List of 10 relevant publications

1. **Nagy-György T.**, Moşoarcă M., Stoian V., Gergely J., Dan D., Retrofit of reinforced concrete shear walls with CFRP composites, fib Symposium - Keep Concrete Attractive, Budapest, Hungary, 2005, ISBN 963 420 838 X (BDI)

2. **Nagy-György T.**, Stoian V., Dan D., Dăescu C., Demeter I., Diaconu D., Dogariu A., Experimental assessment on shear strengthening of clay brick masonry walls using different techniques, PROHITECH, Rome, 2009, ISBN 978-0-415-55804-4, pp 1653-1658 (ISI)

3. Demeter I., **Nagy-György T.**, Stoian V., Dăescu C., Dan D., FRP Composites for Seismic Retrofitting of RC Wall Panels with Cut-Out Openings, First International Conference on Structures and Architecture (ICSA2010), Guimaraes, Portugal, 2010, ISBN 978-0-415-49249-2, pp 1902-1908 (ISI)

4. **Nagy-György T.**, Sas G., Dăescu C., Barros J.A.O., Stoian V., Experimental and numerical assessment of the effectiveness of FRP-based strengthening configurations for dapped-end RC beams, Engineering Structures 44 (2012) 291–303, ISSN: 0141-0296 (IF: 1.838/2014)

5. Dan D., **Nagy-György T.**, Stoian V., Fabian A., Demeter I., FRP Composites for Seismic Retrofitting of Steel-Concrete Shear Walls with Steel Encased Profiles, STESSA 2012, Santiago, Chile, 2012, ISBN 978-0-415-62105-2, pp1071-1076 (ISI)

6. **Nagy-György T.**, Demeter I., Floruţ C., Dan D., Causes and required interventions on the rehabilitation process of large panel buildings in Romania, 2nd International Conference on Civil Engineering and Building Materials (CEBM 2012), November, Hong-Kong, 2012, ISBN 978-0-415-64342-9, pp 853-858 (BDI)

7. Floruţ C., Stoian V., **Nagy-György T.**, Dan D., Diaconu D, Performance assessment of mixed CFRP retrofitting solution for RC slabs, 2nd International Conference on Structures and Architecture (ICSA2013), July 24-26, 2013, Guimaraes, Portugal, ISBN 978-041566195-9, pp. 727-732 (ISI)

8. Sabău C., Stoian D., Dan D., **Nagy-György T.**, Floruţ C., Stoian V., Partial results of monitoring in a passive house, Journal of Applied Engineering Sciences, V1(16), Issue 1, 2013, ISSN 2247-3769, pp 107-111 (BDI)

9. Sas G., Dăescu C., Popescu C., **Nagy-György T.**, Numerical optimization of strengthening disturbed regions of dapped-end beams using NSM and EBR CFRP, Composites Part B: Engineering 67 (2014), 381-390, ISSN: 1359-8368 (IF: 2.983/2014)

10. Toduț C., Stoian V., Demeter I., **Nagy-György T.**, Dan D., Ungureanu V., Seismic Strengthening of a Precast Reinforced Concrete Wall Panel Using Combined NSM and CFRP-EBR Method, FRPRCS-11, June 26-28, 2013, Guimaraes, Portugal, ISBN 978-972-8692-84-1, pp 269-270

RETROFIT OF REINFORCED CONCRETE SHEAR WALLS WITH CFRP COMPOSITES

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SUMMARY

This paper presents the results obtained in a study on the effectiveness of using externally bonded CFRP composites for the seismic retrofit of reinforced concrete shear walls with staggered openings. Five 2600 x 1250 x 80 mm reinforced concrete wall specimens were tested up to failure in the in-plane direction using horizontal monotonic alternate loading forces at constant vertical force. After the initial test the walls were repaired and strengthened with CFRP sheets placed horizontally and vertically on one side, and retested. The objectives were to study the behaviour of the strengthened elements, the specific anchorage detail, the strengthening system, the stiffness, the ductility and the collapse mechanism. Based on the test results it is concluded that this retrofit technique is effective for strengthening reinforced concrete shear walls.

