ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

An Experimental Study on Concrete Strength Optimization with Surkhi as an Eco-Friendly Sand Substitute

Milan Kandel[1]; Sandhya Ghimire[2]; Nikita Bhatta[3]; Bijaya Poudel[4]; Isha Adhikari[5]; Aarti Acharya[6]; Ajay Yadav[7]
[1,2,3,4,5,6]Graduate Student, Department of Civil Engineering, Oxford College Of Engineering and Management, Chitwan, Nepal
[7]Research Scholar, Department of Geo-Technical Engineering, Indian Institute of Techonolgy(IIT), Roorkee, Utrakhand, India
*Corresponding Author - Ajay Yadav

Abstract:- Concrete is a widely used construction material, with sand as key component. However, excessive extraction of sand has led to a significant environmental consequences, including erosion, ecological imbalance, habitat destruction, and water quality issues. This study aims to develop an economical and sustainable alternative to traditional sand-based concrete while maintaining its structural integrity. It explores the potential of using Surkhi (a waste product from burnt clay bricks) as a partial replacement of sand in concrete. For this study, 120 concrete cube samples were prepared in the laboratory.Concrete cubes of M20 and M25 grades were prepared using design and nominal mixes, with different proportions of Surkhi (0%, 10%, 20%, 30%, and 40%) and tested to evaluate the workability, cost-effectiveness, and compressive strength. Compressive strength tests were conducted on concrete cubes at 7 and 28 days to investigate their mechanical properties. The results shows that a 10% replacement of sand with Surkhi optimizes the strength and workability of concrete without compromising its performance, thus supporting sustainable construction practices. However, the negative impact in concrete strength due to addition of higher proportions of Surkhi should be carefully considered. Furthermore, a cost analysis indicates that replacing sand with Surkhi can help to reduce the production costs, while promoting its use as an eco-friendly alternative. The findings provides valuable insights into the potential of Surkhi to reduce environmental damage and costs without compromising performance at moderate replacement levels. However, further research is recommended to assess the long-term durability and structural integrity of Surkhi-based concrete in various applications.

***Keywords:-** Sustainable Concrete, Eco Friendly Concrete, Surkhi Concrete, Waste material utilization, Cost Effective Concrete, Sand Replacement.*

➢ ***Nomenclature***

- **CA: Coarse Aggregate**
- **FA: Fine Aggregate**
- **NA: Natural Aggregate**
- **RFA: Recycled Fine Aggregate**
- **OPC: Ordinary Portland Cement**
- **W/C: Water Cement Ratio**
- **IS: Indian Standard**
- **°C: Degree Celsius**

I. INTRODUCTION

Concrete is the most common and widely used construction material globally, with sand being it's one of the key ingredients. The sand is usually sourced from pits and river beds, which can lead to an environmental issues such as erosion, degradation of aquatic habitats, and more importantly causes ecological imbalance. To address these concerns, the use of Surkhi, waste product from the crushed burnt clay bricks, might be the better alternative for making concrete. The sand can be replaced partially with Surkhi from which we can reduce not only the environmental impact but also can utilize the locally available materials and waste products from the brick industry, which helps in promoting the sustainable construction practices. However, the issue of pollution from the brick industry will be still in existence, which could be the different topic of study. The aim of this study is to develop environment friendly and cost-effective concrete by replacing a portion of sand with Surkhi. The approach of replacing the sand with surkhi not only helps to conserve the natural sand resources but also offers the sustainable solution to the waste disposal problem of the brick industry, where waste from brick industry usually ends up by polluting air, land, and water.

Fig 1: Brick Sample to Prepare Surkhi


Fig 2: Surkhi

The primary aim of this study is to address the challenges related to the scarcity and high cost of sand while promoting sustainability and reducing the environmental impact. Surkhi could be used as a partial alternative of sand as it offers dual benefits of being cost effective and environmental sustainability, as it recycles waste brick material. This study explored the five different replacement levels of sand with surkhi (0%, 10%, 20%, 30% and 40%). This study compared the effects of Surkhi replacement on both nominal and design mixes, unlike previous studies, for M20 and M25 grade concrete. The compressive strength of concrete was measured as a basis for investigating the optimum content of surkhi that could be replaced with sand in concrete. The experimental study was conducted on various replacement levels (0% to 40%) at 7 and 28 days. The concrete mixes underwent workability and compressive strength tests, revealing that 10% replacement level optimally enhanced the strength and workability of concrete maintaining its strength. This study provides the valuable insights regarding the possibility of replacing the sand with Surkhi, emphasizing the importance of proper material proportion to optimize the Surkhi content maintaining the performance. The overall concrete performance could be enhanced by adding the admixtures, which shall be the part of the future study.

Numerous studies have demonstrated that partially replacing natural sand with Surkhi or recycled fine aggregates like brick powder can significantly enhance concrete's compressive strength and durability while addressing environmental concerns. Dong Le Van et al. (2023) showed that using recycled fine aggregate (RFA), specifically brick powder, in concrete grades M10, M20 and M25 increased compressive strength, although workability and density declined with higher RFA content. Similarly, Kousar Ahmed et al. (2022) found that optimal compressive strength was achieved at a 20% replacement level of crushed brick, though workability decreased as the replacement level increased. G.G. Nivetha et al. (2022) observed that a combination of 10% brick dust and 20% ceramic waste provided the best compressive strength and improved workability.

Further research supports these findings. Zamir Irfan et al. (2020-2021) examined replacing sand with Surkhi in various proportions, finding that compressive strength improved significantly at 28 days, particularly with the addition of the FOSROC 440 admixture. Ali & Alam (2019) reviewed several studies that confirmed recycled materials like brick dust can improve compressive and tensile strength, though some reduction in workability and flexural strength was noted. Sruthi et al. (2018) focused on M20 concrete and found that a 40% Surkhi replacement offered the highest compressive strength, making it a viable and eco-friendly alternative.

Other studies reinforce the benefits of using Surkhi and brick aggregates. Bibekkumar Kushwaha et al. (2017) reported that high-strength concrete with 100% Surkhi replacement showed excellent compressive strength and performance. Jan Wakeel (2017) highlighted that bricks made with Surkhi had lower water absorption and higher compressive strength compared to conventional bricks. S. Keerthinarayana and R. Srinivasan (2010) demonstrated that up to 25% replacement with crushed brick in concrete yielded maximum strength, and gop & Dey (n.d.) found that up to 40% replacement of river sand with crushed brick grit improved concrete performance and compressive strength by 28.40%.

A. Statement of Problem

The development in construction field leads to the high consumption of natural fine aggregate and at the same time the production of brick powder and demolitions waste brick is also very high. To fulfill the high demand of fine aggregate in construction industry it should be extracted from natural resources this cause the ecological imbalance thus, partial replacement of sand is vital in construction industries. Surkhi can be the best replacement of sand that should satisfy technical requisites of fine aggregate as well as it should be available locally in large amount and waste generated from brick kilns consumes the large space to dispose, so it can be crushed into powder form and can replace fine aggregate in concrete.

