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Abstract. In the article the analysis of the dimensions of the samples used in the test concrete. Identified an opportunity to reduce of the dimensions of the samples. The tests at the same time the standard and small (25x25x100 mm) of the concrete samples. Small samples were obtained by cutting the standard samples. In the process of conducting research measured the density, strength and deformation of the samples standard and small sizes. The results are shown in tables and graphs. The strength of the small samples was below the strength of the standard samples. Revealed a loss of strength of samples when cutting concrete. Average deformation characteristics of concrete remained. Small samples are recommended for use in the evaluation of the stress-strain state of reinforced concrete structures.

1 Introduction

The current standard methods to determine basic physical and mechanical characteristics of concrete and stone materials are based on the standard prismatic test specimens, the minimum size of which is normalized by the grain size of the filler [1-3] (or heterogeneity):

For rocks it is 30 mm when the ratio of heterogeneity to the minimum sample size of at least 1:10 (grain 3 mm) - (for base measuring a minimum size of 15 mm at a ratio of granules to base of 1:10 or less). For concrete minimum ratio maximum size aggregate relative to of the smallest size of the prism (or cylinder diameter) of 1:5, for samples extracted from the structures allowed in the ratio of 1: 2 with a minimum size of the cross section the specimen 44 mm. The strength of the solution is allowed to determine on cubes with a minimum size of rib 2 cm (1:4 ratio).

Such ratios are defined by the source position the uniformity the test specimen and obtained with the help of this sample results. If the size ratio of the heterogeneity size of the sample is disturbed, the sample is considered heterogeneous and is the result of his test is not accepted.

There are two direct method for the determination of physico-mechanical characteristics of concrete: - the method of parallel production structures and samples of twins (sometimes mold for molding specimens in the manufacture of products placed in the body of the product) and the method of extraction of concrete samples from construction. The first method requires strict adherence to technology, but, even so, always remain differences in scale, the features of compaction and hardening of the sample and the main body of the concrete. This method is applicable only when a specifically developed research methodology (i.e. design). For the ordinary studies of the exploited structures, the second method is practically the only one. However, the existing features extraction standard samples from of exploited structures is often not possible due to sample size, due to variations in the characteristics of concrete.

Therefore, if we remove the condition of homogeneity of the sample, it is possible to reduce the size of the extracted sample to about 2 cm (and less) and greatly facilitate and speed up the testing process. Based on the above we can conclude that if we can eliminate the heterogeneity of concrete caused by the large aggregate, then we can reduce the size of the sample. If the maximum size of the mortar in concrete is assumed to be 5 mm, then the sample size can be 25x25x100 mm.

Earlier in this journal proposed a method of estimating the stress-strain state of reinforced concrete structures, based on the extraction of small sizes samples from of design [4,5]. Known work, justifying the use of small sizes samples when testing masonry materials [6,7]. But the question is about using small samples, the dimensions of which differ from the recommended, remains.

2 The first part of the test

To prepare concrete mix used composition C:S:G:W =1:0.7:3:0.46. Size of crushed stone 10-20 mm. Total produced 14 cubes of size 100×100 mm and 12 prism размером100×100×400 mm. Prisms are divided into series according to the testing methods. The age of the samples when tested 8 months.

The test procedure involved the use of nondestructive and destructive methods of control. For the non-destructive method used ultrasonic tester materials "PULSAR". By destructive method, the samples were tested at the Central compression. To measure the longitudinal strains used indicators with a scale division of 0.001 mm and the device of automatic measurement of deformations AMD-1M joint with strain gages with base 50 mm. Lateral deformation was measured with strain gauges base 20 mm, and strain gauges Hugenberg and Aistova system.

Samples of standard sizes 100x100x400 were tested for central compression with a press SP-2000. For testing small samples used installation piston. General view of the piston device for testing small concrete samples are shown in Fig.1. Characteristics of the prisms are presented in tables 1.

Fig.1. Installation piston for testing small samples.

Table 1. Features of standard prisms.

