Macro synthetic fibres replace steel fabric in Chilean housing

Chile is experiencing prosperous growth and a booming local construction industry as the nation's average household disposable income sky-rockets. One of the companies battling to meet demand is IPEC Constructions who found Barchip Macro synthetic fibre the perfect answer to increase efficiency.

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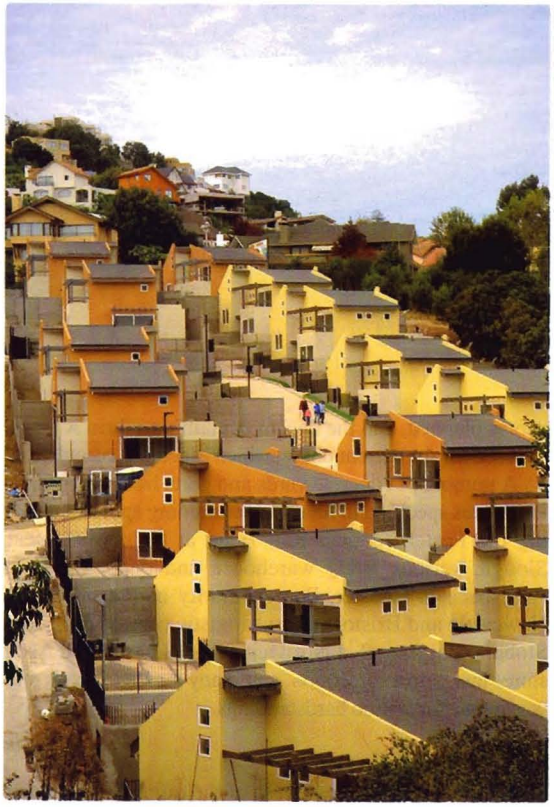

(Photos: Elasto Plastic Concrete.)

Figure 1: IPEC Constructions' 'Jardines del Sol 1' in Renaca, Chile – constructed with Barchip Marco synthetic fibre in the foundations, slabs, walls and roadways.

"Synthetic fibre is extremely light and portable, available in convenient 3kg bags and the site requires no preparation for reinforcement prior to casting or pouring."

The use of synthetic fibres in residential construction remains relatively new. Only in recent years has the performance of synthetic fibre improved to a level where it can match traditional steel fabric in construction. The increasing cost of steel has contributed to making synthetic fibre a competitive cost option. One of the commonly overlooked advantages is the amount of handling and transport required by traditional steel fabric. Synthetic fibre is extremely light and portable, available in convenient 3kg bags and the site requires no preparation for reinforcement prior to casting or pouring. So has the Chilean construction industry gained a head start by replacing steel fabric with synthetic fibre in housing?

In July 2007, IPEC completed its third condominium complex 'Jardines del Sol 3' (Sun Gardens 3) using Barchip Macro synthetic fibre to replace steel fabric in the concrete foundations, slabs, tilt-up walls and roadways.

"Our company has developed from civil and infrastructure projects into housing construction, so we are not new to the role of reinforcement in concrete," says Miguel Perez, IPEC's managing director. "The drive to consider synthetic fibre was part of our strategy to continually search out new technologies to improve our cost base. And this was the challenge I presented to Jim Phillips from Elasto Plastic Concrete. I think he will agree when I say the greatest challenge facing synthetic fibre was its performance in our concrete walls and tilt-up construction method."

Jim Phillips, manager of Elasto Plastic Concrete in South America, worked with Miguel through the engineering design and construction of three condominium complexes: "This is a very important point when you are attempting to introduce a new technology to any existing construction method. Understanding how a company operates and constructs is going to ensure the eventual performance of the product. There were many issues to address from the best way to replace steel reinforcement, the handling of fibre at the batch plant; the mix design; in some situations how to combine synthetic fibre with steel reinforcement; and the traditional working methods of screeding and finishing."

Miguel says the outcome of using macro synthetic fibres proved very worthwhile, "Our use of Barchip (synthetic) fibres has allowed us to significantly reduce conventional steel reinforcement. This means there is less handling and labour involved in construction and we are able to achieve gains in the time required to complete the project.

"In the foundation and slabs we are no longer using steel fabric, which has been completely replaced with Barchip. But we are using steel bars for tie-down purposes. In the tilt-up walls we are using steel fabric in the first floor walls but there is almost no steel in the second level walls, which relies completely on Barchip for reinforcing. This is an important point because it is from the top edge of the walls that we tilt and lift the walls into position. We cast the tilt-up concrete walls (first and second level) directly onto the floor slab and, generally, we let them cure for five days before we erect them."

