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**Methods of texturing the surface of cement concrete pavement**

**Abstract:** This article provides an overview of concrete pavement surface finishing methods. Various methods used since the first introduction of rigid cement concrete pavement technologies are presented. It is concluded that different surface finishing methods significantly impact operational characteristics, particularly noise emissions. Currently, proven and optimal methods are recommended: grinding, grooving, and "exposed aggregates."

**Keywords:** Concrete pavement; Texture; Grinding; Grooving; "Exposed Aggregate"

**Introduction**

The structure of a cement concrete pavement (and not only such pavements) consists of a system of layers whose purpose is to safely transfer traffic loads over the assumed service life. In addition, such a structure should ensure road user safety. This safety is primarily provided by the upper layer, and in particular by the surface of the pavement. The role of this part of the pavement is to ensure appropriate macrotexture and efficient drainage of rainwater. Macrotexture should provide the required friction coefficient between the tire and the pavement surface.

The friction coefficient is a key parameter influencing braking distance and stopping sight distance, which in turn determines minimum values of vertical crest and sag curve radii, as well as horizontal curve radii when checking lateral visibility, etc. The shaping of the pavement surface also affects the noise level generated at the tire-pavement interface.

Methods for shaping the surface of concrete pavements can be divided into three groups:

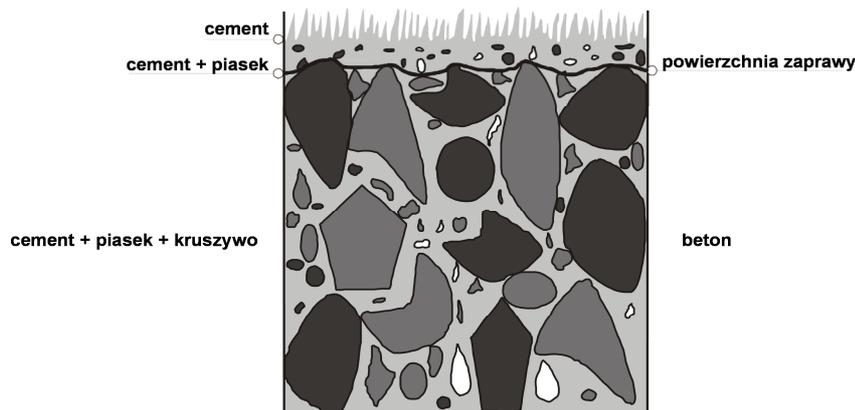
- surface shaping in fresh concrete immediately after placement,
- surface shaping in hardened concrete,
- application of new surface layers based on resins and aggregate hardening.

The above-mentioned surface shaping methods are discussed in this article together with practical examples.

### Surface Shaping in Fresh Concrete after Placement

This section discusses methods of shaping the pavement surface in fresh concrete immediately after placing the concrete mix.

After placing the top layer of the pavement, the surface must be smoothed and given appropriate texture. As a result of compacting the concrete mix using vibrators, a sand–cement mortar is forced to the surface (Fig. 1). In the initial stage of pavement service life, this mortar layer determines the surface roughness. Finishing the surface by providing appropriate texture is a key issue for traffic safety, as mentioned in the introduction.



1. Cross-section of the pavement in the near-surface zone [1]

Texturing to obtain an adequately rough surface can be performed using the following methods:

- dragging burlap fabric parallel to the direction of travel,
- artificial turf dragging,
- transverse brushing of freshly placed concrete using a steel brush,
- transverse grooving using metal forks (rarely used).

Examples of texturing using the above methods are shown in Photo 2. Each of these methods has specific advantages and disadvantages. Burlap dragging is the least expensive method, but it produces the smallest surface texture, typically in the range of 0.2 to 0.6 mm. The durability of this treatment is approximately 1–3 years. Its advantage is lower noise generation. Transverse brushing produces greater texture, typically in the range of 1.0–1.5 mm. The advantages of this method include relatively rapid transverse drainage of water and a high friction coefficient between the tire and the pavement. However, it is associated with increased noise levels. The durability of this treatment ranges from 3 to 5 years.

