Section A-Research paper

EXPERIMENTAL STUDY ON " THE EFFECT ON COMPRESSIVE STRENGTH OF CONCRETE ON REPLACING FINE AGGREGATE BY SUGARCANE BAGASSE AND BLAST FURNACE SLAG

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ABSTRACT

The study aim to investigate the rigid pavement by the use of sugarcane bagasse ash and of ground granulated blast furnace Slag in cement. Various research have been conducted internationally which diagnosed the detrimental results of various waste substances in concrete. Consequently, exclusive waste substances had been discovered to be appropriate starting from five% to 30% for the toll road production purposes. But, nonetheless there may be a want to replace the cement in part by introducing another fabric by using considering the chemical composition of cement with out changing their binding homes. In the present study, an try has been made to conscious the researchers and engineers to fabricate inexperienced concrete so that it will achieve the stability between environment, economical and technical factors by using highlighting special methods of utilizing the discarded substances (i.e. Waste).

An effective road transport system is apre-requisite for sustained profitable evolution. It isn't only the crucial infrastructural input for the growth process but also plays a significant part in elevating public integration, which is particularly important in India. In the road transportation , Energy planning has an important significance because transportation is the second largest consumer of energy. The growth of transport not only leads to pressure on limited vacuity of non- renewable energy but also gives rise to broader environmental issues. As the demand for transport services rise, it leads to increased use of scarce land coffers and contributes to the atmospheric pollution in a big way.There's also a large product of industrial wastes as agrarian assiduity is one of the largest diligence in India as further than 70 of Indian population is dependent on husbandry. On the other hand, accumulation of unmanagedagro-waste, especially from the developing countries has an increased environmental concern. thus, development of new technologies to reclaim and convert waste accoutrements into applicable accoutrements is important for the safeguard of the terrain and sustainable development of the society. numerous agrarian waste accoutrements are formerly used in concrete as relief druthers for cement, fine total, coarse total and buttressing accoutrements .

also, the colorful processes for the product and processing of cement, bitumen, fine and coarse total requires a lot of energy and product of dangerous gassy and chemical wastes into the terrain. therefore in view of the below problems, an attempt is made to study, to reduce the pollution from cement and other accoutrements used in the construction process with a view to produce and develop greener styles of construction by using bagasse ash in the construction of low volume business roads by the partial relief of certain constituent accoutrements . These roads can be constructed in those areas where there's vacuity of sugarcane bagasse. In Uttar Pradesh and Haryana,there's a large scale civilization of sugarcane and therefore the sugarcane bagasse can be fluently carried to be used in the construction of low volume business roads.

Keywords: Cement, waste cloth (sugarcane bagasse ash and of floor granulated blast furnace Slag), Rigid pavement, Environment

INTRODUCTION

1.1 General

A pavement is a durable surface consist of various compacted layer to carried heavy visitors load. Each layer of pavement are consist of decided on advanced pavement cloth laid over a soil subgrade. The heavy traffic load on pavement are switch through distinct pavement layer to big natural surface location. Therefore every layer are well compacted to withstand stresses evolved with the aid of visitors load. On the base of material used in street pavement, the pavement are categorized into two kind i.e. Flexible pavement and rigid pavement.[1]

In flexible pavement, aggregate of asphaltic or bituminous material and aggregates are positioned on a bed of compacted granular fabric, therefore they offer little deformation below heavy wheel masses and resist tensile stresses however have low flexural strength. But in case of rigid pavement, undeniable cement concrete (PCC) are placed on the compacted layer of base path. Therefore, they possess excessive flexural energy and provide splendid resistance to deformation under traffic load. Due to the use of PCC, the enlargement and contraction joint are furnished along the duration of the road [2]. Also the use Reinforcing steel in the inflexible pavements, to decrease or get rid of the joints. The design of rigid pavement is based on supplying a structural cement concrete slab of sufficient power to resists the masses from traffic. The rigid pavement has tension and excessive modulus of elasticity to distribute the burden over a pretty wide location of soil.[3]

The fee of the road is rely on the form of pavement used. The flexible pavement are within your means then rigid pavement therefore flexible pavement are generally used. But Now an afternoon, inflexible pavement are typically used for carried heavy visitors due to the fact they possess high flexural electricity and occasional maintenance cost. In rigid pavement, cement is used as binding fabric, therefore the initial price of rigid pavement is higher than bendy pavement. The many waste cloth like fly ash are utilized in pavement to decreasing the cost of roads without affecting the properties of concrete which used to assemble the pinnacle layer of pavement. But some different waste cloth like sugarcane bagasse ash and ground granulated blast furnace slug also are used in Pavement with the aid of disposing of the few amount of cement in pavement. The impact

on these cloth in concrete pavement are decided by way of compressive power test and tensile strength check. The various design blend with unique proportion of material are organized for accomplishing the exceptional check. These material are effortlessly available in India. With using waste fabric in roads, additionally they assist to reduce the diverse surroundings problem.[4]

1.2 Objectives of present work

The work is focused on using waste material in exclusive percentage with cement for the construction of rigid pavement. The main objective of the paintings are:

1. To discover the optimum percentage of sugarcane bagasse ash and floor granulated blast furnace slag in pavement pleasant concrete.

