iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: XI Month of publication: November 2024

DOI: https://doi.org/10.22214/ijraset.2024.65421

Study on the Mechanical Properties of Concrete by Using Paper Sludge Ash and Granite Powder with Glass Fiber

Arun Singh Pawar[1], Sourabh Lalotra[2]
[1]PG Scholar, Sri Sai College of Engineering and Technology, Pathankot, India
[2]Assistant Professor, Sri Sai College of Engineering and Technology, Pathankot, India

Abstract: Portland concrete cement is made by mixing aggregate, water, and dry cement to create a mass-forming fluid that can be readily molded into the desired shape. In order to create a strong matrix that binds the components together to create a durable stone with multiple uses, cement chemically reacts with water. The paper industry produces Paper Sludge Ash (PSA) as a byproduct. It is produced during the paper manufacture or recycling process. Paper sludge ash (PSA) is the ash that is left over after the sludge is usually dried and burned. The igneous rock that makes up granite is mostly made of quartz, alkali feldspar, and plagioclase. It creates silica-and alkali metal oxide-rich lava that gradually solidifies underground. Crack width and inter-crack spacing are decreased by glass fibers. We compare the strength characteristics of concrete made using replacement and ordinary concrete based on earlier studies. PSA and fine aggregates with granite powder and glass fiber are used in place of cement. The material's strength is tested on several specimens. The outcome demonstrates that, after substituting PSA for cement and granite powder for fine aggregates along with glass fiber, concrete workability is acceptable and within acceptable bounds. However, as more materials are used, workability decreases. Strength metrics including split tensile strength, flexural strength, and compressive strength all rise and reach their peak values when cement is replaced with 8.5% paper sludge ash and 16% granite powder is replaced with sand and addition 1.5% glass fiber, respectively.
Keywords: PSA (PAPER SLUDGE ASH), GP (GRANITE POWDER), GF (Glass fiber) workability, compressive strength, Split Tensile strength, Flexural strength

I. INTRODUCTION

Generally speaking, concrete can be categorized as normal strength, high strength, ultra-high strength, etc. According to Indian standards, a suggested mix design method indicates the 35 MPa separation between normal strength and high strength concrete. Around two tones are consumed annually worldwide. It serves as the foundation for all nations' development initiatives. This attribute could undergo a variety of revolutions.

The main changes include the addition of various mineral admixtures, improved solidity, and greater strength. The properties of the components, the mix percentage, the compaction technique, and other parameters during placement, compaction, and curing all affect a concrete's strength, durability, and other qualities. Careful control of the fundamentals and process is essential to creating high performance concrete, which is robust, long-lasting, and consistent. Cement, aggregate, water, chemical admixtures, and additional cementing ingredients are examples of components.

A. Paper Sludge Ash

Paper Sludge Ash (PSA) is a by-product of the paper manufacturing industry. It's created during the process of paper recycling or paper production, where significant quantities of waste materials, like water, fibers, and inorganic fillers, are generated. These waste materials are often referred to as paper sludge. The sludge is typically dried and can be incinerated, leaving behind ash, which is known as paper sludge ash (PSA).

The main components of this ash include calcium carbonate, silica, and clay, which originate from the raw materials used in papermaking. In paper production, raw materials like wood, recycled paper, or other fibers are processed into pulp. This pulp undergoes several stages, including cleaning, bleaching, and forming into paper.During these stages, water and fiber-rich sludge is produced.

B. Granite Powder

Using granite powder as a partial replacement for fine aggregates (sand) in concrete has been researched extensively as a sustainable practice. Granite powder is a by-product of granite quarrying and processing, which is often discarded. Incorporating this waste material into concrete helps reduce the environmental impact and improves certain properties of the concrete. Granite powder can enhance the compressive strength of concrete. The finely ground granite particles fill voids in the concrete mix, contributing to a denser and more compact concrete structure. This increased density helps improve the overall strength, particularly when the powder is used in optimal proportions. Research has shown that replacing a portion of fine aggregates with granite powder can reduce shrinkage and creep in concrete.

