EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 09, Issue 04, pp973-992, December 2022

Finding Alternative to River Sand in Building Construction

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(Received August 13, 2022; Revised December 17, 2022; accepted December 23, 2022).

Abstract: Due to the increasing expansion of infrastructure, there is a very high worldwide demand for river sand in the modern era. India's annual demand for river sand is 60 million metric tons. In metropolitan cities, the need for river sand is about 1 kilogram per person per day. The rapid extraction of river sand is producing detrimental effects on the environment. The main objective of the research is to determine the impact of rapid sand mining on river bank erosion and accretion and to find substitute materials for river sand. The River bank variations were measured for 1990-2000, 2000-2010, 2010-2020, and 1990-2020, and the corresponding erosion and accretion maps were created. These materials (copper slag, quarry dust, foundry sand, and sawdust) are used as an alternative to river sand to produce concrete mix. These alternatives substituted river sand from 10% to 60% in the mix proportion of M25 grade concrete to obtain the optimum compressive strength. These alternatives were also subjected to physical testing to determine their similarities to river sand. A Scanning Electron Microscope was used to analyze the hardened concrete's microstructure. The hardened concrete (River sand Substituted) is also analyzed to determine the changes in the internal structure of the concrete after 14 and 28 days.

Keywords:River Sand, Sand Mining,Erosion, Accretion, Landsat-8, River Bank.

1. Introduction

River sand is the natural resource that is used the second most often, after freshwater[1]. According to the United Nations Environment Programme (UNEP), water, sand, and gravel are the planet's most widely utilized raw resources[2]. The use of river sand in construction dramatically exceeds its natural renewal rates[3]. Many Indian towns and cities are situated on rivers, so the cost of transporting river sand is minimal. River sand demands are very high compared to artificial sand because river sand is also naturally sorted by grain size and is easily accessible[4]. According to the 2018 framework for sand mining, States must investigate their options for River sand after evaluating the demand-supply mismatch[5]. During peak season, an alternative supply source will lessen river sand dependency and demand[6]. River sand costs might be reduced if more alternatives are available, which might help conserve natural resources[7]. The Indian Government also recommends some alternatives, as shown in Fig. 1[5]. Demand for River sand is estimated to be significantly higher in many states of India due to the rapid expansion of infrastructures[8]. Rajasthan is in third place in the consumption of river sand, as shown in Fig. 2. This study found that Quarry Dust imparted excellent properties and strength on the Replacement of 60%. Replacing river sand with another alternative can affect the river sand demand. Minimization of sand demands can also help in the protection of ecological changes and river habitats.

Fig. 1: Alternate options for River sand

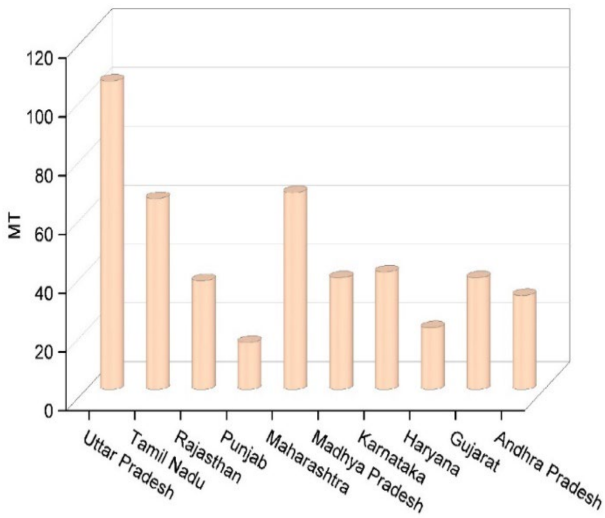
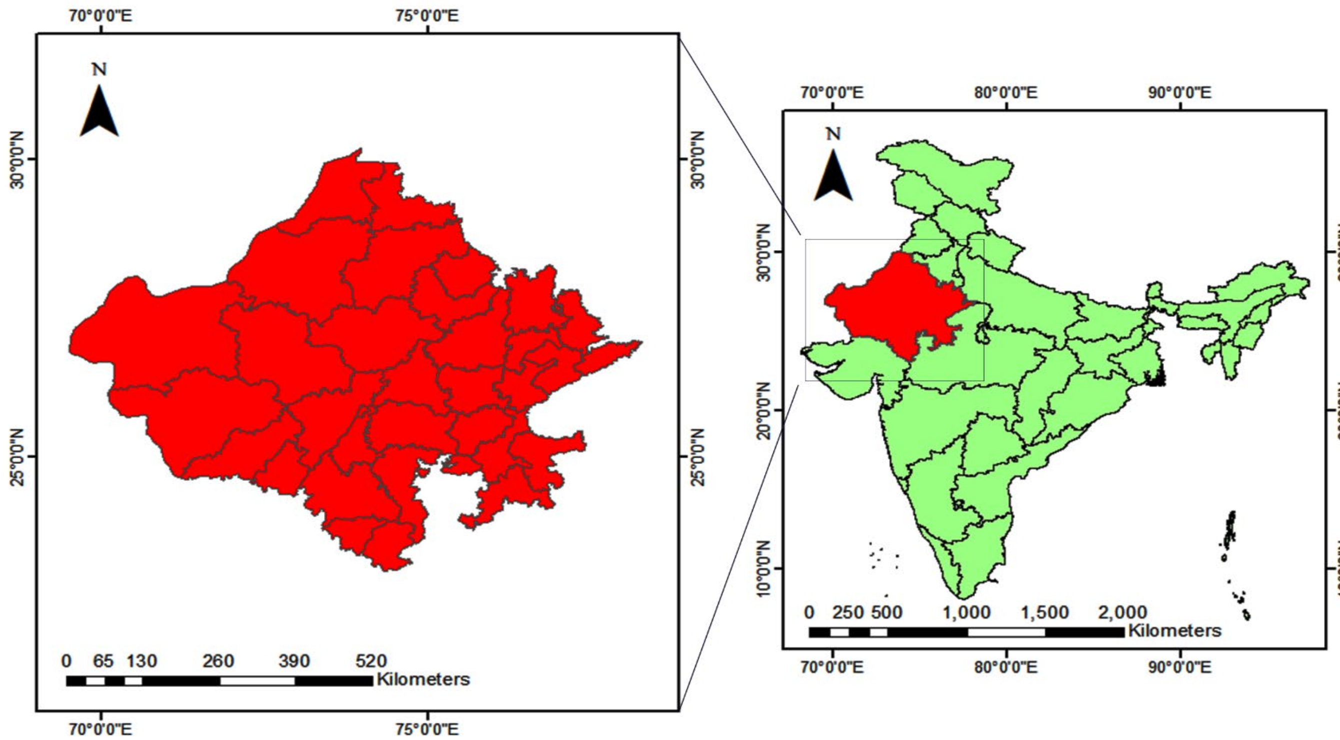


Fig. 2: Estimation of State-wise sand consumption

The research area is the northern Indian river Chambal. It originates in the north and travels south-east across the state of Rajasthan (22°27′N 75°31′E), As shown in study area Fig. 3. After flowing northeast through Kota, it forms part of the border between Rajasthan and Madhya Pradesh and flows into Uttar Pradesh before joining the Yamuna. Their primary tributaries are Banas, Kali Sindh, Sipra, and Parbati rivers. There are many aquatic species, and the Chambal River offers critical habitats for them. In addition to sunbathing, relaxing, and breeding, these animals engage in various other behaviors along the riverbanks. Simultaneously, sand is extracted from these riverbanks. The extensive use of sand mining in their environment directly affects the aquatic life population.



