ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Volume 11 Issue 10 October 2024

An Organized Analysis of Sawdust Usage in Concrete Mix

[1] Shahnawaz Ahmad Mir, [2] Dr. Hemant S. Chore
[1] [2] Dr B R Ambedkar National Institute of Technology Jalandhar,144027, Punjab, India
Corresponding Author Email: [1] shahnawazam.sc.22@nitj.ac.in

Abstract— ***When it comes to the manufacturing of sawdust, India is among the leading nations, facing test of supervising waste generation from saw mills. ITTO (INTERNATIONAL TROPIC TIMBER ORGANISATION) say's 1.5 million Tons of sawdust is annually burned or discarded, generating environmental concerns. According to AHEC (American Hardwood Export Council), there are around 23000 SAWMILLS in INDIA. On an average SAWMILL'S can develop up to 822.4 tons of SAWDUST per year, therefore annually 18million tons of saw dust is generated in INDIA. One potential solution is utilization of SAWDUST in CONCRETE PRODUCTION, which can help in addressing the increasing requirement for concrete while curtailing CO2 emission. The cement industry is a prime source of environmental pollution since it employs a lot of energy in its manufacturing. It releases CO2, which devotes to global warming and distinguishable pollutions, so a new or novel solution was developed to reduce pollution to some extent, namely the substitution of cement with wood byproducts such as SAW DUST. To substitute this cement with saw dust ash, various tests are carried out on the quality and several strengths of the replacement product, such as compressive, flexural, and split tensile strength. The cement is replaced with sawdust ash in amounts ranging from 0% to 4%, 9%, and 13%. Sawdust ash concrete was discovered to be a more economical and environmentally friendly material than Portland cement concrete.***

I. INTRODUCTION

It is very Low-cost building materials are required. to provide houses for the world's increasing populace. The cost of customary or long established building materials continues to increase as most of the people remain poor or poverty stricken. As a result, there is a requirement to look for native or local materials as alternative for creating functional nonetheless economical or cost effective structures in both rural and urban areas. [OSUNADE JA (2002)]

Uninterrupted waste production from industrial byproducts and agriculture waste causes critical environment difficulties in terms of handling and removal. The construction industry is known to imbibe most of such assets as filler in concrete. fillers contain Isozolanic qualities, provide specific edge to final concrete and allow for greater amounts of cement replacement. Suitable use of these materials has both environmental and economic advantages. [HOSSAIN KMA (2003)]

One byproduct of the lumber business is sawdust. It is created at sawmills when wood is cut into planks. This is a regular company that produces mountains of sawdust at peak hours. The focal point of the research is to turn this waste product into useful secondary outcome.

Inclusion of sawdust in mix is of paramount importance because it can be a sustainable resource/asset; sawdust, a consequence of the timber industry and frequently or routinely seen as wasteful. However, by embodying sawdust as replacement, provides more tenacious substitute typical building materials. It also devotes to better covering because sawdust combinations have great insulating potentiality due to less heat conductivity, making them perfect or great to utilize in roofs, floors, and walls. It also assists to cut construction costs because sawdust composites are often affordable or reasonable than conventional building materials enhancing their appeal option for frugal builders. [CHAWDHURY S, MISHRA M, SUGANYA O (2015)]

When sawdust composite is cast-off in construction in lieu of typical building materials, which can produce or generate toxic dust and chemicals that are detrimental to human health, making it possible to improve employee and building occupant health and safety. All things considered or all things thought, there are many advantages or benefits to using sawdust composite in construction. These include better effectiveness, increased flexibility in design, and enhanced safety, as well as a lasts for long time, affordable, eco-friendly solution for building construction. Since cement is the most expensive ingredient in concrete, substituting cement with ash from sawdust is anticipated to have several benefits, such as less pollution, optimal waste management, and long-term cost savings on building. [OBILADE (2014)]

Figure 1: Creation of Saw Dust

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Volume 11 Issue 10 October 2024

