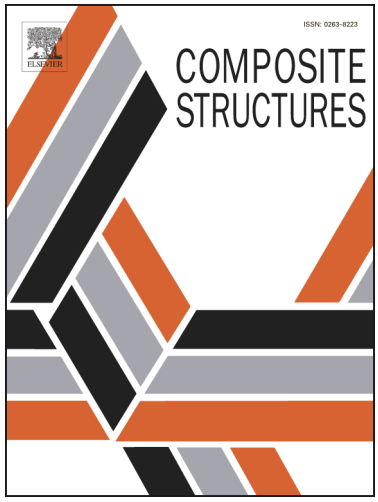

Experimental study of concrete beams prestressed with basalt fiber reinforced polymers. Part I: flexural behavior and serviceability

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Experimental study of concrete beams prestressed with basalt fiber reinforced polymers. Part I: flexural behavior and serviceability

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Abstract. Current research presents a comparative experimental investigation and introduces a new prestressing system for concrete members considering composite materials such as basalt fiber reinforced polymers (hereinafter–BFRP) in lieu conventional steel reinforcement. Certain three groups of total 12 large–scale beams and one non–prestressed control beam were tested depending on the degree of prestressing of the reinforcement. This paper summarizes a study undertaken to analyse flexural behavior in particular to deflection, cracking growth and stiffness. Further research of prestressed BFRP concrete is introduced in order to expand potential application of basalt composite materials in the industry.

Keywords: Prestressed concrete; Basalt fiber-reinforced polymer (BFRP); deflection; cracking; corrosion; LNG; marine; oil and gas.

1. Introduction and background

Nowadays industry economics promotes to use optimal engineering materials and construction techniques. Concrete structures still are very competitive and successfully have been employed in civil engineering industry. But there are many other sectors very important to economy growth of any of the country worldwide such as energy sector: oil product storage units, gas pipelines and risers, gasholders, liquefied natural gas (hereinafter–LNG) and petrochemical terminals; and marine (cargo wharves, petroleum terminals, offshore platforms, piers, quays, jetties, dolphins, fender systems, bulkheads, floating barges and dry docks etc.) infrastructure (see Fig.1) which has high durability and quality requirements for the concrete as a key performance material for the resistance of the specific environmental conditions effecting long–term maintenance of the infrastructure.

In regard to oil industry, in particular to crude oil storage, it often contains anaerobic bacteria which generate sulfides upon contact with seawater. If oxygen is available, they convert to weak sulfuric acid, which can attack weak, porous concrete. Some recent experiences [1, 2] indicate that if air is present over the crude oil, epoxy coating is warranted in the above–oil zones. The hydrogen sulfides (hereinafter–H_2S) and sulfuric acids (hereinafter–H_2SO_4) which may, however, cause corrosion of steel reinforcement and embedment details, refined products, such as gasoline, may be aggressive. Marine structures rank among the foremost applications of concrete. It was early recognized as the optimal material for harbor and marine structures because it combines durability, strength and economy. Considering that concrete is immersed in seawater, a chemical attack on the concrete is maximized i.e. reactivity between alkali in cement and reactive aggregates might be increased by accelerating corrosion of steel. The most serious aggressive element is chlorides, carried to the concrete surface by the splash of seawater. In order to resist environmental conditions mentioned above durability of concrete undertakes a key performance role [3, 4, 5]. Lack of durability may address to cracking, corrosion, excessive deflection and in special cases, failure of the member. Prestressing method itself improves durability by preventing cracking which minimizes the penetration of water and air. Also, prestressed concrete has been shown excellent cryogenic properties at low temperatures (–160 ^{o}C) [6]. However, even concrete member is prestressed, corrosion of reinforcement is still most frequent and most serious form of degradation of the concrete structure and leads to excessive maintenance costs of the remaining design life of the infrastructure. Concrete structures may also experience heating/cooling, freezing and wetting/drying cycles, which also promote concrete decay and subsequent steel corrosion. Consequences mentioned above promote a considerable amount of research in United States, Great Britain, Spain and Baltic States in order to