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INFLUENCE OF CREEP CONCRETE ON SPACE STABILITY THIN-WALLED DOME COVERINGS

Gridnev Sergey[1], Prokshits Ekaterina[1], Sotnikova Olga[1], Zolotukhina Iana[1]

[1]*Voronezh State Technical University, Voronezh, Russia, e.mail: gridnev_s_y@rambler.ru*

ABSTRACT

The task was set, due to the capabilities of modern software systems, to assess the effect of the increase in inelastic deformations under prolonged load action on the loss of stability of thin-walled dome coverings. The study of the dependences of the forms of the loss of stability of dome covering from creep concrete that will help further with optimization calculations when determining of the most influencing parameters of designs.

Calculation results of thin-walled concrete dome roof of circular outline under the influence of operational loadings with use of two modern program complexes are given in article. It is investigated intense and deformation condition of dome coverings as a part of construction from position of forecasting of possible forms of loss of stability, with use of opportunities of the final and element «MidasCivil» computer system. In work provisions of the theory of elasticity, mechanics of deformation of solid body, construction mechanics and also methods of mathematical modeling based on application of finite element method are used.

The received results give the chance to rationally select geometrical parameters and material of design and also to set structural strength safety factors at the solution of problems of stability of different covers taking into account possible creep of material.

Key words: *dome coverings, creep of concrete, final and element model, space stability, stability loss forms*

INTRODUCTION

Recently in connection with mass construction and recovery of cult constructions application of dome designs which represents the space design consisting of cover with vertical axis of rotation and supporting ring increases. The use of dome structures in modern construction is very attractive both functionally and compositionally. The wide variety of spatial and structural solutions available for this period of the domes is a way of individualizing the architectural appearance of the building. The designs of the domed coverings are unique in a number of features and arouse the interest of modern designers, providing wide opportunities for the implementation of new architectural ideas in order to create a vivid, memorable image of the building.

Use at design of constructions of different final and element program complexes («MidasCivil», «Sofistik», «Lusas», «Lira», «Ansys», «Nastran», «Algor», «Danfe», «Mefisto», «Femap») allows to estimate adequately the intense state of strain (ISS) of designs of construction and not to allow emergence of the zones dangerous in terms of destruction and loss of stability [1].

At long influences of loadings (for example, snow) in thin-walled covers the property of material creep, i.e. change of deformations and tension can be shown eventually at invariable loading that leads to considerable decrease in their bearing capacity [2]. The creep is slow increase in deformations of design owing to long loadings. The creep affects stability of cover, reducing it eventually. And deformations of cover which are caused by creep are shown not at once. The loadings caused by creep prove variously on linearly - elastic, sandwich, nonlinear and elastic shell [3].

At design it is necessary to consider what in the course of creation of design constantly changes properties of concrete which depend on time: elastic modulus and durability on compression. Intense strain states of design continue to change not only in the course of design construction, but also after its end because the changes of time-dependent properties of concrete such as creep, shrinkage, elastic modulus (aging).

To research of intense state of strain and stability of covers including at long loadings, number of works is devoted, for example [3,4,5,6] also other authors and foreign scientists [7,8,9]. While questions of bend and stability of thin-walled covers are studied rather well, to question research stability of covers at concrete creep not so many works are devoted. It is explained, first of all, by lack of consensus on formulation of criteria of loss of stability at creep by means of which it is possible to evaluate authentically in the rated way the size of critical time and also complexity pilot researches and labor input decisions geometrically and physically nonlinear tasks.

Therefore the purpose of this work is the research of dependence of forms of stability loss thin-walled dome covering from creep concrete. For this purpose we use the modern licensed final and element «MidasCivil» computer systems and the systems of through architectural and construction design of «ING +» the rated «MicroFe» module.

METHODS AND MATERIALS

Object of research is the round concrete thin-walled dome roof in the plan. The scheme of the studied dome with the main geometrical characteristics is provided below (Figure 1).

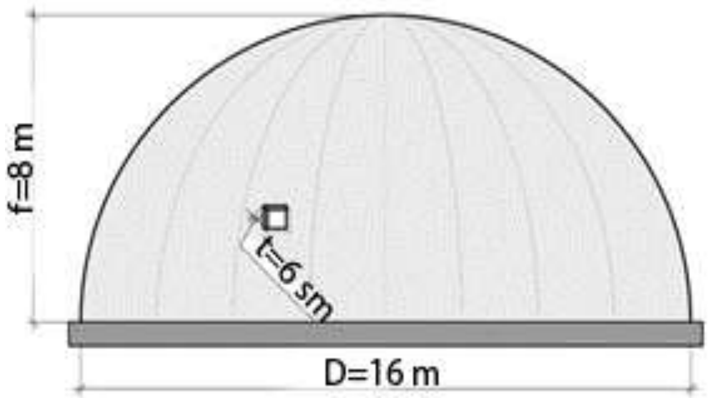

Figure 1 The scheme of the studied dome with the main geometrical characteristics

Material of dome covering – steel concrete: E = 3,25·104 MPa, μ = 0.2, shell thickness t =60 mm have constructive Armataru in the form of grid of 200x200 mm from wire with a diameter of 10 mm, B25 concrete.

