DAN Sorin – LISTA PUBLICAȚII RELEVANTE
(lucrările in-extenso sunt cuprinse pe CD-ul atașat dosarului)

Nr. crt.	Lucrarea publicata	Clasificare publicație
1.	C. Bob, **DAN Sorin**, C. Badea, L. Iures, "Classic and Modern Solutions for Rehabilitation of Reinforced Concrete Structures", Structures and Extreme Events, IABSE Symposium, Lisbon, Portugal, 2005, ISBN: 3-85748-112-9	INGENTA Proceedings
2.	**DAN Sorin**, C. Bob, A. Gruin, "Analysis of Reinforced Concrete Existing Structures in Seismic Regions" – WSEAS International Conference "Engineering Mechanics, Structures, Engineering Geology (EMESEG '08)", Heraklion, Greece, 2008, pg. 96-103, ISBN 978-960-6766-88-6	ISI Proceedings
3.	**DAN Sorin**, C. Bob, A. Gruin, C. Badea, L. Iures, "Strengthening of Reinforced Concrete Framed Structures in Seismic Zones by Using CFRP" – WSEAS International Conference "Engineering Mechanics, Structures, Engineering Geology (EMESEG '08)", Heraklion, Greece, 2008, pg. 67-72, ISBN 978-960-6766-88-6	ISI Proceedings
4.	C. Enuica, C. Bob, **DAN Sorin**, C. Badea, A. Gruin, "Solutions for Bond Improving of reinforced Columns Jacketing" – 11^{th} WSEAS International Conference "Sustainability in Science Engineering (SSE '09)", Timisoara, Romania, 2009, pg. 58-63, ISBN 978-960-474-080-2	ISI Proceedings
5.	**Dan Sorin**, C. Bob, L. Bob, A. Gruin, C. Badea, "Modern Solutions for Strengthening of Masonry Structures" – 11^{th} WSEAS International Conference "Sustainability in Science Engineering (SSE '09)", Timisoara, Romania, 2009, pg. 64-69, ISBN 978-960-474-080-2	ISI Proceedings
6.	**DAN Sorin**, C. Bob, C. Badea, "Impact of New Design Codes on Assessment and Redesign of Reinforced Concrete Existing Structures in Seismic Regions", Large Structures and Infrastructures for Environmentally Constrained and Urbanised Areas, IABSE Symposium, Venice, Italy, 2010, ISBN: 978-385748-121-5	INGENTA Proceedings
7.	**DAN Sorin**, "Energy Saving with Rehabilitation Solutions for Existing Structures", 4th WSEAS International Conference on Energy Planning, Energy Saving, Environmental Education, EPESE'10, 2010, ISBN: 978-960-474-187-8	SCOPUS Proceedings
8.	**DAN Sorin**, L. Iures, C. Badea, "Impact of Structural Rehabilitation of Existing Buildings on Energy Saving in Constructions", 13th SGEM - Multidisciplinary conference, Albena, Bulgaria, 2013, ISSN: 1314-2704	ISI Proceedings
9.	**DAN Sorin**, C. Bob, C. Badea, L. Iures, "Risk Assessment and Rehabilitation of Historical Masonry Buildings", Proceedings of the 12th International Conference on Environment, Ecosystems and Development (EED 14), Brasov, Romania, 2014, ISBN: 978-960-474-385-8	SCOPUS Proceedings
10.	R. Chendes, C. Bob, C. Badea, C.E. Podoleanu, **DAN Sorin**, L. Iures, "Experimental Research on Recycled Concrete Fines", Revista de Chimie, Bucuresti, 2016, 67/No. 9	ISI Journal

DAN Sorin

Classic and Modern Rehabilitation Techniques in Seismic Zones

Corneliu BOB
Professor
Politehnica University
Timisoara, Romania
cbob@mail.dnttm.ro

Sorin DAN
Lecturer, Dr.
Politehnica University
Timisoara, Romania
sdan@ceft.utt.ro

Catalin BADEA
Assistant Professor, Dr.
Politehnica University
Timisoara, Romania
cbadea@ceft.utt.ro

Liana IURES
Assistant Professor
Politehnica University
Timisoara, Romania
liures@ceft.utt.ro

Summary

The paper deals with two aspects of rehabilitation techniques: laboratory tests on RC framed model strengthened by CFRP; strengthening of two RC old structures by classic and modern techniques.
The first rehabilitation example refers to a huge building, built before 1900's, with a composite structure: masonry and reinforced concrete framed structures. The structural main vulnerabilities consist of: overall lateral stiffness values along the two main axes are different; lack of aseismic joints to divide building parts having different dynamic characteristics.
The second example consists in the assessment and rehabilitation solutions for a group of silos. The strengthening solutions, regarding the three parts of the silos, by using classic and modern rehabilitation techniques have been applied: coating of beams, columns and joints by RC or steel profiles; strengthening based on carbon fibre reinforced polymer.

Keywords: rehabilitation; existing structures; seismic zones; reinforced concrete structures; masonry structures; repairs; strengthening; CFRP.

1. Experimental studies on RC frame model

The experimental programme focussed on RC frames (*Fig. 1*) assumed, designed and erected as existing structures.
RC frames were firstly tested, than strengthened and re-tested at alternant horizontal cycles up to the yielding stage of reinforcement and failure stage.
The strengthening was performed on both columns by using CFRP materials (*Fig. 1*): longitudinal strips, SIKA Carbodur, anchored in foundations and at the top joints; transversal confinement with SIKA wrap at both ends of the columns.

Fig. 1 RC frame + CFRP strengthening

The experimental data shown:
- the values of the maximum horizontal loads were chosen differently for the two non-strengthened frames in order to vary the application level of strengthening: 1600 daN (reinforcement yielding stage) for **Frame 1** and 3600 daN (ultimate stage) for **Frame 2**;
- an increase of the maximum horizontal load level by 6 % was obtained for the strengthened **Frame 2** even if previously has been loaded up to the ultimate stage as non-strengthened structure;

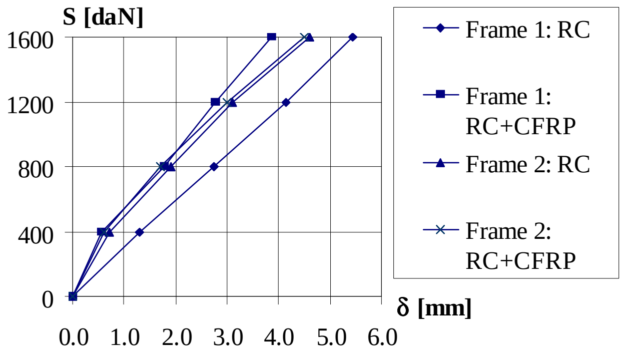

Fig. 2 Top-displacement values

- the stiffness increase of strengthened structure implies the smaller value of the top displacement at the yielding stage of loading (Fig. 2).

2. Rehabilitation of existing structures

2.1 The PALACE building

The "Palace" structure (*Fig. 3*) is a huge building built before 1900's with a composite structure: masonry and reinforced concrete framed structure. Initially it was an entire masonry structure, but later the ground floor was changed: some resistance brick walls were cut and two longitudinal RC frames were erected to sustain all the vertical loads. Due to this architectural operation the structure became more vulnerable at seismic actions: by the transversal direction main part of the ground floor became unstable at horizontal actions because of some erected columns with hinge connection at both ends (masonry wall supports from the underground floor and first storey). The results of the static and dynamic analysis presented below:

Fig. 3 The "Palace" building

Type of Structure	Efforts		
Non-rehabilitated structure	M [kNm]	M_{nec}	700
		M_{cap}	186
	$R = M_{cap}/M_{nec}$		**0.27**
Rehabilitated structure	M [kNm]	M_{nec}	1048
		M_{cap}	1175
	$R = M_{cap}/M_{nec}$		**1.12**

NOTES:
The ratios **R** between the actual values of ultimate bending moment (M_{cap}) and the necessary bending moment (M_{nec}) are very low for columns (0.27) which means that **the building has presents a high risk of collapse at seismic actions**. Results the necessity of structural rehabilitation:

- new reinforced concrete floor with embedded steel profiles (HEB 220) in two directions as beams for the new structure;
- strengthening of columns (by RC coating) and erecting of new transversal RC beams in order to create new transversal frames.

