An Experimental Investigation on Strength properties of concrete by using demolished concrete waste

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ABSTRACT

The concrete material needs to be destroyed while new or old building is being done. "Demolished Concrete" is the name given to the leftover concrete produced by these procedures. Recycled aggregate has become popular due to environmental preservation and the promotion of sustainable development concepts. Large volumes of solid trash are produced by demolished sites and restoration projects, and today, this material is disposed of in landfills. A better economics may be obtained without harming the environment by recycling and reusing the destroyed concrete.In this experiment, coarse aggregates are swapped out for waste aggregates from destroyed concrete structures in order to evaluate the workability, compressive strength, and durability of concrete. In this study, destroyed aggregates were replaced to varying degrees (0, 10, 20, 30, 40, and 50%).

Key words: Demolished Concrete, recycled aggregate, workability, compressive strength, split tensile strength, flexural strength, durability.

1.INTRODUCTION

The way that construction materials are used has changed over time. The conventional and expensive materials have been replaced with inexpensive and locally accessible materials including thatch, bricks made of moulded earth, stones, steel, aluminium, polymers, and fibres in a variety of sorts and forms. To influence the intended economy, these materials have all been produced to fulfil certain climatic, skilled labour, and raw material requirements. Due to the substantial extra expense of disconnecting electric and communications connections to facilitate the passage of multi-story structures, moves involving transportation along public roadways are less prevalent. The expense of this method may be more than that of lifting and transporting the structure. It may be challenging to recycle demolition materials if these pollutants are present. Additionally, it can be costly and time-consuming to separate different demolition components that have been connected together throughout the construction process. In a selective demolition operation, particular interior or exterior building components are removed while safeguarding the remaining building as well as neighbouring buildings and spaces.

With this technique, a structure is carefully taken apart or deconstructed in order to conserve its constituent parts for later use, recycling, or renovation. In general, dismantling requires more effort than destruction. Total destruction goes without saying. So involves demolishing a complete building, and there are several ways to do it, some of which are described here. Nevertheless, relying at the supposed software, demolition substances would possibly on occasion be mixed. For example, concrete, bricks, and ceramics are regularly beaten up collectively and used as fill in different creation tasks which includes growing roads. Although different substances might nevertheless want to be looked after out, this software allows those factors to be mixed at the same time as being demolished.

2.LITERATURE REVIEW

Mohd Monish, Vikas Srivastava, V.C. Agarwal investigated complete to decide the effect of changing a number of the coarse combination with particles from demolition at the workability and compressive power of recycled concrete for the take a look at at 7 and 28 days. The discovered compressive power become as compared to the power of conventional concrete. The compressive power of recycled concrete as much as 30% coarse combination replacement (C. A. R.) through destroyed particles become observed to be just like traditional concrete on the cease of 28 days, in accordance to check findings.

Vikas Srivastava, Mohd Monish, Raushan Ranjan investigated The findings of experimental research carried out to decide the effect of partial substitution of cement, nice mixture, and coarse mixture via way of means of numerous additives of demolished wastes at the energy and workability of concrete fashioned are provided on this work. Using IS: 10262-2009, layout blend concrete of grade M25 (referral concrete) become made for the study. After then, every person factor of concrete become changed separately via way of means of being combined with a special sieved percent of beaten demolition debris.

Anagha Kalpavalli, Dr. S. M. Naik investigated work, the traits and consequences of recycled mixture concrete are identified, contrasted with the ones of herbal mixture concrete, and reported.This led to the conclusion that recycled aggregates had a lower specific gravity and bulk density than traditional aggregates. This is a result of the connected mortar that is present on the surface of the aggregate. Compared to natural aggregates, recycled aggregates absorb more water. Depending on the kind of aggregates, the range might change, and in this case it is 6% higher. Additionally, the connected mortar that is present on the aggregate surface and has a propensity to absorb more water is the source of this. Recycled aggregates have greater aggregate crushing and impact values than natural aggregates. This is due to the recycled aggregates having experienced fatigue during their prior use. It is clear from the workability results that the questioned concrete is high strength concrete. According to the findings of this experiment, recycled aggregates may substitute natural coarse aggregates up to 30% of the time and still achieve the desired strength after 28 days. Additionally, it can be deduced that the split tensile strength exhibits the similar trend of strength loss with rising replacement. However, they still fall within the acceptable range for usage in structural concrete, therefore this is OK. Similar patterns are seen when looking at the outcomes of flexure. And it is determined that the outcomes are adequate.

