A STUDY OF CONCRETE PROPERETIES BY REPLACING FINE AGGREGATES WITH SLUDGE FINES

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Abstract - *Concrete production has seen various attempts using sewage sludge instead of traditional materials .Instead of coarse gravel, sand, or concrete binder, something else might work. Still, it Though tested thoroughly, results showed it just did not hold up when swapped into roles meant for heavier materials because the overall strength fell short Because of how the material weakens and swells when reacting with alkalis. The concrete Fumes rise heavily from factories, yet their role in releasing carbon dioxide stays significant. Machines run endlessly, while smoke pours into skies above industrial zones. Each year, output grows - so does pollution tied to these operations. Tall chimneys belch thick clouds, because energy demand keep climbing across production sites. One big reason Earth gets warmer? About sixty five out of every hundred parts comes from Fumes from CO_2 pour out steadily, while the making of cement pushes roughly 7% into that full pile of planet-warming gase.One way to tackle pollution involves cutting down gas emissions. Shifting away from current methods could help ease harm to nature, so trying new solutions might make a difference here Waste from wastewater treatment now finds purpose in building methods that care for the planet. Here, leftover solids after cleaning water mix into new forms of construction material*

product of wastewater treatment plants, can be effectively utilized in concrete. The main This work looks at possible substitutes for fine aggregate. The focus here shifts toward materials that might serve a similar purpose Concrete labeled M25, mixed with a water-to-cement measure of 0.45, went into the batch. Into that mix stepped fine sand as the smaller grains. Some got swapped out, others entirely, using waste from treatment plants mixed in at five percent, then ten, then fifteen. One fifth, along with full measure. Strength when squeezed, plus how concrete handles pressure, At 7, 14, 21, and 28 days after pouring, tests measured how well the material resisted splitting under tension. Outcomes help in understanding the performance of sludge-based concrete at different replacement Working through different layers. This research mainly wants to find a way to manage waste that lasts over time Out here, where wastewater gets cleaned up, tons of leftover sludge pile up fast - yet that mess could turn into something kinder to nature. Instead of treating it like trash, some spots are finding ways to give it new purpose without hurting the planet friendly construction materials.

Key Words **:concrete, fine aggregate replacement, sludge fines, sustainable construction, mechanical properties, Compressive strength, workability, durability, waste utilization, environmental impact**

INTRODUCTION

Most buildings on Earth use concrete because it holds up well, lasts long, stays strong under pressure. A blend of cement, sand, gravel, plus water creates it - measured just right. Once wet, cement wakes up through chemistry. That process glues everything tight. Slowly, what was loose becomes rock-like, firm, unmoving.

Most times you will see concrete where things are being built - like houses, footpaths, overpasses, streets. Its go-to spot isn't random; it handles heavy squeezing forces well, lasts ages when looked after, takes whatever form builders need while still wet. What happens later - the real-world behavior - hinges on picking the right ingredients, blending them just so, then letting it set under smart conditions. These days, building stuff relies on better concrete mixes - like super-strong kinds that pack themselves into place without shaking plus greener options that ease environmental harm. Getting strength and long-life right means watching how ingredients mix, nothing more. Precision keeps everything standing.

History of Concrete

Thousands of years have seen people pouring concrete into shapes. Back then, Egyptians mixed mud with straw just to raise walls. Romans took a different path - lime met volcanic ash along with water made something tougher. Their aqueducts stand crooked but unbroken. Domes built long ago hold up under modern skies.Back then, in 1824, a man named Joseph Aspdin cooked up something new - mixing limestone and clay under heat to create what we now call Ordinary Portland Cement. That moment shifted how buildings would be made from that point on. Fast forward a bit, builders started slipping steel bars into the mix, turning regular concrete into a stronger version able to handle stretching forces. Right now, fresh ideas and different ingredients keep nudging concrete further, changing it piece by piece.

Cement and What It Contains

A dusty grey substance, Ordinary Portland Cement sticks things together in buildings. When limestone is mixed with clay, fire turns them into lumps called clinker. After cooling, these chunks get crushed. A touch of gypsum joins during grinding to slow drying once mixed with water. The main chemical components of cement include:

1. Lime (CaO)
2. Silica (SiO_2)
3. Alumina (Al_2O_3)
4. Iron Oxide (Fe_2O_3)

Hardening happens because of these chemicals inside. Once mixed with water, it turns into a sticky paste that holds bits of stone or sand in place. Over days, what was once wet becomes solid through slow changes deep within.

How Cement Sets and Gets Strong

Concrete goes through two key changes. One, it stops being workable - that's setting. Strength builds later, which is hardening. Not at once does this happen; time shapes both. What begins soft gains firmness slowly. One kind of setting time happens quickly. Another shows up only after a while. Each behaves differently depending on conditions around it Stiffening kicks off after a while once the cement mix is prepared. That delay marks its initial setting period. Plasticity fades fully - this marks the endpoint. How long it takes? That duration defines the finish. Days pass while the mix grows tougher, slowly building up its power. Concrete gains firmness as time moves on, each hour adding a bit more resistance.

