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*Analysis of Existing Situation and
Opportunities in Building
Construction Material – Structural
Expert*

ESTABLISHMENT OF THE PAKISTAN GREEN BUILDING
CERTIFICATION SYSTEM

GREEN GROWTH. CONSULTANTS (PVT) LTD.

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Analysis of Existing Situation and Opportunities in Building Construction Material – Structural Expert

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1. INTRODUCTION

PURPOSE OF THE REVIEW AND ANALYSIS

The report evaluates the structural integrity of the existing infrastructure in Pakistan, with a focus on the materials used and their impacts. This document however focuses on three major types of buildings that currently exist in the country

- **Residential Buildings:** In Pakistan residential/domestic buildings range from modern apartments to traditional houses with courtyards. These buildings use various construction materials such as brick, mud, concrete, and steel.
- **Commercial Buildings:** Commercial buildings mainly consist of offices, retail stores, malls, hotels, restaurants, and warehouses. These buildings employ a variety of construction materials including steel, concrete, wood, aluminum, and glass, to ensure durability and functionality.
- **Public Buildings:** Public buildings in Pakistan are of various types such as government offices, schools, hospital buildings, religious places, and transportation hubs. These buildings accommodate large crowds with accessibility features.

The evaluation has considered various aspects of the building's structural integrity and has identified the structural enhancements necessary for the transition from conventional buildings to green buildings. This includes an assessment of conventional materials used in the construction of the building sector and the potential of green materials that can replace the current materials. Moreover, it compares the cost of the buildings calculates the energy savings that can be obtained by using sustainable materials, and computes the payback period for the transition of conventional buildings into green buildings. Along with addressing the critical issue of the supply chain for green construction materials, the report recommends measures to promote green construction practices within Pakistan.

BACKGROUND

The construction industry is experiencing a significant boom and is estimated to grow by 35% as compared to the previous decade. The global construction market is expected to expand from US\$4.5 in 2021 trillion to US\$15.2 trillion in 2030, with China, India, US, and Indonesia accounting for 58.3% of the forecasted growth. According to the World Bank, the construction industry is the largest global consumer of raw materials with the construction environment accounting for 25% to 40% of the world's total GHG emissions.

Construction materials used in Pakistan are mostly conventional such as steel, cement, glass, bricks, and wood. These are not always economical, environmentally friendly, and health-conscious. However, by using sustainable alternatives many of these drawbacks can be mitigated. Cement is commonly used in Pakistan but cement production is an energy-intensive process that leads to substantial expenses replacing it with fly ash cement can offer a more cost-effective and environmentally friendly alternative. Glass can be really expensive when it is used in large and intricate designs but it can be substituted by insulated glass that is cost-effective in long term due to energy

efficiency. Traditional bricks are affordable but less sustainable thus fly ash bricks can be a sustainable alternative.

Furthermore, these construction materials result in carbon emissions for instance steel is a widely favored metal selection for constructing buildings in Pakistan but its production is associated with significant carbon emissions. By choosing sustainable alternatives such as bamboo or recycled steel, environmental impact can be significantly reduced. In Pakistan, traditional glass is a commonly utilized building material. However, it keeps the building warm in summer and thus requires more cooling resulting in carbon emissions. By using low emissivity windows or insulated glass units, buildings keep cool in summer and warm in winter hence the energy consumed by the Heating, Ventilation, and Air Conditioning (HVAC) system resulting in reduced carbon emissions. Similarly, replacing conventional bricks with fly ash bricks conserves natural resources and minimizes the environmental footprint.

Moreover, sustainable materials such as rammed earth or bamboo do not emit harmful chemicals contributing to a healthier indoor environment. Likewise, fly ash cement is durable and safe benefiting the safety of residents. Bamboo and low-VOC paint ensure better indoor air quality, and green roofs and galvanized sheet roofing offer improved insulation and provide a better indoor environment resulting in health benefits for occupants.

However, it is difficult to meet the ever-growing demand for buildings by adopting only sustainable materials and construction methods. Hence, there is a need for optimum utilization of available energy resources and raw materials to produce simple, energy-efficient, environment-friendly, and sustainable building alternatives and techniques to satisfy the increasing demand for buildings.

2. PAKISTAN GREEN BUILDING SCENARIO

Currently, Pakistan lacks the adaptation of sustainable materials in the building construction sector, primarily because of the high initial costs, the lack of awareness regarding the benefits of using these materials, and the absence of a dedicated supply chain. According to Green Building Information Gateway (GBIG), Pakistan contains 17 LEED-certified green buildings with 13 registered with the US Green Building Council and 1 with an achiever award, making a list of 31 total green buildings in the country.¹ This number is quite low compared to other developing countries; where India has 323 certified LEED buildings² and Turkey reported 518 certified green buildings.³

Additionally, in Pakistan, the green building approach suffers from market barriers, for instance, there is a lack of government intervention in the market and inadequate tax incentives for green building materials. Besides, Pakistan's construction industry lacks training for sustainable material usage resulting in lesser awareness about the benefits of using these materials at the micro level. Also, the supply chain for sustainable materials is weak in Pakistan, consequently increasing the costs of materials. Although some green and recyclable materials such as fly ash bricks, bamboo, and recycled

1 Azeem, S., Naeem, M.A., Waheed, A. (2020). Adoption of Green Building Practices in Pakistan: Barriers and Measures. In: Gou, Z. (eds) Green Building in Developing Countries. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-030-24650-1_11

2 <https://www.usgbc.org/articles/top-10-countries-leed-demonstrate-green-building-truly-global-movement>

3 Akcay, E. C. (2023). Barriers to Undertaking Green Building Projects in Developing Countries: A Turkish Perspective. *Buildings*, 13(4), 841. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/buildings13040841>

steel are gaining popularity in building construction but are in a nascent state. Hence, the phenomenon of using green building materials is very novel and not widely practiced in Pakistan.

BUILDING CODES AND FRAMEWORKS IN PAKISTAN

The latest **Building Code of Pakistan (2021)** provides a minimum benchmark to ensure seismic resilient building design based for all new buildings. It has comprehensive guidelines on traditional constructional materials (concrete, steel, wood, and glass), but these guidelines are mainly focused on the structural strength aspects of these materials to make the structure robust against **seismic threats** in the future. Furthermore, it lacks guidelines about material usage in buildings from the point of view of energy savings in buildings.⁴

On the other hand, The Energy Efficiency of Buildings section is not included in **Building Code 2021**. as they were covered in Building Code of Pakistan-Energy Provisions 2011.^{5 6} However, Energy Provisions 2011 is no longer used in Pakistan and has been replaced by **the Energy Conservation Building Code 2023 (Pakistan) (ECBC-2023)**. The codes focusing on energy-efficient building materials are being prioritized because energy demand in the country has enhanced substantially. To further increase the future adaptation of sustainable materials reducing electricity consumption and carbon footprints should be included in future provisions of the building code because it will provide a legal framework for the adaptation of sustainable materials in the construction of buildings.