B. Objectives of Study

- To determine optimal percentage of surkhi that can replace sand while maintaining the required strength and durability.
- To study and compare the performance of conventional concrete with concrete partially replaced with surkhi.

C. Scope of Study

- Evaluating the performance of Surkhi added concrete in comparison to conventional concrete.
- Exploring the different replacement levels of sand with surkhi to determine the optimum mix proportions for different grades of concrete.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

II. MATERIALS AND METHODOLOGY

A. Material

Concrete is a material composed of aggregate bonded together with cement and sand. It is the second most used substance in the world after water, and is the most widely used in construction industries. Concrete typically contains the following materials.

- *Cement:*

Cement is the main components of concrete mix which acts as a binder and provide the strength to the concrete. For this project Sagarmatha cement of 43 grade OPC cement was used.

- *Fine Aggregate:*

Sand from Narayani River was used as a filler in concrete mix. It was clean and free from any types of dust, clay and chemicals.

- *Coarse Aggregate:*

Coarse aggregate is the main components of concrete for the strength of the concrete. So, enough precaution was took on choosing the best coarse aggregate for the best results of our project. The coarse aggregate used was passed from 20mm sieve and was dry, clean and of irregular shape with required properties of good aggregates like abrasive strength, impact strength etc. For this project, crushed aggregate from the Narayani River was used.

- *Water:*

For concrete to have adequate strength, the right ratio of water to cement was maintained. Concrete was made with pure, clean water that is devoid of silt, salts, and any organic material. Water is necessary both to activate cement's hydration during mixing and to stop moisture loss during curing. Potable water was used for mixing and curing.

- *Surkhi*

Surkhi is a crushed powder of a burnt clay brick. It was crushed into powder using hammer and sieved through 4.75mm IS: Sieve.

B. Methodology

To meet the study's objectives, a clear methodology is essential. The approach is summarized in a flow chart for clarity and ease of understanding shown in Fig.7. The methodology for incorporating waste brick powder as a partial replacement for sand in concrete involves several key steps. Initially, waste brick samples are collected from sources like construction sites and recycling centres, ensuring the bricks are clean and free from organic material. After cleaning and oven drying the bricks, they are crushed into a fine powder using a manual method with a metal hammer. The crushed brick powder is then passed through a 4.75 mm sieve to achieve the desired particle size, and the sieved material is stored in a dry, labelled container. Concrete mixes are then prepared with varying proportions of brick powder (10%, 20%, 30%, and 40%) replacing sand, following standard guidelines to ensure proper design.

Fig 3: Waste Brick Sample

Fig 4: Oven Drying Sample

Fig 5: Slump Test

Fig 6: Compressive Testing Machine

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

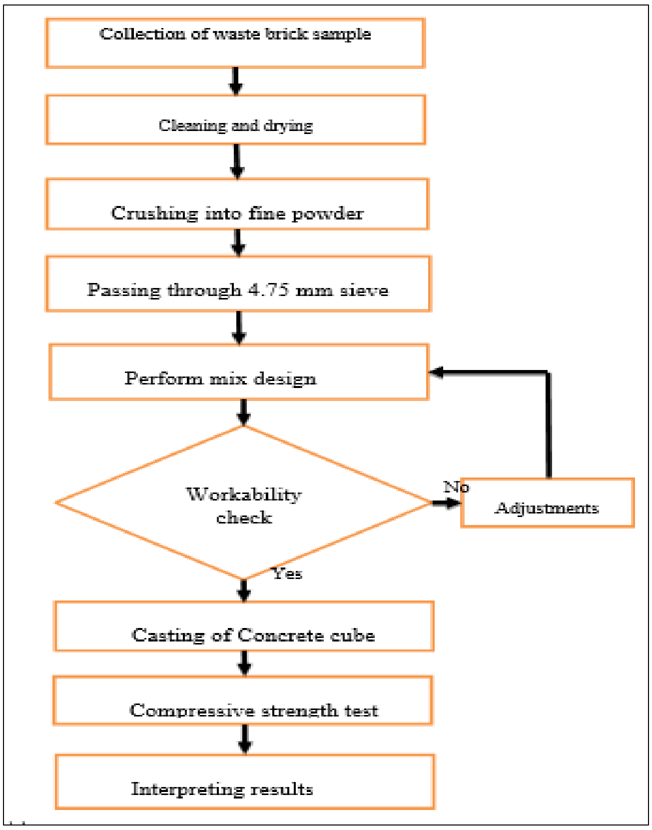


Fig 7: Flow Chat of Methodology

Concrete workability is evaluated using slump tests, with water content adjusted for desired consistency. Optimal mixes are then cast into cubes, compacted, and cured before undergoing compressive strength tests. These tests involve applying increasing loads to determine the concrete's strength, offering essential data on the effectiveness of brick powder as a sustainable sand alternative.

C. Mix Design

Mix design involves determining the best proportions of concrete ingredients cement, water, aggregates, and admixtures to achieve desired properties like strength and durability. It ensures that concrete meets structural requirements efficiently and cost-effectively. We have performed the design mix and nominal mix with varying proportions of the Surkhi replacing sand (i.e. 10%, 20%, 30% and 40%). Proper designing of the mix is needed to achieve the desired results. The estimated quantity of different ingredient of concrete is shown in below Tables.

Table 1: Nominal Mix Proportion of M20 Concrete

No of cubes	Quantity				W/C ratio	Moisture correction
	Cement(kg)	Fine aggregate(kg)		Coarse agg.(kg)		
		Sand	Surkhi			
6	8.153	15.28	0 (0%)	28.02	0.5	
6	8.153	13.752	1.528 (10%)	28.02	0.54	0.25%
6	8.153	12.25	3.056 (20%)	28.02	0.58	0.25%
6	8.153	10.72	4.584 (30%)	28.02	0.64	0.25%
6	8.153	9.19	6.112 (40%)	28.02	0.74	

The nominal mix proportions for M20 concrete shown in Table 1, are emphasized on the different percentages of Surkhi used in place of sand. The amount of cement and coarse aggregate for six cubes is 8.153 kg and 28.02 kg, respectively. As the replacement of Surkhi rises from 0% to 40%, the fine aggregate (sand) gradually decreases from 15.28 kg to 9.19 kg. The quantity of Surkhi that correspond range from 0 to 6.112 kilogram. As the Surkhi content climbs, the water-cement (W/C) ratio likewise rises, from 0.5 to 0.74, with a moisture adjustment done at 0.25% for the majority of mixes.