C. Glass Fiber

Glass fiber-reinforced concrete premix is a mixture of AR glass fiber, sand, cement, water, chemical and mineral admixtures, and aggregate. These fibers reduce crack width and spacing between cracks. They are very high temperature resistant as they absorb high energy thereby providing the property of ductility. Their light weight property makes them very popular for concrete mix. They have found varied use in industry today. They are used as sound reducers when used in thickness of 10 mm and surface mass of 20 kg/m2. They are used for repair material for historical buildings and also for extension of old buildings. Any shape product can be formed with good binding strength due to their excellent design flexibility. They are used in sewer relining, earth retaining walls, architectural product as building facades, claddings, cable troughs and noise protection barrier.

II. LITERATURE REVIEW

Sujata D. Ingale Pravin D. Nemade 2023 The engineering characteristics of PSA as a cementitious material were examined in a study, with particular attention paid to how PSA influences the engineering specifications of cement concrete. Several evaluated research have reported on the viability of using PSA in partial substitution of cement due of its better tensile and flexural strength. The review of the literature indicates that PSA can replace 5–10% of the weight of cement; replacing 15%–20% of the cement with PSA results in a reduction in the concrete's compressive strength. According to the study report, the PSA has a coarser size and has less surface area fluctuation when it is younger. PSA has a high water absorption capacity because of its fineness. Furthermore, it has been noted that the chemical characteristics are diminished as a result of the calcination process. As a result, the calcination is carried out between 700 and 850 degrees Celsius, which has no negative effects on the chemical characteristics of paper sludge ash.

Vikas Mehta et. al. 2020 Waste paper sludge ash (WPSA) was obtained by an uncontrolled combustion process and utilized as an additive to regular portland cement of grades M43 and M53 in concrete. The addition of waste paper sludge ash to concrete increased its compressive strength and split tensile strength. For the study in question, four distinct replacement levels—5, 10, 15, and 20%—with corresponding replacement methods and a wide variety of curing times—from seven to twenty-eight days—were used. Different numbers of six cubes (150 × 150 × 150 mm) and cylinders (150ç × 300 mm) with different WPSA ratios were cast. The test findings showed that a 5% replacement of WPSA increased the compressive strength and split tensile strength by up to 20%. Utilizing used paper sludge ash in concrete shown economical.

Y. Divakar et. al. 2012 The pores in the concrete are filled with granite fines, which increases its strength and allows for the efficient use of a material that is readily available but has disposal issues. In this study, an experimental investigation into the strength behavior of concrete with granite fines added is attempted. Granite fines are added to concrete in five different proportions—5%, 15%, 25%, 35%, and 50%—in place of fine aggregate.

A variety of tests are conducted, including compressive strength, split tensile strength, and flexural strength, and the results are compared to those of conventional concrete that does not contain granite fines.

Amit Kumar and Sheo Kumar (2021) presented the Strengthening of M30 grade of Concrete using Glass Fibre Reinforcement. The engineering strength properties of hardened concrete such as compressive strength, flexural strength and split tensile strength can be improved by adding admixtures. These properties can improved by proper grading by weight and proper curing. The demand for glass fibre is increasing in the Indian market due to high construction activities and also because fibre glass offers versatile shape and design. It is an affordable and cost-effective material when compared to other reinforcement materials. A series of compressive strength, flexural strength and split tensile strength test are conducted with varying percentage of glass fibre (0%, 0.4%, 0.8%, 1.2% and 1.6%).

S.Hemalatha et al. (2016) A study experiment was conducted using the 12-mm-long Cem-FIL fiber, which is resistant to alkali. Concrete was supplemented with fiber in increments of 0.33% and up to 2%. In this experiment, 1% of the cement's weight is made up of ConPlast additive (Super Plasticizer). M40 grade concrete is used in this project. The concrete's compressive strength rises until 1% glass fiber is introduced, at which point it steadily decreases. By 48.88 MPa, the concrete's compressive strength surpassed the desired mean strength by 1.22 times. A 1% glass content increases the flexural strength of M40 grade concrete to 6.86 MPa and the tensile strength to 7.96 MPa.

III. MATERIALS

A. Cement

Ordinary Portland Cement grade 43 was utilized as the binding material for this study. The cement utilized was Khyber Cement, which is produced at its facilities in Jammu and Kashmir by Khyber Cement Private Limited. The compacting and bonding qualities of cement, when submerged in water, aid in holding particles together to create the weight of concrete. Because it adheres to the intricate hydration process that gives the material its water resistance.

