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A Review of Various Masonry Blocks Employed in Wall Construction

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Abstract - This comprehensive review explores the diverse range of masonry blocks commonly utilized in contemporary wall construction. It aims to provide insights into the various types of masonry blocks available in the construction industry, their characteristics, applications, and advantages. By examining these materials in detail, this review contributes valuable information to architects, engineers, builders, and construction professionals, assisting them in making informed decisions about the selection and use of masonry blocks in their projects. Additionally, the abstract may summarize the key findings, trends, and considerations discussed in the full review.
Index Terms – Masonry blocks, Wall construction, Construction materials, Building design, Architectural choices, Construction industry

1. Introduction

The use of masonry blocks in wall construction has been a cornerstone of architectural practice for centuries. From the enduring appeal of traditional brickwork to the innovative applications of modern concrete blocks, masonry offers a versatile and reliable solution for creating robust, aesthetically pleasing walls. This review embarks on a comprehensive exploration of the diverse landscape of masonry blocks employed in contemporary wall construction. As the building industry continually evolves, the range of masonry blocks available for construction projects has expanded significantly. Architects, engineers, and builders face a multitude of choices when it comes to selecting the most suitable masonry blocks for their designs. Factors such as material composition, structural integrity, insulation properties, and aesthetic considerations play pivotal roles in determining the appropriate block for a given application.

As the construction industry continues to evolve, it is imperative to stay abreast of advancements in masonry block technology. This review seeks to provide a valuable resource for professionals in the field by shedding light on the distinctive characteristics of these blocks. By examining aspects such as density, modulus of elasticity, sound insulation, and durability, this review equips decision-makers with the knowledge necessary to select the most suitable masonry blocks for their specific projects. In doing so, it contributes to the creation of structurally sound, energy-efficient, and aesthetically pleasing buildings that meet the diverse needs of today's architectural landscape.

In this review, we delve into the intricacies of various masonry block types, shedding light on their distinct characteristics, advantages, and applications. By providing a detailed examination of these building materials, we aim to empower professionals in the construction industry with the knowledge needed to make informed decisions regarding the incorporation of masonry blocks into their projects. Whether considering traditional clay bricks, concrete blocks, or newer alternatives like autoclaved aerated concrete (AAC) blocks, this review serves as a valuable resource for understanding the diverse options available and optimizing their utilization in wall construction.

2. Types of Masonry Blocks

1. Stone Blocks

Stone walls are commonly crafted from locally sourced stones, ranging from limestone and flint to granite and sandstone. Stones that have been worked and shaped are referred to as ashlar and are frequently used for corners in stone structures. The process of constructing stone walls involves a series of steps: preparing the footing, laying the base course, building the wall itself, marking and cutting the stones, and finally filling the joints. Different types of stone walls can be constructed, such as Field Stone Walls, Pennsylvania Field Stone

Walls, Colonial Stone Walls, Split Face/Mosaic Walls, Veneer Walls, Modular Block Walls, Mortared Walls, Dumped Walls, and Tossed Walls. Stone walls offer numerous advantages. Additionally, stone walls require sealing for proper maintenance. Stone masonry is renowned for its durability and resistance to weathering due to the inherent strength of the material. It's an ideal choice for buildings with high foot traffic, but it's important to note that stone walls tend to be thick and heavy, which can reduce available floor space. The construction of stone masonry is time-consuming and demands skilled workers, as alterations, repairs, or relocation are challenging. In summary, stone walls offer a timeless and durable construction option, but their advantages and disadvantages must be carefully considered when choosing them for a building project.

2. Laterite Stone Blocks

Laterite stones are blocks extracted from quarries or mines that contain lateritic crusts, and they can be cut either manually or using machinery. Laterite itself is a soft rock primarily composed of iron and aluminum oxides. In hot and wet tropical regions, the weathering process gradually transforms lateritic soil into a hardened material. These hard laterite layers are then cut into blocks of varying sizes, depending on factors such as the local conditions, cutting methods, and the hardness of the laterite layer.

