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A State of the Art Review Upon Concrete Block Technology

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ABSTRACT: Industrialization and Urbanization is done rapidly in developing countries like India that involves construction of infrastructure and other facilities, depletion of natural resources has become a very common phenomenon. In regards of this people have started to find other suitable substitute of materials for concrete so that the conventional resources that are present today could be preserved for the future generations. The aim of this paper is to study and analyze but diffuse the literature on utilization of different materials and their testing using concrete block technology, highlight its recent trends or work in research, its uses in the industries and in field works and to suggest or recommend future areas of research and development which can be done in this field. The advantages and disadvantages of different materials that are utilized and tested are discussed according to present or new case studies. Life cycle analysis and cost analysis of materials have also been discussed in this paper. The recent work is highlighted and developments are also discussed.

Highlights: This paper reviews the construction and performance of blocks made with concrete and additive materials. Cost analysis and sustainability of concrete blocks is also reviewed.

Keywords: Concrete, blocks, testing, recycled materials, mud concrete, stone-crete**,** precast stone masonry blocks, plastic bottles, rice husk ash tobacco waste, coconut shell, sawdust, agro waste, industrial waste, blast furnace slag, glass cullet waste, textile waste, steel slag, carbon emissions, life cycle analysis or cost analysis.

I. INTRODUCTION:

Globalization, liberalization and privatization play an important factor in today's world. This has led to the construction of many major infrastructure projects like Airports, expressways, railways and stations, complex malls, multi storey buildings, nuclear plants etc in India every year. Large quantity of valuable natural resources gets consumed every year for such developmental activities. This has led to depletion of natural resources very rapidly and has also put impact on the construction costs of structures which has caused serious problem for the construction sector and mostly for the developing countries like India [1].

Materials are regarded as the most vital element of building construction works. In present days, with the demand of materials alternatives with less energy consumption and with less impact on nature are considered. With the demand of materials the prices are increasing so an alternative which promotes sustainable and affordable construction is considered [2].

In consideration of this, people have started looking for other satisfactory alternatives of materials which can be used as a supplement or as a replacement to the natural ingredients of concrete so as to preserve the existing natural resources for our coming generations. Keeping this in view, different materials or industrial waste material like fly ash, blast furnace slag, waste aggregate, broken bricks, demolition stones, broken glass waste, ceramic waste, tile waste etc have been successfully used as a feasible alternative material to the usual materials in concrete.[3]

Concrete being a composite construction material has three basic conventional components cement, sand, coarse aggregate and water [4]. Cement being the most fundamental component of concrete causes environment problems due to its generation in clinkers. It leads to high carbon emission and causes pollution [5]. So to lower the dependency on cement, different alternative materials provided locally can be adopted as strengthening cementitious material and other low carbon materials can also be adopted [6 ,7].

Constructional and demolition waste is a actual problem, not only in local or regional point of view but also in global perspective. There is a need of using constructional and demolition waste effectively and its application in reusable structural elements, so as to decrease waste dumping and decrease the use of primary resources [8]. This is

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very important considering environmental aspects and for responsible sustainability management [9].

The aim of this paper is to review on eco friendly based enhancements of concrete mixture using different materials for concrete block preparation. The information regarding concrete made with different materials or demolition waste material is provided in different forms and in a very scattered manner. This information has still not reached the large volume of associates engaged with construction activities. It is compulsory on behalf of civil engineering community, to promote sustainable and affordable construction and to promote strategies on the consumption of different alternative materials which has potential and focuses on green environment which is the need of an hour in developing countries like India.

This paper starts by discussing about concrete blocks at first, their different sizes and types are discussed, then different materials that are used in concrete blocks are discussed starting from plastic bottles, then agro waste and different types of agro waste including rice husk ash, coconut shell, tobacco waste and sawdust are discussed. Thereafter, industrial waste and its types including steel slag, waste glass cullet, textile waste cuttings and blast furnace slag are discussed. Then paper discusses about mud concrete blocks and thereafter it discusses about precast stone masonry blocks. Then recycled aggregate used in concrete blocks, carbon emissions from concrete blocks and lastly cost analysis of different materials in concrete blocks is discussed.