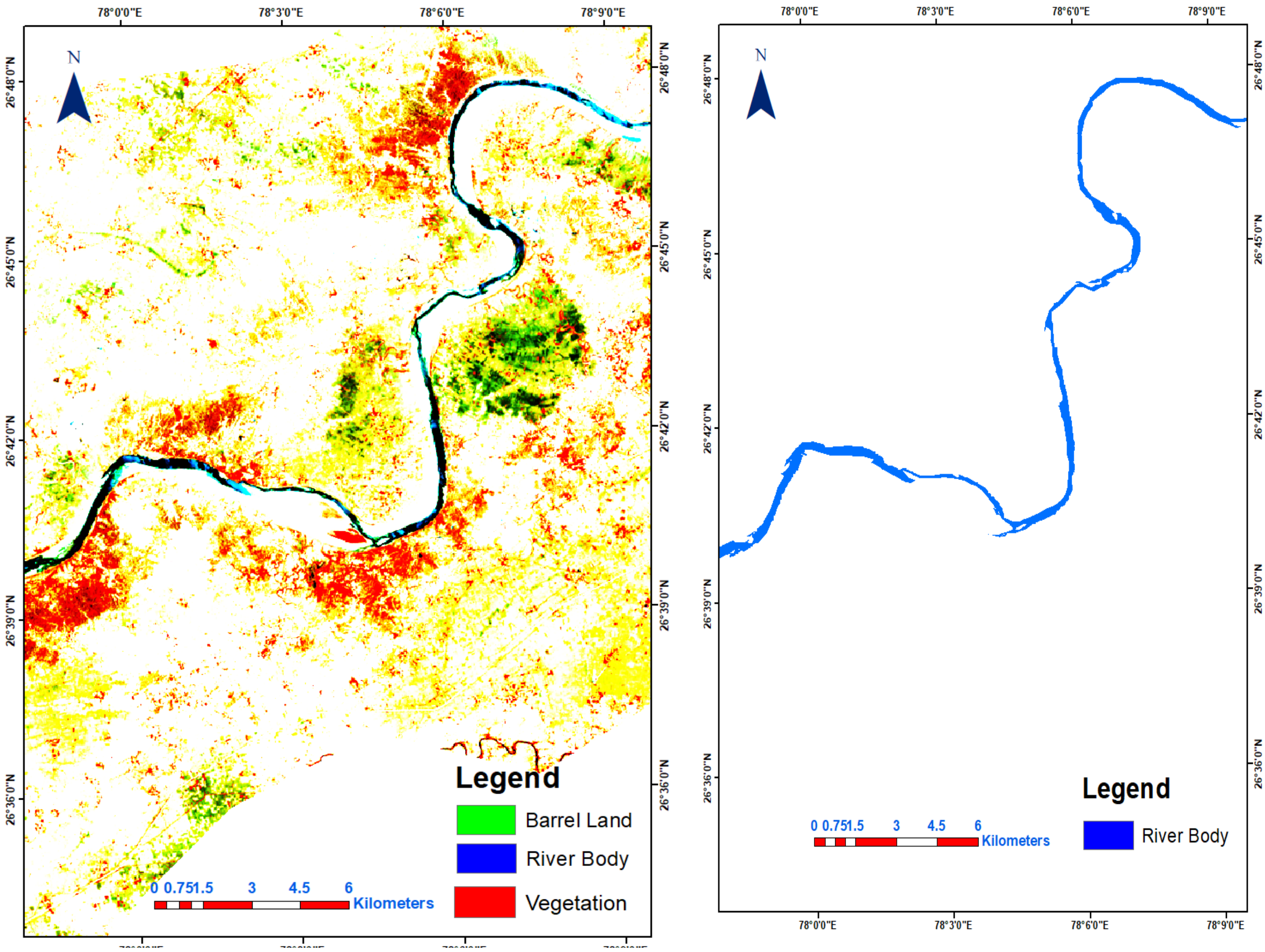


Fig. 3: Study Area Map

Balasubramanian et al. [9] evaluated the sensitivity of the coastal zones in the eastern Ramanathapuram District, Tamil Nadu, India, by examining the shoreline changes of accretion and erosion[10]. More specifically, this study examined Mandapam, Pirappanvalsai and the surrounding villages of Pirappanvalsai and Enmanamcondam, as well as the towns of Nagachi and Terbogi. Ecologically sensitive zones have been recognized in these several locations. Erosion causes irreparable changes in the natural environment. Erosion and accretion studies are thus a primary priority when examining the shore [11]. In addition to the widespread use of GIS (geographic information system) technology during the last two decades, end point rate (EPR) and linear regression rate (LRR) analyses were performed to comprehend the shoreline changes. Patil et al. [12] investigated the effects of copper slag and granite dust, both of which are alternatives to river sand, on the major advantages that river sand possesses. While the tested specimen's strength improved by 19% when copper slag and granite dust were added up to 30%, the additional copper slag and granite dust resulted in an overall decrease in strength[4]. The split tensile strength of concrete is increased by 7% by adding 30 % copper slag and granite dust to the mix. The concrete's flexural strength was boosted by up to 30% of copper slag and granite dust additives[13]. The concrete's split tensile and flexural strengths are improved by a small percentage of age substitution of fine aggregate with copper slag and granite dust. The modulus of elasticity at 30% replacement is 9.52, and it continues to rise above typical concrete up to 90% replacement. There was a 30% drop in permeability, followed by a 40% to 100% rise. Because of the presence of NaCl and MgSO4, the concrete had significantly degraded, and salt deposits had formed on its surface. Up to 50% of copper slag may be used as a sand substitute, and the mix remained just as strong as the control mix[14]. Further copper slag additions, on the other hand, resulted in the weakening of the mix as the free water content rose. This mix's compressive strength was around 16 % lower than that of the control mix when made with either 80 % or 100 % copper slag substitution. 30 - 45 % of copper slag substitution decreased surface water absorption. After this amount of replenishment, the rate of absorption substantially rises. Rajput et al. [15] studied that the alternate fine aggregate of river sand and crushed stone dust is acceptable for cement concrete. Additionally, under Indian circumstances, crushed stone dust is a cost-effective alternative.Crushed stone dust appropriateness as a fine aggregate in cement concrete must be compared to other industrial solid waste, such as copper slag, blast furnace slag, etc. Crushed stone dust's environmental effect evaluation is not mentioned in this article. Foundry sand was used as a substitute for fine natural aggregate in concrete manufacture. As an alternate fine aggregate to river sand, crushed stone dust is acceptable for cement concrete. Additionally, under Indian circumstances, crushed stone dust is a cost-effective alternative.Crushed stone dust may be used as a fine aggregate in cement buildings in undeveloped countries when river sand is scarce and of poor quality[13)]. A greater focus on developing alternative solid industrial waste sources might assist concrete cement manufacturers. Soni et al. [16)] studied an alternative to river sand and the practicality of using course recycled concrete aggregate in place of natural stone (NS) in concrete. The results show that using 100 % course recycled concrete aggregate(CRCA) in place of natural stone in concrete produces an amount of glass fibre had no effect on concrete's tensile strength, as he had predicted. Due to high interfacial adhesion, sawdust fibres treated with NaOH significantly improve the Tensile Strength of every composite. Siddique et al.[17)] stated that use of processed sawdust as a partial substitute for river sand in concrete might be utilized to make concrete. In the final concrete mixture, it is advised to utilize no more than 5 % of water- or sodium silicate-treated sawdust. Using 5 % treated sawdust-modified concrete, interior load-bearing structures and partition walls can be constructed. Sawdust-modified concrete has a lower density, which helps reduce the structure's weight and better compressive strength results than using 50 % or 0% course recycled concrete aggregate(CRCA). Noufal E et al.[18)]Investigates the viability of using I-sand, which has physical properties similar to reinforced cement concrete, as a fine aggregate in manufacturing reinforced cement concrete (RCC). Sand properties were investigated in RCC with considerable attention and accuracy, in contrast to river sand. According to the test results, reinforced cement concrete (RCC) may be manufactured using I-sand and have the same physical properties as RCC created with river sand[19)].Arulmoly et al.[20)] concluded that it is possible to eliminate the use of river sand in concrete by using cement-sand mortar that contains both manufactured and offshore sand. As a binder, Portland limestone cement was utilized in the construction of mortars. In this study, ratios of 1:3, 1:4, and 1:6 of binder to aggregate were tested, and offshore sand was used to replace produced sand at 0%, 25%, 50%, and 75%. Researchers looked at the fresh and hardened states of alternative mortars and compared them to reference mortars made with only river sand[11)]. This was done to find out how sand alternatives and mix ratios affected the mortars. By using less sand from offshore, the bulk densities of both wet and dry mortar were raised. Khalifa et al.[21)]investigated to determine whether it might be utilized as a fine aggregate in lean mortar formulations. Marble debris was crushed into fine aggregate and then utilized in lieu of river sand in amounts ranging from 0% to 100% by volume. Reduced water usage, higher mechanical performance, and more durability might all be achieved by adding 25% to 50% marble debris. Bhoopathy et al. [22)] studied that M-sand may be used as an effective fine aggregate in concrete in order to fulfil the worldwide scarcity of river sand in the future. Using M-sand reduces the need for river sand while also reducing environmental issues like indiscriminate sand mining and soil erosion, all of which help maintain a healthier ecosystem.According to Mane et al.[23)],M-sand substituted river sand in various 0 %,10 %,20 %,30 %,40 %,50 %,60 %,70 % with a water-cement ratio of 0.45 and 20% of pozzolanic materials were used to examine the effect. Per IS 10262:2009, the M30 grade of concrete mix proportions was created. The fresh concrete characteristics and tensile strength values were compared for the various mix amounts. Hardened concrete was put through destructive tests, such as a 28-day curing tensile test on the cylinder, w5816-1999 says816-1999 should be done. According to the findings of this study, replacing 60 % of river sand with M-sand and 20 % of cement with silica fume increases conventional concrete's tensile strength while also improving its microtructure.Mundra et al.[24)] Stated that crushed rock sand as an alternative to natural river sand, which has historically been used as fine aggregate in a cement buildings. According to IS, ACI, and British regulations, several mixed designs were created for different grades of concrete utilizing natural river sand and crushed rock sand[25)]. The compressive strength of the cubes and the flexure of the beams were measured. The study found that crushed rock sand-based concrete had approximately the same strength qualities as traditional concrete. Researchers found that crushed stone sand may be utilized as an inexpensive and easily accessible alternative to river sand, which can help reduce the environmental damage caused by river sand extraction. Chandar et al. [26)] reached out after researching sandstone as a partial substitute for fine particles in concrete. The results of the sieve analysis indicated an S-curve that corresponds to a well-graded aggregate for sandstone that may be substituted for fine aggregates. The fineness modulus of the sandstone was found to be 2.25, suggesting that it may be used in the substitution of fine aggregate. Specific gravity and water absorption are equivalent to conventional fine aggregate, and workability is unchanged. Moisture content indicates whether or not the material is suitable for shipment. In sandstone, SEM analysis reveals the presence of various oxides and high carbon content[27)]. However, dangerous substances like sulphur and calcium are missing. The concrete's workability improved as the quantity of fine aggregate substituted increased. In each case, a genuine decline was documented. Oba et al. [28] studied how a standard mineral filler and a non-conventional mineral filler may be used to replace fractions of aggregates in asphalt concrete to save money and promote waste material reuse. Replacement aggregates of 3 % Quarry Dust and 3 % Saw Dust Ash was used to creating asphalt concrete mix proportions. For a 60/70 penetration grade asphalt binder, the binder concentration was 3, 4, 5, 6, and 7%. The amounts of asphalt and concrete mix were used to make examples of briquettes. Standard laboratory tests were done on samples of aggregates, Quarry Dust, Saw Dust Ash, bituminous binder, and asphalt concrete, following the codes and standards in place. For the asphalt concrete design technique, the Marshall approach was applied[29]. Using typical Marshall curves, the optimal binder concentration was 4.85 %. 15.28 %, and 73.25 %, respectively, for 25mm, 15.28 %, and 73.25 %. Based on the results of the literature research, these four alternatives to river sand have been identified as an alternative to river sand that may help reduce the demand for river sand. As shown in Fig. 4.

