BUILDING CONSTRUCTION METHODOLOGY TO REDUCE GLOBAL WARMING

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Abstract: ***The world today has encountered with warming and climate change. Extraction of natural resources as building materials itself consume energy, causing environmental degradation and contribute to global warming. Greenhouse gas emitters, both in developed and developing countries also contribute to global warming. This paper describes how much a typical building is contributing to global warming by releasing carbon dioxide emission, and how we architects and building designers can decrease the amount of carbon footprints emitted from the building materials by using classical methods of building construction which helps in reducing the carbon dioxide emission and carbon footprints.***

Keywords: Global warming, Greenhouse gas, Carbon dioxide emission, Embodied energy, Carbon footprint and Classical ethods

1. INTRODUCTION

Global Warming is caused by greenhouse gases due to human activities. The composition of greenhouse gases is 76% carbon dioxide CO_2, 13% methane, 6% nitrogen oxide and 5% fluorocarbons. Therefore, CO_2 is a significant contributor for increasing the global temperature. Researches show that there are eight major sectors which are annually releasing considerable amount of Green House Gases thereby CO_2 into the air, causing global warming. They are viz. power station (21.3%), industrial processing (16.8%), transportation fuels (14.0%), agricultural by-products (12.5%), fossil fuel retrieval processing & distribution (11.3%), commercial & other sectors (10.3%), land use & biomass burning (10.0%) and waste disposal & treatment (3.4%). In this paper, we are discussing the emission of CO_2 from building industry and use of classical method of construction to reduce global warming.

2. CLASSICAL & MODERN BUILDING METHDOLOGY

Every year millions of new buildings are being constructed and on the name of modernity new construction materials are being introduced. One of the biggest blunders of the modernity was to throw most of the traditional knowledge away. In architecture, with the advent of new materials, the older materials were abandoned. But, many of these traditional materials and techniques are a work of many generations, perfecting the techniques with experiments, so that the technologies that have evolved have withstood the test of time. Hence, it would be stupidity to disregard this rich heritage that we have inherited. Instead, now it is time to access all the materials, be it new or old, and give all the materials a proper place in the building.

This paper is a comparison between classical method of construction and present day method of construction .In the construction industry, isolation of environmental friendly materials is very necessary. Therefore there is a need to select more green building materials to be used in the construction

2.1 CLASSICAL BUILDING METHODOLOGY

The classical method of construction make use of wooden formwork, use of mud bricks , use of stones and other material that are not harmful for the environment. These materials do not cause any sort of environmental pollution or any other harmful effects to environment.

2.1.1 EXAMPLES OF SOME OF THE DEVELOPING COUNTRIES

India

The most common non-engineered building in India is masonry building (of various types of bricks) with G + 1 story high. Most of the brick masonry building uses mud brick (adobe), CSEB and quarry stone.

Figure 1. Typical Non-Engineered Buildings in India

Indonesia

In general, there are three most common non-engineered constructions found in Indonesia, i.e. unconfined brick or concrete block masonry, confined masonry, and reinforced concrete frame with infill masonry. Unconfined masonry building relies on the wall as the only load bearing structural elements (vertical and lateral). There is no confinement on this type of building and it is rarely found in Bandung area. Confined masonry building relies on the masonry walls as the main load bearing structural elements. The confinement will contribute also to maintain the integrity of the wall when the loads are applied to the structures. Most of the confined masonry structures in Bandung are confined by reinforced concrete practical column/beams. Reinforced concrete with infill masonry wall building relies on the reinforced concrete columns and beams as the main load (both lateral and gravity) bearing structural elements.

Figure 2. Typical Non-Engineered Buildings in Indonesia

Pakistan

Three types of non-engineered building (confined masonry, unconfined masonry and reinforced concrete with infill masonry are mostly adopted in non-engineered buildings in Pakistan.

Figure 3. Typical Non-Engineered Buildings in Pakistan

Peru

In Peru, there are three types of non-engineered buildings. Those are confined masonry building with horizontal and vertical confinements that support the bricks walls, unconfined masonry walls building without reinforced collar beam and reinforced confined elements and Concrete moment resistant frame with concrete shear walls or infill masonry.

Figure 4. Typical Non-Engineered Buildings in Peru

Egypt

The most common types of non-engineered building in Egypt are reinforced concrete skeleton type buildings, wall bearing lime stone buildings and combined reinforced concrete and lime stone wall buildings.

