"EXPERIMENTAL INVESTIGATION OF CONCRETE WITH MARBLE DUST POWDER AND DEMOLITION CONCRETE WASTE TO ENHANCE ITS PROPERTIES"

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Abstract:

Concrete is a mixture of a cement, fine aggregate and coarse aggregates with water. Now a day the availability of natural aggregates is less and it is getting depleted. Even though it is available it is too costly to use it in the construction field. Hence we are thinking the alternatives to the natural aggregates. In India the extractive activity of decorative sedimentary carbonate rocks, commercially indicated as marbles and granites, is the most thriving industry. Due to the new emerging innovative ideas in construction field People are owing to renovate their buildings and also demolishing the old ones to reconstruct the buildings. Due to the demolition of buildings, the demolished waste is generated and it's a big challenge to dispose it off. So we are trying to solve this problem in the view of protecting environment by utilizing this waste by replacing the natural coarse aggregates with this waste.

Our main objective is to know the behavior of concrete with replacement of fine aggregate with marble powder and coarse aggregate with demolished waste respectively.

The main parameter is to study basic engineering properties of the cement aggregates and compressive strength Also to establish the effect of marble powder and demolished waste and marble dust on the properties concrete mixes.

To study the effect of varying percentage of demolition waste as a replacement to natural aggregates on the performance. The collected construction and demolition waste were crushed, sieved and according to gradation it was separated with a required quantity for the analysis. Natural aggregates according to gradation with the percentages of 0%, 10%, 20%, 30% replacement was used, and casted molds.

Keywords: concrete, marble powder, waste powder, aggregate, cement, tensile strength, compressive strength.

Introduction:

Although high strength concrete is considered as relatively a new material, its development has been gradually increasing over years. In 1950s, USA considered the concrete with a compressive strength of 34mpa as high strength. In 1960's, the concrete with compressive strength 41mpa to 52mpa was used commercially. In the early 1970's, 62mpa concrete was been made. With in the world state of affairs, however, within the last fifteen years, concrete of terribly high strength entered into the construction sector of high-rise buildings and long span bridges. The compressive strength over 110mpa has been thought-about by IS 456-2000 for the applications in pre-stressed concrete members and cast-in-place buildings.

However, recently reactive concrete could be the one that having a compressive strength of nearly 250mpa. It is fully supported by pozzolanic materials. The first distinction between high-strength concrete and nominal-strength concrete refers to the relation of utmost resistance offered by compressive strength of the concrete sample for the application of any type of load. Though there is no correct separation between high strength concrete and normal-strength concrete, the Yankee Concrete Institute defined the compressive strength greater than 42mpa as high strength concrete.

Marble has been commonly used as a building material since the ancient time. The industry's disposal of the marble powder material, consisting of very fine powder, today constitutes one of the environmental problems around the world. Marble blocks are cut into smaller blocks in order to give them the desired smooth shape. During the cutting process about 25% the original marble mass is lost in the form of dust as shown in figure below. The marble dust is settled by sedimentation and then dumped away which results in environment pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment.

In addition to marble powder, silica fume, fly ash, pumice powder and ground granulated blast furnace slag are widely used in the construction sector as a mineral admixtures instead of cement.

Fig 1: marble dust

Concrete waste was collected from demolition sites and the reinforcement bars are removed by hammering. The remaining aggregate chunks are sorted by size and these was taken to the crusher. After crushing has taken place, other particulates are filtered out through a variety of methods including hand-picking and sieving. Crushing a Demolished Concrete waste and is separated with different sizes using sieve analysis. Various sizes of DCA was treated with heating and chemical process

Fig 2: Concrete Waste

Literature Review:

Zahiruddin et. Al. the study conducted assessment of plastic and hardens property of M 25 grade of concrete using Partial Substitution of cement by using waste material (marble dust)as a sustainable approach in construction. Use of these materials as additional concrete materials was an extensive progress. Moreover, utilization of waste materials in construction industry reduces the use of Portland cement. Portland cement has high energy consumption and source of emission of carbon dioxide, which can be reduced by replacing cement. The sample was prepared by replacing cement with marble powder 0%, 5%, 10%, 15%, & 20% by volume. Workability was determined in plastic state and compressive strength values are determined after 7 days, 14 days, 21 days and 28 days.

