

Sustainability in Construction through Masonry Alternatives

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ABSTRACT: A meaningful definition for sustainable construction is the need to find a balance between economic, environmental and social factors in the design, construction and use of buildings/structures. With the rapid rate of increase in construction activities, the impact on environment is increasing. The “greenness” of the construction activities have to be increased for long term pay backs by better decision making. The assessment is mainly energy related, as in every stage of construction, starting from material manufacturing through construction, operation till demolition; energy is consumed in one or the other form.

Sustainable design also called environmentally conscious design, is the philosophy of designing physical objects, the built environment, and services to comply with the principles of social, economic, and ecological sustainability. The intention of sustainable design is to eliminate negative environmental impact completely through skilful, sensitive design. Manifestations of sustainable design require no non-renewable resources, impact the environment minimally, and connect people with the natural environment. Beyond the elimination of negative environmental impact, sustainable design must create projects that are meaningful innovations that can shift behaviour. A dynamic balance between economy and society, intended to generate long-term relationships between user and object/service and finally to be respectful and mindful of the environmental and social differences.

KEYWORDS: Masonry, Sustainability, Balance, Sensitive design, Innovations.

I. INTRODUCTION

Sustainability in construction is to reduce the negative environmental impact from manufacturing process of construction materials and construction activities, while optimizing its economic viability, comfort and safety of the occupants. Sustainable construction is based on best practices which emphasize long term affordability, quality and efficiency. At each stage of the life cycle of the building, it increases comfort and quality of life, while decreasing negative environmental impacts and increasing the economic sustainability of the project. A building designed and constructed in a sustainable way minimizes the use of resources in one or the other way, over the whole life cycle of the building.

Greenhouse gases are essential but not beyond a certain level of acceptance. Construction industry is one of those sectors which are largely responsible for GHG emissions. It is estimated that about 38% of all human GHG emissions is from the building sector. To overcome this problem of high GHG emissions, it was aimed towards Low-carbon buildings (LCB), which are buildings specifically engineered with GHG reduction in mind. So by definition, a LCB is a building which emits significantly less GHG than regular buildings. There is presently no emissions threshold under which a building would qualify as a LCB. But our emissions would have to be reduced by about 80% compared to current levels in order not to exceed the Earth's natural capacity to remove GHG from the atmosphere. By comparison, a regular building releases about 5,000 kg of CO₂ /m² during its entire lifetime (though it varies a lot, depending on the project type and where it is located).



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There are different strategies being laid for different sectors to have a control over GHG emissions. Some of the strategies pertaining to construction industry are listed below.

- A. Reduction in quantity of materials used
- B. Selection of materials with low emissions factors associated (e.g., recycled materials)
- C. Opting for material suppliers as close as possible from the construction site
- D. Diverting demolition wastes to recycling instead of landfills or incineration
- E. Reducing energy consumption for manufacturing of materials
- F. Switching to alternate/renewable sources of energy

II. SCOPE AND OBJECTIVE

Cement is one of the most important materials of the construction industry and is being consumed in a very large quantity. A fact to be worried is production of 1KG cement requires about 6 MJ of energy in form of coal and electricity, both being non-renewable sources of energy and manufacturing of one tonne cement liberates about 0.4 to 0.6 tonnes of carbon dioxide (CO₂). And about 350 MT of cement is being consumed in India per year (as per financial year end 2012-13)

RC framed construction with brick in fill walls of one single floor has about 55GJ of embodied energy per 100m² of construction area, which is equivalent to about 2.5 tonnes of coal energy.

The above two simple statistics illustrates the amount of energy being consumed and the impact of it on the environment in many forms. Even though there are many experimental investigations that have been done and still are being planned, on replacement of cement in concrete, use of stabilised mud blocks as alternate masonry units, etc., they are not being adopted at construction sites in the magnitude/scale it has to be. The other major reason of worry is, in view of reducing the time required for construction, many practices which consumes undue energy are being adopted which definitely have some alternate systems or technologies for the same. For instance, filler slab concept, which is known from years, is not being adopted. If not for commercial spaces, with large spans, filler slab may be adopted at individual residential buildings, by which a considerable amount of energy may be saved.