II. CONSTITUENTS OF CONCRETE BLOCKS:

Concrete blocks are common and vital in building construction works. It is widely used as construction material in the residential and commercial construction industries. Concrete blocks can be produced in machines or manually. They are produced in different shapes and sizes. Sizes that are most commonly used are of length 40cm, height 20cm and Width of 8/10/15/20cm [10].

These concrete blocks are produced in different shapes that are Solid blocks and Hollow blocks. Solid blocks have no voids or cavities whereas Hollow blocks have one or more holes opened at both sides. Advantages of solid blocks are that they have high compressive strength, good stability, Good fire resistance and resistance to weathering impact or abrasion. Advantages of hollow blocks are that they can be made bigger than the solid blocks, are lighter in weight, walls can be constructed easily and quickly, good thermal insulation is provided by the air space, concrete or steel bars can be filled in voids to have high earthquake resistance and cavities can be used for plumbing and electrical installation.

Fig [1] and [2] Solid Concrete Block [11]
Hollow Concrete Block [12]

Materials that are used to make concrete blocks are Ordinary Portland cement, sand or gravel with coarse aggregate of maximum particle size of 10mm, common cement aggregate ratio to be of 1:6 or 1:8 and water cement ratio of 0.5 [10]. Concrete blocks are demoulded within 24hrs of casting and curing of these blocks are done for 7 days or 28 days depending on the strength required.[10]

III. PLASTIC BOTTLES:

Plastic usage has grown rapidly and is estimated to create 9 billion plenty of plastic since 1950. Until 2015 9% of plastic was recycled and 12% was burned and 79% was disposed in landfills [13]. It is created in large quantities all over the world and is believed that disintegration of plastic takes thousands of years [14]. Plastic bottles are used daily in our life. They are used in storing cold drinks, water and other liquid ingredients. There usage has grown rapidly and has increased the disposal problem. So, in order to solve this problem different methods have been used and their use in construction as a concrete material has also been taken in account. These plastic bottles provide thermal insulation which reduces electric consumption for cooling process. They can be used to create hollow concrete blocks, which is a significant masonry unit and its uses in masonry construction is growing continuously.

Usage of plastic bottles has lead to environmental issues and its disposal is not good for human health. Reusing and recycling programs of plastic bottles has been started by many societies as they are cost effective and helps in conserving the environment [16]. Concrete blocks plays vital

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role in construction industry. The use of plastic bottles in concrete blocks was to create voids at equal distance between every void. In a masonry unit bottles are kept and concrete is placed around it. According to one of the study, 500ml plastic bottles were used and placed in masonry unit and their compressive strength was found by ASTM C140 standard. The study verified that the compressive strength of plastic bottled concrete used with local materials shows 57% higher compressive strength [17].

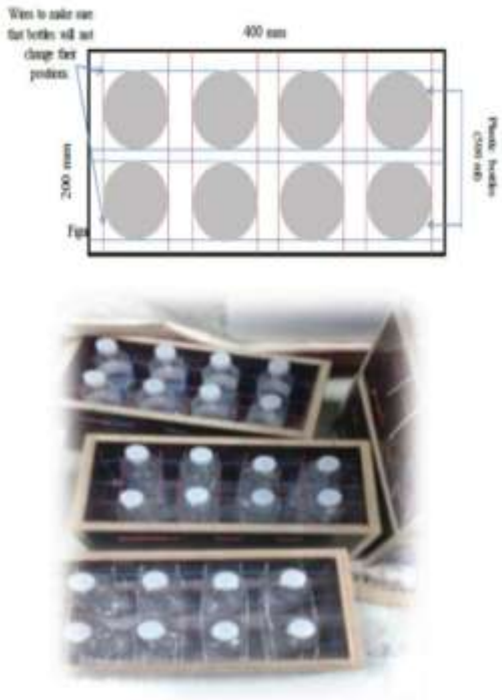

Fig.[3] & [4] Design of concrete block with 500ml plastic bottles placed inside the mould [17]

IV. AGRO WASTE:

Agro waste has become a concern for the environment. With the increase in population the demand has grown which has put an impact on agriculture. The demand of food has grown due to which agricultural demand has grown and this has led to the increase of waste generated due to agriculture. Agro waste has become a problem in today's world, for which more sustainable steps are being thought off. Different steps have been taken and are being taken to solve this problem.