2. To optimize the fee effectiveness of pavement with the aid of using special waste fabric.

3. The use of waste cloth with out changing their houses of concrete pavement.

4. To set the rule regarding the use of waste fabric in pavement production and make new concrete mix layout.

5. To evaluate chemical composition and segment composition of fabric used in the creation of rigid pavement.

1.3 Scope of the work

1.This studies is finished for the future improvement of street network.

2. To examine the end result of various check that's suitable for rigid pavement.

3. To examine the impact of work in environment.

4. To put together a pavement price comparative evaluation for rigid pavement.

1.4 Component of rigid pavement

In inflexible pavement, cement is used as binding material. The issue of rigid pavement is consist of:

-Soil subgrade, at the lowest layer

-Granular sub base course and drainage layer

-base path

-concrete pavement slab

The concrete pavement slab is supported by means of compacted sub grade and base path. Each layer are properly compacted to wear heavy load of traffic on the pavement. The soil subgrade is the bottom layer in rigid pavements encompass properly compacted natural soil, that's capable to switch heavy load on massive floor region of herbal soil. The granular sub-base route serve as an

effective drainage layer of the inflexible pavement, which is used to prevent early failure due to immoderate moisture content in sub grade soil. The base course are offer below concrete slab. On the top, concrete slab are offer in rigid pavement. As the rigid pavement has to face up to high flexural stresses caused by heavy traffic load and temperature variation.[5]

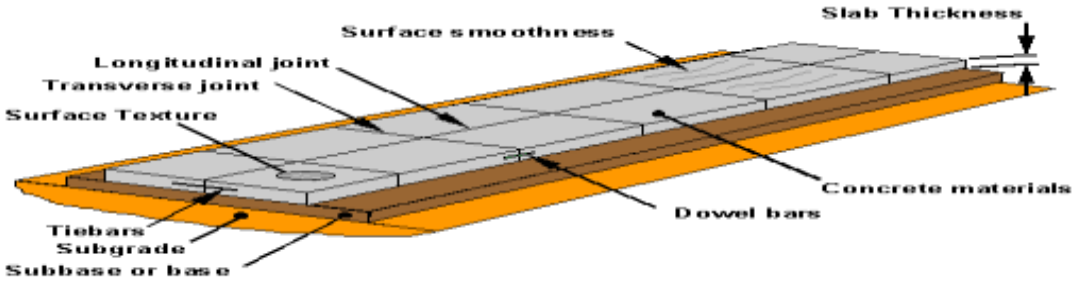

Fig. 1.1 component of rigid pavement

Chemical composition of material used

Cement

Cement is used as binding fabric in rigid pavement. Cement is mainly divided into special shape consisting of normal Portland cement, Rapid hardening cement, low warmth cement blast furnace slag cement etc. But typically, rapid hardening cement and regular Portland cement are utilized in rigid pavement. The chemical composition of cement is given in desk 1.1.

Table 1.1 Chemical composition in cement

S. no	Chemical ingredient	Chemical formula	proportion
1.	Lime	CaO	63%
2.	Silica	SiO_2	22%
3.	Alumina	Al_2O_3	6%
4.	Iron oxide	Fe_2O_3	3%
5.	Magnesium oxide	MgO	2.50%
6.	Sulphur trioxide	SO_3	1.75%
7.	Alkalies (soda and potash)	(Na_2O+K_3O)	0.25%
8.	Loss on ignition		1.5%

Sugarcane bagasse ash

Sugarcane bagasse ash is a solid waste generated from the sugar production industry. Bagasse is the fibrous fabric remaining after removing the sugar, water and other impurities from the sugarcane brought to the mill. India produced average 350 million tons of sugarcane in 2018-2019. The chemical element in bagasse ash are given in the desk underneath:

Table 1.2 Chemical composition of sugarcane bagasse ash

S. no	Chemical	Chemical formula	Proportion
1.	Silica	SiO_2	62.66
2.	Alumina	Al_2O_3	5.20
3.	Iron oxide	Fe_2O_3	5.19
4.	Lime	CaO	4.87
5.	Magnesium oxide	MgO	2.19
6.	Sulphur trioxide	SO_3	0.30
7.	Potassium oxide	K_2O	13.93
8.	Sodium oxide	Na_2O	0.56
9.	Other		4.40

