacture and polluting to the environments around manufacturing plants.

Indoor Air Quality

Vinyl flooring is easier to maintain free of dust, mold, and other allergy-causing agents than are softer flooring types such as carpet. However the manufacture of vinyl uses highly toxic chemicals and contributes to pollution in and around manufacturing plants.² Vinyl will outgas harmful VOC's once installed, and in the event of a fire, vinyl products can release deadly gases such as hydrogen chloride which turns into hydrochloric acid when inhaled.³

Recycling

Vinyl flooring is difficult to recycle at the end of its life cycle. The additives needed to create PVC make large scale mixed product post-consumer recycling nearly impossible.⁴ It is not biodegradable and if vinyl is incinerated, heavy metals remain in the ash and must be treated as hazardous waste.⁵

Other Design Considerations

Rehab: Older vinyl flooring may contain asbestos. The asbestos containing vinyl tiles are not considered hazardous to occupants as long as the top layer of the flooring remains undamaged. Asbestos is released only when the second fibrous layer is disturbed.⁶ Caution should be taken not to break the fibrous layer when removing existing vinyl flooring during a rehab. Project sponsors should consult with an industrial hygienist to determine whether asbestos is present in existing flooring. Only a certified hazardous material company should remove and dispose of asbestos containing flooring.

Design: VCT and solid vinyl tiles are available in many colors and patterns which permit decorative designs with small additional costs.

1 For repair techniques for sheet vinyl and vinyl tiles, see HUD's The Rehab Guide, Vol. 5, "Partitions, Ceilings, Floors and Stairs." www.huduser.org/offices/lead/guidelines/hudguidelines/

2 Manufacture of "PVC produces many highly toxic byproducts, including: dioxins, polychlorinated biphenyls (PCBs), and organochlorines. Hundreds of substances known or suspected of causing cancer are produced." Spiegel, Ross, *Green Building Materials: A Guide to Product Selection of Specification*, Wiley: New York, 1999, p. 196

3 "PVC in Buildings: Hazards and Alternatives," Healthy Building Network, www.healthybuilding.net

4 Ibid.

5 Siegel, Ross, *Green Building Materials*, p. 197

6 *The Rehab Guide*, HUD, "Vinyl Sheet Flooring and Tile."

Ceramic and Stone Tile

Ceramic tiles (a broad category of clay tiles which include porcelain and quarry tiles) and natural stone (such as marble and granite) can be used as floor coverings, wall coverings and countertops, and are appropriate for interior and exterior applications. While products vary in terms of size of tile, finish, thickness, and cost, they share many attributes such as their durability and imperviousness to water.

Key Concepts

Durability and Ease of Maintenance

Ceramic tiles and stone tiles are considered very durable and are especially appropriate as flooring surfaces for areas which receive intense use such as lobbies and community rooms, and in wet areas such as bathrooms and kitchens where they can also be used for countertops and tub surrounds. Though tiles can represent a higher initial cost than other types of materials, this additional cost can be recuperated over time in savings in replacement reserves ("life cycle cost analysis"). Ceramic and stone tile flooring, if properly maintained, will last decades. Their expected life span far exceeds that of carpet or vinyl flooring products, plastic laminate countertops, or fiberglass tub surrounds. Because the material is applied as tiles, selective replacement of the flooring is possible when damage occurs, thus eliminating the need to replace the entire floor, countertop or surround. Stone flooring such as granite or marble tiles are especially durable, and extremely wear-resistant against traffic, spills, burns and water damage. Their higher cost, however, may make them prohibitively expensive except in small areas (such as lobbies) which receive intensive use.

Tiles, despite their durability, can be damaged if not properly cared for. Glazed tiles are subject to scratching and abrasion from traffic or harsh cleaning products. Standing water can degrade grout which can also become eroded over time from traffic and cleaning. Defective or deteriorated construction and substrate can lead to cracking. Floor tiles are also susceptible to cracking when subjected to heavy rolling traffic such as large trash bins.

Tiles should be maintained through damp mopping or vacuuming and the use of a manufacturer approved neutral pH cleaner. Most glazed tile does not require a sealer but some types of unglazed tiles may, so sponsors should check with manufacturers for appropriate sealing instructions. Household cleaners containing acid, bleach or vinegar should be avoided for daily cleaning because they can etch the tile and grout over time. Careful replacement of damaged tiles should be done in a timely manner to avoid water penetration to substrate.¹



The lobby and main hallway at the Curry Senior Center in San Francisco uses durable and colorful quarry tile.

Indoor Air Quality: Ceramic and stone tile are easier to maintain free of dust, mold, and other allergy-causing agents than are softer flooring types such as carpet. Tiles provide a good countertop, floor and wall surfacing material for sponsors wishing to minimize the off-gassing of potentially harmful VOC's (volatile organic compounds). VOC's are commonly associated with the adhesives used to glue down plastic laminate countertops, and with flooring products such as vinyl. Grout lines are more susceptible to mold and staining than tiles themselves. Using a low VOC water based grout sealer will increase resistance to moisture and staining.²

Recycling: Ceramic tile is increasingly available which employs up to 100% waste glass. However, these tiles are typically more expensive and thus difficult to include in affordable housing developments.

Other Design Considerations

Rehab: The thickness of tile may pose accessibility problems in existing buildings especially if new tile is installed over an existing finished floor. A small area of sloped floor may be required to avoid a high, steep threshold.

Safety: Stone and ceramic tiles may become slippery when wet. Use of unglazed tiles is strongly recommended in flooring applications because it reduces the chance of slips and accidents. Matte finish floor tiles may be acceptable if smaller tile sizes are used and sufficient grout lines are established to increase friction. Tile suppliers can help to specify slip resistant flooring that meets accessibility standards.

Installation

Tile can be installed in various ways, including: "mortar-set" or "thick set" in which tiles are set in $\frac{3}{4}$ " - $1\frac{1}{4}$ " of mortar, or "thin-set" where tiles are placed in an adhesive either over cementitious glass fiber mesh board (commonly called "Wonderboard" or "Durarock"), or over water resistant gypsum board ("greenboard").³ Mortar set or thin set over cementitious board should be used in showers, tubs or other wet areas. Avoid thin-set tile installation over greenboard in wet areas.⁴

Finally, tiles may look better longer if darker grout is chosen over lighter colors because the grout lines can be difficult to clean and lighter colors will show dirt more easily. All grout should be pre-colored waterproof and must be certified by the manufacturer as suitable.

1 For a thorough description of tile maintenance and repair issues and methods, see "Partitions, Ceilings, Floors and Stairs", Vol. 5, p. 27, and "Kitchens and Baths," Vol. 6, p. 57, of HUD's The Rehab Guide. <http://www.huduser.org/publications/destech/rehabgds.html>

2 "Recycled-Content Ceramic Tile" Green Resource Center, www.greenresourcecenter.org

3 Tile is part of an assembly which includes grout, mortar bed, and substrate. In order to insure proper installation consult the Tile Council of America's Handbook for Ceramic Tile Installation. Available for purchase at www.tileusa.com/publication_main.htm.

4 Use of tile over greenboard is not permitted in wet areas of projects receiving funding from the San Francisco Mayor's Office of Housing.

MATERIALS

FINISHES

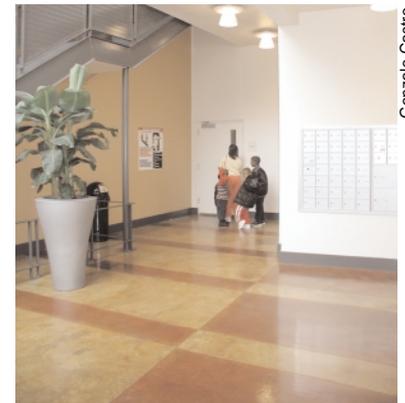
Guidelines for sustainable affordable housing

Colored Concrete Flooring

Colored concrete flooring provides an elegant and durable finish floor that can be used for lobbies, common areas, corridors or exterior applications. Methods for adding color to concrete include staining, color hardener and color conditioning.

Staining concrete is the process of applying a chemical stain color to a concrete surface. The chemical reacts with the surface of cured concrete to produce a long lasting color. The chemical stain can be applied to the surface of a newly placed (installed) slab or to an existing structural slab, as well as to a topping slab (a finish layer of concrete placed over an existing structural slab). If applied to new concrete, the slab must be allowed to cure for a minimum of 14 days. Stained concrete will telegraph any slab imperfections, slab discolorations or defects. Interior floor surfaces should be protected with a compatible, slip-resistant commercial floor sealant. Two coats of acrylic finish are recommended on top of the sealant. The acrylic finish should be reapplied every year.

Color hardener is a powdered, cementitious material which is incorporated into the surface of freshly placed concrete to create a long lasting colored finish. Two applications are generally necessary, and after each application, the dry color hardener should be worked into the surface by using wooden hand floats or a power trowling machine. A slip-resistant flat-troweled finish is suggested for interior floors.¹ Typically, color hardening systems offer the widest color selection of any permanent concrete coloring method, though they are not suitable for use over self-leveling cementitious toppings. Once applied, the concrete should be cured with an approved wax or concrete sealer. Periodic treatment with commercial floor polishes will help maintain the finish. A chemical stain can be applied to the color hardened surface after it has been completely cured in order to create an uneven, variegated color effect.



Gonzalo Castro

The lobby flooring at Rich Sorro Commons in San Francisco is scored concrete with an applied stain.

