## High-Impact Building Materials for the New Generation of Construction

- Carbon-Neutral Concrete
  - Concrete is one of the most-used building materials on Earth but its environmental impact is significant. Cement production alone is responsible for around 8% of global $CO_2$ emissions.
  - Several companies are developing ways to lower this footprint. Some now inject captured $CO_2$ into fresh concrete. This carbon stays locked inside, reducing emissions without hurting strength. Others are making cement-free concrete, using materials like steel slag or fly ash instead.
  - Another example is CarbiCrete, which uses steel slag and $CO_2$ curing to make carbon-negative concrete, it removes more carbon than it emits.
  - As more builders use low-carbon mixes, tracking strength on-site becomes critical. Real-time tools now let crews monitor curing. This helps them remove formwork at the right time, cut delays, and avoid using more cement than needed.
- Self-Healing Concrete
  - All concrete cracks over time. But now, some cracks can heal themselves.
  - Self-healing concrete uses bacteria or special chemicals mixed into the concrete. When water seeps into a crack, these agents activate. The bacteria produce calcium carbonate, which fills the crack just like how a scab heals a cut.
  - This technology was first developed at TU Delft in the Netherlands. It's already been used in Amsterdam's canals, where fixing concrete is hard and expensive.
- Cross-Laminated Timber (CLT)
  - Cross-laminated timber (CLT) is a strong wood panel made by gluing layers of lumber at right angles. This crisscross design makes it strong enough to replace concrete or steel in many buildings. It's also much lighter and has a lower carbon footprint.
  - CLT panels are built in factories and shipped to job sites. They go together like a kit, making buildings faster and cleaner to build. Less waste, fewer workers, and shorter timelines make CLT a smart choice.
- Engineered Bamboo
  - Bamboo isn't just for scaffolding anymore. It's now one of the top green building materials of 2025.
  - Engineered bamboo is gaining attention as a lightweight, renewable alternative to traditional construction materials. While trees can take decades to mature, bamboo grows in 3–5 years and regrows without replanting.
  - Builders turn bamboo into beams, panels, and flooring by pressing treated strips together. These products meet building codes and hold up well in damp climates. Projects like the Green School in Bali use bamboo for frames and trusses. In North America and Europe, it's showing up in floors, walls, and even structural studs.

    - The bamboo nursery classroom with bent beams and a radial roof system, designed for young learners in a naturally lit and breathable structure. Photo Courtesy of Will Cottrell Art.
    - Bamboo is also a carbon sink that absorbs $CO_2$ as fast as it grows. But like any natural material, it needs proper treatment to last and stay insect-free. Still, when handled right, it's tough, flexible, and even helps in earthquakes.
- Recycled Steel
    - Steel is one of the world's most recycled materials and a smart choice for green construction in 2025.
    - Making steel from recycled scrap uses up to 75% less energy than making it from raw materials. Some factories now even run on clean electricity, which makes their steel even more eco-friendly.
    - Recycled steel is just as strong as new steel. It's used in beams, rebar, panels, and frames for everything from homes to bridges.
    - A great example is the Centre Block Rehabilitation Project in Ottawa. Engineers reused nearly 1,700 steel beams from the original Parliament building. This smart reuse saved around 625 metric tons of $CO_2$ and kept the project more sustainable.
    - Recycled steel also helps keep costs stable, since scrap is widely available. For large or complex buildings, it remains one of the best-performing and greenest materials around.
- Smart Glass and Solar Windows
    - Smart glass and solar windows are advanced building materials that dynamically control light and heat, offering energy efficiency and other benefits. Smart glass can change tint or opacity to modulate light and heat, while solar windows can generate electricity from sunlight while remaining transparent. Technologies like electrochromic, liquid crystal, and thermochromic coatings enable smart glass to adjust tint, while transparent photovoltaic technology allows for on-site energy generation.
- Graphene-Enhanced Concrete
    - Graphene-enhanced concrete is a new material that uses graphene as an additive to improve the strength, durability, and sustainability of traditional concrete. Key benefits include reduced carbon emissions, higher mechanical strength, improved durability against elements like chlorides and sulfates, and potential for use in smart sensors due to its electrical conductivity. These enhancements are achieved by using graphene's unique properties to reinforce the concrete matrix and reduce the amount of cement required.
- Fiber-Reinforced Polymers (FRPs)
    - Fiber-Reinforced Polymers (FRPs) are composite materials made of a polymer matrix reinforced with strong fibers, commonly glass, carbon, or aramid. They are used in industries like aerospace, automotive, marine, and construction for their high strength-to-weight ratio, corrosion resistance, and durability. FRPs can be

used for structural reinforcement, creating high-performance components, and in ballistic armor.

- Modular Building Systems
  - Modular building systems construct buildings in prefabricated, three-dimensional sections (modules) in a factory, then transport and assemble them on-site. This off-site construction method allows for greater speed, efficiency, sustainability, and quality control while meeting the same codes as conventional buildings. The modules can be joined side-by-side or stacked to create a wide range of building configurations for various applications, from homes to commercial offices and even cleanrooms.
- Green Roofs and Living Walls
  - Some of the most exciting building “materials” aren’t materials at all, they’re living things.
  - Green roofs are rooftops covered in plants. They include special layers to hold soil, water, and drought-tolerant greenery like grasses, sedum, or wildflowers. These roofs help cool buildings, reduce stormwater runoff, and clean the air.
  - In Toronto, new large buildings are required to include 20–60% green roof coverage. Today, the city has over 1 million square meters of green roofs.