4.1 Rice husk ash:

Rice husk ash is a consequence product of rice milling industry and is obtained by burning the rice paddy husks [18]. Under controlled burning between 500 to 800 °C of rice husks it produces non-crystalline amorphous [19]. It also has 90-95% of amorphous silica [20]. Rice husk ash has become a problem as it requires large area for dumping and effect the surrounding area. There are studies done to use rice husk ash as a replacement of concrete for about 15-25%. Weight density of concrete reduces by 72-75% by adding RHA to it and also reduces the material cost by 8-12%. It also reduces the water absorption of concrete and increases the compressive strength and workability of concrete [21].

Fig [5] Rice husk Ash [21]

4.2 Coconut shell:

Utilization of waste product leads to development of green technology. Coconut shells are wastes from industries and households. They are present abundantly in Indonesia and also in Southern parts of India [22]. The coconut shell is used as material for concrete and reduces its cost and produces eco-friendly concrete blocks which can be used in pavement and makes the pavement more durable by absorbing the water. These pavement blocks can be used on roads, parking area, pedestrians etc [23]. The advantages of using coconut shell as a concrete-mixture materials are that coconut shell have high strength and durability and provides high modulus of elasticity, also due to its fiber texture it provides strong bond with cement [24]. An experimental testing shows that the test specimens tested at 28 days shows that the specimens with coconut shells absorbs 18% higher water absorption then the one with the powder content[25].

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Fig [6] and [7] Conblocks used for pavement of Parking area [25]

4.3 Tobacco waste:

Tobacco waste is produced largely due to high production of cigarette every year [26]. Due to the presence of alkaloid nicotine it is very toxic [27]. There have been experiments done and investigated to see the possibility of making a lightweight concrete using tobacco waste. One of such investigation was done using tobacco waste with different percentages in lightweight concrete carrying pumice and found that pumice lightweight concrete with tobacco waste can be used as a coating and dividing material in construction. It was also noted that the lightweight concrete with tobacco waste have low thermal conductivity (0.194-0.220W/mk) which is lower than the most masonry materials, i.e. brick (0.45-0.6W/mk), briquette (0.7-1.0W/mk), pumice concrete (0.29W/mk) and Ytong (0.23 W/mk)[28].

4.4 Sawdust:

Sawdust can be used as a substitute material for fine aggregate in concrete [29]. It is an important component of particleboard and can be presented as a hazardous material in terms of its flammability in manufacturing industries [30]. Using sawdust to make a lightweight concrete has caught attention from past few years and can solve dumping problem and also help in preserving the natural fine aggregate [31]. Using sawdust makes concrete lightweight and is also cost effective. There are many research works done in past to see the effect of sawdust on concrete, and it has been observed that weight and compressive strength of concrete reduces as sawdust is increased whereas water cement ratio increases with the increase of sawdust in the concrete mix. It can be utilized as lightweight masonry unit for the partition wall in buildings [32].

Fig [8] Saw dust [33]

V. INDUSTRIAL WASTE:

Industrial waste has become a major problem from past few years. Dumping of such waste can be harmful for the environment and needs to be managed or treated. Waste material can be used as a powdered material in concrete or cement mortar. The usage of industrial material depends on the material properties to whether use it after treatment or without treatment. Waste material can be used as aggregate material in concrete and can reduce the problems related to environment and also solve the waste disposal problem.

4.2 Steel Slag:

Steel slag is a solid waste obtained from the production of steel [34]. It can be classified as stainless steel slag and carbon steel slag, depending on the type of steel and as a pretreatment slag [35]. Steel slag is produced after the conversion of scrap iron or iron ore into steel. Construction materials such as cementitious pastes and bricks can be produced using waste steel slag [36]. The increasing amount of steel slag causes environmental problems in developing countries and has become important to utilize the steel slag in order to protect the environment [37,38].Steel slag on using as a fine aggregate in concrete mix shows positive effects on ultimate expansion ratio and toughness and on adding it with concrete it will improve the energy absorption capacity[39].

