



**Polskie Stowarzyszenie Gipsu    Instytut Technologii Eksploatacji  
– Państwowy Instytut Badawczy**

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**Installation of dropped ceiling systems 712[06].S1.04**

**Student's Handbook**



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# 1. INTRODUCTION

You will find this handbook useful while acquiring knowledge about installation of dropped ceiling systems. The Handbook includes:

1. Prerequisite skills, i.e. a list of indispensable skills and knowledge which you should possess to start training within this modular unit.
2. Learning objectives of the modular unit.
3. Reference material (Chapter 4) which will enable you self-preparation for performing the tasks and successful test completion. In order to broaden your knowledge use the literature indicated and other sources of information. It covers also:
  - revision questions checking the knowledge indispensable for task completion,
  - tasks including instructions, the way of task completion and workplace resources,
  - progress checks checking the level of knowledge following a task completion.

While doing a progress check you should use “yes” or “no” to answer a question, which indicates that you have acquired the teaching contents or not. Successful task completion is a proof that you have acquired the skills specified in a given modular unit. If you find the subject or tasks difficult to understand, ask the teacher or instructor to explain or, alternatively, check if you perform a given activity properly.

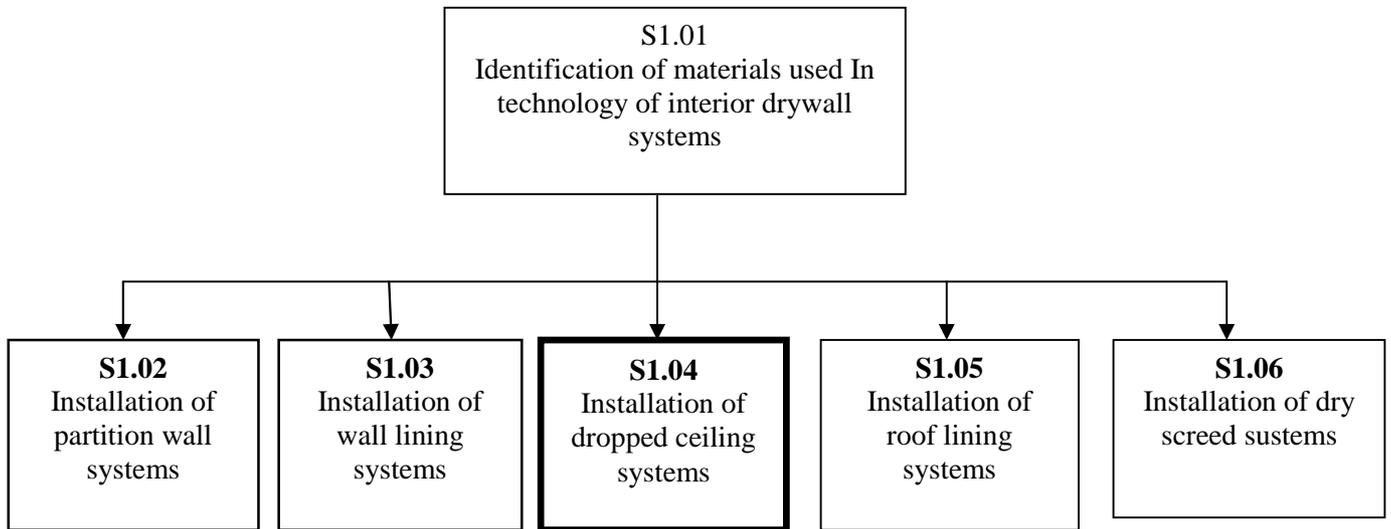
4. A set of revision questions checking your acquisition of the knowledge and skills covered by the entire unit. After getting familiar with the reference material try to take a test covering the whole unit.

The modular unit “Installation of dropped ceiling systems”, the contents of which you will get familiar with now is a part of a module “Technology of Interior Drywall Systems”.

## **Safety and hygiene at work**

During your stay in the workshop you must observe rules, regulations, safety and fire procedures related to the type of work performed. You will get familiar with these regulations in the course of your training .

## Diagram of modular units



## **2. PREREQUISITE SKILLS**

Before starting the modular unit program “Installation of dropped ceiling systems”, you should be able to:

- use technical building terminology,
- read and construe technical building drawings,
- use technical building documentation,
- organize the workplace in line with rules of ergonomics and safety,
- ensure the proper transportation of building materials,
- use different sources of information,
- identify materials used in technology of interior drywall systems,
- prepare gypsum mortar,
- select tools and equipment for assembly works,
- take basic measurements in building works,
- make scaffolding for building works.

### **3. LEARNING OBJECTIVES**

Upon completion of the modular unit program, you should be able to:

- prepare the workplace for installation of dropped ceiling systems,
- prepare a place where materials for the installation of dropped ceiling systems can be stored,
- ensure the proper transportation of materials used for dropped ceiling systems,
- determine the positioning of dropped ceilings,
- prepare and cut to size the boards used for dropped ceiling systems,
- select and assemble steel profiles appropriate for the installation of dropped ceiling systems,
- attach the plasterboards to the steel profiles,
- fit insulation material between the boards,
- complete finish works such as filling, finishing internal angles, board cleaning,
- observe occupational health and safety rules, fire regulations as well environmental law requirements.

## **4. REFERENCE MATERIAL**

### **4.1. Dropped ceiling systems**

#### **4.1.1. Reference material**

A dropped ceiling is a secondary ceiling hung below the main ceiling. It is made of plasterboards in the technology of drywall system. It fulfills many functions difficult to achieve in the case of traditional technologies of interior finish.

It is an element determining the looks of the interior. It helps to conceal old surfaces with cracked plaster and uneven surfaces. It also helps to conceal piping and wiring (apart from gas piping which according the building law cannot be concealed).

In the space between plasterboards and the main ceiling one can install all sorts of plumbing and wiring which otherwise would require troublesome drilling into the solid structure of a building or masking with some covers. Dropped ceilings allow one to conceal air conditioners, ventilation systems or air heating elements. Owing to almost unlimited assembly possibilities as well as plasterboard's flexibility and lightness which allow one to obtain any shapes of the ceiling surface and its connections with the walls, dropped ceilings can satisfy aesthetic needs of the fussiest designers. A dropped ceiling can be lowered over a part of a room (kitchen, a sitting room) without a problem. When special profiles and plasterboards are used one can easily obtain curve-line "islands" with special lighting. Dropped ceilings made of plasterboards allow one to form chamfers, offsets, arcs and arcades. Thanks to this the appearance of an interior can be visually (optically) changed by, for instance installing halogen lighting in a special way. Requirements concerning fire safety and acoustic parameters for walls and ceilings are much stricter for public buildings than family houses. Therefore dropped ceilings which are good enough for the office use, without a doubt, are good for family houses.

Among the advantages of dropped ceilings made of plasterboards fixed to the supporting structure and hung on steel profiles, one should mention:

- fast assembly of a factory-prepared structure,
- adjusted structural height of the ceiling,
- easy application of the insulation material (mineral wool),
- easy assembly of the system-included lighting and air grates.

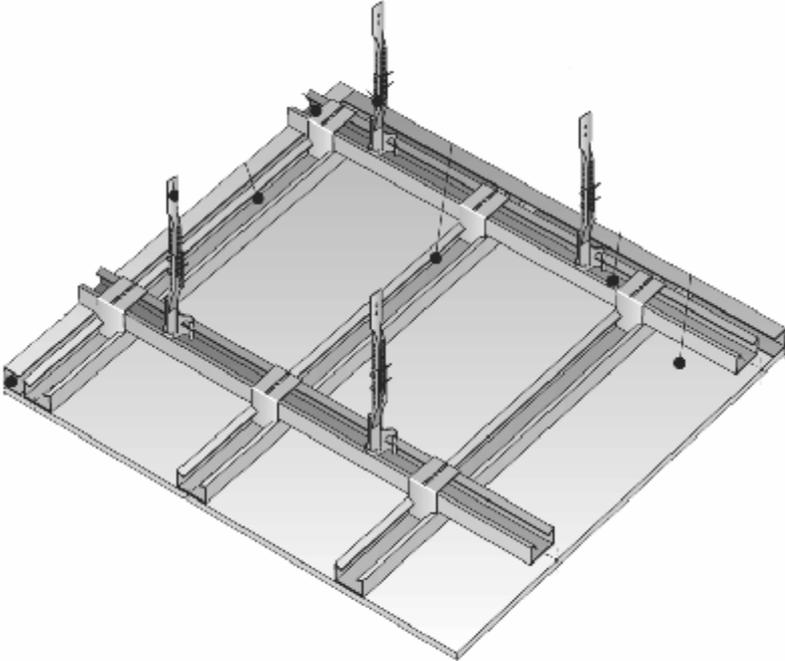
It is noteworthy that a dropped ceiling made of plasterboards can be an element of acoustic insulation between storeys or partly the insulation against material sounds (like the sound of steps). In a room where loud music is played, the acoustic comfort can be enhanced by installing a dropped ceiling of plasterboards and filling the free space with mineral wool.