The efficiency of strengthening solutions is shown by the increased **R** values presented above.

Fig. 4 Strengthening solution

2.2 RC silos

The silos were built 40 years ago and stand 28 m high and 7.30 m in diameter. Silos inspection and assessment (1999 and 2004) revealed: cover concrete dislocated and corrosion of steel reinforcement (circular cells; supporting columns and beams of discharge funnel) due to high humidity; wide open cracks at the windows bottom of RC walls of the charging platform due to temperature action. The strengthening solution consists of: use of CFRP strips as near surface mounted reinforcement for the **silos circular cells** and **charging platform cracked walls**; use of steel profiles for **supporting columns for the discharge funnel**.

3. Conclusions

- The experimental tests performed on RC framed structure emphasized some main aspects of the CFRP strengthening system: the slight increase of bearing capacity and the decrease of top-displacement up to the service stage.
- Rehabilitation solutions for existing structures in seismic zones takes into account the increase in strength, stiffness and ductility. In case of RC framed structures the important increase in stiffness and ductility is to be achieved by coating of beams, columns and joints.
- The strengthening solutions based on CFRP systems for structural upgrading of RC shear walls from a group of silos were applied due to some important architectural, technical and economical advantages.

Analysis of Reinforced Concrete Existing Structures in Seismic Regions

SORIN DAN, CORNELIU BOB, AURELIAN GRUIN
Civil Engineering Department
"Politehnica" University of Timisoara
Str. T. Lalescu, No. 2, Timisoara
ROMANIA

Abstract: - Theoretical aspects on the risk assessment of the reinforced concrete structures are to be presented. The earthquake capacity ratio ($R = S_c / S_n$) is analysed for reinforced concrete framed structure. More attention is paid to the seismic shear force capacity S_c and some new procedures are introduced to estimate the earthquake capacity of existing structures. The authors have used for analysis of RC structures the procedures based on consideration of post-elastic deformation and non-linear dynamic analysis with accelerogrames for modelling seismic action. These procedures were used for analysis and redesign of existing structures in seismic regions. For the damage control of structural members in seismic design the authors proposed and used the following methods: the plastic hinges procedure; the stiffness modification procedure. These procedures show the opportunity of taking into analysis the RC structural degradation.

The above procedures were used for the analysis, redesign and strengthening of two existing buildings having RC frame structures.

Key-Words: - Existing RC structure; Structural damage; Seismic action; Assessment; Structural analysis; Redesign procedures; Plastic hinges; Stiffness; Rehabilitation

1 Characteristics of Existing Structures Under Seismic Actions

The vulnerability of existing structures under seismic actions may be due to structural system weaknesses and specific detailing. Structural weaknesses are characterised by various irregularities and discontinuities or by general structural vulnerabilities:

1. Irregularities in the vertical direction of the buildings: irregular distributions of the stiffness at lateral displacement; strength discontinuities; mass irregularities; vertical load discontinuities.
2. Irregularities in the building layout: horizontal irregularities of masses, stiffness and strength, which all produce torsion effects; unfavourable plan layouts; slab discontinuities due to holes or weaknesses of the connections in some zones.
3. General structural vulnerabilities: the indirect transfer of strong forces by beam-on-beam supports or columns supported on beams; cantilever horizontal members with large spans and / or high loads; weak column / strong beam; eccentricities; finite service life due to deterioration of component parts of a building.

Specific detailing of existing structures is function of building material. RC structures are characterised by common non-ductile detailing:

- inadequate column bending and shear capacity;
- inadequate beam shear resistance;
- inadequate of beam-positive reinforcement and anchorage at the beam-column joint;
- inadequate confinement of the potentially plastic hinges of the columns and beams as well as of the boundary elements of RC frame-wall systems;
- inadequate reinforcement of the RC frame in the longitudinal direction of the building.

2 Assessment and Analysis of Existing RC Structures

According to the Romanian Code for seismic design P100-92 [1] as well as to the other norms, the design of structures to resist earthquake is based on the next design procedures and calculation methods:

(i). Common design procedures based on the following calculation methods: linear static with conventional forces distributed as inertia forces for linear static response; linear dynamic with accelerograms for modelling of seismic actions;

(ii). Design procedure based on consideration of post-elastic deformation of structures with: non-linear static analysis and conventional forces distributed as inertia forces for seismic response; non-linear dynamic method with accelerograms for modelling of seismic action.

The assessment of the existing structures to the seismic action is estimated according to the Romanian Code by calculating the earthquake capacity ratio R:

$$R = \frac{S_{cap}}{S_{nec}} \quad (1)$$

where:

- S_{cap} - seismic shear force capacity (seismic base shear force);
- S_{nec} - conventional seismic load (seismic base shear force) calculated according to the Romanian Code P100-92 at the present-day level of seismic action.

The effect of different actions, ordinary and special (Fig.1), on the structural safety and S_{cap} is presented in Fig.2 for the service live of a structure.

Actions

a) Ordinary actions
- Dead loads
- Variable loads
- Actions from environmental conditions which produce:
  - Reinforcement corrosion
  - Fatigue of structural elements
  - Erosion
  - Specific factors: freeze-thaw cycles, AAR, etc.

b) Extreme actions
- Earthquakes
- Explosions
- Floods
- Others

Fig.1 Types of actions.

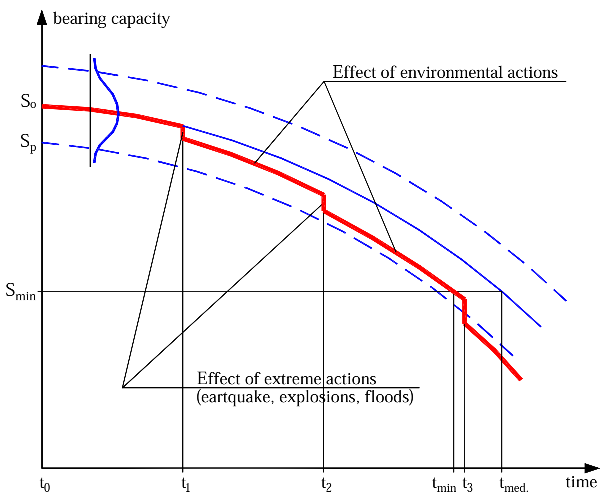

Fig.2 Effect of different actions on structural safety.

The authors have used for design the procedures based on consideration of post-elastic deformation with non-linear analysis. These procedures were used for analysis and redesign of existing structures in seismic regions.

For the damage control of structural members at seismic design the authors proposed and used the following methods:

- the plastic hinges procedure;
- the stiffness modification procedure.

2.1 Plastic hinges procedure

The procedure consists in the analysis of a modified static scheme of the RC framed structure.

Plastic hinges are to be introduced in the cross sections with corroded reinforcement and strength degradation. Simplified, mechanical hinges with applied bending moments loads equal to the real cross section bearing capacity are introduced. A new static scheme is obtained and analysed by using certain computer programme.

A case study at seismic actions was performed on a RC framed structure presented in Fig.3.

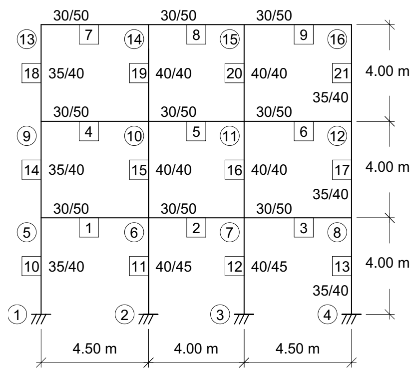

Fig.3 RC framed structure - case study.

Plastic hinges were introduced (Fig.4) in the cross sections at *L/4* of beams with assumed corroded reinforcement at *2/3*, *1/3* and *0* from initial reinforcement area A_a.

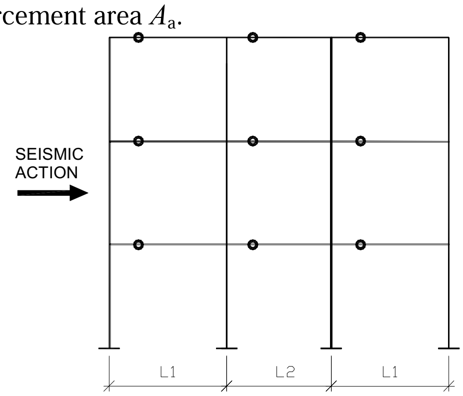

Fig.4 Position of plastic hinges.

