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INTRODUCTION

This manual is the result of the Leonardo da Vinci project titled: Improving Vocational Education in the Construction Industry Sector with the aim of Identification and Recognition Qualifications in European Union Countries

08-LdV/TOI/02059/013.

Polish Association of Construction Industry Employers – Poland was the promoter of the project. Partners of the project were as follows: Polish British Construction Partnership Sp. z o. o. – Poland, CREDIJ (Centre regional pour le dévelopement la formation et l'insertion des jeunes) – France, University of Minho – Portugal, Ufficio Scolastico Provinciale di Venezia – Italy, Econometrica Ltd. – Greece, The Chartered Institute of Building – United Kingdom.

This PROCONSTR involved the comparison and improvement of National and European education systems, with emphasis on vocational schools for construction specialists. The outcome of the project is an innovative didactic resource for beneficiaries. Eight job modules were created on the basis of data collected and domestic markets available. The didactic materials were created with support of construction companies on national levels. The following job modules were created for:

- bricklayer

- carpenter

- plumber

- electrician

- concrete builder

- roofer

- HVAC worker

- plasterer

PROCONSTR is a project that is developing an innovative program of vocational training based on eight selected construction professions for graduates from vocational schools, technical secondary schools, and employees who are professionally active and want to improve their skills. Each job module consists of two parts with the first part being theoretical, including the latest know-how concerning specific trades necessary for employees. The second part consists of training with appropriate examples set out in exercises based on chosen innovative aspects.

The project partners also created manuals for tutors, which consist of the methodology for training as well as additional materials for PROCONSTR courses.

More information about the PROCONSTR project can be found on the project website: www.proconstr.eu.

INFORMATION ABOUT THE COURSE

Participants should have the following knowledge of plastering as a prerequisite prior to attending this course:

- knowledge about plastering using traditional methods,
- reading project and work specifications,
- reading and understanding codes and standards,
- basic practical plastering skills.

The new developments participants will learn about on the course are:

- using x-ray (barite) heavy plaster,
- x-ray protection shields for safe installations in x-ray rooms.

The advantages of this modern technique are:

- use of environment friendly x-ray plasters and protections,
- knowledge about using relevant materials and techniques,
- quality of elements and works improvement.

The participant will learn about using x-ray plaster and other forms of x-ray room protection, new skills and competencies for dealing with these particular materials. After the course participants will be able to choose appropriate mortars for specific types of walls. Furthermore they will be able to apply this technology on their own.

Participants will receive a manual and CD, full of learning materials like PowerPoint presentations, pdf files and vocabulary.

They will be asked to attend theoretical lectures (1 day) and practical workshops (2 days) conducted by a vocational trainer. They will also learn how to read and use the additional materials included in this course.

Their knowledge will be tested/assessed by the trainer with a set of questions at the end of the course.

After completing the course participants will gain the **PROCONSTR CERTIFICATE**.

PREFACE

The PROCONSTR project is intended for two main groups of construction workers; qualified workers and medium-level technical supervisors. Eight trades covered by the project represent the main professions of the large residential house building sector as well as the infrastructure sector that constructs office buildings, hotels, commercial, cultural and sports centres, healthcare and other public service buildings. Experts in the fields covered by the project are also crucial for the single-family house building sector, and equally important in the industrial and road construction sector.

Traditional trades like concrete builder, carpenter, reinforced concrete builder, mason, roofer, and plumber are currently undergoing a dynamic evolution due to technical progress in the construction field.

The common use of concrete pumps together with concrete mixers and the widespread application of chemical products in construction such as self levelling floor compounds and resin are an important part of the prefabricated reinforced-concrete elements which are used for ceiling construction. Common use of prefabricated reinforcement elements like meshes and cages has been an important influence on the change from the traditional concept of separate concrete and reinforced concrete builders. Joining the two trades together creates a more universal trade for the reinforced concrete builder.

The widespread use of formworks and scaffolding on all types of construction sites has a decisive influence on the continuing changes in the profile of the carpenter's profession. Similarly, an exceptionally wide range of roof coverings and new methods of assembly has a serious impact on the modern definition of the profession of a roofer. Important changes are happening in the field of masonry, where masons are required to have an in-depth knowledge of all types of plasters and glues. The knowledge base of an electrical fitter has to cover a broad range of low current electric installations. A trade which is currently undergoing particularly dynamic changes due to huge progress in the field of air conditioning techniques is that of HVAC fitter.

Equally, significant progress can be seen in the field of sanitary techniques. A whole range of equipment is available on the market that has not been used before. The use of internal or external materials made of epoxy resins, carbon fibres and other synthetic materials has already exceeded the percentage use of traditional materials. The introduction of different types of plaster, including x-rays plaster or other wall elements like cardboards with lead (Pb) shield, significantly widens the requirements relating to the trade of a plasterer.

Apart from technological changes that have influenced the profile of vocational training, it is impossible not to mention general requirements which have to be fulfilled by modern construction teams.

These requirements include:

- a significant shortening of the project implementation cycle,
- limiting the area of construction sites, particularly in urban agglomerations,

- the expansion of vertical-building projects,
- the introduction of a top-down method, i.e. a simultaneous construction of both the underground and ground structures,
- carrying out works in extreme weather conditions, due to the possibility of putting concrete layers at both low and high temperatures.

Nonetheless, health and safety at work is the most important issue, relating to both the dynamics of changes in vocational profiles and strict requirements.

The expansion of the European Community favours the free movement of services in the construction sector. This reinforces the creation of construction companies with international capital. It also creates the need for mobile construction teams, which together with the high quality requirements constitutes an incentive for the standardisation of qualification of construction workers on the highest level across the EU. These reasons also underly the importance of changes undergoing in the field of construction trades.

A positive economic situation for the construction market affects economic development substantially. Demand for residential housing, office space and infrastructural building increases, orders placed by investors motivate contractors to carry out their jobs and the contractors stimulate enterprises manufacturing building materials to maximize their production capacities; this enables quick completion of construction investments. Consequently, a system enabling stimulation of economies and decreasing the unemployment rate is launched.

When a market presents a demand for a quick and thorough completion of investments, the most serious obstacle is finding an appropriate contractor team consisting of high-class specialists knowing all aspects of the profession and who are trained in the latest methods and technologies used within the construction project, in particular, in fields they specialize in.

Chapter I – The profession of Plasterer

Introduction

If the construction market is healthy, it can have a very positive influence on economic growth. An increase in orders and contracts mobilizes supplier companies to maximum capacity, and growing demand from investors who need contractors reduces unemployment rates.

The problem of finding a good team of contractors is often encountered. It can be very difficult to find reliable workers. Many contractors have emigrated recently to increase their earning capacity. In real terms, it is increasingly difficult to get a good, well-trained contractor.

Plasterer – a description of the profession

On a construction site, the plasterer performs various activities: plastering, among other things, using custom-made products, bricking-up, insulating walls of external elevations, usually working on platforms, i.e. at height. A plasterer uses a variety of materials, such as ready-made plaster mortars and joint mortars to insulate walls, as well as mechanical devices, like plastering units, electric tools or scaffolds. Therefore a plasterer should participate in training, including regular occupational health and safety training, in order to become familiar with trade-specific threats, as well as safe methods of performing plastering work. Furthermore, before commencing work, the plasterer should be familiar with the occupational risks associated with work on each specific construction site.

A plasterer requires a valid medical certificate, confirming lack of contraindications for performance of construction works, including working at height. Qualifications are also required for the operation of machines and other technical equipment listed in the regulations of the Minister of Economy of September 20th, 2001, regarding occupational health and safety during the operation of technical equipment and machines for earthworks, construction works and road construction works. These are relevant, for example, for the operation of plastering units, concrete mix pumps, lift trucks, concrete mixers with three-phase motors above 1 kW or the assembly of construction scaffolding.

The scope of activities of a plasterer

A plasterer deals with the application of plaster layers (made of lime, cement, cement and lime, gypsum, gypsum and lime, stucco) and the application of dry plaster on the walls and ceilings of buildings and construction facilities. A plasterer prepares plaster mortars and is familiar with the different components used to produce these and the rules of their composition. Currently, plasterers increasingly use factory-prepared ready-made mortars. Before starting plastering, they prepare the base and brick up any holes in walls and ceilings. They apply plaster to convex or concave architectural forms, particularly in historic buildings, e.g. on cross vaults or coffers, and they apply toweling plaster on the cornices. Plaster layers are applied using manual tools or plastering devices and machines. A plasterer operating plastering devices must be familiar with the methods of their operation and maintenance.

The plasterer's tasks also include fixing air grates, hooks and other components to the surface of the plastered wall or ceiling. During repair works the plasterer may install scaffolding which does not require authorization by the Office for Technical Supervision, and mount hoisting winches for transporting materials and tools.

A plasterer should be precise, capable of sustained physical effort, focused, physically fit, able to distinguish colors, persistent and patient.

Plasterers work both inside and outside, standing, with their hands raised.

Working hours are fixed; only during repair works or unfavorable weather conditions, when time is specified as required.

For ergonomic reasons, work tools should be placed within the plasterer's reach. Plasterers work on their own or in teams depending on the scale of the task.

On a construction site, threats may emerge due to slippery surfaces, moving parts of construction machines, as well as factors associated with weather conditions. Plasterers are exposed to the dangers of falling from height and injuries caused by sharp and/or protruding objects. Contact with lime and cement results can trigger allergies and cause skin and eye diseases.

Prior to commencing work, a plasterer should:

- Familiarise him/herself with the type and scope of work for a given day,
- Check whether materials in the work area are available and arranged in a manner that ensures freedom of movement,
- Check the condition of machines, devices and scaffoldings,
- If working in an excavation, check the securing of the excavation walls.

There are also recommendations for the plastering process. For instance, external window frames are to be plastered only from external scaffoldings, equipped with hand rails. During plastering of internal reveal, the window opening should be secured with a board to prevent the plasterer falling out. The concrete material or mortar should be applied in accordance with the instructions supplied by the pump manufacturer. It is also necessary to control the air tightness of the ducts and connections of such a device.

Among other things, a plasterer is prohibited from:

- Leaning against barriers and leaning out from the facility structure
- Dropping materials and other tools from heights,
- Climbing the scaffolding,
- Leaving tools, materials and other objects on the edges of working platforms,
- Overloading platforms and scaffoldings.

Familiarity with at least the basic requirements and provisions of occupational health and safety by employers and employees contributes to the greater safety of building projects.

Plasterer work environment

Like other professions, plasterers must care about their safety. Basic protection is ensured by the overall, shoes, helmet and H-harness. Apart from appropriate equipment, common sense and compliance with the basic rules of occupational health and safety is equally important.

On the evidence of statistics from the Central Statistical Office and accident analysis prepared by the Department for Prevention and Promotion of the State Labor Inspection, it can be concluded that the construction industry is still one of the sectors with the highest percentage of accidents at work. Analysis has also confirmed that most often these are serious injuries or even deaths of employees, as well as falls from height – scaffolding, roofs, terraces, balconies and windows, ladders and stairs. Such events happen most frequently during bricking and demolition of walls, installation of thermal insulation of exterior walls and plastering. The main causes of accidents include:

- Improper behavior of employees during work due to lack of occupational health and safety training,
- Lack of protective equipment or its poor condition,
- Improper workorganization and coordination ,
- The fact that direct supervisors tolerate deviations from basic occupational health and safety rules,
- Lack of assessment or improper assessment of occupational risk.

Work at height is work performed on surfaces located more than 1m above ground or floor level with two exceptions: if the surface is shielded on all sides to a height of at least 1.5 m with solid walls or walls with glazed windows, or equipped with other permanent structures or devices protecting the employee against falls.

Threats associated with plasterer's work

Plastering works should be performed in accordance with the occupational health and safety during performance of construction works regulation of the Minister of Infrastructure of February 6th, 2003. The types of threat, their origins and potential effects that may emerge in the plasterer's work area, as well as how to prevent them, depends upon the specific nature of the situation. However, on the evidence of professional studies exploring occupational health and safety in a plasterer's work area, it is possible to determine the basic threats to be taken into account. These include:

- Slippery and uneven surfaces that pose a threat of fall in the work area, as well as a level difference;
- Poor technical condition of scaffolding and unsecured structural openings;
- Moving objects, movable components of machines and devices (danger of being hit with an object);
- Careless use of electrical and construction tools;
- Carrying of excessive loads, resulting in overloading of the musculoskeletal system;
- Excessive noise caused by machines and equipment used on site;
- Threat posed by moving transport vehicles (being hit, ran over);
- Negative impact of changeable weather conditions – rain, cold, heat;
- Unsecured powder product metering stations (cement, lime etc.)
- Inadequate power supply system (possibility of electric shock);
- Inadequate lighting, including insufficient daylight or bad selection of lighting points;

- Impact of chemical substances, such as liquid concrete and plaster mix and other additives with irritating or allergenic compounds;
- Stress associated with excessive requirements in relation to the worker's abilities, or unreasonable haste.

