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Issue Article

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ASSESSMENT OF VOLUMETRIC STRAIN OF HIGH-STRENGTH CONCRETE DURING COMPRESSION

***Abstract**: The analysis of the volumetric strain of a specimen made of high-strength concrete under the conditions of performing a compression test was carried out in the article. Images of the deformation dynamics and the volumetric strain coefficient of the specimen under various compressive loads are obtained. The most loaded local zones occur in the lower part and in the middle of the specimen at high compressive loads.*

***Key words**: high-strength concrete, compression test, specimen, volumetric strain.*

***Language**: English*

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Introduction

High-strength concrete used as a building material has excellent mechanical, strength and performance properties [1]. The compression tests performed on high-strength concrete made it possible to obtain the actual values of the tensile strength of this material under compressive forces [2-6]. The results of laboratory tests of concrete specimens were checked and compared using special computer programs for engineering analysis [7-10].

In this article, a study of sequential loading of the concrete specimen of circular cross-section is performed to determine changes in the geometry of the specimen, the degree of elastic deformations according to the concrete model with the calculation of the coefficient of volumetric strain of the material. These results can be used as additional reference materials when choosing a brand of high-strength concrete, taking into account the static compressive loads acting on it.

Materials and methods

Appropriate tests were performed to analyze the degree of strain of high-strength concrete under compressive forces. Compression tests of the specimens were carried out in a two-dimensional formulation using the Comsol Multiphysics application. For this purpose, an electronic model of the specimen with a diameter of 150 mm and a height of 300 mm was built.

The properties of high-strength concrete were specified in the electronic model of the specimen:

density – 1997.66-0.06027099×T kg/m^3,
coefficient of thermal expansion – 1.014663×10^{-5} 1/K,
dL – -0.002972963+1.014663×10^{-5}×T,
Poisson's ratio – 0.2,
Young's modulus – 39.5 MPa,
uniaxial tensile strength – 2.75 MPa,
uniaxial compressive strength – 43 MPa,
biaxial compressive strength – 60 MPa.

The following compressive forces were applied to the free-from-basing end surface of the specimen model: 1, 5, 10 and 13 MPa. The concrete model based on the Willam-Warnke criterion was adopted for the calculation. The results of the loaded state of the specimen were recorded in the time range from 0.1 to 1.0 s in 0.1 s increments.

Results and discussion

The volumetric strain of the concrete specimen during compression testing under various loads is shown in the Figs. 1-4.

The gray outline in the form of a rectangle represents the initial shape of the specimen before the application of compressive forces. The color area represents the shape of the specimen when compressive forces are applied. Accordingly, the color scale located to the right of the deformed model of the specimen characterizes the degree of volumetric strain of the material, expressed by a coefficient.

It is calculated that over the entire time range of application of a compressive load of 1 MPa, the coefficient of volumetric strain of the specimen material varies in the range from 0.005 to -0.075. Negative values of volumetric strain prevail, which indicates compression of the layers of the specimen material. The height of the specimen decreases. The specimen material under load undergoes elastic deformations.

With an increase in the compressive force to 5 MPa, the volumetric strain coefficient is determined in the range from 0.2 to -0.23. Compression deformations are also predominantly noted. The height of the specimen decreases. The elastic deformation of the specimen material is weakly expressed.

High compressive loads on the concrete specimen cause tensile deformations of the material layers. A distinctive feature of deformation under such compression conditions is the formation of the most loaded sections in the middle and in the lower part of the specimen. Thus, it can be said that the mechanism of destruction of high-strength concrete occurs in these local areas. The elastic deformation of the specimen material is strongly pronounced.

Conclusion

Thus, based on the analysis of the results of computer modeling of the compression process of the concrete specimen, the following conclusions can be drawn:

1. The volumetric strain coefficient takes negative values at low compressive loads, which characterizes the compression of the specimen material. However, at higher loads, the predominance of positive coefficient values is observed, which indicates the formation of local volumes in the material experiencing critical stretching close to the destruction of the specimen.

2. Elastic deformations of concrete are clearly visible at a force of more than 10 MPa. Elastic deformations are noted relative to the original shape of the specimen, leading to some return of the original volume of the loaded material.

