RESISTANCE OF POLYSTYRENE CONCRETE TO DYNAMIC SHOCK LOADS

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ABSTRACT
The aim of the study is to increase the resistance of polystyrene concrete obtained from secondary polystyrene to shock dynamic loads. The issues of polystyrene concrete resistance to compression forces with increasing load are considered. It is proposed that in terms of impact resistance, polystyrene concrete can be attributed to viscous materials capable of extinguishing large energy shock loads. When used as a Na_2SO_4 hardening accelerator, polystyrene concrete samples can absorb impact energy of more than 178.5 J.

Keywords: secondary polystyrene, polystyrene concrete, strength, shock loads.

INTRODUCTION
Polystyrene concrete is a fundamentally new class of thermal insulation and structural concrete that meets the increased requirements of energy and resource conservation in the field of construction [1-5]. Unlike the nearest analogue - cellular concrete - polystyrene concrete is a heat-insulating and structural concrete with unique properties: increased on average by 2.5 times the tensile strength during bending and by 10-15% compressive strength; reduced by 1.5 times water absorption, by 10-30% thermal conductivity and 2.7 times vapor permeability. In addition, the thermal engineering potential of polystyrene concrete manufactured using traditional technology currently has significant reserves associated with the possibility of technological control of material properties based on a computational model of the dependences of strength, density and thermal conductivity of polystyrene concrete on the composition and quality of its components [6-12].

RESEARCH METHODS
Samples-plates of polystyrene concrete from secondary polystyrene with a size of 100 x 100 x 20 mm by cutting them out of solid blocks of polystyrene concrete have been prepared for testing for shock loads. The dimensions of solid polystyrene concrete blocks are 600 x 300 x 200 mm. Samples of blocks are made on the technological equipment of foam and aerated concrete production of LLC “Blizar”. The tests were carried out on a dynamic pipe with a length of 400 mm and a diameter of 50 mm. Cyclic shock loads were created during the free fall of a steel ball with a diameter of 48 mm and a mass of 455 g.
The resistance to shock loads was assessed by the formation of depressions from the fall of a steel ball and the formation of cracks after every 10 drops of the ball on the surface of the sample. The work of gravity during the fall of the body was calculated according to the generally accepted formulas of the physics course [16].

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RESULTS AND DISCUSSION

The study of the strength of polystyrene concrete on secondary polystyrene [13,14] showed the distinctive aspects of the resistance of this material to compression forces in contrast to traditional concrete, foam concrete, etc., i.e., with increasing load, the samples were destroyed without the formation of cracks characteristic of other types of concrete (Fig. 1). Such destruction of samples prompted the idea that how this material will behave under dynamic shock loads.

Samples-plates of polystyrene concrete made of secondary polystyrene are made of a cement composition, which includes Portland cement additive-free CEM 0 according to GOST 31108-2020, a porous filler - secondary crushed polystyrene and a hardening accelerator - sodium sulfate (table 1). As a sample for comparison, the composition of polystyrene concrete on secondary polystyrene H-4, mass-produced using SDO as a hardening accelerator, was adopted.

Figure 1. Testing of samples for compressive strength

Table 1 Compositions of polystyrene concrete on secondary polystyrene

№	The composition of polystyrene concrete					
	Cement, kg	Sand, kg	hardening accelerator, kg		water, liter	secondary polystyrene, m^3
			name	quantity		
H-1	295	35	Na_2SO_4	3,5-4,5	175	1,5
H-2	305	35	Na_2SO_4	3,5-4,5	186	1,5
H-3	315	35	Na_2SO_4	3,5-4,5	192	1,5
H-4	350	-	CDO	0,35-0,4	200	5,5 kg

The samples were tested for impact strength after reaching the design strength, in a dry natural state. The resistance to shock loads was assessed by the formation of depressions from the fall of a steel ball and the formation of cracks after every 10 drops of the ball on the surface of the sample. The test results are shown in table 2.

Table 2 Testing of samples for dynamic shock loads

№ series	Formation of depressions, mm				
	Number of ball strikes, pc.				
	10	20	30	50	100
H-1	11,0	13,6 (17)	Cracking	-	-
H-2	14,5	18,7	19,1	20,8	25,5
H-3	8,1	11,2	12,7 (27)	Cracking	-
H-4	7,9 (8)	Cracking	-	-	-

Note: The number of ball impacts after which cracking is detected is given in parentheses.

