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Selection of the technology of repair works of concrete industrial floors in view of their degree of technical dysfunctions

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Abstract

Concrete floors are among the elements in construction facilities whose design requires engineering experience, workmanship requires the maintenance of a technological regime, while during their operation it is necessary to conduct periodic repairs. They are most often used as working and communication space in industrial facilities. Regardless of the place of installation, concrete floors require periodic maintenance work, the scope of which should each time be individually adapted to the current, or to the planned to change the use of the object. Improper selection of maintenance work technology and incorrect application of technological solutions related to the renovation of floors can cause deterioration of their technical condition, which may lead to the need to take them out of service, which in turn may result in the need to interrupt the use of the building facility, including production facilities of industrial facilities.

The paper presents a collection of practical information related to conducting repair work on concrete industrial floors. The article has the character of a case study and refers to specific situations related to the loss of technical efficiency of concrete industrial floors.

Keywords: concrete, degradation process, renovation of concrete, polishing of the flor, coarse grinding, impregnation of concrete

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1 Introduction

Floor laying works are among the most responsible and demanding in terms of workmanship in the construction industry, as their quality has a significant impact on the technical, functional and aesthetic value of the entire facility. The article discusses modern methods of repair and renovation of industrial floors, using grinding and polishing technologies with specialized chemical products that impregnate and strengthen concrete floors and substrates. The article provides practical information on repair work on concrete industrial floors.

2 Causes and effects of the degradation process of concrete industrial floors

Over the past few decades, concrete floors in production halls, warehouses, logistics and retail centers have been dominated by: a) monolithic surface-cured DST (Dry Shake Topping) type systemically impregnated with acrylic or paraffin-based preparations, and b) floors finished in coating systems based on synthetic resins or concrete paints. Regardless of the method of finishing (a) or (b), the surface of floors is subject to natural wear over time, especially under conditions of intensive use [1÷7].

Degradation of the floor face first appears in the most exploited areas, such as main traffic routes, transport alleys, passages and access to machinery and technological equipment [8÷11].

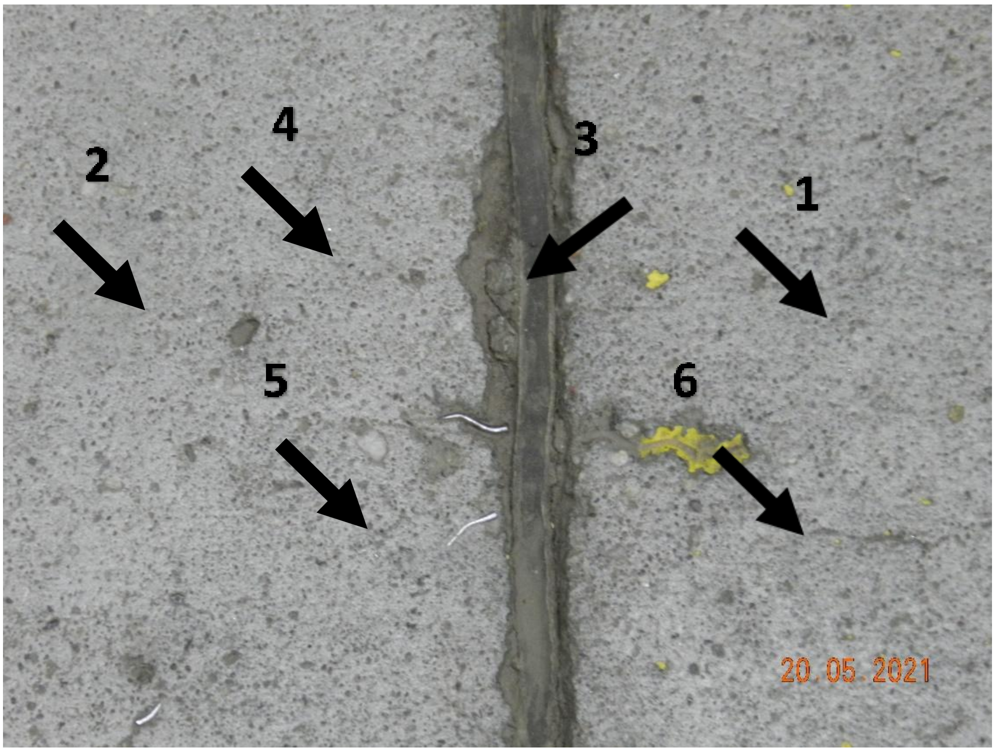

Fig.1. *Visible signs of wear on the top layer of the floor and the filling of the shrinkage joint (description of markings in the text)*

The fastest wear in concrete industrial floors is on coatings and surface coverings such as waxes, acrylics or paints, as well as thin-coat solutions of synthetic ryes applied by painting techniques [40÷49]. Fig.1 shows the stages of floor wear. Marked are: 1) abrasion and wear of the top layer of the floor, 2) aggregate losses, 3) separation of the joint compound, 4) chipping of the joint edges, 5) reinforcement fibers visible after rubbing the top layer, 6) micro-scratches in the structure of the concrete.