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Strengthening of Reinforced Concrete Framed Structures in Seismic Zones by Using CFRP

SORIN DAN, CORNELIU BOB, AURELIAN GRUIN, CATALIN BADEA, LIANA IURES
Civil Engineering Department
"Politehnica" University of Timisoara
Str. T. Lalescu, No. 2, Timisoara
ROMANIA

Abstract: The paper deals with some aspects on efficient solutions for rehabilitation of reinforced concrete framed structures by using composite fibre reinforced polymers systems. The first part of the paper is devoted to general aspects of RC structures strengthening. The second part presents experimental studies on RC frames, which were tested as un-strengthened and as CFRP strengthened structures. Two parameters of the tested structures are reported: bearing capacity and top-displacement. The last part of the paper is focussed on the rehabilitation of existing RC framed structures having weak reinforcement at seismic action. Aspects of CFRP rehabilitation of columns and beams are presented.

Key-Words: Rehabilitation; Existing structures; Seismic zones; RC structures; Strengthening; CFRP.

1 Introduction

Reinforced concrete structures are to be repaired and/or strengthened in cases when the general damage is limited, and demolished when the structural safety is greatly affected and the rehabilitation cost is very high.

Repairs are used for surface deterioration, cracks, casting defects and reinforcement corrosion. The methods used for repairs are: covering of damaged surfaces; infilling of cracks with cement mortar, epoxy resin or other polymers; replacement or strengthening of damaged reinforcement.

Strengthening of RC structures takes into account the increase of strength, stiffness and ductility. In case of RC framed structures, the increase in stiffness and ductility is to be achieved by coating beams, columns and joints [1]. The coating is performed by reinforced concrete, steel profiles, carbon fibres, etc.

Sometimes it is necessary to transform the existing structure completely, especially for framed structures. In this case, special techniques are to be used: steel bracing; infilling of frame holes with reinforced masonry or reinforced concrete.

2 Strengthening of RC Structures by Using of CFRP

FRP systems are suitable for strengthening of RC structures due to their technical and economical advantages. Classic strengthening solutions may lead to some inconveniences; as such methods are costly and disruptive to operation. A typical approach is the increasing of elements' dimensions with consequent mass increasing and leading to seismic problems. Furthermore, if reinforcement corrosion is present and its causes are not carefully removed the corrosion will continue.

CFRP systems provide solutions to retrofit structures, to make its more seismic resistant: its increase load-carrying capacity; section designed only for gravity loads are able to withstand seismic loads; elements' mass remains, practically, the same; the technology is simple and rapid.

For strengthening of existing RC framed structures in seismic zones a very important target is to avoid the development of plastic hinges in columns. For this purpose there is necessary to increase bending and shear capacity. A retrofit using CFRP vertical strips and horizontal wrap for columns means increasing of local ductility and deformation capacity as well as of entire bending capacity.

The strengthening of columns using CFRP vertical strips will increase the *bending capacity* as well as the *stiffness* of the element. The increased flexural strength of column will force the plastic hinge to form at beam ends. On the other hand the increase of vertical elements stiffness will reduce the structural story drift under seismic motion.

The two effects of columns strengthening are responsible for increasing the *horizontal load capacity* and, finally, the structural dissipation energy. The advantages presented above are effective only if the *shear capacity* is also *increasing* and the *debonding* of vertical CFRP strips is eliminated by efficient systems.

The possibility of avoiding shear failure of column end (potential plastic hinge) may be solved by CFRP wrap confinement; results an increase of column shear strength, as well as ductility, and will transmit the plastic hinge at the beams.

The debonding of FRP strips, disposed along the column axis, in the form of peeling-off failure at the beam-column joint or column-foundation joint, it is necessary to be solved by different systems: a continuous fibre application in the longitudinal column direction where this possibility exists; by creating of some vertical gaps around the columns in which strips are anchored; by using special anchoring devices, such as steel plates and rods (El-Amoury and Ghobarah [2], Parese et al [3]). The verifying of the end anchorage can follows the model presented in the *fib bulletin 14* [4] which gives the maximum FRP force which can be anchored and the minimum anchorage length.

The analysis of RC structures members before and after strengthening using CFRP systems are also presented in the *fib bulletin*.

Many authors report experimental results and analytical studies on the effects of CFRP systems used on RC structures. Test results (Mosallam [5]) on beam-column joints of RC frame structures show an important increase of strength, up to 53 % and ductility up to 42 %. Parvin and Granata [6] illustrated an increase in the moment capacity up to 37 % given by an analytical analysis (FEM) on exterior beam-column joints. The confining pressure of the FRP jackets on bridge columns with a circular cross section shows an increase of the lateral bending strength by 19-40 % (Sclick and Brena [7]). The results from an experimental study on a full scale RC structure illustrated an increase by 86-100 % of base shear force and about 100 % increase of lateral top-displacement capacity by using FRP strengthening (Della Corte, Borecchia and Mazzolani [8]).

3 Experimental Studies on RC Frame Models

The experimental programme focussed on RC frames (Figure 1) assumed as existing structures. Single span and single story frame (scale 1:2) was designed and detailed according to the design codes from 1970 under which seismic design was inadequate. These frames were loaded vertically with constant forces V and horizontally with variable alternant forces S^+ or S^- (seismic action). During the test were measured: load forces S; strain in reinforcement bars of columns and beams; horizontal top-displacement.

Figure 1. RC frame model.

Tests were firstly performed as alternant horizontal cycles up to the service stage and secondly up to the yielding of reinforcement and than to the failure stage.

The RC design and the magnitude of applied forces were ensuring the failure mechanism, of non-strengthened RC frames, by plastic hinges at columns ends.

Than the RC frame was strengthened (Figure 2) on both columns by using CFRP materials:

Figure 2. RC frame + CFRP strengthening.

- longitudinal strips, SIKA Carbodur, anchored in foundations and at the top joints in different manners:
    - glued anchorage (Figure 3);
    - wrap anchorage (Figure 4);
    - mechanical anchorage (Figure 5);
- transversal confinement with SIKA wrap at both ends of the columns.

Data obtained from tests performed on frame structures are presented in Table 1.

Solutions for Bond Improving of Reinforced Concrete Columns Jacketing

COSMIN ENUICA*, CORNELIU BOB*, SORIN DAN*, CATALIN BADEA*, AURELIAN GRUIN**
* Civil Engineering Department
"Politehnica" University of Timisoara
Str. T. Lalescu, No. 2, Timisoara
ROMANIA
** INCERC Building Research Institute
Timisoara Branch
Str. T. Lalescu, No. 2a, Timisoara
ROMANIA
cbob@mail.dnttm.ro; sorin.dan@ct.upt.ro; catabadea@gmail.com; agruin@incerctm.ro;
http://www.ct.upt.ro

Abstract: The paper deals with the results and design conclusions based on an experimental programme and its application to a structural rehabilitation. The experimental programme presents the strengthening effect of RC columns by coating with new RC jacketing. Methods of increasing bond between old and new concrete are analysed: no bonding agent; surface chemical bonding agent; mechanical fixed connectors; chemical fixed connectors. The analysed strengthening solutions are applied on an existing four storeys RC framed structures built in 1940 and located in a seismic zone. The structure presents poor quality concrete, poor reinforcement detailing and weakness of reinforcement at present-day magnitude of seismic action.

Key-Words: strengthening; reinforced concrete framed structures; reinforced concrete jacketing; chemical bonding agent; connectors; seismic zones.

1 Introduction

Structural strengthening represents an important aspect of the rehabilitation of existing RC structures. Some techniques for repairing and/or strengthening structures involve adding new concrete to an existing concrete substrate. One of the most commonly used strengthening techniques for structural elements is concrete jacketing.

The RC jacketing strengthening method is characterized by some important advantages:

- leads to a uniformly distributed increase in strength and stiffness of element (column);
- the durability of the original structural member is also improved;
- this strengthening procedure does not require specialized workers.