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Fig [9] Steel Slag Sand [39]

4.3 Waste glass cullet:

Glass is produced by melting soda ash, silica and limestone at high temperatures and is then cooled where it gets solidified without crystallization [40]. It is used in our lives daily in the form of bottles, sheet glass, glassware etc [41]. It is a very good material for recycling, helps in brick and ceramic production, conserves raw materials, reduces energy consumption and the quantity of waste sent to landfills [42]. In most of the cities landfill space is very limited. So, recycling is important as it not only reduces pressure from the landfill but also conserves the natural resources following sustainable development [43]. Study has been done previously where an eco-friendly precast concrete is developed using glass powder and glass cullet. Results showed that the strength was constant despite of increase in glass cullet whereas the combined use of glass cullet and glass powder resulted in water absorption and drying shrinkage of paving blocks within limits [44].

Fig [10] Glass cullet transition to Glass powder [44]

4.4 Textile waste cuttings:

World population growth and high living standards have grown in recent years and has caused an increase in demands of textile products. It has also led to the overconsumption of resources due to the fast fashion trends [45]. Textiles are mainly used to protect our bodies from temperature variations and from UV rays and have become the reflection of personality and interest of fashion and in present days due to technological advancements textiles are used for different other applications other than garments [46]. The idea of recycling products related to textile took place during the industrial revolution in UK in 1700s and 1800s [47]. Textile waste cuttings are mixed with cement and acts as a binder which produces concrete that can be cut or nailed like wood. Tests were conducted previously where different samples were cured for 8,28,30 days and was found that concrete with textile waste cuttings shows high energy absorbing capacity and though textile has high flammability sample shows no burning even after subjecting it to open flame for 30mins[48].

4.5 Blast furnace slag:

Blast furnace slag is a by-product from iron and steel industry and is formed by blast furnaces that are used to produce iron [49]. It is used as a very successful replacement material for Portland cement and provides many benefits such as durability, workability, high strength, environmental benefits and cost efficiency [50]. Sustainable development is an important factor in present world. According to industrial ecology system, by product of one industry can be used as a by-product on another industry [51]. Looking this in mind, the cost, durability and conservation of environment are used in developing concrete technologies [52]. Studies have been done previously in which it was found that the non-ground granulated blast furnace slag can be used as a fine aggregate in concrete. Different samples were taken with Non granulated ground blast furnace slag as 0%, 25%, 50%, 75% and 100% and two groups of sand were taken first type with 0 to 7mm size sand and second type with 0 to 3mm size sand. It was found that the second type has relatively high compressive strength and durability than the first type. Thus, non-ground granulated blast furnace slag can be used as fine aggregate [53]

VI. RECYCLED AGGREGATE CONCRETE BLOCKS:

Recycled aggregates are the future materials. The applications of these aggregates have started in many developed countries. Use of recycled aggregate can help in the protection of environment [53]. Presently, in countries like Spain in order to protect the environment the use of such materials is being promoted considering the development of international standardization like EHE-08 [54], BS-8500 [55], RILEM [56], DIN-4226.100 [57]. This benefit helps by reducing the load on natural resources which are extracted from the river beds and quarries [58]. Recycled aggregate concrete are majorly used in sub-base or granular base applications, for earth construction and construction of embankments, whereas its use in structural construction is insignificant [59]. As, C&D waste has been proved to be a great source of aggregate for concrete production, there has been many studies that shows that concrete made with such aggregates can have similar mechanical properties to that of conventional concrete [60,61]. Studies have also shown that the concrete with recycled aggregate shows reduction in concrete strength which can be as low as 40% [62,63]. Also, recycled aggregate concrete has better carbonation resistance than the conventional aggregate concrete and shows better durability due to presence of higher cement content [64]. The main replacement of using recycled aggregate is only natural aggregate and these are still relatively low cost materials [65]. In India, material cost is increasing rapidly and due to this secondary industries and informal sectors recycle 15-20% of construction solid waste from building works [66,67].

VII. MUD-CONCRETE BLOCK:

Earthen building system was not considered to be the part of engineering historically due to its concern relating to strength and durability. Although mud-house construction was very popular in ancient times, it came into limelight in 1930s only after a written standard for adobe was developed in United States [68]. Mud-concrete mixture was developed as a self compacting mix which consolidates under its own weight. It would not require any compaction and will follow the shape of the mould once it is set [69,70].