Advantages of using laterite blocks include their natural cooling properties, which make buildings comfortable during hot summer months. They also offer good thermal insulation, impart a rustic and natural appearance to structures, and tend to harden and strengthen over time. Due to their larger size, they can be cost-effective by reducing labor and material expenses. Additionally, laterite masonry often eliminates the need for plastering, and it is considered environmentally friendly as it does not emit CO_2 or greenhouse gases.

However, there are disadvantages associated with laterite stones. Their strength may not be uniform, making it necessary to carefully assess the quality of individual blocks. These stones are typically found in limited regions, and stone dressing may be required to match block sizes for construction. Furthermore, due to their weight and chemical composition, laterite stones are generally avoided in multi-story buildings.

3. Clay Bricks

Bricks, a fundamental building material with a history spanning millennia, have evolved from traditional clay-based units to include materials like shale, calcium silicate, and concrete. The manufacturing process involves grinding or crushing clay, mixing it with water for molding, texturing, drying, and firing, resulting in a range of colors and types, including Fired Common Bricks, Fired Porous Bricks, Fired Hollow Bricks, and Non-Fired Bricks. Clay bricks offer advantages like cost-effectiveness, durability, diverse sizes and textures, low maintenance, fire resistance, and minimal environmental impact during production. However, they have limitations, including time-consuming construction, unsuitability for seismic areas, water absorption issues, low tensile strength, potential for mold growth, and challenges in cleaning and color retention.

Clay bricks can be sun-dried or kiln-baked, with the latter providing superior strength and durability, making them resilient even in adverse conditions like flood exposure. Various additives can be incorporated into clay during production to tailor properties such as color, chemical resistance, strength, and longevity.

4. Fly Ash Bricks

Fly ash bricks are a sustainable building material crafted from water, quarry dust or river sand, cement, fly ash, and stone aggregates under 6mm. Typically, they replace 10% to 20% of the cement volume with fly ash, a by-product of coal-fired power plants. These bricks, made with class C or class F fly ash and water, offer several benefits, including reduced dead load due to their lightweight nature (2.6 kg each, with dimensions of 230 mm × 110 mm × 70 mm). They also provide high fire insulation, exceptional strength, and minimal breakage during transport and use, and reduced mortar requirements for joints and plaster by nearly 50%. Fly ash bricks have lower water penetration, requiring only a light sprinkling before use, and gypsum plaster can be directly applied without a lime plaster backing. However, they exhibit slower strength gain, longer setting times, limited air content control, seasonal use restrictions, color inconsistencies, size limitations, and certain suitability constraints.

In terms of environmental benefits, fly ash bricks are manufactured using hydraulic pressure machines, making them eco-friendly. They are 28% lighter than standard clay bricks and possess a compressive strength exceeding 40 Mpa, surpassing regular bricks. These advantages, along with their cost-effectiveness and the elimination of plaster requirements, contribute to reduced construction costs and help combat soil erosion.

5. Concrete Solid Blocks

A Solid Concrete Block, also known as a Concrete Brick, is characterized by having over 75% of its total mass filled with concrete. These heavyweight blocks are commonly used in construction projects, providing strength and solidity to structures. They are particularly well-suited for large-scale endeavors like load-bearing walls, and they offer the advantage of being larger than traditional bricks, which speeds up construction. The quality of solid concrete blocks depends on factors such as the raw materials used, compressive strength, dry density, water absorption, thermal conductivity, environmental impact, and mortar usage.

Solid Concrete Blocks offer several benefits, including ease of design and high resistance to extreme weather conditions like strong winds and storms. However, one drawback is that concealed wiring and plumbing installations can be challenging due to their dense composition. These blocks find application in both load-bearing and non-load-bearing roles within walls, panel walls, and partition walls. Additionally, they are used as backing for piers, retaining walls, as a support for other facing materials, in chimneys, fireplaces, garden walls, and more.

6. Hollow Concrete Blocks

Hollow concrete blocks are widely favored in construction, finding extensive use in multi-story buildings, factories, residential structures, and compound walls. These blocks are composed of cement, sand, and stone chips, offer cost-efficiency, lightweight attributes, and improved ventilation, making them ideal for compound walls. Hollow concrete blocks are categorized based on density and compressive strength into Grades A, B, C, and D.

