Field Guide for Sustainable Construction

June 2004

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Field Guide for Sustainable Construction

Mission Statement:
To provide education and guidance for construction field workers, supervisors and managers on construction methods and practices that amplify and ensure sustainable requirements and goals are achieved in projects.

Introduction:
Sustainable design and construction is gaining significant momentum in the construction industry. Designers and owners are learning that with smart design, buildings can save energy and have a decreased impact on the environment. Sophisticated sustainable projects address issues of the environment, energy use and people, in addition to traditional project goals of cost, quality and schedule. They do so paying acute attention to the business case of the facility.

Most sustainable efforts are concentrated on early design. The focus is on decisions like selecting a site and building layout that minimizes the environmental burden of buildings; creating an efficient and integrated building envelope system; integrating HVAC and electrical systems to reduce energy use; and specifying reused, renewable or recycled materials. The focus in early design has made great strides in achieving and extending sustainable goals for buildings.

The methods for construction are also significant to achieving the sustainable goals of a project. What may appear to be minor decisions to field workers, such as the selection of adhesives and sealants, may have long lasting negative effects on indoor air quality, maintainability or future adaptability of the space. Many of the day-to-day decisions made by construction workers and supervisors are important to achieving sustainable project goals and assuring a healthy built environment.

With this in mind, the ***Field Guide for Sustainable Construction*** has been developed to assist and educate field workers, supervisors and managers in making decisions that help the project team meet sustainable project goals. The field guide is designed to fill a significant void in available information for sustainable construction methods. It systematically draws together and organizes information on many aspects of construction that can assure the sustainability of a facility. Simple methods and suggested practices are presented for the major phases of construction in the field guide.

Readers Guide
This field guide has been developed in a matrix format to enable multiple uses. The columns of the matrix organize the field guide information into chapters based on ten categories of sustainable construction. The rows of the matrix organize the field guide information into 15 phases of a project, starting with general conditions and ending with finishes. This structure allows the guidebook to be read by chapter (sustainability category) or by sections (construction phase). Project managers overseeing multiple trades are likely to use the field guide by chapters. Specific trades are likely to use the field guide by sections. Importantly, the matrix allows simple cross-referencing between the different interests to facilitate clear, accurate and timely communication.

Each chapter is structured to begin with a summary and highlight key planning information. Case studies, sustainable construction facts, emerging technologies and practices from PENREN/C are also provided throughout.

Field Guide for Sustainable Construction

Guidebook Organization

Chapter
Description

CHAPTER 1: PROCUREMENT – *Specific procurement strategies to ensure sustainable construction requirements are addressed.*

CHAPTER 2: SITE/ENVIRONMENT - *Methods to reduce the environmental impact of construction on the project site and surrounding environment are identified.*

CHAPTER 3: MATERIAL SELECTION - *Identifies environmentally friendly building materials as well as harmful and toxic materials that should be avoided.*

CHAPTER 4: WASTE PREVENTION - *Methods to reduce and eliminate waste on construction projects are identified.*

CHAPTER 5: RECYCLING - *Identifies materials to recycle at each phase of construction and methods to support the onsite recycling effort.*

CHAPTER 6: ENERGY - *Methods to ensure and improve the building's energy performance, reduce energy consumed during construction, and identify opportunities to use renewable energy sources.*

CHAPTER 7: BUILDING AND MATERIAL REUSE - *Identifies reusable materials and methods to facilitate the future reuse of a facility, systems, equipment, products and materials.*

CHAPTER 8: CONSTRUCTION TECHNOLOGIES - *Identifies technologies which can be used during construction to improve efficiency and reduce waste (especially paper).*

CHAPTER 9: HEALTH AND SAFETY - *Methods to improve the quality of life for construction workers are identified.*

CHAPTER 10: INDOOR ENVIRONMENTAL QUALITY - *Methods to ensure indoor environmental quality measures during construction are managed and executed properly.*

GUIDEBOOK SECTIONS *(within each chapter – in Enhanced Uniformat Divisions)*

Summary Page	
0. Planning	8. Roofing
1. General Conditions	9. Interior Construction
2. Demolition and Abatement	10. Conveying Systems
3. Sitework	11. Mechanical
4. Foundations	12. Electrical
5. Substructure	13. Information Technology
6. Superstructure	14. Equipment
7. Exterior closure	15. Finishes

Field Guide for Sustainable Construction

	Sections	Chapter 1 Procurement	Chapter 2 Site/ Environment	Chapter 3 Material Selection	Chapter 4 Waste Prevention	Chapter 5 Recycling	Chapter 6 Energy	Chapter 7 Building and Material Reuse	Chapter 8 Construction Technologies	Chapter 9 Health and Safety	Chapter 10 Indoor Environmental Quality
	Summary page	1	2	3	4	5	6	7	8	9	10
0	Planning	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
1	General Conditions	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1
2	Demolition and Abatement	1.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2
3	Sitework	1.3	2.3	3.3	4.3	5.3	6.3	7.3	8.3	9.3	10.3
4	Foundations	1.4	2.4	3.4	4.4	5.4	6.4	7.4	8.4	9.4	10.4
5	Substructure	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
6	Superstructure	1.6	2.6	3.6	4.6	5.6	6.6	7.6	8.6	9.6	10.6
7	Exterior Enclosure	1.7	2.7	3.7	4.7	5.7	6.7	7.7	8.7	9.7	10.7
8	Roofing	1.8	2.8	3.8	4.8	5.8	6.8	7.8	8.8	9.8	10.8
9	Interior Construction	1.9	2.9	3.9	4.9	5.9	6.9	7.9	8.9	9.9	10.9
10	Conveying Systems	1.10	2.10	3.10	4.10	5.10	6.10	7.10	8.10	9.10	10.10
11	Mechanical	1.11	2.11	3.11	4.11	5.11	6.11	7.11	8.11	9.11	10.11
12	Electrical	1.12	2.12	3.12	4.12	5.12	6.12	7.12	8.12	9.12	10.12
13	Information Technology (IT)	1.13	2.13	3.13	4.13	5.13	6.13	7.13	8.13	9.13	10.13
14	Equipment	1.14	2.14	3.14	4.14	5.14	6.14	7.14	8.14	9.14	10.14
15	Finishes	1.15	2.15	3.15	4.15	5.15	6.15	7.15	8.15	9.15	10.15

Chapter 1: Procurement

Goal: Provide guidelines for procurement practices and contracting strategies for general contractors, construction managers, subcontractors, and vendors. Such strategies and guidelines are to be implemented on sustainable construction projects in an attempt to raise the awareness of sustainable issues and increase performance on these construction projects.

Benefits:

- Reduced risk when contracting with subcontractors and vendors on sustainable projects.
- Increased awareness of sustainable issues in construction, deconstruction and demolition projects.
- Improved understanding of the contractor's responsibilities in the construction of sustainable buildings.

Actions and Methods:

Successful subcontractor selection strategies for construction managers:

- Utilize sub-contractors that have **design-build capabilities**. Doing so will increase the ability to identify sustainable improvements through value engineering (Ref. Ch 7: Building and Material Reuse) and waste management recommendations (Ref. Ch 4: Waste Prevention and Ch 5: Recycling).
- Utilize sub-contractors with **"in-house" fabrication capabilities**. Doing so will increase the awareness of waste reduction and provide more control over delivery schedules.
- Contract with sub-contractors that have successfully completed work on sustainable projects in the past. This experience will help create an appropriate sustainable attitude amongst all contractors. A list of contractors who are members of the USGBC can be found at http://www.usgbc.org/AboutUs/memberlist.asp.

Training opportunities for contractors and subcontractors:

- LEED Training Workshops are available across the country and throughout the year. (http://www.usgbc.org/Events/events_training_calendar.asp)
- Advantage Green: (http://www.greenadvantage.org) offers contractor and subcontractor green building certifications.
- Conduct regular in-house training sessions or "toolbox talks" with subcontractors.

PENREN/C Practice:

Design-Build Contracts

The Pentagon Renovation and Construction Program uses only design-build contracts with performance based fee incentives for the design-build contractor. This approach encourages innovative solutions that improve sustainable construction practices. As of June 2004, one project on the Pentagon reservation has been certified under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system, and four others are in the process of pursuing certification. In additional many of the new contracts are now including LEED certification as a contract requirement. http://renovation.pentagon.mil/index.htm

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References

Federal Guide to Green Construction (Draft) (2004). Environmental Protection Agency. http://www.wbdg.org/design/greenspec.php

Riley, D., K. Pexton, et al. (2003). Defining the Role of Contractors on Green Building Projects. 2003 Construction Research Congress, Honolulu, Hawaii.

Wilson, A. and M. Nadav (2003). Greenspec Directory: Product Directory with Guideline Specifications. Brattleboro, VT, Building Green, Inc.

Chapter 1: Procurement

1.1 General Conditions

Goal: Provide guidelines for contracting strategies on sustainable projects for work in general conditions.

Contracting Strategies:

- Require submission of a detailed safety plan from ALL subcontractors implementing key items addressed in Chapter 9
- Allow only non-toxic cleaning agents for building final cleaning activities.
- Require detailed site recycling plans, including incentives/ penalties to ensure execution
- Allow no smoking on-site during construction
- Require interim submissions of electronic asbuilt drawings on a time-scheduled basis rather than at the end of the project. Timing of updates should be based on the project size.

Meeting/ training strategies:

- Require “kick-off” sustainable construction education for all on-site work force
- Require attendance at monthly sustainability meetings by all site personnel
- Require periodic education training sessions/sustainable “tool-box talks”
- Review sustainable building requirements in specifications with each sub-contractor at “kick-off” meeting prior to commencement of work

Incentive Strategies:

- Implement incentives for site staff for implementation of sustainable practices
- Include incentives for exceeding sustainability goals

Staffing/ personnel strategies:

- LEED/Sustainable “Champion” requirement for each team member (i.e. contractor, subcontractor, designer, etc.)
- Require sustainable experience from contractors/sub-contractors
- Pre-qualify subcontractors with experience on LEED projects

Case Study:

See Section 1.6

References

(2002). Green Building: Project Planning and Cost Estimating. Kingston, MA, R.S. Means.

10 9 8 7 6 5 4 3 2 1

Chapter 1: Procurement
1.2 Demolition and Abatement

Goal: Provide guidelines for contracting strategies on sustainable projects for demolition and abatement work.

Contracting Strategies:

- **Require sustainable experience/**performance requirements for abatement and demolition contractors.
- **Require a detailed plan** from the demolition/abatement contractor outlining the separation of waste and recyclable containers/dumpsters
- **For demolition projects** on which no self-performing labor is available, subcontract building clean-up through the demolition contractor. Require each trade's waste be separated and place waste and recycled material in "marked buggies" for the demolition contractor to move to the dumpster or recycling bin.
- **For small O&M projects**, set-up JOC/standing work order contracts with mold, lead and asbestos abatement contractors. By contracting in this manner, many abatement contractors will offer an insurance break compared to the high premium that typically comes with a one-time abatement. Numerous small projects are needed to make this feasible.
- **For large design-build projects,** include abatement as part of the main contract. This allows the design build team to determine the most effective manner to coordinate the contracts.
- **Clearly identify refueling stations** for demolition equipment, material haulers and material lifts to prevent groundwater contamination.

Case Study:

The Aspen Skiing Company Sundeck Restaurant

The Aspen Skiing Company Sundeck and Restaurant project team adopted a construction waste management plan that segregated steel from the construction waste stream and recycled it. Wood and gypsum wallboard was ground on-site and reused as compost. Finally, the existing foundation was processed on-site and reused as fill material.

References

Kerlin, K. (2001). Sustainable Slopes. The Environmental Magazine. XII. http://www.emagazine.com/november-december_2001/1101gl_travel.html

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

Chapter 1: Procurement

1.3 Site Work

Goal: Provide guidelines for contracting strategies on sustainable projects for site work operations.

Contracting Strategies:

- **Require detailed site access plans** at all milestone stages of work (minimize impervious site effects during construction).
- **Require detailed soil/erosion sedimentation control** measures/strategies/requirements from a single source contractor.
- **Utilize local materials** for backfilling operations. The closer, the better. LEED 2.1 defines “local” as within 500-mile radius.
- **Require recycled use of on-site spoils** for existing project backfill or for a local project if spoils need to be exported.
- **Utilize on-site storage of spoils** for backfilling to reduce fuel consumption.
- **Require capturing and re-using site water for dust control** during construction operations as opposed to importing water from off site for this specific use.
- **Require a protection plan** from a single source contractor for protection of existing vegetation during all construction activities. This will reduce the chances of damage due to uncoordinated or incomplete protection.
- **Clearly identify refueling stations** for excavation equipment, landscaping equipment, earthmovers and material lifts to prevent groundwater contamination.
- **Require grinding, chipping and shredding** of bulk site clearing materials for mulch use when applicable.

Case Study:

Donald Bren School of Environmental Science and Management

The Donald Bren School of Environmental Science and Management Project (a LEED Gold Pilot Project) utilized silt fencing, straw bale catch basins and scheduled grading activities in accordance with weather all as a part of the project's erosion control plan.

References

(2003). "Donald Bren School of Environmental Science and Management." http://www.esm.ucsb.edu/

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

(1996). Design for Construction Safety Toolbox. Austin, TX, Construction Industry Institute (CII).

Vleck, R. E. (2001). Advanced Construction and Demolition Waste Management for Florida Builders, University of Florida.

Chapter 1: Procurement
1.4 Foundations

Goal: Provide guidelines for contracting strategies on sustainable projects for work on foundations.

Contracting Strategies:

- **Require "clean-foundations**" with the intention of reducing waste of labor and material resources.
- **Require recycling of on-site spoils** from bulk excavation for fill material.
- **Require planning** for concrete truck wash-down area**s** and procedures.
- **Require detailed schedules** that minimize site disturbance during foundation work.
- **Clearly identify refueling stations** for excavation equipment and lifts to prevent groundwater contamination.
- **Do not use creosote** to treat timber foundations or any other ground contact members.
- **Require detailed site access plans t**hat minimize impervious site effects during construction.
- **Return unused materials to vendors.** Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Require hand excavation** around existing underground utilities.

Case Study:

Greater Pittsburgh Community Food Bank

http://www.nesea.org/buildings/2002openhouse/Foodbank.JPG

The Greater Pittsburgh Community Food Bank utilized low-permeability, cementitious (LPC) material for structural fill that consisted of 95% industrial waste products such as fly ash, lime and flue gas desulphurization material during the foundation phases of construction.

References

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

(1996). Design for Construction Safety Toolbox. Austin, TX, Construction Industry Institute (CII).

Chapter 1: Procurement
1.5 Substructure

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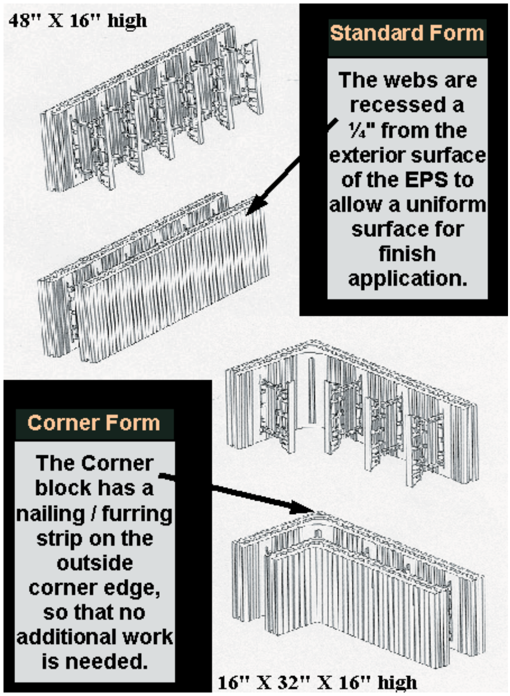
Goal: Provide guidelines for contracting strategies on sustainable projects for substructure work.

Contracting Strategies:

- **Require detailed scheduling** highlighting effects of work to the site that minimize site erosion.
- **Minimize formwork waste** by allowing re-use, or utilize insulated concrete forms (ICFs) to eliminate waste created by formwork
- **Require detailed site access plans** for all milestone stages of work (minimize impervious site effects during construction).
- **Clearly identify refueling stations** for excavation equipment and lifts to prevent groundwater contamination.
- **Do not allow creosote** to treat timber piles or any other ground contact members.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Require hand excavation** around existing underground utilities.
- Require/recommend sleeves/sealants that ensure low transfer rates of radon.

Case Study:

The Pennsylvania Department of Environmental Protection Cambria Office Building



The Pennsylvania DEP Cambria Office Building utilized insulated concrete forms (ICF) during the installation of the building's footings and retaining walls.

http://home.att.net/~SW-DIST-DOWTY/img16.gif

References

(1996). Design for Construction Safety Toolbox. Austin, TX, Construction Industry Institute (CII).

Chapter 1: Procurement
1.6 Superstructure

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Goal: Provide guidelines for contracting strategies on sustainable projects for superstructure work.

Contracting Strategies:

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- **Establish and require recycled content thresholds** for readily available recycled materials such as steel, re-bar, fly ash aggregate, etc. Require documentation of recycled content from product manufacturers.
- **Require locally manufactured materials** when available (varies by region). Give preference to products that are both harvested and manufactured locally.
- **Require a detailed lay-down/sequencing plan** that minimizes site disturbance, erosion and impervious effects on the site.
- **Clearly identify refueling stations** for cranes or lifts to prevent groundwater contamination.
- **Require detailed site access plans** for all milestone stages of work that minimize impervious site effects during construction.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Explore salvage markets** local to the site for use in acquiring salvaged materials and for salvaging reusable materials demolished or wasted on-site (CMU block, steel, etc.). This practice is more common in dense urban regions.

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Case Study:

Monsanto Company Life Sciences Incubator

The Monsanto Company Life Sciences Incubator in St. Louis, MO utilized locally manufactured materials (within 300 miles of the project) for almost two-thirds of the building project. Included were superstructure materials including concrete and structural steel.

References

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

Chapter 1: Procurement
1.7 Exterior Enclosure

Goal: Provide guidelines for contracting strategies on sustainable projects for exterior closure work.

Contracting Strategies:

- **Use a prime contractor or design-build contract** for the entire building façade to ensure accountability for the performance of the façade as a system.
- **Require high-recycled content** in readily available recycled materials such as glass.
- **Sequence/expedite building envelope** enclosure to minimize moisture exposure to interior materials/finishes reducing potential for mold.
- **Utilize "communal scaffolding"** to reduce labor waste, site disturbance and allow for most effective temporary building enclosure if required.
- **Require random field-testing** of building enclosure as work is installed in an attempt to identify any design or construction errors prior to completion of the entire system. This will prevent moisture infiltration during construction and allow for timely design/installation modifications when needed.
- **Clearly identify refueling stations** for material moving lifts to prevent groundwater contamination.
- **Require detailed site access plans** for all milestone stages of work that minimizes impervious site effects during construction.
- **Return unused materials to vendors.** Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Request occasional site visits from designers** to review the progress of the building enclosure and to ensure design intent is being met.

Case Study:

New York Times Building

http://www.businessweek.com/2000/00_43/photo_essay/3-1.html

The New York Times project team gave four curtain wall contractors a $50,000 stipend to mock-up the energy efficient building façade. Lessons learned during this process were then incorporated into the bid documents.

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Chapter 1: Procurement

1.8 Roofing

Goal: Provide guidelines for contracting strategies on sustainable projects for roofing work.

Contracting Strategies:

- Require kettle placement that is acceptable to site and adjacent sites for hot tar roofs.
- **Require sequencing** to be coordinated with interior finishes and building enclosure to prevent moisture infiltration and chances for mold.
- **Clearly outline recycling** and waste management requirements for the roofing contractor. Roofing operations many times create a large amount of waste relative to the rest of the construction activities.
- **Require detailed site access plans** for all milestone stages of work that minimizes impervious site effects during construction.
- **Return unused materials** to vendors. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.

Case Study:

The Ford Motor Company's Rouge River Plant

http://www.freep.com/money/business/roof9_20020809.htm

Ford Motor Company has created on of the world's largest green roofs. This 10.4-acre living roof covers the center section of the new truck plant's final assembly. The sedum plants absorb and filter water from rain and snow, absorb carbon dioxide, give off oxygen and keep the factory cooler in the summer and warmer in the winter.

References

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

Chapter 1: Procurement

1.9 Interior Construction

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Goal: Provide guidelines for contracting strategies on sustainable projects for interior construction work.

Contracting Strategies:

- **Clearly identify recycling requirements** for construction waste and the role of the interiors contractor as it relates to other trades when applicable.
- **For new construction projects** on which no self-performing labor is available, subcontract building clean-up through the interiors contractor. Require the separation of recycled material from waste by each contractor. Place the waste and recycled material in separate "marked buggies" for the interiors contractor to move to the dumpster and recycling bin, respectively.
- **Require ventilation plan** for air-contaminating operations such as sanding, sweeping, etc.
- **Require a detailed plan for renovation/phased work** identifying the needed temporary partitions to separate construction activities from adjacent building activities.
- **Require detailed sequencing plan** coordinating the drywall installation with the building enclosure to eliminate drywall installation prior to the elimination of moisture infiltration from the exterior.
- **Require delivery plan** through site and into building minimizing creation of impervious surfaces during construction.
- **Utilize buy-back opportunities for leasing of materials** such as carpet when available.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.

Case Study:

IST Project – Building Clean-Up

IST Building, Penn State University, University Park, PA.
Photos by George Greico, Penn State.

The Information Sciences and Technology Building on the campus of The Pennsylvania State University, implemented a waste management plan that required all contractors to haul materials to “local buggies”. It was then the interiors contractor’s responsibility to transport the materials in the “local buggies” to central construction waste management dumpsters.

Chapter 1: Procurement

1.10 Conveying Systems

Goal: Provide guidelines for contracting strategies on sustainable projects for conveying systems work.

Contracting Strategies:

- **Utilize communal conveying systems** to minimize energy consumption during construction.
- **Purchase green elevators**.
- **Install freight elevators as early as possible**. Ensure warrantee issues are not compromised. A full-time person may be required to operate the elevator during construction.
- **Coordinate building enclosure** at the elevator shafts to allow an expeditious elevator installation minimizing temporary hoisting needs.
- **Closely coordinate deliveries with installation times** in an attempt to allow installation directly from the truck. This will ultimately reduce the amount of protection required on elevators/ escalators.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.

Chapter 1: Procurement

1.11 Mechanical

Goal: Provide guidelines for contracting strategies on sustainable projects for mechanical work.

Contracting Strategies:

- **Require a plan for protection** of HVAC equipment for early start-up, including additional filters, warranty issues, owner requirements, etc.
- In raised floor applications, require detailed installation and balancing sequencing.
- **Require detailed site access plans** for all milestone stages of work that minimize impervious site effects during construction.
- **Return unused materials** to vendors. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Require a written IAQ plan** during construction.
- Require comprehensive planning that implements sustainable temporary utilities such as utilization of low water use toilets.

Ductwork protection during construction:

- **Require sequencing plan** to be coordinated with the schedule for building enclosure in order to minimize exposed ductwork and ductwork liner to hot/humid conditions.
- **Require a sealed duct liner** in the shop prior to site delivery to minimize the chances of mold during on-site storage.
- **Require "just-in-time" deliveries** to minimize the amount of on-site ductwork storage in uncontrolled environments.

Case Study:

The PA DEP Cambria Office Building

http://drs.yahoo.com/S=96062883/K=cambria+dep+building/v=2/l=IVI/*-http://www.lrkimball.com/Architecture and Engineering/images/Dep.jpg

The PA DEP Cambria Office Building Project design incorporated below-floor air distribution systems. Each diffuser has independent controls, which gives individuals the chance to control the environment in their workstation. This increased control and the natural ventilation flow provide a truly effective ventilation system.

References

"Cambria County District Office." (2003). L. Robert Kimball & Associates. http://www.lrkimball.com/Architecture%20and%20Engineering/ae_experience_green_padep.htm

Chapter 1: Procurement
1.12 Electrical

Goal: Provide guidelines for contracting strategies on sustainable projects for electrical work.

Contracting Strategies:

- **Require early installation of permanent electrical system** to minimize the number of temporary circuits needed to handle construction activities.
- **Require detailed site access plans** for all milestone stages of work that minimize impervious site effects during construction.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- **Provide incentives for reduced PVC use** in site conduit applications.

Temporary lighting and power:

- **Require temporary power plan** to minimize waste during construction.
- **Require energy efficient lamps for temporary lighting** and utilize fluorescent lamping where possible.
- **Require temporary emergency lighting** so that standard lighting can be turned off during non-working hours to conserve energy.
- Require planning that implements sustainable temporary utilities, such as low-energy consumption temporary lighting.

Case Study:

Phillip Merrill Environmental Center Headquarters

The Phillip Merrill Environmental Center Headquarters utilizes photovoltaic sunshades and crystalline photovoltaic skylights to generate energy used to power lighting and office equipment in the building.

References

(2003). LEED Reference Guide for New Construction and Major Renovations. (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

(1996). Design for Construction Safety Toolbox. Austin, TX, Construction Industry Institute (CII).

(2002). Green Building: Project Planning and Cost Estimating. Kingston, MA, R.S. Means.

"Our Tour of the Phillip Merril Center." (2002). Johns Hopkins University http://www.jhu.edu/~recycle/green/philip%20merril/phillip_merril_center.htm

Chapter 1: Procurement
1.13 Information Technology

Goal: Provide guidelines for contracting strategies on sustainable projects for information technology work.

Contracting Strategies:

- **Utilize virtual meetings** (teleconferences, conference calls) to reduce waste produced by travel time and fuel consumption.
- **Require electronic shop drawings** from all contractors and request electronic reviews by the design team to minimize paper waste.
- **Implement an electronic project management system** for the owner, construction manager, architect, engineers, and consultants that allows for paperless RFI's, submittal tracking, budget tracking, project directories, etc.
- Clearly identify the need and use of building sample submittals and minimize the number of samples required to be submitted for approval to reduce waste.

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Chapter 1: Procurement

1.14 Equipment

Goal: Provide guidelines for contracting strategies on sustainable projects for equipment installation.

Contracting Strategies:

- **Implement energy star** requirements for temporary and permanent building equipment.
- **Review equipment-sizing calculations** at milestone stages of the design. This will help to ensure minimized sizing of equipment or delay equipment sizing for a just-in-time design delivery for the equipment.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.
- Contract commissioning responsibilities during start-up when the owner does not employ an independent commissioning agent.

References

(2003). LEED Reference Guide For New Construction and Major Renovations (LEED-NC) Version 2.1. Washington, D.C., U.S. Green Building Council.

Chapter 1: Procurement

1.15 Finishes

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Goal: Provide guidelines for contracting strategies on sustainable projects for finishes work.

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Contracting Strategies:

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- **Require IAQ plan** for implementation during air-contaminating finishing activities such as painting, finishing drywall, VOC containing adhesive installation, etc.
- **Clearly indicate on-site recycling** requirements.
- **Maximize recycled content** in readily available recycled materials, such as carpet.
- **Identify storage areas and sequence deliveries** to allow bulk deliveries minimizing fuel consumption and packaging waste.
- **Require detailed site access plans** for all milestone stages of work that minimize impervious site effects during construction.
- **Return unused materials to vendors**. Owner and contractor should agree upon a plan for returning unused or excess materials that will not be needed for attic stock. Consider using a split savings clause. In most cases, unused materials can be sold back to the supplier at a 50% restocking fee.

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References

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(1997). Research Triangle Park Sequencing of Finish Installation Section 01450. North Carolina, U.S. Environmental Protection Agency.

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Chapter 2: Site/Environment

Goal: To lower the impact of construction on the site and the surrounding environment.

Benefits:

- Preserving the natural environment of the site is important to constructing "healthy" buildings.

Actions and Methods:

- Comply with all local and EPA environment regulations (http://www.epa.gov/epahome/rules.html).

Soil:

- Limit staging areas when possible.
- Preserve pervious surfaces by limiting traffic of vehicles, equipment, materials, and workers to designated areas.
- Protect topsoil during the construction process (ex. mound and seed).
- Prevent erosion by predicting changes in the site's pervious surfaces throughout construction.
- Develop and use an erosion and sediment pollution control program manual.

Water quality:

- Eliminate any and all possibilities of contamination to site's natural estuaries (runoff pollution, spillage, etc.).

Water flow control:

- Think about the impact of processes on-site drainage and runoff to prevent erosion (analyze flow volume, frequency, duration, and runoff rate with respect to predevelopment conditions).
- Use stormwater assessments prior to construction milestones as well as when any significant changes are made to the site.

Waste, recycling and material handling:

- Use proper disposal techniques for all land-clearing debris. Recycle or reuse when possible.
- Follow all guidelines for proper material handling and storage. Label the contents of materials and storage facilities, handling precautions and disposal instructions.
- Have detailed plans posted and readily accessible for all potential hazardous spills.

Habitat:

- Minimize impact on terrain by adhering to site circulation plans.
- Attempt to maintain existing topography, terrain and tree and vegetation population.
- Protect atmosphere against emissions produced through construction processes.
- Control and reduce noise pollution.
- Make use of natural lighting and ventilation.

References

Best Management Practices for Contractors and Inspectors. Field Manual on Sediment and Erosion Control, Jerald S. Fifield Forester Press.

“DRAFT Federal Guide to Green Construction.” (2004). Environmental Protection Agency. http://www.wbdg.org/design/greenspec.php

Greening Federal Facilities. (2001). Brattleboro, Vt, BuildingGreen, Inc.

Hemminway, P. C. a. S. (2004). “Construction Industry Compliance Assistance Center.” National Center for Manufacturing Sciences http://www.cicacenter.org/index.cfm

“High Performance Building Guidelines.” (1999). York Department of Design and Construction. New York.

“Low-Impact Development Design Strategies.” (2000). U.S. EPA and Prince George’s County Department of Environmental Resources.

“Sustainable Building Technical Manual.” (1996). Public Technology, Inc., USGBC, US DOE, US EPA.

“Whole Building Design Guide.” National Institute of Building Sciences http://www.wbdg.org/index.php

Chapter 2: Site/Environment
2.0 Planning

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Goal: To have detailed site work plans which encourage responsible practices and carry out the intent of the sustainable site design.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods:

- Document the site's existing natural features (estuaries, vegetation, etc.) and plan to preserve them.
- Create an environmental management plan for demolition as opposed to a "demo plan".
- Develop and use an erosion and sediment pollution control program manual.
- Formulate a spill plan (or reiterate safety program guidelines on spills).

Sequencing and scheduling:

- Self monitoring should be implemented throughout construction, including inspections of all erosion and sediment controls after each runoff event and on a weekly basis
- Use "Just-in-Time" construction methods to minimize site congestion and reduce the compaction of pervious surfaces. Think through delivery, staging and removal of waste/recycling, pervious buffer spaces and general circulation of the site.
- Sequence asphalt paving, and/or roadbeds that can be used as final bed for paving (concrete or asphalt) early, to provide cleaner surfaces.

Material storage:

- For new, multi-story projects, store materials necessary for each floor prior to completion of that floor's deck.

Temporary power:

- Use temporary exterior lighting and power sources until standard lighting and electricity is installed. Switch over as early as possible to reduce the number of runs necessary to handle the construction load.

Gather geotechnical/soils report:

- Identify vegetation, wildlife habitat, climate, solar, temperature, prevailing wind direction, humidity, precipitation and dominant weather patterns peculiar to the site.

Request detailed site work plans that Include:

- Site limitations (access, egress, drainage, etc.) and current uses (including any current utilities, existing structures, fill, parking etc.).
- A pervious surface analysis.
- A predevelopment analysis of soil, drainage, vegetation, and terrain.
- Best management practices with respect to erosion control, site circulation and traffic plans, and staging of materials and equipment.
- An inquiry to the owner as to the testing for Radon gas.
- A process for dealing with spillage and other hazardous material issues (Material Safety Data Sheets).
- A site layout plan of temporary facilities (toilets, trailers, trash and recycling dumpsters, etc.) added to site for construction purposes.
- Requirements for vehicular facilities (access, parking, loading/unloading, emergencies, etc.).
- A storm water drainage and filtering plan.
- Encouraging alternative transportation of workers to site (distribute public transport routes and schedules, provide a carpooling bulletin board, etc.) with possible incentives to reduce the compaction due to worker vehicles. Otherwise, designate worker parking areas and clearly mark walkways.

References

"Green Building Design and Construction Guidelines." (2004). City of Santa Monica Green Building Program http://greenbuildings.santa-monica.org/introduction/introduction.html

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment
2.1 General Conditions

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Goal: To incorporate sustainable practices into the building's surrounding environment.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Case Study:

Vancouver Island Technology Park
Victoria, British Columbia, Canada

97.8% of degraded habitat was restored by allowing previously irrigated turf area to restore itself naturally and by planting native plants and trees.

A no-build covenant protects treed areas.

Integrated Site Water Management Plan and Salmon Bear Creek Rehabilitation treats storm water from other sites and provides for rehabilitation of local creek.

Green building guidelines and educational program were also used.
http://www.usgbc.org/Docs/Certified_Projects/0113VITPcaseStudy2.pdf

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Chapter 2: Site/Environment
2.2 Demolition and Abatement

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Goal: To lower the impact of construction on the environment due to demolition and abatement.

Key Issues:

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- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries and habitat.
- Minimize erosion through sedimentation control.
- Minimize air pollution due to dust
- Comply with environmental laws and regulations

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Actions and Methods:

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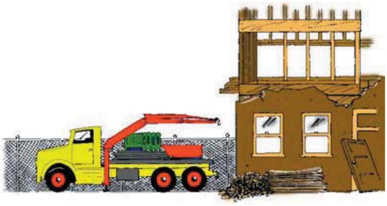
Items to include in demolition plan:

- Disassemble buildings to maximize the materials salvaged. Outline the dedicated areas for de-construction and disassembly. (See 7.2).



