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The Economic Feasibility of using Driwall in a Civil Construction work in the City of Manaus

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***Abstract*—** *In recent years, a growing demand for construction methods has been noticed, aimed at optimizing construction processes and reducing costs, especially with regard to sealing. The Drywall technique (dry wall) is a constructive method that attends to these constructive first fruits and aimed at the perception of sustainability. The general objective is: to present a cost-benefit comparison of the use of "drywall sealing" in comparison with masonry in ceramic blocks, based on the feasibility study of a project in the city of Manaus. Identify the advantages and disadvantages of using the vertical sealing system using the masonry system with ceramic block (conventional) and Drywall. To achieve these objectives, quantitative research (in databases such as Scielo, Public Domain, CAPES and renowned institutions) of an exploratory nature was carried out, with inferences and qualitative data collection from personal experience as professionals working in the field of Civil Engineering and sedimented through bibliographic research limited to the period from 2010 to 2021. The results point to an initial cost reduction of around 20% to 30% of the total cost of the work. It is concluded that even despite the higher cost of acquiring Drywall, its use related to direct costs represented a reduction of 22.68%, not counting the cost reduction related to costs with foundations (which represents something around 9% to 12%, making it economically viable and at the same time regarding the quality and strength of internal seals.*

I. INTRODUCTION

The Brazilian economy in the last eight years has been experiencing moments of great fluctuations due to economic and political factors and, more recently, due to the COVID-19 pandemic. These factors have led to increased competition between companies, according to Pereira & de Azevedo (2020).

According to Ornstein et al., (2017) this way, the search for efficiency through methods of production process aims to bring not only speed and quality in the services offered, but it constitutes a factor of survival and competitiveness in the field of civil construction.

In an initial inference, it is known that conventional methods of internal sealing such as ceramic brick masonry,

in addition to generating a large volume of debris, demand considerable execution time, which increases the costs of the work (Guimarães et al., 2021).

It should be noted, however, that the sealing activity can use other constructive techniques, promoting the replacement of the conventional method by others such as Wood Frame, Light Stell Frame and Drywall, which "among its characteristics stand out speed in installation, lighter weight and debris generation, with a relatively low cost" (Molin & Malandrin, 2017, p. 71).

However, it is noteworthy that the Drywall constructive method still faces some resistance regarding its use by the population of medium and small cities, where it is believed that this opposition to the technique is due to few studies in the area and the population's own cultural issue who insists on not abandoning the traditional construction techniques that the people is used to (Oliveira, 2019).

According to Santos & Rachid (2016), the use of sealing in Drywall provides sustainable benefits, since it is a constructive technique considered clean, with less waste production, thus being a differential in current projects, allowing to add value to the property and the valuation at the time of its sale.

It is still necessary for the moment of choice to assess issues such as control and costs, where one cannot fail to control the cost-benefit ratio, highlighting that these necessarily involve "the price and quality binomial" (SANTOS; RACHID, 2016, p. 13).

Bauer (2012) states that in the construction industry, artisanal production methods can represent damage to several factors, such as waste or failures in execution; requiring continuous inspections to control the performance and quality of services.

With this in place and allied to the growing social pressure in the optimization of resources in the form of the use of technologies with less power of environmental degradation along with the need to reduce costs due to the sector's competitiveness.

Américo et al., (2019) states that by simplifying or reducing the number of steps or parts in the construction processes, these constitute one of the guiding principles of Drywall in the context of rationalized systems. Thus, when using Drywall for internal sealing (walls and/or ceiling) this is cited by several authors as highly productive and economical compared to the construction of ceramic masonry sealing walls.

These issues do not only involve technical-operational aspects, but are reflected from the perspective of the pillars of sustainability, where the environmental, social and economic aspects, when evaluated and applied together, give the enterprise a sustainable characteristic.

When using Drywall, it is clear that, in addition to aspects related to environmental comfort, according to Ching (2016), this is a material with great capacity for recycling and reuse, minimizing the environmental impacts of its use, as well as addressing issues related to the social dimension, since there are social and environmental cooperatives that collect solid waste from civil construction and reuse or recycle it, generating income for the people involved in this process.

Therefore, the present work seeks to bring the population and our peers closer to this constructive technique, contributing to its dissemination through information, demonstrating that Drywall provides, when done correctly, a reduction of the closing load on the structure that will support it, making it slimmer and cheaper, as well as ensuring the comfort and cleanliness of the work, reducing costs and the production of civil construction waste.

It should be noted that in addition to the faster installation and the reduction of manual processes, the construction system using Drywall brings one more positive point, it does not need curing time as with the use of sealing with ceramic blocks that it needs of mortar curing time, in addition to the fact that Drywall does not need preparation for final finishing (as occurs with the conventional system that needs roughcast and plaster).

This new technology brings with it numerous advantages compared to the cost-benefit ratio with conventional masonry, in this sense we highlight, in addition to the aforementioned points, its high versatility, especially if used in association with other materials, such as when you want to obtain a good acoustic performance usually Drywall walls make use of mineral wool and double sheet, thus providing an improvement in sound insulation (Oliveira, 2016).

These solutions, according to Keeler & Vaidya (2010) arising from the use of Drywall, extend to other constructive subsystems, such as electrical, telecommunications and hydraulic installations, resulting in time optimization, since the installation and finishing of these subsystems are quick and generate less waste.

In view of the above, this study aims to respond to a concern that permeates the authors of this article: is there really a competitive advantage of using Drywall as a sealing, compared to conventional masonry fence, using a ceramic block?

To answer this question, the present study has the general objective: to present a cost-benefit comparison of

the use of "Drywall sealing" in comparison with ceramic block masonry, based on the feasibility study of a project in the city of Manaus.

Specifically, it is intended (a) to identify the advantages and disadvantages of using the vertical sealing system using the masonry system with ceramic block (conventional) and Drywall; (b) Discuss the limitations and types of use of the vertical sealing system in drywall masonry; (c) Present comparative data on the feasibility and costs of using ceramic block and drywall sealing methods.

The importance of discussing the use of Drywall in civil construction is justified, given the challenge of choosing the most suitable construction processes, in order to meet the three prerequisites widely discussed in this sector: cost, quality and time.

