IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EXPERIMENTAL STUDY ON CARBON EMISSION OF PARTIALLY REPLACED CEMENT CONCRETE WITH SAW DUST ASH

YASEEN MAQBOOL WANI[1] & NAVDEEP SINGH[2]

[1]Research scholar, Civil Engineering Department, CT University Ludhiana, India.

[2]Assistant Professor, Civil Engineering Department, CT University Ludhiana, India.

ABSTRACT

Concrete, an essential building material, emits a lot of CO_2 from the material production stage to the manufacturing stage, including the production of cement, aggregates, and admixtures. Due to the escalating emissions of carbon dioxide into the atmosphere, the adverse effects of climate change are becoming more and more obvious around the world. Around 5 to 7% of the global carbon emissions caused by human activity are attributable to the cement sector. In light of this, it is necessary to conduct research to determine the optimal level of CO_2 emission during the manufacture of concrete. This study also looked into the effects of using sawdust ash (SDA) as a partial replacement of cement. SDA was replaced by weight in the cement at several concentrations, including 7 percent, 14 percent, and 21 percent. Compressive, flexural, and tensile strength tests were carried out on concrete cubes, beams, and cylinders on the seventh and 28th days after the concrete had been made and had been curing in water. Based on the data, we suggest replacing cement with Saw Dust Ash at 14 percent for better production of eco friendly concrete.

Keywords:

Saw Dust Ash, Cement, Carbon Emission, SEM analysis

1. INTRODUCTION

One of the most essential building materials in the world is cement. It is mostly utilised to make concrete. Sand, gravel, crushed stone, and cement are some examples of the inert mineral aggregates used to make concrete. Cement is produced in almost every nation due to its widespread use as a building material and the geographic richness of its primary raw components. Energy is used in the manufacturing and transportation of these materials, and sandblasting (consolidation with cement) and other chemical processes produce CO2 during production (limestone extraction). Each year, the construction sector contributes significantly to atmospheric CO2 emissions.

One of the greatest environmental challenges facing our society is the threat posed by climate change global temperature, the levelling of the oceans, heat waves, the thawing of the permafrost, etc.. Since these are the top worldwide challenges for which scientists, researchers, citizens, and governments are actively seeking solutions **[1]**. they pose a serious threat to our environment globally. Our communities, our health, and our climate are already being significantly and extensively impacted by these challenges **[2]**. Human activities have been identified as one of the main contributors to the issue of climate change, and this has led to an ecological disruption as a result of the excess atmospheric greenhouse gases. The manufacturing of Portland cement, the primary binder in concrete, is one of the key human activities significantly increasing global carbon dioxide emissions. The manufacturing of cement in response to the strong demand for it accounts for roughly 5-7% of all anthropogenic carbon dioxide emissions worldwide **[3, 4]**. In the upcoming years, increasing urbanisation and population growth are forecast, which will lead to a rise in concrete usage and, ultimately, carbon dioxide emissions.

In addition to this, the growing demand for PC as a binder has also driven up construction costs worldwide, particularly in developing nations. Therefore, finding substitutes for the typical binder is urgently needed to protect the environment and save construction costs **[5]**. So there is a need to use a substance that is less pollutant to the environment and at the same time meet the economical and durability requirements. Since there are many by-products which can be used as partial or full replacement with different ingredients of concrete such as, rice husk ash, fly ash, saw dust ash, glass fiber and steel fiber etc. Saw dust is an organic waste product from the timber or wood sector. Sawdust is produced as a by-product when timber is manually milled, sawed, ground, or mechanically processed into boards of various sizes and shapes in sawmills **[6]**. Sawdust ash, which is produced when sawdust burns at a high temperature and contains a significant quantity of silicate and aluminate, can be used in place of ordinary cement in some applications. Sawdust ash (SDA) as a partial replacement in concrete mixtures has been the subject of several investigations **[7-9]**. However, the majority of these experiments have only restricted the replacement amount to 5-10% **[10, 11]** and only few studies have addressed the issue of carbon emission in partial replacement of cement concrete with saw dust ash.