The present study aims to find alternatives to river sand suitable in the aspect of economics and availability in Rajasthan. The first objective of the present study is to identify the consequences due to rapid sand mining on erosion and accretion of the river bank. The second objective is to find an alternative to River sand so that it could minimize the demand for river sand.

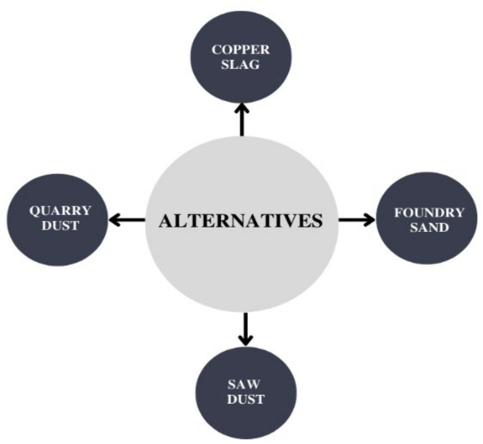


Fig. 4: Alternatives of River Sand

2. Methods and materials

In this study, to find the variability of erosion and accretion due to rapid sand mining, satellite images, i.e., LANDSAT images (1990, 2000,2010, and 2020) of the respective study area, have been used. All geospatial data use the universal transverse Mercator (UTM) projection with zone 43N, datum, and ellipsoid of the World geodetic system (WGS) 84. In Arc-GIS, shape files (images) from 1990, 2000, 2010, and 2020 were changed to 'kml' so that the water level/depth value (h) could be found. For the time periods 1990–2000, 2000–2010, 2010–2020, and 1990–2020, river bank changes in the research area were measured with ArcGIS, and maps were made to show these changes.

These materials that are used in the preparation of concrete mix by substituting river sand in different percentages are as follows: -

2.1 Copper Slag

Copper slag is a low-cost by-product of refinery plants' extraction of copper metal. Its use as a fine aggregate in producing concrete has a number of environmental benefits, such as recycling waste, which eliminates problems with waste disposal. Presently, about 33 million tonnes of Copper Slag (CS) is generated annually, with India's contribution of 6-6.5 million tonnes[27]. In the concrete mix, copper slag can be used as a fine aggregate instead of river sand. According to various studies, copper slag is used as a fine aggregate in cement mortar, which provides good interlocking, resulting in improved volumetric and mechanical quality of various blends. In this study, copper slag is used as the alternative to River sand by replacing 10% to 90% to get the optimum properties and strength of concrete.

2.2 Quarry Dust

Quarry dust is a fine aggregate produced as a by-product of the crushing process and utilized in concrete mix manufacture. The concept of replacing River sand(NS) with quarry dust is that each crusher unit produced nearly 22% to 27% of the dust. This dust is entirely a waste material for crusher units, but quarry dust is useful for construction work as sand, and it can also solve the problem of River sand scarcity[7]. It even causes a burden to dump the crusher dust in one place, which causes environmental pollution. In this study, River sand is 10 to 60% replaced by quarry dust(QD) to obtain the optimum concrete properties and strength.

2.3 Foundry Sand

Foundry sand is a by-product of ferrous and non-ferrous metal casting operations. The physical and chemical qualities of foundry sand depend on the casting method and industry[30]. In this research, River sand(NS) is replaced by foundry sand(FS) from 10% to 60 % for the optimum properties and strength of concrete.

2.4 Sawdust

Sawdust is sometimes known as wooden dust. It is what remains after cutting and drilling wood. It comprises small wood particles and wood-dwelling insects, such as carpenter ants. While sowing wood logs into various sizes, It is composed of tiny, uneven chips or wood trash. A tremendous amount of sawdust is produced annually on a global scale. Sawdust dumped on open ground is harmful to the ecosystem [31]. In this research, River sand(NS) is replaced by sawdust(SD) from 10% to 60 % for the optimum strength of concrete.

These alternatives are used in concrete for the mix proportion in a different ratio. This experimental program consists of sieve analysis and physical test of fresh and hardened concrete along with an ultrasonic pulse velocity test, and SEM analysis is carried out to examine the changes in the internal structure of concrete. The experimental program consisted selection of alternatives, a Sieve analysis, and a Physical Test. After that, the concrete mix was prepared on the different ratios of alternatives, and river sand portions were prepared and tested[6]. A compressive and ultrasonic pulse velocity test is performed to check the compressive strength of the concrete. SEM analysis is also carried out to explore the changes in the internal structure of concrete.

3. Result and discussion

3.1 Analysis of Erosion and Accretion Area

Erosion is always related to extreme weather events and sedimentation. Sediment deficiency is a widespread situation that threatens the development of buildings and infrastructure, beaches, ecosystems, and precious wetlands and may result in the occurrence of erosion. In general, erosion and accretion may influence the riparian zone, resulting in structural stability variations and the groundwater level. There are four significant effects due to sand mining shown in Fig. 5.