Thus, when using the Drywall constructive method, it is sought to identify how this material tends to add value to the enterprise and thus maintain the competitiveness of organizations (Alves, 2012). With this, it is understood that the Drywall sealing system fills a gap of the three prerequisites, as it appears as a promising alternative to conventional sealing masonry, in addition to providing the reduction of waste arising from conventional sealing by ceramic blocks (Bauer, 2012; Bremer et al., 2013; dos Anjos & Teixeira, 2017), in addition to the decrease in the use of materials, time and labor (Guimarães et al., 2021).

II. LITERATURE REVIEW

2.1 Drywall: context, advantages and disadvantages

For Silva & Moreira (2017, p. 17) "more than 6000 years ago, huts were built with clay bricks also known as adobe, baked in the sun and with the addition of straw and grass to avoid deformations and cracks".

This method lasts until today and is widely used in various parts of the world, in particular it is the predominant method in Brazil, but it has gradually lost ground. This method is relatively simple.

Lima & Oliveira (2020) states that masonry consists of the union of ceramic blocks or bricks using mortar. This system has a dichotomy since, while it is extremely simple, which does not require manpower with great specializations, it presents important pathologies if it is not carried out by applying constructive techniques and improvised constructive solutions during the execution of the services (from Silva, 2015).

We agree with Lima & Oliveira (2020), who:

> Ceramic block masonry is the most common system in Brazil, and its main function is to separate and/or compartmentalize environments. The ABNT NBR15270:2005 Ceramic Components defines ceramic block masonry as a "sealing masonry component that has prismatic holes perpendicular to the 2 phases that contain it (p. 4).

The conventional masonry fence constitutes the main load-bearing construction structures that support reinforced concrete, brick, trusses and metal beams that are covered with coatings, usually cement and paint.

In this way, it is clear that a labor force, with little qualification, can even perform the service relatively easily, but the same cannot be said regarding the desired quality and safety of the construction.

Arving (2015) states that the motivation for the invention of Drywall is related to two major fires that occurred in Chicago, in 1871, and the fire in New York, in 1890 which, due to the use of flammable materials and others that are easy to burn, such as wood. and paints, the main materials used in construction at the time, served as ignition and feeders for the claim.

When we carry out a reflective analysis of the construction systems used in the last twenty years in Brazil, it is clear that the development of construction technologies and innovative actions has brought answers to the growing demand for increasingly effective materials that can be used in construction , mainly in interior fences (Camillo, 2012; Faria, 2014; Tidd & Bessant, 2015).

Arving (2020) highlights that Drywall represents the answer to contractors and consumers who want built environments to be dry, warm, safe and aesthetic. Garcia (2018) points out that there is a demand for materials with good properties of

thermal and acoustic insulation, as well as resistance to fire and water, characteristics that are found in Drywall.

Arving (2020) highlights that when Drywall was invented in 1894 by August Sackett and consisted of a layer of plaster and felt. Neto & Fagundes (2020) also emphasizes that the first plasterboards appeared only in 1910 under the name Sackett Boards and consisted of four layers of special felt paper and three intermediate layers of plaster.

These authors further describe that they were placed on wooden slats. The first gypsum board appeared in 1917. In this way, sheets of paper were used on both sides to strengthen the gypsum core.

Drywall arrived in Europe about 20 years later and, after the end of World War II, was used on a large scale to reconstruct war damage. However, their low quality meant they were not widely used in construction. It was only from

1990 onwards that the new technology for producing these boards made them more useful (Labuto, 2014), Lockstein & Kichel, 2019).

Santos & Rachid (2016), Américo et al., (2019), and Neto & Fagundes (2020), agree that it was only around 1970 that Drywall began to be produced in Brazil, at the initiative of physician Roberto de Campos Guimarães, from the foundation in Petrolina (PE) of the first plasterboard factory for Drywall, a subsidiary of Gympsum.

However, it was only in the 1990s, encouraged by the implementation of new factories in the country and the evolution of construction processes, that this product began to gain greater acceptance in the Brazilian market (Labuto, 2014). In a more current context:

> The approval of the system by users caused several buildings, houses and housing developments (KNAUF, 2018). The history of Drywall arrived in Brazil producing practical and intelligent solutions in architecture, for example, in the use of ceilings, coatings and practical divisions for constructions in general (Américo et al., 2019, p. 75).

Despite the growing use of Drywall, in Brazil there is still resistance on the part of the population in the use of this material, combined with a lack of knowledge of this construction technology, which contributes to a certain distrust of the population in relation to Drywall.

In comparative terms, both the conventional method and the use of Drywall have advantages and disadvantages that involve the moment in which the economy and the market also involve the culture of the people. Therefore, in Chart 1, the advantages and disadvantages of each construction system are listed.

Chart 1 Comparison between conventional and Drywall systems

	Drywall	Alvenaria Convencional (Tijolos)
Vantagens	Facilidade na montagem.	Bom isolamento térmico e acústico.
	Ganho de área útil.	Boa resistência à pressão do vento, umidade e fogo.
	Adaptável a qualquer tipo de estrutura.	Resistente á infiltrações de água pluvial.
	Desmontabilidade fácil.	Durabilidade superior a cem anos, sem proteção e sem
	Local da obra limpo.	Facilidade de composição dos elementos de qualquer forma e
	Menor mão de obra.	Sem limitação de uso em relação às condições ambientais.
	Superfície plana.	Baixa inversão de capital na produção.
	Estrutura não contraventada.	Total disponibilidade de matéria prima.
	Mais leve.	Produção não poluente, sem geração de resíduos prejudiciais ao meio ambiente.
	Facilidade de instalação dos sistemas elétricos e hidráulicos.	-
	Bom isolamento térmico e acústico.	-
Desvantagens	Falta de mão de obra especializada.	Como não se utiliza projeto de alvenaria, as soluções construtivas são improvisadas durante a execução dos serviços.
	Baixa resitência mecânica.	Qualidade deficiente dos materiais utilizados e da execução.
	Baixa resitência à alta umidade.	Dificuldade na instalação de sistemas elétricos e hidráulicos.
	Os vazios internos podem ser ocupados por insetos se não pensado corretamente	Superfícies irregulares.
	Umidade relativa do ar elevada tende a desenvolver fungos.	Falta de mão de obra especializada.
	Objetos pendurados precisam ficar próximos aos reforços.	Área útil reduzida.
	-	Aparecimento de fissuras e trincas.
	-	Peso das vedações maiores.