Preventive means

It is the duty of the employer to minimize the occupational risk associated with every work position by applying appropriate preventive measures. The employee is obliged to use these in their work area. Preventive means associated with plasterer's work are as follows:

- Wearing appropriate working shoes and clothes and appropriately selected and applied means of personal protection, such as gloves, goggles, semi-masks, reflective jackets, hearing protectors, helmets;
- Maintainenance of order in the work area and in the surrounding area;
- Use of scaffolding consistent with the technical requirements, only after their approval by the superviser;
- Systematic control of the technical condition of scaffolding;
- Use of adequate protection for structural openings during construction (e.g. use of protective barriers), and, if necessary, protective equipment to ensure protection against fall from heights;
- Use of appropriately selected ladders and lifts
- Use of appropriately selected electrical tools in good working order (tested);
- Compliance with individual transport standards;
- Proper marking of the construction site;
- Employee training;
- Use of electric shock protection systems and their systematic supervision;
- Work area organization in accordance with workstation instructions;
- Ensuring adequate provision of/access to food and drink as preventive measures;
- Adapting requirements to emotional capabilities of the employee;
- Development of teaching and training techniques;
- Specification of clear rules regarding remuneration, bonuses and penalties. The employer should agree any preventive means to be used on site with an employee representative or a commission for occupational health and safety.

Physical and psychical requirements for the occupation

A plasterer should meet the following physical and psychical requirements:

- No acrophobia,
- Hand-eye coordination,
- Good manual skills,
- Ability to distinguish colours,

- Capable of sustained and long-term physical effort,
- Ability to work in unpleasant environmental conditions,
- Precision.

Physical and health requirements

Candidates to become plasterers must meet specific physical and health requirements. Due to difficult work conditions, it is a natural occupation for strong men who are of very good health and physical strength. Every candidate for this profession is subjected to specialist medical tests, among others, in neurology, ophthalmology, internal medicine and laryngology. On the basis of the test results, a doctor of occupational medicine issues a certificate of fitness for the occupation, confirming lack of contraindications to work at height or to operate moving equipment. Representatives of this profession are subject to regular medical examinations every 2 years to update their fitness certificate. Undisputable contraindications for performance of a plasterer's profession include: diseases of the central nervous system, disequilibrium, sudden loss of awareness, epilepsy (convulsive epileptic seizures), subjective vertigo, acrophobia, lack of depth perception (making it impossible to assess distances correctly), diseases of the circulatory system (including heart defects, arterial hypertension, diabetes, diseases of the respiratory system), chronic diseases of the bronchi and the lungs e.g. bronchial asthma, diseases which significantly limit the efficiency of the locomotor system, rheumatism, serious hearing defects, skin diseases – (due to a high susceptibility to allergies).

Learning and training to become a plasterer

Qualifications for becoming a plasterer are obtained at a basic vocational school of construction. The prerequisite to enroll at the basic vocational school at present is graduation from grammar school.

Basic vocational schools accept students who have not turned 18. Training for the profession takes three years. The school curriculum includes general subjects and vocational subjects, such as: technology- including basic information on construction materials and methods of performance of plastering works, an introduction to the general construction trade – knowledge on the rules of construction and building of construction facilities, vocational drawing – rules and standards of technical drawing, and learning how to read technical documentation. A qualified plasterer is a graduate of basic vocational school who has passed the vocational exam organized by the District Exam Commission. In the continuous learning system, professional qualifications are confirmed by titles of a qualified worker and master, obtained as a result of passing of an exam set by state exam commission.

Practical learning of the profession takes place at construction companies, where it is conducted by an instructor on the construction site. An instructor of practical vocational training is a company employee, a master or a construction manager with teaching qualifications. The training curriculum is agreed with the school.

According to a 2007 study prepared by the Ministry of Labor and Social Policy (Sectoral Operational Programme Human Resources Development, project "Preparation and popularization of the domestic standards of professional qualifications") entitled DOMESTIC PROFESSIONAL QUALIFICATIONS STANDARD – Plasterer (713302), a plasterer is obliged to meet the following professional requirements, which should be satisfied within the framework of school education, combined with practical training on the construction site:

- organization of own work area, preparation of materials, tools and equipment for performance of plastering works in accordance with legal provisions on occupational health and safety and fire protection, ergonomics and environmental protection,

- organization of transport of plastering materials and components on site and in storage areas,

- analyzing of construction documentation of plastering works to determine the scope, duration of plastering works and types of materials required,

- preparation of foundation for plastering,

- preparation of plaster mortars manually and mechanically,

- application of single layer plasters, leveled with a brush, trowel or long float,

- application of double and triple layer plasters on the walls and ceilings ,as well as convex and concave surfaces,

- application of toweling plasters,

- fixing of dry plaster boards,

- application of high quality, decorative plasters and stuccos – washed, troweled, scraped and mosaic plaster.

- making plaster with mortars containing synthetic resin,

- mending of plaster,

- assembly of simple scaffoldings for plastering works not requiring approval by the Office for Technical Supervision and their disassembly;

- assessment of quality of the plastering works performed,

- acceptance of plastering works performed by subordinate employees.

Chapter II – Legal basis for plasterer's work

In Poland

Plasterer's work, especially on scaffolding during external plaster application, qualifies as dangerous work. Such work is carried out at height. There is a constant risk of falling objects. The neighbourhood of a construction site is dangerous and unpredictable as well. Therefore, plasterers should adhere to the basic regulations governing safety and health at work. They should also obey the Plan for Safety and Health (known as BIOZ Plan), which is prepared by the construction manager for each site.

Basic law acts regulating the work of plasterers:

- Construction Law Regulation of 07.07.1994 (Dz. U. of 2000 Nr 106, item 1126, with amendment of 06.08.2010, Dz. U. 2010 nr 121item 809).

- Regulation of the Minister of Infrastructure of 27.08.2002 on the detailed scope and form of health and safety plan and the detailed scope of construction work types, posing a risk to health and safety of people (Dz. U. Nr 151, item 1256 with subsequent amendments).

- Regulation of Minister of Economy of 20.09.2001 on health and safety in exploitation of earthmoving, construction and road-building machines and technical devices (Dz. U. Nr 118, item 1263 with subsequent amendments).

Basic regulations concerning safety on construction sites and concerning areas such as plasterers' work include:

- Regulation of Minister of Labour and Social Security of 26.09.1997 on general health and safety rules (Dz. U. Nr 169 item 1650), in particular: § 105 to § 110 – Works at heights,

- Regulation of the Minister of Infrastructure of 6.02.2003 on health and safety during construction work (Dz. U. 2003, Nr 47, item 401),

  - chapter 1 – General Provisions,
  - chapter 2 – Conditions for the preparation and conduct of the works,
  - chapter 8 – Scaffolding and mobile working platforms,
  - chapter 9 – Working at heights,

- Regulation of the Minister of Transport and Building dated 28th April 2006 on technical functions in building industry (Journal of Laws 2006 No. 83 item 547),

- Act dated 16.04.2004 on building products (Journal of Laws 2004 No. 92 item 881),

- Act dated 27.04.2001 Environment Protection Act (Journal of Laws 2006 No. 129 item 902 with subsequent amendments),

- Regulation of the Minister of Infrastructure dated 12.04.2002 on technical conditions for buildings and location of buildings (Journal of Laws 2002 No. item 690 with subsequent amendments),

- Regulation of the Minister of Economy and Labour dated 27.07.2004 on industrial safety (Journal of Laws 2004 No. 180 item 1860 with subsequent amendments),

- Act dated 30.10.2002 on social work accident and occupational diseases (Journal of Laws 2002 No. 199 item 1673 with subsequent amendments),

- Regulation of the Minister of Labour and Social Policy dated 26.09.1997 on general industrial safety regulations (Journal of Laws 2003 No. 169 item 1650 with subsequent amendments),

- Regulation of the Minister of Infrastructure dated 6.02.2003 on building work safety (Journal of Laws 2003 No. 47 item 401),

- Regulation of the Minister of Economy dated 30.10.2002 on minimum safety requirements for machinery use by employees (Journal of Laws 2002 No. 191 item 1596 with subsequent amendments).

In Greece

Under Greek legislation all construction workers' professional activities are considered hazardous. The profession of Plasterer is therefore also considered hazardous.

The major dangers are:

- Falls from height,
- Dropped tools or materials,
- Burns and scalds,
- Incorrect use of equipment,
- Fire,
- Other error.

The legal framework for the Plasterer profession covers the following sections:

1) Rules of preparing and undertaking the job,
2) Health and safety regulations.

1. Work at height without scaffolds

P.D. 778/80 art. 17

2. Work on scaffolds

P.D.. 778/80 art. 9, 11

3. Work on roofs

P.D. 778/80 art. 18, 19

The health and safety regulations can be categorized as following:

- General regulations for health and safety
- Working at height using scaffolding and mobile platforms
- Protection from electrical shock
- Environment protection

Legislation referred to health and safety regulations:

P.D. 22/12/33 (I.G.G 406 A΄) "On security of workers using ladders"

P.D. 778/80 (I.G.G 193 A΄) "On security measures during building construction"

P.D.1073/81 (I.G.G. 260 A΄) "On security measures whilst performing tasks related to housebuilding and engineering works"

L. 1396 (I.G.S 126 A΄) "Obligations of observance of security measures in structures"

L. 1430/84 (I.G.G. 49 A΄) "Ratification of the 62 International Employment contract, "As regards the safety provisions in the construction industry and resolving directly related issues"

L. 1568/85 (I.G.G. 177 A΄) "Health and safety of workers"

P.D.71/88 (I.G.G. 32 A΄) "Regulation for fire protection of buildings"

M.O. 9087 1004/96 (I.G.G 849 B΄) "Operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas"

P.D.395/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use of work equipment by workers at work in compliance with directive 89/655 EU"

P.D. 396/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use by workers of personal protective equipment at work in compliance with the directive of the Council 89/656/EU"

P.D. 105/95 (I.G.G 67 A΄) "Minimum requirements for safety and health at work in compliance with directive 92/58/EU"

P.D.16/96 (I.G.G 10 A΄) "Minimum safety and health in the workplace in compliance with directive 89/654/EU"

P.D. 17/96 (I.G.G 11 A΄) "Measures to improve safety and health of workers at work in compliance with the instructions 89/391/EU and 91/383/EU"

P.D. 305/96 (I.G.G 212 A΄) "Minimum safety and health requirements at temporary or mobile construction sites in compliance with directive 92/57/EU"

P.D.. 62/98 (I.G.G 67 A΄) "Measures for the protection of young people at work, in compliance with directive 94/33/EK"

M.O. 130646/84 (I.G.G 154 B΄) "Security measures calendar"

Glossary:

L.: Law

P.D.: Presidential Decree

I.G.G.: Issue of Government's Gazette

M.O.: Ministry ordinance

In Italy

In Italy to become a mason, carpenter or plasterer one can attend specific training courses that lead to a qualification after compulsory education & training is completed (16 years old). The courses are organized by construction schools, which allows appropriate competencies and skills to enter the labour market.

Vocational training in the construction sector is managed by a national equal education system regulated by the Collective Labour Agreement (art. 90) for construction companies who are members of ANCE – the National Association Construction Builders and various trade unions (FENEAL-UIL, FILCA-CISL, FILLEA-CGIL).

FORMEDIL is the national body for training construction workers and it promotes, manages and coordinates training and refresher courses in the construction sector. These are organized by construction schools located across the different Regions and Provinces.

An individual can choose to take up an apprenticeship in a company (which is different according to each profession) and then be hired. Alternatively, an individual can decide to establish his/her own company. According to the Act 443/85 regarding Crafts, if a person wants to establish a company, then he/she must comply with the information and requirements set out in the act. In particular, the construction company can have a maximum of 10 employees and 5 apprentices. The number can be increased to 14 employees, but these additional workers must be apprentices.

The application should be submitted to the Provincial Register by the local Chamber of Commerce.

Important links:

- FORMEDIL: www.formedil.it
- ANCE – Associazione Nazionale Costruttori Edili: www.ance.it
- CEFME – Formazione, ricerca e servizi per l'industria delle costruzioni: www.cefme.it
- Chamber of Commerce: www.camcom.gov.it/

To find information regarding the legislation in the construction sector, you can visit the following websites:

- Ministry of Infrastructures and Transports: http://www.mit.gov.it/mit/site.php
- www.edilizia.com
- www.edilpro.it
- www.edilportale.com
- www.edilbox.it

Legislation on safety at work in the construction sector

The main legislation relating to safety at work is listed below. Several Regions have also issued regional acts.