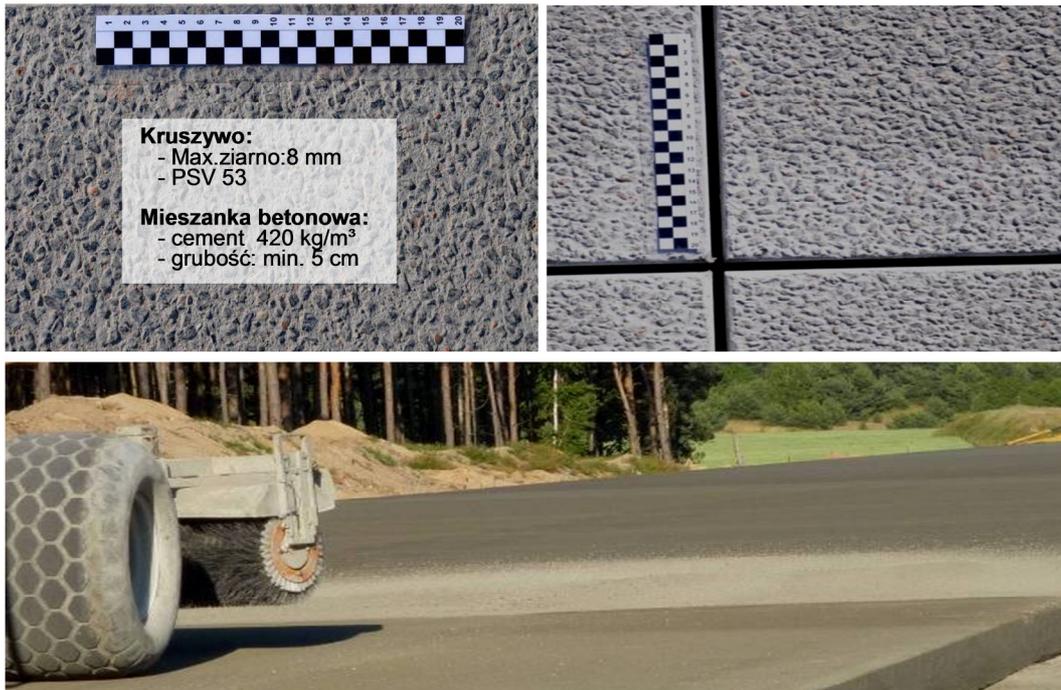
The above-mentioned surface shaping methods are increasingly rarely used on motorways and expressways due to their limited durability. They are still applied on local roads, where traffic intensity and aggressiveness are significantly lower.



2. Examples of pavement texturing using brushing and burlap [1]

A method currently applied in Poland and other European countries (Germany, Austria, Belgium) is the exposed aggregate technique. This method involves delaying cement hydration in the upper layer of freshly placed concrete (e.g. using glucose), followed by washing out or brushing away the unbound cement paste layer.

To construct a pavement using the exposed aggregate technique, concrete is placed in two layers using a “wet-on-wet” method: an upper layer approximately 5 cm thick with aggregate grading up to 8 mm, and a lower layer with aggregate grading up to 22 mm. After placement, the upper layer is sprayed with a retarding agent (e.g. glucose) that weakens the cement paste (in Belgium, plastic foil is sometimes applied as part of curing procedures). After approximately two days (depending on climatic conditions and mix design), the unbound cement paste is removed by washing or brushing, leaving aggregate particles exposed on the wearing surface. The resulting texture provides the required skid resistance properties. Photo 3 shows a view of the surface constructed according to the described method.



3. View of pavement constructed using the exposed aggregate method (author's photo)

The exposed aggregate method is the standard technique used in Poland. It ensures the required friction coefficient and, thanks to its macrotexture, generates less noise compared to transverse brushing methods.

### Surface Shaping in Hardened Concrete

One of the treatments applied to hardened concrete pavement surfaces is micro-grinding, aimed at eliminating surface unevenness. This treatment is applied mainly to exposed aggregate pavements, but not exclusively. Drum grinding machines, such as the Lissmac type, are used for this purpose (Photo 4). The working width of a technological strip is 1.27 m. The number of strips depends on whether one or multiple traffic lanes are being treated. The machine operates “wet,” using water, at an average speed of 5–10 m/min.

The objective of this treatment is to achieve the desired level of longitudinal and transverse smoothness by grinding the pavement to the depth required to remove unevenness. The main tool of the machine is a drum equipped with diamond blades with a diameter of 230 mm and a thickness of 2.2 mm, mounted closely together or with a minimal spacing of approximately 0.6 mm, producing the grinding effect.