1. INTRODUCTION

Fibre reinforced polymer (FRP) composites are non-ductil materials, with high strength-to-weight ratio, low thickness and durability. These materials have been used in numerous applications worldwide to retrofit structural reinforced concrete (RC) elements, as beams, columns or walls. Despite of this, less attention was given to the research on the in-plane behaviour of RC wall members with FRP composites. In fact, proper RC wall experiments were performed only by few teams. Lombard et al. applied carbon FRP (CFRP) sheets in vertical and horizontal direction on the side faces of the walls, and than tested to failure under a predetermined in-plane quasi-static cyclic loading sequence in load control up to the yield load, and then continuing to failure in displacement control at predetermined steps. Antoniades et al. used for strengthening CFRP and also glass FRP (GFRP) sheets, applied in vertical direction laterally and in form of horizontal jacketing, the walls being tested in displacement control mode. Other cases, similar with this theme, were studied by Iso et al. in form of wing walls, by Sugiyama et al. as infill walls and by Paterson and Mitchell in wall strengthening together with other techniques.

The objectives of present experimental programme were to investigate the effectiveness of CFRP composites for the seismic retrofit of reinforced concrete shear walls with staggered openings. Possible field application of this could be the restoring, improving and/or supplying the load bearing capacity of such structural elements before or after earthquake. For that purpose five structural shear walls with staggered door openings were performed, tested up to failure, retrofitted and retested. It was studied the behaviour of the strengthened elements, the specific anchorage detail, the strengthening system, the stiffness, the ductility and the collapse mechanism.

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Experimental assessment on shear strengthening of clay brick masonry walls using different techniques

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ABSTRACT: In this paper studies made on strengthening techniques used for shear deficient clay brick masonry walls are presented. The investigated retrofitting systems were the fibre reinforced polymer (FRP) composites, the reinforced mortar jacketing (RMJ) and the steel wire meshes (SWM). Based on the results obtained, it was proven the effectiveness of the externally bonded techniques for strengthening brick masonry walls. These solutions could be useful in the structural retrofitting of the masonry walls, for improving the shear capacity of the masonry buildings before seismic events or in restoring the shear capacity of the affected walls after an earthquake.

1 INTRODUCTION

The seismic vulnerability of the masonry buildings was obvious during the major seismic events across the world. One of the latest examples was the case of the residential buildings from the town Moldova Noua, Romania, which were damaged after the earthquake in 2002. A significant number of masonry elements suffered serious damages, and the use of an effective retrofit technique was needed to increase the in-plane and out-of-plane strength and stiffness of the masonry walls.

The investigated retrofitting systems were the fibre reinforced polymer (FRP) composites, the reinforced mortar jacketing (RMJ) and the steel wire meshes (SWM). All these strengthening methods were studied in the Department of Civil Engineering of the Politehnica University of Timisoara, Romania, the SWM being a part of the international project PROHITECH. The objective was to investigate the behaviour of the unreinforced clay brick masonry walls subjected to in-plane shear loads strengthened with different techniques.

Although initially the cost of the materials of FRP and SWM solutions is higher than the traditional retrofit methods for the masonry walls investigated, such as the RMJ, the efficiency and the ease of application can lead to an economic result.

2 NUMERICAL ANALYSIS

In the first stage, it was performed an analytical study with a simplified (theoretical) model of the wall. The goal was to conceive a device in which the load system creates a pure in-plane shear of the wall, without much influence from the bending moment. This system is auto-equilibrant and, theoretically, the crack should form in the diagonal direction. The loads applied to the specimen were a constant vertical (V) force and an increasing horizontal (H) force. With this set-up a large number of finite element analysis (FEA) were performed, by modifying the width to height ratio (d/h) of the elements (d/h = 1, d/h = 1.5 and d/h = 2), the quality of the brick and of the mortar, through the strength and the modulus of elasticity of the element, the horizontal load-steps, and finally by applying a constant vertical force of different magnitudes.