Ground granulated blast furnace slag

Ground granulated blast furnace slug is acquired by quenching molten iron slag (a spinoff of iron and metallic making) from a blast furnace in water or steam, to provide a glassy granular product this is then dried and floor right into a first-rate powder [7] . The chemical composition of a slag varies notably relying at the composition of the uncooked substances in the iron production system. Silicate and aluminates impurities from the ore and coke are mixed in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron manufacturing the flux is composed basically of a mixture of limestone and in some instances dolomite [8]. In the blast furnace the slag floats on pinnacle of the iron and is decanted for separation. The fundamental chemical composition of floor granulated blast finance slag are given under:

Table 1.3 Chemical composition of Ground granulated blast furnace slag

S.no	chemical	Chemical formula	proportion
1.	Calcium oxide	CaO	40%
2.	Silica	SiO_2	33%
3.	Alumina	Al_2O_3	16%
4.	Magnesia oxide	MgO	11%

Role of waste material in rigid pavement:

In this work specific fabric are used which include Sugarcane bagasse ash and ground granulated blast furnace slag with the partly substitute of cement in rigid pavement. The role of those to material in inflexible pavement are unique. The percent of silica in bagasse ash are extra than the cement therefore they effect, at the energy and setting time of the cement utilized in pavement due To the formation of dicalcium and tricalcium silicate. Due to the excessive percentage of silica in baggage ash are barely growth the initial putting time of concrete which also assist to boom

energy of concrete. The share of different aspect are impact the homes of cement including durability, soundness and warmth of hydration and so forth. The particle length of bagasse ash is finer then cement which decrease the permeability of concrete however blast finance slug are in the shape of granular, therefore it's far crucial to cloth tested for fineness modulus. The percent of alumina in blast furnace slug are help to lower the initial putting time of cement. [9]

Need for study

The pavement is primary part of any avenue task and wishes to resist site visitors load without deteriorating or deforming to the extent that it will become unusable during the design life length. Till now, flexible pavement has been preferred over rigid pavement due to the low preliminary charges however there flexural electricity is low therefore they without difficulty deform beneath heavy load. The initial value of rigid pavement is not any doubt higher than that of flexible pavement. But all through retaining, rigid pavement has proved to be greater within your means than flexible pavement.

Experts factor out that during selecting the type of pavement, lifecycle cost and now not the preliminary fee need to betaken into attention. The lifecycle value analysis takes into account the preliminary investment cost in addition to the renovation and rehabilitation price over the design life of the pavement structure. The initial cost of inflexible pavement can be added down to add some waste material in mixed concrete. In such case, the lifecycle fee reduces in addition. Rigid pavement is usually preferred for locations experiencing heavy rainfall, waterlogged regions and areas having sub-grade soil with low CBR (California Bearing Ratio) values.

LITERATURE REVIEW

Before starting the paintings, the factors which can be associated with the acquired paintings objective, various literature writings on research papers which relate to this subject matter were amassed and evaluated. This entails amassing the facts and substances on the topic, together with studies papers, magazine articles, outlines and technical information which had been exist already in research agencies and authorities department. After analyzing the specific research papers, a few assessment was made on the bottom of private know-how. It gives a overview regarding the use of strong waste and nano particles as alternatives to make green concrete mix. The Main cause of this bankruptcy become to talk about all the waste material that may be used as opposed to the use of cement and aggregate to lessen CO2 emission that is accountable for the environment pollution. Different waste sources have been highlighted in the have a look at that come from industries facet and many greater. Every yr researcher work on the use of waste cloth in roads and different area. Some literature on the use of waste material in concrete are discussed in this bankruptcy.

EFFECT OF COPPER SLAG IN HIGH PERFORMANCE CONCRETE

- **Al-Jabri (2009 a)** looked at the impact of the use of copper slag as an alternative of sand at the homes of excessive overall performance concrete (HPC). Eight concrete mixtures

had been prepared with one of a kind proportions of copper slag starting from zero% (for the manipulated blend) to 100%. Concrete mixes have been evaluated for workability, density, compressive energy, tensile power, flexural strength and durability. The effects indicate that there is a mild boom in the HPC density of almost 5% with the increase of copper slag content, while the workability elevated swiftly with increases in copper slag percent. Addition of as much as 50% of copper slag as sand substitute yielded comparable strength with that of the control mix. However, in addition additions of copper slag induced discount inside the electricity due to an boom of the unfastened water content inside the blend. Mixes with 80% and a hundred% copper slag alternative gave the lowest compressive strength price of about 80 MPa, which is sort of 16% decrease than the electricity of the control blend. The results also confirmed that the surface water absorption Decreased as copper slag quantity increases as much as 40% alternative; beyond that degree of replacement, the absorption rate increases swiftly.

