Advances and Applications in Mathematical Sciences
Volume 21, Issue 9, July 2022, Pages 5209-5221

EXPERIMENTAL ANALYSIS ON THE USE OF PLANT FIBER AS A SUSTAINABLE REPLACEMENT FOR FINE AGGREGATE AND CEMENT IN CONCRETE

FARHAN KHAN[1], PRATIKSHA MISHRA, RAJSHRI BHAINSARE, RUPAL TRIPATHI and SAKSHI NAHTA

Assistant Professor
Department of Civil Engineering
Rungta College of Engineering and Technology
Bhilai (490024), India
E-mail: Farhan1@rungta.ac.in

UG Students
Department of Civil Engineering
Rungta College of Engineering and Technology
Bhilai (490024), India

Abstract

Concrete is prime construction materials, as it provides strength, durability and stability to structure but due to urban sprawl construction materials demand is increasing day by day. Hence replacing conventional concrete material with different cheap materials is a future need. Cow dung is easily available in rural areas which can be used as construction material by partial replacing of sand and cement. This material in construction can be a source of income for rural community. It can be used as low-cost building material. From the above study we determined the effect of dry cow dung powder by partially replacing cement and fine aggregate individually by 2% of their weight. Here we have use M20 grade concrete made by Portland pozzolana cement, fine aggregate passing through 4.75mm IS sieve, coarse aggregate passing through 20mm IS sieve and retain on 10mm IS sieve, portable water and dry cow dung powder. The compression test is done for 7 days and 28 days. This concrete cube is then compared with conventional plain concrete cube to determine the strength of concrete block with dry cow dung powder.

2020 Mathematics Subject Classification: 65.

Keywords: Dry cow dung powder, compressive strength, Microbial deterioration, SEM, XRD, PPC, Partial replacement.

Received January 5, 2022; Accepted May 23, 2022

1. Introduction

Concrete. Concrete is the most common and useful composite material on the earth. It consists of cement, sand, aggregate, water and other ingredients. Likewise in cement (such as OPC or PPC) there are different brands available in the market and their strength varies very little with their brand [1]. Concrete is the main material, as it provides substance, grit and strength to the structure. Concrete is a building material which can be cast in any shape and size and it is durable enough that requires very less maintenance [2]. Hence replacement of conventional material with low cost and sustainable material is a future need. Cow excreta is surely available in country side and by using this material economic growth of poor section can be promoted and it may be a sustainable occupation for country. Cow dung can be a cheap building material if used in construction. Replacement of cow dung ash in concrete increase the workability, initial and final setting time as we increase its percentage [3]. But up to certain optimum percentage replacement i.e., 10% by weight of cement can increase the strength after that the decrease in concrete strength is observed [4, 5, 6]. In India according to 19th Livestock Census, cattle are 37.28%, buffaloes 21.23%, sheep12.71% and goats are 26.40% [7]. In the current scenario the limitless amount of cow dung is generated. It is a good natural polymer which has potential to be used in different industries [8]. It is our responsibility to find sustainable sources to reduce consumption of conventional building materials as they are not too cheap and their production may pollute the environment [9]. Putting all this visible in this place study we drove the effect of dry intimidate excrement powder by partially replacing cement and fine aggregate separately by 2% of their pressure. Here we use M20 grade hardened fashioned by Portland pozzolana cement, fine aggregate pass through 4.75mm IS sieve, rude aggregate pass through 20mm IS strainer and maintain on 10mm IS strainer, portable water and dry browbeat excrement powder.

Fibre. Fibre is a piece of material which is thin, long and flexible, like a length of thread. It is a material which is used as reinforcement to provide strength in concrete. Fibre helps to reduce tension crack [10]. Generally, short fibres produced from steel, glass and organic polymers are used to enhance the cracking resistance properties of fiber reinforced concrete.

PLANT FIBRE (Dry cow dung)-Plant fibre are those fibres which are obtained from plants. As cows are herbivores their excreta contain few amounts of undigested plant residue [11]. Hence, we have used dried cow dung powder as plant fibre which is obtained from cow excreta. Cow excreta contains 3% nitrogen, 2% phosphorus, 1% potassium (3-2-1 NPK) and other organic materials. Some kinds of plant fibre are seed fibres, bast fibres and hard fibres. Few examples are jute, sugarcane, bamboo, Sal, linum. Due to its chemical composition, it is also used for household cleaning purposes [12]. This cow dung fibre is also used in paper making industry instead of wood [8]. As we studied in recent publications that suggests that dung may improve workability and durability in the construction industry or may act as an additional binder. It is seen that cow dung with clay can be used as a good alternative and low-cost non-structural element like plastering [13]. It is confirmed that cow dung fibre increases the coefficient of friction and wearing resistance [14]. So, we can use cow dung powder as a partial replacement, which is air dried. It can also reduce the cost of construction. So, we can replace 2% of cement and sand by cow dung powder [7].