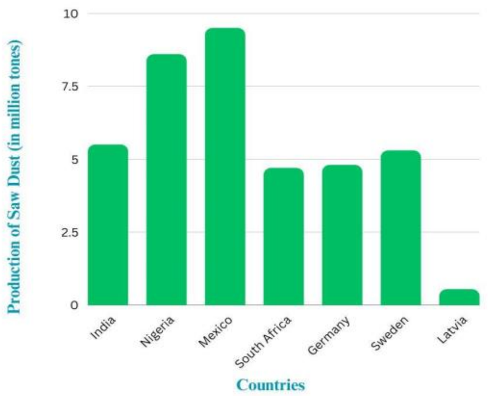

Figure 2: Output of sawdust in the world's leading nations

1.2 Sawdust Mixture Synthesis

Wood dust is a complex material that is produced when wood is processed for a variety of reasons. Its makeup changes remarkable depending on TREE TYPE being treated. The majority of saw dust is cellulose-based composition (about 35–45%). Hence making saw dust one amongst the most economical, sustainable and easily available material in market for construction works. Therefore, sawdust has different components that make it a worthy material to be used as a partial substitute in the concrete mix for better results with better economicity. Following are the components of Sawdust: (IARC, 1995).

Component	Raw Sawdust		Residual Sawdust	
	A	B	A	B
Extractive	4.1	-	13.1	-
Klason Lignin	28.3	-	28.3	-
Holocellulose	82.6	-	65.2	-
Carbon	60.55	65.51	61.92	59.07
Hydrogen	6.32	4.72	4.20	4.19
Oxygen	34.02	28.76	33.86	34.76
Nitrogen	0	0	0.88	0.93

Table I: Components Sawdust, both unprocessed and leftover

Category of SDA Species	SiO_2	Al_2O_3	Fe_2O_3	Cao	Ref.
Pin	8.79	3.35	3.10	47.81	Cheah CB, Ramli M (2011b)
Ork	29.99	4.27	4.25	15.59	Cheah CB, Ramli M (2011b)
Alder-fir	37.55	12.23	8.10	26.46	Cheah CB, Ramli M (2011b)
Calcium rubber	3.37	2.34	2.32	60.4	Cheah CB, Ramli M (2011a)
Rubber	9.18	1.19	1.64	40.21	Tonneaus D, Ribavirin C (2005)

Table II: Chemical Composition of Saw Dust

II. EFFECT OF SAW DUST ON STRENGTH

Various prior researchers have conducted experimental examinations that time and again or routinely showoff or display the optimist effects partially substituting cement/sand with sawdust on the strength properties of concrete. It is of paramount importance to note that various research may find different optimal percentages of SAW DUST replacement for cement that maximize strength increase. The main conclusions from several studies into how SAW DUST affects concrete's strength are summarized here.(OBILADE, I.O et al..,2014) The strength of concrete cubes reduced as the proportion SDA heightened, according to data. However, for each percentage SDA replacement, compressive strengths rose or increased as the number of curing days increased. Table III shows that the compressive strength of the control cube rose from 18.46 N/mm2 at 7 days to 29.36 N/mm2 at 28 days (a 65% increase). Therefore, we get to know that results that we obtained

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Volume 11 Issue 10 October 2024

from the given table show a significant rise in the compressive power of concrete cubes after 28 days. More overly, after 7-D there's also rise in strength up to 65% of the conventional mix, hence inclusion of saw dust in the concrete mixture is proving to be a miraculous invention in the field of concrete industry. Therefore, following TABLE III shows the compressive resistance in contrast with 7,14 and 28 days.

Saw Dust Ash Substitute Percent.	Compressive Force (N/mm^2)		
	7-D	**14-D**	**28-D**
0	17.48	21.62	29.13
5	17.18	17.85	21.00
10	16.61	16.90	20.63
15	14.29	15.87	19.03
20	10.38	11.62	13.52
25	9.30	9.81	12.40
30	6.01	6.61	10.11

Table III: Comparing Concrete Cubes with Different SDA Percentages.

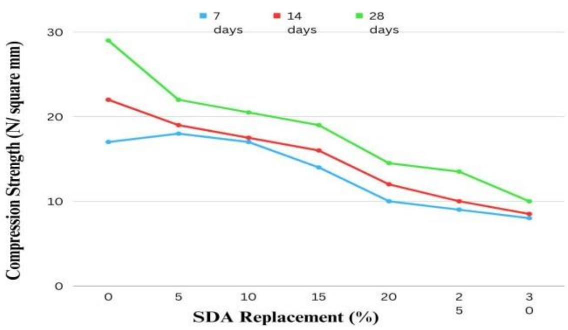

Figure 3: Impact of SDA content at different curing ages on concrete's.