Moreover, SWITCH-Asia-EU – EU, in collaboration with the Ministry of Climate Change (MoCC), Pakistan Engineering Council (PEC), UN-Habitat, and the International Code Council (ICC), has successfully developed the **Green Building Code Provisions**. These provisions are based on the 2018 International Green Construction Code (IgCC-2018), ASHRAE 90.2 2018, and various research projects (Arif 2022/NRPU 9626) conducted in Pakistan.⁷ Chapter 5 of this green building code discusses **materials** and **resources** that need to be incorporated into buildings. This document was prepared for the Naya Pakistan Housing scheme and addresses the need for transition to green materials and provides suggestions for incorporating sustainable materials employing recycling waste, replacing hazardous materials, and usage of insulation to reduce energy requirements. Although it does not provide comprehensive guidelines to transit completely on these materials it can be used as initial guidelines for incorporating sustainable materials in new housing schemes.

Buildings in Pakistan can adopt green materials and strategies that comply with the Energy Conservation Building Code 2023. The code was developed to improve energy efficiency in buildings. ECBC provides minimum requirements for energy-efficient designs and construction of buildings and includes international best practices appropriate to Pakistan's environment. This document can be utilized as a useful framework for encouraging the adaptation of green materials. It covers materials that can be replaced and used instead of conventional materials in the construction phase and the materials that can help in opting energy energy-efficient designs to enhance the operational phase of buildings.

4 <https://www.pec.org.pk/downloads-documents/building-code-of-pakistan/>

5 <https://www.pec.org.pk/downloads-documents/building-code-of-pakistan/>

6 <https://codes.iccsafe.org/content/PKBC2021P1/chapter-13-reserved>

7 https://www.switch-asia.eu/site/assets/files/3619/model_green_building_code_pakistan.pdf

3. CONSTRUCTION MATERIALS PRACTICES IN PAKISTAN

In Pakistan construction industry primarily relies on a variety of materials. The energy conservation pattern exhibited by these materials is still lacking as compared to other countries because hardly any appropriate measure has been taken for heating, cooling, leakage, or orientation.

The figures given below represent the distribution of construction material according to the material used for walls.

PROVINCE & DISTRICT	MATERIAL USED FOR WALLS				
	BURNT BRICKS /BLOCKS	MUD BRICKS/MUD	WOOD	OTHER	TOTAL
Pakistan	79.84	15.32	1.62	3.21	100.00
Urban	95.95	2.94	.46	.65	100.00
Rural	69.68	23.13	2.35	4.83	100.00

Figure 1: Housing Units in Pakistan by Construction Material (Source: Pakistan BUREAU of Statistics 2019-20)

PROVINCE & DISTRICT	MATERIAL USED FOR ROOF					TOTAL
	RCC/RBC	WOOD/ BAMBOO	SHEET/IRON/CE MENT	T-R/GAR	OTHER	
Pakistan	33.31	22.86	4.05	39.19	.59	100.00
Urban	59.74	6.63	4.85	28.29	.49	100.00
Rural	16.64	33.09	3.55	46.06	.65	100.00

Figure 2: Percentage Usage by Material Used in Roofs (Source: Pakistan BUREAU of Statistics 2019-20)

The statistics show intensive usage of concrete and bricks in urban construction while the usage of bamboo and gar is quite prevalent in rural areas. With increasing urbanization, the utilization of bricks and concrete is expected to mount up in urban areas, the higher consumption of this material will consequent in the heat island effect due to the adoption of concrete, and needs to be mitigated by using sustainable materials. Although bamboo and gar are used in higher percentages in rural areas with increasing urbanization fewer people prefer them so the adoption of these and other sustainable materials should be enhanced in both urban and rural areas. In addition, modern techniques should be used to make them resilient and aesthetically appealing

Furthermore, Pakistan lies in a temperate climate zone and according to **Energy Conservation Building Code 2023**, in a temperate climate zone, using appropriate building materials with insulating properties can substantially decrease energy consumption. Hence it is essential to identify the varying energy-saving potential of wall materials with different coefficients of heat transfer (U-values). The estimated values are provided below in Figure 3, these values are based on an energy simulation study outlined in the report of **Building Sector Energy Efficiency Project-2021 (BSEEP)**.

Case	Description	ASHRAE U-value (W/m ² K)	Wall Simplified Energy Index (kWh/y per m ² of wall area)		
			High nighttime baseload	Medium night-time baseload	Low night time baseload
1	Concrete wall, 100 mm	3.40	55	32	28
2	Brick wall, 115 mm	2.82	52	30	25
3	Brick wall, 220 mm	2.16	50	27	22
4	Double brick wall with 50 mm cavity, 300 mm	1.42	48	25	20
5	Autoclave lightweight concrete, 100 mm	1.25	47	24	18
6	Autoclave lightweight concrete, 150 mm	0.94	45	22	17
7	Autoclave lightweight concrete, 200 mm	0.75	45	22	16

Figure 3: Estimated Electricity Reduction for Wall Materials (Source: Public Works Department Malaysia-2021)

The model considered in the above study was designed using a square building without external shades, with a service core located in the building's center. The high, medium, and low night-time baseloads are associated with night baseloads of 50%, 35%, and 10% of the daytime peak load, respectively. It shows that by reducing the wall material's U-value, the simplified energy index can be decreased. Additionally, the U value of lightweight concrete walls is lower thus energy saving potential increases with reducing concrete in the wall.

Materials that have been traditionally used in Pakistan's construction industry are discussed below along with their impacts.

1. Brick

Clay brick has high energy consumption in the operational phase of buildings because of its low insulation properties⁸. Clay bricks however can be replaced with ash blocks that are 3 times costlier and considerably decrease the requirement of cooling resulting in reduced size of the air conditioning system. Hence ash blocks can be an effective substitute for clay bricks.⁹

2. Cement

Cement is a widely used construction material in Pakistan which has multiple negative impacts on the building's operational phase. Cement-based buildings often have high thermal mass, tending to take a long time to heat up or cool down. This results in increased energy consumption, especially in regions with extreme temperature variations. Although the majority of carbon emissions associated with cement occur during its manufacturing, there is still an ongoing carbon footprint during the operational phase due to the energy required for the HVAC system.¹⁰ Alternatively, fly ash cement is an efficient material to reduce the use of cement. Blocks of cement from fly ash have high insulation and a lower carbon footprint which mitigates the negative impacts of cement.

3. Concrete

⁸ <https://ieeexplore.ieee.org/document/9972735>

⁹ Kumar, Ashok & Buddhi, D. & Chauhan, D. (2011). Indexing of Building Materials with Embodied, Operational Energy and Environmental Sustainability with Reference to Green Buildings. *J. Pure Appl. Sci. Technol.* 2.

¹⁰ L. Barcelo, J. Kline, G. Walenta, E. Gartner, Cement and carbon emissions. *Mater. Struct.* 47, 1055–1065 (2014).

The use of concrete is problematic in buildings as it adds to the heat-island effect by absorbing the warmth of the sun and trapping gases from car exhausts and air-conditioner units installed in a building.¹¹ Concrete is widely used in both urban and rural buildings in Pakistan hence energy efficient alternative blends or materials can help to reduce these negative effects. Rammed Earth is a viable alternative that has high insulative properties and high durability against earthquakes.

