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Research paper

Mixes for Concrete Residues Removal from Sidewalk Tiles Production Molds Invention and Analysis

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Abstract

One of the technological operations of production of sidewalk tiles, which increases cost, is removal of of hardened cement-concrete mixture residues. This mixture solidifies on any surfaces. It is easy to remove the fresh residue of the solution, but the solidified mixture is removed badly and is dangerous for both the equipment and for the template forms. In addition, the form with the remnants of hardened concrete cannot be used in the future. The task of removing concrete remnants is complicated by the fact that the concrete is of mineral nature. This means that you can remove it only with acid. Concentrated acid gives the desired effect. It penetrates into the deep layers of the dried cement mortar and destroys it. Any tool to remove concrete contains concentrated acid, which destroys the structure of concrete; inhibitors that protect the surface from the action of acids other auxiliary Ingredients.
The means for dissolving cement mortar from the surface of the mold for production of paving slabs were created and offered. A series of experimental studies on the detection of their dissolution efficiency of hardened cement mortar were performed. A comparative analysis of the created solutions is conducted with those market analogues used in the production and have a satisfactory washing ability, but it is extremely expensive, which significantly increases the cost of the tile fulfilled. It is proved that the washing ability of new solutions meets the requirements and does not destroy the surface of the form. Methods of means preparing is simple and norequires the use of precursors. Significantly lower cost is the main advantage of created means.

Keywords: *cement, means for dissolving, paving slabs, template forms.*

1. Introduction

The construction of sidewalks with concrete pavement is now considered one of the most popular ways to "improve" pedestrian zones. The modern variety of shapes, colors and texture of paving tiles enabels to provide a neat and well-groomed look to city pavements, parks, trade and exhibition pavilions, entrance to shops, summer cafes and many other infrastructure objects.
However, the secret of the popularity of concrete pavement is not only in attractive appearance, which acquires city streets, paved with sidewalk tiles. The high quality performance of concrete pavement also includes the undeniable advantages of this type of coating. For example, strength, low wear, frost resistance and resistance to the effects of many chemicals provide a long lifetime of pavement coating, even in a modern megacity. And the simplicity of stacking and environmental friendliness make the pavement tile the best way to improve the territory [1, 2].
The second name of the concrete pavement tileis a figured paving element (FPE). There are 2 basic technologies for its manufacturing. These methods are semi-dry vibrocompression and vibration casting [3, 4]. Both of these technologies have certain advantages and disadvantages, but are practically equivalent.
Modern and reliable pavement coverage is formed due to the densely stacking of the concrete mixture with the use of mechanical action (vibration or vibropressing) and low water content in the initial composition of concrete.
Basically, large companies that have a significant "start" capital and are able to invest a significant amount in the organization of production are engaged in the production of pressed concrete paving.
The method of vibropressing is considered rather popular and is often used in the manufacturing of building materials in our day. The process of production by the method of vibropressing is as follows [5, 6]. The semi-dry concrete mix is placed in a matrix (mold) located on the floor. The punch and the frame, while in vibration mode, press on a semi-dry mixture that is placed in the mold. This process continues until the mixture is completely sealed. After the specified vibration process, punch and matrix are raised, leaving behind a ready-made construction product. In this method, a high degree of automation is used, so the vibration pressing method is very productive.
With the advent of modern equipment for the production of sidewalk tiles, manufacturers were able to produce vibropressing construction products with a diverse structure. In addition, these products can be applied for different types of construction work. The launch of the vibration prassing method has opened up opportunities for the production of a wide range of construction products. These are like pavement tiles, columns, bricks, panels, building blocks, pillars, curbs, drains, fence covers, etc. This is a far-incomplete list of products produced by the vibropressing method, and is characterized by such positive characteristics as strength, wear resistance, high density of structure, frost resistance, high resistance to mechanical, climatic and chemical influences. The method of vibropressing is disadvantageous for

small enterprises, since it requires significant start-up financial investments. That is why small enterprises, for the most part, prefer the organization of production of sidewalk tiles using vibrocasting technology [6]. This method allows to produce construction products by vibrating a concrete mixture on a vibration table. The concrete mixture is poured into a plastic or rubber form and set on a continuously vibrating vibrotable. During this process it is necessary to monitor the uniformity of the vibration amplitude to prevent the reflection of the concrete mixture from the walls of the form during the vibration. Some time exposure is necessary for ramming mixture.