Figure 3.1 Cement

B. Coarse Aggregates

Coarse aggregate is defined as aggregate that is larger than 4.75 mm or that is retrained on a 4.75 mm IS sieve. Coarse aggregates are materials that are too big to be retained on a 4.75 mm IS sieve and only include the amount of fine particles allowed by the standards. The nominal size of the graded coarse aggregate—40 mm, 20 mm, 16 mm, and 10 mm—defines it. Many of the aggregates' characteristics are derived from the parent rocks since they are created either by the natural disintegration of rocks or by the artificial crushing of rocks or gravel. The coarse aggregate was graded in accordance with IS:383-1970. A graded aggregate is made up of aggregates with nominal sizes of 20 mm and 10 mm.

Figure 3.2 Coarse aggregates

C. Fine Aggregates

Natural river sand or crushed sand particles that have passed through a 4.75mm sieve make up fine aggregate. River sand, which has a particle size of 0.07 mm, is typically utilized as a fine aggregate. The extraction process is carried out from seabeds, lakes, or rivers. Jammu was used to extract the fine aggregate that was on the site. The zone that complies with IS: 383-1970 would be determined using sieve analysis. The relevant lab supplied the physical characteristics of the sand.

Figure 3.3 Fine aggregates

D. Paper Sludge Ash

Paper sludge ash Cement is the binding agent in concrete, which consists of aggregates (like sand and gravel), water, and any other additives. When mixed with paper slug and ash, the concrete may gain some insulating properties, and potentially become lighter, but you must balance these additives to avoid weakening the structural integrity. By combining these materials, the resulting concrete could be more eco-friendly and tailored for specific applications (like lightweight construction or insulation), but careful testing would be needed to ensure it meets strength and durability requirements.

Figure 3.3 PSA

Table no. 1 Properties of PSA

Inorganic Compound	Chemical Formula	Percentage Range
Calcium Oxide	CaO	5-15%
Silicon Dioxide	SiO_2	10-20%
Aluminum Oxide	Al_2O_3	1-10%
Iron Oxide	Fe_2O_3	1-5%
Magnesium Oxide	MgO	0.5-3%
Sodium Oxide	Na_2O	0.1-1%

E. Granite Powder

Using granite powder as a partial replacement for fine aggregates (sand) in concrete has been researched extensively as a sustainable practice. Granite powder is a by-product of granite quarrying and processing, which is often discarded. Incorporating this waste material into concrete helps reduce the environmental impact and improves certain properties of the concrete.

Figure 3.4 GP

Table no. 2 Properties of GP

Constituents	Values
SiO_2	72.04
Al_2O_3	14.42%
K_2O	4.12%
CaO	1.82%

F. Glass Fiber

Glass fibres are characteristic for their high strength, good temperature and corrosion resistance, and low price. Alkali resistant E-glass fibres of 12mm length, 0.014mm nominal diameter, specific gravity of 1.9 and density of 2650 kg/m3 were used. Glass wool, which is one product called fiberglass. These fibers reduce crack width and spacing between cracks. They are very high temperature resistant as they absorb high energy thereby providing the property of ductility.

Figure 3.5 Glass fiber

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XI Nov 2024- Available at www.ijraset.com

Table no. 3 Properties of GF

Property	Value Range
Density	2.5 - 2.6
Tensile Strength	1,700 - 3,500
Elastic Modulus	70 - 75
Poisson's Ratio	0.22 - 0.30
Specific Heat Capacity	0.8 - 0.9

IV. METHODOLOGY

A. Mixing Concrete

All the ingredients of concrete are mixed together however this mix should be homogenous and uniform in color and consistency. The mixing can either be done by hand or with the use of mixer.

B. Mixing Concrete

Thorough mixing of the materials is essential to produce uniform concrete. The mixing should make sure that the mass become homogeneous, uniform in consistency and colour. There are two methods adopting for mixing concrete one is hand mixing and other is machine mixing.

C. Curing

Before removing the mould, it is dried for 24 hours, and then specimens are placed in a water tank made to cure specimens. The specimens must be marked for identification so that there must not be any error. The specimens are removed from the tank and dried before putting in the testing machine. The specimens are kept in the tank for 7,14,28 days.

D. Workability Test

Both on-site and in the lab, it can be utilized. Concrete with extremely low and very high workability cannot pass this test. It is composed of a frustum-shaped mold with a top diameter of 10 cm, a bottom diameter of 20 cm, and a height of 30 cm. If the concrete is placed in the mold in four layers, it will be tested.