Integral colored, or **color-conditioned** concrete employs admixtures mixed directly with the concrete prior to placing. The admixtures disperse color throughout the concrete mix creating an even finish. Color conditioned surfaces should be cured and sealed per manufacturer's recommendations. Some manufacturers recommend the use of a color hardener (see above) for heavily trafficked interior floor applications.

Key Concepts

Durability and Ease of Maintenance

Colored concrete floors are very durable and appropriate for high traffic areas such as hallways, community rooms, lobby spaces, etc. With proper maintenance, the flooring surface can last indefinitely. In choosing to color a concrete slab, project sponsors are in effect exploiting a necessary structural material for use as a finish surface, thus avoiding the financial and material investment in additional finishes such as sheet flooring, tile, carpet, etc. Replacement of those additional finish materials is also avoided, thus reducing the life cycle costs associated with colored concrete.

Colored concrete flooring should be maintained in a similar manner to other hard surfaces: sweeping, mopping, and occasional polishing with a slip-resistant commercial floor polish. In addition, concrete floors, especially in an exterior application, can be hosed down for quick and easy clean-up. A concrete sealer should be applied periodically and according to the manufacturer's recommendation.

Indoor Air Quality

Hard surfaces such as colored concrete are easier to clean and maintain free of dust and allergens than are softer flooring types such as carpet. In addition, concrete flooring does not "off-gas" harmful compounds. However, the process of staining concrete is a highly toxic one which employs powerful acids and creates noxious fumes during application.

Other Design Considerations

Costs: Coloring a concrete slab is not necessarily an inexpensive approach to providing flooring. There is a considerable amount of labor involved both in the application of a color hardener and/or the use of a chemical stain. The avoidance of additional finish materials may be offset by increased costs required for the application of the color. Color conditioned concrete is generally a less expensive approach than using hardeners and stains, though its application is more limited and costs will vary according to the color chosen.

Design: While color conditioned concrete flooring typically requires a monochromatic finish, stains and/or hardeners can be used to create a wide variety of patterns, textures, and finish effects. Staining concrete can create an antique look and narrow saw cuts in the surface of the concrete can define changes in color and simulate the appearance of tile or stone.

Existing Conditions: Imperfections in the surface of the flooring will "telegraph" through and be visible even after the floor has been stained. If a smooth, even finish is desired, newly placed floors must be adequately protected during construction. Existing floor slabs will almost certainly contain imperfections. However, some designers prefer that such imperfections be visible as they contribute to the texture of the flooring and convey a sense of the age and history of the building. Existing older concrete must be cleaned so that the surface is completely penetrable before receiving the initial chemical application. Floors which have been previously treated with sealers, paints, or waxes may need to be sandblasted until such treatments are completely removed.² Follow manufacturers' recommendations for preparation of existing concrete floors.

Resources

Concrete Network is an industry sponsored website with information on a host of concrete topics, including acid-etch staining and colored concrete.
http://www.concretenetwork.com/concrete/acid_etch_staining/index.html

L.M Scofield has good selection of products for colored concrete, admixture, stained concrete and color hardener as well as specifications:
<http://www.lmscofield.com/>

1 LM Scofield tech data bulletin A-104.12, www.lmscofield.com

2 LM Scofield Tech Data Bulletin, A-414.08. www.lmscofield.com

MATERIALS

FINISHES

Guidelines for sustainable affordable housing

Lighting

High quality, energy efficient lighting can reduce energy and maintenance costs while contributing to a safer and more pleasant living environment. Many people have tried to minimize the use of energy efficient lighting because of problems associated with early versions such as noise (humming or buzzing) and poor light quality (flickering and unnatural colors). Fortunately, these problems have largely been resolved. Energy efficient lighting has virtually eliminated the need for incandescent lighting in affordable multifamily housing.

Common Types of Energy Efficient Lighting

Fluorescent lighting is the most common type of energy efficient lighting used in multifamily housing. It is 3 to 4 times more energy efficient than incandescent lighting. While an incandescent light only requires a lamp (or "bulb"), a fluorescent light needs a lamp (or "tube") and matching ballast to operate properly. New high efficiency electronic ballasts are quiet, quick to light, provide flicker free performance, and don't contain harmful polychlorinated biphenyls (PCBs) frequently found in early fluorescent ballasts. Fluorescent lighting is available in a wide variety of shapes and sizes including 4' long tubes, compact fluorescents ("CFL's") with a pin base, and integral sub-compact fluorescents ("sub-CFL's") with an "Edison" base that screws into fixtures designed for traditional incandescent bulbs.

Halogen provides a bright, very high quality light from a small lamp. Halogen lights can be up to 60% more energy efficient than traditional incandescent lights. Most commonly used in retail, halogen also has residential applications, such as the small "puck lights" that are frequently used for under cabinet lighting.

High Intensity Discharge (HID) is typically used for exterior lighting or for large indoor areas with high ceilings. It is generally more energy efficient than fluorescent lighting, though the quality of light may not be as good. HID includes several specific types of lighting including metal halide and high-pressure sodium.

Light Emitting Diodes (LED) are extremely energy efficient (8 times more efficient than fluorescent), though applications at this time are still quite limited, such as for exit signs and elevator call buttons.

Quality of Light

Glare refers to excessive (relative) brightness, whether direct or reflected. A bare light bulb is a classic source of glare. Glare can result from any light source, including natural sunlight. Lenses, diffusers, louvers, shades, and up lighting are all means to distribute light evenly while shielding lamps from direct viewing, thereby reducing eye fatigue and glare.

Color Temperature is measured in terms of degrees Kelvin (K), and is commonly perceived along a spectrum from "warm" (yellow or red tint, 2,700K to 3,000K) to "cool, bright" (blue tint, 3,500K+) light. Generally speaking, warm lighting is preferred for most housing, while cooler, brighter lighting is favored for senior housing and office spaces. Unless otherwise noted on the packaging, Energy Star rated CFLs are in the 2,700K - 3,000K range, similar to the color of most incandescent light bulbs.

Color Rendering Index (CRI). Color rendition describes the accuracy of the appearance of colors under any given type of lighting. CRI is measured on a scale of 1-100, with natural sunlight ranked at 100, followed closely by incandescent light (including halogen). Generally speaking, a CRI of 80 or higher is considered high quality light. Energy Star rated CFLs have an average CRI of 80 or higher, making them an excellent choice for most lighting applications in affordable multifamily housing.

Key Concepts

Durability and Ease of Maintenance

- Fluorescent lamps last up to 10 times longer than traditional incandescent bulbs (10,000 hours vs. 1,000 hours), thereby lowering maintenance labor costs to replace burned out lamps.
- HID lamps can last up to 24,000 hours, or 24 times longer than traditional incandescent bulbs.
- Ballasts typically last substantially longer than lamps themselves, making lights with separate lamps and ballasts most cost effective.
- When choosing fixtures for a building, be conscious of the number of different types of lamps (bulbs or tubes) that the fixtures require. Wide varieties of different types of lamps make building maintenance more difficult and expensive.
- Light fixtures on the exterior, especially those in the public way, can be equipped with vandal resistant features.

Energy Efficiency

- "Energy Star" fluorescent fixtures and lamps are highly energy efficient (3 to 4 times more efficient than incandescent lights) and provide high quality light.
- Common 40 watt 4'-0" fluorescent tubes ("T-12") can be replaced ("relamped") with newer "T-8" 32 watt tubes with equivalent light output ("lumens) and lower energy consumption. However, it may also trigger ballast replacement if the existing ballasts are not compatible with the new T-8 tubes.
- Energy efficiency and life cycle cost savings are maximized when efficient lights are used in applications that require artificial lighting for long periods of time.

Recycling

Any fluorescent ballast that lacks a label stating "Contains No PCBs" (most commonly manufactured before 1979) should be treated as hazardous waste. PCBs are toxic carcinogens that buildup over time (bioaccumulate) in the environment and in organisms (bioconcentrate). PCBs can be ingested, absorbed through the skin, or inhaled. If a ballast suspected of containing PCBs leaks a tar-like material, the room should be vacated, vented and cleaned by trained personnel. Contaminated materials, including cleaning supplies and absorbent materials such as carpet, must be disposed of as hazardous waste.

Virtually all fluorescent lamps contain varying amounts of mercury. Like PCBs, mercury is a persistent and toxic pollutant that bioaccumulates in the environment and the food chain. For a list of local recyclers that accept fluorescent lamps for recycling (for a fee), see SF Environment link below under "Resources."

Other Design Considerations

- Providing hardwired energy efficient light fixtures throughout units, including living and sleeping areas, reduces the need for tenants to provide their own lights, thereby saving them money while maximizing energy efficiency.
- Hardwired energy efficient light fixtures will also reduce the use of older, potentially unsafe, tenant supplied lights, such as torchiere style halogen floor lamps. These lamps operate at very high temperatures and have caused several residential fires.
- Specifying low-mercury lamps reduces the problems associated with fluorescent lamp disposal.

- For rehab projects, prior to initiating a light fixture replacement program, remove several lights fixtures to visually inspect the existing wiring to evaluate whether it is adequate to allow for the installation of new fixtures.
- Ninety percent of the total electricity used by a standard incandescent light bulb is wasted as heat. The cooler operating temperatures of fluorescent lights contribute less to overheating of units on hot days.