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- Reuse concrete as backfill, road base or aggregate.
- Take proper precautions to prevent contamination of site during demolition and removal of hazardous materials. Prevent contact with stormwater to maintain runoff water quality.
- Enforce and communicate site circulation plan for waste and recycling removal equipment to maintain pervious surfaces.

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Case Study:

Jean Vollum Natural Capital Center, Portland OR

Reused warehouse built in 1895. Part of revitalization effort in Portland's historic Pearl District.

- **Construction Waste Management**: 98% of constructed materials recycled/salvaged
- **Resource Reuse**: Salvaged materials comprised 10% of total. Including stone, brick, lumber, paneling, moldings, heavy timbers and doors.

http://www.usgbc.org/Docs/Certified_Projects/0086EcotrustCaseStudy2.pdf

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment

2.3 Site Work

Goal: To lower the impact of construction on the environment due to site work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods

Site considerations:

- Minimize the area to be cleared or graded.
- Stockpile topsoil in storage piles (or otherwise protect) during construction. Protect piles against storm water erosion by constructing them to freely drain surface water (for example, less than 35’ in height and with slopes of 2:1 or flatter). Cover to prevent dust.
- Reduce the size of impervious areas. Disconnect them when possible.
- When possible, limit equipment traffic and staging locations to areas that will eventually be paved.

Storm water:

- Disperse storm water according to preconstruction site work plans. Maintain the natural drainage of the site (flow volume, frequency, duration, and runoff rate) as detailed in the initial site analysis.
- Manage erosion by slowing down surface water (maintain wetlands, construct sediment ponds, pervious pavement etc.).
- Clean water prior to leaving the site to maintain water quality.

Atmosphere:

- Be conscious of emissions of vehicles and equipment. Do not leave equipment running unless re-start issues are a concern.

- Use proper dust control techniques along circulation paths, such as occurrence watering, dust control polymers, etc.

Existing site:

- Minimize the removal of trees and vegetation.
- Mulch or compost on-site vegetation that has been removed from site.
- Sell lumber of trees needing to be cleared. Do not slash and burn. Use selective cutting techniques.
- Maintain the existing topography and terrain. Decrease slopes of graded areas by carrying the rise over a longer stretch.
- Use non-invasive technologies (ex. trenchless and clean cut foundations).
- Place all excavated material on uphill sides of trenches to prevent surface water from entering trench. Backfill exposed trenches daily.
- Plant areas cleared or graded with native species of the site.

Sequence:

- Use "Just-in-Time" construction methods to minimize site congestion and reduce the compaction of pervious surfaces. Think through delivery, staging, and removal of waste/recycling, pervious buffer spaces and general circulation of the site.
- Sequence asphalt paving early to provide cleaner surfaces.

Case Study:

Cambria Office Building, Ebensburg, PA

Reduced Site Disturbance: 75% of the site was retained as open space
Storm water Management: No wetlands are impacted; new wetlands were created; a portion of paving is pervious; there is no net increase of storm water run-off

http://www.usgbc.org/Docs/Certified_Projects/0093CambriaCaseStudy2.pdf

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

"Reducing Runoff - Porous Pavement." Nonpoint Education for Municipal Officials http://nemo.uconn.edu/reducing_runoff/porous_pavement.htm

Chapter 2: Site/Environment

2.4 Foundations

Goal: To lower the impacts of construction on the environment due to foundation work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

Actions and Methods:

- Use dewatering and erosion control methods as defined in section 2.0.
- Check equipment and vehicles for hazardous leaks frequently throughout the project.
- Use trenchless or clean-cut foundation techniques to prevent excessive impervious surfaces.

Site logistics:

- Designate truck and vehicle cleaning areas.
- Re-fuel equipment only in dedicated areas. Protect against spillage and post proper guidelines (MSDS) for dealing with hazardous material ground contamination.
- Stockpile soil and seed or tarp the dirt mounds to prevent erosion.
- Place all excavated material on uphill sides of trenches to prevent surface water from entering trench. Backfill trenches daily.

Sealers:

- Provide protection against groundwater contamination when using exterior concrete sealers (geomembranes, etc.).
- Consider more environmentally friendly sealers and bio-based form releasing agents. (Ref. Section 3.4).

Case Study:

Federal Building – U.S. Courthouse; Youngstown, OH

Brownfield site.

79,000 sq. ft. of previously paved area was reused as engineered fill for new construction rather than adding to local landfills.

Over 600,000 lbs of concrete were recycled.

http://www.ofee.gov/sb/youngstown.htm

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment
2.5 Substructure

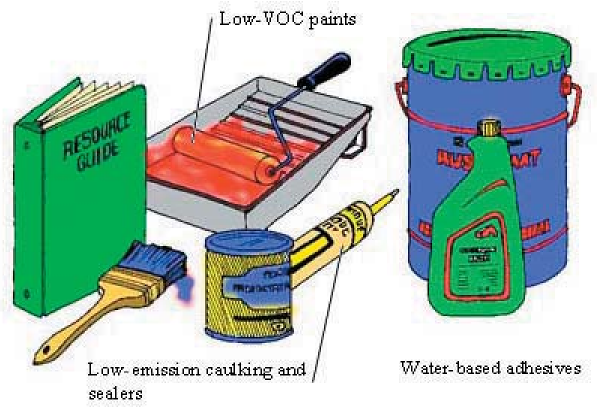
Goal: To lower the impacts of construction on the environment due to substructure work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

Actions and Methods:

- Provide protection against groundwater contamination during water proofing (geomembrane, etc.).
- Use "green" sealants that prevent penetrations through the foundation walls. (Ref. Section 3.5)
- Follow plan for erosion control and surface water diffusion during substructure erection.
- Recycle formwork (will require bio-based from release agent), or use alternative technologies (ex. ICFs).



Emerging Technology:

Insulating Concrete Forms (ICFs)

Highly versatile formwork and insulation.

Decreases pour time and reduces overall amount of concrete required.

Durable.

Energy-efficient.

Exterior noise is greatly reduced.

http://www.quadlock.com/images/general_construction/ wall_transition_horizontal.jpg

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment
2.6 Superstructure

Goal: To lower the impacts of construction on the environment due to superstructure work.

Key Issues:

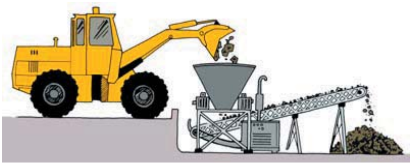
- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

Actions and Methods:

- Consider returning unused materials to the manufacturer (e.g. rebar, standard size steel members or trusses, miscellaneous metals, CMU block, brick).
- Protect the site against contamination during painting, fireproofing, and other potentially hazardous material usages (geomembranes, etc.).
- Use protective containers to protect site against rust from scrap metal. Or keep them of the ground.

Concrete:

- Use concrete waste in productive manner (ex. Jersey barriers, recycle into aggregate). Do not dump "waste" concrete.



- Give preference to off-site, prefabricated assemblies (e.g. precast concrete) over site-fabricated assemblies (e.g. tilt-up construction) which require more space for assembly and increase site disturbance.
- Always recycle steel scraps.
- Seek alternatives to standard fireproofing, environmentally-friendly fireproofing materials now available.

Site logistics:

- Organize lay down materials in order of use (i.e. next material to be used, closest to work activity).
- Reduce the site impact of machinery and cranes. Give preference to tower cranes with large booms and controlled positions over mobile cranes which a larger site area.

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment
2.7 Exterior Enclosure

Goal: To lower the impacts of construction on the environment due to exterior closure work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

Actions and Methods:

- Protect perimeter of building with metal plates or some other form of ground protection to reduce compaction. Also plan for the exterior closure's impact on the erosion control strategies.
- Shield against spillage of sealants and caulks to reduce soil and groundwater contamination.
- Provide signage directing waste and recycling to proper disposal points. See Waste Prevention and Recycling chapters in sections 4.7 & 5.7.

Material storage:

- Protect materials from rain and groundwater (use tarps, stage under protected structures, etc.).
- Stage materials, scaffolding, and lifts on-site on non-pervious surfaces. Maximize movements and placements of scaffolding and lifts to reduce traffic around perimeter. Consider using coordinated placement strategies.

Sequencing:

- Use "Just-in-Time" delivery of materials to minimize compaction.

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

Chapter 2: Site/Environment
2.8 Roofing

Goal: To lower the impacts of construction on the environment due to roofing work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods:

- Use ground protection (geomembranes, etc.) to prevent contamination from waste and spillages produced through roofing construction.
- Use manufacturer's recommendation for proper disposal of excess materials. Post instructions for hazardous roofing material spillages.
- Have erosion control and surface water diffusion strategies implemented prior to the incretion and redirection of the runoff caused by the roofing installation.

Material storage:

- Protect materials from rain and ground moisture (tarps and other geomembranes, etc.).
- Stage roofing materials and equipment on non-pervious surfaces.
- Position hot kettles and other fume producing equipment with concern for wind direction and neighboring environment.

Emerging Technology

Green and Brown Roofs

Dramatically reduce storm runoff by dissipating moisture naturally.
Reduce urban heat islands by reducing rooftop temperatures.
Reduce energy requirements of the building by slowing the transfer of heat into and out of the building. This reduces both heating and cooling requirements.
Lower maintenance required.
Longer life expectancies.
Green roofs also offer comfortable "park-like" settings.

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

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Chapter 2: Site/Environment
2.9 Interior Construction

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Goal: To lower the impacts of construction on the environment due to interior construction work.

Key Issues:

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- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

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Actions and Methods:

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- Heavy amounts of waste and scrap produced through interior construction should be disposed of properly.
- Monitor waste and recycling designated areas to enforce responsible practices.

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References:

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

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Chapter 2: Site/Environment
2.10 Conveying Systems

Goal: To lower the impact of construction on the environment due to conveying systems work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

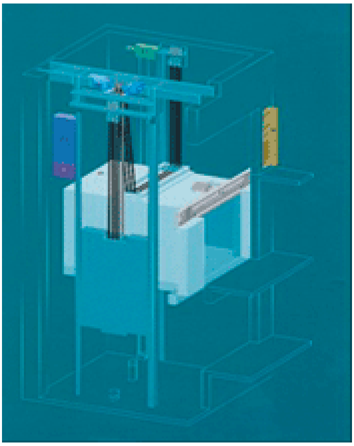
Actions and Methods:

- Use eco-friendly hydraulic fluid**.**
- Protect ground against contamination from elevator pit water proofing (geomembranes, etc.).

Emerging Technology:

Gen2 Elevator

This elevator has a new suspension technology that functions without a machinery room. The results are a reduction of the overall materials used, a substantial energy savings, a narrower design, reduced construction costs, a less noisy elevator and a more comfortable transport.



www.otis.com

Chapter 2: Site/Environment

2.11 Mechanical

Goal: To lower the impact of construction on the environment due to mechanical work.

Key Issues:

- Maintain soil permeability.
- Prevent groundwater contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods:

- Follow SMACNA IAQ Guidelines for occupied buildings (Reference Chapter 10.11).
- Protect against leaks during system tests of mechanical and sprinkler systems. Consider using glycol solutions.
- Stage all major equipment on non-pervious surfaces.
- Encase all PVC underground in concrete.

References

"Duct Cleanliness for New Construction Guidelines," Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), Chantilly, VA, 2000.

Chapter 2: Site/Environment
2.12 Electrical

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Goal: To lower the impact of construction on the environment due to electrical work.

Key Issues:

- Maintain soil permeability.
- Prevent ground contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

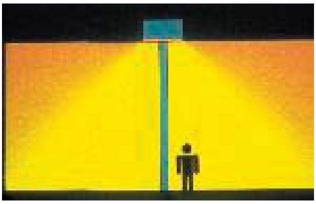
Actions and Methods:

- Protect conduit trenches against storm water and erosion.
- Encase all PVC underground in concrete.
- Use efficient outdoor lighting such as cutoff luminaries.
- Use clean-cut trenches and consult the site protection plans and analysis prior to any site disturbances necessary.
- Place all excavated material uphill of trenches to prevent surface water from entering trench. Backfill trenches daily.
- Use temporary exterior lighting and power sources until standard lighting and electricity is installed. Switch over as early as possible to reduce the number of circuits necessary to handle the construction load.

Emerging Technology:

Cutoff Lighting for Exterior Use

A full cutoff lighting fixture, one with no direct uplight at all, and with essentially no glare. All the light is used, none is wasted. Energy is conserved.



No adverse effects of bad lighting.
Reduces light pollution.

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Chapter 2: Site/Environment
2.13 Information Technology

Goal: To lower the impacts of construction on the environment due to information technology work.

Key Issues:

- Maintain soil permeability.
- Prevent ground contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods:

- Use clean-cut trenches and consult the site protection plans and analysis prior to any site disturbances necessary.
- Place all excavated material on uphill sides of trenches to prevent surface water from entering trench. Backfill trenches daily.

Chapter 2: Site/Environment

2.14 Equipment

Goal: To lower the impacts of construction on the environment due to equipment installation.

Key Issues:

- Maintain soil permeability.
- Prevent ground contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations

Chapter 2: Site/Environment

2.15 Finishes

Goal: To lower the impacts of construction on the environment due to finish work.

Key Issues:

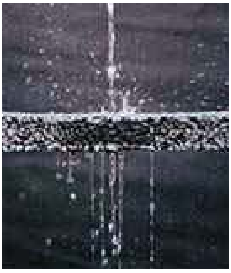
- Maintain soil permeability.
- Prevent ground contamination.
- Preserve natural vegetation, estuaries, and habitat.
- Minimize erosion through sedimentation control.
- Comply with environmental laws and regulations.

Actions and Methods:

- Follow SMACNA IAQ Guidelines for occupied buildings (Reference Chapter 10.15).
- Properly dispose of paint and varnishes. Use manufacturer guidelines.
- Post signage in readily accessible location for the directions of foreseeable spillage of any hazardous materials being used.
- Protect against ground contamination by exterior concrete sealants and stains (geomembranes, etc.).
- Prevent fume build-up by using proper ventilation (utilize fans when necessary).
- Finish site using natural and indigenous surfaces when possible.
- Loosen soil in all planting areas to a depth of 24” and 85% standard density. Till the top 10”.

Emerging Technology:

Porous Paving



Porous pavement is designed to allow storm water to pass through. This filters the water and helps to eliminate surface runoff commonly associated with normal asphalt.

Photo from Titan America.

References

"Low-Impact Development Design Strategies." (2000). U.S. EPA and Prince George's County Department of Environmental Resources.

"Reducing Runoff - Porous Pavement." Nonpoint Education for Municipal Officials http://nemo.uconn.edu/reducing_runoff/porous_pavement.htm

Chapter 3: Material Selection

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Benefits:

- Reduce pollutants and resources consumed from material production by purchasing preferable materials.
- Reduce fuel and transportation costs.
- Reduce solid waste problems, cut energy consumption in manufacturing, and save on natural resource use.

Sustainable Materials are…

- **Durable.**
- **Reused or salvaged.**
- **High recycled content.**
- **Rapidly renewable.**
- **Biodegradable.**
- **Reusable.**
- **Locally manufactured.**

Materials to Avoid:

- **CFC's and HCFC's:** Avoid ozone-depleting chemicals in mechanical equipment and insulation made of CFCs and HCFC's. Reclaim CFCs when servicing or disposing of equipment.
- **VOCs:** Volatile Organic Compounds found in paints and coatings, adhesives and sealants, carpet, and composite wood.
- **PVC.**
- Wood treated with copper chromium arsenate **(CCA).**
- **PBT** (Persistent, Bioaccumulative Toxic Chemicals) (e.g. mercury, lead, cadmium).

References

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Chapter 3: Material Selection

3.0 Planning

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Benefits:

- Reduce pollutants and resources consumed from material production by purchasing preferable materials.
- Reduce fuel and transportation costs.
- Reduce solid waste problems, cut energy consumption in manufacturing, and save on natural resource use.

Sustainable Materials are…

- **Reused or salvaged materials**
- **High recycled content**
- **Rapidly renewable**
- **Biodegradable**
- **Reusable materials**
- **Locally manufactured**

Materials to Avoid:

- **CFC's and HCFC's**: Avoid ozone-depleting chemicals in mechanical equipment and insulation made of CFCs and HCFC's. Reclaim CFCs when servicing or disposing of equipment.
- **VOCs:** Volatile Organic Compounds found in paints and coatings, adhesives and sealants, carpet, and composite wood.
- **PVC.**
- Wood treated with Copper Chromium Arsenate (CCA).
- **Urea formaldehyde.**
- **PBTs** (Persistent, Bioaccumulative Toxic Chemicals). These can

be found in products such as paints, varnishes, caulks, electrical switches and thermostats, fluorescent bulbs, solders, & vinyl.

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Methods to educate the project team:

- Educate the team about environmental impacts of building materials over their lifecycle from the raw materials acquisition through the production process, the packaging and shipping, the installation and use, and the ultimate resource recovery.
- Conduct a training workshop with subcontractors before construction begins to raise awareness of material selection. (discuss project goals, procedures, LEED requirements, reasons for using environmentally preferable materials).
- Require the architect to review all specs with each subcontractor, prior to start of construction, to review, clarify, educate and identify materials with which subcontractors may not be familiar. This gives subcontractors the opportunity to provide input on constructability and local availability issues.
- Utilize the Program Management Policy for guidance on the Material Evaluation Process for Divisions 2-12, as developed by PENREN/C.

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References

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Chapter 3: Material Selection
3.2 Demolition and Abatement

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Temporary Barriers/Enclosures:

- Use recycled rubber and plastic materials for temporary barriers.
- A-Frame Barricades.

Salvaged Materials (reference chapter 7.2):

- Re-use wood of high quality, including wood formerly used structurally, or in sub flooring, by getting it re-milled for finish carpentry.

Paint Removers:

- Low-VOC, non-toxic, biodegradable products.

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Chapter 3: Material Selection
3.3 Site Work

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Subsurface/Foundation Drainage:

- Use geotextile products manufactured from recycled plastic.
- Use on-site crushed rock or recycled content.

Erosion and Sedimentation Control:

- Use natural-fiber geotextiles capturing the benefits of biodegradability once vegetation is established.
- Cellulose hydro-mulching utilizing recycled newspaper content.

Utility Poles:

- FSC-certified wood sources, safer preservatives, and recycled content.
- Certified Utility Poles.

Storm Drainage Piping:

- High recycled content piping.

Outdoor Athletic/Play Surfaces:

- Granulated rubber from recycled tires offers an appropriate surfacing material.

Unit Pavers:

- Pavers made from recycled or salvaged materials such as cobblestone or brick, or products made with oil-contaminated-soils, fly ash or other industrial waste.

Pavement:

- Porous asphalt paving and concrete paving with recycled content (post-consumer recycled HDPE plastic), ideal for parking lots, driveways, and roads that will not carry vehicles traveling at high rates of speed.
- Use Portland cement concrete with 25% fly ash that has less

embodied energy and reduces water permeability.

- Use Rubber Modified Asphalt (RMA) with a crumb rubber content no greater than 20%.

Walk, Road and Parking Appurtenances:

- Recycled plastics for roadway markers, speed bumps, parking stops and traffic signs.

Site Furnishings:

- For trash receptacles, benches, tables and bike racks use recycled content material (made from HDPE or co-mingled plastic).
- Plastic or certified lumber that can be used in benches, tables, chairs, trashcans, etc. is an option for landscape furnishings.

Plantings:

- Use non-toxic waste materials in landscaping applications such as brick nuggets -- a byproduct of brick manufacturing.
- When irrigation is required, use drip or bubbler systems and utilize rain sensor overrides.
- Use soaker hoses made from recycled rubber.
- Use plants native to the region.
- Use bio-solids and sludge from wastewater treatment facilities.

Materials to Avoid:

Erosion and Sedimentation Control:

- Polymer-based products.

Landscape Timbers:

- Wood treated with copper chromium arsenate (CCA).

Plantings:

- High-pressure misting sprinklers.

PENREN/C Practice:

Pentagon Parking Lot and Access Road repairs

Project Description: In 1997 D-M&S, Inc. was awarded a five year $1 million-per-year DOD contract to maintain and repair parking lots and access roads at the Pentagon and three other facilities.
Contract Incentive: A 2% allowable price differential for the use of optional products with specified environmental attributes.
Result: Total cost of the contract, including incentive payments was significantly lower than that of comparable parking lot repair projects.
Materials used as of August 1998 included:

- 3,328 tons of recycled asphalt.
- 1,031 tons of recycled concrete.
- 300 cubic yards of concrete containing recovered materials.
- 3,558 linear feet of low-VOC paint (<50g/l).
- 24,324 ft^2 of low-VOC concrete curing compound.

References

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Chapter 3: Material Selection
3.4 Foundations

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Formwork:

- Biodegradable form-releasing agents.
- Tube formwork made from recycled paper, typically used for stairs these forms can be utilized on all sites.
- Certain tube formwork manufacturers offer re-cycled paperboard forms available from 6”-60”in diameter.
- Insulating Concrete Forms (ICF) in permanent form applications.
- Expanded polystyrene permanent formwork.

Reinforcing Bars:

- Recycled plastic rebar supports.
- High-recycled steel content is available in reinforcing bars (or scrap bars). Certain products utilize 100% recycled engineering-grade plastic.

Concrete:

- Coal fly ash can be used as a substitute for up to 60% of the Portland cement in a concrete mix (dependent upon application).
- Low-VOC and bio-based concrete curing compounds.
- Mortars with high fly ash content are effective when performing rehabilitations to concrete.
- Biodegradable and bio-based concrete cleaning agents are available.
- Industrial waste materials (coal waste and/or palletized blast furnace slag) can be used as lightweight aggregates to replace sand in mortar.

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Miscellaneous:

- Recycled newspaper or waste agriculture materials can be used in expansion joint fillers.
- Foundation anchor systems are available that do not require excavation.

Materials to Avoid:

Formwork:

- Petroleum based form-releasing agents.

Concrete:

- High Portland cement content.

References

Malin, A. W. a. N. (2003). Greenspec Directory. Montpelier, VT, Dan Woodbury.

"Matrix: Overview of Recycled Content Levels and Product Availability." (2003). Integrated Waste Management Board http://www.ciwmb.ca.gov/GreenBuilding/Materials/Matrix.htm#Division2

Mendler, S. and W. Odell (2000). The HOK Guidebook to Sustainable Design. New York, John Wiley and Sons, Inc.

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Chapter 3: Material Selection

3.5 Substructure

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Formwork:

- Biodegradable form-releasing agents.
- Tube formwork made from recycled paper, typically used for stairs. These forms can be utilized on all sites.
- Certain tube formwork manufacturers offer re-cycled paperboard forms available from 6"-60"in diameter.
- Insulating Concrete Forms (ICF) in permanent form applications.
- Expanded polystyrene permanent formwork.

Reinforcing Bars:

- Recycled plastic rebar supports.
- High-recycled steel content is available in reinforcing bars (or scrap bars). Certain products utilize 100% recycled engineering-grade plastic.

Concrete:

- Coal fly ash can be used as a substitute for up to 60% of the Portland cement in a concrete mix (dependent upon application).
- Low-VOC and bio-based concrete curing compounds.
- Mortars with high fly ash content are effective when performing rehabilitations to concrete.
- Biodegradable and bio-based concrete cleaning agents are available.
- Industrial waste materials (coal waste and/or palletized blast furnace slag) can be used as lightweight aggregates to replace sand in mortar.

Dampproofing/Waterproofing:

- Use expanded polystyrene (EPS) in lieu of HCFC's. High-density EPS is acceptable for many water impermeability applications.

Adhesives/Sealants:

- Water-based adhesives are available that contain zero VOCs and are suitable for porous and nonporous surfaces.
- Low VOC water-based silicone sealants.

Miscellaneous:

- Recycled newspaper or waste agriculture materials can be used in expansion joint fillers.
- Foundation anchor systems are available that do not require excavation.

Materials to Avoid:

Formwork:

- Petroleum based form-releasing agents.

Concrete:

- High Portland cement content.

References

Malin, A. W. a. N. (2003). Greenspec Directory. Montpelier, VT, Dan Woodbury.

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Chapter 3: Material Selection
3.6 Superstructure

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Structural Steel:

- Overall the steel industry's recycling rate is over 60%. Capitalize by utilizing high-recycled steel content in your superstructure.
- Search for environmentally friendly primers (primers exist that contain no hazardous materials and have a low-VOC content).
- Give preference to factory finishing rather than site-finishing.
- Consider metal finishing based on physical processes such as abrasive blasting, grinding, buffing, and polishing, rather than multiple coatings.

Concrete:

- Use coal fly ash as a substitute for up to 60% of the Portland cement in a concrete mix (dependent upon application).
- Low-VOC and bio-based concrete curing compounds.

Materials to Avoid:

Structural Steel:

- Lead based or high VOC paints, rust inhibitors, and other coatings.
- Plated metals that use cadmium and/or chromium plating materials.
- Cyanide and/or copper/formaldehyde copper plating solutions.

PENREN/C Practice:

Sustainable Materials Used on Wedge 2 Phases I & II

Material and their respective reused content:

- Unit masonry (20% post-industrial).
- Structural steel (59% post-consumer, 32% post-industrial).
- Concrete reinforcement (59% post-consumer, 32% post-industrial).
- Cast-in-place concrete (30% post-industrial).

References

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Mendler, S. and W. Odell (2000). The HOK Guidebook to Sustainable Design. New York, John Wiley and Sons, Inc.

Chapter 3: Material Selection

3.7 Exterior Closure

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Framing:

- Heavy gauge structural steel framing commonly has 90% recycled content.
- Look for high recycled content in steel fasteners.

Masonry:

- High fly-ash content mortars.
- High recycled content weep vents.
- High recycled content aggregate.
- Brick from oil-contaminated soils.
- Adobe, pressed-soil-cement, or other natural, low-embodied-energy masonry technologies.

Plywood:

- Formaldehyde-free particleboard and plywood.
- Pressure treated lumber not containing CCA's (alternatives include: copper-based, non-arsenic, non-chromium; or alkaline copper and quaternary ammonium compounds (ACQ); or boron-based wood treatment.
- Independently certified sustainably harvested wood; Scientific Certification Systems (SCS), Smartwood Program of the Rainforest Alliance), Forest Stewardship Council (FSC).

Dampproofing/Waterproofing:

- Expanded polystyrene (EPS) in lieu of HCFC's. High-density EPS is acceptable for many water impermeability applications.

Adhesives/Sealants:

- Water-based adhesives are available that contain zero VOCs and are suitable for porous and nonporous surfaces.
- Low VOC water-based silicone sealants.

Insulation:

- Foam insulation should be utilized to combat the problem of thermal bridging. Preferred insulation materials are mineral wool insulation, cotton insulation and cellulose insulation.
- Special steel systems are also designed to combat thermal bridging.
- Expanded polystyrene (EPS) foam for rigid foam board applications.
- Cellulose insulation made from 75 to 85% recycled newsprint.

Materials to Avoid:

Wood/Millwork:

- Formaldehyde treated particleboard and plywood.
- Lumber pressure treated with chromate copper arsenate (CCA).

Dampproofing/Waterproofing:

- High VOC containing asphalt-based coatings.

Insulation:

- Fiberglass insulation that contains phenol-formaldehyde binders.
- Blown spray applied insulation using CFC's or HCFC's.
- Extruded polystyrene (XPS) rigid board insulation.

Adhesives/Sealants:

- Caulks or sealants that contain mercury (PBT).

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

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Chapter 3: Material Selection

3.8 Roofing

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Green Roofs:

- Living/green roofs systems are vegetated roof systems that can significantly reduce heating and cooling costs.

Metal Roofs:

- Metal roof materials, containing high percentages of recycled content of up to 100% of steel and aluminum. Metal shingles can also be considered for high slope roofing applications.

Photovoltaic:

- Photovoltaic roofing systems enable sustainable energy production.
- Reflective roofing technologies help to mitigate the urban heat island effect.

Shingles:

- Plastic shingles made from recycled content resembling slate shingles provide cradle-to-cradle benefits.
- Natural slate shingles are excellent from an environmental standpoint.
- Wood shingles made from certified woods are available.
- Clay roof tiles are made from abundant raw materials and carry effective heat gain characteristics.

Thermoplastic Roofing Membrane:

- Consider using roofing membranes containing thermoplastic olefins (TPO) in lieu of PVC's.

Materials to Avoid:

- Asphalt shingles create a large portion of a demolition project's waste.
- High VOC containing caulking and sealants.
- Insulation products manufactured using CFC's or HCFC's.
- Caulks or sealants that contain Mercury (PBT).

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

"Case Studies." (2004). Greenroof.com http://www.greenroofs.com/north_american.htm

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Chapter 3: Material Selection
3.9 Interior Construction

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Partitions:

- Cold-rolled steel framing typically contains 20-25% recycled material. Maximize recycled content when purchasing interior stud framing.
- 100% recycled cellulose building insulation makes efficient use of existing feedstock and helps create a market for recycled newspaper.
- Use hollow metal doors and frames from recycled metal content.
- Composite boards, including paper and wood/paper building boards use milling by-products, waste woods, recycled paper, and/or agricultural waste (wheat-straw board).

Adhesives/Sealants:

- Water-based adhesives are available that contain zero VOCs and are suitable for porous and nonporous surfaces.
- Low VOC water-based silicone sealants.

Wood/Millwork:

- Use wood products certified by the Forest Stewardship Council (FSC) standards.
- Reclaimed wood lumber and timbers salvaged from various places including demolished buildings.
- High recycled content shims.
- Engineered lumber products utilizing fast-growing, small-diameter trees.
- Structural Insulated Panels (SIP) consisting of Oriented-Strand Board (OSB). Expanded polystyrene (EPS) core material is environmentally preferred over polyurethane.
- Natural cork, strawboard and recycled-content fiber board can be

used in flooring underlayment applications.

- Wood-plastic composite lumber offers an alternative to all synthetic wood materials when needed in some structural applications.

Materials to Avoid:

Adhesives:

- VOC containing adhesives.
- Caulks or sealants that contain Mercury (PBT).

Wood/Millwork:

- CCA Pressure-treated lumber.

Partitions:

- Urea-formaldehyde binding resin.

PENREN/C Practice:

Sustainable Materials on Wedge 2 Phases I & II

Materials and their respective reused content:

- Metal support assemblies (23% post-consumer, 8% post-industrial).
- Steel doors and frames (27.3% post-consumer, 40.6% post industrial).

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

Frevert, K. (2004). "Green Building Case Studies." Integrated Waste Management Board http://www.ciwmb.ca.gov/GreenBuilding/CaseStudies/#Commercial

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Chapter 3: Material Selection

3.10 Conveying Systems

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Elevators:

- Alternating Current (AC) gearless elevators. The technology saves electricity by lowering power consumption by about 40 percent, compared to conventional AC-powered traction elevators, permanent-magnet motor, supplies the power.
- Biodegradable hydraulic elevator oils.

References

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Chapter 3: Material Selection
3.11 Mechanical

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Plumbing:

- High recycled content cast iron for sanitary waste and vent piping.
- Vitrified clay pipes can be used for drain piping to minimize the expense of cast iron).
- High recycled content plastic piping for sanitary waste and vent piping.

Mechanical:

- Non-fiberglass containing duct liners are available.
- Use only non-ozone depleting refrigerants (SP34E).
- Consider easily cleaned ductwork products or those that protect against mold/fiber-shedding.
- Use duct mastics in lieu of duct tapes to minimize leakage effects.

Materials to Avoid:

Plumbing:

- PVC or ABS plastic pose many potential hazards to the environment.

Mechanical:

- Electric resistance water heaters.
- Ozone depleting refrigerants (CFC & HCFC).
- Exposed internal fiberglass duct liner.
- Lead Solders (PBT).

PENREN/C Practice:

Sustainable Materials on Wedge 2 Phases I & II

Materials and their respective reused content:

- Louvers (70% post-consumer).

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

Malin, A. W. a. N. (2003). Greenspec Directory. Montpelier, VT, Dan Woodbury.

Mendler, S. and W. Odell (2000). The HOK Guidebook to Sustainable Design. New York, John Wiley and Sons, Inc.

Chapter 3: Material Selection

3.12 Electrical

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Lighting:

- Use of fluorescent lighting consumes as little as one-fifth the power and lasts up to 13 times longer than incandescent fixtures.
- Slim-profile lighting systems can save energy with better lumen output and a thinner lamp, providing a highly concentrated light source that can enhance the performance of the luminaries.
- Effective reflectors on temporary lights as well as permanent lights decrease energy consumption.
- LED exit sign fixtures consume less energy than incandescent lights and often pay back the additional first cost within one year through energy savings.
- Plastic electrical device wall plates made of 20% recycled plastic can be re-used (if not damaged during removal).
- Photo luminescent signage requires no backup power supply, no conduit, and no battery and are a very simple installation. UL listings are now available which meet code requirements.

Power:

- Plastic electrical device wall plates made of 20% recycled plastic can be reused.
- Air-tight electrical boxes minimize air leakage.

Telecommunications:

- Telecommunications cabling with up to 20% recycled plastic can be reused.

Transformers:

- Bio-based transformer fluids are available that can improve equipment efficiency.

Materials to Avoid:

- Electrical switches and thermostats containing Mercury (PBT).
- Exit signs with fluorescent bulbs containing Mercury (PBT).
- Fluorescent and compact fluorescent lamps (bulbs), high intensity discharge (HID) lamps that contain Mercury (PBT).

PENREN/C Practice:

Sustainable Materials on Wedge 2 Phases I & II

Materials and their respective reused content:

- The electrical transformer oil is a soy-based product.

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

Malin, A. W. a. N. (2003). Greenspec Directory. Montpelier, VT, Dan Woodbury.