Figure 5. Typical Non-Engineered Buildings in Egypt

Nepal,

There are two types of non-engineered brick masonry buildings, i.e. unconfined brick masonry buildings and reinforced concrete buildings with brick masonry infill.

Figure 6. Typical Non-Engineered Buildings in Nepal

Turkey

There are three types of non-engineered building in Turkey, i.e. reinforced concrete frame with clay hollow brick infill wall, unreinforced brick masonry and wooden structures.

Figure 7. Typical Non-Engineered Buildings in Turkey

2.1.2 MASONRY MATERIAL

Most of the non-engineered constructions at the selected countries use baked clay or stone masonry for the wall materials. Brick sizes in Turkey, Nepal, Indonesia, Peru and Pakistan are relatively similar, meanwhile in India and Egypt bricks have different sizes compared to the others. Peru has the highest brick compressive strength, while Turkey has the smallest brick compressive strength compared to the other countries. Test results from sites in each country showed that some do not have adequate strength for the brick (see Figure 8).

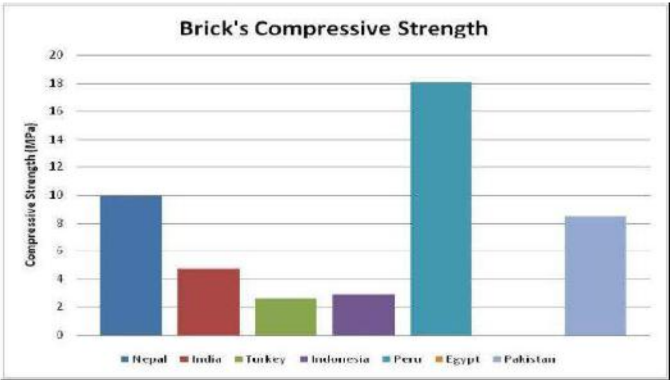


Figure 8. Brick Compressive Strength

Most of the countries use ordinary Portland cement as plaster and mortar cementing agent. Pakistan found to have the highest mortar strength, even though the mix is similar with other countries. On the other hand, Peru has different mortar mix compared to the other countries, but it produce the same compressive strength. The mortar thickness in Egypt is found to be the thickest (25 mm), while Turkey and Pakistan have the thinnest mortar layer (10-20 mm and 11.5mm respectively). The common plaster mix is either 1:6 or 1:4 (Pc: sand), except in Peru where the mix is 1:1. Turkey has the thickest plaster (20-30 mm), while Nepal has the thinnest plaster (10 mm) (see Figure 9)

