Fono-insulating mobile wall partitionings within educational spaces

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ABSTRACT
The purpose of this paper is to study the movable walls starting from the decorative partitions of the 7th century to the contemporary partition walls and the creation of soundproofing walls for the partitioning of the spaces for education. In the educational units it is useful to partition with soundproofing walls because the resulting spaces would be diverse and could help organize the activities specific to each institution. The impact of HPL (High Pressure Laminates) in certain educational units, where random change is required, is being watched and then a practical example of their implementation is detailed.

Keywords: decorative screens, mobile walls, materials, soundproofing, educational spaces, HPL

I. INTRODUCTION

The paper proposes to study the evolution of the mobile walls based on the principle of the functioning of the 7th century folding panels and the possibility of introducing them into the compartmentalization of the learning spaces. For this, the fifth floor of the Faculty of Architecture and Urbanism was studied, aiming at the creation of flexible organizational spaces through a continuous change dictated by the temporary needs and functionalities connected with various school activities (exhibitions, presentations, seminars, courses, recreation place). The 5th floor is rigid and slightly electrically-powered, but its transformation is intended to be modern and innovative with the integration of special mobile partition walls.

II. THE EVOLUTION OF THE DECORATIVE SCREENS. THE RELATIONSHIP BETWEEN PARAVANES AND MOBILE WALLS

II.1. The historical evolution of the screens

Ever since ancient times, man has felt the need for privacy and has used decorative screens to create spaces for meditation or to individualize areas in a larger space. These screens (folding panels) appeared in the 7th century in China and Japan and served several purposes: serving tea, as well as decorating concerts, dancing, a place for Buddhist rituals, and in the process of outdoor pursuits.

The screen was made of paper and textiles. It was painted in ink and natural pigments with oriental arabesques, framed in a light but robust wood frame; the type of folding differed according to the purpose of its use. Thus, the two fold-down screens were used at the tea ceremony, and the large screens, with up to eight folds, decorated with golden leaves served as a background for dancing (Fig. 1) [1].

The main types of Japanese screens are:

• Byobu - windshield (Fig. 2), consisting of two, six or even eight solid panels made of silk or paper, with bamboo-mounted hinges and used as a room separator or decoration for special occasions [1];

• Tsuitate - a small screen, consisting of a single panel of paper, wood or silk, is placed on a wooden or two-legged wood (truncated elephant) wood, richly ornamented with varnished frames and elaborate paintings; was used as a room separator or at the entrances in the 7th century (Fig. 3) [1];

Fig.1. Dance background wallpaper [1]

Fig. 2. Byobu windshield [1]

Fig. 3. Tsuitate screen [1]

• Fusuma - sliding doors with windows made of rice paper on wooden structure (Fig. 4) [1];

Fig. 4. Fusuma sliding doors [1]

• Shoji - is the modern term used for "washi" paper translucent doors or windows that best reflects natural light, mounted on a wooden frame, designed to be folded (Fig. 5, 6) [1];

Fig. 5, 6. Shoji [1]

• Tobosuma - wooden sliding screens;
• Sugido - cedar frame frames.
Introduced in Europe in the fourteenth century, the screens have attracted Europeans not only by beauty and utility, but have also shown a special interest in the folding system and their make-up technique, so they have accommodated their own needs and purposes. For example, the Jesuit missionaries considered the shape of suitable screens for the teaching of Western geography (Fig. 7), religious customs and beliefs [1].
At first, the screens had little impact on Western art. Then, European artists began collecting, being inspired and reproducing them, taking a period of revitalization of decorative arts, inspiring interior design and eventually becoming an indispensable decorative element in homes with aesthetic claims.

In the seventeenth century, the European wallpaper was not fixed directly to the frame, but after it was reinforced on a canvas or canvas support, it was stretched and supported by a frame (Fig. 8). Until the nineteenth century, the popularity and diversity of screens led to the spread of folded and hand-made panels [1].