Mendler, S. and W. Odell (2000). The HOK Guidebook to Sustainable Design. New York, John Wiley and Sons, Inc.

Chapter 3: Material Selection

3.14 Equipment

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

- Bio based transformer fluids can improve efficiency equipment efficiency.
- Use "energy star" rated equipment.

PENREN/C Practice:

Sustainable Materials on Wedge 2 Phases I & II

Materials and their respective reused content:

- The electrical transformer oil is a soy-based product.
- All kitchen equipment is Energy Star compliant.

Chapter 3: Material Selection
3.15 Finishes

Goal: To educate and familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment.

Sustainable Materials:

Partitions:

- Gypsum wallboard incorporates recycled scrap wallboard and by-product gypsum (5% post-consumer and 95% post industrial gypsum are readily available).
- 90% recycled fiberboard and 100%-recycled particleboard are available. These products use reclaimed wood or agricultural fiber as non-structural panels.
- Synthetic gypsum content in drywall (75% or greater) helps prevent against moisture.
- Paper-faced compressed straw panels can be used as an alternative for interior wall partitions.
- Paper joint tape should be used in lieu of fiberglass tape.
- Joint compound is available with zero or low-VOC (<20 g/l) content.

Ceilings:

- Ceiling panels consisting of 25% recycled mineral wool and newsprint (and helps create a market for recycled newspapers.
- Ceiling tiles with 65% recycled content.
- Metal ceilings containing high-recycled content.

Flooring:

- Flooring from recycled and reusable materials, such as rubber, glass, agriculture fibers, and plastic can last longer and are easier to maintain.
- Carpet tiles from post-industrial nylon are available. They are reusable and recyclable.
- Ceramic tile containing post-consumer or post-industrial waste is available.
- Recycled glass tile.
- Terrazzo materials containing recycled content.
- Natural linoleum flooring.
- Reclaimed wood products such as re-milled structural timbers.

Wall Finishes/Coverings/Millwork:

- Use latex paints without VOC's for interior and exterior use.
- Cork wall coverings.
- Seal all edges, ends, and holes of formaldehyde containing substrates.

Materials to Avoid:

Flooring:

- Vinyl flooring with high PVC content.
- Endangered wood species, the Convention on the International Trade in Endangered Species (CITES) provides this list.

Wall Finishes/Coverings/Millwork:

- Vinyl wall coverings containing PVC are significant sources of VOC's.
- Formaldehyde containing products for woodwork substrates.
- Paints and finishes, varnishes, floor polish and wood stains containing Cadmium, Dibutyl phthalate (PBTs).

PENREN/C Practice:

Sustainable Materials on Wedge 2 Phases I & II

Materials and their respective reused content:

- Gypsum wallboard (5% post-consumer, 95% post industrial).
- Acoustical ceiling (82% post-Industrial) (Humidity resistant).
- Ceramic tile (10% post-industrial).
- Resilient flooring (10% post-industrial).
- Toilet compartments (36% post-consumer, 14% post-industrial).
- Smart /academic wall (25% post-consumer, 40% post-industrial).
- Toilet accessories (65% post-consumer).
- Horizontal blinds (30% post-industrial).
- Tenant doors (SCS certified).
- A soy-based sealant is being used for the terrazzo.
- The rubber flooring used in telecommunication closets and in various vestibules is a rapidly renewable resource and also contains 10% post-industrial recycle content.
- Paint contains 0 (ZERO) VOC's.

References

"Building Construction and Maintenance: Products Containing Persistent, Bioaccumulative Toxic Chemicals (PBTs)." (2003). INFORM. New York

Malin, A. W. a. N. (2003). Greenspec Directory. Montpelier, VT, Dan Woodbury.

Mendler, S. and W. Odell (2000). The HOK Guidebook to Sustainable Design. New York, John Wiley and Sons, Inc.

Chapter 4: Waste Prevention

Goal: Eliminate waste produced on the jobsite.

Benefits:

- Reduction in expenditures for materials, and less material necessary.
- Lower labor costs results in less material to be handled and cut.
- Decrease in disposal costs, landfill tipping fees decreased.

Keys Issues:

Material Handling and Purchasing:

- Avoid damage by handling and storing materials properly.
- Estimate material quantities as accurately as possible: more accurate = less waste.
- Purchase precut and prefabricated components when available.
- Order materials to size when possible.

Material Selection:

- Purchase high-quality, construction grade materials.
- Reduce packaging waste through vendor participation (Ref. Section 4.0).
- Reduce the use of non-recyclable materials when viable.
- Replace disposable materials and products with reusable materials and products.
- Reuse jobsite materials such as concrete forms and fencing.
- Use salvaged materials from other jobs.

Construction Methods, Sequencing and Scheduling:

- Coordinate just-in-time deliveries.
- Use methods for construction of temporary structures that allow for reuse, such as screws rather than nails.
- Use a central area for cutting and storage of scraps for reuse.
- Allow for local scavenging, if not a site safety issue.
- Donate or sell (upon owner approval) reusable items from the job.
- Develop a list of anticipated waste and then develop methods to reduce the anticipated waste.
- Develop initiatives to reduce, reuse and recycle waste.
- Have all subcontractors and suppliers propose procedures for waste minimization, including supply, delivery, handling, storage, efficiencies, packaging, protection, pre-cutting and recycling.

References

A Technical Manual for Material Choices in Sustainable Construction. (2000). Sacramento, CA, State of California Integrated Waste Management Board.

Vleck, R. E. (2001). “Advanced Construction and Demolition Waste Management for Florida Builders.” University of Florida.

WasteWise Building Challenge, (2004). Environmental Protection Agency.

Chapter 4: Waste Prevention

4.0 Planning

Goal: Reduce or eliminate waste throughout the building process.

Actions and Methods:

- **Conduct periodic brainstorming sessions** on how to reduce waste.
- **Prepare a Construction Waste Management Plan** that includes waste prevention activities (Reference Simpson 2003).
- **Communicate** your waste management plan at meetings, post it on-line, and promote the results.
- Develop and post jobsite waste reduction plan (with reduction goals) in central locations.
- **Training -** use meetings to inform contractors, subcontractors and laborers about the importance of waste reduction.
- Designate someone to lead and manage the waste reduction program.
- **Provide positive incentives** to crews to encourage waste reduction (pizzas, BBQ, hats, t-shirts – be creative).
- Develop a list of supplier contacts that are proactive in planning their waste reduction techniques.

Opportunities to Avoid Waste during Design:

- Design with standard sizes for building materials.
- Specify materials and assemblies that can be easily disassembled at the end of their useful life.
- Design precast concrete members for concrete (Tilt-up) construction.
- Choose durable non-toxic interior finishes or materials.
- Design spaces to be flexible for changing uses.
- Consider reusing materials (on-site) or installing salvaged materials from off-site sources.

Jobsite Waste Prevention Methods:

- Set up a central cutting area for wood and other materials.
- Reuse concrete forms or choose reusable metal or fiberglass forms.
- Clearly mark areas key to waste prevention, such as the material storage, central cutting, and recycling stations.
- Practice material storage and handling procedures to prevent loss or damage.

Avoid Waste during Purchasing:

- Check to ensure the correct amount of each material is delivered to site.
- Maintain an up-to-date material ordering and delivery schedule to minimize the amount of time that materials are on-site and reduce the chance of damage.
- Replace toxic materials with less toxic or non-toxic products to reduce hazardous packaging.
- Choose products with minimal or no packaging.
- Ask suppliers to deliver supplies using sturdy, returnable pallets and containers. Have suppliers pick up pallets and empty containers.
- Require suppliers to take back or buy-back substandard, rejected, or unused items.

References

Simpson, S. (2003). Construction Waste Management Guide: Methods to Save Money and Resources. Olympia, WA, State of Washington Department of General Administration.

A Technical Manual for Material Choices in Sustainable Construction. (2000). Sacramento, CA, State of California Integrated Waste Management Board.

Vleck, R.E. (2001). Advanced Construction and Demolition Waste Management for Florida Builders, University of Florida.

Chapter 4: Waste Prevention

4.1 General Conditions

Goal: Reduce or eliminate waste throughout the building process.

More waste avoidance methods:

- Keep accurate project records of the costs and savings associated with waste prevention. Provide the information to the building owner and, if possible, estimate the cost savings and the corresponding environmental impacts.
- Use locally available materials and resources.
- Set up stockpiles of free left over or scrap building supplies.
- Work with field personnel to incorporate waste prevention into everyday processes.
- Reuse left over building supplies and materials for the next job.
- Identify methods to share equipment with other contractors (e.g. scaffolding, crane, lifts).
- When constructing temporary structures for site work, use methods that allow for reuse, such as screw rather than nails.

Case Study:

Waste Reduction

A great and free way to reduce waste on-site is to create stock piles or areas where excess building materials and supplies can be taken by employees for personal use.

Source: Contractors Guide King County Seattle 2002-2003

References

"Construction Waste Minimization Methods." (2004). Nebraska Energy Office http://www.state.ne.us/home/NEO/home_const/factsheets/const_waste_min.htm

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

"Minimizing Construction and Demolition Waste." (2000). Hawaii Department of Health. http://www.hawaii.gov/health/eh/cao/sb_library/c_and_d_waste_min.pdf

O'Brien, K. Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii. A Contractor's Waste Management Guide. The State of Hawaii.

Chapter 4: Waste Prevention
4.2 Demolition and Abatement

Goal: Reduce or eliminate demolition and abatement waste.

Actions and Methods:

Salvage Opportunities:

- Assess/ test waste for contamination (lead, asbestos, mold) before determining the correct removal and disposal method.
- Conduct detailed assessments to better understand materials or equipment that are salvageable vs. recyclable.
- Development demolition sequences around salvageable material removal where time allows.
- **During remodeling**, separate metal radiators, grates, piping, aluminum siding and old appliances for reuse, recycling, or supplier/manufacture buy-back.
- **Inventory salvageable materials** (determine the volume and value of salvageable materials).
- Estimate labor hours to dismantle building and to make accessible the salvageable materials vs. simply disposing material.
- **Allow for local scavenging**, if not a site safety issue. Schedule a day or afternoon when people can come by and take salvaged equipment and material. Record the value of these items because they are possible tax write-offs and project savings. The IRS requires items worth more than $5,000 be appraised.

Planning and Education:

- Identify problem areas: Asbestos, lead-based paint and treated wood.
- Include requirements for job training compliances in statement of work.
- Develop a demolition and abatement plan to evaluate costs.
- Institute deconstruction as soon as possible (Ref. Ch. 7).
- Conduct workshops to develop a local strategy for salvaging.

Case Study:

Waste Reduction: Argonne National Lab, Argonne, IL

Project Description: Demolition of office building at Argonne National Lab Combination of wood frame, cinder block and corrugated metal construction.

Current Waste Disposal: 113 cubic yards (ground down from 340 lcy)

Current Recycling Program:

Metals:	200 lcy (60 tons)
Aluminum:	3 lcy (250 lbs)
Concrete:	200 lcy (170 tons)
Paper:	7 lcy (1800 lbs)
Copper:	3 lcy (500 lbs)

Current Waste Reduction Savings: $11,500

Source: Argonne National Lab, Argonne, IL

References

"General Practices Checklist." A Contractor's Waste Management Guide: 5-6.

Pulaski, M., C. Hewitt, et al. (2003). Design for Deconstruction: Material Reuse and Constructability. The Pittsburgh Papers: Best of Greenbuild 2003. Brattleboro, VT, Building Green, Inc.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 4: Waste Avoidance
4.3 Site Work

Goal: Reduce or eliminate waste generated during site work.

Actions and Methods:

- Construct access roads with consideration of minimizing impact on vegetation and permeability of the soil, trying to limit roads to areas that will eventually be paved.
- When constructing temporary structures for site work, use methods that allow for reuse, such as screws rather than nails.
- Avoid clearing additional areas, when possible, on-site for employee parking and equipment storage.
- Save excess PVC drainage piping for use on future jobs. Recycle the scraps and waste.

Concrete:

- Concrete chunks, old bricks, broken block and other masonry rubble can be used as backfill along foundation walls where permitted.
- Utilize excess concrete for parking stops, jersey barriers, etc.

Asphalt:

- Utilize excess asphalt paving to fix surrounding roads, drives, parking lots, etc.

Landscaping:

- Use soil from site excavation for landscaping, agricultural and residential fill.
- Sell all marketable trees designated for removal.
- Grind, chip or shred other vegetation for mulching or composting.
- Designate on-site locations for excavated rock, soil and vegetation.
- Separate stumps, brush and other wood waste for recycling.
- Investigate any unnecessary tree or vegetation removal, reducing the clearing and grubbing waste on-site.
- Store spoils on-site. This reduces transportation costs and energy use.
- Treat contaminated soils for reuse rather than importing new soil.

References

"Construction/Demolition Waste Recycling and Disposal." (2003). Saskatchewan Environment, Environmental Protection Branch. Saskatchewan. http://www.se.gov.sk.ca/environment/protection/land/Construction%20and%20Demolition%20PDF.pdf

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 4: Waste Prevention
4.4 Foundations

Goal: Reduce waste produced during foundation construction.

Actions and Methods:

- Reduce waste factors in take-offs.
- Negotiate material buy-back policies for concrete suppliers when feasible.
- Utilize excess concrete for parking stops, jersey barriers etc.

Site Logistics:

- Designate a separate central location for wood scraps, extra rebar and other partially used material that make it easy and convenient for workers to utilize scraps.
- Limit the number of designated concrete washout areas to avoid the expense of cleaning and maintaining several small washout areas. Make sure washouts are sized appropriately for adequate storage capacity. Use clear, visible signs and educate the contractor to ensure the designated areas are used.
- Perform all cutting, shaping, and tying in a central location.

Formwork:

- Double-check accuracy of formwork erection to help reduce amount of rework/re-pouring.
- Minimize the use of wood forms.

Rebar:

- Sell rebar for scrap or use it on another job.
- Use pre-assembled rebar cages when possible to reduce on-site rebar waste.

Case Study:

Waste Reduction: Pacific Plaza Parking Structure, Daly City, CA

Proper soil conditions and precise excavation can significantly reduce the amount of formwork necessary.
This has a large impact on reducing labor waste during the foundation phase of the project.
On this project in Daly City, CA, the only formwork necessary was that used for bulkheads and changes in footing elevation.

References

"Construction Waste Minimization Methods." (2004). Nebraska Energy Office http://www.state.ne.us/home/NEO/home_const/factsheets/const_waste_min.htm

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 4: Waste Prevention
4.5 Substructure

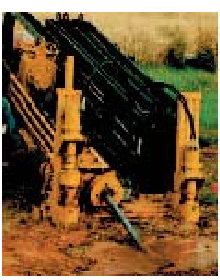
Goal: Reduce or eliminate waste produced during substructure work.

Actions and Methods:

- Use trenchless technology for installing and rehabilitating underground utility systems. This creates minimal surface disruption and can eliminate the need to remove sections of streets, sidewalks and lawns.
- Use trenchless technology to avoid tree loss and tree root damage during construction.
- Repair existing underground substructure where applicable.
- Ensure proper precautions are taken to avoid earth collapse or infill, flooding, etc.
- Save excess PVC drainage piping for use on future jobs. Recycle the scraps and waste.

Case Study:

Waste Reduction



Trenchless technology - A pilot bore is made and piping is pulled back through pilot hole. Then additional sections of pipe are connected and pulled in.

"Open cut", a well established technique.

Damage to trees.

Avoid damage to trees and reduce public annoyance by using trenchless technology for underground substructure work.

References

"Protecting the Urban Forest with Trenchless Technology." (2004). Vermeer Manufacturing Company http://www.vermeer.com/job_stories/Trenchless/horizontal_directional_drills/Tree_Root_protection.htm

"Trenchless Technology as an Environmentally Sound Technology : Some Important Benefits." (2000). International Environmental Technology Centre. http://www.unep.or.jp/ietc/Publications/Urban/UrbanEnv-1/1.asp

Chapter 4: Waste Prevention
4.6 Superstructure

Goal: Reduce or eliminate waste produced while constructing the superstructure.

Actions and Methods:

- Reduce waste factors in take-offs.
- Strive to reduce excess material ordering.
- Use precast or prefabricated assemblies, when possible (e.g. precast concrete).
- Consider using easily stackable units (cladding systems, curtain walls, steel beams, etc.). These can reduce transportation costs to the site.
- Order metal decking to the required length and reduce the number of cuts.

Material Storage:

- Store materials in a safe, dry, above ground location and prevent contact with material that may cause corrosion, discoloration, or staining.
- Store lumber on level blocking and under cover to minimize warping, twisting and waste.
- Separate and store unused portions of reinforcing bar and perform all cutting, shaping, and tying in a central location.

Steel:

- Steel framing is usually delivered to the site in a precise measure. Any on-site cut-offs should be recycled.
- Sell rebar and other steel waste for scrap or use it on another job.
- Give preference to mechanical fasteners and releasable adhesives over monolithic fasteners, to facilitate material recovery and reduce toxicity.

Concrete:

- Large panel formwork systems are effective in reducing concrete waste generated by losses due to damaged formwork, which usually accounts for 30% of the total concrete waste.
- Avoid over engineering customized formwork.
- Use durable forming materials when formwork is required.
- Use pre-assembled rebar cages when possible to reduce on-site rebar waste.

<u>Case Study:</u>

Waste Reduction

Picture on the left is an example of large panel formwork system. This system produces a concrete surface that is neater than normally produced by conventional timber formwork. Furthermore, the surface does not need an applied finish for leveling, thus reducing concrete waste.

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

O'Brein, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

"A Series of Factsheets on New Construction Issues: Construction Waste Minimization Methods." Nebraska Energy Office.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

"Waste Spec: Model Specifications for Construction Waste Reduction, Reuse, And Recycling." Triangle J Council of Governments. Research Triangle Park, NC.

Chapter 4: Waste Prevention

4.7 Exterior Enclosure

Goal: Reduce or eliminate waste produced while enclosing the building.

Materials Associated with Waste:

- Brick
- Concrete Masonry Block (CMU)

Actions and Methods:

- Use large panel formwork systems to reduce concrete waste generated by losses due to damaged formwork.
- Eliminate excessive waste factors when doing take-offs.
- Strive to reduce excess material ordering.
- Save left-over masonry for a future job or return them to the supplier. Use damaged masonry block for site fill.
- Minimize waste of exterior cladding or exterior finish by ordering only the quantity needed.
- Develop efficient ordering systems to ensure minimal waste.
- Use panelized curtain wall systems to reduce material waste on-site. Consider using curtain walls, sheathing, light gauge steel framing & sheathing and precast units.

Reduce Packaging Waste:

- Seek suppliers who deliver materials using bulk packaging techniques or minimal packaging.
- Encourage alternative sustainable packaging techniques (e.g. metal strapping in preference to shrink-wrap, paper packaging as opposed to plastic, and shredded paper as opposed to foam).

Material Storage:

- Use reusable delivery and storage containers where possible.
- Store materials in a safe, dry, above ground location, and prevent contact with material that may cause corrosion, discoloration, or staining.
- Collect and stack bricks or other masonry materials scattered around the jobsite to keep them from getting lost or soiled.

Case Study:

Waste Reduction: Recycle masonry blocks

Piles of loose masonry material are a common occurrence on construction sites. Instead of throwing away loose or broken bricks, recycle them so they can be crushed for landscaping material or collect and stack them so they can be used or returned to the supplier.

References

“Low Waste Building Technologies and Practices.” (2001). The Hong Kong Polytechnic University http://www.cse.polyu.edu.hk/~cecspoon/lwbt/Frame_Page/Frame_formwork.htm

O’Brein, K. “Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii.” The State of Hawaii.

Vleck, R. E. (2001). “Advanced Construction and Demolition Waste Management for Florida Builders.” University of Florida.

Chapter 4: Waste Prevention

4.8 Roofing

Goal: Reduce or eliminate waste produced during roofing construction.

Actions and Methods:

Left over shingles can be donated to local non-profit housing organizations. This can save on disposal costs.

- Save unused roofing material for use on other jobs or donate them to non-profits.
- Employ accurate cutting procedures and quantity takeoffs to reduce roofing waste (shingles, flashing, sheet metal roofing and membrane roofing).
- Use manufactured roofing where possible to reduce on-site fabrication waste.
- Select roofing suppliers with material buy-back programs.
- Seek suppliers who deliver roofing materials using bulk-packaging techniques.
- Store materials properly to avoid damage and excessive moisture build up.
- Order roofing material to actual size to eliminate cut off waste.

References

"Environmentally Responsible Construction and Renovation Handbook." Public Works and Government Services. Canada.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

"Waste Spec: Model Specifications for Construction Waste Reduction, Reuse, And Recycling." Triangle J Council of Governments. Research Triangle Park, NC.

Chapter 4: Waste Prevention
4.9 Interior Construction

Goal: Reduce or eliminate waste during the interior construction project phase.

Materials Associated with Waste:

- Packaging
- Drywall

Actions and Methods:

- Unused items such as drywall, vinyl, carpet and carpet padding may be returned to vendors.
- Inquire about lease options on materials such as carpet & padding.
- Chose products that come with minimal packaging.
- Maintain up-to-date material ordering and delivery log to minimize the amount of time the materials are stored on-site, thus reducing the chance of damage.
- Pay subcontractors based upon square footage of final product as opposed to total quantities consumed to encourage efficient use of materials.
- Order interior materials to actual size (e.g. tile, carpeting, ceiling tile, etc.)
- Employ accurate cutting procedures and quantity takeoffs to reduce interior construction waste (carpeting, vinyl products, flooring and ceiling tiles).
- Use wood frame panels fabricated offsite.

Drywall:

- Order drywall in optimal dimension to minimize cut-off waste.
- Set aside larger drywall scraps for use where filler pieces are needed.
- Protect drywall board edges, corners, and ends during transport, construction and in all high traffic areas.
- Store drywall boards flat and level. Storing them upright could damage the edges creating waste.
- Ensure the area where drywall is being installed is watertight and

leak free.

- When storing or stacking multiple layers of drywall boards, use risers or spacers between the boards, as shown.

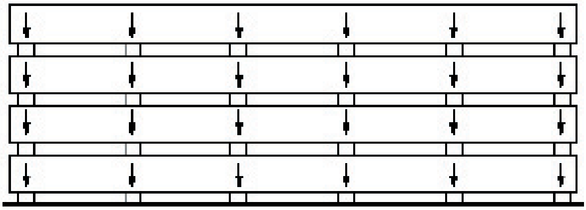
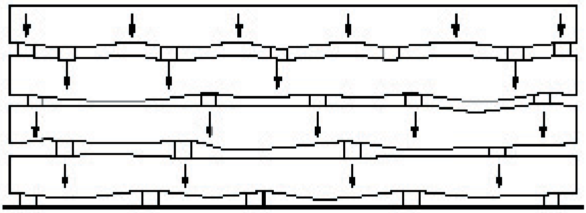


Figure above shows correct riser placement when storing drywall. Risers must be vertically aligned from top to bottom to prevent sagging or bowing.

Figure below shows what will happen if riser placement is incorrect when storing drywall board (Figures from National Gypsum Company Resources).



Case Study:

Waste Prevention: Drywall Waste and Mold

Much of this gypsum drywall waste can be avoided if drywall can be ordered in optimal dimensions to reduce cut-off waste, as seen here to the left. Additionally, some of the larger scraps can be saved and used as filler pieces.

Before completing drywall construction, make sure the building is watertight. This will prevent water damage to the drywall board and prevent mold growth, as seen here to the right, which can create a number of health related problems.

References

O'Brien, K. Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii. A Contractor's Waste Management Guide. The State of Hawaii.

"Construction Waste Minimization Methods." (2004). Nebraska Energy Office http://www.state.ne.us/home/NEO/home_const/factsheets/const_waste_min.htm

"Environmentally Responsible Construction and Renovation Handbook." Public Works and Government Services. Canada.

"Handling and Storage of Gypsum Wall Board." (2000). National Gypsum Company http://www.nationalgypsum.com/resources/other/wallstor.pdf

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 4: Waste Prevention
4.10 Conveying Systems

Goal: Reduce or eliminate waste while constructing building conveying systems.

Materials Associated with Waste:

- Packaging

Actions and Methods:

- Specify equipment with minimal packaging.
- Avoid damaged to conveying systems parts and pieces by handling and storing the materials properly.
- Salvage, donate or sell reusable items from the job if possible.
- Replace disposable materials and products with reusable materials and products.
- Reuse jobsite materials when constructing the elevator shaft. For additional information see sections 4.4 Foundations and 4.5 Substructure.

Case Study:
Waste Prevention

Construction of an elevator pit

Constructing and installing an elevator is a complex process. Try to minimize equipment packaging store and handle materials and equipment properly to avoid damage. When constructing the elevator pit, take advantage of the waste reduction tips from Section 4.4, Foundations, and Section 4.5, Substructure.

References

"Construction Waste Minimization Methods." (2004). Nebraska Energy Office http://www.state.ne.us/home/NEO/home_const/factsheets/const_waste_min.htm

Chapter 4: Waste Prevention
4.11 Mechanical

Goal: Reduce or eliminate waste while installing or constructing mechanical systems.

Materials Associated with Waste:

- Packaging
- Insulation
- Flex Pipe

Actions and Methods:

- Accurately estimate and order the amount of material needed to reduce waste and cost.
- Use a central area for the cutting and storage of scraps for reuse.
- Measure twice – cut once. Accurately measure and mark where material cuts need to be made.
- Save extra HVAC material and equipment not required as attic stock for use on the next job. Other options include returning materials to vendors or donating to non-profit organizations.
- Protect ductwork and HVAC equipment from dust, dirt, damage and other hazards during construction and site demobilization.

Constructability Considerations:

- Purchase precut and prefab components when possible.
- Search for opportunities to reduce bends in piping and ductwork. This can reduce first cost by allowing for a quicker installation and saves on energy (each elbow produces a energy loss to the system).

Packaging and Material Handling:

- Obtain equipment with reduced packaging material.
- Avoid damaged to mechanical systems parts and pieces by handling and storing materials properly.

Salvage Opportunities:

- Items such as hot water tanks, HVAC equipment, and other mechanical equipment may be reused or donated.

- Salvage items such as hot water tanks and other HVAC equipment. These may return to the supplier or a refurbishing company.

Case Study:

Waste Reduction

Designating a storage area for unused ductwork is a great way to prevent damage to this material before it is installed. It also allows you to keep an accurate inventory of the product, and thereby prevent excess material ordering and waste on-site.

References

"Environmentally Responsible Construction and Renovation Handbook." Public Works and Government Services. Canada.

O'Brien, K. Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii. A Contractor's Waste Management Guide. The State of Hawaii.

1 2 3 4 5 6 7 8 9 10

Chapter 4: Waste Prevention
4.12 Electrical

Goal: Reduce or eliminate waste while installing or constructing electrical systems.

Materials Associated with Waste:

- Packaging

Actions and Methods:

- Obtain equipment with reduced packaging.
- To reduce waste and cost, accurately order the amount of material needed.
- **During demolition and renovation** – reuse items such as electrical boxes, breaker equipment, wall outlets and other electrical equipment where possible.
- **Salvage** items such as electrical boxes, breaker equipment, wall outlets and other electrical equipment where possible and return to supplier or refurbishment company.
- Store materials so they are not damaged.
- Measure carefully to avoid end cuts.
- Measure twice – cut once, accurately measure and mark where material cuts need to be made.
- **Reuse** the empty wire spools for other purposes and tasks. They make a great stool during break time. Otherwise return to manufacturer.
- Purchase electrical materials in bulk when feasible to reduce packaging waste (example: Purchase/release fixtures to be shipped in bulk on pallets without individual packaging).
- Save extra electrical components, fixtures, outlets, and other electrical equipment for the next job. It is also important to properly store this material so it is not damaged on-site or during transportation.
- **Protect** electrical equipment and wiring from dust, dirt, damage and other hazards during construction and site demobilization.
- Remove excess drywall build up, chunks and scrapes from wall outlets upon completion of dry walling activities.

- Replace temporary incandescent lights with longer life and more durable fluorescent lights. This will reduce on-site temporary lighting replacement costs and temporary power consumption.

Case Study:

Waste Reduction

Replacing temporary incandescent lights with fluorescent lights may cost more initially, but life cycle costs savings can be realized because fluorescent lights use less energy and have longer life spans then incandescent lights. Additionally, fluorescent lights are more durable and brighter, providing a well-lit, safe working environment.

References

"Environmentally Responsible Construction and Renovation Handbook." Public Works and Government Services. Canada.

Chapter 4: Waste Avoidance
4.13 Information Technology

Goal: Reduce or eliminate excess communication and IT infrastructure waste on-site.

Actions and Methods:

- Obtain equipment and materials with reduced packaging.
- Accurately order the amount of material needed.
- Store materials and equipment so they are not damaged.
- Purchase prefab materials when possible.
- Save left-over materials and equipment for the next job. Items like cable trays, extra data cable, and data connections can be left with the owner for their replacement stock and use.
- The use of multi-conductor power Home Run cables can improve cable management and reduce installation complexity.
- Suggest using a raised floor system. Doing so can reduce data and communication installation costs during initial build-out and allow for easier more economical moves and space reconfiguration.

Waste Reduction Tips When Installing Data Cable:

- Do not untwist twisted-pair cables more than one-half inch before inserting them.
- Do not strip off more than one inch of insulation from copper wire in twisted-pair cables.
- Test each segment of cabling with cable tester. This will prevent rework and cable waste if a faulty cable is discovered once the work is completed.
- Avoid laying cable across a floor where it may sustain damage.
- Install cables at least three feet away from fluorescent lights or other sources of Electro Magnetic Interference (EMI).
- Always leave some slack in cable runs.
- Ensure cable sheath is plenum-rated if you are running cable in a sub floor or above the ceiling.

References

"Intelligent Floor." (2004). AFC Cable Systems http://www.afcweb.com/acs/acs_prod_intell.htm#Anchor-49575

Lyon, P. R. (2003). "Transmission Basics and Networking Media Chapter 4." Pat Rajski Lyon http://faculty.nhmccd.edu/plyon/itnw1425/powerpoints/chapter4/part2/ch4b.pdf

1

Chapter 4: Waste Prevention
4.14 Equipment

2

Goal: Reduce or eliminate equipment waste during construction.

Actions and Methods:

- Properly maintain and use construction equipment for its intended purpose. 3
- **Maintain vehicle emissions** and fluid lines to reduce gaseous pollutant emissions and fluid leakage.
- **Properly store equipment** to prevent damage and excessive wear, thereby increasing its life span. 4
- All vehicles and equipment used during construction should be fueled off site or at a designated fueling pad. This prevents excessive fuel spills, allows for easy clean-up if a spill occurs, and reduces storm water pollution. 5
- **Inspect equipment** upon delivery, reject leaking or damage equipment.
- Oils and lubricants can be reconstituted and reused as other lubricant products. 6
- **Save worn out NiCad batteries** from portable power tools for delivery to a specialized battery-recycling site.
- Keep drip pans and absorbent materials on hand during vehicle or equipment maintenance and fueling for quick and easy clean up. 7

References

8

"Construction Waste Minimization Methods." (2004). Nebraska Energy Office http://www.state.ne.us/home/NEO/home_const/factsheets/const_waste_min.htm

"Cost Savings Tips - Part III: Non-Storm Water Management and Sediment Tracking Controls." (2000). Caltrans Stormwater Management Program http://www.dot.ca.gov/hq/env/stormwater/publicat/const/4_00.htm 9

O'Brien, K. Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii. A Contractor's Waste Management Guide. The State of Hawaii. 10

Chapter 4: Waste Prevention
4.15 Finishes

Goal: Reduce or eliminate finish waste during construction.

Materials Associated with Waste:

- Packaging

Actions and Methods:

- Reject vendor samples you don't need.
- Store remaining floor and ceiling tile as attic stock, or return it to the vendor, or donate it to non-profit organizations.

Site logistics:

- Adopt a "first-in, first-out" policy to prevent finish materials from becoming out dated (See following Case Study).
- Use a central cutting area for carpet, tiles and vinyl base.

Material Storage:

- Protect finish materials (carpets, tile, bases, and trim) from damage during faculty move in and site demobilization.
- Storage areas for liquid hazardous materials should be impervious and bermed, to prevent run-on and run-off. Concrete storage pads with curbs or berms are generally more cost-effective than plastic-lined storage areas, especially for projects over one year in duration.

Reduce Packaging:

- Use suppliers with buy-back policies.
- Products such as paint, joint compound and caulking can be purchased in bulk to reduce packaging waste.

Reuse, Salvage and Donate (Reference Ch. 7.15):

- Donate left over finish materials to non-profit organizations.
- Allow employees to take home excess carpet scraps.
- Reuse spent solvents for cleaning.
- Reuse material buckets, tubes and product packaging for other tasks if possible.

Constructability Considerations:

- Design Suggestion: Eliminate use of acoustical ceiling tile and expose ceiling to minimize material use.

Case Study:

Waste Reduction

A first-in, first-out finish material policy is a simple way to reduce finish material waste. This simply means you first use the materials staged on-site longest. Do not stack newly delivered materials on top of those already staged on-site, which prevents "older" materials from being readily accessible. Additionally, if you can coordinate just-in-time (J.I.T.) deliveries to the site, excess finish material will not stack-up and site and extra finish material will not go to waste.

References

"Cost Savings Tips - Part III: Non-Storm Water Management and Sediment Tracking Controls." (2000). Caltrans Stormwater Management Program. http://www.dot.ca.gov/hq/env/stormwater/publicat/const/4_00.htm

O'Brien, K. Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii. A Contractor's Waste Management Guide. The State of Hawaii.

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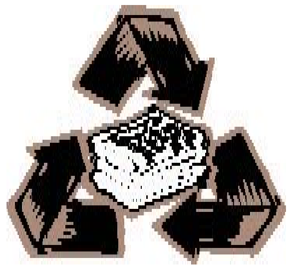
Chapter 5: Recycling



Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Benefits:

- Reduction of waste at the landfill.
- Avoidance of tipping fees.
- Receipt of tax rebates in certain areas.