3.MATERIALS AND MIX DESIGN OF CONCRETE

3.1 Materials used

3.1.1. Cement

The simple components had to create Portland cement encompass argillaceous factors like shale or clay and calcareous minerals like limestone or chalk. Depending on whether or not the mixing and crushing of the uncooked substances is accomplished in a moist or dry environment, there are tactics referred to as moist and dry operations. The raw ingredients used to create bonds primarily consist of lime, silica, alumina, and iron oxide. In the furnace at a high temperature, these oxides work together to create more erratic mixtures.

Figure 3.1: OPC 53 grade cement

3.1.2. Aggregates

Concrete's number one elements are aggregates. They offer concrete body, lessen shrinkage, and feature an monetary influence. As a byproduct of their private raw materials, aggregates are inert granular solids like sand, rock, or crushed stone. They are also the raw elements, which constitute a key element of concrete.

3.1.2.1. Coarse aggregate

Large aggregates are made of debris which can be large than 4.75mm however regularly variety in length from 9.5mm to 37.5mm. They can also additionally come from primary, secondary, or recycled sources.

In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

Figure 3.2: 20mm coarse aggregates **Figure 3.3: 12mm coarse aggregates**

3.1.2.2. Fine aggregate

Sands obtained from the land or the sea make up the majority of fine aggregates. The majority of the particles in fine aggregates are sand or crushed stone that have been through a 4.75mm screen.

Figure 3.4: Fine aggregate

3.1.3 Demolished aggregates

The local building that has been both created and dismantled provides the construction and demolition garbage. The aggregates that pass through an IS sieve with a retention of 12.5 mm are used.

Fig 4.5 Demolished concrete aggregate

3.1.5. Water

Water has a essential feature withinside the compound reaction to bind, making it an crucial element of concrete. It is critical to consciously find out the sort and amount of water as it moulds the concrete gel that strengthens the structure. Compared to C2S, C3S requires 24% more water with the useful resource of the usage of weight.

3.1. 6 Super plasticizers: (High range water reducers)

Superplasticizers are a normally new class and advanced form of plasticizer, whose use become advanced in Japan and Germany among 1960 and 1970, respectively. Compared to not unusualplace plasticizers, they may be purposely distinctive. By the use of superplasticizers, water can be decreased through as much as 30% with out dropping any utility, in comparison to a ability discount of as much as 15% if plasticizers had been to be present.

BASIC TESTS ON MATERIALS

FINENESS OF CEMENT

Cement fineness significantly affects the rate of hydration and, thus, the rate of strength increase. The rate of heat buildup is caused by cement fineness. A greater surface area for hydration is provided by finer cement, hastening the development of strength. Structures develop fractures as a result of concrete's tendency to shrink as cement's fineness increases.

Observations of fineness of cement test.

Trial no.	1	2	3
Weight of cement in gms	100	100	100
Wt. Of residue on sieve in gms.	2.5	2.3	2.4
Amount retained (%)	2.5%	2.3%	2.4%

Amount retained = $\frac{2.5+2.3+2.4}{3*100} * 100 = 2.4\%$

Remaining percentage passing = 97.6%

SPECIFIC GRAVITY OF CEMENT

A cement sample's weight and the quantity of the liquid it displaces are measured as a way to calculate the particular gravity. The liquid a good way to be utilised must be impartial in phrases of chemical reactions.OPC typically has a specific gravity of 3.15 on average.