4. Steel

Steel-framed buildings often require more energy for heating and cooling compared to well-insulated structures. Steel has high thermal conductivity, which results in significant heat loss or gain, depending on the climate. Moreover, steel structures can corrode over time, especially in humid or coastal environments such as Sindh and Balochistan. The corrosion leads to maintenance requirements, including repainting or even structural repairs, which can be costly and resource-intensive.¹² A sustainable alternative for Pakistan can be a galvanized steel sheet that has high heat resistance and low operational cost making it a more appealing choice.

5. Wood

Pakistan has limited forest cover, encompassing less than 6 % of its total land area.¹³ The usage of wood in the building further results in **deforestation** causing loss of carbon sink, reduced biodiversity air quality degradation, and soil erosion. Thus, it is an urgent requirement to replace wood with an alternative material. In addition, wood treatments, finishes, or adhesives emit volatile organic compounds (VOCs), which can affect indoor air quality and occupant health.¹⁴ According to **Energy Conservation Building Code 2023**, wood framing exhibits a lower R-value, allowing heat to conduct more easily compared to insulated regions which increases the energy demand of buildings to cool them. To replace wood works in a building bamboo should be used in Pakistan because of its higher insulation and renewability factor.

6. Traditional Roofing Materials (Asphalt and Metal Tiles)

Asphalt and metal tiles are some of the materials used in the roofing of buildings in Pakistan. They do not provide adequate insulation, leading to higher energy consumption for cooling or heating buildings.¹⁵ Hence, to reduce energy consumption, sustainable insulation materials such as galvanized sheets and bamboo can be viable options for roofing.

7. Non-insulated Glass Windows

Non-insulated windows are less energy-efficient, leading to higher energy consumption for heating and cooling. Unlike insulated glass doors and windows, they do not resist heat.¹⁶ Their insulation ability is not resistant enough to protect the room or building from hot weather. This allows heat to enter more than it would from an insulated glass. In summer or regions where temperatures can be

11 P. J. M. Monteiro, S. A. Miller, A. Horvath, Towards sustainable concrete. *Nat. Mater.* **16**, 698–699 (2017).

12 <https://northern-weldarc.com/blog/advantages-disadvantages-structural-steel-structures>

13 https://www.wfpak.org/our_work_/forests/

14 Roffael E. Volatile organic compounds and formaldehyde in nature, wood and wood-based panels. *Holz: Roh-Werkst.* 2006;64:144–149. doi: 10.1007/s00107-005-0061-0

15 <https://www.zameen.com/blog/type-roofing-tiles-pakistan.html>

16 <https://thearchitectsdiary.com/difference-between-insulated-and-non-insulated-glass-doors-and-windows/>

extreme, this can result in significant energy wastage. In Pakistan due to its cost-effectiveness, it's preferred over the other options but it is not suitable in long-term scenarios because energy losses from its usage result ultimately in higher costs. Alternative double-glazing windows with low emissivity are a viable sustainable alternative that can be used instead of non-insulated windows.

Pakistan continues to grow and modernize, and a strategic shift toward sustainable construction materials is a pressing necessity. The shortcomings in the traditional materials seek the intervention of sustainable alternatives to enhance the overall energy efficiency of the buildings and move towards greener buildings. The construction industry in Pakistan stands at a pivotal state where the adoption of sustainable materials can bring a multitude of benefits. Not only it will address environmental concerns but it will significantly contribute to energy efficiency financial benefits and a resilient future.

4. SUSTAINABLE CONSTRUCTION MATERIALS FOR GREEN BUILDINGS IN PAKISTAN

A large number of viable alternative building technologies have been developed and disseminated over two and half decades. The materials are currently used at a micro-scale in Pakistan but their increased adoption is necessary for a sustainable future.¹⁷

Table 1: Traditional Materials and Available Sustainable Alternatives In Pakistan

Traditional Materials	Sustainable Alternatives
Clay Bricks	Fly Ash Brick
Traditional Paint	Low VOC Paint
Insulated Glass Window	Low Emissivity Window /Insulated Glass Units
Concrete	Rammed Earth/ Bamboo
Cement	Fly Ash Cement
Wood	Bamboo/PVC flooring
Traditional Roofing Material	Green Roofs/Bamboo/Galvanized Sheet

A comprehensive detail of these alternative materials and some additional green building materials is discussed below:

1) Fly Ash Bricks

¹⁷ <https://www.linkedin.com/pulse/sustainable-materials-construction-muhammad-umar/>

Fly ash bricks are made from waste materials produced by coal-fired power plants. They are strong, durable, and environmentally friendly, as they help reduce waste by recycling ash and save energy through high insulative properties. Furthermore, fly ash bricks have excellent insulation properties resulting in less HVAC energy consumption.

Fly ash bricks are a sustainable building material because they have a lower carbon footprint compared to traditional clay bricks. They are also cheaper than traditional bricks, making them an affordable option for construction in Pakistan.



Figure 4: Fly Ash Bricks¹⁸

Building Materials	Composition	Material Compared	Energy saving (%)
Portland Pozzolana Cement	75% ordinary Portland cement and 25% Fly Ash	100% Ordinary Portland Cement	20
Lime-Pozzolana mixture	25% Acetylene gas lime and 75% Fly Ash	25% Lime and 75% calcined brick	75
Calcium silicate brick	90% Fly Ash tailings 10% lime (waste source)	Burnt Clay brick	40
Burnt brick	75% clay and 25% Fly Ash	Burnt Clay brick	15
Fly Ash Brick	50% Fly Ash , 28% Sand, 20% Lime and 2% Gypsum	Burnt Clay Brick	>40

Figure 5: Energy Savings using Fly Ash ¹⁹

¹⁸ <https://dailycivil.com/advantages-and-disadvantages-of-fly-ash-bricks/>

¹⁹ Kamal, Mohammad Arif. (2016). Recycling of Fly Ash as an Energy Efficient Building Material: A Sustainable Approach. Key Engineering Materials. 692. 54-65. 10.4028/www.scientific.net/KEM.692.54.

Moreover, according to the guidelines of **Green Building Code Provisions by MoCC Pakistan**, recycled materials shall be utilized in green housing projects to promote a circular economy and divert material from landfills. The recycled material needs to be a specified percentage of the total material, preferably by cost. Thus, using fly ash bricks is aligned with the provisions.

2) Insulative Material

The heat gain in hot climates can be fairly reduced by well-planned insulation of walls resulting in less (HVAC) and annual energy costs. The kind of insulative material that is available in Pakistan and can be used to lower energy conservation are insulated glass and cellulose insulation.

- **Insulated Glass**

Insulated glass unit (IGU), more commonly known as double glazing, consists of two or three glass window panes separated by a vacuum or gas-filled space to reduce heat transfer across a part of the building envelope. It is a very effective way to reduce air-to-heat transfer through the glazing. When used in conjunction with low-emissivity and/or reflective coatings, IGU performs even better for conserving energy and complying with international standards.²⁰

Double glazing greatly reduces the amount of heat transmitted through a building’s windows, by **20-25 %** and perhaps as much as **50 %**. This means that less energy will be needed to heat or cool the building, saving the cost to the owner as well as reducing the building’s carbon footprint.²¹

However, the **Energy Conservation Building Code 2023**²² has provided guidelines that glazing shall be used very carefully a balance between natural light, ventilation, and heat gain should be maintained properly. The windows must be appropriately shaded and insulated to minimize the heat exchange. These insulated glasses are highly valuable for the compliance of **ECBC**.

