Guidelines

for the

Manufacturing of ceramic floor coverings

using the vibration process

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0 Foreword

The vibration process represents a modified way of laying tiles in thick beds, which was introduced at the end of the 1960s. In contrast to screeds, standard regulations – both for the process as well as for the bedding mortar – do not exist up to the present day. With the aim of developing this process further and enhancing quality, the **Arbeitskreis Qualitätssicherung Rüttelbeläge (AKQR)** was founded in 1989. The first principle examinations and application-technical tests were carried out by this working committee. Thus the first guideline specially for the vibration laying of ceramic tiles and slabs resulted in 1993. The AKQR guidelines are based on material-technological and processing-related test runs and findings derived from these tests as well as systematically analyzed practical experience in manufacturing floor coverings using the vibration process. New building materials, file formats or methods are only incorporated in the regulations after extensive laboratory and construction site testing.

Continuous testing and development serves for further optimization of the process and substantiates the high quality standard. This meanwhile fourth edition of the AKQR guidelines represents the state of the art and applies as a definitive information sheet among relevant experts. The essential properties and requirement criteria are summarized in these regulations.

1 Scope

The AKQR guidelines describe the vibration process for manufacturing mechanically resistant heavy-duty ceramic floor coverings especially for commercial and industrial areas. Typical applications here are floor coverings in shopping centres, DIY stores, bakeries, car workshops as well as industrial and exhibition halls.

The instructions provided in these guidelines serve as a basis for planning and laying.

2 Brief description of the process

For the vibration process the ceramic tiles are laid in a fresh cement-mortar bed with a contact layer (cement laitance, cement powdering with prewetting, adhesive mud, etc.) and patted/shaken-in mechanically using surface rollers (vibrating boards or roller vibrators). The even and intensive compaction enables a floor covering with a layered structure that combines ceramic covering materials, the contact layer and the ballast mortar in a compact unit. This involves a further development of the thick-bed laying process, which – in contrast to conventional mortar bed laying procedure – enables ceramic tiles to be shaken-in mechanically. The vibrating process in combination with a generous

bedding of the floor covering materials also ensures a rational and improved laying process as compared to the conventional processing procedure involving manually tamping in the tiles.

Due to their comparably high bending and pressure resistance, the ceramic tiles and slabs provide a load spreading function that enables the compensation of loads and forces acting on the covering surface by transferring such impacts at a reduced level to the ballast mortar.

Due to the load-spreading effect of the tiles laid using the vibration process, the indirect and reduced load impacting the ballast mortar has a positive effect on the load bearing performance. This effect is taken into account for the defined requirements in respect to the strengths of the bedding mortar.

3 Supporting substrate

The substructure must be stable, able to support loads, sufficiently dry, free of throughout cracks, contamination and loose components.

Its evenness must comply with the DIN 18202 standard.

Rooms exposed to moisture stress must be sealed against ground humidity and/or non-pressure water. Reference is made to DIN 18195. Thermal and sound insulation measures according to DIN 4108 and/or DIN 4109 must be provided for, as the case may be.

Required slopes for draining liquids must already be provided for and required in the load-bearing substructure.

As a general rule, a slope of around 1 to 2 % must be assumed for tiles with an even surface finish. Higher surface slopes can be required for moulded, structured or rough surface finishes. The slope arrangement is to be specified by the planner and coordinated with the implementing company.

4 Mortar composition

Earth-moist mortar mixtures containing sand, gravel, cement and water that serve to extend the processing time and ensuring proper processing characteristics using additives, like retarding agents and plasticizers are normally used for the vibration process. The mortar mixtures are produced according to special recipes on the construction site (mechanical mixers, screeding machine, silo) or delivered by transport concrete plants.

The recipes are based on the research, laboratory results and construction site experience evaluated in the working com-

mittee (AKQR). They are refined and adapted continually.

Suitable common cements CEM I or CEM II according to DIN EN 197-1 must be used as binding agents. Only aggregates compliant with DIN EN 12620 and DIN EN 13139 may be used.