Source: Adapted from Molin & Malandrin (2017), Oliveira (2019), Pereira & de Azevedo (2020).

It is noticed that each of the systems has advantages and disadvantages, but factors such as cost and time feasibility tend to influence the choice of method.

2.2 Drywall: some considerations about the constructive system

Drywall board, goes far beyond its properties and characteristics, offering much more possibilities than it seems at first sight. Among its benefits we highlight:

- Thermal insulation. If necessary, the Drywall layer effectively retains heat, it can be reinforced with a mini layer or other insulation (Rodrigues, 2017).
- Low weight. It does not overload the structure of the walls, thus it does not put much overlapping pressure, although some formations appear heavy and massive (Tres, 2017).
- Fire safety. Only a layer of cardboard can burn, which will not light and will cause a fire (Silva & de Almeida, 2016).
- Smooth surface, which allows an easy correction or perfectly masks imperfections in walls and planes (Soares, 2018).
- Flexibility: Interestingly, Drywall can be bent to give structures a smooth shape. Of course, to do this you need to know how to do it, some

skills will be needed, but they are quite simple (Villela, 2013).

- Resistance. Depending on the type of Drywall sheet, some of them are specially produced to become resistant to moisture and/or fire (Tavares & Gaspar, 2020).
- Environmental appeal and material safety, thus having a strong sustainable appeal (Peurifoy et al., 2015; Sandes, 2019).

These properties characterize the material to the maximum from the positive point of view of material use. However, Drywall has some restrictions, including:

- Fragility. The layer, when brushed, can break causing deformations. Although plaster can be used to correct the problem, but the area in question will be more fragile. Where it is recommended that this fact must be taken into account when designing.
- Insufficient sound insulation. Mass design - hollow, resonates, all sounds are very easy to penetrate, which sometimes creates some inconvenience. Acoustic or thermal acoustic insulators or similar materials are used to solve the problem.
- Weak capacity. If the customer needs to hang a custom cabinet or TV panel wall on a Drywall wall, they will need to be concerned with reinforcement in advance using a double layer of material on the opposite side or in the right place.

According to Lima & Oliveira (2020), since 2013, in Brazil, the Brazilian Association of Technical Standards, through the approval of NBR 15.575 - Housing Buildings - Performance, defined the quality levels to be met in construction systems, establishing levels of acoustic performance and durability of the building.

As previously highlighted, Drywall defects can be compensated, however, the main thing is to know them and take them into account during the project work, and they are chosen according to the characteristics of the place to be applied.

As the material's popularity led to mass use, a number of products and structures were created, among which there are many attractive designs. The excerpt brings many photos that feed the imagination in independent design.

In general terms, there is a standardization of colors that serves as parameters for choosing the different varieties and use of Drywall, as can be seen in Chart 2.

Chart 2 Characteristics of Drywall boards, commercialized in Brazil

Tipo	Caracteristicas e Utilização	Dimemsões
Placa de Drywall branca standard (ST)	A branca, ou cinza, é a placa de Drywall indicada para uso geral em áreas secas. Geralmente empregada em paredes e forros, é recomendada para salas, escritórios, e outros ambientes que precisem de divisão ou isolamento termoacústico do sistema Drywall. As paredes confeccionadas em Chapas Drywall Standart (ST) são as mais comuns e mais frequentemente utilizadas em projetos arquitetônicos em geral.	Branca ou cinza 6mm - 1200x2000; Branca 12,5mm - 1200x1800, 1200x2400, 1200x3000;
Placa de Drywall verde (RU)	Já para a aplicação em áreas úmidas, como cozinhas, banheiros, lavabos, lavanderias ou áreas de serviço, é indicado o uso da placa de drywall verde, resistente à umidade. Esse tipo de placa tem em sua composição química componentes hidrofugantes, que protegem a superfície contra respingos e umidade. No entanto, o material não é a prova de água, e não deve ser usado em tetos, saunas e piscinas, já que a umidade nestes espaços é constante. Isso, se dá devido a sua composição química, que incluí componentes hidrofugantes, as paredes de drywall do tipo RU são protegidas contra qualquer tipo de umidade, garantindo maior durabilidade em ambientes molhados. É importante destacar que a impermeabilização da base da parede de chapa verde é extremamente recomendada, devendo ser feita com a altura mínima de 20 centímetros do piso. As paredes em drywall do tipo RU **NÃO** são a prova da água,.	Verde 12,5mm - 1200x1800, 1200x2400, 1200x3000;
Placa de Drywall rosa (RF)	As placas Resistentes ao Fogo (RF) possuem fibra de vidro em sua composição, o que garante maior resistência ao fogo e ao calor. Dessa forma, paredes de drywall confeccionadas com o material devem ser utilizadas áreas com risco de incêndio (lareira, algumas áreas da cozinha), em escadas enclausuradas e saídas de emergência. Devido o auxílio da fibra de vidro no aumento da resistência ao fogo, a placa de drywall rosa é mais eficaz na proteção e segurança do que as placas standard, incluindo o cumprimento dos requisitos da Norma de Desempenho NBR 15.575.	Rosa 12,5mm - 1200x1800; Rosa 15mm - 1200x2400.

Source: Prepared by the authors.

By using this new technology, it provided, in addition to meeting new demands, it speeds up the completion of the work, in addition to the environmental issue due to the high degree of reuse of the components

According to data available on the website of the Brazilian Steel Construction Center (CBCA), when comparing the years 2014 and 2015, they indicate that the current demand for Drywall is still small compared to international consumption.

III. METODOLOGY

Conceptually, this study uses the deductive method, based on bibliographic research and with an exploratory objective, which, as described by Prodanov & de Freitas (2013), aims to provide greater familiarity with the studied phenomenon and with the issues raised, so that it can thus conduct the analysis in a more legitimate way to what has been produced on the subject under consideration.

It is justified to adopt this methodology, since it allows for a wide and diversified form of information collection, in addition to being able to use dispersed data in numerous publications, also helping in the construction or better definition of the conceptual framework that involves the proposed object of study.

This study began in March 2021 with the choice of the topic that took place through the observations of the authors of this study, where it was possible to identify the problem

to start the exploratory research of bibliographic material to carry out a theoretical approach on Drywall .

