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CALCULATION, DESIGN AND IMPLEMENTATION OF MULTI-LAYER HEAT-RESISTANT REINFORCED CONCRETE STRUCTURE

Abdurahmonov Adkhamjon Sultonboyevich

Namangan Engineering-Construction Institute, Senior lecturer, Tel. +998993206508, adick0377@gmail.com

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Abstract. *The article presents the experimental results of determining its strength under normal conditions as well as the residual strength under the influence of high 8000C temperature on the new composition of heat-resistant concrete based on local industrial waste. Practical application of heat-resistant reinforced concrete slab designed for heat storage in brick cooking stoves. A new heat-resistant reinforced concrete slab made on the basis of industrial waste is intended for covering the walls and tops of trenched brick kilns. Analytical data on the scientific research carried out over the years, conclusions on the relevance and necessity of the problem, experimental test results, new research results on the porosity and structure of the material of the heat-resistant plate construction are presented and analyzed. The proposed heat-resistant reinforced concrete slab reduces the heat dissipation in brick kilns to the environment, and this provides an opportunity to reduce the energy consumption per product unit, increase the efficiency of the kilns, and lower the cost of the product. In addition, it allows to increase the temperature in the brick baking ovens to 1100-1200 0C, speeds up the brick baking process, and increases the quality of the product. The plate makes it possible to mechanize the opening and closing of the stoves, and to use them many times. This heat-resistant reinforced concrete slab has been tested in brick factories in Namangan and Andijan regions, and the obtained scientific results are of practical importance.*

Key words: *concrete, industrial waste,high temperature, strength, concrete slab, experiment, brick, ash, heat-resistant plate, porosity, structure, building materials, building structures.*

Introduction

In our republic, large-scale measures are being implemented to introduce energy and resource-saving technologies in the construction sector. In 2017-2021, the Strategy of Actions for the further development of our republic, among other things, the tasks of "... wide implementation of energy-saving technologies in production..." [1]. One of the important objects in the performance of these tasks is the development of building structures that ensure the quality and efficiency of brick production plants. [2].

In the world, the temperature during brick baking reaches 1000-12000C. Such heat-resistant material (kaolin wool) was brought from Russia until recently, and a lot of money is being spent in this field. In addition, the structure made of heat-resistant material is working normally for 6-8 months. It is clear that there is a need in the field to research and develop heat-resistant material that is cheaper and more durable. Such a cheap, long-lasting, reusable, ecologically clean construction has not been perfected and put into production at present. Therefore, reducing the consumption of energy (natural gas, coal fuel) in heat units, reducing the cost of developed building materials and products is currently is a problem today. A new heat-resistant reinforced concrete slab made on the basis of industrial waste is intended for covering the walls and tops of trenched brick kilns.

In the world, the heat-resistant steel concrete slab reduces the heat spread in the brick kilns to the environment, and this provides an opportunity to reduce the energy consumption per unit of production, to increase the efficiency of the kilns, and to lower the cost of the product. In addition, it allows to increase the temperature in the brick baking ovens to 1100-1200 0C, speeds up the brick baking process, and increases the quality of the product. The plate makes it possible to mechanize the opening and closing of the stoves, and to use them many times.

In existing trench kilns, bricks are covered with clay after they are picked, and during the brick firing process, they dry out, crack, and waste heat. As a result, the temperature in the kilns does not exceed 800-9000C, and the bricks are not baked well and are of poor quality.

Reinforced concrete slab made on the basis of the proposed waste (brick fragments, ash, etc.) eliminates all the shortcomings of the above trench furnaces and is environmentally safe. The production of heat-resistant steel concrete slabs based on industrial waste does not require imported raw materials.

The level of study of the problem - currently in this direction in our country Q.I. Ro'ziev, Kh.Kambarov, Kh.Akromov, S.Abdurakhmonov, A.Ashrabov, in foreign scientific centers A.F. Milovanov, K.A. Maltsov, O.I. Kvitsaridze, M.M. Kekelidze studied the strength of concrete and reinforced concrete structures at different temperatures, some special cases of stress-deformability states and obtained results. Comprehensive theoretical and experimental studies on the one-sided effect of high temperature of small-sized building materials in the private sector, especially on the strength and deformability of concrete based on local raw materials and industrial waste, have not been fully conducted. In the conducted studies, the issues of concrete composition were not considered.