5 Floor covering materials

In general, the following floor covering materials should be used:

- Dry-pressed ceramic tiles according to DIN EN 14411
  - Group BI_a (annex G)
  - Group BI_b (annex H)
- Floor clinker tiles compliant with DIN 18158

In order to fulfil the high quality requirements of these guidelines for evenness of the finished covering, the requirements must be adapted to the evenness of the covering materials. In contrast to the above standards, compliance with lower tolerances is required for the edge curvature and warpage ± 0.25 % are admissible in relation to the edge length and diagonal or maximum ± 0.8 mm.

The tiles can exhibit in square, rectangular or hexagonal shape and should generally not exceed an edge length of 30 cm and/or a format area of 900 cm².

If the process is adapted, it is also possible to lay tiles in the format of 20 cm x 40 cm, 40 cm x 40 cm or 30 cm x 60 cm.

The thickness of the ceramic tiles is of critical importance for the mechanical resistance to static and dynamic loads. In addition to the material's own strengths, a higher thickness supports the resistance to the effects of rolling and impact loads and increases the load limit designated as "breaking load" for the assessment of the load capacity. The thickness must be minimum 14 mm.

For ceramic floor covers exposed to high loads, the breaking load of the deployed ceramic tiles should be aligned to the respective load conditions but in any case amount to at least 3,000 N.

6 Building site requirements

Work may only be performed if the temperatures of the substrate, the materials to be used and the work area are not less than + 5 °C.

Harmful effects, like e.g. caused by rain, draught or sunlight must be avoided.

7 Processing and laying instructions

General

The vibration process has been developed specially against the background of

a rational production of floor coverings subject to high mechanical loads. In this way, a high laying performance is attained by convenient tile formats that are arranged "close-packed" to one another. Over the course of time, the aesthetic requirements in respect to the appearance of floor coverings used commercially have changed and hence also the tiles have changed to larger formats. The significantly greater weight and more difficult to handle format mean the laying performance is reduced. The expense also increases for aligning the tiles. This leads to increased working, cost and time expenditure and must be considered specially when planing and creating vibration floors.

Thickness of the mortar bed

Ceramically covered surface covers can be laid by bonding them directly to the supporting substructure, as well as on separating or insulating layers.

The minimum thickness of the bedding mortar layers for the following coverings is:

in compound layers 40 mm,
on separating layers 65 mm,
on insulating layers 85 mm.

In case of higher loads, a structural calculation to define the thickness of the bedding mortar layer can especially be required for coverings with insulating layers.

Compound installation

In case of compound layers, the substrate surface must provide a sufficient strength. Bonding agent accumulations, impurities and dusts must be removed by corresponding measures before introducing the bedding mortar. The substrate must be prewetted with bonding compound (premixed or self-mixed), if required.

Any creep and shrinkage of the supporting substrate should be mostly completed when using this procedure. This usually takes about six months for concrete.

Separating layers

Coverings laid on separating layers (e. g. PE-foil, min. 0.2 mm) must generally be double-layered. Existing sealings and vapour barriers can be considered as one of the layers in this regard. The individual layers of the separating layer should be laid even and without elevations.

Insulating layers

In order to perform insulating layers, the insulating materials must be laid tightly joined. The insulating boards must be braced and attached firmly and completely to the substrate (if necessary bonded). In case of multi-layered insula-

tion layers, the joints must be arranged shifted against each other.

The insulating layer must be suitable for the expected load and the compressibility must not be greater than 3 mm, even in case of multiple layers.

Reinforcements

When laying on separating or insulating layers, the underlay can be equipped with a reinforcement consisting of a construction steel grid or reinforcing steel meshes. The reinforcing steel meshes must be laid with sufficient overlap at the edges. Movement joints must not be covered by the reinforcement.

The reinforcement, which is generally installed in the middle of the bedding mortar's cross-section, has no structural function and does not prevent crack formation. It can however reduce their width and the occurrence of height offsets.

A fibre-based reinforcement can reduce the formation of early shrinkage cracks.

A reduction of the required minimum strengths and thicknesses in relation to the use of reinforcements is inadmissible.

