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ISSUES FOR ACHIEVING AN EXPERIMENTAL MODEL CONCERNING BUBBLE DECK CONCRETE SLAB WITH SPHERICAL GAPS

BY

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Abstract. After realizing numerous constructions in the world, which use Bubble Deck concrete slabs with spherical gaps, valuable information were gathered, allowing a rigorous processing and systematization, with the purpose of realizing an experimental and documentary study.

The paper presents some experimental programs which refer to concrete slabs with spherical gaps, existing in similar execution and loading conditions as those from a real construction; this implies the realization of a monolithic slab element at a scale of 1:1, which will be subjected to static gravitational loadings in order to determine the deformation (deflection), cracking and failing characteristics. The resultant conclusions will be used in defining the failing mechanisms, very useful in the formulation of an adequate mathematical model.

The research proposed in the project offers an answer to the major objectives of the development of calculus methods and existent prescriptions of the concrete slabs with spherical gaps. The realization of the proposed objectives involves documentation activities, theoretical study, collaboration with different other partners, gathering and processing of the results obtained in laboratory and even *in situ*.

Key words: concrete slab; spherical gaps; reinforcement; static loads.

1. Introduction

The experimental program proposed in what follows, permits the establishing of the behavior, under gravitational loads of the reinforced concrete

slab with spherical gaps type Bubble Deck, that would lead to obtaining of information useful at designing activity.

The area of preoccupations that are referred in the followings can be extended as the feature of the constructive system will better known by the designers and the investors.

After realizing of some constructions that use the Bubble Deck slab in the world valuable information have been gathered that can be processed in order to obtain

a) a documentary study based on an up to date about the constructive making up guide lines and the reinforcement particularities of the reinforced concrete slab with spherical gaps subjected to gravitational and seismic loads;

b) a documentary synthesis that shows the thermal and phonic characteristics as well as behavior particularities at fires that can emerge in buildings that have in their structure these kind of slabs;

c) a compared technical-economic analysis between the classical slabs (continuous) and the new Bubble Deck type based on a illustrating base study.

It is necessary to be mentioned that the laboratory researches will pursuit, mainly, the behavior of the area in contact between the columns and the slab in order to establish the best rational reinforcement in order to adopt the existing designing norms used for classical structures, in particular conditions that represent the constructive system.

As the actual stage of knowledge on international level is regarded we me may consider that inside some European Union researching institutes there are in progress numerous researches regarding the problems faced during designing and execution. Therefore there have been issued and applied programs for research experiments that licensed the elaboration of some methods of computing and production technologies proper to the system.

The important technical-economic advantages that arise from using Bubble Deck system stimulate it introducing on a larger scale [5].

2. The Experimental Program

The research that we initiate will have as basis experimental studies that will be realized in the Faculty of Civil Engineering and Building Services, Iaşi, laboratories, the department of Concrete Structures, Building Materials, Technology and Management.

The program initiates an experimental study regarding the behavior of the reinforced concrete slab with spherical gaps in similar working conditions with those of a real building. This requires realizing of a monolith slab at 1:1 scale that will be subjected to gravitational static loads in order to determine the deformation, cracking, and failure characteristics. The resulted conclusions will help in defining the failure mechanisms that are very useful in establishing an adequate mathematical model.

The structure assumes the realization of a reinforced concrete slab with

spherical gaps Bubble Deck that supports on four columns and in order to observe the behavior of the contact area between the columns and the slab there is a cantilever foreseen with a width of 1 m for all the perimeter of the slab (Fig. 1) [2].