Formula:

Specific gravity = $\frac{weight\ of\ cement}{volume\ of\ cement}$

Observations:

S. No.	Initial residing	Final reading	Volume Of cement (v)	Specific gravity G=W/V
1	0	19.75	20.32	3.15

Calculations:

Specific gravity = $\frac{weight\ of\ cement}{volume\ of\ cement} = \frac{64}{20.32} = 3.15$

Specific gravity of cement = 15

NORMAL CONSISTENCY OF CEMENT

Normal consistency is the quantity of water that the cement paste needs to be that the Vicat plunger can pierce it up to a degree this is five to 7 mm from the Vicat mould's bottom. When water is introduced to cement, the ensuing paste starts off evolved to lose consistency at the same time as stiffening and strengthening.

Observations and calculations:

% of water	Initial reading	Final reading	Height not penetrated (mm)
26%	50	32	18
28%	50	20	30
30%	50	12	38
32%	50	7	43

Normal consistency of cement =32%

INITIAL SETTING TIME

Initial setting time is the period of time it takes for the paste to become sufficiently rigid that the vicat needle cannot pass through it more than 5 millimetres (mm) from the mold's base.

Figure 3.7: vicat apparatus

Observations and calculations:

Time(minutes)	10	20	30	40	50	60
Initial reading	50	50	50	50	50	50
Final reading	0	1	2	2.5	3.5	5

Initial setting time of cement = 60 minutes.

SPECIFIC GRAVITY OF COARSE AGGREGATE

In concrete technology, the design computation of concrete mixtures uses aggregate specific gravity. Knowing each component's specific gravity allows one to translate their weight into solid volume, which allows one to determine the potential yield of concrete per unit volume.

Formula:

Specific gravity = $\frac{(w2-w1)}{(w2-w1)-(W3-w4)}$

Observations of Specific Gravity of 20 mm coarse aggregate:

Observations	Trial-1	Trial-2
Weight of empty specific gravity bottle(gms)(W1)	460	460
Weight of bottle + aggregate(gms)(W2)	1235	1230
Weight of bottle + aggregate + water(gms)(W3)	1718	1705
Weight of bottle + water(gms)(W4)	1215	1215
Specific gravity	2.85	2.75

Average Specific Gravity = (2.85+2.75)/2

=2.80

Specific gravity of 20mm coarse aggregate = 2.80

Observations of Specific Gravity of 12 mm of coarse aggregate*:*

Observations	Trial-1	Trial-2
Weight of empty specific gravity bottle(gms)	460	460
Weight of bottle + aggregate(gms)	1220	1210
Weight of bottle + aggregate + water(gms)	1695	1695
Weight of bottle + water(gms)	1215	1215
Specific gravity	2.714	2.77

Average Specific Gravity = (2.714+2.77)/2 = 2.74

Specific gravity of 12mm of coarse aggregate =2.74

SPECIFIC GRAVITY OF FINE AGGREGATE:

Specific gravity is the load of an combination in terms of the load of an equal extent of water. Cement concrete layout calculations regularly require the unique gravity of an combination with a view to calculate the moisture content material and extent yield of concrete.

Observations of Specific gravity of Fine aggregate:

Observations	Trial-1	Trail-2
Weight of empty specific gravity bottle(gms)	460	460
Weight of bottle + aggregate(gms)	1230	1230
Weight of bottle + aggregate + water(gms)	1695	1705
Weight of bottle + water(gms)	1215	1215
Specific gravity	2.65	2.75

Average Specific gravity = (2.65+2.75)/2= 2.70

Specific gravity of fine aggregate = 2.70

SIEVE ANALYSIS OF FINE AGGREGATE:

The fineness modulus of an mixture is same to the whole probabilities retained on sieves of uniform length extended via way of means of 100.

Weight of fine aggregate = 1000gm.