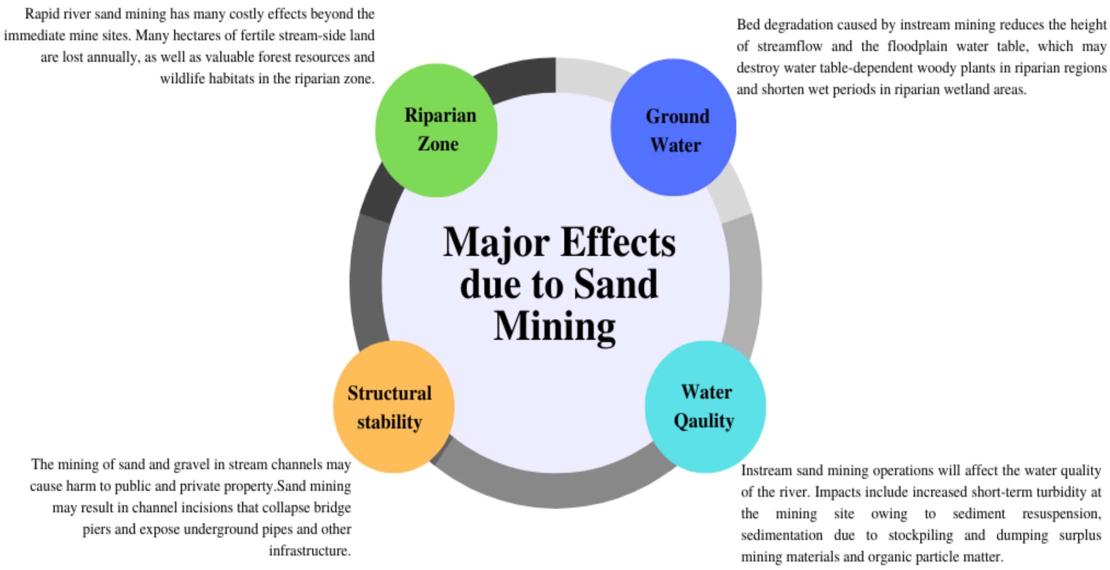


Fig. 5: Major Effects due to Sand Mining

Damage and loss of River beds due to improper and illegal sand mining tend to increase erosion. It will affect the production, ecological, and hydrological functions in the upstream watershed area. The LANDSAT image is used to determine the result for the analysis of erosion and accretion area. LANDSAT data is taken from 1990 to 2020, as shown in the map in Fig. 6. From the analysis of the LANDSAT images of the given years, the following temporal changes along the cross-sections in the right bank of the river in the study area have been observed. The reckoned values are catalogued in Table 1. Erosion and accretion of the river bank are calculated as follows: -

Erosion(E_r)=Previous 10-year area (km^2)-Intact area (km^2)

Accretion(A_r)=Next 10-year area (km^2)-Intact area (km^2)

Spatial variability of erosion and accretion showing in Fig. 6.

Between 1900 to 2000 and 2000 to 2010, more erosion was analysed after spatial variability by the LANDSAT images.

Table 1. Erosion and Accretion data (1990-2020)

Year	Previous 10-year Area (km^2)	Next 10-year Area (km^2)	Intact Area (km^2)	Erosion (km^2)	Accretion (km^2)
1990-2000	8.38	8.90	7.13	1.25	1.76
2000-2010	8.90	8.48	7.34	1.55	1.14
2010-2020	8.48	10.67	8.11	0.37	2.56

1990-2020	8.38	10.67	8.01	0.38	2.66

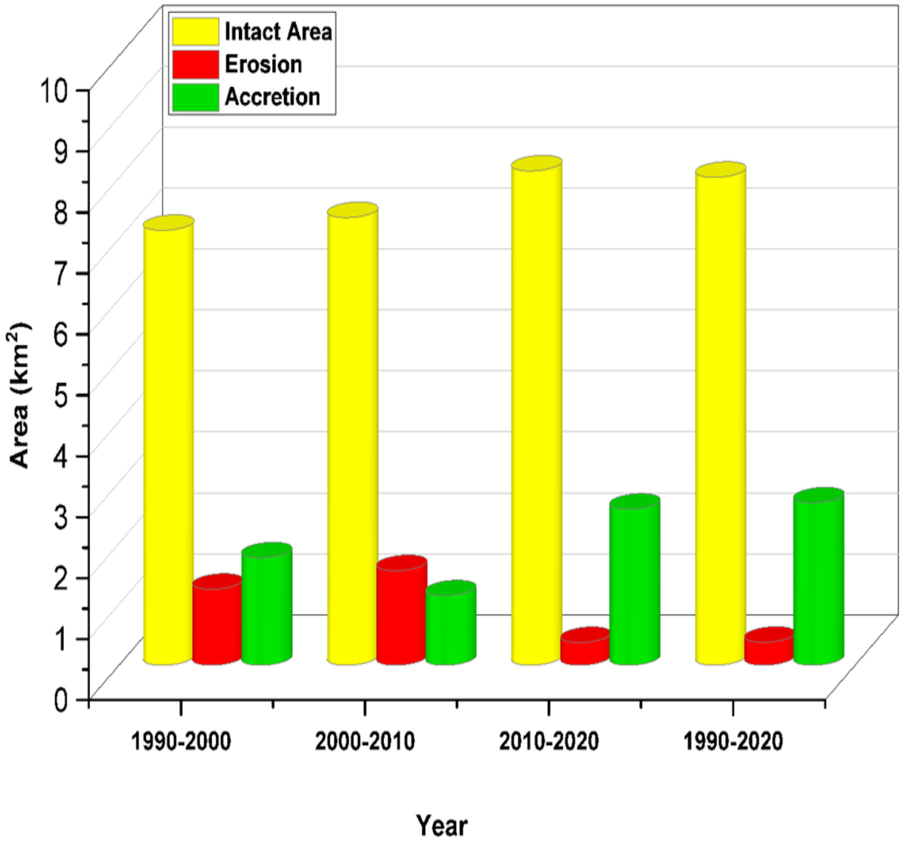


Fig. 6: Erosion and accretion(1990 2020)

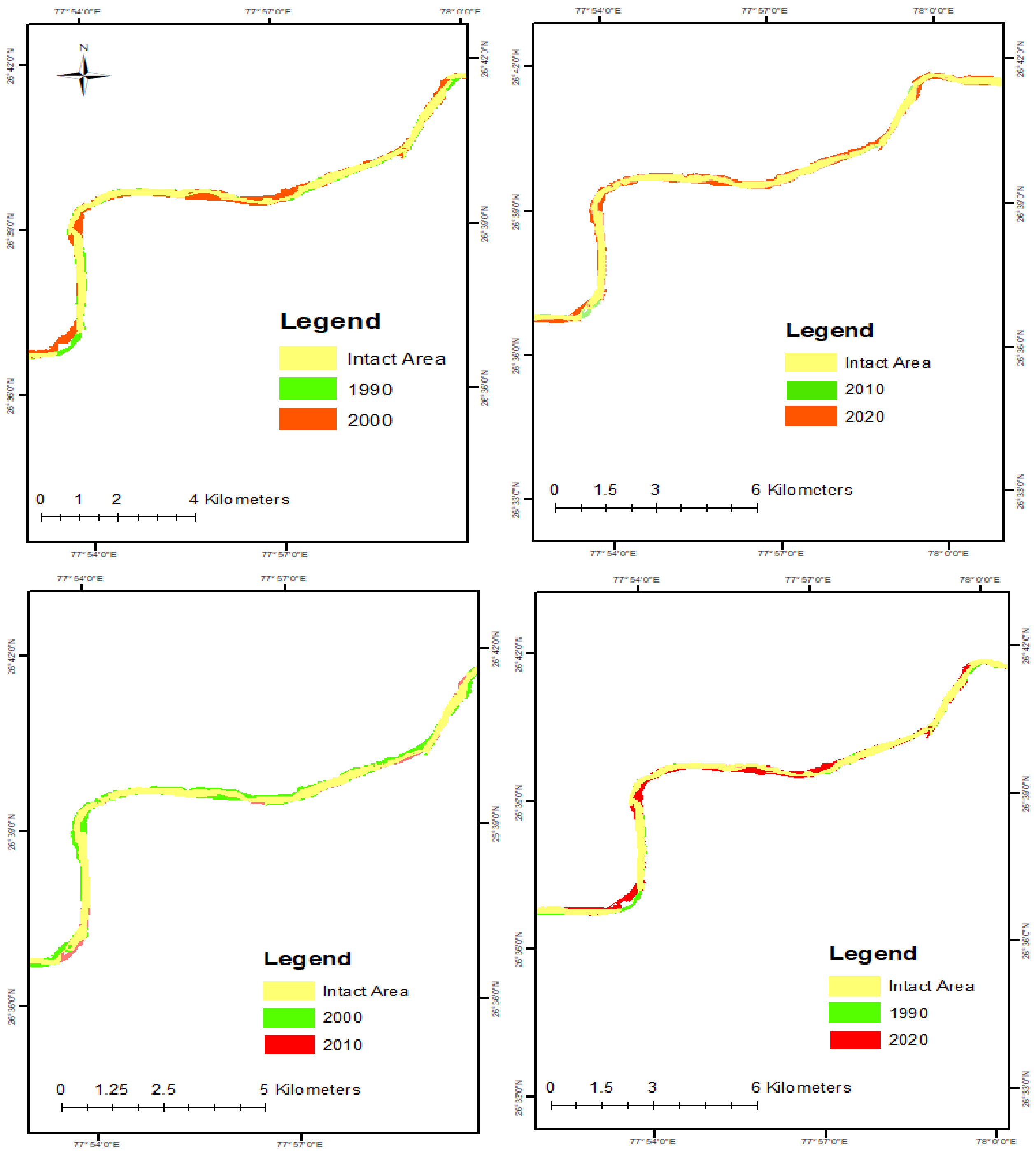


Fig. 7: Spatial Variability of Erosion and Accretion Map(1990-2020)

3.2 Physical test of various alternatives

These physical tests are performed according to IS2386(Part III)- 1963 code[32]. The results of physical tests of different alternatives are determined in the laboratory. Bulk density is the essential factor for imparting strength to the concrete. Bulk density is determined by $\gamma b= W/ V$, where W represents the materials' weight, and V represents the materials' volume. FS has a higher density of 2560 kg/m^3, and SW has a lower density of 760 kg/m^3. The bulk density of these alternative materials is shown in Fig. 8. Water absorption of CS, QD, FS, and SD is 1.1%,0.2%,10.2%, and 30%, as shown in Fig. 9. Water absorption provides an indication of the aggregate's strength. Which material has more water absorption and is more porous. These materials are generally considered unsuitable unless acceptable based on strength, impact, and hardness tests. Moisture content is also determined in the laboratory, and Moisture content refers to how much water is present in a material. It impacts a material's physical properties, such as weight, density, viscosity, and conductivity. After drying, the amount of weight that is lost is often used to determine. CS has less moisture content, which is 0.035%, in terms of NS, QD, FS, and SD.

