

# MANUAL FOR TILER

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## 1. Introduction

### 1.1. Information about the IPCIC project

The main objective of the project was to improve education in the field of construction, in line with new legal regulations and construction sector trends. To achieve that goal, training system was prepared. It contains knowledge necessary for the finishing works specialists and tutors (mentors), with particular emphasis on efficiency of work and quality of education, H&S regulations, and soft skills. The main subjects are: drywall fitter, plumber and tiler. Project also helps to improve mobility of construction personnel, due to its international content (presentation of practices from participating countries) and multi-language form (materials prepared in EN, PL, LT and IT and help users to learn vocabulary specific for finishing works). The project complies with EQAVET requirements and it is foreseen that it should increase quality of didactic process for construction workers education including CPD. The objectives of the project include promotion and improvement of cooperation between construction industry and VET providers, including WBL scheme (that is why one of the partners in the project is a construction company). The partnership was established to ensure the best quality of results. It consists of VET organizations from Italy, Lithuania, and Poland (Centro Edile A. Palladio; Viesoji Istaiga Vilniaus Statybininku Rengimo Centras; Centrum Kształcenia Zawodowego i Ustawicznego Nr 1 in Warsaw), construction company (ERBUDS.A.), professional association (Polish Association of Building Managers - the Project Promoter) and university (Civil Engineering Faculty of Warsaw University of Technology). Target groups of the project are: young people, participants of CPD courses, young technicians, construction workers (also those who would like to retrain), stakeholders and associations in the construction sector, SMEs and companies (construction sector); providers of future courses: vocational schools, technical schools (primary and secondary - depending on the national systems terminology); VET providers, teachers, mentors; construction companies (training departments). 5 intellectual outputs were prepared: courses programmes, courses methodology, didactic materials, movie materials, materials for teachers training. All the results were presented and tested during multiplier events.

### 1.2. General information about the profession

Tiler specialist is a very important profession related to finishing works. The profession deals with fitting of various tiles (ceramic, stone, etc.) at various surfaces (brick, concrete, etc.) with use of various technologies and machineries

People who like mathematics, who are agile, have well-developed hand-motor skills, can become great tilers.

The profession of tiler is in demand in the labour market. It originated in the old times, when man wanted to decorate his dwellings, temples, environment. Ancient examples of tiling have survived to the present day.

During the modern market development, the desire of people to improve their working and living conditions and beautify the environment is constantly increasing. Gorgeous, modern interiors are created in public and private buildings. The tiling of exterior and partition structures with various types of tiles plays an important role in the finishing of buildings.

The ability to use tiles in different spaces and for different purposes requires a wide range of professional knowledge from a tiler.

In addition to professional skills and abilities, a tiler will benefit greatly from personal qualities such as patience and physical endurance. Good eyesight, movement coordination, artistic taste and

spatial thinking, ability to distinguish colour shades, ability to perform the same actions over time, accuracy, organization, communication and stress resistance.

Tiling is performed in different spaces: flats, homes, supermarkets, offices, shops, sanitary facilities, swimming pools and other types of premises, which require improved resistance to various operating conditions. Surface tiling include various tiles such as: ceramic, mosaic, clinker, stone, marble, granite, artificial stone and others, also surface preparation and waterproofing materials, tile adhesives, joint fillers, tile care products. The tiler must know the basic properties of the finishing materials and take advantage of them.

The tiler also uses a wide variety of tools: hand and electric tile cutting machines, various types of spatulas, levels, mixers, measuring tools.

In the very beginning, the tiler prepares a room, cleans it, and checks the smoothness of the surfaces. The second stage is surface preparation: plastering or levelling, priming, waterproofing. Next, tiling on the prepared base, grouting the joints. When all work has been completed, the tiler must clean a room, tools and dust from tiles.

### 1.3. The specifics of future work

A person that is qualified as a tiler will be able to work in construction companies or carry out individual activities.

Working conditions: the activity involves manual, physical work, most often indoors. Due to the specifics of the work, the employee is provided with special clothing.

In its activities, the tiler follows the requirements of work safety and health, ergonomics, work hygiene, fire safety, electrical safety, environmental protection and principles of sustainable construction.

In order to be able to perform tiling properly, the tiler has:

- to know the materials used for tiling, their characteristics;
- to be able to select materials for their purpose and prepare them;
- to know the organization scheme of tiling work, know the solutions;
- to know technological process of tiling of various surfaces and to be able to apply it in practical work;
- to be able to calculate the required quantities of materials;
- to be able to work safely.

The tiler knows how to plan his work according to the given tasks, to use various materials and tools, applying known and tested solutions, using drawings, specifications.

### 1.4. Learning outcomes

Tiler 's qualification is awarded to persons having all the competencies listed in the curriculum. The person's competencies required for gaining a qualification are assessed in accordance with the definitions of the competencies and their limits provided in the Occupational Standard of a Tiler, which express the threshold (minimum) level of acquisition of competence.

Learning outcomes to be achieved upon completion of the course:

1. To know and apply health and safety requirements for tiling of vertical and horizontal surfaces;
2. To describe the preparation of the working place for vertical and horizontal surfaces tiling;
3. To describe the materials for vertical and horizontal surfaces tiling;

4. To list the tools and equipment for vertical and horizontal surface tiling, describe their purpose;
5. To describe the preparation of vertical and horizontal surface for tiling;
6. To describe vertical and horizontal tiling technologies;
7. To prepare working area for vertical and horizontal tiling;
8. To prepare the surface of vertical and horizontal constructions for tiling;
9. To glue tiles on vertical and horizontal surfaces;
10. To fill in the joints of vertical and horizontal tiling;
11. To repair the vertical and horizontal surface tiling.

## 2. Legal aspects of the profession

### 2.1. Occupational Health and Safety

#### 2.1.1. Coaching of employees

The employer, taking people to work and periodically, organizes all the staff coaching, training, certification of occupational safety and health issues.

The company conducts these briefings:

- Introductory;
- primary in the workplace;
- periodic in the workplace; additional in the workplace;
- special in the workplace.



Fig. 2.1. Picture of an employer-leader [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

All employees, before starting work for a company participate in the mandatory introductory coaching. Information about its conduction is registered in the introductory briefing log. There must be one such record book in the company. Briefings are led by the company occupational safety and health professional or the person performing these functions in accordance with the approved introductory instruction manual. The record book for introductory coaching is kept in the company for 75 years after the last entry.

Before starting work in the company initial coaching must be heard by employees whose activities are related to hazardous, noxious or with the degree of risk factors.

Initial coaching is mandatory for employees on a permanent basis as well as for posted or temporary appointed employees. Each employee is individually instructed in accordance with a prepared and approved instruction for workplace briefing. The briefing is registered in the workplace briefing record book.

Periodic workplace coaching shall be provided at least once every twelve months. It shall be recorded in the same record book of workplace coaching.

Additional workplace coaching is leaded for the following reasons:

- changes in technological processes;
- the adoption of new regulatory documents;
- when the employee violates safety and health requirements;
- in the event of an accident;
- employee has not been at work for more than sixty calendar days.



Additional coaching shall be recorded in the same record book of workplace coaching.

Special coaching must be listened to by staff working on accounts – permissions, or by staff assigned to a one-off task outside their main job.

Special coaching is formalized in your account - permission.

Additional and special briefing can be leaded without instruction.

Employees in the workplace are instructed by the head of department.

Instructions must be prepared and take effect before commissioning a company. These instructions must be prepared:

- Introductory instruction;
- instructions for workplace training.

Each instruction (except the introductory) must have a title and a number The instructions shall be registered in the records book of the company's occupational safety and health.

Head of department must have a set of instructions for all occupations (jobs) in that department.

### 2.1.2. Harmful factors in the work environment

Indoor air pollution is often caused by insufficient isolation of sources of pollution, leaking equipment and inadequate ventilation.

Industrial premises are polluted by:

- Dust (organic and inorganic);
- Physical harmful factors (ionizing radiation, vibration, noise, electromagnetic fields, high or low temperature, etc.);
- Toxic chemicals;
- Biological factors (viruses, bacteria, microorganisms);
- Physical factors (discomfort, monotony, weight lifting).



Fig. 2.2. Workplace accident [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

When workers are exposed to harmful, unsafe or risky factors at work, accidents and professional diseases are unavoidable.

### 2.1.3. Requirements for work environment and professional hygiene

The work environment is the part of the worker's immediate space where he may be exposed to harmful and hazardous factors. Meteorological environmental conditions (microclimate) include:

- thermal radiation;
- air temperature;
- relative humidity;

- air circulation speed;
- pressure.

These parameters are very important for working capacity, human heat metabolism, thermal balance of the organism.

The human body responds to a variety of stimuli: the duration of work operations, the effects of auditory, olfactory, visual and tactile organs.

Work is coordinated by the central nervous system through complex neurohumoral connections.

A person quickly gets tired of poorly organized work. The room temperature must be controlled so that its fluctuations do not affect the human body. The temperature in the workroom should not exceed 28° C. It is best to feel comfortable in light physical work when the air temperature is 16 – 20°C and in heavy physical work 10 – 15° C. In addition, it depends on the air circulation speed and air humidity. Effective temperature is the temperature that person feels at a given relative humidity without any movement of air.



Fig. 2.3. Tilers at work [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

Air humidity at workplaces is characterized by relative humidity. It is the ratio of absolute to maximum humidity under specific temperature conditions. The optimum relative humidity in the work should be 40 - 60%. High relative humidity at low temperatures can cause colds, whereas at high temperatures it may result in overheat. The permissible values for the microclimate parameters are mandatory and the optimal ones are recommended.

Permissible and optimal parameters for meteorological conditions are different, depending on the time of year and the difficulty of work.

**Ventilation of premises.** The premises must have natural and mechanical ventilation. Premises ventilated using air conditioning units - air conditioners.

**Workplace lighting.** Workplace lighting can be natural and artificial. Natural lighting: direct or diffused sunlight with varying intensity, depending on the time of year and day, cloudiness, geographical location. Structurally the natural lighting can be upper, lateral and mixed. Artificial lighting is created by electrical light sources. Three systems are available for workplace lighting: general, local, and mixed.

General lighting illuminates the room evenly, while local lighting provides lighting for a particular area. The most widely used is mixed lighting, which is a combination of general and local lighting. Only local lighting is prohibited. When using local lighting, the general lighting should be at least 10%. After starting up a newly built or reconstructed company, the employer must carry out a hygienic evaluation of the workplaces within 3 days at the latest. Hygiene testing is performed by laboratories of public health centres and other accredited laboratories. The evaluation is organized and financed

by the company. Harmful factors of the working environment are evaluated according to the indicators of work severity, stress and harmfulness defined in the hygienic classification of working conditions.

#### 2.1.4. Occupational diseases

Occupational disease is an employee health disorder due to a harmful working environment factor (or factors), which is assessed according to the hygienic classification of working conditions, taking into account compliance with hygiene standards and working hours.

Occupational diseases can be acute and chronic depending on the time of onset. Acute occupational disease (poisoning) is a sudden medical condition caused by a short work environment factor.

Chronic occupational disease (poisoning) is a medical condition caused by a work environment factor over a certain period of work.



Fig. 2.4. Basic protective wear [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

The causes of occupational diseases are investigated by territorial hygiene centres. Acute occupational diseases must be investigated within twenty-four hours.

A representative of the SLI, representatives of the employer and employees participate in the research.

The causes of the chronic illness shall be investigated and the hygienic characteristics of the working conditions shall be developed within fifteen working days. Research involves a representative of the SLI, a representative of the Public Health Centre, a doctor who has suspected of having the disease, and a representative of the employer and employees. Occupational diseases are determined according to the list of occupational diseases approved by the Ministry of Health. Occupational diseases are registered by the territorial hygiene centres in special registers of occupational diseases in accordance with the procedure established by the Ministry of Health.

Occupational diseases are divided into the following groups, depending on their causes:

- caused by chemical agents;
- caused by dust (aerosols);
- caused by biological agents;
- caused by physical agents;
- caused by tension.

### 2.1.5. Electrical hazards

The consequences of electrical damage to a human being depend on many factors: current frequency, type of current, impedance of all elements of the circuit, including the human body, current pathway in the human body, human condition, environmental conditions, heart working phase.

Flowing through the human body, the electric current can burn, damage body tissues, damage body tissues (electrolyze), disrupt biological and physiological processes, which can lead to paralysis of the respiratory and circulatory organs. All electrical injuries are divided into electrical injuries and electric shocks.

Electrical injuries (external injuries):

- burns:
  - Grade I (red skin);
  - Grade II (blistering);
  - Grade III (damaged skin tissue);
  - Grade IV (tissue charring);
- metallization of the skin;
- electric marks (scars);
- electro-ophthalmia;
- mechanical injury.

Electric shocks (Internal bodily injuries, convulsive muscle contractions):

- Grade I (convulsive muscle contraction with no loss of consciousness);
- Grade II (convulsive muscle contraction with loss of consciousness but cardiac and respiratory function);
- Grade III (loss of consciousness, cardiac and respiratory failure);
- Grade IV (clinical death).

Electric shock – a severe reaction in the body caused by an electric current. During this time, blood circulation and breathing are impaired. The shock can last from a few minutes to several days.



Fig. 2.5. Electrician's work [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

#### 2.1.6. Fire safety requirements

Manager (employer) is responsible for fire safety in the company. He must:

- organize training and certification of fire safety personnel matters;
- designate those responsible for the fire-fighting conditions of the work areas;
- provide and guarantee the availability of fire-fighting equipment for the object effectively used for extinguishing fires.



Fig. 2.6. Fire [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

#### Primary fire-fighting measures

One of the primary means of extinguishing a primary fire is fire extinguishers. The most popular are powder, water foam and gas (carbon dioxide) fire extinguishers. Powder extinguishers are filled with ABC, BC and D type powder. The type of powder depends on the class of fire that can be extinguished. In water-based foam extinguishers, foam is recovered when the water – foam mixture flows through a diffuser. Their disadvantage is that it is not possible to extinguish working electrical equipment.

Carbon dioxide fire extinguishers contain compressed gas that erupts through a diffuser extends and cools significantly. In addition to fire extinguishers, the primary extinguishing agents also include water, sand, soil, extinguishing fabrics.

#### 2.1.7. Safety requirements on the construction site

Construction is a type of activity that has many factors that can cause damage to safety and health of employees. The largest number of professional diseases is recorded in construction.

All employees of the company must be familiar with safe working methods – regardless of length of service, qualification, or nature of production. A person working on a construction site must wear work clothes, special footwear, a helmet and additional safety equipment depending on the type of work performed and the materials used.



Fig. 2.7. Workwear and protective gear [<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

Tilers must have undergone a health check and be trained to perform the work safely.

Tiling is not classified as hazardous work, but it is nevertheless necessary to adhere to safe working practices and not to endanger yourself or bystanders.

Apprentice must know instructions on safe work practices, the use of collective and personal protective equipment, the use of electrical appliances, fire safety and emergency procedures.

The use of tools, machines, workplace promotions and other equipment in a malfunctioning or improper use is prohibited.

The tiler has the right to:

- Require employers to provide safe and healthy working conditions;
- Equip collective and personal protective equipment;
- Refuse to work when health and life are at risk.

Before handling unfamiliar materials, it is essential to read the instructions for use and safety advice.

Many materials used for surface preparation and tile fixing contain cement, so care must be taken to avoid contact with the skin, inhalation of dust and, in particular, eye contact.

Special attention should be paid to the use of epoxy agents: good ventilation, use of absorbents, eye protection. Unmixed individual components and unhardened epoxy must not be disposed of with household waste containers as this may pose a risk to people and the environment.



Many tile cleaners contain acids or alkalis that may cause skin or eye irritation.

Ignoring the labels on the packaging of hazardous chemicals can result in long-term health hazards and life-threatening effects.



**Dangerous for the environment**



**Harmful, irritant**



**Warning, Electric danger**



**Common Hazard Warning**



**Warning about flammable material or high temperature**



**Warning about toxic substance**

Fig. 2.8. Various hazard pictograms

[<http://www.statybajums.lt/temos/darbo-gaisrine-sauga>]

The main professional risk factors that a tiler may face at work are these:

- Electric current;
- Falling from a height;
- Fall of materials;
- Inadequate lighting, cluttered workplace;
- Cluttered tools;
- Dustiness;
- Physical overload;
- Cold floors;
- Rotating tile cutting blade.

The negative effects of professional risk factors can be avoided by choosing the right work technology, using the right equipment and safety measures.

## 2.2. Environment protection: waste management

In Lithuania the legal environment for construction and other waste management is being created by the Ministry of Environment of the Republic of Lithuania. The importance of waste management is also reflected in the legislation issued by the European Union. The aim of the Ministry of Environment is to create a nationally and economically sustainable waste management system that will meet national and EU requirements:

- Directive 75/442 / EEC (Waste Framework Directive), as amended by Directive 91/156 / EEC;
- Directive 91/689 / EEC on hazardous waste, as amended by Directive 94/31 / EEC;
- Directive 99/31 / EC on the landfill of waste;
- Directive 94/62 / EC on packaging and packaging waste;
- Directive 96/61 / EC concerning integrated pollution prevention and control (IPPC Directive);
- Regulation 259/93 / EEC on shipments of waste.



Fig. 2.9. Container with debris [<https://utilizatorius.lt/kainorastis/>]

By order of the Minister of Environment of the Republic of Lithuania 2006 December 29th Order no. D1-637 (Consolidated Version 01-11-2016), as amended, „Construction Waste Management Regulations“.

Construction waste management rules oblige builders to separate and keep separately 5 types of construction waste:

- **municipal waste** – food waste, textiles, other household waste and other waste that is similar in nature or composition to household waste;
- **inert waste** – concrete, bricks, ceramics and other wastes in which there is no appreciable physical, chemical or biological change;
- **recyclable waste, secondary raw materials** – packaging, paper, glass, plastic and other recyclable waste or recyclable materials;
- **hazardous waste** – solvents, paints, adhesives, resins, their packaging and other harmful, flammable, explosive, corrosive, toxic or having other properties materials, that may adversely affect the environment and human health;
- **non-recyclable waste** (insulation materials, rock wool, etc.). The sorted waste must be handed over to companies authorized to treat such waste under contracts for their recovery and disposal.

At the construction site, more types of waste can be segregated (sorted) depending on the types of construction, their size and waste management capabilities.

Non-hazardous construction waste may be temporarily stored on the construction site for a maximum period of one year from the date of its production, but until the end of the construction



work. Hazardous construction waste must be stored temporarily in accordance with the requirements of the Waste Management Regulations for no longer than 3 months or 6 months after its generation, but not later than the completion of construction work in such a way that it does not endanger the environment and human health.

**Construction and demolition waste** include concrete, bricks, mineral, rock and glass wool, gypsum, insulation, building materials, Ruberoid, plastic, glass, building paper, hardened paint, varnish, painted, varnished surfaces, tile and ceramic products, slate, polystyrene foam, gas silicate, concrete, expanded clay, silicate and concrete blocks, linoleum, floor coverings, timber from construction, household sanitary ware (baths, sinks, washbasins, etc.).

The construction and demolition waste of medium and large enterprises, which is generated during the construction, reconstruction, repair or demolition of structures, where such works require a building permit or written approval of the structure design, is managed by waste companies which have the right to provide such waste management services, guided by construction waste management regulations approved by ministerial order, under individual contracts. In such cases, it is necessary to contract with a construction waste collection company, which will deliver the waste to a specialized waste management and storage facility for a fee. Also, companies can ship construction waste to landfill themselves for a fixed fee.

Construction waste from minor repairs is prohibited from being thrown into or left in mixed municipal or packaging waste containers. This waste must be delivered to bulky waste collection sites. Up to 300 kg of construction and demolition waste can be delivered to the site at a time.

Construction and demolition waste from residents and small businesses is accepted at specially equipped sites.

Slate at a designated rate is only accepted at sites that are prepared for the storage of such waste and have a valid license.

Construction and demolition wastes contaminated with hazardous waste, e.g. waste containing asbestos must be separated from other municipal waste at the place of its production, placed in durable bags or boxes and delivered to prepared disposal sites.

### 3. General knowledge of tiling

#### 3.1. History of ceramic tiles

The history of tile dates back more than 5 thousand years. Initially, the tiles were made in the form of mosaic tiles, which were used in the III – II millennium BC to decorate palaces and temple complexes in the territory of modern Iraq.

They resembled mosaics in their small size, but the significant difference was that they created a single image within a single tile that was not visible in the mosaic. Mostly the tiles had geometric patterns. Each symbolized a particular element or phenomenon of nature.

Clay played an extremely important role among the peoples of Mesopotamia. There was no abundant vegetation except for reed and date trees. Clay, in practically inexhaustible quantities, served as the basic building material. Initially, the construction of buildings, ranging from small dwellings to palace and temple complexes, was done with glazed bricks.



Fig. 3.1. A tile from Assyria, 880 BC

[<http://kerama-center.com.ua/9-news/41-istoriya-keramicheskoi-plitki.html>]

The thickness of the glaze (more than 10 millimetres) made the clay brick a rather durable material. In the Babylonian era (18th century BC), geometric patterns on tiles were replaced by animal drawings and iconic (flat) images of humans.

In traditional forms familiar to modern man, tiles originated during the Achaemenids, the ancient Persian dynasty (558-330 BC). Remnants of ceramic tiles 15x15 cm and 1 cm thick, which decorated the walls inside and outside the buildings, were found in the residences of the ancient Persian rulers Suzah and Persepolis in Iran, some fragments of which are very well preserved to this day.



Fig. 3.2. Gate of the Goddess Ishtar, Babylon, 575 BC  
[<http://kerama-center.com.ua/9-news/41-istoriya-keramicheskoi-plitki.html>]

Since the mid-8th century, the chain of Arab conquests has surrounded the Iberian Peninsula. Along with the conquests, the Arabs brought tile-making technology and examples to Spain. The Arabs immortalized their rule with castles and palaces of magnificent beauty. Of particular note is the Alhambra Palace (Arabic: "Paradise on Earth"), which has a wide variety of high-quality compositions of mosaic tiles.



Fig. 3.3. Fountain in Alhambro Palace, Granada, Spain,  
14th century  
[<http://kerama-center.com.ua/9-news/41-istoriya-keramicheskoi-plitki.html>]

Spain became the pioneer of European tile. The secret of Arab technology has come to Italy thanks to the Catholic Church. A limited number of artisan workshops executing church orders received tile-making technology. Dissemination of information to outsiders was strictly prohibited. The Spanish

School of Ceramic Tile Production still respects tradition and, unlike the Italian School, does not actively seek new styles and technologies in the production and decoration of tiles.

Italy can be called the birthplace of decorative tiles. At the dawn of the 10th century, ceramic tile production was established in Italy. One of the first craftsmen, whose name is associated with a new tile treatment and a new stage in the history of understanding artistic heights, is Luca de la Robia of Florence. His workshop, in accordance with the orders of the Catholic Church, decorated temples, the main town squares, and noble estates. He left his name in history because he managed to make coloured tiles.



Fig. 3.4. Majolica, Italy, 8th century

[<http://kerama-center.com.ua/9-news/41-istoriya-keramicheskoi-plitki.html>]

### 3.2. Types of tiles

#### Ceramic tiles

Ceramic tiles are always popular no matter where they are laid – in the bathroom, kitchen or hallway. It is a durable floor covering that is moisture-free and easy to maintain, suitable for a variety of applications. Modern tile colours, from light pastels to the brightest, make it possible to create unique home designs.



Fig. 3.5. Modern bathroom lined with tiles

[<https://lt.lt.allconstructions.com/portal/categories/2/1/0/1/product/26529/medzio-imitacijos-plyteles-keraminis-parketas>]

Ceramic tiles of various shapes and colours are made from pressed clay dust and burned at very high temperatures. Ceramic tiles are extremely resistant to moisture and are therefore suitable for bathrooms. Ceramic tiles are decorated with different patterns or frames. During the production ceramic tiles are mixed with oxides, which, instead of glazing, produce a great variety of colours. Ceramic tiles are thinner than terracotta or stoneware, making them much easier to glue.

In terms of finish and structure, tiles fall into two groups: fine and coarse ceramics.

The fine ceramic group includes fine-grained ceramic, faience and stone ceramics (completely fused). Ceramic tiles are formed in two ways: by plastic moulding (extrusion) and dry pressing. Tiles produced by both methods are classified according to the impregnation size (EN ISO 13006), since ceramic tiles having a certain impregnation size have other properties too.

Table 3.1. Tiles divided to groups by making method [author's own work]

Formation method	Impregnation				
	I group $E \leq 3\%$		Ila group $3\% < E \leq 6\%$	Ilb group $6\% < E \leq 10\%$	III group $E > 10\%$
A Extrusion	A I group		A Ila group	A Ilb group	A III group
B Dry pressing	B Ia group $E \leq 0,5\%$	B Ib group $0,5\% < E \leq 3\%$	B Ila group	B Ilb group	B III group

Plastic moulding (extrusion) tile production is more complicated and expensive. Extruded tiles are stronger, more resistant to frost. This allows to form complex shapes such as skirting boards, stair tiles, pool trims, and more. This is how ceramic-clinker tiles are made.

Ceramic tiles are commonly referred to as dry-pressed tiles (their impregnation is between 3% and 15%, groups B Ia, B Ib, B III), as well as plastic formed tiles of a fine-grained mass (usually more than 6% impregnation).

Unglazed and glazed ceramic tiles are produced. Glazed tiles consist of a thin top layer – glaze and tile mass. The thin top layer gives the tile not only aesthetic properties, but also abrasion resistance, stain resistance and other properties. The tile retains compressive and bending loads.



Unglazed ceramic tiles are often referred to as "clay" tiles. These tiles have good absorption of various liquids and are difficult to clean, so it is recommended to cover them with protective materials.



Fig. 3.6. Kitchen lined with tiles [<https://www.apdailosnamai.it/provenza/>]

### Stone mass tiles

Stone mass tiles are no less popular. Stone mass is a type of ceramic tile. In order to reduce their porosity (and thus the absorption of water), a higher compression force, plasticizers and other additives are applied to the clay. The tiles thus prepared are fired at a higher temperature than ordinary glazed ceramic floor tiles.



Fig. 3.7. Various stone mass tiles [<http://www.arsenalas.it/akmens-mases-plyteles/>]

These tiled floors are washed with warm water and mild detergent. The grooves between the tiles can be cleaned with baking soda and bleach, applied with a toothbrush and left to soak for a few minutes, then rinsed well with a sponge.