The first analyses were performed with the program BIOGRAF, developed in the Department of Civil Engineering from Timisoara, which allows a step by step modification in principal stresses and the formation of the cracks, their angles and widths. After every step, the program recalculates the stiffness and the modulus of the element. For complementary analyses AXIS VM software was used. Taking into account the dimensions of the bricks, the studied wall specimen had height to width ratio equal to unit, thus the final width of the wall was chosen 150 cm. This aspect ratio also represents the masonry wall pier dimensions widely encountered in older brick structures. From the analytical models were obtained the distribution of the principal stresses, the crack propagation in the wall, the probable failure load and the collapse mechanism.

Theoretically, the application of the vertical force is not necessary in the case of homogenous materials, but the brick wall is composed of clay brick units and mortars, which have different characteristics. Therefore,

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FRP composites for seismic retrofitting of RC wall panels with cut-out openings

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ABSTRACT: This paper presents a part of an experimental program, conceived in order to quantify the shear capacity decrease of the Precast Reinforced Concrete Wall Panels (PRCWP) affected by cut-out openings and to assess the shear capacity gain using Carbon Fiber Reinforced Polymer (CFRP) composites, as retrofit solution. The experimental elements were representative of four situations: (1) as-built blank solid wall, (2) with cut-out door opening, (3) prior-to-damage strengthened by externally bonded CFRP composites and (4) post-damage strengthened by CFRP externally bonded reinforcement.

1 INTRODUCTION

The structural system of Precast Reinforced Concrete Large Panels (PRCLP) was used in Romania starting from 1954 until 1990, for the destination of housing buildings with 5 and 9 stories. The superstructure is composed of wall panels and slabs with the dimension of a room, connected along the edges by welded laps and caste-in-place concrete. Some general characteristics regarding the dimensions and materials for a 5-story building is presented in Table 1. An example for the disposal of the wall panels for a typical project from 1981 is shown in Figure 1.

An important disadvantage of these buildings is the functional rigidity of the interior space due to the dense distribution of the load bearing walls. Cut-out openings are often required to facilitate direct access from outside or between adjacent apartments, predominantly at the ground floor, where both gravity and seismic capacity demand is maximum. However, cut-out openings performed in structural walls results in the modification of the internal force flow paths, loss of load bearing capacity and reduced structural safety.

Several typical plans were analyzed to obtain the most frequently used dimensions and reinforcement arrangements of the wall panels. Thereafter a 50 component matrix was established, which identifies the possible combinations between original and cut-out or enlarged openings, taking into account 9 opening shapes and the solid wall (without opening).

Table 1. Some characteristics of the residential buildings with PRCLP structure.

<table>
<tr><th rowspan="2">Dimensions</th><th rowspan="2">Building</th><th rowspan="2">Precast wall</th><th>Buildings' self-weight</th><th>Concrete</th><th colspan="2">Reinforcement</th></tr>
<tr><th>kN</th><th>MPa</th><th colspan="2">MPa</th></tr>
<tr><td>Longitudinal [m]</td><td>16.5÷30.6</td><td>1.8÷4.5</td><td rowspan="4">7450÷19040</td><td rowspan="4">16 (C16/20)</td><td rowspan="4">420 (PC60)</td><td rowspan="4">490 (STNB)</td></tr>
<tr><td>Transversal [m]</td><td>9.6÷13.9</td><td>4.8÷5.4</td></tr>
<tr><td>Height [m]</td><td>15</td><td>2.7</td></tr>
<tr><td>Thickness [cm]</td><td>-</td><td>14</td></tr>
</table>

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Experimental and numerical assessment of the effectiveness of FRP-based strengthening configurations for dapped-end RC beams