The result of moisture content is shown in Fig. 11. Specific gravity is the ratio of a substance's mass to the mass of an equivalent volume of water. This Particular Case It is generally agreed that the gravity of a substance may be used as an indicator of its strength or quality. Those materials with a low specific gravity tend to have lower overall strength than those with high specific gravity. The Specific Gravity of CS is higher than all materials, which is 3.50, as shown in Fig. 10.

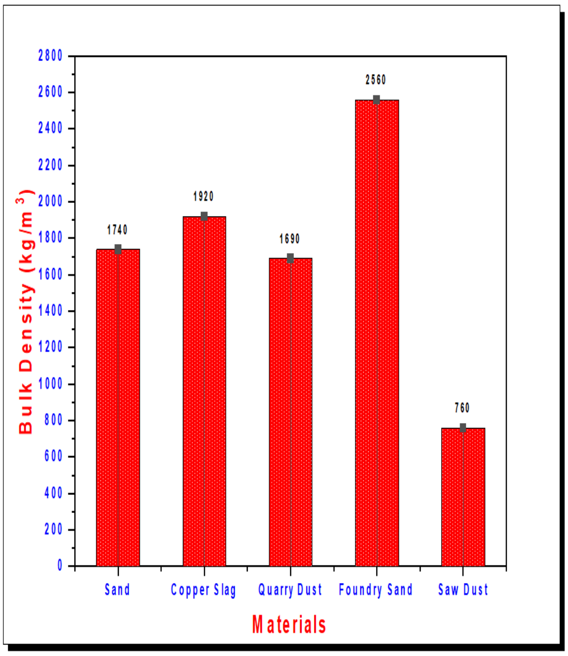


Fig. 8: Bulk Density of different alternatives

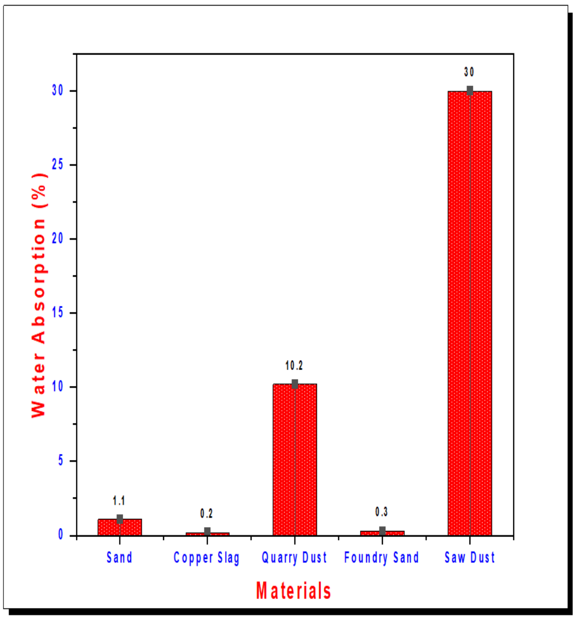


Fig. 9: Water Absorption % of different alternatives.

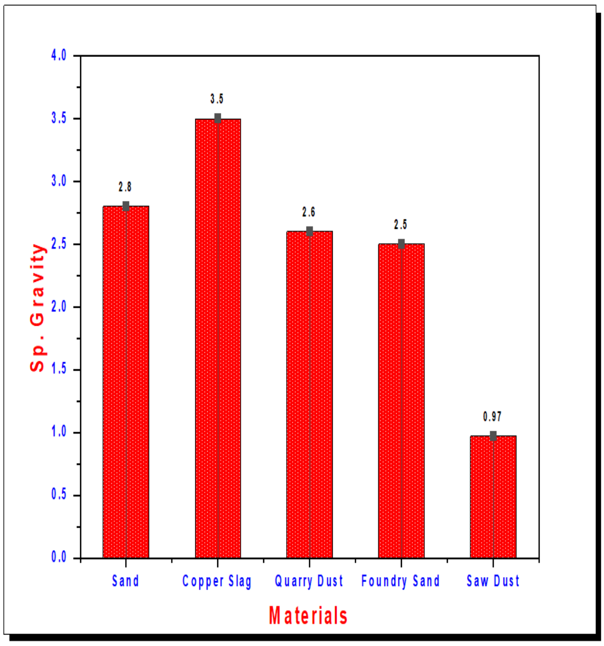


Fig. 10: Specific gravity of different alternatives

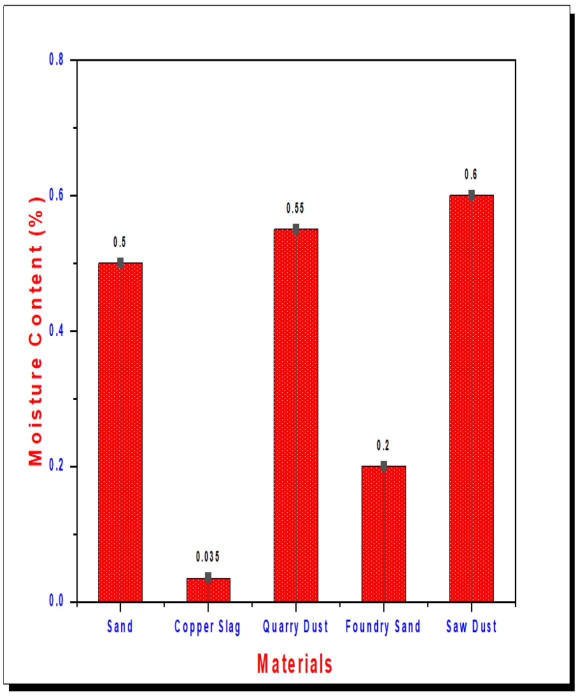


Fig. 11: Moisture content % of different alternatives

3.3 Sieve analysis and fineness modulus of various materials

The Fineness Modulus of Sand is an index number representing the average particle size of sand. It is calculated using conventional IS sieves and a sieve analysis test. Sand has a fineness modulus ranging from 2.2 to 3.2. As per IS 2386-Part-1 in sieve Analysis tests, 10mm, 4.75mm, 1.18mm, 2.36mm, 0.6, 0.3, and 0.15 mm sieves are used to determine the fineness modulus of fine aggregate. The fineness modulus of these materials is the total of the cumulative percentage retained on each sieve, beginning with the 150 m sieve and up to the biggest sieve employed, divided by 100. CS, FS, and SD have a fineness modulus of 7.64, 2.73, and 3.47, respectively. The fineness modulus of Quarry Dust and Copper Slag is calculated to be 2.80 and 2.36, as shown in Table 2 and Table 3.The fineness modulus of Foundry sand and Saw Dust is 2.41 and 2.49, as shown in Table 4 and Table 5. After the determination of the Fineness modular of all four alternatives, a cumulative sieve analysis graph is also plotted, as shown in Fig. 12.