№ sample	ρ, kg/m^3	$E_{b,dyn}$, MPa·10^{-3}	ρ, kg/m^3	$E_{b,dyn}$, MPa	R_b, MPa	$E_{b,n}$, MPa·10^{-3}
	2 months		6 months			
1/1	2.44	48.6	2.41	46.8	30.9	28.8
1/2	-	-	2.41	46.1	33.6	29.2
1/3	-	-	2.39	50.5	35.1	31.2
2/1	2,47	51.0	2.43	48.6	34.6	27.1
2/2	2.44	47.0	2.41	47.6	34.0	29.9
2/3	-	-	2.40	48.0	32.2	26.6
3/1	2.45	49.1	2.41	45.0	32.0	29.6
3/2	2.49	50.2	2.40	47.1	36.3	28.6
3/3	-	-	2.38	43.9	31.7	27.3
4/1	2.47	49.2	2.41	47.2	-	-
4/2	-	-	2.40	46.1	-	-
4/3	-	-	2.39	49.7	-	-
Average	2.46	492	2.40	47.2	33.4	28.7
Variation		2.6%				

The test results of the cubes presented in table 2. The results of the testing cubes in compression at a fixed deformation rate is shown in Fig. 2. For comparison, on this figure shows the measurement of speed of ultrasound in the testing of concrete prisms.

Table 2. Features cubes.

№	ρ, kg/m^3	R, MPa	№	ρ, kg/m^3	R, MPa	$E_{b,дин}$, MPa·10^{-3}
1	2.44	48.5	5	2.31	43.4	53.9
2	2.45	50.1	7	2.32	46.5	55.2
3	2.35	48.7	9	2.35	42.5	51.3
4	2.36	47.1	11	2.33	39.7	49.2
6	2.33	40.0	12	2.33	-	50.1
8	2.44	52.2	14	2.42	46.1	52.0
Среднее				2.37	45.9	51.3

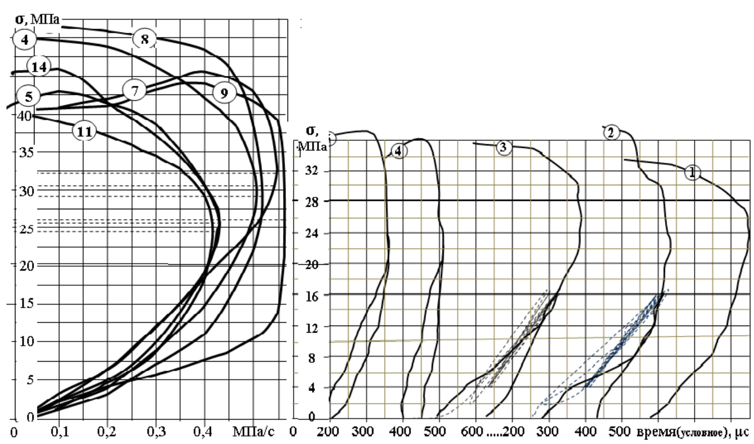

Fig. 2. Diagram of the test cube (left) and speed of ultrasound in concrete prisms.
Numbers – the numbers of the patterns. The maximum speed was achieved at a load equal to 0,61 (57%, 60%, 69%, 62%,60%, 56%, 60%) from the damaging.

On the lateral surface of the cube No.12 was pasted strain gauges with a base of 20 mm (six pieces) and 50 mm (six pieces) for three sensors on each side. To that cube using the gypsum was glued with two sides of the other cubes strength B25. The formed prism was loaded to 20 MPa, measurement of deformations on the steps 4, 9, 14, 19 MPa. Centering was performed only on the risks. The measurement results are shown in Fig.3. Cube No. 12 with glued sensors later tried to cut it into small prisms. However, due to the formation of a grid of cracks in Cuba it was not possible. Education a significant number of cracks is associated with low strength of the glued cubes. Further on the prism in accordance with the scheme of Fig. 4 were cut cube No. 13. The dimensions of the cross section the small prisms were in the range of...of 23.1 to 23.3 mm, height 100 mm. On the lateral surface of the prism in the middle section was glued sensors base 50 mm. Small prisms were tested in a piston is installed with the centering on the risks. The end surface when the installation was covered with gypsum plaster. The prism is placed in the installation, center, exposed vertically on the template and pressed by the piston, together with the gypsum. The tests were repeated one day after the plaster setting.