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ABSTRACT

This paper presents experimental and numerical assessments of the effectiveness of strengthening dapped-end reinforced concrete beams using externally bonded carbon fiber reinforced polymers (CFRPs). The research was prompted by a real application, in which the dapped-ends of several precast/prestressed concrete beams developed diagonal cracks due to errors during assembly. Hence, the dapped-ends were strengthened on-site using CFRP plates to limit further crack opening. In the empirical phase of the study, four similar specimens were tested: one unstrengthened reference specimen, two strengthened with high-strength CFRP plates, and one with high-modulus CFRP sheets. The specimens strengthened with plates had slightly higher load carrying capacity than the reference element, but failed by debonding, while the specimens strengthened with sheets showed no increase of capacity and failed by the fibers rupturing. Nonlinear finite element analysis of the specimens under the test conditions indicated that: (a) debonding is more likely to occur at the inner end of dapped-ends and (b) the capacity could have been increased by up to 20% if the plates had been mechanically anchored.

1. Introduction

Precast prestressed concrete (PC) structures have several advantages compared to cast-in-place structures; they can be constructed more rapidly and are generally more robust and durable. They are made of individual elements and assembled with various types of connections. For beams, these connections may require severe reductions of the cross-section at the ends, called dapped-ends. The abrupt change of cross-section in a beam results in a complex flow of internal stresses, which are typically highly concentrated at the re-entrant corner. Such regions in an element are called disturbed regions (D-regions) [1,2]. According to the PCI Design Handbook [2] dapped-end beams may fail in any of the five modes schematically represented in Fig. 1: (1) Flexure (cantilever bending) and axial tension in the extended end; (2) Direct shear at the junction between the dapped and undapped zone of the member; (3) Diagonal tension failure at the re-entrant corner; (4) Diagonal tension failure in the extended end; and (5) Diagonal tension failure in the undapped zone. Numerous researchers have analyzed and experimentally investigated these failure modes. Using the strut and tie method, Reynold [3], Mattock [4], Mattock and Theryo [5] and Hwang and Lee [6] have all proposed equations for predicting these failure modes and presented design criteria for dapped-end beams. Chen [7] tested four dapped-ends with identical geometry and reinforcement ratio, but different reinforcement layouts. The results showed that the reinforcement arrangement influences the capacity of the elements, and that the provisions given in the ACI 318-08 code [8] are conservative. Lu et al. [9] theoretically and experimentally investigated the shear resistance of 12 dapped-end beams, again finding that the PCI Design Handbook [2] provisions are conservative, and suggested new design proposals.

The load carrying capacity (hereafter capacity, for convenience) of dapped-end beams may be insufficient for reasons such as design errors, code changes, increases in loads, or structural damage. One option to increase the capacity of the dapped-end regions is to use fiber-reinforced polymers (FRPs) using the externally bonded reinforcement (EBR) technique. FRPs are viable solutions for strengthening or retrofitting reinforced concrete (RC) elements, and several guidelines for strengthening RC structures with FRPs have been published recently [10–12]. However, these guidelines

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FRP composites for seismic retrofitting of steel-concrete shear walls with steel encased profiles

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ABSTRACT: The paper presents a part of an experimental program performed on composite steel-concrete slender shear walls, retrofitted using CFRP composites. The reinforced concrete (RC) elements were tested initially cyclic under lateral loads. The experimental program was performed on two shear walls with steel encased profiles tested prior to failure, thereafter retrofitted and retested. The retrofitting solution consists in rehabilitation of tested elements using Carbon Fiber Reinforced Polymer (CFRP) composites. Before retrofitting, the damaged specimens were repaired by replacing the crushed concrete with high-strength repair mortar. The experimental specimens were provided with CFRP strips and plates, to restore the bending resistance of the walls and to provide confinement effect at the ends. The aim of this study is to analyze the possibilities of using CFRP materials for strengthening the shear walls affected by seismic action. The retrofitting solution used and the failure mode is presented for each tested element. The behavior and envelope curves, ductility and energy dissipation and the stiffness degradation are presented comparatively for the strengthened and for the reference elements.