- Decree President of the Republic No. 547 – 27/04/1955 "Legislation to prevent industrial accidents"
- Decree President of the Republic No. 164 – 07/01/1956 "Legislation to prevent industrial accidents in the construction sector"
- Decree President of the Republic No. 303 – 19/03/1956 "Hygiene at work"

- Legislative Decree No. 494 – 14/08/1996 “Implementation of Directive 92/58/CEE concerning minimum safety and health standards to be applied in the construction sites”
- Legislative Decree No. 277 – 15/08/1991 “Implementation of several EU Directives concerning protection of workers against the risks associated with exposure to chemical and physical agents”
- Legislative Decree No. 493 – 14/08/1996 “Implementation of Directive 92/58/CEE concerning the minimum standards for safety signs at work”
- Ministerial Decree 10/03/1998 “Safety criteria for fire prevention and emergencies at work”
- Legislative Decree No. 235 – 08/07/2003 “Implementation of Directive 2001/45/CE concerning minimum safety and health standards when using equipment at work”
- ISPESL guidelines to identify and use protection devices to prevent falls

Links:

- Ministry of Labour: www.lavoro.gov.it/
- Ministry of Infrastructures and Transports: http://www.mit.gov.it/mit/site.php
- ISPESL: www.ispesl.it

In the United Kingdom

Generally, the laws governing health and safety relate to all construction activities and trades (including design) and are not industry specific. There are several Acts and Regulations.

Some of the principal Acts which deal with health, safety and welfare in construction are as follows:

- Health and Safety at Work etc. Act 1974,
- Mines and Quarries Act 1954,
- Factories Act 1961,
- Offices, Shops and Railways Premises Act 1963,
- Employers Liability Acts – various,
- Control of Pollution Act 1989,
- Highway Act 1980,
- New Roads and Streetworks Act 1991,
- Corporate Manslaughter and Corporate Homicide Act 2007.

The fundamental Act governing health and safety in construction is the Health and safety at Work etc. Act 1974. The principal regulations of this Act which affect design and construction, are:

- Management of Health and Safety at Work Regulations 1999 amended 2006,
- Construction (Design and Management) Regulations 2007 (known as the CDM Regulations),
- The Work at Height Regulations 2005 amended 2007.

Some other related regulations and guides are:

- Site Waste Management Plans Regulations 2008,

- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995,
- The Control of Major Accident Hazards Regulations 1999 (COMAH) amended 2005,
- The Chemicals (Hazard Information and Packaging for Supply) Regulations 2003 (CHIP 3),
- The Health and Safety (Display Screen Equipment) Regulations 1992,
- COSHH (Control of Substances Hazardous to Health) Regulations 2002: Provision and Use of Work Equipment Regulations (PUWER 98),
- Lifting Operations and Lifting Equipment Regulations (LOLER 98),
- Personal Protective Equipment at Work Regulations 1992,
- Signposts to the Health and Safety (Safety, Signs and Signals) Regulations 1996,
- Control of Asbestos Regulations 2006.

Some of the principal Acts and Regulations which deal with environment, are as follows:

- The Environmental Protection Act 1990,
- Environment Act 1995,
- The Clean Air Act 1993,
- Radioactive Substances Act 1993,
- The Control of Asbestos Regulations 2006,
- The Ionising Radiation Regulation 1999,
- The Control of Lead at Work Regulations 2002.

The regulatory organisations are (according to the Environment Act 1995):

- The Environment Agency (in England and Wales),
- The Scottish Environmental Protection Agency (in Scotland).

In Portugal

Labour Law - The Labour Code in Portugal is regulated by Law n. 7/2009 of 12th February 2009. Further information regarding construction works contracts may be found in the Collective Work Contracts in the Construction Sector (CCT, Contratos Colectivos de Trabalho para o Sector da Construção) published by the Ministry for Labour and Social Solidarity in the Employment and Work Bulletin (Boletim do Trabalho e Emprego) n. 12 of 29th March 2009.

Standards for the Small and Middle-size Enterprises (SME): There are no specific regulations for SME. For the construction and real-estate companies there is a regulating entity (the Construction and Real Estate Institute -in PT, Instituto da Construção e do Imobiliário, INCI) and specific regulations concerning the admission and practice activity, namely:

- Decree-law n. 12/2004 of 9th January 2004 establishes the legal framework for the admission to and permanency in the construction activity;
- Decree n. 19/2004 of 10th January 2004 establishes the categories and subcategories related to the construction activity;
- Decree n. 21/2010 of 11th January 2010 establishes the value of the construction works according to the qualification categories of the building permit for 2010;

- Decree-law n. 211/2004 of 20th August 2004 regulates the real estate activity.

Basics of construction standards: General Regulations of Urban Buildings (in PT: Regulamento Geral de Edificações Urbanas, RGEU) approved by Decree-law n. 38382 of 7th August 1951 (altered by Decree n. 38888 of 29th August 1952 and further revisions). A new version is foreseen to be published soon (in PT: RGE).

Basics of construction Works Contract: For general contracts, the Civil Code approved by Decree-law n. 47344/66 of 25th November 1966 (1st version) and for public contracts, the New National Public Procurement Code approved by Decree-Law nº 18/2008 of 29th January 2008 (modified by Decree-law n. 278/2009 of 2nd October and Decree-law n. 223/2009 of 11th September).

Health, Safety and Welfare Regulations: Decree 41821 of 11th August 1958 establishes the work safety regulations for building construction; Decree-law 441/91 of 14th November 1991 establishes the general principles for the promotion of Health, Hygiene & Safety at work (transposes Directive n.º 89/391/CEE of 12th June); Decree-law 273/2003 of 29th October revises the legal framework on Health and Safety conditions in the construction site (incorporating the minimum prescriptions required for temporary/mobile construction sites established by the Directive n.º 92/57/CEE of 24 June).

In France

1- Basic concepts: standards, DTU, Technical advice (Avis Techniques).

1.1. Standards: see: Standards and European directives (source: AFNOR)

French approved standards are mandatory for State and local government funded contracts. They are also recommended for privately funded contracts.

1.2. DTUs (Unified Technical Documents) are documents that contain technical rules relating to the execution of building works using traditional techniques. They are recognized and approved by construction professionals. They also provide a reference point for insurance experts and the courts. Failure to comply with DTUs may lead to the invalidation of warranties offered by insurance providers. DTUs specify standards for traditional construction methods and are considered the epitome of reference texts. They are intended for relevant state bodies as well as contractors (whether architects or general contractors), owners and other experts. They are authored by a committee advising on technical texts.

1.3. Technical advice is advice from a committee of experts specialising in relevant trades and the expected behaviours of materials, components or processes. They define the characteristics of any materials, components or processes involved, and give advice on their durability and suitability for use and how they comply with regulations.

2 - DTU

2.1. Status of DTU

The DTUs are established by a body created in 1958, the “Groupe de Coordination des Textes Techniques / Groupe DTU” (the “Coordinating Group of Technical Texts or Group DTU”).

In 1990, this group became the "Commission Générale de Normalisation du Bâtiment/DTU "(the General Committee for the Standardisation of Building / DTU) in order to integrate it into the French official system, which was necessary to comply with European technical harmonization (Eurocodes)

This means that the DTUs have become standards. The transformation took place gradually through the regulatory procedures that govern standardsation.

As a result, the DTU(s) now have one of the following statuses:

Approved French standard (Norme française homologuée): this is a standard which has received official government approval, its technical value is recognized, and it plays an important role in the construction system,

Experimental standard (Norme expérimentale): which is undergoes a period of probation before being confirmed or amended to become a certified French standard,

Documentation booklet (Fascicule de documentation) : standard documents, essentially informative documents,

DTU: the original form of the documents. Not part of the official standard system.

In most cases DTU status is temporarily held in anticipation of its integration into the official standard system.

2.2. Private works

DTU is implemented following an agreement between the "maitre d'ouvrage" and the construction contractor. A DTU only commits the signatories, giving it a sense of obligation of contract.

Some standards and some French registered DTUs can be mandatorily enforced by regulatory decisions (often when safety-related).

2.3. Public works

The amended Decree of January 26, 1984 governs the application of French standards in contracts approved by the government, local authorities, public bodies etc., except in special cases as listed in the decree.

2.4. Composition of a DTU

A DTU may consist of the following documents:

Technical specification clauses booklet (cahier des clauses techniques: CCT) which sets out the requirements for the selection and use of materials,

Specification of special provisions booklet (cahier des clauses spéciales: CCS) which defines performance limits and obligations to other trades,

Rules for calculating the structural design.

All these documents are contractual documents and must be adhered to. There are also other documents, such as memos and selection guides, which are useful for structural designs that are not intended to be imposed by contract.

Like ISO standards, the DTU(s) must be bought. They can be found on the CSTB website: http://boutique.cstb.fr/

(CSTB = centre scientifique et technique du bâtiment: scientific and technical center for construction)

DTUs and other required documents are listed on the CSTB website. There are specific DTUs for each profession.

http://boutique.cstb.fr/dyn/cstb/Upload/Fichiers/Liste_0310.pdf

HEALTH AND SAFETY

On building sites required by the coordinator of safety to have a general plan of coordination, the companies involved must create a PPSPS (Particular plan of safety and protection of health) valid for all workers on the building-site

PPSPS: Particular plan of safety and protection of health

Contents of the PPSPS

1. The name and address of the company, the address of the building site, the name and qualifications of the person in charge of the work.
2. The description of work and methods of work showing the company's specific risks and chosen means of prevention, taking into account any environmental constraints. Work involving risks of interference arising from co-activity with other companies, mutual risks and the prevention methods available.
3. Procedures for observing any measures of general coordination defined by the coordinator.
4. Rules for hygiene and for workers' areas as laid out in the general coordination plan .
5. First aid organization of the company; including the medical equipment available, first-aiders and on site, measures for evacuating any injured persons, according to the general coordination plan.

The descriptive part of the plan is the most important; it must be accompanied by a detailed analysis of the risks related to procedures, materials, devices and installations, the use of dangerous substances or preparations, and to circulation on site.

Plans or sketches drawn for the building site can effectively replace text. Photocopies of documents are to be avoided in general , except for private copies.

The plan can evolve and change, so it is always possible to modify any of the given procedures or preventive measures if the incurred risks are decreased or if the preventive measures give an equivalent guarantee.

Texts referring to the labour regulation:

Principle of prevention articles R 230-1 with R 234-23,

General plan of coordination R 238-20 to R 238-36.

texts for the prevention and the safety of the workers:

N° circular 6 DRT of April 18th, 2002 of the ministry for employment and solidarity,

Law N° 91-1414 of December 31st, 1991 published with the OJ N°5 of January 7th, 1992,

European directive 89/391/CEE of June 12th, 1989,

Decree 2001-1016 of November 5th, 2001 relating to the single document published in the 258 Olympics of the 11/7/01 page 17523.

Chapter III – The new context

Introduction

According to the report of the Supreme Chamber of Control prepared in early 2010, the renovation requirements of Polish hospitals are enormous. Hospital managers have five years to adapt infrastructure to EU requirements, which requires a total of PLN 14 billion. A small proportion of this money can be obtained from EU funds; the rest must be paid by local self-governments, which manage most hospitals.
In Poland, there are more than a hundred hospital buildings constructed in the 19th century. According to global standards, a hospital building requires a major overhaul every 30 to 40 years to ensure the safety of employees and patients. Fast technological progress in medicine is yet another issue; if a facility wants to use state-of-the-art equipment, it must adapt its rooms, including those in which radiating equipment (such as X-ray devices) is used.

Care for the natural environment

Technological progress includes the introduction and use of new materials. It is necessary to make sure that materials used for plastering do not pose a threat to human health. Another very significant issue is the use of recycled materials. The quality of work is also of key significance for the performance of plaster and lining layers discussed in chapter IV of this textbook – high quality plastering and lining work reduces the threats associated with the use of X-ray equipment.

Chapter IV – A description of new solutions

Introduction

Plaster is a hardened layer of mortar (plaster mix), covering or shaping a surface – mainly of walls and ceilings – in construction facilities [2]. Accordingly to the definition provided in PN-EN 13914-1:2009, plaster (masonry mortar) is a mix of at least one type of inorganic binding material, aggregate, water, as well as required additives and/or admixtures. Plasters are applied to improve the appearance of the surface of constructed facilities and to protect them against the harmful impact of various factors, such as weather, and in the case of X-ray labs – to protect those staying in the facilities against harmful radiation. A similar role is played by anti-radiation shields, discussed in the final part of this chapter.

Building components such as the external walls, internal walls and ceilings, apart from their structural properties, play several roles ensuring [2]:

- thermal insulation,
- heat retention and accumulation,
- acoustic insulation,
- steam tightness,
- wind tightness,
- appropriate appearance,
- potential compliance with special requirements, such as insulation properties, ensuring protection against radiation, like in X-ray labs.

According to PN-EN 998-1:2004, depending on the designation, the following types of plaster mortars and their mixes can be distinguished:

- general purpose plasters (marked with symbol GP),
- colored plasters (eR),
- special plasters, which can have the following features: lightweight (LW), single-layer (OC), renovation (R) or thermal insulation (T).

Depending on their location, plasters are divided into [2]:

- internal – constituting the finishing of internal surfaces of walls and ceilings,
- external – applied to the exterior surface of building walls.

