

Plaster Layout Process in Civil Works with a Focus on Clean Production

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Abstract— *The constant expansion of civil construction and the increasing use of plaster gives rise to a solid waste generation problem causing difficulties for the disposal or reuse of this material. The generation of plaster waste represents an economic problem, with serious consequences and impacts. In order to contribute to sustainability, this study sought to evaluate the reduction of plaster waste in an apartment construction project, employing the layout method. With the adequate arrangement of plates, a reduction of 4.41% in the use of plaster could be obtained. This reduction will consequently result in the minimization of waste from civil works, bringing invaluable economic and environmental benefits.*

Keywords—*Drywall, layout, sustainability, waste minimization.*

I. INTRODUCTION

The gypsum mineral, the raw material for the production of plaster, is composed of calcium sulfate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), occurring naturally in various regions of the world and having a broad and diversified field of uses. The great interest in gypsum is attributed to a peculiar characteristic, which consists in the ease of its dehydration and rehydration. When mixed with water, it can be molded and worked before hardening and acquiring the mechanical consistency of the dehydrated and stable form (Baltar; Bastos; Luz, 2008).

Currently, gypsum has numerous applications, and is intensely used in the construction industry. Plaster is the product of the thermal dehydration of gypsum and of its subsequent grinding with temperature limits (Follner et al., 2002). It can be used to line walls and ceilings; build partition walls in block form or drywalls.

According to data presented by the Brazilian Drywall Association (2013), the figures relating to the commercial performance of drywall in the country are growing. With regard to the use of this constructive system, Brazil occupies a modest position in the international scenario, placed 12th in the ranking of plaster consumption with 0.25 m^2 per inhabitant per year, representing a total of 50 million m^2 of panels used in 2013.

The use of plaster is closely related to population growth and changes in markets, technologies and products,

accelerating the industry around the world. The constant expansion of civil construction and the increasing use of plaster gives rise to a solid waste generation problem causing difficulties for the disposal or reuse of this material. The generation of plaster waste in construction represents an economic problem, with serious environmental consequences if the disposal isn't done correctly. Resolution no. 431 from CONAMA classifies the plaster residue as class B, which means it is considered recyclable waste for other destinations, (Conama, 2011).

According to Campbell (2008), in the US the construction industry's losses due to the drywall cutting activities becoming waste is estimated to be between 10 to 12%. In Brazil, the losses in construction are also significant, with 5% of the drywall being estimated to be turned into waste during construction (Sindusgesso, 2006).

The disposal of plaster in landfills is not a recommended practice, except when enclosed and kept out of contact with organic matter and water. The reason is that plaster in contact with moisture and in anaerobic conditions, with low pH, and in contact with sulphate-reducing bacteria - conditions present in many landfills and dumps - may form hydrogen sulfide gas (H_2S), which has a characteristic rotten egg odor and is toxic and flammable (Melo, 2012). It is known that some vermiculite deposits can contain asbestos, and there are also records of the presence of heavy metals, but the presence of boron is the most worrying, since it is a toxic element (Munhoz; Renofio, 2007).

Despite the notorious problems related to the toxicity of the plaster waste, in most cases these residues are not treated and/or reused, being disposed in an environmentally inadequate way and making environmental mitigation measures necessary. A first step would be to reduce the generation of plaster waste. In relation to the losses in the use of drywall and in the manufacture of pre-molded panels, the most important thing is to improve the product technology, the quality of labor and especially a proper layout of the panels available on the market. Studies in this field are still incipient, however, and it is not possible to find layout methods seeking to reduce waste in the literature.