Resources

Pacific Energy Center, 851 Howard Street, San Francisco, CA, www.pge.com/pec (displays, classes, library, tools, a tremendously knowledgeable staff, and factsheets including: "Anatomy of a Lighting System," "Fluorescent Lamps," "Energy Efficient Fluorescent Ballasts," "Luminaires," "Metal Halide Lamps," and "High Pressure Sodium Lamps").

"Recycling Centers: Lighting Directories, Ballasts, Fluorescent Tubes," SF Environment, www.sfgov.org/sfenvironment/directories/lighting.htm.

"Energy Efficient Lighting," Energy Efficiency and Renewable Energy Network (EREN), US Department of Energy (DOE), (12/1995), www.eren.doe.gov/erec/factsheets/eelight.html.

"Lighting," Energy Star, www.energystar.gov/index.cfm?c=lighting.pr_lighting.

"Electrical," Green Building Guidelines for New Construction, Ch. 4.F, pg. 30, (7/2003 rev.), Alameda County Waste Management Authority (ACWMA), www.stopwaste.org/newhomes-c4.pdf.

"High Efficiency T-8 Fluorescent Lamps," University of Michigan, www.p2000.umich.edu/energy_conservation/ec9.htm.

Recommended Practice for Lighting and the Visual Environment for Senior Living, IESNA RP-28-98, Illuminating Engineering Society of North America (1998).

"How to Buy Energy Efficient Exit Signs," Energy Efficiency and Renewable Energy, Federal Energy Management Program (FEMP), www.eere.energy.gov/femp/procurement/pdfs/exitsign.pdf.

"Mercury," SF Environment Fact Sheet, www.sfgov.org/sfenvironment/facts/mercury.htm.

"Polychlorinated Biphenyls (PCBs)," US Environmental Protection Agency (EPA), www.epa.gov/pcb/index.html.

"PCBs in Fluorescent Light Fixtures: A Fact Sheet," EPA (5/1993).

"Energy Use & Conservation," SF Environment Factsheet, www.sfgov.org/sfenvironment/facts/energy.htm.

MATERIALS

ELECTRICAL

Guidelines for sustainable affordable housing

Lighting Controls

Lighting controls are devices used to turn lights on and off, or for dimming them. In addition to the ubiquitous "toggle switch" used to manually turn on and off lights, there are also more advanced lighting controls that conserve energy, including: dimmers, occupancy sensors, photocells, and timers. While they are most frequently used in exterior spaces, common areas and office spaces, the use of advanced controls within individual units is increasing.

Common Types of Advanced Lighting Controls

Dimmers. Dimmers are manual or automatic devices that reduce energy consumption by reducing the amount of light that is produced by a fixture. Dimmers may be inappropriate for many types of fluorescent and high intensity discharge (HID) light fixtures.

Occupancy Sensors (or "motion detectors") automatically control lighting, typically in response to a change in heat and/or motion. They are appropriate for areas that are unoccupied for long periods of time. HID lamps with long warm up times may not be appropriate for use with occupancy sensors. The three types of occupancy sensors are: passive infrared (PIR), ultrasonic, or "dual technology."

- Passive infrared ("PIR") occupancy sensors detect changes in temperature, such as heat radiated by the human body. PIR sensors operate on a "line of sight," and therefore may not be appropriate for a bathroom stall. This type of occupancy sensor typically has the lowest initial cost.
- Ultrasonic occupancy sensors utilize Doppler signaling, emitting ultrasonic sound waves and measuring the amount of time it takes for the waves to return. Ultrasonic sensors do not depend on line of sight, and can cover a greater area than PIR, but they are more prone to false triggering due to air motion. This is an appropriate technology for rooms with obstructed lines of sight, or with low levels of movement.
- Dual Technology occupancy sensors combine PIR and ultrasonic sensors and turn on when both sensors are triggered, and remain on as long as either sensor detects occupancy. While more expensive initially, this may be a good choice for rooms where it is critical that the lights do not turn off inadvertently.

Photo Cells automatically control switches or dimmers in response to a change in light levels. Traditionally used to control exterior lighting, photocells are now also being used for "daylighting," to gradually raise and lower indoor lighting in response to changing daylight levels.

Timers. Timers automatically control interior or exterior lights for specified durations ("elapsed time switch"), and/or at scheduled times ("clock switch"). Timers can be mechanical or electronic.

Key Concepts

Durability and Ease of Maintenance

- In addition to energy conservation, advanced lighting controls also promote lower lifecycle costs by extending the life of fixtures and lamps themselves by automatically turning them off when they are not needed.
- Photocells and occupancy sensors may need to be adjusted for sensitivity in order to fine-tune their operation.
- Timers used to control exterior lighting may need periodic adjustment to respond to seasonal time changes of sunrise and sunset.

Energy Efficiency

- Advanced lighting controls primarily promote lower lifecycle costs through energy conservation by automatically turning off lights when they are not needed.
- Daylighting (gradually raising and lowering artificial light levels in response to changing levels of available daylight) frequently can be incorporated into the design of new multifamily affordable housing. In addition, lobbies of existing residential hotels and apartment buildings sometimes present rehab daylighting opportunities.
- Dimming incandescent lamps reduces their light output more than their wattage, making incandescent lamps less efficient as they are dimmed.

Indoor Air Quality

Elapsed time switches are also used to control bath exhaust fans to eliminate excess humidity.

Other Design Considerations

- An override switch allows users the option of manually control lighting.
- Occupancy sensors are commonly used for security to turn on exterior lighting when motion is detected.

Resources

Pacific Energy Center, 851 Howard Street, San Francisco, CA, www.pge.com/pec (displays, classes, library, tools, a tremendously knowledgeable staff, and factsheets including: "Automated On/Off" and "Occupancy Controls for Lighting").

"Electrical," Green Building Guidelines for New Construction, Ch. 4.F.3, pg. 30 (7/2003 rev.), Alameda County Waste Management Authority (ACWMA), www.stopwaste.org/newhomes-c4.pdf

"Typical Lighting Control Applications," Energy Efficiency and Renewable Energy Network (EREN), US Department of Energy (DOE), www.eren.doe.gov/femp/procurement/light_controls.html

"Fundamentals of Lighting Controls," The Watt Stopper and DOE's Rebuild America, www.wattstopper.com

"Control the Electric Lights to Exploit Daylighting," 8.3.1, Oikos, www.oikos.com/library/eem/skylights/electric.html

MATERIALS

ELECTRICAL

Guidelines for sustainable affordable housing

Photovoltaics

Photovoltaics (PV) are semiconductors which convert energy from the sun into electricity. While PV technology and solar panels met with mixed success when first introduced into residential construction on a large scale in the 1970's, today they are an established and reliable technology that can help to further many of the goals of affordable housing. PV represents a clean, renewable energy source that contributes toward creating a healthy and financially stable residential building. Current government incentives and the inclusion of renewable energy in the basis calculation of the federal low-income housing tax credit program makes PV electric systems feasible on many multifamily projects where they would not have been in the past. The PV market is expanding and there is a wide range of system options, offering the flexibility to meet the specific needs and design constraints of a particular project.

The greatest benefit of including PV in an affordable housing project is that it reduces long-term operating costs. Non-profit entities typically own the development and commit to keeping it affordable for 50 years or more. By installing PV, the owner helps to insulate the development from the volatility of electricity rates, which during an energy crisis can throw operating budgets into disarray and force building managers to reduce other operating expenses to cover the cost of increasing utility bills. PV systems that cover residential units help tenants by reducing the disproportionately high percentage of their income that they pay on utilities. In addition, by showing lower operating costs, it may be possible for the developer to leverage more financing. While long term operating savings and life cycle cost analysis can help to justify an upfront investment in PV, an additional inducement is that at the present time the installation of PV can potentially be fully funded through government incentives and the federal low-income housing tax credit program (see "Funding" below).



Fred Pollack

Nueva Vista Family Housing in Santa Cruz employs photovoltaic panels to offset electricity costs for common areas.

How it works: PV, meaning "light voltage," converts sunlight directly into electricity using semi-conductor technology. PV cells are small semiconductors manufactured from crystalline silicon and other thin-film conductive materials. When light hits the PV cell, electrons from the cell's negative layer flow through a circuit to its positive layer, producing electricity.¹ The cells are arranged into a sealed module, which are grouped together into solar panels and arrays. The panels are wired to an inverter that changes the direct current (DC) into alternating current (AC), so that the electricity is suitable for residential use and the electric grid.

While there are battery PV systems that exist off the grid, grid-tied systems are more efficient and make up the bulk of PV systems. California is one of the many states that have a net metering law, which mandates a special metering and billing arrangement between the PV owner and utility company. The owner first uses the electricity generated by the PV system, and any excess electricity generated goes onto the grid, which is credited back to the owner at the same rate when demand exceeds supply (such as at night). The meter shows the net amount used, and the owner is billed annually for the net electricity consumed over a 12-month period. The PV system value may be maximized by entering into a "Time of Use" net metering arrangement with the utility company, whereby the owner can sell energy during the solar peak period (day), and buy back off-peak (night) at a lower cost. Grid-tied systems, it should be noted, do not provide power if the utility power goes down.

The PV system must be sized to meet the needs of the development, and is most efficient in new construction when use of PV is planned from the very beginning. In the case of multifamily housing, many sponsors are electing to install PV systems that will service the electricity needs of common areas. The cost increases significantly to provide solar power to individually metered residential units, as each unit would require its own direct wiring to the panels and a transformer. In addition, in urban, multi-story buildings, it is unlikely that the roof space could accommodate enough panels to service the entire building's electricity needs. However, by providing self generated electricity to service even a portion of the building's common area needs, PV can significantly reduce long-term operating costs of the building.