Table 2. Sieve Analysis result of Quarry Dust

I.S.Sieve size (mm)	Retained weight(gm)	% of weight retained	Cumulative % of weight retained	Cumulative % of passing
10	0	0	0	100
4.75	14	1.4	1.4	98.6
2.36	30	3	4.4	95.6
1.18	322	32.2	36.6	63.4
0.6	208	20.8	57.4	42.6
0.3	276	27.6	85	15
0.15	105	10.5	95.5	4.5
0.075	25	2.5	98	2
Pan	20	2	100	0
	Total wt. of QD=1000gm		F.M=2.80	

Table 3. Sieve Analysis Results of Copper Slag

I.S.Sieve size (mm)	Retained weight(gm)	% of weight Retained	Cumulative % of weight Retained	Cumulative % of passing
10	0	0	0	100
4.75	7	0.7	0.7	99.3
2.36	10	1	1.7	98.3
1.18	100	10	11.7	88.3
0.6	380	38	49.7	50.3
0.3	293	29.3	79	21

0.15	195	19.5	98.5	1.5
0.075	11	1.1	99.6	0.4
Pan	4	0.4	100	0
Total wt. of CS sample=1000gm			F.M=2.41	

Table 4. Sieve Analysis Result of Foundry Sand

I.S.Sieve size (mm)	Retained weight(gm)	% of weight Retained	Cumulative % of weight Retained	Cumulative % of passing
10	0	0	0	100
4.75	17	1.7	1.7	98.3
2.36	56	5.6	7.3	92.7
1.18	100	10	17.3	82.7
0.6	104	10.4	27.7	72.3
0.3	570	57	84.7	15.3
0.15	130	13	97.7	2.3
0.075	15	1.5	99.2	0.8
Pan	8	0.8	100	0
Total wt. of FS=1000gm			F.M=2.36	

Table 5. Sieve Analysis Result of Saw Dust

I.S.Sieve size (mm)	Retained weight(gm)	% of weight Retained	Cumulative % of weight Retained	Cumulative % of passing
10	0	0	0	100
4.75	7	0.7	0.7	99.3
2.36	8	0.8	1.5	98.5
1.18	100	10	11.5	88.5
0.6	370	37	48.5	51.5
0.3	400	40	88.5	11.5
0.15	100	10	98.5	1.5
0.075	11	1.1	99.6	0.4
Pan	4	0.4	100	0
Total wt. of SD sample=1000gm			FM=2.49	

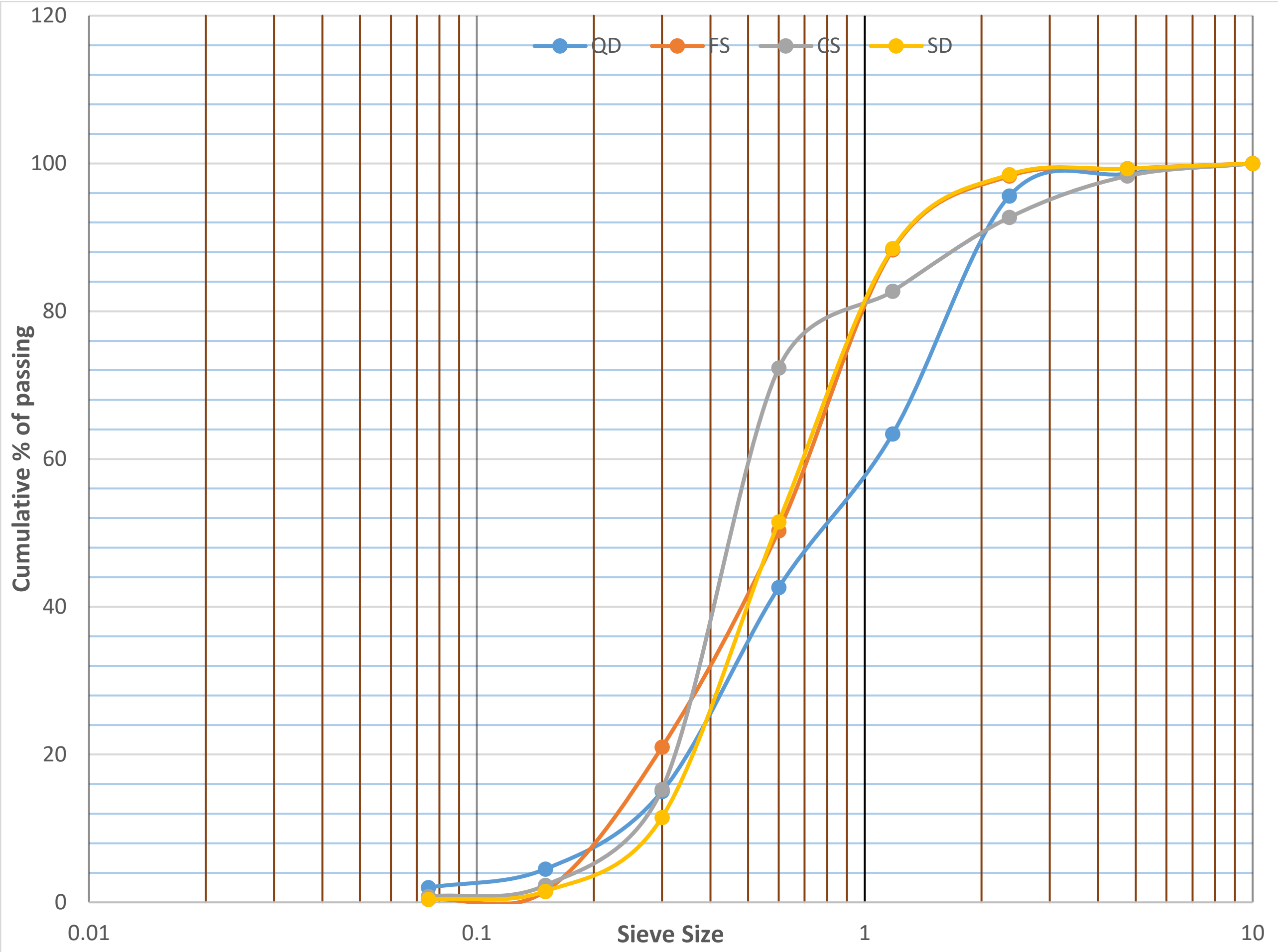


Fig. 12: Particle size distribution of different materials

3.4 Mix proportion & physical test of fresh and hardened concrete

These steps are involved in Mix Proportioning as per IS 10262:200 for the preparation of M25 grade concrete, as shown in Fig. 13. The mix proportions of M25 are prepared by replacing NS on the different % stages by the use of different alternatives for optimum compressive strength. After that, the compressive strength tests were conducted on the Compressive Testing Machine (CTM machine). Concrete cubes size 150 x 150 x 150 mm were tested simultaneously on days 7, 14, and 28. Twenty-eight days of the result of cube testing of concrete are showing. The optimum replacement % stage is determined by analysing the cube test result, as shown in Fig. 14.

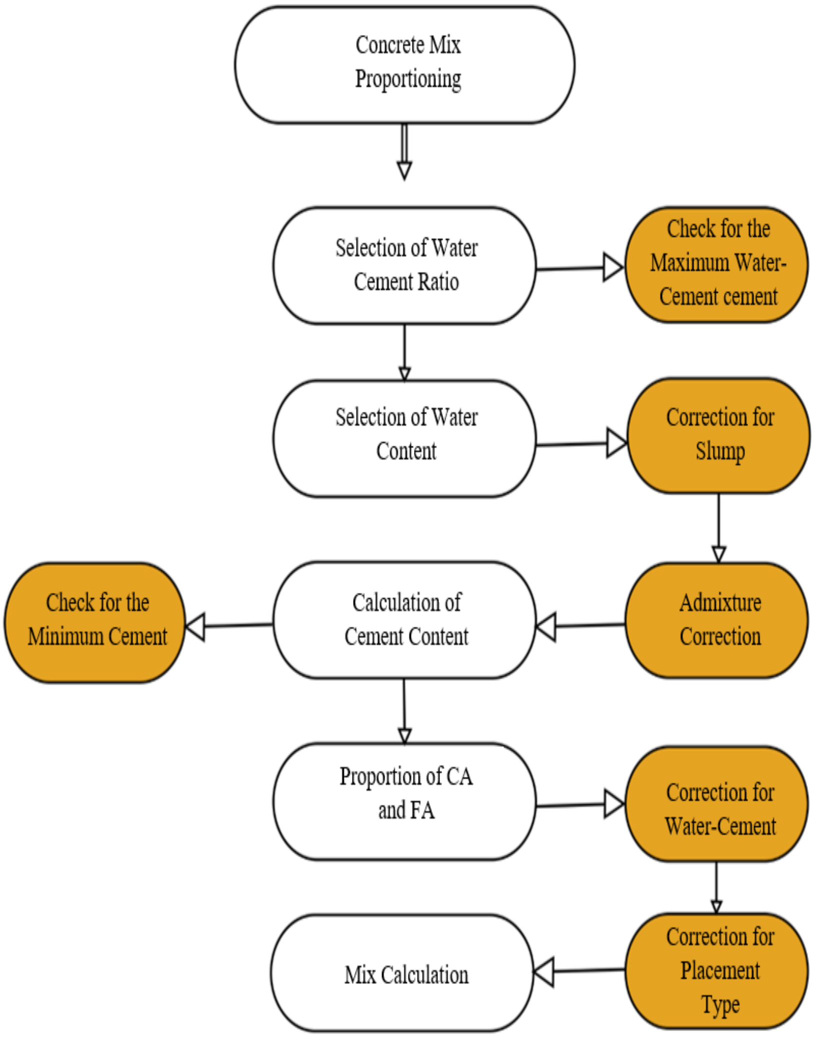


Fig. 13: Steps Involved in Mix Proportioning as per IS 10262:2009

Table 6. Mix proportioning table

Design stipulations for Proportioning	Copper Slag	Quarry Dust	Foundry Sand	Saw Dust
% of Replacement	10-60%	10-60%	10-60%	10-60%
Grade Designation	M25			
Type of cement	OPC 53 Grade conforming IS 12269			
Maximum nominal size of aggregate	20mm			
Minimum cement content	300 kg/m^3 (IS 456:2000)			
Maximum water-cement Ratio	0.50 (Table 5 of IS 456:2000)			
Workability(slump)	100mm	90mm	120mm	80mm
Exposure condition	Moderate (For Reinforced Concrete)			
Type of aggregate	Crushed Angular Aggregates			
Chemical admixture type	Plasticizers			

