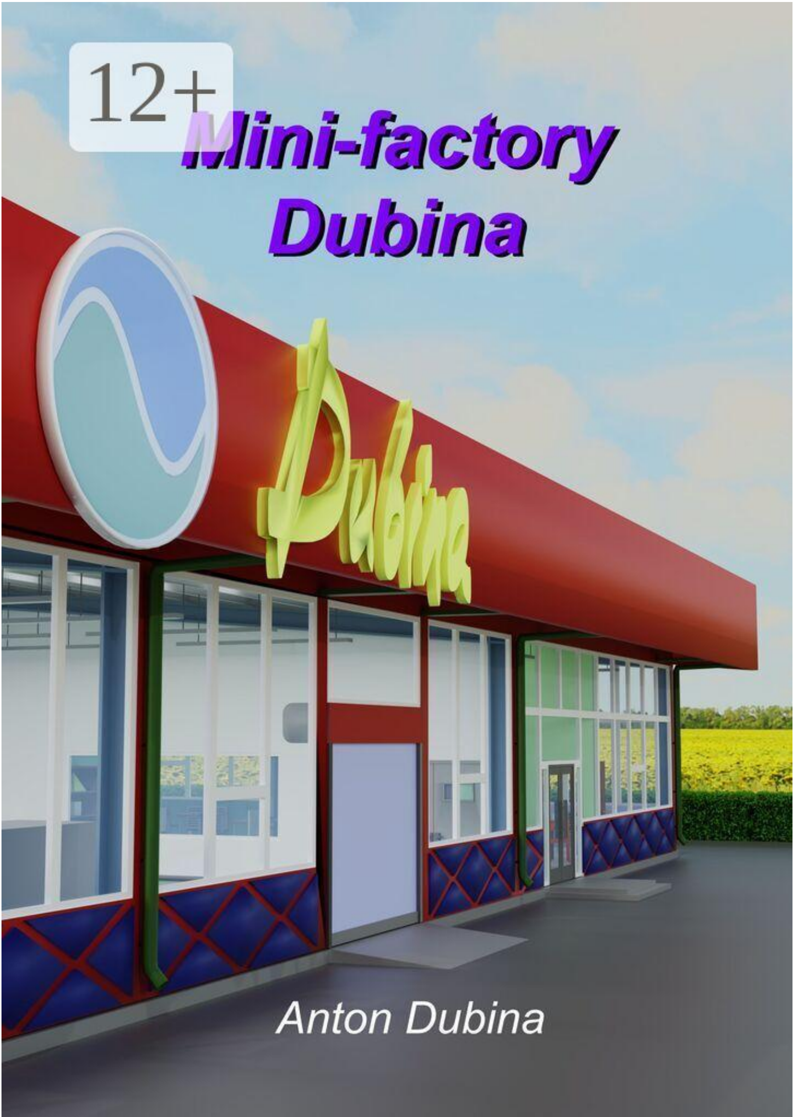

12+
Mini-factory
Dubina
Dubina
Anton Dubina

Anton Dubina

Mini-factory Dubina

https://litres.ru/74246517
ISBN 9785007046244

Аннотация

This book describes a mini-factory for the small-scale production of the Evo electric sports car. It is aimed at anyone interested in industrial design, production organization, and the creation of production spaces. The material is presented in a practical manner and can be used as a textbook, a conceptual project, or the basis for a real-life enterprise. Particular attention is paid to the interactions between people involved in production, the role of each specialist.