Stone mass tiles are durable, water and abrasion resistant. The colour palette is slightly poorer: mostly dark yellow, red and brown to lesser white and black.

Characteristics of stone mass tiles:

- Very low water absorption (up to 0.5% water absorption), this feature allows tiles to be used for outdoor terraces, loggias, stairs;
- They are extremely heat conductive;
- They do not absorb moisture and therefore do not split at negative temperatures;
- Resistant to abrasion and friction;
- Easy to maintain.

### Terracotta tiles

Terracotta tiles, known from immemorial times, are a favourite floor covering today. They are made of pressed or hand-formed clay, are somewhat similar to shale tiles, but burnt at lower temperatures and more porous. Their shapes range from small polygons to large squares, and the charm lies in subtle colour combinations ranging from pale ochre to orange-red. Porous terracotta tiles can be renewed from time to time by rubbing with linseed oil or wax.



Fig. 3.8. Terracotta floor [<http://www.florisa.de/category/terrakotta>]

### Limestone tiles

Limestone is a sedimentary rock formed on the bottom of warm seas by coral and shell deposits. The surface of the limestone ranges from white grained to stained remains of trapped fossils, from dark green to blue. The surface of these tiles can be rough or ideally polished. Limestone is very porous and easily absorbs dirt, therefore it must be sealed. Limestone extracted in ancient times was not very resistant. It has become much more durable thanks to modern technology.



Fig. 3.9. Various limestone tiles [<http://lt.sycmarble.com/limestone/natural-yellow-limestone-flooring-wall-tiles.html>]

### Shale tiles

Clay shale used in tile production breaks down into layers, making relatively thin tiles easy to lay. The broken shale looks quite rough, but captivates with its natural beauty. Its usual colour is bluish-grey with a silver gloss, although it may be produced in pale, yellow, brown or pink colours. They are particularly suitable for hallways, conservatories, rustic kitchens, and other rooms that require durable, practical floors. The shale floor should be scrubbed frequently, with soap and detergent, then rinsed well and rubbed with a cloth dampened in milk for a shiny surface.



Fig. 3.10. Shale tiles [<https://www.akmenys.lt/skaluno-plyteles-monte-black-30x60x3-cm-vnt-lt-lt.html>]

### **Clinker tiles**

It is a natural, frost, acid, moisture resistant, extremely high quality product. Clinker tiles are suitable for interior and exterior walls and floors, stairs, angles. Floor clinker tiles are slightly thicker than stone or ceramic. Clinker tiles are one of the most natural coatings for both indoor and outdoor decoration. Wide range of colours and shapes.

The clinker is characterized by exceptional durability, resistance to abrasion, loads, chemical and atmospheric effects, non-fading, attractive and natural colour, easy tiling, safety (non-slip), eco-friendly (no harmful chemical additives are used in production), clinker paving blocks ensure that rainwater is absorbed.



Fig. 3.11. Floor lined with clinker tiles [<https://www.vokiskakeramika.lt/klinkerio-plyteles-naturkeramik.html>]

### **Marble tiles**

Marble is a multi-coloured solid crystalline rock with a distinctive feature of light-coloured surface furrow cores. Marble floor tiles add luxury to home. True, they cannot be cleaned with any abrasive cleaners and brushes. It is enough to wash such floors with warm water with a mild detergent and scrape away any dirt that has stuck with a blunt knife. Marble surface is polished with silicone or wax.

### **Mosaic**

Mosaic is not just ceramic tiles. Manufacturers offer glass, metal, mirror elements and natural stone. You can find products made from natural materials: nacre shells, coconut shells.

Ceramic products are used as independent parts of small tiles or fragments on a flexible base. The advantage of the material on a flexible base is that it can be used to finish any curved surface.





Fig. 3.12. Room with mosaic [<https://rabotayouth.ru/no/ukladka-steklyannoi-mozaiki-sekretiy-i-nyuansy-poetapnyi-algoritma.html>]

Glass, stone mosaics are made only on a flexible base, while ceramic mosaic fragments are made on paper or mesh. Material laying technology varies depending on the base.



Coconut mosaic



Metal mosaic



Stone and glass mosaic



Nacre mosaic



Glass mosaic

Fig. 3.13. Various types of mosaic [<https://rabotayouth.ru/no/ukladka-steklyannoi-mozaiki-sekretiy-i-nyuansy-poetapnyi-algoritma.html>]

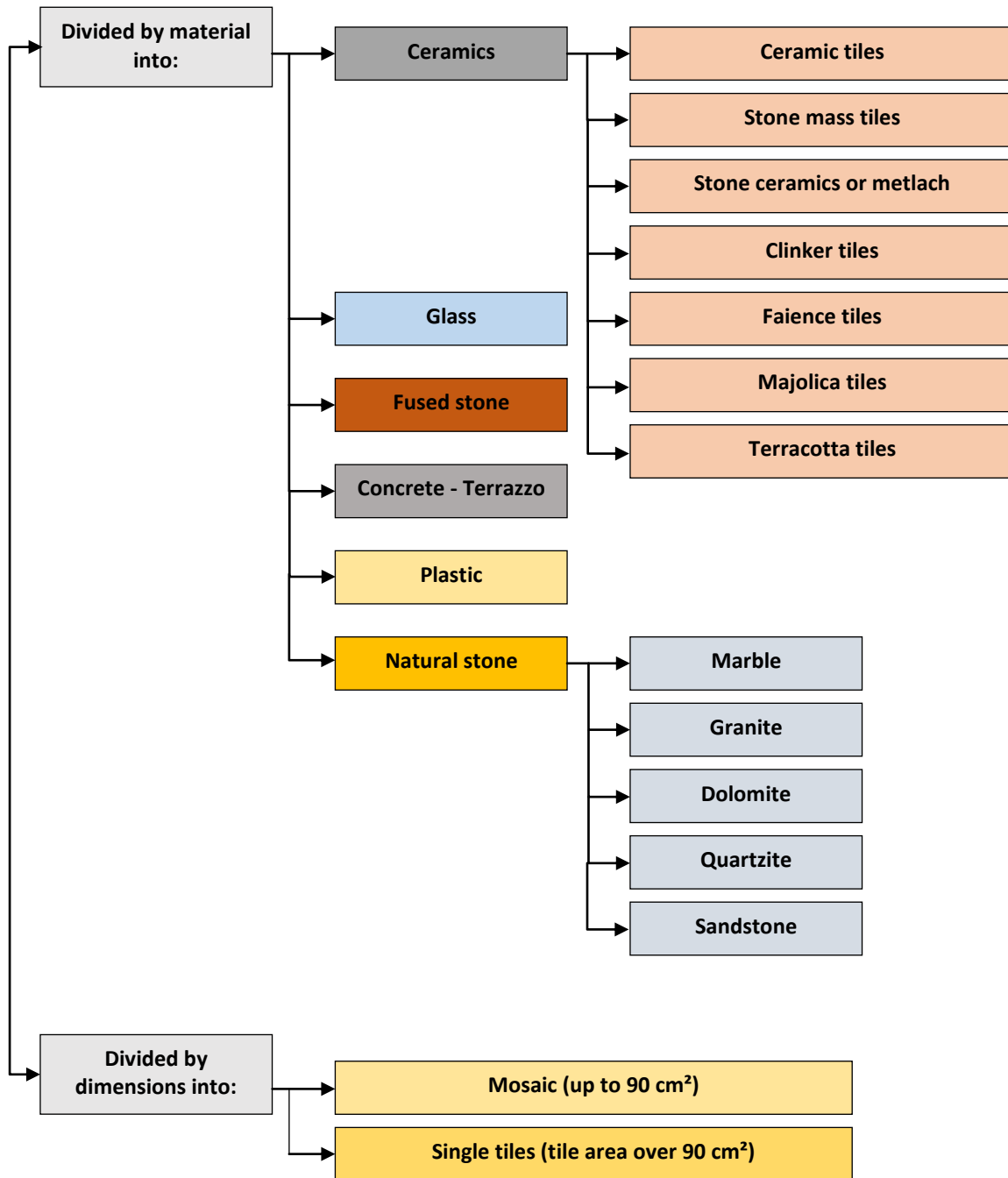


Fig. 3.14. Tile classification scheme [from Mindaugas Černius, „Plytelių klojimo darbai“, Wilno 2007]

Flooring mosaics are made using the same technology as wall mosaics, but the thickness of the elements is larger. The most commonly used flooring mosaic is stone mosaic. The standard size of the square fragments is 40x40 cm, but there are smaller products with dimensions 20x20 cm. Mosaic panels and edging, mosaic stripes with a colour gradient are great for interior decoration.

**Table 3.2. Classification scheme of tiled surfaces** [according to Lithuanian standard LST EN14411:2012. Ceramic tiles]

Lithuanian standard LST EN14411:2012. Ceramic tiles.				Household tile name in Lithuanian	Surface (usually)
Annex of standard	Group	Water absorption (E)	Supplement title		
G	Bla group	$E \leq 0.5\%$	Low water absorption, <u>dry pressed</u> ceramic tiles	Stone mass tiles	Glazed/not glazed
H	Bib group	$0.5\% < E \leq 3\%$	Low water absorption, <u>dry pressed</u> ceramic tiles	Ceramic tiles	Glazed
				Clinker tiles	Glazed/not glazed
I	BIIa group	$3\% < E \leq 6\%$	<u>Dry pressed</u> ceramic tiles	Ceramic tiles	Glazed
J	BIIb group	$6\% < E \leq 10\%$	<u>Dry pressed</u> ceramic tiles	Ceramic tiles	Glazed
K	BIII group	$E > 10\%$	<u>Dry pressed</u> ceramic tiles	Ceramic tiles	Glazed
L	Ala group	$E \leq 0.5\%$	<u>Tape forming</u> ceramic tiles	Stone mass tiles	Glazed/not glazed
A	Alb group	$0.5\% < E \leq 3\%$	<u>Tape forming</u> ceramic tiles	Clinker tiles	Glazed/not glazed
B	AlIa-1 group	$3\% < E \leq 6\%$	<u>Tape forming</u> ceramic tiles	Clinker tiles	Glazed/not glazed
C	AlIa-2 group	$3\% < E \leq 6\%$	<u>Tape forming</u> ceramic tiles	Clinker tiles	Glazed/not glazed
D	AlIb-1 group	$6\% < E \leq 10\%$	<u>Tape forming</u> ceramic tiles	Practically not produced	
E	AlIb-2 group	$6\% < E \leq 10\%$	<u>Tape forming</u> ceramic tiles	Practically not produced	
F	AlII group	$E > 10\%$	<u>Tape forming</u> ceramic tiles	Practically not produced	

\* Note: all tiles designed for flooring can be glued on the walls and tiles designed for walls cannot be used for flooring.

### 3.3. Tile shape and colouring

Tiles come in a variety of dimensions, shapes and styles - from antique to avant-garde. Wall and floor tiles are often combined in colours, patterns and dimensions. In addition, various decorative details, skirting boards, tiles for stairs are produced. Depending on the production method and the combustion temperature, the tiles have different properties. According to the quality tiles are divided into types I, II, III.

Ceramic, stone, clinker and natural stone tiles with a surface area of more than 90 cm<sup>2</sup> are called single tiles. The most widely used tiles are: 10 x 10 cm, 15 x 15 cm, 20 x 20 cm, 20 x 25 cm, 30 x 30 cm, 33 x 33 cm, 40 x 40 cm, 50 x 50 cm, 60 x 60 cm.

There are tiles of very different non-standard dimensions, which are especially trendy to combine and also collections of non-traditional tiles of different shapes.

The most popular are square and rectangular tiles.

Deviation of tile dimensions from the design is defined by tile calibre. For example, a 30 x 30 cm tile can be 29.82 cm or 30.18 cm. Therefore, tiles to be glued together should be of the same calibres.

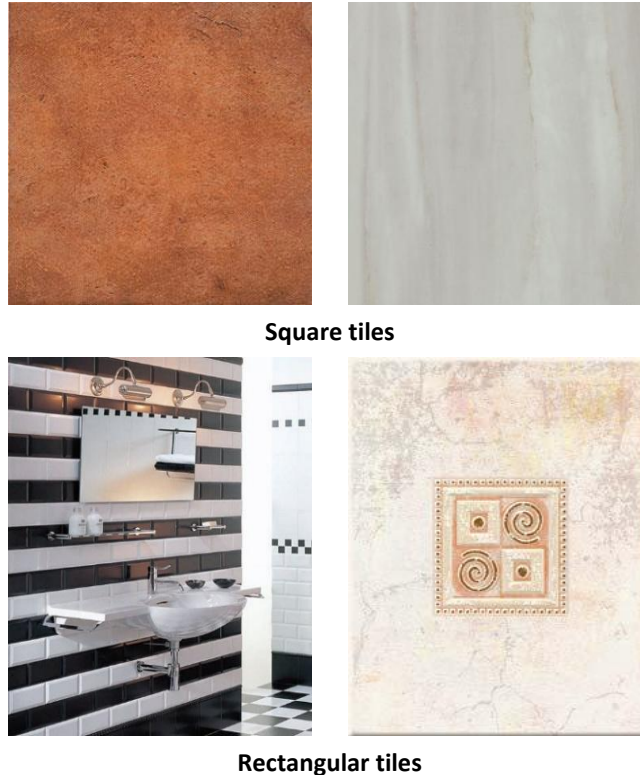
On the tile packaging you will find the following information: manufacturer's name, if imported, name of the importer, reference to the European or national standard they meet, nominal, working, modular or non-modular dimensions, tile surface type (glazed or unglazed), tile code (drawing), calibre, shade and type. Tiles of the same code, shade and calibre must be purchased for one room. If wall tiles of different codes are to be used, it should be ensured that the tiles are of the same calibre.

During the production process, the dimensions of ceramic tiles during combustion are reduced by up to 5%. and this may result in dimensional deviations of the tiles produced. The tiles are calibrated to avoid this problem. During calibration, a special machine divides the tiles according to their dimensions.

### 3.4. Classification of tiles according to their quality

The specifics of ceramic tile production are as follows:

Some tiles (up to 10%) are produced with various surface or dimensional defects. The quality requirements for tiles are defined by a single European standard EN 14411, which defines only the quality requirements for first-class tiles. Other types of requirements are set by the manufacturer himself, the type is usually indicated by the numbers 1 and 2 on the tile box, respectively.



Square tiles

Rectangular tiles

Fig. 3.15. Examples of quadrangular tiles

[<https://design-rom.ru/it/bathroom/variants-of-layout-of-floor-tiles-we-put-the-tile-in-a-descent-to-the-floor/>]

#### First-class tiles:

- The surface of the tile is free from defects.
- The first – class tiles come only in one calibre per box.

#### Second-class tiles:

- The surface of the second-class tiles shows slight defects in the glaze of the painting, usually only in close proximity;
- defects include various surface changes, such as the appearance of dots of another colour, pits, and etc.;
- The dimensions of the tiles in one box also differ: the second-class tiles are usually uncalibrated, tile dimensions may vary by several millimetres.

The second-class tiles are distinguished by marking. The tile surface is usually drawn with a yellow dash, which is cleaned when laying the tile.

#### Defective tiles:

- Visible defects in the glazed surface. These are various surface changes such as the appearance of dots of another colour, pits, etc.;
- defective tiles are usually uncalibrated, i.e. tile dimensions may vary by several millimetres.;

- the tile surface is usually drawn with a yellow dash, which is cleaned when laying the tile.

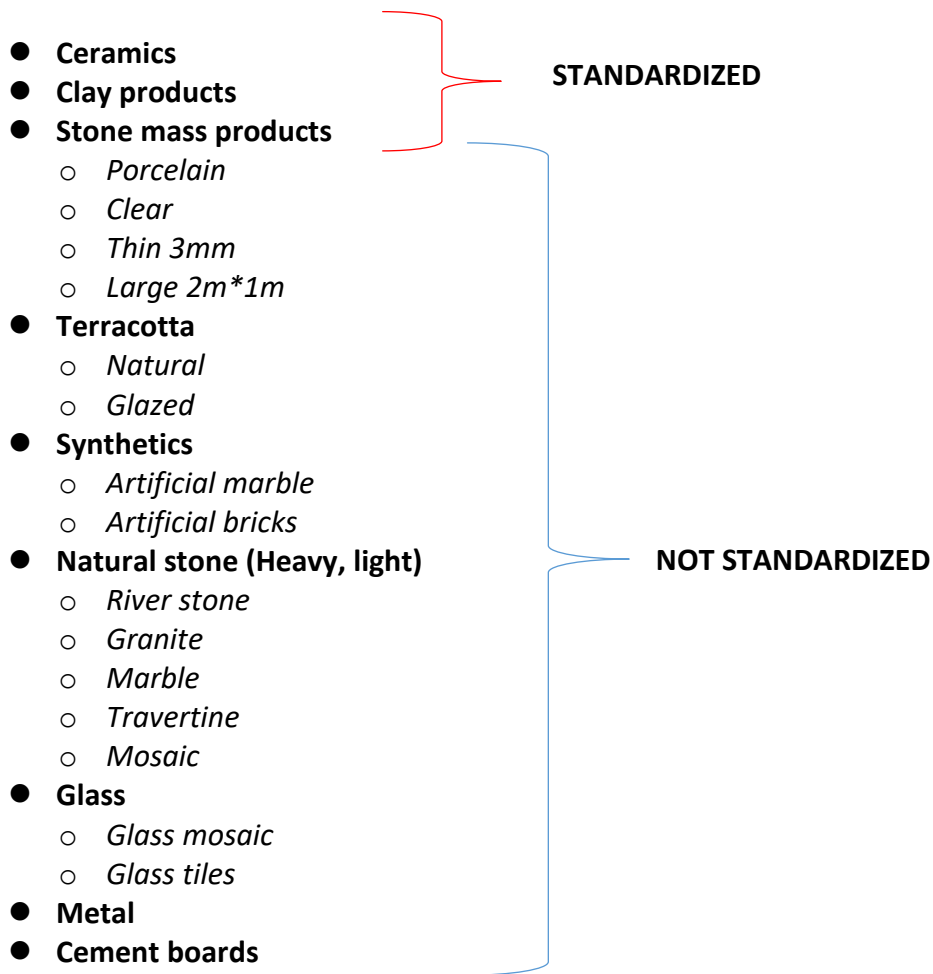


Fig. 3.16. Types and standards

[<https://design-rom.ru/it/bathroom/variants-of-layout-of-floor-tiles-we-put-the-tile-in-a-descent-to-the-floor/>]

### 3.5. Selection of tile format and colour

The colour and shape of the tile depends on the style and purpose of the room. Colour effects are created by combining tiles of several colours and shapes. Optical effects depend on colour matching: black tiles on a white background appear smaller, white tiles on a white background – larger. The surface divided into smaller areas seems larger, divided into larger – smaller.

Choosing the colour of an individual tile or the entire surface, it is useful to create a model of the environment where the tile surface will be. Lighting also needs to be evaluated.

It is not necessary to use variegated tiles for a colourful finish. One-color tiles of different sizes and shades can also create an original finish. This method is particularly suitable for finishing spacious rooms and building facades.



The shape and size of the tile or the shape and size of the tile décor must be adapted to the shape and size of the surface to be trimmed, e.g. large tiles with mosaic decor are also suitable for small spaces. This does not mean that small rooms need to use only small tiles, or that irregularly shaped rooms should look for irregularly shaped tiles. Simply finishing small areas (walls with a lot of angles, niches, pilasters and the like) is better for using smaller tiles – reducing tile costs (leaving fewer cuts) and making finishes look more decorative.



Fig. 3.17. Examples of combining tiles in different formats and colors

[\[http://www.djpowerltd.com/id73.html\]](http://www.djpowerltd.com/id73.html)

It is very common that relatively small surfaces (usually in residential buildings) are covered with very large tiles. This makes the room seem smaller and increases the cost of the estimate and the risk of defects. The width and colour of the joints can emphasize the uniformity of the surface (narrow joints with tiles of the same colour), or the joints can accentuate the pattern and individual tiles.

The most popular rectangular and square tiles produce traditional joint patterns (they can also be combined with each other).

When two or more shapes of tiles are used together, they must be checked for compatibility when designing. It is very important to make sure that the different formats will be used so that joints of the same width can be produced.

Not rectangular tiles or even tile wrecks can also be used for decoration. Tile wrecks can be used to make decorative inserts, strips.

### Avant-garde tiles

In interior design variety of decorative and finishing materials can be used, which vary in appearance and conditions of use. The colour of the tiles used is often noted, but their geometry also offers a wide range of design options.

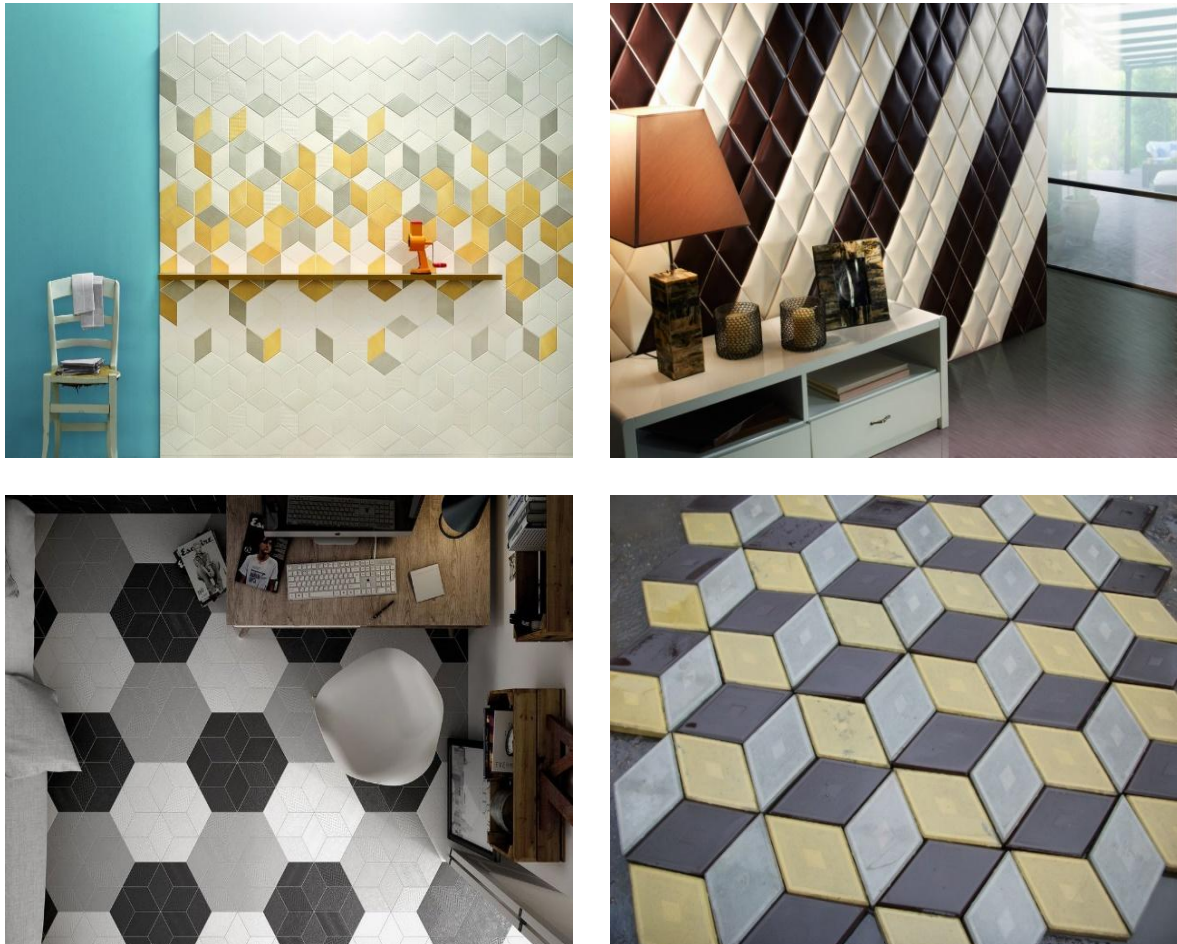


Fig. 3.18. Examples of avant-garde tiles [<https://lt.decoratex.biz/napolnye-pokrytiya/plitka/romb/>]

An impressive example of a unique design solution is diamond shaped tiles.

The main advantage of such tiles is the thoughtful dimension and design. In some cases, only such coating can be 3D coated with minimal cost.

Diamond shaped tiles are made of durable ceramic. This material is practical and easy to maintain, mechanically strong and durable. Configuration of rhombus is attractive because it is completely symmetrical and allows you to create three-color hexagons that can be repeated many times. The composition will be much more original and interesting if diamonds shape tiled areas will be larger.

According to the designers, preference is given when dark tiles are combined with light. The dark ones are placed at the bottom and the light tiles are above them.

Specialists of the Italian firm “Ceramika Casalgrande Padana”, who produce tiles of various styles, formulated the logical aspects of the design:

- A tile is an element of the artistic covering as a whole.
- A tile is exposed to the environment. Meanwhile, the tile itself, together with other elements (tiles), affects the surrounding environment.



- Designing, it is necessary to assess the differences between a single tile and the entire tile surface and adjust them to the environment.
- Floors and walls are treated as a single structure consisting of several functional layers – substructures. The substructures work together and give the cohesive complex, new resistance



Fig. 3.19. Interior model

[[https://placetodwell.com.au/?fbclid=IwAR3IM2bRF6HUyLCediQL9LFt2g2gm5Pd6r3E9edSx\\_lpRfW4w5cQcNEMFM](https://placetodwell.com.au/?fbclid=IwAR3IM2bRF6HUyLCediQL9LFt2g2gm5Pd6r3E9edSx_lpRfW4w5cQcNEMFM)]

properties. They must be evaluated in the finishing project.

- It is recommended to design a surface model (computer, layout, drawing, etc.).

A simple interior model can be created quickly, without prior preparation, using the layout tools available on tile manufacturers' websites.

### 3.6. Joint patterns

Using rectangular and square tiles these traditional joint patterns are obtained:

- Vertical continuous joints.
- Vertical binding joints.
- Diagonal joints.

