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METHOD FOR BUBBLEDECK CONCRETE SLAB WITH GAPS

BY

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Abstract. The composite slabs are made of BubbleDeck type slab elements with spherical gaps, poured in place on transversal and longitudinal directions. By introducing the gaps leads to a 30...50% lighter slab which reduces the loads on the columns, walls and foundations, and of course of the entire building. BubbleDeck slab elements are plates with ribs on two directions made of reinforced concrete or precast concrete with spherical shaped bubbles. These slab elements have a bottom and an upper concrete part connected with vertical ribs that go around the gaps.

Key Words: concrete slab; spherical bubbles; reinforcement; process optimized.

1. Short Description of BubbleDeck Slab

The BubbleDeck method for the two directions reinforced composite concrete slab with gaps was invented in Denmark, it is licensed and it was conceived to achieve saving of concrete and energy in buildings construction.

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By introducing the gaps leads to a 30...50% lighter slab which reduces the loads on the columns, walls and foundations, and of course of the entire building.

"BubbleDeck" slab elements are plates with ribs on two directions made of reinforced concrete or precast concrete with spherical shaped bubbles (Figs. 1 and 2). These slab elements have a bottom and an upper concrete part connected with vertical ribs that go around the gaps.

The reinforcement of the plates is made of two meshes one at the bottom part and one at the upper part that can be tied or welded. The distances between the bars correspond to the dimensions of the bubbles that are to be embodied and the quantity of the reinforcement from the longitudinal and the transversal ribs of the slab. The two mashes are connected after placing the spheres into places in order to form a rigid shell.

The bubbles are made by embodying high density polypropylene in the concrete, arranged according to the project and placed between the reinforcement

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meshes. The material that are made of don't react chemically with the concrete or the reinforcement, it has no porosity and has enough rigidity and strength to take over the loads as much as from the pouring of the concrete as from the subsequent phases of this process.

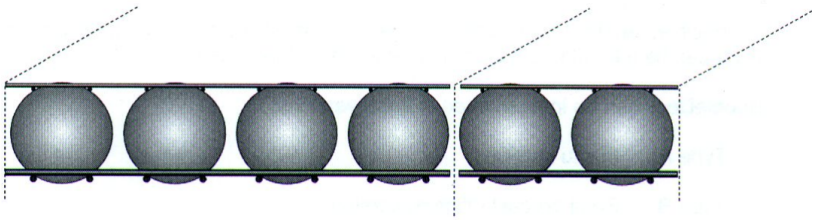

Fig. 1. – The main presentation module of the product in version *A* – reinforcement modules in which the gaps are foreseen. Spheres of polypropylene are placed between the reinforcement at the bottom part ant the reinforcement at the top part.

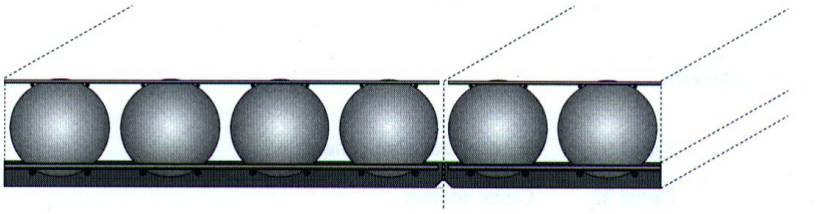

Fig. 2. – The main presentation module of the product in version *B* – Slab elements with BubbleDeck gaps, partially precast.

Table 1

Type of slab	Thickness of the slab, [mm]	Sphere diameter, [mm]	Own weight, [daN/m^2]		Own weight, [daN/m^2]
			Width of the element, 3,000 mm	Width of the element, 2,400 mm	
BD 230	230	180	380	390	1,608
BD 280	280	225	450	490	1,642
BD 340	340	270	550	580	1,617
BD 390	390	315	650	660	1,641
BD 450	450	360	740	720	1,622

Obs. Own weight of the BubbleDeck slab element with gaps (BD) is function of the gaps dimensions.

The nominal diameter of the gaps may be of: 180, 225, 270, 315 or 360 mm.

The minimum distance between gaps is 1/9 of the gaps diameter.

The total height of the BubbleDeck slab elements is constant. Function of the diameter of the bubbles that are used, the total height may be: 230, 280, 340, 390 or 450 mm. The weight of BubbleDeck slabs is function of its dimensions and indicated in Table 1. It's a fact that regardless of the diameter of the bubble used, respectively the thickness of the slab, the own weight stays practically constant.

