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БЕТОН КАК ОДИН ИЗ ФАКТОРОВ ОБРУШЕНИЯ ЖЕЛЕЗОБЕТОННЫХ ЗДАНИЙ В БУРУНДИ

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АННОТАЦИЯ

Введение. *В данной статье представлены результаты натурной оценки участия бетона в обрушении железобетонных зданий в Бурунди.*
Материалы и методы. *Исследование проводилось определением прочности на сжатие бетонных конструктивных элементов исследуемых железобетонных зданий. Прочность на сжатие определялась на колоннах, балках и перекрытиях с помощью промышленного склерометра «SCHMIDT 2000» в соответствии с протоколом, описанным в «NFEN12504-2(2003)». Было изучено 17 (семнадцать) строящихся трехэтажных зданий. Для каждого здания, участвующего в исследовании, были исследованы железобетонные несущие элементы первого этажа. Полученные результаты были классифицированы в соответствии с марками цемента (32,5) и (42,5), которые использовались в бетонах исследованных зданий. Было проведено сравнение прочностей на сжатие, полученных в натурных условиях, с нормативными значениями. Достоверность полученных результатов была подтверждена корреляцией между результатами, полученными в натурных и лабораторных условиях.*
Результаты. *Данное исследование показало, что в Бурунди до 100% обрушений приходится на сооружения, построенные частными лицами. Было выявлено, что 100% колонн, 82% балок и 82% плит из бетона, изготовленного с использованием цемента марки (32,5), имели прочность на сжатие ниже нормативного значения (25 МПа). Также 50% колонн, 50% балок и 84% плит из бетона на основе цемента высокой марки (42,5) была ниже нормативного значения (35МПа).*
Обсуждение и заключение. *В данном исследовании была доказана достоверность результатов, полученных методом склерометрического испытания на железобетонных зданиях. Показано, что бетон является одним из факторов обрушения железобетонных зданий, построенных частными лицами в Бурунди. Отмечено, что низкосортный цемент оказывает большее влияние на разрушение жел3езобетонных конструкций, чем высокосортный. В качестве рекомендации: процесс строительства железобетонных зданий в Бурунди необходимо регулировать и контролировать.*

КЛЮЧЕВЫЕ СЛОВА: *бетон, железобетонные конструкции, факторы обрушения конструкций, обрушение зданий в Бурунди.*

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CONCRETE AS A FACTOR IN REINFORCED CONCRETE BUILDINGS COLLAPSE IN BURUNDI

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ABSTRACT

Introduction. *This paper presents the results of the assessment in-situ of the involvement of the concrete in the collapse of reinforced concrete buildings in Burundi.*
Materials and Methods. *The study consisted in the identification of the compressive strengths of the concrete structural elements of the reinforced concrete buildings under study. The compressive strengths were identified on the columns, beams and slabs using an industrial SCHMIDT 2000 sclerometer according to the protocol described in NF EN 12504-2(2003). Seventeen (17) three-storey buildings under construction were studied. For each building involved in the study, the reinforced concrete bearing elements of the first floor were studied. The results obtained were classified according to the cement grades (32.5) and (42.5) that were used in the studied buildings. A comparison of the compressive strengths obtained in-situ was established in relation to the normative values according to the cement grade used. The reliability of the obtained results was confirmed by the correlation between the results obtained in the laboratory conditions on the reinforced concrete experimental samples.*
Results. *This study showed that in Burundi up to 100% of collapses are caused by privately built structures. It was proved that the compressive strengths of 100% of the columns, 82% of the beams and 82% of the slabs that were made with a low-grade cement (32.5) had compressive strengths lower than the normative value (25MPa). In addition, the compressive strengths of 50% of the columns, 50% of the beams and 84% of the slabs made with a high-grade cement (42.5) were also proved to have compressive strengths lower than the normative values (35MPa).*
Discussion and conclusion. *In this study, the reliability of the results obtained by sclerometer test in-situ on the reinforced concrete buildings has been proved. Concrete has been shown to be a factor in the collapse of privately built reinforced concrete buildings in Burundi. Low-grade cement was observed to have a high impact in the collapse of reinforced concrete structures than the high-grade one. Therefore, as a recommendation, the process of building reinforced concrete buildings in Burundi needs to be regulated and controlled.*

KEYWORDS: *concrete, reinforced concrete structures, factors of structures collapse, buildings collapse in Burundi.*

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INTRODUCTION

In Burundi, architectural and structural design are the mainly documents required to obtain a building permission. These are issued by the urban planning authorities. Thereafter, no measures are planned by the competitive authority for the verification of the material quality, technology and workforce involved in the construction works specifically for structures erected by individuals. Usually, the collapses happen during the construction process. For example, some known cases of collapse of reinforced concrete buildings are the Tankoma, Kinindo, Winterekwa and Buterere cases. In general, the causes are not known.