When the protective layer of a concrete floor wears away, the process of degradation of the visible concrete surface begins with spalling and leaching of the aggregate-binding binder in the concrete substrate. This results in roughening and dusting of the pavement, followed by the exposure of more and more aggregate grains. As this process progresses, localized damage such as chipping of the surface layer, cracking and spalling becomes more common [15÷22], [58÷61].

If DST technology is used to finish a concrete industrial floor, i.e., a surface hardener is rubbed into its face, the degradation process will be delayed because after the protective coatings are wiped off, it is the hardened layer that will wear and wipe away, so to speak, protecting the concrete floor from deterioration [40], [48], [51÷52]. If proper maintenance service consisting of periodic washing and protection of floors with impregnating agents is omitted at the stage of operation, local abrasion, increased dusting cavities and scratches in the face of the floor can be noticed already after several years [27÷32].

When the first signs of wear on the hardened layer are noticed, it may make sense to refinish the face of the floor in order to inhibit the degradation process, as well as to increase its strength by chemically hardening the concrete [33]. A refreshed, strengthened and protected floor will be able to serve without fail for years to come. Failure to take renovation measures at an early stage of industrial floor degradation, always leads to endless, costly repairs. Renovation and repair measures are necessary to maintain performance, regardless of the floor's construction technology and finish [23÷24].

It should be borne in mind that a matter of great importance is the difference between the renovation of the floor face after several periods of use, and the repair of the floor itself [36÷39].

Renovation of the floor face is used to level the top layer, remove old finish coatings, re-impregnate it and/or protect it with protective coatings. The purpose of the measures taken is the chemical strengthening of the floor face, which leads to: restoration or improvement of the original performance, reduction of wear and tear (scuffing) of the pavement and overall improvement of aesthetics.

Repairs to industrial floors, on the other hand, include the repair of primary damages and defects created during the construction stage and during the warranty period, as well as defects and secondary defects created during the long-term use of the pavement. The basic methods of repairing industrial floors include activities including injection and crack stitching, partial replacements of all or parts of the floor, surface repairs and replenishment of defects through the use of specialized repair technologies and materials, as well as the laying of new protective coatings [57÷60].

3 Ways to renovate and repair concrete industrial floors

The technology for the renovation of an industrial floor includes several key stages usually carried out in the following order: repair of expansion joints (I), filling of cavities (II), grinding and polishing of the surface (III), and finally its protection in the process of impregnating the concrete (IV).

I. Expansion joints in floor slabs are extremely important because they help in compensating for movements caused by temperature and load changes. The process of repairing expansion joints includes [34÷35]:

- assessing the condition of structural, contraction and perimeter expansion joints and determining the extent of damage,
- in the case of shrinkage expansion joints, removing the old fill, cleaning the joints of dust, dirt and other contaminants to ensure good adhesion of the newly installed fill, as well as the application of new expansion material resistant to the conditions of the facility,
- in the case of structural expansion joints (working seams) dowel joints, the course of action is the same as in the case of contraction joints. Prefabricated steel structural expansion joints are individually evaluated for wear. In the case of significant mechanical damage, the part placed in the face of the floor is replaced without removing the dowel part embedded below. In more complicated cases or in the case of reconstruction of the object, a decision may be made to completely forge the expansion joint and make a new element.

II. Repairing defects in concrete flooring is necessary to restore its evenness, functionality and appearance. The process begins with the removal of loose fragments of concrete and thorough cleaning of the areas of cavities that have formed. Most commonly, cement-based, less commonly polymer-cement-based compounds are used to fill cavities [22]. To ensure good adhesion of the repair mass, the repaired areas should be moistened with water or primed with suitable agents. The defects are filled with a repair compound, appropriately selected for the type of concrete and operating conditions [40÷46]. Depending on the size and depth of the defects, the mass is applied in layers, carefully compacting each layer. Finally, the repaired areas are leveled and smoothed so that they are level with the surrounding surface.