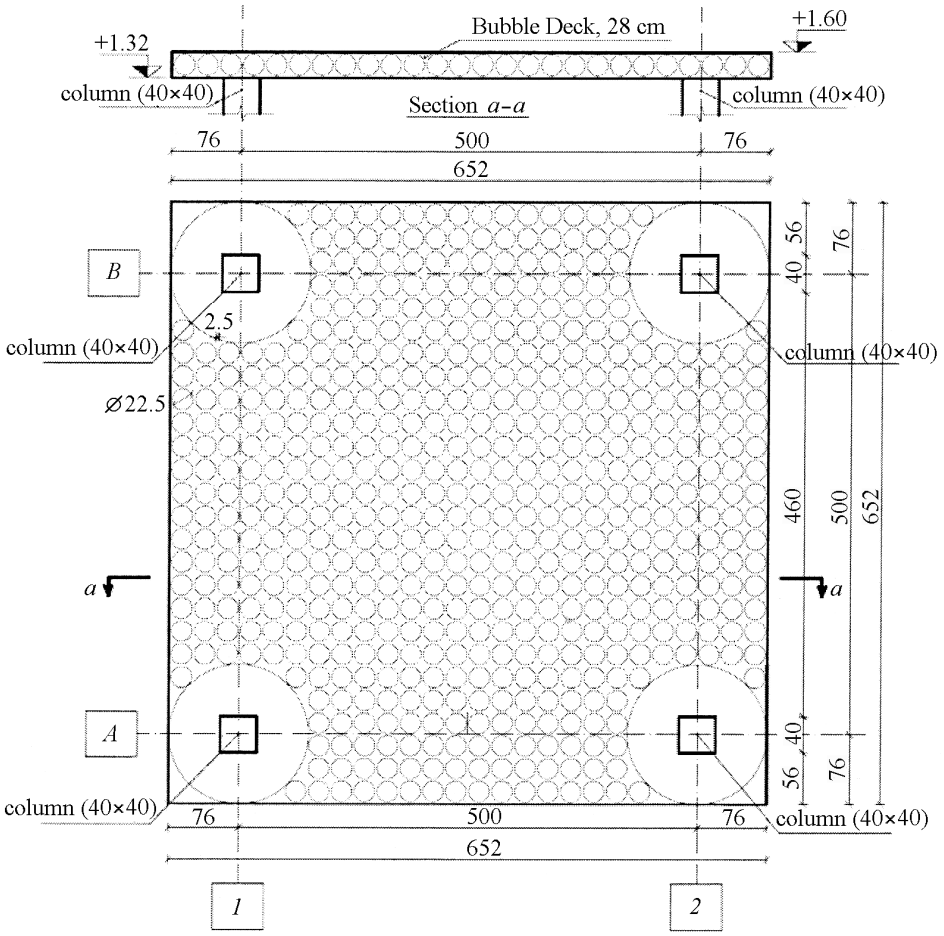

Fig. 1 – Formwork plan for Bubble Deck experimental element.

Fully restrained column at the ground floor level is realized by displaying of equalizing beams between them.

The surface of the slab is of 42.51 m^2; the structure has one level and a total height of 1.60 m. The distance between axes of the columns is of 5 m on both directions Ax *A-B* and Ax *1-2*.

The connecting beams and the columns have the section of 40 × 40 cm, and the concrete covering is 2.5 cm [1], [4].

The slab has the thickness of 28 cm and contains polypropylene spheres with 22.5 cm in diameter. These are lay between meshes that form modules of

reinforcement with spheres for an easy use. Combining of the modules with spheres is foreseen with continuing reinforcements according to Technical Agreement 007-01/120-2007 [3].

Used materials:

a) Self-Compacting Concrete poured in place, in slab, columns, beams.

b) Reinforcement: OB37, PC52.

c) Bubble Deck modules.

Reinforcements and the execution details have been finished according to the calculations made in a computer added design program where the above structure has been introduced, the columns being considered with fixed support at the equalizing beam level. The vertical structural elements, the columns, have been computed and designed according to the efforts given in the static design.

The slab has been displayed directly on the four columns and will be loaded with a uniform distributed load as shown in Fig. 2.