1 INTRODUCTION

Composite steel-concrete walls (CSRCW) are developed from reinforced concrete walls by encasing additional structural steel members, usually at the extremities of the cross section of the wall. As reinforced concrete walls, CSRCW elements are able to withstand high in-plane forces making them particularly suitable for earthquake resisting purposes. The research and specifications for composite steel-concrete walls show a limited level of knowledge related to the seismic behavior, energy dissipation capacity, stiffness degradation, failure modes and retrofitting solutions for damaged elements. Recent research on the behavior of composite shear walls were conducted by Liao, Han and Tao, Saari, Ji, Han and Tao, Hossain and Wright, Tong et al.

According to a literature survey the number of experimental campaigns on RC walls retrofitted by FRP composites is much less in comparison to the large number of programs involving other FRP-strengthened RC members on one hand and bare RC walls or wall-systems on the other. Of particular interest for the present research are the programs with slender cantilever walls. In the framework of the CAMUS dynamic shaking table test series one of the wall system mockups was retrofitted by vertical CF sheets subsequently that it was damaged in a previous test (Sollogoub et al., 2000; Bisch and Coin, 2007). Also post-damage retrofitting was carried out on medium slenderness walls with aspect ratio of 1.5 (Antoniades et al., 2005) using carbon or glass FRP strips for flexural and GFRP wrapping for shear strengthening. Real scale slender walls were strengthened by horizontal CFRP strips and wrapping in the as-built condition (Paterson and Mitchell, 2003). Ghobarah and Khalil (2004) employed a special test set-up and loading procedure to realize 2.25 shear span ratio on walls with 1.1 aspect ratio. The structural upgrading was undertaken by bi- and unidirectional CFRP sheets for shear and ductility improvement (confinement), respectively. Nagy-György et al. (2005) investigated slender wall-systems retrofitted by CFRP strips the post-damage condition.

In order to study the behavior of composite steel-concrete walls an experimental program was conducted in the Civil Engineering Department at the Politehnica University of Timisoara, Romania. Five possible solutions of composite walls called (CSRCW1 to 5) and one reinforced concrete typical shear wall (CSRW6), were designed and tested in laboratory. From these five composite specimens, two were tested prior to failure, then were retrofitted using CFRP composites and retested.

2 EXPERIMENTAL PROGRAM

2.1 *Experimental specimens design and materials*

The experimental program consists of six 1:3 scale elements (CSRCW1 to 6), designed using the principles from the existing European codes

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Causes and required interventions on the rehabilitation process of large panel buildings in Romania

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ABSTRACT: This paper intends to discuss the rehabilitation requirements of the reinforced concrete condominium buildings, especially of those made of large panels system. The necessity, the causes and the procedures of rehabilitation are outlined, finally presenting some recommended solutions. Based on the seriously astonishing data of the European and Romanian Statistical Institutions with regard to the housing conditions, the need of immediate and high performance interventions for rational and energy efficient rehabilitation of the block of flats type buildings is obvious.

Keywords: concrete condominium buildings, large panel buildings

1 INTRODUCTION

The renovation of residential buildings is always a hot topic, irrespective of the structural type, which country or the solutions that are in discussion. Of course, the given conditions are very relevant and it is important to know the causes leading to renovation, as well as the chosen concepts.

In 2008 the European Union (EU) adopted the so called 20-20-20 Renewable Energy Directive; according to this document until 2020 the member states agreed on 20% cut in energy consumption through improved energy efficiency and on 20% increase in the use of renewable energy. The justification was, that buildings sector represents 40% of the EU total energy consumption, and thus reducing energy consumption is a priority objective. However, this directive probably will be overwritten by a more important reason, i.e. 30 million people in the EU suffering both lack of space and poor housing conditions (see Directive 2002/91/EC).

According to data reported by the National Institute of Statistics (NIS 2009), in Romania there are 8.3 million dwellings with 21.6 million rooms. In average an apartment has 2.6 rooms and 2.6 inhabitants. 50% of the population is represented by urban resident, who mostly live in prefabricated large panel buildings (NIS 2009).