III. The process of grinding and polishing an industrial floor begins with preliminary grinding, which removes unevenness, old coatings and other defects. This is done using coarse diamond grinding discs. It then proceeds to the next grinding stages, gradually reducing the gradation of the diamond discs to smooth the surface and remove shallow scratches. Once sanding is complete, polishing is proceeded with diamond polishing discs of increasing gradation until the desired level of shine is achieved. Final polishing is carried out with natural bristle discs and appropriate polishing agents to achieve a smooth, shiny floor surface. Depending on the methodology adopted, the grinding process can be enriched with the application of silicate composite-based preparations, which permanently strengthen the concrete by chemical reaction with free calcium hydroxide [57÷60].

IV. Impregnation of concrete is a key step that ensures long-term protection of the floor [45÷46]. The process of impregnating concrete begins with a thorough vacuuming and cleaning the floor to remove dust and other contaminants. The impregnant is then applied to the concrete surface using a microfiber mop or spray. The impregnant, usually silicate-based, deeply penetrates the concrete, reacts with calcium hydroxide, and over time forms a hard and compact structure. After the impregnator dries, the floor is polished again to give the effect of a smooth, shiny surface. Thanks to the impregnation, the floor becomes more resistant to stains, abrasion and liquid penetration.

The technology for renovating an industrial concrete floor includes comprehensive measures that restore its functionality, durability and aesthetics. Each step, from repairing expansion joints and cavities, to grinding and polishing, to impregnating the concrete, is necessary to achieve the best end result - a high state of technical efficiency.

4 Examples of selection of technical and technological solutions for renovation of concrete industrial floors

Below are case descriptions of concrete industrial floors that have not been subjected to periodic maintenance and protection during years of operation and protection. Various methods of restoration of concrete floors are presented, adapted to the extent of their damage and the intended use of the facilities in which they were built.

4.1 Example 1

Example 1 is a description of the process of renovation of an old floor, damaged and deteriorated during many years of use, in the state after dismantling the steel plates that make up the top usable layer of the slab, as well as the platform for machinery and equipment (Fig.2).

a) b)

Fig.2. *Concrete industrial floor (Example 1) before repair: a), b) after removal of steel plates, visible rust mashing and discoloration on the upper surface of the floor*

The repair site required removal of the steel plates and grinding and polishing of the floor to level it and make it suitable for medium load and forklift traffic conditions [25].

At this point, it is worth mentioning that the parameters classifying the loads on floors are characterized in the standards for static and dynamic variable loads [53-56], but they apply only to the values of nominal loads and safety coefficients, without taking into account, as in the case of road pavements, the traffic category (KR1-KR7), reflecting the frequency of occurrence of loads. In the case of industrial floors, the assessment and qualification of the frequency of impact of dynamic loads, which has a direct impact on, among other things, the durability of protective coatings, as well as technological and material aspects including consideration of aspects related to fatigue of the slab structure and substructure; is up to the discretion of the designer. When analyzing the dynamic loads, special attention should be paid to the type of means of transport (forklifts, pallet trucks, special trucks), the type of wheels (pneumatic, rubber, elastomeric, steel), as well as their spacing and contact surface with the floor. Analysis of the contact stresses on the concrete floor depending on the type of vehicle tires shows that, with the same loads, the highest stresses, and thus having the most destructive effect on the floor, are caused by steel and polyamide wheels, followed by solid rubber wheels. The least influence is exerted by pneumatic (pumped) wheels. The difference between the extreme cases exceeds a hundredfold, so it can be said with certainty that this is a very important factor with a significant impact on the durability of the industrial floor.

a) b)


Fig.3. *Concrete industrial floor (Example 1) before repair: a), b) walkways*

Particularly degraded areas were located in the main passageways (Fig.3). In the first stage, machinery and equipment eating into the facility were dismantled, followed by the removal of coverings in the floors in the form of steel plates. An inventory of anchors and cavities in the pavement was made. The anchors were then removed, and the cavities were repaired using a mineral system by filling with mineral compounds and smoothing (Fig.4).

a) b)


Fig.4. *Concrete industrial floor (Example 1) filling of defects: a), preparation of work area b) filling of work area with repair compound*

