
NON-STRUCTURAL WALLS - PARTITIONS AND CLOSING ELEMENTS - AND CEMENT BOARD CEILINGS

Tudor Panfil TOADER¹, Carmen DICO²

¹ Research Assistant, N.I.R.D. URBAN-INCERC Cluj-Napoca Branch, tudor.toader@incerc-cluj.ro

² Senior Researcher, N.I.R.D. URBAN-INCERC Cluj-Napoca Branch, carmen.dico@incerc-cluj.ro

ABSTRACT

The process of designing / erecting a new building involves, among others, the identification of the optimal variant for non-structural and / or finishing elements. This choice is made considering several factors, including material and labor costs, the construction duration, the desired finishing degree, the thermal and acoustic comfort offered by various solutions, the seismic area (in terms of construction weight), the expected field of use etc. The choice of the partitioning and closing solution and that of suspended ceilings is one of the potentially important factors involved also in the design and assessment of structural behavior. The purpose of this paper is to present one of the current solutions for the use of these partitioning/closing elements and suspended ceilings with cement boards on metallic or wood structures, usable both indoors and outdoors and providing a number of advantages.

Keywords: partitioning elements; closing elements; cement boards.

REZUMAT

Procesul de proiectare/construcție a unei noi clădiri implică, printre altele, identificarea variantei optime pentru realizarea elementelor neportante și/sau de finisaj. Această alegere se face considerând mai mulți factori, printre care costurile materialelor și a manoperei, timpul de realizare a construcției, gradul de finisare dorit, confortul termic și fonic oferit de diferite soluții, zona seismică (prin prisma greutateii construcției), domeniul de utilizare preconizat pentru aceasta etc. Alegerea variantelor de compartimentare și închidere și a celei de plafoane suspendate este unul dintre factorii potențiali importanți implicați în proiectare și în evaluarea comportamentului structural. Scopul acestei lucrări este să prezinte una dintre soluțiile actuale de realizare a acestor elemente de compartimentare, închidere și de plafoane suspendate cu plăci de ciment, posibil a fi utilizate atât la interior, cât și la exterior, oferind o serie de avantaje.

Cuvinte cheie: elemente de compartimentare; elemente de închidere; plăci de ciment.

1. CONTEXT

It is a goal for the energy policy to reduce the environmental impact. To achieve a high seismic and thermal performance modular lightweight systems are developed, based on lightweight steel structure coupled with cement boards, to provide a safe and high-quality solution for wall and ceiling elements. Thus, in (Iuorio *et al.* 2019), the impact on the environment and energy saving of an innovative modular prefabricated system is analyzed.

The choice of constructive solutions for non-structural elements in buildings is made by design engineers / architects, within the projects they develop. In the past, the elements

used for closing / partitions elements etc. were masonry blocks (concrete, ceramic or AAC blocks). Over the years, a lot of new materials were developed for these elements, which allow their much faster, efficient, cheaper, aesthetical etc. application. Among the materials currently used in these elements, OSB boards, gypsum boards and cement boards can be mentioned.

The paper presents the cement boards, as basic products used for the closing / partition elements and non-structural walls, their characteristics and proposals for execution of these elements.

The main advantages of the boards, due to which they are recommended for use, are:
– they are low-weight, being easy to handle;

- they considerably reduce the execution time of the elements they are part of, in relation to their execution out of masonry blocks; studies on labor productivity with different types of such boards (with different thicknesses and widths) are made in the literature (van der Molen *et al.*, 2007).
- they considerably reduce labor costs;
- due to the smooth surfaces of the elements resulting from their assembly, an aesthetic, quality finish can be achieved; it should also be noted that the cement boards support ceramic cladding with weights up to 50 kg per m² of wall;
- the boards, based on cement, are resistant to high humidity and water, keeping their initial characteristics; also, being made of inorganic materials, there is no risk for the development of mold or other fungi;
- cement boards are manufactured in two assortments, both for interior and exterior; the boards for outdoors (with special additions) are also characterized by resistance to the action of atmospheric agents (wind, rain, snow, frost-thaw);
- they contribute to a good seismic behavior of the building they belong to, due to their low mass.

2. CONSTRUCTIVE ELEMENTS MADE WITH CEMENT BOARDS

The components of partition and ceiling elements made of thin cement-based boards are:

- Indoor and outdoor boards, made from Portland cement and mineral aggregates. On both sides, the boards have embedded alkali-resistant fiberglass nets. The outdoor boards also contain an amount of expanded clay.
- Metal or wooden profiles, horizontal and vertical, which are used to create the supporting structure of the cement boards.
- Self-tapping screws for the mechanical fastening of boards, on wooden or metal structure, with sheet thicknesses up to 0.7 mm; self-drilling screws for the mechanical fastening of boards on metal

profiles with thicknesses from 0.8 mm to 2 mm. The screw heads are protected with a special layer against corrosion.