After filling the form with a concrete mixture, it is necessary to cut out excess concrete. With the vibrocasting method, precise control over the filling of the forms with a concrete mixture is necessary. For example, the smallest discrepancy from the norm, even a few millimeters, can further create a lot of inconveniences associated with the use. After the process of vibration treatment, molds are removed from the vibration table and sent to stand in a warm place about 46 - 47 hours. After a full cycle, the product can be considered ready for withdrawal from the form. The next step can be called a process of product stripping. Firstly, the products in forms are placed in water baths. Only after passing this procedure, the reflection of products from the forms with the help of special devices are carried out.

The concrete mix used in the vibropressing method has a low water and cement ratio. That is why the sidewalk tile has high strength, frost resistance, low water absorption and is stable to abrasion. In addition, the pavement tile, produced by this method, has a superficial surface layer, has a high degree of frost resistance. In the future, it is possible to perform various manipulations to polish, burnish and apply anti-slip strips.

In the vibrocasting method, the concrete mixture has a higher ratio of water and cement than in the vibropressing method. That is why to improve technical characteristics of paving slabs prepared by this technology method, more cement and expensive modifiers and plasticizers should be added. The method of vibrocasting allows the production of sidewalk tiles in a large assortment with a presentable appearance and a smooth surface layer.

Pavement tile manufacturers distinguish three main categories of consumers, namely [1]:

building organizations which buy tiles for works to be commissioned by the city authorities;

construction organizations which buy tiles for their own needs or for work on the order of individuals;

private and legal persons who buy paving slabs for their own needs.

According to the monitoring of manufacturers, different categories of consumers prefer different forms of paving tiles. So city authorities, as a rule, buy gray or brown-red "paving", made by the method of semi-dry vibropressing, while private individuals buy predominantly vibroplate tiles ("old city", "retro", "clover", "wave", etc.). Similar differences in "consumer sympathies" are caused, in particular, by an ergonomic factor: the technology of stacking a rectangular "cobblestone" is most simple and does not require complicated calculations of the number of required tiles.

In most countries of Western Europe, to each inhabitant there are 5 m^2 or more territory enclosed pavement tile. In Ukraine, this indicator is much smaller. Der 1 person it takes less than 1 m^2. So the Ukrainian market of concrete paving has quite good prospects for growth. In addition, the city authorities and private homeowners have already appreciated the benefits that provide landscaping of pedestrian and park areas with sidewalk tiles [1, 2].

2. Main Body

Removal of solidified cement-concrete mixture is one of the technological operations of sidewalk tiles production, which significantly increases the cost.

This mixture hardens on any surfaces.. It is easy to remove the fresh residue of the solution, but the solidified mixture is removed badly and is dangerous both for the equipment and for the template forms. In addition, the form with the remnants of hardened concrete cannot be used in the future.

The task of removing concrete remnants is complicated by the fact that the concrete has a mineral nature. This means that you can remove it only with acid. Concentrated acid gives the desired effect. It penetrates into the deep layers of the dried cement mortar and destroys it. There is a considerable amount of means for concrete remnants removing.

Any tool to remove concrete contains the following:

• concentrated acid, which destroys the structure of concrete;

• inhibitors that protect the surface from the action of acids;

other auxiliary Ingredients.

Modern world and Ukrainian markets offer a large number of such means. The names, composition and price of some of them are listed below [7 - 15].

Barracuda CS. Manufacturer PE. «Malva-CT», Ukraine. Composition: Proprietary patented blend – Ureaphilhydrochloricum, demineralized water, SynTech, excipients, anionic surfactants < 7%. Price: 225 UAH for 1 kg.