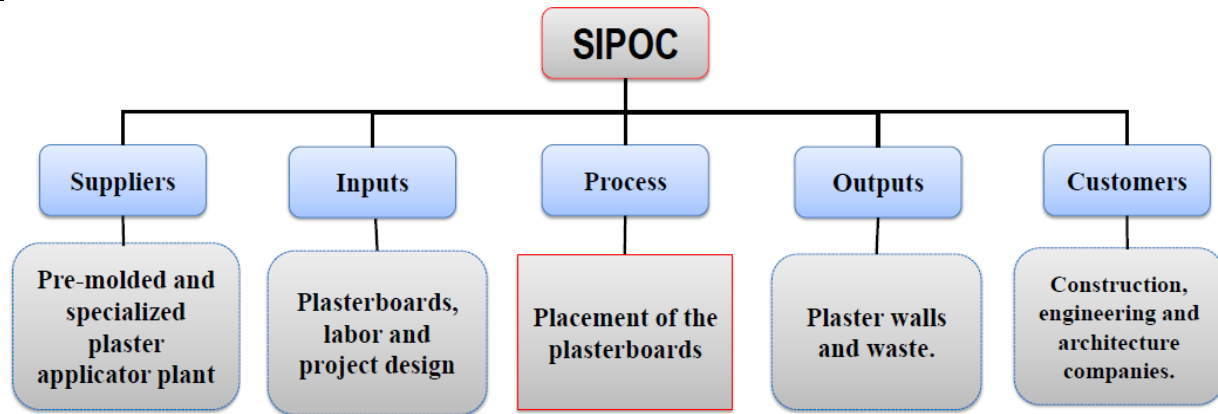


Fig. 1 - SIPOC map - SIPOC for layout

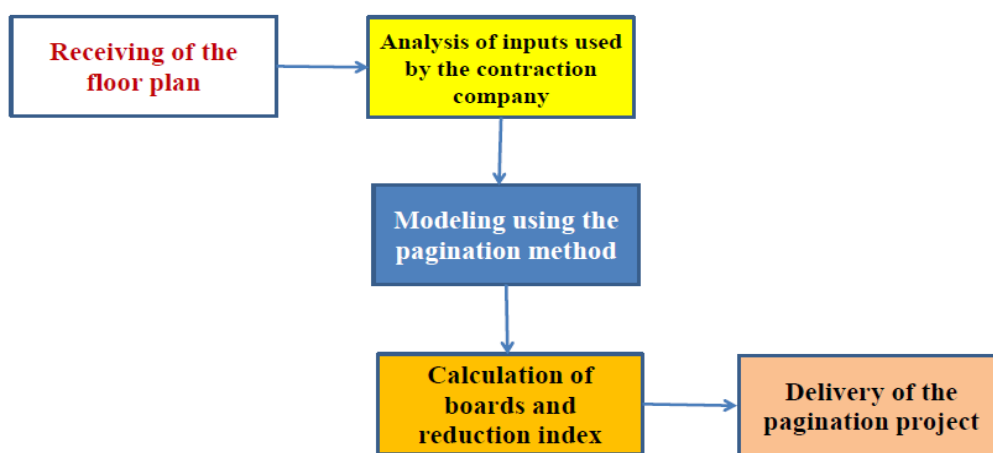


Fig. 2: Flowchart of the developed activities.

Table 1: Actions to be undertaken in the short term.

Name of the Action	Description	Indicators	U/M
Plaster Layout	Plaster layout analysis in civil works with a focus on waste reduction	Waste minimization in civil construction	%

U/M = Unit of Measurement.

In view of concerns regarding the final disposal of plaster waste to minimize environmental pollution, and to contribute to sustainability and the lack of technical/scientific information regarding plasterboard layouts, this study therefore sought to evaluate the reduction of plaster waste in apartments using the layout method.

II. THE IMPLEMENTATION OF CLEANER PRODUCTION

2.1. Diagnosis of the Production Activity

The representation of the process through the SIPOC map (Figure 1) reveals the inter-relationships within the plasterboard layout method, from the suppliers who are responsible for the design of the layout, aiming to reduce waste, until the target customer of the proposal. In Figure 2 the flowchart is shown summarizing the suggested activities to achieve the result.

III. INTERVENTION PROPOSALS / OPPORTUNITIES

Table 1 shows an indicator that was used for the actions undertaken in the short term. The plaster layout method for waste reduction in civil construction is done individually according to the characteristics of each project. To this end, an analysis is performed by the responsible party, the indicator used for monitoring is the minimization of waste at the end of the work calculated in percentages.

IV. ADOPTED METHODOLOGY

In order to analyze the plaster layout with a focus on waste minimization, the floor plan of an apartment (Figure 3) in a residential building with 20 apartments was used, located in Rua Travessa Angelica, 120C - Maria Goretti, Chapecó - Santa Catarina - Brazil, with a private area of 165.00 m².

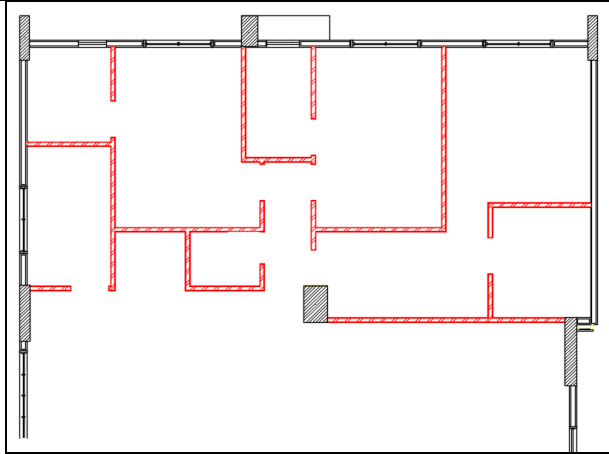


Fig. 3 - Apartment floor plan (internal plaster wall)

The modeling software SketchUp Pro was used to develop the layout of the panels, with them being set up for the most efficient cutting. For a better visualization of this study, colors were used for the distribution of the drywalls, as a sequence to this step, there was a greater concern with the layout of the seams and gaps.