Chemical Reaction in Cement

1. When water is added to cement:
2. Certain compounds mixed with water
3. calcium silicate hydrate forms
4. Heat is released (heat of hydration)
5. Strength develops gradually

Physical Properties of Cement

Fineness

How fine the material is changed by how fast it reacts with water. Tiny bits build stronger results at first yet bring higher temperatures along.

Consistency

Water needed for a normal cement mix sits around 26% to 33%. This figure shifts slightly depending on the type used.

Setting Time

Thirty minutes is the shortest allowed start period; beyond that, completion must happen within ten hours. Though it begins slowly, the full process cannot stretch past ten hours. Not before thirty minutes will it begin to set, yet ten hours marks the longest it can take. Starting too soon won't work - ten hours total remain the outer edge. The first change takes at least half an hour, while the last shift wraps by the tenth hour.

Soundness

Once hardened, cement must stay stable - excess swelling breaks structure. Expansion risks crack formation if material shifts post-set. Stability matters most when mixture locks into place. A solid base refuses to grow outward unpredictably. Fixed shape means no unwanted growth follows hardening.

Compressive Strength

What keeps cement from breaking under pressure defines its strength. When it holds up well, it tends to last longer too.

Sludge in Concrete

From sewage and water treatment facilities, plus industrial sites, comes sludge - a leftover byproduct. This stuff creates big challenges when it's time to get rid of it. One way to ease the burden: mix it into concrete instead of some sand. Out goes part of the fine aggregate, in goes the sludge - less waste, same structure.

After drying, sludge goes through treatment that strips out water and unwanted materials. Next comes blending - cement joins in, along with chunks of rock, sand, and liquid. Ratios shift sometimes just a small slice gets swapped, maybe five percent; other times it climbs up to everything. One part fades out while another steps forward, step by step.

Using sludge helps in:

Reducing environmental pollution Saving

natural sand resources

Improving sustainability in construction

When mixed in small amounts, sludge helps the material flow more easily while closing gaps among coarse pieces, leading to tighter packing. Too much of it, though, tends to weaken the mix because too many tiny grains get in the way.

Benefits of Sludge Use

1. Reduces environmental pollution by reusing waste material
2. Fewer resources pulled from rivers when natural sand sees less demand
3. Low-cost and easily available material
4. Improves workability of concrete
5. Filling gaps comes first, then tightens the structure overall. Density grows once empty spaces disappear completely
6. Supports eco-friendly construction
7. Helps in waste management

Problems With Using Sludge

Fewer materials present means less resistance to squeezing forces

1. May contain harmful impurities
2. Increasing water demand
3. Misuse cuts how long it lasts. When handled wrong, wear happens faster. Lasts shorter when rules get ignored. Breakdown speeds up without care. Survival drops if treated poorly
4. Properties vary depending on source
5. May affect setting time
6. Requires proper treatment before use

Study Goals

The main objectives of this study are:

1. To evaluate the feasibility of using sludge in concrete
2. To determine the optimum replacement percentage
3. To study the workability of fresh concrete
4. To analyze strength properties of hardened concrete
5. To promote sustainable construction practices

Scope of the Study

Every day, urban areas produce tons of sludge, making it tough to get rid of safely. Because of this, researchers investigated swapping some sand in concrete with sludge instead. Doing so might lower harm to nature while keeping structures strong.

The idea isn't about replacing everything - just part of the mix.

From a wastewater facility, sludge was gathered, left to dry, then passed through a sieve prior to testing. Various amounts - none, half a tenth, one-tenth, three twentieths, one fifth, and full substitution - were examined.

Performance was checked using different methods, like slump and strength measurements taken at 7, 14, 21, and 28 days. Sludge-based concrete stood next to regular concrete in analysis.

One goal stands out: finding if sludge works well in building tasks without losing toughness over time. Strength must stay solid, even when mixed into structures. Durability matters just as much as initial power. A closer look shows promise, yet results depend on how it's applied. Performance shifts are based on material blends nearby. Long-term behavior gives clues about real-world use. Some mixes hold up better under stress. Others weaken faster than expected. Testing reveals patterns hidden at first glance. Success links closely to preparation steps taken early. Each batch tells a different story of stability

Literature Review

Cyr Coutand and Clastres 2016

Looking closely at how sewage sludge behaves physically and chemically when mixed into cement stuff took place. After drying out the sludge, they baked it a bit prior to slipping it into concrete batches. When tiny bits of sludge joined the mix, things packed together better - especially if only a little replaced regular material. Strength might dip though, should too much sludge take over the recipe.

Other Researchers (2016)

Concrete mix tests used treated sewage waste instead of sand. After drying, the material broke down and sifted carefully. Each batch mixed varying amounts into the blend. Water soaked in faster, making pouring a bit harder. Strength stayed acceptable when substitutions stayed under one part in seven. Though flow suffered some, performance held up well at modest levels.