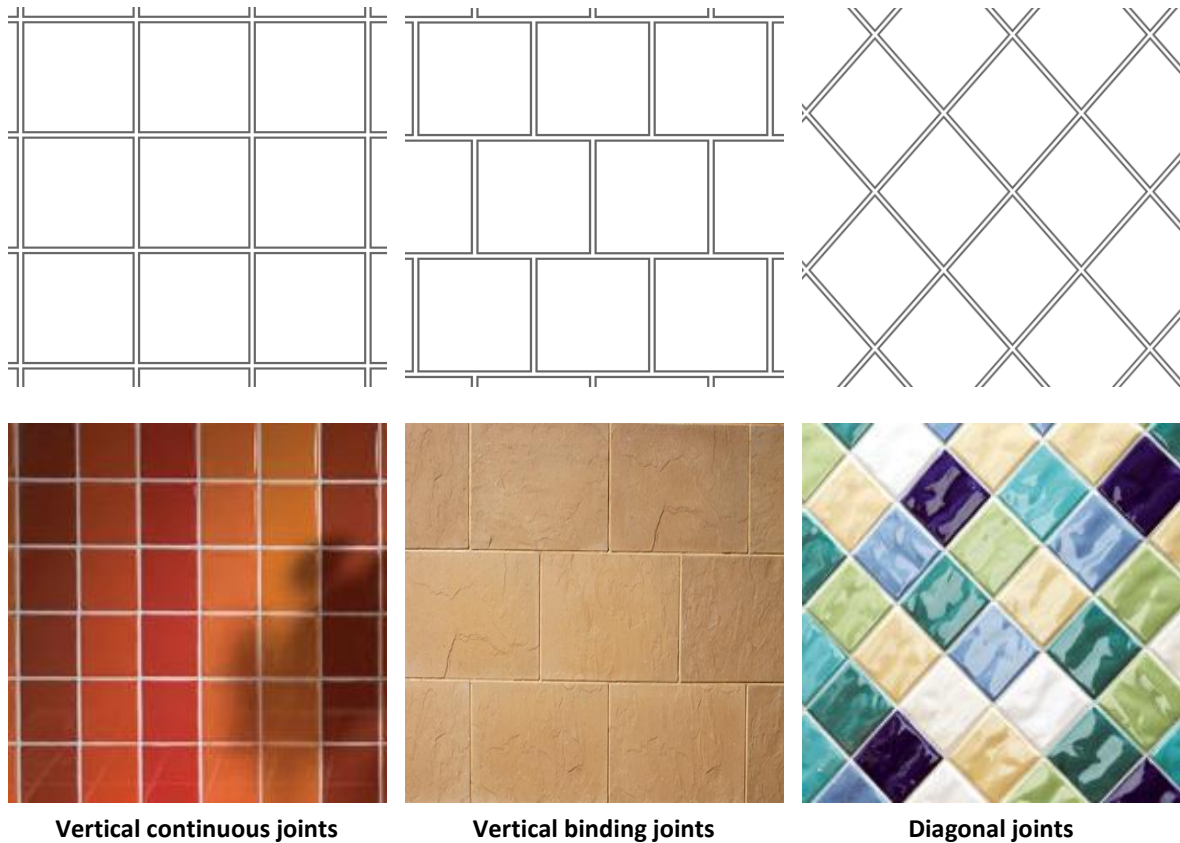


Fig. 3.20. Types of joints  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

### 3.7. The selection of tiles

The durability of the tiled surfaces depends on the precise selection of tiles, in particular its suitability for the specific surface. Therefore, it is always necessary to take into account the characteristics of the surface on which the tiles will be laid. When deciding on tiles for walls or floors, an architect chooses products based on shape, dimensions, colour, décor and technical properties - resistance to the physical, chemical or mechanical effects that can occur in a particular environment. The choice of tiles is largely determined by the quality and wear characteristics of the walls and floors. Likewise, the choice of tiles should be determined by setting the exact relationship between the effects on the tiled surface and the function to be guaranteed by the walls or floor. A good way to choose tiles is to check as many similar premises as possible and identify any defects in the tiled surfaces and problems that may arise during operation.

When starting work, it is necessary to have complete information on the environmental specifications, the planned use of the finished premises in the common building complex. This information is very important as it determines the possible levels of exposure and thus the efficiency of the tiled surfaces. Too much information complicates the classification, which sometimes makes it difficult to evaluate the problem, which is important for purposeful and successful use of the material.

In these circumstances, the next information can be used for four typical cases:

**1. INTERNAL FLOORING:**

- the purpose of building;
- the purpose of the place to be decorated;
- flooring structure and properties;
- load intensity and distribution.

**2. INTERNAL WALLS:**

- the purpose of building;
- the purpose of the place to be decorated;
- wall structure and properties.

**3. EXTERNALL FLOORING:**

- weather conditions;
- the building zone to which they belong;
- slipping risk;
- purpose;
- type of surface;
- basis structure and properties.

**4. EXTERNALL WALLS:**

- weather conditions;
- the building zone to which they belong;
- wall structure and properties.



Fig. 3.21. Surfaces of masonry walls  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]



Fig. 3.22. Surfaces of concrete walls  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

The long-term and successful life of tiled flooring and walls also depends on the quality of the tiles and, in particular, their suitability for the surface for which they will be used. Therefore, it is always necessary to know and take into account the characteristics of the surface on which the tiles will be fixed. The technical properties of the building materials used are determined at the design stage. The choice of ceramic tile is largely determined by the quality of the walls and floor and the wear characteristics. When repairing old buildings, surface diagnostics, in particular, the condition of the existing surface must be evaluated. Only after clearing and removing the causes of the failure of the supporting structure or finish, can the surface be refinished. Often, the cause of defects is moisture (especially outside the buildings), vibration, foundation deposition, and insufficient durability of the supporting structure.

Diagnostics not only identifies structural defects, but also the suitability of surfaces for tiling. The weight of the tile covering is from 10 to 25 kg / m<sup>2</sup>, additional stresses increase with sudden temperature fluctuations, vibration. It is therefore necessary to know a method for reinforcing weak surfaces. The durability of the tiled surfaces depends not only on the properties of the tiles or adhesive, but also on the compatibility of all materials used. Tiling can begin when the windows, door frames, electrical installation, all plumbing work (only non-installed sanitary appliances), underfloor installation and floor markings have been completed. Tiled surfaces must be strong and non-deformable.

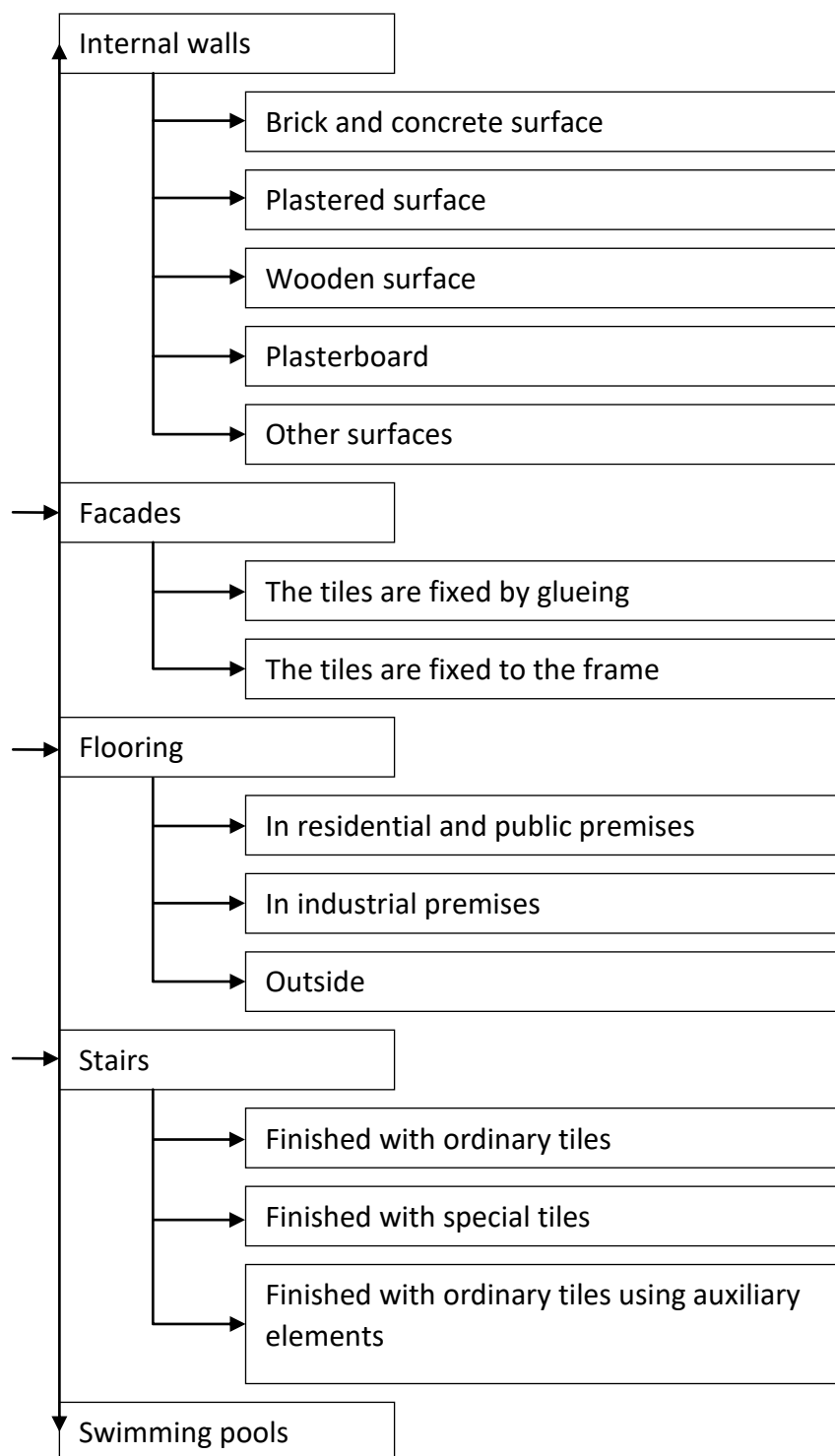


Fig. 3.23. Classification scheme of tiled surfaces  
[author's own work]

### 3.8. The most important indicators of tile properties

The tile strength is determined by the following characteristics: bending resistance, abrasion resistance, scratching resistance. These characteristics are necessary both for the stone mass and for the simple glazed ceramic flooring tiles.

The bending resistance indicates the load at which the tiles break in half. This characteristic is influenced by the thickness of the tile. In residential and public buildings, tile thicknesses of 8 to 10 mm are sufficient to withstand a load of at least 35N / mm<sup>2</sup> (depending on thickness). Technical premises use ceramic tiles up to 18mm and withstand higher loads. The abrasion resistance characteristic is used to determine the strength of glazed stone mass and ordinary glazed ceramic flooring tile glaze. All ceramic flooring tiles produced according to European and international standards are divided into 5 groups according to abrasion resistance. They are labelled PEI-I, PEI-II, PEI-III, PEI-IV and PEI-V. The first group is less resistant to abrasion, the fifth is the most resistant. The higher the number, the more abrasion-resistant (discoloration) the tile glaze. In private house or apartment, it is sufficient for the flooring tile to have PEI-3. Such tiles are also suitable for public premises where there is a small flow of people. Where there is a large flow of people, tiles that have PEI-4 and PEI-5 should be used. Italian manufacturers describe this characteristic by testing how many millimetres of surface are lingered at a given load speed. The European Union standards exist and must not be exceeded by the manufacturer. All this information must be available from ceramic tile dealers (manufacturers always provide it).



Fig. 3.24. Various types of tiles

[<http://www.kvepuojanti-siena.lt/products/cotto-glazuruotos-plyteles-metro-baltos-10x20/>]

Scratch resistance describes the resistance of a glazed tile surface to mechanical stress (scratching). This is relevant in public premises where various rolling stock or sliding loads are used in the process. The MOHS scale from 1 to 9 is used to describe this characteristic. The higher the number, the more scratch resistant the tile glaze is. In private house or apartment, it is sufficient for the flooring tile to have MOHS 5 or 6. Most manufacturers do not produce flooring tiles with a lower performance than MOHS 6. We recommend tiles with MOHS 8 in public premises.

Glazed flooring tiles are the most commonly used type of ceramic tile with low or medium low water absorption, dry pressed. They are also known as glazed ceramic flooring tiles or simply ceramic flooring tiles. The glazed flooring tiles belong to the ISO and EN-UNE normative groups BIb, GL (dry



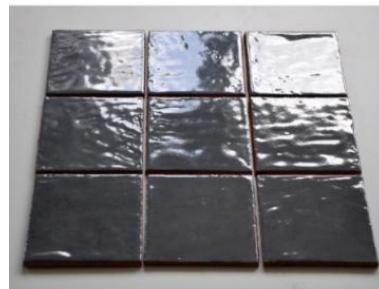
pressed ceramic tile with low water absorption  $E < 3\%$ , glazed) and BIIa, GL (dry pressed ceramic tile with medium low water absorption  $3\% \leq E < 6\%$ , glazed). We have discussed their other technical characteristics earlier.

These tiles are suitable for interior flooring in living or commercial premises. They are made of white or brown clay. Colour does not affect other product characteristics. The tile has a fine and uniform texture. Surfaces and edges are regular and well finished. The surface glaze ranges from matt to very glossy and can be white, monochrome, marble-like, dotted, granular and decorated with a variety of motifs. Glazing the tile surface allows a wide range of colours and designs, which delights the consumers.

Wall tiles are the traditional name for dry-pressed, glazed ceramic tiles with high water absorption and produced by a single or dual combustion process. Wall tiles have ISO and EN - UNE Group BIII, GL standards (dry-pressed ceramic tiles with high water absorption  $E > 10\%$ , glazed). Due to their characteristics, they are suitable for interior walls and for living or commercial premises. They are made of white or brown clay. Colour does not affect other product characteristics. The tile has a fine and uniform texture. Surfaces and edges are regular and well finished. The surface glaze can be white, monochrome, similar to marble, dotted, granular and decorated with various motifs.

### Types of surface processing for tiles

**Glaze is a layer of vitrification during combustion, adhering to the tile.** It fixes previously applied layers of paint on the tile. The composition of the glaze differs from that of the basis. It is poured between the first and second combustion (two combustion process) or before combustion (single combustion process) This gives the top of the tile the appearance and properties of the glaze, which can be very different from those of the basis. Usually it is easy to distinguish the glaze by looking at it or at least observing the cross-section of the tile. Tiles that do not have a glazing layer or unglazed tiles are made by burning basis after casting it once.



Rys. 3.25. Glazed tiles

[<http://www.kvepuojanti-siena.lt/products/cotto-glazuruotos-plyteles-metro-baltos-10x20/>]

The top of the tile has the same properties and appearance as the base.

**Putty** is a light clay or primer plaster that covers the top of the tile for a darker colour. Although the putty is usually covered with a glaze, it can be left as a final surface coating, which after burning becomes matt and is not as hard and waterproof as the glaze.

**Polishing** is a surface processing that smoothes and gives a reflective shine to the tile surface. This technique is widely used for stone mass tiles and has already begun to be applied slightly to glazed wall and flooring tiles.

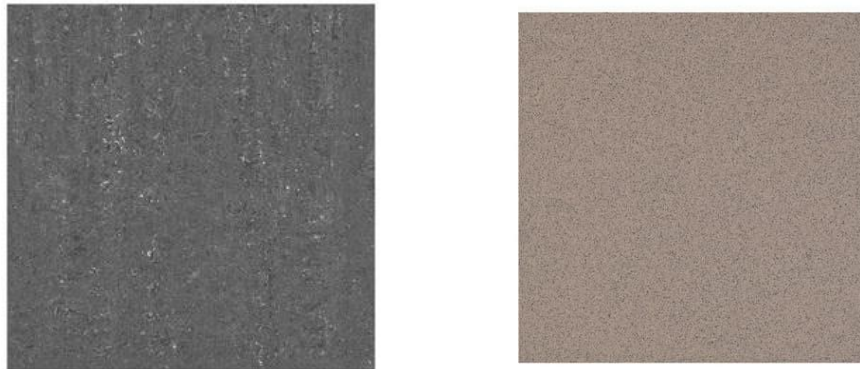


Fig. 3.26. Polished stone mass tiles

[<http://www.kvepuojanti-siena.lt/products/cotto-glazuruotos-plyteles-metro-baltos-10x20/>]

### Hardness of tiles

The surface hardness of glazed and unglazed tiles is characterized by a class on the Mohs scale.

The tests are carried out in accordance with the EN 101 method, by scratching the surface of the tile with standard materials of various hardness. The softest material is chalk, the hardest diamond. The tile belongs to the class of the hardest standard non-abrasive standard material. For example, if a tile is only scratched by a corundum (9) and a diamond (10), it is in Class 8.

**Table 3.3. Standard materials for hardness measurement test** [author's own work]

Class	Standard material	Class	Standard material
1	Chalk, talc	6	Orthoclases
2	Gypsum	7	Quartz
3	Anhydrite, calcite	8	Topaz
4	Fluorite	9	Corundum
5	Apatitis	10	The diamond

Flooring tiles come in classes 5-9. Flooring tiles below class 5 should not be used. For frequently cleaned walls (sanitary facilities, kitchens) at least 3 class tiles should be used.

### The wear resistance of glazed tiles

Wear resistance of glazed tiles is defined by PEI classes (determined according to EN ISO 10545-6).

The tiles are rubbed with alumina grains and steel balls in an eccentric rotating system. According to the number of revolutions after which the surface is not noticeably worn out, the materials are divided into classes:



**Table. 3.4. The wear resistance classes of glazed tiles** [author's own work]






Class	The number of turns	The purpose of tiles	The premises to be decorated
PEI- I 	150	Tiles for low-load premises without abrasive dirt.	Residential showers, bathrooms, bedrooms.
PEI- II 	300-600	Tiles for flooring with medium to light load, slightly exposed to abrasive dirt.	Residential premises: showers, bathrooms, bedrooms, except kitchen, hallway and other places where is frequent walking.
PEI- III 	750-1500	Tiles for flooring with medium to heavy load, slightly exposed to abrasive dirt.	All residential premises, balconies, terraces, lounges, hotel bathrooms, rooms.
PEI- IV 	>2100	Tiles for heavy load flooring.	All private premises, entrances, retail and business premises, offices, dance halls, etc.
PEI- V 	>12000	Tiles for flooring with very heavy load.	Residential and public premises, shops, restaurants, areas next to counters and etc.



Fig. 3.27. Symbol indicating that the tiles are frost resistant [author's own work]

PEI-I and PEI-II tiles are not suitable for premises that have direct access to the exterior and do not use a door mat. In this case, it is recommended to use unglazed or special glazes tiles. Recently, advanced tile manufacturing technology has made it much more durable than PEI-V ceramic tiles. Therefore, some factories offer tiles that are even twice the PEI-V class requirements.

Door mats help remove dirt and protect the flooring. They are especially needed in rooms with direct outdoor or garden access.

The most resistant are tiles belonging to PEI-V class.

#### **Deep abrasion resistance of unglazed tiles**

It is an indicator of wear resistance of unglazed tiles (stone mass, clinker, natural stone). The advantage of unglazed tile is that the tile has the same colour throughout the thickness of a tile. The surface does not change colour when the surface is worn. Therefore, they are used in areas where the tiled surface is subject to intense friction with solids.

Occasionally, deep abrasion resistance characteristic is provided for glazed stone tiles, but it can only be used as additional information. As the glaze loses its aesthetic qualities, the resistance of the deeper layers is no longer relevant.

The resistance is determined in accordance with EN 102.

Deep abrasion resistance is measured by the volume of the notch in the tile (mm<sup>3</sup>).

**Test Principles:** Abrasion resistance is determined by measuring the length of the notch cut using a rotating disk and using an abrasive powder. The volume of the notch is based on the length of the notch (mm<sup>3</sup>). The volume of the notch (mm<sup>3</sup>) is shown in the table.

The tile abrasion resistance is determined from the test results by measuring the length L of the notch and calculating its volume.

**Table 3.5. Classes of unglazed tiles resistance** [author's own work]

Marking	The volume of the notch (mm <sup>3</sup> )	Assessment of resistance
<b>U 1</b>	<150	Particularly resistant to wear
<b>U 2</b>	<205	Extremely high resistance to wear
<b>U 3</b>	<300	High resistance to wear
<b>U 4</b>	<393	Average resistance to wear
<b>U 5</b>	<771	Low resistance to wear

The tiles belonging to class U 1 are the most resistant.

**Strength** – resistance to crushing or bending loading. It is important when selecting tiles for the areas where the transport is going.

#### **Tile impregnation - water absorption**

Materials have the property of absorbing water (soaking it) and retaining it. This is called water absorption. Water absorption is expressed as the ratio of the mass (or volume) of water absorbed to the mass or volume of dry matter. Many existing building materials and structures get wet and exposed to changing temperatures. When the temperature drops below zero, the material saturated with water undergoes stress due to rising ice crystal pressure and hydrostatic expanding water pressure (the volume of the chilled water increases by about 9%; the hydrostatic pressure can be up to 200 MPa). Water-filled pores immediately destroy the substance upon freezing. Substances can be frozen many times due to the fact that not all pores and capillaries are filled with water.

Frost resistance of tiles depends on this property. The higher the impregnation, the lower the frost resistance. The impregnation of tiles used for flooring outdoors is usually less than 3%.

- Tiles with water absorption of up to 3% can be used outdoors and indoors;
- Tiles with water absorption of more than 3% are suitable for indoor use only.

#### **Frost resistance**

The property of materials saturated with water to withstand multiple freezing and warming is called frost resistance. Frost resistance is measured in cycles (freezing and warming).

- Exterior tiles have to perform at least 50 frost resistance cycles (EN 202).
- Outdoor flooring tiles have to perform at least 200 frost resistance cycles.

Many manufacturers do not report the number of cycles, but directly indicate whether or not the tiles are frost resistant.

#### **The slipperiness of a tile**

The slipperiness of a tile is a very important property of flooring tiles. Work safety rules require that the floor is smooth, non-slip and easy to clean. Special care must be taken in areas where the use of water, grease, dirt or waste may cause a risk of slipping. This should be taken into account when

choosing flooring tiles. This claim is based on studies in Western European countries that have shown that slipping is the leading cause of accidents. On the other hand, rough tiles are harder to clean, wear faster, less shiny. Safety is primary, but other properties must be kept in mind.

The slipperiness of a tile is defined by the surface of the tile: smooth, micro-rough, rough, or profiled. Surface roughness is determined according to DIN 51130. The size R indicates the risk class.

**Table 3.6. Smooth tiles classified into groups** [author's own work]

The average tile surface slope	Group
From 3° to 9°	R9
From 9° to 19°	R10
From 19° to 27°	R11
From 27° to 35°	R12
More than 35°	R13

For general work premises with different slippery tile flooring, only tile flooring with the next slippery characteristics may be used.

Embossed tiles are classified into 4 classes (V4, V6, V8, and V10).

Surface relief is measured in cm<sup>3</sup> to 100 cm<sup>2</sup>. The distance of the relief surfaces from the average walking surface to the drainage level is called the profile height.

Embossed tiles are used for flooring indoors or outdoors, where there is a possibility of slipping. For example, for floors near pools, as wet tiles become more slippery, for exterior tiling of terraces and staircases, for floors for industrial premises, etc.



Fig. 3.28. Tiles with embossed surface

[<http://www.kvepuojanti-siena.lt/products/cotto-glazuruotos-plyteles-metro-baltos-10x20/>]

In order to facilitate cleaning work in areas where embossed tiles are required, a 15 cm wide zone can be applied to the walls, corners and around fixed installations with smooth embossed tiles.

The slipperiness of the tiles used in barefoot areas is characterized by the following groups:

**Table 3.7. Slip groups for tiles used in wet rooms** [author's own work]

Slope of surface (°)	Group	Place of use
to 12	A	Almost dry floors for walking barefoot; Individual and communal changing rooms; Pool floor if water level 80-135 cm; Saunas and rest rooms (almost dry).
to 18	B	Barefoot floors, not mentioned in group A; Showers and floors around pools; Swimming pools if the water level in certain areas is <80 cm; Water ladder, stairs: maximum width 1 m, handrails on both sides; Stairs and ladders outside the pool; Stairs for relaxation and underwater ladders; Saunas and lounges not included in group A.
to 24	C	Water stairs, if not included in group B; The sloping edges of the pool.

#### Resistance to stain formation

Glazed tiles are classified into 3 classes (tested according to EN 122; tested with blue solution of methyl an d potassium permanganate:

- Class 1 - stains can be removed with water;
- Class 2 - stains can be removed with cleaning agents;
- Class 3 - stains cannot be cleaned.

#### Chemical resistance

The tests are carried out in accordance with EN 122.

1. Test of resistance to household chemicals: Sodium hypochlorite solution, copper sulphate solution used as standard cleaning solution and bath water additives. According to the resistance of these materials the tiles are divided into classes AA, A, B, C, D. The most resistant class AA tiles.
2. The acid and alkali resistance test is carried out with 3% hydrochloric acid solution, 100 g / l citric acid solution and 30 g / l potassium hydroxide solution. According to the resistance of these materials the tiles are divided into classes AA, A, B, C, D. The most resistant class AA tiles. Chemical resistance may also be tested in accordance with EN ISO 10545-13. According to this standard tiles are divided into groups A, B, C, when tested with low or high concentration acids and alkalis. When indicating the resistance group, the concentration of the substances is indicated by the letters: L - low concentration acids or alkalis; H - Highly concentrated acids or alkalis. Chemical resistance according to EN ISO 10545 - 13 is denoted as follows: e.g. UHA (U - unglazed tile, H - high concentration chemicals, A - class).

Tiles are classified into classes AA, A, B, C, D according to their resistance to these materials. Class AA tiles are the most resistant.

## 4. Materials

### 4.1. Materials for surface preparation

#### 4.1.1. Building mortar

Building mortar is an 'artificial stone' obtained by hardening a mixture of binder, fine aggregate and water. Mortar binder is cement, lime, gypsum as well as their mixtures (cement and lime, lime and gypsum and others). According to their purpose, construction mortars are divided into masonry, plastering and special mortars (waterproofing, decorative, acoustic, etc.). Mortars used in dry environments are made with lime, gypsum and used in humid environments with hydraulic lime and various types of cement. Sand is used as a filler in mortars. Mortars used in masonry have a maximum grain diameter of 2.5 to 3 mm and for plastering depending on the thickness of the plaster layer.