After the first pass, pavement smoothness should be measured using a laser profilograph to verify whether unevenness has been eliminated. If necessary, the micro-grinding process is repeated.



4. Grinding machine: a) general view, b) view of the drum (author's photos)

Photo 5 shows the sanding machine in operation. Behind the sanding machine is a sanding waste extraction system.

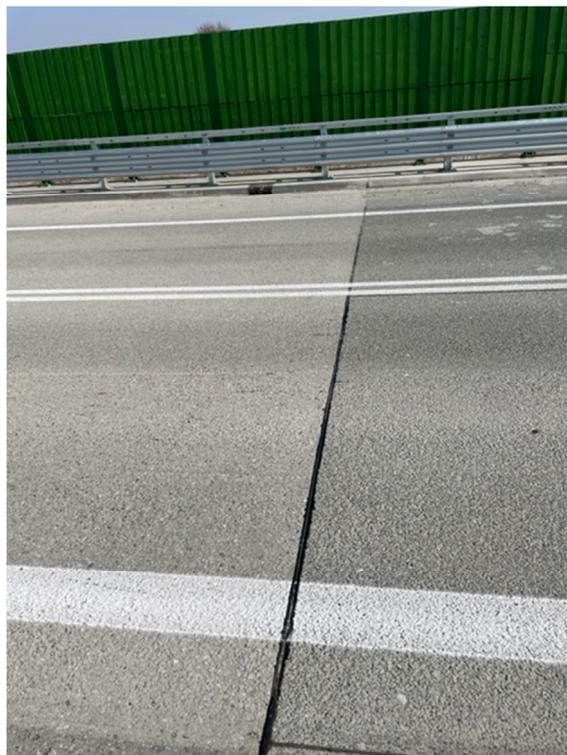


5. Grinding and waste extraction system during operation (author's photo)

After achieving the desired smoothness, the ground surface should be subjected to shot blasting to obtain appropriate macrotexture. A shot blasting machine, such as the Blastrac 2-45 DTM, may be used. The working width of the technological strip is 1.10 m. As with grinding, the number of strips depends on the number of lanes treated. The machine moves at an average speed of approximately 15 m/min. Travel speed should be adjusted to the macrotexture depth achieved after grinding (shallower texture requires slower travel, deeper texture allows faster travel). Photo 6 shows a view of the shot-blasting machine. Photo 7 shows a view of the surface made by micro-grinding and shot-blasting.



6. Shot blasting machine (author's photo)



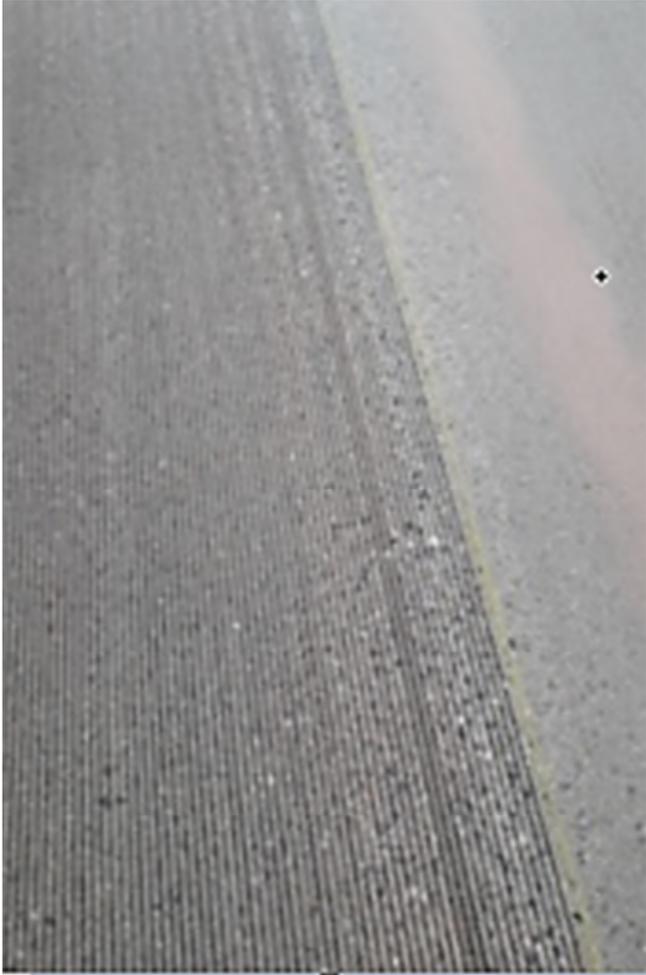
7. View of pavement after micro-grinding and shot blasting (author's photo)

In addition to grinding and shot blasting, longitudinal cutting of the pavement surface is applied to improve tire–pavement adhesion and reduce noise levels. This process can be carried out using a machine similar to a grinder, but with cutting discs mounted on the drum at specified distances from each other (Photo 8).



