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Calculation of Strength of Fiber Reinforced Concrete Beams Using Abaqus Software

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Abstract *- In the research work, the strength, stress-strain state, crack-resistance of fiber reinforced concrete beams dispersed with reinforced concrete and basalt fibers were analyzed using ABAQUS software. It was found that the strength and toughness of fiber reinforced concrete beams increased compared to ordinary reinforced concrete beams.*

Keywords— reinforced concrete, beam, stress, strain, basalt fiber, flexure, strength, dispersed reinforcement.

1. INTRODUCTION

The use of modern software systems based on the analysis of the stress-strain state of structures, their strength using the finite element method is very common in world practice. The advantages of digital study of constructions are:

1) the possibility of changing the initial data of the design (geometric sections, properties of materials, etc.);

2) the creation of conditions for the study and research of many samples with minimal time;

3) the possibility of modeling structures with a high degree of realism, taking into account the operating conditions (especially relevant for cases where it is not possible to test the structures in the laboratory);

4) the ability of the structures at any stage of the load during the calculation to obtain the data necessary for the assessment (stress-strain, displacement, maximum bending moment, etc.);

5) the availability of other options to take into account the various factors influencing the planning of laboratory tests and experimental research.

One of the leaders in automated engineering analysis systems is the ABAQUS software system. Of course, this system is very common among users, because, as mentioned above, the number of results to be obtained and analyzed is not limited [1-10].

The use of this system in our research also gives high results. In particular, the effect of short-term dynamic loads on the strength of elements made of basalt fibers and glass reinforcement in foreign countries has been studied. However, despite such possibilities, the problems of numerical modeling of basalt fiber-based fibro-reinforced concrete elements have not yet been sufficiently studied and have been neglected. This is due to the large demand for basalt fibers and the lack of production in sufficient quantities and volumes.

ABAQUS software system to study nonlinear deformation of basalt fiber reinforced concrete and reinforced concrete beams, to determine the stress-strain state of flat bending beams in the zone of bending moment allows studying the nature of the distribution of relative deformation in the zone. Analytical and numerical methods of calculating the strength of flexible elements with basalt fibers under the influence of short-term static load with the help of software are considered and analyzed. For example, the strength and tensile strength of fiber-reinforced concrete beams under normal sections under static loading, as well as the state of stress-strain are studied [11-21].

2. RESEARCH METHODOLOGY

In the digital study process, reinforced concrete and fiber reinforced concrete beams, which are identical to the experimental samples, were modeled. The cubic and prismatic strengths of concrete samples with added concrete and basalt fibers are shown in Table 1.

Table 1. Strength and deformation properties of concrete samples with the addition of concrete and basalt fibers.

Days	Length of basalt fiber, mm	Amount of basalt fiber,%		
		0,1	0,2	0,3
		Compressive strength, MPa		
28-day cubic strength	0	34,6		
	10	38,7	40,6	38,9
	30	39,8	41,3	38,7

28 days prismatic strength	0	25,8		
	10	28,7	29,8	28,3
	30	28,9	30,4	28,1

The mechanical properties of reinforcement, concrete, and fiber concrete for beams were determined by laboratory tests and used to form a material in the ABAQUS program. The total number of finite elements for the special case in the manufactured beams was 24,356 per beam. The model of reinforcement of flat flexible reinforced concrete and fiber reinforced concrete beams and the scheme of the general appearance of the reinforced concrete beam are shown in Figure 1-2.