Flushing for forms. Manufacturer Ukraine. The composition absent. Price: 109 UAH for 1 kg

Betonloser Manufacturer Germany. Composition: a solution of strong acids. Price: 262.4 UAH per 1 kg.

Atlas Szop. Manufacturer Poland. Composition: contains inorganic acid. Price: 241 UAH per 1 liter

Ecosept-210. Manufacturer Ukraine. Composition: concentrated detergent of strong acid. Price: 190 UAH per 1 liter.

Cementin, a means for removing cements Bagi. Manufacturer Israel. Composition: hydrochloric acid, active substances, distilled water. Price: 163 UAH per 1 liter.

Dezoxyl-2. Manufacturer Russia. Composition: acid solution. Price: 42.3 UAH per 1 kg.

Liquid MONSTER. Manufacturer USA Composition: contains inorganic acid. Price: 337.5 UAH per 1 liter.

EK 100 SUPER. Manufacturer Germany. Composition: liquid of reddish color, which is an aqueous mixture of hydrochloric acid, dyes, corrosion inhibitors. Price: 282.6 UAH for 1 liter.

Glutoclean Manufacturer of Pufas Werk KG. Composition: 5 - 15% hydrochloric acid, <5% noninogenic surfactant, phosphates, limonel flavoring. Price: 195 UAH for 1 liter.

Septosilin C 23. Manufacturer Ukraine. Composition: liquid containing acid, surfactant, solvent, disinfectant, defoamer. Price: 72.15 UAH per 1 liter

The use of means of such price category does not satisfy manufacturers of sidewalk tiles. Therefore, the purpose of the work was to create means with properties that meet the requirements of technological processes of manufacturing sidewalk tiles of low price category. The main requirements are the high dissolving capacity of the cement mortar and, at the same time, the absence of destructive effects on the surface of the forms to ensure their multiple using, as well as the absence of harmful effects in the working zone.

A preliminary search has shown that several means for dissolving and removing hardened cement-concrete solutions are patented [16 - 20].

A known facility for removing hardened concrete from surfaces of trucks, mixers and other equipment [16] used in the manufacture of concrete. This composition contains: hydroxyacetic acid (17.5% by weight), soap (4% by weight), degreasing agent (2% by weight), water (76.5% by weight). To remove hardened concrete, the mean is evenly applied to the surface of hardened concrete and kept in contact with concrete for five minutes. Hardened concrete is converted into soft putty-like pieces that are removed from the surface. The disadvantage of this product is the inadequate softening of the remnants of obsolete concrete.

The composition for cleaning and disinfecting surfaces of building materials [17], which contains: surface-active substances (0.1 -

20% by weight); alkaline or alkaline earth metal hypochlorite (1 - 50% by weight); alkali metal or ammonium silicate (0.1 - 50% by weight); alkali metal or ammonium fluorosilicate (0.01 to 2% by weight); water - the rest is known. According to the chemical characteristics it is a solution. The disadvantage of this composition is a significant amount of its components. In addition, surface-active substances have a negative effect on the environment, and alkaline or alkaline earth metal hypochlorites are unstable compounds and easily decompose, securing active chlorine. That is why this composition creates a sharp unpleasant smell. This greatly complicates of such compositionuse using, since the creation of additional constructions of air cleaning in the workshop is necessary.

The composition of the cement material removal agent [18] from the surface comprising the following components: HCl (40 - 60% by weight); urea (42 wt%); complex substituted ketoamine hydrochloride (0.067% by weight); isopropyl alcohol (0.067% by weight); ethoxylated nonylphenol (0.022 wt%); propargyl alcohol (0.022 wt%); methyl vinyl ketone (0.022% by weight); acetone (0.022 wt%); Acetophenone (0.0022% by weight) is known. The disadvantage of this product is a large number of components, complexity in the preparation of the product, as well as its extremely high cost.