In order to achieve the set goal, the following tasks have been defined: a comprehensive study and analysis of the effect of high temperature on the strength of building materials and structural strength of construction structures in our Republic and foreign countries, as well as the one-sided effect of temperature on concrete and reinforced concrete structures based on local raw materials operating in non-stationary conditions; energy saving in the production of fine-grained building materials, ensuring the reduction of heat loss in trench brick baking ovens due to the use of reinforced concrete structures for covering the top of the furnace, creating a manual on increasing the strength of fine-grained building materials.

Purpose and mission of work - Furnaces of heat aggregates, engineering facilities, and small-scale building materials production plants operate under high temperature conditions. Due to the effect of high temperature, the strength, elasticity and plastic properties of concrete change. Therefore, observation, study and analysis of concrete and reinforcement, as well as reinforced concrete structures under the influence of high and extremely high temperatures, are of great importance in the national economy.

In the process of research, the methods of energy, correct variation and analysis and comparison of obtained experimental results were used for calculation and design of metal constructions, methods of construction mechanics, mathematical modeling, processing of experimental results, numerical calculation of shell structures.

Scientific novelty of the work - The heat-resistant materials used in heat units are mostly small shaped bricks, which are labor-intensive and expensive. In addition, heat-resistant materials (coalin plate) are brought and used from foreign countries - Russia. This, in turn, is not effective in the national economy, but is not justified due to the high cost of the product and the short period of use. Therefore, it is important to create heat-resistant concrete based on local materials and construction based on it. The article presents the results of scientific research on the creation of such a concrete and reinforced concrete structure.

It is known, heat-resistant concretes differ from other concretes in that they can maintain their physical and mechanical properties at a specified level even when exposed to high temperatures for a long time.

These concretes are used to cover the heat-affected surface of the heating units. They are divided into the following groups depending on the degree of fire resistance:

-refractory concretes - resistance level is higher than 17700S:

-refractory concretes - durability level 1580-17700C:

- temperature-resistant concretes - resistance level is lower than 15800C.

Thanks to the large-scale use of concrete and reinforced concrete, it was possible to make changes in construction technology and to restore huge structures that are durable for a long time. According to research, modern building materials should meet the following requirements:

-minimum use of natural resources, maximum use of waste;

- to further increase strength and long-term durability;

- preservation of recyclability and reusability;

- high aesthetic and architectural qualities;

-environmental safety during production and operation.

These requirements are fully met by concrete and reinforced concrete structures. Due to this, the production of concrete and reinforced concrete around the world 2 billion exceeded m3. For example, 20 tons of raw materials are used to produce one ton of steel. Of these, 19 tons return to the environment. And while concrete production is waste-free, it helps to dispose of waste from other industries. Studies have shown that some hazardous industrial wastes are neutralized in concrete. Reinforced concrete structures occupy a leading role among building materials and structures in our Republic.

2009 of the First President of the Republic of Uzbekistan

Resolution No. PQ-1134 of June 19 "On additional measures to encourage the increase in production of valuable materials and improve quality" [1] to establish new enterprises and to modernize existing ones, to reduce production costs and to implement modern energy-saving technologies that ensure the reduction of the price of finished products, to increase the volume of production of high-quality wall-mounted small-scale construction materials and products and, on this basis, to increase the domestic market of such materials and products was adopted in order to fully meet the growing needs of the population who are building houses, especially in rural areas, in which: since January 1, 2010, non-standard, inefficient stoves have not been replaced by special energy-saving technologies, and natural gas in excess of the specified comparative consumption norms it is envisaged that natural gas will be supplied to brick-making enterprises using gas at the current wholesale price.

