Bilingual Course

An Introduction to Materials Science and Engineering

# -----Part II: Inorganic and Nonmetallic Materials

(无机非金属材料部分)

Lecturer: Z. M. Yang (杨中民)
Tel: 87114204, email: yangzm@scut.edu.cn

*An Introduction to Materials Science & Engineering*
*— Lecture 16*

## Building Materials

**Today's objectives:**

- **Why do we produce green construction materials ?**
- **What is green building materials?**




About one ton of concrete is produced each year for every human being in the world (6 billion tons per year)





Ceramic tiles

Glass

## Totally-used Construction Materials
(in USA)

- 54 % Concrete
- 25% Dry wall (residential)
- 22 % Wood
- 5% Cardboard
- 3 % Steel
- 2% Brick





Every day we face problems of

- waste construction material, rubble from the destroyed buildings
- Environmental pollution (water, air, dust)
- Depletion of natural resources
- Global warming (Greenhouse effect)





- We start by looking at the natural resources for making building materials.
- We then go to the making processes of building materials and their utilization.
- This is followed by the disposal of building material waste.
- We will analyze the social, environmental and health impacts associated with each process throughout this presentation.





Now, we start by looking at the natural resources for making building materials

## 1. Raw Materials

Silica Sand

Lime

Soda Ash





Extraction may remain large amount of rubbish on the extracted sites, causing serious environmental pollution and degradation





- Water Contamination:
  - **Blasting & digging during extraction process produce wastes & easily get into the water as runoff**
  - **In waste disposal activities, systems direct waste into rivers & tributaries**
  - **Inadequate rehabilitation of disturbed areas remain wastes behind the sites**





Nordik Mine - Drainage Downstream from Tailings in 1995

Contaminated water of mining site being pumped to a Lake

- Soil disturbance:
  - loosen the soil & cause soil erosion
  - loss of water in soil through evaporation
- Loss of nutrient & minerals in soil:
  - Wet separation process in the manufacturing process of silica sand will wash away minerals and nutrients in soil, that is important for vegetation growth, e.g. lack of magnesium for plant in soil will result in chronic



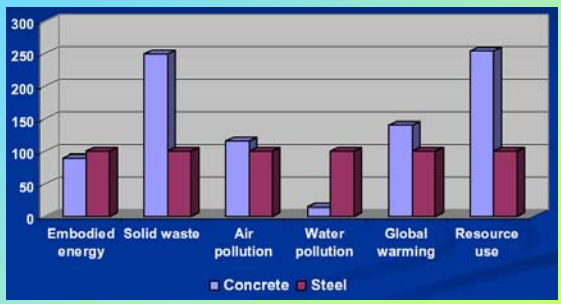


## 2. Effects from building material-manufacturing process

- **Air pollution:**
  - **–raw materials decompose at furnaces produce large volume of gas such as carbon dioxide**
  - **–combustion of gas for energy production release large amount of pollutant gases, such as sulphur dioxide and oxides of nitrogen**
- **Green house effect:**
  - **–green house gases release from the plants increase global temperature and can form acid rain**












## 3. Finally, we will discuss the Disposal of building materials

## How is building material waste treated?

- Landfill
- Recycle






## Landfill

- If people dump useless glass into the garbage and mix it with other rubbish, it will be treated as ***regular*** *waste.*
- Regular waste will then dump into waste dumping site or use for landfill
- Building materials waste will finally break down and decay into sand form naturally under erosion or weathering and once again return to our ecosystem.





## Social impact from Landfill of glass waste

- Huge amount of waste produced by human increases the need of land to get rid of the use up precious landfill space, decreasing possible areas that can be used for landfills of other waste, increasing the need to establish new expensive landfills
- Leachates & gas releases from the landfill site degrade communities' living condition & harmful to human health.





## What is green building materials?

Green building materials are composed of renewable, rather than nonrenewable resources. Green materials are environmentally responsible because impacts are considered over the life of the product.

**Green building material / product selection criteria**

- Resource efficiency
- Indoor air quality
- Energy efficiency
- Water conservation
- Affordability

**Resource Efficiency** can be accomplished by utilizing materials that meet the following criteria:

- **Natural, plentiful or renewable**: Materials harvested from sustainably managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party.
- **Resource efficient manufacturing process**: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gases.
- **Locally available**: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.





- **Salvaged, refurbished, or remanufactured**: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.
- **Reusable or recyclable**: Select materials that can be easily dismantled and reused or recycled at the end of their useful life.
- **Recycled or recyclable product packaging**: Products enclosed in recycled content or recyclable packaging.
- **Durable**: Materials that are longer lasting or are comparable to conventional products with long expectation of life .





**Energy Efficiency** can be maximized by utilizing materials and systems that meet the following criteria:

Materials, components, and systems that help reduce energy consumption in buildings and facilities.