Load of dome: curb weight is 0,55 T/m2 + payload is 0,15 T/m2 + snow load on mark of +117 m (wind load is not considered).

We consider constants the sizes of monolithic supporting ring of 600x600 mm in size from B40 concrete [10,11].

For reinforced concrete, the growth of structural deformations over time is of great importance, due to creep and the possibility of gradual shutdown of the stretched zone from the concrete. As a result of concrete creep in reinforced concrete structures, stress is redistributed between concrete and reinforcement: stress in concrete decreases, and in reinforcement increases.

The amount of creep deformation depends on a number of factors:

- concrete loaded at an early age (all other things being equal) has more creep than the old one;
- creep of concrete in dry environment is much more than in wet environment;
- with an increase in Water/Cement and cement consumption per unit volume of concrete mixture, creep increases;
- with increased strength of aggregate grains, creep decreases;
- creep decreases as concrete class increases;
- Porous aggregate concretes have slightly greater creep than heavy concretes;
- creep depends on the type of cement: concretes prepared on slag portland cement or portland cement have the greatest creep;
- creep the smaller (other things being equal), the larger the cross-sectional dimensions of the concrete element;
- steaming concrete reduces its creep on 10... 20%, and autoclave treatment on 50... 80%;
- presence of reinforcement in concrete reduces creep by 1.5-2 times.

Achievement of critical conditions of thin-walled flexible elements, in particular covers, is reached at much lower values, than at short-term tests [12].

We consider creep of concrete, replacing in the formulas received in the theoretical way, concrete elastic modulus E_b to deformation module $E_{b,def}$. For concrete the size of the module of deformation should be determined on formula (1):

$$E_{b,def} = \frac{E_b}{4} \quad (1)$$

The intensity of gross design load should not exceed sizes calculated by formula (2):

$$q \leq 0.2E_{b,def}\left(\frac{t}{r_c}\right)^2 = \frac{E_b}{20}\left(\frac{t}{r_c}\right)^2 \quad (2)$$

where t – shell thickness

When determining criteria of critical condition at the time of stability loss by us it was offered to accept the following mechanism of stability loss and further destruction of dome design: we accept the mechanism of stability loss of dome’s shape covering similar to the mechanism of durability loss in type of its small flexibility. At the same time, according to us, will occur:

- formation and disclosure of radial cracks
- exfoliation of outside fibers of protective layer of concrete
- further reduction of thickness of concrete section of element follows
- development of plastic deformations in armature and fragile destruction of concrete.

RESULTS AND DISCUSSION

In the system of through architectural and construction design of «ING +» the rated «MicroFe» module forms of stability loss and safety factors of stability dome covering corresponding to them taking into account creep concrete have been defined by the option "Stability". At the same time curb weight remained constant, and the snow load until approach of critical condition increased.

As criterion of stability loss vertical movement of dome’s top at the time of stability loss is accepted. For determination of this size calculation on combination of loadings to increase in snow load until approach of limit state is executed. The deformed type of dome is shown below (Figure 2-3).

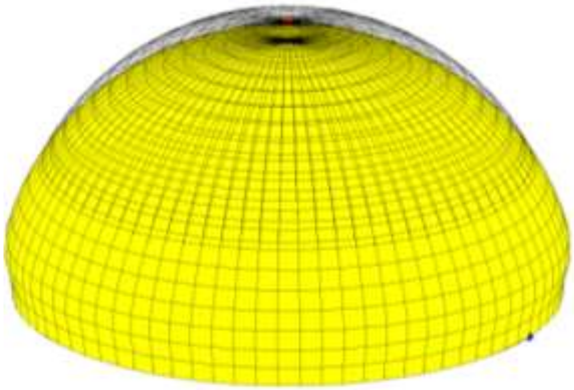

Figure 2 The deformed type of dome at the time of approach of limit state (View 1)
Max. displacement = 0.393445 mm in assembly = 821;

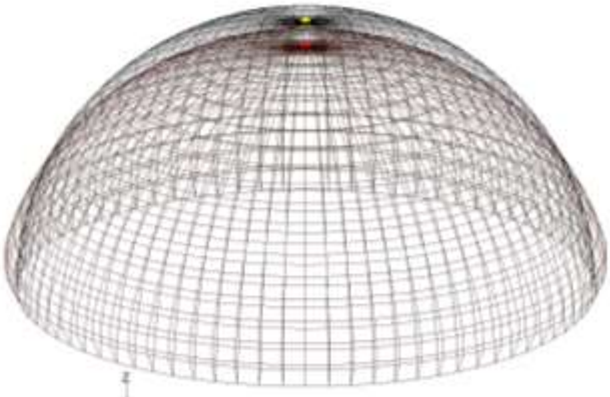

Figure 3 The deformed type of dome at the time of approach of limit state (View 2)
Max. displacement = 0.393445 mm in assembly = 821;