- **Cellulose insulation**

This material is endorsed by the **ECBC (2023)** to be used as insulation material in roofs. One of its significant uses in Pakistan is for thermal insulation. The low thermal conductivity of cellulose foam makes it an excellent choice for insulation purposes.

A comparative evaluation between various sustainable materials has been done and the total load savings by each material is shown below.²³

Table 2: Total Load and Load Saving Using Each Insulation¹⁶

Month	Total Load (MWh)			
	Cellulose	Polystyrene Foam	Polyurethane Foam	Rock Wool

²⁰ <https://greentechglass.com/insulated-glass/>

²¹ Energy efficiency of double glazed windows (2017) Majestic Glass. Available at: <https://majesticglass.com.au/energy-efficiency-double-glazed-windows/>

²² <https://neeca.gov.pk/NewsDetail/ZDY0NTY2MzAtNDBjNi00ODIyLWFKMzgtN2MzMTBmNGNhYTc3>

Jan	0.36	0.309	0.358	0.343
Feb	0.003	0.959	0.003	0.002
Mar	15.29	15.011	15.288	15.21
Apr	45	43.91	44.8	44.551
May	62.17	60.884	62.17	61.81
Jun	52.8	51.714	52.8	52.497
Jul	42.275	41.524	42.275	42.065
Aug	44.301	43.557	44.301	44.093
Sep	42.075	41.347	42.075	41.871
Oct	29.953	29.442	29.953	29.809
Nov	7.933	7.837	7.933	7.906
Dec	0.361	0.367	0.361	0.122
Grand Total	342.317	336.861	342.317	340.279
Percentage Load Saving	28.132%	29.293%	28.132%	28.50%

Findings indicate that polystyrene foam (high density) stands out as the most effective insulating material. However, it's important to note that due to its high flammability, it necessitates an additional layer of fireproof coating material. Typically, this involves the application of a fireproofing chemical known as Hexabromocyclododecane.

On the other hand, rock wool lacks additives that confer fire resistance, making it less suitable for use in extremely hot conditions, though it is inherently non-combustible. Whereas polyurethane foam employs CFC gas as a blowing agent which contributes to ozone layer depletion.²³

Cellulosic insulation is found to be the most eco-friendly, fire-resistant, and suitable insulating material. Using cellulose insulation helps to keep spaces comfortable and energy-efficient, contributing to a more sustainable environment. This is beneficial, especially for Pakistan, where energy conservation and temperature control are important, whether it's for houses, commercial buildings, or public facilities. **Error! Bookmark not defined.**

²³ Ahsan, Muhammad Mubashir, Muhammad Zulqernain, Hassaan Ahmad, Basit Ali Wajid, Saqib Shahzad, and Muzamil Hussain. "Reducing the operational energy consumption in buildings by passive cooling techniques using building information modelling tools." *International Journal of Renewable Energy Research (IJRER)* 9, no. 1 (2019): 343-353.

3) Cool Brick

There is a new material being experimented on in Pakistan, propelled by the Muscatese Evaporative cooling window, which joins a fired vessel loaded up with water and a wood screen. A 3D-printed porous clay block is set in mortar, every block retains water like a wipe and enables air to go through the divider. As air passes through the 3D printed block the water that is present in the tiny scale pores of the clay dissipates, bringing cool air into an inside domain and reducing the temperature using the guideline of evaporative cooling. In Pakistan, the cool brick will provide thermal comfort within the structure without using any mechanical cooling device resulting in less HVAC energy consumption..²⁴ The assessment of 3D-printed green walls shows that they lower the AC load by **11.20%** in summer and **9.12%** yearly.²⁵

4) Low VOC Paint

In Pakistan, paint serves the dual purpose of protecting walls and adding decorative appeal to buildings. The paints used in Pakistan release **harmful chemicals** called VOCs into the indoor air, leading to air pollution indoors. According to **Green Building Code Provisions**, the use of paints and coatings having a high content of VOCs, such as formaldehyde, should be prohibited to ensure healthy indoor air.²⁶

To address this issue, paint manufacturers in Pakistan, are now producing low-VOC paints. Notably, in Pakistan, water-based paints are a preferable choice since they contain **three times fewer VOCs** compared to oil-based paints²⁷. Moreover, lighter-colored paints and those with a flat finish tend to have lower VOC levels, making them a better option for indoor spaces, and contributing to better indoor air quality and health.²⁸

5) Low Emissivity Windows

The **Energy Conservation Building Code 2023** of Pakistan emphasizes using windows that are properly shaded and insulated and have R values under advisable limits. Regular, uncoated glass in Pakistan has a high emissivity value of **0.91**²⁹, which means it allows a lot of heat to escape from buildings, making it less energy-efficient.

To address this issue, low-emissivity (Low-E) glass can be utilized. This glass has a nearly invisible coating on one side that reflects heat away in summer and back into the room in winter, it helps in maintaining indoor temperature making buildings more comfortable and energy-efficient in hot weather.

Windows manufactured with Low-E coatings typically cost about 10% to 15% more than regular windows, but they reduce energy loss by as much as **30% to 50%**.³⁰

24 3D-printed 'cool brick' may provide a cooling solution for arid locations <https://www.bdcnetwork.com/3dprinted-cool-brick-may-provide-cooling-solutionarid-locations> Retrieved on 13th June (2019)

25 He, Y. et al. (2020) 'Energy-saving potential of 3D printed concrete building with Integrated Living Wall', *Energy and Buildings*, 222, p. 110110. doi:10.1016/j.enbuild.2020.110110.

26 GBG. 2021. Green Building Guidelines for Prime Minister's Five Million Naya Pakistan Housing Programme. Ministry of Climate Change, Pakistan. http://www.switch-asia.eu/site/assets/files/3035/green_building_guideline.pdf

27 Brettner, T., R. Kuroпка. & H. Petri. Recipe developments of low VOC interior paints. FATIPEC Congress, 24, A-259 – A-267

28 Buday, M., F. Cater, S. Foulkes, N.S.O. Prakash, & D. Wilson, Sherwin Williams: Splashing into the low VOC paint market. GlobalLens, a division of the William Davidson Institute at the University of Michigan. Case 1-428-993. 1 – 16

29 ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers <https://searchdatacenter.techtarget.com/definition/ASHRAE> Retrieved on 14th July 2019.

30 Window types and technologies (no date) Energy.gov. Available at: <https://www.energy.gov/energysaver/window-types-and-technologies>

- **Single vs Double-Glazed Window**

Replacement of single-glazed windows with brown-tinted double-glazed ones, while maintaining all other factors unchanged can result in a 4.17% reduction in annual thermal loads.