The composition of the mortar (cements, lime, sand) is expressed as the volume of materials needed to produce 1 m<sup>3</sup> of mortar. For example, 1: 0.4: 6 means that said mortar contains 1 part of cement, 0.4 parts of lime and 6 parts of sand.

The most important property of an unhardened mortar is its ductility and water retention. The ease of working with it greatly depends on it. The ductility determines the ability of the compressed or otherwise exposed mortar to bend. When laying bricks or plastering, each surface on which the mortar is applied tends to absorb the water of the mortar. As a result, the mortar becomes stiff, difficult to level, and it reduces the quality of work. This means that the ability of the mortar not to give water to another surface is an important property for good quality work. The most important properties of hardened mortar are strength, frost resistance and minimum shrinkage.

Mortars are divided into the following strong brands: 4, 10, 25, 50, 75, 100, 150, 200 and 300. Mortars, like concrete, are strong because of their binder properties, sand quality, water mass mix, cure time and other conditions. High demands on the quality of plastered surfaces and their aesthetic appearance have shrinkage deformations because they are important. The more cement in the mortar, the greater its shrinkage deformation and the greater the risk of cracking. Decorative plasters are used for finishing the exterior and interior walls of buildings. In addition to the common ingredients, alkali and light-resistant pigments are added to the mixture. Various specialty mortars are still being manufactured and used. These are waterproofing, grouting and other mortars.

**Table 4.1. Groups of mortar** [author's own work]

Mortar groups		Binders materials
S I	a.	Air lime dough or slaked lime (powder), can be used and low amount of cement.
	b.	Weakly hydraulic lime.
	c.	Hydraulic lime.
S II	a.	Strongly hydraulic lime, romance cement, cement.
	b.	Mixture of lime and cement containing 1 part by volume of cement and 1,5 – 2 parts by volume of lime.
S III	a.	A mixture of Portland cement and lime, containing 1 volume of cement and up to 0,25 volume of lime.
	b.	Portland Cement.
S IV	a.	Gypsum without filler.
	b.	Gypsum with filler.
	c.	Mixture of gypsum and slaked lime in which the gypsum is present in quantities of 0.5 to 2.0 parts by volume and 1 part by volume of lime (with filler).
S V	a.	Anhydrite cement.
	b.	Mixture of anhydrite cement and slaked lime or Portland cement, in which the anhydrite cement contains 1 part by volume and the lime and cement 1 parts by volume.

#### 4.1.2. Concrete

Concrete is called artificial stone, which is obtained by hardening a mixture of a rational composition of binder, water and filler. A non-hardened mixture of such materials is called a concrete mixture. Cement concretes are made of cement and fillers, mostly local materials, usually such as sand, pebbles, slag, expanded clay and others. The binder and water are the active ingredients of the concrete mix: the binder paste fills the spaces between the filler particles, covers them with a thin layer and gives the concrete mixture the necessary slip and clutch. When hardening cement, the paste binds the filler particles and an artificial stone - concrete is formed. The fillers form a dense, rigid stone skeleton. Concrete is one of the most important building materials and relatively inexpensive as most of it is made up of local fillers. Depending on the filler size, the concrete may be:

- fine-grained (filler particles up to 10 mm);
- coarse-grained (filler particles up to 150 mm).

Concrete is graded by volume, strength, frost resistance, water absorption, their purpose and binder type.

Concrete is graded by volume density:

- very heavy, with a density greater than 2500 kg / m<sup>3</sup>,
- heavy (1800 - 2500 kg / m<sup>3</sup>),
- light - (500 to 800 kg / m<sup>3</sup>),
- very light (thermally insulated) with a density less than 500 kg / m<sup>3</sup>.

According to the compressive and tensile strength, concrete is divided into strength classes. Strong concretes are C12/15 – C90/105. The first number indicates the cubic strength (accepted in our country), the second number (the denominator) the cylindrical strength.



According to the frost resistance (number of cycles passed), concrete is divided into the following grades:

- heavy 50 – 500;
- lightweight 10 – 500.

An important property of concrete is its waterproofing. According to this the concrete is divided into watertight grades: W2, W4, W6, W8, W10 and W12.

The composition of concrete mixtures (cement, fillers, water) is calculated and selected on the basis of laboratory test results. The physical mechanical properties of concrete (strength, frost resistance, waterproofing, etc.) depend on the quality of the materials used and the production technology (mixing, compaction).

In the production of concrete, the cement grade is higher than the strength of the concrete to be obtained. For example, to obtain C15/20 concrete, cement must be in grades 32.5 – 42.5.

The water for mixing concrete must be clean, free from impurities that stop the cement from hardening or impairing the quality of the concrete. Water must be free of acids, fats, sugars, etc. During the initial hardening period, the concrete is watered with water, which is also suitable for the production of concrete mix.

The used fillers are usually small and larger. Fine filler - natural sand with a grain size of 0.14-5.0 mm. Quartz sand is the most popular for heavy concrete.

The plasticity of the concrete mix depends on the type of cement, the amount of cement and water, the shape and coarseness of the filler grains, the ratio of coarse to fine fillers. As the water content increases, the plasticity increases but the strength of the concrete decreases. The plasticity of the concrete mix is increased by the concrete plasticizers

**Table 4.2. Concrete grade equivalents** [author's own work]

Concrete marking according LST EN 206-1:2002	Concrete marking according LST 1300:2000	Concrete marking according GOST 5802-86
C6/7,5	B7,5	M100
C8/10	B10	M150
C12/15	B15	M200
C16/20	B20	M250
C20/25	B25	M300
C25/30	B30	M350
C30/37	B35	M400
C35/45	B45	M450
C40/50	B50	M500
C45/55	B55	M550
C50/60	B60	M600

#### 4.1.3. Self-levelling mixtures for floors

Self-levelling mixtures are based on cement or gypsum. Their main purpose is to reduce surface roughness that occurs after poor concreting or other inadequate surface treatment. According to the building regulations, the deviation of the concrete floor must not exceed  $\pm 2$  mm, but in the most cases concrete work is less accurate.



Fig. 4.1. Laying a self-levelling mixture

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

The thickness of the casting mixture can vary from 0.7 mm to 40 mm, depending on the unevenness of the basis, the properties and the purpose of the casting mixture. Check the flatness of the basis with a ruler or a spirit level.

- Gypsum mixtures are only suitable for use in dry rooms.
- Cement mixtures are also suitable for use in dry and humid areas.



Fig. 4.2. Examples of self-levelling mixtures

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

#### 4.1.4. Repair mixtures

The repair mixture is factory made, ready for use on site, mixed with water. They are made on a cement basis. The consistency is adjusted by adding water.

Usage: cavity filling; slope formation or levelling of thresholds; levelling stairs, floors, walls.



Fig. 4.3. Repair mixtures

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

They may be:

- Fast hardening mixtures for repairing concrete, resistant to frost and weathering;
- Fast hardening repair mixtures for levelling walls and floors;
- Very fast hardening special mixtures (Used for repair, sealing, anchoring, fixing. In dry and wet areas. Hardening after 5 min and after 30 min. possible load).

#### 4.1.5. Materials for preparing vertical surfaces

Today, prefabricated dry mixes are often used instead of traditional materials for wall and ceiling plastering. They are made of mineral components and additives.

Levelling mixes are used in plastering, preparing walls for tiling, painting or wallpapering.

There are several types of materials:

- **Cement based mortars.** They are used in any room, both wet and dry, such as kitchens, swimming pools, saunas, etc.
- **Gypsum based mortars.** For dry premises.

It is worth noting that mixes differ not only in the above mentioned parameters. The thickness of the coating layer varies. They range from 0 to 30 mm.

#### 4.1.6. Waterproofing materials

Waterproofing materials are materials used to stop the penetration of water into other structures or premises. Waterproofing materials are used before tiling wall structures. Waterproofing materials must be strong enough to hold subsequent layers and loads on tiles. A thin layer of waterproofing adhesive is used for flooring. A special waterproofing mastic, mortar and roll materials are used for walls.

Waterproofing materials are divided into five groups:

- Polymeric dispersions waterproofing materials;
- Polymeric cementitious waterproofing mixes;

- Artificial resins waterproofing materials;
- Roll waterproofing;
- Waterproofing tapes.

#### **Polymeric dispersions waterproofing materials**

Mixes of polymeric dispersion and organic additives with / without mineral fillers, e.g. Knauf Flächendicht, Knauf Hydro Flex.

Hardening occurs during drying.

Ready for use, non-pressurized waterproofing. Suitable for waterproofing wall and flooring surfaces under tile or slab flooring in humid areas such as showers, bathrooms, and public and industrial sanitary facilities with drainage holes in the floor.



Fig. 4.4. Ready-to-use waterproofing materials

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

#### **Polymeric cementitious waterproofing mixes**

Mixes of hydraulically bound binder, mineral fillers and organic additives such as polymer dispersions, in powder or liquid form, e.g. Knauf Flex-Dicht.

Curing occurs due to hydration and drying.

The factory-prepared one-component mixes should be mixed locally with water. This prepares the waterproofing cement mortar for application by brush or trowel.

Quick and easy to coat, does not shrink, does not crack when hardened, well adheres to a basis, even in pressurized water, binds cracks over 0.75 mm wide. it is cold, aging and sulphate resistant. The prepared surface can be tiled using elastic cementitious tile adhesives. Polymeric cementitious waterproofing mixes are environmentally friendly due to the presence of minerals and one component.

Suitable for surfaces such as walls and flooring in wet rooms, balconies and terraces, pools, water tanks, in combination with ceramic tiles inside and outside buildings, restoring old buildings, waterproofing exterior basement walls and foundations.



Fig. 4.5. Polymeric cementitious waterproofing mix

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### Artificial resins

Mix of synthetic resins and organic additives, with or without epoxy or polyurethane resins.

Hardening occurs as a result of a chemical reaction.

Waterproofing of rooms with high humidity - bath and shower rooms, baths, basements, balconies, terraces. Suitable for tiling. Used on solid mineral substrates (concrete, masonry, plaster not less than CSII strength class).

Suitable for silos, rainwater collection tanks with positive water pressure.



Fig. 4.6. Synthetic resins

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### Roll waterproofing

Innovative and highly reliable system, fully waterproofing. Can be used even in emergency situations - on moving basis containing wood structures, e.g. OSB panels. It is also particularly suitable for outdoor use - waterproofing balconies or terraces.

Thin, flexible polyethylene base, coated on both sides with polypropylene. The special fiber fabric on both sides ensures optimum adhesion of roll waterproofing and adhesive.

The waterproofing properties of the roller can be ensured by using it in a system with additional components (special tapes and fittings).

Roll waterproofing is glued with cementitious, fast hardening elastic tile adhesive.



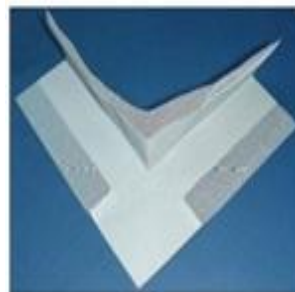
Fig. 4.7. Usage of roll waterproofing [author's own work]

#### Waterproofing tapes

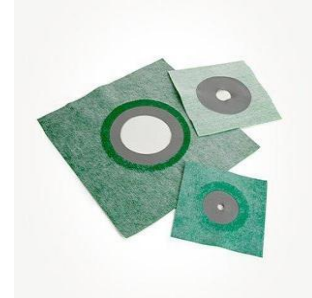
Designed for insulating wall and floor junctions and joints around pipes. Glued on waterproofing mastic.



Waterproofing tape



Corner detail



Waterproofing reinforcement cuff

Fig. 4.8. Various types of waterproofing tapes [courtesy of Knauf KG]

#### 4.1.7. Prime coatings (primers)

The basis must be clean, dry, normally absorbent to ensure a good surface finish. Deep prime coating can meet these requirements. Loosely bound surface particles must be reinforced with a deep primer. Primers equalize surface absorbency.

Primers can be divided into two main groups: water-based and thinner-based primers. One of the most popular water-based primers. Water-based primers are divided according to the binder used:

- **Acetates** – particle size 0.4 microns. The relatively coarse binder (PVA) particles form a weakly sticky membrane on the surface. Acetate primers are unstable in alkaline environments. The primers are suitable for use on porous surfaces.



- **Styrene acrylate** – particle size 0.2 microns. Primers for this binder are among the most popular. In most cases, sufficient penetration depth and appropriate reinforcement is achieved.
- **Acrylic hydrosol** – particle size 0.05 microns. Small binder particles provide a great depth of penetration. Acrylic hydrosol primers are used for standard and problematic surfaces, such as chalky and crumbling surfaces inside and out.

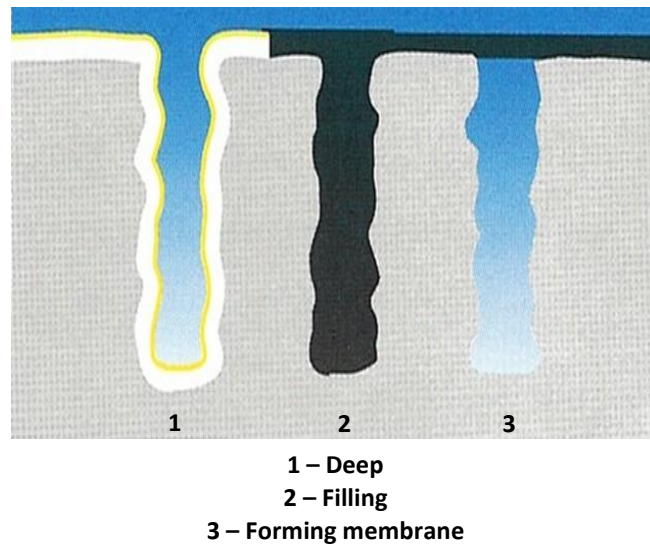


Fig. 4.9. Types of primers [courtesy of Knauf KG]

Priming is required:

- to ensure optimum adhesion to a basis;
- to achieve optimal basis strength;
- to adjust the absorbency of a basis;
- for porous surfaces.

### *Fine and coarse dispersed primers*

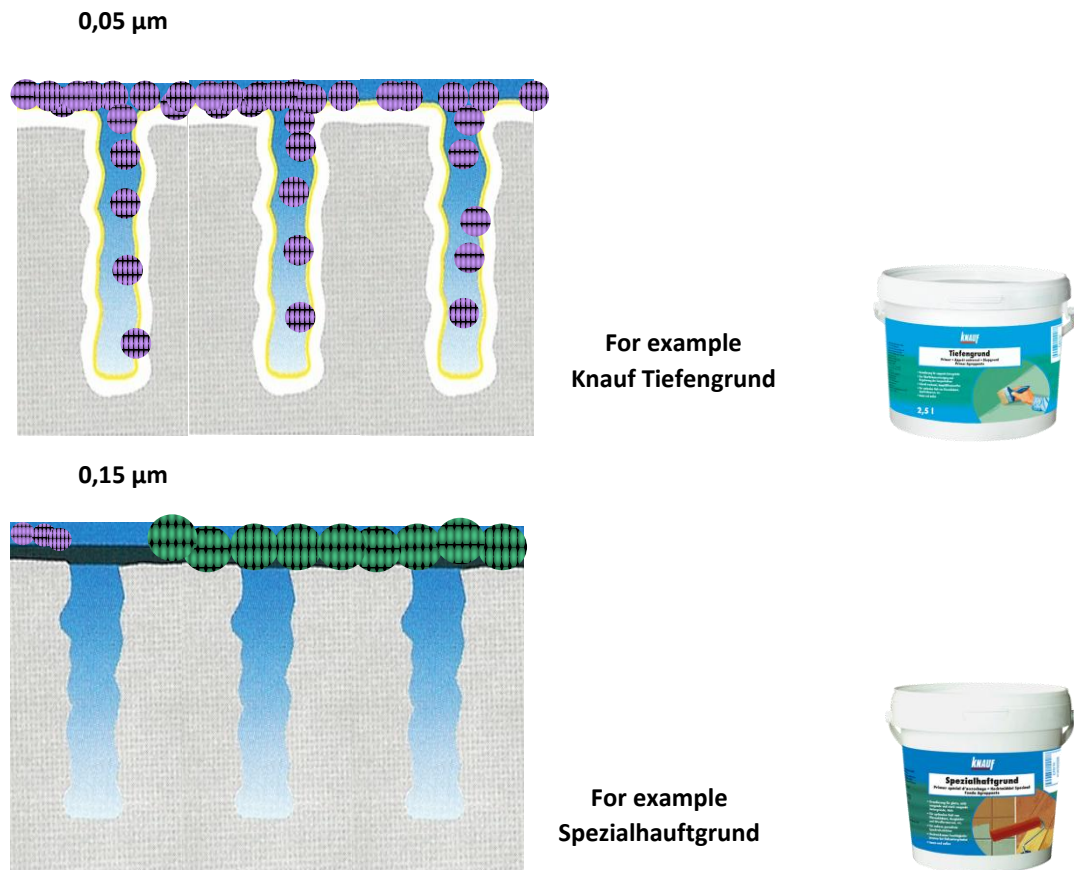


Fig. 4.10. Difference between fine and coarse dispersed primers [courtesy of Knauf KG]

## 4.2. Materials for fixing tile

### 4.2.1. Tile adhesive

Tiles can be glued to structures or fixed to a frame with special details. The frame and special parts are used for finishing exterior surfaces – facades. Tile adhesives are used for tile glueing, cementitious or polymer cementitious mortars.

There is no fully multipurpose adhesive to meet any requirement. Therefore, in each case, the most appropriate should be selected. Of course, the use of high-elastic glue instead of simple glue will not be worse, but care must be taken to select glues that meet a minimum of glueing requirements.

#### **Cement based adhesive – C**

C must be marked with adhesive strength class 1 or 2. Class 2 is higher.

- Class C1 > 0,5 N/mm<sup>2</sup>.
- Class C2 > 1,0 N/mm<sup>2</sup>



Fig. 4.11. Cement based tile adhesives [courtesy of Knauf KG]

Simple tile adhesive (Class 1). Used for glueing ceramic and concrete tiles to concrete, masonry, plaster and similar interior surfaces.

For non-absorbent tiles: stone mass, clinker, glass, natural stone tiles, the class 2 adhesive is used (adhesion > 10-12 kg / cm<sup>2</sup>), on concrete, masonry, plaster, gypsum board, old oil or enamel paint, old tile, MDP, PVC, asphalt and others. surface. Suitable for swimming pools, heated flooring, heavily used flooring in public buildings, terraces, extra-large tiles.

#### **Special purpose adhesives:**

- **Fast hardening – F**

The letter F (fast) means a short hardening time.

The adhesive labelled with the letter "F" has the ability to harden faster than conventional adhesives, so the joints can be filled in 1 – 2 hours after glueing. It is important for objects with a very limited time for work, as the tiled surface can be used in individual cases after 4 hours.

- **Non-slip – T**

The letter T (thixotropic) means that this adhesive will allow a tile to slip no more than 0.5 mm when applied to a vertical basis. If it is unmarked, the maximum allowed slip is up to 2 mm.

The adhesive marked with the letter T ensures that the tile adheres to the vertical surface immediately and does not slip by more than 0.5 mm. This adhesive allows you to glue the tiles from top to bottom.

- **Corrections or extended open time – E**

The extended open time letter means that tiles can be adjusted up to 30 minutes after the adhesive is applied to a basis. This is very important when tiling large areas. This results in higher productivity by spreading and gluing a larger area at the same time without the fear of being unable to use the applied glue. Standard glue without this mark allows for only 20 minutes.

- **Flexibility – S**

S1 – flexibility, deformation ≥2,5mm, <5mm;

S2 – flexibility, deformation ≥5mm.

Only C2 adhesives meet the requirements of S1 and S2. This adhesive is used on a basis which may slightly deform due to mechanical loads or temperature fluctuations. Class S1 and S2 tile adhesives form a more elastic and adhesive glue layer. This allows tiles to be laid on deformable structures such as heated flooring or possible vibration, etc.

**There are also glues (classification for commercial use, not considered by the EN):**

- For flooring

It is very flexible, so even glueing large-format tiles is applied only to a basis. It spreads well under a tile, leaving no voids.

- Based on white cement

For light and thin tiles, glass etc. transparent tiles, mosaic or unit tile glueing.

- Thick-layer tile adhesive

For glueing tiles with a layer thicker than 5 mm (usually used for flooring).

- For swimming pools.

Contains water repellent additives.

- For glueing to a metal surface.

Special purpose adhesives are usually of increased elasticity and are therefore used when these properties need to be exploited.

Dry adhesive mixtures are mixed with water at the workplace. The entire mass of the adhesive must be evenly mixed. After 5 to 10 minutes of repeated mixing, the adhesive is ready for use. Different adhesives, ready for use, retain a wide range of adhesive properties, from 2 to 8 hours, so you need to determine how long they will be used after preparation.

The temperature of a basis and surroundings during tiling must be above + 5°C. Apply glue to the wall with a smooth edge of a special trowel (comb) so that the thickness of the layer is 4-8 mm, then level it with a serrated edge of trowel. The size of trowel teeth depends on the size of the tile. For tiles larger than 400×400 mm, it is recommended to apply adhesive on a basis and on a tile. The position of the glued tiles can be adjusted until the glue has lost its plasticity – about 10 to 45 minutes, depending on the type of glue, the porosity of the surface, the moisture and the thickness of the glue layer.

**Polymeric adhesive – D**

Polymeric adhesives are used less frequently. The same tools are used for tiling.



Fig. 4.12. Polymeric adhesive [courtesy of Knauf KG]

**Epoxy Adhesive – R**

Two-component adhesive for glueing all types of tiles to many solid surfaces (see specific glue instructions for details). High strength, resistance to acids, water, frost etc. The tiles are glued when the temperature is at least 10 ° C. When working with epoxy glue, it is necessary to ventilate the premises well, use rubber gloves, etc. protective equipment. Hardened adhesives are harmless to health and the environment, so glue residues should be mixed as only hardened mass can be disposed of in ordinary landfill.



Fig. 4.13. Epoxy adhesive [courtesy of Knauf KG]

#### EN 12004 – European standard for tile adhesives

It lists the following key markings for tile adhesive:

- **C** – cement adhesive;
- **D** – disperse adhesive;
- **R** – resin based adhesive, epoxy and so on;
- **Class 1**, adhesion to substrate  $\geq 0.5 \text{ N / mm}^2$ ;
- **Class 2**, adhesion to substrate  $\geq 1.0 \text{ N / mm}^2$ ;
- **F** – Fast hardening;
- **E** – Open time, 30 minutes or more;
- **T** – Non-slip  $\leq 0.5 \text{ mm}$ ;
- **S1** – flexibility, deformation  $\geq 2.5 \text{ mm}$ ,  $< 5 \text{ mm}$ ;
- **S2** – flexibility, deformation  $\geq 5 \text{ mm}$ .

#### Examples:

- **C1T** – standard non-slip tile adhesive for interior use;
- **C1F** – standard fast drying adhesive;
- **C2T** – elastic non-slip tile adhesive for interior and exterior use;
- **C2TE** – elastic non-slip tile adhesive for interior and exterior work with increased open time;
- **C2TE S1** – elastic, non-slip tile adhesive for interior and exterior work, with increased open time, resistant to basis deformation.

#### 4.2.2. Tile joint filler

Materials for filling and sealing joints:

- cement based fillers;
- cement-polymer fillers;
- epoxy fillers;
- silicone sealant.

The filler for joints is used for functional and aesthetic purposes. Filling in between the tiles prevents water penetration, balances surface strength and ensures long-lasting adhesion in the gaps. Like the tiles themselves, the joints must withstand high mechanical stresses and be waterproof. Cement fillers for joints are fine-grained and coarse-grained, used to fill narrow and wide joints between tiles. The recommended width of joints is on the packaging of a filler.

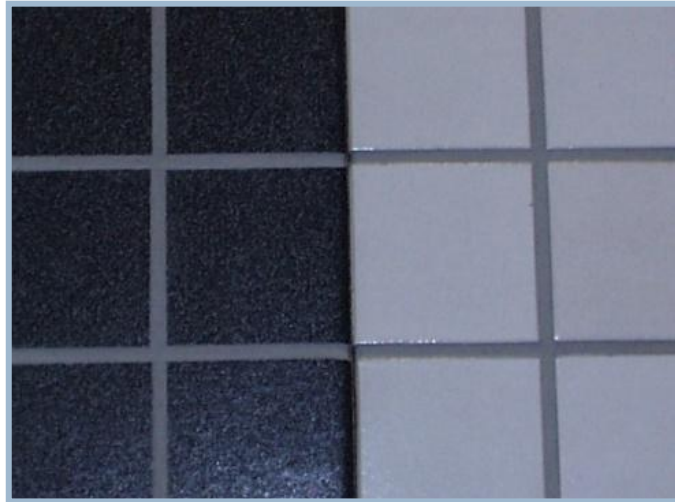


Fig. 4.14. Optical illusion- Is the joint dark or light? Eyes can lie.  
[courtesy of Knauf KG]

**The cement based filler** is used to fill tile joints in dry and humid areas. It is mixed with water, after 5 minutes it should be mixed repeatedly and then it is ready for use. Suitable for 0.5 to 2 hours. The strength of this filler is cement, so moisture is desirable during hardening. The filler is inexpensive and easy to use. Negative properties: low acid resistance, stain formation, difficult to clean, water permeable. The properties can be improved by impregnating with a special emulsion after hardening.

**Cement-polymer based filler** is a cement-based filler enhanced with a latex additive. This filler consists of cementitious putty and latex. Cement-polymer based filler is waterproof, easy to clean, strong and well suited for dry and wet rooms, balconies, terraces, heated ground flooring, industrial premises.

**Epoxy filler** consists of two components: coloured epoxy resin and hardener. The reaction of both components makes the filler very durable, resistant to chemical effect, making it well suited for exterior work, swimming pools and industrial premises, kitchen worktops. This filler is widely used in industrial and commercial premises.



Coloured, light and intense colours are not suitable for flooring because they are stained very quickly. Such colours can be used for wall tiles.



Fig. 4.15. Various colours of joint filler with a visualisation [courtesy of Knauf KG]

### 4.2.3. Silicone sealant

Silicone sealant is a sealant used for ceramic tile joints. Suitable for filling cracks, gaps in sanitary facilities such as bathrooms, kitchens, showers, laundries and other high humidity areas. Particularly suitable for areas where high joint elasticity is required, such as wall corners, flooring joints and offset gaps. Plumbing fixtures, such as baths, shower trays, washbasins, kitchen furniture, ducts, sanitary and heating system pipes, can also be filled. Suitable for use inside and outside buildings.