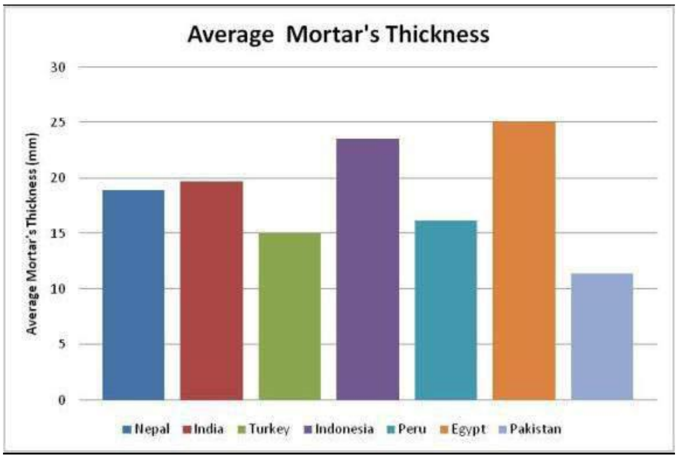


Figure 9. Average Mortar Thickness

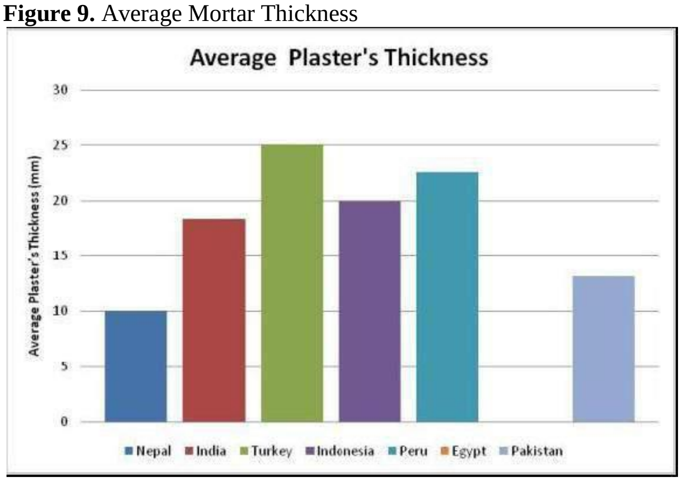


Figure 9. Average Plaster's Thickness

2.1.3 CONCRETE MATERIAL

Based on the survey, some of the non-engineered constructions use very poor concrete strength for the structural elements. Highest concrete compressive strength is found in Indonesia (21.75 MPa) while the smallest was found in Turkey (8-10 MPa). All of the countries use ordinary Portland cement as the construction materials. Most of the aggregate are taken from river and mountain quarry. Concrete mix of 1 cement : 2 sand : 4 aggregate is used in Nepal, India and Pakistan, while in Indonesia mix of 1 cement : 2 sand : 3 aggregate is common. Concrete mix of 1 cement: 1.2 sand: 4 aggregate is found in Peru. Both concrete mix in Indonesia and Peru produces relatively high compressive strength (see Figure 10). In some countries, it is found that workers on some sites do not use any measurement in mixing the concrete.

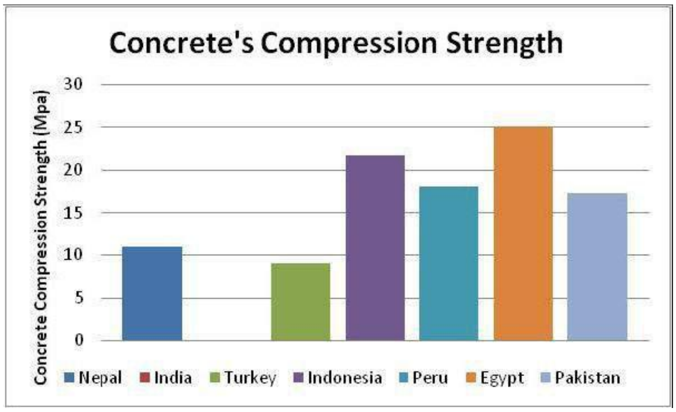
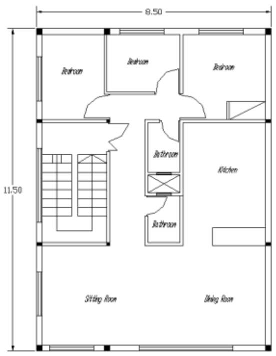


Figure 10. Concrete Strength

2.2 MODERN BUILDING METHODOLOGY

For example, in places where there is a shortage of space, one goes for burnt bricks. But, where there is no shortage of space, it seems sensible to go for traditional walls because; though thicker they would allow retention of heat within the house, an important aspect for comfortable living in colder climates. However, invariably new materials are being introduced due to pressure of perceived necessity. These new materials need much of processing before they come into use. Significant embodied energy consumed in the production of energy intensive building materials and also the recurring energy consumption for cooling and heating of indoor environment. Co2 emission is a result of human activities such as raw material extraction; manufacture and distribution, therefore, Co2 emission can be used as one of the relative measures of the environmental friendliness of a building product and help determine its sustainability and desirability in construction. To demonstrate the same, we selected a typical building and estimated its CO2 emission. For the purpose of this study, concrete building in humid climatic environment is selected. All the materials used in this building are evaluated. Embodied energy of each material is calculated in its lifecycle. Finally, the CO2 emission has been estimated to find the degree of sustainability of the building and its effect on global warming.



Plan Elevation

Figure 11. Plan & Elevation of 3 story RC residential building

2.2.1 BUILDING & BUILDING MATERIALS

Three story reinforced concrete residential building built in 1999 is selected (See Figure1) for the study. The total building area is 95m2. Structure is made of RC frames with brick masonry infill. External surfaces are covered with gypsum plaster. Wood work is used for wardrobes inside three bedrooms and kitchen. Aluminium is used as the frame of windows and the bathroom doors. Table1 shows the quantities of each material used in building. From the table it can be understood that wide variety of processed materials are put in use.