Grade 'A' blocks serve as load-bearing units, with a minimum density of 1500 kg/m^3 and compressive strengths ranging from 3.5 to 7.0 N/mm^2 for 28 days. Grade 'B' blocks, also load-bearing, have a density not less than 1000 kg/m^3 and compressive strengths from 2.0 to 5.0 N/mm^2. Grade 'C' blocks are non-load bearing, with a density below 1500 kg/m^3 but not less than 1000 kg/m^3, and a minimum average compressive strength of 1.5 N/mm^2 at 28 days. Grade 'D' solid concrete blocks have a minimum density of 1800 kg/m^3 and compressive strengths of 4.0 and 5.0 N/mm^2.

Hollow concrete blocks find application in various construction scenarios, including load-bearing and partition walls, curtain walls, fireproofing, fire-safe walls, piers, columns, and retaining walls. They offer several advantages, such as cost-effectiveness, low maintenance, sound and heat insulation, fire resistance, reduced mortar usage, dimensional accuracy, high-stress bearing capacity, suitability for earthquake-prone areas, and environmental friendliness. However, they have a lower load-bearing capacity and are susceptible to water seepage due to their porous nature.

7. AAC Light Weight Blocks

Autoclaved Aerated Concrete (AAC) blocks are gaining prominence in the construction industry, replacing traditional bricks. AAC is a lightweight foam concrete material, up to three times lighter than regular bricks, making it easy to handle. It consists of materials like cement, water, sand, lime, and a raising agent to form a porous structure. Unlike burnt clay bricks, AAC blocks undergo an autoclaving process with high pressure and temperature to achieve their lightweight and sturdy structure. AAC blocks offer numerous advantages, including exceptional thermal efficiency, superior fire resistance, lightweight properties, faster construction due to their larger size, cost-effectiveness for large-scale projects, eco-friendliness with reduced greenhouse gas emissions and solid waste generation during production, and natural moisture absorption, minimizing mildew and humidity.

However, there are some drawbacks to consider. Improper installation can lead to cracks, affecting the building's finish. The porous nature of AAC blocks requires careful handling during transportation to prevent breakage. AAC block prices vary based on order quantity, and their installation should be entrusted to experts. Additionally, AAC blocks are not suitable for heavy loads and are best used for partition walls.

8. Glass Blocks

Glass blocks, also known as glass bricks, are architectural elements crafted from glass and serve a unique purpose in interior design. These translucent building blocks offer both visual opacity and the transmission of light, making them a striking addition to upscale interior spaces. Glass block walls are commonly used for partitioning rooms, floors, and even skylights, enhancing aesthetics and functionality. They come in various textures, finishes, and colors to meet specific construction needs, including styles like See-through, Frosted, Random wave, Vertical/horizontal, Diamond, Leather, Crystalline, and Grid.

The advantages of glass blocks are multifaceted. They allow natural light to permeate a space while preserving privacy and their customization options enable tailored design. Glass blocks offer good thermal and sound insulation and boast structural strength for safety. However, they are not suitable for earthquake-prone regions due to safety concerns, and exposure to alkali solutions can lead to glass block corrosion. Their inherent brittleness requires careful handling, and the manufacturing process involves high energy consumption due to the elevated temperatures required for processing raw materials.

9. Foam Concrete Blocks

Foam concrete blocks, derived from foam concrete, offer a lightweight alternative for construction. These blocks, such as the popular 200mm x 300mm x 600mm size, can replace 13 to 15 conventional bricks, reducing joints and mortar usage significantly. The structural attributes of foam concrete blocks depend on the foam concrete's density used in manufacturing and adherence to specific processes, including the recipe, cement type, and drying method. Foam density, denoted by "D" followed by kg/m3, higher values indicate denser and stronger blocks. They are categorized by density into heat-insulating, structural-heat-insulating, and structural types, each suited for different purposes. Low-density blocks are not suitable for load-bearing walls, while high-density ones lack thermal insulation due to fewer air bubbles.

