AKTET **ISSN 2073-2244**
Journal of Institute Alb-Shkenca **www.alb-shkenca.org**
Revistë Shkencore e Institutit Alb-Shkenca

IMPROVED THE BEARING CAPACITY OF CONCRETE ELEMENTS, INCLUDING COLUMNS, BEAMS, WALLS AND SLABS USING THE FRP
RRITJA E AFTËSISË MBAJTËSE PËR ELEMENTET E BETONIT DUKE PËRFSHIRË SHTYLLAT, TRARËT MURET DHE PLLAKAT ME PËRDORIMIN FRP

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AKTET V, 2: 290-295, 2012

PERMBLEDHJE
Kërkesat e parashtruara me rastin e mbingritjeve të etazheve në objekte, ndërrimet e destinimeve të objekteve në shfrytëzim, si dhe rritja e kërkesave të tjera na shpien drejt analizave për përmirësimin a rritjen e aftësisë mbajtëse të elementeve mbajtëse të betonit, e me këtë edhe të strukturës në përgjithësi. Në këtë punim janë analizuar dhe janë trajtuar disa prej rasteve më të shpeshta me theks të veçantë në mosndryshimin e dimensioneve të prerjeve tërthore si kërkesë e arkitekturës, si dhe në mospengimin e shfrytëzimit të strukturës gjatë sanimit. Kjo mundësi është e arritshme me shfrytëzimin e materialeve të reja, e në veçanti me aplikimin e materialeve në bazë polimeri, të emërtuara si FRP. Po ashtu aplikimi i këtyre është lehtë i arritshëm me përdorimin e softuerëve aplikativë. Shembulli në këtë punim do të shërbejë si justifikim i aplikimit të kësaj metode çdo ditë e me shumë.
Fjale kyçe: betoni; FRP, aftësia mbajtëse; vënia në vepër

SUMMARY
Many requests based on the additional floor in public buildings, including flat house or schools, and also changing the mainly destination of buildings, increasing the actually loads according the Standards towards in detail analyses in improvement of bearing capacity of concrete elements in structures. In this paper are analyses the some of case study, based on the main request on the no changed the dimensions of elements such a request from architects and using the structure during the repairing. This is possible using the polymer materials such FRP (Fibre Reinforcement Polymers). The analyses is followed of the behavior the concrete elements under the bending moments and shear forces analyses with the applicative software. The examples is the result directly in applied the materials and methods in that cases.
Key words: concrete, materials, methods, examinations, assessment, etc..

INTRODUCTION

Development of engineering science is focused toward solving the actual problems in easy way, in same time using the new materials and new methods. Applying the ordering materials such are: steel; concrete, woods or other materials for repairing, in same time result with increasing the dimensions of elements. Also for implementation need the formwork, different support elements and other activities which are not acceptable in time concept.

Also one of the actual problem is the increase the using space and the other different problems in space where is done the strengthening. This is actually present in concrete structures such are:

bridges; public buildings, garage, were the height is one of the main request.

1.General data for FRP (Fibre Reinforcement Polymers)

Definition: Polymers are natural or synthetic substances with the high molecular weight, with the repeated unit (chain form). In macromolecules "mers" are in covalent links.

Structures: Polymers content are from long chain organic molecules. The simplest molecules which construct the polymers are hydrocarbures. [1]

Reinforcement Polymers with fibres-FRP are the composite material with content of fibres (carbon, glass, aramid) and polymer matrix with advance performances comparing with constituent. [1]

1.1.Type of polymer products

Types of polymer products can be: Mesh's FRP; Bars FRP; Fibres FRP, and can be using according to the position or in general depend of the structural elements.

The fibres using such a FRP can be from Carbon (CFRP), glass (GFRP) and Aramide (AFRP). Matrix content is from epoxy resins. [1]

Applications of FRP in strengthening of structures are very variety, and some of main applications are for masonry and concrete structures.