The main objective of our research work is to study the effect of dry cow dung powder when it is added with concrete and the difference in physical strength is compared with standard concrete blocks. The difference in physical appearance in standard concrete cube and concrete with dry cow dung powder is present in it.

2. Materials and Methodology

1. Materials.

Cement. Cement is the 2nd largest construction material on the earth. It consists of calcium, silicon, aluminium, iron and other ingredients. It possesses binding properties which bind fine and coarse aggregate to form concrete [15] Basically, it is a powder of clinker which is grey in colour and very fine and smooth in texture. Cement is a binding material which is used to bind all types of inert compound like sand, aggregate and make a perfect concrete mass. Cement used in this research work is Portland pozzolana cement (fly ash based) which satisfies Indian standard specification IS 1489-1. Cement brought in a sealed bag, 1 bag of cement contains 50 kg.

Fine aggregate. Fine aggregate is granular inert material which is used to fill voids between coarse aggregate and provide strength. In this work sand passing form 4.75mm IS sieve is used which is free from any type of dirt and deleterious substance.

Coarse aggregate. Coarse aggregate provides actual bulk to the concrete mass. Different types of aggregate give different properties to concrete [16]. Good quality crushed stone is used as coarse aggregate in this work. Which is hard, tough, free from any type of dirt, dust, clay and other organic matter. The size of coarse aggregate in this work varies from 20mm to 10mm.

Water. Water is used to initiate the binding process in cement. The quality of concrete depends upon the quality of water used [17]. In this work the quantity of water is estimated as per mix design IS 456:2000 and IS 10262:2009. Drinkable water is used at room temperature for mixing.

Dry cowdung powder. Cow dung is basically cow excreta which consist of high amounts of nitrogen, phosphorus and potassium. It is composed of cellulose, hemicellulose, lignin due to which it is also called as plant fibre. The wet cow dung can erode steel or concrete structure very badly due to high concentration of the above chemical. Hence in this work cow dung is dried for 1 to 2 weeks. After that with the help of stone or metal hammer cow dung is crushed in particle size less than 4.75mm IS sieve. Dry cow dung powder is free from any type of impurity. Empty nylon sack is used to store dry cow dung powder. Precaution is made during collection of cow dung to prevent any contamination like clay, silt, grass, straw etc.

2. Mix Design.

Any work starts with preparation of materials and quality check. For selection of good quality of material (sand, cement, aggregate) fineness modulus, grade, type is to be considered. Then mix design is done to know the quantity of materials required.

Mix design as per IS 10262:2009

Here we use to make M20 grade concrete. We use PPC

As we know-

Max. nominal size of aggregate-20mm

Minimum cement content-250 kg/m^3

Maximum water content ratio-0.50

Now,

Target strength for mix proportion

fck ' = fck + 1.65s

Where,

fck' = target compressive strength at 28 days

fck= characteristic compressive strength at 28 days

s= standard deviation from IS 10262:2009 for M20 s=4

Hence, fck' =20+1.65×4

=26.6N/mm^2

Selection of mix proportion

From table 5 of IS 456:2000 max water cement ratio 0.50

Based on experience, adopt water cement ratio 0.45

0.45<0.50

Selection of water content

As per IS 10262:2009 max water content for 20mm aggregate 186lit

Estimated water content for 100 mm slump= 186+6/100186

=197.16 or 197 litres approx.

