Current state of application building structures, strengthened with external composite reinforcement

Andriy Muryn[1], Roman Kanafotskiy[2]

Department of Bridges and Structural Mechanics,
Lviv Polytechnic National University, UKRAINE, Lviv,
S. Bandery street 12,
[1]E-mail: muryn@ukr.net

[2]E-mail: prime_lviv@ukr.net

Abstract* – *Necessity of strengthening of reinforced-concrete constructions for road bridges are described in the paper. Advantages of application of fiber reinforced plastics comparatively with the traditional strengthening are described. Standards and guidelines for reinforced concrete elements, strengthened with FRP, examples of application FRP in Ukraine and world are described.

Key words – building constructions, external strengthening, fiber reinforced plastic.

I. Introduction

In 20 century buildings have been made from the same types of materials - generally masonry, timber, steel and concrete. Fibre reinforced polymer (FRP) composites have been used in aerospace for over 50 years and are now being used in the buildings industry. Initial applications were with small components, but these have been followed by more significant construction including complete structures.

For many years, pays special attention to the strengthening of structures to enhance their performance. In many countries testing and application of non-metallic reinforcement as an alternative to traditional strengthening with steel elements. The main advantages of non-metallic fittings: high strength, corrosion resistance, lightness and ease of use, no need for docking to length, high fatigue strength, convenient and easy way to use.

II. Standards and guidelines for reinforced concrete elements, strengthened with FRP

The American Concrete Institute, Japan Society for Civil Engineers and other groups, developed the specifications and test methods for structures, strengthened with external composite reinforcement, many of which have already been approved and used in construction.

General guidelines for designing bendings concrete structures, strengthened with FRP, are described in the report ACI 440.1R-06 (2006) "Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars", developed by the American Concrete Institute (ACI).

ACI 440 recommendations based on the principles of equilibrium and compatibility of materials. Have adopted new approaches to design that are considering crushing element FRP, or destruction of the compressed zone of concrete, taken as a basis for a method of limiting states. Concrete elements, reinforced with FRP, projecting strength conditions, and then tested for fatigue slip reinforcement elements and criteria for serviceability. In most cases, the criteria for operational reliability or fatigue or slippage is crucial.

Designers should consider the feasibility of concrete elements, strengthening with FRP, given to projects following basic items:

– direct replacement of steel reinforcement in concrete elements in the FRP is not possible in most cases;
– lower elastic modulus and shear strength limited application of FRP;
– in the fiberglass rebar maximum stress shall not exceed 25% of the guaranteed strength;
– can not use fiberglass rebar as an element of prestressing or tensing element.

International research has resulted to the development of standards and guidelines for reinforced concrete elements reinforced with FRP.

Currently there are the following standards and guidelines:

USA

ACI 440R-07 (2007) "Report on Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich.

ACI 440.5-08 (2008) "Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bar," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich.

ACI 440.6-08 (2008) "Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement," ACI Committee 440, American Concrete Institute, Farmington Hills, Mich.

Canada

CAN/CSA-S806-02, "Design and Construction of Building Components with Fibre-Reinforced Polymers", Canadian Standards Association, Toronto, Ontario, Canada, (May 2002), 187p.

Design Manual No. 3, "Reinforcing Concrete Structures with Fiber Reinforced Polymers"

Design Manual No. 4, "FRP Rehabilitation of Reinforced Concrete Structures"

Design Manual No. 5, "Prestressing Concrete Structures with FRPs"

Japan

Japan Society of Civil Engineers (JSCE) 1997 "Recommendation for Design and Construction of Concrete Structures Using Continuous Fiber Reinforced Materials," Concrete Engineering Series 23, ed. by A. Machida, Research Committee on Continuous Fiber Reinforcing Materials, Tokyo, Japan, 325 p.

Italy

CNR-DT 203/2006 - "Guide for the Design and Construction of Concrete Structures Reinforced with Fiber-Reinforced Polymer Bars."

Europe

FIP Task Group 9.3 “FRP Reinforcement for Concrete Structures” (1999)

Report # STF 22 A 98741 “Eurocrete Modifications to NS3473 When Using FRP Reinforcement”, Norway (1998)

Ukraine

Metodyka rozrakhunku pidsylennya mostovykh zalizobetonnykh balok dodatkovym zovnishnim armuvannyam iz zastosuvannyam metalevykh i kompozytnykh pidsylyuyuchykh elementiv. [Methods of calculating of strengthening reinforced concrete bridge beams with additional external reinforcement using metallic and composite reinforcing elements.]. 218-02071010-605:2006.

Russia

Rukovodstvo po usileniju zhelezobetonnyh konstrukcij kompozitnymi materialami. [Guidelines for strengthening concrete structures with composite materials]. GUP «NIIZhB», OOO «Interakva». M. 2006, 48 p.

III. Examples of application FRP

From 1999 at the National University "Lviv Polytechnic" testing of reinforced concrete beams, reinforced with FRP, are held in under the guidance of Dr. Kvasha V. and Ph.D. Melnyk I.

In 2000...2001 under the guidance of Kvasha V. were carried experimental investigations of full-size concrete bridge beams, strengthened with non-metallic reinforcement CFRP [1]. Task of the research was hold comparative tests of full-scale static load bridge beams after a long period of use, before and after strengthening, define their strength, stiffness and crack resistance.

According to research held first time in Ukraine strengthen reinforced concrete road bridge using FRP (Figs. 1, 2).

In 2008 year in Germany was built first 27 metres long plastics road bridge [2, 3]. This wonder of technology comes in one piece with no nails or screws (Fig. 3). The bridge’s carriageway slab is made of fibreglass-reinforced polymer, glued onto two steel bearers. The bridge can be used as any traditional bridge, but ich is expected to last up to 50 years without any repairs.

This modern plastics bridge is prefabricated and then transported as a unit to the construction site. The total installation takes less than one single day.

While strengthening structures to evaluate the advantages and disadvantages of ways to strengthening and calculation methods that would reflect their actual stress-strain state at any stage of operation. Experimental and theoretical studies have shown high efficiency of strengthening.

Conclusion

In this paper the current state, standards and guidelines of application span structures of bridges, strengthened with external composite reinforcement, and efficiency of FRP in structures are given.

Fig.1 Appearance of road bridge before reconstruction

Fig.2 Appearance of road bridge after reconstruction

Fig.3 First long plastics road bridge in Germany

References

[1] V. Kvasha, I. Mel'nyk, Yu. Sobko, A. Muryn, R. Dobryans'kyy. “Zastosuvannya kompozytiv CFRP dlya pidsylennya zalizobetonnykh mostiv v Ukrayini” [Application of CFRP composites to reinforce concrete bridges in Ukraine], 9th International Scientific Conference “Current issues of civil and environmental engineering”, pp. 221-227, Sep. 2004.

[2] “Pervyj v mire plastmassovyj most vozveli v Germanii”. [First plastic bridge was built in Germany] [Online]. Available: http://top.rbc.ru/wildworld/26/08/2008/229598.shtml. [Accessed Sep. 3, 2013].

[3] “Europe's first plastic bridge is open”. [Online]. Available: http://www.plasticseurope.org/information-centre/news/news-2008/europes-first-plastic-bridge-is-open.aspx. [Accessed Sep. 3, 2013].