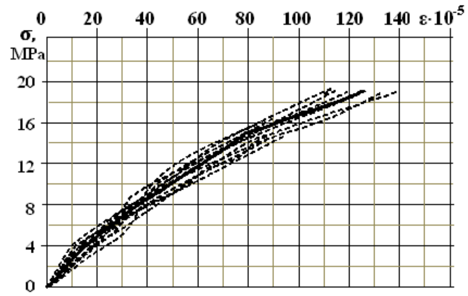

Fig. 3. Graph of strain measurements on the steps 4, 9, 14, 19 MPa.

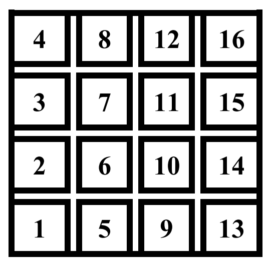

Fig. 4. The scheme of cutting the cube into small prisms.

The results of the tests of small prisms are given in table 3 and the diagram in figure 5. In Fig.6, thick dotted line presents the averaged graph of the standard tests of prisms.

Table 3. Characteristics of small prisms.

№	Density, kg/m^3	Velocity Ultrasound, m/s	$E_{b,dyn}$, MPa·10^{-3}	$E_{b,n}$, MPa·10^{-3}	R_b, MPa
1	2,37	4608	51,3	41	32,5
2	2,37	4521	49,4	26	27,5
3	2,29	4226	41,7	26	29,5
4	2,35	4492	48,4	38	37,0
5	2,36	4698	53,1	20	27,7
6	2,31	4892	56,4	19	28,6
7	2,43	4525	50,7	30	30.3
8	2,18	4436	43,7	45	28,5
9	2,4	4730	54,7	24	26,5
10	2,39	4699	53,8	22	28,2
11	2,43	4579	51,9	22	27,5
12	2,19	4464	44,5	28	33,0
13	2,45	4730	55,9	17	28,5
14	2,27	4653	50,1	30	29,5
15	2,28	4668	50,64	25	26,8
16	2,20	4105	37,8	44	33,0
Average	2,33	---	**49,6**	**28,8**	**29,6**
Average of standard prisms			47.2	28.7	33.4

According to test results the obtained data with a considerable scatter of strength. For cube strength the changes were within to 31.7–36.3 MPa (± 13%), for small prisms of the strength was in the range 26.5–37 MPa, and a relative scatter of 35.5%. On the other hand the average strength value of small prisms and standard prisms differed by 11%, discrepancy the modulus of elasticity is less than 1%.

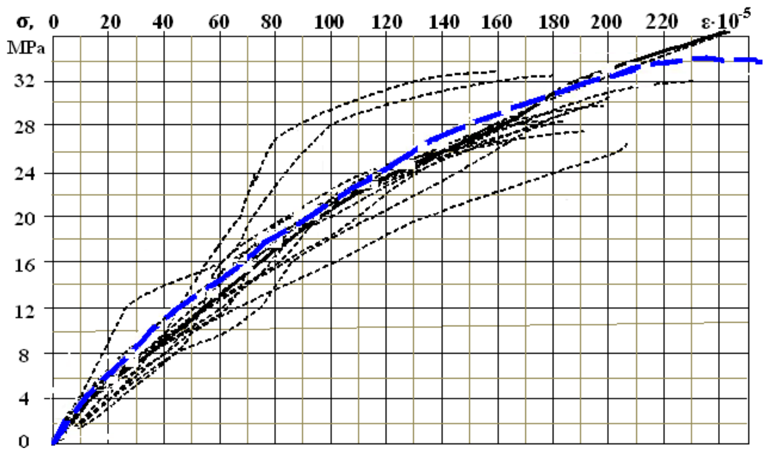

Fig. 5. Graphics tests of small prisms (dashed line –diagram test standard prism).

3 The second part of the test

Experiments were conducted after one year after the first test. For the repeat tests were made 7 concrete prisms with dimensions of 100x100x400 mm, 12 cubes of 100 mm side and 3 cubes with side 150 mm. In the manufacture of the samples used concrete mix at the table.4. Size of crushed stone 10-25 mm. Hardening of the samples took place in normal conditions.

Table 4. The compositions of the concretes for the second series.