Содержание

Mini-factory Dubina

Anton Evgenievich Dubina

ISBN 978-5-0070-4624-4
Created with Ridero smart publishing system

Preface

This book is about a mini-factory for the small-scale production of the Evo electric sports car. It is aimed at everyone interested in industrial design, production management, and the creation of manufacturing spaces. The material is presented in a practical manner and can be considered a textbook, a conceptual project, or a blueprint for a real enterprise. It provides a consistent and detailed description of the mini-factory building structure. When I was designing the Evo car, I contemplated how to manufacture it and what technologies and equipment would be required. I dreamed of my own manufacturing facility and focused on small-scale production. As the project progressed, the factory layout was reconsidered and refined. The result is a compact manufacturing building with the most minimal footprint possible for car production. The building's structural form is derived from the requirements of the technological process and meets standards for strength, stability, and durability. The construction utilizes the latest manufacturing methods that satisfy requirements for material efficiency, industrial production, and rapid assembly. Standardized products manufactured using cutting-edge methods are widely used in the structure. Both production and domestic facilities are accommodated within a single building with a total area of 960 square meters. The floor plan, the organization of the assembly hall, the positioning of production stages, and the choice of engineering systems are shaped by the actual tasks of small-scale car manufacturing. By reading this book, you will discover how a modern manufacturing facility is organized. The production process here offers flexibility, innovation, and the ability to rapidly improve the design directly during the workflow. You will see the factory from the inside: from the powerful steel framework and sun-drenched workshops to the director's office, where the company's development course is charted. The book introduces the mini-factory personnel — a team of sixteen people working in sync, like a single sports team. Special emphasis is placed on the interaction between the people running the production, the role of each specialist, and how their collaborative effort transforms an idea into a finished product. This book is a guide to a world where engineering thought takes shape, where every nut and every byte of code matters, and where a small team is capable of creating grand and complex machines.

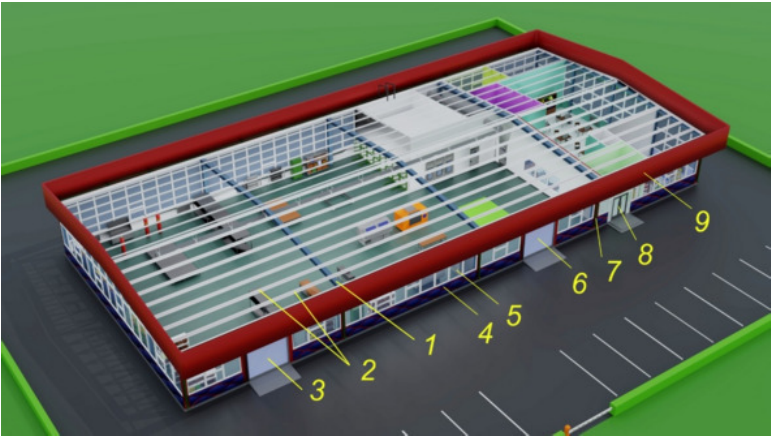
1 General information about the mini-factory

The mini-factory was designed for construction in a humid subtropical climate, with an average annual temperature of +12° C, characterized by long hot summers, short warm springs, and mild but relatively dry winters. The mini-factory is a single-story building with a total area of 960 sq. m., featuring a height of 4.7 m to the bottom of the load-bearing structures and a ridge height of 5.6 m (Figure 1).