In order to increase the shear strength capacity and bending moment in the areas with stress concentration (for example near the columns or walls) it is possible that in these areas gaps are not provided (Fig. 3).

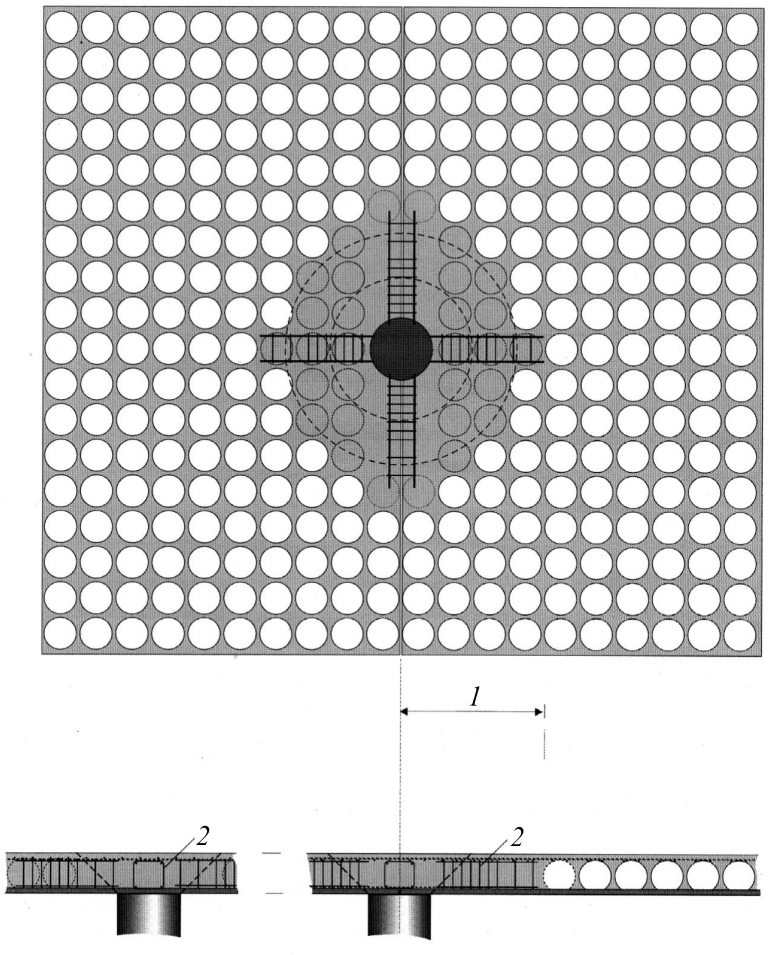

Fig. 3. – BubbleDeck composite slab: *1* – fill area without gaps; *2* – transversal reinforcement for shear force.

The surface of the filled (no gaps) areas are chosen function of the loads and the thickness of the slab.

The BubbleDeck slab gaps elements can be delivered in the following versions:

Version *A*. Reinforcement modules in which the spheres are placed to produce the gaps and if the case, tubes for HVAC (electrical, heating, etc.), modules that are to be placed in formworks. The plates are cast in place.

Version *B*. Partial precast concrete elements. They have the bottom part made of precast concrete and the connections between elements and the overconcreting are cast in place.

In this version the elements are delivered as manufacturing made elements, consisting of a precast concrete layer with 60 mm thickness in which is embedded the bottom part of the reinforcement shell of the entire slab element, the bottom part of the spheres that make the gaps and, function of situation the HVAC tubes. The precast concrete layer from the bottom part is used also as horizontal formwork at the bottom part.

The partially precast elements are made with widths of 2,400 mm or 3,000 mm and spans up to 14 m.

The concrete used for the precast layer can be of common concrete or selfleveling concrete. Minimum class of concrete is C20/25.

The minimum class of the cast in place concrete is C20/25. The reinforcement modules for BubbleDeck slabs in version *A* are identified through a label that specifies, in Romanian language, the producer's name, client's name, code of the element, the dimensions of the element.

In the case of slab elements partially precast, version *B*, each slab element is identified through a label that specifies, in Romanian language, the producer's name, the client's name, the code of the slab element, the sizes of the slab element, the weight of the element, the date of the manufacturing, risk warnings regarding the formwork removing.