Key Concepts

Durability and Ease of Maintenance

PV technology is proven to be very durable and requires low maintenance. The panels themselves, once installed, should last up to 30 - 40 years, and typically are warranted to produce at least 80% of their rated power after 20 years.² Regular inspections will ensure that the wiring and contacts are intact and that the panels are not obscured. The panels can be washed periodically to prevent dust build-up, although some argue that the benefit is not worth the expense of this simple maintenance. Space should be allocated on the surface on which they are installed to allow access when needed. The inverters are constantly in use, and may require replacement or servicing every 15 years. Battery back-up systems require more maintenance as they involve more components. The inverter required for battery operated systems is a more complex piece of equipment as it must feed the battery as well, and the battery typically needs to be replaced every 5 years.

Energy Efficiency

PV should be installed on buildings that are designed to be as energy efficient as possible. The less electricity that a building requires, the greater the percentage of power that can be generated by the PV system. Recognizing the value of starting with an energy efficient building, the California Energy Commission (“CEC”) rebate for affordable housing projects requires that the project has adopted energy efficiency measures as evidenced by receipt of an energy efficiency rebate from the CEC or utility provider.

Whereas sun orientation is important to maximize the PV efficiency, deviations from the ideal angle can still provide an efficient system. South-facing orientation is preferred to maximize annual output, but PV systems that deviate up to 15% from solar south can still collect 90% of the sun's available energy. PV put on a flat roof or on vertical walls collects over 50% to 89% of the sun's available energy.³ PV technology is offered in a variety of materials, from the traditional solar panels to roofing laminates, to building material integrated photovoltaics. While crystalline silicon solar panel products dominate the market, lower efficiency and less expensive products such as thin-film PV products offer a cheaper and more flexible solution if space is not constrained.

Other Considerations

Funding: Installation of PV can represent a significant initial cost. However, government rebates and incentives, as well as the Federal Low Income Housing Tax Credit Program, administered by TCAC, can help to fund the initial cost for affordable housing developments.

- California Energy Commission's Emerging Renewable Program for Affordable Housing: In 2002, the CEC established a rebate for PV systems installed on affordable housing projects, which can reduce the price significantly. Affordable housing projects may qualify for an extra 25% rebate above the standard rebate, not to exceed 75% of the system cost based on meeting additional eligibility criteria. The project must be individually metered, and funding levels decrease every 6 months. The rebate usually goes directly to the installer, simplifying the payment process for the owner.⁴
- State and Federal Tax Credit: The state and federal governments offer tax credits to reimburse a portion of the net cost. While the non-profit owner can't take advantage of these credits, it may be possible for these credits to be transferable to the investor, so that the project can still benefit from the state and federal tax credits.
- California Tax Credit Allocation Committee ("TCAC"): An increase in basis limits up to 5%⁵ is allowed in projects where renewable energy sources such as solar will be implemented. To obtain this increase, the applicant must submit evidence of the savings to be created through the use of the technology, and permission for the increase is granted at the sole discretion of the Executive Director.⁶ (For an example of the potential equity value of the TCAC increase in basis limits for sustainable development items, including photovoltaics, please see Section 1, Challenges, Funding.)

Resources

Photovoltaics for Affordable and Cooperative Housing, April 2003. This booklet is a project of the Twin Pines Cooperative Foundation (www.energy.ca.gov/renewables/documents/2003-04-23_FINAL_HOUSE.PDF), and was written to assist affordable housing builders and owners in the PG&E utility area to incorporate PV into a new or existing residential building. It was funded by the California Energy Commission and PG&E.

GRID Alternatives (www.gridalternatives.org) is a Bay Area nonprofit organization whose Solar Affordable Housing Program is designed to help low-income homeowners take advantage of the current state rebate available for

PV installation on affordable housing units. The volunteer based program involves free installation of solar electric systems, job training, technical assistance, and access to low interest financing to pay for the material component of the system.

San Francisco Solar Energy Monitoring Network (www.solarcat.com/sfsolar/main.htm). The San Francisco Public Utilities Commission (PUC) is mapping the sunniest and foggiest neighborhoods of San Francisco in its efforts to position solar panels around the city, as a result of a ballot measure passed in 2001 that allows the city to issue \$100 million in revenue bonds for renewable energy systems on public buildings.

California Energy Commission Reports (www.energy.ca.gov/reports/reports_500.html) "A Guide to Photovoltaic (PV) System Design and Installation" and "Buying a Photovoltaic Solar Electric System: A Consumer's Guide."

California Solar Center (www.californiasolarcenter.org) offers resources on PV and solar energy in California, including news, publications, and information on financial incentives.

1 Photovoltaics for Affordable and Cooperative Housing, April 2003, Twin Pines Cooperative Foundation, www.energy.ca.gov/renewables/documents/2003-04-23_FINAL_HOUSE.pdf.

2 Ibid.

3 Basics of PV Electric Systems, KEMA-Xenergy Training, October 2003, PG & E Pacific Energy Center

4 To learn more about the state rebate, call the Energy Call Center at 800-555-7794, or visit the website at www.consumerenergycenter.com/erprebate for application forms, eligible systems, and the CEC Guidebook.

5 Threshold Basis Limits are the maximum specified amount, determined by TCAC on a per unit basis (221(d)(3) limits), that a project can use for calculating tax credits if eligible costs exceed this specified amount. A "basis boost" is an increase in this maximum amount for certain items, such as incorporating renewable energy.

6 See Section 10327 (c)(5)(E) of the federal low-income housing tax credit regulations, www.treasurer.ca.gov/ctcac.

MATERIALS

ELECTRICAL

Guidelines for sustainable affordable housing

Cabinetry and Millwork

Cabinetry is a form of closed storage for food, utensils and other items that helps to keep things organized, out of sight, and protected from dust and vermin. Cabinets are typically manufactured offsite in modular units consisting of one or more "boxes", each including a back and two sides, plus a "face" (front) that includes door or drawer panels. The two basic types of cabinets are traditional face frame and frameless ("Eurostyle"). There is an ongoing debate over which is the "better" design. Regardless of what is specified, some cabinet manufacturers simply submit proposals based on their own standard product. While this may result in the best price, it can make it difficult to compare cabinets from different manufacturers ("apples to oranges"). Unfortunately cabinets designed for single-family market rate housing often are not durable enough to perform adequately under the demands of multifamily affordable housing.



Cabinets with solid wood fronts take stains and paint well and can be sanded and refinished.

Millwork refers to interior trim such as baseboards, moldings and chair rails. Millwork is often used to visually cover a gap between two surfaces, such as a baseboard used at the bottom of a wall where it meets the floor. Millwork can promote durability. For example, chair rails protect a wall from being damaged by furniture or equipment being moved within a room.

Glossary of Selected Materials

Edge banding is a veneer that is applied to the exposed edges of cabinet frames, doors and drawers. It is most commonly used in frameless cabinets.

Finger jointed lumber is made from short scrap pieces of lumber that are glued together. The finger joint is used to make the glue joint strong. Like most engineered lumber products, finger jointed millwork is very straight, which makes it a good choice for millwork that will be painted.

Medium density fiberboard (MDF) is manufactured from small particles of sawmill waste mixed with a binder (adhesive). MDF is manufactured to very precise dimensions and can be easily routed. It can be painted or covered with plastic laminate or wood veneer. MDF is used for both cabinetry and millwork.

Particleboard is manufactured from larger particles of wood mixed with a binder (adhesive). Particleboard is an inexpensive building material, readily available, and when covered with plastic laminate or wood veneer, the finished surface is easy to clean.

Plywood is manufactured by peeling a continuous veneer from logs. Adhesive is used to bond layers of veneer with alternating grain patterns into panels. Plywood is commonly used in the construction of the most durable cabinet boxes.

Straw particleboard is a relatively new product manufactured using the agricultural waste after harvesting grains such as wheat, rice, oats, and rye. The fibers are pressed into a board with formaldehyde free binders like methyl diisocyanate binders. It is lighter than regular particleboard and mills well.

Key Concepts

Durability and Ease of Maintenance

- Cabinet Boxes. In general, the sides of cabinet boxes should be constructed from material that is at least 5/8" thick, although 3/4" material is preferred for durability. Face frames (when used) should be constructed from 3/4" material. Durability is also a function of the type of "joinery" used. For example, tongue and groove joints, and doweled joints, are more durable than joints that are simply glued and stapled.
- Plywood is a stronger and more durable material than either particleboard or MDF. In housing designed for families with children or formerly homeless individuals, the higher initial cost of plywood boxes in kitchens or bathrooms can be justified because the cabinets should last longer (life cycle costs).
- Straw-based particleboard is a beginning to be used for cabinet boxes. Durability of this product is assumed to be similar to MDF or traditional particleboard.
- Particleboard and MDF are the least expensive, and therefore the most commonly used materials for cabinet boxes. When properly manufactured and installed they often perform well in light to medium duty applications (including affordable housing for seniors). However, when particleboard or MDF become wet, they swell and lose strength. In addition, when hardware is pulled out of particleboard or MDF boxes, it may be difficult to reinstall using the existing screw holes.
- Steel cabinets are highly durable, though they can dent.

