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UTILIZATION OF RECYCLE AGGREGATE FROM DEMOLISHED STRUCTURE IN CONCRETE MIX DESIGN

Er. Kshitij Singh[1], Prof. Atul Pandey[2], Er. Ankit Lal[3], Shailendra Tiwari(PM)[4], Rabindra Biswas[5]

[1]M.tech (Transportation Engineering) Sam Higginbottom University of Agriculture Technology Sciences, Naini, Prayagraj U.P.
[2,3]Faculty of SHUATS
[4,5]Team of QC staff of OSEPL PCSPL Project

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Abstract - *Presently, the construction industry worldwide is using more and more natural resources for producing course aggregates required in concrete construction. Demolished waste material generated from Building demolition etc. is not put to use in direct construction except for filling low lying land areas. Such large scale demolition waste or MALWA should be put to better use as far as possible. Recycling of demolished waste can offer not only the solution of growing waste disposal problem, but will also help to conserve natural resources for meeting increasing demand of aggregates for long time to come for construction.*

This paper reviews the outcome of tests carried out in the laboratory on use of Recycled Concrete Aggregate (RCA) and MALWA Aggregate tried in Concrete making. The basic properties of these aggregates are determined and compared with conventional and local aggregate. In the present experimental investigation, these materials in different combinations are tried to produce concrete of grade equivalent to M20 or higher. It is found that Recycled Concrete Aggregate from Waste Concrete & MALWA Aggregate can be gainfully used in making fresh Concrete for general construction purposes.

1. INTRODUCTION

Development of Infrastructure in India has become necessary for the better growth of Country's Economy which is reaching nearing 10% of GDP. But, there is severe shortage of infrastructural facilities in India. Thus, rapid developments of infrastructure facilities like Buildings, Roads, Bridges, Power Plants, etc. are needed in a big way. Construction has a major share in developing infrastructure in any Country, and for creating these facilities; large scale Construction is already going on. The planning commission allocated approximately 50% of capital outlay for infrastructure development in successive plans and now in 11th five year plan. Accordingly, in the next five years, infrastructure in India will require an expenditure of more than Rs. 15,200 billion. Rapid infra-structural development such as highways, airports etc. and growing demand for housing requires huge construction materials. In this entire infrastructure, Concrete Construction is preferred as they have longer life, low maintenance and better performance. Concrete is also a vital component of everyday Construction by common men and is being extensively used for all types of Construction including housing. Concrete is also the largest construction material used all over the world, as this can be made in any grade or strength and can be caste in any shape or size as required for structures on land, sea or even on any planet.

In our country and world over, huge amount of demolished waste Material is generated everyday which is not put to use in construction, except it is disposed off by dumping as land fill. Dumping of wastes on land is causing shortage of dumping place in urban areas. Further, due to urbanization growth, distance between demolition waste generation area and disposal land area has also become longer and therefore, transportation cost of disposal has increased.

1.1 CONCRETE CONSTRUCTION

Concrete is a heterogeneous material which is made with Cement, Aggregate (Stone Chips), Sand & Water. A typical distribution of constituent materials in concrete is given in figure 1. Out of the total ingredients in concrete, about 50% is Coarse Aggregate. All these materials are not available in Plenty and they cost money, so their use should be economized as far as possible.

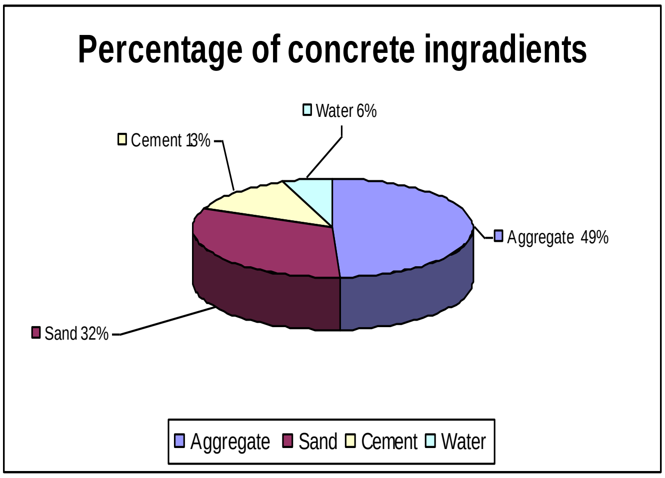

Figure 1- Typical distribution of materials in Concrete

1.2 AVAILABILITY OF FRESH AGGREGATE FOR PRODUCING CONCRETE

Presently, the construction industry worldwide is using more and more natural resources of aggregates. To make aggregate, we have to break stones available in hills or collect them from river bed as pebbles. Environment study says that such rocks / material should not be disturbed as far as possible. If we break more & more hillocks, then there will be indirect effect on environment like deforestation, floods etc. Further, the cost of construction is continuously increasing due to increasing cost of construction materials. In many places, supply of good quality aggregates is depleting, and is to be brought from longer distances which greatly increase the hauling cost and ultimately the construction cost. Presently, due to huge developmental work being carried out in the Country and construction to go on forever, stone aggregates are required for the many years to come and there may be a shortage of natural aggregates after few centuries. Therefore, for conservation of natural resources and protection of environment, it is necessary that. Alternate sources of aggregates be searched which is necessary for any developing/developed country.