Similarly, with the construction practices we have in our country, masonry is a compulsory part of any building. It is more likely that two to three storey buildings can be effectively designed with load bearing masonry design. But the prevailing problem is that the commercially available burnt clay bricks and concrete blocks do not have enough strength for the same. It is important to know that, if a proper control on manufacturing of these materials can be achieved, then they yield satisfactory results. As far as energy efficiency is concerned, there is a need to find alternate masonry units as burnt clay bricks consume higher energy for the process of burning and cement, natural aggregates are the essential raw materials for concrete blocks. Hence the main objective is to suggest a suitable masonry unit with an adhesive which has a satisfactory performance along with energy efficiency.

III. LITERATURE SURVEY

1. Sustainable construction - the role of environmental assessment tools, a journal of environmental management by Grace K.C. Ding.(2007)

Abstract:Construction has been accused of causing environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation to the pollution of the surrounding environment, and research on green building design and using building materials to minimise environmental impact is already underway. However, relying on the design of a project to achieve the goal of sustainable development, or to minimise impacts through appropriate management on site, is not sufficient to handle the current problem. The aim for sustainability assessment goes even further than at the design stage of a project to consider its importance at an early stage, before any detailed design or even before a commitment is made to go ahead with a development.

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2. Sustainable development A Rethinking of Construction Industry in India B. M. Kataria, V. B. Pathak, Dr. J. A. Shah, PG student, Dept. of Civil Engineering, S.N.P.I.T. & R.C., Umrakh, India, Assistant Professor, Dept. of Civil Engineering, S.N.P.I.T. & R.C., Umrakh, India, (2013) Professor, Dept. of Civil Engineering, S.N.P.I.T. & R.C., Umrakh, India.

Abstract: This review brings together research on available alternatives and implementations required for Sustainable development. More than ever, Construction industry of India is concerned with improving the social, economic and environmental indicators of sustainability. We know that we are endangering the future of forthcoming generations by leaving depleted resources or no resources. Hence, an active effort is extremely essential by construction industry of India along with participation of all the institutions, professional bodies, academicians, industry as well as government for sustainable development and hence leave resources for the future generation to satisfy their needs. This paper provides possible aspect where and how sustainability can be adopted and implemented and/or incorporated for sustainable development.

3. Sustainability in Building and Construction: Revising Definitions and Concepts Hossein Zabihi, Dr. Farah Habib, Leila Mirsaeedie (2012).

Abstract: Building construction challenge, in recent years, is reduction of social, economical and environmental impacts of buildings along with their economical nature and increasing of life quality, and for these aims sustainable construction becomes important as building construction has important role in sustainable development. Sustainable development in any fields as construction and architecture defines in any words and from different point of views. In this study by review and studying definitions and concepts of sustainability in building and architecture sector, as sustainable design, architecture and construction, a comprehensive definition as Building sustainability model have been presented. Also, some aspects and main categories of sustainability in architecture and building are presented. Sustainability aspects in the building are categorized in four groups of environmental, social, economical and technical issues. In each group some of general factors are shown. The mentioned characteristics are some items consistent with sustainability principles and goals and they are effective in fulfilling goals of sustainability.

4. Role of construction management in sustainable building design and concepts by Dr. S. Senthamilkumar and R. Latha (2014).

Abstract: In India, The construction industry is the second largest industry of the country which provides employment for huge number of people and makes a major contribution to the national economy after agriculture. The infrastructural development is sign of the economic development of any country. At the same time, the consumption of energy and resources for the construction activities is very enormous. Green and sustainable building design and concept is the only way to control the above problem. The importance of green buildings has been frequently discussed at many platforms and suggested many techniques. But, some of the barriers like complication in planning and design, lack of knowledge in green concept and sustainability, the initial cost overrun for installation, additional cost for special techniques, etc. have hindered the adaptation of green and sustainable structures. The incorporation of proper planning and construction management strategies in green buildings can facilitate to mitigate these barriers. In this paper, some of the management techniques and strategies at various stages of project life cycle have been studied and identified as tools to overcome the problems in green and sustainable buildings from the selected case study.

5. Building Sustainability Assessment by Luís Bragança, Ricardo Mateus and Heli Koukkari (2010).

Abstract: Although social, economic, and cultural indicators are of substantial importance to the concept of sustainable building, this concept is usually related to environmental characteristics. Any building level assessment method is complex and involves contradictory aspects. Moreover, emphasizing qualitative criteria only increases confusion. R&D and standardization are thus concentrated to transparency and usability of the environmental methods. Other directions of research aim at performance-based design and methods to take regional and cultural aspects into account. In this paper, the perspectives of the sustainability assessment of a whole building are presented, based on a state of the art, feasibility study on performance analysis and the development of an extended life-cycle assessment for buildings. Using various tools, and based on the case studies of building sustainability assessment, environmental indicators were often shown to be of lesser importance than the other, soft ones.