3. In the compressive load range from 1 to 10 MPa, the volumetric strain of high-strength concrete increases by more than 100 times.

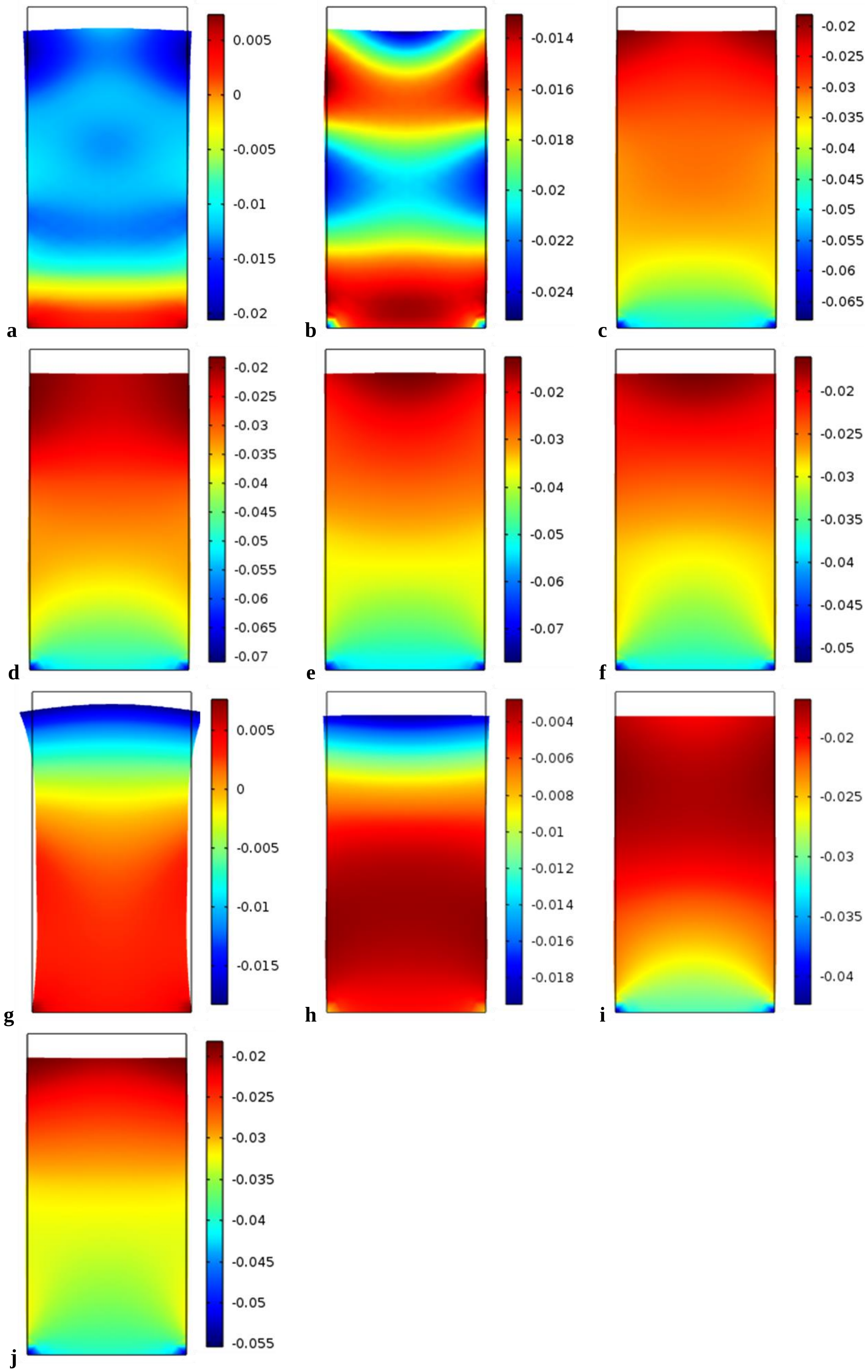

Figure 1. Volumetric strain of the concrete specimen during a compression test (the applied force is 1 MPa). a-j is the time of impact of the force on the specimen from 0.1 to 1.0 s.