Therefore, the purpose of this study was to examine the effectiveness of concrete mixtures including SDA. In this work, the physical and chemical characteristics of the aggregates and binders , also the compressive strength, split tensile strengths and flexural strength of concrete were examined, and the performance of the resulting concrete was assessed. The study also attempted to approximate the reduction of carbon emission that would result from the use of saw dust ash as a partial replacement of cement. Additionally, it is believed that the study's findings will be a helpful tool for all parties involved in finding new approaches to raise the performance and sustainability of concrete mixtures.

2. Experimental methods

2.1 Materials

Any concrete's performance qualities are mostly influenced by the caliber of the cement used in production. Despite the fact that there are numerous cements available, including OPC 33 grade, OPC 43 grade, and OPC 53 grade. The most widely used cement in the world is OPC. This kind of cement is suitable where building is carried out quickly.

In the study, OPC grade 53 that complies with BIS: 12269-1989 **[12-13]** is employed. Numerous significant physical and strength tests were carried out in the lab for this reason. . It is also predicted that there are various elements that are abundant among them are as fallows;

Table 1 Chemical composition of cement

Ingredient	Percentage
Calcium oxide (CaO)	60 – 67
Silica (SiO_2)	18 – 25
Alumina (Al_2O_3)	3 – 8
Iron Oxide (Fe_2O_3)	0.5 – 6
Magnesia (MgO)	1 – 3
Sulphur Oxide (SO_2)	1 – 4.5

Saw Dust Ash

The byproduct of woodworking processes like sawing, milling, planing, routing, drilling, and sanding is called sawdust. It is primarily made of calcium compounds along with other non-combustible trace elements found in the wood,. However, wood ash can be used to supplement organic hydroponic solutions, typically taking the place of inorganic compounds that contain calcium, potassium, magnesium, and phosphorus . Typically, saw dust ash contains the fallowing major elements:

Table 2 Chemical composition of saw dust ash

INGREDIENTS	PROPORTION
Silica (SIO_2)	62 – 67
Alumina (AL_2O_3)	6 – 10
Iron Oxide (FE_2O_3)	3 – 5
Magnesium Oxide (MGO)	2.5 – 5
Calcium (CAO)	6 – 10
Sodium (Na_2O)	0 – 1
Potassium (K_2O)	0 -2.5

2.2 Mix Design and sample preparation

This study examined four concrete combinations, and Table 3 provides a full composition. The mix ratio for M30 concrete was 0%, 7%, 14% and 21% by replacing sawdust ash with suitable cement, using the mix calculation method. These are marked with numbers CM0, CM1, CM2, and CM3. Portland cement (PC) was to be replaced with sawdust ash (SDA) up to 21 percent in increments of 7 percent, with all combinations having a water to binder ratio of 0.50. One of the mixtures is the SDA-free control (i.e. CM0). For instance, CM1 depicts the concrete mixture with SDA substituted for 7% of the Portland cement. Similarly CM2 shows 14% of cement replacement with SDA and so on. Proper curing solutions were employed as the curing solution for each of the mixes. For all formulations, the dry ingredients were combined for 4 minutes before the water was gradually added while the mixing was still going on. The mixture was stirred for an extra 2 minutes to ensure homogeneity after all the water had been added. The fresh mixture was poured into the prepared moulds for the various tests to be conducted right after the fresh qualities of the mixtures were assessed. All samples were demoulded at around 24 hours and cured in water till the testing age. The table shows the amount of different materials used per m3 of grade M30 concrete as shown below;

Table 3 M30 Grade of concrete Quantity required per meter cube

S.No	Mix	%age of SDA	Quantity of material (kg/m^3)			
			Water	Cement	FA	CA
1	CM0	0	197	365	827.01	1022.05
2	CM1	7	197	365	827.01	1022.05
3	CM2	14	197	365	827.01	1022.05
4	CM3	21	197	365	827.01	1022.05