Fig. 7. Geography teaching screen [1]

Fig. 8. Wallpaper screen [1]

II.2. Typology of contemporary screens

The screen, as a tool for separating the meditation break from everyday life, has a continuous transformation and utility in creating new spaces, evolving from the standard size of 1.80 m up to the height of a wall [3].
It becomes a fixed wall with a casting and decorative aspect over time and is used successfully

in home interior designs (Fig. 9, 10).
In art galleries, the wall is vertically anchored on a pulley system, and on the horizontal it is driven by wheels fixed to the base, changing their position depending on the event (Fig. 11).

Fig. 9. Fixed partition wall anchored by the ceiling and floor [4]

Fig. 10. Fixed partition wall [5]

Fig. 11. Mobile wall mounted on a pulley [6]

In offices and public spaces, mobile walls can organize the room, delimit areas through a well-thought ceiling-mounted rails system (Fig. 12).
Thus, the basic principle of the oriental decorative screen is used in our day with success, being adapted to the proportions required by the society we live in.
The movable walls are composed of panels that can move and interlock to form a partition wall and contain door or window openings. This solution allows for the most complicated configurations with minimal effort with the possibility of parking the panels outside the opening area. In addition, once the wall is closed, the panels offer all the properties and appearance of a permanent partition [8].
In principle, there are three types of mobile walls:
- Foldable mobile walls - "harmonic" type (Fig. 13)
- Sliding movable walls (Fig. 14)
-Vertically folding mobile walls (Fig.15)

Fig. 12. Mobile wall using ceiling-mounted rails system [7]

Fig. 13. Foldable mobile walls-"harmonic" type [9]

Fig. 14. Sliding movable walls [10]

Fig. 15. Vertically folding mobile walls [11]

With the mobility of the walls, it is easy to change a space, making it more attractive and brighter, using individual panels completely removable with veneer, melamine, wallpaper, textile, partially or fully glazed, with different sound insulation coefficients.

III. INTEGRATING MOBILE WALLS IN EDUCATION UNITS. CASE STUDIES

Mobile walls are produced and implemented abroad, creating the world's most veritable and attractive project solutions: spacious solutions for offices (public or private), education, restaurants, fairs, event rooms, churches and mosques.

Below I will present some examples of teaching units where the mobile walls have been integrated.

COLFE GRAMMER SCHOOL, LEWISHAM, ENGLAND - A first example relevant to the introduction of mobile walls in a space for education dates back to 1891 is the Colfe Grammer School in Lewisham, England, where in the hallway (polyvalent common space) around which the rest of the functions are articulated, three class rooms open to it (by moving some moving walls), resulting in a flexible space, configurable in some variants [14] (Fig. 16).

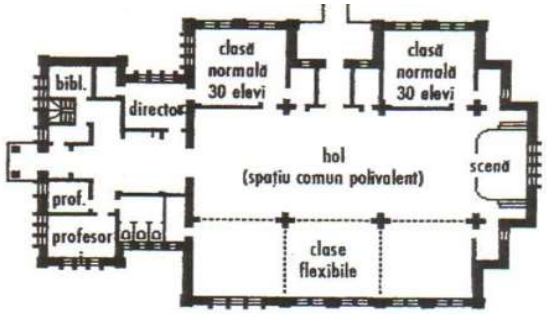

Fig. 16. Colfe Grammer School [12]

THOR HEYERDAHL COLLEGE-LARVIK, NORWAY

Thor Heyerdahl College is a modern and innovative educational institute, being one of the largest buildings in Norway. This institute focuses on innovation and stimulates the integration of different disciplines and social classes, improving social equality. The building has a modern architecture, characterized by transparency and multifunctionality. Thus, on a large portion of the central area of the building, secured glass partition walls are applied having the bottom and top plinth / pan fasteners applied together, the panels sliding together along a face- ceiling. In the classrooms, mobile walls are made of fully removable individual panels with sound absorption coefficient, laminated and painted composite finish, sliding silently along the ceiling-mounted treadmill without the need for a floor guide rail [13-15] (Fig. 17, 18).