It is known that the temperature during brick baking reaches 1000-12000C. Such heat-resistant material (kaolin wool) was brought from Russia until recently, and a lot of money is being spent in this field. In addition, the structure made of heat-resistant material is working normally for 6-8 months. It is clear that there is a need in the field to research and develop heat-resistant material that is cheaper and more durable. Such an inexpensive, long-lasting, reusable, environmentally friendly design has not been perfected and put into production at this time. Therefore, reducing the consumption of energy (natural gas, coal fuel) in heat units, reducing the cost of developed construction materials and products is a problem today.

At least 75% alumina in clay soil cement (AI_2O_3)and a maximum of 1% iron oxide. Periclase cement is mainly magnesium oxide MgO consists of (at least 85%).

In heat-resistant concrete, chromite, magnesite brick fragments, fireclay, talc, pumice, slag and fuel slag from blast furnaces, ash, andesite, basalt are used as additives. The same materials are also used as fillers.

In order for the concrete prepared by adding liquid glass to solidify better, sodium silicon fluoride is added to it. Heat-resistant concretes prepared by adding liquid glass can withstand the effects of acids, but can be eroded under the influence of steam.

The compressive strength limit of such concrete 100-150kg/sm^2 and when other binders are added 150-200kg/sm^2

The composition of heat-resistant concrete. According to SniP 2.03.04.-84, when the temperature of brick baking is 10000C, heat-resistant concrete of not less than 10 classes should be used (class 10;15... determines the performance of concrete at the permissible temperature). Below is a sample composition of concrete made from local raw materials for 1m3 mix.

table

T.p	Binder (kg)	Crushed Additive (kg)	Filler (kg)
1	Portland cement (350) or quick-setting Portland cement	Ash powder (120)	Shamot (1300) Agloparite (860)
2	Portland cement (350)	Shamot (250) recycled catalyst IM-220 (250)	Keramzite (850)
3	Portland cement (350)	Shamot (120)	Brick Shards (1200)
4	Portland cement (450)	Shamot (210)	Heat resistant agloparite (860)

Note: 1) Fine filler is taken equal to 50% of the total filler.

2) Ripe broken brick, developed (igniting) firebrick, heat-resistant concrete can be used as a filler. Impurity should not exceed 5%. Portland cement must meet the requirements of GOST 10178.

Fine additive (tonkomolotaya dobavka) can be prepared at the factory or grinded in a mill during production itself. The crushed additive must meet the requirements of GOST 20956. The fineness of the additive must pass at least 50% of the sample taken from sieve No. 008.

Fillers must meet the requirements of GOST 20955, expanded clay-GOST 9759, agpoporit-GOST 11991.

The filler should be prepared by grinding the grain in a mill. It is strictly forbidden to add granite, dolomite, magnesite as external additives to the ground filler. Water must meet the requirements of GOST 23732-79.

Heat-resistant top coating preparation technology. Concrete mixture according to GOST 9473, hardness according to technical viscometer is 6-16s, mobility (podvijnost). The standard cone should be 2-3 cm according to GOST 10181.0-81-10181.4-81. If the location of the concrete does not correspond to the specified dimensions, it is corrected as follows:

-If podvijnost is higher than 3 cm, the amount of filler is increased.

- If the subsidence is less than 2 cm, the amount of cement is increased.

Crushed aggregate and water are obtained in a water-cement ratio. Additional total time for concrete is 45 min. It should not exceed. When pouring concrete, its temperature should be

300C or less. Crushed aggregate and filling should not be contaminated with izvestnyak, granite, dolomite, etc.

Formwork (formwork) should consist of one base and four walls. In order to prevent the formwork from sticking to the concrete, the formwork must be lubricated before placing the frame (moy-otrabotannaya mashinnaya maslo, emulsion,...). Mold dimensions can vary from project to 5mm. A reinforcing frame is installed on the assembled formwork, that is, after the frame is fastened to the 50x5 corner with the help of studs (Ш 5mm), it takes the shape of the project. The support angles rest on the mold base at four corners in the frame position. All fittings are welded together. The frame is firmly fixed to the base, so that it should not move when the concrete is poured and vibrated.