A concrete cleaning and preparation composition is described [19], which includes urea hydrochloride, surfactant, water, and one or more glycol ethers. The method of preparing a concrete surface is based on pre-wetting a concrete surface, using a cleaning and preparation composition It also includs urea hydrochloride, a surfactant, water, and one or more glycol ethers, and rinsing the concrete surface. Furthermore, a kit for cleaning, preparing, and coating concrete including a cleaning and preparation composition including urea hydrochloride, and a coating is also presented. Concentrated solution consist from following agents: Glycol ether (PnB) (2,5%); Glycol ether (DPM) (5%); Inhibitor (ViHib MSI) (0,9%); Sufactant (Videt Q3) (0,9%);l Urea Hydrochloride (33%) and Water (57,7%). Similarly to the previous mixture, the main disadvantage of this product is the large number of components, complexity during product preparation, as well as its extremely high cost.

Means for removing solid or semi-solid cement [20] containing, in one embodiment, anhydrous citric acid (approximately 60% by weight); xanthan as thickener (0.01 wt%); triethanolamine lauryl sulfate as a moisturizing agent (0.1% by weight); water as the residue of the solution (up to 100%) is the closest analogue to the chemical composition. The mixture is applied to the surface and exposed until the cement substance is transformed into solid components and calcium citrate. The remaining solids and calcium citrate either fall away by gravity, or can be removed from the surface by water or mechanically. The disadvantage of this composition is the use of extremely expensive reagents (citric acid, xanthan, triethanolamine lauryl sulfate), as well as the long exposure time of the composition on the surface.

Therefore, the authors had to be resolved the problem of creating a cheap mean, devoid of the listed disadvantages, to remove the remains of hardened concrete from the forms for the production of sidewalk tiles.

After analysis of previous studies, the authors created and proposed for use four means (hereinafter №№ 2 - 5) for dissolving the cement solution from the surface of the mold. A series of experimental studies to determine their effectiveness of dissolution of the cement solution was performed.

Experimental researches were carried out on materials of forms contaminated as a result of real tile production. For this purpose samples of 2 × 2 cm in size were cut from contaminated forms. The samples were dried for 1 hour in a drying oven at 120°C. and weighed. Then they were then placed in various composite variants of the means for removing the remains of the concrete mixture and held for 30 minutes. After that, they were washed with distilled water and dried in a drying oven for 1 hour. After drying and cooling in a desiccator, the samples were weighed. Reduced mass of samples after treatment was determined. By decreasing the mass of the samples, the ability to dissolve the hardened residues of the concrete mixture in different versions of the proposed agent was determined. The test was treated with an expensive solution with excellent cleaning ability (Mix № 1 Fig.1). The result of the effect on hardened residues (after the production process) on the surface of the form of all the products is shown in Fig. 1.

Mix №1 Mix №2 Mix №3 Mix №4 Mix №5

Fig. 1: Dissolving ability of means on the surface of the form with a layer of hardened cement mortar (after the production process)

Equivalent effectiveness of the means proposed by us (No. 2 - No. 5) in comparison with the existing expensive means (No. 1) is obvious.

But the second task, which the authors had to solve, was to create a solution with no destructive effect on the surface of the form

Therefore, a series of experimental studies of the proposed and created by us mixtures on the impact on the surface of the form was carried out. The essence of the experiments was to immerse and holding samples (No. 1 - No. 5) with a layer of hardened cement mortar (after the production process) for 30 minutes in the appropriate means (No. 1 - No. 5). Then each sample was washed with distilled water, dried in a drying oven, cooled in a desiccator, and weighed to an accuracy of ± 0.00005 g. The results of visual observations are shown in Figures 2 - 6.