Fig. 17, 18. Movable glass walls and HPL (High Pressure Laminates), colored [13]

THE HAGUE UNIVERSITY OF APPLIED SCIENCES DELFT - At the University of Delft, classrooms have the ability to change according to the number of students attending the course. The panels are individual, fully removable, with sound absorption coefficient, laminated composite finish, sliding silently across the ceiling mounted treadmill (no need for a floor guide rail) (Fig. 19).

Fig. 19. Mobile wall finished with laminated composite material [16]

UTRECHT UNIVERSITY, NETHERLANDS - The University of Utrecht has integrated some sliding and folding walls in the arrangement (Fig. 20). They are formed from a series of flat panels (each up to 900 mm wide) hinged together by hinges to provide a flat-faced appearance when closed. The panels are handled either by ceiling mounted rails or a very discreet profile on the floor. Sound attenuation is achieved through modern manufacturing methods, with a unique construction of the slopes, consisting of an aluminum frame, panels and multi-layer interior of sound absorbing material [17].

Fig. 20. Folding-sliding wall [18]

USC GALEN CENTER-CALIFORNIA, USA - Galen Center is a multifunctional sports center owned and operated by the University of Southern California. The sports ground is very large and can be used at the same time by more athletes without disturbing each other, thanks to vertical wall systems that climb and descend mechanically by folding, dividing the arena into several areas. These pliable wall systems are made of wood, consisting of narrow strips of agglomerated particle board, fixed continuously by plastic hinges. They can be made in one row or two rows of panels, with metal reinforcement metal hinges, to provide improved acoustics and greater stability [19]. When the panels are lowered, the image is perfectly flat and has the appearance of a wall (Fig. 21,22).

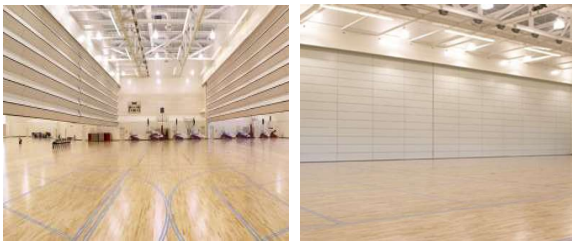

Fig. 21, 22. Vertically folding walls [20]

IV. APPLICABLE EXAMPLE: INTRODUCTION OF FONO-INSULATING MOBILE WALLS IN THE INTERIOR DESIGN OF THE 5TH FLOOR OF F.A.U.T.

Most of the spaces for university education have been designed a long time ago, and they need a change because they do not fully meet the current flexibility requirements generated by the simultaneous or successive use of groups of students, significantly different in number and for completely different activities in terms of spatial configuration.

One of these cases is represented by the fifth floor of the Faculty of Architecture and Urban Planning in Timisoara, a space chosen as a subject to check the possibility of deploying mobile partition walls as a potential solution to the aforementioned problems.

Now the floor is made up of two areas of activity. The first one is located on the left side of the entrance, consisting of a generous recreation hall, lift house, an amphitheater, a classroom, an office, sanitary groups, technical space and two offices for teachers. The second area is on the right and includes the workshops. The present study of integrating soundproofing movable walls to improve the functionality of the space will focus on refurbishing the first area, excluding the workshops. As it can be seen, the space is very rigid, there is no possibility of change, the classrooms are fixed, the only flexible place where one can arrange exhibitions or presentations is the lobby. Being an architecture faculty with a technical, yet artistic-humanistic and therefore creative specific, this implies an increased variation in activity towards a faculty with a strictly humanistic or strictly technical profile.