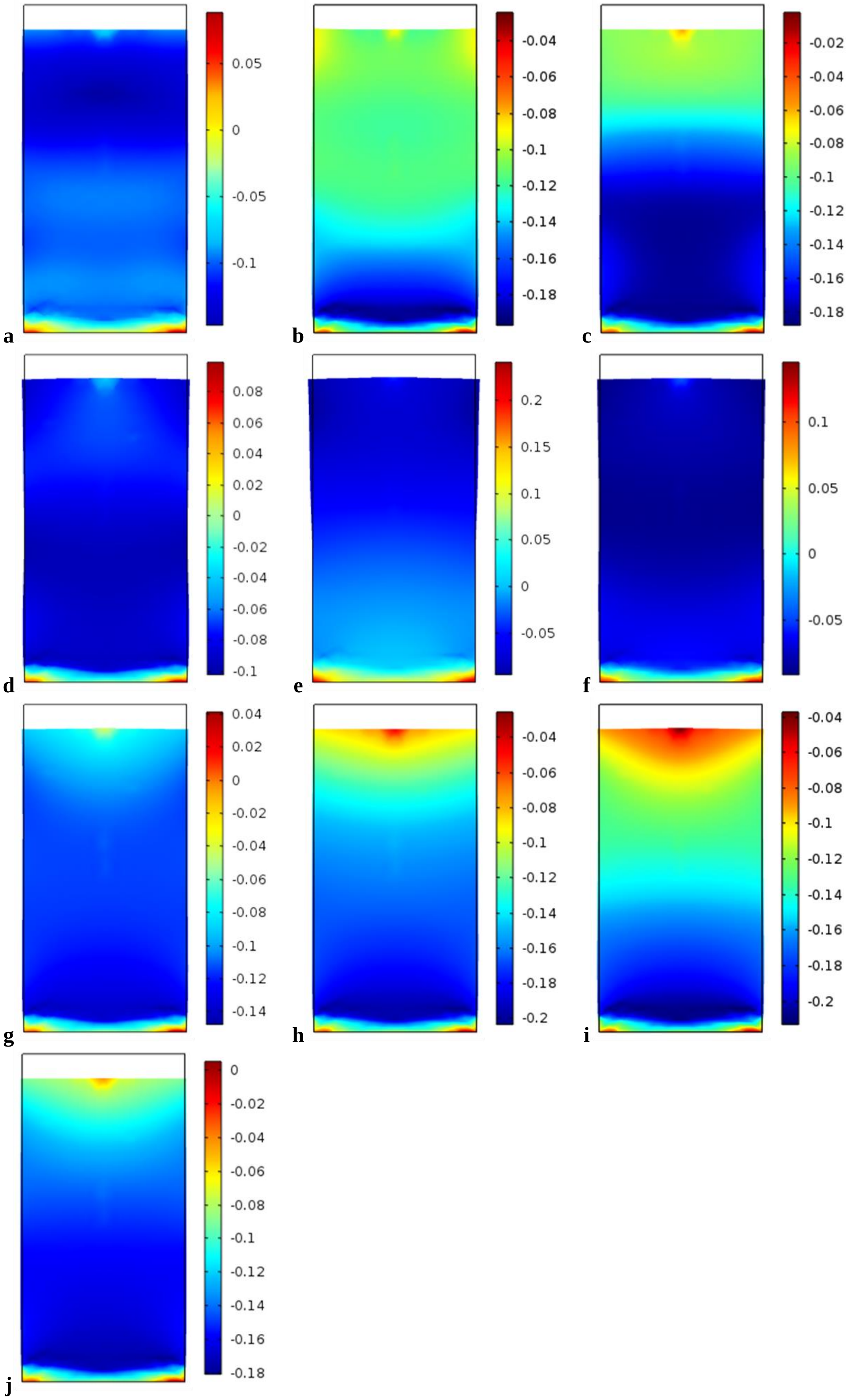

Figure 2. Volumetric strain of the concrete specimen during a compression test (the applied force is 5 MPa). a-j is the time of impact of the force on the specimen from 0.1 to 1.0 s.

