UDC 691.87

METHOD OF MODELING AND PROTOTYPING TERMINAL CONNECTORS FOR TESTING AND OBTAINING PRESTRESSING FRP REINFORCEMENT

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The paper presents the possibility of using the technique of rapid prototyping, 3D printing method based on additive technologies. The resulting product, according to the three-dimensional construction of production technology, allows obtaining the characteristics of the stress and deformed state, as well as navigating to the characteristics of natural products, as model can be manufactured as a plastic or fiberglass one.The use of modeling method has become a characteristic feature of science. In view of this fact, it seems appropriate to consider the problem of the relationship of this method and various sciences in order to find the most adequate, objective and reliable foundation of scientific research. The paper presents the possibility of applying a fiberglass reinforcement in prestressed structures.

Modern views on the use of non-metallic reinforcement have gained greater resonance, ie, used in conjunction with metal designs. However, physical and mechanical properties are much better. This fixture has a high corrosion resistance, in salts, chemical solutions, alkalis and acids. For fiberglass based on polyester resins, a number of general properties relating to their chemical resistance are determined based on the chemical structure of the resins being esters. To expand the applications of composite nonmetallic reinforcement and a detailed study of its joint work with concrete it is advisable to continue research and test various structures, the use of non-metallic reinforcement in prestressed concrete structures. Three ways of prestressing concrete structures with discrete fiberglass reinforcementare mainly used : tension at stops, tension on concrete, continuous winding.

The use of fiberglass reinforcement is expedient only in prestressed structures as fiberglass rods modulus areseveral times lower (4–5 times) than metal. In cases withfiberglass reinforcementoften three basic methods of prestressing concrete structures are used:

1. Tension on abutments (Fig. 1).

This method involves pulling avalve to the desired value with the help of special devices, followed by concreting and concrete hydrothermal processing for faster curing.

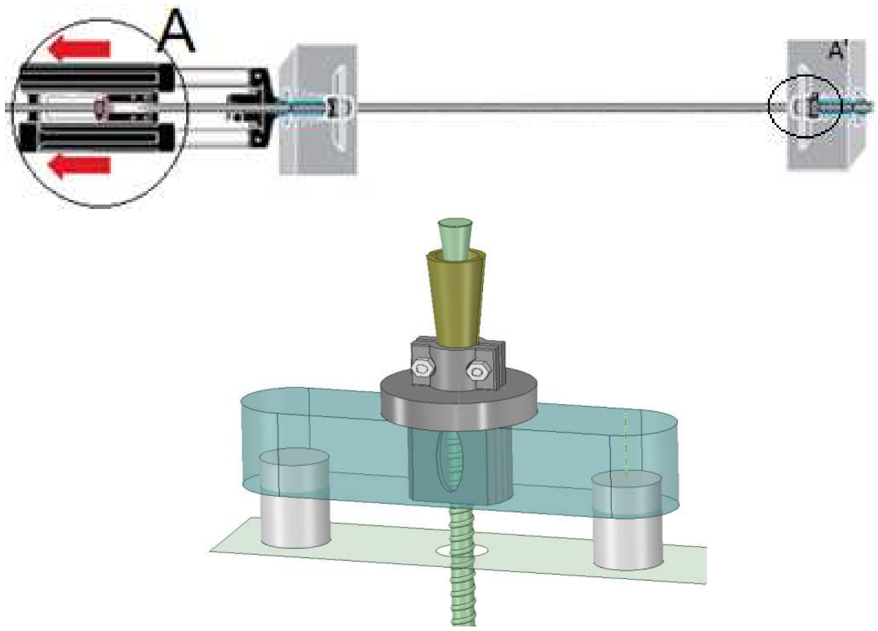

Fig. 1. The method of obtaining pre-stressing by means of hydraulic jacks

2. Tension on concrete.

When tensioning on concrete, channels are laid in it for laying the fiberglass reinforcement. The tension of the reinforcement in this case is made by means of hydraulic jacks, and petrolatum is injected into its systems to fix it.

3. Continuous winding.

This method, which, by the way, is not widely used in modern construction, is coiling ona concrete product of flexible rods or strips of fiberglass.

Developed device (Fig. 2) for testing of fiber reinforcement consists of worm jaws (1) mountedat the ends of fiber reinforcement (3)which is arranged within the support plates and gussets (2), corrugated reinforcement of glass fiber, eliminates the possibility of stress concentrators, the compressive force is controlled by loosening or tightening bolts. Feature constructive execution device is collapsible design elements that provides multiple use. The aim is to reduce the cost of the production of cement and concrete products, reinforced with glass fiber reinforcement periodic profile. The Use of this device enhances the reliability of the results obtained during the test because of lack of destruction in the clamp rod seats. Furthermore,the use of the developed device can create prestressing reinforcement FRP.