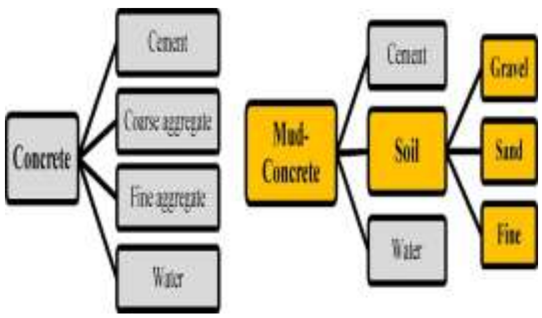

Fig.[11] Similarities between Normal Concrete and Mud Concrete [71]

Fig.[12] Picture showing Mud Concrete Blocks [71]

Mud concrete concept was initially adapted to develop both the strength and durability of concrete into mud based constructions. It introduced low cost, load bearing wall system with easy construction techniques. It helps in minimizing the impact on environment. Mud concrete is a form of concrete that is produced using soil, cement and water. Here soil ensures the role of aggregate, cement with low quantity acts as a stabilizer, usable gravel ensures compressive strength and high amount of water ensures hydration of cement and enhances self compaction. An experimental testing shows that the Mud-concrete block is having 4% Cement, Sand 55-60%, Fine < 10%, Gravel 30-35% and water 18-20% in a dry mix. It also satisfies the durability standards recorded in SLS 1382 [71].

VIII. PRECAST STONE MASONRY BLOCKS:

In some places, abundance of stone is available and forms a major walling material. Walls are normally made as random rubble masonry with the thickness of 380 to 450mm and at some places 300mm walls are also constructed with slightly higher cost due to the requirement of skilled labor and time. The thickness of these walls is huge depending on the practical and structural requirements [72].

A study was carried out by Central Building Research Institute (CBRI) which mainly focused on reducing the thickness and level of skill required for the construction of random rubble walls. This study resulted in developing precast stone masonry blocks using stone spalls and lean concrete mix with a natural stone texture on one side of the block [73]. These blocks can be easily constructed at sites with semi skilled labors. This technique has been successfully used for load

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bearing and non-load bearing walls up to 3 storey's of a building.

Size of blocks has been taken considering the ease of handling and other basic requirements, where the length and height is kept 300mm and 150mm respectively with width varying into three different sizes i.e. 200mm, 150mm and 100mm. The dimensions of these blocks are kept short by 10mm and they weigh from 90N to 180N.

Sl. No.	Block Size (mm)						Mould Dimensions (mm)		
	Nominal			Actual			Internal		
	L	B	H	L	B	H	L	B	H
1.	300	200	150	290	190	140	290	140	190
2.	300	150	150	290	140	140	290	140	140
3.	300	100	150	290	90	140	290	140	90

Fig [11] Size of blocks and Internal Dimensions of Single Mould [74]

Casting of these blocks requires a smooth and a hard surface where a single mould or a gang mould of 72 blocks or 48 blocks can be used. A lean concrete mix is preferred for these blocks, generally 1:5:8 is used which gives a compressive strength of 60 kg/cm^2. However, different concrete mix can also be used depending on the requirements and slightly over sanded mix is preferred to make these blocks. With the use of stone spalls in these blocks, cement is saved and results in higher compressive strength and lower drying shrinkage.

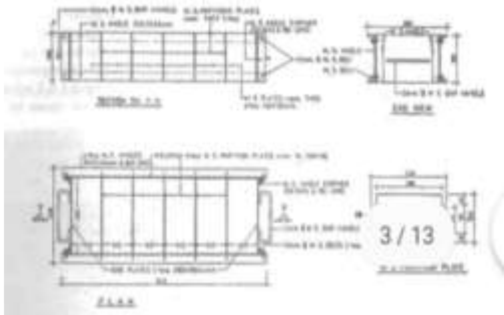

Fig [12] and [13] Gang Mould of Six Blocks [74] Gang Mould for Casting 72 blocks [74]

There are few steps taken for casting of these blocks. Firstly, clean the platform and mould with oil or grease then place the moulds or gang of moulds alongside for demoulding. Arrange a stone spall inside the mould such that there is a gap of 15mm between the stones. Then fill the gaps with the lean concrete using a trowel and set the concrete properly around the stone spall. Then use a plate vibrator for compaction and remove any surplus concrete over the mould. Demoulding is then started after 5 to 10minutes of casting depending on the weather conditions of the place. After 24 to 48 hours blocks are pushed slightly to break bond and then they are taken for curing for 3 days. These blocks are cured by sprinkling water at them for 2 weeks and then air cured for another 2 to 4 weeks depending on the weather conditions so the blocks are dry before laying them on the walls [72].