Table 2: Nominal Mix Proportion of M25 Concrete

No of cubes	Quantity				W/C Ratio	Moisture correction
6	11.21	14.05	0 (0%)	25.72	0.5	0.25%
6	11.21	12.65	1.4 (10%)	25.72	0.45	0.25%
6	11.21	11.25	2.8 (20%)	25.72	0.52	0.25%
6	11.21	9.84	4.2 (30%)	25.72	0.55	0.25%

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

6	11.21	8.4	5.62 (40%)	25.72	0.59	0.25%

The nominal mix proportions for concrete shown in the Table 2, with six cubes represents each mix. The weight of the coarse aggregate is 25.72 kg and the cement is 11.21 kg. With Surkhi levels ranging from 0 to 5.62 kg, the amount of sand reduces from 14.05 kg to 8.4 kg while the substitution of Surkhi rises from 0% to 40%. The water-to-cement (W/C) ratio ranges from 0.5 to 0.59, with a constant 0.25% moisture adjustment.

Table 3: Weight Calculation of Cubes for M20 Mix Design

Items	**Weight (kg)**		
	3 cubes	**6 cubes**	**9 cubes**
Cement	320*0.01265625 =4.050	320*0.0253125 =8.100	320*0.03796875 =12.150
Water	160*0.01265625 =2.025	160*0.0253125 =4.050	160*0.03796875 =6.075
C.A	1214.094 *0.01265625 =15.365	1214.094 *0.0253125 =30.731	1214.094 *0.03796875 =46.097
F.A	782.81*0.01265625 =9.907	782.81*0.0253125 =19.814	782.81*0.03796875 =29.722

Table 4: Weight of Each Batch of M20 Mix Design

	Quantity				**W/C ratio**	**Moisture correction**
	Cement(kg)	**Fine aggregate(kg)**		**Coarse agg.(kg)**		
		Sand	**Surkhi**			
6	8.083	19.83	0(0%)	30.69	0.5	
6	8.083	17.86	1.98(10%)	30.69	0.5	0.25%
6	8.083	15.84	3.96(30%)	30.69	0.58	
6	8.083	13.86	5.94(30%)	30.69	0.68	
6	8.083	11.91	7.92(40%)	30.69	0.77	0.25%

The above table illustrates the mix proportions for concrete with six cubes in each mix. At 8.083 kg and 30.69 kg, respectively, cement and coarse aggregate are consistently measured. When the content of Surkhi rises from 0% to 40%, the amount of Sand reduces from 19.83 kg to 11.91 kg, while the amount of Surkhi varies from 0 kg to 7.92 kg. When 0.25% moisture adjustment is done at 10% and 40% Surkhi replacement, the water-cement (W/C) ratio rises from 0.5 to 0.77.

Table 5: Weight calculation of cube for M25 Mix design

Items	**Weight (kg)**		
	3 cubes	**6 cubes**	**9 cubes**
Cement	380*0.01265625 =4.80	380*0.0253125 =9.61	380*0.03796875 =14.42
Water	190*0.01265625 =2.40	190*0.0253125 =4.80	190*0.03796875 =7.21
C.A	1133.30*0.01265625 =11.343	1133.30*0.0253125 =28.68	1133.30*0.03796875 =43.02
F.A	730.72*0.01265625 =9.248	730.72*0.0253125 =18.496	730.72*0.03796875 =27.744

Table 6: Weight of Each Batch of M25 Mix Design

No of Cubes	**Quantity**	**W/C ratio**	**Moisture**

	Cement(kg)	Fine aggregate(kg)		Coarse agg.(kg)		Correction (%)
		Sand	Surkhi			
6	9.61	18.53	- (0%)	28.73	0.45	
6	9.61	16.70	1.85 (10%)	28.73	0.5	0.25%
6	9.61	14.81	3.70 (20%)	28.73	0.69	
6	9.61	12.96	5.55 (30%)	28.73	0.7	
6	9.61	11.11	7.39 (40%)	28.73	0.73	

The table summarizes the concrete mix proportions for six cubes per batch fixed at 9.61 kg for cement and 28.73 kg for coarse aggregate. With a Surkhi composition varying from 0% to 40% and sand weights ranging from 0 to 7.39 kg, the amount of Surkhi drops from 18.53 kg to 11.11 kg. A 0.25% moisture adjustment with 10% Surkhi replacement results in an increase in the water-to-cement (W/C) ratio from 0.45 to 0.73.

III. RESULT AND DISCUSSION

A. Observation and Calculation

In this project, test cubes were used to determine the mechanical strength throughout the predetermined days. For this experiment, cubes were evaluated on days 7 and 28 for every sample, including regular cubes with and without surkhi, as well as at different grade of concrete i.e. M20 and M25. The focus of this project was on evaluating the compressive strength of concrete when sand was partially replaced with surkhi. Concrete cubes were cast with different proportions of surkhi replacing sand and were subjected to compressive strength tests at two critical curing intervals: 7 days and 28 days. These tests were conducted to assess the early strength development and the long-term strength gain of the surkhi-based concrete. The results provided a comparative analysis between the surkhi-modified concrete and the conventional concrete, highlighting the impact of surkhi on the mechanical properties of the concrete over time. The findings from these tests are crucial for determining the viability of surkhi as a sustainable alternative in concrete production.

Detailed tabulated data are listed in Tables.

Table 7: Compressive Strength of M20 Grade Concrete with Varying Proportion of Surkhi (Nominal Mix)

% of Surkhi	Description	7 DAYS				28 DAYS			
		1	2	3	Avg	1	2	3	Avg
0%	Weight (kg)	8.23	8.13	8.23	8.19	8.5	8.45	8.24	8.39
	Load (KN)	560	501	528	530	577	600	770	649
	Compressive strength(N/mm^2)	24.88	22.26	23.46	23.53	25.64	26.66	34.22	28.84
10%	Weight (kg)	8.37	8.37	8.4	8.38	8.52	8.54	8.53	8.53
	Load (KN)	540	650	560	584	640	673	728	681
	Compressive strength(N/mm^2)	24.00	28.88	24.88	25.92	28.44	29.91	32.35	30.23
20%	weight (kg)	8.57	8.27	8.23	8.35	8.44	8.35	8.42	8.40
	Load (KN)	550	450	580	527	701	666	569	646
	Compressive strength(N/mm^2)	24.44	20.00	25.77	23.24	31.15	29.60	25.28	28.67
30%	weight (kg)	8.36	8.28	8.06	8.23	8.34	8.29	8.34	8.32
	Load (KN)	570	450	470	497	636	597	532	589
	Compressive strength(N/mm^2)	25.33	20.00	20.88	22.07	28.66	26.53	23.64	26.27
40%	weight (kg)	8.21	8.09	8.31	8.20	8.26	8.25	8.25	8.25
	Load (KN)	510	440	490	480	550	570	544	555
	Compressive strength(N/mm^2)	22.66	19.55	21.78	21.33	24.44	25.33	24.17	24.64

Table 8: Compressive strength of M20 Grade Concrete with Varying Proportion of Surkhi (Mix Design)