Series	The Ratio by volume of the mixture			
	Cement	Sand	Crushed stone	Water
1B	1	2	2.1	0.5
2B	1	2	2.1	0.5
S	1	2	–	0.5
C	1	2	2.1	0.5

Testing of samples was carried out similarly to the samples of the first series. On the side of the cube №5, №8, №10 and №12 from the three sides were glued strain gauges with a base of 50 mm, four pieces on each side. On These cubes using the gypsum was glued with two sides of the other cubes strength B40. . The resulting prism loaded to 60 – 62 kN for the determination of deformations in the elastic stage. Measured longitudinal and transverse strains. Centering was carried out on the risks.

Then cuba №5, №8, №10 and №12 with the glued strain gauges sawed in accordance with the scheme of Fig. 4 . Previously, the strain gages were covered with a layer of sealant. Sensors are pasted on all sides the prism. The prism samples were accurately established in the Installation piston. The top and bottom of the prism is aligned with a plaster solution, the excess of which when clamping the sample between the discs piston installation is squeezed out. Through one day the Installation piston was placed in the hydraulic testing machine. The load on the samples was applied degree.

The results are presented in table 5 and 6. On the basis of data obtained by measuring the longitudinal deformation of the samples was the dependence "voltage–deformation", which are presented on the diagrams of figures 6 and 7.

Table 5. The test results of cubes.

№	Series	R, МПа	ρ, kg/m³	$E_{b,dyn}$,MPa $\cdot 10^{-3}$	$E_{b,n}$,MPa	№	Серия	R, MPa	ρ, kg/m³	$E_{b,dyn}$,MPa $\cdot 10^{-3}$	$E_{b,n}$,MPa
1	S	31.567	1788			7	B2	38.248	1970		
2	S	31.547	1768			8	B2	-	2021	5090	18589
3	B1	34.081	2020			9	S	27.16	1788		
4	B1	25.646	2119			10	S	-	1781	4504	12746
5	B1	-	2070	5212	9543	11	C	36.751	2278		
6	B2	34.566	2071			12	C	-	2276	5589	9354

Table 6. The results of testing standard prisms.

№	Series	ρ, kg/m³	R_b, MPa	$E_{b,n}$, MPa
1	S	1781	29.4	9841
2	S	1781	31.2	16539
3	S	1781	28.5	9959
Average			30.0	12113
4	B2	2020	29.4	16005
5	B2	2020	29.5	10010
6	B2	2020	27.2	13094
Average			28.7	13037
7	B1	2277	22.2	16573

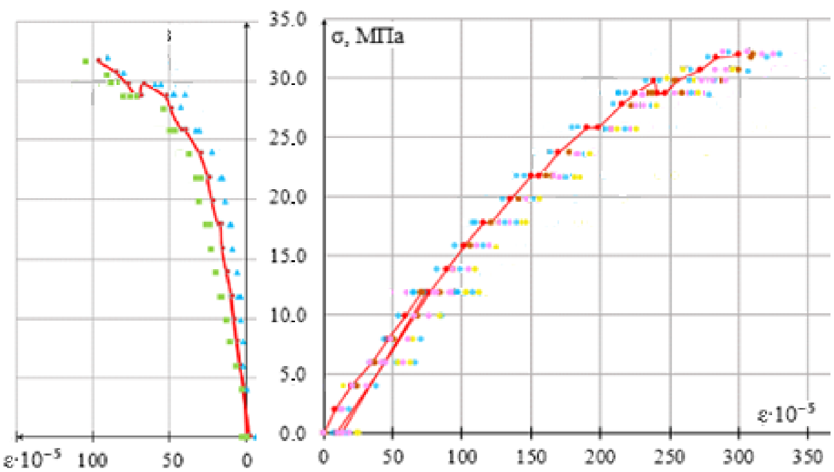

Fig. 6. The diagrams "σ – ε" of the prism 2.

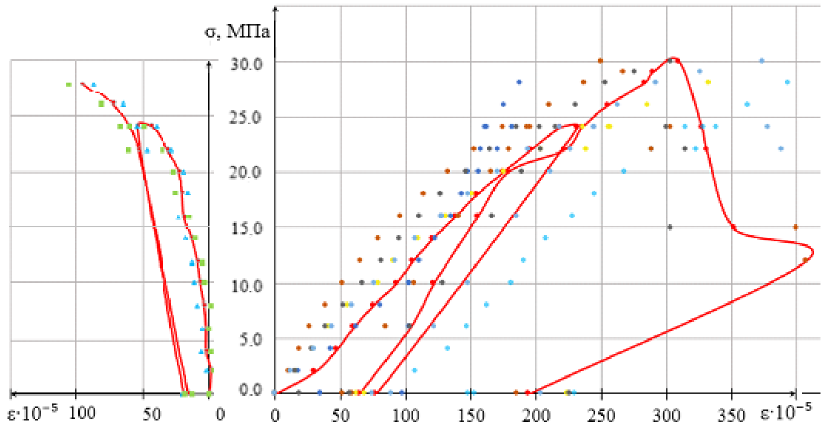

Fig. 7. The diagrams "σ – ε" of the prism 5.