The minimum compressive strength for the average of 8 blocks at 28 days, and for an individual block the minimum compressive strength at 28 days after testing them on a machine with steel bearing blocks and plates is shown in figure below [74].

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TABLE 1 COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS
(Clauses 4.1 and 7.3)

Class Designation	Minimum Average* Compressive Strength of Blocks N/mm²	Minimum Strength of Individual Blocks N/mm²
5	5·0	3·5
6	6·0	4·2
7	7·0	5·0
9	9·0	6·3
10	10·0	7·5

*For 100 mm wide blocks (for 100 mm thick walls), the minimum strength may be 3·5 N/mm².

Fig. [14] Compressive strength of stone masonry blocks [74]

Water absorption tests done in laboratory using 1:5:8 concrete mix has specified that water absorption of 6% are for manually compacted blocks and 4% are for vibrator compacted blocks. Drying shrinkage was found to in the range of 0.33 to 0.38 % for these stone masonry blocks.

IX. CARBON EMISSIONS FROM CONCRETE BLOCKS:

In developing countries like India and China due to rapid economic growth the demand for energy and usage of energy has gone up in recent years. To meet this demand fossil fuels are predicted to be the major energy source [75]. Carbon dioxide is a incombustible, odorless, colorless gas. It is indispensible for many living organisms and is a non-polar molecule made of single carbon atom and is covalently double bonded with two oxygen atoms. It also absorbs infrared rays as deformation vibration energy resulting into greenhouse effect [76]. The increase of carbon dioxide in the atmosphere has led to damages like rising water level, extinction of various species and climate change. So, a effective control of carbon dioxide emission is required to achieve a global carbon dioxide concentration below 550ppm until the next century [77].

Global warming and the emission of green house gases has become a major problem for the modern world. From past few years many strategies has been considered to reduce the carbon emission and to store and utilize the carbon dioxide as to create the high value products [78]. There are technologies focusing on carbon dioxide capture, utilization, storage and conversion into fuels or chemicals [79]. Carbon capture and storage technologies can capture carbon dioxide directly from the emission sources and store it at the sites. But, in recent years focus has come more on the carbon capture and utilization technologies which has the potential to reduce annual emissions by 3.7Gt and can add to valuable products which helps in creating green jobs and provides economic benefits [80].

Cement industry is the primary creator of greenhouse gases and is creating 5-8% emissions worldwide while manufacturing cement, which is the most vital material in concrete and is produced by combustion of limestone and generates large amount of carbon dioxide while its manufacturing [81,82]. In recent years, many industries have incorporated into beneficially reuse the captured carbon dioxide in cementitious construction materials and many of these technologies have been commercialized. For example, Carboncure Technologies Inc. developed a technology to manufacture precast concrete by utilizing waste carbon dioxide captured in the cement industry [83]. Calera corporation used a chemical reactionbetween carbon dioxide, source of alkalinity and a source of calcium to produce a calcium carbonate cement [84].

Cement based substances are used worldwide in a wide range of fields as civil engineering, environment nuclear and petroleum engineering and provide a large scale solution for stabilized storage of carbon dioxide [85]. On the other hand, calculable measurement method for the amount of carbon dioxide being absorbed in cement based materials is scientifically not made yet [86]. Lastly, for the calculation of carbon dioxide absorption in cement-based components following mechanisms can also be considered [85]: 1) carbon dioxide can be diffused to gaseous state by internal matrix of cement based materials, 2) reaction of product and precipitation that occurs due to carbonation, 3) the carbon dioxide gas can be dissipated into aqueous pore solution, 4) other methods governing the carbonation and which brings changes in the mechanical properties of cement based materials.

