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FRP Reinforcement for Concrete Structures : State-of-the-Art

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Summary

Several types of FRP (fibre reinforced polymers) reinforcement have been developed in recent years. These elements are not susceptible to the usual types of corrosion. The paper gives a survey of the main characteristics of FRP reinforcement and shows some of the applications.

Keywords: Fibre Reinforced Polymers, FRP reinforcement, concrete, state-of-the-art

1. Introduction

If properly designed, constructed and maintained, reinforced or prestressed concrete structures generally have service lives of 50 years and more. Nevertheless, durability problems often occur, among which corrosion of steel, especially for concrete structures in aggressive environments. Hence, there is an increasing interest in the use of non-metallic reinforcement which is not susceptible to the classical types of corrosion. Recent evolutions in the field of material engineering offer new possibilities, such as the use of advanced composites or "fibre reinforced polymers". These so-called FRP reinforcements can serve as a viable alternative to reinforcing and prestressing steel, as has been demonstrated by several research and demonstration projects.

2. Materials

As structural reinforcement for concrete members, FRP elements are made available in the form of bars, tendons, ropes, grids, sheets or profiles. For new structures, they are used to reinforce and prestress concrete elements. In the repair sector, they are used to strengthen existing structures e.g. by means of external post-tensioning, external sheet bonding or in combination with shotcrete. The tensile stress-strain behaviour of FRP made of aramid, carbon and glass fibre (AFRP, CFRP and GFRP) as compared to reinforcing and prestressing steel are shown in figure 1. Similar to the behaviour of the fibres and unlike steel, FRP do not experience any yield but rather a linear elastic

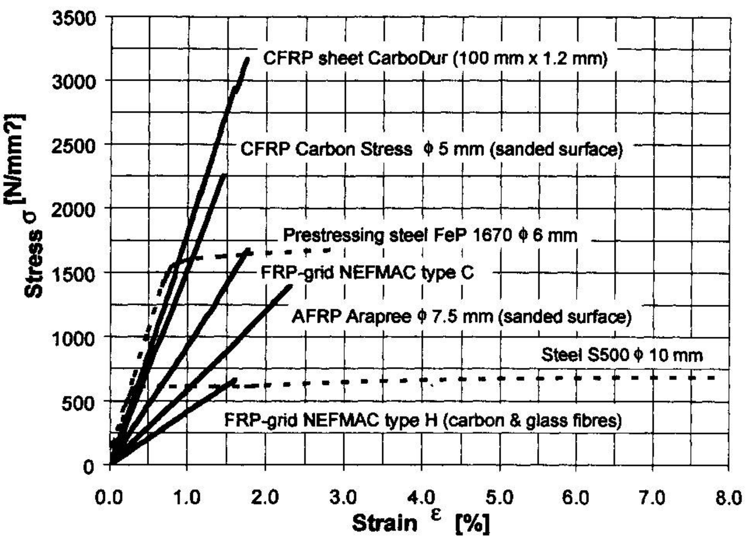

Fig. 1. Stress-strain curves of FRP elements

behaviour nearly up to failure. Compared to steel, the Young's modulus for FRP is often much less and ranges between 50 to 250 GPa, while the tensile strength is close to that of prestressing steel. The mechanical properties of aligned composite materials transverse to the fibres are much less than those parallel to the fibres.

3. State-of-the-Art Overview

When FRP is used for reinforced concrete (RC), the low modulus of elasticity results in large deformations. This makes FRP (from a structural point of view) more suitable for prestressed concrete (PC). Nevertheless, a number of projects with FRP RC members have been completed. Concerning pre- and post-tensioning with FRP, several applications are available in Japan, Europe and North-America.

Whereas, the application of structural FRP reinforcement for RC and PC members basically concerns demonstration projects so far, the use of externally bonded FRP reinforcement is growing commercially in a fast way. With this strengthening technique both advanced properties and ease-of-application are offered.

4. Design Guidelines

The considerable interest in FRP as structural reinforcement will only successfully result in applications on a broader basis, if design guidance and finally code regulations are available. In Japan, the U.S.A., Canada and Europe several initiatives have been. A fib (International Concrete Federation) Task Group "FRP Reinforcement", convened by the first author, is elaborating design recommendations based on the design format of the CEB-FIP Model Code and Eurocode 2.

5. Conclusions

FRP reinforcement may offer a practical and economical alternative to conventional steel reinforcement. It must be appreciated that the application of FRP reinforcement is partly in an experimental stage and that different aspects of this new technology will be the subject of more detailed investigations. Nevertheless, several initiative to establish design guidelines have been taken as a result of the considerable interest in this novel reinforcing material.

The application of FRP reinforcement is related to the utilisation of the specific material properties of FRP. Therefore, it has to be used as a specific alternative for common steel reinforcement, rather than a general substitute for it.