2.REINFORCEMENT OF ELEMENTS OF STRUCTURES

Based on the main properties of structures, in general the strengthening is in direct relations with the elements of structures, and focused on the elements: columns; beams; walls; and concrete slabs.

2.1.Reinforcement of concrete columns

In last three decades the behavior of strengthening elements, in this case such a elements, is analyses and the may results are presented from different Scientifics.

The reinforcement of concrete columns with steel plate it was analyses on improving the axial loads such a hydrostatic pressure, without analyses under the dynamic loads.

The applications of FRP have changed the analyses and solve the problem, in special cases under the seismic loads. [2]

The comparing and advance of using the FRP is very important now, including the simple apply and short time for apply in structure, but the economic reason is not the point in this comparing.

The possibilities of improvement of compressive strength and focused in increasing the ductility is main topic of many researchers works for many years.

Properties of reinforcement with FRP are in functions from limited deformations ε_{fu} and modulus of elasticity E_f for using reinforcement material. [2]

Some of reinforcements forms are presented in Fig. 1.

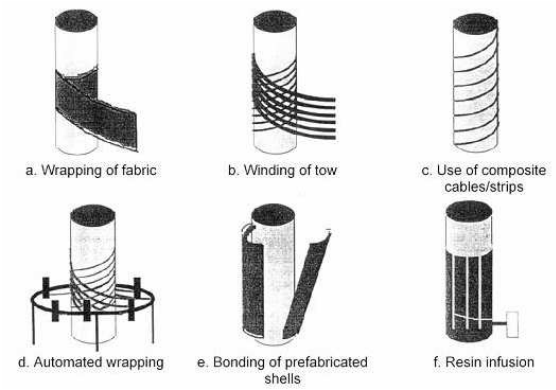

Fig. 1. Reinforcement forms of the columns with FRP [2]

2.2Reinforcement of concrete beams

2.2.1.Behavior of reinforcement beams under flexure

According the ACI conditions, strengthening under flexure can increase the capacity of flexure for 100 %, compare with the initial position (without strengthening). Based on the codes exist the limits for strengthening with FRP. [3], [4].

2.2.2. Behavior the beams under the shearing forces

The beams can be under the other forces, such are shear forces, and in this case the strengthening will be focused in place with the

maximum value of shear forces, near the supports. [3]

According the presented reports from ACI, the increasing the capacity under the applied force is abort 230 %, and the researching in institute EMPA are presented the increasing the performance of ductility for more than 5 times.

In general the theory of strengthening of concrete beams under the different applied loads is presented in Fig. 2, for different materials and using the different methods.

Based on presented materials, the method of strengthening with FRP is the advance method and more applied in last decade, such a method with advance comparing with conventional materials; concrete and steel. [5]

The calculations with FRP is based on the existing odes such are: ACI 318-05; Eurocode 2 and specified knowledge of behavior of strengthening, presented in ACI 440,2R-08,CEB-FIB bulletin 14; CND-DT 200/2004 or other manuals and materials presented in Table 1

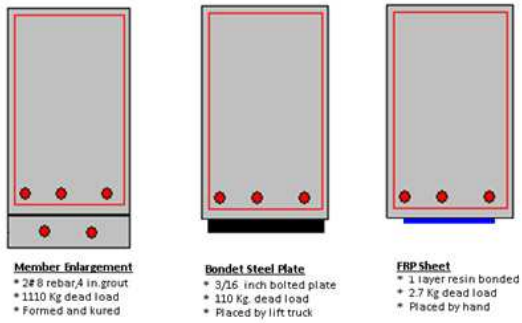

Fig. 2. Strengthening of beams with different materials and methods [3]