The tamping rod is used to compact each 25 times. The concrete subsides as soon as the mold is fully filled because it is immediately raised vertically upward.

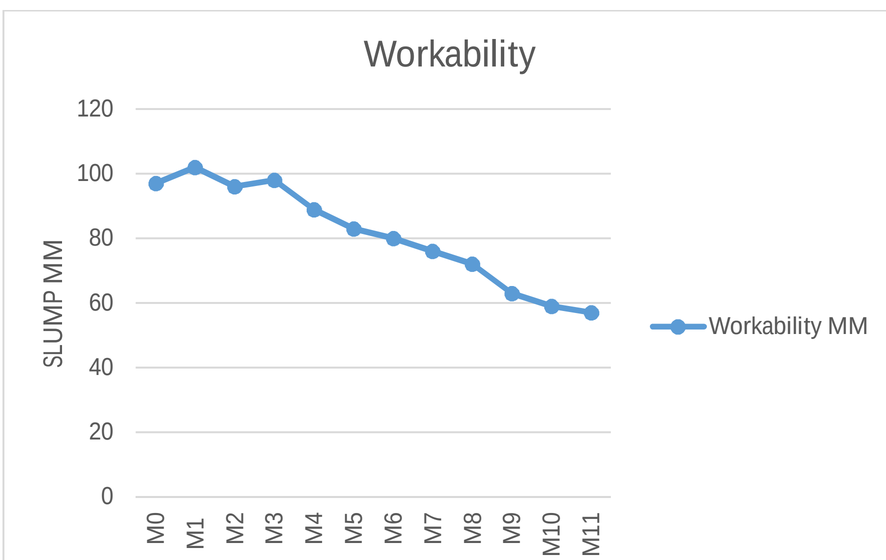

Fig -1: SLUMP CONE TEST

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XI Nov 2024- Available at www.ijraset.com

E. Compressive Strength Test

After that, four layers of fresh concrete are poured into the mold, and each layer should be tamped with a conventional tamping rod 35 times for cubes and 25 times for cylinders. After the mold is full, use a trowel to level the concrete's top surface. The mold will be taken out at the end of the day, and the specimens will be placed in the curing tank at the usual temperature of 27±2°C. Following 7, 14, and 28 days of this study.