X. COST ANALYSIS/ LCA OF CONCRETE BLOCKS

The Life Cycle Analysis is a process to measure the result of the resources, environment and production procedure, product or service of a system [87]. The LCA systematized by ISO 14.040 [88], is a tool to measure the environmental aspects linked to a substance or process that compromise different stages that go from the descent from environment of the underlying raw materials that belong to the productive system to the final product disposal after being consumed. In civil construction

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works the LCA can be used as environmental solution for the various areas as it can be easily applied in the production of civil construction materials [89].As, sustainable development is a matter of concern, so the production of materials and the use of materials those related to civil construction segment and their environmental aspects are in queue. So, the materials that are less impacting must be used and the constructive system must be also encouraged [90].

Many researchers use the LCA tool to check the consequences of the environmental impacts from the usage of particular waste. An LCA tool was used to check the environmental benefits of the blast furnace slag [91]. The results showed that there were large amount of environmental benefits when the waste was used in manufacturing of slag cement and Portland cement as a raw material.

Many studies in recent years indicated that the use of recycled plastic waste as qualified aggregate replacements has gained interest of many researchers significantly. Research works have also shown that the use of these materials can refine the concrete properties under proper mix where the main motive is to find a substitute for the plastic waste rather than directly disposing it to the landfills. It is calculated that the 30% of total waste disposed could be reduced from the solid waste. As, the polymers from plastic waste degrades after decades or with difficulty so the plastic waste can be utilized as partial aggregate material and can be conserved inside concrete structures for generations. Although studies are yet to be done on finding the service life of concrete structures using plastic waste materials as partial aggregate material. The long term performance and the environmental effects of plastic waste in concrete structures after its service life are yet to be surveyed [92].

A research work shows was done to check the strength of cube samples containing rice husk ash (RHA). The quantity of fine and coarse aggregate was taken as same whereas the quantities of cement and RHA varies. The results found that the cost of $1m^3$ of OPC cement works out to be at Rs. 1157 whereas the cost of RHA concrete works out to be at Rs. 959. This shows that the addition of RHA in concrete leads to 8-12% saving in material cost. So, the addition of RHA in concrete helps in making the concrete feasible [21].

A research work was done on different materials used for economical housing in tropic regions and was found that the mud concrete block is most acceptable walling material on comparing with the other walling materials like brick, hollow cement block and cabook. Results specified that brick mud concrete block can be reused again and again for the walling materials. Mud concrete block has a reusable value of 92% and its ingredient can be crushed again and can produce same walling material with an addition of 8% of cement ratio to it. This research showed that the brick and mud concrete block are more sustainable comparing to other walling materials whereas cabook is second best material due to less energy consumption, low cost and low carbon emission and Hollow concrete block is the worst walling material in the topical region as its carbon footprint is higher comparing to the others [93].

Research work was carried for comparing environmental evaluation of Natural aggregate concrete (NAC) and Recycled aggregate concrete (RAC). In this research work it was concluded that the utilization of RAC for non-aggressive exposure conditions and for low to middle strength structural concrete is technically attainable. The LCA results show that the effect of cement (about 5%) and aggregate production stages are a bit more for RAC than for NAC. The environmental impacts depend upon the transport distances and types. If the transport distance of recycled aggregate is lesser than that of natural aggregate, the ecological impacts of the two are same and the profit from recycling the waste and minimization of natural resources is gained. If the distances of recycled and natural resources are same the total impact of recycled aggregate concrete is more and this increase ranges from 11.3% to 36.6% [94].

XI. CONCLUSION:

Industrialization and development has put pressure on the natural resources and has caused depletion of these natural resources so, it has become important to view other suitable methods or substitute of materials for concrete to save these natural resources. As environment protection plays an important role in today's world, different methods are being focused to reuse, recycle and reduce construction and demolition waste in construction works. This paper reviews on different materials being utilized using concrete block technology. Different materials were studied, starting with utilization of plastic bottles in concrete blocks which shows that the plastic bottled concrete blocks has 57% higher compressive strength. Then different types of agro waste were discussed starting with rice husk ash showing that RHA can be used as a replacement of concrete for about 15-25% and it also reduces weight density by 72-75% by adding RHA in a concrete and also reduces material cost by 8-12%.