Actions and Methods:

- Assess probable waste stream prior to construction. Use the waste management hierarchy (listed below) to determine how to manage construction waste.
    1. Reduce the waste generated (Reference Ch. 4).
    2. Reuse materials and products (Reference Ch. 7).
    3. Recycle as much as possible.
    4. Composting.
    5. Burning.
    6. Landfill.
- **Work with subcontractors** to determine the most effective ways to recycle waste (Ref. Section 5.0).
- Incorporate recycling procedures and requirements into contract language (Ref. Ch. 1).
- **Provide training** for all supervisors and workers.
- Emphasize the importance of a clean site. Use a continuous cleanup process and/or a wrap-up procedure at the end of the day.
- Calculate landfill diversion rates by weight.
- **Publicize** your results at the jobsite and within your organization. This can spark competition between trades or projects resulting in even higher levels of recycling. Provide incentives to further increase the recycling efforts.
- Know the legal compliances concerning the type and amount of

waste that is generated.

- **Keep hazardous waste separate**. Do not mix different wastes.

10

Case Study:

Comm. Office Building (31,000 SF remodel, 19,000 SF addition)

9

Without slowing down their schedule, H.S. Wright managed to recycle 1,260 tons of Construction and Demolition waste. Though they went about the job thoughtfully, they didn't take extraordinary measures. Recycling and reducing waste does not have to slow down a fast track job. The breakdown of cost savings and materials recycled were as follows:

8

- 54% recycling rate in the construction phase, saving $6,200
- 93% recycling rate for combined C&D phases, with total cost saving of $195,100
- 55 tons of wood recycled
- 1,205 tons of concrete recycled.

7

Source: Advanced Construction and Demolition Waste Management for Florida Builders

6

References

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"C&D Debris: Construction and Demolition Debris." (2002). Environmental Protection Agency http://www.epa.gov/epaoswer/non-hw/debris/

"DRAFT Federal Guide to Green Construction." (2004). Environmental Protection Agency. http://www.wbdg.org/design/greenspec.php

Rawlings, R. (1999). "Environmental Rules of Thumb." The Building Services Research and Information Association. Brachnell, Berkshire, U.K.

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Chapter 5: Recycling
5.0 Planning

2

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Key Issues:

3

- Local recycling market
- Education
- Management
- Cost

4

Actions and Methods:

5

- Designate a person and/or team to manage the details of creating and implementing the waste management program.
- Integrate waste management into the safety program.
- Continuous education and awareness are crucial to both initiatives.
- Survey the site before demolition begins. Identify salvage, recyclable and hazardous materials.

6

Develop a Construction Waste Management Plan:

7

- Identify items for reuse, salvage and recycling.
- Plan for protection, dismantling, handling, storing and transporting of salvage or recycled materials.
- Schedule in time for removal of salvageable and recycled materials.

8

Plan for Recyclable Materials:

- Include recycling requirements in the statement of work.
- Investigate removal and separation techniques.
- Plan for collection procedures and allocate space on-site.

9

10

Questions for Salvage and Recycling Companies:

- What items or materials do they accept?
- Will they accept drop-offs at their location?
- Will they provide drop boxes?
- Will they come to the site to remove the items or materials?
- When can they come and how long will the waste removal take?
- Will they visit the site and place a bid?
- Will they pay for the items or materials?
- What are the charges/payments for pick ups or drop-offs?
- Can the company provide a receipt for tax deduction of donated items?

Estimate the Costs and Savings:

- Determine disposal costs, hauling costs and revenue generated.
- Compare the cost of reusing materials to purchasing new items.
- Is there a function or atheistic value of having reused materials?
- Are there any marketing or public relations benefits?
- What is the tax benefit to donating items to charities?

Involve Subcontractors and Suppliers:

- Require subcontractors and suppliers to use the recycling and disposal bins on-site.
- Alternatively ask the suppliers and subcontractors to take back and recycle their own waste, and require written reports.
- Involve subcontractors in choosing convenient locations for dumpsters and bins for different phases of construction.
- Charge a fee to those who continually contaminate the recycling bins.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash next to the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Promotion and Education:

- Integrate recycling training into the safety education or design a separate recycling education program.
- Create a name or slogan for the program and use inexpensive rewards such as hats and hardhat stickers to provide incentives.
- Share the project's success. Keep subcontractors and the crew informed and updated on the progress.
- Be positive! When subcontractors are motivated and understand the goals, they will figure out more creative ways to overcome obstacles and work more efficiently.
- Include everyone in the process by encouraging suggestions for more efficient construction methods.

Checklist of Recyclable Building Materials:

- ☐ Acoustical ceiling tiles
- ☐ Fluorescent lights and ballast
- ☐ Asphalt
- ☐ Land clearing debris (vegetation, stumpage, dirt)
- ☐ Asphalt Shingles
- ☐ Metals (ferrous and non-ferrous)
- ☐ Carpet and carpet pad
- ☐ Paint cans and paint (use a hazardous waste outlet)
- ☐ Cardboard
- ☐ Plastic film (sheeting, shrink wrap, packaging)
- ☐ Concrete
- ☐ Window glass
- ☐ Drywall
- ☐ Wood (nails and staples allowed)
- ☐ Glass (colored glass allowed)
- ☐ Insulation

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

"DRAFT Federal Guide to Green Construction." (2004). Environmental Protection Agency. http://www.wbdg.org/design/greenspec.php

"How-To Guides." (2004). Alberta Environment http://www3.gov.ab.ca/env/waste/aow/crd/how-to.html

O'Brien, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

Simpson, S. (2003). "Construction Waste Management Guide: Methods to Save Money and Resources." State of Washington Department of General Administration. Olympia, WA.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 5: Recycling

5.1 General Conditions

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods

- Talk to the client about ideas for public auctions for old appliances and other reusable material.
- Keep the crew and public updated about progress in recycling goals.
- Have separate bins for collecting different types of material.
- Clearly identify boxes for recycling.
- Clearly mark storage areas and post storage recommendations. Use bilingual signage and/or pictorial graphics.
- Maintain careful records of all the material and waste produced.
- Separate waste and store them in relatively clean conditions.
- Make sure that the bins are full and packed before moving onto new ones.
- Manage bins to maintain leakage and spillage.
- Maintain a dedicated area for recycling metal, cardboard, drywall, wood and other recyclable waste.
- Regularly check the recycle bins for improperly sorted material.
- Keep hazardous waste separate. Do not mix different wastes.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with recycling containers.

- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Reference Section 5.0 for checklist.

References

O'Brien, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

Rawlings, R. (1999). "Environmental Rules of Thumb." The Building Services Research and Information Association. Brachnell, Berkshire, U.K.

Wilson, A. (1992). Dealing with Construction Waste: Innovative Solutions for a Tough Problem. Environmental Business News. 1.

Chapter 5: Recycling
5.2 Demolition and Abatement

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods

- Sort and avoid mixing of demolition waste.
- Clean concrete chunks, bricks, broken blocks and other masonry rubble can be buried on-site during foundation back-filling or recycled.
- Separate out metal radiators, grates, piping, aluminum siding, and old appliances for salvage and recycling.
- Use the internet and its power of exchange to market the salvaged items of a demolished building (See Ch 7.2).
- Walk through the site before deconstruction with an experienced contractor to identify potential recyclable items.
- Various methods of dismantling should be considered in a wider sense (e.g. hand, machine, explosives and cutting)
- Remove recyclable materials before mass demolition.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

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Items to Recycle:

- Reference Section 5.0 for a checklist.

Case Study

Pittsburgh Convention Center

The Pittsburgh Convention Center used the website www.freemarkets.com to sell the salvageable items during its deconstruction. The online auction started long before a bolt was pulled or a brick was dislodged at a very low cost and energy.

Note: The Loading Dock in the Baltimore, Maryland provides tax deductions rather than payment for material dropped off. (Tel – 410-728-3625).

References

O'Brein, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

Rawlings, R. (1999). "Environmental Rules of Thumb." The Building Services Research and Information Association. Brachnell, Berkshire, U.K.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Wilson, A. (1992). Dealing with Construction Waste: Innovative Solutions for a Tough Problem. Environmental Business News.

Chapter 5: Recycling
5.3 Site Work

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Branches from trees and shrubs that are cleared during site work can be chipped and used in landscaping.
- Never burn treated wood.
- Preserve existing vegetation and reuse as landscaping.
- Try to avoid cutting down trees unnecessarily.
- Avoid major changes to surface grade.
- Reuse on-site soils for fill operations.
- Reuse on-site rocks for fill or site finishes/aesthetics.
- Use detailed plans to eliminate wasteful cuts and fills.
- Use broken or crushed concrete pieces as a back fill layer. When filling close to the foundation be careful of waterproofing and the other membranes used.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Asphalt
- Concrete
- Landclearing debris (vegetation, stumpage, dirt)
- Wood
- Job-shack waste

Case Study:

Stapleton International Airport, Denver, CO.
"Worlds Largest Recycling Project"

Denver's Stapleton International Airport opened in 1929 and by the time it closed 66 years later, it had become one of the busiest airports in the U.S. In 1995 it was replaced by the new state-of-the-art Denver International Airport.

- Six year project.
- Remove concrete runways (averaging 24 inches thick covering 975 acres.
- Six million tons of aggregate (concrete and asphalt) will be recycled.
- The recycling contractor (Recycled Materials Company, Inc.) donated recycled asphalt to pave wheelchair trails at their summer camp.

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Rawlings, R. (1999). "Environmental Rules of Thumb." The Building Services Research and Information Association. Brachnell, Berkshire, U.K.

Thompson, T. "Recycle This." Associated General Contractors of America http://www.agc.org/content/public/pdf/Environmental_Info/recycle_brochure.pdf

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Chapter 5: Recycling
5.4 Foundations

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Stack old forms next to new ones for reuse.
- Reuse form ties.
- Land clearing debris can be used as a backfill on foundations.
- Reuse soil cut for foundations so that it does not have to be hauled outside of the site.
- When driving piles take the proper precautions. Do not let materials from the borings get mixed with the topsoil and spill over.
- Explore alternative formwork options. Consider using insulated concrete forms (ICFs).
- Consider using bio based form release agents to allow for formwork recycling.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Concrete
- Wood
- Job-shack waste

Case Study:

Comm. Office Building: Boeing Commercial Airplane Group HQ

Baugh Construction's commitment to waste prevention and recycling was evident in this project. Through the recycling plan, the builder achieved an amazing 97percent recycling rate and improved their bottom line by saving $90,000. The materials and the amount of each that was recycled were:

- 64 tons of wood.
- 33.67 tons of drywall.
- 6,401 tons of concrete.
- 39 tons of metals.
- 1.5 tons of cardboard.
- 8.3 tons of land clearing debris.

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Wilson, A. (1992). Dealing with Construction Waste: Innovative Solutions for a Tough Problem. Environmental Business News. 1.

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Chapter 5: Recycling
5.5 Substructure

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Use of concrete debris as clean fill around the building.
- Reuse and recycle rebar and form ties.
- Recycle wooden formwork.
- Identify ways to minimize formwork cutting.
- Backfill around the substructure using dirt accumulated during land clearing.
- Use recyclable/metal formwork.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Concrete
- Rebar
- Wood
- Job-shack waste

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Thompson, T. "Recycle This." Associated General Contractors of America http://www.agc.org/content/public/pdf/Environmental_Info/recycle_brochure.pdf

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Chapter 5: Recycling
5.6 Superstructure

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Collect and stack bricks and other masonry materials scattered around the jobsite to keep them from getting soiled or lost.
- Minimize the use of admixtures.
- Use fly ash with concrete where appropriate.
- Recycle excess concrete used in superstructure for fills, paving, and drainage.
- Separate the different types of metals used and store them separately for recycling.
- Order steel from a production process that uses high levels of recycled content (ie. the Electric Arc Furnace process has up to 99% recycled content).
- Use excess pieces and cut-offs of wood for dunnage.
- Explore salvage market options. Several products, like steel and CMU block have a salvage value. In some markets, services are available to haul the wasted products from your site at no cost, saving on hauling costs for waste disposal (Scrap steel prices have fluctuated from $75/ton to $255/ton).

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.

- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Concrete
- Rebar
- Wood
- Metals
- Job-shack waste

Sustainable Construction Facts:

Did You Know...

Recycling steel:[1]

- Saves enough energy annually to electrically power 18 million homes for an entire year.
- Saves 2,500 pounds of ore, 1,400 pounds of coal and 120 pounds of limestone per ton of steel.
- Accounted for 63 percent of the total amount of steel used for construction projects in 1999.

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

"Steel Scrap Prices." (2002). American Institute of Steel Construction, Inc. http://www.aisc.org/Content/ContentGroups/Documents/general_AISC/ScottsChart.htm

Wilson, A. (1992). Dealing with Construction Waste: Innovative Solutions for a Tough Problem. Environmental Business News. 1.

Chapter 5: Recycling
5.7 Exterior Enclosure

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Save left over masonry materials for a future job or return them to your supplier.
- Expanded polystyrene insulation (EPS) can be recycled for manufacturing new styrene products.
- Brick, block and asphalt shingle waste are insignificant in volume, but can be important in terms of weight.
- Drywall (gypsum) waste can be broken down and used as soil amendment, cement additive, new drywall, paper fiber feedstock, animal bedding and other agricultural products.
- Identify opportunities to reuse crates and pallets from material deliveries.
- Place metal in separate bins for recycling.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create jobsite maps to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Concrete
- Metals
- Wood
- Glass
- Insulation
- Job-shack waste

References

"Construction Waste: Types and Quantities." (2002). Oikos Green Building Source http://oikos.com/library/waste/types.html

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

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Chapter 5: Recycling

5.8 Roofing

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Asphalt roofing materials and aggregates can be recycled into road paving or patching material.
- Left over roofing material can be donated to local non-profit organizations which saves on disposal costs.
- Plastic films like sheathing, shrink wrap and packaging can be recycled.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Metals
  - Aluminum flashing
  - Lead flashing
- Wood
- Cardboard
- Plastic
- Job-shack waste

Case Study:

Seattle Kingdome

Nearly every nook and cranny of the Seattle Kingdome was put to good use. A crew of over 150 people spent weeks stripping the roof and gutting the interior of the building of any materials that would contaminate the recycling effort.

- Furnishings were either donated to local soup kitchens and other non profits or removed and auctioned off in order to raise money for the King County Parks and Recreation Department.
- 97 percent of project waste (or 100,000 tons of wood, concrete, steel, and other construction materials were recycled into the new stadium.
- Over $3,000,000 was saved in materials, removal and landfill costs.

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Thompson, T. "Recycle This." Associated General Contractors of America http://www.agc.org/content/public/pdf/Environmental_Info/recycle_brochure.pdf

Chapter 5: Recycling
5.9 Interior Construction

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Vinyl and metals are generated in small quantities, but have good recycling value.
- Cardboard makes up the largest volume of waste on construction sites and is one of the easiest items to recycle.
- “Clean” wood is unpainted, untreated and recyclable (includes dimensional lumber, plywood, oriented stand board (OSB) and particle board without laminates)
- Clean wood should be placed in a separate dumpster.
- Check carpet and ceiling tile for contaminants before removal.
- Unused drywall should be stored carefully.
- If paint cannot be recycled it should be disposed of according to the manufacturer’s recommendations.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create jobsite maps to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Drywall
- Cardboard
- Glass
- Metal studs
- Wood
- Acoustical Tiles
- Carpet and carpet pads
- Job-shack waste

Sample Signage:

Sign for a co-mingled dumpster:

Sign for a "clean wood" dumpster:

References

"Construction Waste: Types and Quantities." (2002). Oikos Green Building Source http://oikos.com/library/waste/types.html

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Chapter 5: Recycling

5.10 Conveying Systems

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Paper, cardboard and metal packaging should be separated and sorted.
- Bundle the cardboard to permit easier storage and deliver to recycling facility.
- Ask vendors and suppliers to take pallets away after delivery.
- Store pallets in a central location for easy removal.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create jobsite maps to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Cardboard
- Job-shack waste

References

“Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention.” (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Chapter 5: Recycling
5.11 Mechanical

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Ask vendors to reduce the amount of packaging delivered to the site (e.g. pallets, cardboards, plastic shrink-wrap, and metal bands).
- Ask vendors to take back non-recyclable packaging for reuse.
- Retain PVC cut-offs for use as stubs for wall drains.
- Separate and recycle plastics (including PVC if possible), metal and adhesives.
- Control system components, including variable speed drive controllers from air handling units can be used as spare parts.
- Some companies accept old machinery like compressors and recondition them.
- Copper wires can be recycled or reused.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Cardboard
- Plastic packaging
- Concrete
- Sheet metal
- Copper piping
- Paint
- Wood
- Job-shack waste

Case Study:

Waste Recycling: Microsoft Buildings 4-5-6 Remodeling Project

"Of those items that were demolished, about 80% became recycled materials. This greatly reduced bulk volume of materials that ended up in the landfill", Hermanson Corporation

References

"Construction Waste Management Program." SELLEN Construction Company.

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 5: Recycling
5.12 Electrical

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Lamps containing mercury should be recycled (e.g. fluorescent, mercury-vapor, metal halide, high pressure sodium and neon.
- When lamps are removed store them carefully to prevent breakage.
- Recycle metal scrap. Separated metals have higher value than mixed metals.
- NiCad batteries from portable power tools should be sent to specialized battery pick-up sites for recycling.
- Clean up regularly and schedule regular inspection of dumpsters and recycling bins to prevent contamination.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create jobsite maps to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Cardboard packaging
- Fluorescent lights and ballasts
- Metal conduit
- Wood blocking

References

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

O'Brien, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

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Chapter 5: Recycling

5.13 Information Technology

9

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

8

Actions and Methods:

- Recycle old computers.
- Recycle computer monitors. They have heavy metals that can be recycled.
- Recycle job-shack wastes, including office paper, pop cans and bottles and office cardboards.
- Work with vendors to reduce packaging waste.

7

Consistent and Ongoing Actions:

6

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

5

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

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Items to Recycle:

- Computers
- Cardboard packaging
- Plastic films
- Metal conduit
- Job-shack waste

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Sustainable Construction Facts:

Myth:
Landfills and incinerators are more cost-effective and environmentally sound than recycling options.

Fact:
Recycling programs, when designed properly, are cost-effective with landfills and incinerators, and provide net pollution prevention benefits. Recycling materials not only avoids the pollution that would be generated through land filling and incinerating these, but also reduces the environmental burden of virgin materials extraction and manufacturing processes.

Source: Institute for Local Self-Reliance, Washington, DC

References

"Awesome Recycling Products and Programs." (2003). Midpoint International, Inc. http://www.midpoint-int.com/

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

"Garbage Restrictions / Special Instructions for the Stations." (2002). City of Seattle http://www.ci.seattle.wa.us/util/services/transfer/rulegarb.htm

O'Brien, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

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Chapter 5: Recycling
5.14 Equipment

9

Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Key Issues:

8

- Equipment such as construction fences, traps and refillable propane tanks can be reused.
- Do not put containers with oil in recycling bins.

7

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

6

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

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Items to Recycle:

- Wood pallets
- Cardboard packaging
- Plastic films
- Job-shack waste
- Fluids, such as oil or antifreeze removed from vehicles due to maintenance procedures can be recycled at approved facilities

3

References

2

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

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Chapter 5: Recycling
5.15 Finishes

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Goal: To divert waste from the landfill by recycling 75% of construction debris. A minimum requirement of 50% is specified on most PENREN/C contracts.

Actions and Methods:

- Unused or partially empty cans of paint can be donated to local theater groups or low-income housing agencies.
- Municipal solid waste facilities accept paint to make low-cost gray primer.
- The paints, solvents, stains and finishes that cannot be recycled should be taken to a hazardous waste facility or disposed of according to the manufacturer's instructions.
- Specify preference for recycled, returnable and/or recyclable packaging.
- Store materials to avoid damage that would render a material un-recyclable.

Consistent and Ongoing Actions:

- Use safety meetings, signage and subcontractor agreements to communicate the goals of recycling, waste prevention (Chapter 4) and environmental issues.
- Require subcontractors and suppliers to use the recycling and disposal bins on-site.

Make Recycling Convenient:

- Place recycling dumpsters as close to the work area as possible.
- Centralize cutting operations to reduce waste and simplify sorting.
- Always provide a container for trash with the recycling container.
- Create maps of the jobsite to show haulers exactly where to place and pickup their dumpsters.

Items to Recycle:

- Ceiling Tile
- Cardboard packaging
- Carpet
- Drywall
- Paint
- Wood
- Plastic films
- Job-shack waste

Case Study:

Waste Recycling

The city of Seattle mixes its own "Seattle Gray" paint from paint dropped off for recycling.

The flooring is made of vintage hardwood recycled from 200-year-old New England barns.

References

"Construction Waste: Types and Quantities." (2002). Oikos Green Building Source http://oikos.com/library/waste/types.html

"Contractors Guide - Seattle/King County - Save Money and Resources through Job Site Recycling and Waste Prevention." (2003). King County Solid Waste Division. Seattle. http://dnr.metrokc.gov/swd/bizprog/sus_build/ConGuide.pdf

O'Brien, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

Chapter 6: Energy

Goal: To reduce the consumption of energy during construction and operation of the building

Benefits:

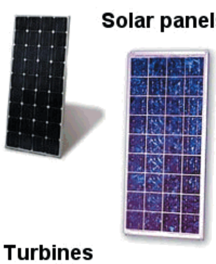
- Lower general conditions costs.
- Savings of hundreds of dollars each year on utility bills.
- Reduced air pollution.
- Reduced reliance upon natural resources (fossil fuels) by utilizing renewable energy sources.

Keys Issues:

- Use sustainable energy source technologies such as wind turbines or solar panels and reduce the energy consumed during construction (Ref Section 6.1).
- Properly insulate and seal all building penetrations and enclosures.
- Create continuous air barriers (Ref Section 6.7).
- Create continuous insulation barriers.

Emerging Technology:


Wind Turbines


Solar panels

Alternative energy sources such as wind turbines and solar panels utilize free and sustainable energy sources.

References

Brown, W. (2000). "Sustainable Design, Construction and Land Development." Southface Energy Institute.

"Energy Efficiency Pays." (2000). Southface Energy Institute.

Chapter 6: Energy
6.0 Planning

Goal: To reduce energy consumption through proper planning.

Key Issues:

- Proper planning while installing systems is required to avoid energy loss through poorly constructed systems.
- Poor commissioning is responsible for increased energy costs throughout the life of a building.
- Proper commissioning often increases energy efficiency by 5 to 10 percent resulting in energy savings of thousands of dollars each year.

Actions and Methods:

- Engage a commissioning authority as early in the construction process as possible, preferably during pre-construction. It is permissible to use a qualified member of the design firm as long as that individual is not responsible for design, construction management or supervision.
- A commissioning plan should be created as early in the project as possible. This plan should evolve to become more detailed as the project progresses.
- Properly train building staff prior to turnover. The commissioning authority must assemble written verification that training was conducted for all commissioned systems.
- A commissioning report must be presented to the owner after commissioning is complete.

10 9 8 7 6 5 4 3 2 1

Case Study:

Savings Resulting from Commissioning Activities:

The Oregon Office of Energy studied direct energy savings for two buildings after applying proper commissioning techniques. In a 110,000 square foot office building, **energy savings of $12,276 per year** were found through commissioning activities. In a 22,000 square foot office building, energy savings equal to $7,630 per year were gained through commissioning.

Commissioning Scope	Estimated Cost
Whole Building (from design through completion)	0.5 - 1.5% of total construction cost
HVAC and Automated Control Systems Only	1.5 - 2.5% of mechanical contract
Electrical Systems Only	1.0 - 1.5% of electrical contract
Energy Efficiency Measures	$0.23 - 0.28/ft^2

References

Greening Federal Facilities. (2001). Brattleboro, Vt, BuildingGreen, Inc.
“Oregon Department of Energy Homepage.” (2004). State of Oregon http://www.energy.state.or.us/

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Chapter 6: Energy
6.1 General Conditions

9

Goal: To reduce energy consumption of temporary power systems.

Key Issues:

- Using alternative sources of power to reduce temporary systems' costs and their impact on the environment. 8
- Green power companies offer a nationwide source of green power which has less impact on the environment.
- Small changes in temporary HVAC and lighting systems can reduce energy use and lower costs. 7

Actions and Methods:

6

Reducing Energy Consumption during Construction:

- Encourage carpooling or public transportation to the jobsite.
- Minimize the use of lit signage outdoors and maximize the use of photovoltaic panels for construction and warning signage where applicable. 5
- Shut off temporary lighting systems when not in use.
- Use compact fluorescent bulbs rather than incandescent bulbs for temporary lighting. Compact fluorescent bulbs use 75 percent less energy and last 10 times longer than incandescent bulbs. 4
- Avoid unnecessary use of temporary lighting systems during daylight hours.
- Use energy efficient HVAC equipment for temporary services. 3
- Purchase power from green power companies listed on the following page.

2

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Green Power Companies:

Home Office Location	Green Power Supplier
Iowa	3 Phases Energy Services
Illinois	AES NewEnergy
New York	Agway Energy Products
Massachusetts	Center for Ecological Technology
New York	Community Energy Inc.
New York	ConEdison Solutions
Massachusetts	Conservation Services Group
Maryland	Constellation NewEnergy
California	electricAmerica
New York	Energy Cooperative of New York, Inc.
Pennsylvania	Energy Cooperative Association of PA
New Jersey	FirstEnergy Solutions Corporation
Texas	Green Mountain Energy Company
Maine	Maine Interfaith Power & Light
Massachusetts	Massachusetts Energy Consumers Alliance
New England	National Grid
Massachusetts	NSTAR
New York	NYSEG
Virginia	Pepco Energy Services
Texas	Reliant Energy
Connecticut	Select Energy
Georgia	Sterling Planet, Inc.
Pennsylvania	Strategic Energy
Texas	TXU Energy
Washington, D.C.	Washington Gas Energy Services

Locations of the Green Power Companies listed above do not limit their power grid radius. Many of the above companies offer nationwide power supply.

References

"Green Marketing." (2004). Green Power Network
http://www.eerw.energy.gov/greenpower/marketing.shtml

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Chapter 6: Energy
6.2 Demolition and Abatement

9

Goal: To reduce energy consumption during demolition and abatement.

Key Issues:

8

- Chlorofluorocarbons (CFCs) are confirmed ozone depleting substances that contribute to global warming.
- The United States is one of the world's largest emitters of ozone depleting substances.

7

Actions and Methods:

Reduce Energy Consumption during Demolition:

6

- Provide a listing of all existing heating, ventilation, air conditioning and refrigeration (HVAC&R) components and state whether each component uses CFCs.
- For components that use CFCs, provide a phase out plan describing how these components will be converted or removed and replaced with CFC-free components.

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Sustainable Construction Fact

Chlorofluorocarbons (CFCs)

CFCs contribute approximately 24 percent to global warming. The source of these gases is leaking air conditioners, refrigerators, industrial solvents, production of plastic foam and aerosol propellants. These gases take 10-20 years to reach the stratosphere and trap 1,500-7,000 times as much heat per molecule as carbon dioxide. These gases are also responsible for the hole in the ozone layer. They remain in the stratosphere for 65 years.

http://www.cs.clark.edu/~mac/physlets/GlobalPollution/chloroflourocarons.html

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References

DeFelice, D. (2004). "Chloroflourocarbons." NASA Glenn Research Center. http://www.grc.nasa.gov.WWW/K-12/Aero2000/studwed/glossary/cfcs.html

Chapter 6: Energy

6.3 Site Work

Goal: To reduce energy consumption through improved site work practices.

Key Issues:

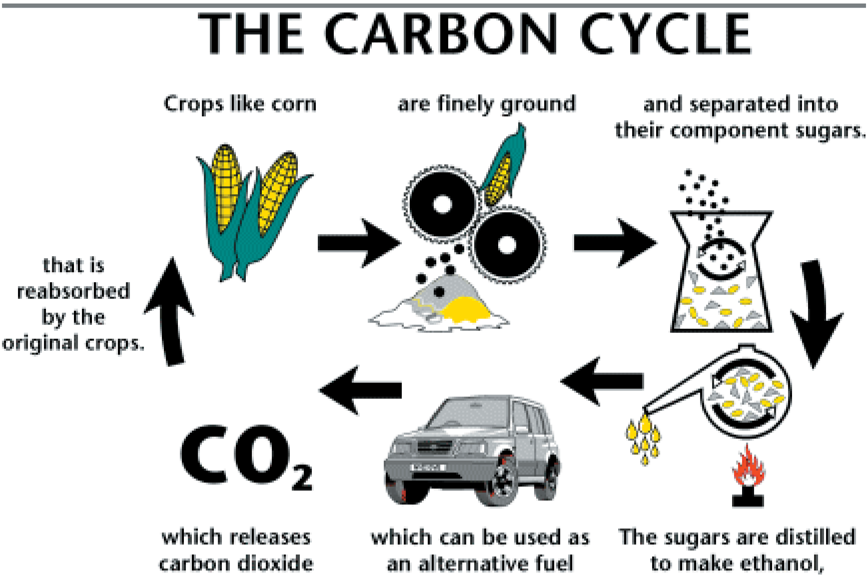
- Construction debris typically disposed of in landfills can now be used as an alternative fuel source through biomass technology.
- Excessive site work and soil removal disturb the surrounding vegetation which is costly to replace.

Actions and Methods:

- Store removed plant materials such as trees, grasses and crops. These materials can be reused to generate electricity through biomass technology. This biomass technology can be used to power construction equipment.
- Design all underground utilities to reach the building footprint in the shortest path possible. This reduces material costs and minimizes disturbances of the surrounding landscape.

Emerging Technologies:

Biomass Technology



Biomass consists of a plant material such as trees, grasses and crops. To generate electricity, biomass is converted to heat energy in a boiler or gasifier. This heat is then converted to mechanical energy in a steam turbine or gas turbine. The turbine then turns a generator that produces electricity.
Currently, biomass technology contributes approximately 1 percent of the nation's energy and is rising. The most economical source of biomass fuel is residue from construction sites.

References

"Equipment, Supplies, and Specialties." (2003). Texas Contractors Supply. http://www.texascontractors.com

Chapter 6: Energy
6.4 Foundations

Goal: To reduce energy consumption through foundations.

Key Issues:

- Extensive heat loss occurs in many structures through the slab on grade into the ground.
- Proper insulation techniques are required in all buildings.

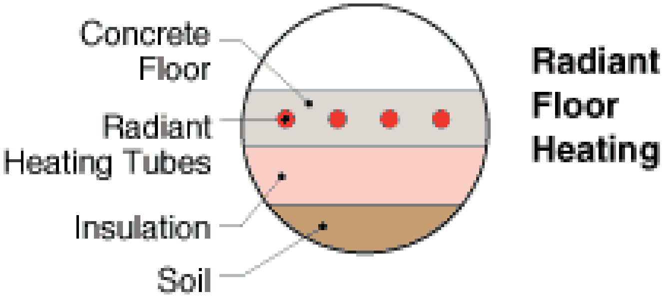
Actions and Methods:

Install an Energy Efficient Foundation:

- Before pouring a slab on grade, ensure that the proper insulation has been installed. Completely insulate the bottom of the slab on grade and foundation walls.
- Seal all penetrations in the slab.
- Use Insulated Concrete Forms (ICFs), see Case Study in Section 6.5.
- ICFs are made of foam insulation that is joined by plastic snaps, steel straps or other means. When concrete is poured into these forms, the result is a strong wall system with an R-value of between R-16 and R-24 depending on the foam thickness. An additional benefit of ICFs is the thermal mass of the concrete which reduces temperature swings between outside and inside temperatures.

Case Study:

Radiant Floor Heating



The BigHorn Home Improvement Center Located in Silverthorne, CO is one of the nation's first commercial buildings to integrate high-performance design in a retail space. It is expected to reduce energy costs by 62 percent when compared to similar retail buildings. Because the building is heated using radiant heating in the concrete slab floors, completely insulating the bottom of the floor and foundations walls was important to minimize heat loss to the ground.

References

"Bighorn Home Improvement Center." (2000). National Renewable Energy Laboratory http://www.nrel.gov/buildings/highperformance/bighorn.html

Brown, W. (2000). "Sustainable Design, Construction and Land Development." Southface Energy Institute.

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Chapter 6: Energy
6.5 Substructure

9

Goal: To reduce energy consumption through the building's substructure.

Key Issues:

8

- Extensive heat loss in the building occurs through the substructure into the ground.
- Proper insulation techniques are required in all buildings.

Actions and Methods:

7

Install an Energy Efficient Substructure

- Completely insulate the foundation walls.
- Seal all penetrations through the foundation walls.
- Insulated Concrete Forms (ICFs) are made of foam insulation which is joined by plastic snaps, steel straps or other means. When concrete is poured into theses forms, the result is a strong wall system with an R-value of between R-16 and R-24, depending on the foam thickness. An additional benefit of ICFs is the thermal mass of the concrete which reduces temperature swings between outside and inside temperatures.

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Emerging Technologies:

Insulated Concrete Forms

Habitat for Humanity recently dedicated six new affordable homes in Yonkers, NY. These houses were made affordable by the use of insulated concrete forms and structural insulated panels which reduced the construction costs and yearly heating and cooling costs.

References

Brown, W. (2000). "Sustainable Design, Construction and Land Development." Southface Energy Institute.

Crosbie, M. (2003). "Habitat for Humanity Founder Praises Energy Efficient, Green Houses." Steven Winter Associates, Inc. http://www.swinter.com/PressReleases/Yonkers.pdf

Chapter 6: Energy
6.6 Superstructure

Goal: To reduce energy consumption through the superstructure.