Materials	Quantity	Unit
Wood & Timber Framing	185.3	M^3
Steel	12827	Kg
Brick(baked clay)	38.9	M^3
Tiles & Ceramics	0.17	M^3
Mosaics	0.28863	M^3
Aluminum	396	Kg
Glass	53.1	M^2
Moisture Insulation	125.2	M^2
Painting(Water-based)	1215.5	M^2
Stone(Local)	49.14	M^2
Concrete	170.4	M^3
gypsum plaster	60.9	M^3
Cement Mortar	1	M^3

Table 1. Quantities of Materials

2.2.2 EMBODIED ENERGY

Table 2 describes the embodied energy of different materials used in construction. It can be clearly seen that the highest embodied energy is related to Stone which is around 7800 GJ. Steel, gypsum plaster and concrete are between 400 to 500 GJ. The embodied energy of brick is around 170 GJ while ceramic tile and aluminium have around 100 GJ only. The energy needed for manufacturing and transporting the mosaic and wood for the case study is between 20 and 40 Giga Joule. The lowest embodied energy in this building is of painting, cement mortar and glass which are lower than 10 GJ. The embodied energy in a product comprises the energy to extract, transport and refine the raw materials and then to manufacture components and assemble the product. The energy consumed directly at each phase is clearly definable and measurable. However, the energy required indirectly to support the main processes is less obvious and more difficult to measure. This includes the energy embodied in other outputs of goods and services and the machinery used to support these processes. The total embodied energy comprises the direct energy purchased to support the process under consideration plus the indirect energy embodied in inputs to the process. In the initial stage of construction of buildings, the direct energy is the energy purchased by contractors on-site or off-site to facilitate any construction, pre-fabrication, administration and transport activities under their control. The indirect energy of construction comprises mainly the energy embodied in building materials. Together, these amounts of energy constitute the initial embodied energy of the building. However, during a building's life, embodied energy is added through goods and services used in maintenance and refurbishment. This are typically modelled by assuming replacement rates for items in the buildings (for example, paint) and is known as the recurrent embodied energy.

Materials	Quantity	Unit	Energy Intensity /Unit	Embodied Energy (GJ)
Wood & Timber Framing	2.5	M^3	3400 MJ/m^3	25.296
Steel	12827	Kg	42 MJ/Kg	538.734
Brick(baked clay)	105030	Kg	1.60 MJ/kg	168.048
Tiles & Ceramics	340	M^2	285 MJ/m^2	96.9
Mosaics	144.3	M^2	250 MJ/m^2	36.075
Aluminum	396	Kg	236.8 MJ/Kg	93.773
Glass (4mm)	15.7	Kg	25.8 MJ/Kg	0.451
Moisture Insulation	125.2	M^2	53.7 MJ/Kg	28.91
Painting(Water-based)	70	Kg	76.8 MJ/Kg	5.376
Stone(Local)	1.5	M^3	2030 MJ/Kg	7825.65
Concrete	170.4	M^3	2346 MJ/m^3	399.758
gypsum plaster	60.9	M^3	2.9 MJ/Kg	407.616
Cement Mortar (1:6)	1	M^3	1226 MJ/m^3	1.226
Total				9627.813 GJ

Table 2. Embodied Energy of materials

2.2.3 EMBODIED ENERGY ANALYSIS METHOD

In order to understand the total CO2 emission from a building, it is necessary to access the emission from each material independently. Initially all the quantities of the building are evaluated using centre line method. And later volume of CO2 emission from each material is estimated by using the formula given below.

Amount of Co2 emission (Kg) = VxDxC

Where, V= Volume of Building Material Used (m3)
D=Density of Building Materials (Kg/m3)
C= Embodied Carbon Emission (Kg Co2 /Kg)

Table 3 describes the amount of carbon dioxide emitted by various materials used in the building. It can be seen that the highest amount of carbon dioxide is releasing from Steel, Aluminium, Stone, Glass and Concrete. The Co2 emission of Brick and Timber wood almost are same. Between all of the used materials just ceramic tile and cement mortar have the minimum level of carbon dioxide emission. Having a look at the total Co2 released gas, it will be perceived that a considerable amount of carbon dioxide is emitting from this building during its construction period, 442175 ton which is a noticeable amount.