(K. GOPINATH et all...,2015) We introduce two reproductive forms of sawdust in this experiment or observation, which we call Dry wood dust and Saw dust ash. Saw dust ash used to in-part substitute fine aggregate and dry saw dust used to in-part replace cement. Separately, dry saw dust and saw dust ash were amalgamated with mix; this investigation, a total of 16 mortar cubes and 46 concrete cubes were cast-in. And are examined, as the Slump test and the Compressive test, before being contrasted to a standard mix of concrete and mortar. Saw dust is also used for dwelling building members such as columns, beams, slabs, as well as foundations, as well as plastering. According to the study, it is also more affordable economically than traditional cement concrete.

COMPRESSIVE STRENGHT FOR DRY SAW DUST CONCRETE

M-20 – 1:1.5:3 Curing time 7-D

Example mark	Cut-to dust ratio (%)	Compressive resistance (N/mm2)
E2	**0**	**20.28**
F2	**5**	**19.80**
G2	**10**	**17.50**
H2	**15**	**16.34**
Example mark	**Cut-to dust ratio**	**Compressive resistance (N/mm^2)**
I1	0	18.788
J1	9	14.125
K1	28	13.732
L1	49	3.278

M-20 – 1:1.5:3 Curing time 21-D

Example mark	Cut-to dust Ratio	Compressive resistance (N/mm^2)
M2	1	21.150
N2	08	18.215
O2	29	16.558
P2	48	8.630

IFERP connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Volume 11 Issue 10 October 2024

M-20 – 1:1.5:3 Curing time 28-D

Example mark	Cut-to dust Ratio (%)	Compressive resistance (N/mm²)
Q3	0	25.11
R3	9	19.319
S3	30	18.090
T3	50	11.464

COMPRESSIVE STRENGTH FOR SAW DUST ASH CONCRETE

M-20 – 1:1.5:3 Curing time 7-D

Example mark	Cut-to dust ratio (%)	Compressive resistance (N/mm²)
A1	0	18.29
B1	5	17.63
C1	10	14.47
D1	15	15.03

M-20 – 1:1.5:3 Curing time 21-D

Example mark	Cut-to dust ratio (%)	Compressive resistance (N/mm²)
E2	0	20.28
F2	5	19.80
G2	10	17.50
H2	15	16.34

M-20 – 1:1.5:3 Curing time 28-D

Specimen mark	Cut-to dust ratio (%)	Compressive Stress (N/mm²)
U3	0	23.42
V3	5	21.24
W3	10	20.55
X3	15	19.90

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Volume 11 Issue 10 October 2024

GRAPHICAL REPRESENTATIONS FOR COMPRESSIVE STRENGTH

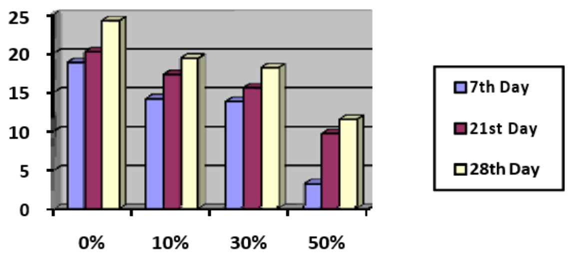

Figure 4: Compressive strength for Dry Sawdust

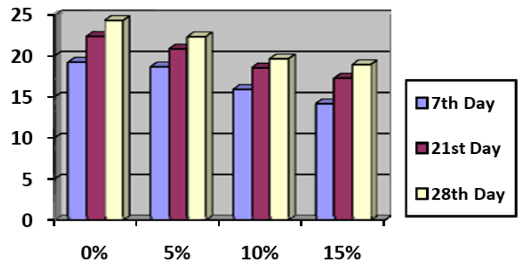

Figure 5: Compressive Strength for Sawdust ash concrete

(M. VIMALA NATHAN et all...,2018) The approach or the way outlined below M 20 is used to conducted research titled " Assessing the strength parameters of substituting sawdust for fine aggregate or attributes of MIX." The ratios used to produce the conventional conventional mix are 1:1.5:3. In subsequently step, sawdust and cubes made of cast cylinders are used to replace 5% of the fine aggregate.