Mortar strengths

The strength of the cured bedding mortar must at least correspond to the following strength categories (designation analogous to DIN EN 13813), depending on design:

- compound installation
  compressive strength class C16
- on separating layers
  compressive/flexural strength class C16/F3
- on insulating layers
  compressive/flexural strength class C25/F4

Processing

Bedding mortars for the vibrating process can be mixed by the manufacturer or at the building site by using a mechanical mixer, etc.

Bedding mortar can generally be laid in an earth-moist consistency.

The bedding mortar is pre-compacted and levelled horizontally or with the required slope.

Contact layer

The mortar surface is covered by a cement contact layer (powdering) or with cement laitance and/or adhesive slurry (premixed or mixed on-site). Cement-powdering requires subsequent wetting. Adhesive slurries should be used when laying tiles with larger formats (e.g. 30 cm x 60 cm).

Tile laying

The tiles are laid into the fresh contact layer.

The laying is generally carried out in combination with narrow-spaced joint network (close-packed). Laying with a joint layout and/or jointing pattern or on cross joints is admissible with greater expense. Tiles of the format 30 cm x 60 cm should not be laid in half-bond.

Vibration process

The compaction of the bedding mortar and vibration of the tiles and slabs is performed without delay using a surface vibrator (vibrating board or roller vibrator) by moving repeatedly over the surface in criss-cross patterns.

The processing time of bedding mortar including the mixing, prestorage, casting and vibrating times has an impact on substantial material and processing specifications, such as compacting, mortar strength, contact surface and adhesiveness. The processing time should not exceed 5 hours.

Jointing

The covering surfaces are usually jointed with pure cement or a jointing material consisting of quartz sand and cement. Ready mixtures or other jointing materials are possible.

Surplus jointing material or residual adhesions must be removed.

8 Movement joints

Movement joints are installed in order to enable a deformation of the covering structure, e. g. due to shrinkage, temperature effects and loads.

Differentiation is made between the following joints:

- building expansion joints
- perimeter and/or connection joints
- screed movement joints

Movement joints in the vibration floor above building expansion joints must be provided at the same position and at least with the same width as in the load-bearing structure.

Movement joints must be provided for at wall connections, pillars, supports as well as fixed built-in parts, components penetrating the floor, in door openings and offsets in the floor plan.

Screed movement joints must be designed under considerations of static and geometrical aspects so as to enable field sizes of a preferably compact (square-type) format. The edge ratio should not exceed a value of 1: 1.5 as a standard.

In addition to the respective structural requirements and functional specifications, the structural design defines the layout of

movement joints for the size limitation of covering surfaces.

Floor coverings produced using the vibration process can be installed in combination with a load-bearing substructure and/or intermediate layers consisting of separating or insulating layers.

Compound floor coverings are connected force-locked and shear-resistantly with the substructure. Substructure deformations, e. g. due to creepage or shrinkage cannot be compensated by installing movement joints in the vibration covering.

Coverings on separating and insulating layers require a separation into partial surfaces in order to compensate expected shape variations. As a standard, movement joints can be provided for with a spacing of 8 to 12 m for defining joint spacings and field sizes.

Movement joints in traffic areas must be minimized. Depending on the load, the upper tile edges should be protected with flush-mounted metal or plastic profiles or similar measures.

Joints filled with resilient joint-sealants require maintenance depending on the expected strain.

When using box profiles, cracks forming between the sections and the adjacent ceramic floor covering can occur for construction-related reasons.

Complete uncut tiles and slabs should be used along movement joints above expansion joints as well as screed movement joints in junction areas to the ceramic floor covering.

Movement joints must be formed as far as onto the supporting substrate, but not less than over ¾ of the construction height.

The joint arrangement is to be specified by the planner and coordinated with the implementing company.

9 Commissioning after completion

The covering surfaces should not be commissioned before the bedding and jointing mortars have cured sufficiently. The curing speed also depends on the temperature. The following can apply as guide values for commissioning: Can be walked over after 7 days, full mechanical load after 28 days have passed.

10 Cleaning

Considering the local installation and load conditions, cement residuals from the jointing process, mineral deposits and subsequent efflorescences on the ceramic floor coverings cannot be excluded. The use of acidic cleaning agents is recommended both for the removal of such

residuals and the basic cleaning to be performed.