S. No.	Sieve sizes Mm	Weight retained	%age weight retained	Cumulative % of weight retained(F)	%age weight passing	Cumulative %age weight passing
1	4.75	0	0	0	100	100
2	2.36	95	9.5	9.5	90.5	190.5
3	1.18	271	27.1	36.6	63.4	253.9
4	600μ	295	29.5	66.1	33.9	287.8
5	300μ	309	30.9	97	3	290.8
6	150μ	30	3.0	100	0	290.8

Fineness modulus $= \frac{cumulative\ \%\ of\ wt.\ retained}{100} = \frac{309.2}{100} = 3.092$

The fineness modulus of fine aggregate = 3.09

MIX DESIGN AND SAMPLE PREPARATION

Step 1: Determining the Target Strength for Mix Proportioning

Fck = fck + 1.65 x S

= 40 + 1.65 x 5.0 = 48.25 N/mm^2

Step 2 Selection of water-cement ratio:-

From Table 5 of IS 456, Maximum water-cement ratio = 0.45

Step 3 Selection of Water Content

Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump)

We are targeting a slump of 100mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump

I.e. Estimated water content for 100 Slump = 186+ (6/100) X 186 = 197litres

Water content = 197 liters

STEP 4 – Calculation of Cement Content

Water-Cement Ratio = 0.45

Water content from Step – 3 i.e. 197 liters

Cement Content = Water content / "w-c ratio" = (197/0.45) = 438 kgs

From Table 5 of IS 456,

Minimum cement Content for moderate exposure condition = 300 kg/m3

438 kg/m^3 > 300 kg/m^3, hence, OK.

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m3, hence ok too.

STEP 5: Proportion of Volume of Coarse Aggregate and Fine aggregate Content

From Table 3 of IS 10262- 2009, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone I) = 0.60

STEP 6: Estimation of Concrete Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

1. Volume of concrete = 1 m^3
2. Volume of cement = (Mass of cement / Specific gravity of cement) x (1/1000)

   = (438/3.15) x (1/1000) = 0.139 m^3
3. Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

   = (197/1) x (1/1000) = 0.197 m^3
4. Total Volume of Aggregates = 1- (b+c) =1- (0.139+0.197) = 0.664 m^3
5. Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000

   = 0.664 X 0.60 X 2.80 X 1000

   = 1115 kgs/m^3
6. Mass of fine aggregates

   = d X Volume of Fine Aggregate X Specific Gravity of Coarse Aggregate X 1000

   = 0.664 X 0.40 X 2.70 X 1000 = 717.12 kgs/m^3

STEP-7: Concrete Mix proportions for Trial Number 1

Cement = 438 kg/m^3

Water = 197 kg/m^3

Fine aggregates = 717.12 kg/m^3

Coarse aggregate = 1115 kg/m^3

Water-cement ratio = 0.45

4.EXPERIMENTAL INVESTIGATION

Slump cone test

A assets of freshly-poured concrete is measured the usage of the concrete droop test. It is an empirical test that gauges how effects new concrete can be worked. It measures consistency amongst batches with extra specificity. Due to the sincere system and clean process, the test is well-liked.

Slump cone test

Compaction factor test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete.

Compaction factor test apparatus

Casting of the specimens

Casting of cubes and cylinders in the same manner as for concrete of the M40 grade, with demolished concrete(0%,10%,20%,30%,40%,50%ofcoarse aggregate replacement respectively).

casting of samples (cubes and prisms)

Curing the test specimens

Allow the test samples to solidify for at least 24 hours after casting them. Now, immerse the demolded specimens in the curing tank according to the water submerged curing (WSC) method used in this study for strength calculations for 7 days, 14 days, and 28 days.

Curing of specimens for 7 days, 14 days and 28 days age

Placing the Specimen in the Testing Machine:

The specimen's floor should be cleared of any loose sand or other particles so that it may come into contact with the compression platens and the bearing floor of the testing equipment. lightly adjusted through hand while the spherically seated block is introduced endure at the specimen to make sure uniform seating.

Testing of specimen at 7 days curing

Split tensile strength of concrete

It was tested in accordance with IS516-1959. The strength of concrete was determined using conventional 150mm x 300mm cylinders. Specimens are positioned on the 200T CTM bearing surface without any eccentricity, and a constant rate of stress is applied until the cylinder fails.