Key Issues:

- Heat loss in a building's superstructure raises heating and cooling costs substantially.
- The superstructure of a building can contribute to the insulating value of the exterior walls.

Actions and Methods:

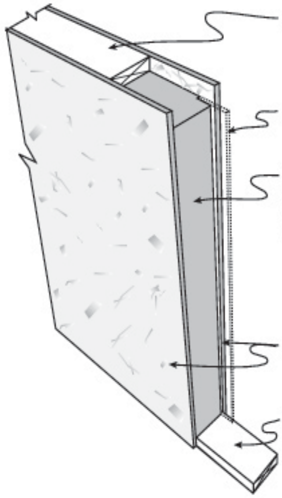
- Use thermal breaks in metal framing systems.

Emerging Technologies:

Structural Insulated Panels

Structural Insulated Panels (SIPs) are made of foam insulation sandwiched between two layers of plywood or OSB. While material costs typically run 10 to 20 percent higher than costs for conventional framing, actual installation time can be cut in half.

SIPs usually offer energy savings of 10 to 30 percent above conventional framing because of their high insulating value and airtight construction. SIPs construction also reduces the amount of wood in the framing by 10 to 30 percent.



Insulated Concrete Forms (ICFs) are made of foam insulation that is joined by plastic snaps, steel straps or other means. When concrete is poured into these forms, the result is a strong wall system with an R-value of between R-16 and R-24, depending on the foam thickness. An additional benefit of ICFs is the thermal mass of the concrete which reduces temperature swings between outside and inside temperatures.

References

Brown, W. (2000). "Sustainable Design, Construction and Land Development." Southface Energy Institute.

Chapter 6: Energy
6.7 Exterior Enclosure

Goal: To reduce energy consumption through the building's exterior enclosure.

Key Issues:

- Proper insulation techniques will raise the walls R-value, thus reducing heat loss through the walls.
- If an exterior wall is not properly sealed, heat will escape through the gaps.

Actions and Methods:

Air Sealing:

- Seal bottom plate of exterior walls.
- Seal inside edge of bottom plate after exterior walls are erected.
- Seal windows and exterior doors into rough opening using spray foam or backer rod.
- Seal exterior penetrations (e.g., exterior mounted light fixtures, outside outlets, and phone and electric service holes).
- Ensure proper installation and continuity of vapor barrier in wall systems.

Insulation:

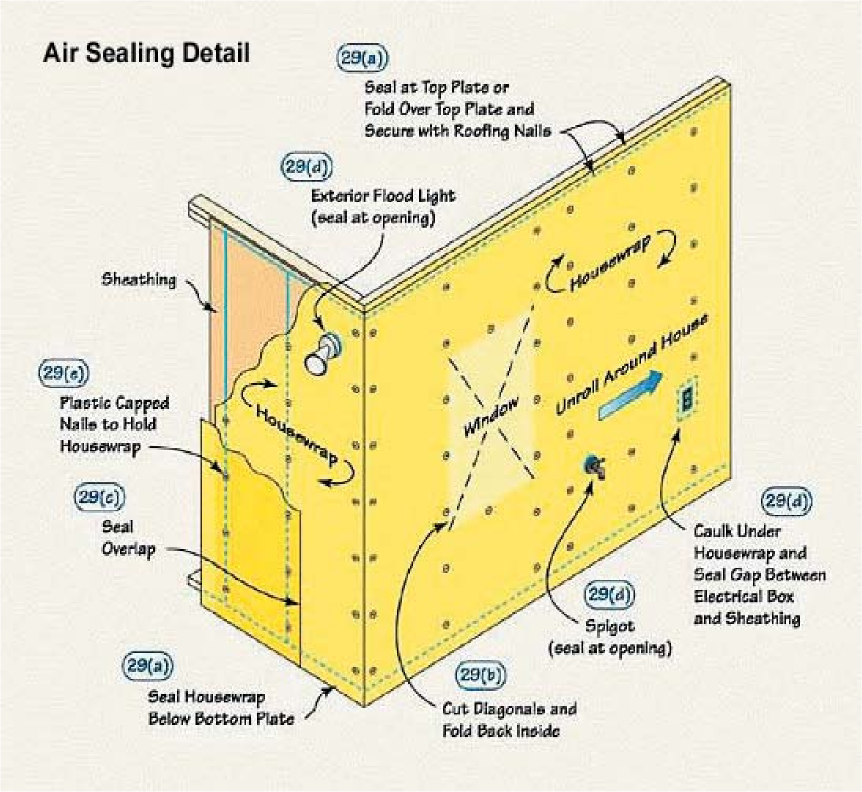
- Use energy efficient framing (e.g., energy corners, T-walls and insulated headers) to improve coverage.
- **Face-staple batt** because side stapling creates channels for air flow and compresses the insulation, thus reducing the R-value. If face stapling is not an option, use unfaced batts or carefully side staple within a quarter of an inch of the stud face.
- Cut wall insulation batt to fit around wiring, wall outlets and plumbing.
- Ensure that there are no voids in the insulation barrier and that materials are installed according to the manufacturer's specifications.

Thermal Breaks:

- Use thermal breaks for steel stud wall and window construction.

Emerging Technologies:

Air Sealing



Air sealing is an easy way to reduce energy consumption in a building
http://www.state.ne.us/home/NEO/home_const/details/asd.htm

References

"Air Sealing." (1999). Southface Energy Institute.

"Residential Energy-Efficient Design and Construction Checklist." (1999). Oak Ridge National Laboratory.

"Wall Insulation." (2000). Southface Energy Institute.

Chapter 6: Energy
6.8 Roofing

Goal: To reduce energy consumption through the roof system.

Key Issues:

- Energy loss through the roof increases the building's heating and cooling costs.
- Albedo traps heat within the building, raising the cooling load.

Actions and Methods:

- Use pre-fabricated roofing panels.
- Properly seal all joints on roof.
- Ensure proper insulation – stagger joints in layer.
- Caulk and seal all roof penetrations.
- Use materials which raise the reflectivity of the roofing system. Reflective roofs have a lower heat absorption which reduces cooling costs. Possible materials are foil-laminated foam board and light colored ballasts.
- Use energy star rated roof-compliant, high-reflectance and high emissivity roofing or install a green vegetated roof system. Avoid using black or metal roofing materials.

Sustainable Construction Fact:

Albedo Roofing

Albedo is a ratio of reflected solar radiation to the total amount that incident on that surface. The amount of albedo found in a roof directly affects the cooling loads within the building. Roofing materials with a low albedo, such as black roofing felt and metal roofs, raise the amount of energy required to cool the interior of the building. Roofing materials with a high albedo, such as light colored ballast, keep the cooling loads low.

References

"Insulating Your Commercial Roof System." (2001). Roofing People. http://www.roofingpeople.com/Index.cfm?Page-Commercial19

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Chapter 6: Energy
6.9 Interior Construction

9

Goal: To reduce energy consumption through interior walls.

Key Issues:

- Poor insulation in interior walls will allow heat loss between rooms, creating an uncomfortable work environment. 8
- Occupant productivity is impacted by the comfort of the interior space.

Actions and Methods: 7

- Seal electrical switch and outlet boxes to drywall with caulk.
- Seal light fixture boxes to drywall with caulk or foam.
- Install insulation between conditioned and unconditioned spaces. 6
- Limit the use of blocking to improve insulation coverage.
- Use single studs or ladder blocking to secure the connection of interior partition walls to exterior walls.
- Face-staple batt because side stapling creates channels for air flow and compresses the insulation, thus reducing the R-value. If face stapling is not an option, use unfaced batts or carefully side staple within a quarter of an inch of the stud face. 5

References 4

"Air Sealing." (1999). Southface Energy Institute.

"Residential Energy-Efficient Design and Construction Checklist." (1999). Oak Ridge National Laboratory. 3

"Wall Insulation." (2000). Southface Energy Institute.

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Chapter 6: Energy
6.10 Conveying Systems

Goal: To reduce energy consumption in conveying systems.

Key Issues:

- Conventional elevators powered by alternating current require large amounts of energy and utilize hydraulic fluid which is detrimental to the environment.
- Conventional elevators require either a penthouse or a large mechanical room.

Emerging Technology:

Gearless Elevators

Elevators exist which are constructed with an AC gearless motor of axial synchronous design with an integrated traction sheave, brake flange and rotor. It does not use hydraulic fluid, which can contaminate up to 250,000 gallons of groundwater with even a one-quart leak.

- Used in simplex or duplex installations for 2-10 landings, up to 80' of travel and operate at 200 feet per minute.
- Powered by a compact, powerful and lightweight permanent magnet motor, which does not use hydraulic fluid and does not require a penthouse or large machine room.
- By using AC gearless technology, gearless elevators can lower power consumption by 40 percent, compared to conventional AC-powered traction elevators.

References

"Bluetooth - Short-Range Radio Technology." (2001). Construction Industry Institute. http://www.new-technologies.org/ECT/Internet/bluetooth.htm

"Fiber-Optic Laser Technology for Decontaminating Metals." (2000). Construction Industry Institute. http://www.new-technologies.org/ECT/Other/fiberopticlaser

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Chapter 6: Energy
6.11 Mechanical

9

Goal: To reduce energy consumption in mechanical systems.

Key Issues:

- Sealing seams and penetrations.
- Insulation of pipes and ductwork.

8

Actions and Methods:

7

- **Clean filters weekly** during construction.

Ductwork:

- Permanently seal all ductwork joints with mastic, a thick paste that provides a durable seal for all types of ducts.
- Insulate all ductwork.
- Ensure ducts are not pinched or restricted.
- Ensure that proper airflow is being delivered to each diffuser.
- Reduce bends and turns in piping and ductwork.
- Line and seal the interior of the return plenum with duct board.

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Penetrations:

- Seal all plumbing and HVAC penetrations between conditioned and unconditioned spaces.
- Seal all duct boots to floor or drywall with caulk, foam, or mastic.
- Seal the air handler closet and the air handler itself, including sealing the air handler to the platform.
- Seal return air grilles at point of penetration through wall.
- Seal around the metal flue of combustion equipment.

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Design Suggestions:

- Design ductwork using either larger, cross-sectional areas to reduce air resistance and fan energy. Round or oval duct cross-sectional shapes will further reduce ventilation losses.
- Design chillers to be step engaged to meet partial load demands.
- Use localized hot water equipment rather than centralized equipment. Localized equipment is typically more efficient than centralized.

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Commissioning:

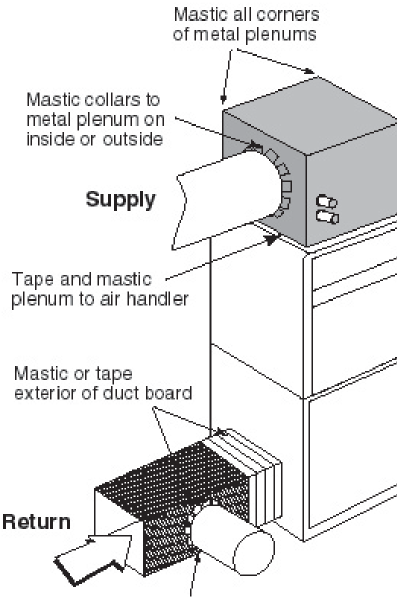
- The commissioning authority must observe installation of each type of commissioned feature and system to ensure they are properly installed according to contract documents and manufacturer's instructions, and that other building systems or components are not compromising the performance of the feature.
- Start-up and checkout results must be clearly documented according to manufacturer's written instructions and contract documents.

Constructability Considerations:

- Reduce elbows in piping and ductwork to reduce pumping/ fan power and improve constructability.

Case Study:

Ductwork Connections



Mechanical equipment and ductwork joints and connections should be properly insulated and sealed to prevent energy losses.

References

"Air Sealing." (1999). Southface Energy Institute.

Barcik, M. (1998). "Breathing Easy....Thanks to Duct and Air Sealing." Southface Journal of Sustainable Building

Chapter 6: Energy

6.12 Electrical

Goal: To reduce energy consumption in electrical systems.

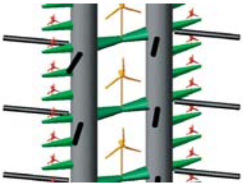
Actions and Methods:

- Verify and confirm incoming amperage and voltage and use capacitors to adjust the power factor as necessary.
- Notch out insulation around boxes and use scraps behind boxes.
- Incandescent bulbs require more energy than their alternatives.
- If recessed lights are installed in a ceiling with an unconditioned space above it, use only Underwriters Laboratory (UL) approved fixtures that are airtight, are Insulation Contact (IC) rated, and meet ASTM E283 requirements.
- For emergency lighting, use LED (light-emitting diode) or photo-luminescent energy star rated exit signs. A LED sign uses 12 percent of the energy, with a life expectancy of 80 years.
- Use metal halide lamps, low-temperature fluorescents and/or solar powered fixtures for exterior lighting.

Emerging Technology:

Wind Power

The new design of New York's Freedom Tower incorporates a 1,000,000 W wind farm. This farm will take advantage of the 21 mile per hour average wind speed to produce an estimated 2.6 million kWh of green electricity annually, a significant portion of the building's energy use.



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"Freedom Tower to Incorporate Wind Turbines." (2004). Green Building News. http://oikos.com/news/2004/01.htm#Anchor-48213

"Wall Insulation." (2000). Southface Energy Institute.

"Whole House Energy Checklist." (2003). Southface Energy Institute.

Chapter 6: Energy
6.13 Information Technology

Goal: To reduce energy consumption through the use of information technology systems.

Key Issues:

- Desktop computers require more energy than laptop computers.
- Control systems for lighting controls can save in energy costs.

Actions and Methods:

- Use laptops instead of desktop computers on the jobsite.
- Use flat screen panels if using a desktop computer.
- Use a printer with duplex capability to allow printing on both sides of a sheet of paper.
- Consider replacing older equipment with Energy Star–compliant equipment.
- Use a power-strip with an on/off switch which can make it easy to turn off all your computer equipment at once.
- Do not turn on your computer until you need to use it and turn it off when you are finished.
- Install either an effective energy management and controls system or a DDC (direct digital control) electronic system.
- Occupancy sensors result in energy savings of up to 60 percent. Another alternative is to use daylighting controls, which measure the level of daylight and illuminate the interior space accordingly.

Case Study:

Using equipment such as notebook computers and power strips in the job trailer will reduce the consumption of energy.

References

Novogrodsk, S. (2001). "Energy Saving Tips for Campus Computer Users." Berkeley Computing & Communications.

1 2 3 4 5 6 7 8 9 10

Chapter 6: Energy
6.14 Equipment

Goal: To reduce energy consumption when using construction equipment.

Key Issues:

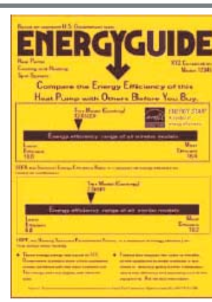
- Non-rated equipment such as extension cords use excess energy.
- New technologies provide alternatives to conventional diesel powered equipment. These alternative fuels are less harmful to the environment.

Actions and Methods:

- Purchase and utilize energy star rated equipment.
- Bio-diesel equipment uses biomass (plant material) as an alternative fuel source. Bio-Diesel equipment uses less fuel and emits fewer gases into the environment.

Case Study:

The use of Energy Star appliances and equipment can greatly reduce the energy consumption of a building.



Regular maintenance and tuning of heavy machinery on a jobsite can greatly reduce fuel consumption.

References

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"Energy Star." (2004). Energy Star. http://www.energystar.gov/

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Chapter 6: Energy
6.15 Finishes

2

Goal: To reduce energy consumption through building finishes.

Key Issues:

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- Insulating paints can help reduce heating and cooling losses through interior and exterior walls.
- Automated window blinds can aid in daylighting attempts.

Actions and Methods:

4

- Apply insulating paints to interior walls and exterior walls and roof to reduce heat loss between interior spaces and the outside.
- Properly install automated window blinds in all windows. These blinds will automatically open and close in response to daylight loads.

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Energy and Technology:

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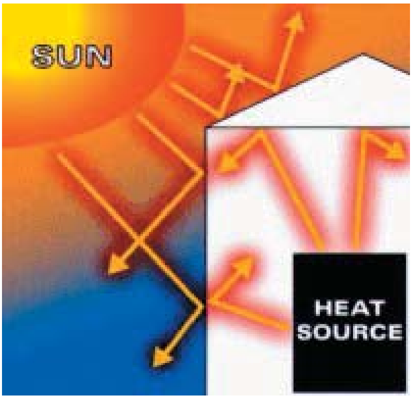
Ceramic Paint Insulation



Insulative paint coatings are available which can be applied to both the interior and exterior finishes of a building. When applied to the exterior walls and roof, the coatings reflect exterior heat and moisture. When applied to interior walls, it controls the loss of heat during the winter by reflecting heat back into the interior space.

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References

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Pope, J. (2004). "Super Therm - Ceramic Paint Insulation." Construction Industry Institute. http://www.new-technologies.org/ECT/Civil/supertherm.htm

Chapter 7: Building and Material Reuse

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

"If you were to take this facility apart or want to reconfigure this space in the future, what would make that job easier and maximize the ability to reuse materials?"

Benefits:

- Reduces future renovation costs.
- Saves money with used materials.
- Diverts valuable materials from landfills and save on tipping fees.
- Improves building/facility value (Buildings in the future that are simpler to renovate, reconfigure or even deconstruct will be more valuable).

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Use standardized modular construction techniques.
- Select fittings fasteners, adhesives and sealants that allow for quicker disassembly and facilitate the removal of reusable materials. Material reuse is highly dependent upon the connections.
- Consider future worker safety and health (Ref. Ch. 9).
- Utilize reusable materials (A list is provided at each phase).
- Dry construction techniques (e.g. drywall instead of CMU block) enable potentially easier dismantling.

Value Engineering Suggestions:

- Minimize distribution systems within structural walls – allows for selective demolition (Ref. Section 7.11, 7.12).
- Open bay design concepts to eliminate interior partitions.

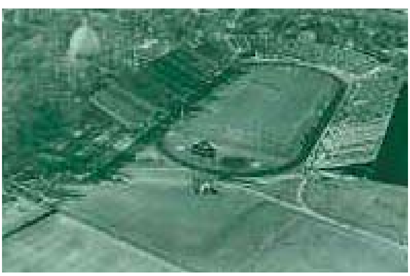
1 2 3 4 5 6 7 8 9 10

- Match the structure and finished grid layout to reduce waste.
- Leave structural steel (after fire proofing) exposed.
- Look to eliminate anything that needs to be formed.
- Suggest using a raised floor system.
- Consider maintenance and disassembly logistics (e.g. access).
- Minimize and standardize building components and materials.
- Utilize prefabricated and preassembled components.
- Simplify and separate building systems and components (Ref. section 7.11, 7.12).

Case Study:

Beaver Stadium, University Park, PA

In 1960 the 30,000-seat stadium was dismantled into 700 pieces and moved one mile across campus, where it was re-erected into what would eventually hold the distinction of the largest all-steel stadium in the world.



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Pulaski, M., et al. (2003). Design for Deconstruction: Material Reuse and Constructability. The Pittsburgh Papers: Best of Greenbuild 2003. Brattleboro, VT, Building Green, Inc.

"A Technical Manual for Material Choices in Sustainable Construction." (2000). State of California Integrated Waste Management Board. Sacramento, CA.

Chapter 7: Building and Material Reuse

7.0 Planning

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Specify contractors with experience in material reuse (i.e. salvaging).
- Assign areas on-site for storing reusable materials.
- Identify materials that are salvage (during demolition and during new construction). Extra materials can be donated to DRMO. If DRMO cannot take materials, then consider Habitat for Humanity or the United Way. A list of online materials exchange programs are listed in Section 7.2.
- Efficiently remove useful items prior to demolition.
- Consider material salvage as a way of economic resource.
- Educate workers on what is appropriate to salvage and things they can do to make the building re-usable.

Reusable Materials Checklist:

	Appliances		Ductwork		Pipes
	Bathroom fixtures		Flooring		OSB & plywood
	Bricks/CMU block		Insulation		Tile
	Cabinets		Landscaping materials		Trim/Molding
	Carpeting		Lighting fixtures		Windows
	Ceiling tiles		Marble		All wood items
	Dimensional lumber		Metal framing		Furniture
	Doors		Paneling		Steel members
	Fencing		Signage		Equipment

Information required for future building reuse:

- As built drawings to identify and locate reusable material.
- Records of all changes.
- Asset registers showing what is in the building and its recycling and reuse potential.
- Identification of potentially hazardous materials.
- Provide details of prefabricated units (e.g. fixing points and carrying points).
- Labeling of materials once removed.
- A future building demolition plan should be developed based up on the construction process.

References

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

"Resourceful Renovation." Portland Metric Deconstruction.

Simpson, S. (2003). "Construction Waste Management Guide: Methods to Save Money and Resources." State of Washington Department of General Administration. Olympia, WA.

"A Technical Manual for Material Choices in Sustainable Construction." (2000). State of California Integrated Waste Management Board. Sacramento, CA.

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

Chapter 7: Building and Material Reuse

7.1 General Conditions

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Maximize opportunities for reuse of temporary structures.

Actions and Methods:

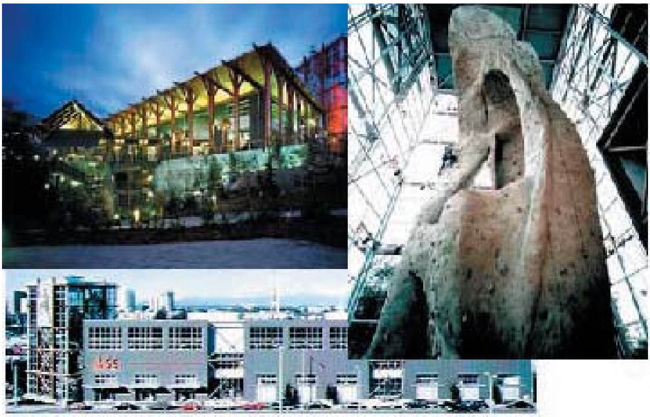
- Minimize the use of wood for temporary structures (e.g. pedestrian walkways).
- Use prefabricated components where possible.
- Use connections that allow for the ease of disassembly of temporary structures so that materials can be reused.

Reusable Materials Checklist:

	Appliances		Ductwork		Pipes
	Bathroom fixtures		Flooring		OSB & plywood
	Bricks/CMU block		Windows		Furniture
	Cabinets		All wood items		Equipment
	Carpeting		Lighting fixtures		Paneling
	Ceiling tiles		Metal framing		Signage
	Dimensional lumber		Doors		Fencing

Case Study:

About 75% of the demolition materials were reused, recycled or sold for salvage in REI's new $30 million dollar flagship building in Seattle.



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Chapter 7: Building and Material Reuse
7.2 Demolition and Abatement

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Identify and protect reusable materials.

Actions and Methods:

- Consider alternatives to abatement (e.g. asbestos encasement – the EPA has included spray-applied enclosures, also known as encasement as an acceptable asbestos abatement method).

Demolition/Deconstruction Process:

- Isolate and make safe services.
- Remove hazardous materials.
- Soft strip, i.e. internal finishes, partitions, carpets, services, etc.
- Remove non-load bearing elements.
- Remove load bearing elements.
- Pre-market materials for reuse.

Demolition Plan Guidelines:

- Reference section 7.0 – Planning.

Case Study:

Disney's Recycle Plus Program

In 2000 alone, Reedy Creek Improvement District (RCID) and Walt Disney World® Resort donated more than $65,000 of reusable building supplies to local affordable housing programs, churches, and nonprofit organizations.

Donated items included:

- Plumbing fixtures.
- Paints.
- Carpeting.
- Lumber.

References

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"Construction Material Recovery Coalition - National Capital Region." (2003). http://www.cmrc.us/

Hermannsson, J. (1996). "The Salvaged Building Materials Exchange." Green Building Resource Guide. http://www.greenguide.com/exchnage/

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"Used Building Materials Exchange." (2004). http://build.recycle.net/index.html

Vleck, R. E. (2001). "Advanced Construction and Demolition Waste Management for Florida Builders." University of Florida.

"WasteWise Update: Building for the Future." (2002). Environmental Protection Agency. Washington, DC.

Chapter 7: Building and Material Reuse

7.3 Site Work

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.

Actions and Methods:

- Consider using reusable perimeter fencing and materials that can be transported easily from site to site.
- Consider using the excess fill and other materials as landscaping.
- Recycle the stone: crush and use as gravel.
- Consider using cleared lumber and shrubs as mulch.
- Use site formwork that is reusable. Minimize the use of plywood.
- Designate areas for storing reusable materials (Ref. Ch. 5).

Reusable Materials:

- Landscaping materials.
- Brick (crush and use as fill).
- Concrete (crush and use as fill).
- Asphalt (crush and use as fill).
- Stone (crush and use as fill).

Case Study:

Kodak Park, NY

"A good way to minimize costs and do the right thing."
– George Thomas, Kodak Pollution Prevention Program Manager

- Kodak deconstructed 40 buildings on the company's 1,900-acre park.
- Valuable wooden beams were reused.
- 50,000 tons of brick, concrete, and asphalt were recovered.
- Kodak stockpiled the material, hired a contractor to crush it into aggregate twice each year, and reused the material on-site as fill.

Associated Savings:

- Nearly $2.7 million in avoided disposal fees.
- The cost of new aggregate was comparable to the cost per ton of crushing the salvaged material.

References

"WasteWise Update: Building for the Future." (2002). Environmental Protection Agency. Washington, DC.

Chapter 7: Building and Material Reuse
7.4 Foundations

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Maximize opportunities for future reuse.

Actions and Methods:

- Consider using prefabricated foundation walls.
- Reusable formwork for concrete walls reduces material use.
- Consider using high quality block with low quality mortar: this allows for ease of removal at demolition/deconstruction.
- Suggest using pre-cast concrete foundation wall panels where feasible.
- Designate areas for storing reusable materials.

Reusable Materials:

- CMU block.
- Formwork.

Chapter 7: Building and Material Reuse
7.5 Substructure

10 9 8 7 6 5 4 3 2 1

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Maximize opportunities for reuse.

Actions and Methods:

- Designate areas for storing reusable materials (Ref. Ch. 5).
- Use prefabricated and preassembled components.
- Use standardized modular construction techniques.
- Install built-in tie offs and connection points for machinery to be used in the eventual removal of the building from the site.

Materials that facilitate future reuse:

- Pre-cast concrete walls.
- Floor panels.
- Cladding systems, curtain walls, steel beams (easily stackable during deconstruction).
- MEP assemblies.
- Rigid key-type joint allow for easy disassembly (1 bolt – no welding).
- Saxe clips for structural steel allow for easy disassembly (1 bolt – no welding).

Reusable Materials:

- Steel.
- CMU block.

References

Grube, R. (2002). A Rigid Key-Type Joint for Sustainable Use in Steel Construction. International Iron and Steel Institute.

Chapter 7: Building and Material Reuse

7.6 Superstructure

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Maximize opportunities for future material recovery and reuse.

Actions and Methods:

- Prefabricate wall systems.
- Select connections that are easily demountable from the structure (e.g. bolted steel connections instead of welded connections).
- Install built-in tie offs and connection points for machinery to be used in the eventual removal of the building from the site.
- Incorporate external fittings around the façade to enable the future attachment of scaffolding.
- Suggest using building elements (beams, columns, girders etc), that are light weight and easy to handle.
- Where applicable consider using jacket type fire proofing. This is easier to remove than spray on fireproofing.
- Suggest using pre-cast concrete floor panels in lieu of cast in place systems. They rest on top of the walls and do not extend through the horizontal plane of the floor. This eases the deconstruction process.
- Designate areas for storing reusable materials.

Reusable Materials:

- Steel.
- CMU block.

Materials that facilitate future reuse:

- Pre-cast concrete walls.
- Floor panels.
- Cladding systems, curtain walls, steel beams (easily stackable during deconstruction).
- MEP assemblies.
- Modular or all-bolted connections for structural steel allow for easy disassembly.

Case Study:

Crystal Palace. Hyde Park, London

Crystal Palace, like many temporary or Festival structures was designed to rest on its original site for only one year and then be dismantled. The modular glass and iron truss components were lifted into place with horse-drawn hoisting devices and field bolted for simplified disassembly. The modular components simplified the construction process and the building went together like a large puzzle.

References

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

Pulaski, M., et al. (2003). Design for Deconstruction: Material Reuse and Constructability. The Pittsburgh Papers: Best of Greenbuild 2003. Brattleboro, VT, Building Green, Inc.

Chapter 7: Building and Material Reuse
7.7 Exterior Enclosure

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Suggest simplifying (or standardizing) connection details.
- Search for opportunities to eliminate caulking, sealants and other high-tolerance connections. The ease of removing components for repair and replacement will offset the need to provide flexible connections and eliminate the jointing products.
- Use easily removable adhesives and caulking.
- Retain all scrap metal and other materials. Reuse and donate appropriate items, recycle the rest.
- Consider eventual deconstruction in the selection of brick and mortar: allow for easy separation. Ensure security, force protection, and structural issues are not compromised.
- Designate areas for storing reusable materials.
- Use releasable adhesives.

Reusable Materials:

- Excess or slightly damaged material may be donated.
- Brick.
- CMU Block.
- Windows.

Materials that facilitate future reuse:

- Pre-cast concrete walls.
- Cladding systems, curtain walls, steel beams (items which are easily stackable during deconstruction).
- MEP assemblies.

Case Study:

Hume Hall, Gainesville, FL

Building Details:

- 133,000 sq ft., four-story institutional building.
- Concrete framing with a concrete roof.
- Built-up tar and gravel roofing.
- Exterior and interior walls were CMU with double wythe brick veneer.

Reused materials:

- Fixtures and hardware.
- Brick veneer was separated from the concrete structure.

Cost effectiveness:

- Removal of hardware and fixtures was cost-effective.
- Removal of brick veneer was not cost-effective.
- Additional de-mortaring was required.
- Mortar was cement-based and did not lend itself to hand separation.
- Costs were avoided by the mechanical reduction of masonry and concrete materials and removal of reinforcing steel for recycling.

References

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

Chapter 7: Building and Material Reuse

7.8 Roofing

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Maximize opportunities for reuse.

Actions and Methods:

- Consider using prefabricated roof structures.
- Suggest alternatives to asphalt roofing such as rubber.
- Use standardized modular construction techniques.
- Simplify connections to facilitate removal or replacement.
- Select fittings, fasteners, adhesives and sealants that allow for quicker disassembly and facilitate the removal of reusable materials. Material reuse is highly dependent upon the connections.
- Create an assigned area for salvage material.

Reusable Materials:

- Metal roofing.
- Tile roofing.
- Slate.

Emerging Technology:

Rigid Key-Type Joints

An intelligent rigid connection technology for the steel assembly process has been developed as an alternative to bolting and welding assemblies. The SIGMA-joint was first used in the construction of the Christus-Pavilion at the EXPO 2000 in Germany. The key-type joint allowed for a simple disassembly and reassembly process.
The SIGMA-joint was determined to be the ideal rigid connection for the façade and roof elements.

References

Grube, R. (2002). “A Rigid Key-Type Joint for Sustainable Use in Steel Construction.” International Iron and Steel Institute.

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

Pulaski, M., C. Hewitt, et al. (2003). Design for Deconstruction: Material Reuse and Constructability. The Pittsburgh Papers: Best of Greenbuild 2003. Brattleboro, VT, Building Green, Inc.

Chapter 7: Building and Material Reuse
7.9 Interior Construction

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Simplify connections within a wall system. Use mechanical fasteners over chemical bonding systems where possible.
- Look to consolidate plumbing services.
- Search for opportunities to minimize building components and materials.
- Select fittings, fasteners, adhesives and sealants that allow for quicker disassembly and facilitate the removal of reusable materials. Material reuse is highly dependent upon the connections.
- Consider maintenance and disassembly logistics (e.g. access).
- Dry construction techniques (e.g. drywall) enable potentially easier dismantling than wet construction techniques (e.g. CMU block walls).
- Suggest leaving structural steel exposed

Reusable Materials:

- Demountable drywall.
- CMU block.

Materials that facilitate future reuse:

- Demountable drywall.
- Prefabricated wall panels (e.g. smartwalls).
- MEP assemblies.

- Wheat-straw interior partitions with integral paper facing.

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Case Study:

Drywall Salvaging Saves Money

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Even with added labor for careful removal, Vermont's largest construction company **saved $15,000** in avoided landfill costs by salvaging demountable drywall.

How did they do it?

They put a notice in the local paper offering drywall free to anyone who would pick it up on 20 sheet-minimum lots.

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The Results:

By the afternoon of the day the article ran, all the drywall was spoken for. "As fast as we could take it down, it was gone." People coming for drywall also hauled off about 50,000 sq ft. of carpeting, saving the company a few thousand dollars more in avoided landfill costs.

7

This was a **win-win situation for everyone** involved, and it happened because someone at the construction company had his eyes open and his mind working.

6

References

Fletcher, S., O. Popovic, et al. (2000). "Designing for Future Reuse and Recyling." School of Architecture, Sheffield University. Western Bank, Sheffield.

5

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

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Wilson, A. (1995). Big Savings from Drywall Salvage. Environmental Building News. 4.

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Chapter 7: Building and Material Reuse
7.10 Conveying Systems

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Maximize opportunities for reuse.

Actions and Methods:

- Research leasing options through the manufacturer.

Chapter 7: Building and Material Reuse

7.11 Mechanical

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Suggest consolidating plumbing services.
- Utilize prefabricated and preassembled components.
- Use standardized modular construction techniques.
- Look for opportunities to separate out MEP and other overhead distribution lines to facilitate the eventual removal/upgrade of the systems.
- Ensure all valves and equipment is easily accessible.
- Select fittings, fasteners, adhesives and sealants that allow for quicker disassembly and facilitate the removal of reusable materials. Material reuse is highly dependent upon the connections.
- Suggest minimizing distribution systems within structural walls – this allows for selective demolition.