Results stated that workability of sample consistently decreases with increasing in marble content. Compressive strength slightly vary up 10% replacement of cement but effect the strength at higher marble content. Results led to the conclusion that marble powder can be replaced up to 10% which will reduces the consumption of cement and also waste product can be utilized in effective manner.

Lochan sai et. Al. The research carried experimental analysis so as to evaluate the effect of partial replacement of cement, fine aggregate and coarse aggregate with various portion of demolished wastes on strength and workability of concrete. The design mix concrete of grade M25 (Referral concrete) was prepared using IS 10262-2009. Thereafter, the replacement of different constituents of concrete, one at a time was carried out by replacing these with the different sieved fractions of crushed demolition waste. The compressive strength at 7, 14 and 28 days and workability in terms of slump value were measured. The compressive strength of these mixes was measured on 100mm cubes. Test results show that the behaviour of recycled waste concrete and the adding of Ad-mixture. The compressive strength of recycled concrete (FAR concrete) with 10%, 15% and 20% fine aggregate replacement by demolition waste coarse aggregate at 7,14 and 28 days is comparable to that of referral concrete.

The compressive strength of recycled concrete (CAR concrete) made using 10% of demolition waste coarse aggregate is almost similar to referral concrete. Further, the results indicate that still higher replacement of the constituent materials is possible without much compromising the 28 days strength and workability. Using demolished aggregate concrete as a base material for roadways reduce the pollution involved in trucking material.

Objectives of the study:

The key objective of this work was to develop concrete mixtures, using marble powder waste as a partial replacement for cement and demolished concrete as coarse aggregate in different proportions namely 5% of MDP and 5% of demolished concrete and the same was nurthured with the extent of 25%

- Study the effect of use of waste marble dust on the mechanical properties of concrete.
- To study To the effect of use of waste marble aggregates on the mechanical properties of concrete.
- To compare the compressive strength using marble products with the given design mix.
- To establish alternative for cement and coarse aggregate with partial use of marble waste powder and demolished waste in concrete.

Materials used and its description:

Cement- The cement used for the current study is the Ordinary Portland Cement having grade - 43 and the average specific gravity of cement used is 3.12.

Fine Aggregate - Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral.

Coarse Aggregate-Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading.

Water- Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

Marble Dust:- One of the major wastes produced in the stone industry during cutting, shaping, and polishing of marbles is the MDP. During this process, about 20-25% of the process marble is turn into the powder form. India being the third (about 10%) top most exporter of marble in the world, every year million tons of marble waste form processing plants are released. Due to the availability of large quantity of waste produced in the marble factory, this project has been planned and preceded

Demolished Concrete- Demolishing the old building produces large amount of waste products. When structures made of concrete are demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble. Concrete once routinely trucked to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of greater environmental awareness, more environmental laws, and the desire to keep construction costs down. Use of construction & demolished material as coarse aggregates in civil engineering applications is beneficial because it reduces the environmental impact and economic cost of quarrying operations, processing, and transport and reuse of construction and demolition waste is becoming increasingly desirable due to rising hauling costs.

Experimental Details & Methodology:

Determination of Workability by Compaction:

Apparatus: Compaction factor apparatus' trowels, hand scoop (15.2 cm long), a rod of steel or other suitable material (1.6 cm diameter, 61 cm long rounded at one end) and a balance.

Procedure:

- **To find the workability of concrete thoroughly mix cement, sand And coarse aggregate according to designed mix proportions to form a homogenous mix of concrete.**
- **Find the Weight of empty cylinder (W1).**
- **Fill the upper hopper with the freshly prepared concrete and after 2 minutes, release the trap door of the hopper. Immediately after the concrete has come to rest, open the trap door of the lower hopper and allow the concrete to fall into the cylinder which brings the concrete to a partially compacted state.**
- **Remove the excess concrete over the top of the cylinder by a trowel.**
- **Clean the cylinder properly and weigh it with the partially compacted concrete (W2).**
- **Empty the cylinder and refill it with the same sample of concrete in four layers, compaction of each layer by giving 25 blows with the tamping rod.**
- **Level up the mi and weigh the cylinder with the fully compacted concrete (W3).**

COMPACTION FACTOR= (W2 - W1)/(W3 - W1)

Fig 3: workability by compaction

Compressive Strength Procedure

Prepare the concrete in the required proportions and make the specimen by filling the concrete in the desired mould shape of 15cm x 15cm x 15cm cube with proper compaction, after 24 hrs place the specimen in water for curing.