Split tensile strength testing at 14 days curing

Calculation:

By applying a load to the pinnacle and bottom of the cylinder's lateral floor in a location that is equal to the lateral floor area, the break up tensile strength is determined.

The split tensile strength = ($2P/\pi dl$) N/mm2

Flexural Strength of concrete

Flexural strength testing procedure from IS516-1959:

Placing the specimen in testing machine:

Testing Square prism for flexural strength

Calculation:

The Modulus of rupture, or fb, is a degree of the specimen's flexural electricity and is computed to the nearest 0.five kg/cm2 if "a" is the space among the road fracture and the closest support, measured at the centre line of the specimen's tensile aspect in cm:

$$fb = (Pl/bd^2)\ N/mm2$$

(or)

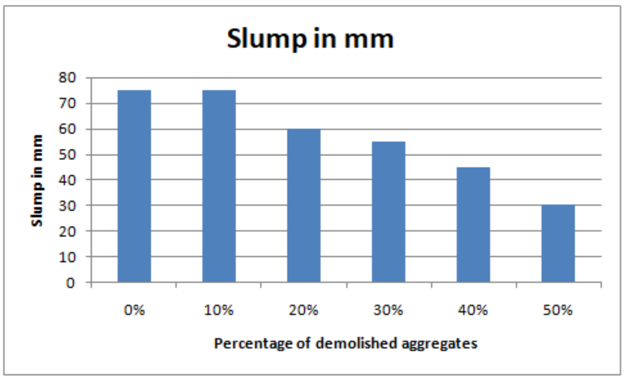
$$fb = 3pa/bd^2$$

5.RESULTS AND ANALYSIS

Workability

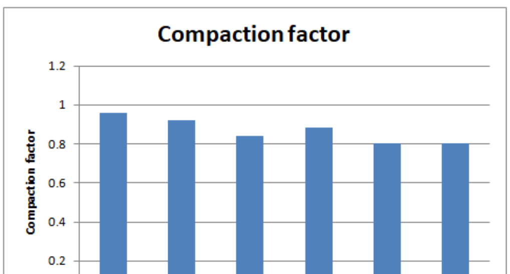
Slump cone test

S. No	% Demolished aggregates	Slump in mm
1	0%	75
2	10%	75
3	20%	60
4	30%	55
5	40%	45
6	50%	30



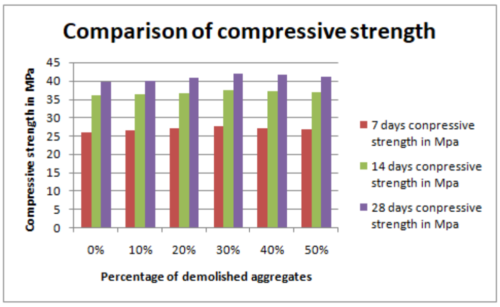
Strength of concrete

S.NO	% Demolished aggregates	Compaction factor
1	0%	0.96
2	10%	0.92
3	20%	0.84
4	30%	0.88



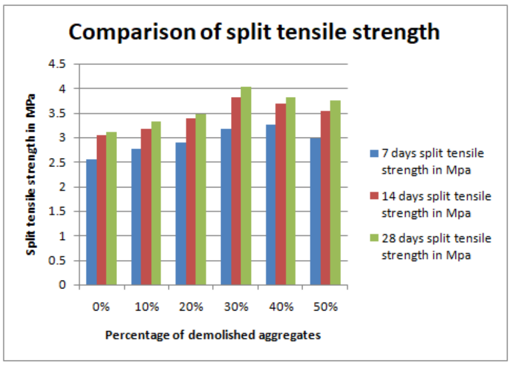
Compressive strength

S.NO	Percentage of demolished aggregates	7 days compressive strength in Mpa	14 days compressive strength in Mpa	28 days compressive strength in Mpa
1	0%	25.77	36	39.55
2	10%	26.44	36.22	40
3	20%	26.88	36.66	40.66
4	30%	27.55	37.33	42
5	40%	27.11	37.11	41.55
6	50%	26.66	36.88	41.11