Table 4 Quantity for 1 Mould of size 150 x 150 x 150 mm

S.No	Mix	%age of SDA	Quantity of material (kg/m^3)			
			SDA	Cement	FA	CA
1	CM0	0	0	1.28	2.89	3.58
2	CM1	7	0.09	1.19	2.89	3.58
3	CM2	14	0.18	1.10	2.89	3.58
4	CM3	21	0.27	1.01	2.89	3.58

2.3 SCHEME OF INVESTIGATION

Therefore, The entire scheme of investigation was appropriately planned under strength studies and durability studies, as shown in Table below;

Table 5 Overall Scheme of the Investigation

Test	Compressive Strength studies	Split Tensile Studies	Flexural Strength Studies
Mix cast	CM0, CM1, CM2, & CM3	CM0, CM1, CM2, & CM3	CM0, CM1, CM2, & CM3
Age of testing	7, 14, & 28 days	7, 14, & 28 days	7, 14, & 28 days
Specimens per mix	9	9	9
Total specimens	36	36	36
Total			108

2.4 HARDENED CONCRETE TESTS

Various tests (Compressive strength test, Split tensile strength test, and Flexure strength test) focused on strength are carried out on hardened concrete specimens after an adequate curing period.

3. RESULT & DISCUSSION

3.1 Compressive Strength Test

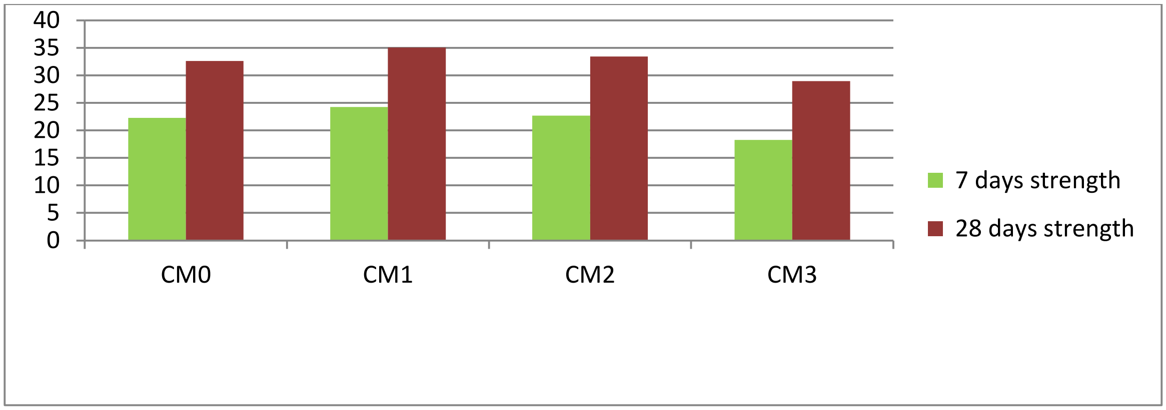
According to the instructions provided in IS 516-1959, **[13]** the compressive strength was tested on cubes measuring 150 mm x 150 mm x 150 mm on various specimens in acceptable and moisture-free conditions. Three cubes of the combination were tested 7, 14, and 28 days following treatment.

According to experimental research, when cement is partially replaced with saw dust ash by 7%, & 14%, The compressive strength is increased by 7.51%, and 2.57% after 28 days respectively. Also when partially replaced cement with saw dust ash by 21%, it decreased up to 11.07%.The slower pozzolanic reaction of the SDA can be blamed for the decrease in compressive strength of concrete mixtures with the inclusion and increase in SDA concentration. From the results, it was observed that the percentage decrease in strength increased from more than 14% of SDA replacement.

TABLE 6 COMPRESSIVE STRENGTH TEST MIX

S.No	Mix ID	%age of SDA	Compressive strength (N/mm^2)	
			7 days	28 days
1	CM0	0	22.29	32.60
2	CM1	7	24.26	35.05
3	CM2	14	22.68	33.44
4	CM3	21	18.46	28.99

Fig. 1 Comparison between 7 and 28 days Compressive strength.