- Cabinet Door Faces and Drawers should be constructed from $\frac{3}{4}$ " thick material.
 - Solid wood doors and drawers are extremely durable, easy to repair, take screws well, and do not delaminate if they become wet. They are available in paint or stain grades. Some owners prefer stained wood because it can be sanded and painted if it is water damaged.
 - Particleboard or MDF doors and drawers covered with a laminate (such as melamine) or veneer (such as birch) often perform well under light to moderate conditions (including use in dry locations such as offices). However, if the hinges are pulled out, it may be difficult to reinstall using existing screw holes. In addition, older particleboard cabinets were notorious for delaminating under high humidity conditions sometimes found in poorly ventilated kitchens.
- Cabinet Hardware (hinges) need to be extremely durable to avoid hinge failure which is one of the most common cabinet problems.
 - Hinges are either exposed or concealed (Eurostyle). Concealed hinges (also called "cup hinges") are the only type used on frameless cabinets. Both styles are available in extremely durable models.
 - Some maintenance personnel prefer simple, exposed barrel style hinges because they are readily available, inexpensive, and easy to replace.
 - Others prefer concealed, Eurostyle hinges because they are highly adjustable. Some concealed hinges allow a cabinet door to be easily removed without the use of tools. However, the replacement of concealed hinges may require re-routing of the cabinet box or door panel, a task that can exceed the skills of maintenance staff.

Indoor Air Quality

- Vector Control. In order to exclude pests such as cockroaches and mice (both of which have been identified as asthma triggers), and thereby reduce the need to use toxic pesticides, cabinets should have fully sealed backs, and all penetrations and gaps should be sealed. It is particularly important to tightly seal plumbing penetrations into the base cabinet under the sink that, if left unsealed, can allow pests to migrate between units by traveling within the wall cavity. In addition any gaps greater than $\frac{1}{16}$ ", such as between cabinet backs and the wall surface, should be caulked at the perimeter to prevent pests from hiding and breeding in these hidden spaces.

installation tip...

- ✓ Ensure a tight connection between wall and cabinet and seal all penetrations to exclude pests

- Formaldehyde is a Volatile Organic Chemical ("VOC") that has been identified as a toxic air contaminant that off gasses at normal room temperature.
 - Particleboard (including straw-based particleboard), MDF (Medite II and Medex) and even plywood are increasingly available with no added formaldehyde.
 - Plywood is commonly manufactured with either urea-formaldehyde or phenol-formaldehyde. Phenol-formaldehyde is most commonly used in exterior grade plywood to help waterproof the wood. Phenol-formaldehyde off gasses more slowly than urea-formaldehyde and therefore exterior grade plywood is preferred for IAQ purposes.
 - If materials with added formaldehyde are used (particleboard, MDF or plywood), they should be completely sealed on all sides, preferably with low-VOC adhesives (for example when the material is sealed with melamine) or sealants (such as varnish or paint). Finishing cabinets with sealants offsite also helps to protect IAQ within multifamily housing.
- Mold. As noted above, when particleboard or MDF cabinets are exposed to water, they may begin to delaminate (particularly at the edge banding). If this happens, the underlying particleboard or MDF substrate may become wet, providing an excellent medium for the growth of mold, another proven asthma trigger.

Recycling

MDF and Particleboard (including straw-based particleboard) are both made with recycled products (saw mill waste). Finger jointing allows short scraps of lumber to be recycled into high quality millwork.

Other Design Considerations

Certified Products. Plywood, MDF and particleboard are all available with independent third-party certification (such as the Forest Stewardship Council, or "FSC") demonstrating that they have been manufactured in a sustainable manner.

Accessibility. Hardware pulls (for doors and drawers) should be accessible and easily opened by people with differing abilities, without the need for tight grasping or pinching.

Fire Safety. Varnished cabinets over a stove pose can present a fire hazard. A ducted range hood over the stove addresses this fire safety issue while protecting IAQ.

Resources

"Minimum Cabinet Specifications," California Housing Finance Agency, Multifamily Programs, Architectural Processing Requirements, Attachment 1, www.calhfa.ca.gov/multifamily/financing/app-process/arch-manual.pdf.

"Indoor Air Quality/Finishes," Green Building Guidelines for New Home Construction, pgs. 38-40, Alameda County Waste Management District, www.stopwaste.org.

"Improve Indoor Air Quality with Cabinetry," HUD Rehab Guide Vol. 6: Kitchens & Baths, pg. 23, (1/2000), www.huduser.org/Publications/PDF/kitchen.pdf.

"Particleboard and Medium Density Fiberboard," Green Report, Green Seal, 10/2001, http://www.greenseal.org/cgrs/CGR_PB%26MDF.pdf.

"Straw Particleboard," Advanced Building and Technology Practices, http://www.advancedbuildings.org/main_t_finishes_straw_particleboard.htm.

Forest Stewardship Council United States, www.fscus.org.

"Manual of Millwork," Woodwork Institute, www.wicnet.org.

Kitchen Cabinet Manufacturers Association, www.kcma.org.

"Case Systems Switches to Straw-Based Particleboard," Environmental Building News, Vol. 12, No. 11 (11/2003), pgs. 7-8, www.BuildingGreen.com.

Gibson, Scott, "An Inside Look at Kitchen Cabinets," Renovating a Kitchen, pgs. 115-123, The Taunton Press (2003).

MATERIALS

WOOD

Guidelines for sustainable affordable housing

Lumber and Alternatives

The traditional framing material for low-rise residential construction in the U.S. is dimensional lumber. Dimensional lumber refers to framing members which are milled from logs and which come in a multitude of pre-cut lengths and dimensions ranging from 2x4's and 2x6's commonly used for wall framing ("studs"), deeper dimensioned members such as 2x12's and 2x14's used for floor framing ("joists") and larger members used for longer structural spans and loads ("timbers").

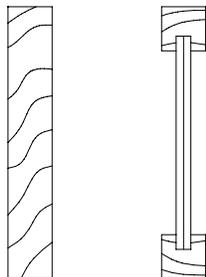
Lumber is easy to build with and typically represents a lower initial cost than other framing materials such as light gauge steel. It can be cut and modified on site, and future remodels are relatively easy when working with wood framing. It is low in conductivity and can contribute to good insulation values when used as part of an exterior wall assembly. Most contractors are very familiar with wood framing techniques and this familiarity can further reduce costs.

However, wood is susceptible to rot and deterioration, in particular if it is used without appropriate flashing and waterproofing details. Termites and other insects can also cause extensive damage. In certain applications such as mud sills, wood must be chemically treated, and available treatments are often toxic in nature. And while wood is a renewable resource, methods of timber extraction vary greatly from region to region as do their effects on the surrounding environment. Logging can result in considerable habitat loss, deforestation, and erosion.

In certain applications, alternatives to dimensional lumber can and should be considered. These alternatives can make more efficient use of wood and even reduce or eliminate its use in favor of recycled synthetic materials. They may use fewer toxics, promote sustainable forestry practices, or address issues of dry rot and susceptibility to insects. Alternatives to dimensional lumber discussed below are: engineered lumber, certified lumber, treated lumber, composite and plastic lumber, and steel framing.



The planter boxes at the Drachma Housing project in West Oakland were made with Wolmanized Natural Select treated lumber, an arsenic-free alternative to CCA treated wood.



2x solid lumber

TJI beam

Engineered lumber products such as the I-joist shown at right use less material to achieve the same structural spans. In addition, engineered products can exploit faster-growing smaller trees thus helping to preserve old-growth forests.

Engineered Lumber: Engineered Lumber is structurally configured strands, chips, veneers, or dimensional lumber bonded with adhesives to form alternate dimensions. Engineered lumber includes sheathing products like plywood and OSB, beams, posts, studs, and truss systems all of which are calculated for various structural applications. From an environmental standpoint, one of the principal advantages of engineered lumber is that these products can exploit smaller, fast-growing trees for their manufacture, thereby reducing the harvesting of large old growth trees which are often used for dimensional lumber. In addition, because they are engineered to account for specific stresses and loads, engineered products typically use less material to achieve the same spanning capacities as lumber. Because of these advantages, many engineered products, such as OSB board, plywood, and engineered floor joists, are now commonly used in construction practice.

Glossary of Engineered Products

Oriented Strand Board (OSB): A panel product composed of cross oriented fibers bonded together. OSB is available in typical plywood dimensions and used in similar applications such as for subfloor, roof decking, exterior sheathing, etc.

Truss joist / beams (TJIs): These beams have a solid lumber cord sandwiching a web of oriented strand board filler (see drawing at left) and are commonly used for flooring and roofing systems. These joists have their own restrictions regarding knockouts.

Glue Laminated Beams: A glue laminate beam is formed by bonding layers of dimensional lumber to form a built-up beam which can span long distances.

Parallel Strand Lumber: The strands of clear sapwood from the outer portions of trees or defect veneers are cut into 1 inch by 8 foot lengths and bonded together with adhesives to form the stiffest and strongest engineered lumber. This lumber has a higher adhesive density than others and may have slightly higher wear and tear on saw blades. They are used as headers above door and window openings, and as long span beams.

Laminated Strand Lumber (LSL): LSL is a structural composite of long strands from fast growing underutilized trees. LSL is used for short span headers, stud, plates, posts, rim joists because it is reliably straight

Laminated Veneer lumber (LVL): LVL is comprised of layers of kiln dried wood veneer taken from outer layer of log. It can take large spans and is typically used between girders and/or headers. It has a plywood look with a parallel orientation. Typically, LVL uses Douglas Fir, Southern Pine, Western Hemlock, and Yellow Poplar.

environmental issue...