A dropped ceiling can also be used as a structure with thermal insulation. A dropped ceiling installed below an unheated loft can additionally prevent heat losses. Drywall system manufacturers recommend mineral wool as the best insulation material characterized by high indicators of thermal insulation, acoustic insulation and A1 fire rating.

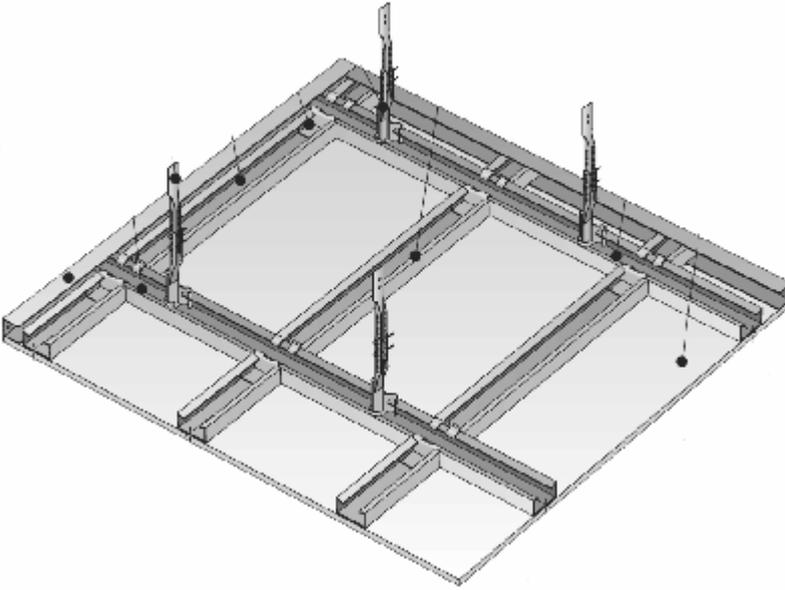
The drywall systems for dropped ceiling which are supplied by manufacturers consist of: standard steel profiles, hangers, other structural elements, plasterboards and, if needed, insulation materials (mineral wool), vapour-insulation (foil), mudding and joint tapes.

We distinguish three techniques of a dropped ceiling assembly:

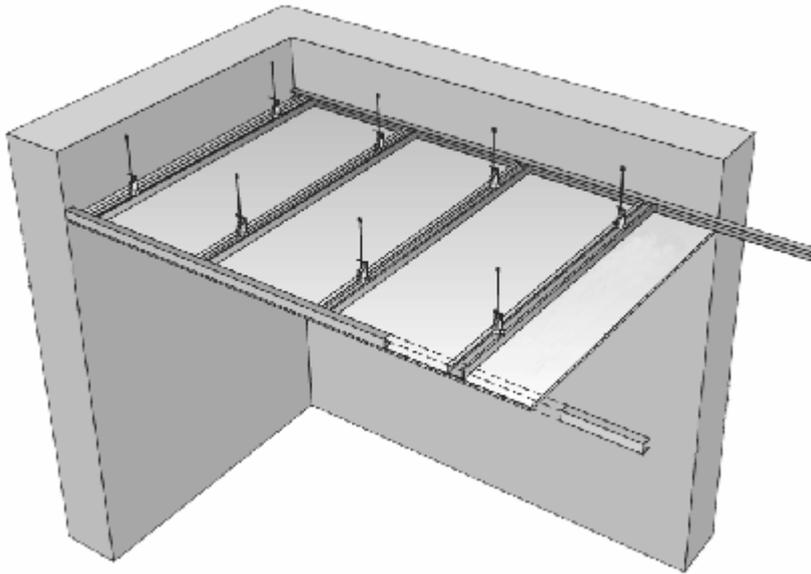
- a) a dropped ceiling installed on a one-level structure,
- b) a dropped ceiling installed on a two-level structure,
- c) a ceiling lining.



A.



B.



C.

*Fig. 1. Types of dropped ceilings: A) a two-level structure, B) a one-level structure, C) a ceiling lining.*

Each of the techniques of a dropped ceiling installation allows one to take advantage of the specific favourable qualities of such a solution. A ceiling lining installed on a structure made of CD profiles enables to minimize losses on reduced headroom.

#### **4.1.2 Revision questions**

Answering the questions you can check if you are ready for the tasks planned and task completion.

- 1) What cannot be hung between a dropped ceiling and the main ceiling?
- 2) What are the three ways of installing dropped ceilings?
- 3) What elements are included in the dropped ceiling systems?
- 4) What function does a dropped ceiling fulfill?
- 5) What are the advantages of a dropped ceiling??
- 6) Can lighting fixtures be hung under a grid?
- 7) Which system permits hanging a dropped ceiling 6 cm below the main ceiling?

#### **4.1.3. Tasks**

##### **Task 1**

On a drawing provided by the teacher, identify elements of a dropped ceiling structure.

The way to do the task:

To do this task, you should:

- 1) get familiar with the structure of dropped ceilings fixed on CD60 profiles (reference material from Chapter 4.1.1),
- 2) get familiar with the drawing provided by the teacher,
- 3) identify the elements of the dropped ceiling structure as depicted in the drawing,
- 4) present the completed task,
- 5) assess correctness and aesthetics of the task completed.

Workplace resources:

- reference material from Chapter 4.1 of Student's Handbook,
- drawing instruments,
- drawings depicting a dropped ceiling structures.

### **Task 2**

Draw a projection and a cross-section of a ceiling lining fixed on CD60 profiles.

The way to do the task:

To do this task, you should:

- 1) get familiar with the structure of a ceiling lining fixed on CD60 profiles (reference material from Chapter 4.1.1)
- 2) organize the workplace for task performance,
- 3) draw a projection and a cross-section of a ceiling lining,
- 4) present the completed task,
- 5) assess correctness and aesthetics of the task completed.

Workplace resources:

- sketch pad, size A4,
- drawing instruments,
- reference material from Chapter 4.1 of Student's Handbook.

### **Task 3**

Classify dropped ceilings made in the technology of drywall systems by the assembly type of the supporting structure.

The way to do the task:

To do this task, you should:

- 1) get familiar with the types of dropped ceiling structures fixed on profiles (reference material from Chapter 4.1.1),
- 2) get familiar with drawings or photographs provided by the teacher,
- 3) organize the workplace for task performance,
- 4) present the completed task,
- 5) assess correctness and aesthetics of the task completed.

Workplace resources:

- sketch pad, size A4,
- reference material from Chapter 4.1 of Student's Handbook,
- paper clips,
- photographs or drawings of ceilings.

#### 4.1.4. Progress check

	Yes	No
<b>Are you able to:</b>		
1) identify different types of dropped ceilings on the basis of a drawing?	<input type="checkbox"/>	<input type="checkbox"/>
2) identify profiles used for a ceiling lining assembly?	<input type="checkbox"/>	<input type="checkbox"/>
3) indicate differences between a one-level and two-level ceiling structures?	<input type="checkbox"/>	<input type="checkbox"/>
4) describe characteristic features of a ceiling lining?	<input type="checkbox"/>	<input type="checkbox"/>

## 4.2. Steps in the installation of dropped ceiling systems

### 4.2.1. Reference material

#### General conditions for conducting works

Starting any work with the use of plasterboards is possible only when all “wet” work (e.g. floor base for screeds or “wet” plaster) have been completed and all window and door frames have been installed. At the same the temperature in the rooms cannot drop below 10° C. If the work is performed in winter, the heating in the building should be on. The requirement of maintaining the minimum temperature refers also to the time when workers are not present on the construction site. Temporary heating of rooms with heaters (e.g. for 8 hours) is not allowed, neither is the temperature drop allowed at night. This requirement is a result of the necessity to maintain the relative air humidity below 70%. It must also be remembered that plasterboards must be stored in closed spaces or under a roof.