Depending on the type of mortar used, plasters can be made of [2]:

- lime – at present only used for interiors,
- cement and lime – used for both interior and exterior parts of buildings,
- cement – used whenever high resistance of plaster is required, e.g. as the underlayer of a water tight insulation,
- gypsum and lime – only used in interiors; cannot be used in rooms exposed to dampness;
- gypsum – widely used as interior plaster, unsuitable for high humidity rooms;
- cement and clay – used, like cement plasters, for insulation of basement walls and in rooms exposed to humidity;
- stucco – apart from binding material and sand, containing pigments, dust and aggregate made of colourful stones;
- special – made of mortars meeting special requirements, such as barite plasters ensuring protection against radiation, heat protection plaster, etc.;
- various factory-made mixes.

Depending on the number of layers necessary to obtain the required plaster coating, plasters can be:

- single layer,
- double layer,
- triple layer.

Each plaster layer has a name. In double and triple layer plasters those layers are as follows:

- the first layer is the rendering material,
- the second layer is the floating coat,
- the third layer is the finishing coat.

Plastering tools and equipment

In their work, plasterers use various bricking and specialist tools, designed exclusively for plastering. The basic tool is the trowel (fig. 4.1a). Liquid mortar can be applied with a plastering bucket (fig. 4.1b). To apply mortar to ceilings and to mend plaster, a plastering board with a handle is used as well as a trowel, although increasingly less often. It is necessary to press the board lightly against the ceiling and move along the surface when applying mortar [2]. To prepare the base for plastering, that is, to remove any excess mortar from the wall, a brick hammer is used, as well as to fix rattan mats to the base and to drive nails necessary to determine the plaster layer surface.

a) b)

Fig. 4.1. Tools for manual application of mortars: a) trowel, b) plastering bucket [15].

Another useful tool is the long float (fig. 4.2), which is a smooth dressed board, usually of dimensions of 20x75 cm, with a handle. At present, long floats are usually made of Styrofoam (foam PVC), and gypsum plaster is applied using aluminium boards. Long floats are used for levelling (so-called trowelling) of the plaster layer. To this end, the long float is applied to the wall along its longer edge and moved up along a zigzag line, pressing lightly. A float is similar to a long float, but much smaller: it is about 24 cm long and 12 cm wide. It may be made of a smooth soft wooden board or of foam PVC. Wooden, Styrofoam and PVC floats are used for either rough or smooth trowelling. To achieve a very smooth category IVf plaster, floats of surface lined with felt should be used - this is why it is called felt plaster.

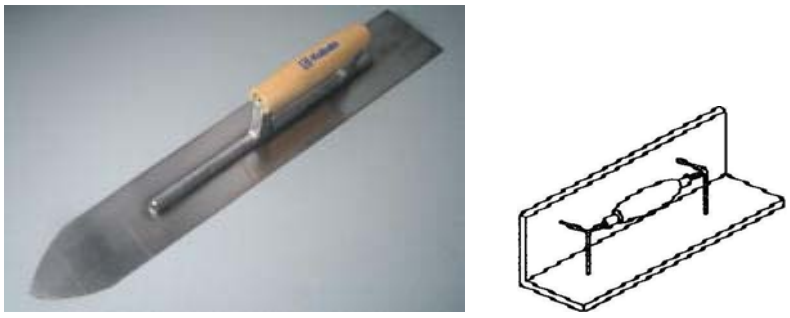
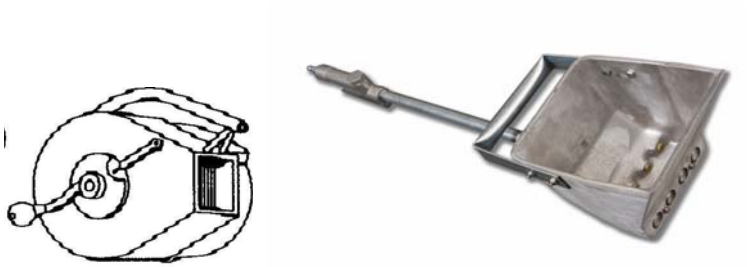


Fig. 4.4. Steel floats: flat and angular [5, 13].

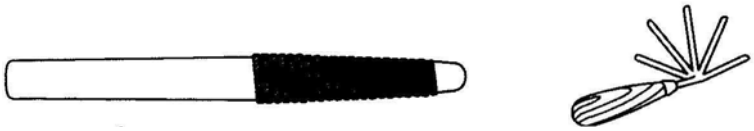
For wall pointing, a set of jointing trowels, know as jointers, are used. Depending on the cross-section of the tool, the joint filling shape varies. During jointing, the worker also uses a plastering board with a handle, with a portion of mortar ready to be put into the joint. Decorative mottled plaster is applied using a birch broom. It is dipped in mortar, and then, as a result of hitting a piece of the floating rule, droplets of mortar are dropped on the surface. Plaster of this type can be applied also using a special manual device (fig. 4.3), which drops mortar using a set of elastic wires, installed on a shaft turned by the worker with a crank [2].



a) b)

Fig. 4.3. A manual device for a) applying mottled plaster, b) for stucco plaster [13].

Workers who apply pargeting use various tools which leave a characteristic trace on the surface. The most popular ones include a cleaner, which leaves a trace of a roughly rectangular cavity, and the crow's feet (fig. 4.4).



a) b)

Fig. 4.4. Pargeting tools: a) cleaner, b) crow's feet

During floating, the plaster surface must often be additionally moistened with water. Rectangular brushes are used for this purpose (fig. 4.5a). To wash out mortar from among aggregate grains, round brushes are used (fig. 4.5b).

a) b)

Fig. 4.5. Brushes used for plastering: a) rectangular b) round [10].

A plasterer also uses measuring equipment:

- a level, which is used to verify the vertical and horizontal level of the plaster surface,
- a hosewater to verify the horizontal level along longer sections
- a plumb bob to determine the plaster surface area.

To check smoothness of the plaster surface, a derby float is used, usually 2 m long with a cross-section of 2 x 6 or 3 x 10 cm. At present, inspections of this kind are increasingly performed using special 2 m long floats and levels – usually made of duralumin. They are used to check the smoothness and vertical level of the surface at the same time. Mortar in the plasterer's working area is stored in boxes and water is stored in buckets.

Plastering work is very time-consuming and requires considerable effort. Traditionally, plastering represents 15 - 30% of the entire cost of construction work. The cost of plastering amounts, on the average, to 7% of the entire building cost [2]. It is therefore unsurprising, that mechanical equipment is used wherever possible. The plastering process consists of the following operations:

- preparation of mortar including:
    - loading mortar components into the mixing device,
    - mixing mortar components,
    - sifting of mortar,
- transport of components or semi-finished products:
    - horizontal,
    - vertical,
- applyicatiob of subsequent layers of plaster, including:
    - coating,
    - levelling of the layer applied,
    - floating.

The basic tools for mechanization of plastering works are plastering units. A plastering unit used for production of mortar on site and its transport and application is usually a complicated machine, consisting of the following components [2]:

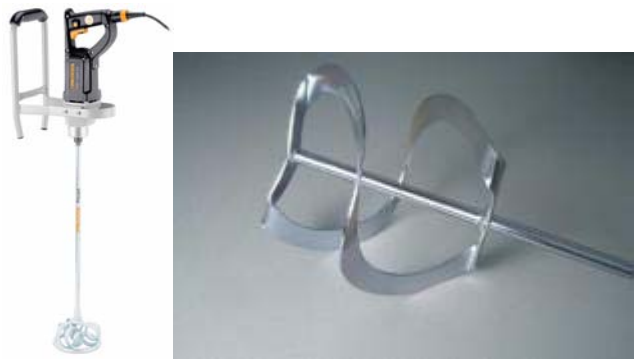
- mixer – usually a drum mixer, allowing mixing of mortar components;
- screen – usually a vibrating screen to separate grains which are too large, to prevent them from getting into the pump or the flexible conduit for transport of mortar, which could cause a failure of the entire system;
- pump and flexible dust - for vertical and horizontal transportation of mortar;
- remote control and signalling system – allowing the operator of the spraying device to turn off the pump and to indicate the need to turn the pump back on;
- spraying device (spray gun)
- optionally - an additional air compressor – that is, a device allowing for break-up of the mortar stream and its application to the plastered surface.

Selecting the plastering unit for a given type of project, it is necessary to take into account the following [2]:

- the type of mortar to be used with the unit;
- the pump type;
- maximum working pressure;
- maximum vertical and horizontal range of the unit;
- useful capacity of the mixer;
- capacity of the mortar container;
- compressed air pressure;
- power supply type;
- diameter of the hose used;
- unit mass.

For plasters consisting of factory-prepared mixes transported to the construction site ready for application or as components that only require mixing prior to use, the following devices are used [2]:

- manual mixers with electric power supply (fig. 4.6) equipped with replaceable mixer arms in various shapes, which make it possible to homogenize different mortars directly in the transport container,
- general means of transport – for transport of factory-prepared packages of mortar,
- Plastering units.



a) b)

Fig. 4.6. a) A manual mixer with electric power supply, b) mixing device [http://www.kneblewski.com.pl].

An example of a modern plastering unit used for mechanical application of gypsum, lime and gypsum and lime and cement plasters, prepared using ready dry plaster mixes, is the AT WG·2 presented in figure 4.7 [2]. It can be used alongside a pneumatic supply device for the transport of dry mortar from silos to plastering machines. After replacement of the screw pump and the pressure conduit, unit AT WO-2 can also be used for self-levelling mortar.

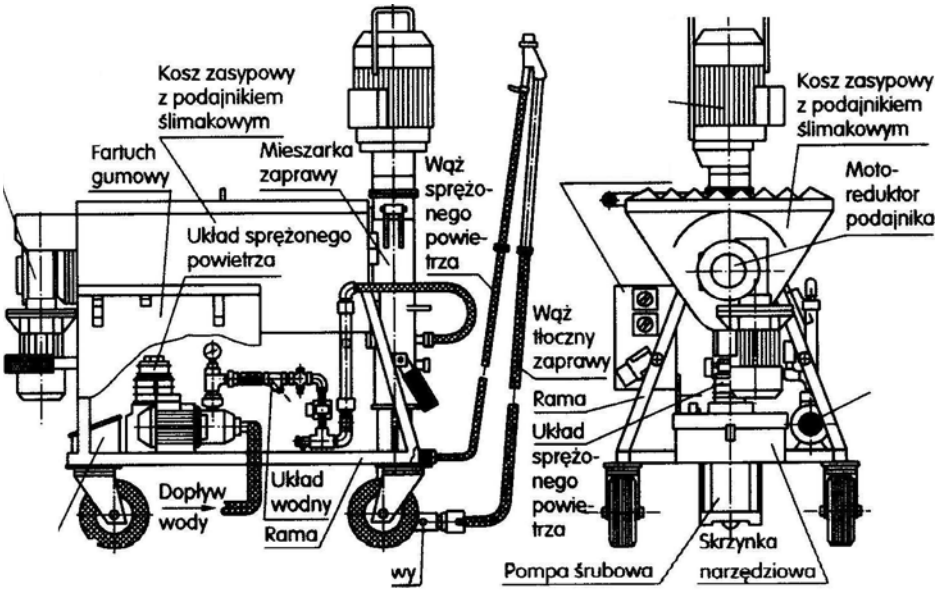


Fig. 4.7. Plastering unit AT WG-2 with a sprayer [2].

Fig. 4.8. Plastering units [pictures from Web page www.budmar-mb.pl].

Unit AT WG-2 consists of the following components [2]:

- frame,
- water supply system,
- compressed air supply system,
- charging hopper with a feeding screw,
- mixer with a screw pump,
- gear-motor of the mixer and the screw pump,
- gear-motor of the feeder,
- electric control box.

Screw pumps [2] belong to the group of rotary positive displacement pumps. In all positive displacement pumps, flow of material is enforced by the rotor, which spins inside the fixed part of the device (the stator), constituting the external part of the pump. The screw pump rotor is in the shape of a screwed bar, which looks like a spring stretched to the maximum and made of stainless or hardened steel, while the stator is a fixed component made of a flexible elastomer (e.g. rubber). Both components are shaped so that between their surfaces inside the pump, there is a set of watertight cavities. During the pump operation the rotor rotates eccentrically inside the stator, and the cavities move along the spiral along the pump axis, transporting the material that fills them, in this case the plastering mix.