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Code	Load Factors		Material Strength Reduction Factors				Strength Reduction Factors
	Dead loads	Live Loads	Concrete	Steel Reinforcement	FRP Reinforcement		
	γ_G	γ_Q	γ_C	γ_S	Strength	E-modulus	ψ_f
BS 8110	1.4	1.6	1.5	1.15	varies	1.1	-
ACI 318	1.4	1.7	-	-	0.85	1.0	0.7 to 0.9
E.C.2	1.35	1.5	1.5	1.15	varies	1.0	-

Tab. 1. The partial lord factors in different codes [4]

The strengthening presented in Fig. 3, is based on the theory of concrete and FRP, and using the base formula for improve the bearing capacity with FRP (second part of formula) [4]

$$M_r = \phi_s A_s f_y \left(d - \frac{a}{2} \right) + \phi_{frp} A_{frp} E_{frp} \varepsilon_{frp} \left(h - \frac{a}{2} \right)$$

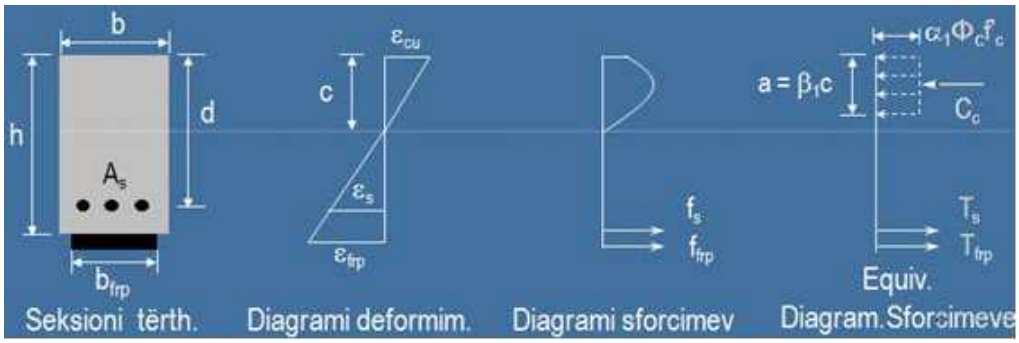


Fig. 3. The section of beam including the effect of FRP [4]

MAPEI

Simple flexure and compression-flexure - Rectangular section
Ultimate limit state approach
Ultimate Bending Moment for RC section

Input data

Geometrical properties of section

width b	250 mm
height H	550 mm
cover d1=d2	30 mm
useful depth d	520 mm
Steel in tension As1	452 mm²
Steel in compression As2	452 mm²
Normal force N	0 kN

Materials

Characteristic cubic strenght of concrete	25
Design stress	11.0 MPa
steel	Feb44k
Design stress	383 MPa
Elastic modulus	210000 MPa
Steel strain at yielding	
εs,el	0.00182

Neutral axis depth

Neutral axis depth in hypothesis:		Neutral axis depth for balanced failure:	
concrete strain	0.0035	concrete strain	0.0035
steel strain	0.00182	steel strain	0.01
Yc,el	**342** mm	Yc,bilan	0.0035 mm