Materials	Density(Kg/m_3)	Co2 Emission(Kg Co_2 /Kg)	Co_2 Emission (Kg)	Co_2 %
Timber(Sawn)	1550	0.49	1898.75	0.000429411
Aluminum	2600	25.48	26234208	5.932985366
Steel	7860	4.116	414976026	93.84871422
Stone(Local)	2570	197.89	762865.95	0.172525602
Glass	2600	2.528	103192.96	0.023337557
Paint	NA	6.1	427	0.00009657
Ceramic Tile	1.75	0.245	0.0729	0.00000002
Brick	2700	0.157	16489.71	0.003729223
Concrete	2300	0.16	62707.2	0.014181518
Mosaic	5.12	NA	NA	NA
Gypsum plaster	2308	0.125	17569.65	0.003973456
Moisture Insulation	224	NA	NA	NA
Cement Mortar	2000	120.162 kgco_2/m^3	120.162	0.00002718
Total			**442175504.955 Kg Co_2**	100%

Table 3. CO2 Emission of materials

2.3 IMPACT ON GLOBAL WARMING: CONCERN

Technology development paves way to all-round growth. Although this fact is undisputable, e.g., invention of motor vehicle, plastic carry bags were treated as a triumph and technology marvel; looking it at a different angle, an aspect of maintaining technology to the contemporary need and its sustainability is often ignored. The menace which these technologies are creating in terms of carbon emissions is in leaps and bounds.

India predominantly lives in rural areas. It is pointed out that in the decade 1990, 70% use to live in rural areas and gradually percentage of urban housing is increasing in the decade of 2000. The materials used for house roofing during 1990's clearly shows that the usage of natural materials is very high and on the contrary the percentage of cement usage is around 12% only. However, as in one decade i.e., during 2000's usage of cement has nearly doubled. This trend is seen both in rural as well as urban areas. This has direct impact on percentage emission of Co2. There is significant increase of natural disasters in recent times compared to older times. Main contributor for it to happen is increased global temperatures; resulting in uneven seasonal changes. Therefore, finding proper replacements for the materials which have a big proportion in contributing Carbon Dioxide is necessary to reduce the amount of Co2 emission in order to prevent the increase in global temperature.

2.4 DISCUSSION & SUGGESTION

Used Materials	Total Co2 Emission (Kg)	Alternative Materils	Co2 Emission reduction (%)	Total Co2 Emission (Kg)
Steel	414976026	Recycled Steel(40%)	-35	261434896.4
Aluminium	26234208	Recycled Aluminium	-9.8	23663255
Stone	762865.95	Lime stone	-37	480605.55
Glass	103192.96	Cullet Glass(100%)	-50	51596.48
Total	442076292.9			285630353.4

Table 4. Emission comparison of materials and alternative materials

Table 4 describes some alternative materials in place of commonly used material. As large amount of carbon dioxide is coming out of steel and aluminium, they can be replaced by other materials with low carbon footprint. It can be seen that Co2 emission can be reduced up to 35%. And by using cullet glass 50 % of Co2 emission can be reduced. Therefore, the best option for cutting down the carbon dioxide emission in the building construction is;

1. Use recyclable materials as much as possible,
2. Use locally available materials for decreasing the fuel used for transporting of materials in order to reduce Co2 gas emission,
3. Using vernacular architecture,
4. Using eco-friendly building materials and
5. Designing the buildings with respect to the nature for having better ventilation and using natural day light.

2.5 SUMMARY & CONCLUSIONS

Due to the rapid modernization even the construction industry has modernized . The present day construction methods make use of concrete .,steel , iron etc. These materials are not easily degraded whereas the extraction of metals used in construction causes a lot of ecological imbalance. Although modern methods of construction are taking building practice into the future , traditional bricks block method still remains one of the most widely used built types in developed and developing countries .It is necessary to choose building materials that are less harmful to environment and at the same time give a modern look to the building .As in the present day world modernization is also equally important. There is a necessity to bring in the classic method of construction along with present day construction to create an eco-friendly environment. Using plant base materials reduces the climate change impact of the building's development achieved through the use of sustainably grown renewable resource and the atmospheric carbon di oxide used up by the plants during their growth. Plant based materials offer other benefits including very high level of thermal insulation and providing healthy space. There is an environment benefit in using bricks over concrete. It uses very less energy and less chemical that means it is less harmful to the environment.

Embodied energy and Co2 emission in a reinforced concrete building has been discussed in this paper. The paper only focuses on the building materials used in construction and not on the functions of the building. Initially volume of each building material is estimated and later carbon dioxide emission due to each material is evaluated. It is observed that stone, steel, concrete and Gypsum plaster are the highest energy consumer materials among the all materials used for construction. Finally suggestions are given to reduce the carbon foot print from a typical building

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