Split tensile strength

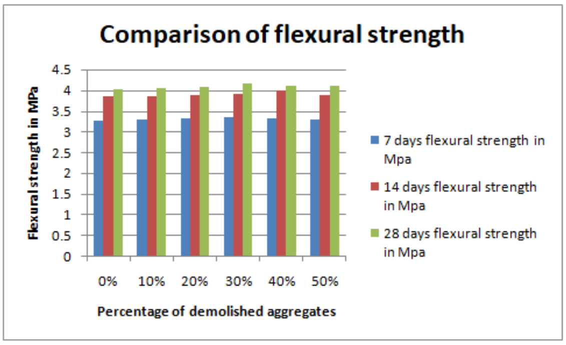
S.NO	Percentage of demolished aggregates	7 days split tensile strength in Mpa	14 days split tensile strength in Mpa	28 days split tensile strength in Mpa
1	0%	2.54	3.04	3.11
2	10%	2.76	3.18	3.32
3	20%	2.9	3.39	3.47
4	30%	3.18	3.82	4.03
5	40%	3.25	3.68	3.82
6	50%	2.97	3.54	3.75



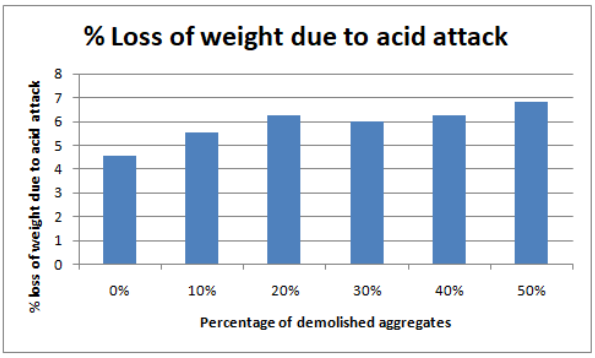
Durability

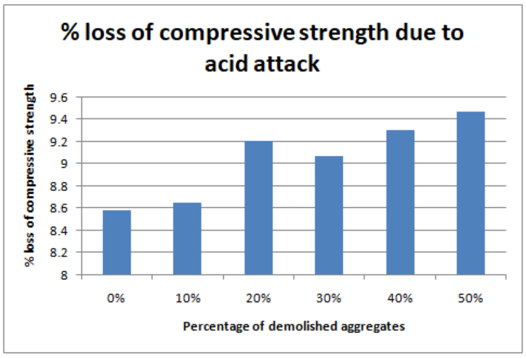
S.NO	Percentage of demolished aggregates	7 days flexural strength in Mpa	14 days flexural strength in Mpa	28 days flexural strength in Mpa
1	0%	3.25	3.84	4.02
2	10%	3.29	3.85	4.05
3	20%	3.32	3.88	4.08
4	30%	3.36	3.9	4.15
5	40%	3.33	3.98	4.12
6	50%	3.3	3.88	4.1

Aci



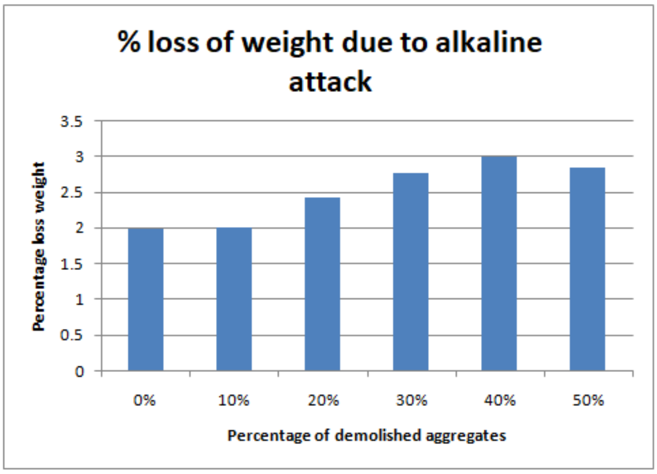
SL.NO	Percentage of demolished aggregates	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength for 90days curing due to acid attack
1	0%	2355	2248	4.54	39.55	36.16	8.58
2	10%	2335	2206	5.52	40	36.54	8.65
3	20%	2265	2124	6.22	40.66	36.92	9.2
4	30%	2230	2096	6	42	38.2	9.07
5	40%	2394	2244	6.26	41.55	37.68	9.3
6	50%	2425	2260	6.8	41.11	37.22	9.46

