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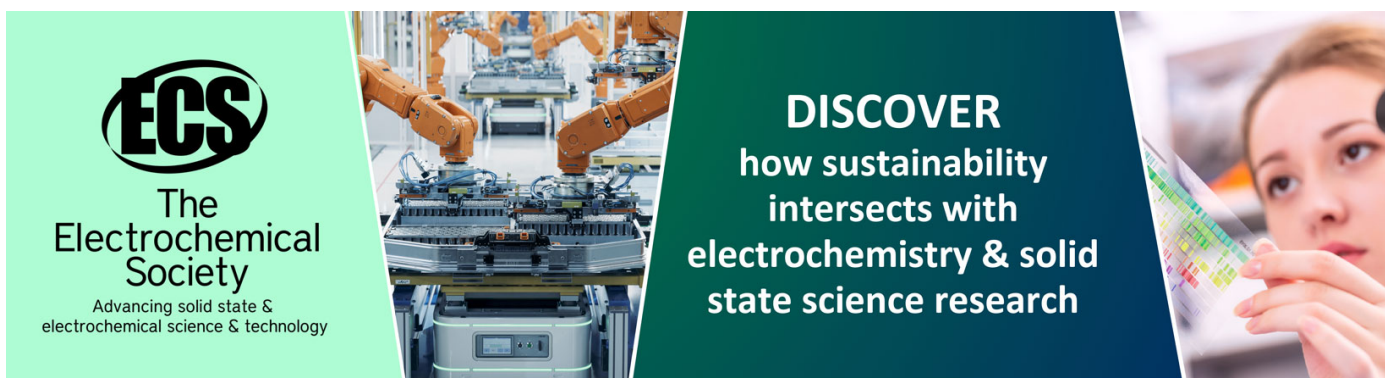
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Effectiveness of reduced model using during building of reinforced monolithic dome

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Abstract. In order to obtain a proved solution for composing a new type molding system, a model of main framework of a dome mold was made as compared with natural sizes on a scale 1/10. As a result of analyzing the values of its constructional and technical-economical parameters there has been found a completely new solution for constructing a molding system with thin-shielded molds.

Construction of a monolithic dome technologically is quite a complex and time-consuming process that in the first place is explained by the fact that an appropriate mold is necessary to create before.

It describes a completely innovative construction of a molding system of the dome of 12 m in diameter with thin-shielded molds in levels and with an original solution of connection and fixation of the curved edges of the cathedral the second in size in Georgia on Mount Makhata in Tbilisi being under construction. It has been established that it is very effective for the selection of a mold system of a large-diameter monolithic iron-concrete dome to carefully study and examine its minimized model.

It has been found out that by thin-shielded molds it is possible to compose separate load-bearing elements of various complexity and configuration included in the molding system. Also, the process of joining in thickened blocks of the above-mentioned elements as well as their mounting and firm fixation has been simplified. It should be noted as well unlimited possibilities of increasing extremely the features of their toughness by adding the edges of simple hardness. And what is more important, use of standard materials and molding devices significantly reduces labor and material consumption connected with formation of molds.

1 Introduction

The dome has many advantages, ranging from the best possible volume to surface ratio - with the minimum material consumption, maximum cubic volume is achieved. This in turn makes it possible to build a dome using fewer building materials than other construction forms [1]. The round shape of the dome is resistant to hurricane winds and seismic shocks. The canopy is not covered by snow, and the



water flows quickly [2]. Even distribution of forces and low center of gravity make it possible to use light materials for the construction and the construction will be very durable [3].

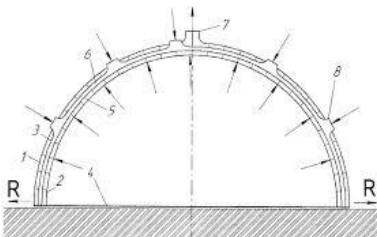
Constructing a monolithic dome is technologically quite a complicated process that in the first place is explained by the fact that an appropriate mold needs to be prepared in advance.

2. Monolithic iron-concrete construction domes

A dome mold actually represents an independent construction and it can be basically made of wood or metal – solid and dismantling. Table 1 provides several examples in this regard. Based on the existing experience there should have been made the most efficient decision about preparing a dome mold with a 12m diameter for the cathedral being under construction on Mount Makhata in Tbilisi [4, 5].