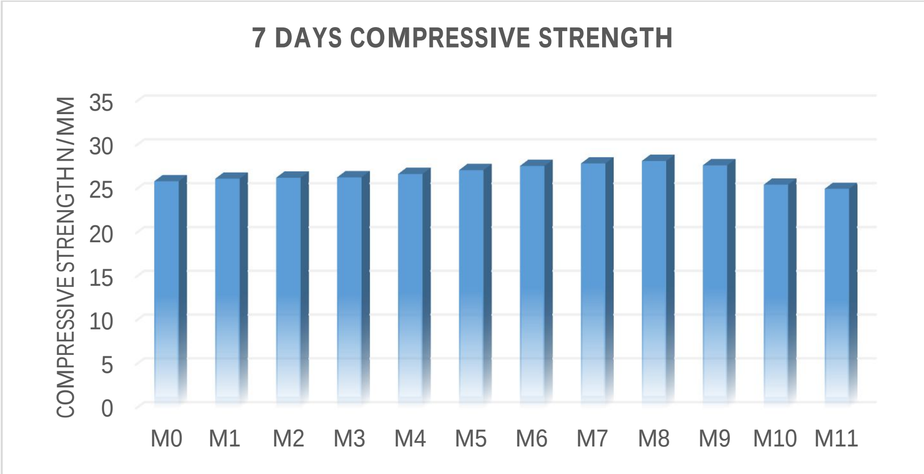

Fig -2: COMPRESSIVE STRENGTH TEST 7

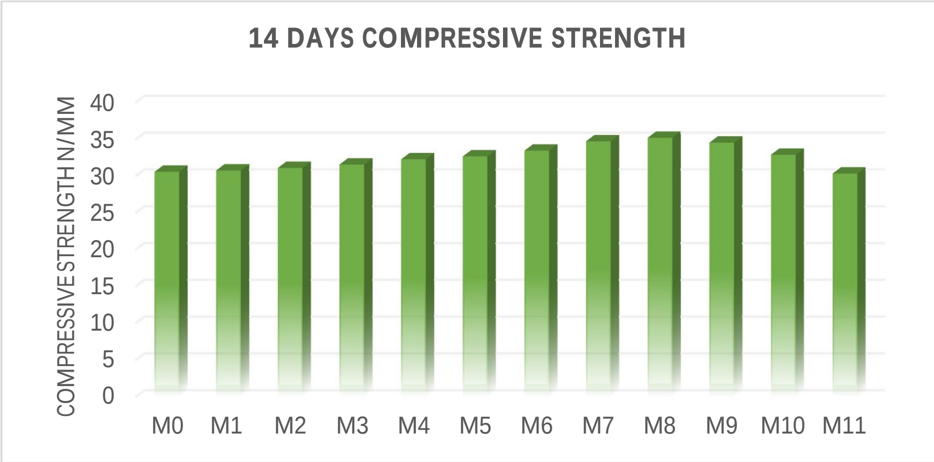

Fig -3: COMPRESSIVE STRENGTH TEST 14

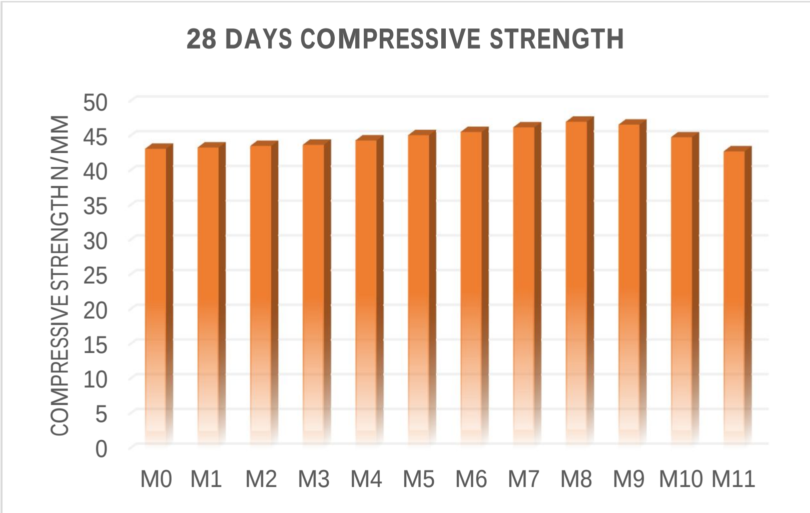

Fig -4: COMPRESSIVE STRENGTH TEST 28

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XI Nov 2024- Available at www.ijraset.com

F. Split Tensile Strength Test

The cylindrical test specimen has dimensions of 150 mm in diameter and 300 mm in length. The universal testing machine is the tool utilized in this test. The necessary grades and mix proportions are followed when preparing the fresh concrete. Layers of fresh concrete are poured into the mold, and each layer is tamped down with 25 blows using a normal tamping rod. Following the day, the mold is taken out, and the specimen is kept in the curing tank at 27+2°C for 7, 14, and 28 days in this study. Then, on the specimen, draw the line.