Buildings collapse in cities is a real risk in town planning in developing countries [1, 2]. That is why there exist a number of norms that gives a protocol of procedures for non-destructive approaches in order to conduct assessments on the mechanical performances of the concrete in-situ or on the precast-concrete[1,2] [3, 4]. These are used to identify whether the concrete is or not one of the factors of the collapse of reinforced concrete buildings. In foreign literature, a number of assessments have been conducted on the causes of the collapse of reinforced concrete structures [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18].

a b c

Figure 1 – Experimental samples preparation (a) and compression testing under hydraulic press (b) and sclerometer (c) used in the laboratory and in-situ study
Source: compiled by the authors.

a b c

Figure 2 – Random example of source of construction materials (a) used in manufacturing concrete (b) used in individual reinforced concrete buildings (c) in Burundi
Source: compiled by the authors.

[1] ГОСТ 22690-88 «Бетоны. Определение прочности механическими методами неразрушающего контроля. Поправка ИУС № 5 1989».

[2] СТО 56947007-29.240.55.269-2019. Требования к качеству конструкций, материалов и выполненных работ при строительстве (реконструкции) ВЛ 35 – 750 кВ. ПАО «ФСК ЕЭС» 2019.

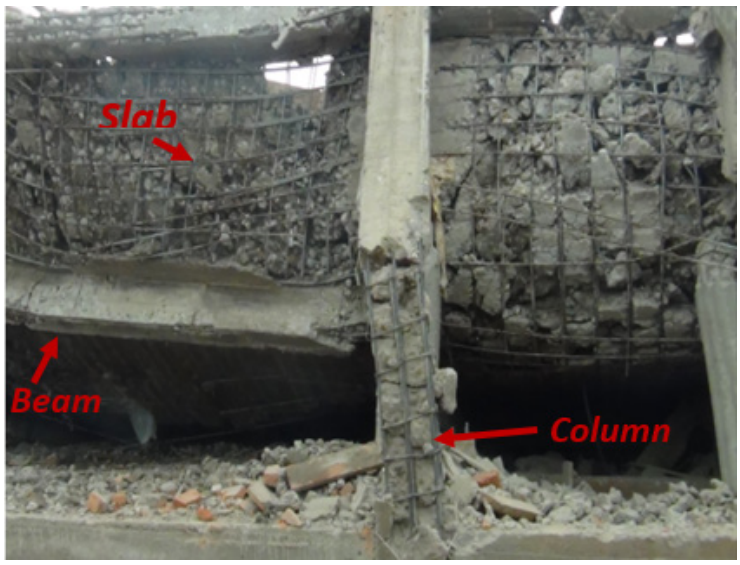

Figure 3 – Designation of the type of the investigated bearing elements (column, beam and slab) on the seventeen (17) three-storey buildings
Source: compiled by the authors.

However, these assessments cannot totally be related to Burundi because they do not take into consideration the local conditions.

MATERIAL AND METHODS

The main instrument that was planned to be used in the investigation of the studied structures was the sclerometer «*SCHMIDT 2000*». Thus, the first step of the research was to identify the correlation between the results obtained from the compression test under the hydraulic press and the results given by the sclerometer on the same experimental samples of the ordinary concrete (Fig.1). Two cement grades were considered for the concrete: low-grade cement (32.5) and high-grade cement (42.5).

The next step was to visit the construction sites in progress in order to observe visually the quality of the construction materials, technology and workforce used in the execution of reinforced concrete constructions (Fig. 2).

The study continued by the analysis of the reports provided by the staff from the civil protection agency about building collapse in Burundi. Finally, in-situ experimental tests on compressive strengths were carried out with the sclerometer on the columns, beams and slabs of the first floor (Fig.3) of seventeen (17) three-storey buildings under construction in Bujumbura Mairie, Bujumbura Rural and Gitega. The tests were performed according to the European norm [3].