The concrete mixture is continuously poured into the mold and compacted with a deep vibrator. Compaction is continued until the mixture settles and cement milk appears on the surface of the concrete. The concrete poured into the mold is immediately cured, that is, the surface of the concrete is covered with a waterproof or absorbent material and stored for 8-10 days. The concrete surface should always be wet. At the beginning, the concrete surface is not wetted with water. 20-30 minutes after pouring concrete. Then, the concrete undergoes plastic deformation. In hot climates this shrinks and cracks. Therefore, the concrete surface should be watered in the morning and evening when it is cool. It is impossible to pour cold water on concrete that has warmed up all day. Maybe the concrete surface should be sealed with a moisture-retaining material and then poured with water.

Hot wet processing is recommended to accelerate concrete hardening. Hot steam treatment should be started 4 hours after concrete pouring. The temperature should rise from 20-300 C/h to 60-80^{0}C and at 80^{0}C. It is advisable to keep it for 10-12 hours. It is necessary to achieve a temperature reduction of 300C/hour. Reinforcement, molding and finished state of the heat-resistant reinforced concrete structure of the prepared sample are presented in the pictures.

Checking the quality of heat-resistant concrete. The control strength of heat-resistant concrete in compression according to GOST 10180 is 3 10x10x10 centimeter under normal circumstances (t=20±2^{0}C, W=90%) 7 days saved and 105±5^{0}C determined by testing a dried sample at Control strength should not be less than the average strength of heat-resistant concrete. Concrete strength class V15 190-196 кg/sm^2. Residual strength of concrete 800^{0}C 30% of control strength should be achieved after cooling after exposure to temperature and stored above water (in practice this has been achieved).

The residual strength of concrete is 3 10x10x10 detected in the sample. Preheat the sample concrete in a chamber furnace (muffle furnace). 150^{0}C / hour from 800^{0}C for 4 hours, then it is cooled to room temperature together with the oven. The cooled sample is placed on a rack in a water bath 4±1sm poured at a height. The thickness of the water in the bath should be 10 sm. After keeping the sample in the bath for 7 days, it is removed and visually inspected. There should be no spillage and cracks in the concrete cubes. If so, it is invalid. Strength is determined according to GOST 10180, if the residual strength is less than 30%, the concrete is considered unsuitable.

Several types of reinforced concrete structures that work under the influence of various movements are presented in the pictures.

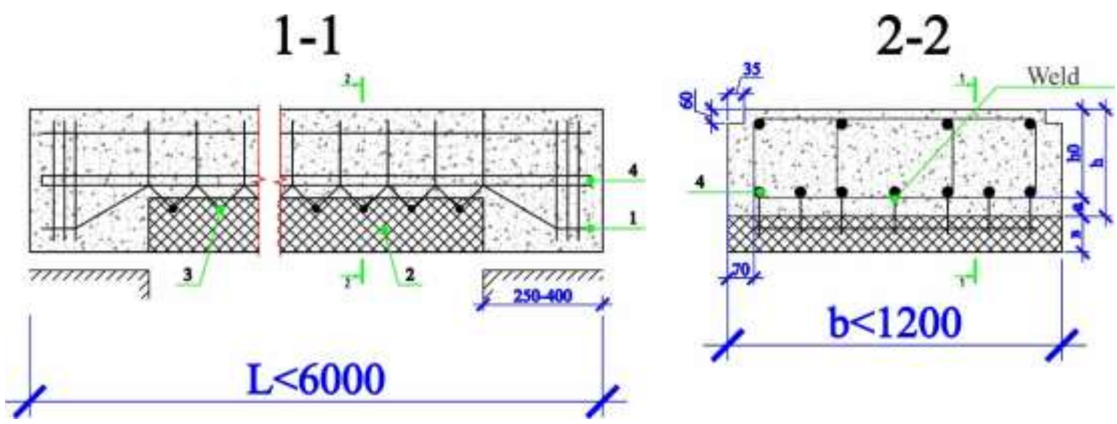
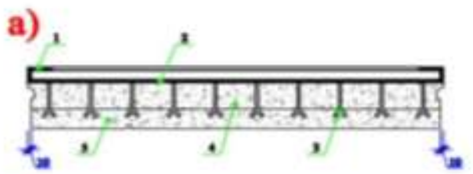
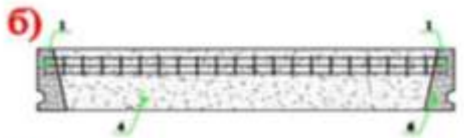


Figure 1. 400 ^{0}C and above it a precast precast concrete structure.