Table 1. Molds for constructing monolithic iron-concrete dome

Nr	Name of mold	Image or scheme	Assessment
1	Wood, solid		1. Easy to construct on the constructing area, but is used to construct domes with small diameters (not exceeding 6-8 mm); 2. Easy to lift and move this kind of mold and install on the mounting area, but it is difficult to unmold it.
2	Metal, solid		1. Is made in a factory for constructing domes of any diameter; 2. The more the diameter and mass of a dome is, the more difficult is to lift, transfer and install it; 3. It is particularly difficult to dismantle it after it has been concreted as it is not easy for a crane to approach.
3	Wood, Dismantling	 	1. As the diameter of a dome increases, it becomes more difficult to arrange its supporting structure as it requires great hardness and material consumption; 2. It is difficult to lift and transfer it, flanking is possible only after it will be installed on site; 3. While arranging factory-furnished shields it is necessary to construct a complex supporting system. It is difficult to receive right flatness and unmold after concreting.

4	Metal, Dismantling		1. Is made in a factory, but after assembling on site it requires difficult operations of flanking; 2. It is difficult to dismantle it after concreting a dome as it is not easy for a crane to approach it;
5	Pneumatic		1. Is used only in special cases and is very difficult for working at a high altitude; 2. It is particularly difficult to carry out concreting due to a bad adhesion with concrete;

3. New type monolithic iron-concrete construction dome molding system

In order to obtain a proved solution for composing a new type molding system, a model of main framework of a dome mold was made as compared with natural sizes on a scale 1/10 (Fig.1). As a result of analyzing the values of its constructional and technical-economical parameters there has been found a completely new solution for constructing a molding system with thin-shielded molds.

Constructing a three-level dismantling and movable molding system appeared to be the most acceptable that has been easily implemented [6, 7, 8]. The process of composing a solid iron-concrete monolithic dome can be divided in three stages:

1. According to the dome diameter, a supporting circular bottom of the whole molding system was constructed with laminated shields and flanks of 20mm in thickness.
2. One of the main tasks was to compose a crossed directing half-circular edges with inner radius of the dome. Only after their installing it was possible to create the whole molding system. Four rimmed edges in 30cm width of the dome shape was made with doubled laminated flanks and 3cm thickness wood flank pads. Rimmed edges were reinforced with additional wood slats for increasing their hardness (Figure 2.).



Figure 1. Model of a main framework for a dome molding system



Figure 2. Setting up half-circular edges

2. Main load-bearing elements of the first-level framework of the molding system were installed in the quarter of the supporting circle separated with directing edges. These elements of dome and trapezoid shape were being made by using wood slats and laminated shields. They were fixed on the circular bottom and in the upper part were united with circular laminated slats of the second level.

4. For providing an appropriate hardness to the molding system narrow edges of additional hardness were placed between the load-bearing elements of the first level. They were fixed between the slats of the first and second levels.
5. Production of the load-bearing elements for the second level was implemented in a similar way as it was in the case of the first level with flat frames of appropriate curves. Besides, two double frames initially were joined in small space blocks and in order to increase the hardness of the blocks narrow hardness edges were installed in here as well. The blocks were disposed and fixed between the supporting circles of the second and third levels;
6. Triangle hardness edges of remaining curves of the third level were directly held by the supporting circle of the third level and their ends were gathered in the upper part, around the center of the molding system. After constructing the framework of the molding system their geometrical sizes and hardness were checked in the carpenter's workshop. The whole system was dismantled and transferred to the working place.
7. A place for constructing a dome was prepared and equipped with flanked floor supported with scaffolds. Levels of the flanked floor were checked by surveying instruments and appropriate grids were marked. A framework of the molding system was constructed in the same sequence as it was done in the carpenter's workshop (Figure 3).

