Media communiqué

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Fiber-reinforced polymers lend new life to old buildings

A "sticking plaster" for geriatric, earthquake-endangered buildings.

Carbon fiber reinforced polymer (FRP) composites are frequently used today to strengthen buildings to make them suitable for new applications and uses, as well as to prevent them suffering earthquake damage. The success of this modern material is due to its ease of use and its lightness. New products, however, must be handled with a certain degree of caution. In mid-January experts from all over Europe gathered at Empa to discuss their experiences involving novel applications with these fiber composite materials.

Just about twenty years ago the then Director of Empa Duebendorf, Prof. Urs Meier, introduced the use of carbon fiber reinforced composites to the construction industry. In what became a quiet revolution, the then rather expensive material proved itself invaluable thanks to its special properties, above all in the aviation and space industries. In countless projects since then, Meier has shown incontrovertibly that carbon fiber composites are also very well suited to use in the building sector, in particular as a substitute for steel reinforcing when structures need to be retrospectively strengthened. Today it is impossible to imagine the building industry without carbon fiber reinforced composites, the two main reasons for this being that these materials are extremely light and resistant to corrosion. Initially the high price was counterbalanced by the ease of handling and use. Increased demand and resulting greater production rapidly brought down the purchase cost of FRPs. And demand is bound to continue to rise, because ever more applications are coming to light as more and more elderly concrete building become due for renovation. In such cases the use of carbon fiber reinforced composites is often the most economic solution – why demolish an old building and replace it with an expensive new one when it could be economically repaired using these modern materials?

Buildings on the shaker platform

This "boom" must, however, not be allowed to lead to sinking safety standards. These are monitored by a working group from the International Federation for Structural Concrete (*fib*), which publicizes the use of carbon fiber reinforced composites in the building industry and simultaneously produces recommendations on their safe use. The working group met in the middle of January at Empa to exchange ideas and experience, and to discuss and work on guidelines. In parallel a symposium took place at which eight well-known engineers reported on their current research work – making buildings earth-quake proof – and other particularly interesting applications using carbon fiber composites. For example Kypros Pilakoutas of the University of Sheffield (UK) and his colleague Marco Di Ludovica of the University of Naples (I) described their work in constructing two and three storied buildings on shaker platforms and then subjecting them to high levels of acceleration. Even at these loads the structures strengthened with carbon fiber reinforced composites suffered little damage, while those which were not so equipped would have rapidly collapsed.

The head of Empa’s Structural Engineering Research Laboratory, Masoud Motavalli, whose own researchers had about eighteen months ago used powerful hydraulic servo actuators to shake a one-family house in Canton Wallis, showed the audience pictures demonstrating how historic buildings in Iran (and also the Swiss Embassy in Teheran) have been rendered earth-quake proof using carbon fiber reinforced composites. One by-product of this project was the transfer of up-to-date research results by the Empa scientist (who is also an Assistant professor at Teheran University) to colleagues in his country of origin, which of course is frequently subject to severe earthquakes. In addition one of Motavalli’s coworkers, Christoph Czaderski, presented a newly developed method which allows carbon fiber reinforced strips to be placed under tension before being attached to the building structure in a “prestressed” state using adhesive without any permanent anchorages. Prestressed strips have the advantage that, for example, the strengthened structure shows smaller distortions and cracks.

An interesting variation on the theme of fiber reinforced material comes from Greece. Thanasis Triantafillou of the University of Patras replaced the modern carbon fibers with textile-based ones, using standard mortar as a binder instead of polymer. Even if laboratory tests showed that his materials did not quite achieve the same high values as the high-tech materials, the textile composite materials do have certain advantages. One decisive plus point lies in its cost-effectiveness – while it is true that the textile fibers must be specially made, and are therefore not significantly cheaper than carbon fibers, the mortar used costs practically nothing when compared to the polymer binder. Another is that “normal” building workers are capable of carrying out the reinforcing work with the “low-tech” material, obviating the requirement to employ expensive specialists.

An end to messing around!

Urs Meier, who in December was awarded the «Lifetime Achievement Award» by the International Institute for Fibre-Reinforced Polymers in Construction (IIFC) for his work in the field of carbon fiber reinforced polymers, concluded the seminar by casting a look into future. The man who was once responsible for bringing this then new technology from the aerospace sector into the construction industry spoke once again of the need to learn from the aircraft industry. Instead of “messing around” with liquid adhesives (as he put it), he wanted to be able to use ready-impregnated FRP strips. A doctoral student at Empa was already working on means of achieving this “clean” method of application.

In any case structural strengthening work in general needed to be made more professional and more automated, otherwise reinforcing large structures would no longer be a practically proposition. Meier gave an example: stabilizing the Felsenau bridge in Bern required about 8 km of carbon FRP strips. Not an easy task, when strip after strip had to be attached by hand. For this reason Meier wished for equipment which would allow the strips to be placed and attached automatically. One must not forget, said the pioneering user of carbon fiber reinforced polymers speaking from experience, that the building industry accepted innovation rather slowly. It had taken twelve years for his ideas on the use of carbon FRP to become widely accepted. Perhaps the representatives of the building industry present at the seminar could show that today progress would not take quite so long?

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At the «2nd Young Researchers' Conference on FRP Reinforcement in Construction», which took place just prior to the symposium, the international jury awarded the «Best Paper Award» to both (left to right) Ernst L. Klamer, Eindhoven University of Technology, and Lander Vasseur, University of Ghent, who each received a silver Mirko-Ros-Medal. The Best Poster Award went to Dionysios A. Bournas, University of Patras, who also received a silver Mirko-Ros-Medal.

A two-storey building on the shaker platform. Thanks to the carbon fiber reinforced polymer material attached to the structure with adhesive, it is capable of withstanding high levels of acceleration.

A building wall strengthened with carbon fiber reinforced polymer strips

Images and text are available in digital form from remigius.nideroest@empa.ch