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COMPLIANCE OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC ACTION

Cosmin IORDACHE, Simona ADAM, Bogdan CONSTANTIN, Miruna PETRARIU

Scientific Coordinator: Assoc. Prof. PhD Eng. Claudiu - Sorin DRAGOMIR

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
Faculty of Land Reclamation and Environmental Engineering, 59 Mărăşti Blvd,
District 1, 011464, Bucharest, Romania

Corresponding author email: cosmin.iordache3062@gmail.com

Abstract

The present study aims to highlight the non-destructive tests on concrete structures by determining the rebound index and the ultrasonic propagation speed, found in the European standards SREN 12504-2 and SREN 12504-4, respectively; the calculation of plane frames and building structure of the Faculty of Land Reclamation and Environmental Engineering(FLREE) in relation to seismic responses.

Key words*: 3D structure, diagrams, non-destructive testing, plane frames, seismic response.*

INTRODUCTION

The article presents in the first part some of the conclusions of a case study carried out in the FLREE laboratory on a concrete cube, followed by a comparative analysis of the calculation of plane frames on different levels using the Robot program, and at the end we present a comparative analysis of the building bodies belonging to FLREE using the 3D frames component of the same software.

MATERIALS AND METHODS

1. Case study carried out in the FLREE laboratory

For the determination of the physical-mechanical characteristics of the materials, non-destructive tests are used, i.e. the determination of the rebound index and the ultrasonic propagation velocity, according to the European standards SREN 12504-2 and SREN 12504-4 respectively.

1.1. Determination of the rebound index

The sclerometer is placed perpendicular to the test surface. After impact, the rebound index is recorded, but for the measurements to be valid, 10 trials are required, after which they are averaged. The minimum distance between two tests shall be 25 mm and shall not be tested closer than 25 mm to the edge of the structural element.

Required equipment: sclerometer, calibration anvil, abrasive stone. The choice of the surface to be tested should be made taking into consideration the following: strength of the concrete, type of surface, type of concrete, state of humidity of the surface, the curing, movement of the concrete during the test, direction of attempt, other factors.

Table 1. The obtained values of the rebound index

No.	Rebound index
1	43
2	42
3	42
4	42
5	44
6	39
7	46
8	44
9	44
10	41

Using this equipment the rebound index and compressive strength of the surface sample were determined. The compressive strength values are shown in Table 1. To determine these values 10 determinations were carried out. In addition to the resistance value, the device indicates the minimum and maximum rebound index, standard deviation and rebound value. Based on the conversion curve recorded in the internal memory of this device it has the ability to show the value of compressive strength determined at the sample surface

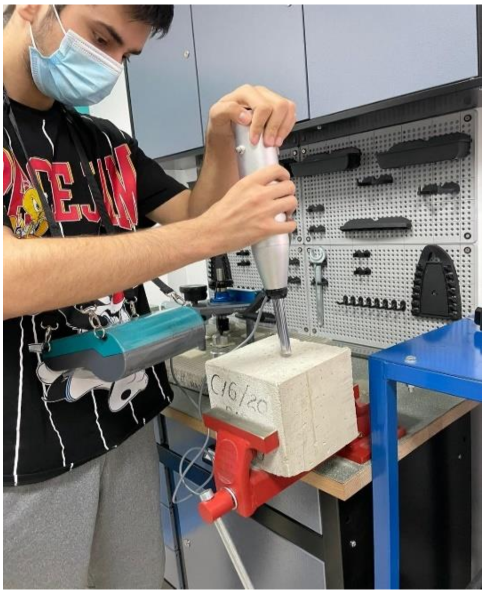

Figure 1. Test using sclerometer

Figure 2. Displayed value resulted after test

1.2. Determination of ultrasound propagation speed

The determination is carried out on a C16/20 concrete sample and involves: a pulse of longitudinal vibration is produced by an electro-acoustic transducer held in contact with a surface of the concrete under test. After travelling a known path length through the concrete, the vibration pulse is converted into an electrical signal by a second transducer and electronic circuits measuring the transit time of the pulse.