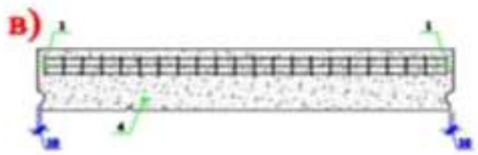
1. Heat resistant heavy concrete
2. Heat protection layer in lightweight heat-resistant concrete
3.Diameter 4 mm heat resistant steel type.
4. Longitudinal working armature



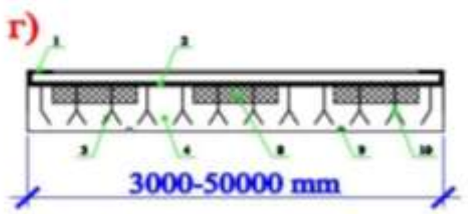
a) Two-layer panel with iron sheet.



б) The frame panel is heavy concrete on both sides



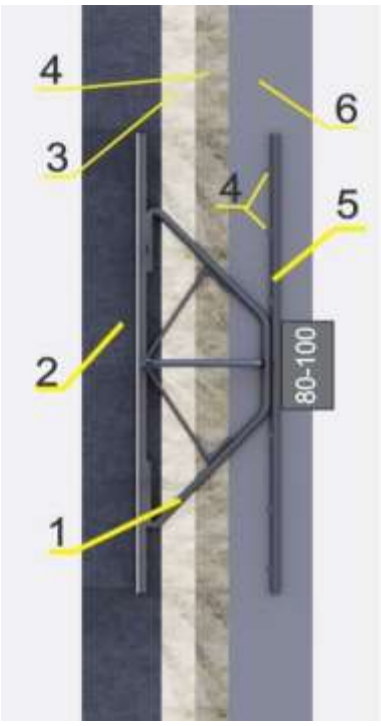
в)



г) Two-layer heat-insulated panel with iron sheet

Figure 2. Lightweight heat-resistant overlay construction

1. Panel stiffness angle 2. Metal sheet 3. Anchor 4. Heat-resistant lightweight concrete D1100 5. Heat-resistant lightweight concrete D1200 6. Heat-resistant reinforced concrete frame burned along the edge of the panel 7. Frame with reinforcement 8. Thermal insulation 9. Shrinking seam 10. Washer



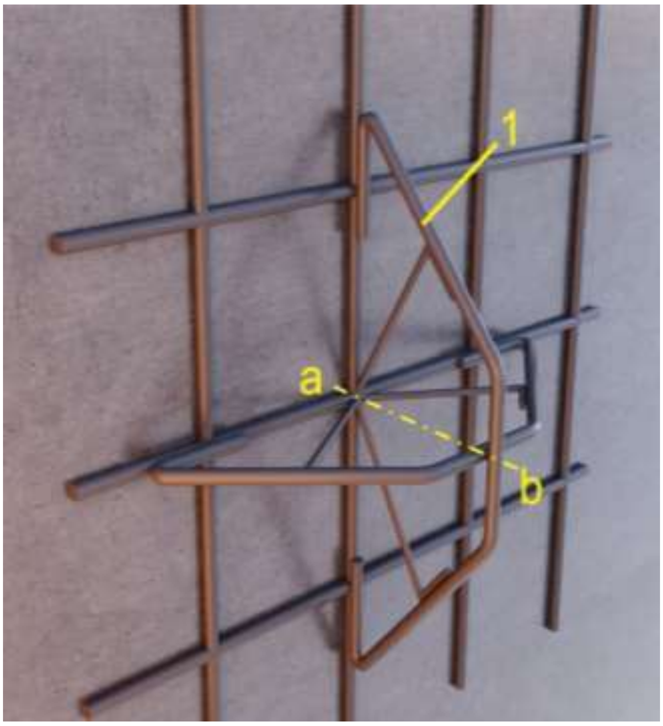


Figure 3. An anchor device that connects the layers when pouring a multi-layer heat-resistant concrete slab.