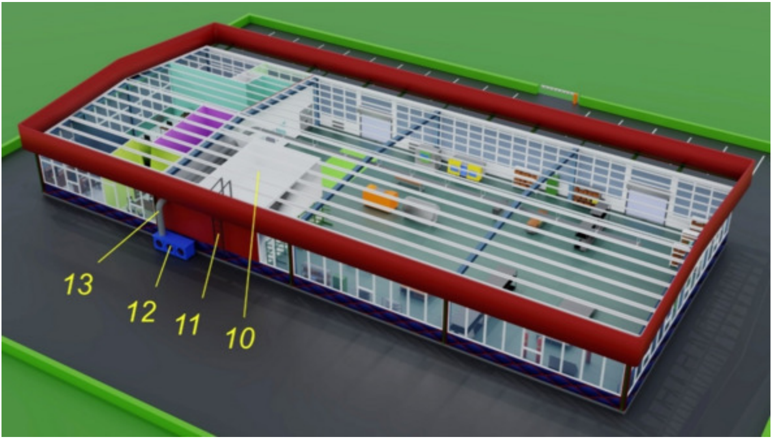
Figure 1 — Mini-factory Dubina

The factory building houses a production hall, administrative offices, and a canteen. The production hall includes a production line consisting of five stages. The manufacturing process throughout the factory is monitored by surveillance cameras. The first production stage involves welding. The second stage is the assembly of the battery pack. The third stage of the production line involves the moulding and assembly of composite material parts. After polymerization, the mould with the part proceeds to the fourth stage for de-moulding and machining. Following machining, the part arrives at the fifth and final stage of car assembly, which takes place at a single workstation. All body parts are assembled there. Two workers install all vehicle equipment and mount the electrical wiring in a specific sequence. Assemblers equip the body with the powertrain, battery, and instrument panel. Once the parts are installed, workers verify the operation of all vehicle systems. After assembly, the vehicle enters the paint booth. After the paint is applied, hot air is supplied to the booth for drying. Following the painting process, the vehicle undergoes a final quality check (Figure 2). The factory personnel operate like a single sports team. The team is led by the factory director. The entire team consists of sixteen people: Factory Director, Senior Designer, Junior Designer, Senior Technologist, Junior Technologist, Senior Hardware Programmer, Junior Hardware Programmer, Senior Web Programmer, Junior Web Programmer, Assembler, Machine Operator, Electrician, Welder, Moulder, Painter, and

Household Worker.



1 — Column; 2 — Roof purlins; 3 — Entrance gate; 4 — Wall; 5 — Windows; 6 — Exit gate; 7 — Downspout; 8 — Entrance door; 9 — Canopy; Figure 2 — Structural elements of the mini-factory



10 — Paint booth; 11 — Stairs; 12 — Split system; 13 — Air duct. Figure 2 — Structural elements of the mini-factory

2 Factory structure

2.1 Framework

The load-bearing framework of the 48 x 20 m mini-factory building consists of variable-section steel frames, comprising columns and beams, as well as a system of wall and roof purlins (Figure 3). Variable-section I-beam steel columns, manufactured by electric welding from 2 cm thick steel plate, are the load-bearing elements of the metal framework, absorbing the primary loads on the clear-span building. Each steel column consists of a shaft, a cap, and a base, with a 12 m spacing, a width of 20 m, a height of 4.7 m to the bottom of the load-bearing structures, a ridge height of 5.6 m, and a roof slope of 4°. Column components are welded at a specialized facility and shipped ready-made to the construction site. All elements of the primary load-bearing framework are coated with an 80 μm thick primer to protect against corrosion during transportation, installation, and operation.

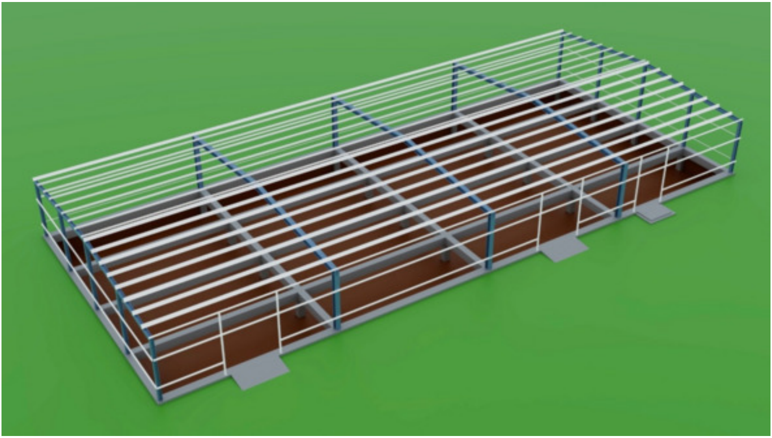
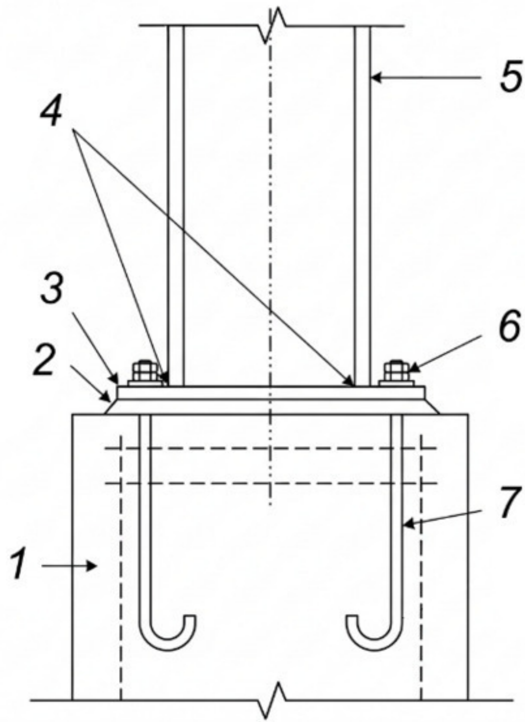