- **Take away the specimen from water when such as natural process time and wipe out excess water from the surface.**
- **Take the dimension of the specimen to the closest 0.2m**
- **Clean the bearing surface of the testing machine**
- **Place the specimen within the machine in such a fashion that the load shall be applied to the other sides of the cube forged.**
- **Align the specimen centrally on the bottom plate of the machine.**
- **Rotate the movable portion gently by hand so it touches the highest surface of the specimen.**
- **Apply the load step by step while not shock and incessantly at the speed of 140kg/cm2/minute until the specimen fails**
- **Record the utmost load and note any uncommon options within the form of failure.**

COMPRESSIVE STRENGTH = (LOAD / AREA) in N/sq.mm

Fig 4: Compression Testing of Cube Specimen

Split Tube Tensile Strength Procedure: Prepare the concrete in the required proportions and make the specimen by filling the concrete in the desired mold shape of 10 cm x 30 cm cylinder with proper compaction, after 24 hrs place the specimen in water for curing.

- Take the wet specimen from water when seven days of natural process
- Wipe out water from the surface of specimen
- Draw diametrical lines on the 2 ends of the specimen to make sure that they're on a similar axial place.
- Note the weight and dimension of the specimen.
- Set the compression testing machine for the specified vary.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so the lines marked on the ends square measure vertical and targeted over very cheap plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate to touch the plywood strip.
- Apply the load incessantly while not shock at a rate of roughly 14- 21kg/cm2/minute (Which corresponds to a complete load of 9900kg/minute to 14850kg/minute)
- Note the breaking load(P)

The splitting tensile strength is calculated using the equation = 2p/nLD

Here, p = applied load

D = diameter of specimen

L = length of specimen

Fig:5-Split Tensile Testing and Specimen

Experimental Results

Test on cement paste

Fineness of cement by Hand sieving

Hand sieving	1	2
Weight of cement taken (W_1) in gms	100	**100**
Weight of residue retained on 90µ sieve (W_2) in gms	4.68	4.72
Percentage fineness of cement =(W_2 / W_1)x100	4.68	4.72

Fineness of cement by Mechanical sieving

Mechanical sieving	1	2
Weight of cement taken (W_1) in gms	100	100
Weight of residue retained on 90µ sieve (W_2) in gms	4.93	5.85
Percentage fineness of cement =(W_2 -W_1)x100	4.93	5.85

Test on Marble dust powder

Fineness of MDP by hand sieving

Hand sieving	1	2
Weight of cement taken (W_1) in gms	100	100
Weight of residue retained on 90µ sieve (W_2) in gms	6.84	6.79
Percentage fineness of cement =(W_2 -W_1)x100	6.84	6.79

Fineness of MDP by Mechanical sieving

Mechanical sieving	1	2
Weight of cement taken (W_1) in gms	100	100
Weight of residue retained on 90µ sieve (W_2) in gms	6.23	6.31
Percentage fineness of cement =(W_2 -W_1)x100	6.23	6.31

Specific gravity of cement

Particulars	1	2	3
Weight of empty bottle (W_1)	100	100	100
Weight of empty+ 1/3rd of cement (W_2) gms	150	150	150
Weight of bottle + cement+kerosene (W_3) gms	337.07	336.74	337.198
Weight of bottle+ kerosene (W_4) gms	294	294	294
Weight of bottle+ water (W_5) gms	345.56	345.56	345.56
Specific gravity of kerosene G_k= (W_4 -W_1)/ (W_5 -W_1)	0.79	0.79	0.79
Specific gravity cement wrt kerosene Gc_k= (W_2 -W_1)/ (W_2 -W_1) – (W_3 -W_4)XG_k	3.13	3.08	3.15
Average Specific gravity of cement =3.12			

Specific gravity of Marble dust

Particulars	1	2	3
Weight of empty bottle (W_1)	100	100	100
Weight of empty+ 1/3rd of marble dust (W_2) gms	145	152	158
Weight of bottle + MDP+kerosene (W_3) gms	326	330	336
Weight of bottle+ kerosene (W_4) gms	294	294	294
Weight of bottle+ water (W_5) gms	345.56	345.56	345.56
Specific gravity of kerosene G_k= (W_4 -W_1)/ (W_5 -W_1)	0.79	0.79	0.79
Specific gravity cement wrt kerosene Gc_k= (W_2 -W_1)/	3.46	3.25	3.625