The results of ultrasonic testing of cubes shown in figure 8.

63,1	63,1	63,0	62,9
63,1	62,8	62,9	62,7
63,2	63,1	63,0	62,9
63,0	63,0	63,2	63,0

63,1	63,2	63,2	63,2
63,0	63,0	63,1	62,9
62,9	63,0	62,8	63,1
63,0	63,0	62,9	62,8

62,9	62,8	62,7	62,8
62,8	62,7	62,7	62,6
62,7	62,8	62,7	63,1
63,2	63,3	63,0	62,9

63,7	63,8	63,6	63,6
63,7	63,9	63,7	63,6
63,7	64,0	63,9	63,9
63,8	64,0	63,8	63,9

Fig. 8. The distribution of the propagation time of ultrasound in cubes (left to right) No. 5 (Re = 63,00 µs); No. 8 (Re = 63,01 µs); No. 10(Re = 62,86 µs); No. 12(Re = of 63.79 µs).

The test results of cubes with sensors are summarized in table 7.

Table 7. The results of measuring the deformations of the cubes under a load of 6.15 MPa.

Cube / Strain gauges	№5	№8	№10	№12
1	65	44	51	65
2	59	50	46	63
3	55	58	51	53
4	–	49	44	55
5	–	61	45	60
6	55	47	54	50
7	61	52	47	63
8	76	42	42	48
9	64	56	53	53
10	49	48	46	58
11	59	54	56	42
12	–	56	53	62
Average	60.3	51.4	49.0	56.0
The strain gauge Aistova				
Side 2	65	58	53	53
Side 4	56	49	47	64
Average	60.5	53.5	50.0	58.5

After sawing, each prism was measured. The dimensions of the side section changed from of 16.85 mm to 25.55 mm. Unfortunately, not all the prisms were suitable for testing.In a series of 16 samples was fit only 9 pieces.

The distribution of the transit time of the ultrasound along the section of the cube shown in Fig. 9.

Fig. 9. Distribution of the propagation time of ultrasound for sawn prisms from cubes from left to right №5, 8, 10, 12

Comparison of the results of ultrasonic sounding of the individual prisms , Fig.8 and 9, show that the discrepancy was not more than 1% and was in the area of statistical dispersion of the data. Identify features of the concrete samples ultrasonic testing failed.

The results of the tests of small prisms in compression is shown in Fig. 10 – 13.

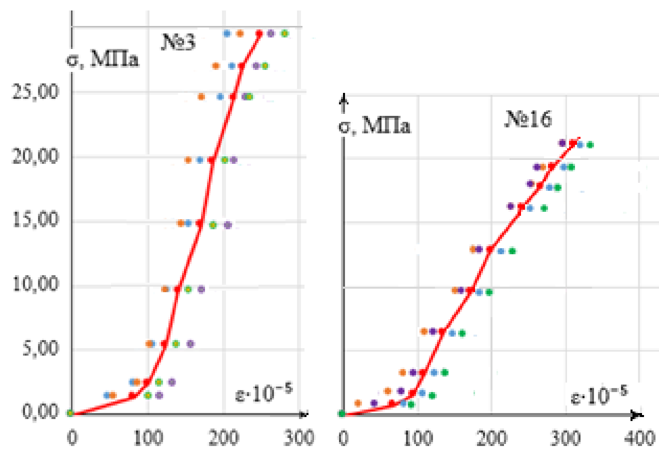

Fig. 10. The diagrams "σ – ε" for small prisms of the series B1 on the testimony of strain gages.

