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Assessing the Potential of Porotherm Clay Bricks as a Walling Material in Building Construction

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Abstract Technological progress has introduced many innovations and technologies in the field of building industry. Construction industry is growing at a rapid pace due to the rapid advancing economy and rising standards of living and to meet the requirements of people in India. Due to rapid urbanization, the demand for brick as filler material in buildings has been increasing exponentially. This rapid increase leads to increase in use of natural resources which are depleting alarmingly without the source to replenish it. The traditional bricks are the main building materials that are used extensively in the construction and building industry. The Porotherm bricks are recently one of the newly adopted and suitable materials in the building construction. In this paper, an overview of Porotherm bricks with reference to its potential as a novel building material has been presented. The paper also presents a comparative cost analysis of Porotherm bricks with the Concrete bricks with its suitability and potential use in the building construction industry.

Keywords: *porotherm bricks, walling, building construction, architecture*

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1. Introduction

Porotherm clay bricks are horizontally or vertically perforated clay bricks. They are manufactured in variety of sizes (common size is 400x200x200 mm) from natural clay, coal ash, rice husk, and granite slurry. The term porotherm is used for this type of brick due to its desired thermal insulation characteristics. The perforation of the clay brick provides an exception walling system which facilitates thermal insulation resulting in cooler interiors in hot seasons and warm interior conditions in cold seasons. The porotherm clay bricks are easy to use, economical, environmentally friendly, and it can be used for the construction of both non-load bearing walls and load bearing walls. The porotherm bricks are low weight, durable, strong, and possess a satisfactory fire resistance. It can be used with dry mortar which eliminates the need for curing time [1]. Porotherm clay brick is an innovative building material. Having the traditional values of clay material, it delivers versatile, high performance, and sustainable walls with full technical support available at all project stages. Porotherm has become well established as an excellent alternative to traditional masonry such as concrete bricks, as well as other systems such as timber or lightweight steel frames [2].

Figure 1. Porotherm Clay Bricks

2. Research Methodology

In this paper, an overview of Porotherm bricks with reference to its potential and sustainability as a novel building material has been presented. In order to identify sustainable construction materials, this paper provides a framework for categorizing sustainability-related materials and conducts an initial literature review of research papers, books and articles, as well as texts that are available magazines and internet sources. The literature review has been explored through internet and secondary data from the research papers and journals articles. The data

collection in the study comprises from the number of cases that are comprehensively elaborated and supported with illustrations and photographs and therefore reinforcing this study.

3. Properties of Porotherm Bricks

Following are the physical properties of Porotherm bricks:

a). The compressive strength is greater than 3.5MPa
b). High thermal and sound insulation.
c). Low weight: it is lighter than traditional solid concrete brick by 60 percent. High fire resistance
d). Density range from 694 to 783 kg/m^3
e). Large in size but light in weight results in low dead load.
f). Generally the sizes are of 100 x 500 x 224; 140 x 500 x 224 and 190 x 300 x 224
g). Water absorption is around 15 percent.

4. Materials Used in Manufacturing of Porotherm Bricks

The following basic materials are used in the manufacturing of the Porotherm Clay Bricks [3].

4.1. Clay Soil

Clay soils are compounds of silica and alumina. Calcareous clay has calcium carbonate and will burn to a yellow or cream color. Non-calcareous typically contain feldspar and iron oxides and will burn to a brown, pink or red depending on the amount of iron oxide. It is finely-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxide and organic matter. It is plastic due to their water content and become hard, brittle, and non-plastic upon drying or firing.

4.2. Granite Powder

Granite powder is a byproduct in granite polishing industries while cutting into desired shapes. It belongs to the igneous rock family. Granite industry products around 18 million tones waste per annum. The physical properties of granite powder are similar to the natural sand; hence it can be used in replacement of natural sand. Granite powder is locally available waste material hence it is possible to make economical brick.

4.3. Rice Husk Ash

Rice milling industry generates a lot of rice husk during of milling of paddy which comes from the fields. This rice husk ash is mostly produced by burning rice husk between 600-700 degrees Celsius temperature for 2 hours. Rice husk ash is about 25% by weight of rice husk when burnt in boilers. It is estimated that about 70 million tones of rice husk ash are produced annually worldwide. This husk contains about 75% organic volatile matter and the balance 25% of weight of this husk is converted into ash during the firing process, is known as a rice husk ash (RHA). It contains of non-crystalline silicon dioxide.

5. Advantages of Porotherm Bricks

The range of benefits offered by building with Porotherm covers a broad spectrum of subjects from economic to environmental to lifestyle [1,2]. Following are the top benefits of Porotherm bricks:

5.1. Good Strength

The compressive strength of porotherm brick is greater than 3.5MPa. The application of high temperature during its manufacturing process and the present of terracotta material in its composition gives the material excellent strength.