✘ Urea formaldehyde, a common adhesive in engineered wood products, is more toxic and off-gasses for a longer period of time than phenol formaldehyde. Ask your supplier about binder content for engineered wood products or specify exterior grade plywood which uses phenol formaldehyde even for interior applications.

Certified Lumber

Certified lumber, including dimensional lumber, plywood, and engineered wood products, is lumber that has received third party certification of compliance with sustainable forestry standards. **Sustainable forestry** refers to logging practices which minimize or eliminate many of the detrimental environmental impacts which can result from traditional logging practices such as habitat destruction, soil contamination from pesticides, erosion, and monoculture. In contrast, sustainable forestry enhances biodiversity and wildlife habitat, requires monitoring of forest health, emphasizes respect for indigenous people's rights, and supports community relations and workers' rights.

Often, forests are managed solely on a short-term economic scale without addressing future harvest, erosion of topsoil and other environmental and social issues. Lumber which is "certified" meets the rigorous standards of a wood certification program, the most widely endorsed of which is the Forest Stewardship Council (FSC) -an international non-profit organization founded in 1993 to support environmentally, socially, economically sustainable management of the world's forests.¹ FSC accredits third party organizations who in turn certify companies which meet the performance standards. Unfortunately, because companies have to pay for certification and often have to stop production in order to become certified, costs associated with certified lumber tend to be higher than typical dimensional lumber. However, as the market for certified lumber increase, prices will become more in line with other lumber products.

When specifying certified wood, project sponsors should recognize that certified products are not as readily available as uncertified wood. It is thus a good idea to specify percentage goals rather than require that it be used 100% of the time. (For example, LEED certification requires that 50% of all wood-based materials be FSC certified.) This will allow the contractor to get a small supply of lumber if needed to keep the project moving forward.

Treated Lumber

Treated wood or "pressure-treated" wood is injected with chemicals to reduce the potential of dry rot or fire. It has a green or brown color and often has knife cuts along its surface. Treated lumber is available in dimensional lumber as well as plywood and is typically used for exterior applications where exposure to the elements or soil contact is likely (for example: playground equipment, decks, landscaping ties, planter boxes, fence posts, etc.)

environmental issue...

✘ CCA treated wood is difficult to dispose of after its useful life. Incineration of the material will release harmful toxins into the air. If landfilled, the wood will continue to leach arsenic into the soil threatening groundwater.

For years, the most common type of preservation treatment was **CCA** which stands for Chromate (a bactericide), Copper (a fungicide), and Arsenic (an insecticide).² However, on February 12, 2002 the EPA established a voluntary industry phase-out of CCA treated lumber in specified residential uses such as decks, playgrounds, docks, picnic benches, etc. As of January 2004, CCA is no longer available for most residential uses, though it will continue to be available for many industrial and commercial applications. Two of the major alternatives to CCA-treated wood are: Copper Boron Azole (CBA which is also called "Wolmanized **Natural Select**") and Alkaline Copper Quaternary (**ACQ**). CBA and ACQ treated lumber are significantly less toxic than arsenic though they are currently more expensive than CCA.

Decay resistant woods such as redwood or cedar which are naturally resistant to the effects of weather, insects and fungus, offer an additional alternative to CCA treated lumber. No chemicals are used in their preparation and they pose no known health risks. Unfortunately, their cost is generally too high for use in most affordable housing.

Composite and Plastic Lumber

Composite lumber or decking is manufactured using recycled plastic resin and wood fiber (the fiber used may or may not be a waste product - check with the manufacturer). **Plastic** lumber is manufactured with recycled plastic. Both products can be used in place of traditional wood species and pressure treated lumber for outdoor decks, furniture and play structures. Although both products have a higher initial cost, they can be more affordable in the long run ("life cycle costs") because they do not rot, split, crack or absorb water. Plastic lumber and composite decking are environmentally preferable because they recycle plastic, a waste product, and because they do not require annual staining, which eliminates off-gassing of "VOC's" (as well as the associated maintenance costs).

Neither plastic lumber nor composite lumber, however, are approved for structural applications. They typically have lower span ratings than wood and therefore require horizontal support framing to be spaced more closely together. Plastic lumber has greater thermal expansion and contraction than wood and will require greater spacing between decking members.

Steel Framing vs. Wood Framing

Considerable debate exists as to the advantages of steel framing over wood framing. Steel framing employs light gauge galvanized steel members instead of dimensional lumber for the framing of a building. While certain applications require steel because of fire-ratings, increasingly contractors and developers are choosing to use light gauge steel framing in low rise residential applications citing its dimensional stability, insect resistance, and potential to be recycled. Unlike wood, steel does not rot and is immune to the effects of termites and other wood-boring insects. Also, steel framing typically includes significant recycled content (at minimum 20-25%) and it is easily separated from other demolition debris at the end of its lifecycle which facilitates its recycling and reuse.

However, there are several disadvantages associated with light gauge steel framing that need to be evaluated carefully. While steel is easily recycled, it is very energy intensive to produce. It is manufactured from non-renewable resources and its extraction through mining has significant negative environmental impacts. Perhaps most significantly for project owners and property managers, steel is a thermally conductive material that can provide a "bridge" for the transfer of heat through the wall assembly, thus lowering the insulation value, or R-value, of the wall. Steel framed exterior walls, without appropriate detailing, can have a much lower effective R-value than a wood framed building using the same insulating material. This heat loss will result in increased energy costs over the life of the building. Adding continuous rigid insulation at the exterior is one way to combat this problem but the additional insulation costs then must be added to the overall costs for the wall assembly.³

1 There are five sustainable forestry standards available to forest companies in the U.S. and Canada: International Organization for Standardization, Canadian Standards Association, Sustainable Forestry Initiative, American Tree Farm System, and the Forestry Stewardship Council.

2 Arsenic, a component of CCA treated lumber, is a known human carcinogen which can cause a wide range of adverse health effects. Children are particularly susceptible to the effects of arsenic and often are at increased risk of exposure due to the prevalence of CCA-treated wood in playground equipment. In addition, disposal of CCA treated lumber is problematic as it will continue to leach arsenic and contaminate the soil if buried in a landfill. It is not suitable for mulch and is toxic if burned.

3 For an in depth comparison of Steel Framing to Wood Framing, see, "Steel or Wood Framing: Which Way Should We Go," *Environmental Building News*, Volume 3, No. 4., available at www.buildinggreen.com.

MATERIALS

WOOD

Guidelines for sustainable affordable housing

Windows

Choosing an appropriate window requires evaluating a variety of criteria. A typical window should be both durable and easy to maintain while providing good thermal protection to ensure an energy efficient building envelope. Light should pass freely through the glazing (glass) to allow for a well-lighted interior during the day, though unwanted heat gain should be minimized so that a comfortable temperature is easy to maintain. Windows should be operable by persons with disabilities, but may also need to be designed to limit a child's ability to open them. They must provide security against intruders, but in many cases also allow for easy egress in case of an emergency. Finally, windows must be both economical (low initial cost) and long lasting (low life cycle costs).



Dual glazed single-hung vinyl windows at this historic affordable housing rehab in West Oakland provide an economical and energy-saving window which approximates the profile of a traditional single glazed, double hung wood window.

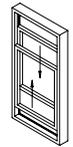
Glossary of Window Frame Materials

- **Vinyl** frames are made from PVC (poly vinyl chloride) which is mixed with dyes and additives to increase resistance to ultraviolet radiation and impact. Vinyl is considered to be an inexpensive and durable window frame material with low maintenance requirements. It provides good thermal performance, thereby limiting condensation. Larger vinyl windows, however, require additional structural support using a stiffer material which can increase the initial cost and reduce thermal performance. Vinyl windows mimic the "look" of wood frames, making them a good choice where there are tight budget constraints and an interest in matching the profile of older wood windows. Vinyl windows have limited color selection and typically are not painted.
- **Aluminum** can be a strong, durable, and relatively inexpensive window frame option. Because aluminum is more rigid than vinyl, the frames require a narrower profile to achieve the same strength, especially when used in a single glazed application. In order improve thermal insulation, aluminum frames can include a "thermal break," typically a hardened polyurethane channel which separates the interior and exterior aluminum extrusion and limits the transfer of heat across the profile of the frame.
- **Wood** is a traditional framing material for residential windows. They are strong, durable, but relatively expensive. They combine good appearance and good thermal performance, and can be painted or stained virtually any color.

SLIDING



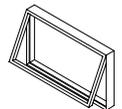
DOUBLE OR SINGLE HUNG



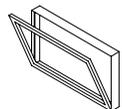
CASEMENT



AWNING



HOPPER



- **Other:** Steel frames are very durable. They are often used in commercial and industrial buildings. Composite frames are made of a new generation of wood scrap/polymer composites that are very stable, have equivalent or better structural and thermal properties than conventional wood, with superior moisture and decay resistance. They can be textured, stained or painted. Fiberglass frames are very stable, stronger than vinyl, and have thermal performance similar to insulated vinyl frame. Finally, hybrid frames use two or more frame materials to provide the benefits of each material. Examples of hybrid frames are wood windows with aluminum or vinyl cladding, and vinyl windows with interior wood veneers to provide an attractive interior finish.

specification tip...