% of Surkhi	Description	7 DAYS				28 DAYS			
		1	2	3	Avg	1	2	3	Avg
0%	Weight (kg)	8.24	8.24	8.34	8.27	8.22	8.26	8.35	8.27
	Load (KN)	712	664	713	697	819	767	819	802
	Compressive strength(N/mm^2)	31.67	29.51	31.68	30.94	36.4	34.04	36.4	35.61
10%	Weight (kg)	8.26	8.37	8.28	8.30	8.60	8.61	8.45	8.55
	Load (KN)	840	880	810	844	1095	901	910	969
	Compressive strength(N/mm^2)	37.33	39.11	36.00	37.47	48.66	40.04	40.44	43.04
20%	weight (kg)	8.35	8.34	8.29	8.32	8.31	8.42	8.48	8.40
	Load (KN)	677	630	664	657	712	678	710	700
	Compressive strength(N/mm^2)	30.08	28.00	29.51	29.43	31.64	30.13	31.55	31.10
30%	weight (kg)	8.32	8.06	8.17	8.18	8.15	8.27	8.26	8.22

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

	Load (KN)	596	570	606	591	615	702	593	637
	Compressive strength(N/mm²)	26.48	25.33	24.41	25.40	27.33	31.21	26.25	28.29
40%	weight (kg)	7.88	8.04	7.85	7.92	8.28	8.21	8.24	8.24
	Load (KN)	556	543	552	550	616	681	631	643
	Compressive strength(N/mm²)	24.71	24.13	24.53	24.45	27.37	30.26	28.40	28.67

Table 9: Compressive Strength of M25 Grade Concrete with Varying Proportion of Surkhi (Nominal Mix)

% of Surkhi	**Description**	**7 DAYS**				**28 DAYS**			
		1	**2**	**3**	**Avg**	**1**	**2**	**3**	**Avg**
0%	Weight (kg)	8.33	8.29	8.21	8.27	8.32	8.43	8.29	8.34
	Load (KN)	579	605	642	609	796	837	781	805
	Compressive strength(N/mm²)	25.73	26.88	28.53	27.04	35.37	37.34	34.71	35.77
10%	Weight (kg)	8.32	8.30	8.46	8.36	8.18	8.38	8.40	8.32
	Load (KN)	697	652	632	660	844	806	788	813
	Compressive strength(N/mm²)	30.97	28.97	28.08	29.34	37.51	35.82	35.02	36.11
20%	weight (kg)	8.12	8.08	8.02	8.07	8.15	8.23	8.07	8.15
	Load (KN)	463	500	530	468	689	725	585	666
	Compressive strength(N/mm²)	20.57	22.22	23.55	22.00	30.62	32.22	26.00	29.61
30%	weight (kg)	7.94	8.05	7.87	7.95	8.14	8.06	7.94	8.04
	Load (KN)	392	403	372	389	544	570	534	549
	Compressive strength(N/mm²)	17.42	17.91	16.53	17.28	24.17	25.33	23.73	24.41
40%	weight (kg)	7.98	7.87	7.89	7.91	7.91	7.99	7.89	7.93
	Load (KN)	457	456	435	450	604	647	556	602
	Compressive strength(N/mm²)	20.31	20.26	19.33	19.96	26.84	28,75	24.71	26.76

Table 10: Compressive Strength of M25 Grade Concrete with Varying Proportion of Surkhi (Mix Design)

% of Surkhi	**Description**	**7 DAYS**				**28 DAYS**			
		1	**2**	**3**	**Avg**	**1**	**2**	**3**	**Avg**
0%	Weight (kg)	8.40	8.31	8.30	8.37	8.54	8.51	8.49	8.51
	Load (KN)	854	787	835	825	738	933	882	851
	Compressive strength(N/mm²)	37.95	34.97	37.11	36.67	32.8	41.46	39.20	37.82
10%	Weight (kg)	7.89	7.98	8.04	7.97	8.04	8.18	8.23	8.15
	Load (KN)	608	655	571	611	804	780	807	797
	Compressive strength(N/mm²)	27.02	29.11	25.37	27.16	35.73	34.66	35.86	35.41
20%	weight (kg)	7.93	8.03	8.01	7.99	8.08	8.22	8.30	8.2
	Load (KN)	624	635	663	641	871	731	891	831
	Compressive strength(N/mm²)	27.73	28.22	29.46	28.48	38.71	32.48	39.6	36.94
30%	weight (kg)	7.83	8.02	7.95	7.93	8.04	7.98	8.08	8.03
	Load (KN)	541	600	475	539	698	719	675	697
	Compressive strength(N/mm²)	24.64	26.66	21.11	23.93	31.02	31.95	30	30.99
40%	weight (kg)	7.91	7.91	7.98	7.93	7.85	7.99	8.00	7.94
	Load (KN)	602	415	471	496	674	628	700	667
	Compressive strength(N/mm²)	26.75	18.44	20.93	22.04	29.95	27.91	31.11	29.65

B. Comparative Analysis of Compressive Strength

➢ *M20 Nominal Mix*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

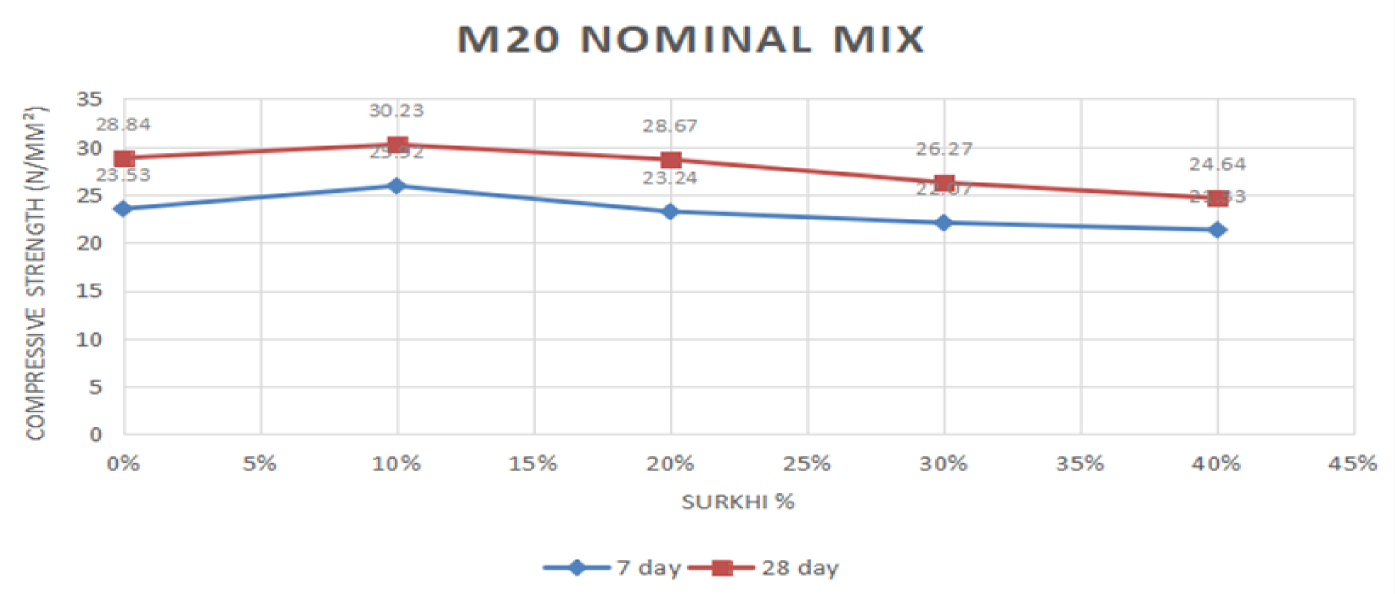


Fig 8: Scatter Chart Showing Initial and Final Strength Of M20 Nominal Mix

The Figure 8 displays a scatter chart of the initial and final compressive strengths of the M20 mix design. It shows an increase in both initial and final compressive strengths at 10% surkhi replacement, with values of 37.47 N/mm² and 43.04 N/mm², respectively. However, as the surkhi content increases beyond this point, the compressive strength follows a decreasing trend.