Reusable Materials:

- Ductwork.
- Equipment (pumps, fans, AHUs, cooling coils, radiators, etc.).
- Pipes.

PENREN/C Practice:

Wedge 2-5 Universal Space Plan

The Universal Space Plan (USP) for tenant office areas in the Pentagon Renovation Wedge 2-5 project provides a flexible environment which is easily and efficiently reconfigured. The Fan Powered Induction Unit Mechanical system allowed for the space flexibility. It reduced the amount of ductwork required by allowing return air to be taken directly from the occupied space.

The USP design provides the following benefits:

- Space flexibility.
- Waste reduction.
- Greatly increased access to natural light and the outdoors.
- Ease of maintenance.
- Efficient integration of mechanical, electrical, and telecommunication systems.
- Durability.

References

Fletcher, S., et al. (2000). "Designing for Future Reuse and Recyling." School of Architecture, Sheffield University. Western Bank, Sheffield.

Guy, B. and S. Shell (2002). Design for Deconstruction. CIB Task Group - 39 Deconstruction, Karlesruhe, Germany.

Pulaski, M., C. Hewitt, et al. (2003). Design for Deconstruction: Material Reuse and Constructability. The Pittsburgh Papers: Best of Greenbuild 2003. Brattleboro, VT, Building Green, Inc.

Chapter 7: Building and Material Reuse
7.12 Electrical

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Remove and recycle all copper wiring. This will add to the salvage income.
- Consider using reusable modular wiring systems.
- Pre-wiring, mated plugs and clip-on mounting systems for lighting fixtures reduce overhead work, installation time and safety hazards.
- Surface-mount electrical wiring to allow for ease of reconfiguration.

Reusable Materials:

- Motors.
- Transformers.
- Circuit Breakers.
- Switchgear.
- Panel boards.
- Conduit.
- Cable trays.

References

Tsao, I. T. a. C. (2001). Integrated Product-Process Development by a Light Fixture Manufacturer. 2001 Annual Conference on the International Group for Lean Construction (IGLC-9), Singapore.

Chapter 7: Building and Material Reuse
7.13 Information Technology

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Improve building space and flexibility to maximize reuse.
- Simplify future renovations for technology upgrades.

Actions and Methods:

- Install larger conduit and raceways for upgrades/expansion.
- Surface mount wiring to allow for simple reconfiguration.

Case Study:

Intelligent Workplace, Carnegie Mellon University

The Intelligent Workplace at CMU was designed to provide unprecedented levels of organizational flexibility and technological adaptability. Just-in-time connectivity and redundancy are accomplished by providing:

- Modular 19” racks as satellite closets.
- Harnessed roll-out wiring, power, merged data, voice, video.
- Home runs with clip-connects absorb changing technologies of peripherals, networks, servers, LANs.
- Open cable trays under an access floor, divided power and data grid of service nodes on 5 meter tethers.
- Relocatable boxes.

References

“Center for Building Performance and Diagnostics.” (2004). School of Architecture, Carnegie Mellon University. http://weld.arc.cmu.edu/cbpd/index.html

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Chapter 7: Building and Material Reuse
7.14 Equipment

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Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

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- Reuse or donate equipment.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

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- Ensure all equipment is easily accessible and can be easily removed if necessary.
- Are there proper clearances to remove the equipment without damaging walls or the existing structure?

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Chapter 7: Building and Material Reuse
7.15 Finishes

Goal: To enable the reuse of facilities, systems, equipment, products and materials.

Key Issues:

- Reduce and reuse materials.
- Improve space and building flexibility.
- Maximize opportunities for reuse.

Actions and Methods:

- Suggest using structural elements as finished materials (i.e. stained concrete floor, architecturally exposed structural steel, painted CMU block, concrete walls and pre-cast panels).
- Minimize the use of drywall.

Reusable Materials:

- Wood finishes, floors, framing.
- Carpet tile.
- Ceiling tile.
- Fixtures and hardware.
- Metals.
- Plumbing fixtures.
- Stair treads.
- Handrails.

Materials that facilitate future reuse:

- Prefabricated wall systems (smartwalls).
- Demountable drywall.

Materials to avoid:

- Fibrous insulation.
- Chemical treatments for wood and many synthetic materials such as sealants, chemical coatings, binders and adhesives.

- Composite materials (i.e. loose and bonded insulation found in curtain walls) hamper deconstruction efforts.

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Case Study:

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Intelligent Workplace, Carnegie Mellon University

The Intelligent Workplace at CMU was designed to provide unprecedented levels of organizational flexibility and technological adaptability. Spatial flexibility was provided with:

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- Modular, stackable, storage wall systems.
- Floor based, modular work surfaces.
- Acoustic control of diverse office configurations.

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Chapter 8: Construction Technologies

Goal: To reduce time and waste on various project administration and construction processes.

Key Issues:

- Save time.
- Reduces effort.
- Decrease paper waste.

Actions and Methods:

Documentation:

- **E-paper** can be used to make multiple images such as blueprints, construction documents. It is best applicable where lots of changes in the plans could occur.

Communication:

- **An internet video camera via wireless modem** can help report the daily progress at the construction site.
- **On-line digital streaming video** would document the progress of construction projects and through the Internet this information can be shared with other departments.
- **Portable mobile field devices** provide help with field reporting, contractor-owner billing, payroll entry, punchlists, etc.
- **Short-range radio technology** makes it possible to transmit signals over short distances between mobile PC's, mobile phones and other portable devices and can track locations of people and equipment.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Electronically distribute documents**. Subcontractors can review plans online and print only the drawings they need.

Material Tracking:

- **Various software programs** could be used for inventory accounting, updating through purchase orders, accounts payable invoices, etc.
- **Bar coding** could be used for the inventory control. PDAs can be used for tracking materials into or out of the site.

Construction Management Efficiency:

- **Electronic Punchlists** are an online computer based punchlist system with embedded digital photographs of each item accessible via internet.
- **Pocket version of CAD** could be used in palmtops which can replace blueprints, drawings, etc.

Case Study:

Commercial Construction Project

Project Description: Bechtel used advanced communication technologies for its project in Sulawesi, Indonesia. They faced some problems with the design but field engineers were able to communicate with the designer and find the solution without any delays.

E-paper

PDA

Field engineers on-site

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Chapter 8: Construction Technologies
8.0 Planning

Goal: To reduce time and waste on various project administration and construction processes.

Key Issues:

- Save time.
- Reduces effort.
- Decrease paper waste.

Actions and Methods:

Documentation:

- **E-paper** can be used to make multiple images such as blueprints, construction documents. It is most applicable where lots of changes in the plans could occur.
- **3D Laser Scanning & Modeling System** lets users economically obtain accurate, complete, and timely as-built geometry information for large structures and sites.
- **Document Management Systems** (a centralized electric repository for all project related information) partially eliminate the need for duplicate copies for the office and the field and reduces paper filing requirements.

Communication:

- **Web conferencing technology** allows users to avoid expensive long distance rates by having participants listen in over the Web using only their standard Internet connection and browser. Users can talk on the phone, watch your live presentation and submit their questions via text chat.
- **Digital and interactive white boards** have the capabilities to capture handwritten, color drawings and text as real-time data for use on PCs anytime, anywhere.
- **Global Mobile Communication Systems** can improve information flow from the jobsite to the home office.
- **Internet Video Camera via Wireless modem** can help report the daily progress at the construction site.
- **On-line Digital Streaming Video** would document the progress

of construction projects and through the Internet and this information can be shared with other departments.

- **Portable mobile field devices** provide help with field reporting, contractor-owner billing, payroll entry, punchlist, etc.
- **Short-range radio technology** makes it possible to transmit signals over short distances between mobile PC's, mobile phones and other portable devices and can track locations of people and equipment.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Electronically distribute documents**. Subcontractors can review plans online and print only the drawings they need.
- **Digital signatures** can increase the efficiency of a number of authorization steps in the construction process.

Material Tracking:

- **Various software programs** could be used for inventory accounting, updating through purchase orders, accounts payable invoices, etc.
- **Bar Coding** This could be used for the inventory control. PDAs can be used for tracking materials into or out of the site.
- **Real-time Construction-component Tracking System** has the potential to enable the construction industry to seamlessly integrate work processes at the job-sites.

Construction Management:

- **An Electronic Punchlist** is an online computer based punchlist system with embedded digital photographs of each item that are accessible through the Internet.
- **Pocket version of CAD** could be used in PDAs, which can replace blueprints, drawings, etc.
- **Real Time Positioning** reduces time, labor, expenses, and errors while survey and inspection data is gathered, transcribed and processed.
- Use **personal air monitoring systems** to inform workers of hazardous environments. This technology can improve occupational safety and health in construction workplace.
- **Implement web based construction management**. Productivity is enhanced by the electronic submission of documents through a web-based system by: simplifying the submittal process; eliminating reproduction and mailing/shipping costs; and reducing labor costs associated with distribution and

filing of documents.

- If possible, practice **Electronic Procurement (E-Procurement)** through the Internet to obtain materials and supplies, saving time on consuming administrative and regulatory business activities.
- **Online bidding** with digital signatures can save the time otherwise used to prepare bids on paper, and the travel time and expense involved in attending meetings and submitting bids in person.
- Using a **lean project delivery system** approach to project management to maximize value delivered to the customer, while minimizing waste and improving the construction process.
- **PDA Estimating** allows users to have access to the same precision estimating data used in the office. Using this technology ensures estimators have the information needed to collect project details necessary to deliver complete and accurate estimates.

Case Study:

Asset Management

In suburban Chicago, Jorge Rojas, purchasing manager for F.E. Moran Inc., a mechanical contractor based in Northbrook, Ill., remembers tracking assets from a weathered clipboard hanging on his company's warehouse wall. He says his company owns about $1.5 million in small tools and portable equipment used to install fire-protection, security and HVAC systems. "It was a nightmare," he says. After every job wrapped up, the company was losing at least 50% in small assets, or about $300,000 annually.

Now, Rojas manages tools with his computer. In 1989, he began bar-coding and data basing every tool worth $20 or more. "When we put tools together for a job, we gather them up and scan them with a portable scanner," says Rojas. "After we send them out, I download the scanner into my computer system. When I need to get a tool, I find it in the system, so I don't need to buy another one."

–ENR E-Construction 7/7/03

Left: Handheld devices scan and upload tool data
Right: Bar-code labels are a popular method for tracking small assets within firms

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Chapter 8: Construction Technologies

8.1 General Conditions

Goal: To reduce time and waste on project administration and construction processes.

Key Issues:

- Save time.
- Reduces effort.
- Decrease paper waste.

Actions and Methods:

Documentation:

- **E-paper** can be used to make multiple images such as blueprints, construction documents. It is most applicable where lots of changes in the plans could occur.
- **Document Management Systems** (a centralized electric repository for all project related information) partially eliminates the need for duplicate copies for the office and the field and reduces paper filing requirements.

Communication:

- **Web conferencing technology** allows users to avoid expensive long distance rates by having participants listen in over the Web using only their standard Internet connection and browser. Users can talk on the phone, watch your live presentation and submit their questions via text chat.
- **Digital and interactive white boards** have the capabilities to capture handwritten, color drawings and text as real-time data for use on PCs anytime, anywhere.
- **Global Mobile Communication Systems** can improve information flow from the jobsite to the home office.
- **Portable mobile field devices** provide help with field reporting, contractor-owner billing, payroll entry, punchlist, etc.
- **Short-range radio technology** makes it possible to transmit signals over short distances between mobile PC's, mobile phones and other portable devices and can track locations of people and equipment.

- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Electronically distribute documents**. Subcontractors can review plans online and print only the drawings they need.
- **Digital signatures** can increase the efficiency of a number of authorization steps in the construction process.

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Chapter 8: Construction Technologies

8.2 Demolition and Abatement

Goal: Reduce time, effort and waste using sustainable technologies during the demolition and abatement process.

Key Issues:

- Using sustainable technology can reduce paper waste for demolition and abatement activities.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during demolition and abatement.

Actions and Methods:

Documentation and construction photos:

- Use **digital documentation of current conditions** for reference before the demolition and abatement process begins
- **Digital Photos** provide a useful tool to communicate site analyst information between different project players during the demolition and abatement process.
- Develop a reliable storage system. **Images can be stored on CD or DVD formats**. This will eliminate the need for cumbersome photo albums and allow easy access for future reference.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication devices** to cut down on the amount of paper waste generated.

Complex Demolition Projects:

- **4D CAD modeling** can be utilized to better understand the demolition and abatement process on complex jobs

Emerging Demolition Technology:

- Using **Soundless Demolition Chemical Agents (SCDA)** has proven to be a viable substitute for the use of explosives.

<u>Emerging Technology:</u>

Soundless Demolition Chemical Agents (SCDA)

Examples of demolition work using SCDA. SCDAs are powdery materials that will expand considerably when mixed with water. This expansion, when occurring under confinement, generates significant expansive pressures. These pressures are sufficient to break up rock and concrete when the SCDA is confined in a borehole or a series of boreholes.

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Chapter 8: Construction Technologies

8.3 Site Work

Goal: Reduce time, effort and waste using sustainable technologies during site work.

Key Issues:

- Using sustainable technology can reduce paper waste for on-site work activities.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during on-site work.

Actions and Methods:

Documentation:

- Use **digital documentation** of current conditions for reference before site work begins. This will produce a database that can be referenced if necessary during project site work.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

Estimating:

- Use **on-screen take-off tools** during site work planning and estimating. This leads to fewer printed drawing sets.

Emerging Technology:

GPS Based Earthmoving system:

Some of the benefits are:

- A reduction of additional surveys that may be required to convey information on the next site work phase, to make changes to the current work and to document completed work against plan. Using the conventional process of cross-referencing the site work can be time-consuming and it contains numerous opportunities for error.
- Fast and accurate decision and control due to real-time information of position and grade displayed in the cab.
- Reduction of surveying and grade checking costs and increased machine and operator productivity.
- A faster job cycle.
- Reduction of the re-work caused by the lack of correct information in the field.
- Lower operating costs.

Using GPS during Site Work:

Left: A view out from a dozer using a GPS system for site work.
Right: A schematic diagram showing how the GPS works on-site.

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Chapter 8: Construction Technologies

8.4 Foundations

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Goal: Reduce time, effort and waste using sustainable technologies during foundation work.

Key Issues:

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- Using sustainable technology can reduce paper waste for foundation activities.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during foundation work.

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Actions and Methods:

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- **Safe excavation technology devices** provide real-time warning of the utility lines immediately ahead of the digging tool. The data can be easily interpreted via a real-time computer readout of the depth, location, and size of buried metal objects.

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Documentation:

- Utilize the capabilities of PDAs, portable laptop computers and other **electronic communication** devices to cut down on the amount of paper waste generated.
- **Electronically distribute documents**. Subcontractors can review plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.

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Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to the site.

9

Tool and Material Tracking:

- **Bar-code tracking devices** can be helpful in tracking and updating inventories of foundation material and supplies. They also provide real-time quantity updates and reduce paper documentation of inventories.

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- Bar-coding and data basing foundation tools can help tool recovery from job-to-job.

Estimating:

- Use **on-screen take-off tools** during foundation planning and estimating. This leads to fewer printed drawing sets.

Construction Planning and Coordination:

- A **4D CAD model** of the foundation is a cost-effective and efficient alternative to a built mock-up.

Emerging Technologies:

- Use a **Concrete Encounter** for measuring concrete moisture content instantly without the need to drill or damage the surface. (See Case Study).
- Employ **laser technology** and equipment during foundation work.
- Using a s**oil-stiffness gauge for soil compaction control** can produce better soil compaction data and information. This tool provides a reliable means to rapidly measure the in-site soil stiffness and elastic modulus of soils.
- **Electrochemical chloride extraction** can remove the chloride ions and re-establish the passive oxide layer around the reinforcing steel in concrete. This eliminates continuous rebar corrosion.

Emerging Technology:

A Concrete Encounter

The figure on the left is a concrete encounter. The benefits of using this tool are as follows:

- Instant readings.
- Non-destructive in operation.
- No need to probe, drill or mechanically damage the surface.
- Reproducible results.
- Battery operated and pocket sized.
- Clear, easy to read analog dial.
- Strong, robust, extruded aluminum body.

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Chapter 8: Construction Technologies
8.5 Substructure

Goal: Reduce time, effort and waste using sustainable technologies during substructure work.

Key Issues:

- Using sustainable technology can reduce paper waste during substructure work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during substructure work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

Underground Piping:

- Pipeline repairs and rehabilitation using **trenchless technologies** can be a cost-effective alternative to open trench replacement.
- **Digital subsurface imaging technology** used for the inspection and assessment of pipelines is an excellent alternative to open trench cuts. This technology uses a high-resolution, digital optical scanner and a continuous, directionally-oriented, 360-degree scanned visual image so that the interior surface of

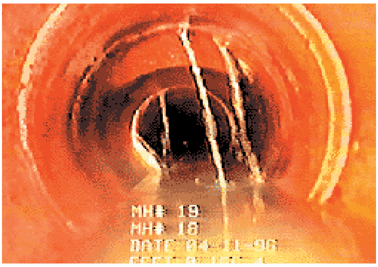
the pipe is recorded. When paired with trenchless technology, digital subsurface imaging can significantly improve the cost-effectiveness of the operation.

Emerging Technology:

Digital Subsurface Imaging and Cured in Place Pipe Repair

Pipe bursting can be used to replace pipes without using open trench methods. Pipe bursting is accomplished by pulling a bursting device through the existing pipe. This device by virtue of its size or its radial expansion ability (depending on the type) shatters the old pipe and forces the fragments into the surrounding soil.

Cured-in-place pipe repair can be used to reline the pipe, restoring its ability to transport, and slowing or stopping further deterioration.



Left: A digital subsurface image during an inspection.
Right: A completed, cured in place, repaired pipe

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Chapter 8: Construction Technologies

8.6 Superstructure

Goal: Reduce time, effort and waste using sustainable technologies during superstructure work.

Key Issues:

- Using sustainable technology can reduce paper waste during superstructure work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during superstructure work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

Tool Tracking:

- **Bar-coding and data basing superstructure tools** can help tool recovery from job-to-job. This can significantly reduce tool replacement costs.

Estimating:

- **Use on-screen take-off tools** during superstructure planning and estimating. This leads to fewer printed drawing sets.

Steel Erection and Decking:

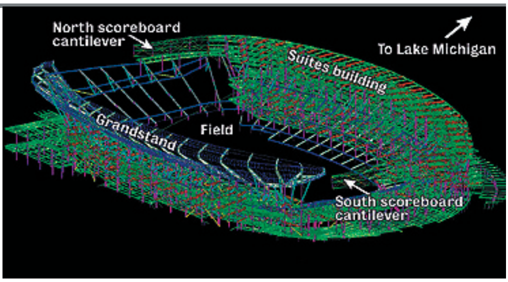
- Explore **new steel erection technologies**. For example new devices can safely "grab" the place of structural steel, bar joists, and other difficult to handle structural materials.
- When attaching **steel decking** use special nails, driven either by powder propellant (powder actuated tools), or by compressed air (pneumatic tools).

Scheduling and Sequencing:

- A 4D CAD model of the superstructure is a cost-effective and efficient alternative to a built mock up. It also has the potential to reveal construction sequence and scheduling problems that might not have been identified using a traditional mock up.

Emerging Technology:

Structural Framing Model Used on the Solider Field Project



A 3-D model, shared between designer and fabricator, can eliminate the need to create shop drawings, a process vulnerable to human error. Instead, the steel detailer enhances the engineer's design model by adding all the elements, such as bolt holes, bolts, angles and plates required for fabrication and erection. The process minimizes requests for information and reduces the time to answer them.

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Chapter 8: Construction Technologies
8.7 Exterior Enclosure

Goal: Reduce time, effort and waste using sustainable technologies during exterior closure work.

Key Issues:

- Using sustainable technology can reduce paper waste during exterior closer work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during exterior closure work.

Actions and Methods:

Documentation:

- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos with a global position database allows pictures to be marked at the location in the project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.
- **Digital photos** allow you to take a snapshot of an activity or location and then disseminate it within minutes. This can help

decrease communication time to resolve issues or problems with the project.

Tool Tracking:

- **Bar-coding and data basing exterior tools** can help tool recovery from job-to-job. This can significantly reduce tool replacement costs.

Estimating:

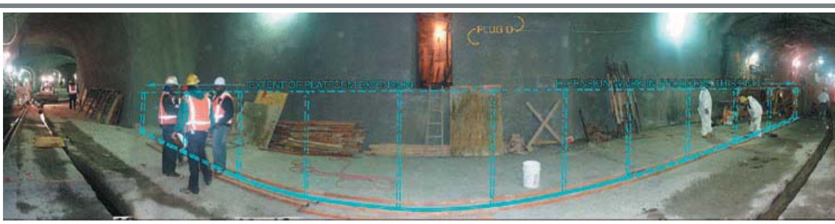
- Use **on-screen take-off tools** during exterior closure planning and estimating. This leads to fewer printed drawing sets.

Sound Barriers:

- **Ultra screen sight and sound barriers** are lightweight panels that require no special equipment for installation, maintenance or replacement, making them an excellent alternative to traditional sight and sound barriers.

Emerging Technology:

Combining Digital Photos with Real Time GPS information



An example of a digital image with GPS project location information applied

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Chapter 8: Construction Technologies
8.8 Roofing

Goal: Reduce time, effort and waste using sustainable technologies during roofing work.

Key Issues:

- Using sustainable technology can reduce paper waste during a roofing installation.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during roofing work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos with a global position database allows pictures to marked at the location in project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress on line. This can reduce travel time and expenses to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.
- **Digital photos allow** you to take a snapshot of an activity or location and then disseminate it within minutes. This can help

decrease communication time to resolve issues or problems with the project.

Estimating:

- Use **on-screen take-off tools** during roof planning and estimating. This leads to fewer printed drawing sets.

Sequencing and Scheduling:

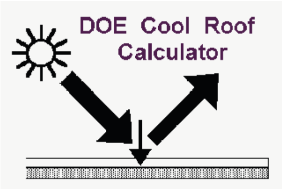
- A **4D CAD model** of the roof is a cost-effective and efficient alternative to a built mock up. It also has the potential to reveal construction sequence and scheduling problems that might not have been identified using a traditional mock up.

Building Energy Performance:

- The **Cool Roof Calculator** will estimate how much energy you'll save in the summer and how much extra energy you'll need in the winter.

Emerging Technology:

The Cool Roof Calculator



The Cool Roof Calculator provides answers on a 'per square foot' basis, so you can then multiply by the area of your roof to find out your net savings each year.

References

"Cool Roof Calculator." (2002). Building Energy Software Tools Directory. http://www.eere.energy.gov/buildings/tools_directory/software/coolroofcalculator.html

Hampton, T. (2003). "Firms Are Using Tool Tracking for Smarter Asset Management." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

Hampton, T. (2003). "Project Teams Use Digital Cameras To Shoot It, Then Share It." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/031229.asp

"Magichalk." (2003). Thor Systems, Inc. http://www.thortools.com/products.asp?ProductID=8

Chapter 8: Construction Technologies

8.9 Interior Construction

Goal: Reduce time, effort and waste using sustainable technologies during interior construction work.

Key Issues:

- Using sustainable technology can reduce paper waste during interior construction activities.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during interior closure work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to marked at the location in a project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress online. This can reduce travel time and expenses to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.
- **Digital photos** allow one to take a snapshot of an activity or location and then disseminate it within minutes. This can help

decrease communication time to resolve issues or problems on the project.

Estimating:

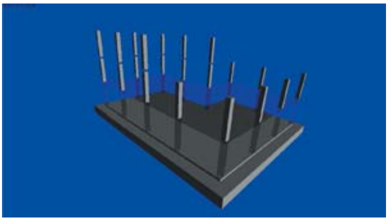
- Use **on-screen take-off tools** during interior construction planning and estimating. This leads to fewer printed drawing sets.

Sequencing and Scheduling:

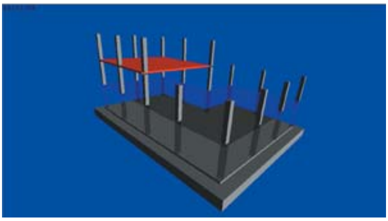
- A **4D-CAD model** of the interior space is a cost-effective and efficient alternative to a built mock up. It also the ability to display interior finish colors, artificial and natural light patterns, and the interior construction sequence.

Emerging Technology:

4D CAD Applications



These two pictures show an error in the sequencing of the 3rd floor deck and the 3rd floor columns. The top picture shows the 3rd floor columns being erected prior to the completion of the 3rd floor deck in the bottom picture.



4D CAD can greatly assist in finding sequencing issues early in the project when they can be anticipated and dealt with in a manner which does not affect the building's completion.

References

Hampton, T. (2003). "Firms Are Using Tool Tracking for Smarter Asset Management." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

Hampton, T. (2003). "Project Teams Use Digital Cameras To Shoot It, Then Share It." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/031229.asp

Roe, A. (2002). "New Players Push Project Management to the Web." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/020916b.asp

Chapter 8: Construction Technologies
8.10 Conveying Systems

Goal: Reduce time, effort and waste using sustainable technologies during the construction of the conveying system.

Key Issues:

- Using sustainable technology can reduce paper waste during conveying system work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during conveying system work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to marked at the location in a project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress online. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.
- **Digital photos** allow you to take a snapshot of an activity or location and then disseminate it within minutes. This can help

decrease communication time to resolve issues or problems with the project.

Estimating:

- Use **on-screen take-off tools** during conveying systems planning and estimating. This leads to fewer printed drawing sets.

References

Hampton, T. (2003). “Firms Are Using Tool Tracking for Smarter Asset Management.” Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

Roe, A. (2002). “New Players Push Project Management to the Web.” Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/020916b.asp

Chapter 8: Construction Technologies

8.11 Mechanical

Goal: Reduce time, effort and waste using sustainable technologies in the construction of the mechanical system.

Key Issues:

- Using sustainable technology can reduce paper waste during mechanical work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during mechanical work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to marked at the location in a project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress online. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

Estimating:

- Use **on-screen take-off tools** during mechanical system planning and estimating. This leads to fewer printed drawing sets.

Sequencing and Scheduling:

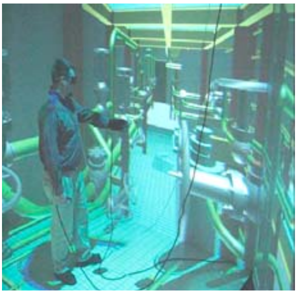
- A **4D CAD model** of the mechanical system layout is a cost-effective and efficient alternative to a built mock up. It also has the potential to reveal construction sequence and scheduling problems that might not have been identified using a traditional mock up.

Piping:

- **Friction stir welding technology** has the ability to provide greatly improved weld properties as an aluminum joining method.
- **Chain clamps** are versatile alternatives to traditional methods of pipe fit-up as each clamp can fit-up elbows, tees, flanges and other pipe fittings.
- To **locate leaks in pressurized water pipes**, new technology is available that utilizes acoustic leak noise sensed at two locations on a pipe, one on either side of a suspected leak. This new technology works on all pipes including plastic/PVC, and eliminates the high cost and difficultly of use traditionally associated with leak noise correlators.

Emerging Technology:

4D CAD in a Virtual Environment



4D Cad and VRML modeling allows for a comprehensive understanding of mechanical construction. The viewer has the ability to navigate through the space on a 1:1 scale. This can reveal potential design and construction sequencing problems and methods.

References

"Friction Stir Welding Technology - Adopting NASA's Retractable Pin Tool." (2002). Construction Industry Institute. http://www.new-technologies.org/ECT/Mechanical/fsw.htm

Hansen, D. C. a. D. (2002). Commercial Buildings R&D and Analysis Tools. ASERTTI Collaboration Meeting. http://ciee.ucop.edu/docs/commbuild.pdf

Hampton, T. (2003). "Firms Are Using Tool Tracking for Smarter Asset Management." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

Roe, A. (2002). "New Players Push Project Management to the Web." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/020916b.asp

"Urban infrastructure rehabilitation - New LeakfinderRT technology: how it works." (2003). Construction Innovation 8(4). http://irc.nrc-cnrc.gc.ca/newsletter/v8no4/technology_e.html

Chapter 8: Construction Technologies
8.12 Electrical

Goal: Reduce time, effort and waste using sustainable technologies in the construction of the electrical system.

Key Issues:

- Using sustainable technology can reduce paper waste during electrical work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during electrical work.

Actions and Methods:

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to be marked at the location in a project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress online. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

Estimating:

- Use **on-screen take-off tools** during electrical system planning and estimating. This leads to fewer printed drawing sets.

Sequencing and Scheduling:

- A 4D **CAD model** of the electrical layout is a cost-effective and efficient alternative to a built mock up. It also has the potential to reveal construction sequence and scheduling problems that might not have been identified using a traditional mock up.

References

Hampton, T. (2003). “Firms Are Using Tool Tracking for Smarter Asset Management.” Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

Roe, A. (2002). “New Players Push Project Management to the Web.” Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/020916b.asp

Chapter 8: Construction Technologies
8.13 Information Technology

Goal: Reduce time, effort and waste using sustainable information technologies.

Key Issues:

- Using sustainable information technology can reduce paper waste.
- Sustainable information technology generates efficient project communication.
- Time and effort can be saved using sustainable information technologies.

Actions and Methods:

- **Wireless ceiling systems** enables wireless communications that enhance employee mobility and workplace effectiveness throughout the building.
- **Bluetooth technology** makes is possible to transmit signals over short distances between mobile PC's, mobile phones and other portable devices. Bluetooth can offer fast and secure access to wireless connectivity all over the world including remote project sites.

References

"Palm Estimating." (2000). Construction Industry Institute. http://www.new-technologies.org/ECT/Other/palmest.htm

Chapter 8: Construction Technologies

8.14 Equipment

Goal: Reduce time, effort and waste combining sustainable technologies and equipment selection.

Key Issues:

- Using equipment with sustainable technology can reduce paper waste.
- Sustainable equipment technology generates efficient project communication.
- Time and effort can be saved using sustainable equipment technologies.

Actions and Methods:

- To **locate leaks in pressurized water pipes**, new technology is available that utilizes acoustic leak noise sensed at two locations on a pipe, one on either side of a suspected leak. This new technology works on all pipes including plastic and eliminates the high cost and difficultly of use traditionally associated with leak noise correlators.

References

"Urban infrastructure rehabilitation - New LeakfinderRT technology: how it works." (2003). Construction Innovation 8(4). http://irc.nrc-cnrc.gc.ca/newsletter/v8no4/technology_e.html

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Chapter 8: Construction Technologies
8.15 Finishes

Goal: Reduce time, effort and waste using sustainable technologies during finish work.

Key Issues:

- Using sustainable technology can reduce paper waste during finish work.
- Sustainable technology generates efficient project communication.
- Time and effort can be saved using sustainable technologies during finish work.

Actions and Methods:

- **By using digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to be marked at the location in a project where they where taken.
- **Cordless finish nailers** allow the user to be able to work comfortably in cramped, overhead and other hard-to-reach conditions. One of the greatest benefits is this equipment does not require an air compressor for operation.

Documentation:

- **Electronically distribute documents**. Subcontractors can review the plans online and print only the drawings they need.
- **Electronically distribute specifications**. Scan in the specifications on a high-speed scanner and distribute them on a CD or electronically.
- **Digital photographs** can eliminate the need to take pages of field observation notes. Now these field observation notebooks can be replaced with a digital photo diary of the project.
- By using **digital photographs and GPS technology**, project documentation efficiency can be improved. Combining digital photos and a global position database allows pictures to be marked at the location in a project where they where taken.

Communication:

- A **Web-connected video camera** can photographically document jobsite progress online. This can reduce travel time and expenses to go to the site.
- Utilize the capabilities of PDAs, portable laptop computers, and other **electronic communication** devices to cut down on the amount of paper waste generated.

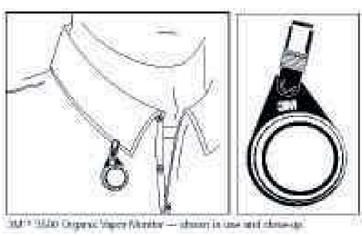
Estimating:

- Use **on-screen take-off tools** during finish planning and estimating. This leads to fewer printed drawing sets.

Emerging Technology:

Improving the Worker's Environment

Use 3M™ personal air monitoring systems to inform workers of hazardous environments. This technology can improve occupational safety and health in construction workplace.



3M™ Air Monitors are simple and effective devices that collect contaminants through the scientific principle of diffusion. They provide the environmental contamination data of a work area, which can be used to protect workers from exposure to poisonous environments, and can improve occupational safety and health in a construction workplace.

References

"3M Personal Air Monitoring Systems." (2001). Construction Industry Institute. http://www.new-technologies.org/ECT/Safety/3mairmonitorsys.htm

Hampton, T. (2003). "Firms Are Using Tool Tracking for Smarter Asset Management." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/030707.asp

"Paslode - Cordless Finish Nailer." (2001). Construction Industry Institute. http://www.new-technologies.org/ECT/Civil/paslode.htm

Roe, A. (2002). "New Players Push Project Management to the Web." Engineering News-Record. http://www.enr.com/features/technologyeconst/archives/020916b.asp

Chapter 9: Health and Safety

Goal: To improve the quality of life for construction workers.

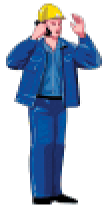
Benefits:

- Minimized use of harmful products on the jobsite in order to reduce harmful affects to workers.
- Increased awareness of harmful products and ingredients in order to protect workers and minimize use.
- Increased use of personal safety apparatuses.