5.2. Thermal Insulation

Porotherm bricks have great thermal insulation which is obtained due to the perforation of the bricks.

Figure 2. Insulation using Porotherm Clay Bricks

5.3. Highly Durable

The high compressive strength, fire resistance, and resistance against carbonation makes porotherm bricks highly durable and has long life span. Water absorption is around 15% that is why the risk of dampness, cracks or shrinkage of walls are substantially low. The compressive strengths of Porotherm's core range are typically 10 N/mm^2, which is more than standard concrete bricks that are usually around 7 N/mm^2. As clay bricks are versatile, one brick can usually fit the majority of requirements, as a result, there is no need to keep multiple bricks on-site, reducing the risk of the wrong brick being used and optimizing storage space on-site.

5.4. Cost-effective

Not only does the porotherm bricks saves a lot of energy but also cut construction and operation cost. The usage of this type of brick would eliminate need for using AC in summer and heaters in winter hence save energy. It does not require sand and cement for wall construction, hence it cut construction cost. Finally, it has zero maintenance cost.

5.5. Environmental Friendly

The porotherm bricks have recycled content. Due to the fact that chemical materials are not used in its composition, so it would not cause allergic issues.

5.6. Speed of Construction

Wall construction speed increases substantially when porotherm bricks are used. This is due to brick lightweight, ease of handling, and elimination of curing time since sand and cement is not needed for the construction of porotherm brick walls. Additionally, it can be cut and chisel easily which makes fixture installation much easier. Finally, porotherm ensure clean and dry work site that is why it leaves no debris to be disposed. Due to the interlocking precision design, the lighter weight compared to other materials and the specialist tools, such as the mortar roller, Porotherm are very quick to build with. An average of 25-30m² per man, per day, is easily achievable, which is much quicker than traditional masonry which is between 12-15m² per man, per day. Porotherm is more stable and rigid than traditional masonry construction, allowing single storey height construction in a day.

Figure 3. Ease of construction with Porotherm Clay Bricks

5.7. Dry Laying of Bricks

Construction with Porotherm uses around 95% less water than construction used in traditional methods. In a typical 212m² building, traditional mortar will consume circa 1060 litres of water when compared to just 72 litres for the thin joint mortar that is used with Porotherm. Therefore, Porotherm projects are much less reliant on the local water supply and the system takes less time to achieve a watertight shell. Porotherm is virtually dry compared with concrete bricks that can come with up to 30% moisture content within the brick itself adding to the 1000 litres extra water in the mortar.

5.8. Sustainable Material

Used for thousands of years in construction worldwide, clay remains the most sustainable solution for modern buildings. Clay is an inert material that provides no risk to either the environment or end-user. Its natural properties mean that it provides complete, long term sustainability, not only offering increasingly sophisticated low-carbon product manufacture, but giving a building life of over 150 years with little or no maintenance. Strong and durable, yet lighter and often less of a strain to work with than many of the alternatives, clay also builds-in sound and temperature-control benefits wherever it's used – creating the ideal internal living environment. The 30% of materials are procured from alternative, recycled or secondary sources. The life expectancy of more than 150 years and bricks are recyclable at end of life, for example into hard core. Porotherm benefits from having excellent thermal properties for both heat loss aiding u-value calculations and thermal mass reducing overheating, creating a stable and even all year round internal temperature and hence a comfortable living environment. Builders can achieve higher quality brickwork thanks to the precision engineered bricks and true 1mm bed joints.

5.9. Efficient and Low Wastage

Thermally efficient in helping to regulate variations in temperature; air-tightness is maximized with a parge coat or wet plaster on it's inner face. Porotherm bricks are acoustically efficient. Their fire resistance is outstanding; The Porotherm bricks achieve a Class A1 rating in preventing fire. They are breathable, and can help with regulating room humidity when used in conjunction with other breathable materials. There are no moisture shrinkage and no disruption to finishes, fewer movement joints (1:20 linear metres) and reduced risk of cracking. On an average there is only a 2% wastage provision, improving site waste management as well as offering reduced costs and cleaner sites. With Porotherm bricks there is no need for installation of bed joint reinforcement.

Figure 4. Load bearing Porotherm Clay Brick wall

5.10. Green Accreditations

Porotherm is listed by IGBC (Indian Green Building Council) in the 'Green Product Category' under energy-efficient product, material with recycled content & use of regional material. It is also rated by GRIHA, Green Rating for Integrated Habitat Assessment.