➢ *M20 Mix Design*

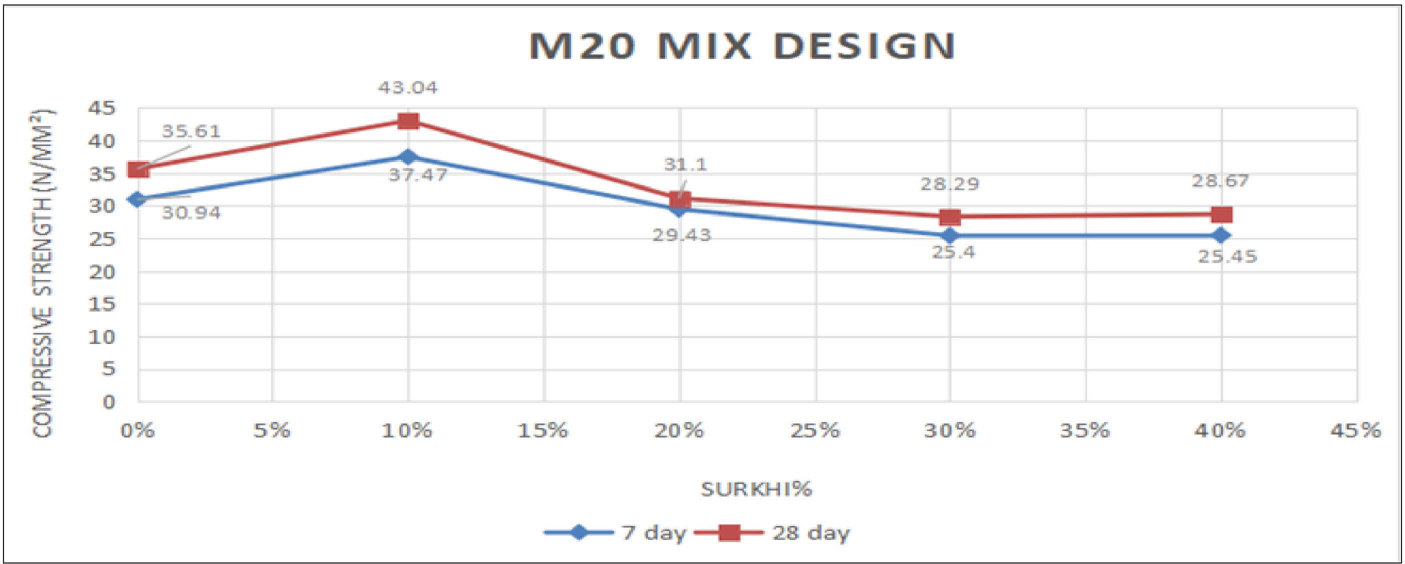


Fig 9: Scatter Chart Showing Initial and Final Strength of M25 Nominal Mix

The Figure 9 displays a scatter chart of the initial and final compressive strengths of the M20 mix design. It shows an increase in both initial and final compressive strengths at 10% surkhi replacement, with values of 37.47 N/mm² and 43.04 N/mm², respectively. However, as the surkhi content increases beyond this point, the compressive strength follows a decreasing trend.

➢ *M25 Nominal Mix*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

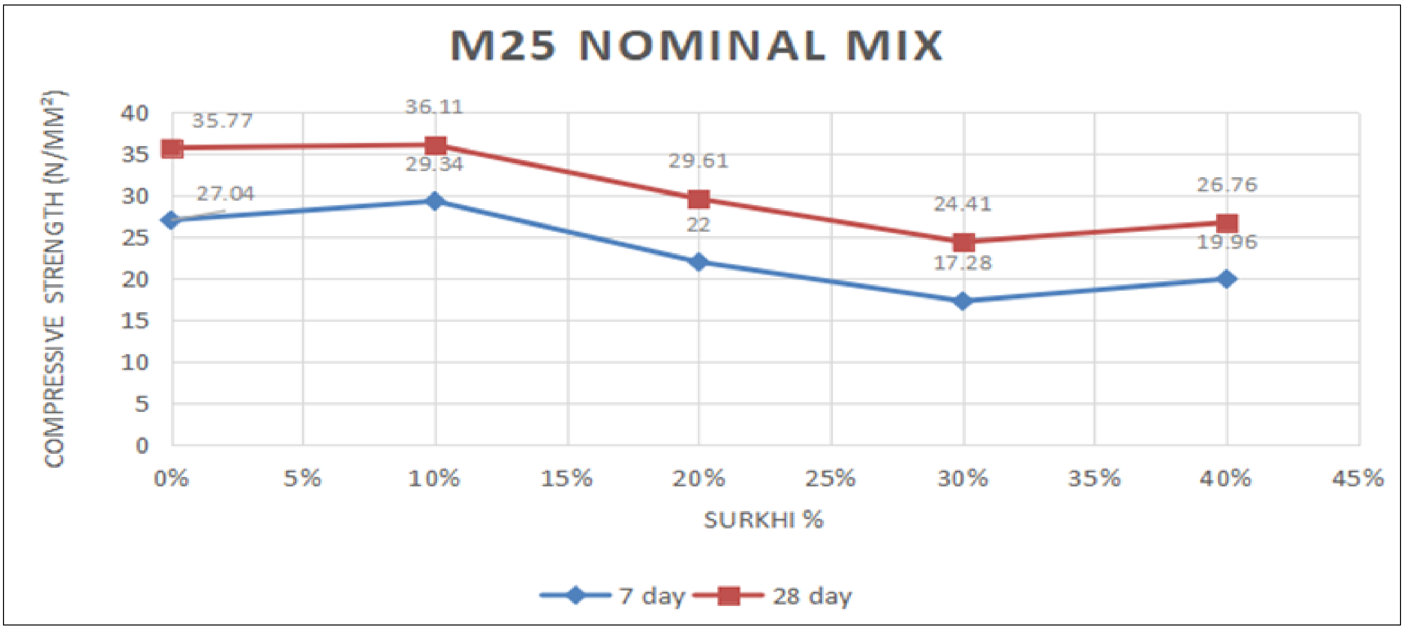


Fig 10: Scatter Chart Showing Initial and Final Strength of M25 Nominal Mix

The above Fgure 10 represents compressive strength of M25 mix design of 7days and 28 days tests. It shows that compressive strength increases at 10% surkhi replacement with sand i.e. 29.34 N/mm² and 36.11 N/mm² of 7 days and 28 days respectively.