2. Areas of Acceptance for Utilization in Constructions Field

The method for BubbleDeck composite elements made of concrete with gaps reinforced on two directions is used on making the slabs and roof terrace of the buildings, inclusively on areas for F and G category as defined in SR EN 1991-2:2004 and which are not subjected to efforts that can produce the fatigue phenomena. Using of slabs on buildings in areas with seismic hazard is made corresponding to the SR EN 1998-1:2004 and P100-1:2006 prescriptions.

It is recommended the use of BubbleDeck procedure in making the slabs and roof terrace for buildings with big spans and reduced number of support elements: conference rooms, spectacle rooms, parking buildings.

The products fulfill the requirement of 10/2005 Romanian Law regarding the quality in constructions.

BubbleDeck slabs with gaps reinforced on two directions, assure mechanical strength and stability of the construction by designing of the slab by calculating it for stresses given by dead and live loads according to Romanian Standards.

Reducing the weight of the construction leads to reducing of the calculus seismic force.

The product is considered to be class A1(C0) as reaction to fire. The degree of fireproofing of BubbleDeck composites slabs with gaps can be calculated according to SR EN 1992-1-2:2004.

BubbleDeck slabs with gaps are not toxic and environmental friendly, doesn't diffuse noxious substances and they are not radioactive. The materials used are not on the list of cancer producing list nor on the potentially cancer producing list according to 91/2002 Decree of Ministry of Health

Polypropylene used to make the sphere is recyclable, the BubbleDeck slabs being entirely recyclable.

By using BubbleDeck method, the quantity of concrete and cement is reduced by 30...50% for the same built surface compared with the classical slabs, fact that gives an important reduced quantity of carbon emitted.

BubbleDeck slabs with gaps are conceived so they don't produce risks during its working period.

The designer of the building will design the slabs corresponding to the efforts given by the dead and live loads and the recommendations of the producer.

Due to the own weight of the BubbleDeck slabs – minimum 280 kg/m^2 – the slabs assure an sound proof index of at least 49 dB.

The constituent elements of the BubbleDeck slabs don't influence significantly the thermal insulation requirement of the building.

Through the decrease of concrete's amount, through the decrease of transports, as and through the possibility of foreseeing of pipelines, cables and element of electric fittings is achieved important saving of manual labor and energy.

3. The Manufacturing and the Checking

The reinforcement modules and partially precast elements are made according to the dimensions given by the execution project of the slab. Therefore the designer must optimize the dimensions of the prefabricated elements function of the configuration of the slab and the capacity of transportation mean. On the general plan of the slab each element has a labeled number.

A. In order to achieve the reinforcement modules for BubbleDeck slabs with gaps in version A the following operations must take place:

a) making the reinforcement meshes (Fig.1);

b) placing the pipelines, cables and element of electric fittings if the case;

c) fixing small boxes or pieces of polystyrene on reinforcement meshes for marking the position of the walls or the columns and installations;

d) placing of the polystyrene spheres between the meshes according to plans;

e) labeling of the reinforcement modules.

B. Phases of manufacturing process of the BubbleDeck slab with gaps, version B and the checking during quality control are as follows:

a) making of the reinforcement meshes (Fig.2);

b) placing of the installations on the reinforcement meshes, if necessary;

c) fixing small boxes or pieces of polystyrene on reinforcement meshes or directly on the formwork for marking the position of the walls or the columns and installations;

d) placing of the polystyrene spheres between the meshes according to plans (Fig. 2);

e) preparing the formwork (cleaning, assembling, greasing);

f) checking of the formwork and the reinforcement before pouring the concrete;

g) preparing the concrete;

h) pouring the concrete;

i) foreseeing labels on elements.

Quality controls in assured trough the entire technological process beginning with the checking the materials and continuing with checking of the intermediate phases of execution and ending with final product checking.

1° At the materials reception it is checked if they are according with the documents that come with the materials: reinforcement, aggregates, cement, polypropylene spheres, etc.

2° During the manufacturing process the following are checked:

a) the reinforcement is according to the project;

b) placing of the spheres is according to the plans;

c) marking of positions of walls, columns and installations;

d) functionality of concrete station;

e) fresh concrete characteristics.

3° After the manufacturing process is complete the final product is checked for dimensions and aspect.