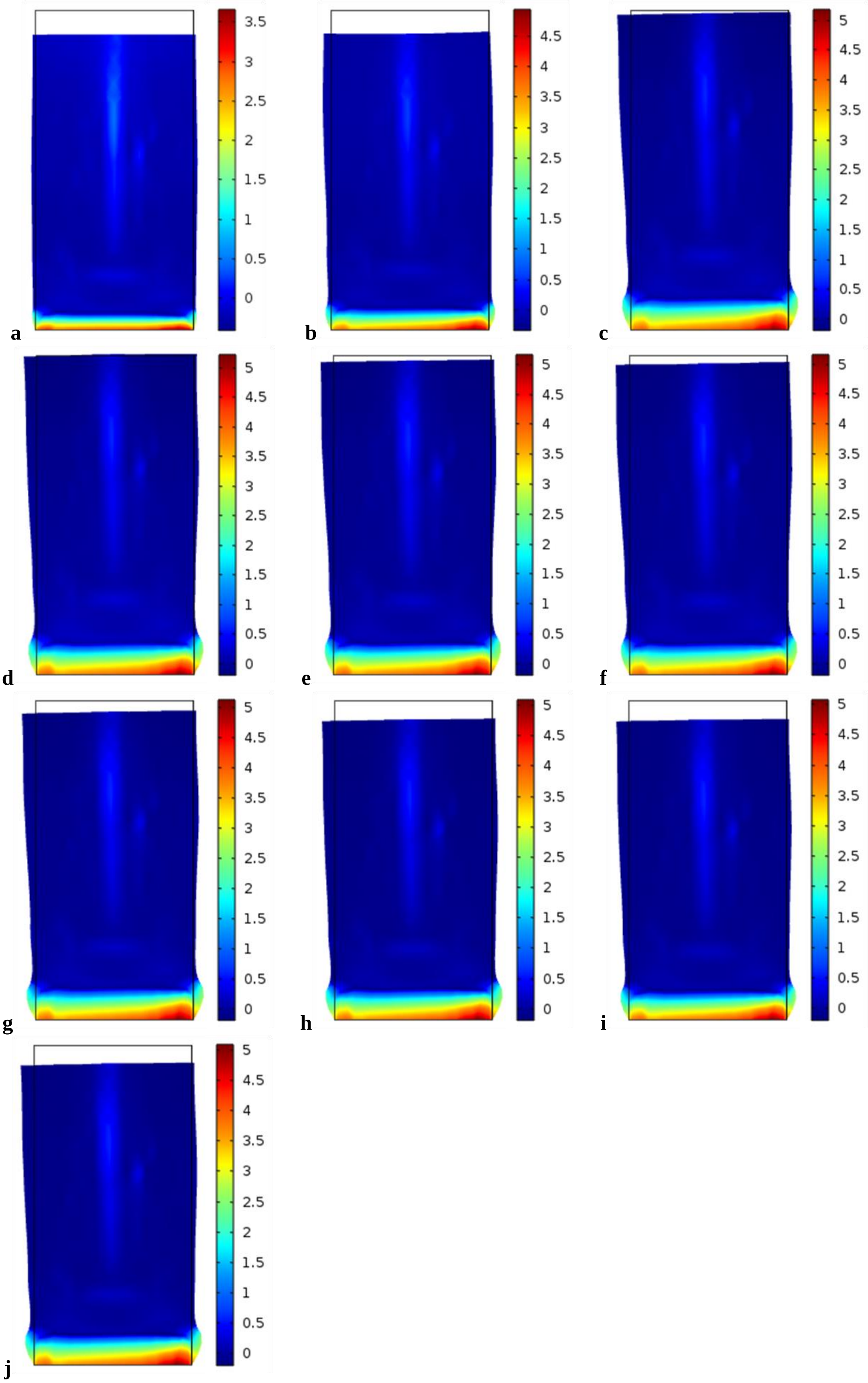

Figure 3. Volumetric strain of the concrete specimen during a compression test (the applied force is 10 MPa). a-j is the time of impact of the force on the specimen from 0.1 to 1.0 s.