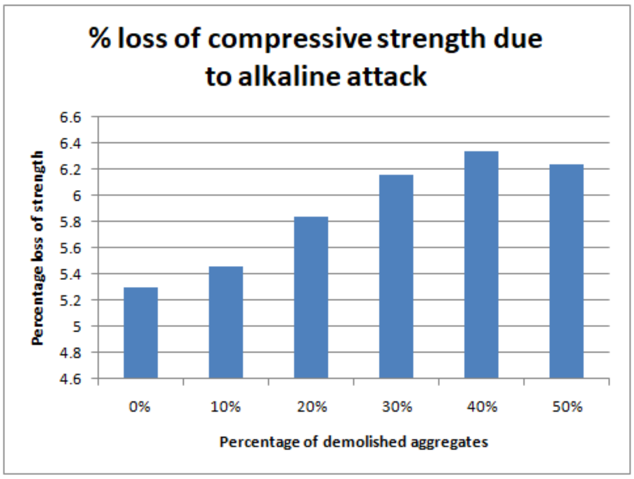




Alkaline attack

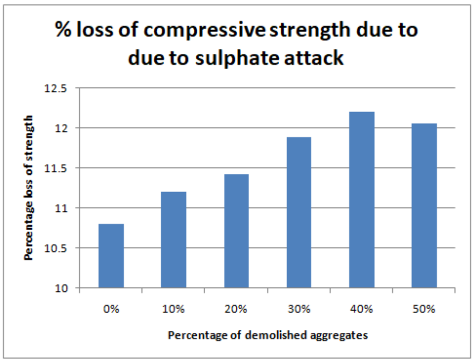
Sl. No	Percentage of demolished aggregates	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack for 90days curing
1	0%	2280	2235	1.98	39.55	37.45	5.3
2	10%	2245	2200	2	40	37.8	5.46
3	20%	2365	2308	2.41	40.66	38.28	5.84
4	30%	2458	2390	2.766	42	39.41	6.16
5	40%	2468	2394	2.99	41.55	38.5	6.34
6	50%	2538	2466	2.83	41.11	38.55	6.24





Sulphate attack

Sl. No	Percentage of demolished aggregates	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to due to sulphate attack for 90days curing
1	0%	39.55	35.28	10.8
2	10%	40	35.52	11.2
3	20%	40.66	36.02	11.42
4	30%	42	37.01	11.88
5	40%	41.55	36.48	12.2
6	50%	41.11	36.16	12.05



6.CONCLUSIONS:

1. Reusing destroyed concrete as a substitute for some of the coarse aggregates gives us another way to turn waste into valuable materials.
2. Removing the garbage from demolished buildings and using it as coarse aggregate lessens the load on landfills and the pollution it causes.
3. The density of the destroyed concrete is lower than that of traditional concrete, which lowers the price of the concrete and results in the production of light-weight concrete structures.
4. Where natural coarse aggregate are not readily accessible and soil carrying capacity is limited, demolished concrete is typically employed.
5. As the percentage of Waste that is destroyed rises from 0% to 50%, the value of slump diminishes.
6. From 0% to 50% of the waste is destroyed, and the value of the compaction factor drops.
7. From 0% to 30%, the concrete's compressive strength, split tensile strength, and flexural strength all rise with the amount of material that is removed; but, after that point, the strength value starts to decline.
8. As the percentage of aggregates that are destroyed rises, so does the percentage of weight loss attributable to acid and alkaline assault.
9. As the percentage of aggregates that are destroyed increases, so does the percentage of compressive strength loss caused by acid and alkaline assault.

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