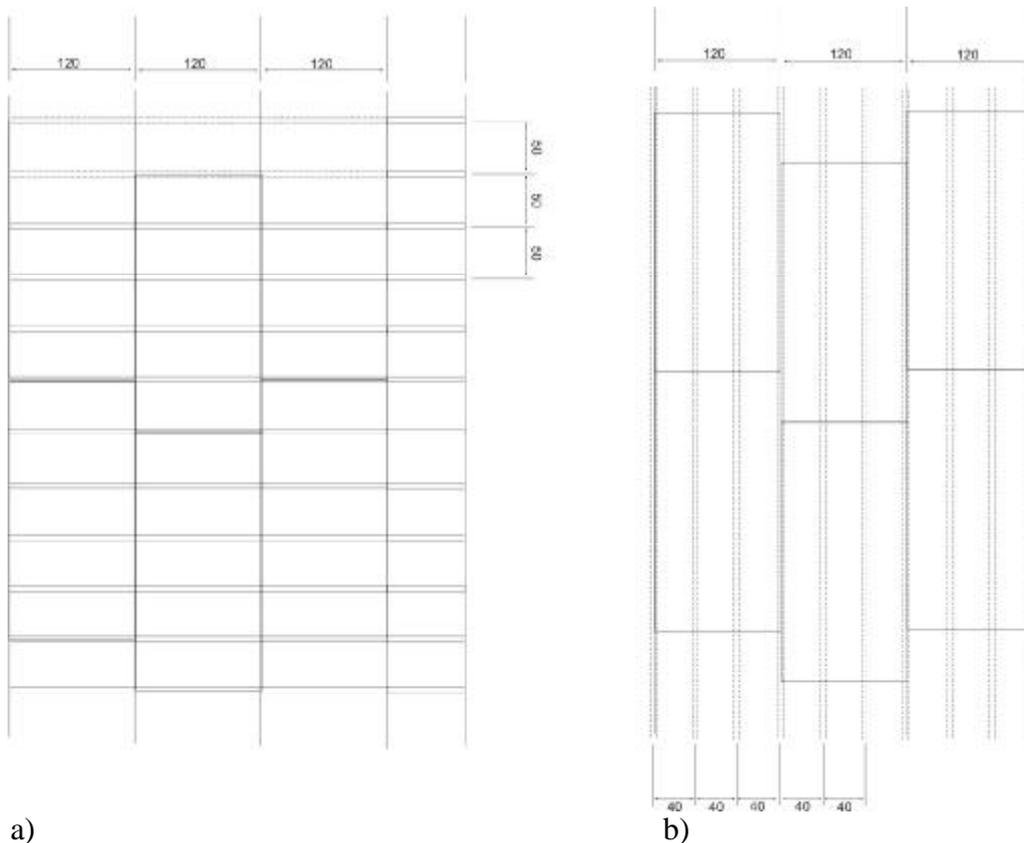
#### Principles of plasterboard assembly in dropped ceiling systems

Plasterboards can be installed not only in the vertical position on the walls. When installed horizontally overhead, they can form a ceiling.

In buildings of higher standards (the erection of which is on the increase), there are so many different service lines that their installation causes problems and sometimes it is even impossible if the technical documentation does not solve the issue individually. A very convenient solution (and in the case of central air conditioning – an indispensable one) is to mark off a special, technical space between the structural ceiling and the dropped ceiling (the plenum space). It is a very simple solution and at the same time allowing one to maintain high standards of the finished interior aesthetics.

Whereas on the walls plasterboards can be fixed with adhesive and attached with mechanical connectors (e.g. screws, nails, or staples), on the ceiling one can use only mechanical connectors. Plasterboards must not be fixed with adhesive to horizontal or slanted surfaces (ceilings, chamfers). This necessitates earlier preparation of the structure to which a plasterboard will be attached. A plasterboard installed on the ceiling is subject to loads different from those when it is installed on the wall and therefore the structure (known as a “grid”) used on the structural ceiling under a plasterboard is completely different from the structure on the wall. The very weight of the horizontally placed plasterboards causes a bending stress in the plasterboard cross-section. Therefore the spacing of profiles which form the structure depends on the bending strength of the plasterboard used. In other words, it depends on the average thickness of a plasterboard and the direction of the load. Intervals

between steel metal screws along profiles must also be smaller than in the case of wall assembly and should be between 150 and 200 mm. If the profiles to which a plasterboard is going to be fixed by screws are perpendicular to the plasterboard length – such an arrangement is called a lateral (crosswise) one; however, when the profiles are parallel to the plasterboard length – we are dealing with the longitudinal (lengthwise) arrangement. The maximum spacing of profiles to which a plasterboard is attached, is given in the Table on page 17.



*Fig.2. Plasterboard assembly in dropped ceiling systems: a) crosswise arrangement, b) lengthwise arrangement.*

### **Direction of plasterboard arrangement in dropped ceilings**

Prior to making a decision about the direction and type of a grid, the direction of plasterboards on the given room's ceiling must be determined. The main factor influencing such a decision is the direction of the ceiling's illumination. If the room is illuminated by the sunlight coming through the windows located on the walls of the room, then plasterboards must be positioned with their length parallel to the wall with windows. This requirement results from the fact that crosswise joints (contact lines of edges not covered by the cardboard) should be parallel to the direction from which the light comes. These joints are slightly convex in relation to the plasterboard plane and the light which is perpendicular to them can make them more visible and cast a shadow beyond the joint. In the rooms where windows are located on two walls perpendicular to each other, it must be analyzed which windows look towards the south and plasterboards must be placed in relation to them following the above specified rules.

### **Structure types and ways of suspending them**

To make a ceiling grid, most frequently a set of two profiles is used: the main profile – “CD” being 60 mm in width and a UD profile made of a zinc galvanized steel sheet (0.6 mm or 0.55 mm thick). Together with these profiles accessories are available which allow one to join them and to hang a dropped ceiling.

After the direction in which plasterboards are to be placed on the ceiling has been determined, the next step is to plan the positioning of the structure supporting profiles (in this handbook the term supporting profiles applies to lower profiles, to which the plasterboard will be attached directly) and structural solutions meaning the way in which the dropped ceiling will be hung below the structural one. The type of the structure designed depends also on the function of the ceiling. If apart from improving the aesthetics of the room, the ceiling is also to play the role of a fire barrier, or to bear extra loads (e.g. lighting fixtures, or insulation material) – then profiles must be fixed more densely.

An important element of a dropped ceiling is its attachment to the structural ceiling. If the structure is not further away from the structural ceiling than 120 mm, then hangers for direct fixing are used (ES type). In the case of a reinforced concrete ceiling, this element is fixed by means of a metal anchor the structure of which makes up for the hole diameter in the concrete. In the reinforced concrete ceiling, the lower part of concrete is subjected to stretching. This phenomenon is accompanied by the occurrence of a network of microcracks. The opening of these cracks is changeable and depends on the ceiling load. The bolts for fast assembly can fall out of holes which were drilled in the construction phase when there are no service loads on the ceiling yet. When the building is used and ceilings are under load, the cracks going across a hole increase its diameter and for this reason the bolt structure must allow it to make its diameter bigger so that the force pulling the anchoring screw out of its hole would remain stable. This requirement is met by a number of metal bolts with a conical or wedge element. Definitely, to fix hangers, one must not use an expansion bolt with a plastic expanding element. Also the bolts which are “shot” must not be used if they are to work in the conditions of stretching.

If a dropped ceiling structure is to be lowered, then either the hangers with an expanding element and a fixing rod or nonius hangers must be used. Nonius hangers are used in ceilings used as a fire barrier and also when the ceiling must be protected against lifting, e.g. as a result of differences in air pressure in the spaces above and below the ceiling, or vibrations.

### **A ceiling on a one-level structure**

It is usually used in corridors and in the rooms whose width does not exceed 2.6 m. This solution is the least material consuming, however, one should realize that lower costs of materials will be accompanied by higher labour outlays. In this type of structures CD profiles are located between two longitudinal walls and are additionally attached to the main ceiling by means of hangers located along the profile, at intervals of less than 100 cm. The ceiling lining consists of a plasterboard attached lengthwise in relation to the profile without any connection widthwise – joining plasterboards lengthwise is not permitted. On longitudinal walls the “UD” profiles are fixed in the ceiling’s plane. The ends of “CD” profiles are interlocked between the shelves of wall profiles. The increased labour expenditure while making such a structure results from the necessity to fix more hangers (ca. 2.5 pieces/1m<sup>2</sup>) in the structural ceiling than in the case of the cross-tee structure (ca.1.1 pieces/1m<sup>2</sup>). Levelling of this grid is also labour-consuming and troublesome.