The design implementation was planned with assembly details for each wall, as starting points for the drywall layout and the required cuts. Figures 4 and 5 show the finished layout to be implemented. The total number of panels used in the layout was summed to estimate the rate of reduction.

The executive version of the drywall layout project was guided by the use of numbering on the plates and letters for the cutouts, e.g., Panel 01, Panel 02, Panel 02-A, Panel 02-B, and so forth.

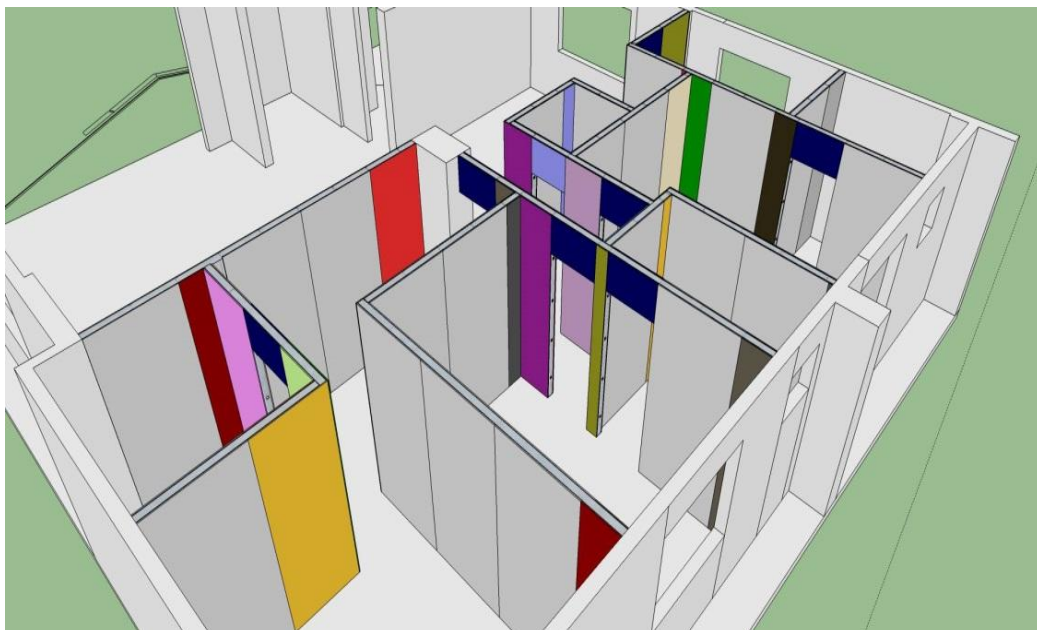


Fig 4: Plaster layout in the apartment

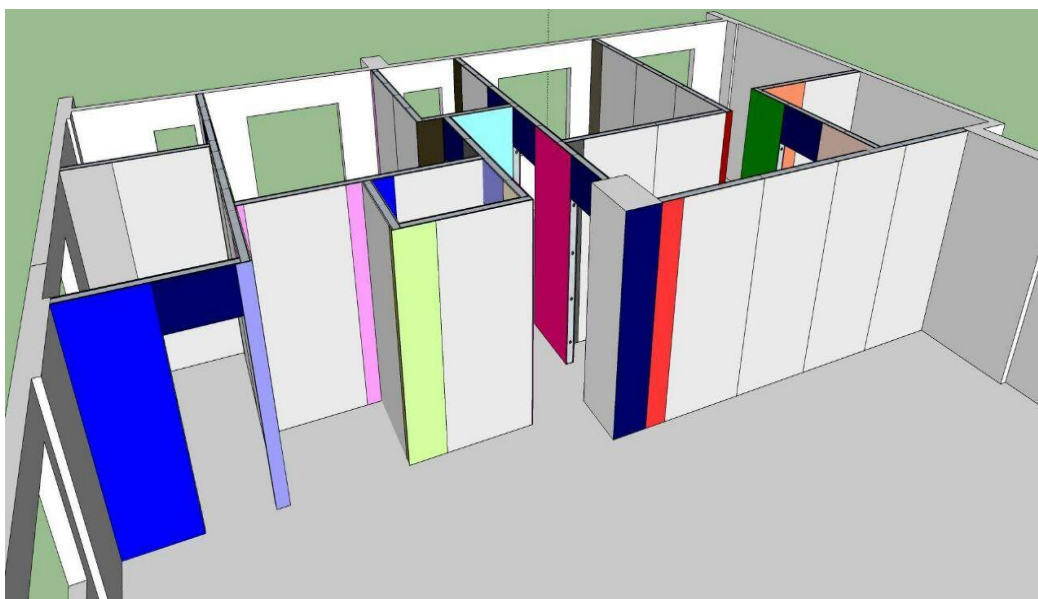


Fig. 5 - Plaster layout in the apartment



Fig. 6: Arrangement of the plaster in the apartment



Fig. 7: Arrangement of the plaster in the apartment

The work is in its implementation phase with estimated completion in 2018. The drywalls are being implemented without a layout design, and the only guidance in the use of the panels is the experience of the executing plasterer. Figure 6 and 7 show the placement of the drywall panels without layout. In the conventional method, the executing company informed that a total of 68 panels are being used, i.e. 220.32 m², for the modeling of the internal walls (data provided by the contractor responsible for the work) per apartment.

Considering the 68 panels (220.32 m²) that the contractor uses per floor, and the theoretical consumption of 207.36 m², the loss in cuts is 12.96 m² (6.25%) of drywall per floor.

After the end of the execution of the work, the amount of boards used in the conventional work method will be compared with the layout design to check the reduction in consumption of panels with the use of the layout design, which consequently will generate a reduction in waste of this raw material in the work.

V. RESULTS AND DISCUSSION

Table 2 shows the reductions in losses with the layout of the panels. The drywall layout design used a total of 65 drywall panels (210.60 m²) to modulate the internal walls of the apartment, considering a consumption of 207.36 m², the loss with cuts was of 3.24 m² (1.562%) of drywall per floor.

Table.2: Reduction indicators using the layout

Indicators	Without layout	With layout
Drywall panels	68.00	65.00
Plaster consumption	220.32 m ²	210.60m ²
Losses with cuts (waste)	12.96m ²	3.24 m ²
Percentage of losses	6.25%	1.562%
Percentage of waste reduction	-----	75%

Taking the consumption with the layout method in comparison with the consumption by the executing company into consideration, the layout yielded a reduction in consumption of 4.41%.

This reduction represents a total of 3 panels less per apartment. This number may seem of minor importance, but when added up, for example in a building with 20 apartments, this represents a total reduction of 60 panels. Consequently, the reduction in the amount of plaster panels will cause a considerable reduction in the generation of waste, approximately 162.00 m², or 2.02 m³ of plaster residue. As such, the waste reduction generated by the layout design with the best arrangement and utilization of panels will be positive.

