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The Influence of Technological Factors on the Basic Properties of Vibropressed Concrete Paving Slabs

Lyudmila Alexandrovna Suleymanova, Karina Alexandrovna Kara,
Marina Valerievna Malyukova, Karim Abdullaevich Suleymanov and Kirill Romanovich Kondrashev
Russian Federation, Belgorod State Technological University Named after V.G. Shoukhov,
Str. Kostyukov 46, 308012 Belgorod, Russia

Abstract: The study describes a set of basic technological factors affecting the properties of the vibro pressed concrete in the production of concrete paving slabs. Evaluated regularities of movement components of the concrete mix and the accompanying energy flows based on the study the influence of external vibration and pressing actions.

Key words: Energy flows, external vibration, paving slabs, technological factors, vibropressed concrete

INTRODUCTION

In practice, widespread manufacture of vibropressed products (concrete paving slabs, figured paving elements, border stones, products for cladding facades and socles, wall stones, etc.) with the required physical and mechanical properties, accurate geometric parameters and high architectural expressiveness.

At the moment, the industrial production takes place on a fully automated production lines (Mescherin and Palzer, 2009). However, in order to finished products meets all requirements imposed on it and the characteristics of strength, density, frost resistance and architectural expressiveness, it is necessary to optimize each stage of the production technology of concrete paving slabs (Kosukhin *et al*., 2007).

THE MAIN PART

The technology of production method of vibration pressing is the impact on the concrete mix with the highest aggregate grain size of 10 mm vibration loads and static pressure using without inertia or inertial devices (springs, pneumatic, hydraulic or combination cantledge), allows manufacturing a wide range of vibropressed products with improved physical and mechanical properties exceeds similar parameters traditionally compacted concrete (with the same water-cement ratio concrete mixes), improve working conditions, reduce wear and tear forms and in the case of optimally selected regimes of production and forming to reduce energy costs (Lesovik *et al*., 2007).

For the production of durable vibropressed paving slabs necessary to study not only physical and mechanical properties of concrete but also the properties that should have the concrete mix and the fresh concrete at different stages of processing: when mixing, transporting, unloading, vibration, stripping, curing, etc.

In considering, the process of production of paving slabs by methods of semidry vibropressing identified the main factors affecting the quality of products at each technological stage.

The quality of metal form is one of the key characteristics that affect of the quality vibropressed products (Suleymanova *et al*., 2011). Form consisting of male mold (cantledge) and matrix (metal cells), resulting in considerable deterioration breaks down after 50,000-70,000 work cycles, thus than greater hardness the metal form, the greater period of its operation.

The quality of form essentially affect on geometrical sizes formed product, during operation on the form as a result of wear shelfplasty male mold and matrix appears a wear form, products have increased in the length, width and defect as crest (Fig. 1).

Installation matrix form on vibropress should be performed in a strictly horizontal plane with the fixation on all four sides using air cushions and the mold table, at the same male mold (cantledge) must be perfectly centered when lowered the matrix.

If in one form plan to deployment of elements of different size and shape, the smaller elements should be placed closer to the center of the form which is due to the specific filling form concrete mix (Lesovik *et al*., 2011).

Corresponding Author: Lyudmila Alexandrovna Suleymanova, Russian Federation,
Belgorod State Technological University Named after V.G. Shoukhov, Str. Kostyukov 46,
308012 Belgorod, Russia

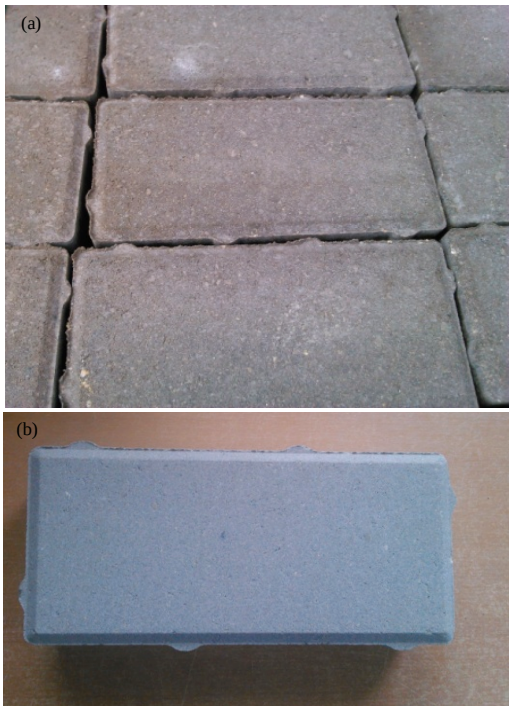

Fig. 1: a) Product with a defect as crest and b) high quality product

Production of stiff concrete mix with the specified parameters should be provided in the concrete mixing unit with compulsory concrete mixer planetary type (allowed to use twin-shaft mixers and disintegrator).

