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Construction Concerns: Composite Materials and Assemblies

May 8, 2017

By Gregory Havel

For www.fireengineering.com *Photos by author*.

Architects and engineers often use “composite” materials and assemblies to achieve greater strength using less material, saving space inside the building and often reducing cost.

A composite material is one in which two dissimilar materials are combined to take advantage of the best characteristics of both materials.

A common example is the composite of concrete and steel. Concrete has little tensile strength, but greater compressive strength. Steel has both tensile and compressive strength, but it has a greater cost than concrete. Adding steel reinforcing bars, cables, or wire to concrete at the locations in a column, beam, or structural slab where greater tensile strength is needed results in a composite called reinforced concrete. The reinforced concrete structural assemblies have more compressive strength than ordinary concrete, most of the tensile strength of steel, and it occupies less space inside the building than a concrete assembly of equivalent strength (although it occupies more space than one made of more expensive steel). A composite beam of concrete and steel can also allow greater unobstructed spans in a building without interior columns or load-bearing walls.

Photo 1 shows the assembly of reinforcing bars and wire in a foundation wall and load-bearing column.

(1)

Photo 2 shows a prestressed concrete “double-tee” presenting the array of steel cable tendons near the bottom of the load-bearing beam.

(2)

Sometimes, composite floors of concrete and steel are constructed. Photo 3 shows a composite of concrete on corrugated galvanized sheet steel with embossings to better bind to the concrete.

(3)

Photo 4 shows the underside of this floor, supported by steel bar joists.

(4)

Post-tensioned concrete floors are also an example of steel and concrete composites. (See the July 2009 “Construction Concerns” for details and photos of this construction method.)

Other common examples of composite structural elements include the following:

- Wood trusses in which the compression members are of heavy timber (photo 5) or dimensional lumber (photo 6) and the tension members are of steel tubing or rod with much smaller dimensions.
- Flitch plate girders, sandwich a steel plate between two pieces of dimensional or manufactured lumber [laminated veneer lumber (LVL), parallel strand lumber (PSL), or laminated strand lumber (LSL)] with bolts or other mechanical fasteners holding the assembly together. This provides a girder or beam with greater strength than wood alone; uses less materials and has less depth than a wood member of equal strength; and can use standard carpentry connections like nails, screws, and sheet metal hangers. (For details and photos of this type of composite, see the “Construction Concerns” articles dated April 14, 2008; May 15, 2008; and April 10, 2012.)
- A brick and block wall is used in less expensive concrete masonry units (CMU) (or hollow tile or terra cotta units), behind the brick where it does not show, and where the brick and block are both part of the load-bearing wall. Photo 7 shows a composite masonry wall in which the CMUs are notched to accept full-depth header courses, which bind the brick and CMU into a load-bearing composite.

(5)

(6)

(7)

This type of composite does not include a brick-veneered CMU wall; in this type of construction, the CMU is the load-bearing element; the brick is a non-load-bearing veneer, and they are often separated by a cavity that may or may not be filled with insulation.

From the left, photo 8 shows the load-bearing CMU wall with embedded anchors for the brick veneer, two inches of rigid polystyrene foam board insulation, a two-inch cavity, and the brick veneer. The anchor system used to connect the load-bearing CMU wall and the non-load-bearing brick veneer allows for the load-bearing CMU and the brick veneer to expand and contract at different rates because of temperature changes.

(8)

To function properly, the materials in a composite structural element must remain bonded together so that they can function as designed. If the bond between the elements is weakened or broken, the two elements will begin to function independently of each other, will be weaker than the original composite, and can fail under less load for which the composite was designed to carry. This failure is likely to occur under or above firefighters and other emergency responders.

Events and conditions that can set up composites for failure include the following:

- Fires, both room-and-contents and structural.
- Earthquakes, floods, and high winds where the building and its structural elements can be stressed beyond their design limits.
- Moisture damage, including swelling and rotting of wood elements, and oxidation (rusting) of steel elements.

Tours of buildings under construction or renovation can acquaint us with the composite structural elements that are used in buildings, and this information can be added to our preincident plans. Company fire inspections can also suggest that there may be a weakening of composite structural components in that area (if any) from evidence of pipe and roof leaks and wall openings, and that the building's owner or occupant needs to follow up on this condition for the health and safety of our personnel responding under emergency conditions.

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