The internal checking of quality is made on the basis of the procedures of the producer. The external checking of the product is made in a special authorized and neutral laboratory. Storing the products is made on special shelfs.

4. Casting in Place of the Element

These products are laid in place without any particular difficulties in a normal precision building by execution units with qualified personal including the following phases:

1° Making cast in place slabs:

a) the formwork is made with supports calculated to hold the concrete's own weight and the loads that occur during pouring the concrete;

b) the reinforcement is placed according to the plans;

c) the position of the spheres is checked;

d) placing the reinforcement at the connection with the columns or the walls areas;

e) the concrete of 20/25 class is poured and vibrated, the maximum nominal diameter of aggregates is function of the distance between the reinforcement bars but not larger than 15 cm;

f) the supports of the formwork and the formwork are removed when the slab is able to take over the own weight and the live loads (the compression strength of the concrete should be at least equal to the characteristical strength fck).

2° Making the semiprecast concrete slabs

Each slab element needs to be temporary propped. The supporting elements need to be dimensioned so they can take over the weight of the semiprecast elements, the reinforcement and the fresh concrete and also all the loads that occur until the operation of concreting is finished.

The distance between the supporting beams should be not larger than 1800 mm.

The temporary propping elements are kept in position until each part of the slab can support by itself the own weight and the supplementary live loads.

The precast elements can be lifted only by grabbing on the special provided reinforcement bars (ears).

During the final positioning of the slab elements it is checked if the displaying of the spheres is according to the plans. Also it is checked the reinforcement in the overconcreting areas. The transversal reinforcement bars must be embedded in the adjacent slab elements.

Partially precast made elements are designed and realized so that the building configuration is maintained. They are delivered with pieces of polystyrene included that mark the position of the walls or the columns. In the case that geometrical misshapes occur the adjustments of the element is possible by the means of a diamonded disk that creates the area that takes over the shear force. In these situations the integrity of the top part mesh is assured and also of the inclined reinforcement.

Also, in this phase, the polystyrene pieces that mark the position of different elements (columns, walls, etc.) are removed.

The upper part reinforcement is directly led on the partially precast elements according to the reinforcement plans.

The following types of reinforcement are observed: reinforcement bars for bottom part of concreting, reinforcement bars for shear force around the columns, reinforcement bars at the upper part of connections, cramps on the perimeter of the slab element.

Before pouring, the surface of the precast element is thoroughly cleaned. Immediately after pouring, the surface of the concrete is cleaned with under

pressure water to remove the dust and to moister the surface. Especially in times of high temperatures the surface of the precast element is kept wet to ensure the needed adherence.

When the geometry of the connections of the partially prefabricated elements are not rigorously followed according to the design the concreting is adjusted with fluid mortar or with a thin layer of silicon pumped at the bottom part of the connection. In order to adjust the connections one should never use expanded foams that may lead to reducing the thickness of the concrete layer and therefore to reducing the durability of the reinforcement and the fire resistance.

The concrete poured on site is of minimum class C20/25, the dimension of the aggregate is function of the thickness of the slab. The nominal maximum dimension of the aggregates should be between 3 and 5 mm and it is chosen function of the thickness of the concrete element that is to be poured.

Because of the little space between spheres, it is used a thin vibrator. The surface of the poured concrete in leveled with a metallic profile.

Usually, between the 7th and the 14th day after pouring it is checked the compression strength of the poured concrete. If the compression strength is minimum fck, the temporary props may be removed.

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PROCEDEU DE REALIZARE A PLANŞEELOR DIN BETON CU GOLURI, TIP BUBBLEDECK

(Rezumat)

Planşeele compozite sunt alcătuite din elemente de planşeu cu goluri sferice, tip BubbleDeck, monolitizate pe direcţie longitudinală şi transversală. Prevederea golurilor conduce la micşorarea greutăţii planşeelor cu 30...50%, ceea ce duce la reducerea încărcărilor în stâlpi, pereţi şi fundaţii, precum şi la reducerea greutăţii întregii structuri. Elementele de planşeu tip BubbleDeck sunt plăci cu nervuri pe două direcţii, din beton armat sau precomprimat, cu goluri de formă sferică. Aceste elemente de planşeu au o parte inferioară şi una superioară din beton, legate prin nervuri verticale, constituite în jurul golurilor.