A study conducted by Feijo, França and Caetano (2013) sought to estimate the importance of the layout before placing ceramics and tiles in bathrooms. They showed the layout resulted in economic gains, with a reduction of 10% in the amount spent for the execution of the lining. The same authors emphasize a reduction of 6% in the amount of tiles used, and a 47% reduction in the amount of waste generated. Similar results were obtained by Pimentel (2009).

The absence, or even omission, of data in the literature in all the projects regarding specifications and information about the inherent technology for the implementation of the proposed solutions, in addition to the absence of information allowing for a geometric, technological and productive integration between components and subsystems, demonstrates the importance of developing projects to contribute to sustainability (Novaes, 1998). The layout study also proved to be important for the economic analysis, aiming to reduce costs (Poubel, 2001), which may vary significantly according to the decision taken.

The result of this layout methodology enables gains in competitiveness, either through the financial aspect of waste reduction, or by minimizing the environmental impact caused by the plaster residue. Using this new technique makes it possible to conquer increasingly

restricted markets in terms of technical and environmental requirements.

VI. IDENTIFICATION OF BARRIERS

The layout design is laborious and should be done by professionals in the industry. There is a need to train professionals in the labor market in the development of plaster layout designs.

The lack of qualified professionals for the implementation may hinder the full understanding and execution of the layout method, which is the main barrier in the reduction of waste. Because of the costs of developing a layout design, this type of design is rarely performed in small works, where the consumption of gypsum in the work is small, but in the global scenario this use in small works is significant.

VII. CONCLUDING REMARKS

The layout of plaster in drywall system projects significantly decreases the employment of panels through their optimal arrangement. The main benefit of the layout is the reduction in waste generated in civil construction. The use of sustainability as an environmentally correct and economically viable option makes the implementation of the layout method extremely relevant in the construction industry.

More studies are needed in order to estimate the exact reduction of plaster that the layout method can generate.

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