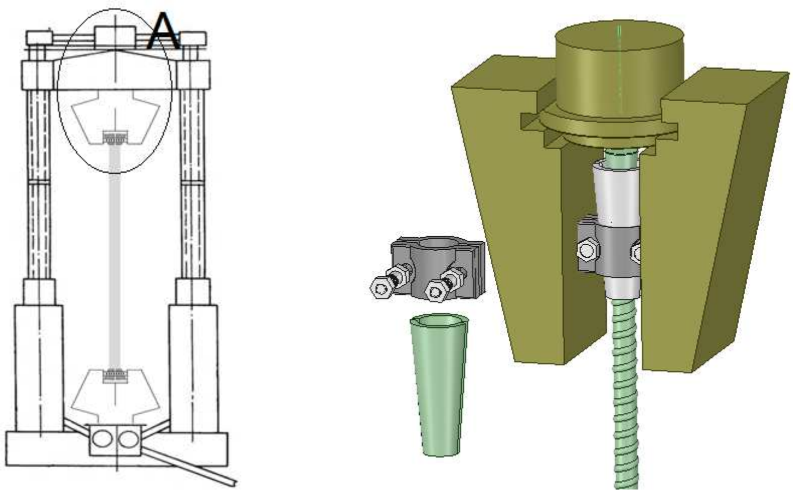

Fig. 2. The terminal clamp for testing and obtaining prestressing FRP reinforcement

In discussions related to the properties of FRP bars or tendons, the following points must be kept in mind. First, an FRP bar is anisotropic, with the longitudinal axis being the strong axis. Second, unlike steel, mechanical properties of FRP composites vary significantly from one product to another. Factors such as volume and type of fiber and resin, fiber orientation, dimensional effects, and quality control during manufacture, play a major role in establishing product characteristics. Furthermore, the mechanical properties of FRP composites, like all structural materials, are affected by such factors as loading history and duration, temperature, and moisture.

While standard tests have been established to determine the properties of traditional construction materials, such as steel and concrete, the same cannot be said for FRP materials. This is particularly true for civil engineering applications, where the use of FRP composites is in its stage of infancy. It is therefore required that exact loading conditions be determined in advance and that material characteristics corresponding to those conditions be obtained in consultation with the manufacturer.

Table 1. – Comparison of mechanical properties

	Steelreinforcingbar	GFRP tendon
Tensilestrength, MPa (ksi)	483–690 70–100	165–2410 240–350
Yieldstrength, MPa (ksi)	276–414 40–60	Notapplicable
Tensile elstic modulus, GPa (ksi)	200 29,000	152–165 22,000–24,000
Ultimateelongation, mm/mm	> 0.10	0.01–0.015
Compressive strength, MPa (ksi)	276–414 40–60	Notapplicable
Specificgravity	7.9	1.5–1.6

Mechanical properties of composites are dependent onmany factors including load duration and history, temperature, and moisture. These factors are interdependent and, consequently, it is difficult to determine the effect of eachone in isolation while the others are held constant.

Tensile strength—FRP bars and tendons reach theirultimate tensile strength without exhibiting any materialyielding.Thecomparison of the properties of FRP and steel reinforcingbars and tendons is shown in Table 1. The mechanicalproperties of FRP reported here are measured in thelongitudinal (i.e. strong) direction. Values reported for FRPmaterials cover some of the more commonly available products.

Unlike steel, the tensile strength of FRP bars is a functionof bar diameter. Due to shear lag, fibers located near the centerof the bar cross section are not subjected to as much stressas those fibers that are near the outer surface of the bar. This phenomenon results in reduced strength and efficiencyin larger diameter bars.

Compressive strength—FRP bars are weaker incompression than in tension. This is the result of difficultiesin accurately testing unidirectional composites in compression,and is related to gripping and aligning procedures, andalso to stability effects of fibers. However, the compressivestrength of FRP composites is not a primary concern formostapplications. The compressive strength also dependson whether the reinforcing bar is smooth or ribbed.

Creep and creep rupture—Fibers such as carbon andglass have excellent resistance to creep, while the same is nottrue for most resins. Therefore, the orientation and volume offibers have a significant influence on the creep performanceof reinforcing bars and tendons. One study reports that for ahigh-quality GFRP reinforcing bar, the additional straincaused by creep was estimated to be only 3 percent of the initialelastic strain. Under loading and adverse environmental conditions, FRPreinforcing bars and tendons subjected to the action of a constantload may suddenly fail after a time, referred to as theendurance time. This phenomenon, known as creep rupture,exists for all structural materials including steel. For steelprestressing strands, however, this is not of concern. Steelcan endure the typical tensile loads, which are about 75 percentof the ultimate strength, indefinitely without any loss ofstrength or fracture. As the ratio of the sustained tensilestress to the short-term strength of the FRP increases, endurancetime decreases. The above limit on stress may be of little concern for mostreinforced concrete structures since the sustained stress inthe reinforcement is usually below 60 percent. It does, however, require special attention in applications of FRP compositesasprestressing tendons. It must be noted that otherfactors, such as moisture, also impair creep performance andmay result in shorter endurance time.

Test methods are important to evaluate the properties of resin, fiber, FRP composite, and structuralcomponents. The resin groups included are: polyester, vinyl ester, epoxy,and phenolic. The fibers included are: E-glass, S-2 glass, aramid,and carbon. FRP composites made of thecombination ofthe above resins and fibers with different proportions areused for reinforcement of concrete members as bars, cables,and plates. Test methods are needed to determine properties of FRP products. Test results are used for qualitycontrol during production and for field use. Hence, test methods must be reproducible and reliable. Variation of testprocedure and specimen geometry should be addressed todevelop meaningful comparisons. Statistical methods of approvalare needed to establish the properties of bars, plates, and cables. Other tests that take into consideration environmentalchanges such as temperature and moisture should beincluded in the evaluation of FRP products.

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