8. View of cutting drum (author's photo)

The cutting discs are mounted at fixed intervals on a rotating drum. The cutting process creates grooves on the concrete surface, accompanied by ribs of defined geometry (groove depth, groove width, and rib width). Grinding is a method of controlled surface texturing in hardened concrete along the longitudinal axis of the pavement, providing uniform and durable functional properties. Grooves enhance surface drainage, reduce water spray formation at high vehicle speeds, and improve wet pavement skid resistance (Photo 9).



9. Longitudinal grinding grooves (author’s photo)

In the case of grooving technology, deeper grooves with larger spacing are cut into hardened concrete in a separate technological process. This may be performed with or without additional deeper grooves. An example of such surface finishing is shown in Photo 10.



10. Pavement surface finished using grooving technology [2]

The methods of surface shaping in hardened concrete discussed above represent efforts to develop technological solutions that increase tire–pavement friction, reduce noise, and improve overall pavement performance.

### **Application of New Resin-Based and Aggregate-Hardened Surface Layers**

This section presents a method of shaping concrete pavement surfaces using resins and aggregates [3]. A reactive resin, such as epoxy resin, is applied mechanically and without pressure onto a prepared concrete surface, and then sprinkled with aggregate of a specified grading. The thickness of the applied surface layer is only a few millimeters and depends on the selected aggregate size.

The quality of resin surface treatment depends on the bond between the reactive resin and the substrate, as well as on the embedding of aggregate particles within the resin. The most important condition for durability is proper and careful preparation of the concrete substrate. Before applying the resin layer, the surface must be cleaned of all separating substances such as oils, grease, rubber deposits, dust, curing agents, bitumen, or road markings. Cleaning should be performed using high-pressure water jets with immediate slurry extraction, or alternatively by shot blasting.

When cleaning with high-pressure water, additional time must be allowed for surface drying before resin application. If macrotexture depth exceeds 1.5 mm, additional preparatory measures are required to reduce texture depth. Road markings should be removed or covered prior to resin application.

The tensile strength of the concrete surface determined by pull-off testing indicates whether the resin treatment can be applied directly or whether weak surface layers must first be removed. Without adequate tensile strength, durable bonding is not possible. Weak surface layers should be removed (e.g. by high-pressure water cleaning or shot blasting). Joint seals should be inspected and repaired if necessary. Hot-poured sealants generally do not require additional preparation, whereas cold-applied sealants should be covered before resin application. Rubber profiles do not need covering if their height meets specification requirements. Height differences at slab edges and joints should not exceed 3 mm.

During resin application, the concrete surface temperature should be at least +8°C and not exceed +40°C, and should be at least 3 K above the dew point. Relative humidity should not exceed 85%. Application should not be carried out in conditions of expected rapid temperature increase, precipitation, condensation, or fog.

The resin must be applied evenly. Immediately after application, aggregate should be evenly spread and pressed into the resin using a small roller (maximum 2 t with rubber tires). Aggregate should be dust-free. The largest aggregate particles should be embedded to approximately half their diameter. The surface must be protected against damage, moisture, and contamination until the resin has fully cured. After curing, excess aggregate is removed by sweeping, and the surface is immediately ready for use. This method is analogous to surface dressing used on asphalt pavements and is recommended for localized applications, such as improving surface properties of individual concrete slabs.

### **Conclusions**

The methods of surface shaping of concrete pavements presented in this article demonstrate the evolution of pavement surface finishing techniques. Surface properties of concrete pavements are of great importance to road users, as they affect driving comfort, traffic safety, fuel consumption, noise emissions, and pavement durability. The most important surface properties include smoothness, skid resistance, drainage capability, tire-pavement noise, rolling resistance, and light reflection and absorption characteristics.

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**Source materials**

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