Required equipment: electrical pulse generator, a pair of transducers, an amplifier, an electronic measuring device for measuring distance and pulse time. The expression of the results for the transmission of the direction, half direction and propagation speed of the pulse is given by the formula: $v = \frac{L}{T}$.

V- pulse propagation speed (Km/s)

L- lenght (mm)

T- time in which the pulse crosses the length of the concrete sample (μ*s)

The time periods recorded are in microseconds, the signal needed to travel the 150 mm distance of the cube. On the other hand, speeds were recorded with the signal travelled over that distance, in m/s. Depending on the speed values, the corresponding compressive strength can be determined as in the first test case.

Table 2. Ultrasound propagation speed results

No.	Result (m/s)
1	4348
2	4478
3	4298
Average	4374,6

Figure 3. Electronic propagation speed measuring device

Figure 4. Conducting a test

2. Comparative analysis of the calculation of plane frames on different levels using Robot software

In this analysis we chose the representation of the planar frames of a P+5 building, for the comparison of the results we used the planar representation of the 2, 4 and 6 levels frames following the deformations of the planar frame in the earthquake along the x direction.

2.1. Plan representation of the 2-level frame

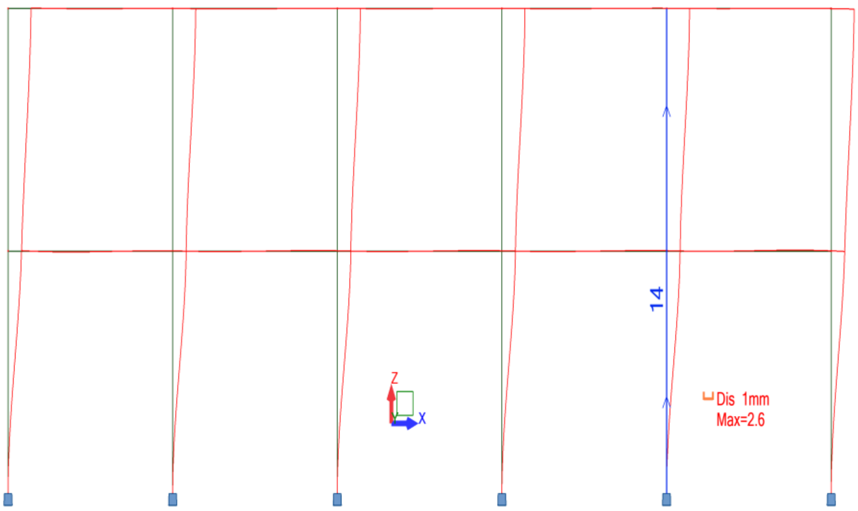

Figure.5. Deformations of the plane frame in the earthquake after x direction: ds = 2.6 mm

