Lightweight concrete plays important role in

'Construction Breakthrough' in Chicago's Hancock Center

A 100-story building with unit costs comparable to those of a building half its size is being hailed as a major technological breakthrough in building construction — and owes much of its economy to the use of expanded shale lightweight concrete in a composite design in its floor slabs.

Topped out in May of this year at 1,107 feet above ground level — plus twin, 344-foot TV antennae — the John Hancock Center on Chicago's Near North Side is the tallest combined residential-office building in the world, and has a gross area of 2.8 million square feet. It represents the largest single real estate investment in the 104-year history of John Hancock Mutual Life Insurance Company.

A tower tapering on all four sides, from 50,000 square feet at the base to 16,000 square feet at the summit, the building represents a unique approach to architecture, with the structure functioning as an integral part of the exterior, using diagonals to provide stability and strength. In effect, it is a bridge-type structure consisting of a vertical truss.

In a perpendicular rather than tapering design, the structural system could be extended to 150 stories, say the architects.

The Hancock frame consists of vertical exterior columns and diagonal members crossing the building face several times in the full height. All of these members are capable of functioning as compression and tension members particularly when subjected to lateral loads during extreme winds. Essentially, the frame is a braced rigid vertical tube with dimensions equal to the exterior dimensions of enclosing frame.

Lightweight concrete was chosen for the slabs because of the great dead load savings involved in a structure of this magnitude. Additionally, the structural engineers planned for the decks to provide diaphragm action throughout the building, and it was determined that the most economical way in which to do this was to use a lightweight composite design. The deck was designed so that the concrete slab was attached directly to the steel support beams by means of headed stud shear connectors — as opposed to concrete fill on a metal pan.

By specifying lightweight concrete, the designers realized a great saving in concrete dead load, which resulted in smaller, lighter weight steel beams. By utilizing composite design, additional weight savings were gained because smaller sections were required to carry the superimposed loads. These weight savings were also reflected in column sizes and foundation costs.

The designers, in order to facilitate their studies of the structural system, had a full size section of floor constructed and load tested to failure. The section of deck

Contrasting vividly with Chicago's historic Water Tower, the John Hancock Center exhibits the bridge-type structure which will enable it to withstand high lateral forces against its 1,107-foot height. Lightweight concrete in floor slabs played important role in economy of structure, with unit costs comparable to those of buildings half its height.

was made up of two 14 WF 34 beams, 31 feet in length, with 32 equally spaced ¾" x 3" headed shear studs welded to the center of the top flange. The two members were spaced 10 feet apart, spanning 30 feet. A 5" thick lightweight concrete slab was cast, 31 feet long and 20 feet wide (a 5 foot overhang beyond each beam) reinforced with one layer of 6x6-6/6 WWF top and bottom.

The initial load tests and vibration tests were carried out at ambient temperatures ranging from 30 to 65 degrees. The test to failure was conducted at 15 days. All of the test results were extremely satisfactory, with a factor of safety of over 2.2 in the test unit.

Owner — John Hancock Mutual Life Insurance Company.
Architects — Skidmore, Owings & Merrill, Chicago.
Construction Consultant — Paul A. Keim.
Ready-Mix Supplier — Material Service Division, General Dynamics, Chicago.
Materialite lightweight expanded shale aggregate from Marblehead Lime Company, a subsidiary of General Dynamics, Chicago.

Towering above nearby buildings, John Hancock Center tapers from 50,000 square feet at base to 16,000 square feet at summit. Twin, 344-foot TV antennae will extend building's total height to 1,451 feet above ground level. Engineering studies indicated that the most economic way to meet structural requirements was through use of lightweight concrete in composite construction in which deck is "keyed" to support beams by headed shear stud connectors.