Vouk along with colleagues back in 2017

Concrete tested with sewage sludge ash revealed mixed outcomes. Lower amounts swapped in kept structural power intact, also cutting material dumped in landfills. Testing pointed to 10–15% as a workable range before drops in durability began. Strength started fading once ratios climbed beyond that point.

Rodríguez et al 2018 Sharma & Verma 2018

Sludge, once dried and treated, stepped into the role of sand - just partly though. A bit less smoothness showed up when more sludge joined the mix. Still, squish resistance held strong if only a small amount was added, thanks to tighter grain arrangement. Around 10 to 15 percent seems to be where it works best.

Cheah and Ramli 2019 Rao and Prasad 2019

Concrete mixed with varying amounts of sludge was examined. Workability dropped, yet strength stayed within limits when less sludge replaced cement. Filling gaps inside the material made it denser. As sludge amount climbed, resistance to wear weakened.

Kumar and Sharma 2020 Ramesh and Kumar 2020

Water soaked into the sludge more, which made it a bit harder to mix by hand. Still, when pressed together, the material held its shape well enough if only small amounts were used. Up to one part in ten could safely replace regular ingredients.

Singh and Patel 2021 Ramesh and Kumar 2021

Most tests showed sludge works when swapped for some sand. As more sludge mixed in, the blend got stiffer to handle. Yet strength stayed within limits if only a small amount replaced sand. When too much sludge took sand's place, things started weakening.

Patel and Desai 2022 Zhao et al 2022

Workability dipped just a bit as sludge increased. Still, the material held decent crushing resistance when less was swapped in. Fifteen percent tops seems safe to use.

Reddy and Kumar 2023 Ahmed et al 2023

One thing became clear through their research - particle arrangement got better with sludge, yet mixing grew harder. Good strength appeared only when amounts stayed low; beyond that, it weakened. Higher doses messed up performance even if structure seemed tighter.

Rao and Kumar 2025 Patel et al 2025

Work lately has shown sludge from wastewater works fine when swapped in at around 10 to 15 percent. Go past that, though, performance tends to dip. Strength drops off. Longevity takes a hit too.

Objectives Of the Project

1. Evaluating Sludge Use in Concrete
The main objective of this study is to examine whether sludge can be effective.
Concrete sometimes includes it instead of some sand. That process means looking at how it feels and what it's made of, while also seeing how it affects things around it concrete acts in certain ways. This work looks at if waste mud can change how, it performs when mixed right, concrete holds up over time without cracking too soon.

2. Determine Best Replacement Level

Another important objective is to identify the suitable percentage of sludge Ffr replacement, try values like 0%, then maybe 5% or even 10%. Sometimes 15% work; at times it could be 20% or go all the way to 100%. Finding what fits best is the aim here concrete performs best when it reaches a balance where mixing stays smooth while holding solid structure afterward its quality takes a hit. That's when picking what works best - and won't cause harm - becomes clearer replacement ratio.

3. To Assess How Easy Fresh Concrete Is to Use

One goal here is testing how easily new concrete blends can be shaped. Moving through each mix reveals its flow under pressure. What matters most shows up during placement efforts. Every batch behaves differently when handled right after mixing. Testing focuses on real handling traits seen early. Attention stays on practical performance from start to finish some mixtures hold thick mud. Checking how easily they flow through a slump check, working the concrete well helps it settle right. Good flow means smoother surfaces when done development of strength.

4. Analyzing Strength of Hardened Concrete Concrete's ability to handle pressure becomes clearer through testing. One looks at how mixtures behave reveal their true nature under stress. Strength shows itself when samples face heavy loads. What happens during crushing tells a story about quality. Pressure applied exposes hidden weaknesses. Each batch responds differently to force. Results point toward reliable performance levels
Some samples sat for a week, others two, three, then four weeks. That way we see how time changes things and how sludge affects strength development compared to conventional concrete.

5. Promoting Sustainable Building Methods

The overall objective of this study is to encourage the use of waste materials in
Building things differently now helps cut down on taking sand from nature. This shift also lowers harm to ecosystems around us dirty air makes buildings harder to maintain, so using green methods helps. A recent report backs choosing materials that last without harming nature.

Methodology

In this study, concrete was prepared by partially replacing fine aggregate with sewage sludge fines to evaluate its effect on workability and compressive strength. M25 grade concrete was used, and mixes were prepared with sludge replacement levels of 0%, 5%, 10%, 15%, 20%, and 100%. All materials were properly collected, tested, and proportioned before mixing. The concrete was mixed uniformly and cast into standard cube moulds of size 150 mm × 150 mm × 150 mm. After 24 hours of casting, the specimens were demoulded and cured in water for 7, 14, 21, and 28 days. The workability of fresh concrete was determined using the slump test. Compressive strength tests were conducted using a Compression Testing Machine (CTM) at different curing periods. The results obtained were analyzed to study the performance of sludge as a partial replacement for fine aggregate and to determine the optimum replacement level for achieving desirable strength and durability.