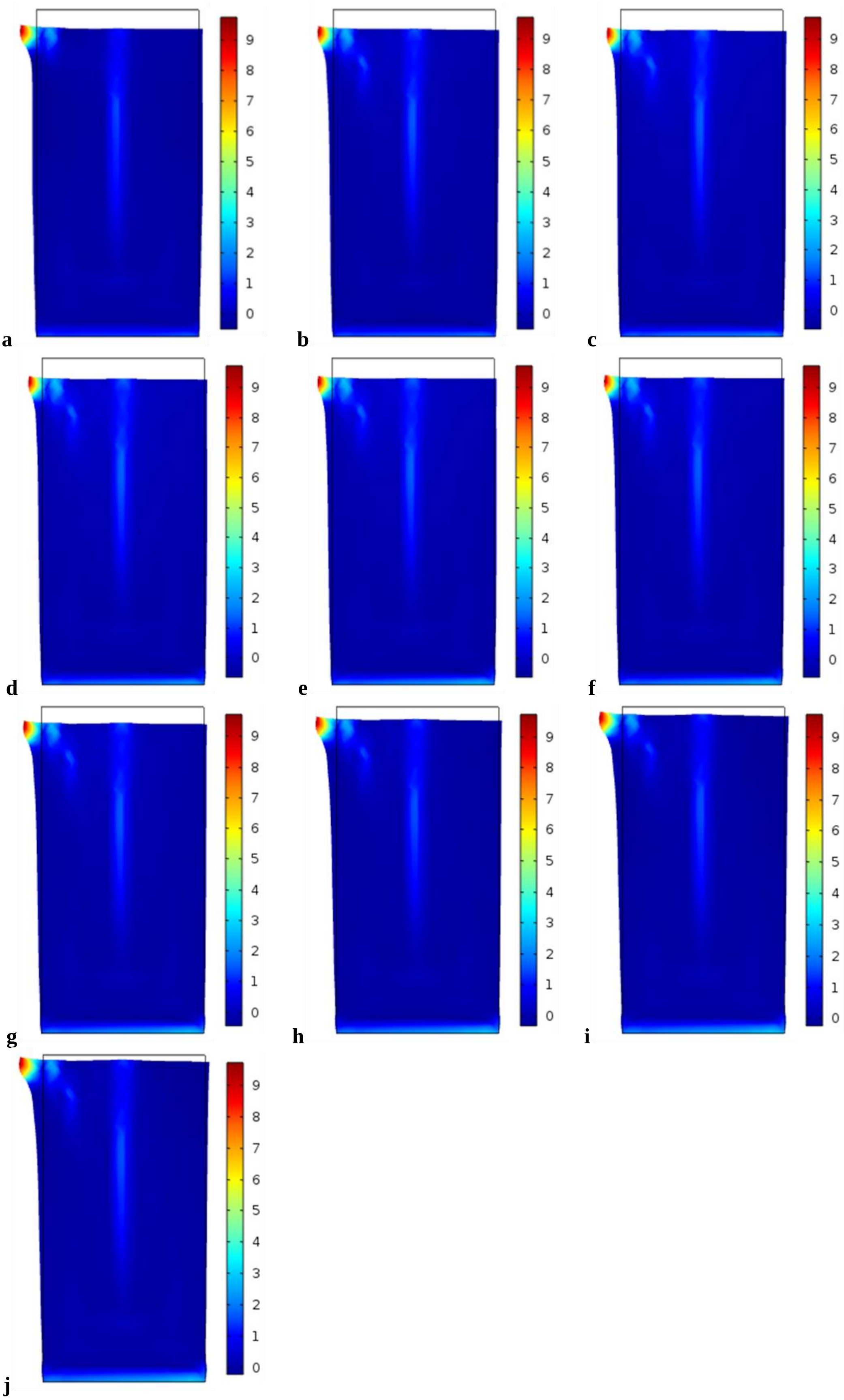

Figure 4. Volumetric strain of the concrete specimen during a compression test (the applied force is 13 MPa). a-j is the time of impact of the force on the specimen from 0.1 to 1.0 s.

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