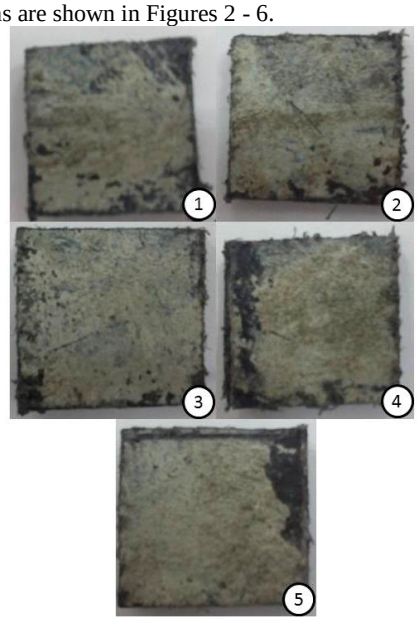

Fig. 2: Initial appearens of specimens of the form with a layer of hardened cement mixture (after the production process)

After the first exposure in mixtures, the mass loss of the cement solution of all specimens was recorded, respectively, No. 1 - 1.00%, No. 2 - 1.27%, No. 3 - 0.9%, No. 4 - 2.27%, No. 5-3,00%. It is obvious that the greatest effect of the destruction of the cement layer is in solutions No. 5 and No. 4.

The result of visual observations after the first treatment is shown in Fig. 3

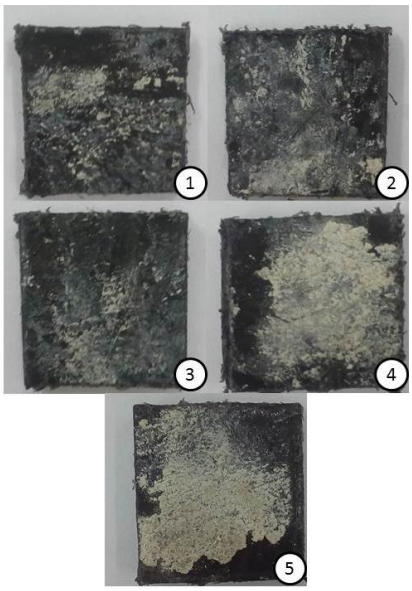

Fig. 3: The appearens of the form samples with a layer of hardened cement mixture (after the production process) after the first treatment with the appropriate mixtures

After the second exposure, the weight loss of the hardened cement solution of all specimens was recorded: No. 1 - 0.12%, No. 2 - 0.12%, No. 3 - 0.04%, No. 4 - 0.21%, No. 5 - 0.95%. It can be concluded that the maximum effect of dissolution of hardened cement mortar in all means occurs during the initial treatment. This indicates a sufficiently effective dissolving of hardened cement mixture and cleaning forms surfaces with means created and proposed by the authors. Moreover, solution No. 4 also effectively removes cement during secondary treatment. Since the reduction of mass depends on the thickness (mass) of the primary layer of the cement solution, we estimated the mass loss in percentages.

The result of visual observations after the second treatment is shown in Fig. 4

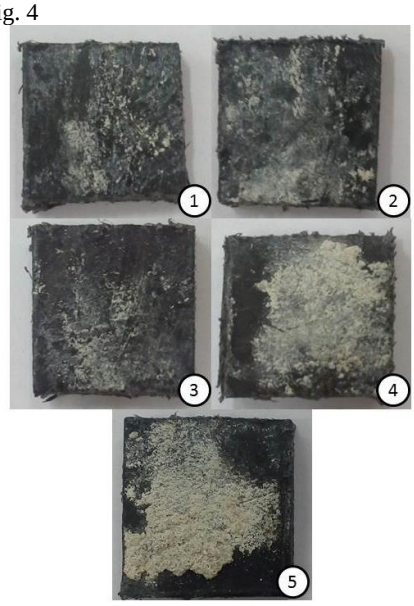

Fig. 4|: The appearens of the form samples with a layer of hardened cement mixture (after the production process) after the second treatment with the appropriate mixtures

Since we compared the effect on the surfaces of the forms under the real conditions of the means created by us and mean No. 1, a series of samples treatment of under similar conditions was performed several times.. After the third treatment, the mass loss was respectively: No. 1 - 0.05%, No. 2 - 0.02%, No. 3 - 0.00%, No. 4 - 0.08%, No. 5 - 1.74%.