1. Spatial anchor
2. Load-bearing composite plate
3. Protection with mineral wool
4. Plate protection
5. Armature type
6. Scientists of the LightNamangan Institute of Engineering and Construction are conducting a series of practical studies on determining the composition of heat-resistant concrete from local raw materials for covering the top of rotary kilns with trenches. In particular, four different types of concrete were prepared from materials such as ash, ash powder, molten brick fragments produced in brick baking, and burnt quartz sand used in cast iron foundries in the region (Fig. 4-5).

The composition of the first batch of concrete: 0-20 mm aggregate of crushed brick fragments without dividing into fractions, burnt quartz sand from cast iron melting as an additive, and Portland cement of 400 grade and water as a binder. The samples were left in the workshop to harden under natural conditions, and concrete maintenance was carried out during the first seven days. Seven-day strength of concrete in this batch was R=86.7 kg/cm2. Concrete samples are still stored in the workshop.

a) b)

Figure 4. *Burnt brick and its grinding process:*
a) burnt brick; b) crushed brick.

The composition of the second batch of concrete: as aggregates, fractionated fine aggregates with a diameter of 0-5 mm and coarse aggregates with a grain size of 5-20 mm, crushed brick chips, binder portland cement and water.

Figure 5. *The process of dividing crushed brick fragments into fractions.*

The composition of the third and fourth batches of concrete: as a filler, fractionated small crushed brick fragments with a diameter of 0-5 mm and a grain size of 5-20 mm, and as a crushed aggregate, ash and burnt quartz sand and binder portland cement and water.

a) b)

Figure 6. *Concrete samples placed in molds and the process of testing the sample in a press: a) molding the sample; b) test the sample under the press.*

Concrete cube samples with sides of 10x10x10 cm were prepared from each batch of concrete (Fig. 3). Part of the prepared samples was kept in natural conditions and part was heat treated. After the heat treatment, the samples are released from the molds,

Tested for consistency after 4 hours. The test was carried out in a hydraulic press with a gradual increase in force. (Frame 5). The strength of the samples was determined based on the requirements of the international standard [2] approved in 2012 by Uzbekistan (Ozdavarkhitekstroy) among other countries such as Russia, Azerbaijan, Kyrgyzstan, and Kazakhstan. That is,

$R = \alpha \frac{F}{A} K_W$ according to the formula, the average strength (R) of the concrete cube was 110.9 to 154.4 kg/cm2.

Of concrete 800^0C residual strength under the influence of temperature was determined according to the requirements of GOST 20910-90 [3]. In this case, the sample is in a SNOL - po TU 16.681.032 brand drying cabinet 105 ± 5^0C dried for 48 hours. After that, the sample was cooled together with the cabinet. After the cooled sample has stood for 4 s in workshop conditions, in an electric oven of SNOL - po TU 16.681.139 brand 800^0C was heated to a temperature of 1500C per hour (Fig. 7). Temperature 800^0C after reaching , it was kept at this temperature for 4 hours and the sample was cooled together with the oven. The sample was removed from the oven and kept for 4 hours at room temperature as required by the standard. After that, the compressive strength of the sample was determined in a hydraulic press. The strength was 86.6 kg/cm2.

Figure 7. *The process of heating the sample at a temperature of* 800^0C.

Conclusion: If we take into account that the residual strength of the sample after exposure to temperature of 800^0C according to the requirement of the standard [3] is 30% of the strength under normal conditions, then it was determined that this content can be used for working at high temperatures in terms of the strength of concrete..

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