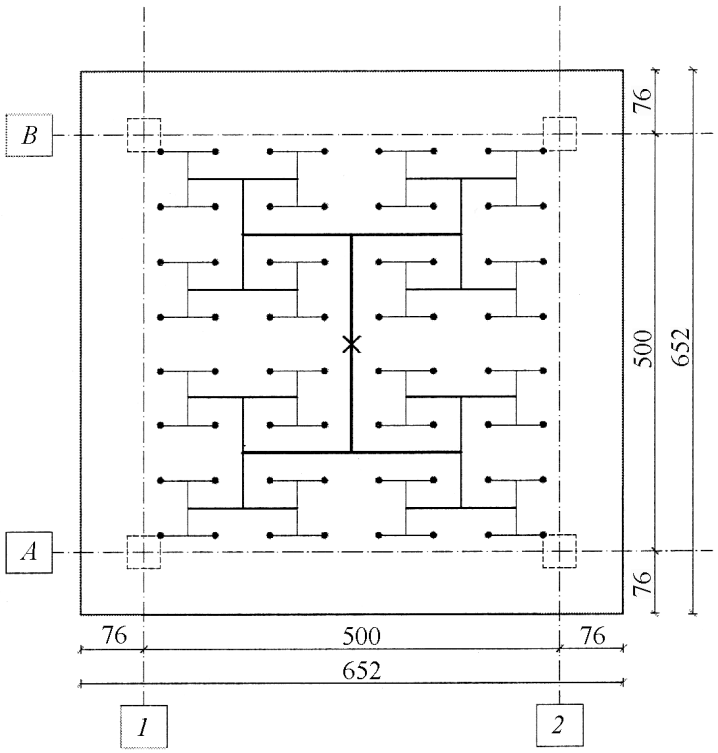

Fig. 2 – Loading sketch for Bubble Deck experimental element.

Because of the presence of the spheres in the slab, for static computation the weight of the concrete is considered 1,650 daN/m^3.

It was made a discretization of the slab in finite elements and then the computation of the structure following diagrams and tension maps shown in Figs. 3 and 4.

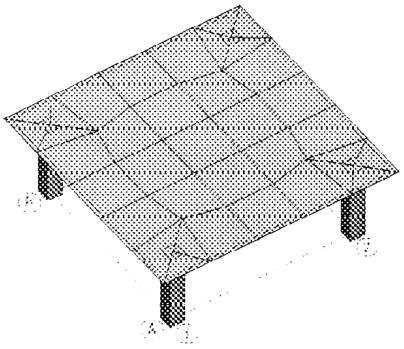

Fig. 3 – The discretization of the slab.

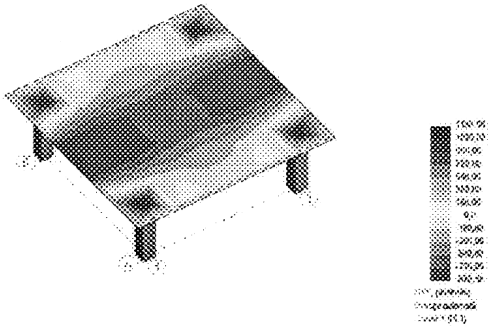

Fig. 4 – Tension maps for the slab.

2.1. Performing of the Experimental Pattern

The execution of the experiment begun in September 2009 event from which we present some pictures (Figs. 5,..,10).

Fig. 5 – Connection beams formwork.

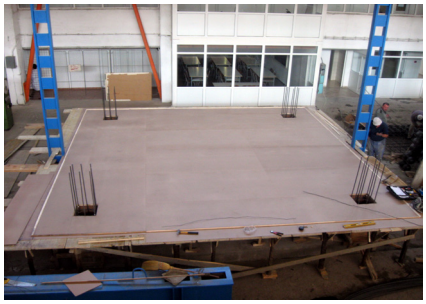

Fig. 6 – Beam formwork.

Fig. 7 – Mounting of Bubble Deck modules.

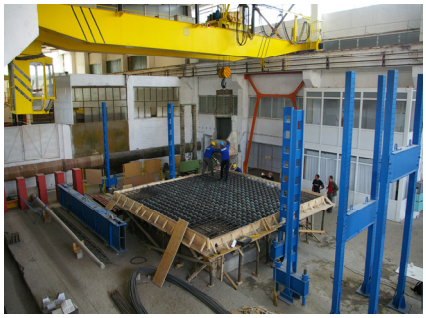

Fig. 8 – General view during pouring.