Living in the age of technology, projects are not made exclusively on paper, and rarely on the floorboard. They are predominantly digital, computer-based, each student coming with personal laptop. This requires many sockets, and faculty has not been designed with so many to reach every student. Finally, the project is submitted, exposed and supported on the analogue paper format, and for this it takes a large exhibition space with enough vertical exposure panels. Thus, the current compartmentalization (Fig.23) does not allow the privacy of a restricted discus-

sion, nor does it ensure the need for sockets for a large number of students, nor does it have the minimum exhibition support necessary for the organization of a design presentation. For this reason, in order to obtain an organized space so as to be flexible and easily configurable in as many variations, it will be further shown the use of two types of movable walls considered suitable to obtain a subdivision of the fifth floor according to the intentioned purpose (Fig. 24).

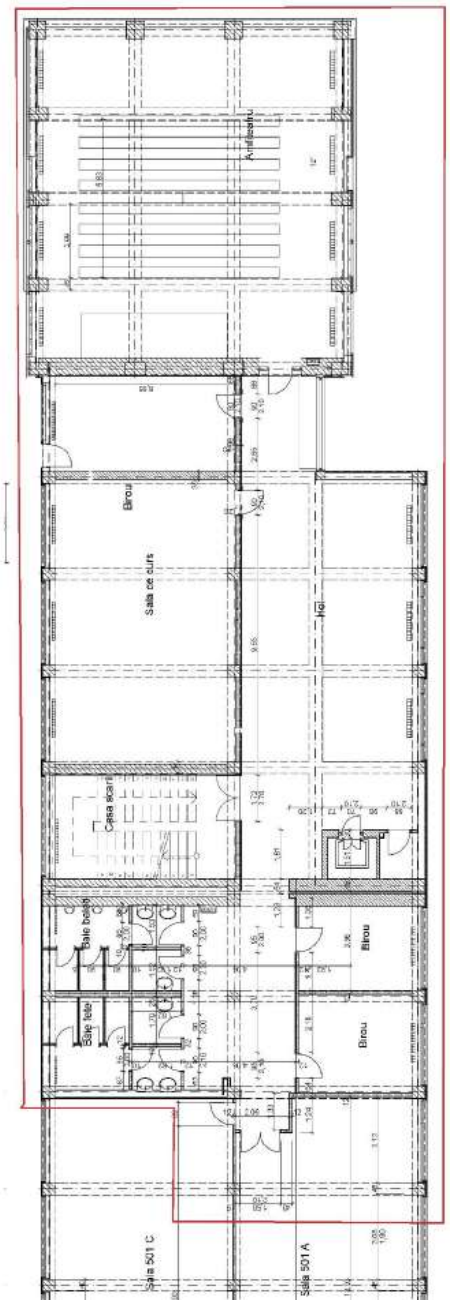

Fig. 23. 5th floor - studied area

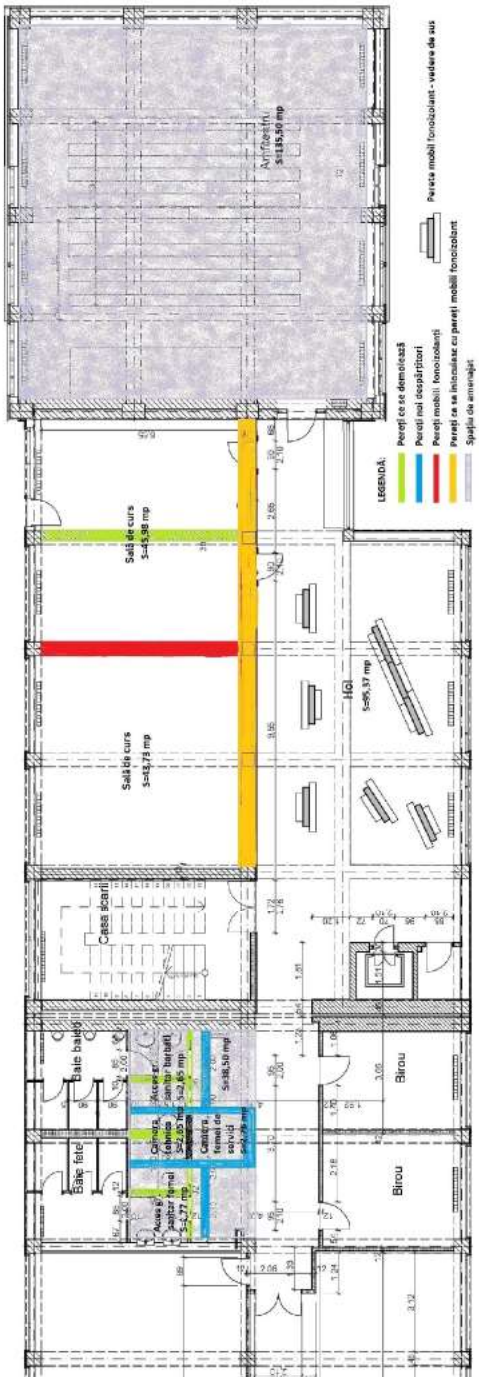

Fig. 24. Reconfiguration of the space and installation of soundproofing walls in the hallway

Mobile walls made up of individual and fully removable panels that work on a ceiling-mounted rack system and do not require a floor guide system. Panels are pushed very easily into an end of the room (parked), sit on top of each other, opening the space. [14,15]. In this case,