As can be seen from the data in table 2, cracks in the formation of depressions equal to 7.9 mm were found on the samples of polystyrene concrete from secondary polystyrene and CDO after 8 impacts of the fall of the steel ball. The nature of the destruction of the sample is shown in fig. 2.

Fig 2. The nature of the destruction of the control (H-4) sample

Samples of polystyrene concrete on secondary polystyrene, where Na_2SO_4 was used as a hardening accelerator, withstand shock loads much more compared to the control one. So, on the samples of the H-1 series, the formation of similar cracks is observed after 17 impacts and the depth is 13.6 mm (Fig. 3, a). And on the samples of the H-3 series, the formation of cracks is observed after 27 impacts of the ball, and the size of the recesses is 12.7 mm (Fig. 3, b), whereas cracking on the samples of the H-2 series is not observed even after 100 impacts and the formation of recesses is equal to 25.5 mm (Fig. 4).

a б

Fig 3. The nature of the destruction of samples H-1 (a) and H-3 (b)

According to the course of physics, it is known that if a body of mass m is uniformly lifted up to a height of H using the force F = mg, then the force does the work $A_F = mgH$, equal to the potential energy N = mgH, and gravity does the negative work $A_P = –mgH$ [15]. It is also known that the potential energy corresponds only to the work performed by gravity during the free fall of the body [16]:

$$A = mgH$$

Fig 4. The appearance of the sample H-2 after the impact strength test

In our case, when a steel ball makes cyclical falls from a certain height, the total work performed by gravity during the free fall of a steel ball mass m can be calculated by the formula:

$$A_{ш} = (mgH) \cdot n$$

where: m – the mass of the falling ball, kg;
g – acceleration of gravity equal to 9.81 m/s^2;
H – ball drop height, m;
n – number of ball drops.

Calculations have shown that for the destruction of a sample with a size of 100 x 100 x 20 mm from commercially produced polystyrene concrete on secondary polystyrene using CDO as a hardening accelerator (composition H-4), it is sufficient to perform work with a free fall of a steel ball weighing 0.445 kg equal to 14.28 J, whereas for the destruction of a sample of similar sizes from polystyrene concrete on secondary polystyrene using Na_2SO_4 as a hardening accelerator, work costs from 30 to 48 J (compositions H-1 and H-3).
It should be noted that the magnitude of the destruction work depends not only on the composition of polystyrene concrete, but also on the polystyrene concrete hardening accelerator used. If we take a concrete example of comparing Na_2SO_4 and CDO, then we can see the superiority of the first hardening accelerator. Samples from the composition of H-2 have no signs of destruction even after the work of the impact is equal to 178.5 J.

CONCLUSION

The conducted research suggests that, in terms of impact resistance, polystyrene concrete can be attributed to viscous materials capable of extinguishing large shock loads. Samples made of polystyrene concrete on secondary polystyrene using Na_2SO_4 as a hardening accelerator can absorb impact energy of more than 178.5 J.

