C & D WASTE – USE OF RECYCLED AGGREGATES

By

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Estimates Of 'C & D' Wastes Composition In India

Composition of C&D	Typical as per TIFAC	MCD Survey, 2004	Survey 2005 by IL&FS ECOSMART
Soil/Sand, Gravel	36.0	43.0	31.5
Bitumen	2.0	-	-
Metals	5.0	-	0.4
Masonry / Brick	31.0	15.0	59.0
Concrete	23.0	35.0	-
Wood	2.0	-	1.5
Others	1.0	7.0	7.6
Total	100.0	100.0	100.0

Total C & D concrete wastes = 12 million tonnes annually

International Practice - Specifications

- **UK - BS 8500-2:2006, the complementary British Standard to BS EN 206-1 :**
  - **Recycled concrete aggregate (RCA), and**
  - **Recycled aggregate (RA).**
  - **RCA is obtained from crushing demolished concrete structures, discarded precast elements and unused hardened concrete (1). Such aggregate can be used in structural concrete having cube strength of concrete 50 MPa.**
  - **RCA has no strength limitation provided the aggregate is not contaminated. For concrete cube strengths of 25 to 50 MPa, a maximum of 20 percent replacement of coarse aggregate applies, for designated concrete.**

International Practice - Specifications

- **RA may contain masonry up to 100 percent.**
- **Additional specification clauses required on a case by case basis.**
  - **maximum acid soluble sulphate, alkali content, ASR reactivity and any limitations on use in concrete.**
- **RA use is limited to concrete cube strength of 20 MPa.**
- **Provisions for the use of fine recycled concrete aggregate and fine recycled aggregate are not given in BS 8500-2: 2006, but it can be used if demonstrated, that significant quantities of deleterious materials are not present.**

Indian - Specifications

- **IS: 456-2000 permits use of aggregates other than natural aggregates in plain concrete with following restrictions:**
  - **Should meet strength and durability requirements**
  - **Water absorption should not be more than 10 %**
  - **Sulphate content –not more than o.5 %**
- **RCA from C & D waste can thus be permitted if meeting above requirements**

Studies Conducted

- C & D waste of a demolished building in Delhi used to make coarse and fine aggregates
- Aggregates so produced , tested for various engineering properties
- Trials conducted for compressive strength and workability
  - Different percentage of recycled aggregate used as replacement of natural aggregate

These Studies conducted at NCB were part of a joint project with Sintef , Norway

Recycling for lab trials

- C & D waste was taken from a site at Subhash Nagar area of Delhi.
- The demolished concrete was segregated into three lots:
- Lot1- Concrete resulting from RCC member of buildings.
- Lot2- Concrete resulting from RCC members of culvert slab.
- Lot3- Concrete resulting from flooring like brick-concrete, tiles, mosaic, plaster etc.
- Lot1 and Lot2 mixed together and named as RCA1 sample, while Lot3 samples were named as RCA2.

The site from where recycled aggregate was taken

Crushing

The ‘as received’ samples were broken into approximate size of 50 to 60 mm by manual hammer action.

The manually broken samples were separated into three fractions of sizes (-20mm to 10mm), (-10mm to 4.75mm) and (-4.75mm).

The aggregates of +20mm size were crushed in small motorized crusher, and then again sieved through 20mm, 10mm and 4.75mm sieves.

Heap of aggregate RCA2 (Uncrushed)

Partial crushed aggregate RCA1

Crushed aggregate (RCA)

Crushed coarse aggregate Heap (RCA)

Carbonation test performed on RCA1

Average carbonation depth in RCA1-40mm (about 35% volume carbonated).

Carbonation test performed on RCA2

For RCA2 sample the carbonation was much less at 3.1mm because most of the material was PCC under flooring

Sieve analysis for recycled coarse aggregate (10 mm & 20 mm)

	10 mm		20 mm	
Sieve Size mm /micron	% Passing	% Passing (Permissible limit as per IS 383)	% Passing	% Passing (Permissible limit as per IS 383)
40 mm	-	-	100	100
20 mm	-	-	99.8	85-100
12.5 mm	100	100	-	-
10 mm	99.8	85-100	6.6	0-20
4.75 mm	11	0-20	0.8	0-5