Foam concrete blocks offer excellent heat retention with a thermal conductivity coefficient significantly lower than bricks. However, they are susceptible to shrinkage when exposed to excess moisture during production, causing potential wall deformation. Proper curing for 28 days without water exposure is crucial for their solidification.

10. Porotherm Blocks

Porotherm clay bricks are innovative building materials known for their unique perforated design. These bricks, typically measuring 400x200x200 mm, are crafted from natural clay, coal ash, rice husk, and granite slurry. The term "porotherm" reflects their exceptional thermal insulation properties. Their perforated structure allows for effective insulation, maintaining comfortable indoor temperatures in both hot and cold seasons. Porotherm bricks are versatile, cost-effective; eco-friendly, suitable for non-load bearing and load-bearing walls, and boast attributes like low weight, durability, strength, and satisfactory fire resistance. They can be used with dry mortar, eliminating the need for curing time.

Porotherm bricks offer several advantages, including good strength, thermal insulation, durability, cost-effectiveness, environmental friendliness, and speedy construction. However, they have limitations, such as unsuitability for large structures due to their density (694 to 783 kg/m^3), susceptibility to salt attacks due to their 15% water absorption, and incompatibility with foundation and base-slab work in areas with high groundwater tables, as they may not withstand negative water pressure and capillary action.

3. Comparative Analysis on various parameter’s

Table 3.1: Cost Comparison of each block with their Standard size’s & No. of blocks required for 10 cum work

Sl No.	Type of Block	Standard Size	Rate per Block	No. of Blocks Required
1	Stone Block	445×230×100 mm	Rs. 18 to Rs.30 per	977
2	Laterite Stone Block	300×200×200 mm	Rs. 18 to Rs.30 per piece	834
		300×200×225 mm		667
		400×225×150 mm		741
3	Clay Brick	190×90×90 mm	Rs. 8 per piece	6498
4	Fly Ash Brick	230×110×70 mm	Rs. 10 per piece	5647
5	Concrete Solid Block	400×200×200 mm	Rs. 50 per piece	625
		400×200×150 mm	Rs. 36 per piece	834
		400×200×100 mm	Rs. 25 per piece	1250
6	Hollow Concrete Block	400×200 ×200	Rs. 28 per piece	625
		400×200×100 mm	Rs. 25 per piece	1250
7	AAC Lightweight	600×200×100 mm	Rs. 57 per piece	834
8	Glass Block	190×190×80 mm	Rs. 130 per piece	3463

9	Foam Concrete Block	600×200×100 mm	Rs. 40 per piece	834
10	Porotherm Block	600×200×200 mm	Rs. 67 per piece	417

(* While calculating the number of blocks wastages were not considered)

Table 3.2: Comparison of Water Absorption & Compressive Strength of blocks

Sl No.	Type of Block	Standard Size	Water Absorption in %	Range of Compressive Strength in Mpa
1	Stone Block	445×230×100	5	86.1 – 104.9
2	Laterite Stone Block	300×200×200 300×200×225 400×225×150	10 to 25	4.5 – 8.3
3	Clay Brick	190×90×90 mm	10 to 20	7.36 – 10.76
4	Fly Ash Brick	230×110×70 mm	5 to 10	3.5 – 10
5	Concrete Solid Block	400×200×200 400×200×150 400×200×100	5 to 15	3.5 – 21
6	Hollow Concrete Block	400×200 ×200 400×200×100	5 to 15	2.5 – 10
7	AAC Lightweight	600×200×100	5 to 10	3 – 7
8	Glass Block	190×190×80 mm	Less than 1	5 – 10
9	Foam Concrete	600×200×100	Less than 10	3 – 5
10	Porotherm Block	600×200×200	5 to 10	3 – 10