The in-situ measurements were recorded in tables designed for further processing according to the cement grade (32.5 or 42.5) used for the concrete of the investigated buildings.

RESULTS

To start with, the results obtained show a good correlation between the tests obtained under the hydraulic press and the sclerometer (Fig.4; Fig.5).

As the results show (Fig.4, Fig.5), for concretes aged 28 days, the compressive strengths obtained by crushing under the hydraulic press are lower than those determined by the sclerometer with a maximum difference of 7%.

Furthermore, tests in-situ showed that there may be remarkable difference between the compressive strengths of the concrete for columns, beams and slabs for a given reinforced concrete building. That difference was found to be more accentuated for buildings with concrete made with high-grade cement (42.5) than those with concrete made with low-grad cement (32.5) (Fig.6).

Thus, a detailed analysis of the previous results (Fig.6) show that a 100% of the columns, 82% of the beams and 82% of the slabs of the reinforced concrete buildings made from cement grade (32.5) had compressive strengths lower than the required normative compressive strength (25MPa). In addition, it was also found that 50% of the columns, 50% of the beams and 84% of the slabs of the reinforced concrete buildings made with cement grade (42.5) had compressive strengths lower than the required normative compressive strength (35MPa) (Fig.6).

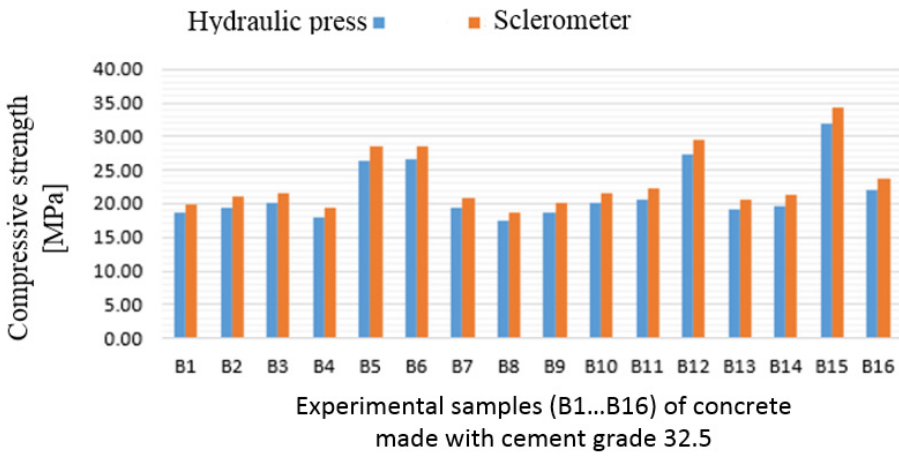

Figure 4 – Comparative results of compressive strengths obtained under t he hydraulic press and the sclerometer on the same experimental concrete samples with cement grade (32.5)
Source: compiled by the authors.

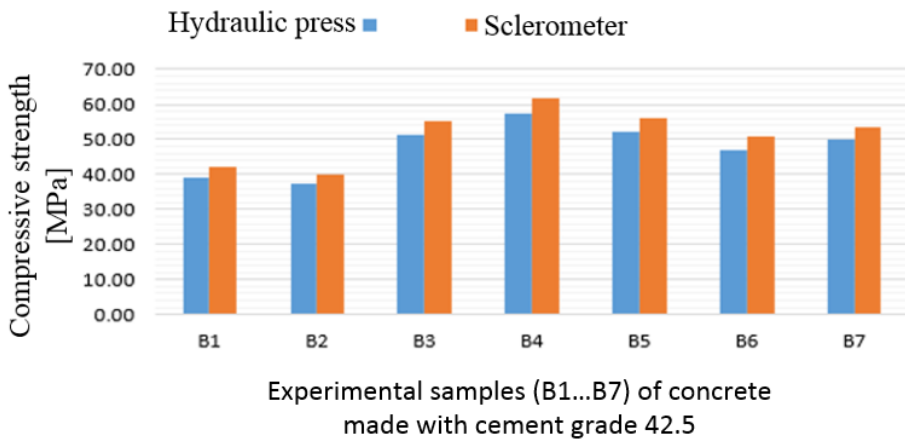

Figure 5 – Comparative results of compressive strengths obtained under the hydraulic press and the sclerometer on the same experimental concrete samples with cement grade (42.5)
Source: compiled by the authors.