The main disadvantage consists of a slightly lower sustainability (higher energy incorporated into material and longer duration of erection) in comparison to other strengthening solutions (i.e. carbon fibre reinforced polymer composites).

Different techniques for increasing the roughness of substrate surface are presented in literature. Eduardo N.B.S. Julio et all [1] have been considered the following techniques: reference (1), surface prepared with steel brush (2), surface partially chipped (3), as in (3) plus water saturation 24 h prior concrete cast (4) and surface treated with sand-blasting (5). The values of the bond strength in tension, determined with the pull-off tests are: 1.92 N/mm^2 for surface prepared by procedure (2), 1.47 N/mm^2 for (3), 1.02 for (4) and 2.65 N/mm^2 for (5).

According to E.S. Julio, F. Branco and V.D. Silva [2] the structural behaviour of a building rehabilitated by RC jacketing is highly influenced by applied technique and following aspects are to be considered: application of steel connectors – this should be considered only in the case of short RC columns to improve the level of strength and stiffness under cyclic loading; anchoring of the added longitudinal reinforcement – the steel bars can be efficiently anchored to the footing with a two-component epoxy resin.

The longitudinal reinforcement should be uniformly spread; added stirrups – half of the spacing of the original transverse reinforcement is recommended for the added stirrups to obtain a monolithic behaviour under cyclic loading; added concrete – a non shrinkage concrete should be adopted with characteristics of a self-compacting, high-strength and high-durability concrete.

The problem of pre-wetting the interface surface is controversial. The AASHTO-AGB-ARTBA Joint Committee recommends that the new concrete be cast on a dry concrete surface and on the other hand Canadian Standards Assoc. A 23 recommends wetting the old concrete surface for at least 24 h before the new concrete layer is cast.

2 Experimental Programme

The experimental programme focuses on quantifying the influence of different techniques for connecting between the two concrete layers: old concrete substrate and the added new concrete.

Also, the influence of different old concrete quality was studied: a higher concrete class, as used in the present; a lower concrete class, as used in the past and encountered at old existing structures.

The test selected for the study was the pull-off test. The specimens were tested under compression using the standard procedure of cubes for compressive strength.

For the substrate concrete two classes were adopted – C 20/25 and C 16/20, since for the added concrete just one class of C 20/25 was adopted.

The adopted geometry for the pull-off specimens is presented in Fig. 1: a prism of 200x200x500 mm for the concrete substrate, reinforced with 8Φ12 mm PC52 longitudinal bars and stirrups Φ6/150 mm OB37; added concrete as RC jacketing of 100 mm width as illustrated in Fig. 2 and a reinforcement similar to the inner prism.

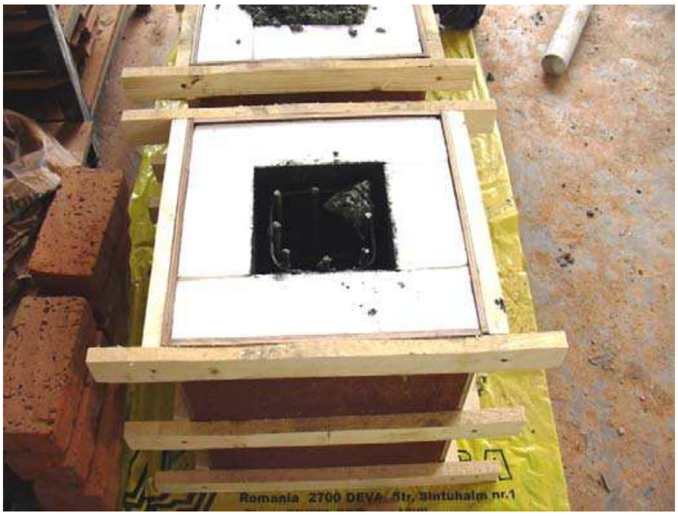

Fig. 1. RC columns – initial specimens.

Fig. 2. Initial RC columns and RC jacketing.

The connection between the substrate (RC inner prism) and the added concrete (RC outer jacketing) were:

- three specimens without special technique for connection (concrete-to-concrete bond);
- one specimen with a bonding agent – a two-component epoxy resin;
- three specimens with steel connectors Φ10 mm PC52, anchored in the prism with a two-component epoxy resin (Fig. 3);
- one specimen with special mechanical connectors M10/40/100 mm, anchored in the substrate into holes drilled in the prism (Φ12 mm), Fig. 4.

Fig. 3. Using of chemical anchored connectors.

Fig. 4. Using of mechanical anchored connectors.

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Modern Solutions for Strengthening of Masonry Structures

SORIN DAN*, CORNELIU BOB*, LIANA BOB**, AURELIAN GRUIN***, CATALIN BADEA*
* Civil Engineering Department "Politehnica" University of Timisoara Str. T. Lalescu, No. 2, Timisoara ROMANIA
** ICECON Research Institute Timisoara Branch Str. Oltul, No. 1, Timisoara ROMANIA
*** INCERC Building Research Institute, Timisoara Branch Str. T. Lalescu, No. 2a, Timisoara ROMANIA
sorin.dan@ct.upt.ro; cbob@mail.dnttm.ro; agruin@incerctm.ro; catabadea@gmail.com
http://www.ct.upt.ro

Abstract: The paper presents the rehabilitation methods for masonry structures. In the first part, an experimental programme concerning the technical efficiency of the masonry strengthening with different type of bars/rods is presented. The test elements are erected as models, scale 1:2, and represent shear walls with window opening. In the first stage the models are tested at vertical and horizontal actions. Finally, the models are strengthened with different types of bars / rods (Romanian High Adherence Steel Bar; Brutt Helical System – Brutt Saver BHS) as near-surface-mounted-reinforcement and Fibre Reinforced Polymer Systems CFRP and retested. In the second part, the rehabilitation of an existing church of about 150 years old is presented: a brick masonry structure with local damages was strengthened with near-surface mounted reinforcement.

Key-Words: existing masonry structures, seismic zone, strengthening, near-surface-mounted reinforcement, CFRP.

1 Introduction

The motivation for research and development into repairing, strengthening, and restoration of existing buildings in seismic zone is sustained by necessity to extend the life of structures. The masonry structures are the oldest and still very used type of buildings. The main target of the paper represents the rehabilitation of old masonry buildings located in seismic zones.

Masonry structures present some important vulnerability in seismic zones: the overall lateral stiffness values along the two main axes are different; lack of seismic joints to divide building parts having different dynamic characteristics; lack of reinforced concrete straps at each level; defects of wall connections at corners, crossings and ramifications as well as the presence of cracks; inadequate bearing capacity at normal forces on the walls. On the other hand, structural weakness is characterised by various irregularities and discontinuities or by general structural vulnerabilities: irregular distribution of stiffness at lateral displacements; strength discontinuities; mass irregularities; vertical load discontinuities.

Masonry, made with bricks, stones or other blocks, has a high compressive strength but its main disadvantage is poor tensile strength due to masonry members will crack and fail even if they are subjected to relatively small loads.

The methods of strengthening existing masonry structures with the use of traditional technology are various: erection of RC cores appropriate distance combined with straps at each level, masonry lining with reinforced concrete, masonry confinement with steel profiles, interlocking of masonry walls at corners, crossing and ramifications with RC elements and/or some steel profiles, adding new inner walls and/or some outside abutments.

Near-surface-mounted reinforcement implies that steel bars/rods mainly of CFRP are bonded in sawn grooves in the masonry or concrete cover. The use of this technology has a lot of advantages: no requirement for surface preparation work, installation time is minimal, no change of the existing structure dimensions, the cost compared with traditional methods is lower even thaw the material costs are higher.

2 Experimental Programme

2.1 Bond strength tests

The bond between strengthening bars and substrate material like concrete, mortar, brick/stone masonry is an important factor in order to perform an efficient rehabilitation on structural members.

Aim of this paper is to investigate the mechanism of bond between two types of bars and brick masonry element taking into account two parameters: type and diameter of strengthening bar.

The bar types used for the experimental program are: Romanian Profiled Steel Bar PC 52 which is a hot-rolled steel and Brutt Helical System – Brutt Saver which is a special bar which gives a high bond at a small cross-sectional area. Three diameters have been used for each type of bars. The geometrical and mechanical properties of the bars are presented in Table 1.