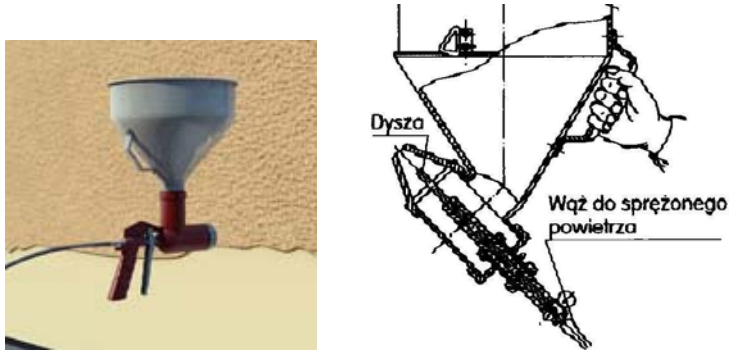
A dry plastering mix is put in the charging hopper of the unit, from which the feeding screw with a gear-motor transports it to the mixer chamber. At the same time, water from the water conduit, connected to the water supply system, is delivered to the chamber. The mixer is connected to the screw pump and driven by the gear-motor. The mixed mortar flows from the mixer to the screw pump and it is supplied by a flexible conduit to the spray gun. The mortar stream is adjusted with compressed air, supplied to the spray gun from the compressed air system through a flexible hose. The unit can be turned on and off using the air valve in the spray gun. The unit capacity can be regulated to an extent by selecting the appropriate screw pump.

During operation of the unit AT WG-2, the following rules of occupational health and safety apply:

- assembly and disassembly of the unit components should be conducted by at least 2 persons; it is necessary to maintain special caution;
- the employee operating the unit must have protective goggles, and if the working time is to be longer than 4 hours per day, it is also necessary to use hearing protectors;
- switching on the unit without the screen screwed to the charging hopper is prohibited;
- particular care is necessary during closing and connecting of the gear-motor to the mixer or liquidation of the so-called mortar plug in the hose; performing these activities without protective goggles is prohibited;
- after each activation of the safety valve, it should be rinsed thoroughly;
- no defects can be eliminated during operation of the unit;
- during any repairs, the main switch must be in the “0” position, and the main power supply conductor must be disconnected from the plug at the control box;
- only employees with power supply qualifications can repair the power supply system;
- as the unit is being connected and turned on, the conductors and electrical equipment must be dry.

From the unit, mortar is transported by flexible pressure conduits, e.g. made of sackcloth and rubber of 51, 38 or 25 mm diameter, which may operate under pressure up to 5.1 MPa. Pressure conduits are supplied in sections of length of 8 - 10 m and 26 - 28 m. [2]

For the application of mortar, spray nozzles are used (fig. 4.9) to ensure the appropriate shape and speed of the mortar spray so that the mortar particles dropped on the surface connect well to the surface and to each other, creating a strong layer of plaster.



a) b)

Fig. 4.9. Units for mechanical application of the setting coat: a) on the walls, [http://www.pneumatig.eu], b) on the ceilings [2].

Levelling of layers of any kind of mortar applied to the wall or ceiling is performed manually using boards or long floats.

Floating of traditional and gypsum mortars is carried out using floats of various kinds and kinematic parameters of the floating disks. Floats for traditional plasters usually consist of the drive installed in a metal casing, a flexible shaft and a floating head. The electric engine power feed is transmitted by the coupling and the flexible shaft to the floating head, equipped with a worm gear. The worm drives the wormwheel, which in turn causes movement of the floating disk.

Floating of plaster with a float is a result of rotating movement of the floating disk, as well as circular or reciprocal movement of the plasterer's hand, holding the head.

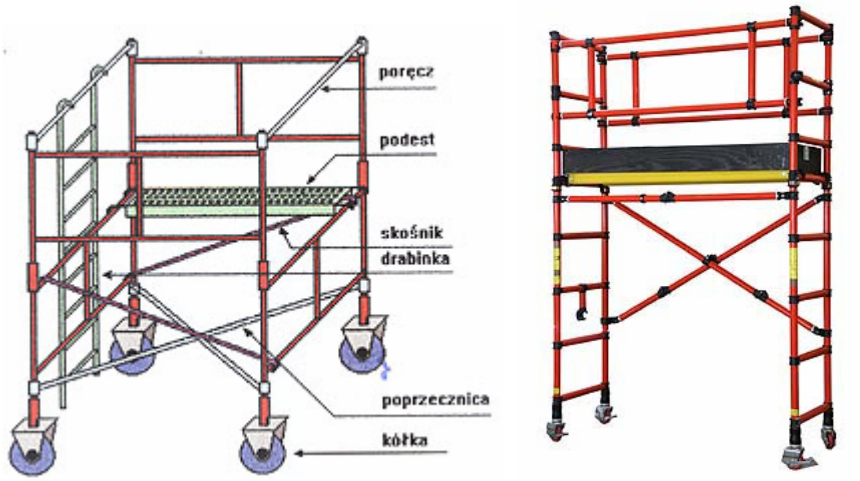
Depending on the plaster texture to be achieved, the floating disks are made of flaxboard or Styrofoam. The float allows processing of up to 30 m^2 of plaster per hour. The weight of the head with the disk is 1.3 kg. Floating of plaster with a mechanical float is possible after binding but prior to hardening of mortar.

Scaffolding is an auxiliary device used during the performance of construction works. Scaffolding is classified into the following categories, depending on the intended use [2]:

- assembly scaffolding, which hold the structure components in the designated position until they are connected to form a permanent building structure,
- shoring, which supports boarding to shape brick or concrete components,
- working scaffolding that supports working platforms necessary to perform construction works (including bricking and plastering works) at a height of 1.2 m or more from ground, excavation bottom or floor level etc.

At present, metal scaffolding is usually used, made of either steel or aluminium alloys. The structure of metal scaffolding is based on traditional wooden scaffolding. It consists of tubes and profiles made of metal, equipped with various attachments and joints, which, ensuring the appropriate rigidity of connections, are simple to assemble and disassemble. In Polish and European standards, scaffolding is divided into classes (PN-EN 12811-1:2007), groups or nominal sizes (PN-M-47900:1996) [2].

Movable scaffolding (rolled, mobile) is used whenever it is necessary to perform short-term works at height (fig. 4.10). Mobile scaffolding is at present manufactured almost exclusively using the structural components of other, mass-produced types of scaffoldings, adding the specific components of such structures (e.g. wheels) [2].



a) b)

Fig. 4.10. A rolled scaffolding [a) www.rusztowania.bialystok.pl, b) www.nopex.com.pl]

Working on scaffolding is dangerous. The most significant threats include: falling from height, dropping of objects, electrical shock; therefore when working on scaffolding, it is necessary to follow occupational health and safety rules. Scaffolding should [2]:

- be characterized by the appropriate structure and have the working platform of the area sufficient to hold the people working on it, storage of the necessary tools and materials
- have the structure adapted to the expected workloads, ensure safe vertical movement and access to all work areas, enable performance of work in a position which does not require excessive effort.

Assembly and disassembly of scaffolding should not be performed [2]:

- after dusk (without appropriate artificial lighting)
- in fog, during rain, snow and glazed frost,
- during a rainstorm and if windspeed exceeds 10m/sec.,
- next to overhead power lines, e.g. less than:
  - -2 m from a low voltage line
  - 5 m from a high voltage line up to 15 kV,
  - 10 m from a high voltage line up to 30 kV,
  - 15 m from a high voltage line up to 30 kV.

Use of scaffolding can only be started after the full completion of assembly and checking. The scaffolding must be secured to prevent access to work platforms by unauthorized persons.

The weight of materials necessary to perform the work, should be 80 kg less than the acceptable working load when loaded on the platform.. The value of this load should be shown on the scaffolding platform. Working platforms cannot be loaded with machines or equipment which cause vibrations during operation.

Loading and work on two or more platforms at various scaffolding levels along a single vertical line is prohibited.

Working platforms and duck boards should be regularly and systematically cleaned to remove building material waste. During the winter, platforms and duck boards must also be cleaned to remove ice and snow (immediately after snowfall stops) and covered with materials that increase friction (sand, slag of grain size up to 4 mm, etc.).

During use, scaffolding should be subjected to the following inspections:

- daily – by the foreman using the boarding
- every 10 days – by the scaffolding maintenance employee or an engineering and technical worker appointed by the construction manager,
- as necessary (e.g. after strong winds, rainstorms, long-term rainfalls etc. prior to re-commissioning for the purpose of performance of works on the scaffolding) – by a commission including the supervision inspector, the building master and the foreman using the scaffolding.

General requirements for the plaster base

Durability and quality of plaster depends largely upon the proper and careful preparation of the base. Every base prepared properly for plastering should [2]:

- ensure good adhesion,
- be sufficiently rigid, durable, and its dimensions should remain unchanged over time,
- be even to avoid the need to apply a thick layer of plaster locally.

Adhesion of plaster to the base is associated mainly with mechanical interpenetration of the plaster mortar and roughness on the surface of the base. This is clearly visible in plastering of base made of mesh and core perforated chipboard. For the same reason, bricks to be plastered are constructed with empty joints. Another adhesion factor is the chemical compounds that are created on the edge of the base and mortar, as well as the absorption of grout from the freshly applied mortar by a moisture containing base. Excessive moisture content in the walls, particularly made of concrete, may result in the mortar falling off during application of plaster, and then the scaling, or emergence of surfaces, in which plaster is not bound to the base. Such places are usually scratched, and generate a hollow noise when sounded with a hand or a hammer. Another reason for lack of adhesion may be the difference between the expansion coefficient of the base and plaster.

Durability and rigidity of the base is mainly due to its structure. These properties must be analyzed prior to application of plaster, and wherever the base is subject to strain, it is better to apply a different method of finishing of the surface.

Evenness of the surface of the component serving as the plaster base greatly influences its quality. It cannot be expected that errors made by preceding teams, such as bricklayers, can be covered with plaster without any consequences. Unevenness of the base usually results in a lowering of plaster quality, or a significant increase in the workload associated with its application due to the need to level the surface [2].

During proper preparation of a plaster base, it is necessary to perform numerous minor tasks that affect the quality of plaster, as well as the course of plastering. These include: driving in pins for fixing of installation equipment, covering with a steel mesh, or bricking up wall chases etc. If any of these tasks is not performed, this may lead to repairs being required afterwards, which are always visible on the plaster surface.

A base consisting of new bricks is widely used. It can be plastered no earlier than 2 months after the wall is built. This time is necessary for stabilization of the wall and to allow for any contraction. Moreover, plastering a wall which is still moist lengthens the process of drying, which negatively influences subsequent finishing works in the building. Plastering a fresh wall may also result in the emergence of efflorescence caused by the dissolution of various salts contained in the bricks. A bricked wall which is to be plastered should be made with empty joints. If this has not been done, it is recommended that prior to plastering, mortar is partially removed from the joints (to the depth of 10-15 mm from the wall face). Prior to commencing plastering bricked ceilings, remove any mortar sticking out of joints and cover beam flanges with mesh.

Immediately prior to plastering, the wall should be thoroughly cleaned with brushes. Dust should be washed with water and potential efflorescence should be removed with a wire brush. Grease and soot should be removed with particular care, since even small amounts may result in brown stains on the plaster surface and a reduction in adhesion to the base. Grease stains can be washed with a solution of grey soap or water with detergent. Excessively dry wall surfaces should be moistened with water to avoid moisture being drawn out from the mortar by dry brick. If the mortar becomes too dry as a result of this phenomenon, the binding material (cement, lime) has nothing to bind to and the plaster fails to attain the required durability. Moistening is significant particularly during hot weather and warm winds.

The surface of walls made of re-used bricks from demolition sites should be cleaned particularly carefully, paying attention to grease and soot stains. If bricks had previously been used to construct smoke flues, they should be removed and replaced with new, clean bricks. No subsequent treatment aimed at removal of soot from such bricks can guarantee that there will be no brown stains on plaster.

Plasters on a base of stone are usually used in interiors, since the external elevations of such walls are usually pointed. Preparation of a natural stone wall as a base is performed in the same way as a brick wall. As such, it is necessary to remove mortar from joints to a depth of 5 - 15 mm from the wall face and to remove dust and wash the walls with water. The scratch coat on the stone wall base should consist of a thin cement mortar, and if porous stone was used for construction, it should be very thin and made with clearances (e.g. places with no mortar applied). In this way, it is possible to prevent the creation of a tight layer of cement mortar, which will hinder „breathing of the wall" or penetration of steam from the interior to outside.

A base made of monolithic ordinary concrete or light aggregate concrete should be even but rough. Therefore, the surface of concrete components made in boarding of whittled wood, plywood or metal, characterized by substantial smoothness, should be notched with hand or pneumatic chisels and then thoroughly cleaned of dust.

The old concrete base should be notched, even in boarding made of non-whittled wood.

The surface of prefabricated concrete components to be plastered should be clean, free from dust, grease or any mould lubricating agents. A surface with such residues should be cleaned by sand blasting or washed with water and detergent. It is also possible to increase the adhesion of plaster, using contact agents. On the surfaces designated for plastering, there can be small defects, but scaling of fragments of the prefab component surface is unacceptable.

A base consisting of ordinary concrete monoliths or light aggregate concrete can be plastered no sooner than 8 weeks after construction (in the summer), provided that the moisture content in the base does not exceed 3%. Immediately prior to plastering, concrete should be moistened thoroughly with water or a grounding agent.