Failure regions

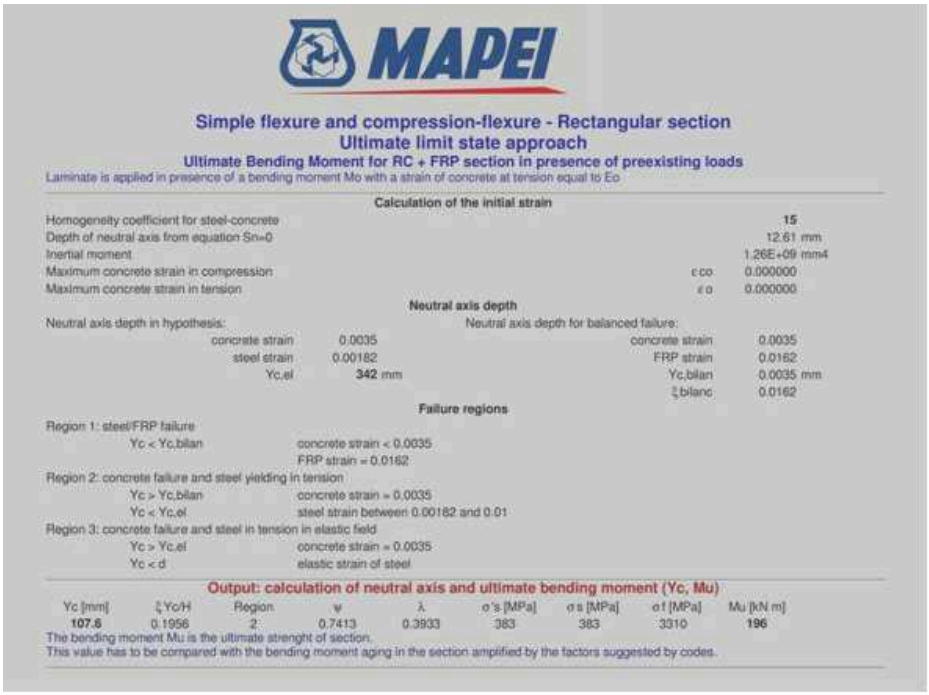
Region 1: steel failure
Yc < Yc,bilan — concrete strain < 0.0035; steel strain = 0.01
Region 2: concrete failure and steel yielding in tension
Yc > Yc,bilan — concrete strain = 0.0035
Yc < Yc,el — steel strain between 0.00182 and 0.01
Region 3: concrete failure and steel in tension in elastic field
Yc > Yc,el — concrete strain = 0.0035
Yc < d — elastic strain of steel

Output: calculation of neutral axis and ultimate bending moment (Yc, Mu)

Yc [mm]	ξ = Yc/d	Region	ψ	λ	σ's [MPa]	σs [MPa]	Mu [kN m]
65.7	0.1263	1	0.544	0.359	165	383	**85.37**

The bending moment Mu is the ultimate strenght of section.
This value has to be compared with the bending moment aging in the section amplified by the factors suggested by codes.

Fig. 4. Calculations of bearing capacity in initial state/without the strengthening



MAPEI

Simple flexure and compression-flexure - Rectangular section
Ultimate limit state approach
Ultimate Bending Moment for RC + FRP section in presence of preexisting loads
Laminate is applied in presence of a bending moment Mo with a strain of concrete at tension equal to Eo

Calculation of the initial strain

Homogeneity coefficient for steel-concrete		15
Depth of neutral axis from equation Sn=0		12.61 mm
Inertial moment		1.26E+09 mm4
Maximum concrete strain in compression	ε co	0.000000
Maximum concrete strain in tension	ε o	0.000000

Neutral axis depth

Neutral axis depth in hypothesis:

concrete strain	0.0035
steel strain	0.00182
Yc,el	342 mm

Neutral axis depth for balanced failure:

concrete strain	0.0035
FRP strain	0.0162
Yc,bilan	0.0035 mm
ξ bilanc	0.0162

Failure regions

Region 1: steel/FRP failure
Yc < Yc,bilan — concrete strain < 0.0035; FRP strain = 0.0162

Region 2: concrete failure and steel yielding in tension
Yc > Yc,bilan — concrete strain = 0.0035
Yc < Yc,el — steel strain between 0.00182 and 0.01

Region 3: concrete failure and steel in tension in elastic field
Yc > Yc,el — concrete strain = 0.0035
Yc < d — elastic strain of steel

Output: calculation of neutral axis and ultimate bending moment (Yc, Mu)

Yc [mm]	ξ Yc/H	Region	ψ	λ	σ's [MPa]	σ s [MPa]	σ f [MPa]	Mu [kN m]
107.6	0.1956	2	0.7413	0.3933	383	383	3310	196

The bending moment Mu is the ultimate strenght of section.
This value has to be compared with the bending moment aging in the section amplified by the factors suggested by codes.

