Fiber Reinforcement in Residential Concrete

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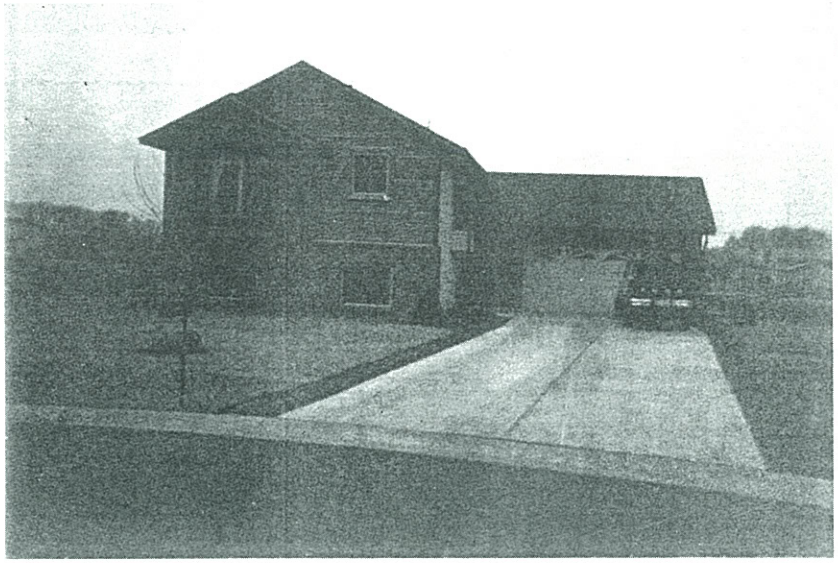
Though the basic theory of using various forms of fibrous reinforcement in building materials is centuries old, synthetic fibers have only been used in concrete construction since the mid-to-late 1970s. Of the many synthetics available, polypropylene has become commonly used due to its high tensile strength (70,000 psi [480,000 kPa]), its relatively low cost, and its chemically inert nature. While may synthetics are resistant to alkali and chemical attack, polypropylene is inert or impervious to attack and does not absorb water, making it the most suitable synthetic to use in a portland cement concrete.



Courtesy of P.M. Gagnon Construction/Norwood Homes, Anoka, Minn.

Fig. 1 — Single family house constructed using polypropylene fibers in the concrete.

Basic fiber types

Many types and grades of fibers are available today, and most fit into two basic categories: fibers for early plastic shrinkage control and fibers for improved long-term crack control. Almost any type of discreet fiber (if properly and uniformly distributed) can help reduce plastic shrinkage cracking in the very early life of the concrete (i.e. the first three to six hours).

By improving the mechanical bonding or anchoring ability of the fiber within the concrete matrix, the fiber may be expected to offer improvements to residual strength — the ability to carry some degree of load after cracking. These improvements may be obtained by resorting to a heavier or coarser fiber, longer fiber lengths, increased dosages, etc. This type of fiber is more apt to anchor within the paste and continue to work rather than debond and pull out under stress.

Both types of fiber have been used extensively as a secondary (non-structural) crack-control reinforcement in commercial or industrial applications such as interior floor slabs, machine pads and overlays, and exterior pavements and parking areas. Polypropylene fibers are also now commonly used in residential concrete applications.

Residential applications

One of the first known residential uses of polypropylene fibers in the U.S. was in March of 1979 in western Pennsylvania. In this project, a 2¼ in. (57 mm) long fiber was used at a dosage rate of 1.6 lb/yd^3 (0.95 kg/m^3) of concrete in the exterior sidewalks and steps and interior basement floor slab areas.

Since that time, polypropylene fibers have been used in countless residential concrete projects throughout the country. The fibers have been used in relatively small projects such as single family homes and in larger multi-family housing units. For instance, one concrete contractor and home-builder located near Minneapolis, Minn., has used polypropylene fibers to control cracking in more than 300 custom-built homes (Fig. 1).

Polypropylene fibers were also used in more than 100 yd^3 (76 m^3) of curbs, sidewalks, walkways, and steps for the multi-family Harbor Homes project in Erie, Pa. (Fig. 2).