➤ *M25 Mix Design*

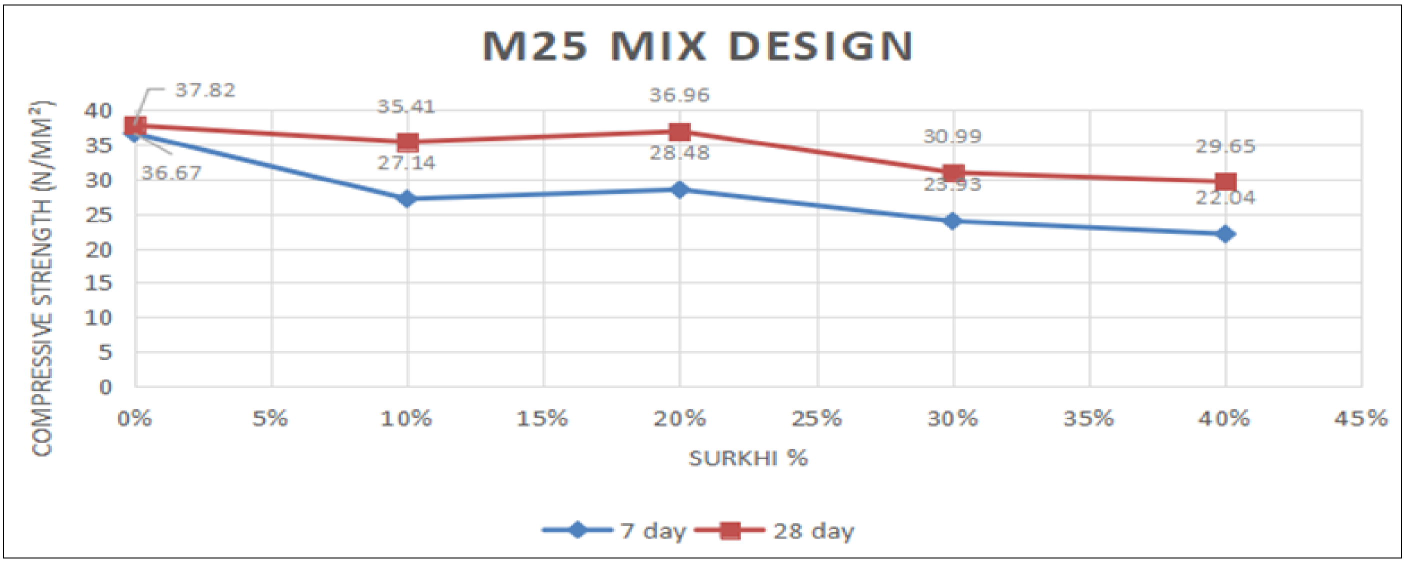


Fig 11: Scatter Chart Showing Initial and Final Strength of M25 Mix Design

Similarly, the scatter Figure 11 of M25 mix design shows exceptional change in compressive strength. It displays the increase in 20% replacement of surkhi content i.e. 28.48 N/mm² and 36.96 N/mm² of 7 days 28 days respectively and continue to decrease after 20% surkhi content.

C. Average weight comparison of Surkhi based concrete

The comparison of weight with varying percentage of surkhi replaced concrete. The trend shows that there is no significant change in weight between 0% and 10%

replacement of Surkhi. However, the weight is slightly increased at 10% surkhi replacement and gradually decreases after further replacement of surkhi. M25 design mix does not follow the trend as weight gets decreasing even in 10% replacement of surkhi and keeps decreasing in further replacement.

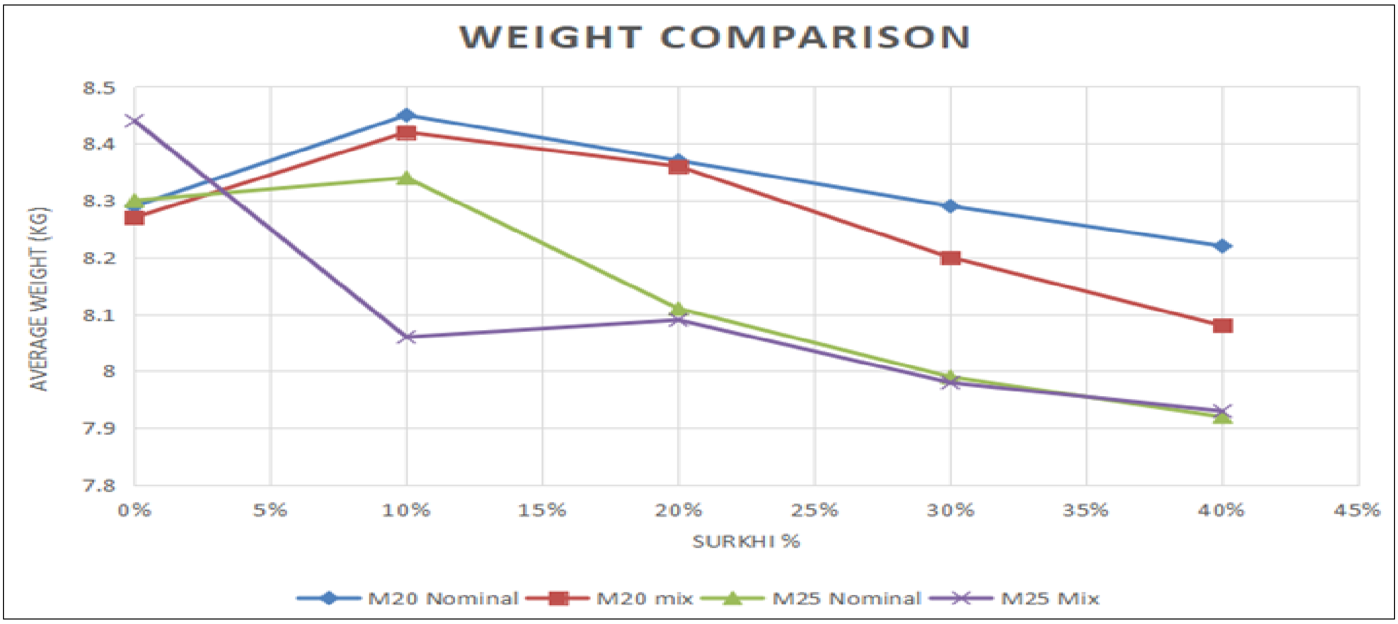


Fig 12: Bar Chart between Average Weights of surkhi Mix Concrete

The Figure 12 shows the trend of weight analysis on different grades which reflects the variation of weight in different percentage of surkhi replacement in concrete (i.e. 10%, 20%, 30% & 40%).