Figure 3 — Mini-factory building framework

The load from the building framework is transferred to the foundation through the base of the frame; the building frame has a rigid connection to the foundation. Rigid column support ensures the transfer of lateral and bending moments, creating a stable structure. The steel column is attached to the foundation using anchor bolts and a base plate, which is made of a 500 × 500 × 20 mm steel plate and welded to the base of the column (Figure 4). The base plate distributes the load from the column over a larger foundation area, preventing point loads. Anchor bolts serve to fix the column's position and transfer tensile forces arising from bending moments into the foundation. The column base is designed for the uniform distribution of concentrated pressure from the column to the foundation surface and guarantees the fixation of the lower end of the column in accordance with the established design scheme.



1 — Concrete foundation; 2 — Grout; 3 — Base plate; 4 — Butt weld; 5 — Steel column; 6 — Double lock nuts and washer; 7 — Anchor bolt. Figure 4 — Column-to-foundation connection

2.2 Roof

A double-layer steel standing seam roofing system with an insulation thickness of 120 mm is used on the roof (Figure 5). The inner panel provides an aesthetic appearance inside the building, acts as a vapor barrier, and enhances the fire resistance of the roofing system. It offers the advantages of a system with an additional framework and is suitable for rooms with high relative humidity.

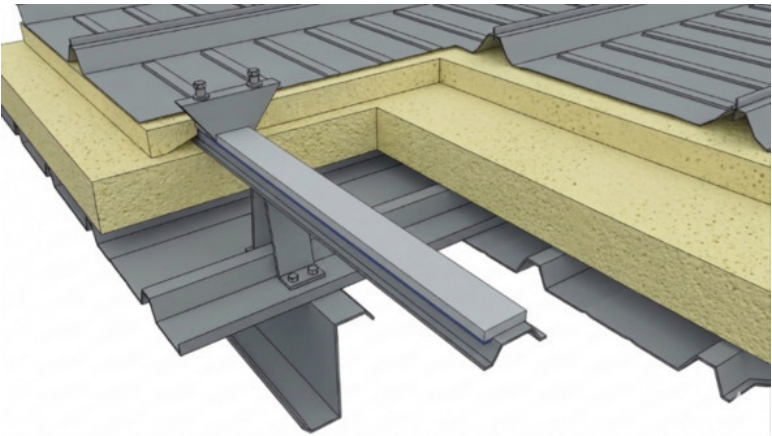
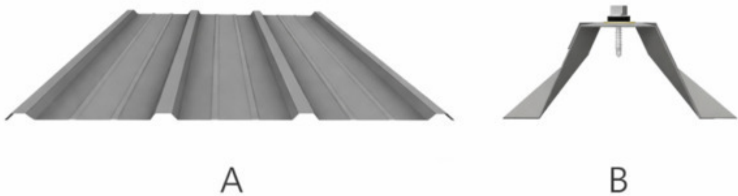


Figure 5 — Double-layer steel standing seam roofing system

The roof utilizes factory-rolled panels with a width of 1 m. The fastening system allows for the longitudinal movement of the panels during seasonal thermal expansion. Transverse ribs provide additional stiffness to the panels. The panel material is 0.75 mm thick galvanized steel with a zinc mass of 275 g/m^2 (Class 1). This ensures decades of corrosion protection; the coated steel panel does not crack at bends and is UV-resistant. The panels are attached to the roof purlins using stainless steel self-tapping screws with polymer caps matching the color of the panels (Figure 6).