Like this, sawdust is used as substitute of the fine aggregate in amounts up to 15% at 5% intervals. The compressive resistance and split tensile power of each of these cast cubes and cylinders were measured after they were cured for seven and twenty-eight days, therefore consequences were pretty much up to the stage of nominal concrete mix, hence proving that saw dust concrete can match strength characteristics of nominal concrete mix. Therefore, saw dust concrete is proven to be an innovation or revolution in construction field. Hence being economical and most importantly sustainable to the surroundings, which makes it an environmentally friendly material. Using sawdust as a substitute is best because it is environment friendly nature.

Based on experimental, compressive strength results are:

Table 5.1- ZERO % replaced dust in the compressive power of concrete cubes:

DAYS	Variants of cubes	Packaging weight of cubes	Put in Load	Compressive power in N/mm^2	Avg. compressive resistance in N/mm^2
7	A	7.10	493	22.70	22
	B	7.13	505	21.25	
	C	7.15	515	21.60	
28	D	7.11	675	29.25	29
	E	7.15	666	31.38	
	F	7.12	644	27.46	

Median compressive resistance for 7-D =22 N/mm^2.
Medial compressive power for 28-D =29 N/mm^2.

Table 5.1- FIVE % replaced dust in the compressive resistance of concrete cubes:

DAYS	Variants of cubes	Packaging Weight of cube	Put in Load	Compressive power in N/mm^2	Avg. compressive resistance in N/mm^2
7	G	8.98	490	21.79	21.8
	H	8.08	480	21.30	
	I	8.06	500	22.25	

28	J	8.06	630	28.03	27.70
	K	8.015	620	27.59	
	L	8	620	27.55	

Midpoint compressive power for 7-D =21.8 N/mm².
Centre compressive resistance for 28-D =27.70 N/mm².

Table 5.1-TEN % replaced dust in compressive power of concrete cubes:

Days	**Variants of cubes**	**Packaging Weight of cube**	**Put-in load KN**	**Compressive power in N/mm²**	**Avg. compressive resistance in N/mm²**
7	M	7.98	462	20.43	20.9
	N	8	443	19.59	
	O	8.06	505	22.34	
28	P	7.97	580	25.87	26.37
	Q	7.99	591	26.77	
	R	8.05	609	27.97	

Mean compressive power for 7-D =20.9 N/mm².
Medial compressive resistance for 28-D =26.37 N/mm².

Table 5.1- FIFTEEN % replaced dust in compressive resistance of concrete cubes:

Days	**Variants of cubes**	**Packaging Weight of cube**	**Put-in Load**	**Compressive resistance in N/mm²**	**Avg. compressive power in N/mm²**
7	S	7.96	435	19.90	19.1
	T	8.02	423	18.34	
	U	7.65	430	19.44	
28	V	7.86	530	23.35	24.15
	W	8.05	560	24.78	
	X	8	540	24.00	

Middle compressive resistance for 7-D=19.1 N/mm².
Norm compressive power for 28-D=24.15 N/mm².

(A.A. RAHEEM et all.2012) The study looked at sawdust ash's (SDA) physical and chemical characteristics and the workability and compressive power of mix made replacing SDA for 2%, 4%, 6%, 8%, and 10% of the volume of regular Portland cement. Tests for compacting factors, slump, and compressive strength were performed on both fresh and cured concrete. Tests were conducted on the concrete cubes at 3, 7, 28, 56, and 90 days of age. According to the data, SDA has a total SiO_2, Al_2O_3, and Fe_2O_3 percentage of 73.07%, making it appropriate or suitable pozzolan. As the SDA percentage grew, the slump and compacting factor reduced, suggesting that the concrete becomes less workable.

Sample	Mix proportion (kg/m³)					
	Cement	Sawdust ash	Fine aggregate	Coarse aggregate	Water	w/b
Control	21.67	0	42.96	85.92	10.74	0.50
4	19.48	.482	41.82	86.23	9.74	0.51
8	18.33	1.178	41.88	86.52	10.63	0.52

14	17.22	2.230	42.20	87.22	10.74	0.53
18	16.16	3.236	43.15	87.32	11.46	0.63
24	15.31	4.348	43.88	87.52	12.75	0.65

Table IV: Mix proportions

Specific Gravity	Loose bulk Density (kg/m^3)	Loss in ignition (%)	Yield (%)	Moisture Content (%)
2.19	1040	4.30	3.00	0.30

Table V: Physical properties of saw dust ash (SDA)

Percentage SDA replacement (%)	Slump (mm)	Compacting factor
0	110	0.94
5	100	0.94
10	100	0.90
15	95	0.92
20	95	0.91

