STEEL REINFORCED CONCRETE:

The Sustainable Solution

GREENER CONCRETE CONSTRUCTION

Leveraging the Attributes of Reinforced Concrete in the Design of Sustainable Structures

In the built environment, the goal of sustainability is to reduce the negative environmental impacts and extend the useful application of material and energy resources in the use of a structure over its service life. This can be pursued through informed material choices, a holistic accounting of environmental impacts over all stages of a structure's life and consideration of adaptability and resilience in a world where the climate is changing. Worldwide, the broadly accepted definition of sustainability remains the one developed in 1987 by the World Commission on Environment and Development (the Brundtland Commission). Its definition offers more useful guidance related to human needs and extends consideration of impacts to both social and economic ones.

"Sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs."

Green Building & Economics

Both public and private organizations have traditionally considered development with a primary focus on first cost. However, there is an increasing trend towards a more holistic and responsible approach, referred to as the Triple Bottom Line, which incorporates the social and environmental impact of decisions and activities along with economic performance.

A common hurdle by early adopters of any new technology is a cost premium paid for employing something new or unfamiliar. While that may have been true for sustainable projects 15 years ago, experienced design firms now have portfolios of projects that weave sustainable strategies into the initial programming, rather than as a costly add-on. Studies reveal that when sustainability is integrated into initial design objectives, the total cost of ownership for a project is often competitive with or lower in cost than traditional design approaches.

Sustainable buildings typically have reduced operating costs over their lives, which can offset initial cost increases for new technologies. A classic example of this is LED lighting, which has a higher initial cost than incandescent or compact fluorescent lighting, but a longer life and lower annual operating costs. Green buildings are also built to have healthier indoor environments, leading to reduced sick days and increased worker productivity. For many owners, these factors contribute to a greater market value of sustainable buildings when compared to conventional buildings.

Reinforced concrete construction can offer cost benefits to reduce both initial and operating costs in high performance buildings. For example, flat plate floor slabs offer lower floor-to- floor heights which, for the same number of stories, corresponds to a smaller building envelope area, which can result in reductions to both initial material costs and lifetime operational energy use. Offering both resilience and energy efficiency, insulated concrete form construction combines thermal mass and insulation to create a load-bearing wall assembly whose high-performance is difficult to match with traditional stick-frame wood construction.

MODERN MATERIALS – IT'S NOT THE SAME OLD CONCRETE

Portland Cements

For over a century in the United States, ordinary portland cement (OPC) has been used for making concrete. With a market share exceeding 95% for concrete, OPC (ASTM C-150) is allowed to contain up to 5% inter-ground limestone.

In recent decades, tremendous advancements have been made in concrete chemistry. Beginning in the 1960s, Europeans experimented with portland limestone cement (PLC) which uses the same main ingredients as OPC in slightly different proportions. After 4 decades of commercial use, current European PLC standards allow up to 30% limestone additions and these PLCs have a solid history of good performance. ASTM standards for the U.S. approved the use of PLC (ASTM C595) Type 1L in 2012, which contains from 5% to 15% limestone addition. With an eye towards lower greenhouse gas (GHG) emissions, U.S. designers can employ a half-century of proven performance with PLC on buildings, paving and bridges. A specification change to PLC Type 1L cement from OPC can typically achieve a reduction of about 10% of the CO2 footprint for concrete.

South Warren High School and Middle School

In the early 2000s, Kentucky began a program for implementing high-performance schools across the state. Citing energy efficiency as a primary driver, the Warren County Public School District built their first large net-zero school and commercial building in the nation, Richardsville Elementary in 2010.

Four years later, South Warren High School and Middle School achieved the status of being the most energy efficient high school in the state. An essential component in achieving that was the load bearing insulating concrete form (ICF) envelope. These integrate dual layers of continuous polystyrene insulation with a high thermal mass core of loadbearing reinforced concrete.

The school has an Energy Use Intensity (EUI) is a measure of energy use of 22.1 (EUI per sq. ft. per year), compared to a national average of 141.4 EUI. Even seven years later, this still ranks in the top 5% of building energy performance. Despite these sustainable features and cutting-edge components, South Warren was still remarkably affordable to build. The construction cost came in at $169 per sq. ft., the lowest in the state for school construction at the time of the bid.