A — Roofing panel; B — Joining method. Figure 6 — Roofing panel and its joining method

The building's roof purlins are horizontal beams that are part of the roof's metal structure and serve to distribute the load from the roof to the columns. They ensure the strength and stability of the roof and are also used for mounting lighting fixtures and the ventilation duct (Figure 7).

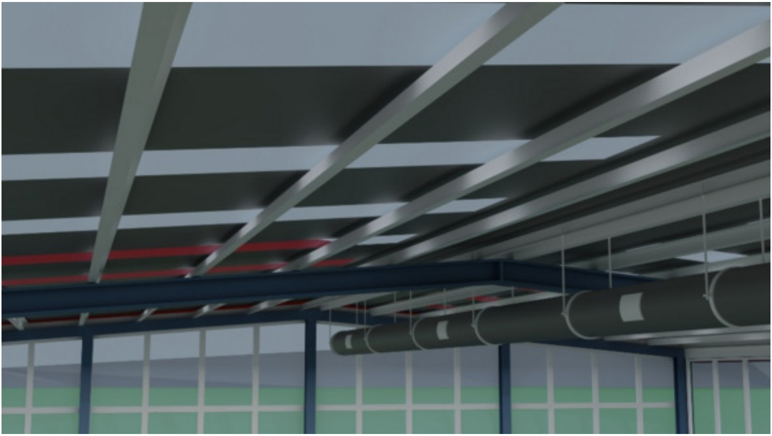


Figure 7 — Roof purlins

Skylights (mansard windows) are installed on the roof directly in the plane of the slope at the same angle as the roof (Figure 8). Special flashings for standing seam roofs are used for their installation, ensuring a watertight connection with the metal panels. For a steel standing seam system, it is critically important to use watertight flashings designed specifically for flat metal coverings to prevent leaks at junction points.

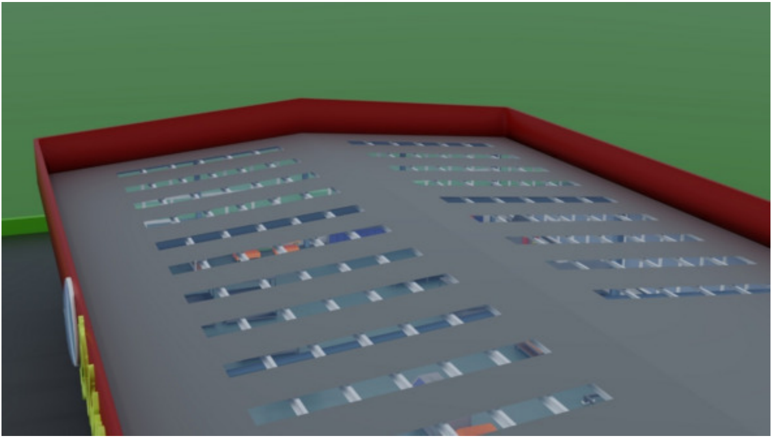


Figure 8 — Skylights on the roof

2.3 Walls

The walls are curtain walls; they are loaded only by their own weight and wind loads within the floor level and transfer the load to the building's framework. Wall systems consist of profiled steel panels attached to the secondary framework using self-tapping screws with polymer caps matching the color of the panels (Figure 9). The installation of panels requires less labor, and their cost is lower than that of brick walls.

Figure 9 — Mini-factory wall

Installation of the internal wall panel provides protection for the thermal insulation against possible mechanical damage and improves interior aesthetics. A perforated panel is used, which features increased sound absorption. The internal wall finish conceals the elements of the secondary framework. Ventilation grilles, opening trim elements, and decorative accessories are mounted within the wall panel. Advantages of wall panels include: aesthetic appearance, high-quality coating, simple and rapid installation, easy replacement of damaged panels, a wide range of adapted accessories, a full set of trim details and elements, cost-effectiveness, functionality, and durability.