EFFECT OF LADLE FURNACE SLAG (LFS) IN CEMENT CONCRETE MIX DESIGN

- **Marinho et al. (2017)** carried out examine to use ladle furnace slag (LFS) as a binder in Cement concrete blend. Ladle furnace slag (LFS) is a by-product of low carbon metal manufacturing, acquired from the manner of secondary refining in ladle furnaces The most important additives of the LFS are calcium, silicon, magnesium, aluminum oxides, and calcium silicates below numerous allotropic bureaucracy. LFS is acquired in a gradual cooling method and offers a huge content of satisfactory particles, with 20–35% underneath seventy five μm. Calcium oxide and calcium magnesium silicates are the 88% of general mix. After plenty of exams it changed into concluded that usage of LFS in preference to lime for cement composite primarily based fabric. It is the pleasant suitable fabric for the partial alternate of cement.
- **Manso et al. (2005)** conducted a take a look at of utilization of LFS in creation. Test become carried out to find that it is going to be appropriate for paving roads in place of cement. It turned into concluded that LFS seems appropriate for paving roads as a soil–cement mixture. The cheap cost and time based residences, i.e., bearing to load and resilience, also donate to its capability use.

EFFECT OF RICH HUSK ASH IN CEMENT CONCRETE MIX DESIGN

- **Zabihi et al. (2018)** investigated that rice husk ash blend with geopolymer concrete guarantee 100% alternative of cement until property like Water absorption, flexural energy and splitting tensile energy get compromise to some extent.
- **Sathiparan et al. (2018)** measures the impact on cement block with the aid of in part alternative of sand with the aid of a few agricultural waste. Open dumping of agricultural waste causes diverse fitness dangers and also pollutes the surroundings. Cement blocks were made from agricultural waste like rice husk. Cement, sand and waste substances had been jumbled in exceptional proportions like (1:five:1), (1:4:2), (1:3:three) to make four hundred samples. Test was performed to determine the compressive power and flexural tensile power ”density, water absorption charge,” acid attack resistance and alkaline attack resistance of the sample after achieving the curing of 28 days at room temperature. It was

concluded that the cement block of 1:five:1 offers equal strength to the regular mix of blocks as all the residences had been observed to be comparable to the everyday one.

METHODOLOGY

In this bankruptcy the experimental setup and distinct techniques that are to be achieved and allows to acquire the various targets accompanied in this file. The whole investigations were performed on two extraordinary sort of concrete blend layout by way of including ground granulated blast furnace slag and sugarcane bagasse ash. The diverse check carry out with the aid of including exceptional waste cloth in exclusive percentage in cement and discover the end result of those take a look at and additionally evaluation the effect of end result on the houses of concrete, which used in rigid pavement.

This is divide into four classes:

- Collecting raw material,
- Preparing blend layout,
- Sampling and
- Testing on sample

Raw material used

(a)Cement: cement used in this work is everyday Portland cement of grade 43 due to the fact the compressive energy of grade 43 is extra than grade 33. Cement utilised in rigid pavement as binding cloth. Portland cement commonly make up about 15% of the PCC mix by using weight. The following check are conduct on cement are as

1. Fineness test by sieving

2. Consistency Test

3. Initial and final putting times check

(b) Aggregate: A crushed granite rock with a maximum size of 20mm with particular gravity of 2.74 changed into used as a coarse mixture. Natural sand from Chenab River in Akhnoor with specific gravity of 2.60 changed into used as a satisfactory mixture. The fineness modulus of nice and coarse aggregates is 3.Sixteen and 7.19.The individual aggregates were blended to get the favoured blended grading. The combinations used for making the cube are of an exclusive length. The sieve evaluation is used for selecting the unique length of combination, which is given in desk three.2.

(c) Sugarcane bagasse ash: Bagasse Ash turned into burnt for approximately seventy two hours in air in an out of control burning technique. The temperature turned into in the variety of seven-hundred- 60000C.The ash accumulated from the nearest sugar mill. After accumulating, it became sieved thru BS general sieve size seventy five μm and the colour of bagasse ash changed into black. It was then measured through quantity to replace the cement at 5%, 10%, 15%, 20%, 25% and 30%. The Specific gravity given Bagasse ash is set 1.84.

(d) Granulated blast furnace slag: It is also used as uncooked cloth. Blast furnace slug are gathered from iron factory in granular form. After accumulating, they're grind into powder form. After grinding they become sieved through BS widespread sieve size 75 μm and the shade of blast furnance slug is white. It become then measured with the aid of volume to replace the cement at five%, 10%, 15%, 20%, 25% and 30%.