2.2. Plan representation of the 4-level frame

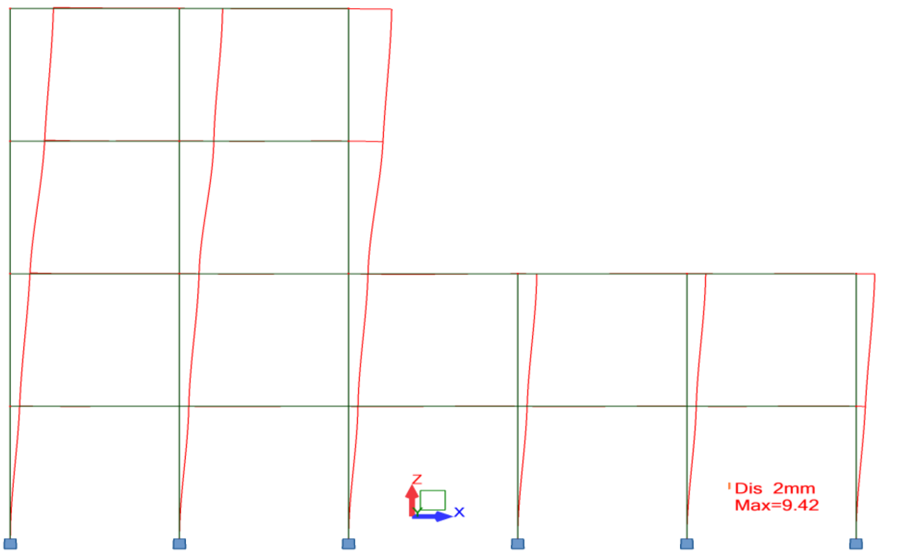

Figure 6. Deformations of the plane frame in the earthquake by x direction: ds = 9.42mm

2.3. Plan representation of the 6-level frame

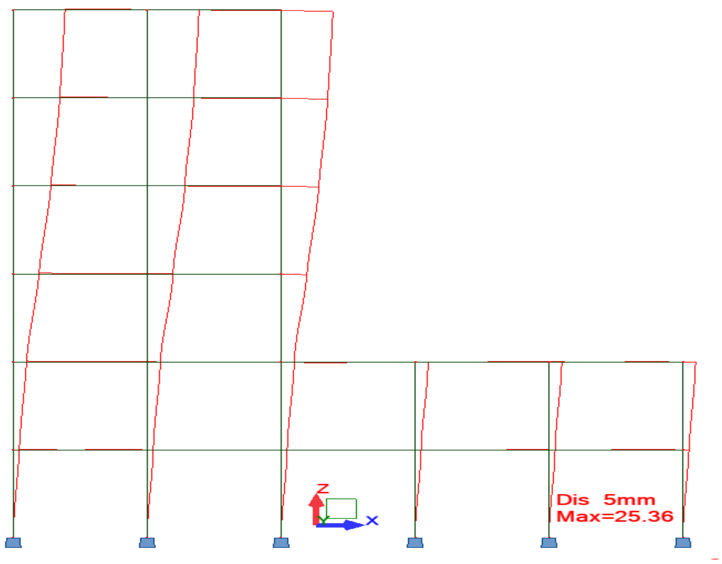

Figure 7. Deformations of the plane frame in the earthquake by x direction: ds = 25.36mm

2.4. Results comparison

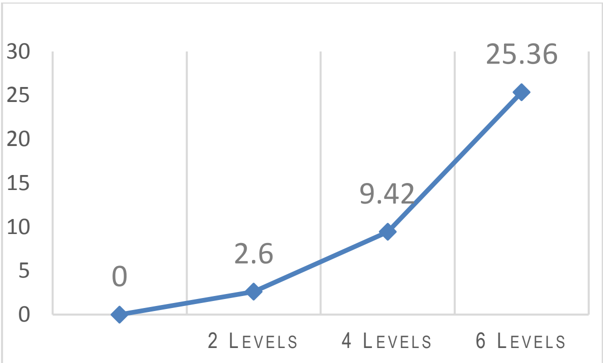

Figure 8. Plane frame displacement

Following the representation of the three particular cases we can observe an increase in displacement that is directly proportional to the number of levels.

3. The comparative analysis of FIFIM buildings using the spatial frames component of the Robot Structural Analysis software

Using this method we can observe the spatial deformation of the 3D structure and the displacement on each level of the building. In Autodesk Robot Structural Analysis Professional software, different types of structures were simulated and determined an axis system. The concrete used is C16/20, the cross-section of the pillars at ground level is 45x45 cm and at the top will be 30x30 cm; the cross-section of the beams is 25x50 cm and the reinforcement is made according to the standards in force.