3.2 SPLIT STRENGTH TEST

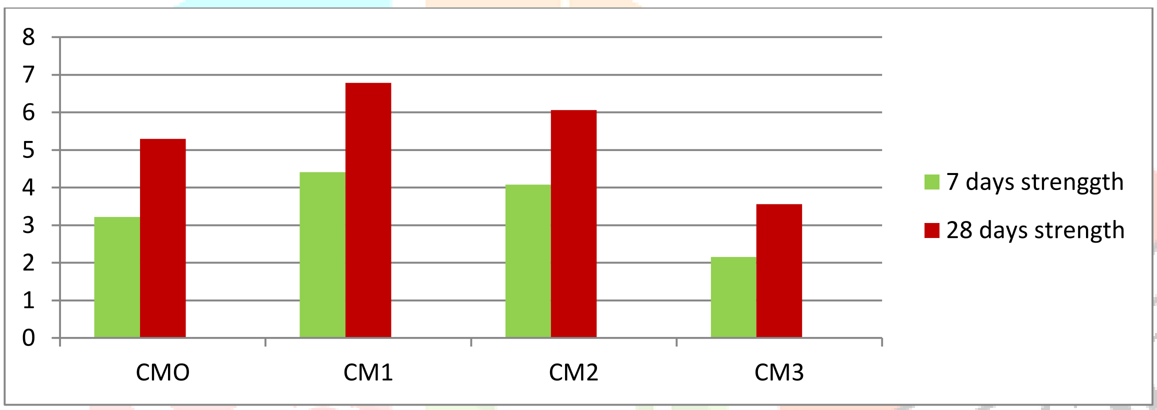
According to IS 516-1970 **[14]** specifications, the tensile strength of concrete is tested using cylinders 150 mm in diameter and 300 mm in length in various mixtures. After the surface had dried for seven and 28 days, cylindrical specimens were tested. During the test, the cylinder is positioned so that it is parallel to the launch point. A precise alignment is made between the sample's axis and the spherical plate's centre of gravity. The load was gradually applied without creating any impact, and the sample's tensile strength was calculated by gradually increasing it until it broke at a steady rate of 2.4 N/mm2/min. The experiment was conducted using a compression machine.

Concrete's split tensile strength is a reliable indicator of how well it will perform in applications where tensile and fexural loads are applied to concrete structures. Figs. 2 display the mixtures' split tensile strength. The split tensile strength of all combinations increased with age while decreasing with SDA content, with respect to the compressive strength (Fig. 1). However, when combinations aged, their Split Tensile strength increased. Compressive strength at 28 days for combinations including CM1 is 32.8% and 28.1% higher than compressive strength at 7 and 14 days, respectively.

TABLE 7 SPLIT TENSILE STRENGTH TEST MIX

S.No	Mix ID	%age of SDA	Split tensile strength (N/mm^2)	
			7 days	28 days
1	CM0	0	3.32	5.30
2	CM1	7	4.41	6.79
3	CM2	14	4.08	6.06
4	CM3	21	2.16	3.56