In the next step, coarse grinding was performed in three steps, successively with metal segments of gradation: 30÷40, 60÷80 and, in the third step, with metal segments of 120÷140 gradation. This was followed by obliteration of surface cracks, using plastic diamond pads of 50 gradation. The floor was washed, vacuumed and impregnated with lithium silicate-based agents.

a)

b)

c)

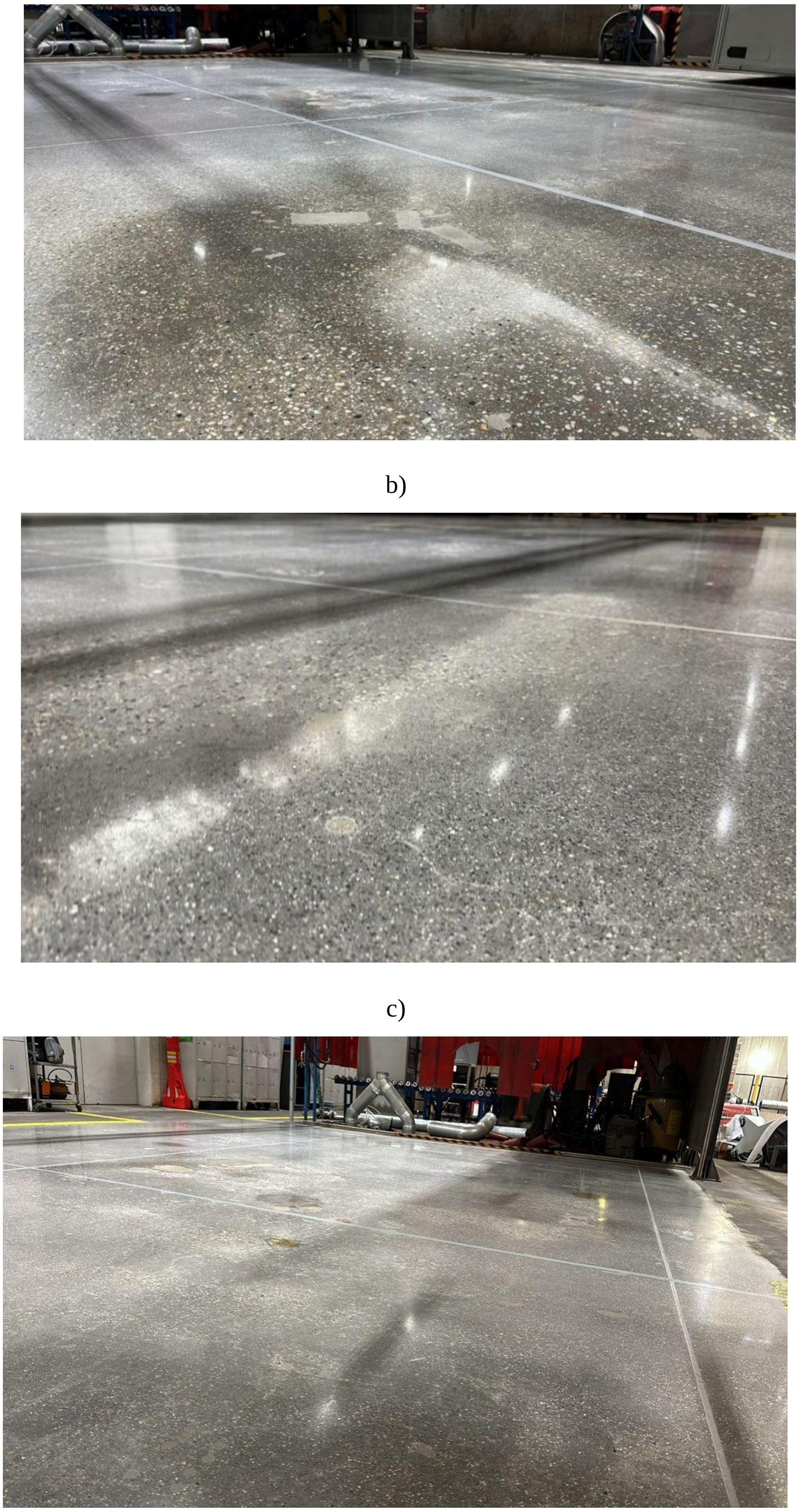

Fig.5. *Concrete industrial floor (Example 1) after repair: a) view of shiny surface and expansion joint fillings, b), c) view of filled cavities and filled expansion joints*

For the final polishing of the floor, diamond pads of gradation successively were used: 100 and 200. The floor was washed and cleaned of any residual dust from grinding. A polymer-based sealer was applied to the floor to give it the desired performance characteristics. The application of the protective preparation was done using the spray method. After it dried, polishing was proceeded with a white polishing pad using a high-speed polisher, and the gaps were filled with expansion joint compounds.