Table 1. Geometrical and mechanical properties of bars

Type of bar	Bar nominal diameter φ [mm]	Cross-sectional area A [mm^2]	Load at failure P_{max} [kN]	Ultimate strength f_u [N/mm^2]	Elongation at failure ε [%]
Profiled steel bar PC52	6	28.26	14.43	510	15.00
	8	50.24	25.50	507	15.00
	10	78.50	40.04	510	15.00
Brutt Helical System (BHS)	6	9.00	8.10	900	14.70
	8	11.00	9.95	905	7.25
	10	16.00	11.30	706	8.64

The effect of the near-surface technology can be explained by results of the experimental tests of adherence between brick masonry and steel bars. The test samples before the two bricks specimen are glued together are presented in Fig.1.

Fig. 1. The samples before embedment.

The embedment of bars in brick-mortar have been chosen to avoid the slipping of the bars during the test and are presented in Table 2.

The pull-out test arrangement is illustrated in Fig.2. The brick block dimensions are different in function of the bar embedment in brick-mortar system.

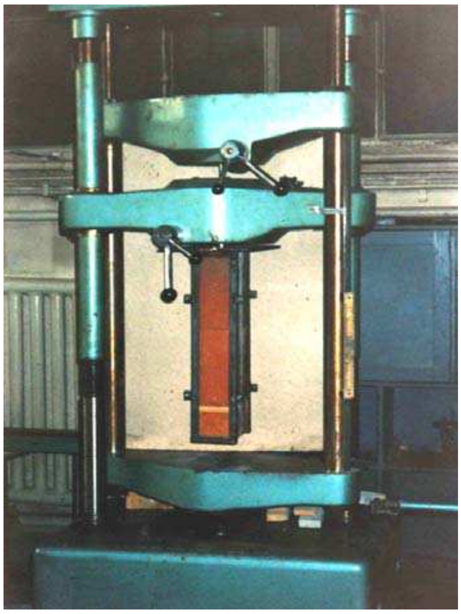

Fig.2. The pull-out test arrangement.

The results of the experimental program are presented in Table 2. Pull-out load P_{po} is influenced by the type and diameter of bars. The smaller values obtained for Brut Helical System bars are in accordance with the cross-sectional area and it is explained, too, by the ratio pull-out load P_{po} – load at failure P_{max}.

Table 2. Data from pull-out test arrangement

Type of bar	Bar diameter φ [mm]	Embedment in brick-mortar system l_b [mm]	Pull-out load P_{po} [kN]	Bond strength τ_a [N/mm^2]	Ratio $\frac{P_{po}}{P_{\max}}$
Profiled steel bar PC52	6	300	19.85*	3.510	1.38
	8	400	29.45**	2.930	1.15
	10	600	38.25**	2.030	0.96
Brutt Helical System (BHS)	6	300	7.87*	1.390	0.97
	8	400	8.25*	0.820	0.83
	10	600	12.15*	0.645	1.08

Notes: * failure in bar; **slipping of bar

Impact of New Design Codes on Assessment and Redesign of Reinforced Concrete Existing Structures in Seismic Regions

Sorin DAN
Lecturer, Dr.
”Politehnica” University
Timisoara, Romania
sorin.dan@ct.upt.ro

Sorin Dan, born 1966, received his civil engineering degree and PhD from the “Politehnica” Univ. of Timisoara.
He published many papers in the field of RC structural analysis re-design and rehabilitation.

Corneliu BOB
Professor
”Politehnica” University
Timisoara, Romania
cbob@mail.dnttm.ro

Corneliu Bob, born 1939, received his civil engineering degree and PhD from the “Politehnica” Univ. of Timisoara.
He published many papers in the field of structural rehabilitation, new concrete types and durability.

Catalin BADEA
Lecturer, Dr.
”Politehnica” University
Timisoara, Romania
catabadea@gmail.com

Catalin Badea, born in 1971, received his civil engineering degree and PhD from the “Politehnica” Univ. of Timisoara.
He published many papers in the field of structural rehabilitation and construction materials.

Summary

The present seismic design and assessment of existing structures are done in Romania by using new codes in agreement with the Eurocodes. The impact of these new design codes in comparison with the previous codes is presented for reinforced concrete structures.

The assessment and rehabilitation were performed on a office building RC framed structure built in 1971. The assessment of in-situ conditions showed up the main problems of the RC structure which consisted of inadequate concrete strength at some columns. The strengthening solution consisted in transversal confinement with composite fibre reinforced polymers of the columns.

Keywords: existing reinforced concrete structures; design codes at seismic action; assessment and rehabilitation; structural analysis; CFRP strengthening.

1. Assessment and Analysis of Existing Reinforced Concrete Structures

The assessment of the existing structures to the seismic action is estimated according to the Romanian Code by calculus of the *earthquake capacity ratio* $R = S_{cap} / S_{nec}$ where: S_{cap} - seismic shear force capacity (seismic base shear force); S_{nec} - conventional seismic load (seismic base shear force) calculated according to the present Romanian Code for seismic design action.

The equivalence between the Romanian earthquake capacity ratio and the more common safety approach according to Eurocodes is presented in Table 1. The values R are according to the “present” and the “***proposed***” Romanian codes for assessment of existing structures in seismic regions.

Table 1: Safety factors of new and existing buildings

Building class of importance			Earthquake capacity ratio R_{min}		Global safety coefficient C_0	Reliability index β	Failure probability P_{f}
New buildings				1,00	2,250	4,75	$10^{-6}\ldots10^{-7}$
Existing buildings of class:	I.	Buildings of vital social importance	Present	0,70	1,575	3,09	10^{-3}
			Proposed	***0,90***	***1,962***	***4,27***	$\boldsymbol{10^{-5}}$
	II.	Very important buildings	Present	0,60	1,350	2,00	$2\cdot10^{-2}$
			Proposed	***0,80***	***1,771***	***3,72***	$\boldsymbol{10^{-4}}$
	III.	Normal importance buildings	Present	0,50	1,125	1,28	10^{-1}
			Proposed	***0,65***	***1,575***	***3,09***	$\boldsymbol{10^{-3}}$
	IV.	Reduced importance buildings	Present	0,50	1,125	1,28	10^{-1}
			Proposed	***0,50***	***1,125***	***1,28***	$\boldsymbol{10^{-1}}$

Note: Values are given for normal distribution of actions and strengths and variation coefficient $C_v^r = C_v^a = 10\%$

2. Rehabilitation Example

The office building (Fig. 1) from Timisoara Nord Railway Station, a reinforced concrete framed structure with five storeys (one underground storey; ground storey and three upper storeys) was assessed and strengthened. The building was erected in 1971 in a seismic zone – Timisoara. The monolithic RC structure consists of: spatial frame; horizontal slabs supported by frame beams; isolated foundations under columns.

The assessment of in-situ conditions showed up the main problems of the RC structure which consisted of inadequate concrete strength at some columns; f_{co} = 6,5 N/mm^2 at underground storey; f_{co} = 9,5 N/mm^2 at the ground storey.

Fig. 1: Office building from Timisoara Nord Railway Station

The results of the structural analysis are presented in Table 2 for the most dangerous situation of columns. The maximum design efforts M_{Ed} were given by the accidental design situation.

Table 2: Analysis results for columns

Columns	N_{Ed} [kN]	M_{Ed} [kNm]	M_{Rd} [kNm]	σ_{Ed} [N/mm^2]	Initial structure f_{co} [N/mm^2]	Initial structure $R = \frac{f_{co}}{\sigma_{Ed}}$	Strengthened structure f_{cu} [N/mm^2]	Strengthened structure $R = \frac{f_{cu}}{\sigma_{Ed}}$
Underground storey	455	132	142	12,2	6,5	***0,53***	12,5	***1,02***
Ground storey	587	155	167	17,4	9,5	***0,55***	15,5	***0,89***

The design compression stress σ_{Ed} for concrete cross-section of columns at flexure with compression axial force presented some higher values than the concrete compression strength $\sigma_{Ed} > f_{co}$. This could lead to a very danger situation of concrete cross-section fracture.