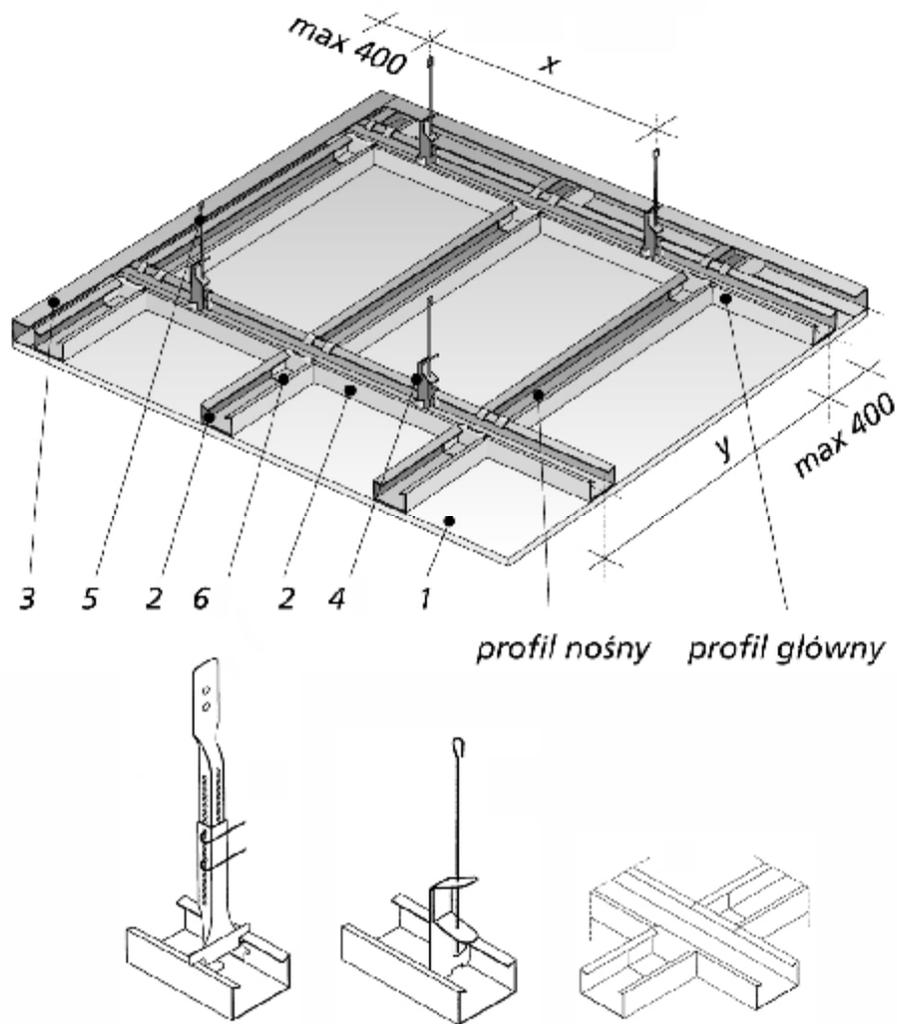


Fig. 3. Ceiling on a one-level structure: 1. plasterboard, 2. supporting profile CD, 3. Wall profile UD, 4. Hanger (nonius, rotary or a hanger with an expanding element), 5. Upper part of a hanger, 6. Crosswise connector for a one-level structure

### Ceilings on a cross-tee, two-level structure

They are a basic solution used in the rooms mainly on account of their easy assembly and adjustment of the ceiling plane level. In this type of grid, hangers can be located in a grid of 90 x 100 cm. Hangers support the upper (main) part of the structure also made of the “CD” profiles. At the walls, the ends of the main structure profiles rest on the upper shelf of a “UD” profile. Supporting profiles (“CD”) are hung on crosswise connectors embracing the upper profile and interlocked between the shelves of the lower profile. The ends of supporting profiles are between the shelves of the “UD” profile. The commercially available “CD” profiles are made in lengths up to 4 m. To lengthen them, one must use a longitudinal connector. While connecting the profiles of the upper part one must bear in mind that the nearest hanger cannot be further away than 20 cm from the place where profiles are connected. At the same time one must follow the rule that connecting two adjacent profiles must be shifted by minimum 80 cm.

While installing these ceilings, the following rules must be borne in mind:

- the maximum distance of the axis of the supporting (lower) layer perimeter profile from the wall parallel to it cannot exceed 15 cm.
- the maximum distance of the axis of the main (upper) layer perimeter profile from the wall parallel to it cannot exceed 30 cm.
- the maximum length of the perimeter hanger (counting from the wall) on the main (upper) profile cannot exceed 30 cm.

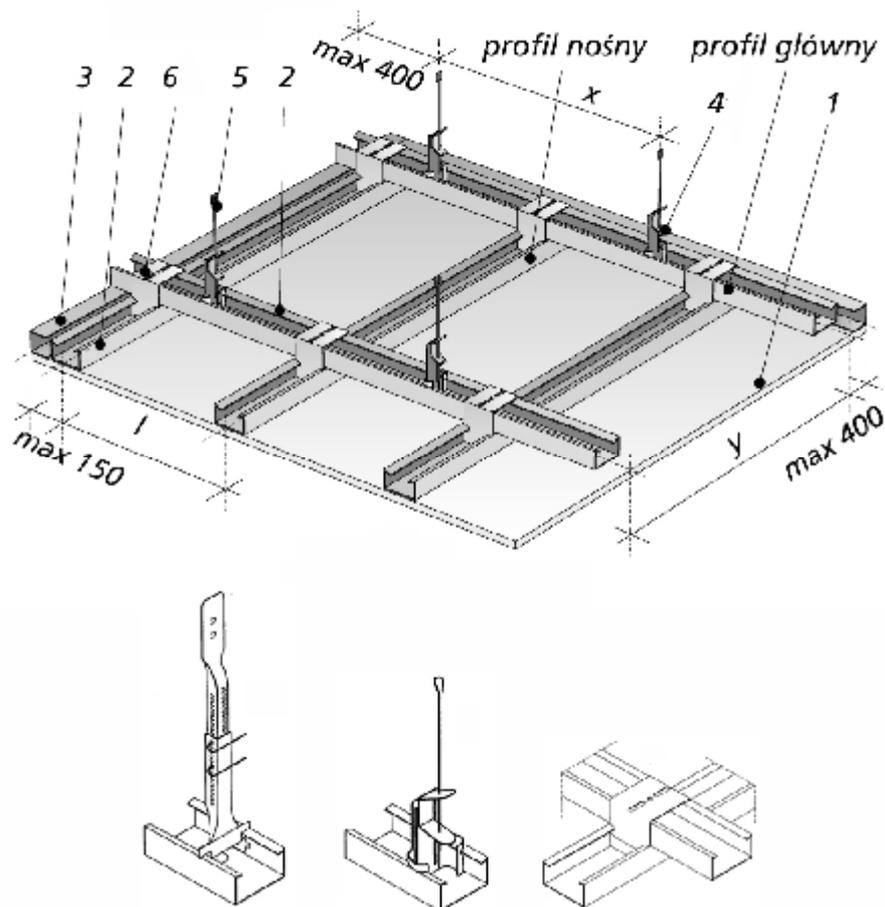


Fig. 4. Ceiling on a cross-tee, two-level structure: 1. plasterboard, 2. Supporting profile CD, 3. UD profile, 4. Hanger (nonius, rotary or a hanger with an expanding element), 5. Upper part of a hanger, 6. One-part cross connector.

### A ceiling lining on CD60 profiles

This type of structure is used wherever it is essential to reduce the ceiling structure thickness. The minimum thickness consists of: a 15.5 mm profile and a plasterboard of at least 12.5 mm in thickness. For the strength reasons plasterboards of lesser thickness should not be used.

During the installation special attention must be given to the fact that perimeter profiles CD60 cannot be further than 10 cm from the wall. The space where a dropped ceiling is installed should be divided into so many parts as to prevent the distances between profiles from being bigger than permitted. A crosswise arrangement of plasterboards in the ceiling allows one to

move profiles within the permitted ranges but they should be easily and safely fixed. Plasterboards are fixed to profiles with the TN 25 screws for plasterboards of 12.5 and 15 mm in thickness and TN 35 screws for plasterboards of 20 and 25 mm in thickness, at 15 cm intervals. The installed plasterboard should be cut to length in such a way as to have its lateral edge - following its fixing with screws - in the centre of the profile. In the next row of plasterboards crosswise junctions must be shifted by minimum one profile so as to avoid formation of joints in the shape of a cross. The direction of panelling in the room should be the one in which long joints are parallel to the main direction of the incoming light.