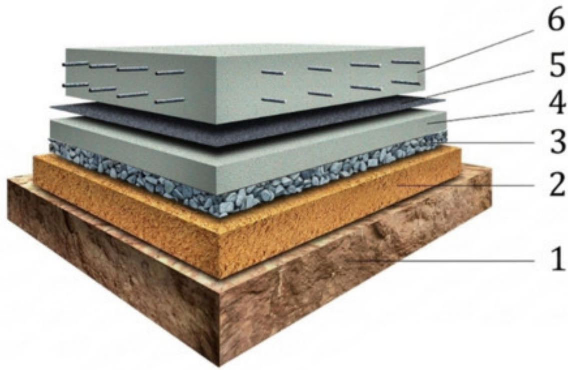
Wall purlins (girts) are used to support the wall panels, cladding, and windows. Wall purlins (horizontal beams) distribute loads to the building's framework. They are an important element of the building framework and are manufactured from steel. Wall purlins are made of cold-formed galvanized Z-profiles. Installation is carried out using galvanized bolts. Openings are constructed from galvanized cold-formed L, C, U, and Z profiles. All elements of the load-bearing framework are shot-blasted and coated with an 80 μm thick primer to protect against corrosion during transportation and installation.

2.4 Heating

To ensure a comfortable temperature at the factory in a humid subtropical climate, a system of sixteen electric convectors with a total capacity of 32 kW is used. Given the mild winters and an average air temperature of +12° C, such a system is optimal for maintaining the working microclimate. Each convector has a power output of 2 kW. This modern heating device is enclosed in a steel housing shaped like a rectangular parallelepiped with dimensions of 120 × 60 × 6 cm. The convector features a large heat-exchange surface area despite its slim profile. Cold air intake vents are located at the bottom of the housing, while louvers for the heated airflow exit are at the top. An innovative X-shaped monolithic heating element made of aluminum alloy allows the device to reach operating temperature quickly and heat the air silently without over-drying it or burning dust. The control unit includes an electronic thermostat and a power mode switch for precise temperature maintenance, allowing for flexible regulation of the building's temperature and the factory's energy consumption. Internal tip-over and overheat protection sensors provide an immediate electrical circuit break in case of an emergency. The operation of the convector is based on the physical law of natural air convection. Cold air at the bottom of the room enters the device through the lower vents. As it passes through the blades of the heating element, the air warms up. Heated air becomes lighter, expands, and rises through the upper louvers due to natural draft. Rising to the ceiling, the warm air gradually cools, descends, and enters the convector again. This creates a continuous circulation of warm air that effectively heats the building's interior space. Using convectors with an IP24 splash protection rating reliably protects the electronics from condensation. The electronic thermostat and auto-restart function allow the system to resume operation independently with preset settings even after brief power outages, which is vital for an uninterrupted production cycle. Sixteen such units with a total capacity of 32 kW effectively compensate for heat loss through the factory's glazing and gates, creating a stable thermal environment for engineers and technicians. The heating system operates on a temperature schedule with a «night mode.» The use of programmable thermostats integrated into a single climate control system makes the enterprise efficient. Climate control for the factory saves energy while constantly monitoring indoor temperatures. Reducing the temperature by just 1 degree saves approximately 7% of electricity. A constant temperature without fluctuations improves health and reduces the risk of colds. Furthermore, a stable temperature extends the service life of equipment and protects electronics from the humidity of the subtropics. Condensation forms on cold surfaces. If the car's metal frame or a machine tool is colder than the air in the workshop, they will become covered in water droplets. Constantly maintaining the temperature above +12…+15° C at night prevents the equipment from cooling to the critical point where moisture begins to condense on it. According to sanitary standards and technological production requirements, the recommended temperature for offices and administrative areas — where work is sedentary and physical activity is minimal — is between +21° C and +23° C during working hours to ensure employees do not get cold. This is the temperature at which the brain functions productively and the body does not overcool. In the assembly hall, where the main production takes place, people are moving, and the equipment generates some of its own heat. During working hours, the temperature there is maintained between +18° C and +20° C. This is an ideal temperature at which workers do not overheat while moving, and it is the optimal mode for the precision of CNC machines. At night, the temperature throughout the building is set between +12° C and +14° C. This is sufficient to prevent condensation on metal without wasting excess energy. For «by-the-hour» automation, a «smart factory» system with programmable thermal regulators is used: 08:00 — Start of the shift: temperature in the workshop +19° C, temperature in the engineering hall +22° C. 17:00 — End of the shift: transition to «night mode,» the thermostat switches to maintain an indoor temperature of +13° C. 06:00 — Automatic activation of convectors at full power to pre-heat the building after the night to +19° C in the workshop and +22° C in the engineering hall.