**Water Conservation** can be obtained by utilizing materials and systems that meet the following criteria

Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas

**Affordability** can be considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget

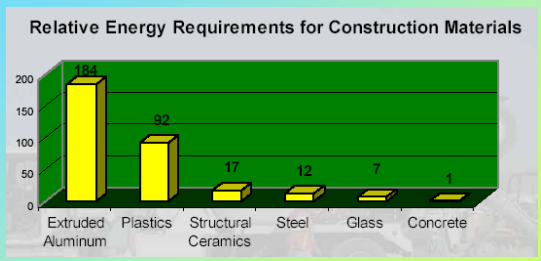




## Green concrete

- **Cement and Concrete can be made with a lot of recycled materials**
- **Concrete typically produces structures with low maintenance**
- **Durability**
- **High strength can reduce the amount of concrete required**
- **Concrete is recyclable**

## Concrete Has Low Embodied Energy








## The concrete industry uses tons of by-product and waste materials…

- **Alternative fuels for cement production**
- **Supplementary cementing materials (SCMs)**
- **Chemical admixtures (many are based on byproducts from the wood/paper industry)**
- **Wash water**
- **Recycled concrete (as aggregates)**
- **Others (in small quantities)**





## So the concrete industry does have a significant impact on sustainable development…





## Brick prepared by waste

## Recycling glass

- Recycle of glass is mostly used for packaging
- Recycle process






## Develop new building materials - CLSM

What is CLSM?

- CLSM is a self-compacting, cementitious material used primarily as backfill in lieu of compacted fill
- Compressive strength of 8 MPa or less
- Usually compressive strength is less than **1MPa**, especially when future excavation may be required.
- Typically contains water, cement, sand, and often fly ash, other by-products
- Commonly called “Flowable Fill”





## Innovative use o CLSM --“FLASH FILL”

- No portland cement, just high Ca-O fly ash, sand, and water
- Sets in less than five minutes, 1 MPa strength gain in first few hours…





## FLASH FILL

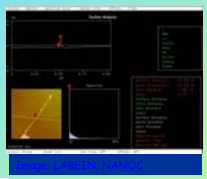
Cast at 3:00 a.m.

Hot-mix asphalt placed over CLSM BY 6:00 a.m.

New technology used in building materials







## What is Nanotecnology ?

Nanotecnology can be defined as:

- The ability to create materials, devices and systems, through control of matter in the nanoscale.
- The exploitation of properties and phenomena occurring at the nanoscale.





## Nanotechnology contribution in construction

Knowledge based economy

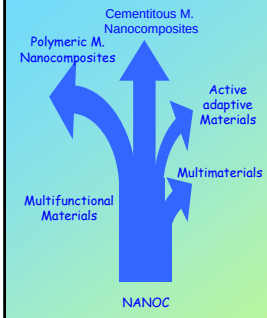
Sustainable development

- It is envisaged a great contribution to the change towards a knowledge based activity on construction materials and components supply (high performance ones)
- Nanotechnology and its application to materials (highly added value) and subsequently to construction components
- Shift from intensive resource-based to knowledge-based activity on materials
- Energy saving on buildings use



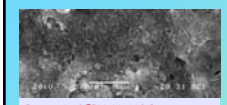


## Nanotechnology




- Nanotechnology is a competitive tool for the construction industry
- Development of ultra high performance materials for the construction
- Materials microstructure knowledge. Nano-macro connection
- Multiscale materials modelling

## Knowledge Areas



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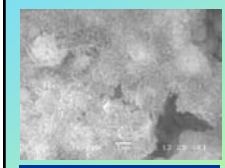


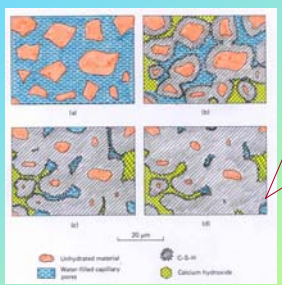
Image: LABEIN, NANOC

- Ultra-high performance materials development
  - Active-adaptive materials
  - Nanocomposites
    - Cementitious matrix
      - C-S-H gel modification
    - Nanostructures and nanofillers
  - Multifunctional materials
    - Organic-inorganic hybrid materials
- Multiscale modelling

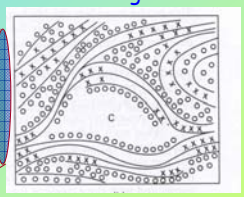




## Hydration process



## C-S-H gel



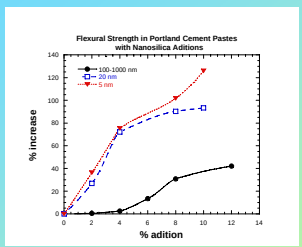
x inter-laminar water  O adsorbed water
c capillary pore  — C-S-H layers

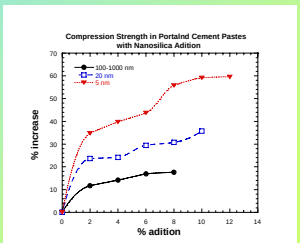
All derived properties are consequence of its nanostructured nature





## Concrete








*"It's not easy being green."* -- Kermit the Frog, 1972.

## Key knowledge to grasp

1. What is green building ?;
2. understanding characteristics of green building materials.