Calculation of cement content,

As we know here w/c ratio=0.45

Therefore,

Cement content = 197/0.45

= 438 kg/m^3

as 250<438 [hence ok]

Preparation of volume of coarse aggregate and fine aggregate content

As grade of aggregate is III

From IS code

Water cement ratio of 0.50=0.64

But water cement ratio is 0.45 there for volume of coarse aggregate is required to be increased to decreases the fine aggregate content as water cement ratio is lowered by 0.05 the proportion of volume of coarse aggregate is increase by 0.01

-0.05=+0.01

there for volume of coarse aggregate =0.65 1=0.65

Volume of fine aggregate =1-0.65=0.35

Now mix calculation,

Volume of concrete = 1 m^3

Volume of cement = mass of cement/100specific gravity of cement

= 438/3.151000

= 0.139 m^3

Volume of water = mass of water/1000sp. gravity

=197/11000

= 0.197 m^3

Volume of all in aggregate = (1-(0.139+0.197))

=0.664 m^3

Mass of coarse aggregate = 0.664 volume of coarse aggregate specific gravity of course aggregate1000

= 0.6640.652.741000

= 1182.58 kg

Mass of fine aggregate=0.664volume of fine aggregate specific gravity of fine aggregate1000

= 0.664 0.352.741000

= 636.776 kg

Mix proportion,

Cement = 438kg/m^3

Water =197 lit/m^3

Fine aggregate = 636.776kg/m^3

Coarse aggregate = 1182.58kg/m^3

Now we have prepared 12 cubes of concrete

Volume of concrete for 12 cubes = 0.0405 m3

Therefore,

Cement require = 0.0405 438 =17.739 kg

Sand require = 0.0405 636.776 = 25.78 kg

Coarse aggregate requires = 0.0405 1182.58 = 47.89 kg

Water require=0.0405×197=7.97 litres

3. Sample preparation.

The concrete block of 15 cm×15 cm×15cm is prepared by replacing 2% of sand with dry cow dung powder and 2% of cement by dry cow dung powder individually. After 24 hours in mould cubes are demoulded and cured for 7 days and 28 days respectively. After respective days of curing the sample is tested in a universal testing machine.

4. X-ray Diffraction Test:-

X-ray diffraction test is generally performed to study structure of crystalline material. It shows the crystalline structure of material by X-ray diffraction in some different angles. It is also used to differentiate between amorphous and crystalline materials. It shows the periodic atomic arrangement of any substance [18]. In our research we use a pinch of crushed sample of partially replaced concrete for testing purpose. This test is rapid as well as it can be non-destructive in nature [19].

5. Scanning electron microscope.

Scanning electron microscope abbreviated as SEM, is a technique which gives the image of a sample by backscatter of an electron beam. It shows a three-dimensional image [20]. Which have magnification up to 20 to 200µm. As our concrete block does not gain sufficient strength. Therefore, we conducted a SEM over our partially replaced concrete block.

3. Result

Property of cement (PPC)

Fineness of cement - 2gm for PPC (shouldn't be greater than 5 gm).

Soundness value - 6.76mm

Property of fine aggregate. Less than 4.75mm in size.

Specific gravity - 2.58

Fineness modulus - Grade-3

Water absorption - 0.46

Property of coarse aggregate- min. size (18mm) - max. size (25mm)

Specific gravity- 2.66

Water absorption - 0.42

Impact value - 9.572%

Crushing value - 8.026%

The size was taken between 10-20mm because if the size reduces from 10mm there will be crushing and if the size is more than 20mm there will be more voids as there will be difficulty in setting the aggregate.

Compressive strength test

A detailed result presentation of the research work after the laboratory test. When curing is done for 7 and 28 days respectively.

The strength of standard concrete cube came out to be 20.28N/mm^2 and 27.16 N/mm^2 which is enlisted in table-1. When cow dung is added for the replacement of cement, due to microbiological activities the generation of

voids and decrease in compressive strength is observed and by replacing sand with dry cow dung powder the amount of silica is decreased and concrete strength is also decreased. As silica provides strength and durability, the concrete cube with replacement of sand has the least compressive strength.

Figure 1. Formation of white bubble and root like structure.

Table-1. Compressive strength.

Concrete Specimen (Cowdung powder)	7 days	28 days
2%fine replaced	9.036 N/mm2	10.96 N/ mm2
2%cement replaced	10.51 N/ mm2	17.03 N/ mm2
Standard Cube	20.28N/ mm2	27.16 N/ mm2

X- Ray Diffraction (XRD).

X-axis- 2 Theta

Y-axis- Intensity (points).