The energy efficiency of new windows can easily be evaluated by reviewing the National Fenestration Rating Council ("NFRC") rating. www.nfrc.org.

Key Concepts

Durability and Ease of Maintenance

Wood windows regularly last more than a hundred years. However, regular maintenance including painting is required to ensure their continued performance as wood is susceptible to deterioration by ultraviolet radiation and exposure to water (dry rot). Modern vinyl, aluminum and "clad" windows on the other hand require very little maintenance.

Energy Efficiency

The National Fenestration Rating Council (NFRC) analyzes the performance of an entire window assembly (including the frame and glazing). All projects should specify windows based on NFRC ratings.

The NFRC label rates:

- **U-factor.** U-factor is a measure of how well a window retains heat inside a building. The lower the U-Factor, the better the window is at keeping heat in the building. In San Francisco, the U-factor should be .40 or less in order to achieve an energy star rating.¹
- **SHGC (Solar Heat Gain Coefficient).** SHGC measures a window's ability to block solar heating of the building. The lower the SHGC, the better the window is at blocking heat gain. Any portion of a building that is air-conditioned and has a South or West facing windows should have an SHGC rating of about .40 or less.²
- **Visible Transmittance (VT).** Visual Transmittance measures how much light the window lets in. A higher VT rating will maximize daylight and view. Select windows with .50 or more.

- Air Leakage (AL). This optional rating (manufacturer's are not required to include it) measures air infiltration through cracks in the window assembly. Select windows with an AL rating of .30 or less.
- Condensation Resistance (CR). Also an optional rating, CR measures the ability of a product to resist the formation of condensation on the interior surface.

A "Low-emittance" (Low-E) coating is a virtually invisible metal or metallic oxide layer deposited on the glazing surface primarily to reduce the U-factor by lowering heat flow through the window. Different types of Low-E coatings have been designed to allow for different levels of solar gain, depending on the demands of the local climate.

The "Energy Star" designation for products meeting certain energy performance criteria varies by climate. When comparing among different Energy Star products, use the NFRC label to compare window performance.

Indoor Air Quality

Mold sometimes forms on and around window frames. Molds are associated with a variety of health problems including allergies, respiratory problems, headaches, nosebleeds, etc. Like humans, molds require food (any organic material) and water (moisture) in order to survive. Windows can be a source of moisture, either because of water penetration where windows and walls meet, or because of condensation due to temperature differentials between indoors and out. Proper detailing and flashing will help to minimize the potential for water to seep into the wall cavity, thereby limiting one source of moisture that could allow mold to grow.

Choosing windows with insulating frames will help to limit the potential for condensation to occur at the interior side of the window. Vinyl and wood framed windows are relatively good insulators because of their inherent properties. Aluminum, on the other hand, is not a good insulator. Instead it is a highly conductive material and this conductivity contributes not only to heat loss, but also to the tendency for moisture to accumulate at the cold interior surface of the frame (condensation). Therefore, when specifying aluminum windows it is a good idea to include a thermal break (described above) to limit heat loss and condensation.

specification tip...

As a general rule, dual glazed windows with a low-E coating are a good choice for San Francisco.

design tip...

Operable windows can improve indoor air quality by allowing for natural ventilation.

environmental issues...

Evaluating the environmental effects of window selection can be a complex endeavor. The production of window frames often has significant negative environmental impacts. Vinyl windows are made with PVC (poly vinyl chloride) which has been found to be detrimental to workers during its manufacture and a contributor to poor regional air quality near manufacturing plants. Aluminum is fabricated from bauxite, a mineral found primarily in tropical areas and its extraction is a significant factor in the clearcutting of tropical rain forests. Wood is a natural renewable resource but standard logging practices can contribute to habitat loss and soil erosion.

However, all durable, energy efficient windows will limit energy use over time as well as reduce the investment of materials in maintenance and replacement. In addition, durable, energy efficient products are a cost-effective choice for precisely the same reasons: energy savings and longevity. By emphasizing durability and energy efficiency when specifying new windows, project sponsors are ensuring that both economic and environmental considerations are taken into account.

Other Design Considerations**Cost**

There is a wide variety in the cost of windows (\$200 - \$1,000+). Aluminum and vinyl can be very close in cost, while wood may be twice as expensive. Low-e coatings can add up to 10% to the cost of the window (although labor costs to install a window are not affected by low-e coatings). For operable windows, sliders are the cheapest, followed by single hung, then double hung, with casement typically being the most expensive.

When evaluating costs, it is important to consider the energy costs of the building over time. Windows, and their relative efficiency, can have a significant effect on the energy performance of the building envelope and associated heating and cooling cost. Better, more efficient windows are available at a relatively small increase in initial cost that will generate substantial savings over time.³

Historic Preservation: When historic preservation is an important consideration, existing windows are often repaired on the front of a building, with new windows provided for the remainder of the building. Under these circumstances, the new windows typically will need to be visually similar to the windows being replaced (you may not be allowed to replace wood, double-hung windows with aluminum sliders).

Rehab: While re-use is generally an environmentally preferred option, old wood or steel framed windows are frequently coated with lead-based paint and can present a significant lead hazard. Properly installed new windows can eliminate the lead hazard within the unit, while dramatically improving thermal and acoustic insulation.⁴ The initial costs of new windows is so high that window replacement typically cannot be justified solely for energy efficiency reasons.

Safety: Care must be used when replacing bedroom windows to maintain proper fire access / egress dimensions.

Comfort: Windows with good NFRC ratings not only improve energy efficiency, they also improve occupant comfort. A poorly insulated window creates "thermal gradients" within a room, which means that different parts of a room are at different temperatures. Most people have experienced discomfort from sitting next to a cold (or hot) window. In a small room or unit, a window with a good NFRC rating can effectively increase the usable space within a unit by insuring that the area adjacent to the window is comfortable.

Resources

"Selecting Windows for Energy Efficiency," www.windows.lbl.gov/pub/selectingwindows.

Vol. 4, The Rehab Guide: Doors & Windows" (HUD) "Guidelines for the Evaluation and Control of Lead-Based Paint Hazard in Housing," Chapter 11: Interim Controls (HUD)

The Efficient Windows Collaborative. www.efficientwindows.org

The National Fenestration Rating Council. www.nfrc.org

1 www.energystar.gov/index.cfm?c=windows_doors.pr_crit_windows.

2 Ibid.

3 For cost comparison estimates based on energy performance, see the Efficient Windows Collaborative at www.efficientwindows.org.

4 As with any work that impacts surfaces coated with lead based paint, care must be taken to protect tenants and workers in accordance with the HUD guidelines. www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm.

MATERIALS

EXTERIOR ENVELOPE

Guidelines for sustainable affordable housing

Paving

The traditional paving materials for walks, driveways and parking lots are asphalt and concrete. These materials should last for years and can be recycled at the end of their use. There are also a variety of materials being developed as alternative paving. Some are being developed with the goal of providing a porous surface with the associated environmental benefits. Others are impervious but made with non-toxic components. Each alternative paving material has specific installation and maintenance requirements. The first challenge to their widespread use is lack of experience and expertise with these developing technologies. Although experience with alternative paving materials is limited in affordable housing in San Francisco, their environmental benefits are promising. Listed below are descriptions of traditional paving materials and a summary of emerging paving technologies with links to further information.

Traditional Paving

Asphalt Concrete (AC): Asphalt, also known as AC, is the standard in the paving field. It is a black solid or semisolid mixture of bitumen obtained from native deposits or as a petroleum by product. Asphalt can be used as paving, roofing, and waterproofing, and is usually mixed with an aggregate. It is easy to work with, inexpensive, durable, and it meets accessibility requirements. Asphalt can be recycled by being ground up for use as a base material for recycled asphalt concrete. Rubberized asphalt concrete also contains recycled content using crumb rubber from scrap tires mixed with asphalt and aggregate to resurface roadways. Disadvantages associated with asphalt are that removal is often necessary to resurface; it can sink, crack and perform poorly if not properly installed; it softens in hot weather; and, it increases ambient air temperature (“heat island effect”). Asphalt is impervious, causing storm water runoff to the surrounding areas.

Concrete (PCC): Portland Cement Concrete, also known as PCC, is produced by mixing cement, sand, aggregate (usually gravel or crushed stone) and water, plus small amounts of various chemicals called admixtures. Concrete is very durable, lasting longer than asphalt. It can be recycled for use as aggregate base in roads, buildings, or fill. Concrete is more expensive than asphalt, and equally impervious.

Alternative Paving

Porous Pavement: Porous pavement allows rain to pass through it, thereby reducing storm water runoff and improving ground water recharge. The environmental benefits of porous pavement are recognized by the US Green Building Council's LEED rating system which provides site credits to projects using porous pavement that provide no net increase in the rate or quantity of storm water runoff, and to projects that reduce the heat island effect by using an open-grid pavement system. Porous pavement can be used for parking and areas with light traffic, provided that the site conditions are suitable, such as permeable soils, flat or gentle slopes, and room for a permeable stone reservoir beneath the pavement. Porous pavement can also be used for driveways, walkways and paths. Two types of porous pavement are porous asphalt and pervious concrete.

- Porous asphalt pavement is an open-graded coarse aggregate bonded by asphalt cement which allows water to infiltrate through the interconnected voids into gravel or crushed stone sub base and finally to the soil below.
- Pervious concrete is made of specially formulated mixtures of cement with uniform, open-graded coarse aggregate and water.