In order to prove the practice observed, bibliographical references were searched for in related studies for the development of the theoretical basis. Thus, this research is of a quali-quanti nature, since it is based on methodologies whose objective is to make a critical, contextualized and exploratory analysis about the use of Drywall as a constructive method, as well as to demonstrate the results obtained in our observations through data collected from the company responsible for the project.

Thus, articles, books and other materials that focus on studies on the theme Drywall as a constructive method were read and analyzed, in order to verify what already exists in the literature on the subject and what is being produced.

It should be noted that the data that supported the results and discussions is based on the definitions of NBR 6120/2019, which allowed us to calculate building structures, using the following formula:

- To calculate the weight per m² of wall: P = $\gamma ap\ x\ e\ x\ h\ x\ l$

  Which:
  $\gamma Tijolo$: Specific Weight

  e: Masonry Thickness

  h: Masonry Height

  l: Width

Finally, for comparative purposes, the Excel spreadsheet was used, built from data on average prices practiced in specialized trade in the city and Manaus, from budgets obtained in three construction material stores, a survey carried out between the second April fortnight and first week of May 2021.

With these data, charts, tables and graphs were elaborated as a way to expose perceptions, concepts, definitions, characteristics and values that are discussed and compared with the literature used.

It must be clarified that in order to identify the feasibility of using Drywall in the enterprise, the deduction method was used, in which it is assumed that the research goes from the general to the private. The author will share with readers his own experience in developing a feasibility study for a project as part of a group of companies that were developing an enterprise in the city of Manaus-AM.

In turn, the comparative analysis method consists of identifying the best results among the existing ones, identifying the factors that affect the achievement of the presented results.

IV. RESULTS AND DISCUSSIONS

The constructive calculation method is used most often in developing perspectives for the development of individual branches of the organization of financial and economic activities. It allows the Civil Engineer to choose the most effective option to achieve the organization's ultimate goal and justify measures to master the ideal solution.

The economic and mathematical method is used in solving production optimization problems as a whole or in individual technological processes, as well as in choosing effective organizational, economic and technical and technological solutions.

It allows you to find the best option for using the organization's material and technical resources, promising practical areas of action for obtaining optimal results.

The balancing method allows you to coordinate and link all indicators that reflect the essence of processes or phenomena. It is widely used in the development of various plans, with its help a balance of all quantitative proportions is achieved.

With a systematic approach to the phenomenon under study, it is important to use the most appropriate methods for the dissemination of certain provisions. More often than not, several methods are used in combination - in this case, the identified economic patterns complement and enrich each other. It is necessary to know the potential of each method and know how to apply it in practice.

There are universal methods to calculate a feasibility study that save time in preparing a feasibility study that follows the originally developed feasibility study, these are done more efficiently using software, in this study, the spreadsheet owned by the company was used. company, which is all parameterized to perform calculations.

Due to the business strategy factor, the formulas and data sources will not be mentioned, being exposed a simulated construction of a 1.0 square meter wall.

Assis (2016) states that before directly considering the development and methodology for the formation of a feasibility study, it should be clarified that the feasibility study is mainly intended to confirm the feasibility of implementing a project and its financial return.

This process involves a multidisciplinary team that involves administrators, managers, financial, accounting and construction planning personnel, including the Civil Engineer.

The financial and economic service consolidates the information received from others and prepares this document both for internal users (a project to launch a new

type of business, investments to expand an existing business, modernization of production equipment, etc.) and for users external (obtaining a loan from a bank, recording the lease of fixed assets, attracting external investors in the development of the company, requesting a grant, etc.).

At its core, a feasibility study is obviously a kind of economic forecast for future periods and is on the same level as documents like:

- business plan;
- revenue and expense budget;
- forecast of the project's financial result;
- investment plan.

At the same time, the feasibility study has indisputable differences from these calculations: compared to the business plan, the feasibility study is less detailed and does not require detailed economic calculations; while the expense and income budget operates only with quantitative and total indicators of the results of the company's activities, then in the feasibility study, on the contrary, the financial plan of the results of the activities is only one of several sections; the forecast of the financial result is based only on sum indicators and contains only the final probabilistic result of the size of the enterprise's profit, in the feasibility study it is necessary to confirm the degree of probability of success in the implementation of the project; an investment plan requires not only certain calculations, but also a cash flow forecast to confirm the company's ability to return attracted investments (Souza & Carvalho, 2019).

In a feasibility study, the question of cash flows becomes important only when it is constituted in the context of loans or acquisition of fixed assets on a lease basis.

In general, the feasibility study is necessary so that, based on it, the recipients of the document can make an informed management decision on the feasibility of launching the proposed project, taking into account the technical, financial, organizational and technological resources allocated to the project. Therefore, the feasibility study, in our opinion, should still be recognized as a simplified version of the business plan.

In this study, we will highlight the importance of Drywwall as an innovative alternative in civil construction, so the idea of an exploratory research to develop this study proved to be inspiring and appropriate.

It is not intended to detail the steps and calculations of the feasibility study, but to bring one of the essential and necessary data for the elaboration of the feasibility. The study carried out by the Civil Engineer: the definition of the constructive method of sealing, depending on the cost.

With the evolution of materials technologies used in civil construction over the last thirty years, it led civil construction professionals at the time to seek to develop and use construction materials that were more resistant to fire and weather and that would allow construction quickly and efficiency (de Mattos; Guimarães, 2013).

In the conventional constructive method, used in sealing, where, in general, the base is prepared from the calculation of the weight that the project will support, to then lay the ceramic (brick) or cement blocks with the help of mortar to fixing them and joining them, in another phase, the walls are sectioned for the passage of installations and embedding of boxes, and then patches are made using mortar to fill in the voids (do Rosário, 2017).

The breaking of bricks in transport and execution, the use of mallets to open the tears in the walls and the frequency of removal of debris buckets from the work show the waste, many of the actions and occurrences are resolved through constructive solutions, sometimes at the base improvisation during the execution of services (Debs, 2017). Although:

> It must be clarified that masonry, when it has the function of sealing, means that it has no attribution to support loads beyond its own weight. This type of system allows for making cuts in the masonry, without harming the structure, as it does not have a structural function, however, it generates a large amount of waste (Lima & Oliveira, 2020, p.4).