Table 3.3: Comparison of Building Envelope Parameters of each blocks

Sl No.	Type of Block	Standard Size	Thermal Co-efficient (Conductivity) in W/(m·K)	Thermal Expansion Co-efficient in microstrain per degree Celsius
1	Stone Block	445×230×100 mm	1.43	4 to 8
2	Laterite Stone Block	300×200×200 mm 300×200×225 mm 400×225×150 mm	1 – 2	4 to 8
3	Clay Brick	190×90×90 mm	0.5 – 1	5 to 10
4	Fly Ash Brick	230×110×70 mm	0.90 – 1.05	6 to 10
5	Concrete Solid Block	400×200×200 mm 400×200×150 mm 400×200×100 mm	0.70 – 0.76	10 to 14
6	Hollow Concrete Block	400×200 ×200 mm 400×200×100 mm	0.2 – 0.6	10 to 14
7	AAC Lightweight Block	600×200×100 mm	0.1 – 0.7	9 to 12
8	Glass Block	190×190×80 mm	0.8 to 1.4	8 to 10
9	Foam Concrete Block	600×200×100 mm	0.021 – 0.035	4 to 8
10	Porotherm Block	600×200×200 mm	0.20 – 0.26	5 to 10

- Thermal coefficient typically refers to the material's thermal conductivity. It is a measure of how well a material conducts heat. Thermal conductivity describes how quickly heat can move through a material when a temperature difference exists across it. The units of thermal conductivity are typically watts per meter per degree Celsius (W/m°C) or other similar units.

- Thermal coefficient of expansion or thermal expansion coefficient refers to how a material's dimensions (length, area, volume, etc.) change with temperature. It quantifies the degree to which a material expands or contracts when subjected to temperature variations. The units of thermal expansion coefficient are typically per degree Celsius (°C^-1) or per Kelvin (K^-1).

Table 3.4: Comparison of Percentage of Cement Mortar used for wall Construction

Sl No.	Type of Block	Standard Size	Cement Mortar in %
1	Stone Block	445×230×100 mm	20 to 30
2	Laterite Stone Block	300×200×200 mm	20 to 30
		300×200×225 mm	
		400×225×150 mm	
3	Clay Brick	190×90×90 mm	20 to 30
4	Fly Ash Brick	230×110×70 mm	15 to 25
5	Concrete Solid Block	400×200×200 mm	15 to 20
		400×200×150 mm	
		400×200×100 mm	
6	Hollow Concrete Block	400×200 ×200 mm	
		400×200×100 mm	
7	AAC Lightweight Block	600×200×100 mm	10 to 15
8	Foam Concrete Block	600×200×100 mm	10 to 15
9	Porotherm Block	600×200×200 mm	15 o 20

4. Additional Explanations on Blocks Characteristics

- **Density:** The density of masonry blocks can impact their weight and structural performance. Higher-density blocks tend to be more durable but may also be heavier and more challenging to handle.
  The density of masonry blocks varies significantly, with stone, concrete, and clay bricks being relatively dense, while AAC lightweight blocks, foam concrete blocks, and Porotherm blocks are designed to be lightweight. Glass blocks fall in the dense category due to their solid composition.
- **Modulus of Elasticity:** This measures the block's ability to deform elastically when subjected to stress. It's important for determining how much a block can deflect under load without permanent deformation.
  The modulus of elasticity varies widely among masonry blocks, with natural stones, concrete blocks, and glass blocks having high values, indicating their stiffness. AAC lightweight blocks and foam concrete blocks have lower modulus values, suitable for lightweight construction with some flexibility. Clay bricks and laterite stones fall in the moderate range, offering a balance of strength and flexibility.
- **Sound Insulation:** Masonry blocks can have varying degrees of sound insulation properties. Blocks with better sound insulation can be used in noise-sensitive areas or for acoustic purposes.
  Masonry blocks vary in their sound insulation properties, with AAC lightweight blocks offering the highest sound insulation, making them suitable for noise-sensitive areas. Concrete blocks also provide good sound insulation. Stone, laterite, clay, fly ash, and glass blocks offer limited sound insulation, while foam concrete and Porotherm blocks offer moderate insulation.
- **Durability:** Durability is a comprehensive property that considers a block's resistance to weathering, abrasion, freeze-thaw cycles, and other environmental factors over time.
  Durability varies among masonry blocks, with natural stone, AAC lightweight blocks, concrete blocks, and Porotherm blocks considered highly durable options. Clay and fly ash bricks also offer good durability but may require maintenance over time. Laterite stone blocks may be less durable in

humid environments. Glass blocks are durable in terms of structural integrity but may require aesthetic maintenance. Foam concrete blocks are moderately durable and may benefit from protective coatings for exterior use.

