Division of Technical Resources
Office of Research Facilities
The National Institutes of Health
Vol. 01, No. 69
December 2015

News to Use

Design Requirements Manual

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_j U_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho\overline{U_i}\,\overline{U_j})=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U_i}}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho\overline{U_i}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ *biomedical research facilities.*

'Design Requirements Manual (DRM) News to Use' is a monthly ORF publication featuring salient technical information that should be applied to the design of NIH biomedical research laboratories and animal facilities. NIH Project Officers, A/E's and other consultants to the NIH, who develop intramural, extramural and American Recovery and Reinvestment Act (ARRA) projects will benefit from 'News to Use'.

Please address questions or comments to: shawm@mail.nih.gov

Concrete and Sustainability

Concrete is one of the most widely used construction materials, so its impact on the environment must be understood to fully assess the sustainability of any construction project. Concrete is a global environmental concern because it is estimated that the cement industry produces 5% of global carbon dioxide (CO2) emmissions[1] and concrete use is increasing.

Cement is the active ingredient in concrete and Portland cement is the most common type of cement used in the Unites States. Portland cement, which typically constitutes 7 to 15% of concrete's mass by weight, reacts with water and air and hardens (carbonates), binding together fine and rough aggregate to form a solid, strong mass. The proportion of concrete, water and aggregates and the addition of additives are used to modify the characteristics of concrete to meet the requirements of a particular application.

Environmental Concerns:
The primary environmental concern is the CO2 produced during the manufacturing and carbonation of Portland cement. During manufacturing, limestone is heated in kilns at temperatures exceeding 1000°F for a long duration, in a process called calcination. Both the fuel required to heat the kilns and the calcification process produce large quantities of CO2. As the concrete sets and carbonates a large amount of CO2 is absorbed from the atmosphere, offsetting most of the CO2 released in the calcination process. The process is a net emitter of CO2, however, due to the energy required to heat the kiln. Considering the large volume of concrete used in some projects, the quantity of emitted CO2 can be substantial.

Other Concerns:
Portland cement is highly alkaline and exposure is limited by the Occupational Safety and Health Administration. The dust produced by the manufacturing of cement and the mixing and working of concrete and concrete demolition is hazardous and must be controlled.

Environmental Advantages:
Concrete has many characteristics which can offset the environmental concerns and make it a good choice for many applications:

- Most components of concrete (limestone, water, sand, gravel) can be locally sourced and the cement can be locally produced.
- Concrete is a very durable material and can last longer than other materials due to its resistance to rot, rust and insects. The life-cycle aspects of concrete should be considered when assessing its environmental impact.
- Concrete is noncombustible, so concrete elements usually do not require fireproofing. Concrete can also be left exposed, which can eliminate the need for finish materials.

Figure 1: Concrete structure and finish panels

- Pervious Concrete can be used for exterior flatwork, including sidewalks and low-load roads and parking areas. Pervious concrete allows the passage of water to the underlying soil, reducing the need for stormwater management systems.
- Concrete manufacturing can use industrial byproducts, removing them from the waste stream. Materials include fly ash, slag and silica fume.
- Hazardous organic and inorganic materials can be used as fuel for cement kilns and are destroyed by the extremely high operating temperature
- Concrete has a higher solar reflectance (albedo) than asphalt, and can effectively reduce heat island effect when used for sidewalks, roads and other horizontal surfaces.

Recycling:
Unlike other building materials (e.g. steel, glass, aluminum), Portland cement cannot be recycled and new cement must be manufactured for every installation. Concrete can be recycled, but at a lower installed value as the original installation. High value concrete elements (structural members, wall panels, etc.) can be crushed and used as fill, aggregate and other uses requiring inert volume. Care must be taken to ensure that the concrete is not contaminated with lead paint or other hazardous materials.

References

[1] The Cement Sustainability Initiative: Progress report, *World Business Council for Sustainable Development* (1 June 2002).

Further details on this month's topic are available on the DRM website:
Design Requirements Manual
DRM Chapter 1, Section 10 Sustainable Design