Second agro waste was coconut shell and it was studied that use of coconut shell in concrete block has 18% higher water absorption then the one with powder content. Third agro waste discussed was tobacco waste and it was found that lightweight concrete block with tobacco waste has low thermal conductivity (0.194-0.220W/mk)which is lower than the most masonry materials. Last agro waste discussed was sawdust and study showed that the compressive strength of concrete reduces with increase in sawdust whereas water cement ratio increases with increase of sawdust in the concrete mix.

Industrial waste and its different types were also discussed in which the first industrial waste discussed was steel slag, whose study showed that on using steel slag as fine aggregate in concrete mix shows positive effects on ultimate expansion ratio, toughness and also improves the energy absorption capacity. Second industrial waste studied was waste glass cullet whose results showed that the strength was constant despite increase in glass cullet whereas the combined use of glass cullet and glass powder resulted in keeping water absorption and drying shrinkage within limits of paving blocks. Third industrial waste discussed was textile waste cuttings and tests were studied in which different samples were cured for 8, 28, and 30 days and was found that concrete with textile waste cuttings show high energy absorbing capacity and though textile is highly flammable, it showed no burning signs after being subjected to flame for 30mins. Last industrial waste discussed was blast furnace slag and a study showed that different samples with 0%, 25%, 50%, 75% and 100% Non Granulated Blast furnace slag were tested with two types of sand samples one with 0 to 7mm size sand and other with 0 to 3mm size sand and was found that the sample tested with second type of sand shows relatively high compressive strength and durability. Thus, Non-granulated blast furnace slag can be used as fine aggregate.

Recycled aggregates were discussed which can be used as replacement of natural resources and also reduces the load from the use of natural resources. Studies have shown that concrete with recycled aggregate shows showed reduction in concrete strength as low as 40%. Recycled aggregate concrete has better carbonation resistance than conventional concrete and shows high durability due to presence of higher cement content. Recycled aggregates are replacement of natural aggregate and are relatively low cost materials.

Mud-concrete blocks were also discussed and an experimental testing was studied which showed that mud-concrete block have 4% cement, sand 55-60%, fine < 10%, gravel 30-35% and water 18-20% in a dry mix.

Precast stone masonry blocks were discussed and their casting techniques were studied. These blocks show high compressive strength and durability. Water absorption for 1:5:8 concrete mix stone masonry blocks was found to be 6% for manually compacted blocks and 4% for vibrator compacted blocks. Drying shrinkage was found to be 0.33% to 0.38%.

Carbon emission due to cement based construction works was also discussed. Carbon emission due to cement industries causes high pollution and there is a need to find different methods to reduce carbon dioxide emission below 550ppm. Different technologies can be used to store, utilize, capture and convert carbon dioxide into fuels or chemicals.

Lastly, Life cycle analysis and cost analysis of different materials were discussed starting with blast furnace slag which has large environmental benefits while using it for manufacturing of slag cement and Portland cement as a raw material. Study was made on Plastic waste material used as partial aggregate materials, it is estimated that 30% was plastic waste can be reduced from the solid wastes. The studies are yet to be made in finding the service life of use of plastic waste in concrete structures. Study was discussed on cost analysis of RHA where it was found that cost of $1m^3$ of OPC cement works out to be at Rs. 1157 whereas the cost of RHA concrete works out to be at Rs. 959. This shows that the addition of RHA in concrete leads to 8-12% saving in material cost. So, the addition of RHA in concrete helps in making the concrete economical. Study was done on research work done on different materials used for economical housing in tropical region, its results specified that brick mud concrete block can be reused again and again for the walling materials. Mud concrete block has a reusable value of 92% and its ingredient can be crushed again and can produce same walling material with an addition of 8% of cement ratio to it. This research showed that the brick and mud concrete block are more sustainable comparing to other walling materials. Last analysis discussed was on a research work carried for comparing environmental evaluation of Natural aggregate concrete (NAC) and Recycled aggregate concrete (RAC). In this research work it was concluded that the utilization of RAC for non-aggressive exposure conditions and for low to middle strength structural concrete is technically attainable. The LCA results show that the impacts of cement (about 5%) and aggregate production

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phases are a bit more for RAC than for NAC. The environmental impacts depend upon the transport distances and types.

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