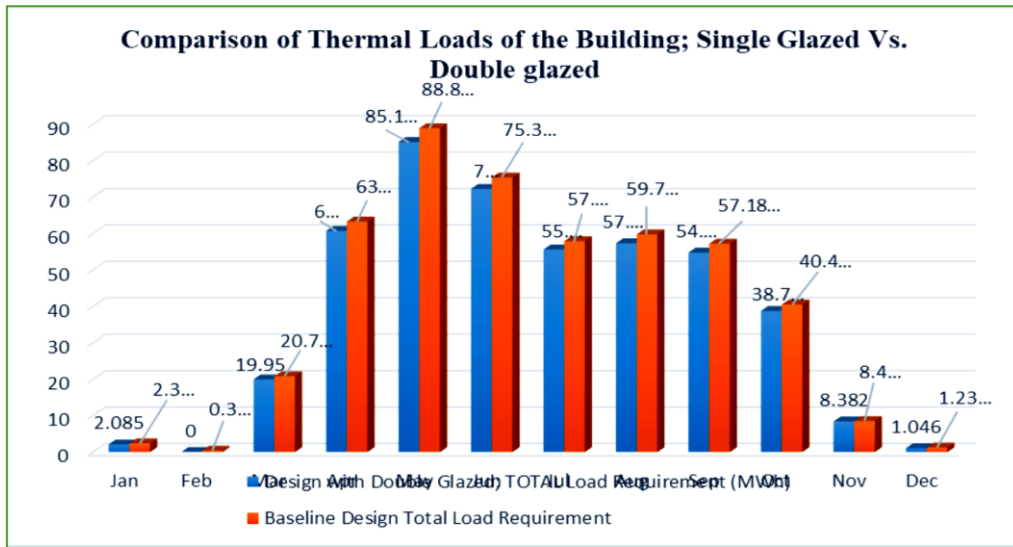


Figure 6: Comparison of Thermal Loads for Single Glazed and Double Glazed Window³¹

- Annual Load with Single Glazed Windows = 476.024 MWh
- Annual Load with Brown Tinted Double Glazed Windows = 456.150 MWh
- Load Saving = **4.1683%**

Table 3: Comparison of U values between Different Categories of Glazing Glass³²

Window Type	Average U Value
Single Glazing	5.2 W/m ² K
Uncoated Double Glazing	2.7 W/m ² K
Coated Double Glazing	1.2 W/m ² K

³¹ Ahsan, Muhammad Mubashir, Muhammad Zulqernain, Hassaan Ahmad, Basit Ali Wajid, Saqib Shahzad, and Muzamil Hussain. "Reducing the operational energy consumption in buildings by passive cooling techniques using building information modelling tools." International Journal of Renewable Energy Research (IJRER) 9, no. 1 (2019): 343-353.

³² <https://www.cuin.glass/blog/u-value-single-vs-double-vs-triple-glazing-vs-c-u-in/>

The lower the U value, the better the thermal performance of the glass. Hence, the lower U value of double-glazing glass as shown in the above table validates better thermal performance that increases energy saving potential.³³

6) Rammed Earth

It is a sustainable building material that is made by compressing layers of earth, gravel, and other locally available materials. Rammed-earth buildings are highly durable and can withstand **earthquakes, fires,** and other natural disasters. They have excellent **insulation properties**, which can help reduce the need for heating and cooling systems. The maximum average energy saving in a study indicates a saving of **2192.27 kWh/annual** from houses built on Rammed Earth.³⁴

Table 4: Heat Losses Comparison of Masonry and Rammed Earth³⁴

Heat loss (KW)	Masonry	Rammed earth
Walls	7,75	4,11
Roofs	2,73	1,94

The added benefit is that this will reduce the carbon output by around **1 tonne per year**, primarily from heating and cooling.³⁵



Figure 7: Rammed Earth Structure in Pakistan³⁶

³³ <https://www.cuin.glass/blog/u-value-single-vs-double-vs-triple-glazing-vs-c-u-in/>

³⁴ Li, S.; Wang, M.; Shen, P.; Cui, X.; Bu, L.; Wei, R.; Zhang, L.; Wu, C. Energy Saving and Thermal Comfort Performance of Passive Retrofitting Measures for Traditional Rammed Earth House in Lingnan, China. *Buildings* **2022**, *12*, 1716. <https://doi.org/10.3390/buildings12101716>

³⁵ <https://www.earthhouseaustralia.com.au/energy-savings-of-our-rammed-earth-homes/>

³⁶ <https://sirewall.com/new-tallest-rammed-earth-structure-on-earth-we-broke-our-old-record/>

7) Bamboo

Building Code Of Pakistan (2021) has provided the framework for wood usage concerning preservative treatment, fire safety, ASTM standards, and other compliance regulations, but in practice, wood is being used without proper adherence to these regulations, However, it lacks the direction of wood usage considering resource depletion and that should be an integral part of the codes in future to conserve the natural wood sources.

The **Green Building Code Provisions** developed by MoCC and Switch Asia suggest that 5 % of the building materials used, based on cost, shall be biobased products (**IGCC 2018**).³⁷ Moreover, it should be composed of solid wood, engineered wood, bamboo, wool, cotton, cork, agricultural fibers, or other biobased materials with at least 50 % biobased content.

The use of Bamboo in Pakistan as an alternative to woodwork is gaining popularity because hardwood and bamboo are the only renewable flooring options available. Bamboo has the benefit of being rapidly renewable and minimizing CO₂ emissions and generates up to **35% more oxygen** than equivalent stands of trees.³⁸ A study conducted for energy efficiency concluded that the use of bamboo instead of the conventional reinforced concrete structure would reduce energy consumption by **3% to 5%** and reduce **CO₂ emissions by 7% to 20%**. The analysis of results demonstrates that bamboo residential buildings are more carbon-efficient in cold climates.³⁹



Figure 8: Utilization of Bamboo in Navy Housing Scheme Zamzama Karachi⁴⁰

8) Galvanised Sheet

Galvanized steel sheets also come with a corrugated pattern. **For heat resistance**, these sheets are dipped and coated with zinc. As compared to **stainless steel**, a galvanized steel sheet is low in price, requires **less maintenance work**, and can be used for a longer period. All these qualities make it one of the best types of heat-resistant roofing sheets in Pakistan.

³⁷ GBG, 2021. Green Building Guidelines for Prime Minister's Five Million Naya Pakistan Housing Programme. Ministry of Climate Change, Pakistan. http://www.switch-asia.eu/site/assets/files/3035/green_building_guideline.pdf

³⁸ <https://dassopakistan.com/why-dasso/>

³⁹ Bolun Zhao, Yang Yu, Yitong Xu & Haibo Guo (2023) Bamboo as a sustainable construction material for residential buildings in the cold and severe cold regions of China, Architectural Engineering and Design Management

⁴⁰ <https://dassopakistan.com/portfolio-item/mariyum-asad-ali/>

They can also be used as additional coatings with heat and waterproofing chemicals, exhibit amazing quality of **damage control**, and are widely known for their robustness. This makes the galvanized steel one of the best roofing materials in Pakistan.⁴¹

Hence along with traditional materials used in buildings, these options are viable considering the market demand, awareness, and other factors that influence their role in the building construction.