5. Observations and Remarks

The suitability of different types of blocks for wall construction depends on various factors, including the specific requirements of your project, local building codes and standards, and your budget. Here are some observations about the usage of the mentioned block types in wall construction:

1. **Stone Block:**
   - Suitable for traditional and rustic aesthetics.
   - Often used in retaining walls and decorative features.
   - Requires skilled labor for installation due to irregular shapes.
   - Provides good thermal mass but may need substantial mortar.
2. **Laterite Stone Block:**
   - Common in regions with lateritic soil.
   - Suitable for traditional and eco-friendly construction.
   - Requires experienced masons for proper installation.
   - Offers natural beauty and thermal mass.
3. **Clay Brick:**
   - Widely used for residential and commercial construction.
   - Provides good insulation properties.
   - Available in various sizes and textures for design versatility.
   - Requires mortar with good adhesion properties.
4. **Fly Ash Brick:**
   - Sustainable choice with reduced environmental impact.
   - Good strength and durability.
   - Can be used in load-bearing and non-load-bearing walls.
   - Suitable for green building projects.
5. **Concrete Solid Block:**
   - Versatile and commonly used in various construction projects.
   - Offers good structural strength.
   - Provides thermal mass but may need insulation for energy efficiency.
6. **Hollow Concrete Block:**
   - Lightweight and cost-effective.
   - Suitable for partition walls and infill walls.
   - Offers some thermal insulation properties.
   - Requires proper reinforcement for structural applications.
7. **AAC Lightweight Block:**
   - Excellent thermal insulation properties.
   - Lightweight and easy to handle.
   - Suitable for both load-bearing and non-load-bearing walls.
   - Energy-efficient and environmentally friendly.
8. **Glass Block:**
   - Adds aesthetic appeal with translucency and light diffusion.
   - Often used for decorative purposes and interior walls.
   - Requires specialized installation techniques.
9. **Foam Concrete Block:**
   - Lightweight and suitable for non-load-bearing walls.
   - Good thermal insulation properties.

- Requires less labor and is cost-effective.

10. Porotherm Block:

- Lightweight and easy to handle.
- Offers good thermal insulation.
- Suitable for residential and commercial construction.
- Requires proper mortar mix for optimal performance.

Ultimately, the choice of block type for wall construction will depend on specific project requirements, such as load-bearing capacity, insulation needs, aesthetics, and budget. It's essential to work with a qualified architect or engineer and adhere to local building codes and regulations when selecting and using these block types in construction project.

6. Conclusions

1. From factors such as size, cost per block, and the total number of blocks required, with options ranging from natural stones and clay bricks to more cost-effective alternatives like fly ash bricks, concrete blocks, and AAC lightweight blocks.
2. Based on compressive strength for various block types, it's evident that there is a wide range of options available for different construction needs. These options include high-strength stone blocks, lightweight AAC blocks, and various sizes of concrete and clay bricks. The choice of block type should consider both the intended application and the required compressive strength, allowing for flexibility in construction projects.
3. The thermal conductivity data for various block types demonstrates a significant range in insulation properties. Stone and laterite blocks have relatively higher thermal conductivity, making them less suitable for insulation, whereas AAC lightweight blocks, foam concrete blocks, and hollow concrete blocks exhibit much lower thermal conductivity, making them excellent choices for thermal insulation in construction projects.
4. It's essential to consider the thermal expansion characteristics when selecting block types for construction. Blocks with lower thermal expansion coefficients may be more stable in the face of temperature fluctuations, making them suitable for structures where thermal expansion and contraction are critical considerations. Conversely, blocks with higher coefficients may require more attention to control potential expansion-related issues.
5. The choice of block type and the corresponding cement mortar percentage should be based on the specific project requirements, including load-bearing capacity, insulation needs, and adherence to local building codes and standards. Proper mortar selection is crucial for ensuring the stability and longevity of the constructed walls.
6. Variations in water absorption properties are important considerations for selecting the right type of block for specific construction applications, as it can impact the structural integrity and durability of the building.

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