Table VI: Slump and Compacting factor values of concrete

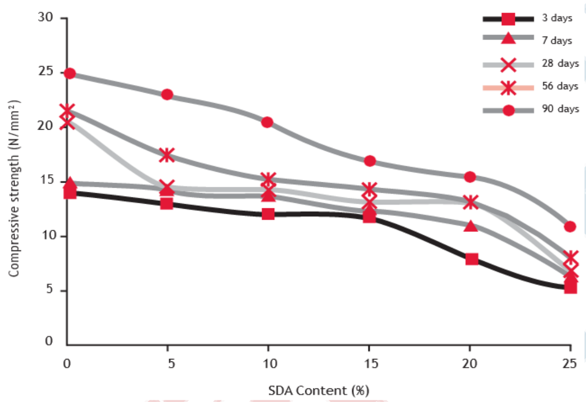

Figure 6: Effect of saw dust ash (SDA) replacement on the compressive resistance of mix

III. EFFECTS OF SAWDUST ON LONG-TERM ASSETS

A BIG body of earlier researchers carried out experimental examinations or investigation that consistently or routinely demonstrate or display the positive effects of partially substituting/ replacing SAW DUST for cement on the longevity qualities of concrete. It is important to understand, nevertheless, that different tests may show different absolute replacement proportions of SAW DUST for cement, which will maximize imperishability improvements. Here, we provide a synopsis of research findings from multiple investigators about the impact of SAW DUST on concrete's endurance.

(DHULL, H. et all.2017) The article states that structure mix with compressive resistance greater than 19 MPa can be made by substituting/replacing saw dust ash for cement in concrete mixes at a ratio of 5% to 15%, or substituting sand with sawdust at a rate of 5% to 17%. Bricks and blocks made from sawdust can have compressive strengths more than 3 MPa when 10% to 30% of the sand used to make them is replaced with sawdust. The excellent sound insulation, high absorption, and low heat transmission of sawdust composites make them appealing as well. According to these results, using sawdust composites more often in building can protect the environment from potential sawdust pollution, save energy, and save disposal expenses. Because saw dust is potentially the perfect material to be used as in for "sustainable waste management."

(SUPRAN CHAKRAVARTY et all.2023) Given that good quality sand sources are being depleted or misused globally, research investigates use of sawdust in place of sand in the creation of M-20 concrete cubes. The compressive strength of replacement is measured and contrasted to conventional mix without replacements. The concentration of partial substitutions is set at 2%, 6%, and 8%. According to the study, sawdust replaces 6% of sand and increases compressive strength by 6.63%. It also lowers costs by 0.47%, 0.79%, and 1.404% for replacements of 3%, 5%, and 7%, respectively. This makes it a durable and cost-effective choice for the manufacturing of masonry. Therefore, the ideal% of SAWDUST is about 5-7% in which we measure a certain amount of gain in the compressive power of masonry.

(SOLOMON AYUBA et all.2014) To improve cement's mechanical and long-lasting qualities, sawdust ash (SDA) was investigated and the results are presented in this work. The SDA that was utilized was produced by carefully burning saw dust. After burning at certain temperature, it is then cooled, passed through a 75μm sieve, examined. SDA's impact on cement paste and masonry were observed for additions of 0, 4, 6, 8, and 10% of cement weight, respectively. Eighty-eight 100 mm cubes of healed mix were tested for compressive resistance at 7, 14, and 28 days after new 1:2:4 concrete mixes with a 0.50 water-to-cement ratio and SDA additives showed signs of slump. Investigations were conducted on concrete specimens exposed to solutions with 2.5% concentrations of hydrochloric and sulfuric acid. The studies' findings demonstrated or displayed that the main components of SDA were calcium oxide (49.44%), potassium oxide (20.23%), and a combined 13.24% of other components. SDA enhanced consistency, shortened initial and final setting periods, and had retarding properties when added to cement.

When SDA was added to concrete, slump decreased but compressive strength increased; 2% SDA was the ideal amount. Additionally, the addition of SDA to concrete improved its flexibility to conditions including hydrochloric and sulfuric acids.

Thus, in normal and acidic settings, up to 2.5% saw dust ash is advised as a retarding additive and strength enhancer. Therefore, according to the studies done two % is the optimum percentage.