3.1. C/B body before consolidation

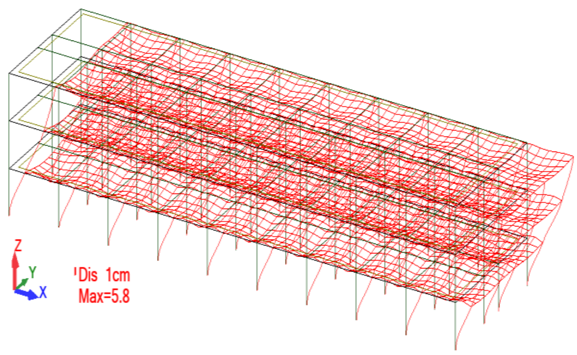

Figure 9. Spatial deformation of the 3D structure

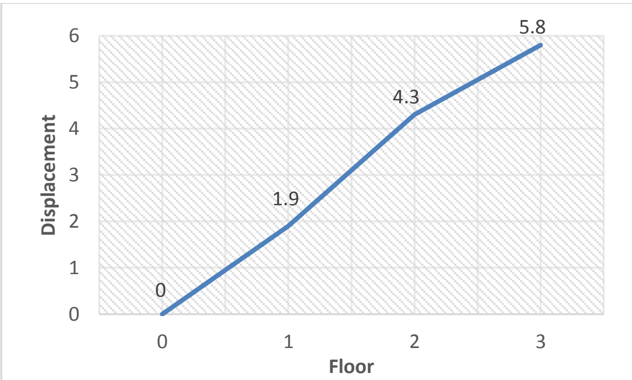

Figure 10. Displacement on the 3 floors

3.2. C/B body after consolidation

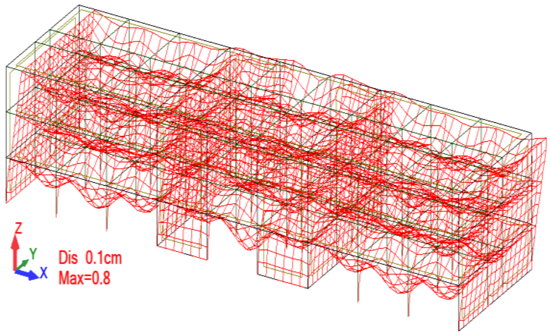

Figure 11. Spatial deformation of the 3D structure

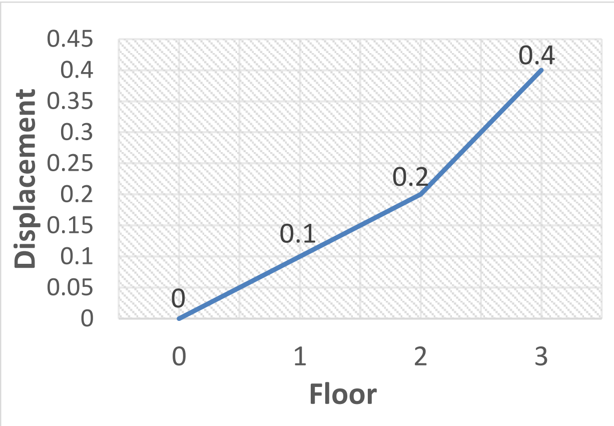

Figure 12. Displacement on the 3 floors

3.3. A body

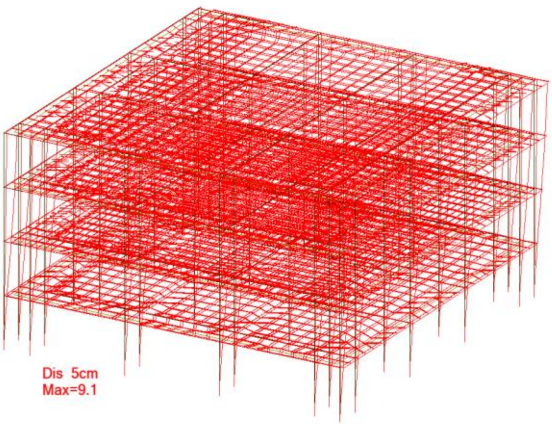

Figure 13. Spatial deformation of the 3D structure

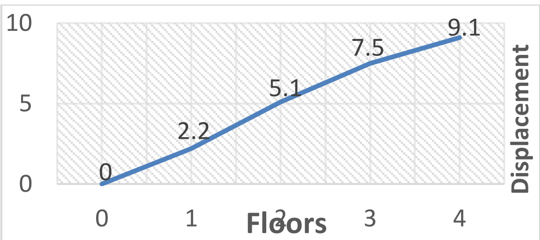

Figure 14. Displacement on the 4 floors

3.4. Results comparison

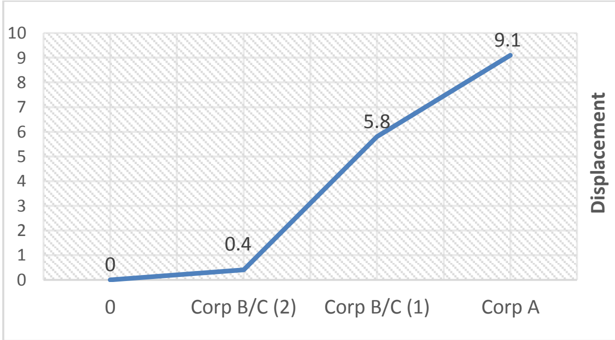

Figure 15. Results comparison

The analysis carried out on the three bodies of the FLREE showed the displacements they suffered during the earthquake.

CONCLUSIONS

Following the analysis carried out in the Robot software on the plane frames on different levels (2, 4 and 5), it is observed that the displacement increases directly proportional to the number of levels.

Using the space frame component of the Robot program, before consolidation, the C/B body of FLREE, subjected to a seismic action, undergoes a significant displacement and, after consolidation, a reduction in it is detected.

The reduction of behaviour factors to take into account uncertainties in the seismic behaviour of irregular structures will be determined according to the degree of this irregularity. As a guideline for case 2 the reference behaviour factor will be reduced by 20% and for case 4 by 30%.

Conditions relating to building masses In order to reduce the adverse effects due to the irregular positioning of mass loads, the aim should be to arrange the gravity loads as evenly as possible on the floors, both in plan and vertically. In order to reduce the seismic inertia forces acting on buildings, the aim should be to construct buildings with the smallest possible masses. Accordingly:

- When building non-structural elements: roofing, thermal insulation, screeds, partition walls, balcony parapets, etc., lightweight materials should be used as a priority. Efforts should also be made to reduce the thickness of rendering and screeds, slope layers and to reduce the weight of ornamental elements in buildings where they are needed.

- In high-rise and/or high-mass construction it is recommended to use high-strength concrete in structural elements, especially in pillars and structural walls.
- On the roofs of ground floor halls with large openings, including skylight and deflector elements, lightweight material solutions should be applied as a priority.
- In the case of buildings with different functions by height it is recommended that activities, functions, which involve high live loads are placed at lower levels.

Comments on geometrical irregularities and eccentricities between the two centres:

- Construction irregularities cannot be avoided. They arise for functional reasons in plan and technological reasons in height. The theoretical problems of irregularities are dealt with by studying the relative relationship between the centre of rotation CR and the centre of gravity CG. The practical problems of irregularities are solved by diaphragms, strong structural components and rigid slabs.
- The safety of irregular constructions must be checked both locally and holistically (in general). Solutions to avoid damage have a cost. In non-regular constructions the geometry-mass relationship plays an important role and is regulated by the conceptual design principles of Eurocode 8 or Code P100-1:2013. No construction is perfect. Deviation from perfection means cost or collapse.

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***EN 12504-4:2021 Testing concrete in structures - Part 4: Determination of ultrasonic pulse velocity