In order to quantify the seismic risk of failure the earthquake capacity ratio R was calculated as the ratio between the design compression stress σ_{Ed} and the concrete compression strength f_c . The earthquake capacity ratio $R > R_{min}$ = *0,50* (see Table 1) according to the present Romanian codes. But, according to the ***proposed*** Romanian Code P100-3 project [2] for assessment of existing buildings to seismic action, the earthquake capacity ratio $R < R_{min}$ = *0,65* (see Table 1) for normal importance buildings, meaning that the structure would present an increased seismic risk of failure.

The strengthening was proposed in order to increase the RC columns cross-section compression strength at underground and ground storey and consisted of in transversal confinement with a CFRP single layer of wrap closed jacket at both ends of the columns. The jackets had a width b_f = 600 m and a thickness t_j = 0,12 mm. CFRP materials characteristics used for strengthening are: E_j = 231 kN/mm^2 and ε_{ju} = 0,017.

The technical efficiency of CFRP confinement is shown in Table 2 and consisted in obtaining, for the strengthened concrete cross-section, values of the earthquake capacity ratio $R > R_{min}$ = *0,65* in accordance to the ***proposed*** Romanian Code for assessment of existing buildings to seismic action.

3. Conclusions

The main ideas which emerge from this paper are summarised below:

1. The earthquake capacity ratio ($R = S_{cap} / S_{nec}$) is analysed for reinforced concrete framed structure according to the “present” and the “***proposed***” Romanian codes for assessment of existing structures in seismic regions.

2. The assessment and strengthening of an existing office building having a five storeys RC framed structure, erected in 1971 and located in a seismic zone, was performed. As the assessment of in-situ conditions showed up the main problems of the RC structure which consisted of inadequate concrete strength at some columns, some rehabilitation solutions were adopted: CFRP confinement of columns in order to increase the concrete compression strength.

Energy Saving with Rehabilitation Solutions for Existing Structures

SORIN DAN
Civil Engineering Department
"Politehnica" University of Timisoara
Str. T. Lalescu, No. 2, Timisoara
ROMANIA
sorin.dan@ct.upt.ro http://www.ct.upt.ro

Abstract: - The paper deals with aspects regarding energy saving of reinforced concrete existing structures strengthened in seismic zones. Some case study and the rehabilitation of characteristic structures are analysed. The rehabilitation solutions were chosen in accordance with the actual stage of building deterioration as well as function of the actions characteristics. Classic (reinforced concrete and/or steel) and modern (Carbon Fibre Reinforced Polymers) materials and technologies for strengthening have been used. Finally, the total cost of strengthening solution and the energy used with raw materials are presented.

Key-Words: - Existing reinforced concrete structures; Seismic action; Strengthening; Classic rehabilitation solutions; Modern rehabilitation techniques; Carbon fibre reinforced polymers (CFRP); Raw material; Embodied energy.

1 Introduction

Sustainable construction has recently been identified as one of lead markets for the near future of Europe because of its high innovation potential, its ability to respond to market needs, the strength of European industry and the necessity to support it through the implementation of public policy measures.

The main concept of sustainability regards buildings with a long service life, low operating and maintenance costs and high energy efficiency.

In addition the sustainability is based on the environmental, economic and social components and includes criteria such as technical process and site quality. A global quantitative model for evaluating the sustainability is difficult to be produced but for each structural element or building it may be established. In this paper the calculated components of sustainability are: total cost of strengthening solution; the energy used with raw materials.

The sustainability and the energy saving of the strengthening solutions were slightly discussed in comparison to the new buildings.

Three strengthening solutions will be analyzed in the paper. The strengthened elements are existing reinforced concrete columns as vertical structure of different constructions.

The rehabilitation solutions are:

- steel bracing with four angle steel shapes connected by flange plates;
- carbon fibre polymer composites (CFRP): longitudinal strips and transversal wraps;
- jacketing by reinforced concrete using longitudinal reinforcement bars and transversal stirrups.

2 Rehabilitation Solutions

2.1 Structural rehabilitation using steel profiles vs. carbon fibre reinforced polymers

2.1.1 Reinforced concrete silos

The assessment and rehabilitation solutions for a group of silos owned by the SAB Miller Brewery Company “Timisoreana” are presented. The silos (Fig.1) were built 40 years ago and stand 28 m high and 7.30 m in diameter.

Fig.1. RC silos.

Initial silos inspection (1999) revealed large zones of circular cells with concrete cover dislocated and corrosion of circumferential steel reinforcement. Recent silos inspection and assessment (2004) emphasized other vulnerable parts: infrastructure and charging platform (gallery).

The silos infrastructure consists of foundation raft, discharge funnel and its supporting columns and beams.

The main damages are due to water infiltration and high humidity inside of each cell bottom part, which caused important dislocated concrete cover and corrosion of the columns steel reinforcement (Fig.2).

Fig.2. Reinforcement corrosion of discharge funnel supporting columns.

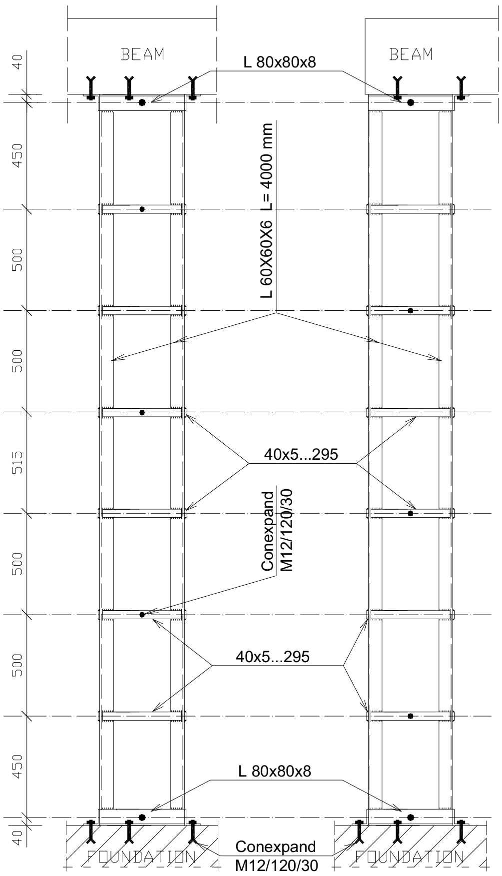

Fig.3. Strengthening solution with steel profiles.

The strengthening of supporting columns for the discharge funnel consists of steel profiles (Fig.3). This solution has a smaller cost than CFRP materials. On the other hand, steel profiles have a better buckling behaviour than CFRP strips.

In order to have the comparison of sustainability and energy saving criteria of the rehabilitation solutions, the column strengthening was re-designed using CFRP as follows (Fig.4):

- longitudinal strips S1012, on four sides, having a width of 100 mm, a thickness of 1.2 mm and the length of the column. The strips were anchored in foundations and at the top joints;
- transversal confinement with a single layer of wrap closed jacket at both ends of the columns. The jackets had a width of 900 mm and a thickness of 0.12 mm.

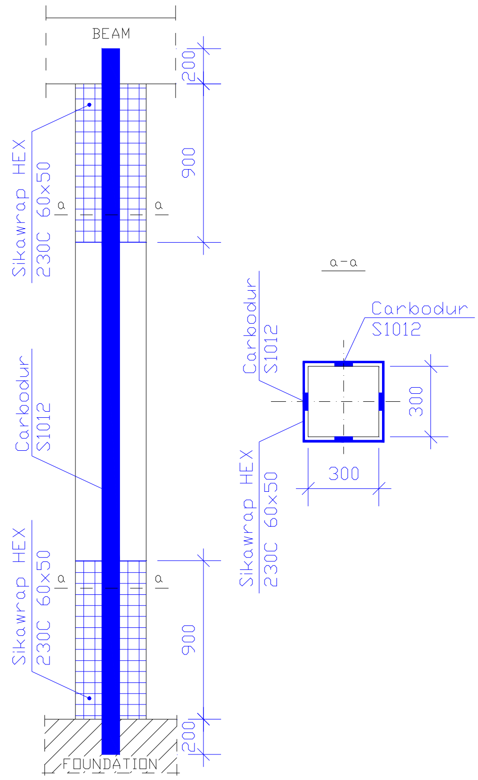

Fig.4. Strengthening solution with CFRP.