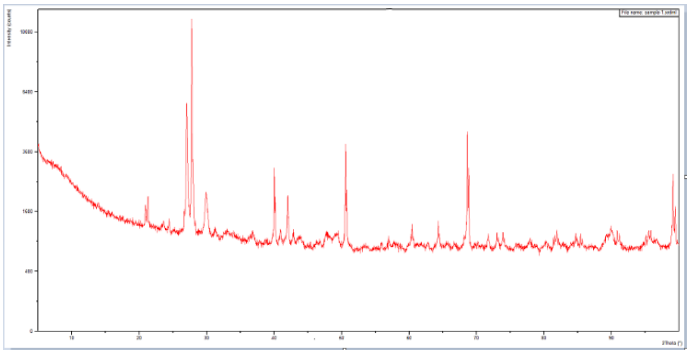

Figure 2. XRD.

Scanning Electron Microscope (SEM).

From figure 2 and 3 we can see the microscopic view of the cow dung concrete. And table-2 enlists the composition of chemicals present in it. We have observed that the amount of potassium is high, about 53.06% weight and 70.12% atomic.

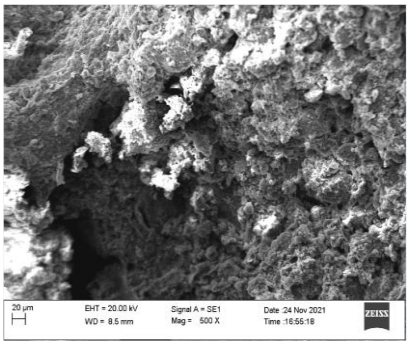

Figure 3. SEM of cow dung concrete.

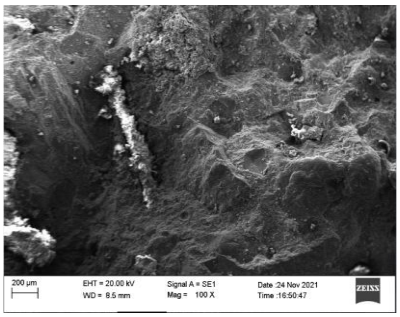

Figure 4. SEM of cow dung concrete.

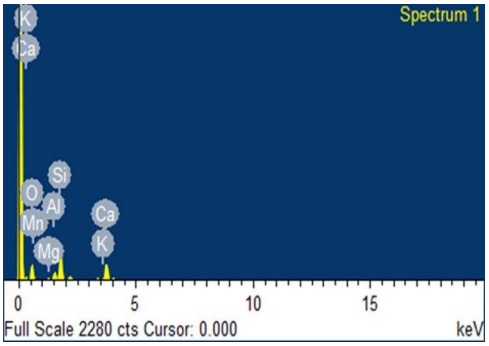

Figure 5. Analysis of element using SEM.

Table 2. Chemicals and its composition.

Element	Weight (%)	Atomic (%)
O K	53.06	70.12
Mg K	1.02	0.89
Al K	4.68	3.66
Si K	18.46	13.90
K K	2.32	1.25
Ca K	16.68	8.80
Mn K	0.15	0.06
Fe K	2.23	0.84
Co K	0.63	0.23
Cu K	0.77	0.26
Total	100	

4. Conclusion

As our main objective was to investigate the effect of dry cow dung powder with concrete when we partially replace it with cement and fine aggregate individually, we have seen that it ultimately reduces the strength of the concrete when cement is replaced and the strength reduces further more in the case of sand as it provides strength. The cow dung is organic matter and any type of organic matter like plant debris; if present in concrete it reduces its strength. Due to the presence of cow dung, the physical

appearance of concrete blocks also changed. During 7 days of curing, we saw the presence of small white bubbles and few voids but after 28 days of curing we saw the whole concrete cube was covered with a thin white layer of bubbles and a lot more voids we from the above graph we can see the increase concluded that during the curing period the water has activated the microorganism which was already present in the cow dung Powder. We saw how the presence of cow dung powder has Table-2 Chemicals and its composition deteriorated our concrete blocks. We also noticed certain of alkaline materials i.e., potassium and calcium, microbiological activities like the presence of many small which cause an increase in the setting time voids where there was cow dung powder, bubble like of concrete. It also reduces the compressive formation in many parts of the cube due to these various strength due to which the concrete block reasons we have seen that our cow dung concrete cube failed fails beforehand. [21] as compared to standard concrete cube. The compressive with cow dung is less than standard concrete cube. The presence of potassium in high amount also decreases the strength of concrete. So, from the above results, we found out that even 2% replacement of cement and sand by weight can cause so much damage to concrete cube, so we cannot use the cow dung powder as a partial replacement cement and fine aggregate.