That said, it is shown in table 1 and 2 the average values using the Drywall and conventional masonry method to build any room with the following dimensions 2m x 3m wide and 3m high with a total area of 30m², to obtain average price in the city of Manaus was researched in the table of SINAPI - 03 / 2021– AM in which it provided all the value of the input and the value of labor. SINAPI (National System for Research on Civil Construction Costs and Indexes) is a software created by the Federal Government, and widely used when the project is financed by Caixa Econômica, where through data inputs by the registered user, as a way to make it available by means of standardized calculations, information on costs and rates of civil housing construction.

With the evolution of SINAPI, other institutions started to use it and contribute to feed the database, today SINAPI is a reference in the composition of project costs in Brazil.

Among the parameters used are calculations such as the labor productivity indicator, whose formula is:

$$RUP = \frac{Hh}{Qs}$$

Which:

RUP: Unit Production Ledger

Hh: Wasted man-hours

Qs: Number of services performed

Thus, productivity depends on the effectiveness of the tasks to be performed due to the downtime, where it will only be productive if a greater amount of activities are performed in the shortest possible time, with the same number of people and with a minimum of stopped time.

It should be noted, however, that these correlations between SINAPI and the budget do not always reflect reality, since:

> A budget can result in two results: when poorly prepared and without defined criteria, it brings errors and omissions that generate losses and when well prepared, it guarantees the companies' profits and survival. As works with resources from the union are by decree obliged to use the SINAPI database, they seek compositions of ready services that resemble the projected services, in this way the quantifications are performed by the agency, and the unit cost applied is that found directly in the compositions spreadsheet. synthesis of SINAPI (Cavalcante; Silva & Carvalho, 2018, p.2).

average cost was obtained in the city of Manaus.

Table 1 Average cost of Drywall room of 30m²

Drywall						
Tipo	**Descrição**	**Tipo**	**Unidade**	**Quantidade**	**Valor Unitário**	**Total**
Composição	PAREDE COM PLACAS DE GESSO ACARTONADO (DRYWALL), PARA USO INTERNO, COM DUAS FACES SIMPLES E ESTRUTURA METÁLICA COM GUIAS SIMPLES, COM VÃOS AF_06/2017_P	PARE - Paredes/Paineis	m^2	1,0000000	80,97	R$ 80,97
Composição Auxiliar	MONTADOR DE ESTRUTURA METÁLICA COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	H	0,6280000	25,4	R$ 15,95
Composição Auxiliar	SERVENTE COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	H	0,1570000	17,01	R$ 2,67
Insumo	FITA DE PAPEL REFORCADA COM LAMINA DE METAL PARA REFORCO DE CANTOS DE CHAPA DE GESSO PARA DRYWALL	Material	M	0,7925000	1,81	R$ 1,43
Insumo	FITA DE PAPEL MICROPERFURADO, 50 X 150 MM, PARA TRATAMENTO DE JUNTAS DE CHAPA DE GESSO PARA DRYWALL	Material	M	2,5027000	0,14	R$ 0,35
Insumo	MASSA DE REJUNTE EM PO PARA DRYWALL, A BASE DE GESSO, SECAGEM RAPIDA, PARA TRATAMENTO DE JUNTAS DE CHAPA DE GESSO (NECESSITA ADICAO DE AGUA)	Equipamento	KG	1,0327000	2,44	R$ 2,51
Insumo	PINO DE ACO COM ARRUELA CONICA, DIAMETRO ARRUELA = *23* MM E COMP HASTE = *27* MM (ACAO INDIRETA)	Material	Cento	0,0290000	44,81	R$ 1,29
Insumo	PERFIL GUIA, FORMATO U, EM ACO ZINCADO, PARA ESTRUTURA PAREDE DRYWALL, E = 0,5 MM, 70 X 3000 MM (L X C)	Material	M	0,9093000	7,06	R$ 6,41
Insumo	PARAFUSO DRYWALL, EM ACO ZINCADO, CABECA LENTILHA E PONTA BROCA (LB), LARGURA 4,2 MM, COMPRIMENTO 13 MM	Material	UM	0,9149000	0,15	R$ 0,13
Insumo	PARAFUSO DRYWALL, EM ACO FOSFATIZADO, CABECA TROMBETA E PONTA AGULHA (TA), COMPRIMENTO 25 MM	Material	UM	20,0077000	0,06	R$ 1,20
Insumo	PLACA / CHAPA DE GESSO ACARTONADO, STANDARD (ST), COR BRANCA, E = 12,5 MM, 1200 X 2400 MM (L X C)	Material	m^2	2,1060000	12,26	R$ 25,81
Insumo	PERFIL MONTANTE, FORMATO C, EM ACO ZINCADO, PARA ESTRUTURA PAREDE DRYWALL, E = 0,5 MM, 70 X 3000 MM (L X C)	Material	M	2,8999000	8,01	R$ 23,22

MO sem LS:	14,19	**LS:**	0,00	**MO com LS:**	R$ 14,19
Valor do BDI:	0,00	**Quant.:**	30,0000000	**Valor com VDI:**	R$ 80,97
				Preço Total:	R$2.439,10

Source: SINAPI – 03/2021 - Amazonas

In a first inference, it leads us to infer that by using specific products, Drywall makes the construction value of the square method a little more expensive, but it should be noted that the Company on screen is a construction company that buys in large quantities. quantities for their projects, which reduces costs.

With regard to the conventional construction, the values identified in table 2 were reached.