A base made of cellular concrete blocks and slabs should be cleaned prior to plastering by removing mortar particles, as well as grease stains. Removing mortar from joints to the depth of 2 - 3 mm from the wall face is also recommended. A base prepared in this way should be dry cleaned of dust using a brush.

Larger defects in the wall should be mended at least 3 days before plastering, cutting out the defective surface to create openings in form of regular polyhedrons. Afterwards, appropriately cut pieces of cellular concrete of the same kind as the wall are fitted into these openings using thin cement mortar.

During the summer or where there is excessive drying of the base, it should be moistened with water.

A gypsum or gypsum and concrete base for plaster other than gypsum or gypsum and lime should be characterized by moisture content not exceeding 6% (determined by weight). The surface of the base should be scratched with a sharp object (e.g. a nail) in a diagonal net of mesh size of about 5 mm. If there are any metal parts that adhere directly to gypsum, these should be secured with anti-corrosive agent (e.g. asphalt varnish).

Immediately before plastering, the base should be cleaned and dried by the removal of dust with a soft brush and then slightly moistened with water.

A wooden base consist of wooden boards up to 12 cm wide. If wider boards have been used in the component to be plastered, they should be notched in 1 or 2 places. It is necessary to provide a metal mesh or plaster lathes under the wooden base.

The metal mesh should be expanded or braided, made of l mm thick wires. The mesh should be fixed to steel bars of 3 or 4 mm diameter or to wooden components. At the points of contact, it is necessary to make overlaps of 3-5 cm width and connect them with 1 mm thick soft binding wire. The mesh should be cleaned of rust, and after fixing, rendered lightly with cement mortar. If gypsum and lime plaster is to be applied to a wooden component, it is necessary to use zinc-coated or asphalt varnish coated or stainless steel mesh, bars and nails [13].

In traditional solutions, which are still encountered during renovation of old buildings, plaster lathes were used on wooden walls [2]. Plaster lathes are wooden strips fixed in 2 layers to wooden walls. Prior to fixing, they should be sorted. Thin and slanting strips can only be used for the first layers, while it is necessary to use straight and wider lathes in the second (top) layer. Lathes should have be at least 2 cm wide but no more than 5 cm. Theyr should be 3 cm thick, so that after fixing the second layer, mortar can easily get behind the strips.

Lathes are fixed to create a slanting grate, so that the strips of one layer are perpendicular to the strips of the other layer, and at a 45° angle to the wall or ceiling boards. The distance between lathes should be 5 cm on walls and 3 cm on ceilings.

The first layer is nailed rather sparsely. In the second layer, nails are fixed in a checkerboard pattern so that the top strips are fixed to the base through every other strip of the bottom layer.

Sometimes the plaster base consists of insulation slabs. The mode of preparation of such a base depends on the properties of these slabs.

Wood wool slabs and soft panel boards have characteristically good adhesion properties. In order to avoid plaster cracking in points of contact between slabs, it is necessary to provide 10 cm wide metal mesh strips. The mesh, which should be free from scaling rust, is to be fixed every 10 cm. Directly prior to plastering, the base should be cleaned and moistened with water.

Other insulation slabs usually cannot be plastered directly, since they are not moisture-resistant or cannot guarantee mortar adhesion. Firstly, such slabs should be covered with a layer of tar board to which a metal mesh is fixed, like in the case of wooden base.

If plaster is to be applied to division walls made of insulation slabs, it should be kept in mind that both surfaces of the slab need to be plastered simultaneously.

Metal components (sheets and profiles) that serve as a plastering base should be entirely wrapped in steel or steel-ceramic mesh, tied or fixed permanently in any other way to the structure. The mesh should be free from scaling rust, and if it is to be used as a base for cement and clay or cement plaster, it is necessary to sand it twice with cement grout. The metal base of gypsum and lime plaster should be secured against corrosion, for instance, by coating it with asphalt varnish.

Sometimes, only the metal mesh is used as the base. The mesh base is used on the ceilings under the beam and slab floors not filled with hollow bricks or on ceilings containing installation conduits, as well as on surfaces of diversified shapes, made due to architectural and interior design considerations. In such situations, a uniform (expanded) metal mesh is used.

Sometimes, usually during renovation works, it may be that the base for new plaster consists of old plaster. Preparing such a base makes it necessary to remove any defects and paint found on the old plaster. Places characterized by scaling or defects should be removed entirely and filled with new mortar. Cracks should be widened with spatulas, moistened and filled with mortar. Smooth or hard base should be hacked with a hammer or scratched with a scratcher made of a wooden board with long protruding nails. Before the application of new plaster, the repaired and cleaned base should be washed and moistened thoroughly, and a rendering coat of thin cement mortar of proportion 1:1 should be provided. If the new mortar contains gypsum, there is no need to apply a rendering coat, and plaster should be applied to the moistened base.

Applying new cement, cement and gypsum or gypsum plaster on an old base of gypsum plaster makes it necessary to cover its entire surface – after the initial tasks described above – with a thin layer of a cement rendering coat. In this way, a tight coating is established which protects the new plaster layer against the absorption of water by the gypsum base.

Conditions required for plastering works to commence

Plastering works can be commenced after completion of the following works [2]:

- shell state works,
- flush-mounted installation works,
- bricking up of punctures and wall chases
- works associated with installation of window and door frames and incorporated furniture components.

Plastering cannot be performed immediately after construction of the wall, but only after the time required for the mortar to completely set and contract, that is, after 4 to 6 months.

The minimum temperature for plastering is + 5 °C. However, it is necessary to make sure that after applying the plaster, the temperature will not drop below 0 °C in the next 24 hours. If it is colder than +5 °C, it is necessary to use appropriate means of protection.

Fresh outdoor plaster should be protected for the first 2 days against sun exposure for more than 2 hours a day. If the temperature exceeds +20 Celsius degrees, fresh cement, cement and lime and lime plaster should be moistened with water during the binding and hardening period, which usually lasts about one week.

Determining of the plaster surface area

The process of applying ordinary plaster can consist of the following operations [2]:

- determining the plaster surface area (the so-called face), if provided in the requirements concerning the plaster category,
- applying a plaster coat to the base,
- levelling of the coat surface,
- floating of the surface of the levelled plaster coat.

Plasters belonging to category III and IV should have a face surface finished very precisely. This will not be possible, if, prior to commencement of plastering, this surface – which at this stage does not exist – is not defined. In order to define the plaster coating surface on flat surface walls, it is necessary to do the following [2]:

1) Near the upper corner of the wall to be plastered (25 - 30 cm from the ceiling) drive in a nail so that its head protrudes to the level corresponding to the expected thickness of the plaster layer, that is, about 1.5-2cm;
2) Use a water hose to transmit the nail level to the remaining 3 corners of the room and fix similar nails to both walls creating the corner;
3) Along the corner nails of individual walls, stretch a rope, establishing the so-called horizon line, and drive nails along the rope at intervals of about 1.0 - 1.2 m – depending on the length of the long float used to apply plaster;

4) From the heads of nails driven along the rope (horizon line), lower the plumb bob and at a distance of 20-30 cm above the floor along each vertical line, drive a nail in; stop driving when the head touches the plumb bob rope;
5) Between the heads of the upper and the lower nails, stretch a rope vertically and drive nails along the rope in the intervals of about 1.5 m, making sure that the heads are located within the same plane.

It is also possible to drive nails first along the line of plumb bobs suspended at the corners and then stretch the rope along the subsequent levels and drive nails in horizontal rows.

Determining the plaster surface area on the ceiling can be done in two ways. The first way requires use of a large angle known as the square, of arm length of 1.5 or 2 m. To determine the ceiling area, it is necessary to [2]:

1) Place the square near the upper corner of the wall, so that it leans with one arm against 2 nails situated on top of the vertical row of nails determining the plaster surface area on the wall (fig. 4.11);

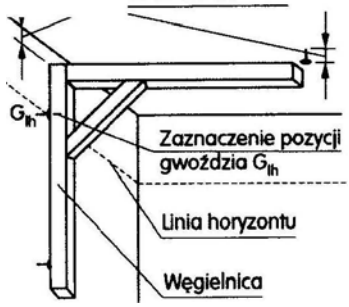


Fig. 4.11. Establishing of the plaster coat face on the ceiling using an angle gauge [2].

2) Bring the second square arm closer to the ceiling, to a distance equal to the planned thickness of plaster (rendering coat + floating coat, total of 1.5-2.0 cm) and at the end of this arm drive a nail so that the length of its protruding part is equal to the total thickness of the rendering coat and the floating coat;
3) On the vertical arm of the angle applied to nails on the wall, mark the position of the horizon line nail (in fig. 4.11 marked as G_{lh});
4) Go to the second corner of the same wall and apply to it an angle as described in clause 1, making sure that point G_{lh} marked previously on the vertical arm of the angle is located at the level of the horizon line nail, and then at the end of the horizontal arm of this angle, positioned in such way, drive a nail into the ceiling determining the plaster surface – as described in section 2;
5) Repeat the activities described in section 4 for both corners of the opposite wall;
6) Between the nails driven into the ceiling at the corners, stretch a rope parallel to the wall and drive nails along this rope at intervals of about 1.5 m, levelling the nail heads with the rope line;
7) At the opposite wall, repeat the activities described in the previous section;

8) Stretch the rope between the subsequent pairs of nails on the opposite walls and drive nails along the rope at intervals of about 1.5 m, levelling their heads with the rope line.

3.

Proceeding in this way, it is possible to determine the ceiling plaster surface area. It is necessary to keep in mind that during marking, the rope should be always stretched tight. Otherwise, if the rope is hanging loosely, the ceiling surface will be protuberant.

Another way of marking the ceiling coat [2]:

1) Mark the ceiling axis along the longer wall of the room;
2) In the middle of the room, drive a nail so that the length of its protruding part is equal to the total thickness of the rendering coat and the floating coat;
3) Using a strip positioned above the level, drive nails along the ceiling axis, making sure that their heads are within the same horizontal plane (intervals between nails are to be about 1.5 m);
4) Determine rows of nails perpendicular to the ceiling in the same way (fig. 4.12).

In this way, it is possible to cover the entire ceiling with rows of nails that define the future plaster surface.

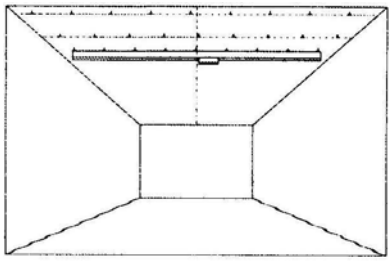


Fig. 4.12. Establishing of the plaster coat face on the ceiling using a staff [2]

The next operation – both during plastering of ceilings and walls – is to prepare mortar pats around the nails [2]. It is recommended that this is done with the same kind of mortar that is used to apply the floating coat. It is also possible to use gypsum mortar; in this case, the nails should be made of stainless steel. The surface of these pats is to be smoothed and levelled with the nail heads. Sometimes, instead of mortar pats, wooden blocks fixed adjacent to nails with thick mortar are used. Mortar pats and wooden blocks can be replaced with special clout nails.

The next operation consists of applying strips of mortar to the lines marked on the walls (vertically) and ceilings (horizontally) using pats, blocks or clout nails [2]. The surface of screeds, established in this way, is to be levelled with the surface of pats, blocks or clout nails with a float.

Instead of the operation, described above, wooden or metal screeds are used [2], fixed

along the ropes stretched between nails. This makes the task easier and less labour-intensive. Screeds can be mounted in two ways: either so that their lower surface marks the plaster surface, or so that their distance from the base is equal to plaster thickness, which means they mark the plaster surface with their upper surface. In the former, if traditional wooden screeds are used, it is necessary to remove the screeds after plastering and fill the remaining grooves with mortar and level them. In the latter, there are no grooves, but it is much more difficult to plane the plaster surface.

Screeds are fixed to the wall at intervals of 1.5 - 2.5 m, checking their position with a plumb, and their alignment with the plaster coat face with a float. The precise vertical positioning of the screed is checked by lowering a plumb bob from its upper end, located at a distance slightly greater than one half of diameter of the plumb weight. If the distance between the rope and the screed in the lower and upper end is the same, the screed is positioned vertically.

Positioning of the screed in the plaster coat plane can be checked by pressing the float against the 3 subsequent screeds. If in each of the positions examined 3 screeds touch the float, they are within the same plane.

Determining the plaster coat on curvilinear surfaces is much more complicated. It requires using guides to mark the surface and moving special templates along these.

The rendering coat is the first layer, applied directly to the base [2]. It ensures the adhesion of the rest of the plaster to the base, therefore it should be bound very strongly. The rendering coat thickness is 4-6 mm. The type of mortar and mode of performance of the rendering coat depends on the base type. On ceramic material, stone, wood wool slabs, the rendering coat should be made of thin cement or cement and lime mortar. The mortar is applied with a trowel or a bucket, throwing it with strong gestures, so that long spatters are created. The rendering coat can be applied after preparation of the screeds or earlier. In the first case, it is necessary to make sure that the screed face surface is not splashed, and if it is splashed – it should be cleaned gently. In the latter case, the surface is not splashed, but it is necessary to hurry up with marking the surface of plaster to make sure that the rendering coat does not bind too quickly. If this happens, the rendering coat must be moistened thoroughly with water to ensure good adhesion of the floating coat [2].