(e) Water: Potable water turned into used for blending and curing of concrete cubes.

ANALYSIS OF RESULTS AND DISCUSSIONS

This chapter address various test bring about tabular and graphical form one of a kind check of materials are carried out to test the suitability of available fabric in inflexible pavement. Test of sand, aggregate and cement turned into executed. According to mix layout each material ought to possess the identical property and identical values. Test like Normal Consistency test, Initial & Final placing time, precise gravity of sand cement and mixture and compressive strength changed into completed.

Test result

The following end result of different take a look at are proven within the table given below:

Table 4.0 Result of different test

S.NO	TEST	RESULT
1.	Consistency Test	28%
2.	Initial setting times test	31 min.
3.	Final setting times test	9 hour approximate
4.	compressive strength test 3 days 7days 28days	 23N/mm2 31n/mm2 43N/mm2
5.	Tensile strength of concrete	

	3days 7days	21kg/cm2 27kg/cm2
6.	Specific gravity of sand	2.73
7.	Specific gravity of coarse aggregate	2.65

Table 4.1 Compressive strength by using Ground Granulated Blast furnace Slag in cement after 7 days

Percentage of ground granulated bl furnace slag in cement for making concr block	Sample 1	Sample 2	Sample 3	Average
0	27	27.2	27.2	27.13
5	29.8	30	29.5	29.77
10	30.2	30.5	29.7	30.13
15	28.3	28.6	27.7	28.2
20	26.7	24.4	25.8	25.63
25	22.5	23.6	22.4	22.83
30	20.1	19.5	18.7	19.43

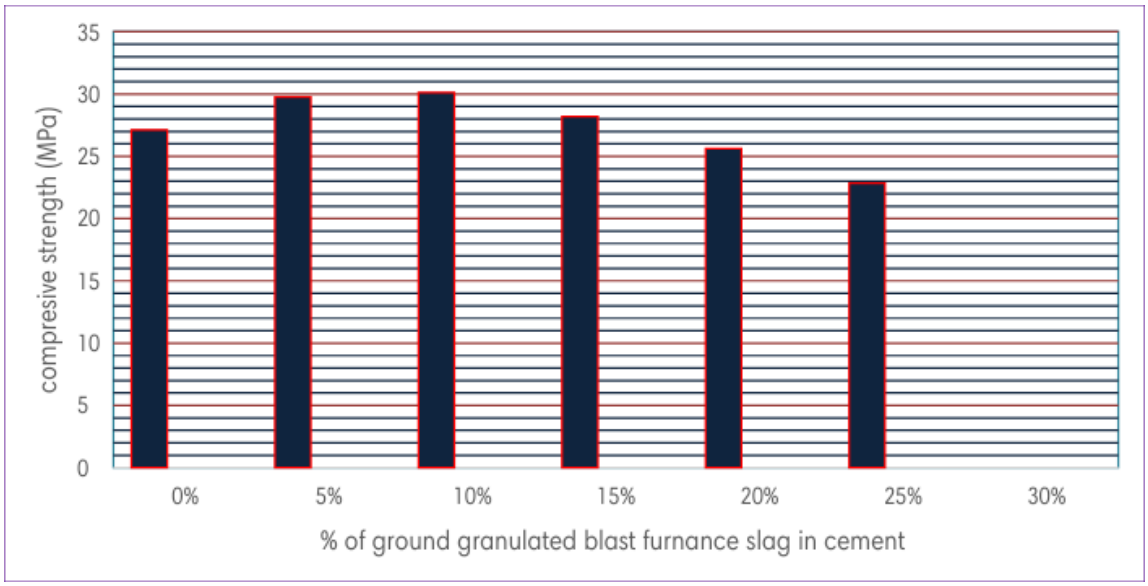

Fig 4.1 Fluctuation in compressive strength with the % of Ground Granulated Blast Furnace Slag after 7 days

Table 4.2 Compressive strength by using Ground Granulated Blast furnace Slag in cement after 28 days

Percentage of ground granulated blast furnace slag in cement for making concrete block	Sample 1	Sample 2	Sample 3	Average
0	42.5	43.7	41.1	42.43
5%	44.7	42.9	45	44.2
10%	45.8	46.5	46.5	46.26
15%	40.5	43.4	41.7	41.86
20%	40.1	41.6	39.5	40.4
25%	37.6	38.2	38	37.93
30%	35	34.9	33.8	34.5