5. COST EVALUATION OF CONVENTIONAL AND SUSTAINABLE CONSTRUCTION MATERIALS

This analysis is focused on comparing the cost if the traditional construction material is replaced with sustainable material. For this purpose, the commercial office building is chosen such that a G+3 rectangular building is considered for a conventional building and a G+4 "L" shaped building is considered for a green building model. Moreover, AutoCAD 2021 and SketchUp were used for rendering the design of the building models, and STACK (take-off and cost estimation) was used for quantity and cost estimation⁴². The models for both buildings are given below:



Figure 9: Conventional Building⁴³

41 <https://www.zameen.com/blog/heat-resistant-roofing-pakistan-types-cost.html>

42 <https://ijert.org/papers/IJERT22A6552.pdf>

43 <https://ijert.org/papers/IJERT22A6552.pdf>



Figure 10: Green Building⁴⁴

CONSTRUCTION MATERIAL

The material used for the construction of both buildings is given below:

Table 5: Construction Material Used in Conventional Building⁴⁵

Sl. No.	Item	Quantity	Unit	Embodied Carbon contribution per Kg	Total (Kg)	Total (Tonne)
1	Portland Cement	22,50,000	Kg	0.958	2155500	2155.5
2	Sand	1,13,60,000	Kg	0.25	2840000	2840
3	Aggregate	1,07,58,750	Kg	0.7	7531125	7531.125
4	Cement Blocks	49,37,500	Kg	0.368	1817000	1817
5	Reinforcement Steel	4,53,600	Kg	2.289	1038290.4	1038.2904
6	Stones	5,80,000	Kg	0.141	81780	81.78
7	Window Glass	16,000	Kg	1.551	24816	24.816
8	Timber - Plywood 100%	54,000	Kg	1.12	60480	60.48
9	Solvent borne paint	6,979	Kg	3.76	26241.04	26.24104
10	Earthwork	7,975	m ³	0.107	853.325	0.853325
11	Asphalt	5,25,600	Kg	0.007	3679.2	3.6792
					Total Embodied Carbon in Metric Tonnes	15579.76497

44 <https://ijcrt.org/papers/IJCRT22A6552.pdf>

45 <https://ijcrt.org/papers/IJCRT22A6552.pdf>

Table 6: Construction Material Used in Green Building⁴⁶

Sl. No.	Item	Quantity	Unit	Embodied Carbon contribution per Kg	Total (Kg)	Total (Tonne)
1	GGBS	8,52,930	Kg	0.042	35823.06	35.82306
2	Portland Cement	6,82,350	Kg	0.958	653691.3	653.6913
3	Sand	21,90,240	Kg	0.25	547560	547.56
4	Locally sourced aggregate	43,29,936	Kg	0.6	2597961.6	2597.9616
5	Fly ash based plaster & Mortar	1835538	kg	0.04	73421.52	73.42152
6	Brickwork	43,88,050	Kg	0.285	1250594.25	1250.59425
7	Steel - Rebar - 97% recycled	4,38,805	Kg	0.835	366402.175	366.402175
8	Timber - Manufactured structural timber	62,000	Kg	0.432	26784	26.784
9	granite	23,275	Kg	0.141	3281.775	3.281775
10	Double glazed Window Glass	83,600	Kg	1.551	129663.6	129.6636
11	Earthwork	4,212	m ³	0.107	450.684	0.450684
12	Non VOC paint	3,875	Kg	2.54	9842.5	9.8425
13	Permeable Pavement	91,800	Kg	0.007	642.6	0.6426
					Total Embodied Carbon in Metric Tonnes	5696.119064

- Total Embodied Carbon for Conventional Building 15,580 MTCO_{2e}
- Total Embodied Carbon for Green Building 5,696 MTCO_{2e}
- Reduction in Embodied Carbon = **9,884 MTCO_{2e}**

For the above calculations, only using green/sustainable material, 9,884 MTCO_{2e} can be reduced in the provided case before the implementation of any other green building controls, technologies, or building equipment.

COSTS OF BUILDING CONSTRUCTION MATERIALS

The estimated cost for construction materials for conventional and sustainable buildings is given below:

1) Conventional Building

Table 7: Conventional Building Construction Material Cost⁴⁷

Item	Quantity	Unit	Estimated Price (\$)
Portland Cement	2,250,000	Kg	195,430
Sand	11,360,000	Kg	91,623
Aggregate	10,758,750	Kg	80,098
Cement Blocks	4,937,500	Kg	127,433
Reinforcement Steel	453,600	Kg	225,136
Stones	580,000	Kg	44,980
Glass	16,000	Kg	14,766

46 <https://ijcrt.org/papers/IJCRT22A6552.pdf>

47 <https://ijcrt.org/papers/IJCRT22A6552.pdf>

Timber	54,000	Kg	457
Paint	6,979	Kg	8,327
Earthwork Excavation	7,975	m'	138,538
Asphalt	525,600	Kg	163,045
Grand Total			1,089,833

The costs given above are only focused on the construction material in a fully functional green building other costs can be for:

- Electrical Wiring
- Water Supply & Sanitation
- Labour Charges
- Scaffolding, Shuttering, etc.
- Consultation and miscellaneous work
- Contingencies

2) Sustainable Building

Table 8: Green Building Construction Material Cost⁴⁸

Item	Quantity	Unit	Estimated Price (\$)
GGBS	852,930	Kg	10,583.385
Portland Cement	682,350	Kg	59,280.504
Sand	2,190,240	Kg	17,665.032
Locally sourced aggregate	4,329,936	Kg	37,605.120
Fly ash-based plaster and mortar	849	m'	22,123.943
Brickwork	4,388,050	Kg	52,691.713
Recycled Steel	438,805	Kg	435,584.829
Reclaimed hardwood	62,000	Kg	456.202
Linoleum	23,275	Kg	19,917.753
Window Glass	83,600	Kg	390,860.465

⁴⁸ <https://ijcrt.org/papers/IJCRT22A6552.pdf>

Earthwork Excavation	4,212	m'	73,169.079
Non-VOC Paint	3,875	Kg	6,840.679
Permeable Pavement	91,800	Kg	178,679.070
Grand Total			1305,457.773

The costs given above are only focused on the construction material in a fully functional green building other costs can be for:

- Solar Power System
- Rainwater Harvesting System
- Electrical Wiring
- Water Supply & Sanitation
- Labour Charges
- Scaffolding, Shuttering, etc.
- Consultation and miscellaneous work
- Contingencies

Note: The cost of building materials is adjusted considering the year when costs were recorded (2022) and the present scenario (2023).

ELECTRICITY CONSUMPTION

Electricity consumption and saving comparison of a conventional and green building are given below:

Table 9: Electricity Consumption

Building Type	Duration	kWh	\$
Conventional Type	1 Year	1,672,200	255,847
Green Type	1 Year	929,000	142,137

- 1 kWh= Assumed \$ 0.15 for commercial electricity unit
- Saving/ year = 255,847-142,137
- Saving/ year = **\$ 113,710 / year**

Note: In green buildings, electricity can be generated using renewable energy technologies. However, this analysis is only focused on construction material thus it has not been considered.

PAYBACK PERIOD

The payback period for converting conventional buildings into green buildings is calculated and provided below.

- Cost Difference = Grand Total for Sustainable Building - Grand Total for Conventional Building
- Cost Difference = 1,305,458 - 1,089,833
- Cost Difference= \$ 215,625
- Payback Period= 1.89 Years
- Payback Period= **Approximately 2 Years**

Note: The payback period is only focused on building construction materials, it does not include any design advancements, technology installation, rainwater harvesting system, or any other costs.