Table 7. Result of compressive strength on 28 days.

S.No	% of Replacement	Weight of Cube(gm)	Density of Cube(gm/cc)	Failure Load(kN)	Compressive Strength (N/mm^2)	Avg. Compressive Strength (N/mm^2)	Avg. Compressive Strength (Conventional Concrete) (N/mm^2)
1	10%CS+90% NS	8561	2.537	560	24.89	24.44	26.8
		8575	2.541	550	24.44		
		8570	2.539	540	24.00		
2	20%CS+80% NS	8010	2.373	575	25.56	24.67	
		8705	2.579	550	24.44		
		8760	2.596	540	24.00		
3	30%CS+70% NS	8561	2.537	570	25.33	25.78	
		8575	2.541	580	25.78		
		8589	2.545	590	26.22		
4	40%CS+60% NS	8685	2.573	580	25.78	26.22	26
		8790	2.604	600	26.67		
		8690	2.575	590	26.22		
5	50%CS+50% NS	8000	2.370	510	22.67	22.89	
		8701	2.578	520	23.11		
		8764	2.597	515	22.89		
6	60%CS+40% NS	8561	2.537	510	22.67	22.74	
		8575	2.541	515	22.89		
		8589	2.545	510	22.67		
1	10%QD+90% NS	8561	2.537	555	24.67	24.37	26.5
		8575	2.541	550	24.44		
		8589	2.545	540	24.00		
2	20%QD+80% NS	8000	2.370	560	24.89	24.44	
		8705	2.579	550	24.44		
		8764	2.597	540	24.00		
3	30%QD+70% NS	8561	2.537	555	24.67	24.81	
		8575	2.541	550	24.44		
		8589	2.545	570	25.33		
4	40%QD+60% NS	8575	2.541	570	25.33	25.93	26.2
		8585	2.544	590	26.22		
		8595	2.547	590	26.22		
5	50%QD+50% NS	8690	2.575	580	25.78	26.22	
		8701	2.578	590	26.22		
		8764	2.597	600	26.67		

6	60%QD+40% NS	8561	2.537	540	24.00	24.15	
		8575	2.541	540	24.00		
		8589	2.545	550	24.44		
1	10%FS+90% NS	8561	2.537	570	25.33	25.93	25.8
		8575	2.541	590	26.22		
		8589	2.545	590	26.22		
2	20%FS+80% NS	8000	2.370	575	25.56	25.70	
		8605	2.550	580	25.78		
		8564	2.537	580	25.78		
3	30%FS+70% NS	8761	2.596	595	26.44	26.44	
		8875	2.630	600	26.67		
		8689	2.575	590	26.22		
4	40%FS+60% NS	8575	2.541	580	25.78	25.63	25.5
		8585	2.544	570	25.33		
		8589	2.545	580	25.78		
5	50%FS+50% NS	8000	2.370	550	24.44	24.00	
		8701	2.578	545	24.22		
		8764	2.597	525	23.33		
6	60%FS+40% NS	8561	2.537	530	23.56	23.19	
		8575	2.541	520	23.11		
		8589	2.545	515	22.89		
1	10%SD+90% NS	8561	2.537	570	25.33	25.78	26.2
		8575	2.541	590	26.22		
		8589	2.545	580	25.78		
2	20%SD+80% NS	8000	2.370	575	25.56	25.93	
		8705	2.579	590	26.22		
		8764	2.597	585	26.00		
3	30%SD+70% NS	8760	2.596	585	26.00	26.22	
		8875	2.630	595	26.44		
		8789	2.604	590	26.22		
4	40%SD+60% NS	8875	2.630	585	26.00	26.30	25.8
		8790	2.604	600	26.67		
		8789	2.604	590	26.22		
5	50%SD+50% NS	8000	2.370	510	22.67	22.89	
		8701	2.578	520	23.11		
		8764	2.597	515	22.89		

	60%SD+40%	8050	2.385	510	22.67	
6	NS	8090	2.397	515	22.89	22.74
		9000	2.667	510	22.67	

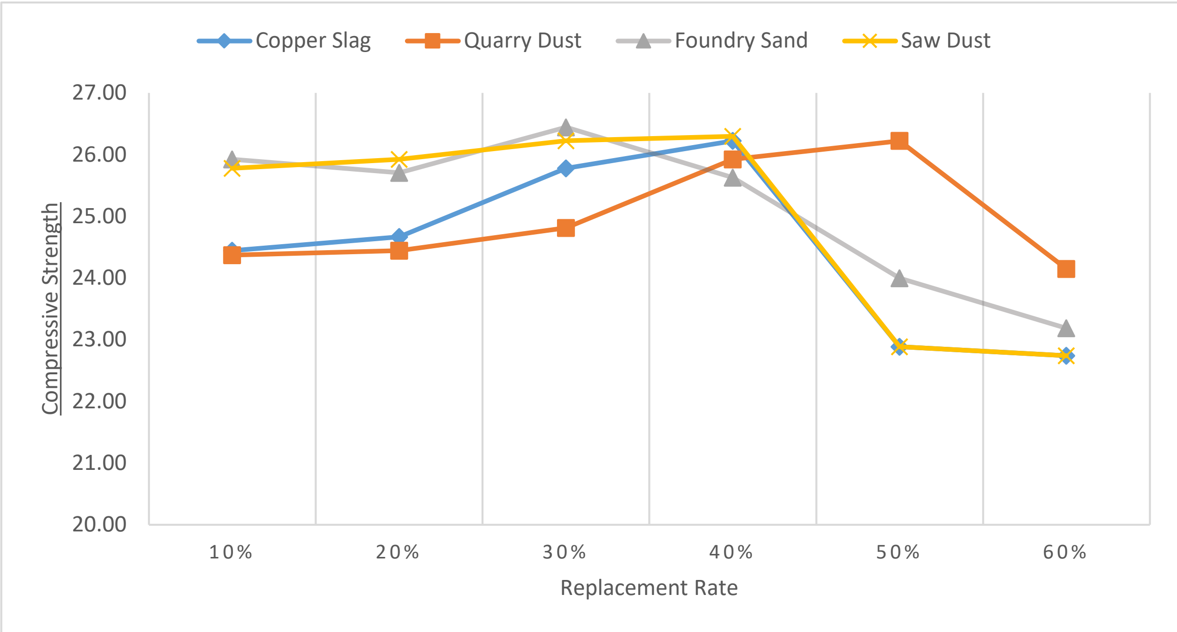


Fig. 14: Optimum % of NS Replacement by CS,QD,FS and SD

At the end of 28 days, the compressive strength of the concrete cube was tested according to IS Code Is 516 (Part-1 Sec-I)[33] on the CTM machine. Copper slag, quarry dust, and sawdust imparted optimum compressive strength on substitutions of 40%, 50%, 30%, and 40%, respectively, as Table 8 shows.