Most often CD profiles are fixed to the ceiling with the ES brackets. On the ceiling the places for bracket fixing are marked and they are usually placed 60 cm from each other horizontally and maximum every 130 cm vertically. Screws are used to fix profiles to ES brackets. On each side of the profile there should be two screws. The protruding ends of ES brackets are bent under the angle of 90° so that they would not extend above the profile surface. Prior to the beginning of the process of fixing plasterboards with screws, using a long spirit level one must check if the plane of the structure is even. The structure in which profiles are fixed in the way as described above gives more chance to make up for the main ceiling's irregularities. Besides it allows to hide all kinds of piping and wiring installed under the ceiling if their thickness does not exceed 9 cm, or the dropped ceiling in relation to the main ceiling is lower by no more than 12 cm. All fixing to the main ceiling should always be performed with metal dowels.

#### Technical parameters for particular dropped ceiling solutions

	Structure description	Number of plasterboards	Spacing of structure elements			Fire protection class
			CD supporting (lower) channels	CD main (upper) channels	hangers	
1	single	1x12.5	100	-	120	-
2	Two-level, cross-tee	1x12.5	50	100	90	-
3	One level, cross-tee	1x12.5	50	120	120	-
4	Two-level, cross-tee	1x12.5	40	100	75	REI 30
5	One-level, cross-tee	1x15.0	40	120	70	REI 30
6	Two-level, cross-tee	2x15.0	40	100	70	REI 30
7	One-level, cross-tee	2x15.0	40	120	65	REI 30

#### Panelling

To make handling the whole plasterboard on the ceiling easier, the plasterboards of 200 cm are often used. Such a plasterboard (panel) is lighter and its length enables covering the whole structure without the necessity to cut the panel. Many manufacturers offer plasterboards of 200 cm in length with crosswise edges bevelled in the factory, which makes joint filling of adjacent plasterboards easier. Crosswise joints in adjacent rows of plasterboards should be shifted in relation to each other by at least a spacing module, i.e. 50 cm. With multi-layer panelling, the position of plasterboards in the second layer must be planned in such a way as

to avoid parallelism of joints, both crosswise and lengthwise, at least in adjacent layers. Basically, requirements concerning the length of screws fixing panels to the ceiling are identical with those applied to the walls. Nevertheless, it is more convenient to fix the first layer with screws which are longer by 10 mm.

### 4.2.2. Revision questions

Answering the questions you can check if you are ready for the tasks planned and task completion.

1. What are the general conditions for conducting works in the technology of drywall systems?
2. What are the rules governing plasterboard assembly in dropped ceilings?
3. What types of steel profiles are used for a dropped ceiling assembly?
4. What are the rules of fixing a dropped ceiling structure to the main ceiling?
5. What are the rules of assembling a dropped ceiling on a one-level structure?
6. What are the rules governing the assembly of a dropped ceiling on a two-level cross-tee structure?
7. What are the rules of plasterboard assembly on CD60 profiles?
8. What are the rules of multi-layer panelling on the dropped ceiling structure?

### 4.2.3. Tasks

#### Task 1

Determine the position of a dropped ceiling on a one-level structure on the basis of the technical documentation of the room. Mark this position on all four structural walls.

The way to do the task:

The teacher will provide you with the technical documentation needed to perform this task. Your task is to determine the dropped ceiling level on structural walls.

To do this task, you should:

- 1) get familiar with the one-level structure of dropped ceilings (reference material from Chapter 4.2.1,
- 2) get familiar with the technical documentation of the room,
- 3) organize the workplace for task performance,
- 4) select the tools and equipment for determining the dropped ceiling's position,
- 5) determine the dropped ceiling's position on the structural walls of the room,
- 6) present the completed task,
- 7) assess correctness and aesthetics of the task completed.

Workplace resources:

- technical documentation of the room,
- measuring instruments,
- drawing instruments,
- reference material from Chapter 4.2.1 of Student's Handbook,

## **Task 2**

On an earlier determined position of the dropped ceiling of one-level structure, fix the profiles.

The way to do the task:

To do this task, you should:

- 1) get familiar with the techniques of fixing profiles in the dropped ceiling structure (reference material from Chapter 4.2.1,
- 2) get familiar with the determined position of the dropped ceiling in the room,
- 3) organize the workplace for task performance,
- 4) select profiles, accessories and equipment needed for fixing the profiles,
- 5) fix the profiles to the one-level structure,
- 6) present the completed task,
- 7) assess correctness and aesthetics of the task completed.

Workplace resources:

- profiles needed to install a dropped ceiling,
- tools and equipment needed for fixing profiles,
- reference material from Chapter 4.2.1 of Student's Handbook,

## **Task 3**

On an earlier determined position of the dropped ceiling of two-level structure, fix the profiles.

The way to do the task:

To do this task, you should:

- 1) get familiar with the techniques of fixing profiles to the dropped ceiling structure (reference material from Chapter 4.2.1,
- 2) get familiar with the determined position of the dropped ceiling in the room,
- 3) organize the workplace for task performance,
- 4) select profiles, accessories and equipment needed for fixing the profiles,
- 5) fix the profiles to the two-level structure,
- 6) present the completed task,
- 7) assess correctness and aesthetics of the task completed.

Workplace resources:

- profiles needed to install a dropped ceiling,
- tools and equipment needed for fixing profiles,
- reference material from Chapter 4.2.1 of Student's Handbook,

### 4.3.4. Progress check

	Yes	No
<b>Are you able to:</b>		
1) identify basic steps in the assembly of a one-level dropped ceiling?	..	..
2) identify types of profiles used to install the ceiling lining?	..	..
3) determine the spacing of screws fixing plasterboards in a one-level structure dropped-ceiling in the first lining layer?	..	..
4) determine the spacing of screws fixing plasterboards in each layer of a two-layer lining?	..	..
5) identify the type of plasterboards used in rooms of higher humidity?	..	..
6) identify the rules of plasterboard assembly in dropped ceilings?	..	..

## 4.3. Plasterboard joint filling and finishing works

### 4.3.1. Reference material

After the plasterboards have been fixed to the walls, all plasterboard edges and heads of the screws used for fixing are clearly visible. To get a uniform surface the joints and screw heads must be masked and all possible defects should be concealed as well as other damage in plasterboard edges. To this purpose a system-included joint compound is used.

The purpose of joint-filling is not only to conceal plasterboard joints but first of all to make all plasterboard sheets into one continuous whole. A characteristic quality of a significant majority of the joint compounds used is the fact that their resistance to compression is several times higher than their tensile strength. To allow the joint to transfer even the slightest tensile forces, it must be provided with a tape made of a fibrous material.

Joint filling is one of the most important stages in wall lining installation. An appropriate selection of filling materials and appropriate execution assure a faultless performance of interior drywall systems.

The surface for joint filling must be cleaned of gypsum dust. Depending on the type of the joint compound or gypsum mud used we distinguish joint filling with and without a joint tape. In both cases, when we apply joint compound for the first time, it is spread laterally to the contact line of plasterboards, and pressed as deeply as possible to fill the whole joint tightly. Next, applying a uniform movement, preferably a single stroke, we spread and smooth out a joint compound along the whole joint.

For joint filling on tapered edges in commercially available plasterboards, we use a tape. We distinguish three types of tapes:

- paper tapes,
- self-adhering mesh tapes of glass fiber,
- glass fiber (felt) tapes.

In the case of tapered-edge plasterboards (NS, PRO, KS and KPOS), all types of joint tapes can be applied to their vertical junctions. In the case of the NS and PRO type edges, a self-adhering (mesh) tape should be applied to the edges of joined plasterboards directly onto their

cardboard; in the case of edges of the NS, PRO, KS and KPOS types – a self-adhering tape should be embedded in an earlier applied construction joint compound ("on wet gypsum"). "Felt" or paper tapes should be applied to the "wet gypsum" joints.

Vertical joints (on edges lowered in the factory) between plasterboards of half-round tapered edges (KPOS) can be "mudded" without the use of a tape in a situation when a special joint compound is prepared specially to this purpose.

Mudding horizontal joints between plasterboards, i.e. of the so-called "cut" edges should be accomplished with the use of tapes of the "felt" or paper type applied on "wet gypsum".