the opening is fixed, the panels can only move to the left or to the right, with only two variants available, the space found closed or open, large or small, which is a limitation regarding the freedom of spatial configuration (Fig. 25).

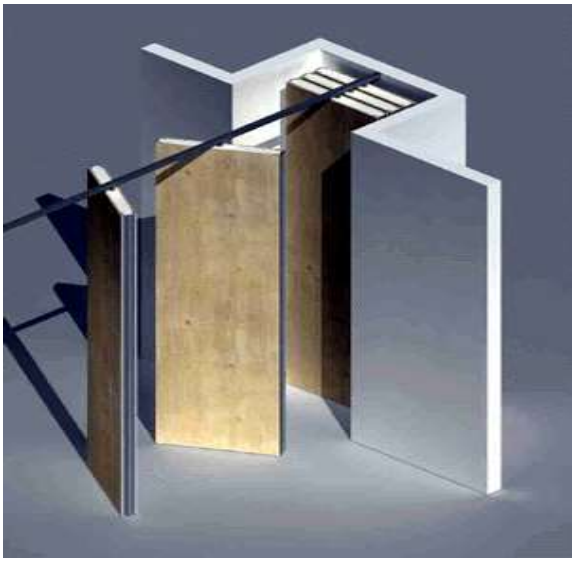

Fig. 25. Mobile panel system [21]

Exhibition mobile walls that are composed of a panel (wall type) that can be trapped in a ceiling pivot for vertical stability and for horizontal displacement mounted at the base of some wheels or can be mounted only on wheels , the anchoring area in the ceiling may be missing. On this type of wall, the material from which it is made and the thickness may be different, but the main disadvantage is the empty space above the surface, which prevents the sound tightness of simultaneous activities in the adjoining spaces without any acoustic discomfort (Fig. 26, 27, 28).

Fig. 26. Mobile wall mounted on a pulley [6]

Fig. 27. Mobile wheeled exhibition wall [22]

Fig. 28. Mobile wall on hidden rolls [23]

In these examples the panels are much more mobile, different configurations can be made, but the space can not be closed and especially can not be soundproofed because there is no gripping system and ceiling and the free space at the base is too large.