Likewise other Eastern European countries, Romanian urban areas underwent significant transformation during the second half of the 20th century, regarding the housing conditions. A considerable 28% of the total room area of residential buildings was represented by blocks of flats built as reinforced concrete construction realized in the period of 1950-2000, totalizing more than 57000 buildings. Over 40000 of these blocks are low-rise 5-storey Precast Reinforced Concrete Large Panel (PRCLP) buildings, more than 3500 are 9-storey and more than 4500 are 11-storey mid-rises (Fig. 1). The Romanian terminology used the large-panel residential building or large-panel block. The structural system of the PRCLP buildings is composed of the cast-in-place reinforced concrete (RC) infrastructure and the entirely precast superstructure. The infrastructure consists in strip foundations and 200 mm thick RC walls. The superstructure was made of room-size (2×5 m in their plane) precast slab and wall panels, assembled on-site through vertical and horizontal joints along their edges by lap welding of steel reinforcement and casting in-place concrete, emulating the conventionally formed cast-in-place RC structures. Modular construction was employed using M300 mm as unit. (Demeter 2011).

According to a study published by Rybkowska & Schneider (2011) and extracted data regarding Romania can be affirmed that the European average of 15 m^2/person is significantly lower in Romania. Although it seems unbelievable, but more than 55% of the population lives in overcrowded dwellings (Fig. 2), which is considerably above of the European average of 18%. Further serious problem is the severe housing deprivation, which reaches more than 28%. Due to poverty, defined as individuals living in households with a disposable income below 60% of the national average, it is more likely to live in overcrowded condition. Based on the recorded data, in Romania the rate of these persons reached 65% (Fig. 2). These problems are generally associated with more deficiencies, such as leaking roof, lack of a bath or a shower or a flushing toilet and the insufficient natural light in the rooms. By far the most unfavourable situation can be found in Romania, where over 43% of

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Performance assessment of mixed CFRP retrofitting solution for RC slabs

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ABSTRACT: The paper presents results obtained through experimental investigations on Reinforced Concrete (RC) slabs retrofitted by using Fiber Reinforced Polymer (FRP) composite materials. The research program was conducted at the "Politehnica" University of Timisoara, Romania and covers tests on two-way slabs with and without cut-out openings. Theoretical and experimental research have been carried out in order to determine the effectiveness of the proposed strengthening/retrofitting solutions in the particular case of cut-outs created in the corners and on the edges of the slabs. The results presented in this paper were obtained by performing eight tests on four full scale RC elements. In the first stage, each element was tested in as-built condition up to a certain stage. Afterwards, a mixed retrofitting solution that involves the use of both Near Surface Mounted Reinforcement (NSMR-FRP) and Externally Bonded (EB-FRP) techniques was applied. Finally, the elements were retested up to failure. The results are encouraging, proving the fact that the capacity can be regained and even increased by applying the retrofitting system.

1 INTRODUCTION

One interesting application in which the use of CFRP may be found very useful relates to the strengthening/retrofitting of RC slabs. Generally, the need of such interventions appears after changes in design codes and/or changes in functionality of some buildings. There is also the case in which large refurbishment interventions require changes that relate to vertical circulation and access, leading to the need of inserting supplementary openings inside the floors of the building. In most of the situations mentioned above, a series of strengthening procedures are required to be applied in order to account for the new reality of the slabs.

While attempting to strengthen/retrofit one or more elements of a structure or even the entire structure as a whole, a number of classical solutions can be chosen, such as: span shortening, bond of steel members, use of external or internal post-tensioning systems, increase the cross-sectional dimensions, or a combination of these methods (Alkhrdaji, 2004). Supplementary, a more modern approach would consist in applying of CFRP elements either by bonding or by using mechanical fasteners. Whereas the available traditional approaches are completely known and experimented, the use of CFRP offers a series of advantages in terms of ease of application, required time for application, architectural interference, etc. Even so, the situation was not sufficiently accounted for, the available data and research on the topic being relatively limited.