- Polyurethane adhesive for joints-to walls and interior claddings - product under the form of a paste, based on polyurethane resins, which is applied when mounting, to the joints between the boards, to walls or cladding.
- Primer - in liquid form, based on synthetic resins in aqueous dispersion, used to even the absorption of surfaces in the case of the finishing of boards with ceramic tiles.
- Adhesive mortar / base coat, with mixed use, applicable in joints and also in a continuous layer on the entire surface of the boards.
- Surface finishing, which can be paint, decorative coat, ceramic tiles, wallpaper etc.

The specific fields of use for cement boards for indoors are the following:

- non-load-bearing partition walls, indoors, in dry or spaces with humidity (bathrooms, kitchens, toilets),
- walls for closing technical spaces (elevator gaps, gutters, wells),
- cladding of the construction elements in indoor spaces (cladding of massive concrete or masonry walls) and
- suspended ceilings.

The specific areas for cement boards used in outdoor spaces are:

- outdoor claddings, as support for facade plasters,
- renovation of existing (ventilated and unventilated) facades and
- exterior ceilings (on the underside of some concrete slabs located outdoors).

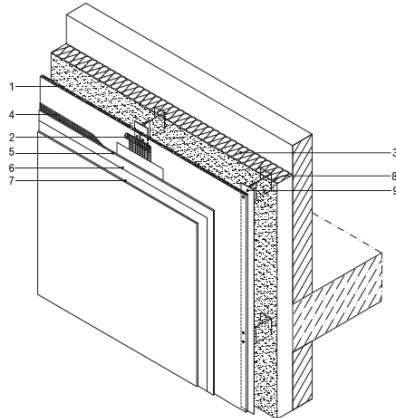
By the use of cement boards for non-structural elements inside and outside of buildings, a wide variety of wall, ceiling and cladding systems can be obtained. Some solutions are presented below:

a) Outdoors

- Cladding of concrete walls and / or of masonry walls with cement boards for

outside spaces, fixed directly to the wall (Figure 1)

- Reinforced concrete and / or masonry wall cladding, with cement boards for the exterior, fixed to the wall by means of a load-bearing structure made of wood, galvanized metal profiles or aluminum, thus creating ventilated



Legend:

1. Cement board
2. Jointing material
3. Thermal insulation product
4. Reinforcement
5. Base coat
6. Primer for decorative coat
7. Decorative coat
8. Sealing tape
9. Metal profiles

Fig. 1. Exterior cladding of the facade, on aluminum or galvanized steel structure (KNAUF)

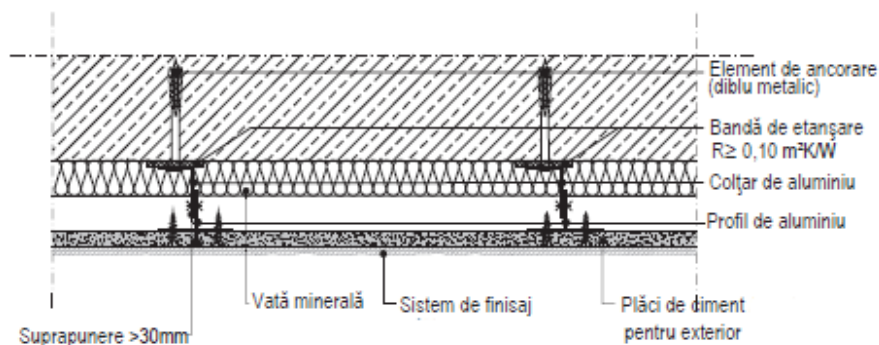
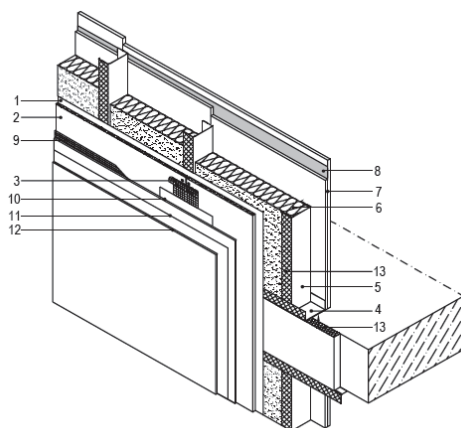


Fig. 2. Ventiladed facade – horizontal section (KNAUF)



Legend:

1. Diffusion foil
2. Cement board for outside
3. Jointing material
4. and 5. Metal profiles
6. Thermal insulation product
7. Board for inside
8. Vapor barrier
9. Reinforcement
10. Base coat
11. Primer for plaster
12. Plaster
13. Sealing tape

Fig. 3. Exterior wall made between concrete slabs, on a simple metal frame, over which the external thermal insulation composite system (ETICS) is applied (KNAUF)

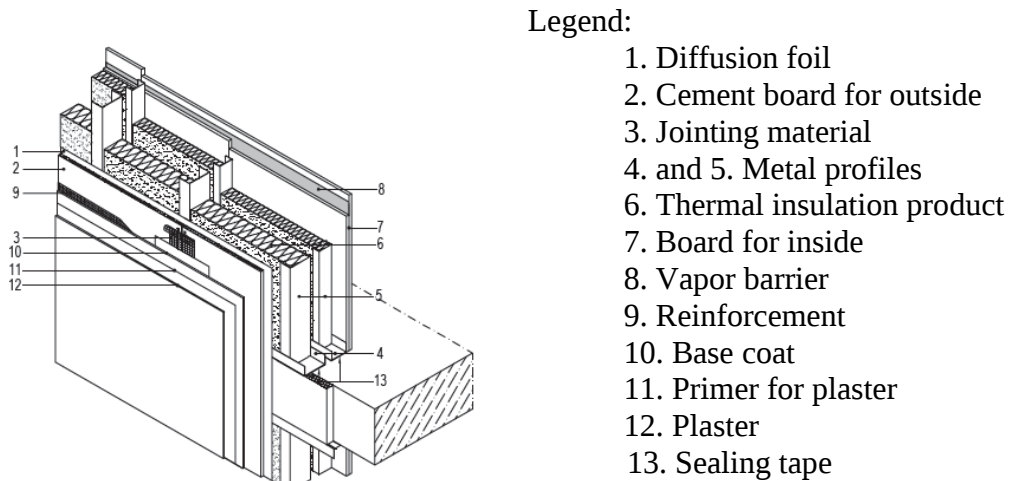


Fig. 4. Exterior wall made between concrete slabs, on a double metal frame, over which the external thermal insulation composite system (ETICS) is applied (KNAUF)

- Self-supporting exterior walls with double load-bearing metal structure, one of which is arranged between the concrete slabs, and one is continuous on the facade, made of cement boards located on the outer face of the continuous metal structure, on the entire height of the exterior structure. In this case, an additional metal structure fixed in the resistance concrete slabs, consisting of laminated profiles, dimensioned to take the loads from the

weight of the wall, and also those from the wind, placed outside is required (Figure 5).

- Outside ceilings (cladding of the underside of outside concrete slabs), made of one or two layers of exterior cement boards, mounted on a support structure (fixed to the concrete slab) of wooden rulers or metal profiles, fixed with metal flanges (Figure 6).

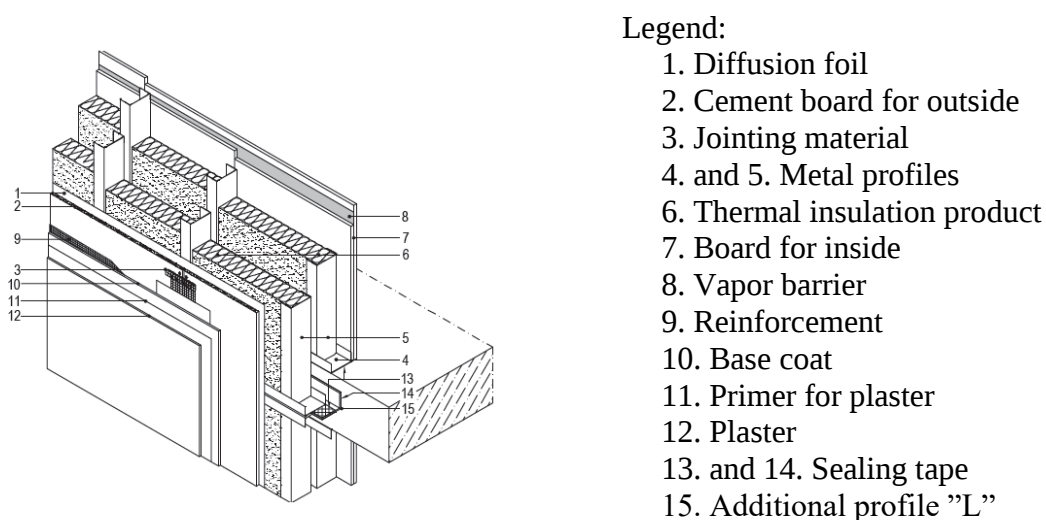


Fig. 5. Self-supporting exterior wall, consisting of two metal structures, one on the outside (continuous on the facade) and one on the inside (between the floors), over which the ETICS is applied (KNAUF)

- b) At the inside of the building:
- Partition walls, which may consist of one or two layers of cement boards,

mounted on the faces of load-bearing wooden or metal structures (single or double metal structure). The walls can

be filled inside with thermal insulation / sound-absorbing products, in order to improve thermal / acoustic comfort.