D. Cost Analysis

Cost analysis is performed for comparative evaluation of the market cost for conventional concrete and surkhi based concrete. The following are the market cost of different ingredient used to prepare concrete.

Cement = Rs. 11/ kg, Sand = Rs. 3000/m^3, Coarse Aggregate = Rs. 3700/m^3, and Surkhi = Rs. 2300/m^3

The detailed cost analysis for M20 and M25 grade concrete shows a constant decrease in the total cost of concrete production when 10% of the sand is replaced by Surkhi shown in Figure 13. By using Surkhi, the cost per cubic meter of M20 and M25 grade concrete is reduced for both nominal mix and mix design. This indicates that replacement of 10% sand with Surkhi is somewhat more cost effective for all concrete grades. Although the cost decrease is slight, it implies economic benefit of using Surkhi as a partial replacement of sand which may result in substantial savings on larger projects.

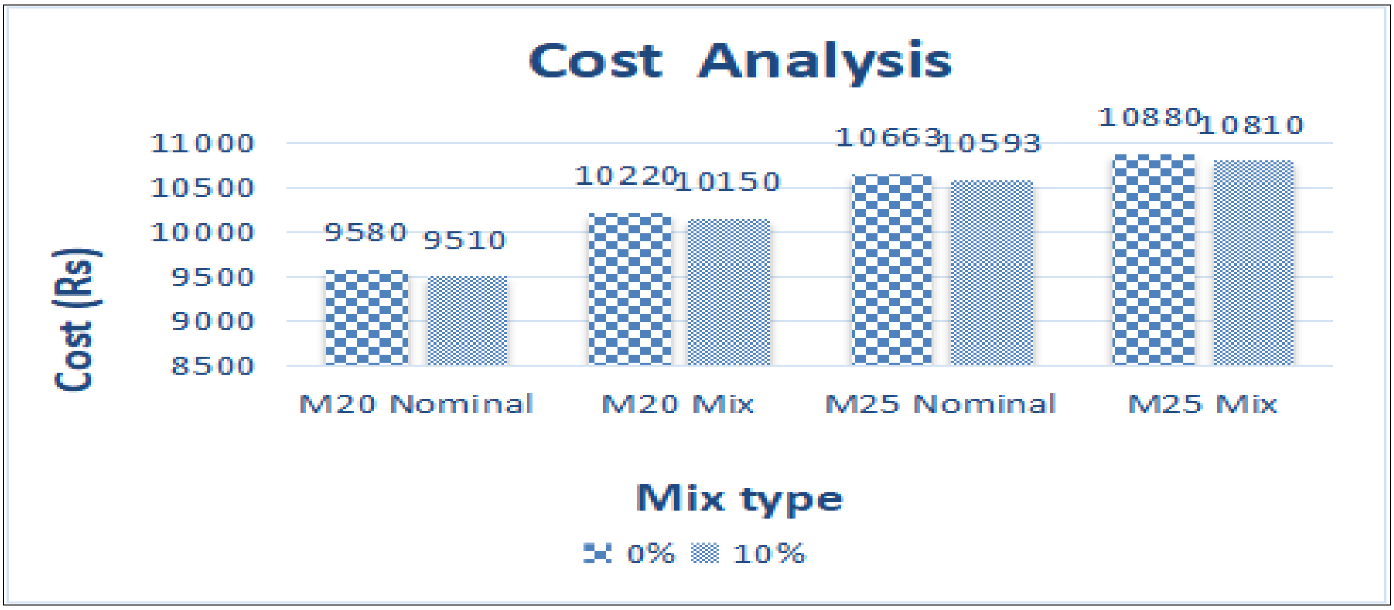


Fig 13: Bar Graph Showing Cost Analysis

Furthermore, Surkhi, produced from waste brick not only supports the economic benefit but also promotes sustainable construction method by recycling materials. Due to the dual advantage of financial benefit and recycling of materials, the 10% replacement of sand by Surkhi in concrete design is more favorable option for both M20 and M25 grades encouraging the use of alternative materials in construction sectors.

The experimental results provide valuable insights into the effect of incorporating Surkhi as a partial replacement of sand in concrete mixes for both M20 and M25 grade concrete, analyzed over 7-day and 28-day curing periods. It is found that, the addition of different percentage of Surkhi positively impacts the compressive strength of concrete up to a certain limit for both mixes of M20 and M25 grade concrete.

Specifically, in Figure 4.2.1 M20 grade concrete with 10% Surkhi showed an average strength increase from 23.53 N/mm² (7 days) and 28.84 N/mm² (28 days) to 25.92 MPa (7 days) and 30.23Mpa (28 days) respectively for the nominal mix, while Figure 4.2.2 shows an increase to 37.47 N/mm² at 7 days and 43.04 N/mm² at 28 days from 30.94 MPa at 7 days and 35.61 MPa at 28 days respectively. Similarly, M25 grade concrete displayed a compressive strength increase with 10% Surkhi, achieving 29.34 N/mm² at 7 days and 36.11 N/mm² at 28 days in the nominal mix as shown in Figure 4.2.3 and 27.16 N/mm² at 7 days and 35.41 N/mm² at 28 days in the mix design from Figure 4.2.4 The trend of increase in initial (7days) and final (28 days) compressive strength is similar for both M20 and M25 grades in both types of concrete mixes. These findings suggest that the inclusion of small proportion of Surkhi (10% of Surkhi) can effectively improve the mechanical properties of concrete, likely due to its role in enhancing bonding and filling voids, thus increasing its density and strength. This improvement can be attributed to Surkhi's fine particle size, which fills voids more effectively and enhances the packing density of the concrete, leading to increased strength. Furthermore, the use of Surkhi can improve the proper placement and compaction of the mix, which in turn enhances its overall mechanical properties.

However, as the proportion of Surkhi increased to 20%, 30%, and 40%, a noticeable decline in compressive strength was observed for both M20 and M25 grade concretes. For instance, M20 grade concrete with 40% Surkhi showed a reduction in strength to 24.45 N/mm² at 7 days and 28.67 N/mm² at 28 days, compared to 30.94 N/mm² and 35.61 N/mm², respectively from figure 4.2.2, for the control mix. A similar trend was noted for M25 grade concrete, where the strength decreased significantly with higher Surkhi content. This decline is likely due to the excessive replacement of sand, leading to insufficient bonding and reduced structural integrity.

The cost analysis reveals that substituting 10% of sand with Surkhi in M20 and M25 grade concrete leads to a consistent decrease in production costs. Although the reduction per cubic meter is slight, the cumulative savings can be significant in larger projects. This demonstrates that using Surkhi as a partial sand replacement is economically beneficial for both nominal mix and mix design, making it a cost-effective choice in concrete production.