#### The type of basis

Ceramic tiles (glaze, terracotta, stone, mosaic, clay, clinker), glass tiles and elements, sanitary ceramics, porcelain and faience, enamelled elements, impregnated wood, anodized aluminium, stainless steel. Adhesion testing is recommended before application on plastics (polyacrylic, PVC, polyester and epoxy panels, polystyrene) or paint coatings. Do not use for joints with teflon, polypropylene, polyethylene and mirrors, natural stone, non-protective metals.

#### Requirements for the basis

The basis must be dry, without adhesive mortar or filler residue, dust, dirt, fat, rust, weak adherent layers or other dirt (such as previous sealing layers) which could reduce silicone adhesion. Adjacent surfaces that do not need to be silicone coated should be protected with a paint strip. Tear off the tape after installing the silicone.

The function of the joint is to withstand stretching, shearing, compression and rotation loads. Therefore, the silicone joints must be technologically correct. The silicone joint will be correctly installed when it has adhesion to only two planes.

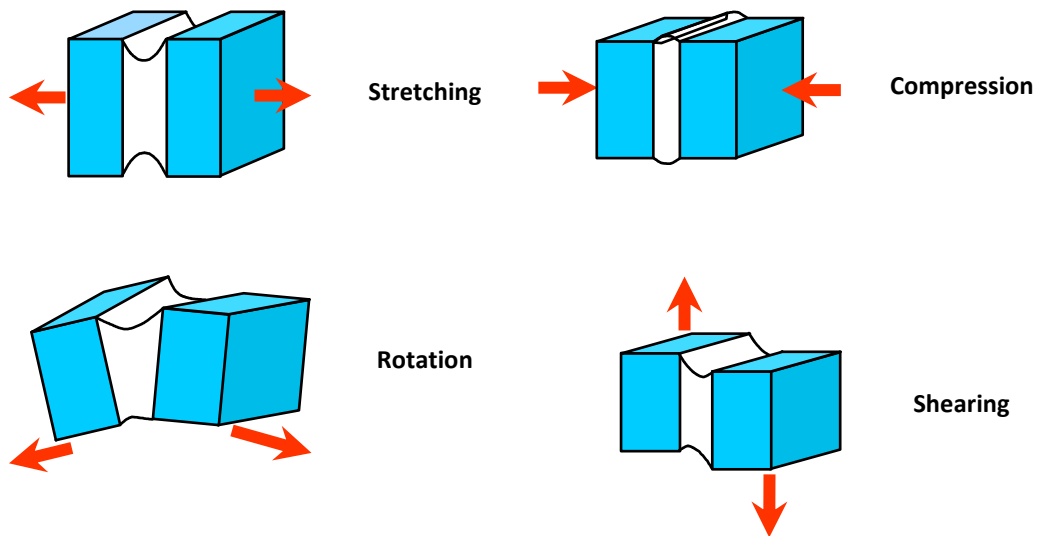


Fig. 4.16. Behavior of a silicone sealant under a various types of load [courtesy of Knauf KG]

#### Joint installation in accordance with DIN 18540

Remember: the silicone joint will be correctly installed when it has only two planes of adhesion!

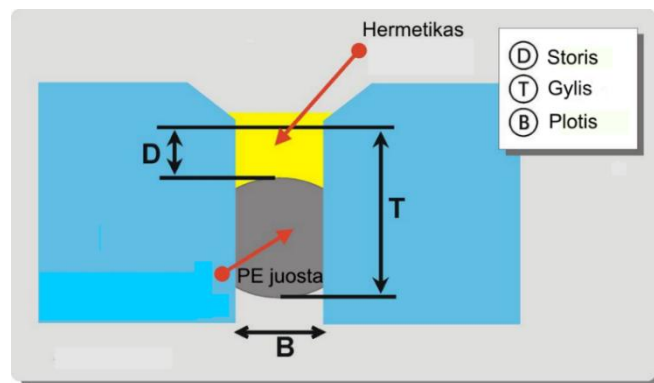
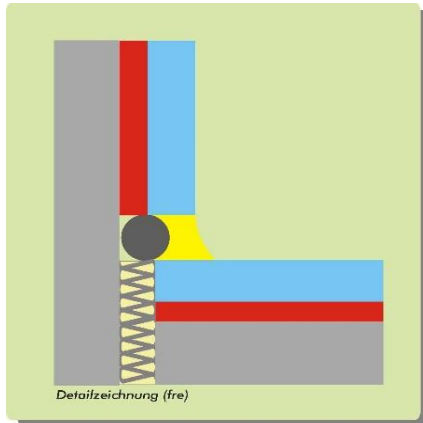
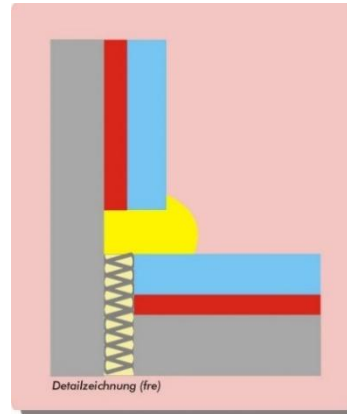


Fig. 4.17. Scheme of a silicone joint [courtesy of Knauf KG]

**Angle and connection joint eg. wall/wall, wall/floor, joining of individual building structures - wall/wall, wall/floor, stairs.**

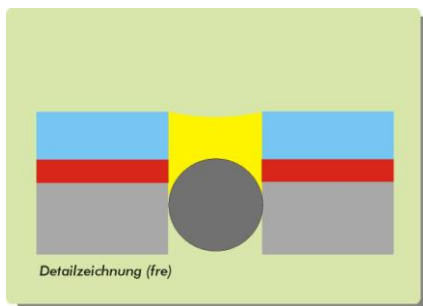


**Correctly**

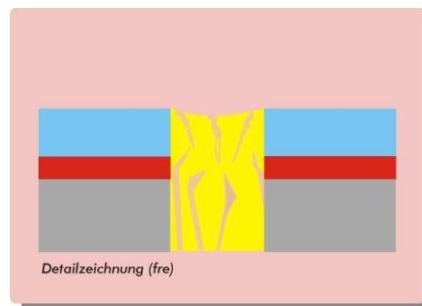


**Incorrectly!**

**Deforming joint eg. on the flooring  
Tiles in underfloor heating areas, balconies, terraces (Large tiles, building deformation joints, door openings, joining different floor coverings).**

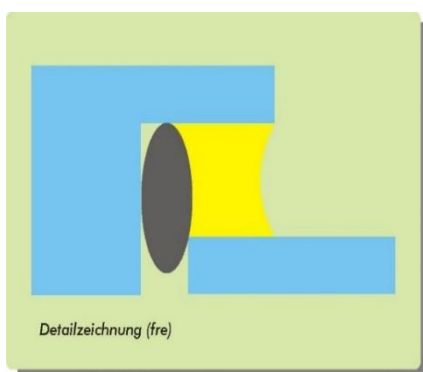


**Correctly**

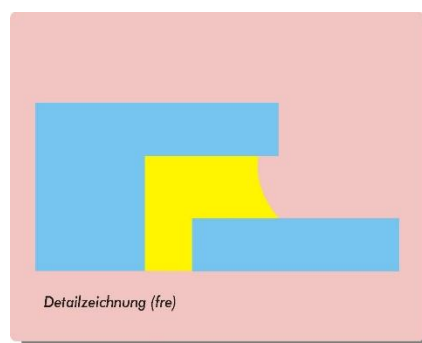


**Incorrectly!**

**Variable direction joint eg. roof installation  
- Acrylic roofing**



**Correctly!**



**Incorrectly!**

Fig. 4.18. Good and bad methods of making silicone joints [courtesy of Knauf KG]

#### 4.2.4. Auxiliary elements for corners and stairs

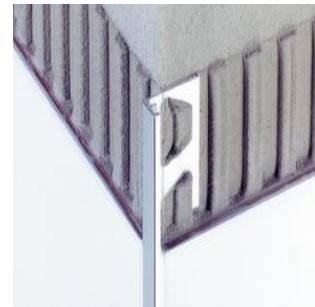
Auxiliary elements are made of PVC, aluminium alloy, brass, steel and combined for professional and aesthetic decoration of edges of tiled surfaces. They are used at the intersection of two ceramic planes (inner and outer corners) as an element to complete the tile coating, as well as where the tile joins with another building element or other finishing coating.



(1)



(2)



(3)



(4)



(5)



(6)



(7)



(8)

1,2,3,4 – PVC and metal exterior corners;  
5,6 – Inner corners;  
7,8 – Profiles for finishing tiles.

Fig. 4.19. Various types of an auxiliary elements [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

Auxiliary elements are suitable for finishing various edges of openings (e.g. windows, doors, shelves, pillars, stairs, bathroom circuits, shower cubicles) as well as ceramic joints with window, door frames, other decoration elements and etc.



Fig. 4.20. Example of auxiliary element usage [from „PLYTELIQ KLOJIMO TECHNOLOGJA“]

Special profiles are used for finishing staircases edges, which perform not only finishing but also protective function - increase resistance to mechanical impact and reduce the risk of slipping. Step elements are made of metal or combined: metal – PVC.



Fig. 4.21. Staircase edge profiles [from „PLYTELIQ KLOJIMO TECHNOLOGJA“]

Combined auxiliary elements are also used in tiled surfaces, in the area of deformation joints. All supporting elements accelerate and make tiling easier, hide and protect the edges of cut tiles. Special profiles or auxiliary elements are fixed by gluing together with the tile or after tiling, depending on the construction and purpose of the element. Depending on the thickness of the tiles selected, it is necessary to choose the appropriate height of the supporting elements.



Fig. 4.22. Profiles used for installation of deformation joints in tile covering  
[from „PLYTELIQ KLOJIMO TECHNOLOGJA“]



### Selection of the required thickness element

PVC finishes come in different heights – from 6 to 10 mm and in different colours, which are matched to the tile colour. Plastic elements are commonly used because they are cheap, easy to fit and machinable.

Metal profiles are usually used in the same locations as PVC profiles. However, due to their higher mechanical strength, edges that may be mechanically vulnerable (such as outside corners on industrial sites) are more recommended.

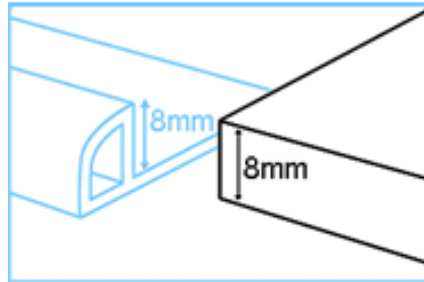


Fig. 4.23. Thickness selection [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

Curved joints are finished with PVC or metal profiles with special notches for this purpose.

### Curved profile

Some accessories only serve a decorative function and are used as part of the design.



Fig. 4.24. Curved profile [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

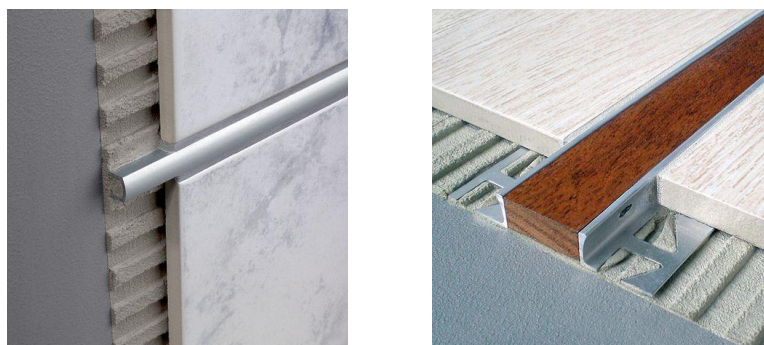


Fig. 4.25. Accessories for decorative function [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]



### 4.3. Cleaning and maintenance materials for tiled surfaces

Like many other surfaces, ceramic tiles require proper maintenance and cleaning to maintain their technical and aesthetic properties.

Of the many cleaning products available on the market, it is best to choose the ones recommended by tile manufacturers. Both ceramic and stone mass tiles are easy to maintain as they do not absorb moisture, dirt and are easy to clean. Only a few tips should be followed: wash the tiles after construction and periodically clean.



Fig. 4.26. Basic cleaning of the tiles [<https://enamai.lt/lt/statybos-akademija/kaip-priziureti-plyteles>]

#### **The dirt will not be absorbed if:**

The tiled and washed surfaces will be impregnated. Impregnant is a special agent that penetrates into the tiles, reacts with its structure and forms a protective layer which repels water, all kinds of dirt, but allows the surfaces to breathe. Impregnated tiles remain clean even after intensive use. Their surface does not darken, dirt is not absorbed and is easily removed during daily cleaning.

The tiles can be impregnated with a colourless or saturated surface impregnant.

To save, an impregnant can only be chosen for cementitious filler for tile joints. The product penetrates well into the structure of the joints, forms a durable protective layer, the joints remain as new for a long time, and their colour is not changed.

Many cleaning products are suitable for daily tile maintenance. It should only be noted that the pH (acidity of the solution) of such cleaners is as close as possible to 7, as neutral as possible. Such a cleaner will not harm the tiles and their filler.

Clean dirty tiles with a damp sponge and wipe with a dry cloth. It is not recommended to overdo it with abrasives and metal brushes.

#### **Tiles can be waxed:**

Special wax is created not only for wooden floors but also for tiled flooring. It protects the tiled surface from mechanical scratches. To wax the floor, that is to say polish them with special liquid wax, is recommended periodically; how often you do it depends on the intensity of the movement. By the way, wax can be matte, glossy, very glossy, and even non-slip!

**Anti-bacterial agents for fillers**

Highly stained surfaces are best cleaned with alkaline cleaners. They remove filth, grease, soot and traces of shoes.

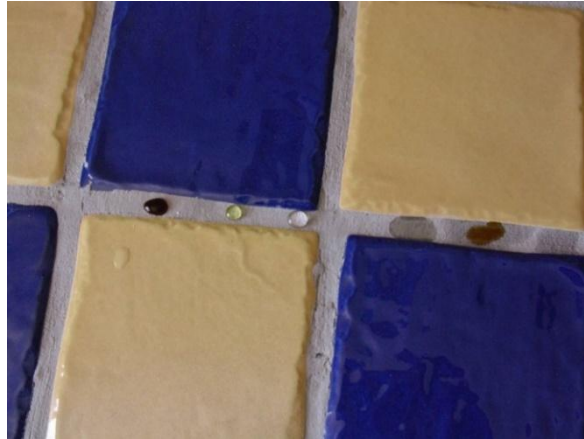


Fig. 4.27. Highly stained joints [<https://enamai.lt/lt/statybos-akademija/kaip-priziureti-plyteles>]

Special agent is used for cleaning and renovating stone mass and ceramic tile fillers. It is an antibacterial agent that completely eliminates bacteria, mold or algae, providing long-lasting protection against re-contamination. These special cleaners not only remove biological contamination, they also remove dirt from various different surfaces and also works well against lime deposits. This agent is not replaceable for bathroom tile maintenance.

**The materials for cleaning and maintenance of tiled surfaces and their use:**

**Table. 4.3. Proper cleaning and maintenance agents for various types of surfaces** [author's own work]

No.	Type of a tile	Maintenance or cleaning agent						
		Alkaline cleaner	Dirt cleaner	Acidic cleaner	The wax that provides shine	Wax that gives matte finish	Impregnating materials	Fat – solvent, cleaner
1.	Unglazed ceramic tiles	x	x	x			x	x
2.	Stone mass tiles	x	x	x			x	x
3.	Clinker tiles	x	x	x	x		x	x
4.	Terracotta tiles	x	x	x	x			x
5.	Marble tiles		x		x	x	x	
6.	Granite tiles	x	x	x			x	x
7.	Cement surface	x	x		x		x	
8.	Joints between the tiles		x				x	

## 5. The tools of a tiler



Fig. 5.1. Folding meter for measuring distances

Source of all pictures in Chapter 5: [„Vertikalių ir horizontalių paviršių apdaila plytelėmis“]



Fig. 5.2. Ruler for measuring distances



Fig. 5.3. Corner - for surface marking and quality control



Fig. 5.4. Laser gauge - for measuring distances, calculating room areas



Fig. 5.5. Ultrasonic gauge - for measuring distances, calculating room areas



Fig. 5.6. Cross-line laser for tiling and joints marking



Fig. 5.7. Level - for checking and marking vertical and horizontal surfaces

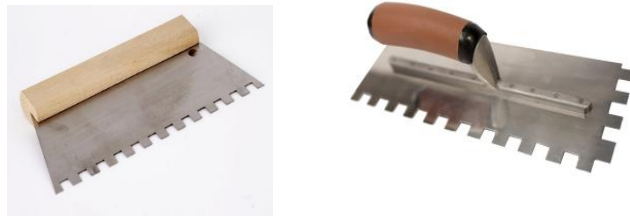


Fig. 5.8. Toothed trowel - for glue applying



Fig. 5.9. Spatula - for applying glue on a toothed trowel



Fig. 5.10. Rubber trowel for applying joints



Fig. 5.11. Trowel with replaceable sponges



Fig. 5.12. Crosses for tiles – to keep equal joints between tiles



Fig. 5.13. Trowel - for forming the inner corner joint



Fig. 5.14. Cord - for checking and marking surfaces



Fig. 5.15. Tool for joint cleaning and removing crosses



Fig. 5.16. Tool for joint cleaning and removing crosses



Fig. 5.17. Rubber hammer - for working with large tiles

## Manual - Tiler



Fig. 5.18. Silicone gun



Fig. 5.19. Tile leveling system



Fig. 5.20. Pliers for breaking tiles



Fig. 5.21. Hand tile cutter



## Manual - Tiler



Fig. 5.22. Tool for tile cutting



Fig. 5.23. Portable tile cutting machine



Fig. 5.24. Hand tile cutter



Fig. 5.25. Bucket for grouting (22 l)



Fig. 5.26. Electric drill - mixer

## 6. The quality of work

Building Regulations of the Lithuanian Builders Association ST 121895674.06.2009 "Finishing work" states:

1. The tiling is carried out in accordance with the recommendations of the companies – manufacturers, design decisions, construction rules. Such finishes are long lasting and therefore tiles are applied to the exterior and interior surfaces of buildings.
2. Surfaces are finished:  
with natural rock tiles and slabs (marble, granite, sandstone, dolomite, etc.);  
with tiles made of various materials (ceramic, stone mass, plastic, glass, etc.).
3. When installing natural rock tiles on external walls, the method of fixing them must be specified in the design.
4. For the vertical tiling the glazed wall tiles with bending strength not less than 20 N/mm and impregnation not more than 16% are usually used. The tiles are glued with Atlas, Ceresit, Keramfix, Keramflex, Hydrofix and other adhesives.
5. The walls are tiled when the flooring is installed. The design is coordinated with the project authors and a builder. After 1 – 2 days the joints are filled with specially prepared fillers according to the manufacturers' recommendations.
6. Permissible deviation from the vertical of the finished surface over a length of 1 meter:
  - mirrored, glossy tiles - up to 2 mm;
  - polished, flattened, roughened, grooved tiles - up to 3 mm;
  - ceramic tile on the outside - up to 2 mm, inside - up to 1.5 mm.
7. Vertical and horizontal permissible deviation of joints between tiles:
  - mirror, glossy surface tiles - up to 1.5 mm;
  - polished, flattened, roughened, grooved tiles - up to 3 mm;
  - split stone surface tiles - up to 3 mm;
  - ceramic tiles on the outside - up to 2 mm, inside - up to 1.5 mm.
8. Permissible deviation of joints of architectural finishing details:
  - mirrored, glossy surface - up to 0.5 mm;
  - polished, flattened, roughened, grooved - up to 1 mm;
  - split stone textures - up to 2 mm;
9. Permissible deviation of smoothness of the finished surfaces measured with a 2 meters long ruler:
  - mirrored, glossy - up to 0.5 mm;
  - polished, flattened, roughened, grooved - up to 1 mm;
  - ceramic tiles - up to 3 mm outside, up to 2 mm inside.
10. Permissible deviation of the width of joints for tiled surfaces:
  - mirrored, shiny - up to 0.5 mm;
  - granite, artificial stone, marble - up to 1 mm;
  - polished, flattened, roughened, grooved - up to 1 mm;
  - ceramic tiles inside and outside the building - up to 0.5 mm;
  - split stone textures - up to 2 mm.

## 7. Work performance technology

### 7.1. Higher humidity indoor decoration. Waterproofing installation.

Waterproofing is required in all rooms with increased relative humidity

- bathrooms,
- kitchens,
- laundries,
- toilets,
- saunas and elsewhere.

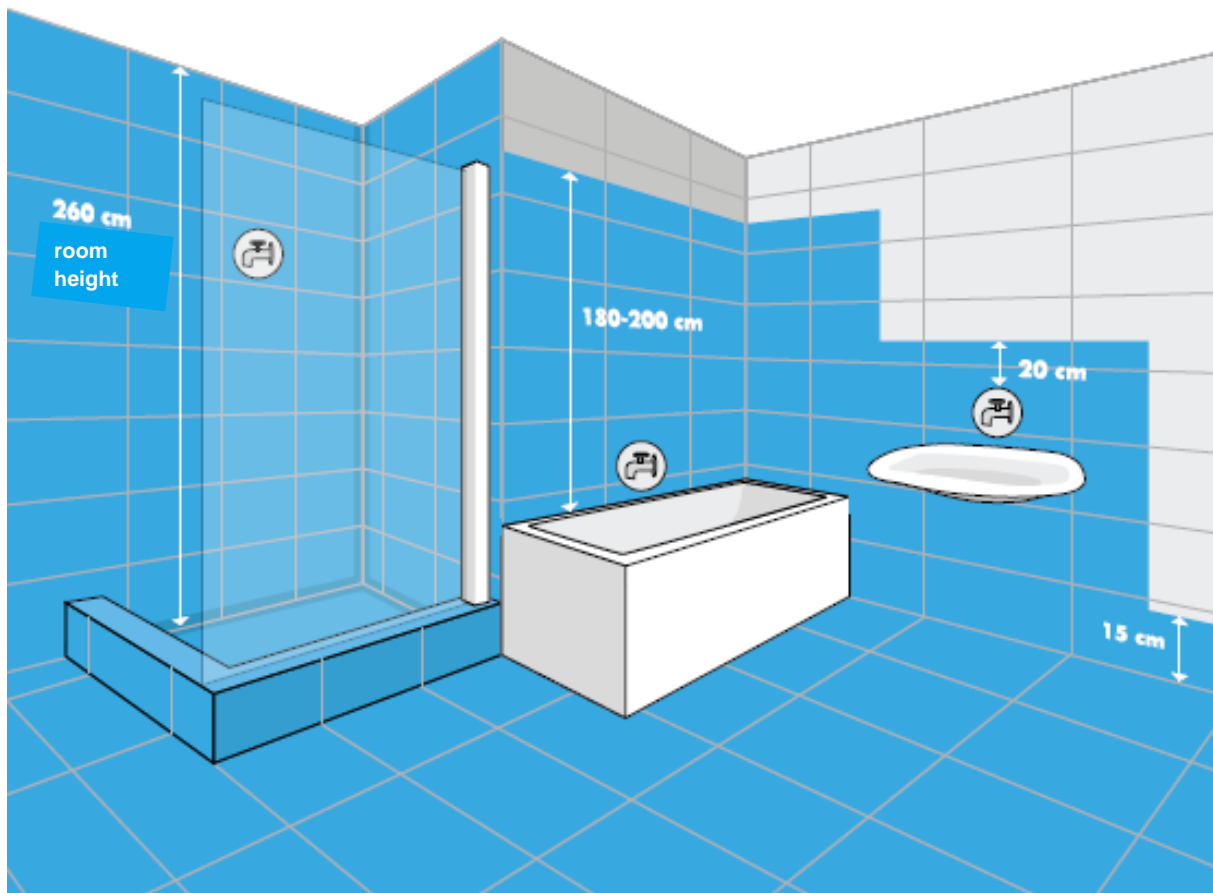


Fig. 7.1. Typical reach of waterproofing in a bathroom

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Waterproofing such rooms helps to protect the building's structures from the adverse effects of moisture like wall frostbite, mold or even water leakage to a lower floor in the event of a domestic accident.

If high humidity premises are not equipped with waterproofing, the resulting vapour is easily absorbed into partitions, especially wood fiber and gypsum boards, which are permeable to water vapour. In bathrooms adjacent to an exterior wall or roof, moisture can accumulate in the insulation layer or on the wall in the form of condensation. This can lead to mold, which not only damages buildings but also causes health problems.

For showers and other humid premises, it is advisable to use waterproofing materials that can be elastic and relieve deformation of structures such as heated floors and walls. Such materials are best polyurethane because they are most elastic (up to 600% elongation), or from a mixture of cement and acrylic (up to 150% elongation). The worst choice for a bathroom would be solid materials with less than 150% elongation. Such a waterproofing coating breaks along with the waterproofed surface.

Range of waterproofing materials on the market is very wide and they are constantly being improved. The most important thing is that the waterproofing should be compatible with the chosen finishing materials.

One of the most important characteristics of the material used for waterproofing wet premises is elasticity. The elastic coating does not crumble under temperature fluctuations typical of bathrooms. In addition, the material must adhere well to the surface and tile adhesive, and be durable.



Fig. 7.2. Waterproofing [author's own work]

### **Work process with mastic waterproofing**

During operation, premises and basis temperature should be 15-25 degrees Celsius, and the underfloor heating should be switched off 2 days before. The drying of the waterproofing can be accelerated by ventilating the premises but not by heating radiators or hot air heaters.

First of all, walls should be covered with waterproofing and tiled. Only the bottom row of wall tiles is left – it is only glued when the flooring tiles are already glued. The floor is then waterproofed and its surface is covered with a planned coating.

### **It is important not to damage the waterproofing layer when working.**

Before laying the waterproofing material, the building materials and dust must be removed from the basis. The basis must be strong, clean, smooth, with no cavities or cracks. Otherwise, the waterproofing material may be damaged and any defects must be corrected in a timely manner.

Work process can be divided into following phases.

### 1. Priming of walls before waterproofing

If the surface is weak, porous and dusty, it should be primed. Priming strengthens the surface and improves adhesion to the waterproofing coating.