For slabs with cut-out openings strengthened using FRP, the available research is scarce, only several research programs being reported in literature, as work conducted by Vasquez & Karbhari (2003), Tan & Zhao (2004), Enochsson (2005) or Smith (2009) being of high importance. The solution applied by all of the researches consisted in laying up CFRP or GFRP strips or sheets of fabrics around the cut-out and bonding them to the concrete surface, on the tensioned side, using epoxy based resins. Different configurations for the lay-out of the

PARTIAL RESULTS OF MONITORING IN A PASSIVE HOUSE

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ABSTRACT
This paper presents a strategy for data monitoring into a Passive House. The Passive House has been built and is under monitoring since November 2011. After one year time there is sufficient data recorded to be able to calculate the annual energy consumption of the building and validate the design method. The monitoring system records data from 41 sensors, with the measuring pace set to 1 minute. Thus, in one year it records over 21 million different values. Therefore, a strategy is required in order to efficiently substract the relevant and important information. Because not all measured data are equally relevant at a certain stages of optimising the energy efficiency of the building, this paper will focus on the parameters relevant for evaluating the overall energy performance of the monitored building.

Keywords: *energy efficiency, passive house, energy consumption, design*

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INTRODUCTION

To pave the way for low-energy residential buildings in Romania, a Passive House has been design and built. Then after, a monitoring system was implemented, providing a planning and evaluation of the demonstrative project for future energy efficient houses in Eastern Europe. The construction of the house began in 2010 and ended by November 2011. Since then, the building is under continuous monitoring. After one year of monitoring there is sufficient data recorded to be able to assess the annual energy consumption of the building and to assess its energy performance.

MATERIALS AND METHODS

1. Analysis of energy use in the building

As it is known, a passive house is defined as a building with very low energy consumption (max 15kWh/m^2/year for heating and cooling and a total energy footprint of less than 120kWh/m^2/year) [1]. The house has approximately 144 m^2 living space, corresponding to the needs of an average family. The project complies with Passive House Standards, being built in a newly developing urban area nearby the city of Timisoara. [2] The exterior envelope of the passive house is composed of masonry structural walls from ceramic hollow blocks of 25 cm thickness, complemented with 300 mm thickness thermal insulation, for the vertical surfaces (fig. 1) [3] .

Fig.1. Facade detalil and exterior finishing of the passive house

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Numerical optimization of strengthening disturbed regions of dapped-end beams using NSM and EBR CFRP

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ABSTRACT

This paper presents a parametric investigation, based on non-linear finite element modeling, to identify the most effective configuration of carbon fiber-reinforced polymers (CFRP) for strengthening reinforced concrete (RC) dapped-end beams. Following a field application and laboratory tests, it focuses on effects of 24 externally bonded (EBR) and near surface mounted reinforcement (NSMR) configurations on yield strain in steel and the capacity and failure mode of dapped-end beams. The investigated parameters were the mechanical properties of the CFRP, the strengthening procedure and the inclination of the fibers with respect to the longitudinal axis. Two failure scenarios were considered: rupture and debonding of the FRP. The results indicate that high-strength NSM FRPs can considerably increase the capacity of dapped-end beams and the yielding strains in reinforcement can be substantially reduced by using high modulus fibers.

1. Introduction

1.1. Literature review

Effective construction using precast components is reliant on their standardization and design practicality. These elements may be linear (beams, columns), planar (walls, floors) or spatial sub-assemblages (beam-column nodes, pad foundations). In order to reduce the floor height and to facilitate the connection between beams and columns, dapped-end beams are generally used in precast concrete industry. As beams are generally placed on corbels or directly on columns severe reduction of the cross-section at their ends (dapped-ends) may be required, resulting in a complex flow of internal stresses, typically highly concentrated at the re-entrant corners. Such regions in an element are called disturbed regions (D-regions) [1,2]. Currently empirical methods are applied for designing D-regions, the standard used in design guidelines being the strut-and-tie model [2–4]. Using this approach, various authors Reynolds [5], Mattock [6], Mattock and Theryo [7], Hwang and Lee [8], Chen et al. [9], Lu et al. [10] Yang et al. [11] have proposed design models for dapped-end beams, all of which have yielded less conservative results than provisions in codes [3] or design guidelines [2].