EPC developed the Barchip Macro synthetic fibre and has undertaken comparative testing between its structural synthetic fibre and steel fabric (welded wire reinforcing) using what is known as the Large Round Panel Test (LRDP), which is similar to the ASTM C 1550[1] standard test. The results reported by EPC over a range of low and high concrete strengths show that Barchip Macro outperforms steel fabric for crack widths up to 5mm.

"The advantage of Barchip Macro over fabric is that it reinforces through the full depth of the slab and prevents the crack from propagating wherever it might start," says Jim. "What interests most engineers, in civil and construction applications, is the performance of reinforcement at small deflections where cracks are only 1–2mm. A crack of 5mm is considered a major failure regardless of the type of reinforcement being used."

Miguel is quick to add that his research has shown improved anti-seismic characteristics in the Barchip reinforced concrete due to the tri-dimensional nature of the reinforcement. "The matrix of the fibre throughout the concrete provides greater control and the synthetic fibres produce a more ductile structure that is able to absorb high levels of energy. Additionally, I have noticed problems that we were having with the appearance of very fine cracks due to shrinkage while curing, which has been resolved with Barchip."

Figure 2 right: 'Jardines del Sol 3' in Val Parasio, Chile – tilt-up wall construction using Barchip Macro synthetic fibre.

Figure 3 far right: Barchip Macro has been used exclusively to reinforce the concrete foundation and slab. The only steel used is for tie-down purposes.

Figure 4 right: Barchip Macro is added at the concrete batching plant. Mix recommendations from EPC indicate Barchip should be added bag-and-all to initial water and prior to adding aggregate and cement.

Figure 5 far right: Formwork for tilt-up walls on the house slab. The formwork for two walls can be seen. Also the 5mm round steel peg used to secure formwork into position. Damage caused to the floor surface from this construction method has been reduced to nil using Barchip Macro synthetic fibre.

"In the tilt-up walls the use of fibre is very important. We place sheets of polystyrene in the wall for insulation, reducing the concrete thickness in sections to 50mm. The fibre makes the walls more flexible than steel and this accommodates lifting the walls and positioning them using a crane on site. Our ability to have thin walls with high insulation helps reduce cost and our clients notice and appreciate the difference living in these thermally insulated houses.

"We cast everything on-site and the walls of each house are cast directly on one of the house slabs. In the past this method of construction has caused a great amount of damage to the flooring surface, requiring extensive repair work before installing the ceramic flooring. With Barchip there is no spalling when the 5mm steel bars we use to secure the formwork are removed from the surface of the slab. This is important to us because the floor is used as a working surface not only to make the walls but also all the concrete elements of the house including the overhead beams."

Barchip macro for each application

- **Foundations** – the foundation is reinforced with a dosage of 4kg/m^3. Steel cages have been replaced. Starter bars remain for the purpose of tie down.
- **Slabs** – the slab is reinforced with a dosage of 3kg/m^3. Slab thickness has been reduced from 80mm to 60mm.
- **Tilt-up walls** – the wall is reinforced with a dosage of 4kg/m^3. The walls include polystyrene for thermal insulation. The first level walls are reinforced with steel and fibre. The second level walls are reinforced only with fibre. A single perimeter bar remains to assist with the load during tilting of the walls into position.
- **Internal roadways** – the roadway is reinforced with a dosage of 4kg/m^3. This fibre-reinforced concrete has completely replaced a traditional asphalt surface.

Concluding remarks

Miguel has also changed the traditional approach IPEC Constructions took to building roadways within the condominium complexes by replacing asphalt with synthetic-fibre-reinforced concrete.

"With roadways the main idea is to support a high level of traffic. On a construction site with over 100 houses there is a lot of heavy traffic with trucks and machinery. Combining research from Australia, the USA and the Chilean Institute of Concrete, I found the EPC equivalence tables for fabric to fibre to be very accurate.

"The fibre-reinforced concrete pavement has an excellent appearance and functions very well when compared to asphalt under high temperatures. This change has also completely removed our reliance on any asphalt contractor. We can now better control the cost of roadways and doing the work ourselves means we have greater flexibility in scheduling the work.

"Our workers on-site do everything else so it is excellent that we can now also complete the roadways. Our workers have adapted easily to these changes, mainly because the concrete application is the same. We acquire the concrete pre-mixed with the fibre from the concrete plant. There is no need for any workers to be involved in this activity. There have been only minor changes to our finishing technique." ■

References:

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS, ASTM C 1550. *Standard test method for flexural toughness of fiber-reinforced concrete (using centrally loaded round panel)*. ASTM, Pennsylvania, USA, 2004.