The district's five ICF schools, including Alvaton, Richardsville, and South Warren, saved the district $597,250 in energy costs for the 2014-2015 school year alone.

What is a Carbon Footprint?

There are many definitions of carbon footprint. For purposes of this document, it is meant to include all greenhouse gas (GHG) emissions and removals associated with a product through all life-cycle stages, from raw material extraction to end of life, excluding those GHGs from operational energy use.

PLC replaces OPC at a one-to-one ratio and can still use similar dosages of fly ash, other pozzolans, and slag cement for supplementary cementitious materials (SCMs) . Testing of fresh and hardened properties is warranted (as with any new mix design) to check air content, slump, bleed potential, setting time, and compressive strength. Many ready-mixed concrete producers report little to no adjustments are needed to achieve the desired performance for their customer's preference.

To learn more about PLC, visit: www.greenercement.com. This site is dedicated to raising awareness of and educating users about how to best employ PLC on your next project.

Supplementary Cementitious Materials

SCMs have long been used to enhance concrete's performance while reducing its environmental impact. These products are often industrial by-products from industries that have the necessary mineral content to replace virgin materials in cement and concrete production. Using SCMs is an EPA-designated best practice that reduces the amount of OPC in a mix design as well as redirecting industrial by-products from landfills.

The key to reducing the carbon footprint of concrete and maintaining quality is using a performance-based approach for specifying the mix design. As previously noted, combining SCMs with PLCs will result in even greater GHG reductions. Concrete producers are willing to consult on appropriate performance mix designs and the material availability for your project.

Concrete Advancements

In October 2021, the Portland Cement Association (PCA) released its Roadmap to Carbon Neutrality. The roadmap outlines a comprehensive plan to make the industry's value chain carbon neutral by 2050. The report demonstrates how the U.S. cement and concrete industry, along with its entire value chain, can address climate change, decrease GHGs, and eliminate barriers that are restricting environmental progress. It is aligned with the Global Cement and Concrete Association's Roadmap.

The PCA Roadmap encompasses the entire value chain, beginning at the cement plant and extending through the entire life cycle of the built environment. It identifies five main areas in their value chain for opportunity: clinker, cement, concrete, construction and carbonation (using concrete to sequester carbon dioxide). Interim goals for 2030 and 2040 have been established

THE VALUE CHAIN

NEAR- AND LONG-TERM SOLUTIONS

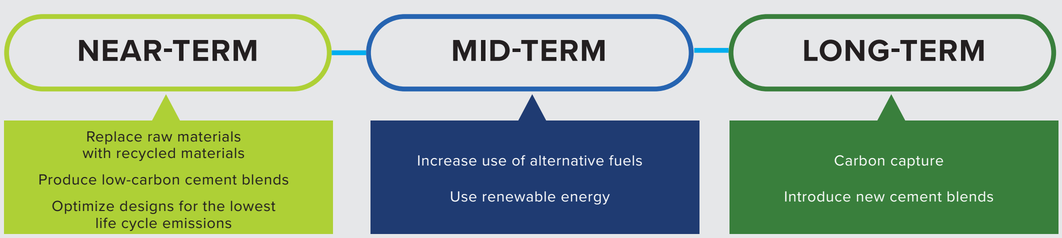


Illustration sourced from Portland Cement Association's *Roadmap to Carbon Neutrality*

*“Very little of what civilization has built, and continues to build, would be possible without relying on the **INHERENCIES** of steel reinforced concrete.”*

Photo: McKinney & Olive, Dallas, TX

for benchmarking purposes. The association notes that, over time, market conditions will inevitably change, industry innovation will occur, and governments will modify existing or issue new policies. The PCA Roadmap is subject to revision in response to these influences. PCA will publish a yearly progress report on its mission.

Steel Reinforcement

Structural concrete usually employs steel reinforcing bars to provide the necessary tensile strength to a concrete assembly. Steel-reinforcing concrete systems offer designers a broad range of performance attributes. Systems range from slender flat-plate assemblies (for low floor-to-floor heights on short span / light live load applications typical in residential/hospitality projects) to stiff and strong waffle grid or pan-formed joist and girder systems. These stiffer systems are commonly used for long spans with heavy live loads and/or vibration resistance found in laboratories and institutional markets.