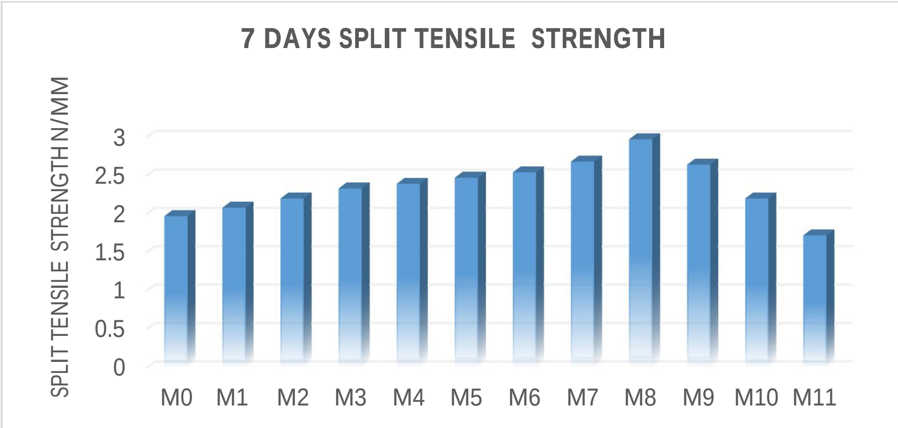

Fig -5: SPLIT TENSILE STRENGTH TEST 7

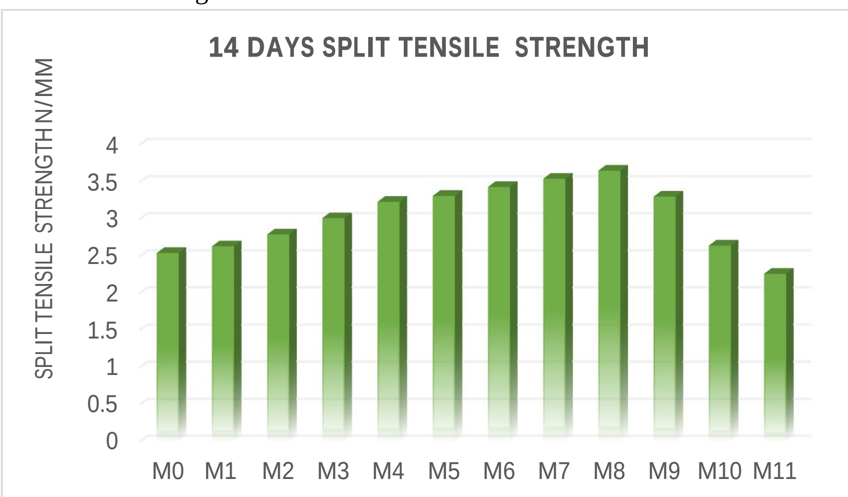

Fig -6: SPLIT TENSILE STRENGTH TEST 14

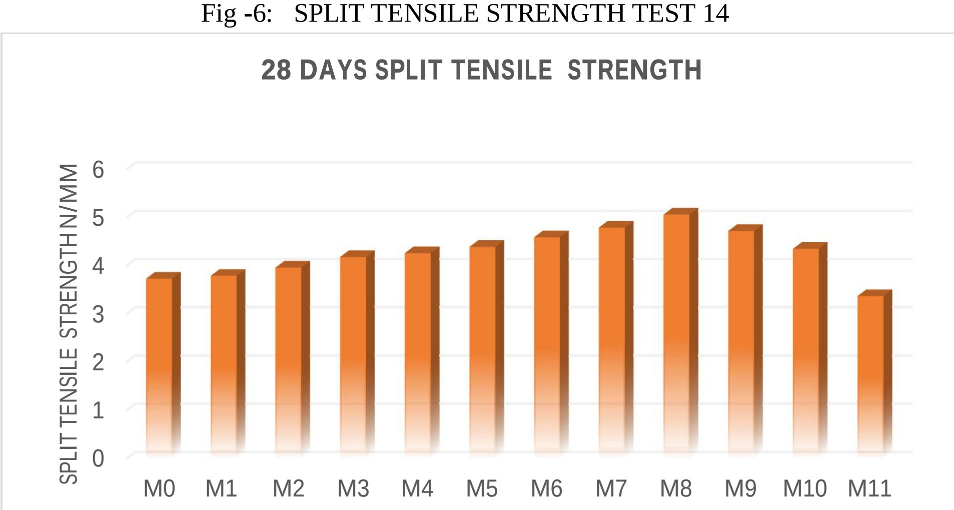

Fig -7: SPLIT TENSILE STRENGTH TEST 28

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XI Nov 2024- Available at www.ijraset.com

G. Flexural Strength Test

The concrete is prepared at the necessary mass element rate by filling the mold in layers and using a normal tamping rod to blow it 25 times. The mold is taken out and the specimen is put in a water tank to cure at 27 + 2 C for a day, or perhaps 24 hours. Depending on the needs, the test specimen is taken out of the water tank and thoroughly cleaned for 7, 14, and 28 days before testing.