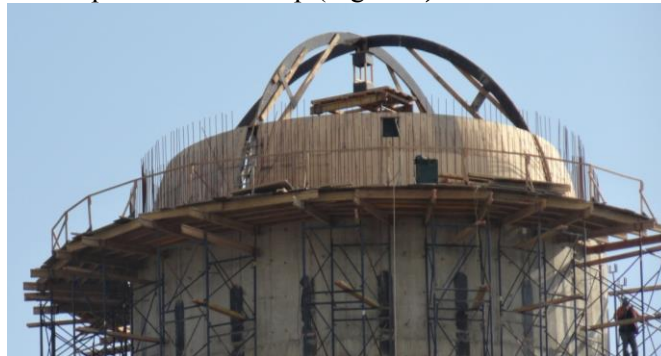
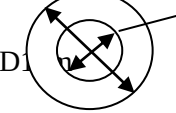


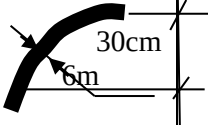
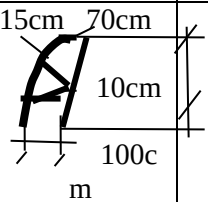
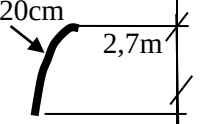
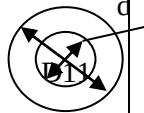
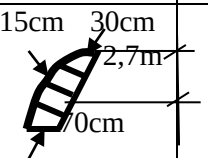
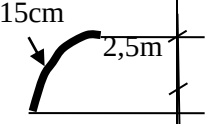
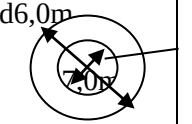
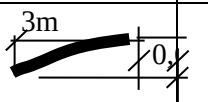
Figure 3. Constructing a first level of the dome on the working place

4. Consumption of the material required at new domes molding system

It should be noted that by three-level solution of the dome framework and using main load-bearing elements obtained by connecting laminates and flanks of 30 mm in thickness, consumption of the material required for constructing a molding system significantly reduced as compared with the other domes to be constructed with the same diameter. It totally made up 9,516 cubic meter flank of 30 mm in thickness and 489,34 square meter laminate (Table 2). Due to the small weight and convenient sizes of the constituent elements production/installation and afterwards, what is more important, unloading of the framework of the molding system was implemented very quickly [9-12].

Table 2. Material consumption for a mold framework

N	Element	Expression and size	Amount, unit	Material and consumption	Basic material consumption	
					Laminate, m ²	Flank – 30 mm in thickness, m ³
1	2	3	4	5	6	7
1	Supporting circle		1	1. Laminate 34.54 m ² ; 2. Flank – 30 mm in thickness – 1.04 m ³	34.54	1.04

2	Principal edge		4	1. Laminate – 3.6 m ² 2. Flank – 30 mm in thickness – 0.54 m ³	14.4	2.16
3	Load-bearing edge of the first level		32	1. Laminate – 2.3 m ² 2. Flank – 30 mm in thickness – 0.042 m ³	73.6	1.344
4	Edges of the first level		84	1. Laminate – 1.2 m ² 2. Flank – 30 mm in thickness – 0.018 m ³	100.8	1.512
1	2	3	4	5	6	7
5	Circle of the second level		1	1. Laminate – 31.4 m ²	31,4	
6	Load-bearing edge of the second level		40	1. Laminate – 2.1 m ² 2. Flank – 30 mm in thickness – 0.045 m ³	84,0	1,8
7	Edges of the second level		84	1. Laminate – 0.9 m ² 2. Flank – 30 mm in thickness – 0.012 m ³	75,6	1,01
8	Circle of the third level		1	1. Laminate – 10.2 m ²	10,2	
9	Edges of the third level		54	1. Laminate – 1.2 m ² . 2. Flank – 30 mm in thickness – 0.012 m ³	64,8	0,65
Total basic material consumption					489,34	9,516

5. Summary

For selecting a mold system of the monolithic iron-concrete dome of a large diameter it is extremely efficient to comprehensively study and investigate its reduced model. This is, for example, the model of main carcass of the dome formwork, natural sizes compared to 1/10 scale. In this peculiar case

construction of a three-level dismantling/movable mold system by using thin-shielded mold appeared to be the most reasonable. As a result, along with significant saving of materials Almost 2 times, its unmolding procedure after setting up a dome and concreting it was simplified, which overall took 2-3 times less time, compared to arrangement of similar size domes.

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