Materials Used

The materials used in this study
Ordinary Portland Cement
Fine Aggregate Natural Sand Coarse
Aggregate Crushed Stone
Sewage Sludge Fines Dried and Sieved Water
Suitable for Mixing and Curing

Ordinary Portland Cement

Standard-grade Ordinary Portland Cement served as the binder here. A common choice, it held everything together reliably. This type stayed consistent across applications. Its role remained central throughout the process. Performance matched expected patterns without surprise Checking the details the cement came from a nearby source, arrived in proper shape, then kept safe under correct storage conditions. Store it somewhere dry so damp does not get in. What holds concrete together is cement. Sticking close during the mix, they gain power as water works its way in. Different trials. Tests like how thick the mix is, when it starts to harden, when it fully sets, also its texture - were carried out to ensure the quality of cement.

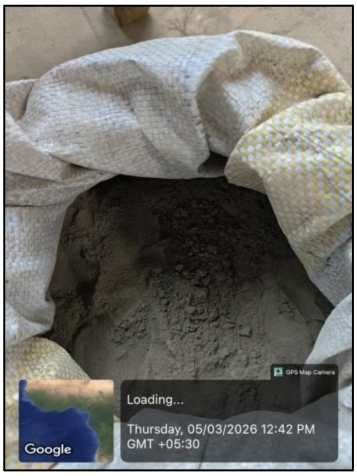

Fig :1 cement

Fine Aggregate

From a local source near the construction site. The material flowed smoothly through sieves during testing. A local source provided it, clear of contaminants like dirt, sand, or plant debris. Starting off, a sieve sorted the sand to clear out bits that didn't belong, making sure only well-sized grains remained. Then again, uneven pieces were left behind so consistency stayed intact through each step. Filling gaps among larger stones? That is where fine gravel steps in. It slips into empty spaces left by bulky bits, doing its part in shaping what comes together. Without it, pockets of emptiness would weaken the whole mix. Each grain plays a role, linking pieces that otherwise stay apart. Stability grows quietly through these tiny connections
Concrete must hold shape while being easy to place. Its toughness comes after hardening fully.

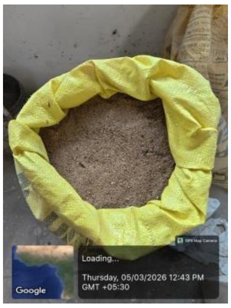

Fig :2 Fine aggregate

Coarse Aggregate

Fine chunks of broken rock, picked by size, went into the mix here. These bits served as the larger particles needed for testing. From a local quarry came the aggregates, washed thoroughly prior to being used. The larger particles stood out clearly. Concrete gets its shape mostly from aggregates. These materials give it toughness while holding everything together. Strength comes through their presence, yet stability depends on how they fit. Each bit plays a role even if unseen. Shape matters just as much as quantity.
Without them, the mix would collapse under pressure. Tiny stones carry weight far beyond their size. Heavy particles lend firmness inside the mix.
Chosen pieces fit by how they sit together - length, outline, bulk guiding each choice strength characteristics.

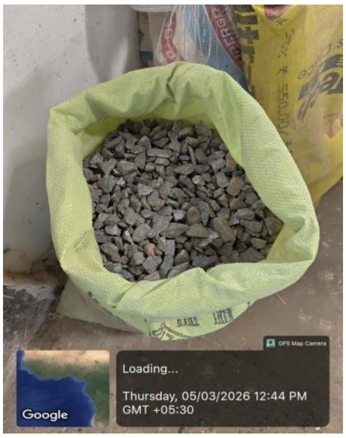

Fig :3 course aggregate

Sewage Sludge

Sewage Sludge Collected from Narava Treatment Plant. Out in the open at STP, Visakhapatnam, the sludge sat drying slowly. Moisture left it piece by piece under sun and wind. What began wet turned firm over days without help from machines. Nature took its time reshaping the muck into something lighter, thinner. Each hour shifted its texture just a little more Water got taken out first. Once dry, pieces broke apart by hand then sifted through a mesh till only small grains stayed behind tiny bits much like real sand. This cleaned waste took the place of small aggregate in different percentages such as 5%,10%,15%,20%, and 100% to study its effect on the properties of concrete.

Fig :4 Sludge

MIX CALCULATION FOR M25 GRADE CONCRETE USING FINE AGGREGATE WITH SLUDGE FINES FOR 1 CUBE

- Quantities were calculated based on standard mix design and converted into weight for laboratory batching .