Fig. 7.3. Priming

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### 2. The waterproofing of wall and floor joint

Abundant and even application of waterproofing mastic in the wall-floor joints area. Immediately apply an elastic waterproofing tape to the fresh layer, press lightly, adjust the smoothness and press with a blunt trowel.

Apply the edges of the elastic tape with fresh residue of waterproofing mastic. Then apply a second and, if necessary, a third layer of waterproofing mastic.



Fig. 7.4. Making of a waterproofing of wall and floor joint

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### 3. Waterproofing corners

Apply abundantly evenly undiluted waterproofing mastic in the corners area with a brush or a roller, immediately fix the inner corners to a fresh coat, press and smooth with a plastic trowel or a blunt metal trowel. Do not leave empty cavities. Then apply fresh waterproofing mastic residue to the corners. For exterior corners, factory-made waterproofing corners can be used.

The joint between the elastic waterproofing tape and waterproofing corners should overlap at least 5 cm.



Fig. 7.5. Proper waterproofing of a corner

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

#### 4. Waterproofing of areas around pipes

Abundant and even application of undiluted waterproofing mastic around the pipe inlet with a brush or roller. Optional waterproofing cuff: it is in the right size if the inner sealing area fits at least 3 mm into the outflow pipe. The waterproofing cuff is immediately applied to the freshly coated layer, pressed lightly, levelled with a trowel, and then applied with fresh waterproofing mastic residue from the first layer.

If wrinkles or air bubbles form, the waterproofing layer will be water-permeable. The cuffs must be adequately covered with waterproofing mastic to form a uniform layer.

After the first layer of waterproofing dries, a second coat is applied and allowed to dry for about 6 hours. The dried waterproofing layer should be approximately 0.5 mm thick.

The tiles should be glued from the second row of the floor. Tile joints can be sealed 1 – 3 days after glueing.

As the walls are tiled, it is better to rush to waterproof the floor in humid premises. If the floor is uneven, it is firstly sanded or levelled with special floor mixes. If the floor of the room is heated with electric cables, then a temperature-resistant levelling mix is used.



Fig. 7.6. Making of waterproofing around pipes

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]



### 5. Waterproofing of floor drain

Clean the drain area and put a centring element. For better comfort, the back of the cuff has two split protective membranes. The waterproofing cuff should be inserted into the centre of the floor drain. Its joint with the auxiliary centring element should be at least 5 cm. Remove one part of the protective membrane, fix it and secure it. After that, remove the other side of the protective membrane and secure it as well. Press the cuff firmly. Air bubbles must not remain. Use a plastic roller or similar tool to press firmly to the base and drain joint. Then apply the first layer of waterproofing mastic to the entire flooring area. The first coat dries in 2 hours. When the applied layer is dry, a second layer of waterproofing is applied.

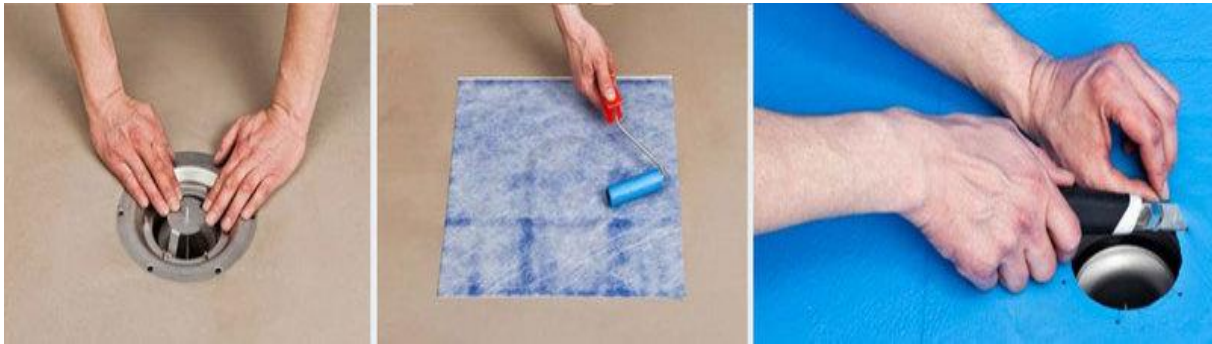


Fig. 7.7. Making of waterproofing around hole in a floor

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### Work process with roller waterproofing Knauf Abdichtungs- & Entkopplungsbahn

Knauf Abdichtungs- & Entkopplungsbahn Waterproofing Roller Coating is suitable for not quite stable wooden or wood-based basis, but is not suitable for uneven basis. Cracks and unevenness must be levelled before fixing.

The basis must be solid, clean, dry, free of oil, grease and other adhesion resistant materials. It is necessary to remove dust, paint and mortar residue.

#### 1. Basis priming before waterproofing

The prepared basis is primed with one coat of primer. Deep priming is required for normally absorbent surfaces and Knauf Spezialhaftgrund for weak or strongly absorbing surfaces. It dries for at least 2 hours. The primer should be completely dry before the next application.

#### 2. The installation of roller waterproofing

Roller waterproofing is applied with Knauf K6 adhesive. The surface is covered with glue, applied with a toothed trowel and after the Knauf Abdichtungs- & Entkopplungsbahn coating is firmly pressed into their layer. The adhesive should always be applied in such a way that roller waterproofing can be applied on time, until a membrane forms on the surface. The presence of a membrane can be checked with a finger. With a plastic trowel (or similar tool), roll waterproofing is pressed and levelled. This should be done from the middle with no air bubbles left.



Fig. 7.8. Steps of applying a roller waterproofing

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### 3. Insulation of joints in waterproofing roller coatings

Knauf Abdichtungs- & Entkopplungsbahn roller waterproofing has a 6 cm wide mark indicating the junction area. Apply a Knauf Power-Elast sealant to the area and spread it with a 2 mm serrated trowel. Apply another roll of waterproofing tape on this area, lightly pressing the joint area by hand. Then press firmly and swipe with a plastic spatula or blunt metal trowel.

The joints can be formed without overlapping at the edges. In this case, the edges of the coatings are placed side by side, Knauf Power-Elast sealant is applied and the top is covered with a Knauf Flächendichtband elastic waterproofing tape.



Fig. 7.9. Steps of insulating of joints in roller waterproofing

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

### 4. Pipe and gully area insulation with waterproofing coating

Apply sealant evenly around plumbing, sewerage inlets. Apply the cuff of the correct size into the fresh layer of sealant and press firmly. Level and press with a plastic trowel.



Fig. 7.10. Preliminary steps of insulating pipe area

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Apply a primer to the floor and glue a Knauf Butyl-Dichtmanschette waterproofing cuff to a drain. Only apply Knauf Power-Elast sealant to the waterproofing cuff, do not apply to the gulley area and then apply Knauf K6 adhesive to the surrounding floor with a serrated trowel.

Glue Knauf Abdichtungs- & Entkopplungsbahn roller waterproofing on the entire surface of the drain. Alternatively, roll the waterproofing on a freshly covered waterproofing layer of the Knauf Flächendicht. Press down firmly in the drain area. Place a template and accurately cut the hole in the drain.



Fig. 7.11. Next steps of insulating pipe area

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminu-plyteliu-klojimo-instrukcija>]

### 5. Joining of waterproofing coatings

Apply Knauf PowerElast sealant over a 6 cm wide area and spread with a 2 mm serrated trowel. Apply another waterproofing coating, lightly press the joint area by hand. Then press firmly and swipe several times with a plastic spatula or trowel.



Fig. 7.12. Steps of joining of waterproofing coatings

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminu-plyteliu-klojimo-instrukcija>]

### 6. Laying of waterproofing roller coatings at corners and plane joints

Apply a Knauf Power-Elast sealant evenly to the corner area with a serrated trowel. Knauf Dichtecke waterproofing corners are quickly laid in a fresh layer and lightly pressed. Use a plastic spatula or blunt metal trowel to squeeze the air out of the voids, press and smooth.

Apply a Knauf Power-Elast sealant to the floor and wall joints, using a serrated trowel. Apply elastic waterproofing tape the Knauf Flächendichtband, squeeze the air and level.

Knauf Abdichtungs- & Entkopplungsbahn waterproofing can also be used outdoors to waterproof the terraces and balconies. The material and workflow is the same as the above described use on more complex surfaces. For waterproofing balconies, it is recommended that part of the coating is fixed to the wall and from the edges of the terrace, fold the roller coating down and glue it to the bottom to prevent the walls from getting wet.



## 7.2. Joints between tiles and other structures

Wide joints are preferable to narrow ones, especially when using elastic fillers. The modulus of elasticity of the tiled surface is significantly reduced, which reduces the effect of deformation of the underlying layers. This reduces the risk (practically to zero) that the tile will be lifted off the locking layer due to parallel forces.

When the joints are wide, it is easier to control that they are well filled with a joint filler that prevents the penetration of water, dirt or other aggressive materials. Narrow joints, although not recommended, may be used only on condition that the basis, adhesive layer and tiles are properly aligned.

The joints can be filled with filler on the basis of cement or on the basis of polymers (silicone, synthetic resins). Cement based filler is not elastic, acid and stain resistant. Latex additive, which partially or completely replaces water, reduces the absorption of water for cementitious filler, increases acid and stain formation resistance. The silicone filler is elastic and its application reduces the modulus of elasticity of the coating. It is also sufficiently resistant to aggressive environments. Epoxy filler is used to fill joints in pools, aggressive environments, and for coatings that are subject to extremely high hygiene requirements.

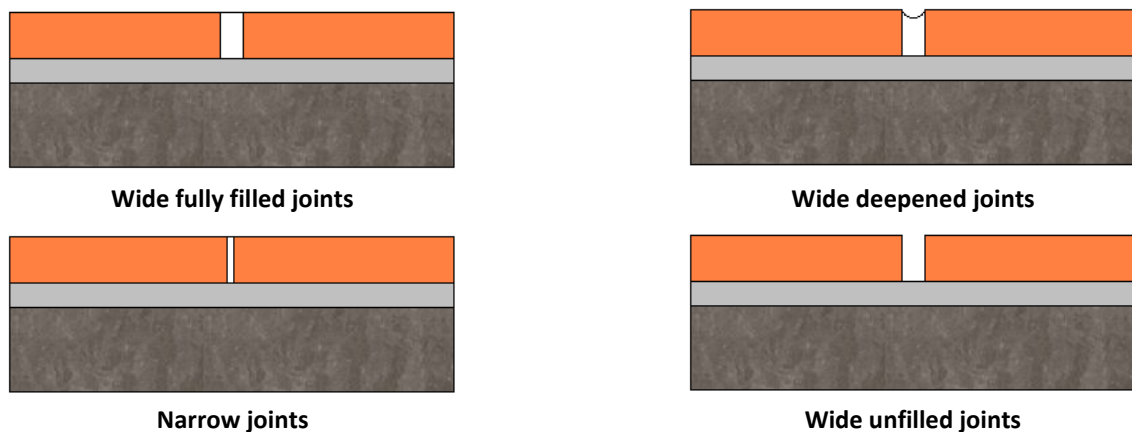


Fig. 7.13. Various types of joint filling - joint width should be correlated with tile height  
[author's own work]

**Table 7.1. Recommended joint width selection according to tile dimensions** [author's own work]

	Tile format (cm)	Width of joint (mm)
Wall tiles	15x20	3-4
	20x20	3-4
	20x25	3-4
	25x33	4-6
	Larger formats	4-10
Floor tiles	20x20	6-8
	25x25	6-8
	30x30	6-8
	40x40	8-10
Clinker tiles or tiles for turning points	11,5x24	Not less than 10
	20x20	Not less than 10
	24x33	Not less than 10
	30x30	Not less than 10

### 7.3. Installation of deformation joints

Deformation (temperature) joints are joints filled with dense, elastic material that ensure the stability and durability of the coating.

Deformation joints are recommended to:

- large concrete surfaces would be divided into smaller ones;
- concrete surfaces are separated from walls, columns and other fixed structures throughout the perimeter of the entire area;
- the deformation of the concrete occurs at the intended locations.

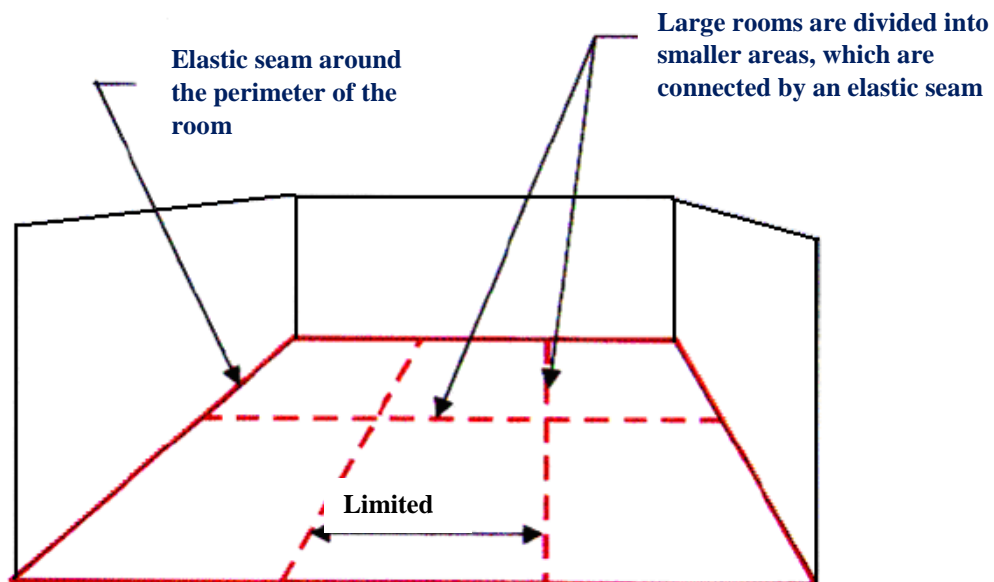


Fig. 7.14. Layout of deformation joints in large premises  
[from „Vertikalių ir horizontalių paviršių apdaila plytelėmis“]

Depending on the type of flooring, the joints are filled with silicone, polyurethane or other elastic material. However, at the beginning, the floor is laid, and then the deformation joints are cut, prepared and filled.

Several types of installation are possible when using deformation profiles, depending on their type:

- the seams are installed in the manner already mentioned. The profiles are pressed into place;
- profiles are installed before concreting - it is only necessary to concrete the floor and install the desired covering. In this case, no additional labour costs are required for jointing and additional equipment.



Fig. 7.15. Deformation joint profiles [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

Special plastic or metal (with rubber insert) strips can be used for tile joints, depending on the expected loads and chemical irritants in operation. Standard profiles for deformation (temperature) joints are used in all types of flooring construction. Inserts for deformation profiles are made of high quality and certified elastic rubber. The insert allows for a large range of floor structure to move (expansion/contraction) while providing excellent protection of the temperature joints from moisture ingress, dirt build-up and etc.

The amount of deformation joints depends on:

- flooring area;
- fluctuations in heat and humidity;
- the type and size of loads to be applied.

**Recommended dimensions of the restricted area of deformation seams: 4-10 meters.**

The placement of deformation joints is very important and needs to be fully evaluated right from the design stage. Recommended dimensions of the restricted area of deformation joints:

- **Internal surfaces:**
  - Narrow joints – from 4×4 m to 6×6 m;
  - Wide joints – from 6×6 m to 10×10 m.
- **Exterior surfaces:**
  - Narrow joints – from 2×2 m to 3×3 m;
  - Wide joints – from 3×3 m to 5×5 m.



#### 7.4. Selection of serrated trowel

The serrated trowel is selected according to the size of a tile:

**Table. 7.2. Rules of choosing a proper serrated trowel** [author's own work]

Tile size (cm)	Size of trowel teeth (mm)
Up to 10x10	6
10x10 to 20x20	8
20x20 to 30x30	10-12
Over 30x30	bigger

#### 7.5. Adhesive application rules

The quality of adhesive application will depend on:

- selected glue,
- the right tools,
- the correct amount of water,
- the required open time,.

The prepared adhesive mortar is evenly distributed on the basis with a steel serrated trowel, first with a smooth trowel edge and then distributed over the surface with a serrated edge. When the size of the tile is more than 40 x 40 cm, the adhesive is applied to both the basis and the tile.



Fig. 7.16. Tile covered in adhesive [from author's archive]

Problems related to adhesive application:

- Trowel teeth too small - too little glue:
  - It is difficult to adjust a tile;
  - too little surface contact with glue.
- Too little or too much water:
  - Complex fixing;
  - Reduced open time;
  - No adhesion.
- Correct open time:
  - The adhesive will stick to the entire surface of a tile.

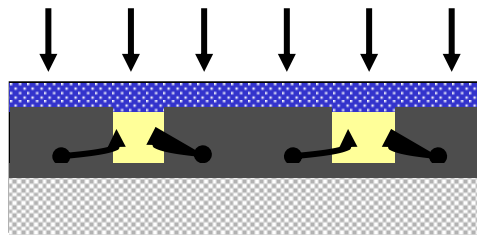


Fig. 7.17a. Correct open time, the adhesive will stick to surface of the entire tile  
[from author's archive]

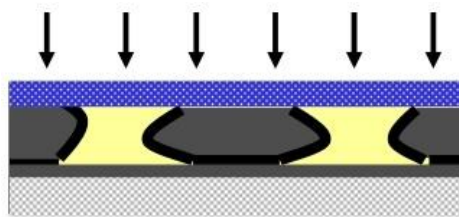


Fig. 7.17b. Open time is "over," the glue no longer sticks, leaving air spaces open  
[from author's archive]

## 7.6. Tile laying technology

### 7.6.1. Basis preparation – cleaning

The surface on which tiles are laid must be stable, dry, hard and levelled. All layers that reduce adhesion, such as dust, dirt, lime, grease, lacquer, oil paint, emulsion or bituminous coating, must be removed (as any other anti-adhesive agents). Larger irregularities should be removed mechanically, e.g. using a trowel, and smooth cavities using a levelling compound.



Fig. 7.18. First step of the surface preparation

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Depending on its ability to absorb water, the basis should be primed with a deep or adhesive primer.



Fig. 7.19. Priming of the surface

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

On a freshly plastered surface, the tiles should only be glued when the plaster layer is completely dry. Mostly it takes 3 – 4 weeks.

If the tiles are laid on the floor, it is usually concrete or cementitious basis, but it can also be laid on more complex basis, such as OSB or chipboard or even old ceramic coatings (in which case the basis must be primed with adhesive primer). Note that no matter what the basis the tiles are to be laid on, the surface must be thoroughly cleaned.

### 7.6.2. Basis preparation: priming and levelling

Depending on the surface absorbency, a deep primer should be used for normally absorbent basis, non-absorbent basis, particularly absorbent basis and wooden basis.

The primer does not create a membrane, but reduces the absorption of moisture from the adhesive mortar and strengthens the surface layer if it is not fully rigid, and also increases the water resistance of the surface. This is especially true for gypsum-based basis.

### 7.6.3. Basis preparation: waterproofing

When levelling or priming the basis, waterproofing must be carried out, it is necessary in wet premises, especially when insulating the surfaces directly exposed to water. In addition, some types of waterproofing prevent the transmission of cracks from the basis into the finishing layers. The flooring basis can also be waterproofed with a cementitious mixture - elastic cemented waterproofing.



Fig. 7.20. Waterproofing of the floor-wall joint

[\[https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija\]](https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija)

Waterproofing is usually done in two stages. First, at the joints between the walls and the floor, a waterproofing tape is applied to the coated first layer of waterproofing mastic, which "retains" the joint deformation as different planes "move". A second layer of waterproofing is then applied. And only then can the tile begin to be laid.

Outdoor balconies and terraces should be insulated with cementitious elastic waterproofing. It is suitable for massive basis, e.g. concrete layer. If the structure of a terrace or balcony is framed, e.g. If OSB is used, it is better to use a waterproofing and separating membrane, Knauf Abdichtungs und Entkopplungsbahn, on which it is easy to glue the tile covering.

#### 7.6.4. Tiling

Successful tiling will only occur if the workflow is well thought out. Tiling the floor, a line should be drawn from the middle of the long wall to the floor with a rope. After that, repeat the steps with the short wall. You will have two intersecting lines dividing the room into four.



Fig. 7.21. Division of the tiled surface

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

According to the defined lines, the tiles should be laid on the floor. Look for the best tile position. In some cases, the lines will have to be pushed to fit a larger part of a tile. Avoid a situation where the tile at a wall is trimmed on all sides. It will fall into your eyes and look ugly.

To maintain the geometry, for example, you can draw a horizontal line at the bottom of the wall and fix a straight wooden board along it, so the tiles will be glued correctly. The way of laying is also determined by the operating conditions - inside and outside of a building and a tile format.

In small rooms, tiling starts from the edge row, and if the edge row tiles need to be cut, from the second row. In large rooms tiling starts from the middle of the room or the room is split into several sectors.

#### Tiling: stages

The dry glue is poured into cool, clean water and mixed until a uniform mass is obtained. Large quantities of glue should be mixed with an electric mixer and smaller quantities should be mixed by hand. With a smooth side of a trowel apply about 1 m<sup>2</sup> of wall or floor with glue, then smooth it out with a serrated side and start tiling. Use the lines as a guide. Move along one of them.

Large tiles (60-120 cm long) should only be glued in a mixed manner, i.e. y. glue on both a basis and tiles. It is recommended to use elastic adhesive with increased adhesive strength (min. C2S1 class) for gluing such tiles. Large format tiles should have a minimum 3mm of joint width.





Fig. 7.22. Glueing of normal-sized tiles

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Move from the centre of the room toward the walls, keeping the line direction. First tile one side of a room, then the other. Apply and distribute adhesive to the basis. Too little adhesive or uneven distribution of adhesive reduces adhesion. This can cause the tiles and joints to crack. It is not recommended to apply a large amount of adhesive immediately, as the best adhesive properties (depending on the substrate) remain for about 15-30 minutes.



Fig. 7.23. Applying of an adhesive

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

It is always advisable to check whether a tile can still be glued: press your finger or your hand to the glue - if the glue stays on your hand, it is still possible to glue, if your hand clean - remove the old layer of glue, apply a new one and then glue.

The air temperature is also important when tiling. The ideal conditions for working with any adhesive are: + 18- + 24 ° C. It can also be tiled at different temperatures, but that can cause unforeseen difficulties. Two days after finishing work, the temperature of the filler and tiles must not be lower than +5 C. Low temperatures and humidity can prolong the drying time of the adhesive.

The amount of glue can vary greatly. This depends not only on the different physical properties of adhesive, but also on a basis and a tile, the natural conditions and the force used to distribute



adhesive. For example, a relatively porous cement substrate will absorb more adhesive than a concrete slab and a porous unglazed tile will absorb more glue than a glazed one. Handmade tiles with uneven backing and some cut ceramic or stone tiles will require an additional layer of glue to be applied to the back of the tile.

This will ensure contact between an entire tile and a basis. This type of adhesive coating is necessary for exterior and indoor tiling where higher physical loads are possible, such as industrial floors, garage floors and the like. Such gluing is also recommended when installing on heated surfaces such as heated flooring or walls.

The time it takes to adjust a position of tile also depends on the type of adhesive and environmental conditions.

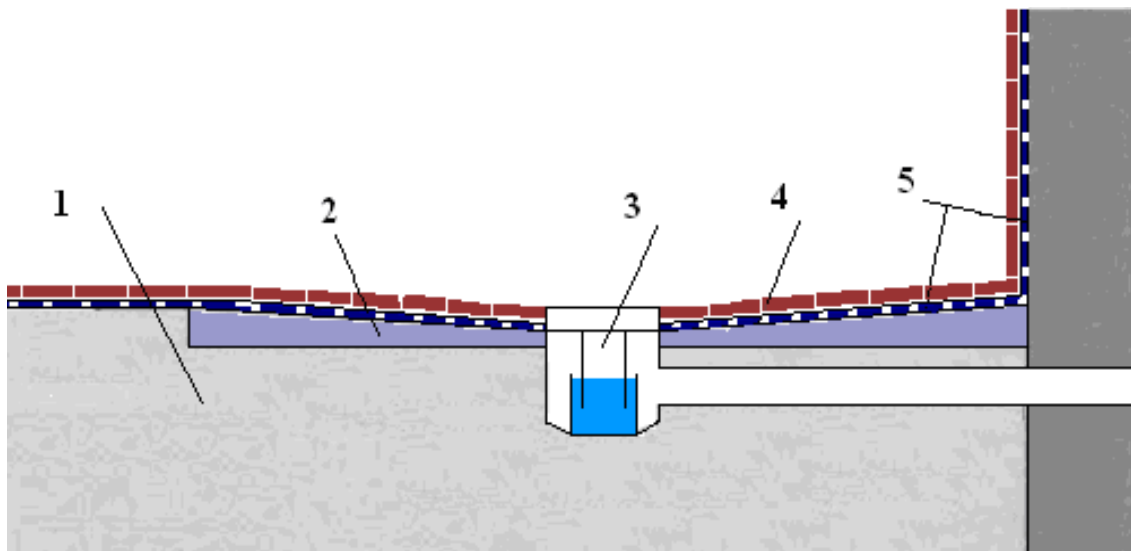
**IMPORTANT!**

**Check that the tiles are levelled. If necessary, apply more glue under the tile below. If the flooring is subjected to heavy mechanical loads or temperature fluctuations, it is very important that no glue-free space remains under a tile.**

#### 7.6.5. Floor tiling with slope

Floors with slopes are usually installed in wet premises. A drain is installed at the lowest point of a room floor. The slope can be installed on the whole or a small part of the floor of a room (e.g. shower floor). An overall slope of 2-5% is sufficient for the water to run down to drain.

Forming the slope with the help of a smoothing layer, at the beginning, markers with a predetermined slope are marked and the slope is formed according to them. Tiles are glued on the formed slope as on horizontal surfaces.



1. Panel; 2. Smoothing mixture; 3. Drain; 4. Tile; 5. Waterproofing.

Fig. 7.24. Section of the outflow [from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

#### 7.6.6. Tiling on old tiles

Ceramic tiles can be glued on old tiles as long as they hold well.

1. Old tiles should be degreased with a cleaner and primed with adhesive



Fig. 7.25. Tiles degreasing

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

2. Use of high elasticity adhesive



Fig. 7.26. Putting on adhesive

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

3. And glue the tiles in the standard way.



Fig. 7.27. Tiles glueing

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

When tiling on a stable, hard and water-resistant wooden surface, or on old ceramic tiles, it is recommended to use a mixture of highly elastic adhesive and necessarily prime such basis with adhesive and moisture resistant coatings.