The load carrying capacity (hereafter capacity) of dapped-ended beams may be affected by: design errors, code changes and structural damage. One method that can be used to increase their capacity is to apply externally bonded (EBR) or near surface mounted (NSM) fiber-reinforced polymers (FRP). Several guidelines for designing and applying FRPs as strengthening systems for RC structures have been published recently [12–14]. However, strengthening of D-regions with FRPs is marginally addressed in these guidelines due to lack of experimental and theoretical investigations on the variations in geometry, materials and loading conditions. Only few investigations of the FRPs effects on disturbed regions are reported in literature [15–18]. Gold et al. [15] tested several FRP-strengthened dapped-end beams used in a three-story parking garage, and found they had double the capacity of reference specimens. Tan [16] investigated effects of various types of FRPs on the capacity of dapped-end beams with deficient shear resistance and showed that tested mechanical anchorage devices improved the FRP systems' strengthening by preventing debonding. He also derived an empirically based strut-and-tie model that proved to be sufficiently accurate for predicting the shear capacity of the tested beams. Taher [17] tested 50 small-scale dapped-ends strengthened with various techniques and found that FRPs were the most viable solution for strengthening/retrofitting

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Seismic Strengthening of a Precast Reinforced Concrete Wall Panel Using Combined NSM and CFRP-EBR Method

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SUMMARY

The experimental study presented in this paper is part of an experimental program on seismic performance of precast reinforced concrete wall panels (PRCWP), retrofitting strategies and investigations on the weakening induced by several cut-outs in the walls due to architectural aspects, change of use in buildings or other reasons. The experimental element is a 1:1.2 scaled PRCWP having a narrow door opening, enlarged to a large door opening afterwards (9-E1/E3). The prior-to-damage strengthened specimen (9-E1/E3-R/T) was subjected to cyclic load reversals, using combined Carbon Fiber Reinforced Polymer Externally Bonded Reinforcement (CFRP-EBR) and Near Surface Mounted Carbon Fiber Reinforced Polymer Reinforcement (NSMR-CFRP). The PRCWP (9-E1/E3-R/T) is compared with two other wall panels, (7-E1) having a narrow door opening, tested unstrengthened until failure (7-E1-T), repaired and post-damage strengthened using CFRP-EBR technique (7-E1-T/R) and (8-E3) having a large door opening, tested unstrengthened until failure (8-E3-T), repaired and post-damage strengthened using CFRP-EBR method (8-E3-T/R).

1. INTRODUCTION

The main objectives of the current paper are to determine the seismic performance of the precast RC wall panel having a narrow door opening, enlarged to a large door opening afterwards, describe the retrofitting strategy using CFRP-EBR and NSM-CFRP, compare the results with two PRCWP post-damage strengthened using CFRP-EBR, evaluate the weakening induced by the cut-out for the (9-E1/E3-R/T) and analyze the retrofitting costs for the three situations.

2. EXPERIMENTAL PROGRAMME DESCRIPTION

The precast reinforced concrete wall outlines and reinforcing details are presented in Figure 1a for the (7-E1) specimen, Figure 1b for the (8-E3) specimen and Figure 1c for the (9-E1/E3) specimen. Figure 1d shows a typical PRCWP building (770-81). The wall specimens were laterally loaded, reversed cyclic - displacement controlled [1]. The boundary conditions consist in restrained rotation and out of plane displacement prevention. The measured compressive strength (cubic) of concrete for (7-E1) was 45.5 MPa, for (8-E3) was 17.5 MPa and for (9-E1/E3-R/T) was 44.5 MPa. For the (7-E1) specimen the reinforcement includes horizontal and vertical bars, a spatial cage on the entire height in the left pier, a spatial cage in the coupling beam, welded wire mesh in the right pier and a transverse mesh at the top right corner of the door opening (according to Figure 1a). Reinforcement of (8-E3) specimen