1. Dry Volume of Concrete

- Dry Volume $= 1 \times 1.54 = 1.54\ m^3$

2. Mix Ratio

Mix ratio: 1: 1: 2

Total parts: $1 + 1 + 2 = 4$

3. Volume of Each Material

Binder Volume

$$\frac{1}{4} \times 1.54 = 0.385\ m^3$$

Fine Aggregate Volume

$$\frac{1}{4} \times 1.54 = 0.385\ m^3$$

Coarse Aggregate Volume

$$\frac{2}{4} \times 1.54 = 0.77\ m^3$$

MIX FOR EACH CUBE

5%MIX

Cement = 1.84kg

Sand= 1.90kg

Sludge = 0.10kg

Coarse aggregate = 4.0kg

10%MIX

Sand= 1.80kg

Sludge = 0.20kg

15%MIX

Sand= 1.70kg

Sludge = 0.30kg

20%MIX

Sand= 1.60kg

Sludge = 0.40kg

100%MIX

Sand= 0kg

Sludge = 2.0kg

MIXING AND BATCHING

Getting concrete right starts with careful measurement and blending. What comes first is weighing out cement sand, gravel, treated sludge, along with water each amount set by the recipe. Precision here makes sure the final product holds up

over time, resisting wear without cracking easily. For this work, a standard M25 mix guided the ratios, nothing adjusted on instinct. Weight-based measurements removed guesswork, keeping every batch consistent. Once gathered, everything combined by hand on a flat surface free of dirt or moisture. The goal: an even mixture, no pockets of dryness or clumping visible throughout.

eventually checked how replacing materials with sludge changed concrete behavior.

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Fig :4 dry mixing

Procedure

After weighing each ingredient - cement, sand, gravel, plus sludge - one by one on a scale, everything dries into the mixer first. A steady blend followed, going till the color looked even throughout. Next came the water, poured in slowly as the machine kept turning. The spinning didn't stop until the goop turned smooth, consistent, ready to pour. Starting with a base mix, sewage sludge took part of the sand's place in varying amounts - none at all, a small bit, up to half, even fully swapped in some cases. Once mixed, the material is filled with molds shaped like cubes, ready for testing later on.

Fig :5 Adding of water

Starting off, cement blended with sand, gravel, and sludge through thorough dry stirring till the shade looked even throughout. After that, liquid trickled in slowly as blending carried on without pause, forming a smooth, ready-to-use mixture. Once set up, the blend poured into molds making cubes - these pieces

Fig :6 Mixing

WORKABILITY TEST

A test began by placing a steel cone - 300 millimeters tall, 200 at the base, narrowing to 100 at the top - onto a flat metal plate. Instead of filling it all at once, workers added fresh concrete in three separates
portions, each one roughly the same size. For every section poured, someone used a straight metal rod, exactly 16 millimeters thick, delivering 25 firm taps to press down the material. Once full, they scraped off excess, so the top sat perfectly even with the rim. Then came the lift: raising the mold slowly upward while leaving the concrete behind. What followed was quiet observation - the distance it sank revealed how soft or stiff the mix truly was. Starting from the top, subtract the height of the settled concrete from the mould's full height to find the slump. When testing M25 mix, if that number lands between 50 and 100 millimetres, it means the mix flows just enough for everyday building jobs.

Fig:6 slump cone test

HARDENED CONCRETE TESTING

1. Once cured, concrete gets tested to check how strong it really is. Strength results show

whether the material can handle heavy loads over time. Performance during these checks reveals how long the structure might last under stress.

2. Concrete cubes made with M25 mix and varying amounts of sludge - 5%, 10%, 15%, 20%, up to 100% - were tested after hardening. Following curing, each cube faced a compression machine's force until it cracked. Strength measurement focused on how much pressure the material held just before breaking apart. Results showed what peak load these modified mixes could endure.
3. A batch of 150 mm cubes served as samples during this trial. Once their time in the curing tank ended, they came out to air-dry briefly. Surface moisture and debris got wiped away before moving forward. Into the compression machine each cube went, ready for evaluation.
4. On top of the CTM's base plate sat the concrete cube, positioned with care to spread the force evenly. Gradually, pressure built - no sudden jolt - as weight increased till collapse came. When the break happened, the highest point of load reached got noted down.