Table 8. Replacement % of different alternatives for optimum strength

S.No	Name of Martials	Optimum %
1	Copper Slag	40
2	Quarry Dust	50
3	Foundry Sand	30
4	Saw Dust	40

Table 9. Result of Ultrasonic Pulse Velocity Test

Mix	Specimen	Weight (gm)	Density (gm/cc)	Transit Time (µs)	Pulse Speed km/second	Concrete Quality Grading
(40%)CS+(60%)NS	A	8690	2.575	30.4	4.93	Excellent
	B	8795	2.606	32.5	4.62	
	C	8680	2.572	33	4.55	
	Average	**8722**	**2.584**	**31.97**	**4.70**	
(50%)QD+(60%)NS	A	8680	2.572	33.8	4.44	Excellent

	B	8700	2.578	34.2	4.39	
	C	8760	2.596	33.2	4.52	
	Average	**8713**	**2.58**	**33.73**	**4.45**	
(50%)QD+(60%)NS	A	8770	2.599	32.5	4.62	Excellent
	B	8880	2.631	30.2	4.97	
	C	8690	2.575	33.2	4.52	
	Average	**8780**	**2.6**	**31.97**	**4.69**	
(35%)SD+(65%)NS	A	8760	2.596	35.6	4.21	Excellent
	B	8875	2.63	37.4	4.01	
	C	8789	2.604	35.7	4.20	
	Average	**8808**	**2.61**	**36.23**	**4.14**	

3.5 Micro-Structure analysis

This analysis is carried out to examine the changes in the internal structure of concrete. The microstructure of the concrete mixes was analyzed using an SEM (Scanning Electron Microscope), which aids in the visualization of the microstructure of the hydrated cement mix. This instrument operates on the principle of an electron beam passing through concrete and displaying images of the concrete at various magnifications. The test is performed on two samples after 14 days and 28 days simultaneously, in which quarry dust gives an optimum result of 50% replacement of river sand. This analysis depicts particle cohesion and adhesion as well as a pictorial representation of the pore structure of concrete. The internal structure of concrete mixing is shown in Fig.15 and Fig.16.

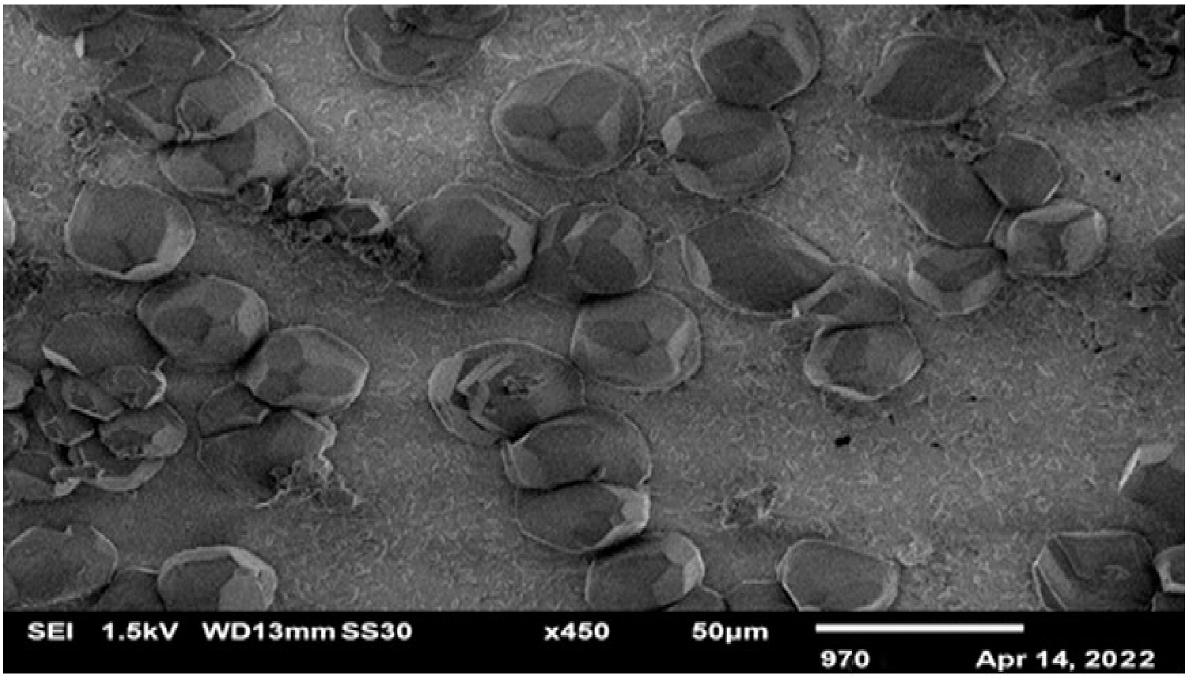


Fig.15: Microstructure of (M25 Grade Concrete,50% QD+ 50% NS) after 14 days at x450

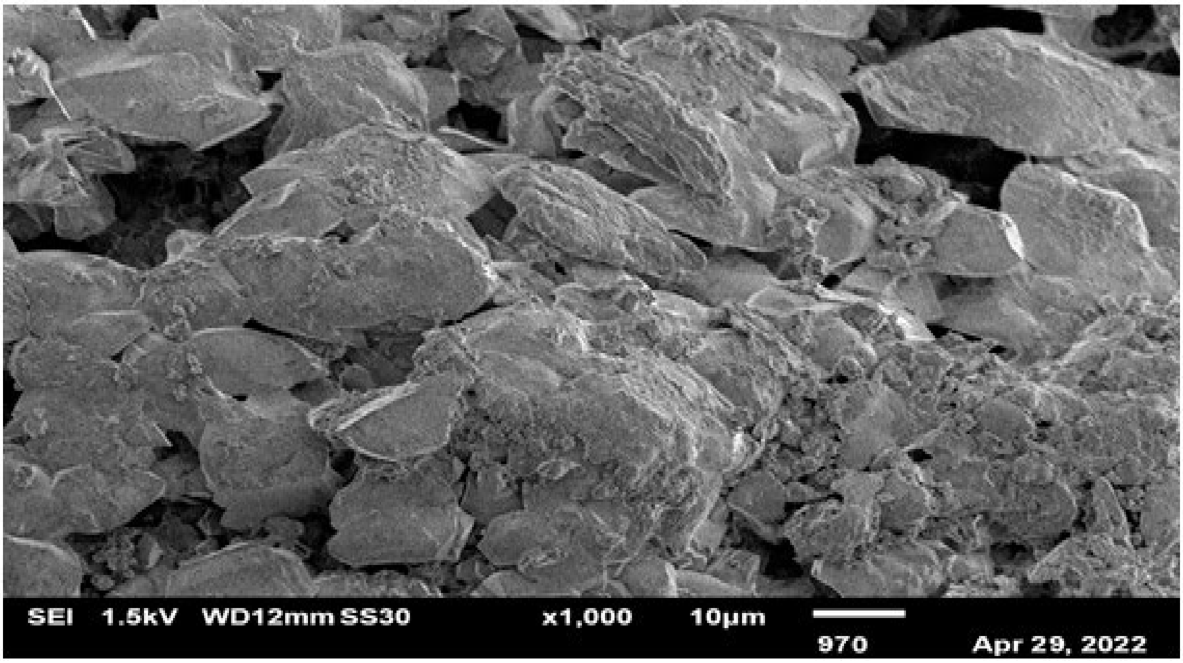


Fig.16: Microstructure of (M25 Grade Concrete,50% QD+ 50% NS) after 28 days at x1000

4. Conclusion

The conclusions drawn from this study are as follows: These materials can be utilized because these four alternative materials are locally available. We can achieve economy and the required design strength by using these alternatives.

- The bulk density of the foundry sand is 32% higher than the river sand, which is higher than among these four alternatives, and copper slag and quarry dust also have similar values to the river sand. It means this alternative gives perfect hardness, like river sand.
- The water absorption and moisture content of copper slag, foundry sand, and quarry dust are similar to the river sand, which means these materials will not affect the W/C ratio in the concrete mix.
- Specific gravity is an essential aspect of any material. In this study, it is determined that
- copper slag has a higher value than river sand. Quarry dust and river sand have approximately similar values.
- The fineness modulus is also determined by the sieve analysis method, and the fineness modulus range is 2.2-2.6, approximately near to class-I sand
- After performing several physical tests(Bulk Density,Water Absorption,Specific Gravity and Finess Modulas) of concrete and Micro-Structural Analyses of hardened concrete, it is concluded that 50% Quarry Dust can be used as the alternative to river sand, same as copper slag, foundry sand, and sawdust is given optimum strength on the 40%,30%,35% replacement simultaneously of river sand.

From the above studies, it can be readily inferred that these alternatives to river sand will serve as a potentially feasible solution to the problem of excess river sand mining. Erosion and accretion of the river can be minimized by stopping the dependency on the natural river.

Acknowledgements

We Would like to give appreciation to Dr Shruti Kanga , for her important contribution to the discussion about finding an alternative of natural sand to minimize the river bank erosion.

Nomenclature

FS	Foundry Sand
QD	Quarry Dust
CS	Copper Slag
NS	Natural Sand
γb	Bulk Density
Er	Erosion
Ar	Accretion

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