Fig. 2 Comparison between 7 and 28 days of Split Tensile Strength



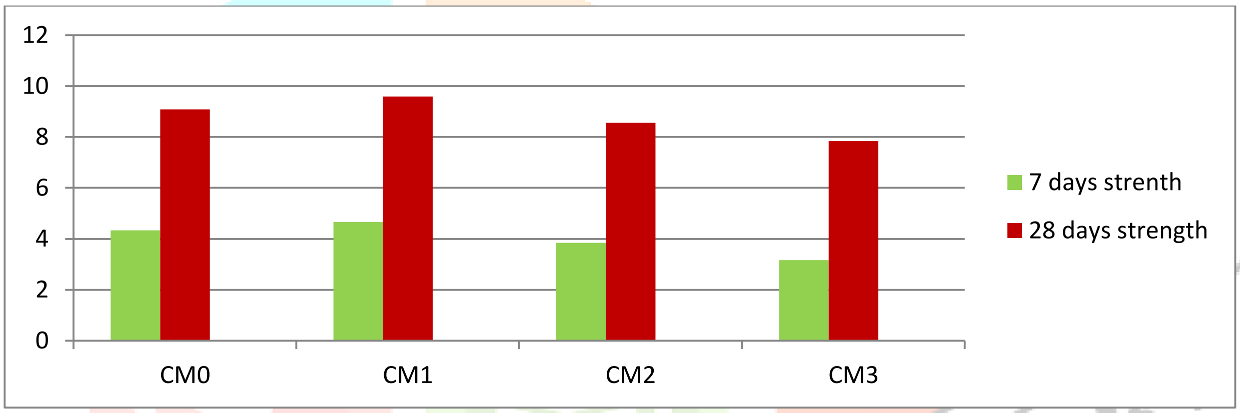
3.3 Flexural strength test

According to the guidelines in BIS 516-1959 **[15]**, a beam with dimensions of 150 x 150 x 500 mm is subjected to a flexural strength test. Three specimens must be ready for each test, which has an age range of 7 and 28 days. To the loading points, place the specimen. Applying loads ranging from 2 to 6% of the calculated ultimate load Load the sample steadily and without interruption until it fails, at a consistent rate. According to experimental research, when cement is partially replaced with saw dust ash by 7%, the flexural strength increases by 7.62% after 7 days and 5.61% after 28 days. However, when cement is partially replaced with SDA by 14 and 21%, the flexural strength starts to decrease.

TABLE 8 FLEXURAL STRENGTH TEST MIX

S.No	Mix ID	%age of SDA	Flexural strength (N/mm^2)	
			7 days	28 days
1	CM0	0	4.33	9.08
2	CM1	7	4.66	9.59
3	CM2	14	3.85	8.56
4	CM3	21	3.17	7.84

Fig. 3 Comparison between 7 and 28 days of Flexural Strength



SCANNING ELECTRON MICROSCOPE [SEM] ANALYSIS

The hydrated cement paste that was made from the powder samples is analysed using SEM in the current investigation. The SEM examination employed a resolution of x5000 and a scale range of 5 µm. Below is a full description of the sample preparation procedure for SEM analysis.

After the completion of the compressive testing, the concrete cube samples were crushed, and the hydrated cement was extracted from the sample's innermost core. The samples are put through a 300 µm mesh screen after collection. To reduce the sample size, the sample was prepared using the cone and quartering procedure.

The sample was applied to a flat surface and dispensed, causing it to assume a conical shape. The conical shape's top was made flat. The cone has four equal segments. The other two quarters were combined after discarding two opposite quarters. The procedure was repeated until the ideal sample size was attained. The sample preparation process for micro structural analysis is illustrated in the below;

Fig.4 SEM sample prepration

A concentrated electron beam is used to scan a sample's top surface in a scanning electron microscope, which creates images of the sample.

A scanning electron microscope (SEM) scans a focused electron beam over a surface to create an image. The interaction between the beam's electrons and the sample results in a variety of signals that can be used to learn more about the surface composition and topography.

This is a useful technique, especially when a microprobe analyzer is installed on the microscope. It uses methods akin to X-ray fluorescence to determine the chemical make-up of hydrates. The microstructure of the hydrated cement paste can be seen thanks to the SEM's increased resolution. To identify and research concrete or mortar. But when understanding, care must be taken. The pictures produced during sample preparation and the vacuum required by the majority of microscopes not available in the wet specifications paste.

One of a scanning electron microscope's major benefits is the variety of applications it may be used for. Another benefit is the detailed three-dimensional and topographical imaging. various detectors With the right training and advancements in computer technology, SEMs are very simple to use. The utilization of technology and related applications facilitates operation.A typical Mix design for M-30 Concrete is tabulated as below:

Table 9 Mix Design proportion of M30 Concrete.