### 7.6.7. Tile cutting

Lay full tiles in visible areas and cut tile on the sides. After scratching a tile, the tile can be broken by leaning it against the edge of a table or using angle pliers. Break the tile along the scratch line.



Fig. 7.28. Breaking the tile

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Part of a tile can be broken by placing it on a solid base or using pliers.



Fig. 7.29. Usage of tile cutting device

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Easy cutting of tiles is also possible with modern tools - manual or electric disc tile saws make work easier and faster.



If a hole needs to be made in a tile, its centre is punched with a hammer, starting from the glaze side. The hole is widened with careful hammer blows. It is important that the tile is supported so that it does not break when punching the hole. The hole can also be made with a special saw or an electric



drill.

Fig. 7.30. Making hole in a tile using an electric drill

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

#### 7.6.8. Filling of tile joints

Joints between tiles are necessary. When glueing to the heated floors or larger areas exposed to direct sunlight, deformation joints (max. distance 5 m) must be formed.



Fig. 7.31. Tile joints and deformation joint on heated floors

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

Make sure that the joints between the tiles are of the same width, inserting the tile crosses in the corners. After a few hours, they must be removed before the glue is dry completely.

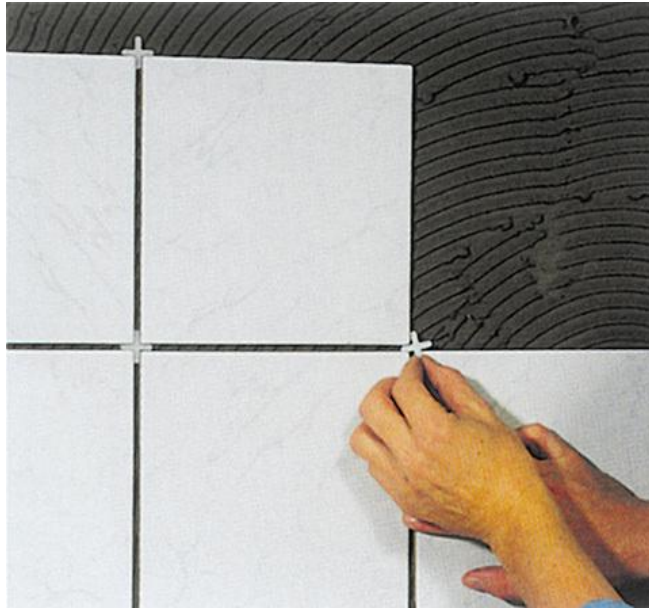


Fig. 7.32. Usage of crosses

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

After glueing the tiles, immediately remove excess the glue (if the glue is more than half of a joint). It is recommended to fill the joints between wall tiles one day (24 hours) or two after glueing, and two or three days after tiling the floor. Before filling the joints, they should be moistened with a wet sponge. It is very important that the joints are filled when the adhesive dries.



Fig. 7.33. Applying of joint filler

Apply joint filler by sliding diagonally across the tiles. Both wall and floor tiles use the same joint fillers and come in a variety of colours and shades.

The prepared filling mass should be inserted deep and densely into the space between the tiles using a rubber spatula. If the filled joint is to be protected from pigmentation change or leaching of fresh



mass, the joint should not be over-wetted. Ceramic tiles cannot be dry-cleaned after filling, as dry particles rubbed into the fresh filler can change its colour.

It is recommended that the joints to be slightly moistened by spraying or rinsing with clean water for two days after filling. The true colour of the joint will appear after two to three days when it is finally



dry.

Fig. 7.34. Moistening the joints

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

It is also possible to apply decorative strips (inside or outside corners, on the joints) or elastic material (silicone) to hide the joints.

If it is desired to increase the resistance of the filler to water or dirt, it can be impregnated with special protective materials when completely dry.



Fig. 7.35. Impregnating the joint filler

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

#### 7.6.9. Filling of flooring joints

Dry filling mixes are usually made of white cement with natural fillers, modified chemical additives and pigment. Polymeric additives prevent the formation of sedentary cracks, give the material strength and moisture resistance.

Need to know! Moisture resistance does not mean that a specific material can be used in swimming pools, food industry premises, etc. In this case, epoxy based mixes may need to be used.

Structural deformation joints are necessary. They are intended to compensate for spontaneous displacements in the structure of a building. They are installed using special deformation profiles. Structural deformation joints must be provided at all junctions between the wall and the floor. The minimum width of such joint is 8 mm. The joints are filled with an elastic material, silicone. They can be hidden under skirting boards.

Joint fillers are divided according to the coating widths, mechanical and chemical resistance, elasticity. For narrow joints of 2-4 mm, they are made of finer particles and have a softer surface when smoothed. Fillers for larger joints are usually more elastic, more durable and more resistant to water. Manufacturers indicate where to use fillers: for wall, flooring, or as a universal filler for joints. It is also possible to choose from a variety of colours to match tiles. It is recommended to use a filler of the same colour code and the same date of manufacture.

Wait until the adhesive hardens completely before filling the joints. The joints should be clean and free of dust and debris. It is best to use a scraper with a rubber tip to apply the joints. After applying, make sure that the mixture is in each joint and wipe away any residue with a damp cloth immediately before it dries. Then the tiles should then be cleaned with a dry cloth.

#### 7.6.10. Tiling of stairs

Apply glue on a stairway, level it.



Fig. 7.36. Stairs tiling

[<https://lt.lt.allconstructions.com/porta/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

The tiles are fixed one after the other.

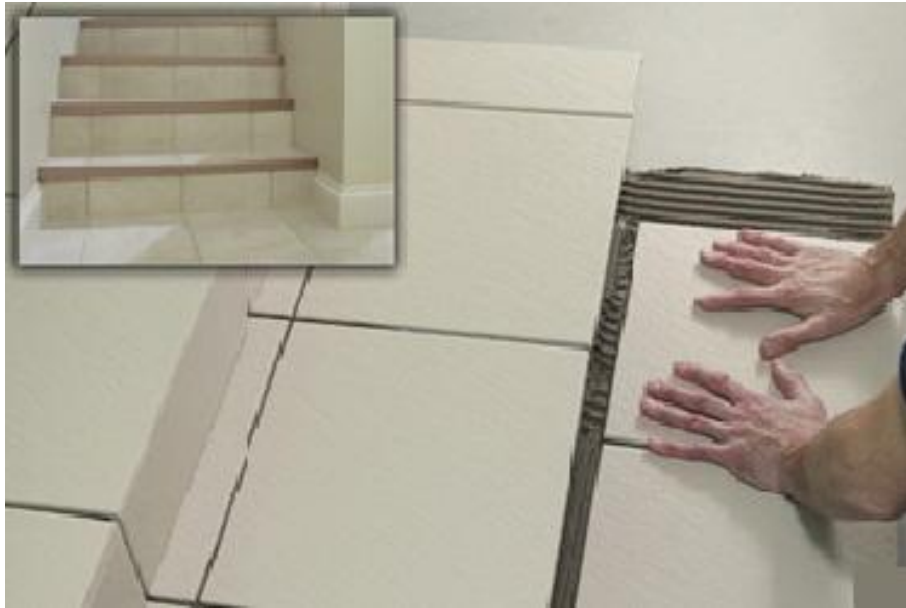


Fig. 7.37. Laying of next tiles

[<https://lt.lt.allconstructions.com/portal/categories/62/1/0/12/article/1532/keraminiu-plyteliu-klojimo-instrukcija>]

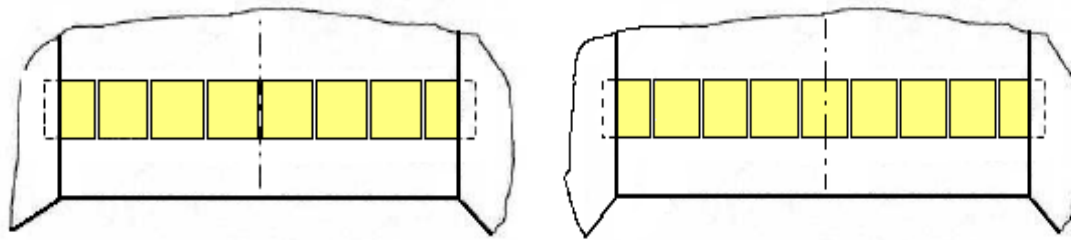
When laying tiles on stairs, it is very important to measure and cut the tiles precisely so that all joints are of the same width.

The exploitation of tiled surfaces:

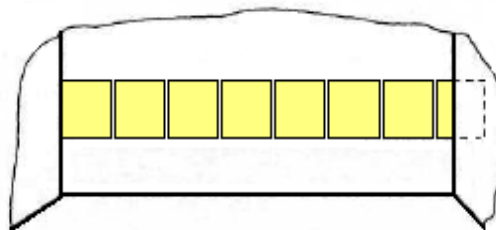
When to put tiled surfaces into service depends on the adhesive, tile and environmental conditions used. If standard glue was used, the newly laid floor can be walked on in a day or two, but it should not be overloaded, i.e. running, working on them and etc. This requires at least three days as recommended by the manufacturers. If a quick-drying adhesive was used, it is possible to walk on such a floor in as little as three hours. The floor can be fully used after two weeks.

## 7.7. Tile layout

Before tiling, it is necessary to foresee their exact placement on a surface. When the width of the wall and the width of the tile are not multiples, the tile will need to be cut. The wall will look nicer if the tiles are symmetrically arranged. The cut tiles are glued symmetrically at the edges of the wall.



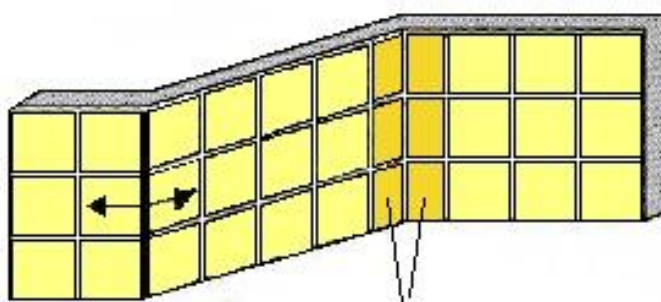
Symmetrically arranged tiles



Not symmetrically arranged tiles

Fig. 7.38. Various tile layouts  
[from „PLYTELIQ KLOJIMO TECHNOLOGIJA“]

When one corner of the wall has an inner corner and the other has an outer corner, then tiling begins from the outer corner with the intact tiles. The cut tile is placed at the inner corner.



Cutted tiles

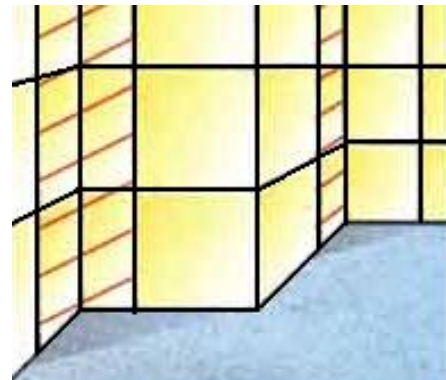


Fig. 7.39. Optimization of tiles cutting  
[from „PLYTELIQ KLOJIMO TECHNOLOGIJA“]

Tiles are arranged symmetrically at niches, doors or windows. The method is preferable when the niche is higher than half the wall.

If the height of the tile covering is unlimited and the the bottom tile row is not cut (floor without slope and level), then the tiles from the bottom row are intact (Figure 7.40a).

If the height of the tile covering is strictly stated, then the intact tile should be laid from above.

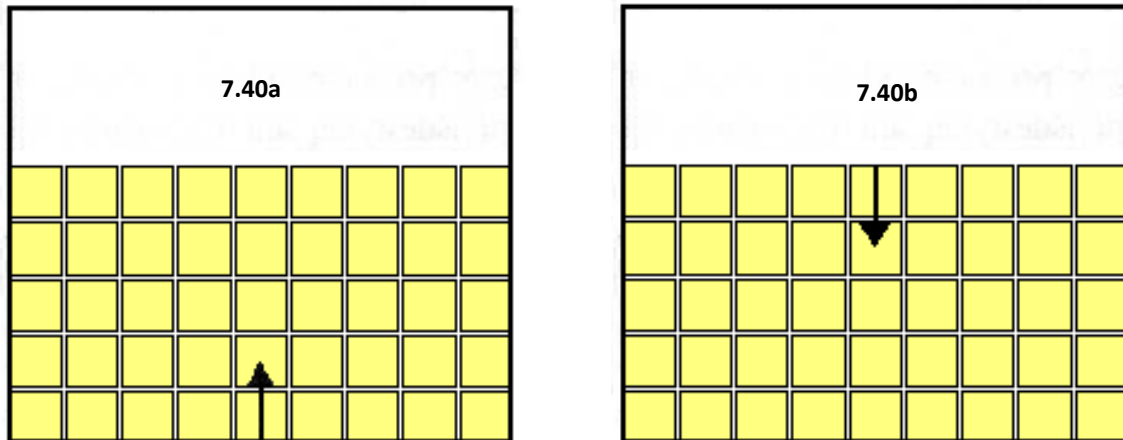


Fig. 7.40. Methods of tiles fitting  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

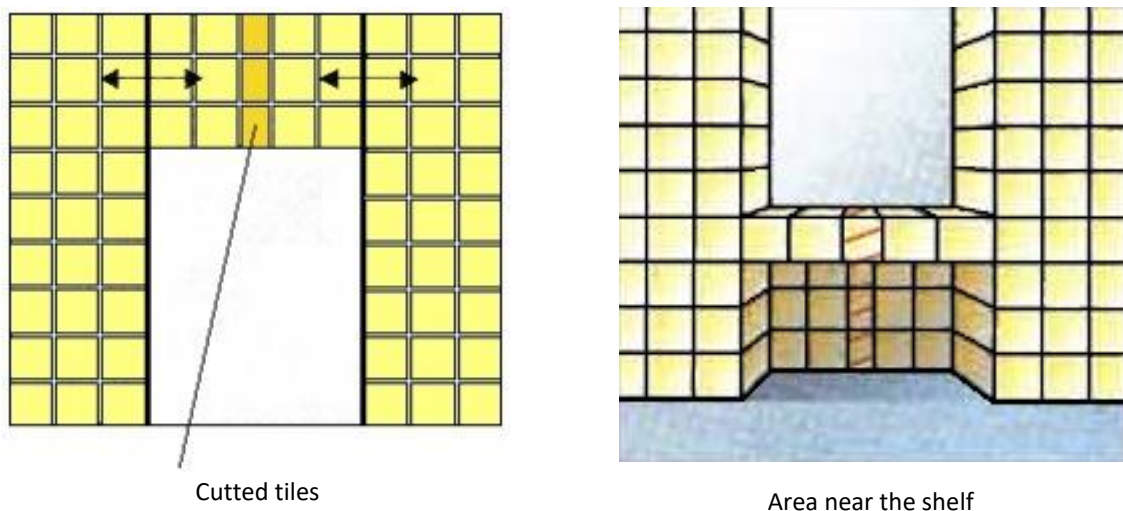


Fig. 7.41. Tiles layout in a niche  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

If the floor and wall tiles have the same dimensions, then the floor and wall joints must coincide (Fig. 7.40b). A deformation joint is provided between the floor coverings of the two rooms. When adjacent rooms have the same tile dimensions, the joints should coincide.

As already mentioned, both wall and floor tiles will look nicer if placed symmetrically, but not necessarily in relation to the finished surface. The symmetrical tile arrangement to a column, niche, fireplace or other interior detail is often more noticeable.



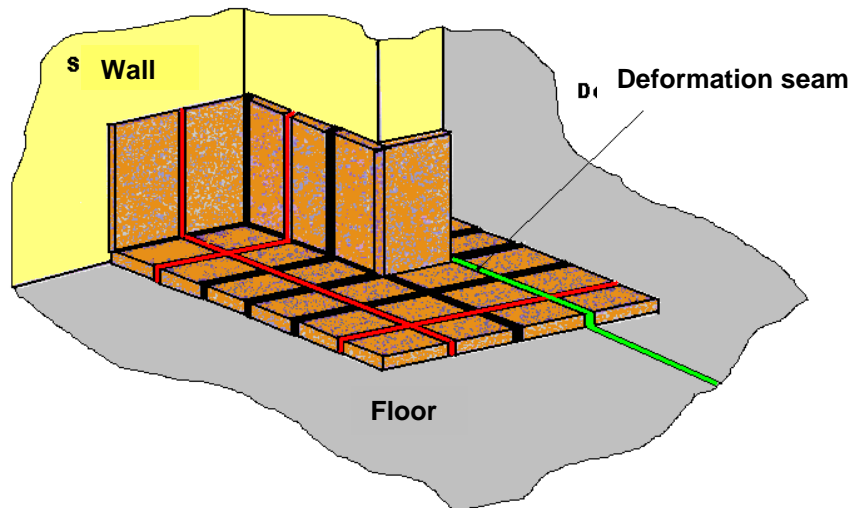


Fig. 7.42. Tiles arrangement near the wall  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]

The wall tiling starts from the second row. The first row is laid when the flooring tiles are already glued. This makes it possible to hide the uneven edges of floor tiles which, due to their higher strength, are harder to cut.

At the height of the second row of tiles a wooden plank or metal ruler is fixed. In addition to the height of the bottom tile, the size of the two joints is also taken into account when determining the position of the wooden plank. When laying floor tiles first, wall tiles can also be started from the bottom row.



Fig. 7.43. Second row marking and plank fixing  
[from „PLYTELIŲ KLOJIMO TECHNOLOGIJA“]



## 8. Work organization

### 8.1. Factors determining technological process

Tiling technology depends on:

- Organization of works;
- Location of buildings in the surrounding environment;
- Architectural, structural and plan solutions of buildings;
- The characteristics of the components of the finishing materials;
- Equipment and tool performance;
- Qualifications of workers;
- Supervision and control of work.

All the factors of the technological process are closely interrelated in direct and feedback and form the structure of a united technology. The unity of the work is determined by the harmonious structural elements – any change of the element changes the whole technology, sequence of work, quality and durability of the coating.

When designing the technology for tile finishing, the following are required:

- Building (premises design);
- Technical design of finishing works;
- Designer solution (design, visualization);
- Specialist experience;
- Analog technologies.

Organizational issues and preparatory work must be examined and evaluated before the tiling begins:

- The requirements of the customer were discussed and the project was made;
- Adopted architectural and design decisions;
- Diagnostics of finishing structures;
- Technical decisions made;
- The performance of participants was assessed; (tilers, material suppliers, etc.);
- Organization of tiling and tiling methods were discussed;
- Quality control of works is carried out;
- Assessed operating conditions.

So the process of tiling is not just about tiling.

The tiling process, like other construction processes, has many stages and therefore involves various objects with different functions and interests.

The functions of a tiler depend on the organization of the work, the volume and complexity of the work, and the relationship with the customers.

Tiling works are usually performed by teams of 2 – 5 persons.

Two-person brigades are usually made up of workers of similar skill, laying the tiles simultaneously, finishing large areas. They also carry out preparatory, auxiliary and final work.

Before tiling on different walls of the room at the same time, it is very important to mark the horizontal line at the same height and and cut tile places in advance.

Larger brigades are made up of workers of different qualifications, who divide jobs of varying complexity by ability. Advantages of a larger brigade: unskilled work is performed by auxiliary workers.

Tiling work can also be performed by one worker.

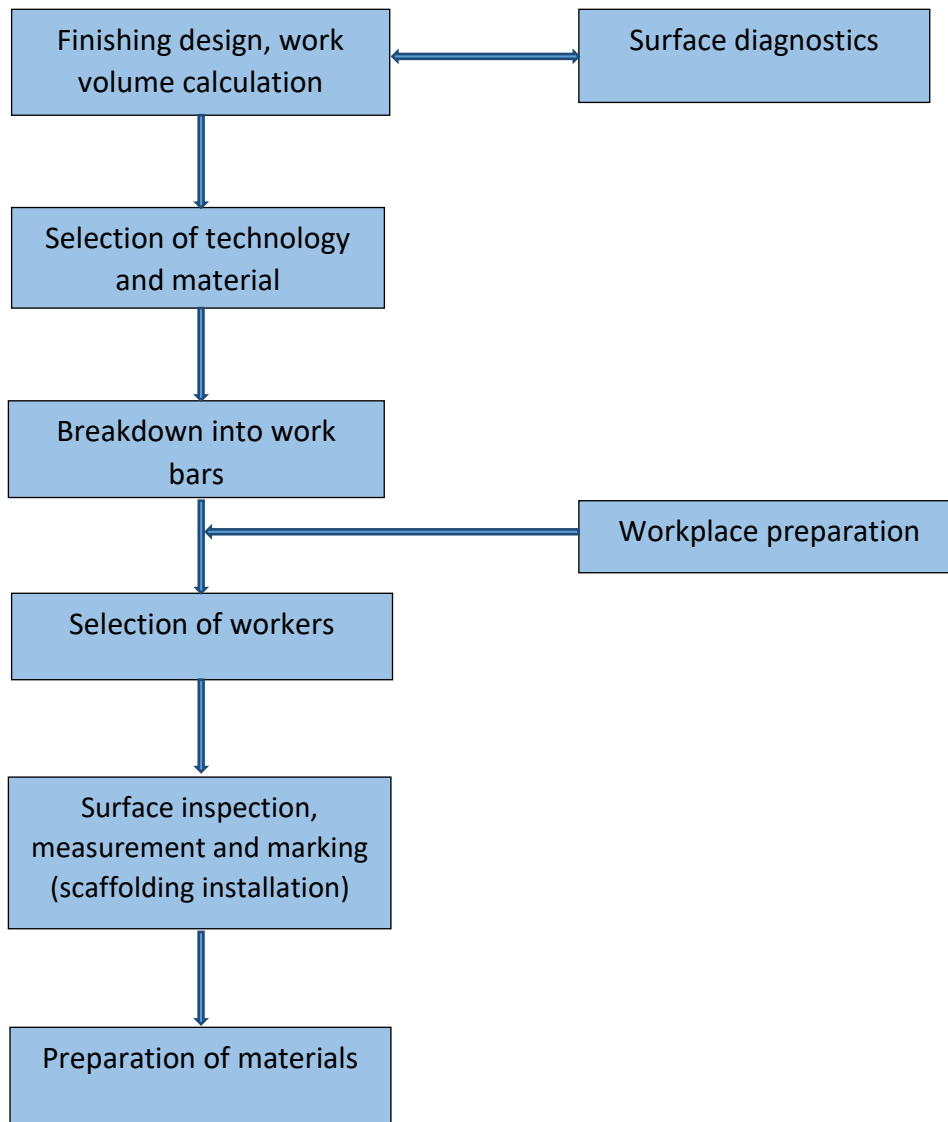


Fig. 8.1. Organization scheme of tiling work  
[author's own work]

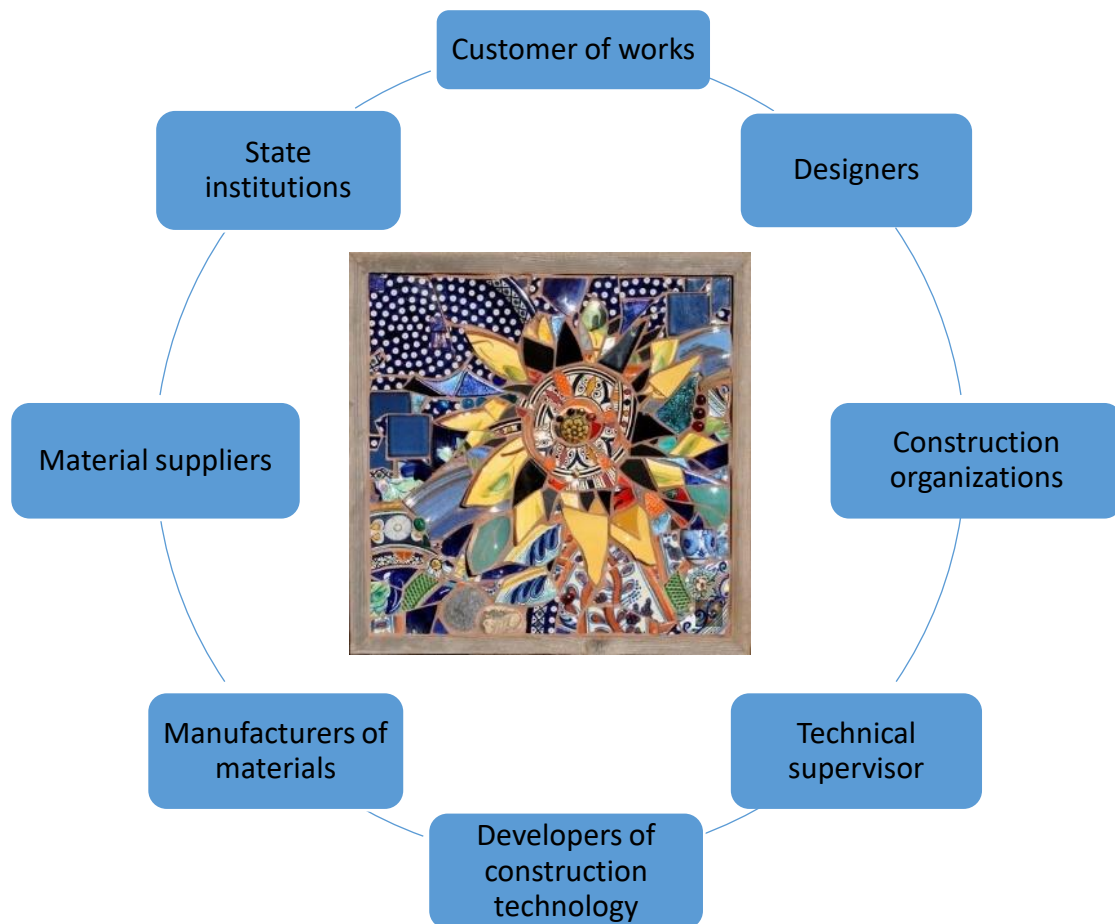


Fig. 8.2. Participants in the finishing process  
[author's own work]

## 8.2. Getting in touch with a designer

The principles of finishing design and choice of materials have already been discussed. These issues are less frequently solved by a tiler. In most cases, a tiler does the work according to the projects: architectural and technological.

Architectural design makes architectural decisions on finishing, technological – implementation methods, tools, material characteristics, work organization decisions.