(SAMUEL OLUFEMI FOLAGBADE et all.2018) This research looked at the effects of sawdust ash (SDA) on lateraled concrete's captivity and compressive strength. At the stale contents of 15% and 35% as a part-in substitution for sand and SDA contents of 5, 10, 15, and 20% as a part in substitution for Portland cement (PC), compressive power up to 25 days and captivity at 26, 56, and 90 days were obtained. In identical 28-day strengths, 15 different mixes were evaluated at w/c ratios of 0.28, 0.44, and 0.50. When sand was replaced with laterite at a percentage of 0.77% and PC with SDA at a percentage of 1.63%, respectively, at equal w/c ratios, compressive resistance decreased. Contrarily, captivity improved by 0.82-0.90% when sand was replaced and 0.48-1.05% for percentage substitution of PC with SAW DUST ASH.

Contrarily, at comparable strengths, lateraled and SDA-lateraled concretes exhibit greater sorption resistance than standard PC concrete, with up to 40% laterite and SDA concentrations.

(MOHAMMED QASIM AL KARAWI et all.) This study offers a novel or new method for partially substituting plaster of Paris (POP) with recycled sawdust from western sources. To examine the mechanical and physical characteristics of these mortars, six composite mortars were made with sawdust ratios of 0, 2, 4, 6, 8, and 10% by weight of POP. Additionally, the impact of temperature variations ranges (150, 250, 350, 450, and 600 C) the characteristics of these composite mixes were examined. Researchers indicate 10% sawdust was ideal amount to add to the mortar, increasing its compressive strength by roughly 51.47% at 50°C when compared to the reference mix that lacked sawdust. Furthermore, a change in rupture modulus (MOR) for mixes was observed. Percentage increase in MOR was 28.33% at the 6% sawdust content. Sawdust was also observed to reduce the sample densities. Temperature increases to 200 C₠ and above have a harmful effect on the mechanical qualities.

Therefore, ideal amount fended was **10% saw dust** replacement.

IV. CONCLUSION

The use of SAWDUST as an additional material in concrete to partially replace cement has tremendous prospects and holds great promise for the building industry. SAW DUST, which is obtained from rice milling, is easily available and offers an eco-friendly solution to the complication of rice husk waste. By adding SAW DUST to concrete mixtures, we improve the overall performance of the material while also lessening the environmental effect of waste disposal. Therefore, saw dust will reduce the usage of high-cost materials which bring the fact that it is also ecofriendly and economical than standard concrete.

According to the investigations, the ideal variation of SAW DUST substitution for cement varies depending on research, gaping between from 2% to 12%. Within this range, the concrete's strength and longevity often increase. It is of the utter importance to take a note that the part-in substitution ratio may change depending on many other factors involved in making a particular grade of mix. Therefore, if these factors like w/c ratio, curing time, and addition of additives are changed than part-in substitution values are also to be changed.

Embodying SAW DUST into particular mix not only induct eco-friendly techniques in the development business, but enriches overall, the research results point to SAW DUST as having considerable potential for the development or growth of eco-friendly building materials. To optimize the proportion of SAW DUST replacement and investigate its use in various concrete mix designs, more research and testing are required. The construction industry may advance toward more eco-friendly techniques while keeping the necessary strength and durability of concrete structures by continuing to research and improve the usage of SAW DUST eco-friendly building practices. It helps to reduce or lessen environmental pollution and dependency on non-renewable resources by repurposing a waste item. Furthermore, adding RHA into concrete provides economic benefits by giving a low-cost or affordable substitute to regular cement.

REFERENCES

[1] Sundae JA (2002) Impact of adding granite particles to lateritic soils to replace them on later-sized concrete's compressive and tensile strengths. 37:491–49

[2] Olusola K, Adesanya DA (2004) Acceptability by the

public and negative effects of employing local building materials to create homes. J Prop Res Construct 1:83–98

[3] Ayan Gade JA, Olusola KO, Iko IJ, Ata O (2004) Henleaze floor finish's performance attributes are affected by granite dust. Build Environ 39:1207–1212

[4] Olopade KA (2013) Economy of RHA in concrete for low-cost housing delivery. J Civil Eng Architect 7(11):1464–1470

[5] Malik MI, Jan SR, Peer JA, Nazir SA, Mohammad KF (2015). A sustainable approach to partially replacing cement in concrete is to use sawdust ash. Int J Eng Res Dev 11(2):48–53

