LCT ONE: CASE STUDY OF AN EIGHT STORY WOOD OFFICE BUILDING

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Learning Objectives

At the end of this program, participants will be able to:

1. Participants will become familiar with an innovative "timber" research project called the Life Cycle Tower.
2. Participants will have a better understanding of why the use of wood, as a renewable, natural resource should be substituted, where applicable, for concrete, steel or other fossil fuel intensive materials.
3. Participants will have an understanding of how an integrated “system built” approach can improve building delivery and performance.
4. Participants will be able to describe how an 8 story office building can be built in 8 days.
Nabih’s Experience

Austria
- Multi-family projects
- Pre-fabricated in wood
- Low energy standard
Nabih’s Experience

Ireland
Imported low energy, pre-fabricated homes from Austria

Berkeley
Remodeled home to Passive House Standard
MOTIVATION for the LIFE CYCLE TOWER
We don’t inherit the Earth from our Ancestors; we borrow it from our children

Native American Proverb

If 5 billion people lived in our “western” manner…

...we would need the resources of more than 2 planets!

Source: Prof. Dr. Schmidt-Bleek, Wuppertal-Institut
More than half of humanity now lives in cities - and that figure will likely reach 75% by 2050.

Source: National Nations
Worldwide, the building industry is responsible for:

- 40% consumption of resources
- 30% - 40% emission of greenhouse gas
- 60% of the transportation

- 25% - 40% consumption of energy
- 30% - 40% of solid waste generation

1) Source: UNEP SBCI – United Nations Environment Program
2) Ton kilometer
TRADITIONAL BUILDING INDUSTRY

- We build every building manually
- Using very complex methods
- Long construction schedules
- High consumption of energy and resources
- Commercial buildings are exclusively built out of steel and reinforced concrete
RESEARCH
Natural Change in Urban Architecture

Develop a timber based construction system for sustainable multi-storey buildings in urban environments

LifeCycle Tower

- Timber construction system up to 30 floors / 100 m
- Industrial pre-fabrication
- Passive house standard and power generation

Architekten Hermann Kaufmann ZT GmbH

Pre-Certified Gold 81.5%
DEVELOP LIFE CYCLE SYSTEMS

Include:
- Structural
- Façade
- Mechanical
- Electrical
- Fire Sprinkler
- Alarm System
- Code Analysis
- Energy Targets

The amount of wood used as the main building material for a 30-story LifeCycle Tower re-grows in United States forests within 3.5 minutes.
LIFE CYCLE ASSESSMENT

MATERIAL SELECTION ➔ MANUFACTURE ➔ OFF-SITE CONSTRUCTION ➔ OCCUPANCY ENERGY-EFFICIENCY MAINTENANCE ➔ DEMOLITION ➔ RECYCLE / REUSE DISPOSAL
MATERIAL SELECTION
FORESTRY CARBON CYCLE – IT’S SUSTAINABLE
MANUFACTURING
ENGINEERED, HIGH PERFORMANCE TIMBER PRODUCTS

- Finger jointed framing lumber
- Glue laminated timber
- Structural members
- Cross Laminated Timber
OFF-SITE CONSTRUCTION
ASSEMBLE AND FABRICATE COMPONENTS

Computer Numerical Control (CNC) wood working machinery

Precision workmanship

Assemble on Tables
Flip components over
Assemble completed wall, floor and roof components
ON-SITE CONSTRUCTION
ASSEMBLE COMPONENTS AND ERECT

Wall components

Floor components

Roof components

Mechanical system components
DEMOLITION-RECYCLE-REUSE-DISPOSAL
ENGINEERED, HIGH PERFORMANCE TIMBER PRODUCTS

Make furniture

Reused redwood shiplap siding to make rain screen

Güssing, Austria is the first community in the European Union to produce its whole energy demand – electricity, heating/cooling, fuels – out of renewable resources, from within the region.
PRODUCT DEVELOPMENT
TRADITIONAL METHODS OF DELIVERING BUILDINGS

TRADITIONAL METHOD
Design – Bid - Build

INTEGRATED DESIGN PROCESS

Figure 2-1 Traditional Project Design Team
Adapted from ASHRAE (2009)
DESIGN / BUILD SYSTEM APPROACH
Cree’s in-house Integrated Design Process

Core

Slab and Posts

Slab Design

Bearing Posts
DESIGN / BUILD SYSTEM APPROACH

Facades

- Photovoltaic-Element
- Shading
- natural ventilation
- Vertical-Garden

MEP

- Heat- and cooling bar
  + fire alarm system
  + sprinkler system
  + illuminating
  + ventilation
SLAB DESIGN
TESTED SYSTEM IN EUROPE - MAY OBTAIN ICC CERTIFICATION FOR USA
A Case Study
OFFICE BUILDING
LCT ONE

Height: 8 stories
FA: app. 17,000 ft²
LIFE CYCLE TOWER ONE

Conditions before starting on-site construction:

- Concrete basement with podium

- Concrete core for stairs, elevator and shafts, with the floor support mounting angles, which are installed at the exact elevations required.