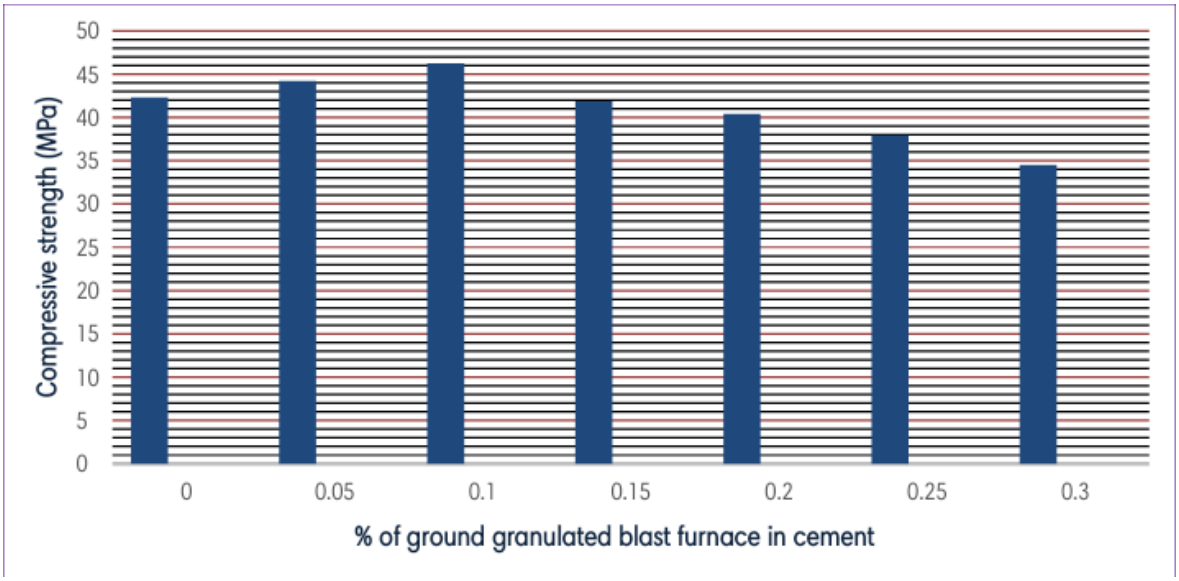

Fig 4.2 Fluctuation in compressive strength with the % of GGBS after 28 days

Table 4.3 Compressive strength by using sugarcane bagasse ash in cement after 7 Days

Percentage of sugarcane bagasse ash cement for making concrete block	Sample 1	Sample 2	Sample 3	Average
0%	26.9	27.1	27.2	27.1
5%	27.43	27.5	28.1	27.68
10%	30.2	30.0	29.8	30

15%	30.2	30.5	30.4	30.37
20%	26.4	27.4	26.6	26.8
25%	24.5	23.9	23.7	23.93
30%	20.2	23.1	23.4	22.2

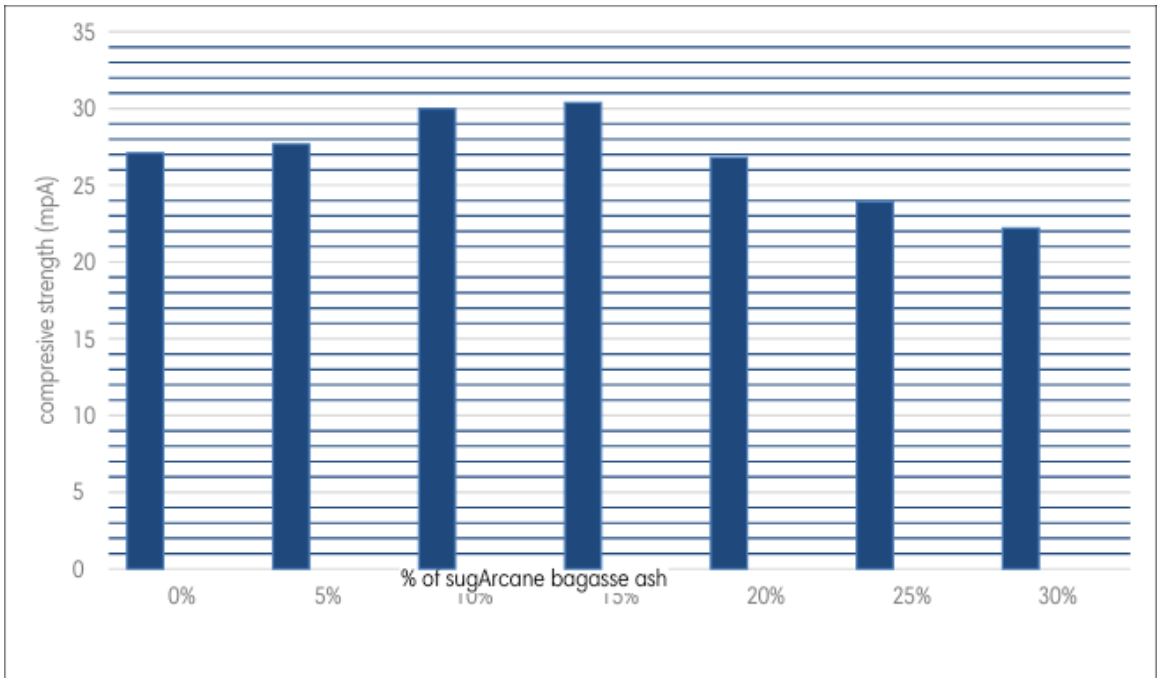

Fig 4.3 Fluctuation in compressive strength with the % of sugarcane bagasse ash after 7 day