For accounting of creep concrete according to item 6.1.15 of SP 63.13330.2018 "Concrete and reinforced concrete constructions. Revised edition" has been reduced modul concrete deformations: dome (B25) – by 3,5 times, supporting ring (B40) – by 2,9 times (Figure 4-5).

a) b)

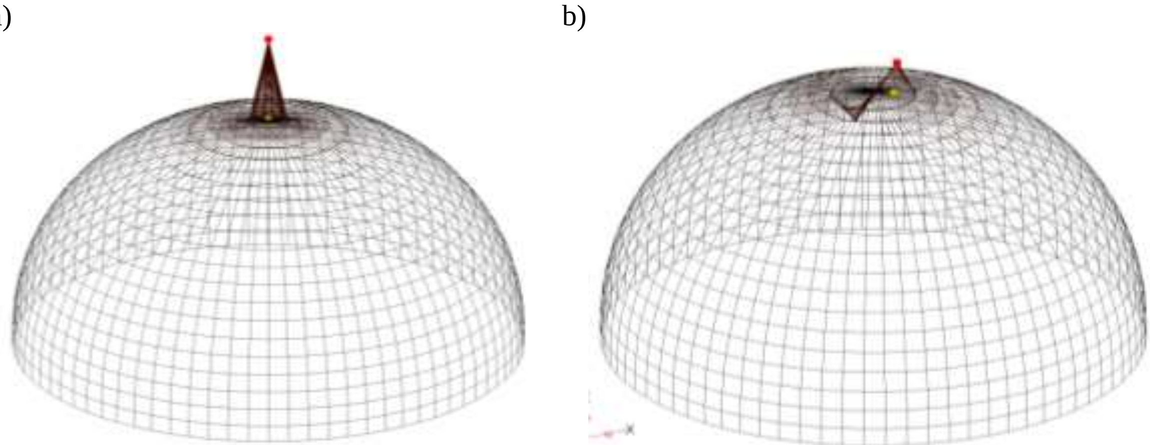

Figure 4 a) Stability safety factor = 40.0445 - The first form of stability loss;
b) Stability safety factor = 48.695 - the Second form of stability loss

a) b)

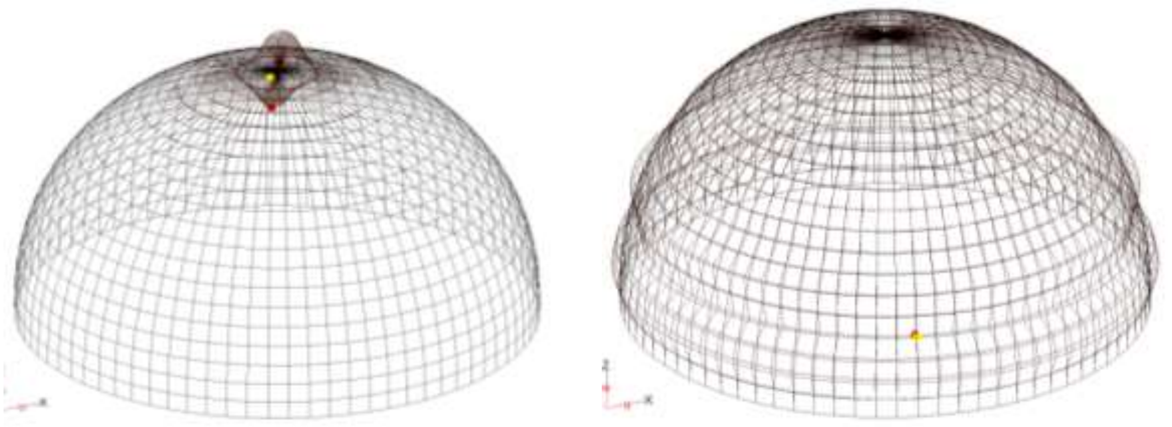

Figure 5 a) Stability safety factor = 57.5012 – the Third form of stability loss;
b) Stability safety factor = 69.206 – the Fourth form of stability loss

The received results allow to draw the following conclusion: decrease in the initial module of deformation of concrete due to creep, it does not change the form of loss of stability of the system, and only a safety factor decreases. The margin factor for mold stability is 44, which is more than the minimum recommended value of 3. Consequently, the stability of the system is ensured, and irreversible deflections as a result of creep are not observed.

CONCLUSIONS

Thanks to the program complex «MidasCivil» there is possible receiving highly effective final and element model of dome design in the interactive visualized environment. The developed graphical environment of CAD modeling has potential of import of models from other systems of three-dimensional modeling of geometrical objects. Therefore this complex can be considered multifunction and convenient means of computer-aided design.

The received results give the chance to rationally select geometrical parameters and material of thin-walled dome designs and also to set durability safety factors at the solution of stability problems of different covers taking into account possible creep of material.

The established interrelation between creep and forms of stability loss of thin-walled dome coverings will help further with optimization calculations when determining of the most influencing parameters of designs that will allow to create them more rational, economic and reliable.

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