Mudding of vertical and horizontal joints between plasterboards with the use of a tape embedded in the earlier applied joint compound (to "wet gypsum") requires the second stage of mudding with joint compound the aim of which is to "cover" the tape. The aesthetic standard of finishing works in interiors in which drywall systems were applied is determined by the smoothness of their wall surfaces. Joints (convex, concave) cannot be visible following painting or wall papering.

Four quality levels of mudding are used to describe and classify the quality of drywall finishing in Technology of Drywall Systems. The Polish standards in this field are conformable with the European classification of Quality Levels and are described with the use of four different standards of mudding.

### **Levels of gypsum board finish (Quality Level 1 (Q1))**

Quality Level 1 for mudding refers to wall surfaces made of plasterboards towards which no aesthetic requirements are formulated (e.g. a substrate for ceramic tiles). It is enough to apply basic mudding which consists of filling the plasterboard joints and covering the visible fixing and finishing elements with joint compound. At this quality level the mudding process includes application of a joint tape of glass fiber (self-adhering mesh) to the edges of the NS and PRO type plasterboard and – depending on the system supplier's recommendations – covering it with one or two layers of joint compound.

Joint filling in the case of plasterboards having the KS type of edges should look a bit different. In this case, when a paper or felt tape or a fiber glass mesh tape is applied, the first step should be applying the system-included joint compound to an edge joint and then the tape should be applied. It must be borne in mind that after the first layer of joint compound with a tape applied to it has dried up, the joint should be mudded again with the use of one layer of the system-included joint compound.

If the joint compound has been applied to the edges of KPOS plasterboards, then - like in the case of KS edges – when we use a paper tape, or a felt tape, or a mesh tape of glass fiber, the first thing which must be checked is the use of the system-included joint compound into which the tape is embedded. After the first layer of the joint compound with a tape applied to it has dried up, the joint should be mudded again with one layer of the system-included, joint compound.

It is worth remembering that the application of joint compound without the use of any tapes is also possible in the case of KPOS edge plasterboards. Special, system-included joint compound is employed for joint filling without the use of a joint tape. Subject to a system supplier's recommendations, two or three layers of joint compound should be applied to such plasterboard joints.

When the walls are covered with many layers of plasterboards, joint compound is applied to all subsequent layers, and the joints in the external surface must be additionally taped for joint filling. On the other hand, applying joint compound to screw heads in internal layers is not needed.

At this quality level of mudding, the occurrence of occasional ridges resulting from the joint compound shrinkage or tool marks are permitted. Additional application of finishing joint compound is not practised. Plasterboards finished in line with the Quality Level 1 recommendations are suitable as a substrate for wall linings (ceramic tiles, panels, etc.) and in temporary or technical rooms.

### **Levels of gypsum board finish (Quality Level 2 (Q2))**

The aim of finishing works performed by an assembler of drywall systems at this level is to even up and smooth out the joint surface so that it will make one uniform surface with a plasterboard. This applies also to fixing elements, internal and external angles and other joints. Mudding at the Quality Level 2 includes basic Q1 mudding and repeat mudding with the system-included “mud”: structural – when it is required, and finishing mud until a joint and a plasterboard surface make a smooth, seamless whole. No ridges or tool marks are permitted. If it is necessary, the mudded surfaces should be sanded. The surface which has been treated in such a way is well-prepared for, e.g. wallpaper, structural paints and decorative plaster. After Q2 mudding we cannot exclude that an ultimately finished surface (e.g. painted one) will reveal a visible transition between the surface of drywall cardboard and a surface coated with a mud layer (e.g. on a joint).

### **Levels of gypsum board finish (Quality Level 3 (Q3))**

Gypsum board finish at Q3 Level includes Q2 level mudding as well as mudding the entire surface of the drywall element (joints and cardboard) with the system-included “mud” compounds and skim coats the aim of which is to smooth out the surface and close the micropores, making the texture and absorbability of these surfaces uniform. In this case the thickness of the coat applied is negligible and usually it does not exceed 1 mm. Attaining such an effect is possible only on condition we use steel trowels whose working surfaces are polished and edges - perfectly straight. Possible irregularities of surface, after the coat applied has set, should be sanded delicately with the use of a sanding mesh or sandpaper (grain 200).

### **Levels of gypsum board finish (Quality Level 4 (Q4))**

To meet the highest aesthetic standards of mudded drywall system surfaces, it is necessary to apply a thin coat of gypsum plaster (type: alabaster stuccowork gypsum) to the whole surface. Q4 Level mudding includes manual or mechanical application of a thin plaster layer or a special skim coat to the whole surface of the drywall system element (layer thickness: up to 3 mm). Besides, it is frequently needed to polish the whole layer applied.

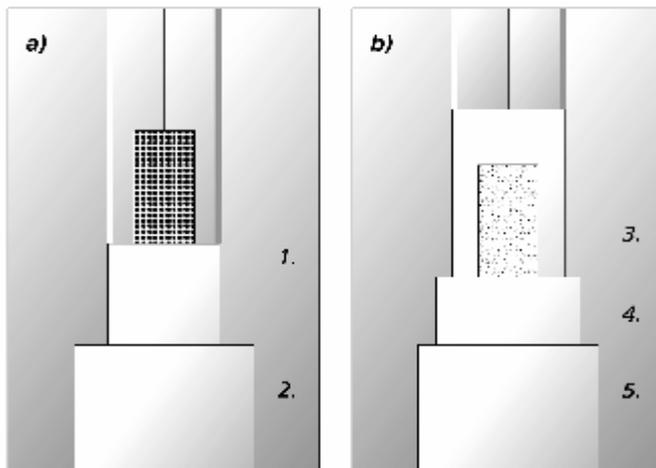
Gypsum board finish of Quality Level 4 is always a result of the class of the interior and the method of its ultimate finish. A wall surface which has been treated like this can be painted with matt paints or wallpapered with thick wallpaper.

### **Preparation of cut edges**

In the case of plasterboards whose edges have been cut, joint filling is more difficult. The “sharply cut” edges, not covered with cardboard, must be joint filled in several stages. To joint fill such edges, the following activities should be performed:

- the plasterboard edge must be bevelled at an angle of 22.5°, to the depth of 50-75% of the board thickness; to this end we must use an assembler’s knife, a rasp or a special chamfer plane,

- the visible gypsum core should be wetted with water,
- a triangle which has been formed between the bevelled edges should be filled with the system-included mud; at the same time a paper tape should be applied in such a way as to prevent its excessive jutting out over the surfaces of joined plasterboards,
- when the first coat has set, another coat of the system-included mud intended for finish mudding should be applied. The width of this coat spreading is ca. 60 cm (30 cm on each side of the joint axis),
- after the previous coat has set or dried up, in order to achieve maximum surface smoothness, sandpaper can be used for additional smoothing of the joint.



*Fig. 5. Stages of plasterboard joint filling*

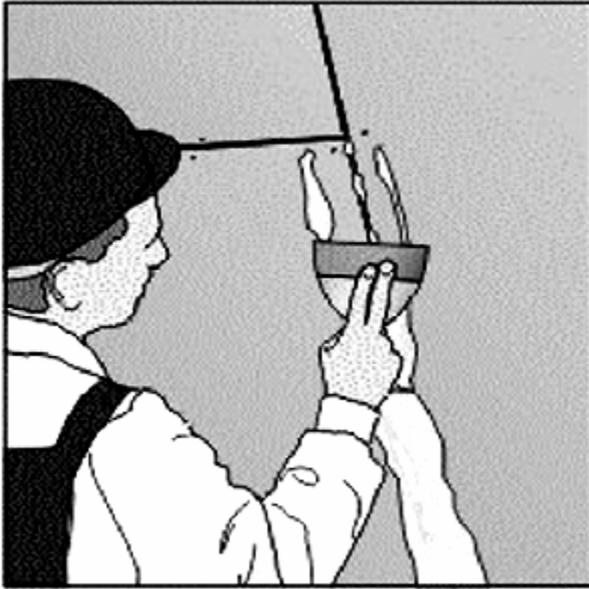
*a) applying a tape to the plasterboard edge and filling the joint with a joint compound (1) when the first layer has dried up – applying the second, thinner layer of the finishing compound more widely (2).*

*b) when a fibre or paper tape is applied, the joint filling process consists of 3 stages: joint filling with a joint compound and pressing a tape into it (3), after it has set – applying a wider layer of the same compound (4) and after it has dried up – applying the finishing mud (5)*