IV. EXPERIMENTAL STUDIES

Tests on masonry units

Without assessing the performance parameters, analysing the energy criteria does not have a greater significance. If the chosen energy efficient materials, does not perform at least at par with the conventional materials, the energy analysis is of no use. The masonry units used are Burnt clay bricks, Fly ash bricks, Solid concrete blocks and compressed soil blocks.



Fig 1. Masonry units (a) Fly ash bricks (b) Compressed soil block (c) Burnt clay bricks (d) Concrete blocks

1. Compressive strength test:

For any masonry unit, which is used as a load bearing member in compression, compressive strength is one of the major factor of consideration. Test was conducted in a compression testing machine of 10tonne capacity. Results are as tabulated below

Table 1: Compressive strength of masonry units

Masonry unit	Crushing load (KN)	Compressive strength(N/mm ²)
Burnt brick	80	3.6
Fly ash brick	140	5.8
Solid concrete block	150	2.5
Compressed soil blocks	120	2.7

2. Initial Rate of Absorption test:

Another important factor which mainly affects the bond strength of masonry is the initial rate of absorption (suction) by masonry units. It is expressed in terms of weight/area/time (grams/30square inch/min). This test was conducted in a metal pan, with 1cm water in it and the results are as tabulated below.

Table 2: Initial rate of absorption of masonry units

Masonry unit	Area immersed (square inch)	Increase in weight (Grams)	IRA(grams/30inch ² /min)
Burnt brick	34.10	18	15.83
Fly ash brick	37.44	35	28.00
Solid concrete block	124.03	174	42.08
Compressed soil blocks	69.76	21	9.03

3. Moisture absorption:

Moisture absorption is the gain in weight of the unit, expressed in percentage. It is the ratio of weight of moisture to the dry weight of the unit. The test may be conducted using water at room temperature or boiling water. Moisture absorption test was conducted by immersing the units in water at room temperature for 24 hours, and the results are as tabulated below.

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Table 3: Moisture absorption of masonry units

Masonry unit	Average increase in weight (KG)	Moisture absorption (%)
Burnt brick	0.509	14.97
Fly ash brick	0.355	11.94
Solid concrete block	0.86	3.53
Compressed soil blocks	0.85	6.46

4. Cost analysis:

It is equally important to compare the cost of masonry units along with performance and energy parameters. As the dimensions and in turn the volume of units are different, cost comparison is done by considering equivalent of one masonry unit, which is burnt brick.

Table 4: Cost comparison of masonry units

Masonry unit	Dimension(mm)	Brick equivalent	Cost (INR per unit)	Cost equivalent (Rupee)
Burnt brick	220x100x75	1	6	6
Fly ash brick	230x105x75	1.1	6	5.45
Solid concrete block	400x200x150	7.2	30	4.20
Compressed soil blocks	300x150x150	4.1	20	4.87

Overall comparison:

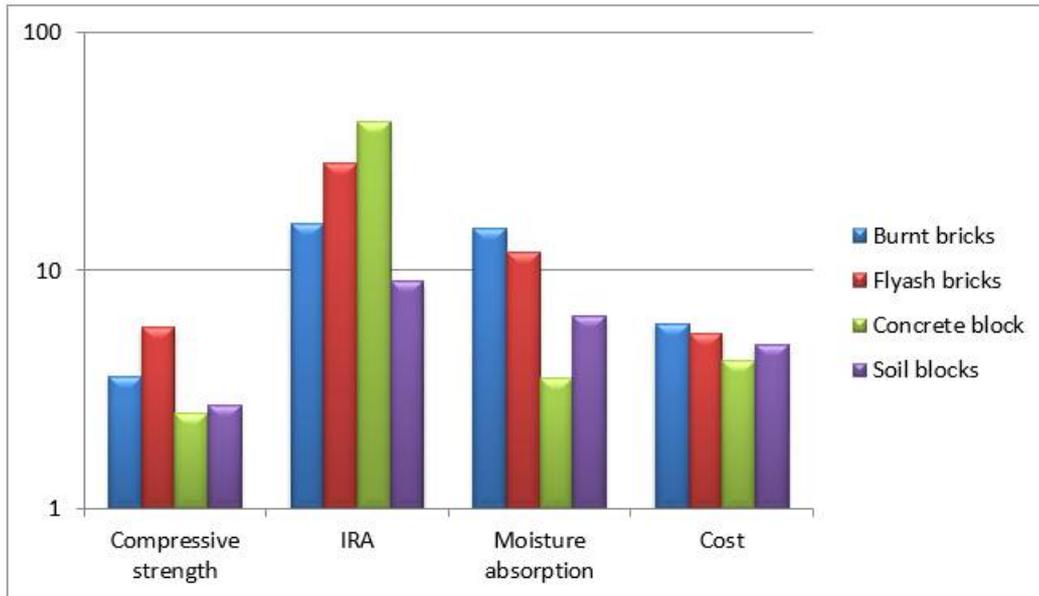


Fig 2: Overall comparison of masonry units

Tests on masonry prisms:

Masonry prism is a representative sample to analyse the performance of masonry units along with masonry mortar. The purpose of testing prisms is to know the masonry efficiency, so as what percentage of actual strength of the wall can be achieved.

Compressive strengths of prisms are tabulated below. The correction factors as per IS 1905 is not used, as it is a comparative measure. Height to width ratio of both prisms are about 3.2, and even if correction factor is considered, the compressive strength will be about 93% of the below mentioned values. It is very much evident from the results that fly ash bricks with masonry adhesive have the highest efficiency in comparison with compressed soil blocks and with other adhesives.

Table 5: Compressive strength of masonry prisms

Masonry unit/Mortar	1:6 Cement mortar	1:4:0.25 cement-lime mortar	Masonry adhesive
Fly ash bricks	3.5	3.2	4.1
Compressed soil blocks	1.1	0.9	0.9

Energy parameters:

In the present study, energy required for manufacturing of fly ash bricks and compressed earth blocks are assessed. The same for burnt clay bricks and concrete blocks are not considered as the performance and cost of previous are

acceptable over the later and the energy parameters of burnt clay bricks and concrete blocks have been studied time and again.

Table 6: Energy calculation for fly ash bricks

Particular	Quantity	Energy/unit	Total energy
Fly ash	1.09 KG	0.1 MJ	0.109 MJ
Stone dust	1.92 KG	0.3 MJ	0.576 MJ
Cement	0.41 KG	4.6 MJ	1.886 MJ
Electricity	0.028 KW-h	3.6 MJ	0.100 MJ
Total energy per fly ash brick			2.671 MJ

Table 7: Energy calculation for compressed soil blocks

Particular	Quantity	Energy/unit	Total energy
Soil	10.37 KG	0.45 MJ	4.666 MJ
Cement	0.85 KG	4.6 MJ	3.910 MJ
Electricity	0.1 KW-h	3.6 MJ	0.360 MJ
Total energy per compressed soil block			8.936 MJ

IV. CONCLUSION

As per the experiments conducted, fly ash bricks have the maximum compressive strength and highest masonry efficiency. Unit strength of masonry is about 5.8 MPa and compressive strength of masonry prism with masonry adhesive is about 4.1 MPa, which accounts for about 70% efficiency without considering the factors of conversion.

If we consider the conversion factors as per table 12 of IS 1905, for a height to width ratio of 3.2 a correction factor of 0.88 is applied, the efficiency will be 62% which is generally very high compared to the transformation ratio of brick masonry with cement mortar.

A study on energy parameters is evident that fly ash bricks consume much less energy for their manufacturing than that for burnt clay bricks. Even material composition suggests that use of fly ash, which is a by-product, helps for environment protection cause. On the other hand, compressed soil blocks are much more energy efficient than the concrete blocks. The interlocking nature of the compressed soil blocks has an advantage of less thick mortar joints, and are preferable for taking compressive loads. It is important to know that, only cement paste can be used for bonding between compressed soil blocks, which results in saving on natural fine aggregates.

V. SCOPE FOR FUTURE WORK

- The durability properties of fly ash bricks can be studied. But as per the available results, the durability of fly ash bricks is considerably satisfactory.
- The chemical composition of the masonry adhesive can be studied, and the influence of individual components can be known.

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- Shear strength of masonry can be studied, as it is one of the important parameters for the performance of masonry.
- A more detailed study on manufacturing process of masonry units may form another study project of its own.
- Impact of different class fly ash on masonry performance can also be studied.

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