Sieve Analysis for recycled coarse (RCA-1) aggregate (10 mm & 20 mm

	10 mm		20 mm	
Sieve Size mm /micron	% Passing	% Passing (Permissible limit as per IS 383)	% Passing	% Passing (Permissible limit as per IS 383)
40 mm	-	-	100	100
20 mm	-	-	99.1	85-100
12.5 mm	100	100	-	-
10 mm	99.2	85-100	7	0-20
4.75 mm	3.6	0-20	0.9	0-5

Sieve Analysis For Recycled Fine Aggregate

	% Passing	% Passing (Permissible limit as per IS 383)			
Sieve Size mm /micron		Grade Zone –I	Grade Zone -II	Grade Zone–III	Grade Zone–IV
10 mm	100	100	100	100	100
4.75 mm	99.8	90-100	90-100	90-100	95-100
2.36 mm	89.3	60-95	75-100	85-100	95-100
1.18 mm	68.3	30-70	55-90	75-100	90-100
600 micron	49.2	15-34	35-59	60-79	80-100
300 micron	27.8	5-20	8-30	12-40	15-50
150 micron	13.7	0-10	0-10	0-10	0-15

Sieve analysis for recycled fine aggregate (RCA1)

	% Passing	% Passing (Permissible limit as per IS 383)			
Sieve Size mm /micron		Grade Zone –I	Grade Zone -II	Grade Zone–III	Grade Zone–IV
10 mm	100	100	100	100	100
4.75 mm	99.7	90-100	90-100	90-100	95-100
2.36 mm	89.7	60-95	75-100	85-100	95-100
1.18 mm	67.2	30-70	55-90	75-100	90-100
600 micron	53.2	15-34	35-59	60-79	80-100
300 micron	28.3	5-20	8-30	12-40	15-50
150 micron	16.4	0-10	0-10	0-10	0-15

Other Test Results Of Recycled Coarse Aggregate

Sl No.	Parameter	Value	Permissible limit as per IS 383 (maximum)
1	Specific Gravity	2.17	--
2	Water Absorption %	6.7	--
3	Crushing Value %	36.1	30 (max) *, 45 (max) **
4	Impact Value %	34.9	30 (max) *, 45 (max) **
5	LA –Abrasion %	50.9	30 (max) *, 50 (max) **
6	Soundness, Sodium Sulphate %	4.1	12
7	Elongation Index %	21.1	--
8	Flakiness Index %	5.6	--

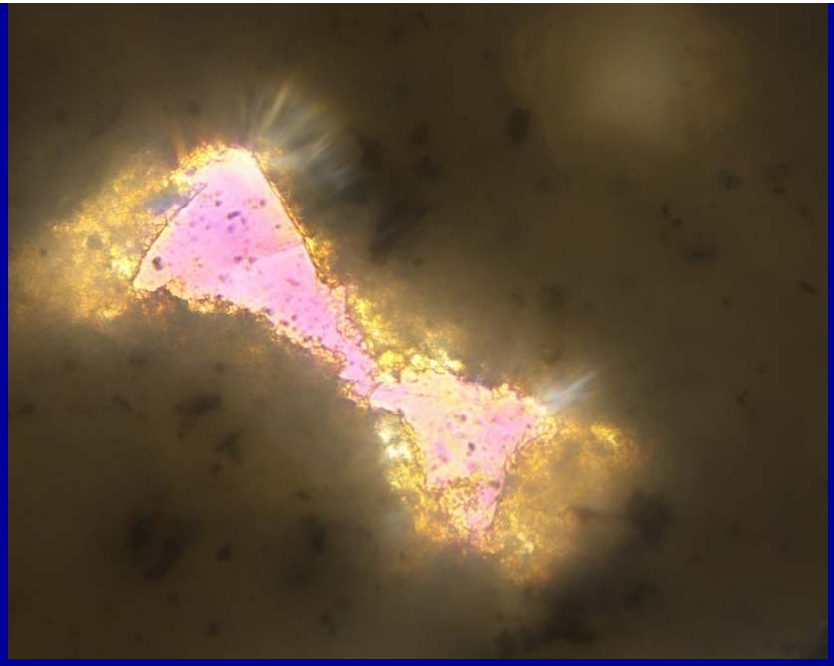
* For aggregates to be used in concrete for wearing surfaces