5.11. Versatile and Easy to Use

Porotherm can be used for monolithic and cavity wall construction and provides an airtight yet breathable solution using a fabric first approach. It is a strong, stable, adaptable method of construction which allows flexibility in the choice of external facades and systems. There is no shrinkage and minimal need for movement joints (typically at 20m centres) meaningless snagging and follow up work required for the builder.

5.12. Safe and Non-Toxic

Porotherm bricks are generally lighter than concrete bricks, allowing workers to maintain steady production rates without the risk of repetitive strain injuries. They and non-toxic and reduce the risk of sharp cuts.

Figure 5. Masonry walls constructed by Porotherm Clay Bricks

6. Disadvantages of Porotherm Bricks

Following are the few disadvantages of using Porotherm clay bricks in building construction [1].

a). Porotherm clay bricks cannot be used in the construction of huge structures due to its density which is about 694 to 783 kg/m^3.

b). It may could be exposed to salt attacks due to its water absorption which is about 15% and hence the strength of the structure would be decreased.

c). Porotherm bricks cannot be used in the construction of foundation and base-slab works in areas of high ground water table. This is because such bricks may not able to withstand the negative pressure of water and capillary action.

7. Applications of Porotherm Bricks

Porotherm bricks can be used in a range of applications, including:

a). Load bearing and non-load bearing walls.

b). Partition wall

c). Infill panels within framed structures.

d). Single leaf or internal and external walls.

e). Inner leaf of brick-faced cavity walls.

f). Inner and outer leaves of cavity walls.

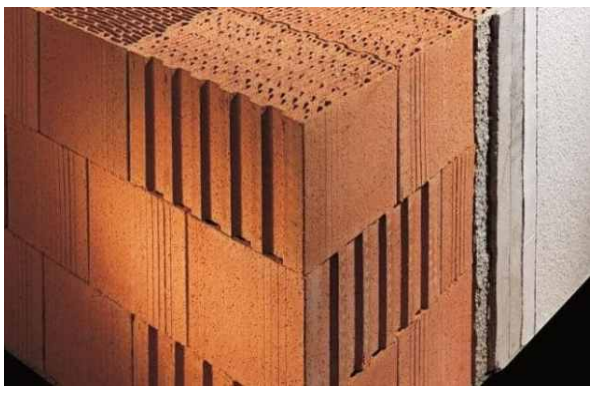

Figure 6. External wall constructed using Porotherm Clay Bricks

8. Comparative Analysis of Porotherm Bricks with Concrete Bricks

Table 1 shows the comparative analysis of porotherm bricks with the traditional concrete bricks across a number of different factors [4].

Table 1. Comparison of Porotherm Bricks with Concrete Bricks

	Porotherm Bricks	Concrete Bricks
Speed of Laying	30-40m^2 per worker, per day.	12-15m^2 per worker, per day.
Mortar	Once applied to the bricks, the bed joint mortar starts to set in just 30 minutes, with full strength reached within 24 hours.	Once the wet bed joints are laid, the mortar is slower to set and takes around 48 hours to reach full strength.
Safety	Lighter, with no sharp corners.	Bricks are heavier and have sharp corners.
Strength	The core range typically has compression strength of 10 N/mm$^{2.}$	Bricks are dense and manufactured to a range of compressive strengths, usually around 7 N/mm$^{2.}$
Waste	Minimal mortar waste and 2% brick wastage, on average.	An average of 40% mortar waster and 15% brick waste.
Efficiency	High thermal efficiency.	Lower thermal efficiency.

9. Conclusions

The Porotherm bricks is a novel and one of the most suitable and sustainable building materials in the present building construction industry. The use of porotherm bricks in construction projects saves a substantial amount of money as there is less usage of steel and other building materials. Also, labor work is simultaneously reduced as a lighter framework can be used. These are very easy to install and are durable enough to withstand extreme temperatures. They are adaptable when it comes to aesthetics; they can be easily be combined with any color blend of interior décor, glasses, and paint. The Porotherm bricks are eco-friendly and have lower embodied energy per square meter than a concrete alternative building material [5]. The Porotherm bricks have more insulation value and thus it has low energy usage for heating and cooling loads requirement. The Porotherm bricks have proven to be more durable, provide thermal insulation and structural requirements, and also have major economic and environmental benefits as compared to other traditional building components and products [6]. Thus Porotherm bricks can be said to a suitable and potential eco-friendly building material, which is beneficial for the environment, which fulfills the requirement for the construction of sustainable architecture and construction [7]. Since the Porotherm bricks use readily available natural raw materials in the manufacturing process, have excellent durability, are energy efficient, are cost-effective, and also can be recycled, therefore the Porotherm bricks can be said to be a green and sustainable building material.

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