2.1.2 Reinforced concrete framed building

The Western University of Timisoara has many buildings, among them the Main Building (Fig.5 and 6) that is used as administrative part as well as classrooms for students, was built in 1962-1963.

The RC structure consists of:

- transversal and longitudinal frames with eight storeys and two spans of 5.6 m and eleven bays of 3.8 m;
- floors with girder mesh in two directions and a slab of 10 cm;
- foundation with a thick slab and deep beams in two directions.

IMPACT OF STRUCTURAL REHABILITATION OF EXISTING BUILDINGS ON ENERGY SAVING IN CONSTRUCTIONS

Lect. Dr. Sorin Dan

Assist. Prof. Dr. Liana Iures

Lect. Dr. Catalin Badea

"Politehnica" University of Timisoara, **Romania**

ABSTRACT

The assessment of the protection level of structures, generally and particularly of reinforced concrete structures, has become a constant preoccupation of many specialists involved in design, execution and monitoring of structures.

The paper deals with aspects regarding energy saving of reinforced concrete existing structures strengthening. Some case study and the rehabilitation of characteristic structures are analysed. The rehabilitation solutions were chosen in accordance with the actual stage of building deterioration as well as function of the actions characteristics. Classic (reinforced concrete and/or steel) and modern (Carbon Fibre Reinforced Polymers) materials and technologies for strengthening have been used.

Assessment and rehabilitation of some existing reinforced concrete framed structure are presented. Finally, the total cost of strengthening solution and the energy used with raw materials are presented.

Keywords: Existing reinforced concrete structures, Strengthening; Modern rehabilitation techniques, Carbon fibre reinforced polymers (CFRP), Embodied energy.

INTRODUCTION

The assessment of the protection level of structures, generally and particularly of reinforced concrete structures, has become a constant preoccupation of many specialists involved in design, execution and monitoring of structures. For achieving this goal it is necessary to estimate quantitatively two parameters: durability and safety – principal components of construction quality.

The structure durability may be defined as the time period during which the construction preserves its own normal characteristics of function. The structural safety has to take into account the effect of all possible actions, ordinary loads and extreme loads: permanent, variable and extreme actions and the environmental factors.

The vulnerability of existing structures under seismic motions may be due to structural system weaknesses and specific detailing [1-4]. Structural weaknesses are characterised by various irregularities and discontinuities or by general structural vulnerabilities:

1. Irregularities in the vertical direction of the buildings: irregular distributions of the stiffness; strength discontinuities; mass irregularities; vertical load discontinuities.

2. Irregularities in the building layout: horizontal irregularities of masses, stiffness and strength, which all produce torsion effects; unfavourable plan layouts; slab discontinuities due to holes or weaknesses of the connections in some zones.
3. General structural vulnerabilities: the indirect transfer of strong forces by beam-on-beam supports or columns supported on beams; cantilever horizontal members with large spans and / or high loads; weak column / strong beam: eccentricities; finite service life due to deterioration of component parts of a building.

Reinforced concrete structures may be characterized by common non-ductile detailing and vulnerabilities [1-3]:

- inadequate column bending and shear capacity;
- inadequate beam shear resistance;
- inadequate joint shear resistance;
- inadequate quantities and anchorage of beam-positive reinforcement at the beam-column joint;
- inadequate confinement of the potentially plastic hinges of the columns and beams as well as of the boundary elements of reinforced concrete frame-wall systems;
- inadequate reinforcement of the frame in the longitudinal direction of the building.

ANALYSIS OF EXISTING REINFORCED CONCRETE STRUCTURES

According to the Romanian Code for seismic design P100-92 [1] as well as to the other norms, the design of structures to resist earthquake is based on the following design procedures and calculation methods:

- Common design procedures based on the following calculation methods: <u>linear static</u> with conventional forces distributed as inertia forces for linear static response; <u>linear dynamic</u> with accelerograms for modelling of seismic actions;
- Design procedure based on consideration of post-elastic deformation of structures with: <u>non-linear static</u> analysis and conventional forces distributed as inertia forces for seismic response; <u>non-linear dynamic</u> method with accelerograms for modelling of seismic action.

The assessment of the existing structures to the seismic action is estimated according to the Romanian Code by calculus of the *earthquake capacity ratio R*:

$$R = \frac{S_{cap}}{S_{nec}} \qquad (1)$$

where: S_{cap} - seismic shear force capacity (seismic base shear force);
S_{nec} - conventional seismic load (seismic base shear force) calculated according to the present Romanian Code for seismic design action.

For the assessment of existing structures the general Equation 1 may be written for different sectional efforts and applied for individual structural members, as for instance:

$$R = \frac{M_{cap}}{M_{nec}} = \frac{M_{Rd}}{M_{Ed}} \qquad (2)$$

where: M_{cap} or M_{Rd} - resistance bending moment;
M_{nec} or M_{Ed} - design bending moment calculated for the present-day level of actions.

Risk Assessment and Rehabilitation of Historical Masonry Buildings

SORIN DAN, CORNELIU BOB, CATALIN BADEA, LIANA IURES
Civil Engineering and Installations Department
"Politehnica" University of Timisoara
Str. Traian Lalescu, No. 2, Timisoara
ROMANIA
sorin.dan@upt.ro; cbob@mail.dnttm.ro; catalion.badea@upt.ro; liana.iures@upt.ro
http://www.ct.upt.ro/cci/index.htm

Abstract: The paper is focused on the risk assessment, analysis, redesign and rehabilitation solutions applied for old existing structures in seismic zones. The old malting building, erected between 1857-1876 at the "Timisoreana" Brewery, is a five storeys masonry structure and a tower composed of: walls of (50-140) cm thickness; inter-storey floors - brick masonry vaults supported by steel profiles; a tower, of about 14 m height and 2.80 m diameter, supported by an interior dome. The main structural damages were: vertical cracks in the tower masonry structure; corrosion of steel members: horizontal circular rings for confining the tower; profiles for supporting the floor masonry vaults. The static and dynamic analysis at different actions showed up major structural vulnerability, mainly due to the period of design and erection (19th century). In order to preserve the old building as architectural monument and to reduce the seismic failure risk, some strengthening solutions were designed and applied. The strengthening solutions were selected in order to obtain technical and economical advantages: safe behaviour at seismic actions; slight change of overall structural stiffness; easy strengthening technology and short refurbishment period; low rehabilitation cost.

Key-Words: masonry; old buildings; seismic zones; risk assessment; strengthening

1 Introduction

The main target of the paper represents the risk assessment and rehabilitation of an old masonry buildings located in seismic zones.

Masonry structures present some important vulnerability in seismic zones: the overall lateral stiffness values along the two main axes are different; lack of seismic joints to divide building parts having different dynamic characteristics; lack of reinforced concrete straps at each level; defects of wall connections at corners, crossings and ramifications as well as the presence of cracks; inadequate bearing capacity at normal forces on the walls.

On the other hand, structural weakness is characterised by various irregularities and discontinuities or by general structural vulnerabilities: irregular distribution of stiffness at lateral displacements; strength discontinuities; mass irregularities; vertical load discontinuities.

Existing masonry structures without reinforcement may be strengthened by different classic and/or modern technologies: erection of RC cores at appropriate distance combined with straps at each level; masonry jacketing with reinforced concrete; masonry confinement with steel profiles; masonry coating with CFRP systems; interlocking of masonry walls at corners, crossing and ramifications with RC elements and/or some steel profiles; adding new inner walls and/or some outside abutments.

2 Rehabilitation of a Tower Structure

The old malting building, erected between 1857-1876 at the "Timisoreana" Brewery, is a five storeys masonry structure and a tower (Fig. 1) composed of:

Fig. 1. Old malting building.

- walls of 50 – 140 cm thickness;
- inter-storey floors - brick masonry vaults supported by steel profiles;
- a tower, of about 14.00 m height and 2.80 m diameter, supported by an interior dome.

2.1 Structural assessment

The assessment of the structure was performed in 2007 according to the present-day Romanian codes for existing structures and codes for design loads magnitude.