For a faculty of architecture, the two types of mobile walls presented would still be too rigid, requiring more mobility that can be given not only by closing and opening spaces or by actually exposing, but by generating with these walls multiple spaces, different in each case, with multiple uses. The ceiling, with its differing heights given by the presence of the beams, could create a problem in choosing the rail path of the wall, and the pulley system would be too fixed. That is why, through this study, I propose a combination of the movable walls made of individual panels, completely demountable, and the mobile walls used in exhibitions, in the art galleries. The result could be innovative: the removable, mobile walls are moving on wheels, fitted at the top with an inflatable system (airbag-type cushions) and an integrated electrical system (lighting at top and electric plugs at

bottom), connectable to floor-mounted power sockets (Figure 29), having the same technical specifications as those of the mobile walls shown above.

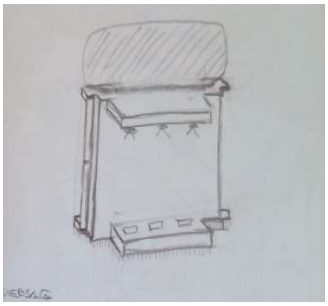

Fig. 29. Draft-concept: soundproof mobile wall

The airbag system acts as a sound insulator on the side between the panel and the ceiling or beam and will be operated manually when the panels are joined together, and the base will be fitted with a set of brushes on the perimeter. For stability, the panel will be wider at the bottom, where the sockets will be embedded, and at the top the same width will mask the inflatable system and the inserted lights for the lighting from above, or even become a "light wall". The wall thus created will be called a "soundproof mobile wall" (Fig. 30, 31).

Fig. 30. Soundproof mobile wall

The soundproof mobile wall panel will have a width of 0.62 cm and a height of 2.70 m. The inflatable system will increase until it encounters the first obstacle, the beam or the ceiling, respectively 0.38 cm or 0.06 cm.
The soundproofing walls will be made of HPL (High Pressure Laminates) white matt and colored "door" panels, with a wheel lock mechanism with sound absorbing material and an internal electrical system. HPL (High Pressure Laminates) is a material composed of multiple layers of phenolic (plastifiable) resin impregnated kraft paper bonded to high pressures and temperatures, resulting in a rigid and homogeneous material [24-25].

Fig. 31. Soundproofed mobile wall with inflatable system

The flap and groove joint of the soundproof movable walls is provided with gaskets and offers the possibility of joining the panels in a straight line or at an angle of 90, and their attachment to the floor will be done by a proper wheel lock system. The mobile walls will have built-in electrical sockets and lights, and the gray inflatable will be wrapped inside the wall and masked by the top of the wall. The space created will consist of such panels, with a perfectly flat surface, and access to the room will be done by pushing the soundproof movable wall that will act as a door. This "door" will be colored to always recognize its function.

V. CONCLUSIONS

Any visual change in a space where you spend more time is beneficial to human behavior, but if change also implies a usefulness, it becomes attractive from all points of view.
In education facilities, space is very important, so it has to be thought and organized with care. Soundproofing walls offer mobility and acoustic comfort to the space, and can be organized dif-

ferently depending on the size and specificity of the activities taking place there.
Of course, this type of wall is not necessary for any educational unit, because not in all cases there is a real need for reversible and successive remodeling and reconfiguration of space.
In other cases, different from the framed structure analyzed in the present paper, the bearing structure does not allow the masonry walls to be replaced, as long as they have a structural role. That is why specific compartmentalization must be chosen in order to suit the individual context of each learning space.
At the same time, the presence of significant discontinuities at the ceiling (especially the apparent beams) creates difficulties for the system of mobile walls presented at the level of the tightness and appearance of the inflatable subassembly, especially when it is desired to arrange such a transverse panel on the track of a beam or the joining of two or more ceiling areas at different elevations, which is a limitation in the use of the system.
However, in the context of the existence of a ceiling with a high degree of uniformity in relation to the difference in dimensions - the ideal case being the one without bumps - and a sufficiently large number of sockets disposed in the floor, the system of soundproofed movable walls in any direction , equipped with lighting and sockets and "clothed" in the proposed material can be a feasible solution for fast and efficient reconfiguration of the spaces for the didactic process and its complementary functions.

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