REFERENCES

1) Yakimov, V.M. Osobennosti fiziko-mexanicheskix ispitaniy trex sloynix polistirol betonnix paneley [Features of physical and mechanical testing of three-layer polystyrene concrete panels] / V.M.Yakimov, A.V.Permyakov, I.F.Xafizov, F.Sh.Xafizov // Neftegazovoedelo. – 2020. – № 1. – S. 73-88.
2) Gushin, S.V. Mirovie tendensi i razvitiya energo sberegayushix texnologiy [Global direction and development of energy saving technologies] / S.V.Gushin, A.S.Seminenko, S.Shen //Vestnik BGTU, 2020, №5. –S. 31-43.
3) Otarbaev, Ch.T. Issledovanie i spolzovaniya polisterol betona v kachestve konstruksionnogo stroitelnogo materiala v Kazaxstane [Research and use of polystyrene concrete as a structural building material in Kazakhstan] / Ch.T.Otarbaev, N.N.Atchabarov // Vestniknauki i obrazovaniya. Arxitektura. – 2019. – № 3. – S. 92-94.
4) Xalikov, D.A. Evolyusiya teplo izolyasionnix stroitelnix materialov [Evolution of thermally insulated building materials] / D.A.Xalikov, G.S.Xalikova, T.V.Goncharova, K.F.Islamov // Fundamentalnie issledovaniya. Texnicheskie nauki. – 2015. – № 10. – S. 529-533.
5) Pak, A.A. Kompozisionnie izdeliya iz polistirol gazobetona i obosnovanie zavisimosti ix teploprovodnosti ot plotnosti i sloistosti metariala [Composite products made of polystyrene aerated concrete and substantiation of the dependence of their thermal conductivity on density and layered metarials] / A.A.Pak, R.N.Suxorukova, N.N.Grishin // Stroit.mater., 2006, № 6. –S. 28-30.
6) Jeleznyak A.R. Polistirolbeton – otlichniy stenovoy i teploizolyasionniy material [Polystyrene concrete is an excellent wall and thermal insulation material] //Texnologiibetonov, 2008, №4. –S. 24-25.
7) Raxmanov, V.A. Innovasionnaya texnologiya polistirol betona s optimalnimi svoystvami [Innovative polystyrene concrete technology as optimal properties] / V.A.Raxmanov // Stroitelnie materiali, oborudovanie, texnologii XXI veka. – 2011. – № 9. – S. 37-41.
8) Lobachev, F.S. Innovasionnaya texnologiya polistirolbetona s optimalnimi svoystvami [Innovative polystyrene concrete technology with optimal properties] / F.S.Lobachev, A.O.Nurgazinova, L.A.Varlamova, P.V.Kornienko // Nauka i texnika Kazaxstana. – 2012. – № 3-4. – S. 46-56.
9) Kopilov, I.A. Penopolistirol: noviy vitokpopulyarnosti [Expanded polystyrene: a new round of popularity] / I.A.Kopilov // Stroitelnie materiali, oborudovanie, texnologii XXI veka. – 2012. – № 11. – S. 26-28.
10) Zarubina, L. P. Teplo izolyasiya zdaniy i soorujeniy [Isolation of buildings and structures]. Materiali itexnologii. 2-e izd./L.P.Zarubina. – SPb.: BXV-Peterburg. – 2012. – 416 s.
11) Leshenko, M.V. Teplo texnicheskie svoystva stenovix ograjdayushix konstruksiy iz stalnix tonkostennix profiley i polistirolbetona [Thermal engineering properties of wall enclosing structures made of thin-walled steel profiles and polistirolbetona] / M.V.Leshenko, V.A.Semko // Injinerno-stroitelniy jurnal, 2015, №8. – S. 44-55.
12) Duboviskaya, N.S. Teploprovodnost polistirolbetona [Thermal conductivity of polystyrene concrete] /N.S.Duboviskaya, Z.A.Muxamedbaeva, A.A.Muxamedbaev //Mater. Resp.onlayn praktich.konf. «Zamonaviy bino – inshootlarni va ularning konstruksiyalarini loyihalash, barpo etish, rekonstruksiya va modernizasiya qilishning dolzarb muammolari». Fergana, 2021. –S. 100-102.
13) Duboviskaya, N.S. Sementnaya kompozisiya s ispolzovaniem vtorichnogo polistirola [Cement composition using a second polystyrene] /N.S.Duboviskaya, Z.A.Muxamedbaeva, A.A.Muxamedbaev // Sb.tr.mejdunar. nauchyu-texn.konf. «Aktualnie problem innovasionnix texnologiy v razvitii ximicheskoy, nefte-gazovoy I pishevoy promishlennosti». Tashkent, 2021. –S.176-177.

14) Dubovitskaya N., Mukhamedbaeva Z., Mukhamedbaev A. Durability of Expanded Polystyrene Concrete on Recycled Polystyrene // International Journal of Advanced Research in Science, Engineering and Technology. Vol. 8, Issue 9, September 2021, pp. 18247-18250. www.ijarset.com.
15) Kikoin, I.K. Fizika: Uchebn. Dlya 9 kl. sredn. shk. / I.K.Kikoin, A.K.Kikoin. – M: Prosveshenie, 1990.
16) Ivanov, Ye.M. Rabotapadeniyatela v odnorodnom pole tyajesti / Y.M.Ivanov //Sovremennie problem nauki i obrazovaniya. – 2006. – №4. – S. 12-14.