Keys Issues:

- Be aware of the components in the products you use and their affect on you and your fellow workers. Ref. Ch. 3 for a list of materials to avoid.
- During demolition be aware of the materials you are working with, and take precautions to protect yourself.
- Asbestos, lead based paint, mold, etc. are products harmful to you and your environment.
- Use respiratory protection when applicable.
- Take appropriate measures to minimize and eliminate mold (Ref. Ch. 10).
- Be aware of the dangers of carbon monoxide poisoning due to running gas powered engines in enclosed spaces.
- Minimize products containing Volatile Organic Compounds (VOCs) and other off-gassing materials including glues, solvents, cleaning materials and aerosol sprays (Ref. Ch. 3).
- Allow for adequate ventilation during activities such as painting, laying carpeting and other activities where workers are exposed to high concentrations of off-gassing materials.

Personal Protective Equipment



According to OSHA standards, personal protective equipment includes eye, face, head and extremity protection. **Hard hats and goggles are required**. OSHA also endorses protective clothing, respiratory devices, protective shields and barriers. All equipment must be usable, reliable and clean. The goal of these safety regulations is to protect the worker from hazardous environments including exposure to dangerous chemicals, radiological matter or mechanical irritants. These can cause injury to the worker through absorption, inhalation or physical contact.

-OSHA 1926.95(a)

References

"Criteria for Personal Protective Equipment - 1926.95." (1993). Occupational Safety and Health Administration. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10658

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

"The Owners Role in Construction Safety." (2003). Research Summary 190-1 Construction Industry Institute. Austin, TX.

"Safety Plus: Making Zero Accidents a Reality." (2003). Research Summary 160-1 Construction Industry Institute. Austin, TX.

Chapter 9: Health and Safety
9.0 Planning

Goal: To improve the quality of life for construction workers.

Key Issues:

- Proper health and safety planning is required in most specifications.
- A well developed and maintained safety plan has the potential to save workers' lives.
- Addressing safety during design can significantly reduce or eliminate many safety hazards.

Actions and Methods:

Safety Plans:

- Implement a fire control plan.
- Require the submittal of a jobsite safety survey and plan, and an emergency action plan from the general contractor and subcontractors.
- Require pre-construction meetings between the **general contractor and all subcontractors** to discuss safety and harmful substance issues.
- Discuss health, safety, IAQ and other environmental issues of which to educate workers. At weekly foreman meetings, make clear such hazards as they pertain to the current work activity.

Scheduling:

- Stairway:
  - A permanent stairway should be constructed at the beginning construction.
  - A permanent handrail should be erected along with the structural steel as one assembly.
- Fire Hazards:
  - An underground fire water system should be installed at the beginning of the project.
  - A fire protection system, permanent emergency exit signage, fire walls and fire doors should be installed as early as

1 2 3 4 5 6 7 8 9 10

possible.
    - During demo and abatement, fire walls and fire doors should be kept in place as long as possible.
- Electrical:
    - Sources of permanent power and lighting should be installed early and used during construction.
- Mechanical:
    - HVAC should be available for contractor use after building close-in.
- Materials:
    - Require regularly scheduled on-site housekeeping to ensure a neat, clear work area, free of hazards.
    - Materials, piping and equipment should be painted and/or insulated prior to erection or installation.
- Elevated work:
    - Limit lift heights of steel erection and concrete pours.
    - Pre-fabricate building components to ease work at higher elevations.
    - Erect permanent lighting system along with structural framing as one assembly.

Workers:

- Require a pre-construction safety meeting including all workers on the site.
- Require a jobsite safety survey and plan to be submitted before construction begins.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

O'Brein, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

"The Owners Role in Construction Safety." (2003). Research Summary, 190-191. Construction Industry Institute. Austin, TX.

"Safety Plus: Making Zero Accidents a Reality." (2003). Research Summary 160-1 Construction Industry Institute. Austin, TX.

Chapter 9: Health and Safety

9.1 General Conditions

Goal: To improve the quality of life for construction workers throughout the project.

Key Issues:

- Personal protective equipment is required by OSHA standards.
- A well trained worker with knowledge on safety techniques and hazardous materials has the potential to save lives, including his own.
- Proper scheduling can help to improve the quality of health on a jobsite.

Actions and Methods:

Contract Requirements:

- Establish minimum levels of Volatile Organic Compound (VOC) emissions for standard products. (Reference LEED Reference Manual for acceptable VOC levels).
- Require safety and worker health awareness (highlighting Indoor Air Quality (IAQ) and worker health) on-site by requiring each individual to complete a test before stepping onto the site.
- **Require proper personal protective equipment** including a hard hat, goggles or safety glasses, respirators when necessary, a cotton shirt with long sleeves, leather or heat resistant gloves, long pants with no cuffs, nonskid shoes or boots with six-inch leather uppers.

Contractor Provisions:

- Provide the contractor with a list of toxic substances and other hazardous materials on-site.
- Provide a list of toxic or harmful substances which the contractor should avoid.
- Provide hand-washing stations in eating areas so that workers can wash their hands before they eat, and after using the restroom.
- Schedule activities such as painting, carpet removal or installation at times that allow for adequate ventilation for

workers.

- Provide adequate lighting for workers at all times.
- **Keep the site clean** and clear of debris.
- Minimize night work and avoid work on Friday or Saturday nights.

PENREN/C Practice:

Good Housekeeping on the Pentagon Renovation, Wedge 2

With slight modifications, a clean safe site can become a "waste busting" site. The effective use of signage, education at weekly meetings and incentives to encourage safe practices is common among safety programs and should be extended to include sustainability and hazardous substance issues.

Sites adjacent to the work areas must also be considered. Laydown areas, dust mitigation, fume mitigation and dirt from excavation are common problems that require constant attention.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2, Construction Industry Institute (CII). Austin, TX.

O'Brein, K. "Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii." The State of Hawaii.

Chapter 9: Health and Safety
9.2 Demolition and Abatement

Goal: To improve the quality of life for construction workers during demolition and abatement.

Key Issues:

Asbestos Facts:

- Asbestos is a natural mineral fiber known for its strength and ability to resist fire. It is also used in thermal insulation and fire proofing.
- When fibers enter the lungs, they become lodged, and cause shortness of breath and leads to lung cancer and mesothelioma.
- Found in many materials, including:
    - Asbestos cement can be used in roofing and siding shingles.
    - Insulation in buildings built between 1930-1950.
    - Textured paint and patching compounds before 1977.
    - Walls and floors around wood-burning stoves.
    - Vinyl floor tiles and adhesives.
    - Hot water and steam pipes in older buildings.
    - Insulation in oil and coal furnaces and door gaskets.
    - Stove-top pads.

Lead Based Paint Facts:

- Lead poisoning may occur in workers during abrasive blasting, sanding, cutting, burning, or welding of bridges and other steel structures coated with lead-containing paints (NIOSH).
- High risk workers include abrasive blasters, inspectors, iron workers, painters, laborers, home contractors.
- Health Issues include:
    - Decreased intelligence and mental retardation.
    - Hyperactivity.
    - Hearing, behavioral and learning problems.
    - Poor appetites, stomach aches, vomiting, constipation, crankiness, energy loss, headaches and sleeplessness.
- Lead is found in many materials, including:
    - Household dust from peeling, chipping and chalking of paint.

- Soils and drinking water.

Actions and Methods:

- Encasement is a new alternative to the removal of asbestos and lead-based materials. It is a waterproof, protective coating that is applied directly over hazardous materials, sealing the material for a minimum of 20 years.
- Encasement is typically 50-75% cheaper than removal and requires less time to apply.
- Indoor air quality is improved because the hazardous materials are not disturbed and released into the air.

Case Study:

Fort Drum Army Base: Asbestos Encasement

Office and hallways floors at the base consisted of badly worn and missing vinyl asbestos tile (VAT). The VAT was encased in a seamless, monolithic, waterproof membrane that dried in 30 seconds. All furniture and equipment was re-installed and all workers were back at their workstations that same afternoon.

Benefits included:

- Long lasting solutions.
- Minimum down time.
- Cost effective.

References

"Cost Effective Indoor Air Quality Solutions." (2004). Global Encasement, Inc. http://encasement.com/

"Design for Construction Safety Toolbox." (1996). Publication 101-2. Construction Industry Institute (CII). Austin, TX.

Kupecki, N. (2004). "Is Your Indoor Air Making You Sick?" AIRBRAINS.

http://airbrains.org/

Chapter 9: Health and Safety

9.3 Site Work

Goal: To improve the quality of life for construction workers during site work.

Key Issues:

- Earthwork dangers include: falling objects and collapses.
- Exposure to asphalt can lead to fatigue, reduced appetite, eye, nose, throat and skin irritation, nausea, drowsiness, coughing, shortness of breath, and an increased risk of lung cancer.

Actions and Methods:

Earthwork:

- Erect rock fences on embankments to avoid falling rocks and prevent further site impact.
- Minimize the amount of excavation in backfills or other loose soil areas.
- Provide road access to large deep excavations.
- Locate underground utilities prior to excavation and hand excavate when near underground utilities.

Asphalt Paving:

- Notify building occupants before beginning.
- Schedule work during off hours.
- Use personal protective equipment including a hard hat, goggles or safety glasses, respirators when necessary, a cotton shirt with long sleeves, leather or heat resistant gloves, long pants with no cuffs, nonskid shoes or boots with six-inch leather uppers.
- Provide warning tape and signs, traffic cones, etc., to warn the public of paving operations.
- Pre-chop asphalt into pieces that can be easily handled and melted.
- Consider using fume-suppressing asphalts.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2. Construction Industry Institute (CII). Austin, TX.

"Health Effects of Occupational Exposure to Asphalt." (2000). National Institute for Occupational Safety and Health (NIOSH). http://www.cdc.gov/niosh/pdfs/01-110.pdf

"Publication No. 2003-107." (2003). National Institute for Occupational Safety and Health.

Chapter 9: Health and Safety
9.4 Foundations

Goal: To improve the quality of life for construction workers while constructing foundations.

Key Issues:

- All excavations are hazardous due to their instability.
- Excavated material at the site (spoils) can be potentially dangerous, especially if located too near a trench or excavation.
- Ensure proper access and egress from excavations.

Actions and Methods:

Excavation:

- Evaluate soil conditions daily to select appropriate protective systems.
- Plan ahead – contact utilities to locate underground lines, develop a plan for traffic control, etc.
- Test regularly for low oxygen, hazardous fumes and toxic gases such as radon or carbon monoxide from exhaust.
- Provide safe access into and out of the excavation.
- Keep excavations open for a minimal time.
- Inspect protective systems daily for evidence of possible cave-ins, hazardous atmospheres, failure of protective systems or other unsafe conditions.

Spoil Placement

- Set spoils and equipment at least two feet back from the excavation.
- Use retaining devices, such as a trench box, to prevent equipment and spoils from falling into the excavation.
- Haul spoils to another location if two foot setback is not possible.

Avoiding Excavation Hazards

- Provide stairways, ladders, ramps, or other safe means of an egress in all trenches more than four feet deep.
- Position means of egress within 25 lateral feet of workers.
- Provide ramps of uniform thickness and connections that prevent displacement.

- Use non-slip surfaces on ramps and stairs.

10

Case Study:

9

Safety in the Trenches

OSHA's excavaton standard requires employers to provide sloping, benching, or shielding to protect workers in excavation five feet or deeper.

OSHA's excavation standard requires employers to provide sloping, benching, shoring, or shielding to protect workers in excavations five feet of deeper.

8

A 27-year-old construction worker was digging a trench for a new sewer line when the walls of the 10-foot-deep excavation collapsed around him, burying him under mounds of clay and dirt. Only his hand extended above the dirt, signaling his coworkers where he was as they rushed to the scene to dig him out using their hands and hand shovels. Forty-five minutes later, a cut and bruised but fully conscious worker stepped from the hole, surviving what might have become a fatal accident. Many workers aren't so lucky.

7

-Donna Miles, eLCOSH

6

This could have been prevented if proper setbacks or a trench box was used.

Safe excavation technology devices provide real-time warning of the utility lines immediately ahead of the digging tool. The data can be easily interpreted via real-time computer readout of the depth, location, and size of the buried metal objects.

5

References

4

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"Preventing Deaths and Injuries from Excavation Cave-Ins: NIOSH Alert." (1985). Publication No. 85-110 National Institute for Occupational Safety and Health.

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"Preventing Fatalities." OSHA Construction eTools http://www.osha.gov/SLTC/etools/construction/index.html

"Safe Excavation." (2000).Construction Industry Institute http://www.new-technologies.org/ECT/Civil/safeexca.htm

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"Safety In Trenches." (2001). eLCOSH - Electronic Library of Construction Occupational Safety and Health http://www.cdc.gov/elcosh/docs/d0100/d000002/d000002.html

1

The Science of Making Belmont Safe. (2001). L.A. Weekly.

Chapter 9: Health and Safety

9.5 Substructure

Goal: To improve the quality of life for construction workers while constructing the substructure.

Key Issues:

- The tremendous loads that need to be supported pose a high risk to workers, especially when jacks or lifting equipment are used to position slabs and walls or when shoring is required until structures support themselves.
- Falls are the leading cause of fatalities in construction.
- Improper scaffolding construction leads to worker injury.

Actions and Methods:

- Do not place loads on a concrete structure until it is tested for sturdiness and certified by a professional.
- Use appropriate shoring and bracing until permanent support is tested for strength.
- Prevent unrolled wire mesh from recoiling.
- Do not load a lifting device beyond capacity.
- Use supplemental support devices to support forms in case lifting device fails.

Unprotected Sides, Openings and Other Hazards:

- **Use guardrail systems –** place a fence or guard rail around any open areas.
- **Safety net –** when working on an open joist system, install safety nets for falling debris and other objects.
- **Fall arrest systems –** utilize body harnesses and appropriate devices when workers are at higher elevations. Workers must be rigged to prevent a free fall of more than six feet.

Scaffolding Safety:

- Construct all scaffolding according to manufacturer's guidelines.
- Use guard rails and fall arrest systems.

Case Study:

OSHA Reports: Deaths Due to Constructing Masonry Walls

The victim was a member of a crew that was erecting tilt-up wall panels around the perimeter of the slab floor of a one-story warehouse. The last three wall slabs were being hoisted into place with two 12-foot nylon web slings in a basket hitch. While the second panel was suspended in preparation for being set, it tilted in the sling and slid slightly, cutting through one sling and partially through the other. The erection crew scattered as it dropped, but the victim stopped momentarily to look back as he fled the building. Just then, the upper edge of a previously set panel, which had been dislodged by the falling panel, fell on him. He was crushed and killed.

This could have been prevented with proper awareness of hazards on-site.

References

"Deaths Due to Constructing Masonry Walls." Occupational Safety and Health Administration. http://www.osha.gov/SLTC/etools/construction/struckby/fatexstruck3.htm

"Design for Construction Safety Toolbox." (1996). Publication 101-2. Construction Industry Institute (CII). Austin, TX.

Chapter 9: Health and Safety
9.6 Superstructure

Goal: To improve the quality of life for construction workers while constructing the superstructure.

Key Issues:

- The tremendous loads that need to be supported pose a high risk to workers, especially when jacks or lifting equipment are used to position slabs and walls or when shoring is required until structures support themselves.
- Falls are the leading cause of fatalities in construction.
- Improper scaffolding construction leads to worker injury.

Actions and Methods:

Concrete and Masonry Wall Construction:

- Do not place loads on a concrete structure until it is tested and certified by a professional.
- Use appropriate shoring and bracing until permanent support is tested for strength.
- Prevent unrolled wire mesh from recoiling.
- Do not load lifting device beyond capacity.
- Use supplemental support devices to support forms in case lifting device fails.

Proper Scaffolding Construction:

- Construct scaffolding according to manufacturer's instructions.
- Use guard rails and fall arrest systems.

Unprotected Sides, Openings and Other Hazards:

- **Use guardrail systems:** place a fence or guard rail around any open areas.
- **Safety net**: when working on an open joist system install safety nets to prevent falling objects.
- **Fall arrest systems:** utilize body harnesses and appropriate devices when workers are at higher elevations, workers should be rigged as to not free fall further than six feet.
- Follow all of the safety requirements of OSHA Subpart R for

structural steel erection.

Case Study:

OSHA Report: Deaths Due to Steel Erection

Two connectors were erecting light weight steel I-beams on the third floor of a 12-story building, 54 feet above the ground. One employee removed a choker sling from a beam and then attempted to place the sling onto a lower hook on a series of stringers. While the crawler tower crane was booming away from the steel, the wind moved the stringer into the beam the employee was standing on. The beam moved while the employee was trying to disengage the hook, causing him to lose his balance and fall to his death.

This could have been prevented with a proper fall protection procedure and training.

References

"Deaths Due to Steel Erection." Occupational Safety and Health Administration.

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

Chapter 9: Health and Safety
9.7 Exterior Enclosure

Goal: To improve the quality of life for construction workers while enclosing the building.

Key Issues:

- Ladders can cause injuries ranging from sprains to death.
- Scaffolding poses serious risks without proper fall protection.
- Mold is highly susceptible in moist or damp areas.

Actions and Methods:

Ladders:

- Be sure that ladders are safely positioned before use.
- Inspect ladders for broken or cracked parts.
- Secure side rails at the top of the ladder to a rigid support.
- Always have three points of contact with the ladder.
- Adhere to weight restrictions.

Scaffolding:

- Construct scaffolding according to manufacturer's guidelines.
- Install all guardrails on open sides and utilize fall arrest systems when necessary.
- Do not climb cross bracing.

Mold/Moisture Protection:

- Check for proper installation and connection of materials.
- Check for leaks, repair all tears or punctures in vapor barriers.
- Check caulking and flashing for proper installation.

Common Health Effects of Mold:

- If you or others around you are experiencing any of the following symptoms, contact your Safety Manager immediately:
  - Irritation of skin, eyes, nose, throat, causing allergy like symptoms.
  - Difficulty breathing, runny nose, watery eyes.
  - Fatigue or headache.

- Asthmatic attacks for allergic individuals.
- Burning in nose, nose bleeds, weakened immune system.

Case Study:

Australian Bricklayers Accident

A bricklayer was working alone on the roof of a new six story building. He had ~500 lbs of bricks left over and decided to rig up a pulley system using a barrel to lower the bricks to the ground. The bricklayer weighed 135 lbs. As he attempted to lower the 500 lb bucket of bricks to the ground he was suddenly jerked off the ground, and forgot to let go of the rope. He proceeded at a rapid rate up the side of the building and met the barrel on the third floor, fractured his skull and broke his collar bone. Slowed only slightly, he continued his rapid ascent, not stopping until the fingers were deep into the pulley. The barrel of bricks hit the ground and the bottom fell out of the barrel. Now the barrel weighed 50lb and he still weighed 135 lbs, so he began a rapid decent down the side of the building. Again on the third floor he met the barrel coming up and fractured both ankles and broke a few teeth. The encounter with the barrel slowed him enough to lesson his injuries when he fell into the pile of bricks, where he cracked only three vertebrae. Then he let go of the rope and the empty barrel began its journey back down, breaking both of his legs.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

"Falls: Improper Scaffold Construction." Occupational Safety and Health Administration. www.osha.gov/SLTC/etools/construction/falls/improper_scaffolds.html

"Falls: Misuse of Portable Ladders." Occupational Safety and Health Administration. http://www.osha.gov/SLTC/etools/construction/falls/ladders.html

Garvey, D. (2003). Mold in Construction. Construction Safety Council's 13th Annual Construction Safety & Health Conference & Exposition, Rosemont, Illinois. http://www.cdc.gov/elcosh/docs/d0300/d000358/d000358.html

Mold in Construction Checklist. (2003). Construction Safety Councils' 13th Annual Construction Safety & Health Conference & Exposition, Rosemont, Illinois. http://www.cdc.gov/elcosh/docs/d0500/d000512/d000512.html

Sahai, D. (1999). "Moulds: Controlling Exposure is Essential." Construction Safety Magazine 10(2). http://www.cdc.gov/elcosh/docs/d0100/d000071/d000071.html

Chapter 9: Health and Safety

9.8 Roofing

Goal: To improve the quality of life for construction workers while installing roofing.

Key Issues:

- Asphalt fumes pose numerous adverse health effects including:
  - Headache.
  - Eye, nose, throat and skin irritation, which can lead to coughing, wheezing or shortness of breath.
  - Nausea, fatigue and drowsiness.
  - Long term exposure can cause changes in skin pigment which can be worsened by sunlight exposure.
  - Increased risk of lung cancer.
- Improper use of an asphalt kettle could result in tipping and extreme burns.
- Materials dropped from the roof pose a threat to pedestrians walking below.

Actions and Methods:

To Improve Health and Safety During Roof Construction:

- Notify building occupants prior to construction by posting hazard and warning signs.
- Schedule work during off hours.
- Provide warning tape, traffic cones, etc. to advise the public.

To Protect against Asphalt Fumes:

- Use personal protective equipment including a hard hat, goggles or safety glasses, respirators when necessary, a cotton shirt with long sleeves, leather or heat resistant gloves, long pants with no cuffs, nonskid shoes or boots with six-inch leather uppers.
- Consider using a tanker to supply asphalt to the kettle or directly to the rooftop.
- If kettles are used, place them at a safe distance from workers, away from air intakes, doors and windows.
- Pre-chop asphalt into pieces that can be easily handled and

melted.

- Use roofing equipment with lids to reduce exposure to fumes.
- Select an insulated kettle that is the right size for the job.
- Place the kettle on an even, firm surface and use in the proper operating conditions.
- Reduce the number of times the lid is opened.
- Consider using fume-suppressing asphalts.
- If you or others are experiencing any of the following health effects, contact your Safety Manager immediately.
    - Headache.
    - Eye, nose, throat and skin irritation, which can lead to coughing, wheezing or shortness of breath.
    - Nausea, fatigue, or drowsiness.
- Long term exposure can cause changes in skin pigment which can be worsened by sunlight exposure and increased risk of lung cancer.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

"Reducing Roofers' Exposure to Asphalt Fumes." (2003). Publication No. 2003-107 National Institute for Occupational Safety and Health.

Chapter 9: Health and Safety
9.9 Interior Construction

Goal: To improve the quality of life for construction workers during interior installation.

Key Issues:

- **The dust created from sanding drywall** can cause many adverse health effects including:
  - Eye, nose, throat and respiratory tract irritation.
  - Long exposure can cause persistent throat and airway irritation, coughing, phlegm production and breathing difficulties similar to asthma.
  - Smokers and those with sinus or respiratory conditions are at a higher risk.
  - Where silica is present, there is an increased risk of silicosis and lung cancer.
- **Water damaged or moist areas** are highly susceptible to mold which can lead to serious health effects.

Actions and Methods:

To Reduce Health and Safety Effects of Dust :

- Use respiratory protection when sanding.
- Use wet sanding whenever possible.
- Ventilate the area to decrease exposure to dust.
- **Use Vacuum Sanding Systems –** light weight vacuums that gather drywall dust.
- **Use Pole Sanding –** this increases the space between the worker and the sanding surface, and reduces exposure.

To Reduce the Risk of Mold in Preconstruction:

- Keep interior materials dry prior to, during and after installation.
- Do not install wet building materials; allow sufficient time to dry out completely.
- Report any water damage, leaks or intrusion to project manager immediately.
- Build in strict compliance with design and specifications.

- Alert architects or engineers to designs that may allow water intrusion or moisture accumulation.
- Question “conceptual only”, inadequate architectural detailing or outright improper building plans.

To Reduce the Risk of Mold during Construction:

- Check for proper installation and connection of materials and check for leaks.
- Properly insulate water lines, especially chilled water lines.
- Repair all tears or punctures in vapor barriers.
- Check caulking and flashing for proper installation.
- Vent all moisture-generating equipment outdoors.
- Utilize drying equipment – fans, dehumidifiers, wet-dry vacuums and “super-sucker” trucks.

Common Health Effects of Mold Exposure:

If you or others around you are experiencing any of the following health effects, contact your Safety Manager immediately.

- Irritation of skin, eyes, nose and throat causing allergy like symptoms.
- Difficulty breathing, runny nose, watery eyes.
- Fatigue and headache.
- Asthmatic attacks for allergic individuals.
- Burning in nose, nose bleeds, coughing and weakened immune system.

References

“Control of Drywall Sanding and Dust Exposure.” (1999). Publication No. 99-113 National Institute for Occupational Safety and Health.

“Design for Construction Safety Toolbox.” (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

Garvey, D. (2003). Mold in Construction. Construction Safety Council’s 13th Annual Construction Safety & Health Conference & Exposition, Rosemont, Illinois. http://www.cdc.gov/elcosh/docs/d0300/d000358/d000358.html

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Sahai, D. (1999). “Moulds: Controlling Exposure is Essential.” Construction Safety Magazine 10(2). http://www.cdc.gov/elcosh/docs/d0100/d000071/d000071.html

Chapter 9: Health and Safety
9.10 Conveying Systems

Goal: To improve the quality of life for construction workers while installing conveying systems.

Key Issues:

- Ladders can cause injuries ranging from sprains to death.
- Scaffolding poses serious risks without proper fall protection.

Actions and Methods:

Ladders:

- Be sure that ladders are safely positioned before use.
- Inspect ladders for broken or cracked parts.
- Secure side rails at the top of the ladder to a rigid support.
- Always have three points of contact with the ladder.
- Adhere to weight restrictions.

Scaffolding:

- Construct scaffolding according to manufacturer's guidelines.
- Install all guardrails on open sides and utilize fall arrest systems when necessary.
- Do not climb cross bracing.

References

"Falls: Improper Scaffold Construction." Occupational Safety and Health Administration. www.osha.gov/SLTC/etools/construction/falls/improper_scaffolds.html

"Falls: Misuse of Portable Ladders." Occupational Safety and Health Administration. http://www.osha.gov/SLTC/etools/construction/falls/ladders.html

Chapter 9: Health and Safety

9.11 Mechanical

Goal: To improve the quality of life for construction workers while installing mechanical equipment by reducing the risk of mold and other contaminants.

Key Issues:

- Water damaged or moist areas are highly susceptible to mold which can lead to serious heath effects.

Actions and Methods:

To Reduce the Risk of Mold in Preconstruction:

- Keep interior materials dry prior to, during and after installation.
- Do not install wet building materials, allow sufficient time to dry out completely.
- Report any water damage, leaks or intrusion to project manager immediately.
- Build in strict compliance with design and specifications.
- Alert architects or engineers to designs that may allow water intrusion or moisture accumulation.
- Question “conceptual only”, inadequate architectural detailing or outright improper building plans.

To Reduce the Risk of Mold during Construction:

- Check for proper installation and connection of materials and check for leaks.
- Properly insulate water lines, especially chilled water lines.
- Repair all tears or punctures in vapor barriers.
- Check caulking and flashing for proper installation.
- Vent all moisture-generating equipment outdoors.
- Properly ventilate attics, crawl spaces or other enclosed areas.
- Utilize drying equipment – fans, dehumidifiers, wet-dry vacuums and “super-sucker” trucks.

To Reduce the Risk of Mold in the HVAC System:

- Properly install appropriate filters.
- Properly drain drip pan for cooling coils.
- Do not insulate interior ventilation ducts as this can increase the potential for mold.
- Seal all duct joints.
- Clean and commission entire HVAC system.

Common Health Effects of Mold Exposure:

If you or others around you are experiencing any of the following health effects, contact your Safety Manager immediately.

- Irritation of skin, eyes, nose, throat resulting in allergy like symptoms.
- Difficulty breathing, runny nose and watery eyes.
- Fatigue and headache.
- Asthmatic attacks for allergic individuals.
- Burning in nose, nose bleeds, coughing and weakened immune system.

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

Garvey, D. (2003). Mold in Construction. Construction Safety Council's 13th Annual Construction Safety & Health Conference & Exposition, Rosemont, Illinois. http://www.cdc.gov/elcosh/docs/d0300/d000358/d000358.html

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Chapter 9: Health and Safety

9.12 Electrical

10 9 8 7 6 5 4 3 2 1

Goal: To improve the quality of life for construction workers while installing electrical systems.

Key Issues:

- Overhead and buried power lines pose risks of electrical shock to workers.
- Insulation breaks, short-circuits and exposed wires increase the risk of electrical injuries.
- Improper grounding can cause electrical burns or death.
- Improper use of electrical equipment.
- Wear and tear can loosen or expose wires and create hazards.

Actions and Methods:

Overhead and Buried Power Line Hazards:

- Look for warning signs.
- Contact utilities for the locations of buried power lines.
- De-energize and ground lines when working nearby.
- Stay 10 feet from overheard power lines.
- Assume all power lines are energized.
- Use non-conductive wood or fiberglass ladders when working near power lines.

Ground Fault Hazards:

- Use ground fault interrupters (GFCIs) on all 120V, single phase, 15 and 20 amp receptacles.
- Use double-insulated tools and equipment.
- **Visually inspect all electrical equipment** for frayed cords, missing ground prongs, cracked tool casings, etc. **Apply warning tags to all defective tools** and do not use until problem is corrected.

Un-Grounded or Discontinuous Electrical Currents:

- Ground all power supply systems, electrical circuits and electrical equipment.

- Visually inspect systems before use.
- Use double insulated tools.
- Ground all metal parts of equipment.

Improper Equipment Use:

- Use only approved equipment that meets OSHA Standard [1926.403(a)].
- Use equipment according to manufacturer's instructions. (OSHA Standard [1926.403(b)(2)])
- Do not modify cords or use them incorrectly.
- Be sure equipment that has been shop fabricated or altered is in compliance.

Improper Extension and Flexible Cord Use:

- Use factory assembled cord sets.
- Use only extension cords that are 3-wire type, designated for hard or extra-hard usage.
- Use only devices and fitting with strain relief.
- Remove cords from receptacles by pulling on the plugs, not the cords.

Electricity: How it Works

Think of electricity as water. Turning on a switch is similar to turning on a water faucet. There is a reservoir which holds the electricity, similar to a water reservoir. A generator, like a water pump, provides the pressure for the electrical current to travel through the conductor. Substances with little resistance to electricity flow are called conductors (e.g. metals). Substances that have a higher resistance to electricity flow are called insulators (e.g. glass, plastic, dry wood). Pure water is a poor conductor of electricity, however small impurities in the water increase its conductivity. For this reason water, wet wood and dampened human skin, can be a conductor for electricity.

-OSHA
http://www.osha.gov/SLTC/etools/construction/electrical_incidents/elecworks.html

References

"Electrical Incidents." Occupational Safety and Health Administration. http://www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html

Chapter 9: Health and Safety

9.13 Information Technology (IT)

Goal: To improve the quality of life for construction workers by providing electronic tools and products for health and safety compliance, training and education.

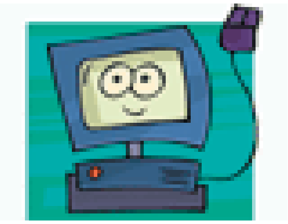
Key Issues:

New computer technology and online assistance provide additional support in ensuring the health and safety of construction workers.

Actions and Methods:

Information available from the U.S. Department of Labor OSHA:

- **eTools** - interactive web-based training tools on safety and health topics. Utilizes graphics and illustrations for easy navigation. Enables user to answer questions and receive reliable advice on how OSHA regulations apply to their work site. Also available as downloadable files and in Spanish. **http://www.osha.gov/dts/osta/oshasoft/index.html#eTools**
- **OSHA Safety and Health Topics** this website has assembled a variety of information on more than 150 topics to provide users reference materials including standards, directives, training materials etc. The website includes multimedia material, an updated 'What's New' category, and User's Guide. Everything from Accident Investigation to Youth (teen) workers. **http://www.osha.gov/SLTC/index.html**



- **PowerPoint Presentations.** These are pre-assembled power point presentations for contractor's use on the job or in the office for training purposes. Everything from Ammonia Refrigeration to Workplace Violence. **http://www.osha.gov/SLTC/multimedia.html**
- **Targeted CD-Roms** - developed for Health Care, Construction and others providing Technical Links, eTools, and Powerpoint presentations related to specific topics, such as Construction. Only available as handouts for specific OSHA courses. Available through the OSHA website. **www.osha.gov**

Information available from the Center for Disease Control, NIOSH:

- **eLCOSH** (Electronic Library of Construction Occupational Safety and Health) provides worker information categorized by hazard, trade, jobsite, and other training. Information is also offered in Spanish, with some documents available in Creole, French, Italian, and Portuguese. Developed by Center to Protect Worker's Rights funded by NIOSH.

References

Center for Disease Control, Electronic Library of Construction Occupational Safety and Health. http://www.cdc.gov/elcosh/index.html

U.S Department of Labor Occupational Safety and Health Administration website. www.osha.gov (Compliance Assistance, eTools).

Chapter 9: Health and Safety

9.14 Equipment

Goal: To improve the quality of life for construction workers by increasing awareness of the health implications of using gas powered vehicles in confined spaces.

Key Issues:

- Carbon monoxide is a lethal poison produced from burned gasoline. It is found in the engine exhaust.
- Carbon monoxide is colorless, tasteless, odorless, and nonirritating.
- Carbon Monoxide health effects include:
  - Weakness and confusion.
  - Headache, dizziness, nausea- similar to a flu or cold.
  - Suffocation caused by carbon monoxide bonding with hemoglobin, replacing the oxygen in your blood causing oxygen deficiency/replacement.
  - Those with heart disease and fetuses of expecting mothers are at increased risk.
- Severity of exposure is influenced by three factors:
  - The concentration of carbon monoxide in the environment.
  - The length of exposure.
  - The workload and breathing rate of the individual.

Actions and Methods:

- Coordinate monitoring of air quality with CBRN efforts.

To Reduce the Risk of Carbon Monoxide Gas Emissions:

- Do not use equipment and tools powered by gasoline engines inside buildings or other partially enclosed spaces unless the gasoline engine can be placed outdoors and away from air intakes.