The main structural damages are:

- vertical cracks in the tower masonry structure – Fig. 2;
- corrosion of steel members: horizontal circular rings for confining the tower; profiles for supporting the floor masonry vaults.

Fig. 2. Vertical cracks of masonry tower.

The static and dynamic analysis at different actions showed up major structural vulnerability, mainly due to the period of design and erection (19^{th} century):

- the tower, about 14 m high, presents general instability at seismic actions: the total bending moment at tower base leads to an eccentricity $e_0 = 1.78\ m > D_{ext} / 2 = 1.50\ m$ where D_{ext} is the tower exterior diameter;
- in some zones of the tower masonry structure actual stresses, due to various loads, are greater than the tensile strength f_{ti} of masonry:
  - $\sigma_{ef} = 0.93$ daN/cm^2 $> f_{ti} = 0.8$ daN/cm^2 at the tower – dome crossing (50 cm width masonry);
  - $\sigma_{ef} = 3.10$ daN/cm^2 $> f_{ti} = 0.8$ daN/cm^2 at the tower base (20 cm width masonry);
- in the masonry dome, which supports the tower, the actual stresses by parallel direction are:
  - $\sigma_\theta = 0.85$ daN/cm^2 $> f_{ti} = 0.8$ daN/cm^2 at the lower part of the dome;
  - $\sigma_\theta = 2.19$ daN/cm^2 $> f_{ti} = 0.8$ daN/cm^2 at the upper part of the dome;
- temperature variations inside-outside the tower produce actual stresses $\sigma_t = 1.0$ daN/cm^2 $> f_{ti}$ which causes the vertical cracking.

The structure, also, presents general and specific detailing lacks: no rigid floors at two storeys; no straps at all levels; the ratio between span and width of masonry shear wall is too large.

These major vulnerability classify the structure as having high risk of failure at present seismic code design magnitude.

2.2 Strengthening solutions

In order to preserve the old building as architectural monument and to reduce the seismic failure risk, the following strengthening solutions were designed:

- for general stability of masonry tower: vertical reinforcement (Fig. 3) bars (4 x 2ϕ28) embedded at the upper side of the tower in a RC beam (Fig. 4) and welded on steel profiles (Fig. 6) I 30 placed in the dome, at the tower base (Fig. 5); vertical CFRP wrap (4 x 2 strips of 20 cm width) on the entire tower height (Fig. 3);

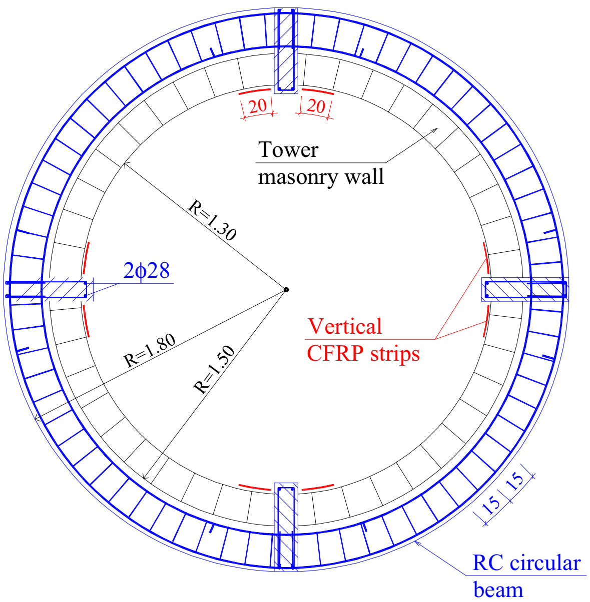

Fig. 3. Tower strengthening at base section.

Experimental Research on Recycled Concrete Fines

REMUS CHENDES, CORNELIU BOB*, CATALIN BADEA, CORNELIU EUSEBIU PODOLEANU, SORIN DAN, LIANA IURES
Politehnica University of Timisoara, 2 T. Lalescu Str., 300223, Timisoara, Romania

Recycling is defined as the process that changes materials into new products for preventing the waste of potentially useful materials, reducing the consumption of fresh raw materials, the energy usage and the air and water pollution. Many of the large, existing buildings which don't have any historical importance, such as industrial type, office buildings or apartments, have a reinforced concrete structure. Recycled concrete is mainly used as coarse aggregate and filler in road construction industry; another usage of it could be adding it into new mixtures. So far this usage has led to a significant decrease in mechanical properties for the new mixture. It is well known that the cement industry is an important energy consumer and also a CO_2 releaser. Present paper is devoted to the use of recycled concrete materials obtained from concrete elements into new mixes as a replacement of the cement. An experimental program was developed in this purpose; physical and physical-chemical tests were made on obtained materials. The mechanical properties of the obtained mortar samples have been also studied.

Keywords: recycled concrete fines, SEM analysis, EDAX, specific surface-BET, mechanical strength, sustainability

Nowadays, the attention on recycling of construction and demolition waste (C&Dw) is increasing. A comparison of the C&Dw recycling around the world was made in 2005 by Oikonomou [1]. Most European countries have high recycling goals when it comes to C&Dw (between 50% and 90%). Many studies on technologies for producing recycled concrete aggregate [2], recycled concrete fines and life-cycle analysis, have been carried out in Japan and US. In the U.S.A., aggregates are divided by use: in pavements (10-15%), road construction and maintenance work (20-30%) and structural concrete (60-70%). In Japan, the concrete recycling ratio is almost 99% and it is used generally as sub-base material in road construction. An important role may also have the waste [3] from different production processes, reused as concrete preparation materials [4].

The biggest energy-consumer component of a concrete is the cement, with high CO_2 emission during the manufacturing process, a part of it being bound by carbonation process [5]. Replacing an amount of cement into a concrete mixture with recycled concrete finest (RCF) it is helpful for environment protection and natural resources preservation.

A disadvantage of replacing a percent of cement with RCF is that the mechanical and elastic property of the obtained material is reduced [6]. This can be caused by the high water absorption of RCF. This effect is also in line with observations from literature [7, 8]. From literature it is well known that with smaller particle fraction of RCF there are obtained better mechanical properties. Another characteristic of smaller particles fraction resulted after crushing and milling the concrete, is the lower SiO_2 content compared with bigger particles fraction of RCF [9].

By demolishing concrete buildings, collecting the used concrete and crush it, there are also created recycled concrete aggregate (RCA). The RCA [10] has different properties than normal aggregates and it behaves differently in concrete mixes. There are also studies focused on the effect of heat treatment on RCA used to obtain new concrete [11], but this aspect was not considered in this study.

Katrina McNeil [12] describes the variation between the properties of RCA concrete compared to normal river aggregates concrete; the results from recent tests show the strength reduction due to higher water absorption of the RCA.

The present policy concentrates on recovery, recycle and reuse (RRR) of various waste including C&Dw. The reuse, recycling and reducing the waste are considered the only methods to recover the wastes generated; however, the implementations still have much room for improvement [13].

According to European Directive 2008/98/EC [14], until 2020 EU countries are obliged to increase the percentage of RRR of demolition waste with at least 70% of the total. In Romania the Law no. 211/2011 [15] was adopted based. Therefore, it is compulsory for the researchers to concentrate on obtaining sustainable methods for using wastes into new domains, including C&Dw.

The targets of the studies presented in this work are the following:

-to observe the material structures of the RCF by use of a complex analysis like SEM, specific surface-BET, EDAX;
-to determine the main mechanical strength of the RCF;
-to demonstrate the importance of a complex analysis for obtaining new materials by using RRR of various types of wastes from construction and demolition.

Experimental part

Studied materials

The RCF was obtained after crushing a concrete beam, realized with concrete compressive strength of 33.2 N/mm^2 at 28 days and 22.9 N/mm^2 at 7 days, established by use of cylindrical samples extracted from the beam.

First the beam was demolished on site using an excavator and pre-crushed using a jaw crusher. The resulted material was transported into a hall where it was crushed using a Prototype Crusher (PC). Afterwards, the obtained material was divided into three grain size groups: RCA1 (having the particle size between 1.0 and 16.0 mm) and RCF-i (with the particle size from 0 to 1mm) and RCF –s (with particle size from 0 to 0.063 mm).

* *email: cbob@mail.dnttm.ro, Tel:+40740191006*