Fig 7: compression testing machine

Table 1 : Slump cone values

Sludge (%)	Slump Value mm
0	140
5	150
10	120
15	80
20	40
100	30

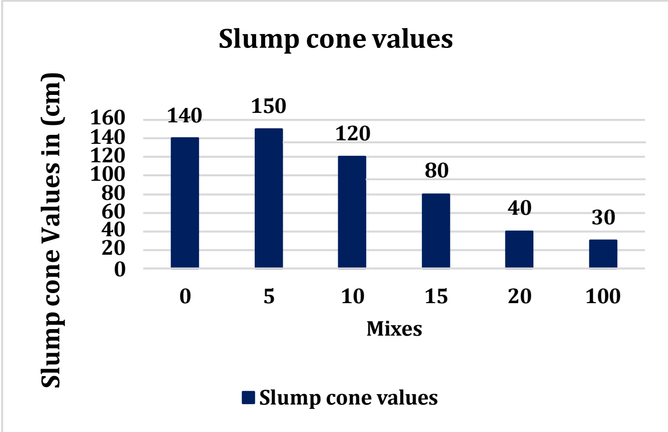

Chart -1 Slump Cone Values

Table 2: Compressive Strength Test and Results

Mix	7 Days	14 Days	21 Days	28 Days
0	12.89MPa	29.04MPa	30.22MPa	32.29MPa
5	22.22MPa	24.89MPa	27.11MPa	30.22MPa
10	23.11MPa	26.22MPa	28.44MPa	32MPa
15	20.44MPa	23.11MPa	25.78MPa	28.89MPa
20	18.67MPa	21.33MPa	24MPa	26.67MPa
100	8.89MPa	11.11MPa	13.33MPa	15.56MPa