- Scaffolding in preparation for assembly

Note:
LCT ONE was engineered according to the Austrian building regulations.

Cree is in the process of adapting the structural and fire systems to North American standards and will have a local system available shortly.
OFF-SITE - PREFABRICATION – hybrid wood / concrete floor slabs

1 - Wood beams are delivered to the precast concrete company

2 - The wood beams are installed inside the form work and concrete poured to produce hybrid slabs
OFF-SITE - PREFABRICATION – Load Bearing Posts

High strength metal tubes are inserted in top of all posts.

View from top of tubes

At ground level posts, flat plates are attached to the bottom of the posts.
(Shown in blue and purple on page 2)

At upper level posts, flat plates with pins are attached to the bottom of the posts.
(Shown in yellow on page 2)
OFF-SITE - PREFABRICATION – Wood framed curtain walls

Prefabricated walls include insulation, sheathing and windows, with taped joints, to reach maximum energy performance.
SITE PREPARATION

Slabs are delivered to site

Mounting angles with inserting pins are attached to core at exact elevations
ON-SITE — INSTALL POSTS — Ground floor

Posts for 2 story space at entrance — note steel tubes on top, used for inserting slabs

Ground floor posts are fastened to the foundation through the plates
ON-SITE — INSTALL WALLS — Ground floor

Note: The load bearing members are the double posts. The wall is a non-bearing, curtain wall wood framed façade. LCT ONE will have an aluminum rain screen installed on site.
INSTALL — FLOOR SLABS

Slabs are unloaded off the trucks and set in place.

All four corners of the slabs have holes used to insert the slabs through the pipes at top of posts or the pins at mounting angles.
INSTALL – FLOOR SLABS THROUGH TUBES AND PINS

Slabs are installed through pins at core

Slabs are set through tube at double posts on exterior walls
TUBES - PROTRUDING ON TOP OF SLABS

Tubes, from post below, are protruding ½” above slabs

The bottom of upper floor walls have pins that fit inside tubes. Plate at bottom of posts rests on tubes.
Upper floor walls have been set on top of slabs, with pin at bottom of post inserted into tube of post below. The walls are ready to accept slabs above, through the upper tubes.
ON-SITE -- BEAMS AND GIRDERS

Concrete edge beam

Installing girder on post

Note:
Through the use of concrete or steel girders, it is possible to extend a 30’ x 30’ grid, without supporting the slabs on a core.
INTERIOR — Exposed timber — watertight and airtight
INSTALLATION – ONE FLOOR PER DAY

March 19, 2012

March 20, 2012

March 21, 2012

March 22, 2012

March 23, 2012 - with temporary rain protection for weekend

March 26, 2012
The Natural Change in Urban Architecture
INVENTED BY RHOMBERG
IZM MONTAFON
OFFICE BUILDING
IZM Montafon

Length: 420 ft
Width: 65 ft
Height: 5 stories
FA: 107,000 ft²
OFFICE BUILDING
IZM Montafon

Architect:
Hermann Kaufmann – winner of international design competition using this system approach
DESIGN
LIFE CYCLE TOWER
Changeable to Various Uses

Hotel Plan

Office Plan
Ongoing work by ARUP to perform an initial seismic analysis including adapting designs and details to the California seismic and fire requirements
POST – SLAB CONNECTION

SLAB CONNECTION

[Diagram showing details of a slab connection with labels such as "Leimfuge" and "10mm Fichte Füllholz"]

[Images of slabs and connections with bolts and fixtures]

Note: The text and labels are in German.
SUPPLY CHAIN MANAGEMENT
Timber / Concrete Hybrid Slabs
Timber / Concrete Hybrid Slabs
Posts – Load bearing at exterior walls
Timber Facades – Timber Frame

Transfer carpentry know-how to local carpentry firms
MEP – Mechanical, Electrical and Plumbing

Prefabricate repetitive components
MEP – Mechanical, Electrical and Plumbing

- heating
- cooling
- fire alarm system
- sprinkler system
- illuminating
- ventilation
PERFORMANCE
LifeCycle Tower: Cost comparison
Wood construction vs. Reinforced Concrete construction