$(W_2 - W_1) - (W_3 - W_4) X G_k$			
Average Specific gravity of MDP=3.445			

Specific gravity of coarse aggregate (20mm)

Particulars	1	2	3
Weight of empty Pycnometer in gm	318	318	318
Weight of saturated surface dry aggregate (C) (gm)	500	500	500
Weight of Pycnometer + fine aggregate +water (A) gm	1589	1587	1592
Weight of pycnometer + water (B) gm	1262	1262	1262
Weight of oven dry sample (D) gm	497	498	495
Specific gravity fine aggregate G = D/C-(A-B)	2.87	2.84	2.91
Water absorption G_a=(C-D/D)X100	0.6036	.4016	1.010
Average Specific gravity of coarse aggregate = 2.87			
Average water absorption =0.67%			

Specific gravity of Demolished Waste

Particulars	1	2	3
Weight of empty Pycnometer in gms	318	318	318
Weight of saturated surface dry aggregate (C) (gm)	. 500	500	. 500

Weight of Pycnometer + fine aggregate +water (A) gms	1562	1568.64	1571.23
Weight of pycnometer+ water (B) gms	1262	1262	1262
Weight of oven dry sample (D) gm	498	495	496
Specific gravity fine aggregate G = D/C-(A-B)	2.49	2.56	2.6
Water absorption G_a=(C-D/D)X100	0.4016	1.010	0.8064
Average Specific gravity of DCW aggregate = 2.55			
Average water absorption =0.73%			

Specific gravity of fine aggregate (Sand)

Particulars	1	2	3
Weight of empty Pycnometer in gms	318	318	318
Weight of saturated surface dry aggregate (C) (gm)	500	500	500
Weight of Pycnometer +fine aggregate +water (A) gms	1572	1577.35	1574.87
Weight of pycnometer+ water (B) gms	1262	1262	1262
Weight of oven dry sample (D) gm	496	493	494
Specific gravity fine aggregate G = D/C-(A-B)	2.61	2.67	2.64

Water absorption G_a=(C-D/D)X100	0.8064	1.4198	1.2096
Average Specific gravity of fine aggregate = 2.64			
Average water absorption =1.142			

Compressive strength

Normal concrete

Compressive strength of normal concrete

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD kN	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8456	2505.48	507	22.53	22.4
		8478	2512	500	22.22	
		8462	2507.25	505	22.45	
2	28	8485	2514.07	760	33.77	33.51
		8510	2521.48	752	33.42	
		8489	2515.25	750	33.34	

Concrete with 5% Replacement of cement by MDP & 5% Replacement of coarse aggregate by Demolished Waste

Compressive strength of concrete with5% Replacement of cement by MDP & 5% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD kN	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8518	2523.85	535	23.77	23.58
		8527	2526.51	525	23.33	
		8508	2520.88	532	23.64	
2	28	8536	2529.18	775	34.45	34.25
		8549	2533.03	772	34.31	
		8521	2524.74	765	34.00	

Concrete with 10% Replacement of cement by MDP & 10% Replacement of coarse aggregate by Demolished Waste

Compressive strength of concrete with 10% Replacement of cement by MDP & 10% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD kN	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8583	2543.12	550	24.45	24.52
		8572	2539.85	545	24.23	
		8567	2538.37	560	24.88	
2	28	8596	2546.96	780	34.67	35.07
		8588	2544.59	795	35.34	
		8580	2542.23	792	35.20	

Concrete with 15% Replacement of cement by MDP & 15% Replacement of coarse aggregate by Demolished Waste

Compressive strength of concrete with 15% Replacement of cement by MDP & 15% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD kN	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8611	2551.40	535	23.78	24.11
		8632	2557.62	553	24.57	
		8624	2555.25	540	24.00	
2	28	8639	2559.70	795	35.34	34.99
		8657	2565.03	787	34.97	
		8644	2561.18	780	34.67	

Concrete with 20% Replacement of cement by MDP & 20% Replacement of coarse aggregate by Demolished Waste

Compressive strength of concrete with 20% Replacement of cement by MDP & 20% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD kN	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8649	2562.67	472	20.97	20.82
		8653	2563.85	469	20.84	
		8672	2569.48	465	20.67	
2	28	8661	2566.23	702	31.20	30.91
		8678	2571.25	690	30.67	
		8693	2575.70	695	30.88	