The main details for such walls are shown in Figures 7 to 10.



Fig. 7. Wall of cement board (one layer), on a simple metal structure (KNAUF)

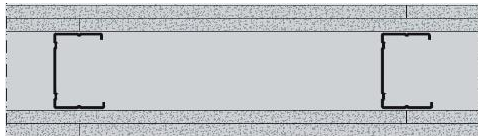


Fig. 8. Wall of cement board (two-layer), on a simple metal structure (KNAUF)

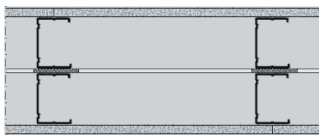
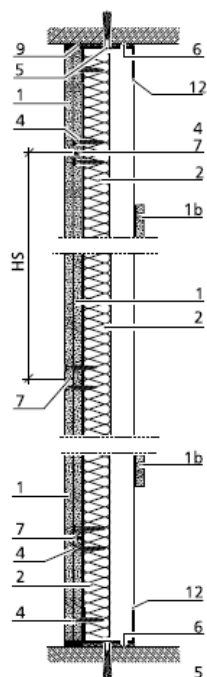


Fig. 9. Wall of cement board (one layer), on a double metal structure (fixed between them) (KNAUF)



Fig. 10. Wall of cement board (one layer), on a double metal structure, distant (KNAUF)

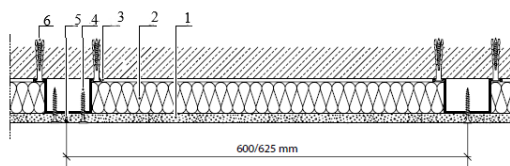
- Walls for closing technical spaces (wells / lifts / gutters), also made by cladding a simple metal structure with one or more cement slabs, mounted only on one side of the load-bearing structure (Figure 11);
- Interior cladding of concrete and / or masonry walls, single or double layers, mounted on a metal structure fixed to the front of the cladding wall. Thermal / sound insulation can also be provided inside the metal structure, in order to improve the thermal / acoustic comfort (Figure 12);
- Interior ceilings, made of one or two layers of cement slabs, mounted on a support structure (fixed to the concrete slab), of wooden rulers or metal profiles, fixed with metal flanges (Figure 13).



Legend:

1. Cement board;
- 1b. Mounting strip;
2. Thermal insulation product/fonoabsorbant;
3. Vertical metal profile;
4. Mounting screws;
5. Anchor element in the floor;
6. Sealing / insulating tape;
7. Glued joint;
9. Flexible putty;
12. Horizontal metal profile fixed in reinforced concrete slabs.

Fig 11. Technical space wall, double clad, on metal structure, with thermal insulation behind the boards (KNAUF)

**Legend:**

1. Cement board
2. Thermal / sound insulation
3. Hanging profile
4. Screws
5. Joint sealed with polyurethane adhesive
6. Fixing anchor in the concrete slab

Fig. 12. Reinforced concrete wall clad inside with cement boards, on metal structure (KNAUF)

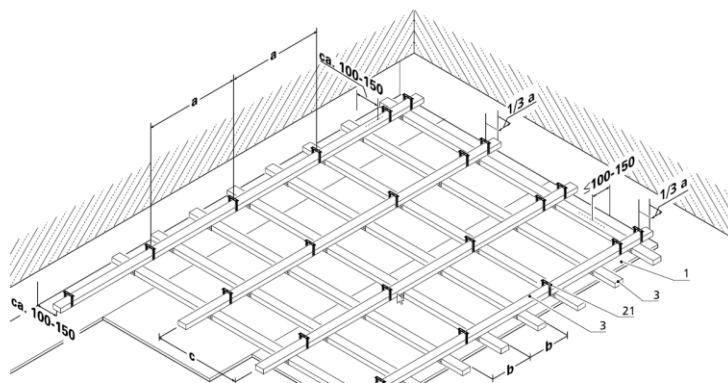


Fig. 13. Indoors ceiling, with cement boards fixed on wooden slats (KNAUF)