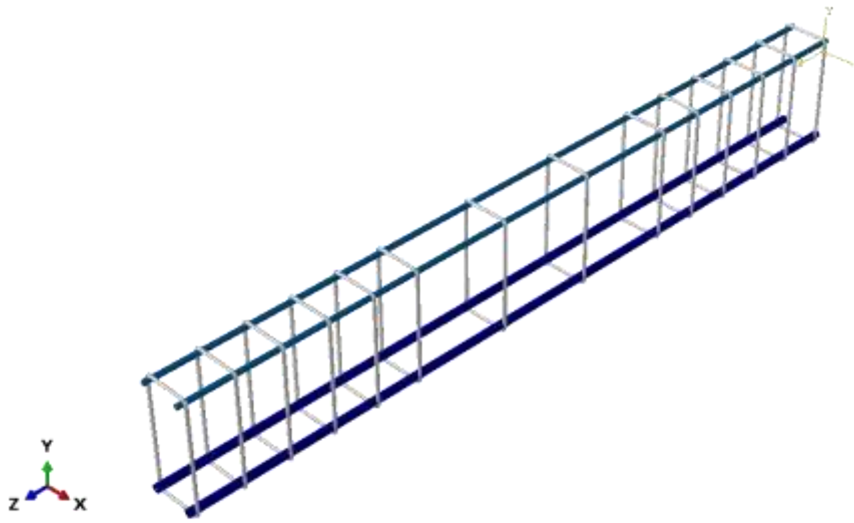

Fig. 2. *Designed beam reinforcement model*

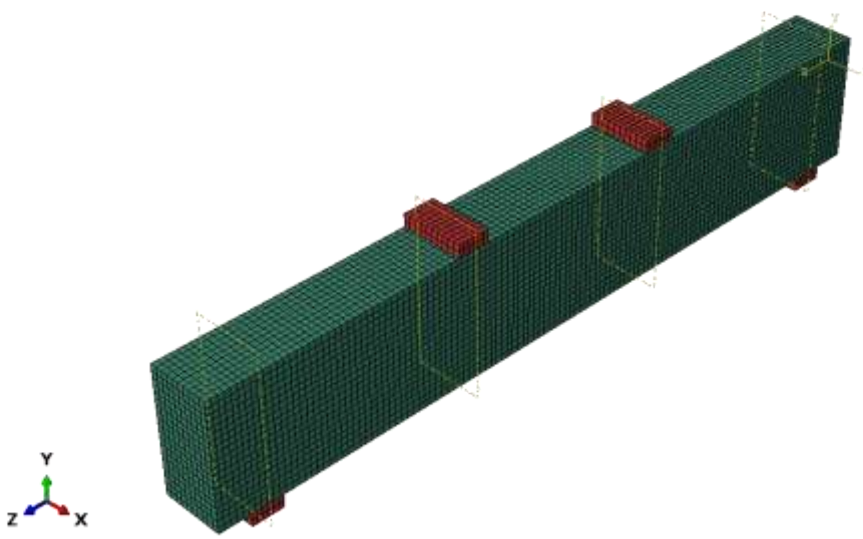

Fig. 3. *An overview of the beams modeled in the ABAQUS program*

3. ANALYSIS AND RESULTS

As a result of digital modeling of beam samples using ABAQUS software, information was obtained on the nature of the stress-strain state of the elements:
- stresses in reinforced concrete and basalt fiber reinforced concrete beams;
- relative deformations of reinforced concrete and basalt fiber reinforced concrete beams;
- voltage distribution in fittings;
- distribution of relative deformations in fittings.

The stresses of the reinforcement in ordinary reinforced concrete beams and the formation of cracks in the beam are shown in Figures 4-6.

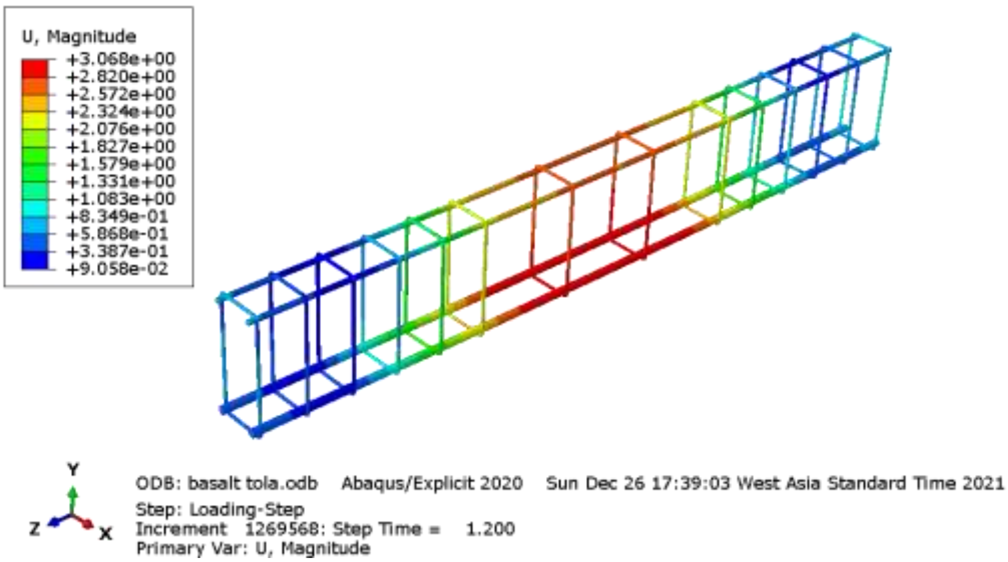

Fig. 4. *General view of the stresses of the reinforcement in a simple reinforced concrete girder*