Fig. 5. Calculations of bearing capacity-moment after the strengthening

2.1. Practical Example of strengthening the concrete beams

2.2. Properties of concrete beam

For the applying the FRP is used the practical example with the following geometric characteristics.

Length of the beam: L_0 = 8.0 m

High of the beam: 55.0 cm

Wide of the beam: 25 cm

During the analyses is calculate that the maximum bearing capacity for existing beams with the all parameters is 85.37 kNm'. After the uploads the needed bearing capacity result 160.0 kNm', and this request is point for deep analyses in strengthening the existing beam.

The flexure moment is the main parameter, and in this case our target is the improving the bearing capacity under this main indicate parameter. The other parameters such are the shear force are minimum in this case.

During the analysis the different methods for improving the bearing capacity under the flexure moment, based on the request for no changed the height of the beam and also using the very fast process of applied, we prefer the strengthening with FRP. The analysis is based on the calculations applying the program MAPEI FRP, such a adequate software.

The calculation bearing capacity (M_u = 85.37 kN m' < M_u^* = 160 kNm'), and the problem is analyzed for improve the bearing capacity. Such a result it was the applying the material MapeWrap C UNI Ax-300/20, in down zone to increase the flexure moment.

The detail is presented in Fig. 5.The dimensions of the FRP are chosen based on the geometric properties of beams (wide of beam) and adequate products from producer. Applying the FRP materials is result of the mechanical properties of materials (high tensile strength; high Modulus of Elasticity, and other properties.)

The procedure for strengthening is done using the program Mapei FRP, and the results after applying the strengthening is, the bearing moment is M_u** = 196 kNm' > M_u* = 160 kNm. In

this case the strengthening is realized with the applying the layers of FRP materials.
The calculation is presented in Fig. 5.

3.CONCLUSIONS AND RECOMMENDATIONS

The requested for increase the loads in structure, such is the in direct correlation with additional floors , in this case is one of the practice in existing buildings, is objective for using the buildings for different business or for using the same place and existing foundations.
The procedure for apply and fulfill the request is on the function of many parameters, such are: control of building materials in old structure; verification of geotechnical parameters; and using the new codes for applying loads.
In this case the aim of this paper was only the strengthening of the beam, because the other elements, such are columns and slabs are not under the critical loads after the additional floor of school, parameters evident during the statically calculations.
Appling the FRP materials has the many advantages, comparing with the conventional materials:

- Fulfilling the request for no change the dimensions (architectural request)
- No the additional loads, which is the main problem with other materials
- Easy way for applications in different structures and different materials, such are: concrete; masonry; stele; and also the wood
- The mechanical properties of FRP materials is one of the significant advance comparing with the other materials

But applying the new materials, request also the new knowledge, in engineering fields:

- New knowledge for engineers and FRP materials, properties and applying
- Development of new capacities for execution of works and applying the materials using the adequate methods.
- The quality control of execution of works, right executions and positions for right functions.

The applications of FRP materials, in the last 10 years, are without concurrence with other materials, and also the examinations of applying material sis one the important fact for improvement of elements and also the structures.
The economical reason for comparing is not the topic of this paper, and without hesitation we recommend applying the FRP materials with deep analyses but without the cost.

REFERENCES

[1]N. Kabashi; Polymer Materials, Prishtina, 2010.
[2]Giovanni Cerretini; The design of externally bonded reinforcement (EBR) for reinforcement concrete structures by means of fibre reinforced polymers; Firenze, Italia, 2008.
[3]Chote Soranakom; Barzin Mobasher: Flexure Design of Fiber-Reinforced Concrete; ACI Materials Journal, 2009.
[4]ACI 440.2R-08; Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures, 2008.
Suiji, D; Natesan, S; Murugesan, R; Experimental study on behaviours of polypropylene fibrous concrete beams, JZUS, 2007.