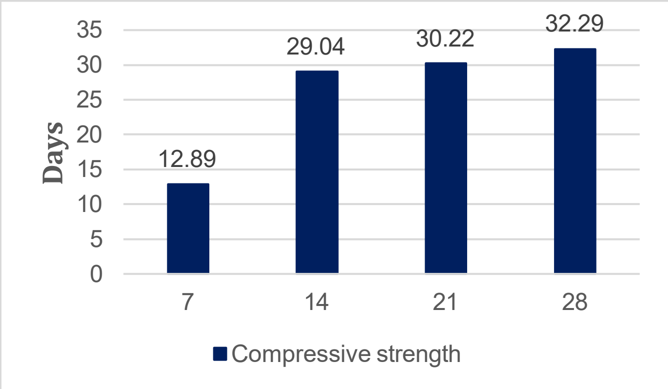

Chart -2 Compressive strength 0f concrete for standard cube

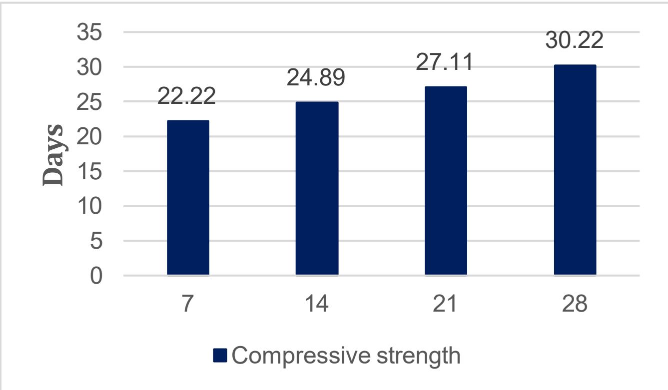

Chart -3 Compressive strength of concrete for 5% sludge replacement

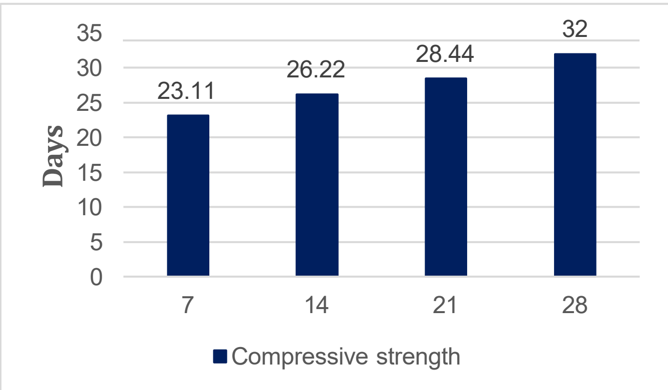

Chart -4 Compressive strength of concrete for 10% sludge replacement

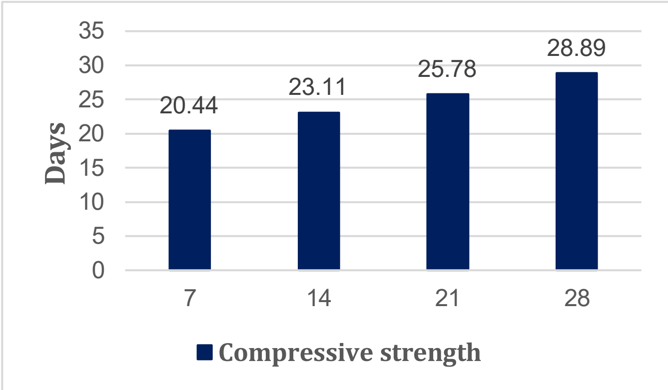

Chart -5 Compressive strength of concrete for 15% sludge replacement

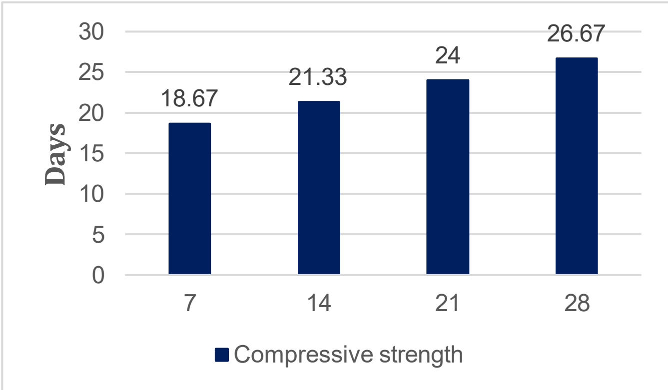

Chart -6 Compressive strength of concrete for 20% sludge replacement

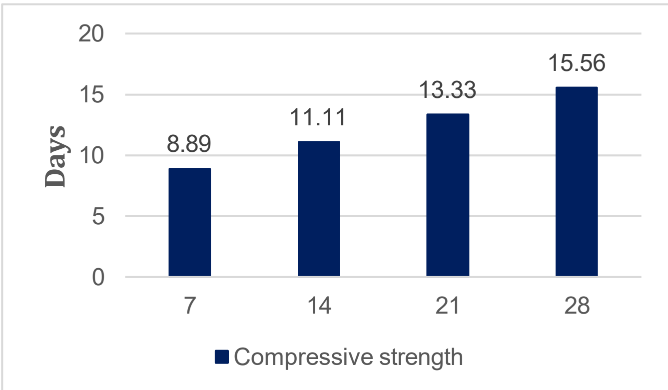

Chart -7 Compressive strength of concrete for 100% sludge replacement

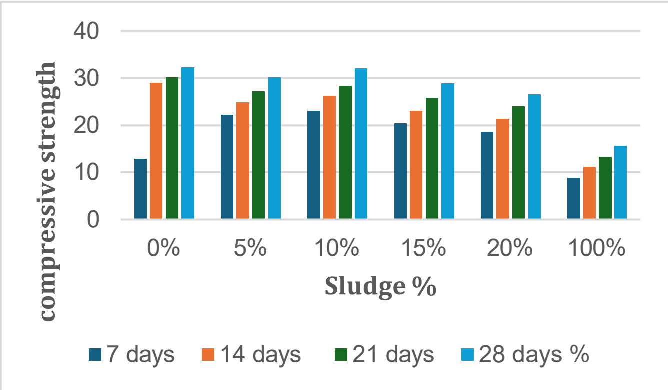

Chart -7 Comparison of compressive strength

Water absorption test results

Table 3 : water absorption results

Sludge %	Dry weight (g)	Wet weight (g)	Water absorption
0%	8200	8282	1.00
5%	8180	8294	1.39
10%	8150	8305	1.90
15%	8120	8315	2.40
20%	8080	8330	3.09
100%	8000	8360	4.50

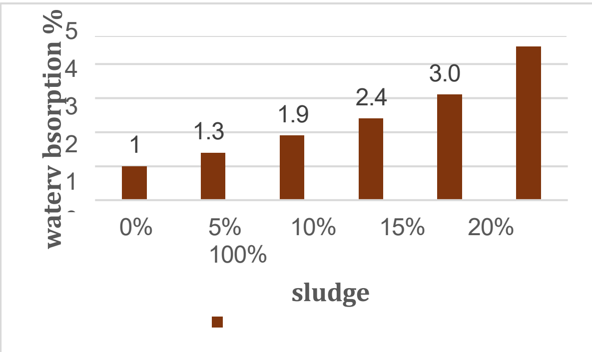

Chart – 8 water absorption vs sludge replacement

Rate Analysis

Rate Analysis is the process of calculating the cost of one unit of work by considering the cost of materials, labour, equipment, transportation, overheads, and contractor's profit.

Purpose of Rate Analysis

1. To determine the unit cost of construction work.
2. To estimate the total cost of a project.
3. To check whether the contractor's quoted rate is reasonable.
4. To prepare detailed estimates and budgets.

Table -4 rate analysis of sludge – based concrete

Material	Rate (₹/kg)
cement	5.50
Fine aggregate	0.40-2.00
Coarse aggregate	0.35-1.5
Sludge	0
Transportation	500

Table -5 comparison between nominal concrete and sludge concrete

Property	Nominal Concrete (0%)	Sludge Concrete
Compressive Strength	Higher strength due to proper bonding	Reduced strength due to weak bonding
Workability	High and easy to mix	Reduced due to water absorption
Water Absorption	Low	High due to porous sludge
Density	Higher (denser)	Slightly lower
Durability	Good long-term performance	Reduced due to porosity
Cost	Higher	Lower
Material	Natural sand used	Sludge replaces sand
Environmental Impact	Depletes natural resources	Eco-friendly & waste utilization

CONCLUSION

From tests done on concrete using sludge fines instead of sand, these outcomes emerged: one idea follows another like steps on a path

1. Concrete moves less freely as more sludge is swapped into the mix. How it flows shifts each time the sludge level climbs.
2. Concrete got stronger over time, no matter the mix used. Strength rose as days passed under curing conditions.
3. Beyond 10 percent substitution, gains leveled off - hinting that tighter clustering of particles initially helped lock things together. Concrete's squeeze resistance rose just a bit when waste filled one-tenth of the mix, thanks to closer contact between components.
4. Porosity grew higher when more sludge was used, which made the material less strong under pressure. The link between particles weakened as substitution levels rose, lowering overall durability.
5. More sludge in the mix meant the concrete soaked up more water, showing it let fluids through easier. A rise in replacement level led to greater uptake across samples.
6. Looking at everything, using 10% sludge instead of regular material works best when making concrete that holds up well and lasts long.