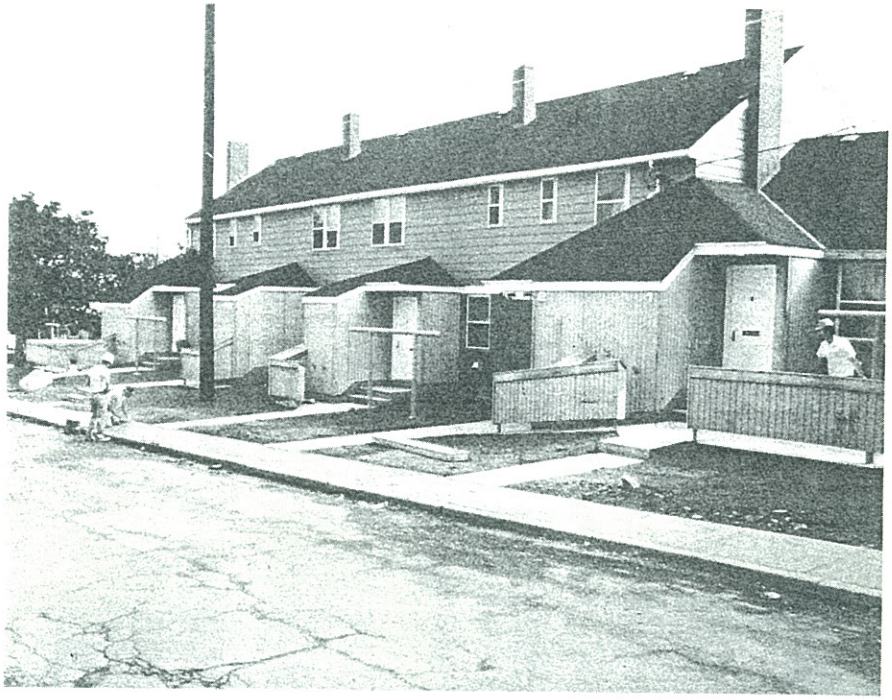


Fig. 2 — Harbor Homes housing project, Erie, Pa., used polypropylene fibers in the curbs, sidewalks, and steps.

Residential advantages

Polypropylene fibers have gained a rapid acceptance in residential applications due to their flexibility. They have the ability to conform to forms, such as in the case of a winding residential driveway with multiple curves and turns (Fig. 3).

As a result, polypropylene fibers have been used in many residential areas, such as driveways, patios, sidewalks, garage and basement floors, pool decks, and cast-in-place walls. In many areas of the country, homebuilders promote concrete as a highly durable, low maintenance, and attractive construction surface to enhance their particular home design. Polypropylene fibers have aided many of these same builders in improving the concrete's image by reducing the potential cracking and subsequent homeowner complaints.

Precautions

Polypropylene fibers have proven to be very effective over their more than 10 year history, but their use does not constitute a guarantee for crack-free concrete. Though fibers certainly can control and inhibit temperature-related cracking, good concrete is heavily dependent on good design, water-cement ratios, ambient temperatures, wind conditions, etc.

It would also be advisable to alert the home buyer to the potential change in surface finish appearance of fiber reinforced concrete. In the case of polypropylene fibers, though they float in plain water due to their 0.91 specific gravity, they do not float to the surface or sink to the bottom in a portland cement concrete matrix. There may be fibers at or near the surface simply because they are distributed three-dimensionally throughout the slab.

Even the coarser and longer long-term performance fibers can be effectively ingrained in the surface finish of the slab if the proper finishing techniques are observed. The fibers can be made to virtually disappear by resorting to smaller dosages of very short, hair-like fibers, but, if this is done, any benefits of the hardened concrete may be reduced or eliminated. Surface fibers are naturally more apparent with a textured or broom finish due to the scouring or scrubbing of the surface paste, but finishing tips are available to minimize or camouflage their appearance.

Polypropylene fibers have proven to be a viable and valuable construction material in residential applications. However, regardless of how effective fibers have been over a reasonable period of time, their use certainly does not replace good concrete practices. Polypropylene fibers should not be expected to replace structural reinforcement, and they are not a replacement for adequate concrete cross-section, joints, curing, or proper mix design. If used properly, polypropylene fibers can help control plastic shrinkage cracking and therefore improve the merits of concrete construction in residential applications.

Fig. 3 — Fibrous reinforcement conforms to forms.

Selected for reader interest by the editors.

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