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SIMCON: Slurry Infiltrated Mat Concrete

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SIMCON: SLURRY INFILTRATED MAT CONCRETE

THE NEED

The cost of civil infrastructure constitutes a major portion of the national wealth. Its rapid deterioration has thus created an urgent need for the development of novel, long-lasting and cost-effective methods for repair, retrofit and new construction. A promising new way of resolving this problem is to selectively use advanced composites, such as High-Performance Fiber Reinforced Cementitious Composites (HPFRCCs). With such materials, novel repair, retrofit and new-construction approaches can be developed that would lead to substantially higher strengths, seismic resistance, ductility, durability, while also being faster and more cost-effective to construct than conventional methods.

FIGURE 1 SIMCON: CONTINUOUS FIBER-MAT HIGH-PERFORMANCE
FIBER REINFORCED CEMENTITIOUS COMPOSITES

THE TECHNOLOGY

The investigations conducted in North Carolina University have demonstrated that a special type of continuous fiber-mat HPFRCC, called SIMCON which stands for Slurry Infiltrated Mat Concrete, is well suited for the development of novel repair, retrofit and new-construction solutions that lead to economical and improved structural performance. SIMCON, uses a manufactured continuous mat of interlocking discontinuous steel fibers, placed in a form, and then infiltrated with a flow able cement-based slurry. The use of continuous mats, typically made with stainless steel to control corrosion in very thin members, permits development of high flexural strengths and very high ductility with a reduced volume of fibers. The experimental results demonstrate that SIMCON exhibits improved properties in tension, compression,

flexure and shear even when comparatively low fiber volume fraction fiber-mats are used. Furthermore, since fiber-mats are pre-packed in the plant, distribution and orientation of fibers can be more accurately controlled, than is the case with short discontinuous fiber HPFRCs. These characteristics allow for the manufacturing of a unique cement-based fiber composite that can have different yet easily controllable properties in the longitudinal and transversal directions. These material characteristics are desirable in repair/retrofit of structural elements such as columns, which require a high increase in strength and toughness in the transverse direction while increasing only ductility but not strength in the longitudinal direction (i.e., "moment-carrying" direction). The investigations also demonstrate that SIMCON has considerable potential for both seismic repair/retrofit, as well as the development of novel, high-performance composite structural systems. In a retrofit situation continuous SIMCON fiber-mats, delivered in large rolls, can be easily installed by wrapping around members to be rehabilitated. In new construction of high-performance composite frames SIMCON is well suited for manufacturing high strength, high ductility, and thin stay-in-place formwork elements that eliminate the need for secondary and most of the primary reinforcement. Straight fibers can pull free of the matrix material if the fibers bond weakly with the surrounding matrix. On the other hand, if the fibers bond strongly with the matrix, they can snap under the high stresses generated by a crack in the matrix. The bone-shaped fibers connect mechanically with the matrix predominantly at their ends. They have a weak interface, and so don't experience extreme stress, but remain anchored at their ends and so still help carry the load felt by the composite. The bone-shaped fibers promote significant plastic deformation in bridging ligaments and the formation of multiple cracks. Multiple cracking is another effective mechanism for improving the composite toughness. Distributed multiple cracking allows more bridging bone-shaped fibers to plastically deform.

Step 1. Re-bars wrapped in SIMCON are put along the column to provide moment continuity through the joint region, as well as replacement of concrete with SIMCON in the anchorage region of the discontinuous bottom beam reinforcement.

Step 2. Additional layers of SIMCON mat are added to increase moment capacity at the column and beam zones facing the joint.

Step 3. The entire column (and portion of adjacent beams) is jacketed with SIMCON. Formwork is put next and mat is injected with a high-strength slurry (say 14,000 psi).

FIGURE 2 SIMCON: IMPLEMENTATION PROCEDURE

THE BENEFITS

The presence of a SIMCON layer led to: (a) both improved structural performance and durability of the member, and/or (b) optimization of member dimensions, amount of reinforcement and member weight. A two-dimensional layout of SIMCON and its unique manufacturing properties related to its fiber-mat configuration, open up novel possibilities for a cost-effective and improved structural performance that were not previously possible using other HPFRCCs, FRCs or any other conventional construction materials. Construction with SIMCON was also found to be simpler than if other HPFRCCs, reinforced concrete, steel plates or different non-cement based composites were used. It is thus anticipated that when used in repair, retrofit, or new construction, the proposed approach will be less labor and equipment-intensive and more economical than conventional methods.

Manufacturing of SIMCON is based on the use of widely available construction equipment and building expertise, and can thus be relatively easily introduced into the field without major re-training and changes in existing construction practices. Hence, this novel type of HPFRCC provides some unique new ways of developing durable and cost-effective high-performance infrastructural systems, essential for the economic well-being of the nation in the next century.

STATUS

New generation of HPFRCCs made with continuous fiber-mats, called Slurry Infiltrated Mat Concrete (SIMCON) can be used in: (1) seismic retrofit, (2) the development of a novel, partially-cast-in-place High Performance Composite Frame, and (3) the development of a "self-stressing" SIMCON stay-in-place formwork that can provide active confinement after the core of the member has been cast-in-place.

Silacon sought assistance from Los Alamos National Laboratory and The Department of Energy to develop further high performance concrete. The Government is funding the DOE to provide new technologies to rebuild the Nation's bridges, dams and government structures.

BARRIERS

The use of SIMCON in seismic retrofit and for new construction, and the development of self-stressing SIMCON are still under investigations. It is anticipated that, if successful, the investigations could open a new approach in developing durable and cost-effective solutions to the problems of the aging civil infrastructure, essential for the economic well-being of the nation in the next century.

POINTS OF CONTACT

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REVIEWERS

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