After repair and renovation (Fig.5), the floor gained not only an aesthetic appearance, but also evenness. Before the renovation, the local unevenness measured according to [50] was 9÷11 mm on a 2 m patch, after the renovation it was 3 mm / 2 m, which corresponds to the increased performance standard of 5 mm / 2 m according to [50]. The smoothness of the surface implied as the degree of light reflection by the matte floor before renovation was estimated at ÷5÷15%, after renovation more than 70%, where 100% light reflection occurs on mirrored surfaces. Naturally, this was also influenced by the removal of local dirt. The floor also gained increased abrasion resistance, which before renovation was classified as Ar2 [52], while after renovation as the highest abrasion resistance class Ar0.5 [52]. Abrasion tests were performed using the BCA method [21]. 45Visible signs of quality improvement also include a reduction in the floor's dustiness, as well as a 45% reduction in its water absorption [45].

4.2 Example 2

Example 2 is a description of a floor renovation at an early stage of operation. The floor in question was made without consideration of technical and technological aspects in very difficult realization conditions.

Fig.6. *Concrete industrial floor (Example 2) before renovation: arrows indicate cold joints*

During the execution of the floor, the hall was subject to temperatures exceeding 35°C and drafts. As a result, so-called cold joints formed on the floor surface, the floor was not fully rubbed to a smooth surface (Fig.5). After a period of only a few months of operation due to problems with cleaning, washing and aesthetic properties of the pavement, a decision was made to renovate the pavement in order to improve the overall aesthetics but also to restore it to a condition that would allow normal exploration, including carrying out periodic cleaning work.

a)

b)

Fig.7. *Concrete industrial floor (Example 2) after regeneration by polishing and impregnation process: a), b) view of pavement treatment in the area of structural expansion joints*

Due to the low level of wear and tear from use, the grinding process omitted the use of metal pads, and the entire restoration process began with grinding with plastic diamond discs with a gradation of 50 in order to perform the so-called “honeying.” The floor was then reinforced with a silicate composite-based impregnant and final grinding was performed with discs of 100 and 200 gradation, which increased its resistance to abrasion and intensive cleaning (Fig.7).

5 Conclusions

Based on the information in the scientific and technical literature, technical literature, and taking into account our own experience, the following observations can be made:

- each floor should be considered individually, as there is no single effective method of repair and renovation, and the selection of renovation technology, including chemicals and tools should always be preceded by a detailed inventory and analysis of the existing condition of the floor,
- very good results in the restoration work of industrial floors, especially floors with a top layer of DST sprinkles, are obtained by using grinding and polishing technology with segments and pads,
- when using this technology, the key issue is the selection of appropriate tools, i.e. the cleaning machines themselves, as well as the segments and pads, which should be carried out on the basis of a test plot.

6 Final Conclusions

Renovation and secondary maintenance of concrete industrial floors is key to maintaining their functionality and extending their life. Regular inspections and systematic repairs allow for early detection and repair of minor damage before it develops into major problems that can lead to costly downtime and shutdowns. Maintenance, including cleaning and waterproofing, increase the protection of the concrete floor's face against harmful operating factors, such as intense abrasion and mechanical loads caused by the movement of transportation equipment.

Renovation of concrete industrial floors using concrete grinding technology improves their appearance, which is important not only aesthetically but also functional, as clean and floors reflect light and brighten up the interior, as well as reduce the risk of slips and falls.

Keeping concrete floors in a state of high maintenance translates into lower operating costs, as costly repairs are avoided.

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[54] PN-82/B-02004 Obciążenia budowli – Obciążenia zmienne technologiczne – Obciążenia pojazdami.

[55] PN-EN 1991-1-1 Eurokod 1 Oddziaływania na konstrukcje. Część 1-1: Oddziaływania ogólne. Ciężar objętościowy, ciężar własny, obciążenia użytkowe w budynkach.

[56] PN-EN 1991-1-1 – cz. II, Zestawianie obciążeń zmiennych.

[57] Techniczne materiały informacyjne firmy FAMAR Fabian Rudziak, www.centrum-famar.com.pl

[58] Techniczne materiały informacyjne firmy Bautech sp., z o.o. www.bautech.pl

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