Table 2 Average cost of brick masonry in a room with an area of 30m²

Alvenaria						
	Descrição	Tipo	Unidade	Quantidade	Valor Unitário	Total
Composição	ALVENARIA DE VEDAÇÃO DE BLOCOS CERÂMICOS FURADOS NA HORIZONTAL DE 9X19X19CM (ESPESSURA 9CM) DE PAREDES COM ÁREA LÍQUIDA MAIOR OU IGUAL A 6M² SEM VÃOS E ARGAMASSA DE ASSENTAMENTO COM PREPARO EM BETONEIRA. AF_06/2014	PARE - Paredes/Paineis	m^2	1,0000000	70,43	R$ 70,43
Composição Auxiliar	ARGAMASSA TRAÇO 1:2:8 (EM VOLUME DE CIMENTO, CAL E AREIA MÉDIA ÚMIDA) PARA EMBOÇO/MASSA ÚNICA/ASSENTAMENTO DE ALVENARIA DE VEDAÇÃO, PREPARO MECÂNICO COM BETONEIRA 400 L. AF_08/2019	SEDI - Serviços Diversos	m^3	0,0098000	702,88	R$ 6,88
Composição Auxiliar	PEDREIRO COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	H	1,3700000	20,86	R$ 28,57
Composição Auxiliar	SERVENTE COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	M	0,6850000	17,01	R$ 11,65
Insumo	BLOCO CERAMICO VAZADO PARA ALVENARIA DE VEDACAO, DE 9 X 19 X 19 CM (L X A X C)	Material	Mil	0,0279300	796,5	R$ 22,24
Insumo	PINO DE ACO COM FURO, HASTE = 27 MM (ACAO DIRETA)	Material	Cento	0,0050000	38,53	R$ 0,19
Insumo	TELA DE ACO SOLDADA GALVANIZADA/ZINCADA PARA ALVENARIA, FIO D = *1,20 A 1,70* MM, MALHA 15 X 15 MM, (C X L) *50 X 7,5* CM	Material	M	0,4200000	2,16	R$ 0,90
	MO sem LS:	28,01	**LS:**	0,00	**MO com LS:**	R$ 28,01
	Valor do BDI:	0,00	**Quant.:**	30,0000000	**Valor com VDI:**	R$ 70,43
					Preço Total:	R$2.112,90

Chapisco						
	Descrição	Tipo	Unidade	Quantidade	Valor Unitário	Total
Composição	CHAPISCO APLICADO EM ALVENARIA (SEM PRESENÇA DE VÃOS) E ESTRUTURAS DE CONCRETO DE FACHADA, COM ROLO PARA TEXTURA ACRÍLICA. ARGAMASSA INDUSTRIALIZADA COM PREPARO MANUAL. AF_06/2014	REVE - REVESTIMENTO E TRATAMENTO DE SUPERFÍCIES	m^2	1,0000000	11,36	R$ 11,36
Composição Auxiliar	ARGAMASSA INDUSTRIALIZADA PARA CHAPISCO ROLADO, PREPARO MANUAL. AF_08/2019	SEDI - Serviços Diversos	m^3	0,0015000	6.153,66	R$ 9,23
Composição Auxiliar	PEDREIRO COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	H	0,0730000	20,86	R$ 1,52
Composição Auxiliar	SERVENTE COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	M	0,0360000	17,01	R$ 0,61
	MO sem LS:	1,68	**LS:**	0,00	**MO com LS:**	R$ 1,68
	Valor do BDI:	0,00	**Quant.:**	30,0000000	**Valor com VDI:**	R$ 11,36
					Preço Total:	R$ 340,80

Emboço						
	Descrição	Tipo	Unidade	Quantidade	Valor Unitário	Total
Composição	EMBOÇO, PARA RECEBIMENTO DE CERÂMICA, EM ARGAMASSA TRAÇO 1:2:8, PREPARO MECÂNICO COM BETONEIRA 400L, APLICADO MANUALMENTE EM FACES INTERNAS DE PAREDES, PARA AMBIENTE COM ÁREA ENTRE 5M2 E 10M2, ESPESSURA DE 10MM, COM EXECUÇÃO DE TALISCAS. AF_06/2014	REVE - REVESTIMENTO E TRATAMENTO DE SUPERFÍCIES	m^2	1,0000000	23,36	R$ 23,36
Composição Auxiliar	ARGAMASSA TRAÇO 1:2:8 (EM VOLUME DE CIMENTO, CAL E AREIA MÉDIA ÚMIDA) PARA EMBOÇO/MASSA ÚNICA/ASSENTAMENTO DE ALVENARIA DE VEDAÇÃO, PREPARO MECÂNICO COM BETONEIRA 400 L. AF_08/2019	SEDI - Serviços Diversos	m^3	0,0213000	702,88	R$ 14,97
Composição Auxiliar	SERVENTE COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	H	0,1140000	17,01	R$ 1,93
Composição Auxiliar	PEDREIRO COM ENCARGOS COMPLEMENTARES	SEDI - Serviços Diversos	M	0,3100000	20,86	R$ 6,46
	MO sem LS:	7,41	**LS:**	0,00	**MO com LS:**	R$ 7,41
	Valor do BDI:	0,00	**Quant.:**	30,0000000	**Valor com VDI:**	R$ 23,36
					Preço Total:	R$ 700,80
	Total sem BDI:	3.154,50				

Source: SINAPI – 03/2021 - Amazonas

These data can serve as a budget comparison and when compared with other forms of budget calculation, such as the TCPO (Table of Compositions and Prices for Budgets) and CUB (Basic Unit Cost) they bring the Civil Engineer the necessary information to assess the overall cost of contracted works and services.

Given the above and correlated what was described in relation to Drywall, the characteristics, advantages and disadvantages of the main construction methods are described in a comparative way (Chart 3).