3. PERFORMANCE, RESULTS AND DISCUSSIONS

Cement boards have physico-mechanical characteristics that recommend them in the specified uses above, as follows: being cement-based materials, they are non-combustible, having a fire reaction class A1 and a relatively high mechanical resistance to bending, of over $6 \text{ N} / \text{mm}^2$. Their apparent density of approx. $750 \text{ kg} / \text{m}^3$ (boards for indoors) and approx. $1150 \text{ kg} / \text{m}^3$ (boards for outdoors) ensures normal maneuverability during installation and good performance over time. Resistance to water vapor permeability ensures the indoor hygrothermal comfort. The appearance of the tile surfaces is smooth. The thickness of the interior and exterior boards is 12.5 mm, their width is 1200 mm, and their length is variable, between 2000 mm and 2800 mm.

The walls and ceilings made with these boards ensure a thermal insulation depending on the thermal insulation type and thickness embedded in the construction elements, the cement boards having a thermal conductivity coefficient of approx. $0,35 \text{ W/mK}$.

The construction elements achieved with these cement boards contribute to a certain extent to the protection against noise depending on the total thickness of the wall, the nature of the supporting structure (wood or metal, single or double structure), the density and thickness of the sound-absorbing layer. The airborne insulation index of construction elements made of cement slabs varies between 38 dB and 63 dB.

At the NIRD URBAN INCERC Laboratory, Cluj Napoca Branch, some of these physical-mechanical characteristics were verified, and the obtained results confirmed the compliance of the declared characteristics and also the advantages of using the cement slabs, both mechanically and from the point of view of the assurance of the internal hygrothermal comfort.

Cement boards, assembled into numerous construction elements, can ensure their fire resistance, in the range of 30 to 120 minutes, depending on the number of cement slabs provided, the total thickness of the construction element (of the walls), the type of load-bearing structure (wood or metal) and the

existence of non-combustible thermal insulation inside the element.

Also, the fire resistance of construction elements made of cement slabs is influenced by the additional protection of joints between slabs with strips (cut from cement boards) that are located behind the joints and ensures a tightness of these, to the action of flames, through the so-called "the back-blocking technique" (Ariyanayagam *et al.*, 2016). This technique has been studied on a wall made of joining gypsum boards, but it remains valid in the case of ensuring the fire resistance of the walls made of cement boards, too.

Using of some types of closing elements, partition elements, ceilings achieved of cement boards on metallic or wood structure, a significant reduction in the total mass of the construction is obtained, improving its seismic behavior. In (Macillo *et al.*, 2017), the authors investigate from the point of view of rigidity and resistance to seismic actions the behavior of several wall light structures from metal profiles, used together with these types of boards. The article presents the results of an experimental program on these metal profile systems, in different configurations, subjected to monotonous or cyclic loads.

There are also studies in the literature regarding the behavior of light metal ceiling structures, as diaphragms, in case of earthquakes or under the wind action.

4. CONCLUSIONS

The durability of the cement board elements is ensured by their performance: high mechanical resistance, resistance to mold, moisture, water resistance, impact, frost-thaw etc.

Partition walls, enclosures, ceilings, as nonstructural construction elements made of cement boards, relatively light, do not significantly influence the strength and stability of the building in which they are placed. The cement board fixing system (on metal or wooden structure), fixed in the construction load-bearing elements, shows stability under gravitational or pulling loads.

Put in place, the cement boards are a stable supports for all kind of finishes: ceramic tiles, plasters, paints, wallpaper.

REFERENCES

1. Iuorio O., Napolano L., Fiorino L., Landolfo R., *The environmental impacts of an innovative modular lightweight steel system: The Elissa case*, Journal of Cleaner Production 238, 2019.
2. van der Molen F.H., Mol E., Kuijer F. M. P. P., Frings-Dresena H. W. M., *The evaluation of smaller plasterboards on productivity, work demands and workload in construction workers*, Applied Ergonomics 38, 681–686, 2007.
3. Ariyanayagam D. A., Kesawan S., Mahendran M., *Detrimental effects of plasterboard joints on the fire resistance of light gauge steel frame walls*, Thin-Walled Structures 107, 597–611, 2016.
4. Macillo V., Fiorino L., Landolfo R., *Seismic response of CFS shear walls sheathed with nailed gypsum panels: Experimental tests*, Thin-Walled Structures 120, 161–171, 2017.
5. Saifullah I., Gad E., Shahi R., Wilson J., Lam N., Watson K., *Behaviour of plasterboard-lined steel-framed ceiling*, Thin-Walled Structures 141, 2019.
6. KNAUF, Catalog Systeme Knauf, https://www.knauf.ro/uploads/system_downloads/595214876501d.pdf