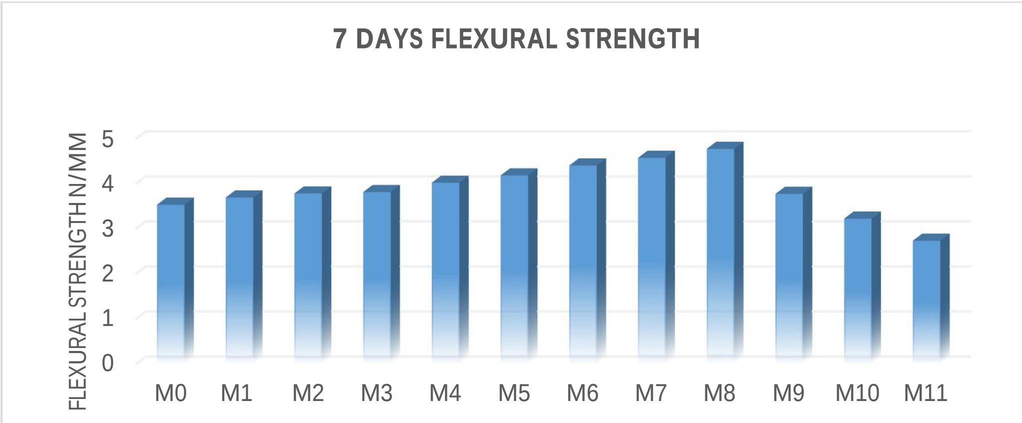

Fig -8: FLEXURAL STRENGTH TEST 7

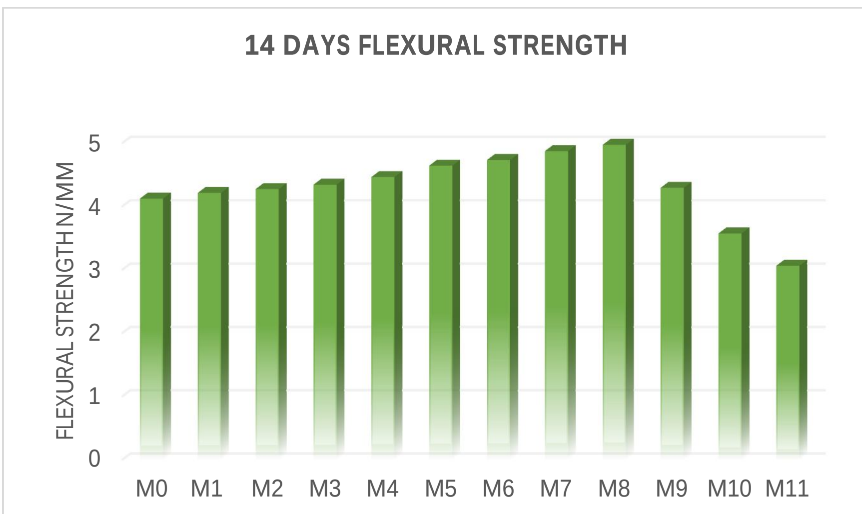

Fig -9: FLEXURAL STRENGTH TEST 14

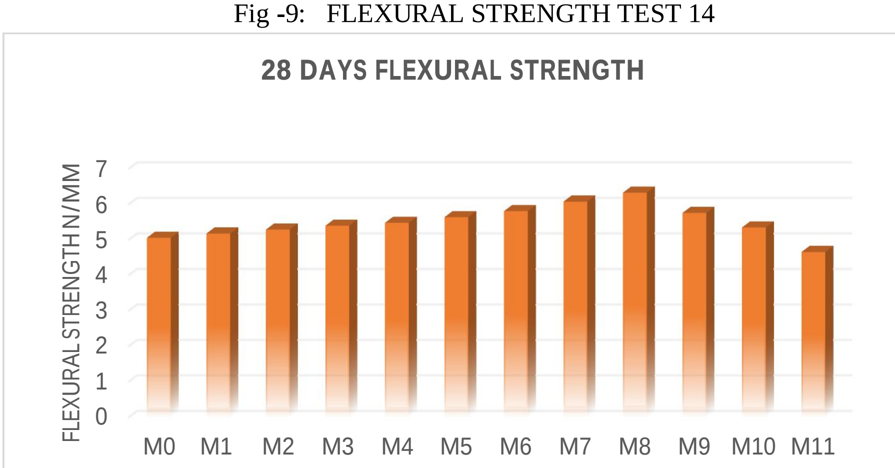

Fig -10: FLEXURAL STRENGTH TEST 28

V. CONCLUSION

By replacing the paper sludge ash in cement and granite powder replace with sand with addition of glass fiber strengths get increased, also the replacement can be taken into consideration up to certain percentage workability factors gets enhanced as well. The compressive, tensile, flexural strength of the concrete on comparing with conventional concrete gets increased till at 8.5% paper sludge ash in replacement of cement and 16% granite powder replace with sand and addition of 1.5% glass fiber.