Concrete with 25% Replacement of cement by MDP & 25% Replacement of coarse aggregate by Demolished Waste

Compressive strength of concrete with 25% Replacement of cement by MDP & 25% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	DENSITY OF SPECIMEN (kN/m3)	FAILUR LOAD Kn	COMPRESSIVE STRENGTH MPa	AVERAGE COMPRESSIVE STRENGTH MPa
1	7	8686	2573.62	418	18.57	18.41
		8679	2571.56	415	18.45	
		8694	2576	410	18.23	
2	28	8698	2577.18	648	28.80	28.87
		8704	2578.96	657	29.20	
		8726	2585.48	644	28.62	

Split tensile strength

Normal concrete

Split tensile strength of normal concrete

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	FAILUR LOAD kN	SPLIT TENSILE STRENGTH MPa	AERAGE SPLIT TENSILE STRENGTH MPa
1	7	4450	160	2.26	2.23
		4385	145	2.05	
		4356	170	2.40	
2	28	4472	235	3.32	3.43
		4412	250	3.53	
		4338	245	3.46	

Concrete with 5% Replacement of cement by MDP & 5% Replacement of coarse aggregate by Demolished Waste

Split tensilestrength of concrete with 5% Replacement of cement by MDP & 5% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	FAILUR LOAD kN	SPLIT TENSILE STRENGTH MPa	AVERAGE SPLIT TENSILE STRENGTH MPa
1	7	4490	175	2.47	2.54
		4520	185	2.61	
		4476	180	2.54	
2	28	4515	265	3.75	3.82
		4550	285	4.03	
		4497	260	3.68	

Concrete with 10% Replacement of cement by MDP & 10% Replacement of coarse aggregate by Demolished Waste

Split tensilestrength of concrete with 10% Replacement of cement by MDP & 10% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	FAILUR LOAD kN	SPLIT TENSILE STRENGH MPa	AVERAGE SPLIT TENSILE STRENGTH MPa
1	7	4485	195	2.76	2.75
		4435	205	2.90	
		4510	185	2.61	
2	28	4505	270	3.82	4.03
		4460	290	4.10	
		4525	295	4.17	

Concrete with 15% Replacement of cement by MDP & 15% Replacement of coarse aggregate by Demolished Waste

Split tensilestrength of concrete with 15% Replacement of cement by MDP & 15% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	FAILUR LOAD kN	SPLIT TENSILE STRENGH MPa	AVERAGE SPLIT TENSILE STRENGTH MPa
1	7	4520	210	2.97	3.13
		4480	230	3.25	
		4465	225	3.18	
2	28	4535	280	3.96	4.12
		4500	305	4.31	
		4495	290	4.10	

Concrete with 20% Replacement of cement by MDP & 20% Replacement of coarse aggregate by Demolished Waste

Split tensilestrength of concrete with 20% Replacement of cement by MDP & 20% Replacement of coarse aggregate by Demolished Waste

S.NO	NUMBER OF DAYS	WEIGHT OF SPECIMEN (g)	FAILUR LOAD kN	SPLIT TENSILE STRENGTH MPa	AVERAGE SPLIT TENSILE STRENGTH MPa
1	7	4460	195	2.76	2.73
		4435	180	2.54	
		4480	205	2.90	
2	28	4505	275	3.89	3.86
		4465	290	4.10	
		4560	255	3.60	

Conclusion:

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength and flexural strength considering the―environmental aspects also:

- The results demonstrated comparative analysis on normal concrete against the different proportion as 5%, 10%, 15%, 20% and 25% of similar percentage of Marble Dust Powder (MDP) and Demolished Waste.

Compressive Strength

- The average compressive strength of normal concrete stands as 22.4 Mpa in 7 days and 33.51 Mpa in 28 days. The best results with the mixture of MDP and demolished concrete provided best results with percentage as 5%, 10% and 15% in both 7 days and 28 days, and the compressive strength starts to decline with further addition of the MDP and demolished concrete in the mix.

Split Tensile Strength

- The average split tensile strength of normal concrete was 2.23 mPa in 7 days and 3.43 mPa in 28 days. The best results with the mixture of MDP and demolished concrete provided best results with percentage as 5%, 10% and 15% in both 7 days and 28 days, and the split tensile strength starts to decline with further addition of the MDP and demolished concrete in the mix.

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