Table 4.4 Compressive strength by using sugarcane bagasse ash after 28 days

Percentage of sugarcane bagasse ash cement for making concrete block	Sample 1	Sample 2	Sample 3	Average
0%	43.9	43.2	42.0	43.03
5%	45.5	46.1	45.7	45.77
10%	47.5	47.3	46.7	47.27
15%	47.5	49.1	49.2	48.6
20%	44.2	42.1	42.7	43
25%	38.2	39.1	38.7	38.37
30%	35.8	34.2	35	35

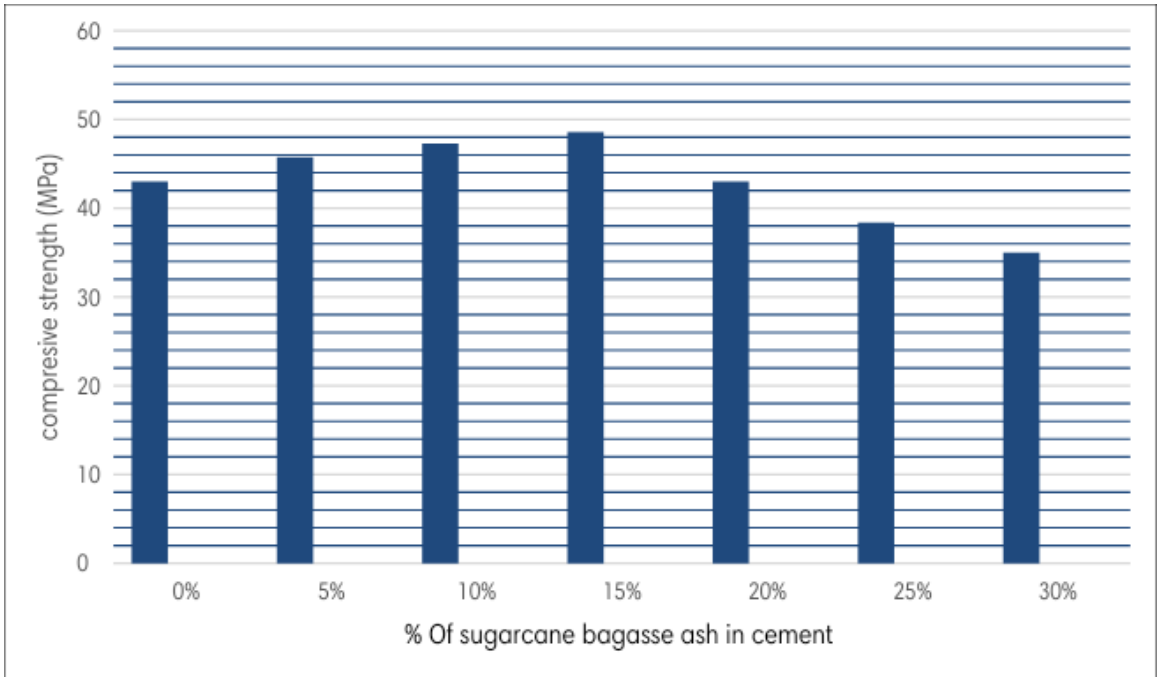

Fig 4.4 Fluctuation in compressive strength with the % of sugarcane bagasse ash after 28 days

Conclusion

The Compressive electricity of concrete block after 28 days by using the use of Ground Granulated Blast Furnace Slag and after 7 days gives most reliable consequences, while cement become replaced up to 15%. At 10 % replacement there was an increment of 12% Compressive power. . After that sugarcane bagasse changed into partially changed up to 30% and it was concluded that, at 15 % it gives the most strength after 28days of curing. Different combos of these two waste substances were prepared in the course of the have a look at. On the premise of the effects it became located that 5% of Ground Granulated Blast Furnace slag and 15% of inside the mix exhibit most compressive electricity. Tensile strength of Ground Granulated Blast Furnace Slag and Sugarcane bagasse ash are barely better than the traditional concrete. The Cost of creation of rigid pavement may even lessen because of the reduction of cement in rigid pavement. The putting time of cement also are increase slightly due to the high percent of silica in bagasse ash.