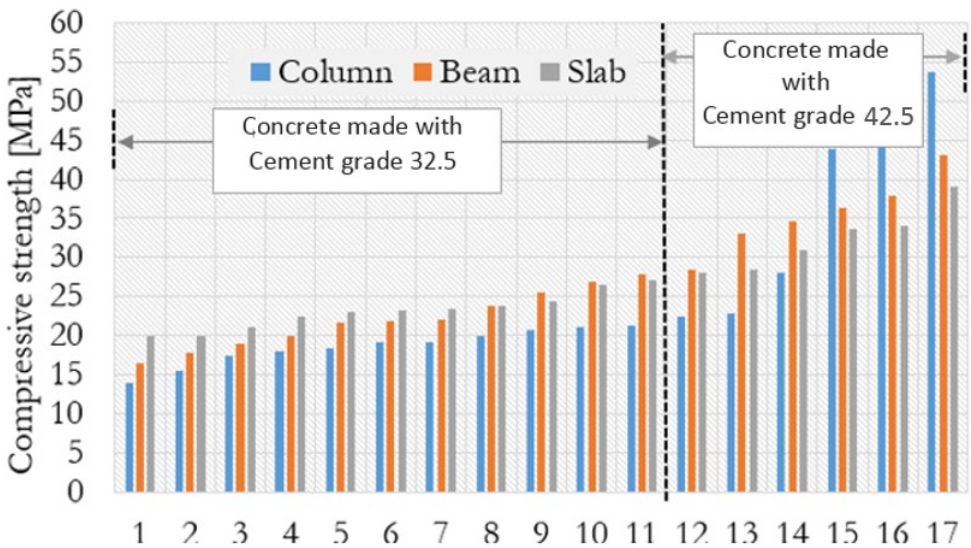

Figure 6 – Compressive strengths determined by sclerometer test in-situ for concrete from columns, beams and slabs of the investigated reinforced concrete buildings
Source: compiled by the authors.

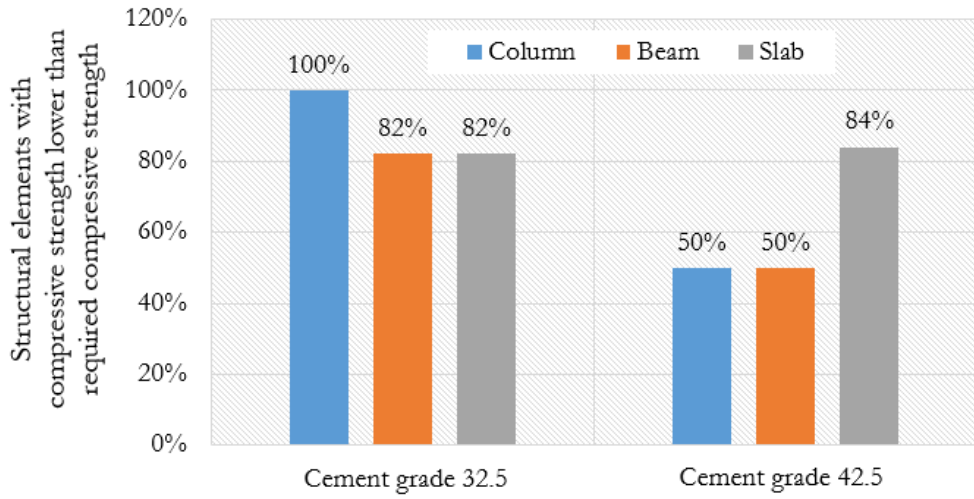

Figure 7 – Concrete bearing elements whose compressive strengths are under normative compressive strengths in studied individual's reinforced concrete buildings in Burundi
Source: compiled by the authors.

DISCUSSION AND CONCLUSION

In this study, the reliability of the results obtained by sclerometer test in-situ on the reinforced concrete buildings has been proved. It is demonstrated that the concrete is one the factors of the collapse of reinforced concrete buildings constructed by individuals in Burundi. Low-grade cement is observed to have a high impact in the collapse of reinforced concrete structures than the high-grade one. Therefore, as a recommendation, the process of building reinforced concrete buildings in Burundi needs to be regulated and controlled.

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Justin Ndikumana – Methodology, data collecting and processing.

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