FUTURE STUDY

1. One way to go further? Try swapping in stronger concrete, like M30 or M40. Different mixes might reveal new patterns worth noting.
2. Using tougher blends could shift how results play out. Instead of sticking with basic formulas, stepping up the grade may add clarity. What happens next depends on material choices made early. Heavier-duty options open doors that standard types often block.
3. Checking how well sludge concrete holds up over time might involve testing its resistance to wear, water passage, or bending stress.
4. Some labs run these extra checks just to see what happens under strain, moisture exposure, or repeated load cycles. Results often reveal hidden weaknesses that standard measures miss entirely.
5. Looking closer at how sludge changes concrete's inner structure requires high-end methods.
6. Trying out sludge fines alongside materials like fly ash might work. Silica fume mixed in could change how things turn out. Each addition plays a part somehow.
7. One way to go deeper is by checking how sludge fines in concrete affect nature and cost.
8. Another path looks at what happens when waste material becomes part of building mixtures. It might help to see if cleaner outcomes come with cheaper results.
9. Watching long-term effects could reveal hidden gains or problems. Some answers may show up through testing real-world applications.
10. A closer look at production cycles brings more clarity. Results often depend on where and how materials are sourced. New data tends to shift old assumptions slowly.

REFERENCES

[1] **A. M. Neville**, Properties of Concrete, 5th ed., Pearson Education Limited, London, 2011.

[2] M. S. Shetty, Concrete Technology: Theory and Practice, S. Chand and Company Ltd., New Delhi, 2005.

[3] Bureau of Indian Standards, IS 456:2000 – Plain and Reinforced Concrete – Code of Practice, BIS, New Delhi, India.

[4] Bureau of Indian Standards, IS 10262:2019 – Concrete Mix Proportioning – Guidelines, BIS, New Delhi, India.

[5] Bureau of Indian Standards, IS 383:2016 – Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, BIS, New Delhi, India.

[6] J. H. Tay and K. Y. Show, "Reuse of wastewater sludge in concrete construction," Journal of Environmental Engineering, vol. 123, no. 8, pp. 798–803, 1997.

[7] C. S. Poon and D. Chan, "Feasible use of sewage sludge ash in cement-based materials," Waste Management, vol. 26, pp. 675–680, 2006.

[8] X. Chen and D. Lin, "Experimental study on utilization of sewage sludge in concrete," Construction and Building Materials, vol. 23, pp. 245–251, 2009.

[9] **M. Cyr, M. Coutand, and P. Clastres**, "Technological and environmental behavior of sewage sludge ash in cement-based materials," Cement and Concrete Research, vol. 37, pp. 1278– 1289, 2007.

[10] D. Vouk, D. Nakic, and I. Stirmer, "Use of sewage sludge in concrete industry," Tehnicki Vjesnik, vol. 24, no. 5, pp. 1405–1412, 2017.

[11] N. H. Rodriguez, M. J. Coello, and J. M. Ortega, "Reuse of sewage sludge in construction materials," Construction and Building Materials, vol. 169, pp. 178–186, 2018.

[12] S. Verma, "Utilization of waste materials in concrete," International Journal of Engineering Research, vol. 7, no. 4, pp. 45–50, 2018.

[13] C. B. Cheah and M. Ramli, "The implementation of sewage sludge ash in concrete," Journal of Cleaner Production, vol. 227, pp. 1079–1090, 2019.

[14] P. Rao and K. Prasad, "Sustainable use of industrial waste in concrete," Materials Today: Proceedings, vol. 19, pp. 345–350, 2019.

[15] S. Kumar and R. Sharma, "Strength properties of sludge-based concrete," International Journal of Civil Engineering, vol. 10, no. 3, pp. 210–215, 2020.

[16] M. Ramesh, "Experimental study on partial replacement of sand with sludge," International Research Journal of Engineering and Technology, vol. 7, no. 6, pp. 1200–1205, 2020.

[17] A. Singh and R. Patel, "Use of waste materials in concrete for sustainability," Journal of Construction Engineering, vol. 5, no. 2, pp. 88–95, 2021.

[18] K. Ramesh and P. Kumar, "Performance of sewage sludge in concrete," Materials Science Forum, vol. 1020, pp. 55–60, 2021.