The result of visual observations after the third treatment is shown in Fig. 5

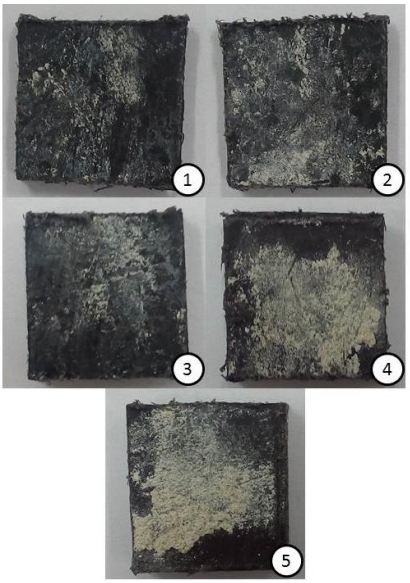

Fig.5: The appearens of the form samples with a layer of hardened cement mixture (after the production process) after the third treatment with the appropriate mixtures

The fourth treatment of samples by means took place for five days in order to investigate the destructive effect of our detergents on the material of the form with prolonged exposure. All other experimental procedures were similar to those described above. Mass losses were respectively: No. 1 - 0.00%, No. 2 - 0.024%, No. 3 - 0.00%, No. 4 - 0.06%, No. 5 - 0.69%.

The result of visual observations after the fourth treatment is shown in Fig. 6

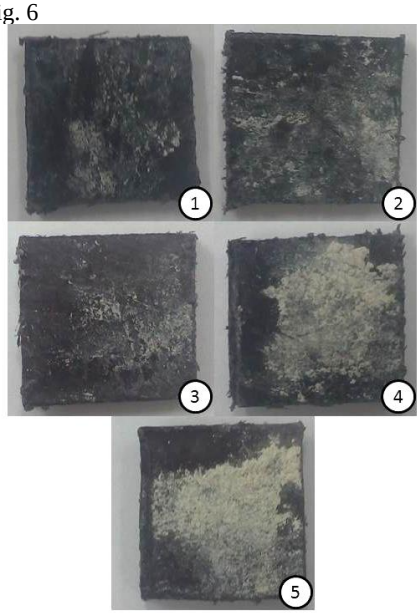

Fig. 6: The appearens of the form samples with a layer of hardened cement mixture (after the production process) after the fourth treatment with the appropriate mixtures

Obviously, the means № 2 and № 3 are similar to the means № 1 have the maximum destructive effect on the hardened cement mortar.

The fact that all three of these solutions practically do not have a destructive effect on the surface of the form is positive. As a consequence of the presence of a larger layer of mass of hardened cement solution per unit of surface of the form on specimens No. 4 and No. 5, which were immersed in the investigated mixtures, there is a decrease in mass after the 3rd and 4th

exposures. The influence of these agents on the surface of template forms will be investigated in the process of additional experiments. But we do not discard their remarkable destructive ability to hardened cement mortar with simultaneously inert impacts on the surface of the mold. Therefore, the authors recommend the means № 2 and № 3 for the effective use of cleaning of forms surfaces from hardened cement mortar in the process of manufacturing sidewalk tiles.

The authors filed applications for the patent of Ukraine for an invention in which the formulation of the means for removing the remnants of concrete from the molds for the production of sidewalk tiles is presented [20, 21].

3. Conclusions

- The means of dissolving the hardened cement mortar from the surface of the mold for the production of sidewalk tiles have been developed and proposed.
- A comparative analysis of the created solutions with those used in the production and have a satisfactory washing ability, but is extremely expensive, which significantly increases the cost of the tile is carried out.
- It is proved that the washing ability of new solutions meets the requirements and does not create particularly harmful conditions in the working area.
- Methods of means preparing is simple without causing damaging effects to the surface shape and norequires the use of precursors.
- Means № 2 and № 3 for effective washing of molds from hardened cement mortar in the process of manufacturing of sidewalk tiles are recommended.
- The main advantage of the created and recommended means is much less their cost.
- According to the results of the study, an application for the patent of Ukraine for an utility model and the patent of Ukraine for an invention were filed.

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