2.5 Floor

A structural element recessed below the ground surface that absorbs loads from the building and transfers them to the base is called a foundation. The factory foundation is a pad foundation (column foundation) with a grade beam (rostverk) and a slab-on-grade floor. The soil at the foundation site consists of semi-solid loams and clays. The bearing capacity of the soil beneath the footing of the pad foundation is 200 kPa (1.5—2.0 kg/cm^2). The soil withstands the loads from columns and grade beams, transferring them evenly without excessive settlement. The reinforced concrete grade beam is monolithic, with a height of 700 mm and a width of 500 mm, constructed at the floor level. The floor is independent of the grade beam. The slab-on-grade is not rigidly connected to the grade beam; instead, it is separated by an expansion joint — a 20 mm thick strip of PSB expanded polystyrene. Foundation settlement is not transferred to the floor. The grade beam and pad foundations absorb the loads from the columns and the framework, while the floor absorbs the loads from equipment and loading vehicles. The floor consists of a compacted base of sand and crushed stone with a thickness of 400 mm (Figure 10). Then, a 100 mm thick lean concrete bed (class B7.5) is laid upon it, followed by a waterproofing membrane, and finally, a concrete screed (class B22.5) reinforced with A500C welded wire mesh (Ø10 mm with a 200 × 200 mm pitch). The upper and lower mesh zones are set on chairs (spacers). The thickness of the screed is 150 mm.



1 — Soil; 2 — Sand; 3 — Crushed stone; 4 — Lean concrete; 5 — Waterproofing; 6 — Concrete screed. Figure 10 — Building floor

The concrete bed (lean concrete) serves as an intermediate layer between the compacted base and the screed. This preparation layer is designed to protect against groundwater and to provide additional pressure distribution onto the soil. For the concrete bed, B7.5 concrete with a low stiffness class is used, as the strength requirements for this layer are less demanding. In this case, the lean concrete performs the following functions: it prevents the cement paste from leaking into the soil, ensuring the required strength of the monolithic floor screed; it levels the site and provides convenience for the installation of the reinforcement cage and the monolithic screed; it acts as an additional shock absorber during minor soil deformations, thereby protecting the base structure. Next, waterproofing is laid over the lean concrete, and the screed is poured on top of it. A topping is applied to the surface of the floor screed to create an ultra-strong, wear-resistant, and sealed finish layer. The final floor covering is a polyurethane coating, chosen for its strength, chemical resistance, and ease of maintenance. This is a seamless polymer coating based on polyurethane resins. It forms a dense, slightly textured surface with high wear resistance and multi-colored markings. The polyurethane coating offers: high strength and wear resistance; resistance to impacts and abrasive loads; resistance to chemicals (oils, fuels, weak acids, and alkalis); elasticity (it does not crack under vibration or temperature fluctuations, unlike epoxy coatings); seamlessness and airtightness (no crevices where dirt can accumulate); and durability (10—15 years under normal operation). The total thickness of the coating is 3 mm.

Конец ознакомительного фрагмента.