Chart 3: Main construction method

Tipo	Descrição	Vantagens	Desvantagens
Alvenaria de Vedação ou Convencional	Edificações de alvenaria de vedação ou convencional compõem-se por vugas, pilares e lajes de concreto armado. Estes elementos fazem parte da estrutura para a sustentação da edificação e a alvenaria tem função somente de vedar e separar ambientes. Para isso, normalmente são utilizados blocos cerâmicos.	Suporta grandes vãos. Grande disponibilidade de mão de obra e materiais. Pouco exigência de qualificação da mão de obra. Facilita futuras reformas e mudanças de projeto.	Maior custo. Maior tempo de execução. Gera muitos resíduos.
Alvenaria Estrutural	Na alvenaria estrutural, une-se a estrutura e vedação edificação, utilizando blocos cerâmicos ou de concreto, os dois específicos para este fim. O projeto de alvenaria estrutural deve ser muito bem detalhado e compatibilizados com os projetos elético e hidro-sanitário. Deve também, definir os vãos da edificação de acordo com a modulação do bloco que será utilizado.	Rapidez e facilidade de construção. Redução na mão de obra. Maior economia. Maior qualidade na execução. Menor desperdício de materiais.	As paredes não podem ser removidas sem realocar um elemento estrutural para suprir cargas. Limitações estéticas nos projetos arquitetônicos. Vãos livres limitados.
Steel Frame	O Steel Frame é um sistema construtivo industrializado e racionalizado. Sua estrutura é formada por perfis de aço galvanizado e seu fechamento é feito por meio de placas cimentícias, de madeira ou drywall. A principal diferença do steel frame para os outros sistemas é a limpeza do canteiro de obras, pois a geração de resíduos é mínima e não há necessidade do uso de água.	Agilidade na contrução. Redução do peso da estrutura. Maior precisão na execução. Melhor isolamento térmico e acústico. Menor custo.	Limite de pavimentos. Dificuldade em encontrar mão de obra especializada.
Wood Frame	O método de construção do wood frame é muito parecido com o steel frame. A diferença é que no lugar dos perfis de aço galvanizado são utilizados perfis de madeira, normalmente de reflorestamento, como o pinus. Este sistema construtivo é constituído por perfis de madeira maciça, contra ventados com chapas de OSB e estrutura de madeira autoclavada com função de proteger a edificação de cupins e umidade.	Canteiro de obras organizado e limpo. Uso de madeira de reflorestamento, única matéria-prima renovável da construção civil. Ótimo desempenho acústico e térmico. Agilidade na construção. Redução de geração de resíduos. Baixo custo.	Mão de obra especializada. Limites de pavientos. Maiores cuidados com impermeabilização.
Paredes de Concreto	As paredes de concreto consistem em um sistema construtivo em paredes estruturais maciças de concreto armado. Estas paredes são concretadas com o auxílio de formas de madeira ou metálica que são montandas "in loco" de acordo com o projeto arquitetônico.	Alta produtividade. Alta resistência ao fogo. Pouco desperdício de materiais.	Baixa flexibilidade. Não tem um bom isolamento térmico e acústico. Devido ao uso de formas, tem alto custo para produção em pequena escala.

Source: Adapted from Camillo (2012), Fleury (2014), Kochem (2016).

It is thus perceived that based on the characteristics highlighted in 3, they allow the Civil Engineer to choose a wide range of different materials, since these methods allow their exclusive use or a mix of methods, depending on each project under analysis.

According to Tisaka (2011), conventional masonry is defined as a constructive system whose characteristics are the fact that the entire load of the structure is absorbed by the slabs, beams, pillars and foundation. In this system, according to the author, the vertical walls do not have any structural function, therefore they only serve as closing gaps and separating environments.

Thus, by choosing to use different dimensions of blocks, walls with different thickness of seals and thermal-acoustic efficiency will be obtained, which infers to make the work practical and suitable for each customer's needs.

According to Bauer (2012) and De Mattos; Guimarães (2013) these types of construction methods, consume a larger amount of mortar, mainly used in the settlement, have high costs in the construction or rental of wooden or metallic forms (those generally used in large projects) which increase costs, once, in general, these forms are removed at least twenty-one days after concreting. Ferreira (2014) adds that another point of material waste and cost increase in conventional construction occurs during the internal and external roughness for the execution of the plaster.

In the Drywall method, this can be installed in general from five basic steps and depending on the installation according to Ching (2016), it starts with the choice of material, followed by the demarcation of the place where the Drywall plates will be fixed , followed by fixing and installing the plates for subsequent electrical and hydraulic installation, followed by finishing. For a better understanding, a basic installation flow was elaborated (1), the step by step installation of Drywall slabs is described.

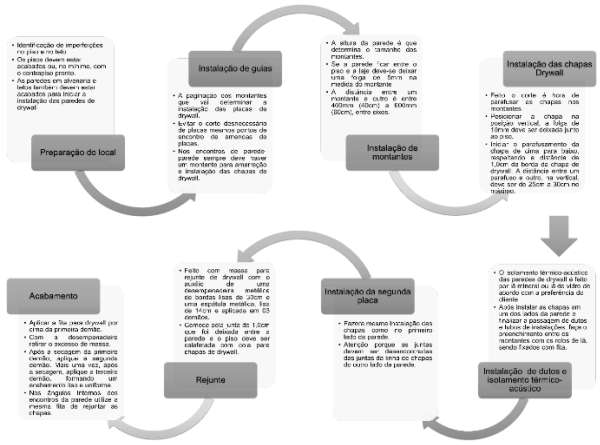

Fig. 1: Macro flow of Drywall installation process

Source: Adapted from DRYWALL (2011), Cardoso (2013), De Mattos; Guimarães (2013) and Leopoldo (2015).

It is inferred that despite being a relatively simple method to be installed and the finishing process uncomplicated, but as recommended (DRYWALL, 2011) that only specific materials should be used for use in Drywall type material, materials that are generally indicated or recommended by manufacturers, in general it is recommended to use acoustic insulation (Marinho & Cavalcante, 2017, Lima & Oliveira, 2020).

With this demonstrated, it is believed that the main forms of constructive methods and Drywall can be explored well, which will serve as a basis for future works.

The advantages of using conventional building systems (ceramic block or structural masonry) are public and notorious. For the defenders of this method, the examples of Egyptian pyramids or Greek temples stand out, which despite the bad weather and the action of time, still are standing demonstrating the technical legacy and architectural beauty of these constructions developed by ancient peoples (Martha, 2010).

However, proponents of using other systems such as Drywall point out that currently more than 80% of all single-family homes being built in the US state of Florida are using modern construction systems such as Drywall, Steel Frame Ligthing and ICF (Labuto, 2014; Kochem, 2016; Marinho & Cavalcante, 2017).

Another comparative pro Drywall refers to the analysis of waste compared to conventional systems, which have steel and waste from ceramic blocks as the materials that contributed a lot to the generation of waste (Fleury, 2014; Fonseca, 2018; Garcia, 2018).

This is due to the specific needs of cutting and preforming steel materials to meet the reinforcement specifications in a concrete structure, in the same way, the waste caused in the transport and laying of bricks and the need for after lifting the seal vertical, it is necessary to break parts of the walls to facilitate the installation of windows and doors or electrical installation.

In turn, the rigidity and strength of connections used in Drywall panels are crucial factors that influence the overall structural behavior, these connections use screws to be fixed, as they have the advantage of being cheaper and easier to make joints than glued joints by means of tapes (Fernandes, 2020). Where complementary preparation processes are required (Eastman et al., 2014).

These factors tend to affect the health of construction workers who install Drywall boards, as this exposes them to the risk of contracting various musculoskeletal injuries and disorders, especially for the lumbar, back and shoulder areas.