[6] Antiochus S, Masanari K, Times S (2005) Assessment of high- and low-calcium fly ash blends for usage as additional cementing ingredients. Cem Concrete Comp 2:349–356

[7] Mwango A, Kambole C (2019) Sawdust Composites' engineering properties and possible rise in use in construction —A Review. J Build Constar Plan Res 7:59–88

[8] Coutinho JS (2003) The benefits of RHA in improving the durability of concrete structures. Cem Concrete Comp 25:51–59

[9] Ramos T, Matos AM, Sousa-Coutinho J (2013) Wood waste ash mortar: mechanical strength, resistance to carbonation, and expansion of ASR. Constar Build Mater 49:343–351

[10] Hossain KMA (2003) mix of cement with volcanic ash and pumice. Cem Concrete Res 33:1601–1605

[11] Chowdhury S, Mishra M, Suganya O (2015) Using wood waste ash in place of some of the cement when creating construction grade concrete: an overview. Ain Shams Eng J 6(2):429–437

[12] Brockovich S, Howe J, Bowyer J, Pepke E, Frank M, Fernholz K (2014) Wood waste creation and recovery in the United States from municipal solid waste (MSW) and construction and demolition (C&D). Dovetail Partn Minheap 1:1–16

[13] Röder M, Thornley P (2018) Waste wood as bioenergy feed: climate change impacts and related emission uncertain- ties from saw dust-based energy systems in the UK. Waste Manag 74:241–252

[14] Brown M, Kearley V (2009) Wood waste's function as a source of biomass fuel in the UK. Energy Mater 4:162–165

[15] Cheah CB, Ramli M (2013) The high-performance concrete's engineering characteristics with the HCWADSF supplemental binder. Constar Build Mater 40:93–103

[16] Obi lade IO (2014) Inclusion saw dust ash as partial substitute for cement in concrete. Int J Eng Sci Invent 3(8):36–40

[17] Kashyap R, Chaudhary M, Sen A (2015) Impact of part-in substitution of cement by saw dust ash in concrete. Int J Sci Res 4(5):1572–1574

[18] Ganesha K, Rajagopal K, Thangavel K, Selvaraj R, Saraswathi V (2004) Rice husk ash - A versatile supplementary cement- pious material. Indian Concur Inst J 78(11):29–34

[19] Kumar D, Singh S, Kumar N, Gupta A (2014) less-cost construction material for concrete as Saw dust. Global J Res Eng 14:33–36

[20] Tilak LN, Kumar S, Manvendra MB, S. and, Niranjan (2018) Inclusion of saw Dust as fine aggregate in concrete mix. Int Res J Eng Technol (IRJET) 5:1249–1253

[21] Gopinath K, Anuratha K, Hari Sundar R, Saravanan M (2015) inclusion of saw dust in cement mortar & cement concrete. Int J Sci Eng Res 6(8):665–682

[22] Ogundipe O, Jimoh Y (2012) resistance-based appropriateness of sawdust concrete for rigid pavement. Adv Mater Res 367:13–18

[23] Adu S, Ado G, Frimpong-Mensah K, Antwi-Bosanko C, Effat B, Adjei S (2014) Reducing the rate of production and maximizing the use of wood residue to combat climate change. Int J Plant Forestry Sci.

[24] Augustine U. Elinwa and Ahmed M. Mamuda, SAW dust ash as a powder material for self-compacting concrete. Hindawi Publishing Corporation.

[25] Okere OB, Facile BS, Sonicare JA, Eliminate FB, Adesina OA (2017) Particulate matter pollution in the Southwest caused by sawdust burned outdoors. Cogent Environ Sci. https://doi.org/10.1080/23311843.2017.1367112

[26] Schmidt GBS (2014): Case Study about Zimba Bian Timber Sector. 8th International Quality Con- refence, Kragujevac, 23 May 2014, 37–49

[27] Claudiu A (2014) Utilizing sawdust in plaster mortar formulation. Pro-Environ Premedia 7:30–34

[28] Mama PA, Ezeh EC, Gimba E, Arthur DE (2014) Phenol Formaldehyde and Urea Formaldehyde Par-tileboards from Wood Waste: A Comparative Study for a Sustainable Environment. Int J Sci Technol Res 3:53–61

[29] Murkowski E (2017) How to Minimize Environmental Degradation in Wood Construction? European Forest Institute, Joensuu