On a wooden base with lathing or a mesh, the rendering coat is thrown with a trowel and pressed with a long float. The first layer of mortar can also be applied to the wall directly from the float. To this end, the float with mortar should be applied to the wall and moved in zigzags bottom to top, pressing it lightly. The thickness of the first layer of plaster, applied in this way, together with mesh, should not exceed 20 mm.

After the rendering coat hardens slightly and it is moistened with water, the second layer is applied – the floating coat. This task is very significant, labour-consuming and requiring substantial skills. The floating coat thickness is 15-20 mm. It can be applied:

- with a trowel from a box,
- with a trowel from a board,
- with a bucket,
- with a float.

Regardless of the method of applying the floating coat, a substantial part of the mortar falls off the base: on the walls – 30-35%, and on the ceilings 40-50%. Mortar, which has fallen off should be picked up and applied again after mixing in the box, making sure that no dirty mortar is used.

Application with a trowel is performed in a way similar to application of the rendering coat. Application with a bucket is much more effective, since the plasterer can apply 4 times more mortar in comparison with the trowel. Buckets cannot be used to apply fast binding mortars (gypsum or gypsum and lime mortars), as they become clogged up quickly.

Application of mortar with a trowel from a board is often used during plastering of ceilings. It consists of the following activities [2]:

- putting mortar from the box on the board,
- putting mortar from the board on the trowel,
- throwing mortar on the surface.

Mortar can be applied to the ceiling in three ways [2]:

- over the head (fig. 4.13a), where subsequent portions accumulate behind the plasterer's back,
- above, where subsequent portions accumulate almost directly above the plasterer's head (fig. 4.13b), and the trowel movement should point slightly outside in relation to the hand, in which the plasterer holds the trowel,
- away, when the trowel movement takes place and mortar is thrown away from the plasterer (fig. 4.13c).

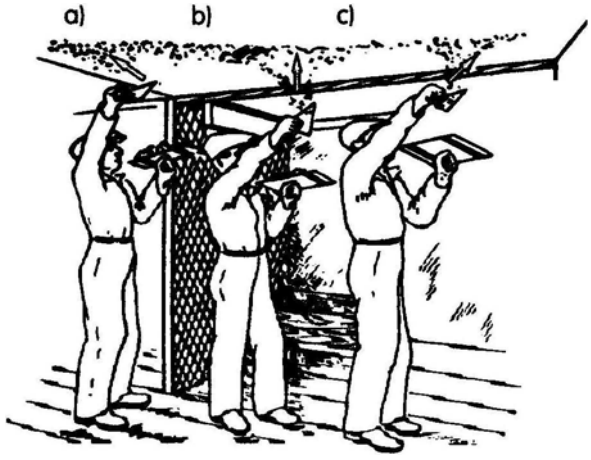


Fig. 4.13. Methods of applying mortar from the board to the ceiling: a) over the head, b) above, c) away [13]

When applying mortar, it is always necessary to avoid splashing it on plasterers working nearby. Application of mortar directly to the walls using a long float or a board takes place as explained in the description of application of the rendering coat. A substantial amount also falls off.

The floating coat layer applied is levelled with a long float or a board, moved bottom to top along a zigzag line (fig. 4.14a) along the screeds. The floating coat on the ceiling is levelled in the same way, but movement is always towards self (fig. 4.14b). Excess mortar, gathered with the board, is thrown into the box and used to mend defects. In concave corners, mortar is levelled with a long float in the shape of a profile with a sharp or oval corner, moving it up and down with two hands (fig. 4.14c).

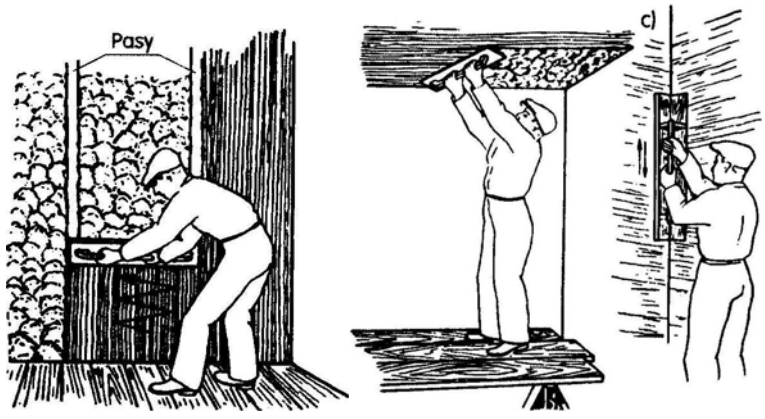


Fig. 4.14. Leveling of plaster surface with a long float: a) on the walls, b) on the ceilings, c) in concave corners [13]

On curvilinear surfaces, mortar is levelled using special templates.

After levelling the floating coat, it is possible to apply the finishing coat [2]. This layer should be applied after binding of the floating coat, but before it hardens. The finishing coat is made of thin mortar made of sifted sand, more greasy than the rendering coat and the floating coat,. In order for the finishing coat to bind well with the floating coat, it should be moistened thoroughly prior to application of the finishing coat. The finishing coat is applied with a trowel to establish a layer 1-3 mm thick, it is levelled with a long float and – after initial hardening – finished with a float.

Depending on the required plaster smoothness parameters, the applied finishing coat layer is finished with a wooden, metal, plastic or felt-coated float. The plasterer finishes the coat with spiral movements of the float, holding a brush submerged in water in his other hand (fig. 4.15), to moisten the surface, whenever he notices that the mortar is too dry or that it is chipping or falling off. A finishing coat which has not been bound sufficiently or is too wet cannot be finished because it daubs under the float. Such places need initial drying.

Fig. 4.15. Application of the finishing coat [13].

As is known from previous chapters, the moisture content of the base at the time of plaster application is very important relative to the subsequent durability of the plaster and the quality the work. Therefore the proper consistency of mortar is of great importance. Consistency of cement or cement and lime mortar used as the rendering coat should be 10 - 12 cm of submersion of the measuring cone, and if the mortar is to be used as the floating coat, this value should be 6 - 9 cm. The consistency of each new portion of the mortar should be assessed by the plasterer after thorough mixing using the measuring cone, or assessed by observation of its behaviour during the trial application. Plastering may require mortar that is thinner than that delivered to the site. In such cases, it is necessary to add water to the mortar container and mix the mortar with a trowel. At each plastering position, there should be a water container (usually a metal bucket) and a mug to scoop water.

A skilled plasterer is able to determine the proper consistency of mortar depending on absorbability of the base. Those who are less experienced and who do not have a measuring cone may apply the trial of scooping a portion of mortar from the box, throwing it on the wall and observing the effect. If the mortar sticks to the trowel, it is too greasy, if it falls off the base it is too dry, and if it flows off it is too thin.

Special plasters

Plasters may perform additional special functions, such as protecting construction components against moisture (watertight plasters), heat penetration (heat preserving plasters) or radiation.

Watertight plasters are created by using additives and with the proper compacting of plaster. Watertight plaster is obtained by producing cement mortar 1:4. A greater amount of cement will result in cracking, and water evaporating from such mortar leaves pores, which reduce its tightness. Therefore, watertight plasters are made using mortars mixed with as little water as possible.

To enhance water tightness and plasticity of mortars, fatty acids and their salts are used: these are available as preparations with various trade names (including Hydrobet, Plastibet). They are added to mortar used to make plaster. The amount of additive needed in relation to water, cement or ready mortar is usually specified on the packaging. Watertight plasters are usually applied in a single layer with a trowel, or in two layers. Cured plaster, as well as plaster applied by shotcreting, is also characterized by water tightness.

The watertight plaster layer should be applied without any construction joints. If these are unavoidable, the floating coat thickness in the strip along the construction joint decreases gradually to 10mm. This strip is thickened with mortar after the next batch of plaster is performed. If there is a long break between the subsequent batches, prior to adding the new batch, the joint strip (hardened) is to be notched and cleaned.

Fresh plaster must be moistened by pouring water on it at least for one week after it is made. Plaster in dry rooms is moistened for 2 weeks. Plaster should not be washed with a stream of water from the hydrant, as it can be easily washed off and separated from the base. Water sprayers as used in gardening are recommended. On sunny days, plaster should be poured 4 times, otherwise – 3 times a day.

Heat insulating plasters are applied to walls which do not have sufficient thermal insulation. The method of preparation for this type of plaster is not different from preparation of ordinary plaster; however, a mortar containing light aggregate is used. This can be combustion or blast-furnace slag, breakstone from aerated concrete, granulated Styrofoam or special light aggregates. There are also dry ready-mixes of thermal insulation mortars on the market. Heat insulating plasters are applied manually in single or double layers. The surface is not smoothed or finished, and the thickness is 1.5 - 10 cm.

Plasters that protect against X-ray radiation are used in physics laboratories, X-ray labs etc. Mortars used to produce such plasters differ from mortars used for ordinary plasters by the addition of heavy aggregate: barite (BaS04) of grain size of 0,05 - 2,0 mm (up to 4 mm), limonite or steel filings. The mortar should contain 2 parts of such aggregate, 2 parts of sand and 1 part of cement. The amount of water used is minimized. The method of applying plasters that ensure protection against radiation does not differ from application of ordinary plasters.

Occupational health and safety protection during plastering

Threats to human life and health during manual performance of plastering works are basically the same as for bricklaying work. The introduction of mechanization in plastering work has resulted in the emergence of new threats, including [2]:

- harmful vibrations,
- harmful effects of operation of devices under high pressure,
- excessive noise,
- electrical shock.

In general, the above threats pertain not only to the plastering gang members, but to all persons within their working area.
A particularly serious threat is posed by the operation of devices under pressure and electrical shock. Therefore, plastering equipment operators should [2]:

- refrain from turning on units which have been connected to the power supply network in a manner which is not consistent with the operator's manual; the proper connection should be verified by the construction site electrician;
- unauthorized persons are prohibited from conducting repairs of power supply equipment;
- a pump that is not equipped with a working manometer, cannot be turned on;
- altering the pump safety valve settings is prohibited;
- conducting any repair or maintenance activities during the pump operation and before it is disconnected from the power supply is prohibited,
- people who are not wearing protective goggles are prohibited from working near the hose (this particularly relates to the hose terminal operator and the cooperating plasterers).

On the other hand, it is absolutely necessary to [2]:

- perform measurements of efficiency of neutralization or grounding of the plastering unit after its assembly or shift to another working area,
- check every day operation of the manometer, the power supply and the pump operation,
- turn the pump off immediately, if pressure exceeds the acceptable level specified in the operator's manual, if the automatic system has failed to turn it off,
- control every day the condition of the plastering hoses in order to detect early any damage that may result in breaking,
- use the plastering hose shields in the zones of passage of workers and presence of servicing personnel,
- care for the good condition and working order of rotating components and replace immediately the defective ones,

- immediately repair or replace components or assemblies in machines that cause excessive noise.

A plasterer operating the floating coat applicator should be well trained, strong, skilled and sober. The plasterer must realize that dropping of the applicator without turning off the pump poses a substantial threat to other team members and may result in substantial contamination.
The plasterer operating the float must take care to avoid being injured by the rotating disk.
Specific issues associated with plastering works include [13]:

- prohibition of working on movable ladders,
- prohibition of using additives (particularly to stucco) that are harmful to health (e.g. compounds of lead, arsenic, etc.),
- the necessity to ensure good ventilation of the plastered rooms during performance of works, as well as after drying them with heating units. Near the location of the plastering unit, there should be a first aid kit, containing the accessories necessary to wash skin and body parts burned with lime, particularly the eyes.

Harmfulness of X-ray radiation

X-ray radiation is harmful. In doses used in medical diagnostics, it should not result in adverse events. However, it is necessary to be careful and to avoid using X-ray diagnostics if it is not necessary.

Fig. 4.16. X-ray lab.

Modern X-ray equipment is safer for the patients, while the high quality of tests is maintained. X-rays result mainly in damaging of bone marrow, which results in anaemia. However, thanks to the constant development of technology, the side effects

of use of X-ray in medicine are constantly being reduced. Response to X-ray radiation depends on:
- the dose absorbed,
- age (young persons are more sensitive to radiation than adults),
- body organs and tissues exposed to radiation – most susceptible to damage are testicles, ovaries, bone marrow, peripheral blood, epithelium of the digestive system and the lymphatic system, while bones and cartilage (apart from growth stage) are considered to be insensitive to radiation.

X-ray technicians are exposed to larger doses of radiation; therefore, the appropriate design of X-ray shields in labs is of particular significance.