** For aggregates to be used in other concrete

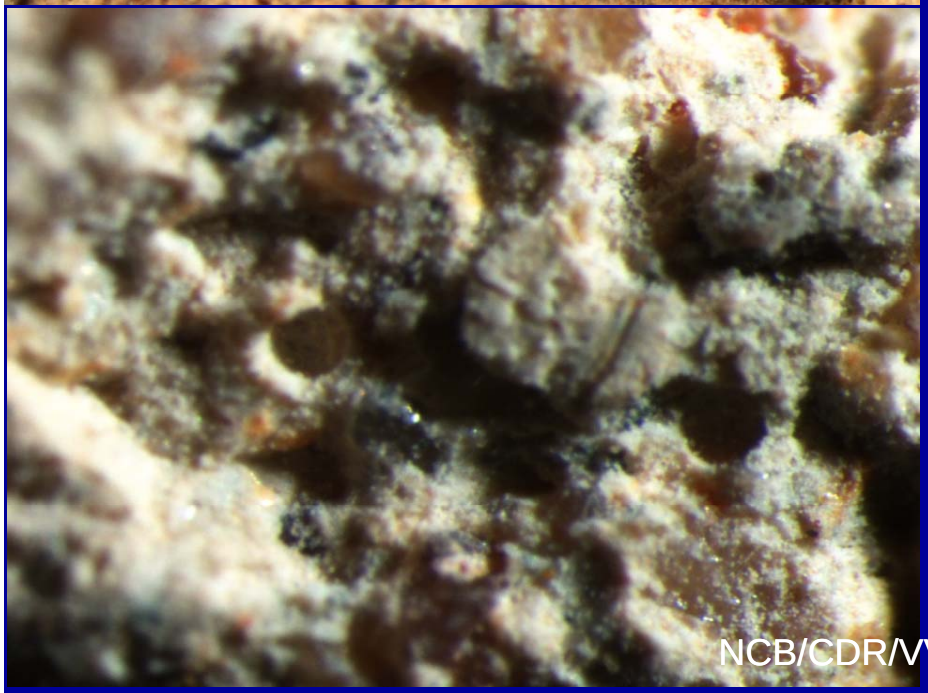
Other Test results of recycled fine aggregate

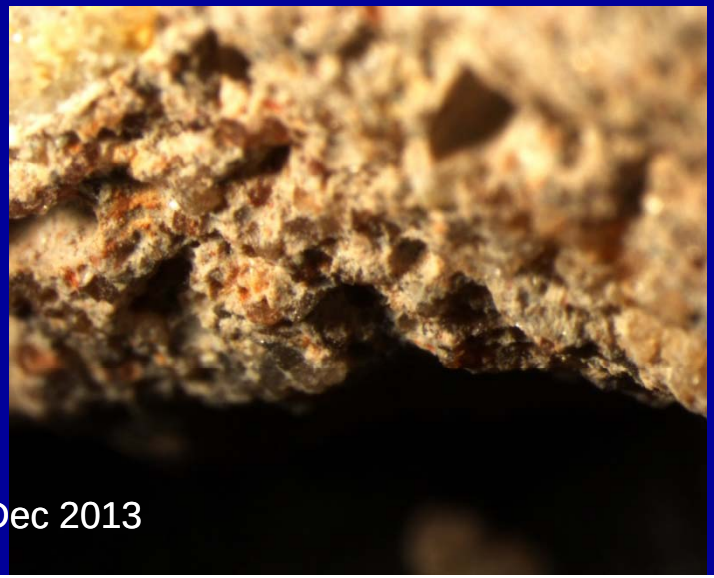
Sl No.	Parameter	Value	Permissible limit (maximum)
1	Specific Gravity	2.12	--
2	Water Absorption %	8.2	--
3	Silt content by, %	7.7	8%
6.	Material finer than 75µ, %	8.0	15%