The basic information is given in the drawings. It is very important to understand the drawings correctly and to be able to mark the specified points on the surfaces to be decorated.

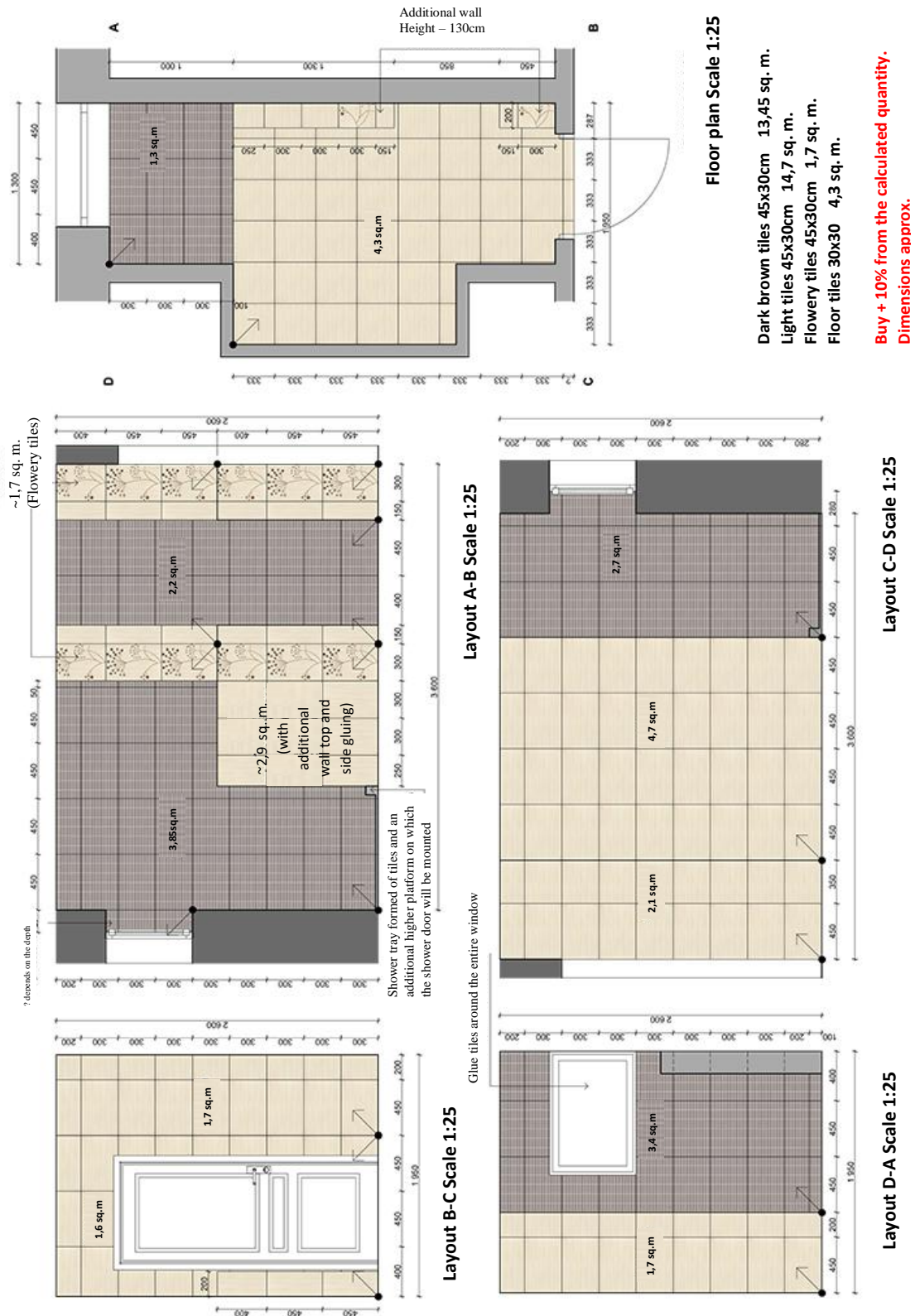


Fig. 8.3a. Examples of tile layouts

<https://www.e-interieras.lt/vonios-plyteliu-klijavimo-isklotines/>

## Manual - Tiler

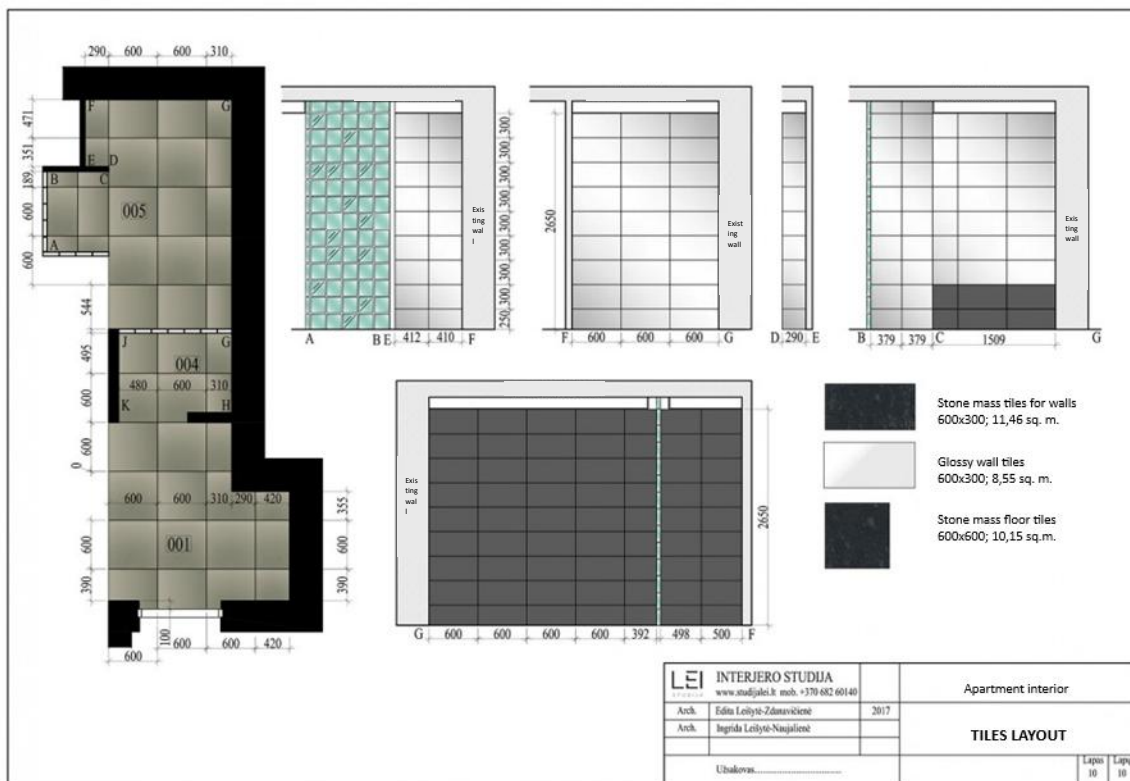


Fig. 8.3b. Next examples of tile layouts  
[<http://www.studijalei.lt/lt/paslaugos/sienu-isklotines/>]

### 8.3. Diagnostics of surfaces to be tiled

The purpose of diagnostics is to determine and evaluate the possibilities of tiling of new and existing structures of buildings or premises, which ensure the quality and durability of exterior and interior.

Diagnostics determines:

- Factors influencing surfaces;
- Influence of communications and engineering networks;
- Results of stasis deformities ( cracks);
- Surface defects (spots, blemishes, caverns) caused by aggressive environment;
- Damage to structures caused by vibration;
- Condition of rainwater drainage areas (for external surfaces);
- Consequences of operating internal communications (for internal surfaces);
- Surface smoothness (vertical and horizontal);
- Dimensions of angles and junctions and deviations from the design angle.

When determining the size of surface defects, it is also necessary to find out the reasons for their occurrence.



## 9. Ethics of work

Codes of professional ethics for some professions, those with special social meaning and a deep impact on human situations, have been compiled for a very long time.

At present, however, much attention is paid to values virtually in any profession. The industrial era ended – not only physically, but also spiritually. The binder related to that era, industrial relations, is fading away as well. At the time of virtual network-based organisations spread across many locations, a new binder is needed – values.

The management manner, organisational culture and organisational ethics cannot be enacted overnight and one cannot count that the actual state will adapt to one's needs. This is a lengthy process the performance of which requires a good concept, proper communication, consistency, patience, trainings and monitoring. Sometimes personal changes must be reverted to. It is highly significant who is employed, who is allowed to work in an organisation – whether or not there will be good cooperation with such a person, also in terms of building or maintaining the desired organisational culture and ethics. However, such diagnosis is not easy to make. It requires knowledge, experience and intuition. It is easy to make mistakes here, for instance employ only people similar to each other in terms of age, education and culture. Such homogeneous teams may fail where new solutions and are sought and extraordinary situations have to be dealt with. Heterogeneous teams do a much better job, which are teams composed of people of different sexes, at different age, with different experience and education, representing diverse disciplines of knowledge and speciality, more creative in general. In a lot of companies, this is what **diversity policy** is: it is said how valuable "diversity" in teams is.

Helpful in shaping the principles of ethics in organisations are codes of good practices, more often than not referred to as **codes of ethics** – they promote selected values and fair and ethical practices (of conduct and behaviour), both inside the organisation and in its relations with the external environment, notably with all stakeholders.

Therefore, the function of such codes is twofold: internal and external. The internal function is expressed in striving to promote ethical practices and eradicate unethical practices in one organisation. The external function is expressed in striving to find the relations with external partners on the followed ethical standards and values. This activity may lead to benefit for the given organisation as well as a result of feedback. The external function also entails the shaping of good image of the organisation.

For several dozen years, the number of corporations and larger companies employing codes of good practices has been growing in highly developed countries. It is assumed that most global companies already belong to this group. According to various estimates, such codes occur in 18-23% of medium and large organisation operating in Poland.

### 9.1. Status of the construction worker

Construction enterprises have a specific nature. In most companies, there is a division into two closely cooperating employee groups – supervision employees (engineers with a university diploma, foremen, construction work managers, construction site managers, contract/design managers), who direct the execution of a building structure in a specific place or to a specific extent, and manual labour workers – persons having the skills and qualifications to carry out physical technical activities at the construction site.

The construction industry is witnessing many problems related to the deficit of manual labour workers in particular. No labour is one of the more burdensome barriers in the operation and development of construction companies. There is no supply of new workers in the country, there is no education that would be effective for the labour market and that would supply young and qualified craftsmen and specialists in such professions as the following: Steel fixer, concrete placer, shuttering carpenter, bricklayer, tile layer or hydraulic. The experienced part of the workers have retired and they did not even have the opportunity to teach their hands-on knowledge. This results in more and more companies starting to employ workers from abroad. This resulted in multiculturalism among construction works crews and a stronger need for acceptance and respect for the norms and customs of others.

In each organisation, the personal freedom is to some extent limited due to the requirement to follow the working strategy and discipline, achieve collective aims, perform tasks and follow instructions of superiors etc. From the vantage point of ethics, there should be no more limitations than what is absolutely necessary. Furthermore, people should understand the reasons for which some limitations are necessary so that they accept them. In the case of construction industry organisations, this mostly applies to OHS regulations and observance of the requirements of technology and the ordering party, other important work-related procedures, specified limitations and self-limitations related to teamwork etc. There should be no limitations where they are not absolutely necessary.

#### 9.1.1. Ethical standards in the recruitment phase

An organisation builds its image through quality of communication with prospective workers. Ethics provides that the information given to candidates both in the recruitment phase and after it, when communicating a refusal to hire, should be true. A high standard in this area includes reliable and specific job descriptions and specification of offered worker benefits, including the spread of possible earnings. Benefits for the worker should be described specifically, e.g. “We allow you to obtain a crane operator’s licence in 2 years.”

A high recruitment standard also involves a situation where all job applicants have an opportunity to demonstrate their skills regardless of sex, ethnic origin, disabilities, age and other factors unrelated to the job. All forms of recruitment should be related to the tasks that will be performed on the job. It is recommended to use the so-called job samples as a stage in the recruitment process for construction industry jobs involving manual work. For supervision-related jobs, one can test their knowledge or skills in using given software.

Questions which go beyond the code of labour and penetrate the personal life of future employees are not a good choice. Such issues as the worldview or addictions should not be used as actual criteria to assess a candidate.

### 9.1.2. Quality of life at work - friendly work environment

Upon signing the employment contract, a person starts to systematically train in the duties imposed on them by the organisation. They get to know their subordinates and colleagues: they already met their superiors at the very start. They are in the phase that cannot be critically assessed from the ethical vantage point. The fresh worker is showered with new information. As a result, they have difficulty assessing things in ethical terms and gain some distance.

There is a lot of liberty and sense of personal freedom in an ethical organisation. One can voice their thoughts and views (and criticise others while maintaining good manners and being respectful) without fear of sanctions or harassment. Actions that are surprising and contrary to the workers' will are avoided, people are not held in uncertainty. In addition, workers in such an organisation should avoid actions surprising the employer and causing them trouble. The freedom and the sense of security are facilitated by transparency, a principle applying to everyone.

Ethics organisations ensure that their members enjoy:

- protection against violation of their personal dignity and the need for respect, freedom from rudeness and lack of good manners – in particular, this applies to relations between the employee and their superior. This is so as the superior's evaluation of their subordinate is often expressed in a manner violating the employee's dignity. All employees, even those with poor evaluation results, have the right to experience civil behaviour that complies with the principles of community life;
- freedom from persecution, mobbing and sexual harassment in any form;
- freedom from any discriminatory practices – each employee has the right to equal treatment and access to the same resources and benefits regardless of their religion, sex, age, origin etc.;
- freedom from violation of law and good morals – the organisation cannot use prohibited contractual provisions towards any entities and persons, force its employees to perform unfair competition acts or unfair market practices; the organisation is obliged to create safe and hygienic working conditions and exercise effective supervision over the observance of OHS regulations and the labour law, law of commercial companies etc. being in vigour;
- freedom from burdensome, dehumanised leadership styles – fighting all pathologies (corruption, discrimination, nepotism, glass ceiling, manipulation and other);
- freedom from interference with privacy – each employee has the right to preserving their private life as unavailable to others from their professional environment.

Ethical organisations operate so as to support innovativeness and creativity of the people involved. They do it by accepting the assertiveness of others (clients, workers, subcontractors) and supporting the professional development of workers – expansion and modification of work content in directions which the workers and the organisation are interested in.

Such organisations create for all their workers conditions for equal opportunity for promotion according to the same fair and proper criteria – they do not allow the formation of the so-called glass ceiling.

## 9.2. Social relations with company / client / environment

### 9.2.1. Social relations with company

The harmony among the basic human life spheres, professional and non-professional, is the foundation of ethical relations in the company-worker dyad. The time and manner of work cannot be detrimental to the family and reduce it to a secondary social phenomenon. It is best for the work and the family when mutual harmony is sustained and positive signals from both spheres complement each other. Such a phenomenon is referred to as the **Work Life Balance**.

This principle is difficult to maintain in the construction industry. It is often the case that the investments being implemented are located outside the place of residence of workers. This creates the need for working far from home. However, an ethical employee guarantees its workers a regular opportunity to contact their family and home and establishes such terms of rest that ensure comfort and suggests additional benefits such as sports, cultural or social events.

Here attention needs to be drawn to the growing frequency of integration meetings for workers, organised by employers. This is related to creating the involvement atmosphere and the so-called team spirit – the ideal for many organisational cultures. However, participation in integration meetings or charity events of the company should always be voluntary – a worker unwilling to spend their free time in such a way should be able to say no to such events.

### 9.2.2. Social relations with client and contractor

The quality, innovation and client's satisfaction have taken the first three places in terms of the values that are the most cherished – both in the world and in Poland. The only difference is that in the world the order was quality, innovation and client's satisfaction and in Poland – client's satisfaction, quality and innovation.

Clients cherish the quality of goods and services the most – this also endows quality with an ethical dimension. It is unethical to sell or use products that are defective, dangerous to use, burdensome and costly in upkeep. A service poor in quality and provided negligently is particularly unethical. In terms to service provision, widely understood competences of persons responsible for order execution might be assumed as having a high ethical rank.

As regards client relations, several topics of ethical nature can be listed:

1. Quality of products (goods or services) – the organisation should make an effort for the provided services to be at the highest level or to meet the expectations of the ordering party;
2. Sale contracts – making sure that contractual provisions are fair and reliable, parties' obligations lawful and terms of contracts fulfilled;
3. After sales service, warranty repairs, implied warranties – fulfilment of obligations under the effective law, satisfaction of clients' legitimate interests, care for the good name of clients and the company;
4. Promotion, including advertisement – communication of true information, activities compliant with the principles of fair competition, observance of good manners and good taste, possibility to tell the difference between the facts and the fiction.

**As regards contractors and subcontractors:**

1. Taking into account reasonable interests of both parties – care for the cooperation terms and conditions to be equally beneficial for the organisation's contractors; avoiding situations where the company's brand and size (including the available resources, e.g. legal services) to force contractual provisions unfavourable for the other party;
2. Settlement of amounts due on time – the problem of payment gridlock impacts nearly a half of businesses in Poland (48%). It most often occurs in the construction and production industries. Therefore, delays in payment settlement are a common phenomenon that hinders operation because only slightly more than a half of receivables are paid on time in the group of companies having problems with obtaining their receivables;
3. Mutual provision of the necessary and true information – avoidance of holding information back or manipulating it;
4. Avoidance of actions surprising the contractors and unfavourable for them.

**9.2.3. The essence of Corporate Social Responsibility**

Enterprises' attitude to corporate social responsibility (CSR) varies. Most have the sense of duty, but to a limited extent. The problem boils down to the conflict between the enterprise's striving for profit increase and the social interest. Life shows that the enterprises often ignore social interests when striving for higher profitability of the business.

**Corporate Social Responsibility applies to the following relations:**

1. Organisation-clients (discussed above)  
In this relation, what is the most important is the quality and safety of use of products, warranties and warranty repairs, servicing and satisfaction of other obligations under the contract (see above);
2. Organisation-state  
This relation mostly includes payment of taxes, insurance contributions and other effective tax-like charges, which are required for normal functioning of the state and the society, but also the prestige and image of the state. It is unethical to offer workers payment of remuneration "under the table" – such incidents are at least violation of law, or even circumvention of law, to exclude an element or part of remuneration from the tax base and the system of insurance contributions.
3. Organisation-natural environment  
This relation ensues in cooperation with the local authorities and other institutions responsible for the environment condition and ecological supervision. Neglects in this area, let alone ecological disasters, are always shocking and have far-reaching consequences. Ecological sensitivity and awareness of the society is growing and organisations' impact on the environment is becoming to be seen as more and more important.
4. Organisation-competition  
In the market economy, competition should be protected as it plays an important role in it. Everything degenerates without competition. Even though it is difficult to grasp and understand to many entrepreneurs, they should not strive to destroy their competition. All the more so as competitors are more and more often creating networks of cooperating entities, are participating in joint technical, logistic, marketing and other ventures and – in turn – make profit on it.

In practice, the shaping and harmonisation of all those relations is a complicated process. On the one hand, in such a process an organisation must protect itself against excess in demands and expectations which may sometimes be threatening its future and existence. On the other, it cannot be egocentric as bad image and enmity of clients, the state or the society towards the organisation are not conducive to its far-reaching interests either.

Time is of essence when discussing ethics. In the short run, people in charge of an organisation may have an impression that unethical behaviour may “be profitable.’ This looks different in the long run, though.



## 10. The test

### 10.1. Questions

Question No.	Question	Answer options	Correct answer
1.	According to the quality of the tiles are divided into types.	A. Highest, defective tiles, brock. B. First, second, third. C. Ceramic, stone mass, natural stone.	
2.	The deviation of the tile dimensions from the design defines the tile.....	A. Calibre. B. Size cm. C. Type.	
3.	Tile absorption refers tile .....	A. Resistance to stain formation B. Water absorption. C. Scratch resistance.	
4.	What letter indicates tile resistance to wear and scratching?	A. N. B. U. C. C.	
5.	Glazed tiles are divided into three groups according to the formation of stains, which group stains are removed with water?	A. 3. B. 2. C. 1.	
6.	Which class tiles are the most resistant to wear?	A. 3. B. 1 C. 5	
7.	Which classes of wear tiles will be used to encase the outside stairs?	A. U1. B. U3. C. U4.	
8.	Which tiles before glueing with cement glue is irrigated with water?	A. Ceramic. B. Stone mass. C. Both answers are incorrect.	
9.	What kind of glue is used for tile bonding?	A. Cementic, Disperse, Epoxy. B. Cementic, silicone, KMC. C. Atlas, Knauf, Dvarčionių keramika.	
10.	What kind of mortars are used for glueing tiles?	A. Rotband, cementic, lime. B. Mineral, gypsum, cementic. C. Cementic.	
11.	What kind of glue is used to glue the tiles on the heated floor?	A. Makrofleks. B. Any. C. Cementic- increased elasticity.	

12.	What kind of glue is used to glue large-format floor tiles?	A. Cementic – increased elasticity. B. Increased sliding or thick layers. C. Glue – joint filler.	
13.	What is the time to pass after mixing the adhesive before re-mixing it and preparing it for use?	A. 15 - 20 min. B. 5 - 10 min. C. 1 - 3 min.	
14.	What kind of glue is used in premises where acids are used?	A. Epoxy. B. Increased elasticity. C. Disperse.	
15.	On which surfaces is mandatory to make water-proofing before laying tiles?	A. Everywhere. B. In wet ones. C. In moist ones.	
16.	How to prepare a plastered surface for tile bonding?	A. Putty. B. Scratch the surface and prime. C. Clean from dusts and prime.	
17.	What to do when preparing enamel painted surfaces for tile bonding?	A. Degrease and prime with deep primer. B. Degrease if needed and prime with sticky primer. C. Putty and prime.	
18.	What kind of primer will you use for priming gypsum surfaces before tiling?	A. Silicate. B. Roughen the surface. C. Deep primer.	
19.	What kind of waterproofing will you use for bathroom walls?	A. One-component mastic. B. Bituminous mastic. C. Ruberoid	
20.	Is it possible to glue the tiles on old tiles?	A. It is possible if the old tiles hold well. B. Not allowed, they need to be removed C. Not allowed, because size of premises will decrease significantly.	
21.	How to prepare the surface of old tiles for glueing new tiles without knocking them down?	A. Prime old tiles with deep primer and glue new tiles. B. Wash old tiles with hold house soap, prime with sticky primer and glue new tiles with increased elasticity glue. C. Brush the surface of old tiles with sandpaper, prime with deep primer and glue with strong adhesive.	
22.	What tool can be used to cut a hole in the tile of the required shape?	A. With tongs. B. With glass cutter. C. With special hard metal drill.	

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23.	To cut the tiles at 90° angle you will use.....	A. With a tungsten saw. B. With electric tile cutter. C. Both answers are correct.	
24.	For what purpose crosses are used in tiling?	A. To ensure that tiles are evenly laid. B. To ensure equal joints between tiles. C. To make the tile pattern uniform	
25.	After what time, joints between the tiles can be filled?	A. After 12 hrs. B. When the teacher tells. C. After 24 hrs.	
26.	Specify the recommended technology for tile laying on vertical surfaces (when the floor is not yet laid).	A. From first row. B. From second row. C. Start of tiling depends from where the customer tells	
27.	What determines the size of toothed trowel spacing between teeth?	A. Type of adhesive. B. Size of tile. C. Abilities of the masters.	
28.	How long can the position of a tiles be adjusted on a wall when glueing it?	A. To 10 min. depends on adhesive. B. 10 - 45 min, depends on surface and adhesive. C. As much, as needed.	
29.	If the coated structure is not rigid enough, the tiles will bounce off. For which surface this is particularly important when tiling?	A. Concrete surfaces. B. Masonry surfaces. C. Wooden surfaces.	
30.	How to calculate the bottom height of the second row (even when the floor is not laid yet)?	A. Thickness of floor glue + Thickness of floor tile + 2 thickness of a joint between tiles + height of wall tile. B. Thickness of vapour barrier + thickness of heat and sound insulation + thickness of concrete + height of wall tile. C. Thickness of floor glue + length of floor tile + 2 thickness of a joint between tiles + thickness of wall tile.	
31.	Can the floor be covered with wall tiles in public areas?	A. Possible, their features are the same, except the colour and size. B. No. C. It is possible when using special adhesives.	
32.	How correctly should the expansion joint be filled with sealant?	A. There are no specific regulations. B. Sealant must stick only to the sealing surface. C. Sealant must fully fill the joint.	

33.	What is necessary to do if the tiles are larger than 400x400mm?	<p>A. Prime the bad side of the tile with contact primer.</p> <p>B. Cover floors with contact primer</p> <p>C. Apply glue on the substrate and tiles.</p> <p>D.</p>	
34.	Where do you begin the tile laying of horizontal surfaces?	<p>A. From the middle of the room.</p> <p>B. From the farthest angle</p> <p>C. In small rooms from side, in big rooms – from middle.</p>	
35.	What is the purpose of deformation seams?	<p>A. Divide large areas into smaller ones to prevent them from cracking</p> <p>B. Divide large areas into smaller ones to work easier.</p> <p>C. Expansion joints are installed in small spaces for sound suppression</p>	
36.	At what distance should expansion joints be located in large rooms?	<p>A. Every 20 - 25m.</p> <p>B. How nicer and how customer tells.</p> <p>C. Every 4 - 10m.</p>	
37.	How the tiled floor with slope is installed?	<p>A. When laying tiles on the floor with a slope, the slope should be into gully.</p> <p>B. When laying tiles on the floor with a slope, the base must already be formed with the required slope of 1% - 3% and must go into the gully.</p> <p>C. When laying tiles on the floor with a slope, the base must already be formed with the required slope of 1% - 3% and must go into the middle of the room.</p>	

## 10.2. Answers

Question number	Correct answer
1.	B
2.	A
3.	B
4.	B
5.	C
6.	C
7.	C
8.	C
9.	A
10.	C
11.	C
12.	B
13.	B
14.	A
15.	B
16.	C
17.	B
18.	C
19.	A
20.	A
21.	B
22.	C
23.	C
24.	B
25.	C
26.	B
27.	B
28.	B
29.	C
30.	A
31.	B
32.	B
33.	C
34.	C
35.	A
36.	C
37.	B

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