- **Wood construction**:
  - MEP: 1,586 Mio US$
  - Interior: 6,863 Mio US$
  - Shell & Core: 9,534 Mio US$
  - Design: 859 Mio US$
  - Total: 19,842 Mio US$

- **Reinforced concrete construction**:
  - MEP: 1,109 Mio US$
  - Interior: 8,079 Mio US$
  - Shell & Core: 10,328 Mio US$
  - Design: 1,109 Mio US$
  - Total: 20,645 Mio US$

### Share in the costs
- **MEP**
- **Interior**
- **Shell & Core**
- **Design**
CO₂ EQUIVALENTS

LifeCycle Tower: CO₂-equivalents
Wood construction / Reinforced Concrete construction

- Wood construction: Total: 1,944,944 lbs CO₂
- R.C.C.: Total: 22,874,081 lbs CO₂

- EOL Maintenance total: 3,423,241 lbs
- Maintenance total: 1,290,434 lbs
- EOL Production total: 18,277,481 lbs
- Production total: -117,075 lbs

- 92% reduction

-5,000,000 lbs to 5,000,000 lbs
CURRENT TRENDS IN THE WOOD INDUSTRY
USDA Leads the Way on Green Buildings, Use of Wood Products

WASHINGTON, March 30, 2011 -- Agriculture Secretary Tom Vilsack announced today USDA’s strategy to promote the use of wood as a green building material. At an event this evening to launch the International Year of the Forest, Secretary Vilsack will lay out a three-part plan addressing the Forest Service’s and USDA’s current green building practices.

Strategies:

• U. S. Forest Service will preferentially select wood in new building construction.

• U.S. Forest Service will …demonstrate the innovative use of wood as a green building material for all new structures of 10,000 square feet or more…

• “Our country has the resources, the work force and the innovative spirit to reintroduce wood products into all aspects of the next generation of buildings”, Forest Service Chief Tom Tidwell

• A recent Forest Service lifecycle analysis found that harvesting, transporting, manufacturing and using wood in lumber and panel products in building yields fewer air emissions – including greenhouse gases – than resource extraction, manufacturing and using other commonly-used building materials. In fact, wood based wall systems can require significantly less total energy for manufacturing than thermally comparable buildings using other common material systems.
House Bill 3429

Requires Oregon Department of Administrative Services to adopt rules regarding use of wood in buildings constructed by public body using state funding. Prohibits use of state funding for buildings not conforming with rules. Requires department to consult with representatives of local government, building trades, wood products industry and other parties before adoption or modification of rules.

Makes rules applicable to buildings for which initial disbursement of state funding occurs on or after July 1, 2012.

Declares emergency, effective on passage.

A BILL FOR AN ACT

Relating to the wood content of buildings constructed using state funding; and declaring an emergency.

Whereas wood is a strong, lightweight and flexible building material; and
Whereas wood is organic, sustainable, natural, recyclable and renewable; and
Whereas wood products require less water and energy and are more carbon efficient to manufacture than any other material; and
Whereas wood sequesters carbon for or beyond the life of a wood product; and
Whereas wood products reduce greenhouse gases in the atmosphere by being energy and carbon efficient and by sequestering carbon; and
Whereas wood is cost-effective and abundant, allowing wood to easily be sourced locally; and
Whereas wooden building systems have superior seismic performance; and
Whereas wood has a much lower thermal conductivity than comparable building materials; and
Whereas the use of wood for building supports the economy of Oregon and its rural communities; and
Whereas wooden buildings are long-lived and are easy to renovate, expand and adapt for changing uses; and
Whereas wood is visually appealing, warm and inviting; now, therefore,
Residential Mid-Rise Wood-Frame Code Change

In May of 2008, Minister Rich Coleman announced government’s intention to increase the maximum height for wood-frame residential construction from four to six storeys. These new BC Building Code requirements were approved in January 2009 and become effective April 6, 2009 giving the residential construction sector time to prepare for implementation.

New Provision # 1 – Building Height Clause 3.2.2.45.(1)(B) & (C)

Summary

This code change for building height requires that buildings built under 3.2.2.45 are less than 18 metres to the uppermost floor level of the top storey, which precludes the use of top floor mezzanines to achieve additional height without triggering high building requirements.

3.2.2.45. Group C, up to 6 Storeys, Sprinklered

1) A building classified as Group C is permitted to conform to Sentence (2) provided

   b) it is not more than 6 storeys in building height, and

   c) has a maximum height of less than 18 m measured between grade and the uppermost floor level of the top storey, and
Timber facades – Cross Laminated timber
Forte Building – 10 stories in Melbourne, Australia
Questions?

This concludes the American Institute of Architects Continuing Education Systems Course

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