According to the American Iron and Steel Institute, the domestic production of a given unit of steel today requires less than half the energy than was needed 40 years ago, resulting in a 50% reduction in GHG emissions. Domestic processing of steel for rebar uses Electric Arc Furnace (EAF) technology and scrap steel, which reduces the typical energy required to make a ton of product by about 65 to 70% over steel from virgin materials.

Micro-mill technology is the latest innovation in EAF steel production, which hot rolls steel reinforcement in one continuous operation, further reducing the manufacturing energy required. Several new micro-mill plants have been constructed in the U.S in the past decade.

Steel is the most recycled material in the world, with U.S. producers recycling more than 70 million tons of scrap each year. According to the 2022 Environmental Product Declaration (EPD) for Fabricated Reinforcing Steel, the most common reinforcing steels (ASTM A615 and A706) exceed 97% for recycled content. Specialty reinforcing steel products have a recycled material content typically greater than 75%.

After its service life is complete, both concrete and steel reinforcement can be recycled, into fill and base for the concrete and yet another steel application by the rebar.

CONCRETE IN APPLICATION

Concrete is the most used human-made material on the planet – more than steel, wood, plastic and aluminum combined. The wide-spread use of concrete across the globe is due to the attributes it provides for its users. It is highly durable, and does not rust, rot or burn. It's strength and stiffness make it suitable for the dams, bridges and the world's tallest buildings as well as smaller structures such as hospitals, hotels and homes. It is produced from some of the most commonly available minerals and is an economical construction option virtually everywhere.

Over the past decade of green building, best practices emphasize the concept that design and development teams consider the following strategies collaboratively, with a focus on where new efficiencies can be created, materials optimized and both initial and operational costs reduced. The earlier in the design process that these strategies are evaluated collaboratively, the better.

Energy Efficiency

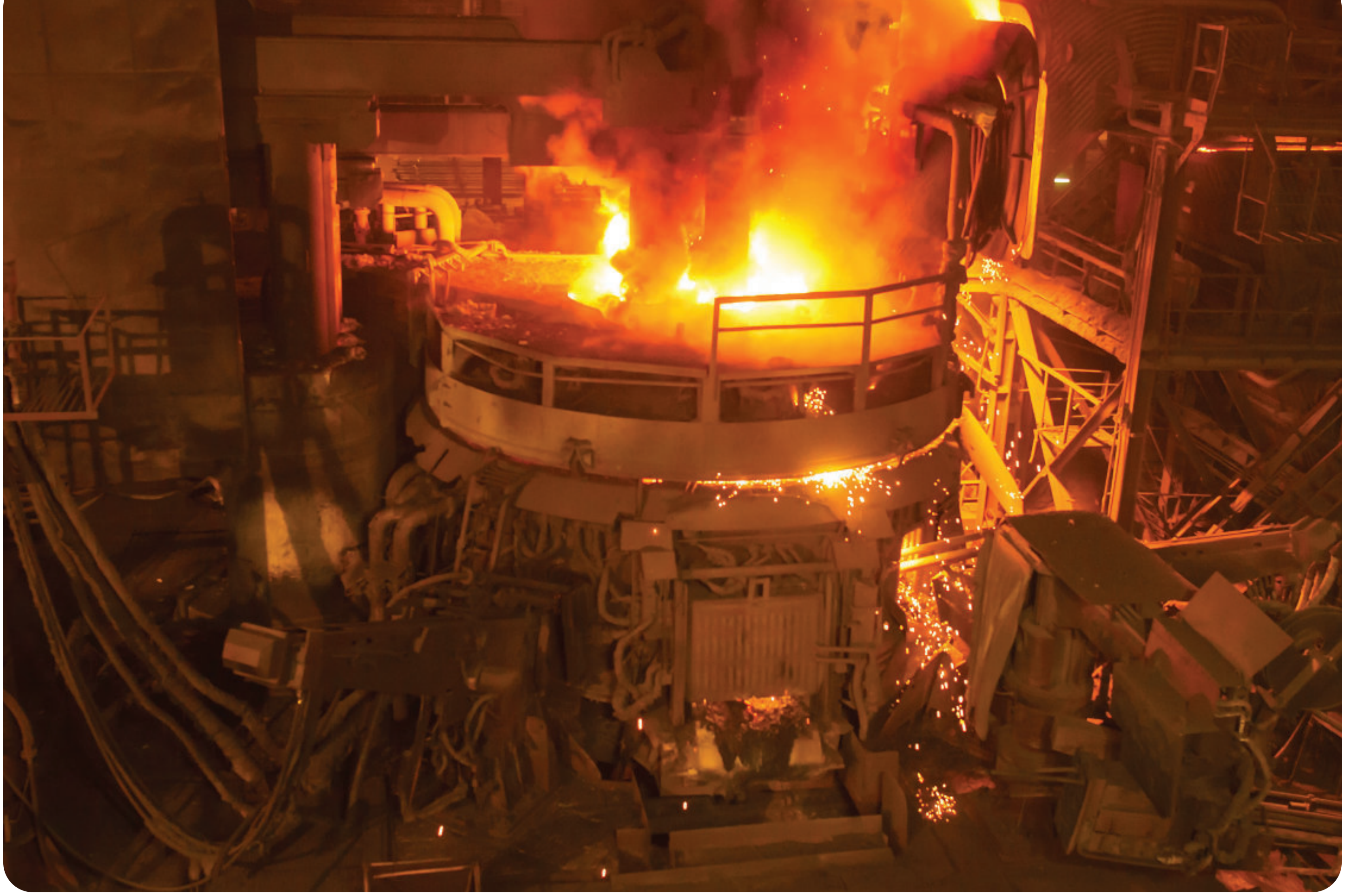
Today's concrete framing systems reduce operating energy in three ways:

- Unlike frame walls with batt insulation, insulated concrete form (ICF) and pre-cast systems employ continuous insulation from footing to parapet.
- Monolithic concrete construction reduces number of joints and the potential for undesired air infiltration.
- Concrete offers a unique energy-saving advantage because of its inherent thermal mass. Concrete absorbs energy slowly and holds it for much longer periods than do less massive materials.

Daylighting

- Concrete's high albedo reduces initial construction and operational energy costs by lowering artificial lighting fixturing requirements and energy consumption as well.
- Energy savings from effectively day-lighted spaces can reduce initial mechanical, electrical, and plumbing equipment requirements and lower operational costs over time.
- Light-colored spaces enhance a feeling of security and comfort.


Photo: Wong Tai Sin Temple, Ontario, CN



All steel reinforcing bar produced in the United States come from electric arc furnaces (EAF), as opposed to traditional blast furnaces, that greatly reduce CO2 emissions. Furthermore, steel mills are investing in new casting process that do not require reheating to create finished products.

Acoustics

- The greater mass of concrete walls significantly reduces sound penetration through a wall when compared with wood- or steel-frame construction.
- Monolithic site-cast reinforced concrete reduces joints and possible paths for sound transmission.

Indoor Air Quality

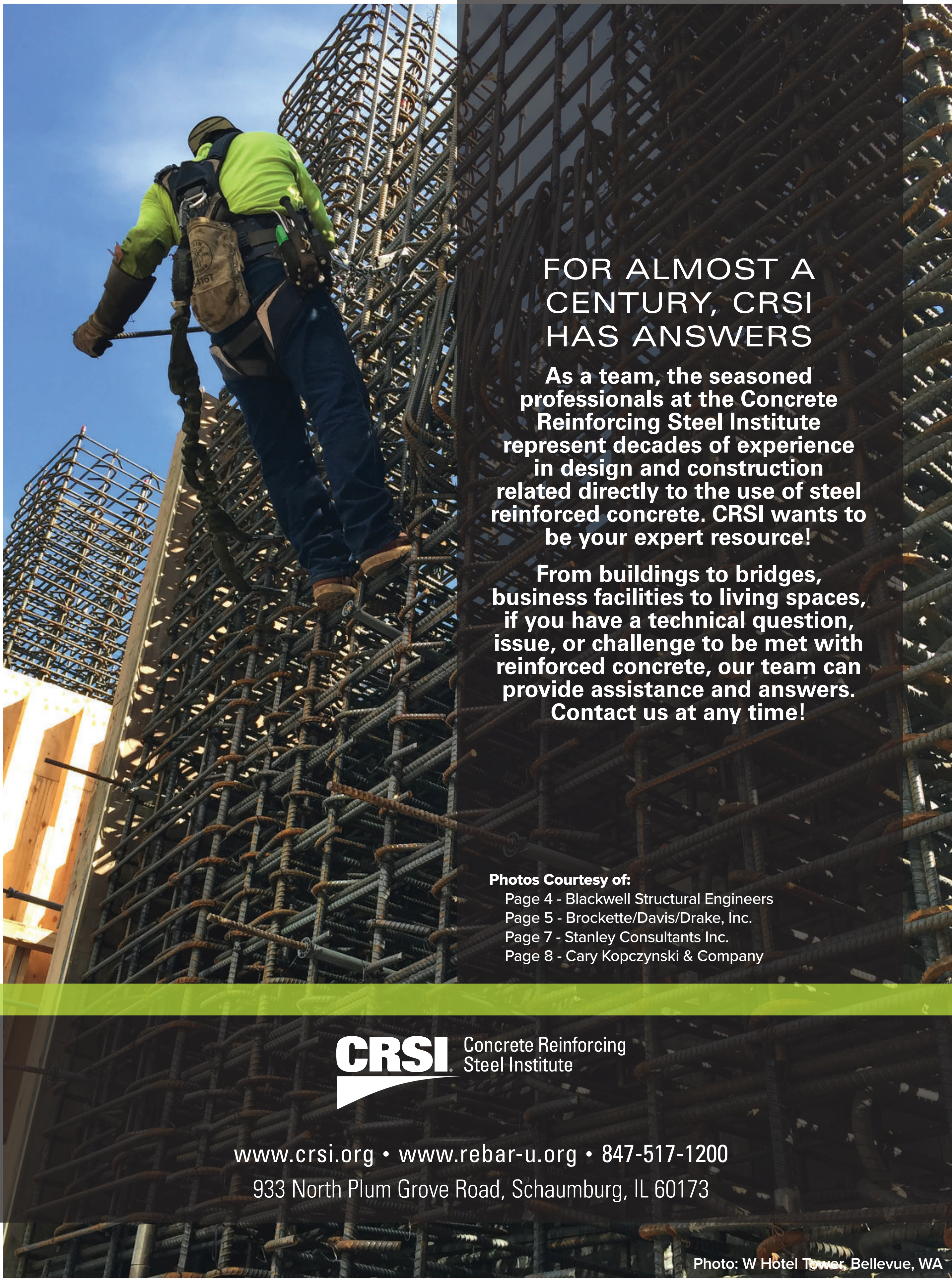
- Concrete's inorganic mineral nature contains no to negligible levels of volatile organic compounds that can degrade indoor air quality.