These results imply that while Surkhi can serve as an effective partial replacement for sand up to a certain threshold (10% in this study), exceeding this limit compromises the structural integrity of the concrete. The reduction in strength at higher Surkhi percentages could be attributed to a decrease in the cementitious content and the resulting lower bonding quality within the concrete matrix, highlighting the need for careful optimization of Surkhi content to maintain desirable mechanical properties. While low percentages of Surkhi enhance strength and can make concrete production more sustainable, high percentages compromise the material's structural integrity, making them less suitable for structural applications. These results indicate that while Surkhi can be an effective partial sand replacement, exceeding a 10% replacement threshold compromises the mechanical properties of concrete. The findings suggest that excessive use of Surkhi compromises the structural integrity of the concrete, thus highlighting the need for careful optimization of the replacement proportion.

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

This study demonstrates the potential of using Surkhi as a partial replacement of sand in concrete. The experimental analysis shows that incorporating Surkhi into M20 and M25 grade concrete offers both economic and mechanical benefits. Replacing 10% of sand with Surkhi improves compressive strength and reduces production costs, making it a cost-effective and sustainable option. Specifically, M20 concrete with 10% Surkhi exhibited a notable increase in compressive strength, reaching 25.92 MPa at 7 days and 30.23 MPa at 28 days for the nominal mix. Similarly, M25 concrete also demonstrated improved strength with 10% Surkhi, achieving 29.34 MPa at 7 days and 36.11 MPa at 28 days. These enhancements are likely due to Surkhi's fine particle size, which effectively fills voids, enhancing the concrete's density and strength. This highlights Surkhi as a reliable alternative to sand for sustainable concrete production.

However, increasing the proportion of Surkhi beyond 10% (to 20%, 30%, and 40%) resulted a significant decline in compressive strength. For example, M20 concrete with 40% Surkhi experienced a reduction in strength to 24.45 MPa at 7 days and 28.67 MPa at 28 days, indicating that excessive Surkhi compromises the concrete's structural integrity. This decline is attributed to a decrease in cementitious content and weaker bonding within the concrete matrix, indicating a limit to the amount of sand that can be replaced without compromising structural integrity.

In conclusion, while incorporating 10% Surkhi as a sand replacement enhances strength and reduces costs, exceeding this threshold diminishes the material's mechanical properties. Therefore, while Surkhi can effectively improve concrete strength and promote sustainability, its content must be carefully optimized to maintain the structural integrity and durability of the concrete.

B. Recommendations:

To optimize concrete's strength, sustainability, and cost-effectiveness, limit Surkhi to 10%. This balance improves performance and reduces costs while maintaining structural integrity. Combining Surkhi with other materials may offer further enhancements.

Further research should focus on Surkhi's durability, including water resistance and sulphate attack. Using 10% Surkhi-modified concrete in non-critical structures can be a sustainable alternative. For practical use, adjust mix designs to specific project needs and continue research to maximize Surkhi's real-world benefits.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to Oxford College of Engineering and Management for providing materials, laboratory, and equipment support. Likewise, We would likes to Thanks Oxford Builder (OB) for providing the instruments during the project work and Special thanks to Our Professor Dr. Prakash devkota sir and Santosh Bhandari for guidance.

REFERENCES

[1]. Sapkota, S.C., Yadav, A., Khatri, A. et al. Explainable hybridizedensemble machine learning for the prognosis of the compressive strength of recycled plastic-based sustainable concrete with experimental validation. Multiscale and Multidiscip. Model. Exp. and Des. 7, 6073–6096 (2024). https://doi.org/10.1007/s41939-024-00567-4

[2]. Chhetri Sapkota, Sanjog and Dahal, Dipak and Yadav, Ajay and Dhakal, Dipak and Sharma, Ram Kumar and Saini, Gaurav, A Paradigm Shift in Corrosion Inhibition using Botanical Extracts: From Conventional Methods to Advanced Methods for Reinforcing Steel, http://dx.doi.org/10.2139/ssrn.4963462

[3]. Ali, A. &., & Alam, S. (2019). Partial replacement of fine aggregate with brick dust.

[4]. Bibekkumar Kushwaha, L. P. (May 2022). Utilization of Surkhi as a Partial Replacement of Sand in. 106-110.

[5]. Dong Le Van, N. V. (2023). Using Recycled Brick Masonry Aggregate for Partial Replacement of Fine Aggregate of Concrete. Mientrung University of Civil Engineering and Van Lang University.

[6]. G.G Nivetha, M. P. (June 2022). 'Study on Partial Replacement of Fine aggregates with ceramic waste and brick dust in concrete'. IJIRT.

[7]. Gop, M. &., & Dey, G. (. (n.d.). An experimental study on strength and durability of concrete with partial replacement of sand by crushed brick grit.

[8]. Shruthi, H. G., & Harsha, K. M. (2018). A survey on partial replacement of sand with crushed brick powder in concrete. International Journal of Advanced Research in Engineering & Management,, 7026–7030.

[9]. Hemant Basnet, Chudamani Bista, Ajay Yadav, and Umesh Adhikari, A Case Study of Using the Concrete Cover Block in Steel Reinforcement Bar: Ghorahi Dang,Nepal, interantional journal of scientific research in engineering andmanagement(2024). https://doi.org/10.55041/IJSREM38466

[10]. Sapkota, S.C., Saha, P., Das, S. et al. Prediction of the compressive strength of normal concrete using ensemble machine learning approach. Asian J Civ Eng 25, 583–596 (2024). https://doi.org/10.1007/s42107-023-00796-x

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV566

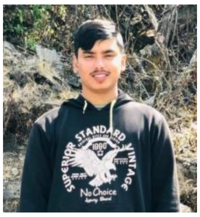
BIOGRAPHIES

Er. Ajay Yadav, a **University topper** and Dean's List honoree, is a dedicated researcher and author of multiple engineering textbooks. Recently, he received a fully funded scholarship through ICCR to pursue an M.Tech in Geotechnical Engineering at **IIT Roorkee**. He was also honored with the prestigious **Geo-Tech Award** during his undergraduate studies.

Er. Milan Kandel is a civil engineer with a passion for research in sustainable construction and infrastructure resilience. He is eager to contribute innovative solutions to contemporary engineering challenges.

Er. Sandhya Ghimire is a Civil Engineer honoured with dean list from Pokhara University.Known for her dedication, sincerity, and enthusiasm, she is a hardworking individual committed to excellence. Her passion for engineering and academic success reflects in bothher work and writing.

Er. Nikita Bhatta holds a degree in Civil Engineering from Oxford college of engineering and management, pokhara university. She is interested in environmental practises with a particular focus on sustainable materials for construction. She aims to make a meaningful impact in the field of Civil Engineering



Er. Bijaya Poudel is a civil engineer, with a particular interest in the design and development of resilient infrastructure. He is committed to advancing civil engineeringthrough sustainable design solutions.

Er. Isha Adhikari is a civil engineer graduated from Oxford College of Engineering and Management, Pokhara University, with a deep interest in structural systems and sustainable development. She strives to address real-world engineering challenges with innovative solutions.

Er. Arati Acharya is a scholarship student and civil engineering graduate from Oxford College of Engineering and Management, Pokhara University. Specializing in sustainable infrastructure and advanced design, she aims to contribute to the field through innovative research and practical applications.