Following conclusions have been drawn based on the present study

1. Sugarcane bagasse ash modified concrete performed more when compared to ordinary concrete up to 20(finer SCBA) for cement relief and 10(less finer SCBA) of beach relief in ordinary concrete.
2. Increase of strength in paver blocks is substantially due to presence of high quantum of silica in sugarcane bagasse ash.
3. These pavements are innocent by the spillage of oil painting from vehicles and are ideal for machine stops, machine depots and parking areas.
4. As far as the costs are concerned, it's estimated that the quantum needed per kilometre length of flexible pavement isRs. and the cost of interlocking bagasse ash paver blocks

road isRs. per kilometre. The construction of road using bagasse ash paver blocks seems to be further cost effective than the conventional flexible pavement by23.50.

5. Block pavement doesn't need in- situ curing and so can be opened to business soon after completion of construction.
6. The circumstance of damage is less in bagasse ash paver blocks road and it's easy to remove and amend the road with lower quantum. The digging and reinstatement of fosses for repairs to serviceability is easier in the case of block pavement.
7. Since the blocks are prepared in the plant, they're of a veritably high quality, therefore avoiding the difficulties encountered in quality control in the field.
8. Concrete block pavements circumscribe the speed of vehicles to about 60 km per hour, which is an advantage in megacity thoroughfares and corners. The block pavements are ideal for corners where pets have to be confined and controlling stresses are high.

REFERENCES

[1] Jagadesh, P., Ramachandramurthy, A., & Murugesan, R. (2018) Evaluation of mechanical properties of Sugar Cane Bagasse Ash concrete

[2] Jamsawang, P., Poorahong, H., Yoobanpot, N., Songpiriyakij, S., & Jongpradist, P. (2017) Improvement of soft clay with cement and bagasse ash waste. Construction and Building Materials, 154, 61-71.

[3] Janbuala, S., Eambua, M., Satayavibul, A., & Nethan, W. (2018) “Effect of bagasse and bagasse ash levels on properties of pottery products.” Heliyon, 4(9), e00814.

[4] Kazmi, S. M. S., Munir, M. J., Patnaikuni, I., & Wu, Y. F. (2017) Pozzolanic reaction of sugarcane bagasse ash and its role in controlling alkali silica reaction. Construction and Building Materials, 148, 231-240.

[5] Ashish DK., 2018. Feasibility of waste marble powder in concrete as partial substitution of cement and sand amalgam for sustainable growth. Journal of Building Engineering. Jan 31;15:236-42.

[6] Bahurudeen A, Kanraj D, Dev VG, Santhanam M., 2015. Performance evaluation of Sugarcane bagasse ash blended cement in concrete. Cement and Concrete Composites.

[7] Bourtsalas, A.T., Zhang, J., Castaldi, M.J. and Themelis, N.J., 2018. Use of non-recycled plastics and paper as alternative fuel in cement production. Journal of Cleaner Production, 181, pp.8-16.

[8] Das S, Singh G, Ahmed AA, Saha S, Karmakar S., 2015. Ground Granulated Blast Furnace Slag (GGBS) based Concrete Exposed to Artificial Marine Environment (AME) and Sustainable

Retrofitting using Glass Fiber Reinforced Polymer (GFRP) sheets. Procedia-Social and Behavioral Sciences.

[9] Deepika S, Anand G, Bahurudeen A, Santhanam M., 2017. Construction Products with Sugarcane Bagasse Ash Binder. Journal of Materials in Civil Engineering. Jul 21;29(10):04017189.

[10] Huda SB, Alam MS. 2014, Mechanical behavior of three generations of 100% repeated recycled coarse aggregate concrete. Construction and building materials.

[11] Kuo WT, Chen SH, Wang HY, Lin JC., 2013.A study on the mechanical and electricity properties of cement mortar added with GGBFS and piezoelectric powder. Construction and Building Materials. Dec 1;49:251-6.

[12] Kurup AR, Senthil Kumar K., 2017. Effect of recycled PVC fibers from electronic waste and silica powder on shear strength of concrete. Journal of Hazardous, Toxic, and Radioactive Waste. Feb 9;21(3):06017001.

[13] Law Yim Wan DS, Aslani F, Ma G., 2018.Lightweight Self-Compacting Concrete Incorporating Perlite, Scoria, and Polystyrene Aggregates. Journal of Materials in Civil Engineering. May 31;30(8):04018178.

[14] Liu J, Guo R. ,2018. Applications of Steel Slag Powder and Steel Slag Aggregate in Ultra-High Performance Concrete. Advances in Civil Engineering.;2018.

[15] Ankit dharma,2019. Utilisation of waste material in pavement