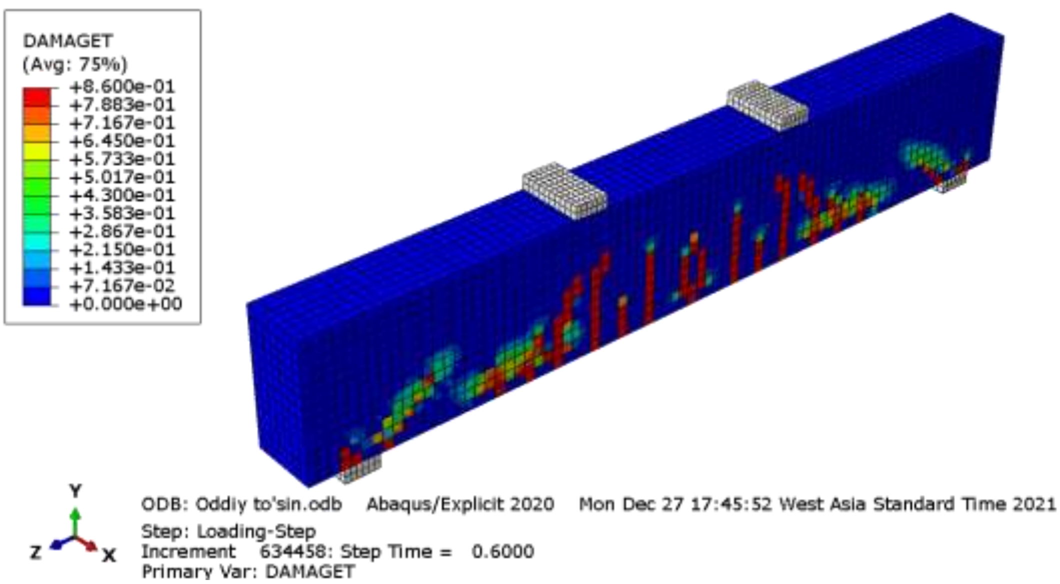

Fig. 5. *General view of the formation of cracks in a simple reinforced concrete beam*

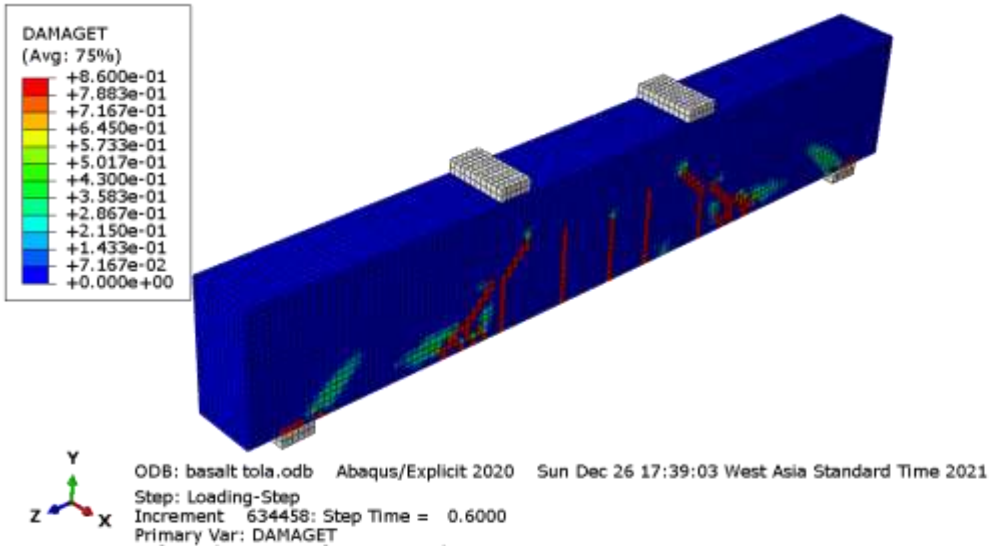

Fig. 6. *General view of the formation of cracks in the fibro-reinforced concrete beam dispersed with basalt fibers*

The comparison of the results was carried out after the development of engineering calculation methods to make a complete comparison of the data obtained. The values of the final moment obtained by numerical modeling for all series of reinforced concrete and fiber-reinforced concrete beams are given in Table 2.

Table 2. Values of the ultimate bending moment according to the results of numerical research

Series	№	Cipher of beams	Ultimate bending moment, kN·m
1	1	БО-1	12,41
	2	БО-2	
2	3	ББ10-I-1	15,07
	4	ББ10-I-2	
3	5	ББ10-II-1	15,20
	6	ББ10-II-2	
4	7	ББ10-III-1	14,98
	8	ББ10-III-2	
5	9	ББ30-I-1	14,56
	10	ББ30-I-2	
6	11	ББ30-II-1	14,23
	12	ББ30-II-2	
7	13	ББ30-III-1	14,10
	14	ББ30-III-2	

4. CONCLUSION

1. ABAQUS software allowed numerical modeling of reinforced concrete and fiber reinforced concrete beams and on this basis to determine the strength of the beams, the states of stress-strain at each stage of loading.

2. It was found that the strength and rigidity of fiber reinforced concrete beams increased compared to ordinary reinforced concrete beams working with bending.

3. When the ordinary reinforced concrete beam was modulated, the load-carrying capacity of the sample was 12.41 kN·m. The load-bearing capacity (ultimate bending moment) of dispersed reinforced concrete beams with the addition of 0.1; 0.2; 0.3% of basalt fibers of length 10 mm and 30 mm was in the range of 14.10-15.20 kN·m.

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