And in the production of two-layer products to the concrete mixing unit is necessary to provide two mixer, one of which is for making the base layer of concrete, the other for making the facial (decorative) concrete layer while the performance of the mixer to the base layer of concrete should be in 5-6 times more than the performance of the mixer for face layer.

During the mixing of the components of the concrete mix in in the effective planetary concrete mixer, concrete becomes the bearer of properties as a continuous system which can be conventionally considered as a homogeneous medium with a specific set of structural, rheological and physico-mechanical properties (Woertz, 2010).

Opportunities of mixer allow obtain a homogenous concrete mix but do not allow to get a stable humidity concrete mix from batch to batch. The amount of water in the batch defined by norms of consumption of materials and adjusted depending on the humidity of the aggregates used. Water metering accuracy is of paramount importance, since any changes in water-cement ratio regarding the optimal lead to deterioration physical and mechanical characteristics vibropressed products and cause marriage.

In the preparation of concrete mix humidity adjustment is carried out by a laboratory measurement of humidity of aggregates and determine the amount of water after the necessary measurements. It is effective only in case of closed raw-material storage where the humidity of aggregates does not change during the day. If the row-material storage of aggregates is open, significant jumps humidity of aggregates is very difficult to keep track of time and adjust the parameters humidity of the concrete mix.

In addition, determine the consistency of the concrete mix has to be carried Organoleptically Method, one of the less effective. Installation microwave sensor humidity in concrete mixer allowed to perform automatic adjustment of humidity of the concrete mix without additional measurements (Fig. 2).

For evaluation of the humidity sensor were carried out researches water-cement ratio concrete mix produced in planetary compulsory mixer with skip hoist series SM (SCHLOSSER PFEIFFER).

Sensor for the measurement of humidity has been built into the bottom of the concrete mixer. When material enters the mixer are metered humidity of aggregates to determine the reference point of water dosage. Further, on the basis of a predetermined parameter in the water-cement ratio in an automated program automatically procedure are counted necessary amount of water (Motes, 2004). For correct work of the sensor is enough to 60 sec of dry mixing and 60 sec of wet mixing.

In order to evaluation changes in water-cement ratio tests were conducted to assess the humidity of the concrete mix with a working off and humidity sensor. Samples were taken directly from the concrete mixer after immediately after mixing. The mixing time, the composition of the concrete mix remained constant.

To estimate the change in the water-cement ratio tests were conducted to assess the humidity of the concrete mix with and without humidity sensor. Samples were taken directly from the concrete mixer immediately after mixing. The mixing time, the composition of the concrete mix remained constant. The graph of the water-cement ratio from humidity inert components is shown in Fig. 3.

With a sharp jump in humidity of aggregates from 3-7% (Fig. 3a) the operator of concrete mixing unit corrects water flow only to the sixth mixes, thus a water-cement ratio in the fourth and fifth mixes greatly exceeds what is required.