In the various Drywall manufacturers' manuals, there are recommendations that the plates be stored in flat places, they bring recommendations to their customers and installers about the risk of injuries caused by Drywall (dos Anjos & Teixeira, 2017; do Rosário (2017), mainly related to the fall of the plate on the installer and due to the repetitive movements resulting from these operations (da Silva, 2015).

Another argument for Drywall, refers to the characteristics of the materials used in its manufacture, which make this material a kind of barriers resistant to fire and even (Calçada, 2014). No studies were found related to the costs of maintaining these panels (Côrtes, 2018), likewise there is little or no experimental data and

information about Drywall assembly mechanisms that make them resistant to realistic fire conditions (Arving , 2020).

It should be noted that as there is no further information on physical properties, this can affect the calculation of the project's life cycle and cysts resulting from the time to be used to correct assembly failures (Crescêncio & de Barros, 2018).

Another appeal to the use of Drywall is that, due to the aforementioned characteristics, they make the buildings safer and, therefore, when passing this information on to the insurance company, the owner can claim a reduction in the value of the insurance.

In medium and large buildings and constructions, the building codes and municipal regulations (in medium and large cities) generally indicate the need to use flame-resistant materials and in larger projects there is a determination of compartments that inside a building must be insulated by fire barriers.

The studies listed here highlight that globally, Drywall systems are used as a replacement for bricks and construction with mortar (Medeiros & Pacheco, 2019). In the developed world, construction solutions are quite advanced from a standpoint as construction practices have evolved over a period of time mainly due to their performance and aesthetic appeal.

Other advantages of Drywall are highlighted by Kochem (2016) which highlight that construction practices are evolving and, therefore, the use of advanced construction systems is focused on effective performances related to situations such as fire, acoustics, recycling etc.

According to Eastman et al., (2014) in Brazil, the Metropolitan region of São Paulo gathers most of the consumption of plasterboard (Drywall) in the country, which represents between 38 and 40% of the Brazilian market.

According to Do Rosário (2017) Brazil has great possibilities of using the construction method in Drywall, due to the great demand for popular housing, which according to Assis (2016) recommends that one should take into account the minimum performance of the buildings that will use this method , in which they must have the minimum technical standards by type of

enterprise.

In the case of masonry walls made with perforated ceramic bricks, ABNT NBR 6120:1980 has as its main recommendation the use of a specific weight of 1300 kgf/m³, the same specification defined for reinforced concrete structures.

With this, it can be inferred that when using the Drywall system, the Civil Engineer must evaluate not only the costs themselves, but an entire production chain from a holistic perspective, which involves, in addition to the economic question, the socio-environmental question and of worker safety (Botelho, 2019).

Criticism of this constructive method, in addition to those already mentioned above, refers to failures arising from the lifting phase of the vertical fence that can have the consequences: waste of material, time and the constant evaluation of inspectors and the Civil Engineer himself. Some evidence of these failures was selected (Fig 2).

Fig 2: Examples of waste and failures in the conventional construction system

Source: Photomontage prepared by the author

In Fig 2A (we can see the excess of concrete used to lay the bricks), it is not uncommon to see cases of cracks (Fig 2B) resulting from a structural base consistent with the weight or from failures in the execution of the service.

Vechi, Gallardo & Teixeira, (2017) highlight that the civil construction segment, in addition to appropriating natural resources, is responsible for relevant transformations in the landscape which can, through the waste generated and when discarded incorrectly, cause significant impacts environmental issues.

With the increase in the number of works in progress and the availability of technologies, comparison becomes essential. According to Debs (2017) it has been adopted by medium and large corporations as a way to minimize costs and increase construction speed.

Likewise, the cost of recovering these failures is relatively high, compared to corrections arising from

construction in Drywall. In Fig. 3 a comparison of the construction methods is performed: conventional/structural masonry and Drywall.

Fig. 3: Comparison of Masonry x Drywall Construction System

Source: Chagas, 2017.

This comparison is more evident in the studies by Tisaka (2011) who, when analyzing the cost of construction using masonry and Drywall based on material and labor costs, show that when evaluating an area of 5,475.71 m² of walls , where 2,334.61 m² in a dry environment and 3,141.10 m² in a humid environment.

As indicated in the initial comparison, it is clear that in the acquisition cost analyses, the values alone already represent a reduction of 22.68%, which added to something around 16.11% of cost reduction with the material and foundation execution time, allows the entrepreneur to seek this cost reduction and productivity gain as a way to remain competitive.

It should be noted, however, that the studies demonstrate the feasibility of using Drywall only in internal seals and that do not require applications such as the need to use moisture-resistant (green board) and fire-resistant (pink) boards.

These become viable only after parts of these costs are passed on to the client. As noted earlier.

V. CONCLUSION

This study brought to light the discussions on the use of Drywall, as an innovative and viable constructive method in constructions in regions such as the Amazon, where high temperatures and humidity tend to affect the durability of materials.

The study was limited to comparing similar studies in relation to data collected in an enterprise in the city of Manaus (AM), which, due to the sanitary crisis resulting from COVID-19, created an additional challenge for data collection. At the request of the companies, neither the project nor the study company is identified.

It was demonstrated in this study, both with the data brought by the authors of this article and the comparison of similar studies, that there is a growing demand for construction methods that allow faster execution of works, implying process optimization and cost reduction, within the scope Drywall has been widely used for internal fences, despite the resistance of some consumers to use this constructive method.

It was found that the use of Drywall boards in interior fences has very satisfactory results. This is due to the basic advantages of using the Drywall system, which include a light structure, ease of adjustment of interior design, speed of installation which reduces the delivery time of the work.

It is concluded that the use of Drywall is viable and safe, as long as it is applied technically and economically and by trained personnel. Likewise, Drywall tends to become more popular as features such as fragility to impacts and abrasion are being remedied, as well as the use of techniques for fixing heavy objects are evolving.

Finally, it is concluded that despite the positive facts previously highlighted, the sustainable appeal of the use of Drywall must be added, which allows us to conclude that there is still a arduous path to be taken as a way to overcome the stigmas that Drywall is a price product it elevates (and it is in the case of small purchases) and does not offer adequate resistance and isolation, a fact that is not supported as an argument, due to numerous studies in the area.

Far from exhausting the subject, the quantitative comparison of the cost of the square meter of internal fences, built in Drywall in a house and in an apartment of equal dimensions, is left as suggestions for further studies.

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