6. MARKET DEMAND FOR GREEN CONSTRUCTION MATERIALS

The construction industry in Pakistan has traditionally been a significant contributor to the country's GDP and employment. However, the rapid urbanization and industrialization taking place in Pakistan have raised concerns about environmental sustainability. This has led to an increasing demand for green construction materials, which are characterized by their environmentally friendly attributes.

One of the primary drivers of the demand for green construction materials in Pakistan is the rising awareness of environmental issues. As the country faces the adverse effects of climate change, there is a growing recognition of the need to reduce carbon emissions, minimize resource depletion, and curb pollution. Green construction materials are seen as a practical solution to address these concerns.

Another factor fueling the demand for green construction materials is the need for sustainable infrastructure development. Major government initiatives like the **Naya Pakistan Housing Scheme** and the **Ravi Riverfront Urban Development Project** have the potential to reshape Pakistan's urban landscape. To ensure the long-term sustainability of these projects, there is a requirement for materials that are not only durable but also environmentally responsible.^{49 50}

REFLECTIONS ON SUSTAINABLE MATERIAL ADOPTION CHALLENGES

Despite the increasing demand, the availability of green construction materials in Pakistan remains limited. The construction industry in the country largely relies on conventional materials that may not meet modern sustainability standards. Several key observations can be made regarding the current state of green construction materials in Pakistan.^{51 52}

Limited Product Variety

49 <https://www.ctc-n.org/technical-assistance/projects/adoption-green-buildings-pakistan-achieve-pakistan-s-nationally>

50 <https://www.linkedin.com/pulse/rising-demand-green-buildings-major-driver-building-market-pujari/>

51 <https://www.ctc-n.org/technical-assistance/projects/adoption-green-buildings-pakistan-achieve-pakistan-s-nationally>

52 <https://www.linkedin.com/pulse/rising-demand-green-buildings-major-driver-building-market-pujari/>

Green construction materials such as bricks manufactured from zig-zag technology, green cement, and other eco-friendly products are relatively scarce in Pakistan. The market lacks diversity in terms of sustainable construction materials, hindering the construction industry's ability to adopt green practices.

Lack Of Awareness and Education

A significant challenge lies in the lack of awareness and education regarding the benefits of green construction materials. Builders, developers, and consumers often have limited knowledge about these materials and their advantages, which can slow down their adoption.

Cost Considerations

Green construction materials, while environmentally friendly, may be perceived as more expensive than traditional options. This cost differential can discourage builders and developers from choosing sustainable materials, particularly in price-sensitive markets.

Regulatory Framework

The absence of comprehensive regulations and standards for green construction materials poses a barrier to their widespread use. Clear guidelines and certifications could encourage the adoption of these materials by ensuring their quality and performance.

RECOMMENDED MEASURES

To overcome the challenges in promoting green construction in Pakistan following measures are recommended.

- **Active collaboration of government with renowned green building certification bodies** like EDGE, LEED, NESPAK, NEECA-Pakistan, etc. These organizations can provide expertise and guidance in implementing green building practices in construction projects. Furthermore, builders and developers should be encouraged to seek green certifications for their projects, which can serve as a benchmark for sustainability.
- Offer **tax incentives** for builders and developers who embrace green construction practices. These incentives can include reduced income taxes, property tax reductions, or deductions for investments in green technologies. **Fee concessions** should be provided for green building map approvals and permits to incentivize eco-conscious construction.
- **Encourage the banking industry** in Pakistan to establish green banking divisions or departments that specifically cater to the financing needs of green construction projects. Low-interest rates and financial incentives should be available for builders and developers engaged in green and affordable housing projects.
- Launch **public awareness campaigns** to educate builders, developers, and the general public about the benefits of green construction materials and practices. **Training and workshops** should be offered on green building techniques to professionals in the construction industry.

- Develop and implement **clear and comprehensive regulations** and standards for green construction in Pakistan. These standards should cover building materials, energy efficiency, waste management, and water conservation.
- Encourage **public-private partnerships** in the construction sector to promote the use of green materials and technologies. These partnerships can lead to innovative solutions and shared resources.
- Invest in **research and development efforts** to develop locally sourced green construction materials and technologies that are cost-effective and eco-friendly.
- Promote **innovation and entrepreneurship** in the green construction sector.
- Establish a system for **monitoring and evaluating** the environmental performance of green construction projects to ensure compliance with sustainability standards. Regular reports should be published on the environmental impact and benefits of green construction initiatives
- To assess the environmental impact of construction materials thoroughly, **a life cycle assessment (LCA)** should be adopted. This assessment evaluates materials from extraction to disposal, helping make informed choices. Finally, **certification and labeling systems** like LEED (Leadership in Energy and Environmental Design) or Green Building Councils can assure material sustainability.

7. MATERIAL SUPPLY CHAIN ANALYSIS

Based on materials availability and its perception in the market, the supply chain of materials in a country influences its adaptation in a sector greatly. In this section green building material supply chain existence in Pakistan, the challenges it faces, and recommendations for the future are discussed comprehensively.

ANALYSIS OF EXISTING MATERIAL SUPPLY

The concept of a green construction material is a transformative idea in Pakistan's construction industry. The supply chain of green construction materials encompasses various key components, starting with the responsible sourcing of eco-friendly raw materials or recycled materials. Manufacturing processes prioritize environmental sustainability, aiming to reduce energy consumption and emissions. Efficient distribution and logistics networks are crucial to ensure a steady supply of green construction materials across Pakistan, while appropriate storage facilities maintain material quality. Effective waste management and recycling strategies are vital to reusing the material and minimizing environmental impact.

Currently, Pakistan lacks a dedicated supply chain for green construction materials. The existing supply chain primarily caters to conventional construction materials, which are readily available and widely used. Green construction materials, on the other hand, are relatively scarce and often require specialized sourcing. An infographic that shows different stakeholders present at various stages of the value chain existing in the green buildings in Pakistan is shown below:

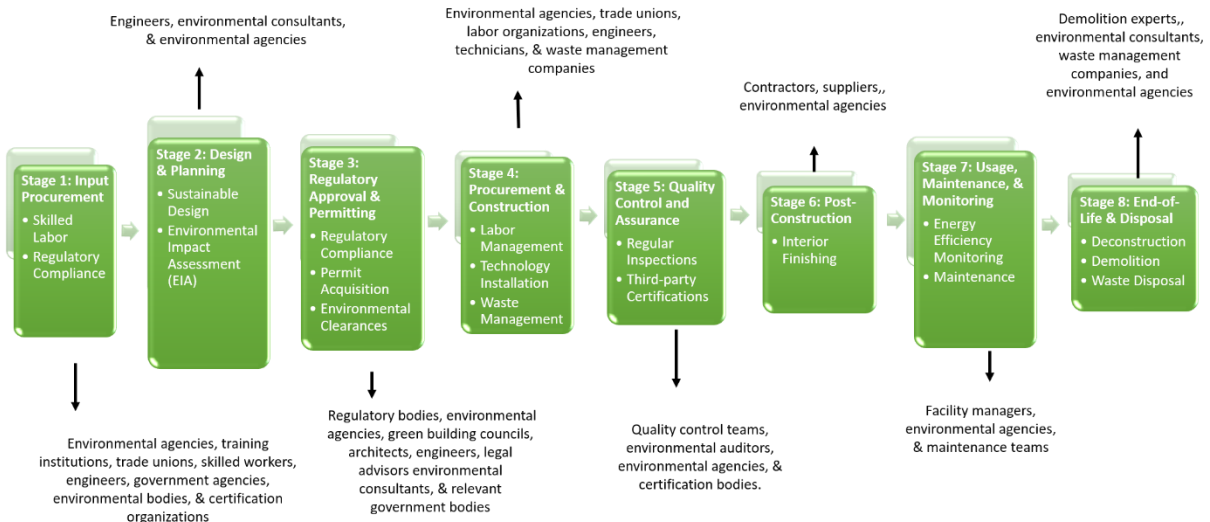


Figure 11: Value Chain Analysis of Green Buildings in Pakistan

SUPPLY CHAIN CHALLENGES AND RECOMMENDATIONS

The establishment of a sustainable supply chain for green construction materials in Pakistan faces a set of challenges that need careful consideration and strategic solutions. The major supply chain challenges and their recommendations are briefly discussed in the infographic below:

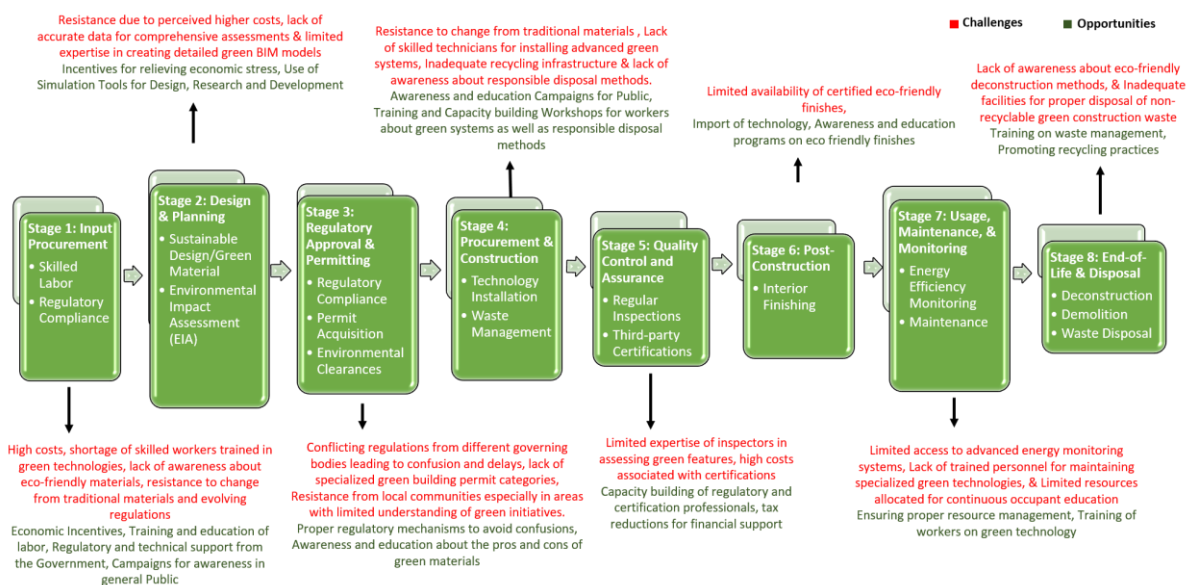


Figure 12: Challenges and Opportunities in the Value Chain of Green Buildings in Pakistan

One of the most pressing challenges is **generating consumer demand** due to a **lack of awareness** among contractors, owners, and other key stakeholders about the advantages of green construction materials. This challenge is surged by **regulatory and policy gaps** related to green construction materials and practices. There is absence of clear standards and regulations that are creating uncertainty in the industry. According to some websites **PEC has published the Green Building Code of Pakistan-2023** but these are not available on the official website. It is utterly important to publish these codes officially and make them mandatory to create the demand for green construction in Pakistan. In addition, relative stakeholders should be made aware of these codes or any other relevant policy and in case of non-compliance actions should be taken against them.⁵³

Another critical challenge is the **insufficient recycling** of waste materials generated during construction activities. In Pakistan, mainly plastic and glass are segregated from waste, not construction materials. As well as Pakistan currently lacks recycling infrastructure for construction waste and materials, leading to increased environmental impact and missed opportunities for resource reuse. Therefore, it is highly recommended to develop efficient recycling mechanisms for construction materials and use such recycled materials for making green construction materials following the second-tier supply chain concept.

Moreover, some green construction materials already exist in Pakistan but there is **no dedicated supply chain** for them which limits the utilization of these materials. Establishing an effective supply chain for green construction materials should consider a carefully structured approach. The initial step can be **conducting an inventory assessment** of available materials while **identifying local sources** like bamboo forests and straw bales. Parallely **education and training programs** should be implemented for local stakeholders, including suppliers and builders, to raise awareness about sustainable construction practices. In addition, **supplier network development** should be prioritized which can involve collaborating with existing suppliers in respective areas or supporting community-based cooperatives to ensure a consistent supply. However, **quality control measures** must be in place to maintain material standards. Local communities should be involved in material sourcing and promoting sustainable practices and regulations for environmental, labor, and safety standards should be adhered to. Once the supply chain is created it is recommended to **continuously monitor and evaluate the supply chain's performance**.



Figure 13. Recommendation for Generating Supply Chain in Pakistan

⁵³ <https://www.iccsafe.org/about/periodicals-and-newsroom/pakistan-engineering-council-releases-green-building-code-based-on-the-international-codes>

Furthermore, the **limited availability of new and innovative sustainable construction materials** in Pakistan poses a significant hurdle to the widespread adoption of green construction practices. To address this scarcity, **investments and public-private partnerships** can play essential to diversifying the range of sustainable materials, making them more accessible and appealing to builders and contractors.

Lack of skills and training represent another challenge, as construction professionals need specialized knowledge and expertise to effectively work with green construction materials. Educational programs and training are suggested to equip the workforce with the capabilities required to implement green practices successfully.

Indeed, high costs remain a concern, as green construction materials often come with **higher initial costs compared to conventional materials**. This cost differential can deter stakeholders from embracing sustainable materials and practices. To overcome this obstacle, policymakers should consider implementing incentives such as **tax benefits and subsidies** to help offset initial costs and encourage the use of green materials.

8. CONCLUSION

The report highlights the drawbacks of conventional materials used in Pakistan, such as clay bricks, cement, concrete, steel, wood, and non-insulated glass windows, and suggests specific sustainable alternatives to mitigate these drawbacks. The construction industry in Pakistan is at a critical phase, with significant opportunities to transition toward more sustainable and green building practices. By addressing the barriers to the adoption of sustainable materials, updating building codes, and promoting awareness, Pakistan can reduce its environmental footprint, improve energy efficiency, and create healthier living and working environments for its citizens. This transition is not only essential for addressing the environmental challenges but also for ensuring the long-term sustainability of the construction sector in the country.

The adoption of sustainable alternative building materials in Pakistan offers the potential to reduce energy consumption, improve indoor air quality, and contribute to environmental sustainability. While there may be higher initial costs, the long-term benefits and savings make these materials a valuable choice for the construction industry. Encouraging green building practices and compliance with building energy frameworks, such as the Energy Conservation Building Code 2023, are critical steps toward a more sustainable future in Pakistan's construction sector.