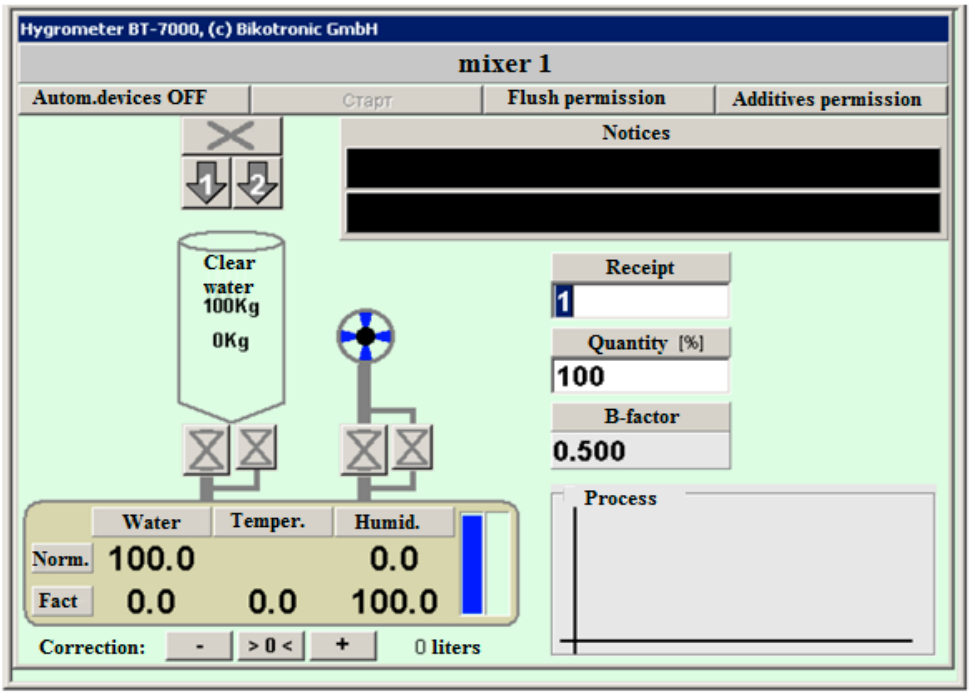

Fig. 2: Automatic adjustment of humidity of the concrete mix

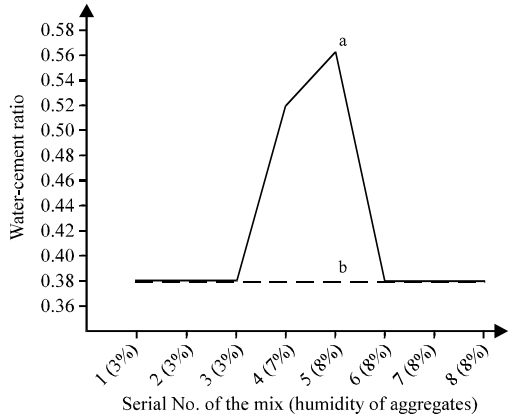

Fig. 3: The dependence water-cement ratio from changes humidity of aggregates with; a: off and b: on humidity sensor

Additional installation of a humidity sensor in the mixer allows you to quickly adjust the water-cement ratio of concrete mixes (Fig. 3b) which improves the quality of products and increases productivity.

Stiff concrete mix is fed through a system of address feeding from concrete mixing unit in the feed hopper vibropress and vibropress formed concrete products. Uniform, uninterrupted supply of concrete mix is the main condition. Each batch of concrete mix should have a constant consistency and composition (Suleymanova and Malyukova, 2013).

The need for the time and the volume filing of the next batch of concrete mix is dependent on the produced assortment and chosen so that during forming there is no change of humidity and consistency of concrete mix wherein the concrete mix from the feed hopper vibropress not be work out until the end, it necessary to refill with remainder at least 30% of the total volume of feed hopper.

Quantity of concrete mix in the dispenser depends essentially on the pressure of the mixture on the bottom of the hopper, i.e., is the amount of the mixture in the hopper which affects the uniformity of the concrete mix in filling box and is one of the important factors that determine the quality of filling cells form (Woertz, 2010; Suleymanova and Malyukova, 2013).

Means, the volume of concrete mix in the hopper depending on the type of product and the number of cells in the matrix should be selected, so that the pressure of the mixture is sufficient for uniform distribution mixture in the filling box dispenser and does not affect the basic desired properties.

To ensure stable quality characteristics of the formed products need precise dosing the same amount of concrete mix in the filling box for each production cycle (Semikopenko *et al*., 2011).

The volume of concrete mix in the dispenser is considered optimal if after filling the matrix are clearly visible agitator rods (grate) of the remaining concrete mix.

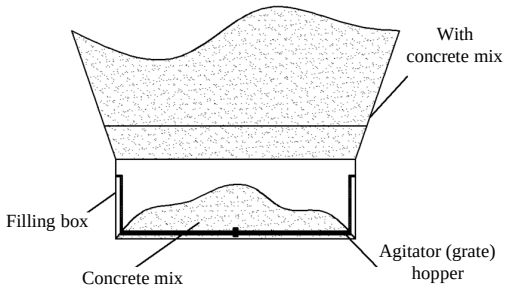

Fig. 4: The uniform distribution of concrete mix in the filling box

Important is the uniform distribution of concrete mix in the filling box (Fig. 4). Forming, transportation of freshly prepared products in the chamber shutter speed and from the chamber to site packaging occurs on technological pallets.

On the choice of technological pallets is influenced by such factors as the overall dimensions; the quantity of the forming zone; the transmission of vibration to the concrete mix; resistance alternately wetting and drying; resistance to mechanical loads and vibration.