### **Mudding the places of fixing**

Before you start mudding, check whether screws do not stick out of plasterboards. A correctly installed screw should be ca. 0.5 mm – 1 mm below the plasterboard surface. The cardboard next to its head must not be broken. Screws are covered with mud in two cycles: at the first mudding of joints and then at final mudding with a finishing mixture. Screw mudding is performed together with joint mudding.

a)



b)

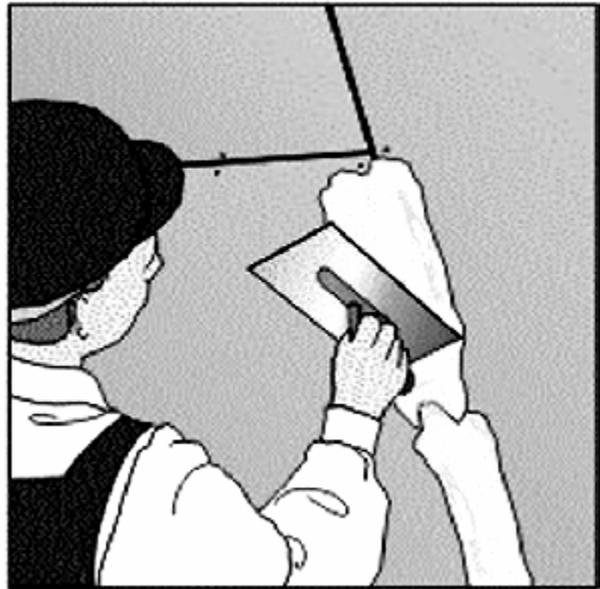


Fig. 6. Joint filling: a) filling with joint compound, b) smoothing out

### **Evaluation of the final effect of works in technology of drywall systems**

Like in the case of majority of construction works, the final effect of using drywall systems depends on each and every stage of their installation. When we talk about the final effect we mean completion of all works connected with drywall system installation, from the moment of the wall positioning until final mudding preceding painting, wallpapering or any other method of finishing the surface.

A number of activities undertaken by the drywall system assembler belong to the so-called “disappearing works”. Therefore, at the moment of the works acceptance some difficulties can occur when it comes to assessing their quality. For this reason the drywall system assembler should realize that whereas careless positioning of a wall or a ceiling will be clearly visible and easy to prove at the moment of the works acceptance, a careless execution of a steel profile structure or fitting the mineral wool insulation will become visible later after the building has been used for some time.

The following “disappearing works” are usually specified when we speak about the installation of drywall system elements:

- making a steel profile structure,
- mineral wool fitting,
- installation of plasterboards and the use of a joint tape,
- joint filling and mudding.

The final effect of the works performed is equally important. A drywall assembler – while performing works - should be aware that during the acceptance procedure of the works he did among the aspects assessed there will be dimensional tolerances for the positioning of planes and edges. Particular attention will be given to:

- deviations of surfaces from the plane, in other words – is the wall surface “corrugated”,
- deviation of the plane edges from the straight line, in other words – are there any deviations vertically and horizontally in the places where two planes intersect, e.g. in internal angles, and external wall angles,
- deviations of surfaces and edges from the vertical direction,

- deviations of surfaces and edges from the horizontal direction,
- deviations of intersecting planes from the angle specified in the documentation.

You can find a detailed description of possible dimensional deviations in a book entitled "Warunki techniczne odbioru i wykonania systemów suchej zabudowy z płyt gipsowo-kartonowych" (Technical standards for acceptance of drywall system installation and execution works - group work, Polskie Stowarzyszenie Gipsu, Warszawa 2010)

### **Finishing works**

To the finished ceiling surface, a coat of primer is applied. Primer helps to eliminate the differences between absorbability of a plasterboard and mud compound. Before further treatment is started, the primer must be dry.

Commonly available dispersion paints are used for painting such ceilings. The paints which contain lime and water glass (liquid glass) should not be used. All commonly available wallpaper types and wallpaper adhesives can be used to wallpaper the ceiling plasterboards. Impregnated plasterboards of the H2 type are recommended for kitchens and bathrooms.

### **4.3.2. Revision questions**

Answering the questions you can check if you are ready for the tasks planned and task completion.

1. What activities are described as "disappearing works"?
2. Identify 5 basic stages of plasterboard joint filling?
3. What are the characteristics of the basic standard mudding?
4. Identify 5 most common errors made during the dropped ceiling installation?
5. What finishing works can be performed on dropped ceilings executed in technology of drywall systems?

### **4.3.3. Tasks**

#### **Task 1**

Perform joint filling on a fragment of a dropped ceiling made of plasterboards and indicated to you by the teacher.

The way to do this task:

To do this task you should:

- 1) get familiar with the dropped ceiling structure on which joint filling is to be accomplished,
- 2) select the quality level of joint filling,
- 3) select the joint filling method,
- 4) organize the workplace for task performance,
- 5) select materials and tools for joint filling,
- 6) perform joint filling of the indicated part of the ceiling,
- 7) present the completed task,
- 8) assess correctness and aesthetics of the task completed.

Workplace resources:

- a fragment of a dropped ceiling made of plasterboards,
- materials for joint filling,
- tools for joint filling,
- reference material from Chapter 6 of Student's Handbook.

## **Task 2**

Finish a fragment of an internal angle between the dropped ceiling made of plasterboards and the wall.

The way to do the task:

To do this task you should:

- 1) get familiar with the place in which the internal angle is to be finished,
- 2) specify the way in which the angle should be finished,
- 3) select the quality level of joint filling,
- 4) select the joint filling method,
- 5) organize the workplace for task performance,
- 6) select materials and equipment for joint filling,
- 7) select materials for finishing the internal angle,
- 8) finish the angle indicated to you,
- 9) present the completed task,
- 10) assess correctness and aesthetics of the task completed.

Workplace resources:

- fragments of a ceiling made of plasterboards,
- materials for joint filling,
- tools for joint filling,
- materials for finishing the angle,
- reference material from Chapter 4 of Student's Handbook.

## **Task 3**

Finish a fragment of an external angle being a fragment of a dropped ceiling made of plasterboards.

The way to do this task:

To do this task you should:

- 1) get familiar with the place, where the external angle is to be finished,
- 2) decide on the way in which the angle should be finished,
- 3) select the quality level of joint filling,
- 4) organize the workplace for task performance,
- 5) select materials for the external angle finishing,
- 6) select materials and equipment for joint filling,
- 7) finish the angle indicated,
- 8) present the completed task,
- 9) assess correctness and aesthetics of the task completed.

Workplace resources:

- fragments of a ceiling made of plasterboards,
- materials for joint filling,

- materials for making the external angle,
- tools for joint filling,
- materials for finishing the angle,
- reference material from Chapter 6 of Student's Handbook.

#### 4.3.4. Progress check

	<b>Yes</b>	<b>No</b>
<b>Are you able to:</b>		
1) identify the characteristics of the basic Q1 mudding?	..	..
2) gypsum board finish quality levels ?	..	..
3) list the stages of the finishing mudding?	..	..
4) identify the types of joint tapes?	..	..

## 5. TEST OF ACHIEVEMENTS

### INSTRUCTIONS FOR STUDENTS

1. Read the instructions carefully.
2. Sign the Answer Sheet with your name and surname.
3. Get acquainted with test tasks.
4. The test consists of 20 tasks of two difficulty levels. It includes tasks of the following types: open, gap-fill, multiple-choice and True/False.
5. Give your answers on the enclosed answer sheet only. Put a cross (X) in the appropriate column or write the correct answer. If you make a mistake, put a circle around the incorrect answer and then put a cross (X) next to the correct answer.
6. The test consists of 2 parts containing tasks of different difficulty levels: tasks 1, 2, 4, 5, 6, 8, 9, 11, 12, 15, 16, 17, 18, 19 – represent the basic level, whereas tasks: 3, 7, 10, 13, 14 and 20 – represent the above-basic level.
7. Work on your own because only then you will get satisfaction of completing the task.
8. When you find answering a question difficult, leave it for a later time and return to it when you have time.
9. You have 90 minutes to complete the test.

Good luck !

### A SET of TEST TASKS

- 1) Identify the most important advantages of dropped ceilings:
  - a) .....
  - b) .....
  - c) .....
  - d) .....
- 2) Identify basic elements of a dropped ceiling structure executed in technology of drywall systems:
  - a) .....
  - b) .....
  - c) .....
  - d) .....
  - e) .....
- 3) The intervals between steel metal screws along profiles in a dropped ceiling are?:
  - a) from 200 to 300 mm,
  - b) from 150 to 200 mm,
  - c) from 100 to 300 mm,
  - d) from 250 to 400 mm.