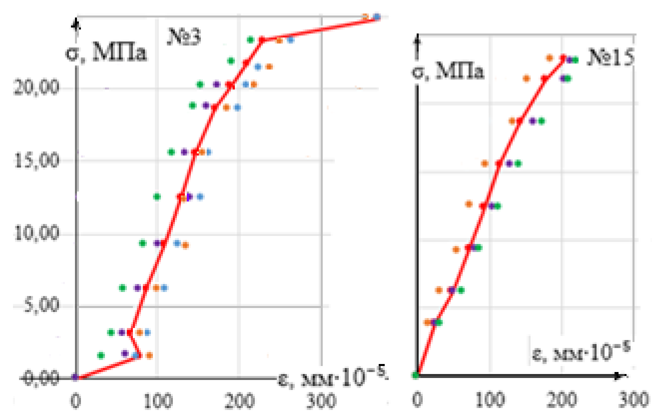

Fig. 11. The diagrams "σ – ε" for small prisms of the series B2 on the testimony of strain gages.

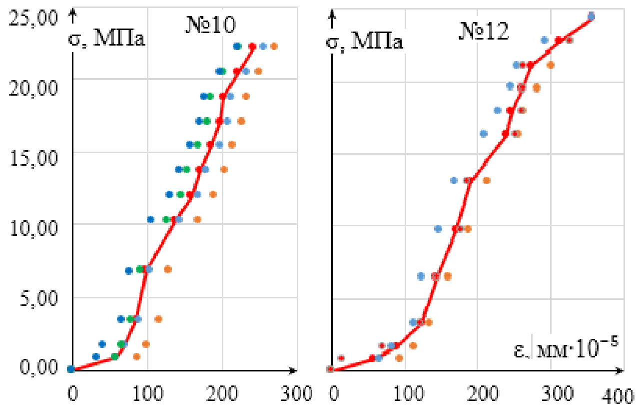

Fig. 12. The diagrams "σ – ε" for small prisms of the series S on the testimony of strain gages.

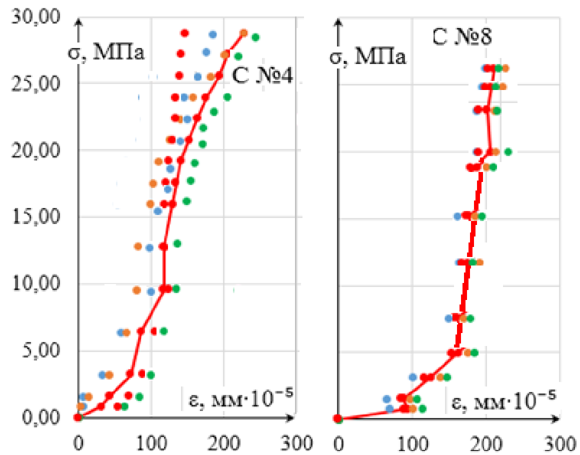

Fig. 13. The diagrams "σ – ε" for small prisms of the series C on the testimony of strain gages.

The discrepancy on strength between the standard and small samples made according to the average strength values: series B1 – 22.2 and 22 (+1%); series B2 of 27.2 and 22 (+19,1%); series S is equal to 28.5 and 23.4 (+17,8%). The difference on the module accordingly to the series B1 –16x103 and 15x103 (+6%); series B2 – 16x103 and 16,5x103 (-3%); series S – 12x103 and 12,1x103 (-1%). The difference of the ultimate strain of small prisms(266x10-5) and standard (300x10-5) was 11.3%.

Conclusions

1. Ultrasonic testing did not reveal significant variations in the characteristics as the standard concrete samples so sawn samples.

2. Removing small samples from the body of the concrete reveals the dispersion characteristics of small specimens in accordance with the structure of the concrete.

The use of averaged properties of concrete estimation during its stress state can lead to large inaccuracies in the determination of the stresses. For each study point need obtain their material characteristics.

3. The process of cutting and extraction of the sample from the array affect its strength and deformation characteristics. The strength of all the small samples were less than 10%

the strength of standard samples. The deformation characteristics of small samples vary only in the initial stages of loading.

4. Deformation characteristics of samples of small dimensions, excluding the initial stages of loading, do not differ from the deformation of standard samples.

5. The use of small samples of concrete in the assessment of stress-strain state of concrete structures is possible with high accuracy within 0,1...0,8 from its ultimate bearing capacity

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