Designing of shields for X-ray labs

All of the existing or designed walls and ceilings of an X-ray lab require calculation of thickness of the shields to determine whether they ensure sufficient protection against radiation for persons present in the surrounding area. Calculations are to be conducted on the basis of provisions of the standard PN - 86/J-80001. (Materials and equipment protecting against X-ray and gamma radiation. Calculations for fixed shields), taking into account the designation of adjacent rooms, assuming the appropriate limit values for these (in accordance with the binding legal provisions: regulation of the Minister of Health of August 21st, 2006 on the detailed conditions of safe work with X-ray equipment - Journal of Laws no. 180, item 1325, and regulation of the Council of Ministers of August 18th, 2005 on limit value of doses of ionizing radiation - Journal of Laws no. 25, item 168), taking into account the additional factors, listed in the standard. While selecting shields, it is necessary to take into account the limitations of individual doses (risk constraints) to ensure optimization, generally known as the ALARA principle (As Low As Reasonable Achievable).

Performance of X-ray plasters

As a rule, poured concrete walls and ceilings, as well as walls made of solid bricks of thickness of 24 cm, and often also 12 cm, constitute a sufficient protection. The shields used include barite plaster (a relatively cheap material, which, however, is difficult to apply), lead metal sheet, steel sheet (particularly in dental offices) and lead glass for the sight glasses.

Barite plasters consist of barite powder, mineral fillers, cement binding material, plasticizer and water. These mixtures are used as protection against X-ray radiation. It is estimated that a layer of barite plaster, which is 2 cm thick, is an equivalent of 1.5 mm of lead. Barite powder contains barite sulphate. This mineral is extracted in Poland in the town of Boguszów-Gorce in the Lower Silesia. It is not chemically aggressive; it is only soluble in sulphuric acid. Therefore, there are no reasons to avoid using it on a gypsum base. A problem, however, is posed by high bulk density of hardened plaster, amounting to 2.7 – 3.0 t/m3. Plaster is applied in layers of 6-8 mm to the total thickness of 20-30 mm. Its surface mass is thus about 60-90 kg/m2. There is a risk of loosening of such heavy layer and its separation from the gypsum block surface, even if the for example - Betonkontakt agent is used. Therefore, use of barite plaster on gypsum block walls is not recommended.

Fig. 4.17. A package of barite plaster.

In order to obtain the appropriate barite plaster, it is recommended that the recipe presented below is used.
Barite plaster is to be made of cement CEM II B-S 32.5 and barite aggregate. As barite aggregate, use barite sand of grain size of 0-4mm.
Barite sand containing at least 90% BaSO4 of grain size 0-4mm.
Specific gravity of at least 4.25 g/cm3.

Barite plaster – net consumption of materials in dry condition per 1 m3 of mortar:

- cement CEM II B-S 32,5	420.00	kg
- additive CHRYZO STAB H2	2.52	kg
- barite /aggregate and powder	2950.00	kg
- water	246.00	l
- total	3616,00	kg

Note: aggregate in its natural condition has moisture content of 5%, therefore it is necessary to reduce the amount of water by 3%.

The rules of plastering with barite plaster are as follows:
- prior to plaster application, the wall should be cleaned and washed with water, plaster should be applied in layers and the number of layers depends on the plaster thickness
- application of plaster of thickness of 30mm ensures protection against radiation
- thickness of layers applied:

- first layer	2-5	mm
- second layer	5-10	mm
- third layer	6-12	mm
- finishing coat	2-3	mm

- barite plaster is to be laid in layer, and each layer of thickness of 5 m is to be applied after binding and before drying of the previous layer. The first layer is to be thrown strongly, perpendicularly to the wall, to fill the gaps between bricks,

- barite plaster is to be mixed constantly in the concrete mixer to avoid falling of barite to the bottom,

- the total plaster layer thickness should not exceed 3mm. If plaster of thickness of 30mm is applied, metal meshes are to be used,

- during hardening, due to its high specific gravity, barite plaster is characterized by strong settling, which results in cracking; therefore, it must be applied in layers,

- during plastering of protective walls and ceilings with barite plaster, the room temperature during work and in the first 15 days should not be lower than 15 Celsius degrees, and for 10 days, the plasters are to be washed with water to prevent cracking due to drying too fast.

Under the ceiling, to enhance adhesion, it is necessary to use a mesh, e.g. Rabitz net. If cracking occurs, remove the entire plaster coat and apply it again.

In the floor, lead metal sheet is placed on a smooth underlayment and secured against damage with e.g. an additional layer of underlayment; afterwards, the floor finish is applied.

Doors are made of the same slabs. Slabs are made of lead metal sheets of varying thickness. Windows made of lead glass are provided in a frame sealed with lead. Assembly of slabs, windows and doors (hinged or sliding) is performed by manufacturers in a manner warranting their tightness in contact points. In operating rooms, where X-ray equipment is used, walls are made of thick steel sheets with in-built lead sheets.

Use of shield slabs with lead sheets

At present, apart from barite plasters, lead sheets installed between two chipboards or plasterboards are used. Such boards can serve as an independent structure and they ensure clean assembly, which is significant when it comes to renovation works in existing buildings. Similar boards are mounted under the ceiling. If the ceiling does not require additional shielding, shields on the walls do not have to reach higher than 2.0 m.

Presented below is an X-ray protection system of Knauf company as an economic and reliable solution for construction of new facilities, as well as for modernization purposes.

Fig. 4.18. Installation of lead sheets on the walls and ceilings of X-ray labs [www.baugips.pl/].

Drywall assembly, which is a modern, progressive method, has been used for years and is increasingly popular in the field of protection against radiation in diagnostic rooms of hospitals and clinics, as well as measurement workshops of industrial plants. This mode of construction is most cost-effective, it offers unlimited possibilities of modifications in planning and use of the facility, the shortest performance deadlines and general compliance with the legal standards in force.

Wherever people work under exposure to X-rays, the investor must apply means to protect them against harmful radiation doses. Radiation strength depends on [3]:

- nominal voltage of the tubes (kV),
- distance between the device and the surrounding structural components,
- density of the building material (in g/cm^3) and its lead equivalence (in mm).

The physical and technical "lead equivalence" coefficient is based on the fact that a heavy metal, such as lead, from the economic point of view, is most effective in blocking X-ray radiation. Thus, the lead equivalence coefficient of a given building material refers to protection against radiation, offered by a layer of lead of appropriate thickness.

According to the standard, manufacturers and designers of X-ray equipment must create a project of protection against X-ray radiation, which is to serve as a basis for all means of protection in the construction trade. According to DIN 6812, they offer protection against [3]:

- usable radiation, which, according to the structure of the X-ray device, acts only in one direction,
- interference radiation, which acts all the time with various intensity and in various directions.

X-ray labs, built using traditional techniques, are constructed in diagnostic offices, mostly using as dense and heavy materials as possible (barite concrete, concrete, solid brick wall, iron etc.) and providing the appropriate wall thickness. Upon less restrictive requirements with regard to reduction of radiation intensity (e.g. reconstruction), barite plasters are also used. However, these require a high degree of specialist knowledge and their lead equivalence reaches only 1,6 mm [3]. Unlike the above, Knauf walls and ceilings offering protection against radiation have multiple advantages when it comes to their structure and usability:

- Dry finishing ensures quick and simple assembly and a „clean" construction site, as well as the immediate access to new and renovated facilities,
- There is a substantial increase in usable area, lesser load and maximum flexibility of any changes in planning and use,
- Smooth walls and ceilings without cracks, installed in only a few steps,
- Industrial prefabrication of all system components under rigorous quality control, a watertight system and simplicity of use are the basic components of reliable and cost-effective protection against radiation.

Protection against radiation in the building trade requires particular emphasis on tightness of the shields [3]. This defines the most strict requirements for the contractor and manufacturer of protection systems. The basis for the systems are drywall products laminated with sheet lead of various thickness, depending on the required lead equivalent. They are mounted on a load-bearing structure made of wood or metal and they serve as division walls, front shields or suspended ceilings. Protection against radiation in the joint area is provided by self-adhesive lead sheet tapes, mounted prior to assembly to the light frame, of thickness equivalent to laminate made of lead sheets on drywall products.
Doors protecting against radiation, glazing protecting against radiation and shields mounted on cable boxes are additional components of the Knauf system.
Protection against radiation in the dry mounting system got few advantages:

- Quick, rational and clean assembly,
- Short performance deadlines, immediate readiness to use,
- Unlimited susceptibility to changes in planning and use,
- Low load, increased usable area,
- Easy installation of technical equipment.

A reliable protection against radiation thanks to a complete system made of components, which are strictly controlled with regard to their quality, simple application techniques and the system of know-how of a leading manufacturer.

Construction and assembly of a Knauf wall ensuring protection against radiation should be conducted as follows [3] - a light division wall built as a stand with a metal load-bearing structure according to DIN 18183 and the drywall at the top is largely consistent, when it comes to construction and assembly, with the reliable Knauf walls mounted on metal stands W 111 /W 112. A significant difference is the lead sheet lamination of construction slabs of thickness, which must be consistent with the project of protection against radiation, devised by the investor, and thorough protection of joints with self-adhesive tape of lead sheet. Depending on the noise protection and fire

protection requirements, a Knauf wall protecting against radiation may be provided with a single or double lamination layer.
Prior to commencement of assembly, to save time, it is good to apply self-adhesive Knauf tapes, made of lead, of appropriate thickness, to the previously cut UW profiles for connecting the walls to the ceiling and floor on the side exposed to radiation. UW profiles, shielded against radiation, are then fixed to the face and vertically to the ceiling and the floor; afterwards, CW profiles are mounted and also provided with self-adhesive lead tapes. Finally, the Knauf radiation protection shields are fixed (all contacts and joints are to be provided in a manner ensuring protection against radiation). Filling and closing of joints is to be conducted in accordance with the manual. In places, where electric sockets are planned, radiation protection are fixed using two screws.

Construction and assembly of radiation protection ceilings [3].

- K 111: Knauf boards ensuring protection against radiation (b = 625 mm) on a wooden load bearing structure (like slab ceiling Knauf D 111) fixed with screws Knauf TN 45, but longitudinally.
- K 112: Knauf boards ensuring protection against radiation (b = 625 mm) on a metal load bearing structure (like slab ceiling Knauf D 112) fixed with screws Knauf TN 35, but longitudinally.

The following are applicable to both systems:

- Maximum intervals between screws of 150 mm,
- Lead equivalent equal to thickness of lead sheet according to the radiation protection project,
- Securing of contact points of the long edges and slabs or load bearing profiles using self-adhesive lead tapes (thickness equal to the lead equivalent of the boards),
- Securing of contact points of the short edges using self-adhesive lead tapes,
- Levelling of other strips or load bearing profiles with strips made of lead or other material.

During radiation protection works, it is necessary to follow strictly the radiation protection project, paying particular attention to tightness of the anti-radiation shield. Holes, joints, contact points (e.g. of the ceiling and the wall) must be sufficiently shielded. In the first place, it is necessary to make sure that thickness of materials required for protection against radiation are not reduced by the integrated systems or other structural components. If necessary, they are to be secured e.g. by lead inserts to warrant the proper protection in every possible direction of propagation of rays.

Chapter V – Training part

The training part is an integral part of the module. It encompasses a three-day training cycle, during which the following topics will be discussed:

Theory training (1 day)

- Plastering tools and equipment,
- General requirements for bases,
- Conditions of commencement of plastering works,
- Determining of plaster surface,
- Special plasters,
- Occupational health and safety during plastering,
- Harmfulness of X-ray radiation,
- Design of shields for X-ray labs,
- Application of X-ray plasters,
- Use of shields containing lead sheets,

Practical training (2 days)

- Workshops for teams of 2/3 persons
- Independent performance of all tasks ordered by the instructor, including:

Workshop - day one

- Plastering of walls with barite plaster

Workshop - day two

- Installation of X-ray shields

Workshop summary, questions and answers, comments and conclusions.

Test part / Verification questions

Example questions [2] to verify knowledge gathered during the course (The correct answers are contained in the teacher textbook).

1. Describe the occupational profile of a plasterer
2. List and characterize at least three tools used by plasterers for application of ordinary plasters
3. List and characterize the tasks included in the plastering process, which can be mechanized
4. List basic devices included in a plastering unit.
5. What should be taken into account when selecting the plastering unit for performance of a specific type of work?
6. List the criteria of plaster classification.

7. Compare the specific features of preparations preceding plastering of bases made of LECA concrete and cellular concrete
8. Explain the conditions that must be met to begin plastering work
9. List operations included in the process of performance of ordinary plasters.
10. Explain how the rendering coat, the floating coat and the finishing coat should be applied.
11. Describe the method of determination of plaster surface on the ceiling.
12. What are the basic rules of safe work during plastering using mechanical devices?
13. What equipment should be used by plasterers to make their work more safe?
14. Discuss the specific nature of application of barite plasters.
15. Discuss the specific nature of installation of radiation protection shields (by Knauf company).

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