References

[1] M. C. Arimanwa, D. O. Onwuka and J. I. Arimanwa, Effect of chemical composition of ordinary portland cement on the compressive strength of concrete, International Refereed Journal of Engineering and Science (IRJES) 5(3) (March 2016), 20-31.

[2] S. Ayeni, S. Adekanmi and A. Olumuyiwa, Performance of cow dung powder on compressive strength of blended concrete (2018), 24-30.

[3] O. Y. Ojedokun, A. A. Adeniran, S. B. Raheem and S. J. Aderinto, Cow dung ash (CDA) as partial replacement of cementing material in the production of concrete - (Polytechnic, Ibadan, OYO state, Nigeria) 4(24) (2014), 3445-3454.

[4] K. Vasu, Experimental investigation on partial replacement of cement with cow dung ash, IJARIIE 5(3) (2019).

[5] V. S. R. Pavan Kumar, Rayaprolu and P. Polu Raju, Incorporation of Cow dung Ash to Mortar and Concrete, International Journal of Engineering Research and Applications (IJERA) 2(3) (2012), 580-585.

[6] J. Dhaka and S. Roy, Utilization of fly ash and cow dung as partial replacement of cement in concrete, International Journal of Civil and Structural Engineering 6(1) (2015), ISSN- 0976-4399.

[7] Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers' Welfare, 19th Livestock Census-2012: Livestock Censuses; New Delhi, India, 2012.

[8] Vinayak Fasake and Kavya Dashora, A sustainable potential source of ruminant animal waste material (dung fibre) for various industrial applications: A review, Bioresource Technology Reports 15 (2021), 100693.

[9] J. C. More, J. E. Aubert, Y. Millogo, E. Hamard and A. Fabbri, Some observations about the paper Earth construction: Lessons from the past for future eco-efficient construction by F. Pacheco-Torgal and S. Jalali. Constr Build Mater 44 (2013), 419-421.

[10] A. B. Ngowi, Improving the traditional earth construction: a case study of Botswana, Constr Build Mater 11 (1997), 1-7.

[11] P. Magudeaswaran and A. S. Hilal, Development of Eco Brick and Concrete with the partial replacement of cow dung, International Journal of Science and Engineering Research (IJ0SER) 6(5) May 2018.

[12] A. Anbuchezhian and S. Sathish Kumar, An experimental study of partial replacement of cow dung powder for cement.

[13] Leopold Mbereyaho, Dieudonné Irafasha, Etienne Habumugisha and Julius Musabirema, Assessment of cohesive soil - cow dung mortar properties as replacement of cement mortar for simple plastering works, Rwanda Journal of Engineering, Science, Technology and Environment 3(2) 2020.

[14] Yunhai Ma, Siyang Wu, Jian Zhuang, Ji Tong and Hongyan Qi, Tribological and physio-mechanical characterization of cow dung fibres reinforced friction composites: An effective utilization of cow dung waste, Tribology International 131 March (2019), 200-211.

[15] S. K. Duggal, Building materials third revised edition (New Age International (P) Ltd Publishers, Ansari Road, Daryaganj, New Delhi, 2008).

[16] M. Abdullahi, Effect of aggregate type on compressive strength of concrete, (2013).

[17] Gholamreza Asadollahfardi, Mohammad Delnavaz, Vahid Rashnoiee, Alireza Fazeli and Navid Gonabadi, Dataset of producing and curing concrete using domestic treated wastewater, Data in Brief 6 (2016), 316-325.

[18] Andrei A. Bunaciu, Elena gabriel Udriştioiu and Hassan Y. Aboul-Enein, X-Ray Diffraction: instrumentation and applications, Critical Reviews in Analytical Chemistry, 45(4) 2015.

[19] H. A. Foner and N. Adan, The characterization of papers by X-Ray diffraction (XRD): measurement of cellulose crystallinity and determination of mineral composition, Journal of the Forensic Science Society 23(4) (1983), 313-321.

[20] Ladan Rashidi, 1-Magnetic nanoparticles: synthesis and characterization, in Magnetic Nanoparticle-Based Hybrid Materials (2021), 3-32.

[21] Mohammed M. Selman and Asmaa M. Ali, The effect of alkalis on the properties of portland cement, Anbar Journal for Engineering Sciences (2012), 25-38.