Emerging Technology:

Alternative Fuel Sources for Equipment: Biodiesel

Biodiesel is a clean burning fuel alternative produced from domestic renewable resources. Biodiesel:

- Contains no petroleum, but is mixed with petroleum diesel to create a biodiesel blend.
- Can be used in compression-ignition engines (diesel) with little to no modifications.
- Is biodegradable, non-toxic and essentially sulfur and aromatics free.
- Fuel must be produced at ASTM D6751 standards.
- Emits 47 percent of the carbon monoxide gas compared to regular fuel.

Why should we use this? Better for the environment, made from U.S. based renewable resources, produces lower emissions, less toxic than table salt and biodegrades faster than sugar.

References

"Biodiesel." (2004). National Biodiesel Board http://www.biodiesel.org/

"Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools." (1996). Publication No. 96-118 National Institute for Occupational Safety and Health.

Chapter 9: Health and Safety

9.15 Finishes

Goal: To improve the quality of life for construction workers while installing finishes.

Key Issues:

- Volatile Organic Compounds (VOCs) are gases emitted from certain solids or liquids such as formaldehyde, benzene, toluene, styrene and xylene.
- VOCs found in many finishing materials can cause adverse health effects.

Actions and Methods:

To Reduce Exposure to VOCs:

- Require minimum VOC levels for all products and materials identified in the LEED Reference Manual.
- Ensure proper ventilation when using adhesives, carpets, hairsprays, household cleaners, lacquers, paints, paint thinners/strippers, pesticides, dry-cleaning fluids, building materials, home furnishings, copiers and printers, permanent markers and photographic solutions.

Installing Carpet and Rugs:

- Avoid hazardous adhesives by choosing non-VOC products.
- Ask the manufacturer to air the carpet at least (3) days before delivery.
- Clean old carpet before removing. Carpets hide dust, pollutants, pesticides, lead, chemicals and other undesirables within their fibers and minimize your exposure during removal.
- Vacuum floors before new carpet installation and clean both sides of carpet and pad.
- Install carpet only in well ventilated spaces.
- Tack carpets instead of using adhesives.
- Air all installation areas for 72 hours after installation.

Healthy Painting Guidelines:

- Select paints designed for indoor use. Use water-based or latex paints when possible.
- Schedule painting for dry periods such as fall or spring, when windows can be kept open.
- Keep windows open for 2-3 days after painting.
- Use fans to exhaust unwanted fumes and provide adequate cross ventilation.
- Provide notice to nearby occupants.
- Take frequent fresh air breaks while painting.
- Look for local recycling programs to discard excess paint. Contact your local government for more information.

Common Health Effects of VOC Exposure:

- If you or others around you are experiencing any of the following health effects, contact your Safety Manager immediately.
    - Conjunctiva irritation.
    - Nose, throat discomfort, or headache.
    - Allergic skin reaction.
    - Dyspnea, nausea, emesis, dizziness or fatigue.

Emerging Technology:

Alternative Flooring Materials

Many flooring choices contain VOCs which contribute to air pollution. Vinyl flooring utilizes off-gassing glues and contains solvents with VOCs. Even hardwood flooring can be chemically treated and emit VOCs.

Luckily there are safe alternatives to synthetic and treated flooring. Alternatives include true linoleum, untreated hardwood flooring, cork flooring, marble, slate and ceramic floor tiles. Choose wisely!

References

"Design for Construction Safety Toolbox." (1996). Publication 101-2 Construction Industry Institute (CII). Austin, TX.

"Healthy Indoor Painting Practices." (2000). Environmental Protection Agency. http://www.epa.gov/opptintr/exposure/docs/inpaint5.pdf

Chapter 10: Indoor Environmental Quality

Goal: To ensure the proper management of Indoor Air Quality (IAQ) measures during construction.

Benefits:

- Improved IAQ for occupants.
- A healthier working environment for construction workers.
- Minimized risk of mold and other IAQ related warranty issues and call backs.

Keys Issues:

The main sources of IAQ problems in buildings are related to:

- **Moisture** intrusion.
- **Dust** build-up and intrusion.
- Off-gassing of harmful materials.

Actions and Methods:

- Steps taken during construction to manage moisture, dust, and harmful materials are key to managing the risk of IAQ problems.
- **Implement an IAQ Management Plan** including key project trades and a qualified commissioning agent (Ref. Section 10.0).
- Test and monitor ventilation and exhaust airflow and suspected contaminant particles and gases within occupied areas of the building.
- **Identify sources of contamination** from construction activities and position them to minimize IAQ problems. Example: Do not locate a diesel generator, or a roofing kettle, near a building air intake.
- Identify materials likely to impact IAQ and select a similar but less toxic substitute. Examples provided below are rules of thumb and while they are generally applicable, they may not apply in every situation.

Environment and Occupant Friendly Alternatives:

- Latex paint over oil based paint.
- Hardwood over pressed wood.
- Water based over solvent based adhesives.
- Low formaldehyde emitting fabrics.
- Continuous filament carpet.

Enclose Dust Generating Activities:

- May include the physical isolation of a section of the building with polyethylene sheeting or other barriers.
- May need to isolate the space from the general ventilation system by blocking return air grilles or added filtration.
- Keep doors closed and seal stairwells, so that they do not act as conduits for contaminants.
- Positively pressurizing non-work areas and use ventilation systems overnight to purge the building and minimize contaminant migration into occupied spaces.

References

"DRAFT Indoor Environmental Quality Guidance for Green, High Performance and Sustainable Buildings." (2004). Environmental Protection Agency.

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Chapter 10: Indoor Environmental Quality

10.0 Planning

Goal: To educate the workforce and to provide the necessary tools to minimize Indoor Air Quality (IAQ) problems during the construction process.

Key Issues:

- Develop an IAQ management guide to include in the request for proposal (RFP) and construction documents (CDs).
- Effectively communicate and enforce the plan.

Actions and Methods:

Educate the Workforce:

- Develop subcontractor agreements that communicate the goals of the construction IAQ plan.
- At weekly foreman's meetings, discuss upcoming IAQ issues and how they will be managed.
- Communicate the goals of the construction IAQ plan to workers via consistent on-site training, toolbox talks and signage.
- Post prominent signage about unacceptable behaviors that may have a potential negative impact on long term IAQ, including:
  - No smoking inside building.
  - No chewing tobacco.
  - Do not wear contaminated work clothes.
- Minimize the use of un-vented combustion (as occurs with propane or diesel "salamander" space heaters).

Develop a Construction IAQ Management Plan, which:

- Meets or exceeds minimum Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 1995.
- Protects on-site absorptive materials from moisture damage.
- Requires replacement of all filtration media (with MERV of 13 per ASHRAE 52.2-1999) immediately prior to occupancy.

Enforce the IAQ Management Plan:

- Inspect and maintain IAQ measures including ventilation system protection and ventilation rates.
- Monitor and control lapses in IAQ measures by trades.

Scheduling:

- Install porous materials (e.g. insulation, fire proofing and drywall materials) only after the building is weather tight.
- **Sequence material installation** so that materials with significant sources of contaminants (e.g. composite wood, liquid products including adhesives, paints and coatings, gypsum board) have time to off-gas before porous products (e.g. carpet and padding, fabric wall coverings, acoustic tiles, upholstered furniture) that have the capacity to absorb or trap the contaminants are installed.
- When proper sequencing is not possible, **protect absorptive surfaces with vapor barriers** and provide for air exchange with temporary or permanent ventilation systems.
- Provide proper filtration and adequate ventilation with 100 percent outdoor air during curing period to aid in the removal of pollutants within interior finishes. (Dehumidification may be required in certain applications).
- **Materials in need of curing/off-gassing time:**
  - Wet-spray cellulose takes several days or longer to dry.
  - Install carpeting and furnishings after interior finishes have cured to eliminate VOCs from being absorbed by porous materials (e.g. unfinished drywall).
  - Paint before installing carpeting or furnishings.
- Expedite the installation of the mechanical system to allow for humidity control of the building prior to the installation of drywall. If possible, use a temporary system of ventilation.
- Limit operation of the building's HVAC system during construction. If it is unavoidable, clean all filters, ducts and equipment surfaces (including coils) to the same level of cleanliness as unused equipment.
- Coordinate roofing sequence with interiors to prevent moisture infiltration.
- Sequence elevator construction after roof and enclosure is complete.
- Require two week building flush-out at the end of construction before occupancy per LEED 2.1 credit requirement.

References

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"Indoor Environmental Quality." City of San Jose http://www.ci.san-jose.ca.us/esd/gb-indoor-environment.htm

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Chapter 10: Indoor Environmental Quality

10.1 General Conditions

Goal: To ensure Indoor Air Quality (IAQ) issues are managed and executed properly.

Key Issues:

- Control of dust and moisture during construction.
- Installation of temporary partitions.
- Installation of temporary ventilation.
- Housekeeping.

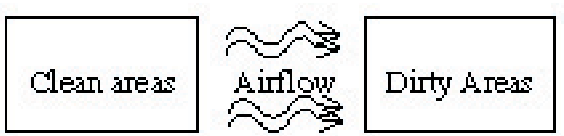
Actions and Methods:

Signage:

- **Post prominent signage** about unacceptable behaviors that may have a negative impact on long term IAQ, including:
  - No smoking inside building.
  - No chewing tobacco.
  - Do not wear contaminated work clothes.
  - No eating inside the building.

Temporary Barriers:

- **Create clean-to-dirty airflow** with pressurization strategies.



- Positively pressurize non-work areas and use ventilation systems overnight to purge the building and minimize contaminant migration into occupied spaces.
- Keep doors closed and seal stairwells so that they do not act as conduits for contaminants.
- **Enclose dust generating activities** with temporary barriers to isolate them from other areas of the building. This may include physically isolating a section of the building with polyethylene sheeting or isolating the space from the general ventilation system by blocking return air grilles or adding filtration.

Housekeeping:

- **Develop a cleaning program** and provide high efficiency particulate filters (HEPA) filters on vacuums.
- Seal all openings in walls, floors and ceilings that separate conditioned spaces from unconditioned spaces.
- Designate a space outside for breaks and eating. This will keep all trash contained in one area and provide a healthier environment for workers.
- **Minimize accumulation of dust** and other contaminants by using integral dust collection systems on drywall sanders, cut off saws and routers.
- Isolate dust-generating activities so that cleanup can be easily carried out without contamination of other areas of the building.
- **Use wetting agents or sweeping components** to keep dust from becoming airborne during cleanup.
- Use wet rags, damp mops and vacuum cleaners with **HEPA filters** to clean dust.
- Keep work area dry by fixing any leaks that allow rainwater entry and any water accumulation.
- Seal containers of volatile liquids (fuel, paint, finishes, solvents) and store outside when possible.

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

"Indoor Environmental Quality." City of San Jose. http://www.ci.san-jose.ca.us/esd/gb-indoor-environment.htm

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10.2 Demolition and Abatement

Goal: To prevent Indoor Air Quality (IAQ) problems during demolition and renovation projects.

Key Issues:

- Contain any flow of **dust** particles into adjacent occupied areas.
- Seal, and manage closely, the removal of **hazardous materials**.
- Use qualified and competent **abatement contractors**.
- Consult International Corps of the Red Cross (ICRC) standards if demolition is taking place in or near a healthcare facility.

Actions and Methods:

Educate:

- Brief all workers on-site to ensure full compliance with the dust control measures in the Construction Documents (CDs).

Temporary Barriers:

- **Install barriers** between work areas and occupied areas.
- Install barriers and closures **above ceilings** to prevent the transmission of dust into adjacent areas.
- Barriers should be managed with **negative air pressures** (airflow into the construction area) with a pressure difference greater than 0.1” w.g., or 2.5 Pascals.
- Use HEPA filters for **all discharged air** for particulate removal.
- **Replace ceiling access panels** beyond the sealed areas once investigations are complete. Do not leave open ceilings unattended.

Reduce the Risk of Mold:

- Use exhaust methods similar to **asbestos local exhausting** for heavily contaminated areas of mold and mildew infestations.
- During remediation of mold, minimize potential exposure to building occupants by working during off hours.

Control and Minimize Dust:

- **Do not allow dust and debris to accumulate on-site** – remove dust daily. Fit out containers with clean polyethylene covers when transporting waste through occupied areas of the building. Before leaving construction areas wipe clean all containers with a damp sponge to prevent tracking of dust.
- Provide walk-off mats inside of dust control barriers. Clean or change walk-off mats daily, or more often as needed, to prevent accumulation of dust.
- Upon completion, carefully remove dust control barriers and ceiling protection to minimize the spread of dirt and debris.

PENREN/C Practice:

Pentagon Renovation

Approximately 1,000,000 lbs of asbestos will be removed from the Pentagon during its renovation.

Temporary barriers and ventilation systems were used throughout the project to contain dust and debris during construction.

www.ibew.org/stories/02journal/ 0211/p10.htm

References

"Section 01502 Dust Control." (2003). http://fmweb.virginia.edu/fpc/HSDivision/DustControlRevised(BF).doc

Streifel, A. (1998). "Barriers are Critical to Protect IAQ during Renovation." Indoor Air Quality Project 1(2).

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Chapter 10: Indoor Environmental Quality

10.3 Site Work

Goal: To prevent equipment generated toxins/VOCs from entering the building during construction, and ensure the safe storage of materials on-site.

Key Issues:

- **Dust** penetration into the building.
- Contamination of air from equipment **exhaust**.
- Moisture damage to stored materials.
- **Moisture** problems due to improper drainage and moisture control during construction.

Actions and Methods:

Control and Minimize Dust:

- Dust control measures should be taken on worker and equipment travel paths.
- Temporary window barriers should be used on lower floors.
- Route traffic away from building openings when possible.

Equipment exhaust:

- Site related construction equipment should be located away from the building access areas and building air intakes.

Material Storage:

- The storage of materials outside the building should be minimized.
- Materials should be stored off of the ground, on pallets or on dunnage.
- Do not store materials in areas of the site that are low, or that have insufficient drainage.

Site Drainage:

- **Ensure site is graded to channel water** away from the building, especially if construction is below grade.
- Connect building rain leaders to a storm drain system.
- Within a few feet of the building provide a low-permeability soil mix (high clay content) to minimize infiltration of rainwater immediately adjacent to the building.

Case Study:

Dust Control

Site work can create dust during building construction. Water trucks and wheel cleaning operations can help contain dust on large sites.

Images courtesy of Caterpillar®

References

Kuehn, T. (1998). "Construction and Renovation Impact on Indoor Air Quality - Control Strategies." Indoor Air Quality Project 1(2).

Wilson, A. (2001). Mold in Buildings. Environmental Building News. 10.

Chapter 10: Indoor Environmental Quality

10.4 Foundations

Goal: To prevent Indoor Air Quality (IAQ) problems in buildings through effective measures taken during the construction of sub-grade and slab on grade systems.

Key Issues:

- Ensure proper **moisture barriers** are used under slabs.
- Ensure **drainage gravel** is clean and of proper depth.
- **Seal all slab on grade** penetrations.
- Ensure **radon mitigation** is performed properly if required (see below).

Actions and Methods:

Vapor Retarder:

- Provide polyethylene vapor retardant under floor slab.
- For slab on grade construction, provide either a layer of polyethylene (6-mil min.) or rigid insulation under the slab, to block capillary movement of moisture into the slab from below.
- For a monolithic slab on grade, the poly vapor retarder should extend beneath the grade beam.
- Avoid a layer of sand between the poly and the concrete. This can provide a mold reservoir.

Radon Reduction:

- Install a layer of gas-permeable material under the foundation (usually four inches of gravel).
- Install plastic sheeting over the gas-permeable material.
- Seal and caulk all openings in the concrete foundation floor.
- Run a gas-tight three- or four-inch vent pipe under the foundation, through the house, to the roof.
- Rough-in an electrical junction box for the future installation of a fan.

Moisture Protection:

- Provide dampproofing and a drainage plane on the foundation wall. The drainage plane should be provided next to the foundation wall (a layer of drainage mat or free-draining insulation plus backfilling with crushed stone is preferable).
- Provide drainage tile at foundation footings. Perforated perimeter drainage pipe should be installed with a minimum slope of half an inch in 10 feet. Locate pipe below floor level but do not extend below bottom of footing. Drain to daylight or sump. Surround drain pipe with crushed stone and protect the layer of stone with filter fabric to keep fines out.
- Provide capillary break (dampproofing or membrane) between the footing and foundation wall or perimeter foundation for slab on grade.

Case Study:

Slab On Grade

Preparations for slab on-grade construction should ensure proper depth of sub-grade, and the use of approved vapor retarders. Exposed slabs should be sealed to minimize infiltration of harmful gas and dirt into buildings.

Courtesy of http://www.neffandjensen.com/pages/slab4.htm

References

"Radon Reduction in New Construction." (1998). Environmental Health Center http://www.nsc.org/ehc/radon/construc.htm

Wilson, A. (2001). Mold in Buildings. Environmental Building News. 10.

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10.5 Substructure

Goal: To prevent Indoor Air Quality (IAQ) problems caused by construction of foundation walls and other below grade structures.

Key Issues:

- **Minimize penetrations** through foundation walls.
- **Seal all penetrations** through foundation walls.
- Ensure proper installation of moisture protection and water stops on foundation walls.
- Ensure proper installation of drainage gravel, drainage pipe, and filter fabric.
- **Control site drainage** during substructure construction.

Actions and Methods:

Site Drainage:

- Grade site **away** from sub-grade construction.
- Provide dewatering systems to keep substructure dry.
- Provide **dampproofing** and a drainage plane on the foundation wall. The drainage plane should be provided next to the foundation wall (a layer of drainage mat or free-draining insulation plus backfilling with crushed stone is preferable).
- **Provide drainage tile at foundation footings**. Perforated perimeter drainage pipe should be installed with a minimum slope of half an inch in 10 feet. Locate pipe below floor level but do not extend below bottom of footing. Drain to daylight or sump. Surround drain pipe with crushed stone and protect the layer of stone with filter fabric to keep fines out.

Moisture Barriers and Sealants:

- **Inspect installation** of waterstops and penetration sealants.
- Choose low VOC sealant and moisture barrier materials. See Chapter 3 for materials.
- Ensure workers installing moisture barriers use proper breathing and eye protection.
- Provide capillary break (dampproofing or membrane) between

the footing and foundation wall or perimeter foundation for slab on grade.

Case Study:

Foundation Walls

Foundation walls are a major source of moisture intrusion. Waterstops must be used at construction joints and utility penetrations must be properly sealed.

Foundation wall construction

References

Allen, E. Fundamentals of Building Construction: Materials and Methods. New York, John Wiley and Sons.

Wilson, A. (2001). Mold in Buildings. Environmental Building News.

Chapter 10: Indoor Environmental Quality

10.6 Superstructure

Goal: Minimize risk of Indoor Air Quality (IAQ) problems during superstructure construction, specifically, expediting roof construction, and the weather protection of the building.

Key Issues:

- Minimal IAQ risks are related to superstructure construction.

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10.7 Exterior Enclosure

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the exterior building enclosure.

Key Issues:
- Moisture and dust intrusion/entrapment during façade construction.
- The **timely completion of building enclosures** to allow loading of materials that are sensitive to moisture.
- The inclusion of all flashing and joint sealants is clearly indicated in contracts.

Actions and Methods:
General Construction:
- Properly seal joints and unnecessary openings.
- Extend flashing past edge of mortar in brick/stone clad wall systems.
- Ensure clean air cavities in exterior wall construction.
  - **Problem:** Mortar and other debris that falls into air cavities may block vents and weep holes, which will cause condensed moisture to collect and results in mold and mildew growth.
  - **SOLUTION:** Use a piece of wood to catch mortar before it falls into air cavity.

Material Storage:
- Cover dry materials with plastic to prevent rain damage. If resting on the ground, use spacers to allow air to circulate between the ground and the materials.
- Wet materials should be allowed to dry prior to installation.
- Be aware that some materials such as wood may arrive on-site with a high moisture content due to moisture before arrival or during transportation.

Façade Contract:
- Use a prime contractor or **design-build contract** for the entire building façade to ensure accountability for the performance of the façade as a system.

Case Study:

Complex Building Facades

Leaks in facades are a major risk to IAQ in buildings. Building facades often require numerous materials such as metal panels, stone, and glass. In many cases, multiple contractors are required to complete the work. Extra care is needed to ensure that all joints are covered in the scope of work for the façade, and that a sequence plan is designed to ensure timely completion of the building enclosure.

Five different façade materials were required in the enclosure of the David S. Pottruck Center, University of Pennsylvania

References

"Duct Cleanliness for New Construction Guidelines." (2000). SMACNA. Chantilly, VA.

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

Wilson, A. (2001). Mold in Buildings. Environmental Building News.

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10.8 Roofing

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the roofing system.

Key Issues:

- Moisture infiltration.
- Prevention of toxic chemicals being absorbed in other materials.

Actions and Methods:

- Sequence roofing to **prevent moisture infiltration** during the construction of interior finishes.
- Schedule installation of toxic chemicals (tar, sealant) **before installation of materials that absorb** chemicals/VOCs, such as drywall, carpet, wood and furniture. This will prevent these porous materials from absorbing harmful toxins and releasing them over the life of the building.
- Locate hot tar and hot asphalt materials **away from air intakes** when feasible and consider wind patterns. Indoor air intakes may need to be shut down temporarily.
- Instruct occupants to keep doors and windows closed when using hot tar or hot asphalt materials.
- When possible, schedule work during low occupancy periods and provide good communication to all affected parties, which may include neighboring buildings.
- Do not use materials that contain asbestos.

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Case Study:

Roof Construction

Locate tar kettles away from air intakes to prevent occupant exposure to contaminants.

www.powellsequip.com/used_8.htm

Chemicals released from installation of roofing membranes can be absorbed by materials such as carpet and drywall. Roofing should be scheduled before such materials are installed to prevent the re-release of these toxins throughout the life of the building.

www.marshallconstruction.co.uk/roofing.htm

References

"Environmental Health and Safety." (2004). Boston College. http://www.bc.edu/offices/facilities/ehs/

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10.9 Interior Construction

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the interior finishes.

Key Issues:

- **Moisture** infiltration.
- **Dust** control.
- **Toxicity** and off-gassing.

Actions and Methods:

Scheduling:

- Expedite building enclosure to prevent moisture buildup and allow for dry-in.
- Schedule application of toxic chemicals (tar, sealant) before installation of materials that absorb chemicals/VOCs, such as drywall, carpet, wood and furniture as these materials will re-release toxins throughout the life of the building.

Material Storage:

- **Store materials inside** or in an enclosed space whenever possible.
- **Cover dry materials** with plastic to prevent rain damage, and if resting on the ground, use spacers to allow air to circulate between the ground and the materials.
- Wet materials should be allowed to dry as much as possible as weather permits.
- **Beware:** Some materials, such as wood, may arrive at site with a high moisture content or may have become wet before arrival or during transportation.
- **Store hazardous liquids outside** in proper containers to reduce the possibility of spills during storage, transfer, or mixing. Protect liquids from freezing.
- **Rent warehouse space** to allow materials to off-gas before installation.

Drywall Installation:

- Use vacuum assisted drywall sanding equipment to reduce dust.
- **Measure and document moisture content** of all concrete block and do not install gypsum board on these walls until the moisture content of the blocks measures the same as the identical type of block stored away from exposure to rain.
- Run seams of drywall vertically along wood/metal studs to reduce infiltration.
- Install a fire sealant bead of $^3/_8$ of an inch in between the floor and the bottom edge of the gypsum.

Mechanical Rough-in:

- All return and supply air vents and any open ductwork should be temporarily sealed to prevent the ductwork and air handling units from being contaminated with construction debris or dust.
- Seal unnecessary openings in walls, floors and ceilings that separate conditioned spaces from unconditioned space. **Example:** It is common to punch large holes in floors to allow pipes and wires to run between the rooms above and the crawlspaces or tunnels below. These oversized openings can cause two significant IAQ problems. Air that is contaminated with mold, radon, moisture and pesticides can easily enter the rooms; and pests such as roaches or rodents can enter the rooms, leaving behind odors and allergens.

Rough Carpentry:

- **Use interior grade plywood or wheatboard** for interior uses.
- Seal all exposed particleboard or Medium Density Fiberboard (MDF) to eliminate any off-gassing.

Housekeeping:

- **Use vacuums instead of brooms** to make clean-up easier and reduce the spreading of dust.
- Provide walk-off mats at inside dust control barrier entrances. Vacuum or change walk-off mats daily or more often as necessary to prevent accumulation of dust. Additionally, provide (sticky) walk-off mat immediately outside dust control barrier entrances.
- Use less toxic cleaning agents. See Chapter 3 for materials
- If solvents, cleaners, gasoline, or other potentially toxic liquids are spilled onto the floor, clean-up immediately to reduce further contamination.
- **If a toxic spill occurs** on easily replaceable building material, it may be safest to discard it and replace it with new material. Odors from significant spills can linger sometimes for years, causing comfort and health problems for future occupants.

Emerging Technology:

Desiccant Dehumidifier

Use a **desiccant dehumidifier** to control moisture levels during installation of interior finishes.

A desiccant dehumidifier is a device that employs a desiccant material to remove humidity from the surrounding space. The process involves exposing the desiccant material to a high relative humidity air stream, allowing it to attract and retain some of the water vapor and then exposing the same desiccants to a lower relative humidity air stream which has the affect of drawing the retained moisture from the desiccant.

Photo: http://www.dri-eaz.com/DriTec150.html

References

Chapter 3: Green Building Checklist. (2003). New Home Construction Green Building Guidelines. http://www.co.contra-costa.ca.us/depart/cd/recycle/gbg/GrnBldg-NewConstruction-Chap3.pdf

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

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10.10 Conveying Systems

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of elevators and conveying systems.

Key Issues:

- **Mold** growth in elevator shafts.
- **Debris** build-up in elevator pits.
- **Material choices** in elevator cabs.

Actions and Methods:

Mold growth in elevator shafts:

- **Protect shaft liner** from moisture intrusion and replace liner damaged by moisture.
- **Install rain leaders** and temporary water dams at roof penetrations to minimize moisture in building.
- Sequence the elevator construction after roof and enclosure is complete.

Prevent debris collection in elevator pits:

- **Construct toe-boards** around openings to prevent dust and debris from being brushed into pits.
- **Seal and clean pits** before installation of elevators.

Elevator and Escalator Construction:

- Sequence installation of escalators after tasks that create dust, such as installation of drywall. Dust particles from other tasks that fall into escalator will cause future operation and maintenance problems.

Material Selection:

- Choose finish materials for elevator cabs that are environmentally friendly with minimal off-gassing.

Case Study:

Escalator Construction

Escalator maintenance is greatly increased by construction dust. By minimizing dust generating activities during and after installation of elevators and escalators, many operation problems and maintenance issues can be avoided.

www.estec.ltd.uk/services.html

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

Chapter 10: Indoor Environmental Quality

10.11 Mechanical

Goal: To prevent Indoor Air Quality (IAQ) problems caused by the installation of the building's mechanical system.

Key Issues:

- **Dust** contamination of ductwork and equipment.
- **Mold** in ductwork and equipment.

Actions and Methods:

- Ensure proper installation of all equipment through commissioning.
- Properly seal all openings in walls, floors and ceilings that separate conditioned spaces from unconditioned space (i.e. exhaust fans to outside).

Scheduling:

- Expedite installation of mechanical system to allow for humidity control of building prior to installation of drywall.
- **Conduct minimum 2-week flush-out** with new filtration media and 100 percent outside air after construction prior to occupancy, or **conduct baseline IAQ testing** consistent with EPA's current Protocol for Environmental Requirements, Baseline IAQ and Materials, for the Research Triangle Park Campus, Section 01445.
- Continually commission mechanical system as construction progresses.
- If mechanical system is used during construction, **filters will need to be replaced frequently**, due to increased air contaminants from construction.

Ductwork:

- All return and supply air vents as well as any open ductwork should be temporarily sealed to prevent the units from being contaminated with construction dust or debris.
- **Seal all ducts** (plenums, distribution box connections, duct collars, return-air duct collars and air-supply registers) to ensure dirt, dust and other debris does not enter the air distribution system. These contaminants enhance the chances for mold growth.
- Storage should be clean and dry with minimal exposure to dust.
- Completed work should be clean, dry and protected from the elements.
- **Inspect duct sections** to ensure that they are free of dust and debris prior to installation. Wipe internal surfaces of the un-insulated ductwork to remove dust immediately before installation.
- To prevent the entry of debris into the duct, all risers must be sealed.
- Use duct mastic and tape on duct joints.
- Clean air plenums before closing them in (including access flooring).
- **Frequent replacement of air filters** during construction will prevent dust build-up within the ducts prior to building occupancy.

Piping:

- **Ensure condensing lines properly drain** to the outdoors or to a waste line as specified by the manufacturer.
- Provide proper slope and drainage of drain pans under unit air conditioners. (Places where water sits in drain pans are a prime environment for mold growth).
- Investigate the use of UV tubes at drain pans to decrease the risk of mold and bacteria growth.
- **Insulate** cold components and cold water pipes.
- Ensure plumbing is easy to inspect and repair.

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Case Study:

Fiber-reinforced mastic is a better choice than duct tape for sealing the joints in ductwork because it won't pull away and fall off.

www.taunton.com/finehomebuilding/pages/h00021.asp

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

"Duct Cleanliness for New Construction Guidelines." (2000). SMACNA. Chantilly, VA.

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Chapter 10: Indoor Environmental Quality

10.12 Electrical

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the electrical system.

Key Issues:

- Provide back-up power.
- Dust filtration via wall openings.

Actions and Methods:

- Provide back-up power for building ventilation system during construction, in particular during renovation projects.
- Seal unnecessary openings in walls, floors and ceilings that separate conditioned spaces from unconditioned space.

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

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10.13 Information Technology (IT)

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the information technology systems.

Key Issues:

- Dust filtration via wall openings.
- Moisture.

Actions and Methods:

- Seal unnecessary openings in walls, floors and ceilings that separate conditioned spaces from unconditioned space.
- Protect sensors during construction to prevent dust or moisture from damaging sensors.
- Provide an integrated commissioning process for all control systems, mechanical and electrical systems.

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

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Chapter 10: Indoor Environmental Quality

10.14 Equipment

Goal: To prevent Indoor Air Quality (IAQ) problems related to construction equipment.

Key Issues:

- Exhaust from equipment.
- Protection of liquids.
- Dust.

Actions and Methods:

- Avoid use of combustion equipment indoors.
- **Engines and heaters** that run on gasoline, diesel, kerosene, or other fossil fuels should not be operated indoors unless absolutely necessary. If equipment is used inside, ensure isolation and sufficient ventilation of the space to restrict and remove contaminants.
- Store liquid fuels outside to reduce the risk of spills during storage, transfer or mixing. Protect liquids from freezing.
- **Use vacuum assisted** cutting and sanding equipment.
- Use desiccant dehumidifiers (or mechanical dehumidifiers in hot weather) for drying construction materials.

References

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

L. Harriman, D. S., M.Fowler (2002). "Preventing Mold by Keeping New Construction Dry." ASHRAE Journal: 28-34.

Chapter 10: Indoor Environmental Quality

10.15 Finishes

Goal: To prevent Indoor Air Quality (IAQ) problems caused by installation of the interior finishes.

Key Issues:

- VOCs released during installation.
- Dust control.
- Moisture penetration.

Actions and Methods:

Scheduling:

- Schedule installation of toxic chemicals (tar, sealant) before installation of materials that absorb chemicals/VOCs, such as drywall, carpet, wood, furniture.
- Minimize occupant exposure to interior painting by scheduling it during off hours, isolating the space, and ventilating the area during and after painting is completed.

Ventilate when:

- Performing activities that release large amounts of VOCs. VOCs can be absorbed onto building materials and be re-released into the air later when the building is occupied.
- Installing wet materials or if materials have a "wet odor". Odors from building materials are the result of chemicals being released from the material into the air, so if there is an odor, ventilate. See Chapter 3 for alternate materials.
- Painting.
- Spreading floor adhesives.
- Applying large amounts of caulk, sealants or cleaning agents.
- Large installations of carpet or vinyl-based flooring products.
- Composite wood cabinets and shelves (if materials have not been carefully selected and aired-out before being unpackaged).
- During installation of carpet, paint, furnishings and other VOC-emitting products, provide supplemental ventilation for **at least 72 hours after work is completed.**

Managing Moisture

- Do not apply interior finishes on drywall until the moisture content is below 0.4 percent on a gypsum moisture meter, or below 12 percent on a wood meter.
- Before installing finish floor, measure the moisture content of concrete floor slab as soon as the building has been closed-in and as soon as the slab temperature can be brought within the 65˚F to 75 ˚F temperature required for measurement. If the moisture content is excessive, the air above the concrete shall be held below 30 percent RH until the material is dry enough to meet the specification established by the flooring manufacturer.

General Construction

- Use less toxic cleaning agents. See Chapter 3.
- Provide walk-off mats at inside dust control barrier entrances. Vacuum or change walk-off mats daily or more often as necessary to prevent accumulation of dust. Additionally, provide (sticky) walk-off mat immediately outside dust control barrier entrances.

<u>Case Study:</u>

Ventilate when painting. This will speed the drying process, ensure any toxins are not spread around the building, and keep workers safe.

Photo: www.sherwin-williams.com/.../ppc-summer02/product-showcase.asp

References

"DRAFT Indoor Environmental Quality Guidance for Green, High Performance and Sustainable Buildings." (2004). Environmental Protection Agency.

"IAQ Design Tools for Schools." (2004). U.S. Environmental Protection Agency. http://www.epa.gov/iaq/schooldesign/

L. Harriman, D. S., M.Fowler (2002). "Preventing Mold by Keeping New Construction Dry." <u>ASHRAE Journal</u>: 28-34.