Microscopic Analysis of Normal Aggregates

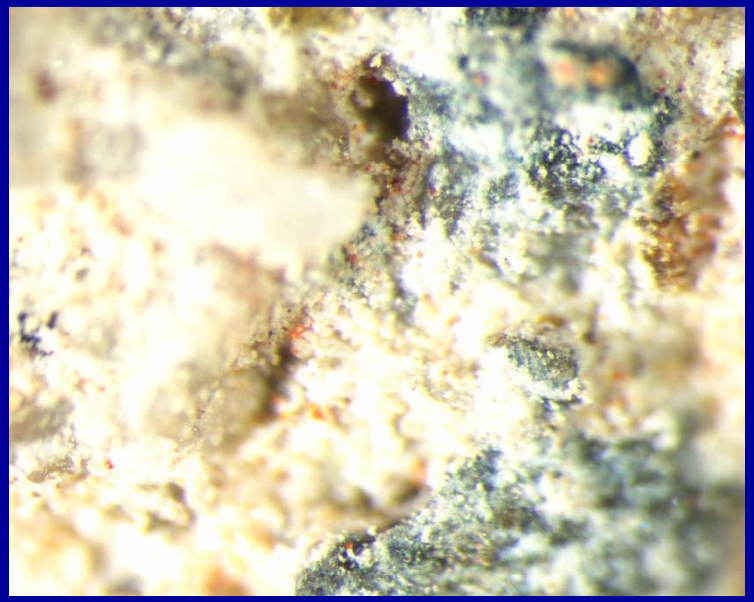


Microscopic Analysis of Recycled Coarse Aggregates





Microscopic Analysis of Recycled Fine Aggregates



Testing Of Concrete Incorporating Recycled Aggregates (RCA2)

Materials Used:

i. Cement (OPC), natural aggregates, recycled aggregates & chemical admixture.

ii. Cement (OPC), natural aggregates, recycled aggregates, micro silica and chemical admixture.

Replacement of normal aggregates with Recycled aggregates :
25%, 50%, 75% and 100%

Test results – Compressive strength of Concrete mixes with and without incorporating silica fume Replacement Of Natural Agg With Recycled Agg (10-20 fraction only)

Silica Fume %	Aggregate 10-20 mm		Aggregate 4.5-10 mm		Compressive Strength (MPa)			Slump (mm)
	Normal aggregates %	Replacement %	Normal aggregates %	Replacement %	7 days	28 days	90 days	
0	100	0	100	0	37	41	46	80
0	75	25	100	0	34	41	47	90
	50	50	100	0	35	41	44	80
0	25	75	100	0	32	37	41	90
0	0	100	100	0	17	29	34	100
7	50	50	100	0	28	36	38	95
7	25	75	100	0	27	36	40	95
7	0	100	100	0	22	35	40	90

Test results – Compressive strength of Concrete mixes

Replacement Of

Fine Aggregate With Recycled Fine Aggregates

Silica Fume %	Aggregate <4.5 mm		Compressive Strength (N/mm^2)			Slump (mm)
	Normal aggregates %	Replacement %	7 days	28 days	90 days	
0	100	0	37	41	46	80
0	75	25	25	36	40	90
0	50	50	31	35	41	85
0	25	75	31	35	34	90

Test results – Compressive strength of Concrete mixes

Replacement of Fine Aggregate With Recycled Fine Aggregates

Silica Fume %	Aggregate 10-20 mm		Aggregate <4.5 mm		Compressive Strength (N/mm^2)			Slump (mm)
	Normal aggregates %	Replacement %	Normal aggregates %	Replacement %	7 days	28 days	90 days	
7	100	0	0	100	36	40	42	80
7	100	0	50	50	25	36	39	90
7	100	0	25	75	25	33	40	85
7	100	0	0	100	17	28	36	100
7	50	50	50	50	24	29	34	95
	0	100	0	100	22	33	35	90

Can We Use Recycled aggregates in Concrete ?

- Requirements:
  - Strength
    - Suitable for part replacement in concrete up to gradeM25
  - Durability
    - High Water absorption, Voids
    - Generally not suitable for RCC (except if waste is exclusively from good quality concrete)
    - Suitable for Plain Cement Concrete (PCC)
  - Serviceability
    - Can be affected by leaching from mixed waste
    - However if used with care, can be part replacement can be permitted in PCC blocks, PCC internal Road work, Lean concrete etc.

Conclusion

- Construction and Demolishen waste can be Recycled to make coarse and fine aggregate (sand) for selective use in concrete
- Air voids and Water absorption is high in Recycled C&D waste aggregates
- Large variations in type of waste, needs to be carefully segregated before processing for effective utilization

.....contd.

Conclusion

- **Cohesiveness of concrete increases with the increased recycled aggregate content**
- **With increased replacement of fine or coarse aggregate with recycled concrete aggregates - no significant difference in slump value, while the addition of silica fume results in reduction of workability.**
- **With increased recycled coarse aggregate the strength gets reduced,**

.....contd.

Conclusion

- With the increasing content of recycled fine aggregate the compressive strength is increased.
- It was found that the100% replacement of recycled fine aggregate shows good results which are comparable to control mix at 3-Day, 7-Day and 28-day.

* In the presence of silica fume the increased percentage of fine aggregate reduces the strength of concrete.


THANK YOU