The primary advantages of porous pavement are that it reduces storm water runoff while filtering pollutants. It facilitates groundwater recharge to maintain groundwater levels and base flow in streams. It reduces the need for curbing and storm sewers, thereby conserving land space. However, relatively few pavement engineers and contractors have expertise with this technology. It can require more maintenance than traditional paving. Also, there is potential groundwater contamination because porous pavement cannot filter certain pollutants such as vehicle fuel. The reservoir underneath must be sized and soil testing for density and permeability is required.

Natural soil pavement: Natural soil pavement is made from locally available aggregate and binders derived from plant byproducts that don't contain petrochemicals, making them ideal for environmentally sensitive areas. Examples of plant-derived aggregate binders are Road Oyl, PolyPavement and Stabilizer.

- Road Oyl is a proprietary product made with a liquid binder from pine pitch and resin combined with decomposed granite to form a durable "paved" surface. This surface is impervious and behaves much like asphalt, with a slightly loose surface. It can be used for roads, parking lots and pathways. Road Oyl Pavement can cost as much as or more than asphalt, though is less expensive than installed concrete.

The primary advantages of Road Oyl are that it uses recycled products and is excellent for environmentally sensitive sites. It has a nice color varying from gray to dark brown to a golden tan color (as seen at San Francisco's Crissy field). The spray on finish is smooth and can meet ADA accessibility requirements. There is no leaching of petroleum product, and it can be recycled at the end of its life, making a good base material for new paving aggregate. However, it is expensive to use in the San Francisco, due in part to transportation costs since it is mixed and brought from Napa. To increase durability, the sealer may need to be sprayed as often as every 2 years. The installer must be certified, although the distributor can supply a contractor, which will also help to guarantee performance.

- PolyPavement is the trademark name for natural soil pavement: a product made from an environmentally safe water-based polymer emulsion mixed with site soil and tamped to provide a solid "paved surface." Polypavement requires little to no maintenance, and can support heavy traffic. It is twice as strong as asphalt, and no leaching is involved. However, Polypavement is impervious and reacts to water like asphalt; it will take sheet flow but can erode with channel flow. It is not recommended for highly expansive clay soils because as the soil dries, unwanted cracks can occur. It is approximately half the strength of concrete.
- Stabilizer binds aggregate together with a nontoxic powder derived from the byproducts of plantago (Indian Wheat) and creates a pervious, resilient paving surface that resembles well- compacted aggregate. Stabilizer costs less than asphalt, and according to tests done by Stabilizer Solutions, can be 20 degrees cooler than asphalt because its light color reflects heat.

Resources

www.epa.gov/OW-OWM.html/mtb/porouspa.pdf. This EPA article addresses the benefits and challenges of porous pavement. There are several links available at the end of the article.

Cahill Associates is an environmental consulting firm which designs porous pavement parking lots. www.thcahill.com/porous.htm

BuildingGreen.com provides an analysis of the pros and cons of Road Oyl as an alternative to concrete and asphalt at http://www.buildinggreen.com/products/road_oyl.cfm

SSPC and Stabilizer Solutions are makers of soil stabilization products. <http://www.sspco.org>, www.stabilizersolutions.com

Polypavement provides natural soil pavement systems. www.polypavement.com

MATERIALS

SITE

Guidelines for sustainable affordable housing

RESOURCES

Affordable Housing Design Advisor. A step-by-step guide to affordable housing design. www.designadvisor.org.

Alameda County Waste Management Authority (ACWMA). Sponsors of several green building guides, including a forthcoming document which focuses on multifamily housing. www.stopwaste.org.

Architects, Designers, Planners for Social Responsibility (ADPSR). Advocates for socially responsible development and environmental protection. The Northern California Chapter produces the *Architectural Resource Guide* which provides information on environmentally conscious building materials and techniques. www.adpsr-norcal.org.

Asian Neighborhood Design (AND). A non-profit 501(c)3 organization which provides architecture and planning assistance to community groups and non-profit organizations. www.andnet.org.

Building for Environmental and Economic Sustainability (BEES). Provides software for selecting environmentally preferable materials. www.bfrl.nist.gov/oe/software/bees.html.

California Air Resources Board. Conducts research into the causes of, and solutions to, air pollution. www.arb.ca.gov/homepage.htm.

California Department of Housing and Community Development. Website includes resources for housing education and outreach strategies. www.hcd.ca.gov/hpd/nimby.htm.

California Energy Commission. Information on residential energy efficiency standards. www.energy.ca.gov/title24.

California Housing Financial Agency (Cal HFA). Architectural processing requirements for multifamily programs. www.calhfa.ca.gov/multifamily/financing/app-process/arch-manual.pdf.

California Integrated Waste Management Board. Website includes information on construction and demolition debris recycling, www.ciwmb.ca.gov/ConDemo/, and a Recycled Content Product Database, www.ciwmb.ca.gov/rcp.

California Tax Credit Allocation Committee (TCAC). Tax Credit application rules and point allocation. www.treasurer.ca.gov/ctcac.

Carpet and Rug Institute ("CRI"). National trade association representing the carpet and rug industry. Sponsors a "Green Label" testing program to identify carpet products that are truly low VOC. www.carpet-rug.com.

Efficient Windows Collaborative. Provides information on energy efficiencies and cost comparisons for window types by region. www.efficientwindows.org.

Energy Star. EPA-sponsored rating system for energy efficient products and buildings. www.energystar.gov.

Environmental Building News. A monthly newsletter reporting on green building materials and systems. Publishes informational website, www.buildinggreen.com, which includes searchable database for selected published articles. Also publishes the *GreenSpec Directory*, a "green" product directory with guideline specifications.

Environmental Protection Agency (EPA). Website includes Indoor Air Quality design tools for schools. www.epa.gov/iaq/index.html.

Global Green. Advocacy and education organization. Publishes *A Blueprint for Greening Affordable Housing: Developer Guidelines for Resource Efficiency and Sustainable Communities*. www.globalgreen.org.

Greenclips. A free email newsletter summarizing recent "green" articles from other sources. www.greendesign.net/greenclips/start.htm.

Green Affordable Housing Coalition. A coalition of San Francisco Bay Area public and private-sector groups committed to incorporating green building practices into affordable housing. Website includes fact sheets, case studies, and links. www.greenaffordablehousing.org.

Green Resource Center. Links consumers with emerging green building industry. Provides fact sheets on a variety of "green" building products. www.greenresourcecenter.org.

Green Seal. A non-profit organization that identifies and promotes environmentally sensitive products and services. www.greenseal.org.

Healthy Building Network. Promotes use of healthier building materials. www.healthybuilding.net.

Home Affordable Sustainability. Practical information and technical assistance aimed at single-family homes, though much of it applies to multifamily housing. www.homesta.org.

National Fenestration Rating Council (NFRC). Provides rating system for glazing in windows, doors, and skylights. www.nfrc.org.

Non Profit Housing Association of Northern California (NPH). Membership-based advocacy, policy, and research organization. www.nonprofithousing.org.

Pacific Energy Center (PEC). Offers classes on energy efficiency and building design and construction.

www.pge.com/003_save_energy/003c_edu_train/pec/003c1_pac_energy.shtml.

San Francisco Department of the Environment (SF ENVIRONMENT).

Provides information on City of San Francisco recycling programs, energy efficiency, etc. www.sfgov.org/sfenvironment/index.htm.

San Francisco Mayor's Office of Housing (MOH). Provides funding and support for the construction and preservation of affordable housing. In addition, provides information on City of San Francisco programs, workshops, and reports, as well as the Affordable Housing Information System. www.sfgov.org/moh.

San Francisco Mayor's Office on Disabilities (MOD). Produces "Quick Sheets" which provide easy to understand accessibility design guidelines. www.sfgov.org/site/sfmod_index.asp.

San Francisco Public Health/Environmental Health. "Guidelines for Mold Control." www.cal-iaq.org/mold0107.htm. See also EPA's "A Brief Guide to Mold, Moisture, and Your Home", EPA, www.epa.gov/iaq/molds/moldguide.html.

Seattle Office of Housing. Publishes affordable housing guide entitled: "Sea Green: Greening Seattle's Affordable Housing".

www.seattle.gov/housing/07-FreePublications/SeaGreen.pdf.

Strategic Energy Innovations. A small non-profit company focused on helping communities to design and implement energy savings program.

www.seiinc.org/who_we_are.html

The Forest Stewardship Council. Allows you to search a database for available FSC certified wood products.

www.fscus.org/buying_and_selling/index.html.

U.S. Department of Energy (DOE). Provides information on alternative energy, energy saving measures, and strategies for sustainable development. www.eere.energy.gov. Programs include: the Energy Efficiency and Renewable Energy Network (EREN), www.eren.doe.gov., the Building Technologies Program. www.eere.energy.gov/buildings, the Rebuild America Program www.rebuild.org and the Center for Excellence for Sustainable Development, www.sustainable.doe.gov.

U.S. Department of Housing and Urban Development (HUD). Extensive website includes "HUD-user" Policy Development and Research Information Service which includes downloadable version of "The Rehab Guide" at www.huduser.org/publications/destech/rehabgui.html, and HUD Guidelines

for the Evaluation and Control of Lead-Based Paint Hazards in Housing.
www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm.

U.S. Green Building Council. A coalition working to promote buildings that are environmentally responsible, profitable and healthy places to live and work. Supports the Leadership in Energy and Environmental Design (LEED) rating system. www.usgbc.org.