- Exposed concrete walls and ceilings require no additional coatings or finishes, which can contribute to lesser indoor air quality.
- Substantial material and maintenance savings are possible with polished concrete floors as compared to applied finishes such as carpeting or tile.

Resilience and Adaptive Reuse

- Concrete's inorganic makeup means it doesn't burn or rot, nor is it a food source for mold, insects and vermin.
- Buildings with reserve capacity are more readily adaptable to functional changes thus enhancing market value for building owners.
- A reasonable increase in load capacity to a concrete building can be achieved with only a nominal increase in the structural cost. This economy applies to virtually all concrete floor systems.

Locally Sourced

- Both concrete and reinforcing steel are produced at locations across the U.S. and sold locally.
- Reduced shipping distances minimizes transportation impacts and subsequent GHG emissions. Local economies benefit from locally produced materials.


FOR ALMOST A CENTURY, CRSI HAS ANSWERS
As a team, the seasoned professionals at the Concrete Reinforcing Steel Institute represent decades of experience in design and construction related directly to the use of steel reinforced concrete. CRSI wants to be your expert resource!
From buildings to bridges, business facilities to living spaces, if you have a technical question, issue, or challenge to be met with reinforced concrete, our team can provide assistance and answers. Contact us at any time!
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CRSI Concrete Reinforcing Steel Institute
www.crsi.org • www.rebar-u.org • 847-517-1200
933 North Plum Grove Road, Schaumburg, IL 60173
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