REFERENCES

[1] Kumar P and Kaushik S K, 2003. Some trends in the use of concrete: Indian scenario, The Indian Concrete Journal, December 2003, pp.1503-1508.
[2] Mamlouk M S and Zaniewski J P 2006. Materials for Civil and Construction Engineers, National Bookstore: Manila, pp. 305-311, 2006.
[3] Ch. Sravan Kumar Reddy, Bendapudi Sarath Chandra Kumar, SS.Asadi, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019. pp.62 67
[4] Gunasekaran K, Kumar PS, Laxmipathy M 2011. Mechanical and Bond properties of Coconut Shell Concrete, Construction and Building Material 2011, pp 92-96
[5] Kabiru Usman Rogo, Selah Abu-Bakr 2010. Exploratory study of coconut shell as aggregate in concrete production, Journal of Engineering and Applied Sciences, Vol.2, Dec 2010.
[6] Kambli Parag S, Mathapati Sandhya R, 2014. Application of Coconut Shell as Coarse Aggregate in Concrete: A Technical Review 4(3)March 2014, pp.498-501.
[7] Kraus R N, Naik T R, Y N Chun 2003. Concrete Containing Recycled Fibers from Pulp and Paper Mills, Sixth CANMET/ ACI International Conference June 2003, Recent Advances in Concrete Technology. Bucharest, Romania.
[8] Kosmatka S H, Kerkhoff B and Panarese W C 2002. Design and control of concrete mixtures, Portland Cement Association, Skokie, Illinois, USA.
[9] Indian Standard Institution 1983. Indian Standard, Recommended guidelines for concrete mix design, IS 10262-1982, 1983, Indian. Standard Institution, New Delhi, India. Invention, 2(5); pp 07-11.
[10] IS: 456-2000 2000. Code of practice for plain and reinforced concrete (fourth edition) 2000, Bureau of Indian Standards, New Delhi.
[11] Divakar Y., Manjunath S. and Dr. Aswath M.U, “Experimental investigation on behaviour of Concrete with the use of granite fines”, International Journal of Advanced Engineering Research and Studies, Vol. I Issue IV July Sept., 2012.
[12] Felixkala T. and Partheeban P, “Granite powder concrete”, Indian Journal of Science and Technology Vol. 3 No. 3 (Mar 2010).
[13] A.M. Neville, “Properties of concrete”, Trans-Atlantic Publications, Inc. 2012(5th Edition). Criteria for fifth ed., a Recommended Standard: Occupational Exposure to Crystalline Silica, US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) publication no. 75–120, 1974 (1974).
[14] S. Singh, R. Nagar, V. Agrawal, A. Tiwari, S. Siddique, “Review on properties of sustainable concrete using granite dust as replacement for river sand”, J. Clean. Prod. (2016).
[15] Semion Zhutovsky, Konstantin Kovler,” Influence of water to cement ratio on the efficiency of internal curing performance ,Construction and of high concrete” Building Materials 144 (2017) 311–316.
[16] Alan J. Brookes, “Cladding of Buildings”, Third Edition Published 2002, (pp 82). Arnon Bentur and Sidney Mindess, “Fibre Reinforced Cementetious Composites”, Second Edition 2007, Chapter 8, (pp278).
[17] J.G. Ferreira, F.A. Branco 2005, “Structural application of GRC in telecommunication towers”, Construction and Building Materials Journal, Published August 2005.
[18] Majumdar, A.J. (1974), “The role of the interface in glass fibre reinforced cement”, Building Research Establishment, Published 1974, Current Paper (cp 57-74).
[19] M. Levitt 1997 “Concrete materials problems and solutions”, “GRC and Alkali-Glass reaction”, First Edition 1997, (pp 22-24).
[20] M.W. Fordyce and R.G. Wodehouse, “GRC and buildings”, Published First Edition 1983.
[21] Perumelsamy N. Balaguru and Surendra P. Shah, “Fibre reinforced cement composites”, February 1992, Chapter 13, (pp351).
[22] Dr. P. Perumal and Dr. J. Maheswaran, “Behavioural study on the effect of AR-Glass Fibre reinforced concrete”, NBW & CW October 2006, (pp 174-180).