Cement (kg/m^3)	Water Content (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)
365	197	827.01	1022.05

Fig.5 SEM of OPC Concrete & Saw Dust Ash Concrete at Age of 7 Days

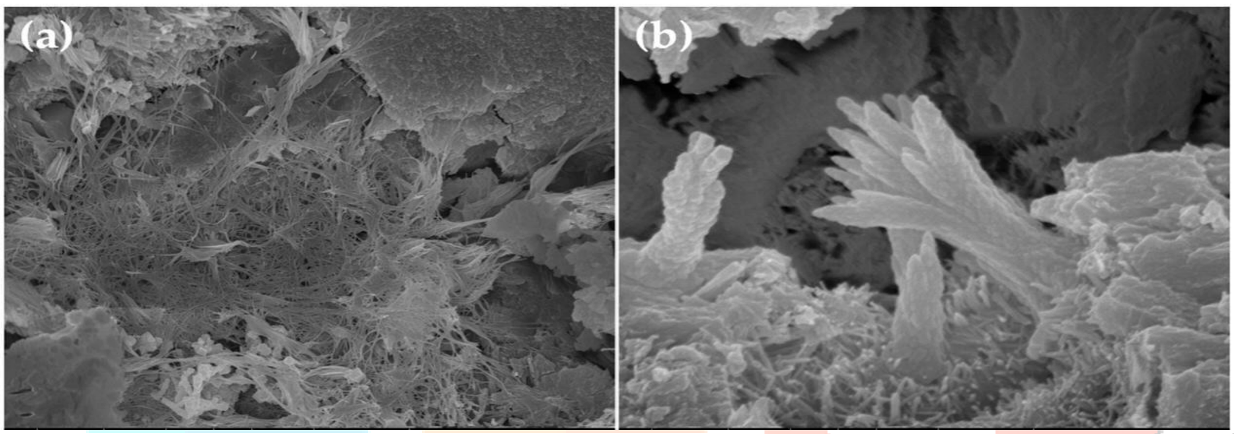
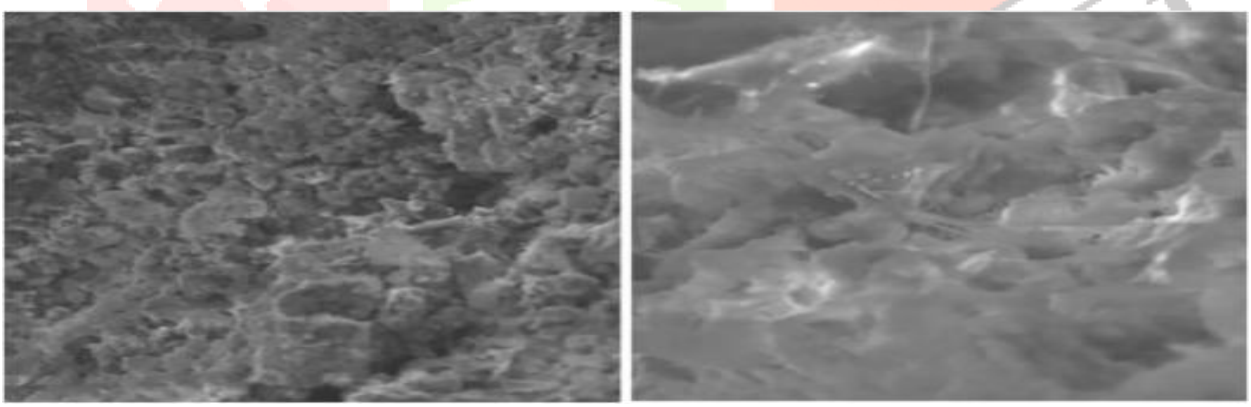


Fig.6 SEM of OPC Concrete & Saw Dust Ash Concrete at Age of 28 Days



CONCLUSION

In this study, sawdust ash (SDA) was partially used in place of some of the cement in concrete, and the effect this had on the concrete's performance was examined. also made an effort to estimate the decrease in carbon emissions that would be brought about by using sawdust ash as a replacement for some of the cement. Based on the findings of this study, it is possible to take the following conclusion:

1. According to the chemical composition of the sawdust ash, used in this experiment had a combined proportion of SiO2, Al2O3, and Fe2O3 of 74.31 percent and thus can be classified as class C pozzolano.
2. According to experimental research, when cement is partially replaced with saw dust ash by 7%, & 14%, The compressive strength is increased by 7.51%, and 2.57% after 28 days respectively. Also when partially replaced cement with saw dust ash by 21%, it decreased up to 11.07%.
3. The split tensile strength show that by the partial replacement of cement with saw dust ash by 7%, & 14%, the split tensile strength increases by 28.11% and 14.34% also when partially replaced cement with saw dust ash by 21%, it decreased up to 32.83% .
4. According to experimental research, when cement is partially replaced with saw dust ash by 7%, the flexural strength increases by 7.62% after 7 days and 5.61% after 28 days. However, when cement is partially replaced with SDA by 14 and 21%, the flexural strength starts to decrease.
5. Based on the data, we suggest replacing cement with Saw Dust Ash at 14 percent for better production of eco friendly concrete.

REFRENCES

[1] Skytt T, Nielsen SN, Jonsson BG (2020) Global warming potential and absolute global temperature change potential from carbon dioxide and methane fuxes as indicators of regional sustainability—a case study of Jämtland, Sweden. Ecol Indic.

[2] Basil AM, Sam-Amobi C, Ugwu CC, Odoh PE (2019) Com-bating global warming/climate change via reduction of CO2 emission of buildings. IOP Conf Ser Mater Sci Eng.

[3] Boden, T. A., Marland, G., and Andres, R. J.: Estimates of Global,Regional, and Naitonal Annual CO2 Emissions from Fossil-FuelBurning, Hydraulic Cement Production, and Gas Flaring: 1950–1992, Carbon Dioxide Information Analysis Center (CDIAC),Oak Ridge National Laboratory, Oak Ridge, Tennessee, Technical Report, Report Number(s): ORNL/CDIAC-90; NDP-030/R6

[4] World Energy Counc. 1995. Efficient Use of Energy Utilizing High Technology: An Assessment of Energy Use in Industry and Buildings. London: World Energy Counc.

[5] Adesina A (2018) Concrete sustainability issues. In: 38th Cement and concrete science conference UK, London, 2018.

[6] Kumar D, Singh S, Kumar N, and Gupta A. Glob. J. Res. Eng., **14,** 33-36 (2014).

[7] Mangi S. A., Norwati J. and Wan I. M.H, Mo-hamad N. and Sohu S., "Utilization of Sawdust Ash as Cement Replacement for the Concrete Production", Engineering Science and Technology International Research Journal, Vol. 1, No. 3, pp. 11–15, 2017.

[8] Malik M. I., Syed R. J., Peer J. A and Syed A. N., Mohammad K.F., "Partial Replacement of Cement by Saw Dust Ash in Concrete A Sustainable Approach", International Journal of Re-search and Development, Vol. 11, No. 2, pp. 48–53, 2015.

[9] Raheem A. A., Olasunkanmi B. S. and Folo-runso C. S., "Saw Dust Ash as Partial Replace-ment for Cement in Concrete", Organization, Technology and Management in Construction an International Journal, Vol. 4, No. 2, pp. 474–480, 2012.

[10] Singh & Sharma, "reverberation of sawdust ash and rice husk ash on mechanical properties of concrete", International Journal of Mechanical and Production Engineering Research and Development, Vol. 10, 10581-10588, 2020

[11] Munir, A., Memon, B., & Oad, M. (2020)"Impact of Cement Replacement by Sawdust Ash on Workability and Compressive Strength of Concrete", Quest Research Journal, Vol. 18, No.1.

[12] Draeger: Guide for selection and use of filtering devices" (PDF). Draeger. Accessed on 12 march 2022. Retrieved on 18 march 2022.

[13] BIS:12269-1987, 'Specification for 53 grade ordinary Portland cement', Bureau of Indian Standards, New Delhi, India.

[14] BIS:516-1970, 'Indian Standard Methods of Test for Strength of concrete', Bureau of Indian Standards, New Delhi, India.

[15] BIS:516-1959, 'Indian Standard Methods of Test for Strength of concrete', Bureau of Indian Standards, New Delhi, India.