In the production of vibropressed products pallets must turn over regularly to ensure that they use double-sided. After removing the product from the pallet, the pallet is necessary to clean the surface with a regular and uniform wetting of the entire surface of the water which must be carried before inverting the pallet. This is necessary to ensure that pallets receive humidity from top of freshly prepared products are wetted and as the bottom surface. In this processing are excluded stress and warping of the wood pallet during manufacturing shutter speed chambers.

Should be avoided as excessive drying of pallets which leads to the formation of cracks in wood and the formation of slits and overwetting wherein the wood becomes too soft and technological form leaves prints on the surface and deteriorates the quality of vibration transmission.

In the technology of vibropressing concrete paving slabs allocate mainly three successive process: Filling a form, vibropressing (sealing) and demoulding freshly prepared products.

For filling the form concrete mix, matrix is lowered onto the technology pallet, put forward the filling box on the matrix and by the action of vibration (or not) and activator (grate) fills the volume of the cells of form. At this time, the mix was affected by vibrations of vibrating table and horizontal vibrations transmitted from the filling box.

With an optimized frequency (amplitude) of the vibration of vibrating table particle oscillations aggregates, thus, reducing of the emptiness of the mix. At this stage, vibropressing uniform good filling of concrete mix of cells forms on the principle of as little as possible and as necessary is a key aspect affecting the quality of products.

After filling the cells concrete mix male mold is lowered into the matrix. With the help of pre-established parameters of vibration and the pressure of the male mold stiff concrete mix is compacted to the required density.

The intensity of the vibration determines by the amplitude of oscillations of the particles of aggregates in the compaction process. Parameters of vibropressing depend on the chosen composition of concrete mix, water-cement ratio and the desired characteristics.

Duration of vibro pressing chosen, so that there is enough time from the moment of contact of the male mold borders matrix cells filled concrete mix to the maximum possible degree of compaction of concrete mix (Giersiepen, 1973). Superstrong or overlong vibration can lead to the destruction of early concrete structure.

After compaction of concrete mix matrix rises, the male mold remains in the lower position to keep the compacted product on the pallet. Then, after the matrix has risen above the upper surface freshly prepared products male mold is raised and the process of demoulding.

At the end of the process of demoulding a pallet with freshly molded product is pushed out of the vibropress. At this stage, the impact on product quality renders rate during pushed out. The process of pushing the pallet should be as slow as possible, freshly molded products may be destroyed due to sudden impact or fast movements.

The fully automated production lines pallets are fed to multi-tiered platform, united with the transporter. Pallets with molded study can be placed on a platform to 30 storeys in height and two rows horizontally. After filling in all tiers of the platform, it are removed by means of transport and stored group, equipped with special grabs and are transported into the camera shutter speed.

Considering the good productivity vibropresses, a problem in the technology is the need for maturing products before demoulding strength, i.e., strength before allowing stacking of finished products without their destruction or damage. The optimum is to get through the day required strength.

To use the highest possible performance of automatic line is considered the best steam curing of concrete products. However when optimally chosen composition of concrete mix, water-cement ratio and parameters of vibropressing products are gaining strength in 1 day at no steam curing.

Shutter chambers should be sealed and insulated. he temperature in the chamber shall be maintained at least 20°C and the relative humidity is above 85%.

CONCLUSION

Based on these results, it is assumed that the processes of the vibration and vibropressing are nonstationary.

The energy intensity of these processes is determined by the balance of internal and external forces is different because of the additional pressing load vibropressing. Energy of the process vibropressing consists of the energy of relative motion of the particles of the solid phase which depends on the action of volume forces associated, primarily with the density, shape, surface properties of the particles and their motion parameters. Under the action a relatively small compaction pressure, coinciding with the direction of gravity, the particles tend coarse component to occupy the energetically favorable position in the limit corresponding to the classical ideal packaging in which the interparticle space is filled with fractal-cluster formations of microheterogeneous component. Pressure promotes the best organization of the particles of the solid phase, the restructuring that occurs at all levels of scale of concrete mix and continues to strike a balance between external vibration and internal forces.

Energy changes in the system and structural changes at the vibropressing will take place only at the optimum value of the pressing pressure which is created for effective joint action of vibration and pressure of the male mold. At this pressure, the pressing force coincides with the direction of gravity and as it increases them at the same time does not prevent the vibratory movement of the components of concrete mix.

Optimization of values pressing pressure on the structure-forming processes of dispersion-grained systems with regard to actions carried out by the internal forces of the structural changes which are measured by the density of freshly molded concrete paving slabs samples.

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