The use of acidic cleaning agents can result in a chemical stress of cementitious building materials. In order to minimize the strain, the covering surfaces must be wetted prior to the use of acidic cleaning agents. The manufacturer's recommendations and instructions must be observed when using these agents.

11 Special considerations

New floor coverings must be sufficiently protected against weather impacts, like rain, frost or high temperatures through corresponding measures.

12 Quality assurance

Specialist companies that are members of the AKQR guarantee that the performed works meet the requirements specified above and consider the present guidelines for the vibration process.

The member companies of the AKQR (laying companies and manufacturers) are subjected to a regular quality control. The quality control is performed according to national, European and international standards (DIN / DIN EN / DIN EN ISO) as well as technical requirements for building materials, processing and application.

The acceptance of the surface coverings is performed by the client shortly after the completion at reasonable vertical illumination without side/strip lighting.

Sided light can make uneven spots in the surface of ceramic coverings as well as height differences between adjacent tiles (irregular edges) visible. The compaction type related to the vibration process ensures a consistent finishing accuracy that limits height differences between adjacent tiles and slabs. In general, 1.3 mm maximum is permissible.

In the case of larger tile formats – due to the edge length – height differences up to 1.6 mm are admissible.

The evaluation of the evenness of ceramic surface coverings is subject to the dimensional tolerances specified by the DIN 18202 standard. The surface quality depends on the workmanship and the dimensional accuracy of the ceramic material.

The vibration process may lead to joints of the ceramic surface not always running thoroughly linear. The installation of ceramic surfaces on a narrow joint mesh can also lead to admissible dimensional deviations even in case of standard-compliant tiles that can only be compensated to a limited extent by the covering surface

joints. Shifts of the jointing pattern can therefore not be excluded.

When tamping down surfaces with metallic objects, an absolutely consistent sound pattern of large areas of ceramic covers cannot be expected. This type of measure prevent generally applicable statements regarding the strength characteristics or bonding performance of a covering system.

Audibly perceptible differences in the acoustic performance of individual tiles cannot be considered as defective workmanship, as the suitability of the intended purpose of a covering surface is dependent on its overall load-bearing capacity. Individual hollow-sounding spots do not necessarily impair the functionality or durability of the ceramic flooring.

In case of strength assessments of floors installed using the vibration process, such checks must be performed as verification checks. The samples taken from the building site are deemed to comply with the strength classes mentioned in section 7, if the average measuring values amount to at least 70 % and the lowest individual value amounts to at least 60 % of the nominal strength.

Ceramic floor coverings commissioned and used for transport equipment are subject to load-independent pressings mainly influenced by the selected type of tyre material.[1)]

Therefore the use of transport equipment with e. g. solid rubber or pneumatic tyres is recommended. While transport equipment with plastic wheels can be used, it increases the risk of damage in proportion to an increasing hardness of the tyres. Rolls and wheels made of polyurethane are to be preferred to polyamide wheels. Metallic wheels are inadmissible.

13 Quoted standards and publications

DIN 4108
"Thermal insulation in buildings"

DIN 4109
"Sound insulation in buildings"

DIN 18158
"Clinker floor tiles"

DIN 18195
"Water-proofing of buildings"

DIN 18202
"Tolerances in building construction"

DIN EN 197-1
"Cement – Part 1: Composition, specifications and conformity criteria for common cements"

DIN EN 12620
"Aggregates for concrete"

DIN EN 13139
"Aggregates for mortar"

DIN EN 13813
"Screed material and floor screeds – Screed materials – Properties and requirements"

DIN EN 14411
"Ceramic tiles –
Definitions, classification, characteristics, evaluation of conformity and marking"

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1) "The mechanical load of industrial screed floors induced by transport equipment"
F. Beisteiner und E. Maisch, Stuttgart,
fördern und heben 25. Jg. (1975) No. 17

The following sections have been amended and/or modified as compared to the Guidelines for Workmanship issued in August 2010:

0, 1, 2, 3, 4, 5, 7, 8, 12 and 13.

These guidelines are available from:

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