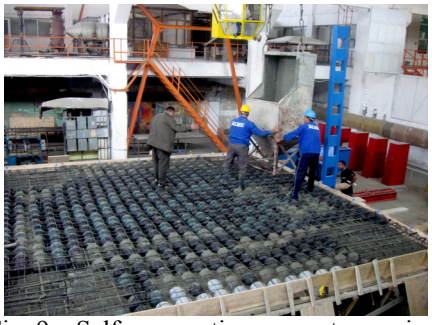

Fig. 9 – Self-compacting concrete pouring.

Fig. 10 – General view of the project.

2.1. The Project's Organization

The project's organization stages are indicated in Table 1.

Table 1

Objectives and Activities that Take Place in the Research Project

University year	Objective		Activities
2009…2010	1	Initiating of a documentary study regarding the existing prescriptions for computing and making-up of the reinforced concrete slab with spherical gaps.	a) Study of the principles of making-up the gravitational and seismic loads. b) The synthesis of the theoretical researches made in the field so far.
	2	Realizing of a documentary synthesis regarding the behavior, under static loads, of the reinforced concrete slab with spherical gaps in order to determine the specific failure mechanism.	a) Highlighting of the particularities of forming and cracking of the studied system function of the load level applied. b) Assessing the failure mechanisms of the reinforced concrete slab with spherical gaps subjected to gravitational loads.
2010…2011	3	The experimental study of the reinforced concrete slab with spherical gaps in similar conditions as a real construction.	a) Experimental research of a structure at 1:1 scale subjected to gravitational loads in laboratory conditions. b) Performing of measurements regarding the evolution of the deforming state and cracking that foregoes and escorts the failure of the slab. c) Writing a report with conclusions and recommendations useful in the designing process.

2.2. The Feasibility of the Potential Contributions that are Suggested

A priority must be given to the designing and execution according to the recent achievements gained through the experience and the latest results on the research field.

The researches that are to be undertaken in this project answer to the major objectives of developing the calculus methods and the existing prescriptions of the reinforced concrete slab with spherical gaps. Achieving the desired objectives imply documentary activities, theoretical study, in co-operation with other partners in collecting and processing of the results obtained in the laboratory and even *in situ*.

2.3 Technological Transfer

As the technological transfer is regarded there might be the possibility of a co-operation between the "Gh. Asachi" Technical University of Iaşi and aboriginal designers/investors that deal with the problems mentioned in the research theme. Through these co-operations it is possible an experience exchange between doctoral students or technical personal of the "Gh. Asachi" Technical University of Iaşi and other educational, research and design institutions.

4. Conclusions

Realizing the researches embedded into the project will lead to results that, taken into practice, will have a positive impact under technical, economic and social point of view materialized in

a) clarifying the conditions of making-up that ensures certain rigidity in horizontal plan of the reinforced concrete slab with spherical gaps based on which the slab is capable to transmit efficiently the horizontal loads (specially the seismic ones);

b) involving in co-operation of teams from other superior educational institutions will ensure a better synthesis of the achieved results.

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ASPECTE PRIVIND REALIZAREA UNUI MODEL EXPERIMENTAL PENTRU PLANŞEE CU GOLURI SFERICE TIP BUBBLE DECK

(Rezumat)

În urma realizării a numeroase construcţii în lume, care utilizează planşee cu goluri sferice tip Bubble Deck, s-au acumulat informaţii valoroase, care se pretează prelucrării şi sistematizării riguroase, în scopul realizării unui studiu documentar şi experimental.

Se prezintă un program experimental referitor la planşeele din beton cu goluri sferice, aflat în condiţii similare de execuţie şi solicitare cu cele existente într-o construcţie reală; acesta presupune realizarea unui element de planşeu monolit la scara 1:1, care va fi supus încărcărilor statice gravitaţionale, în vederea cunoaşterii caracteristicilor de deformare, fisurare şi cedare. Concluziile rezulate vor servi la definirea mecanismelor de cedare, deosebit de utile în formularea unui model matematic adecvat.

Cercetările propuse în cadrul proiectului răspund obiectivelor majore ale dezvoltării metodelor de calcul şi a prescripţiilor existente ale planşeelor din beton cu goluri sferice. Realizarea obiectivelor propuse implică activităţi de documentare, studiu teoretic, colaborare cu alţi parteneri, de colectare şi prelucrare a rezultatelor obţinute în laborator şi chiar *in situ*.