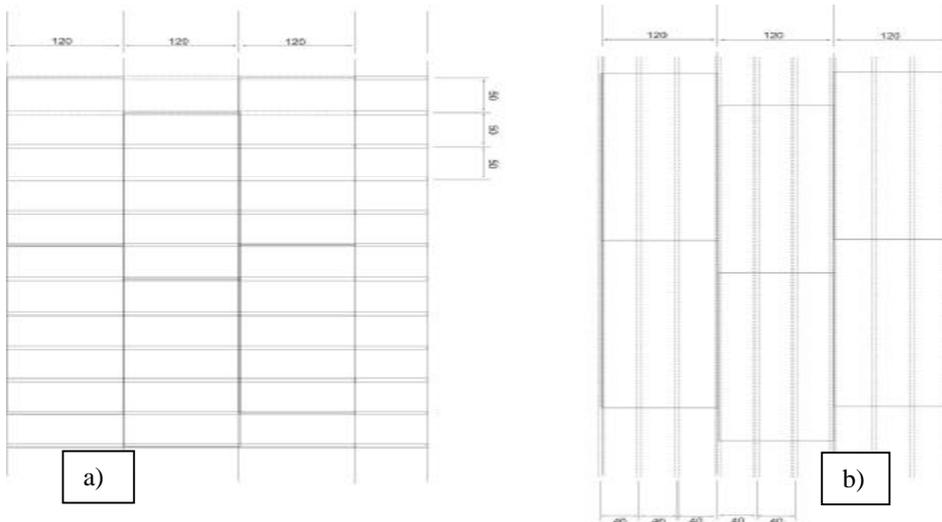
4) Identify the main types of dropped ceiling structures.

- a) .....
- b) .....
- c) .....

5) In dropped ceiling structures, plasterboards are fixed in the following ways:

- a) adhesive bonding,
- b) adhesive bonding and mechanical fixing,
- c) only mechanical fixing,
- d) depends on the type of the structure.

6) Identify plasterboard installation arrangements on dropped ceilings:

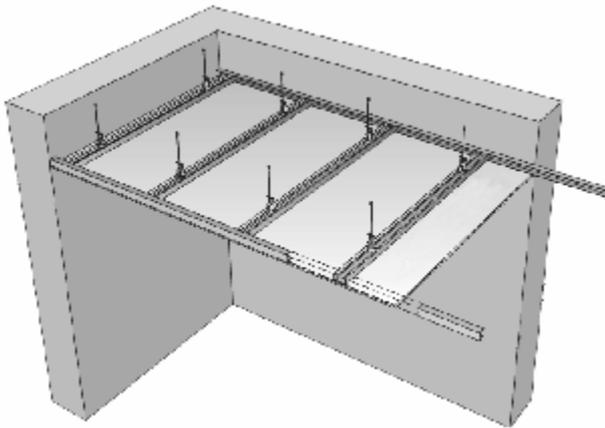


- a) .....
- b) .....

7) What is the direction of plasterboard installation on the ceiling determined by?

- a) the size of the room,
- b) the type of the dropped ceiling structure,
- c) direction of the sunlight,
- d) the shape of the room.

8) The dropped ceiling system depicted in the drawing below is:



- a) a one-level structure,
- b) a wall lining,
- c) a two-level structure.

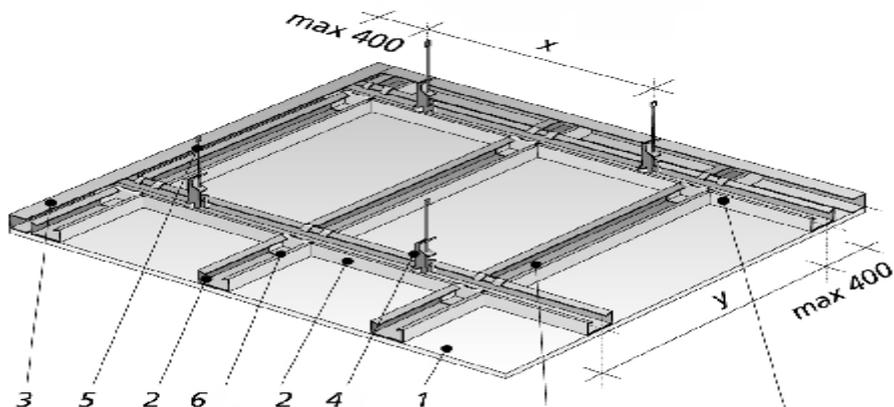
9) What type of hangers is used for fixing dropped ceiling profiles when the distance between the dropped ceiling and the main one is up to 120 mm?

.....,

10) What sets of profiles are most commonly used for constructing ceiling grids:

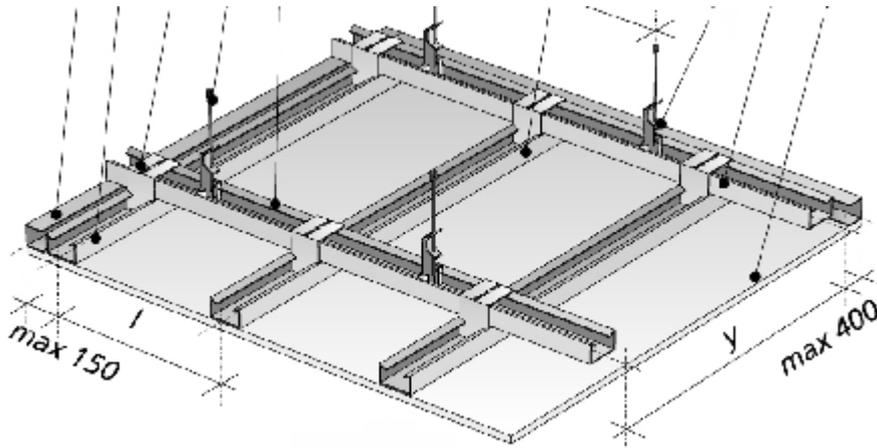
- a) CD, ES,
- b) UD, ES,
- c) CD, UD,
- d) CD, ES, UD.

11) Identify particular elements of a dropped ceiling:



- a) 4 – .....
- b) 2 – .....
- c) 3 – .....
- d) 1 – .....

12) What type of a dropped ceiling structure is depicted in the drawing below?



a) .....

13) The recommended distance between a hanger and a connection of the main layer profiles is:

- a) at least 20 cm,,
- b) less than 20 cm,
- c) from 40 to 60 cm,
- d) below 30 cm.

14) A shift in the adjacent profile joining place should be:

- a) from 40 to 60 cm,
- b) at least 20 cm,
- c) at least 80 cm,
- d) from 60 to 80 cm.

15) Which profiles are used for walls:

- a) ES,
- b) CD,
- c) UD.

16) Plasterboards in ceiling linings are cut to size in such a way as to let their lateral edge rest

- a) in the middle between profiles,
- b) on the profile's end,
- c) in the middle of the profile,
- d) up to 20 cm from the profile.

17) Identify the sequence of joint filling stages for the KS type plasterboard in the gypsum board finish quality level 1:

- a) .....
- b) .....
- c) .....

18. Following the standard QL2 mudding, the gypsum board finish QL3 requires:

- a) elimination of all irregularities on joints,
- b) elimination of all ridges on the entire plasterboard surface,
- c) a thin layer (ca. 1 mm) mudding of the entire ceiling surface,
- d) mudding with a layer of min. 3 mm in thickness.

19. Gypsum board finish Quality Level 4 consists in:

.....

20. Identify basic dimensional tolerances for the positioning of completed planes and edges which will be assessed during the construction works acceptance:

- a).....
- b).....
- c).....
- d).....
- e).....

# ANSWER SHEET

Name and surname .....

## Installation of dropped ceiling systems

Mark the correct answer, write in a missing phrase or an answer.

Question number	Answers				Points scored	
1	a	b	c	d		
2						
3	a	b	c	d		
4						
5	a	b	c	d		
6	a		b			
7						
8	a	b	c			
9						
10	a	b	c	d		
11	a	b	c	d		
12						
13	a	b	c	d		
14	a	b	c	d		
15	a		b	c		
16	a	b	c	d		

<b>17</b>	<b>a</b>	<b>b</b>	<b>c</b>		
<b>18</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	
<b>19</b>					
<b>20</b>					
<b>Total</b>					

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*Bibliography should be updated as new publications appear on the market.*