1.3 AVAILABILITY OF DEMOLITION WASTE & MALWA

In the country and world over, huge amount of demolished waste Material is generated every day. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons; out of this, waste from construction industry accounts for more than 25%. Management of such high quantum of waste puts enormous pressure on solid waste management system. The basic composition of Solid waste or Garbage varies in composition from place to place and from time to time, but a typical distribution of basic constituents in solid waste is shown in figure 2. Though, the organic waste can be put to use for making Bio-gas & Manure and Metal pieces & Polyurethane for recycling, but MALWA or demolition waste is not put to use anywhere. However to do all these processes, it is necessary to sort the Solid waste in different categories. This is also the need of hour and is being done in most advance Countries. In general, MALWA gets mixed up with organic waste or garbage, so it becomes difficult to process the garbage even for organic manure or biogas or for any other thing. However, by observing a few simple precautions during the demolition process of depilated buildings, or renovation of Buildings, the potential for sorting or recycling of the demolished Waste can be improved and the value of product in the form of MALWA & RECYCLED CONCRETE AGGREGATE (RCA) may be more useful in Construction Industry where huge quantities can be consumed.

MALWA and Concrete Waste are generated not only through demolition of the deteriorated structures but also due to natural calamities like earthquake, wind storm etc. These depleted buildings are broken or remodeled, which gives rise to lots of waste material called **MALWA**. This MALWA has in it broken brick pieces, plaster / set mortar pieces, aggregate, sand etc. More than 12 million tons of demolished waste are generated every month by the construction industry and it is increasing every day. It is therefore, desirable to start recycling and use garbage, **MALWA** and demolished concrete waste to save environment and energy. Thus, it will conserve natural resources and reduce the space required for the landfill disposal.

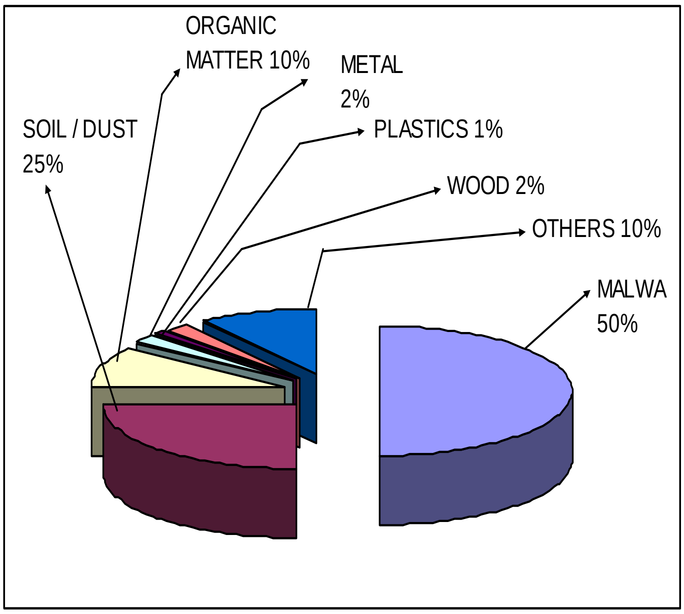

Figure 2- Basic composition of Solid waste or Garbage

TIFAC had conducted a techno-market survey on 'Utilization of Waste from Construction Industry' targeting housing / building and road segment. The total quantum of waste from construction industry is estimated to be 12 to 15 million tons out of which 8 to 10 million tons are concrete & brick waste. Such material is not put to use. According to public survey findings, 70% of the respondent had given the reason for not adopting recycling of waste from Construction Industry as "Not aware of the recycling techniques" while remaining 30% have indicated that "they are not even aware of recycling possibilities". Further, the user agencies/industries pointed out that presently, the BIS and other Codal provisions do not provide the specifications for use of recycled product in the construction activities. In view of the need to use **MALWA** in Construction Industry (Being the largest Industry), the technology is being developed to explore the role of recycled construction material and its technology for the use in development of urban infrastructure.

This paper deals with the feasibility study for the utilization of Demolition waste or MALWA in Construction Industry.

MALWA can be used for making recycled coarse aggregate for making Concrete. Such MALWA / concrete can be crushed to required size, depending upon the place of its application and crushed material is screened in order to produce recycled aggregates of appropriate sizes. An aggregate produced by demolished buildings will be called MALWA aggregate and broken concrete to be known as Recycled Concrete Aggregates (RCA).

1.3 NEED FOR PRESENT STUDY AND IMPLEMENTATION

Normally coarse Aggregate is the fractured stone from rocks in hills or pebbles from river bed, and because of depletion of supply of good conventional aggregate in certain regions, the need for development of MALWA & CONCRETE as RECYCLED AGGREGATE technology is being developed. It is similar to fly ash, which is available from electrostatic precipitators of various super thermal power stations, and is a industrial waste material. It is chemically reactive when, mixed with cement for use in concrete. This is a very useful as a partial substitute, as it gives better concrete and having better impermeability record. Thus, it has a wider use in Construction Industry. This is also a common byproduct used in making Portland Pozzolana Cement by cement Industry and Fly ash Concrete. Similarly, large scale recycling of demolished waste and concrete will offer, not only the solution of growing waste disposal problem, but will also help construction Industry in getting aggregates.

2. EXPERIMENTAL INVESTIGATIONS

2.1Materials and Material Properties:

Experimental investigations have been carried out so as to develop the methodology to collect MALWA and its conversion to recycled aggregate. Its use as aggregate in low to middle range Concrete strength is investigated. In the present experimental investigation, conventional aggregate, local and brick aggregate have also been taken for comparison on the parallel basis. Thus, following five materials in different combinations are tried.

1. Fresh Conventional Aggregate; (**Granite** from Adanapattu Quarry, Tamilnadu).
2. Fresh Local Aggregate; (**Sand stone** from Asanur Quarry).
3. Extracted / Recovered Aggregate From Old Concrete Works **- RCA.**
4. Broken Brick pieces **- BRICK** Aggregate
5. Broken Building Part – **MALWA** Aggregate

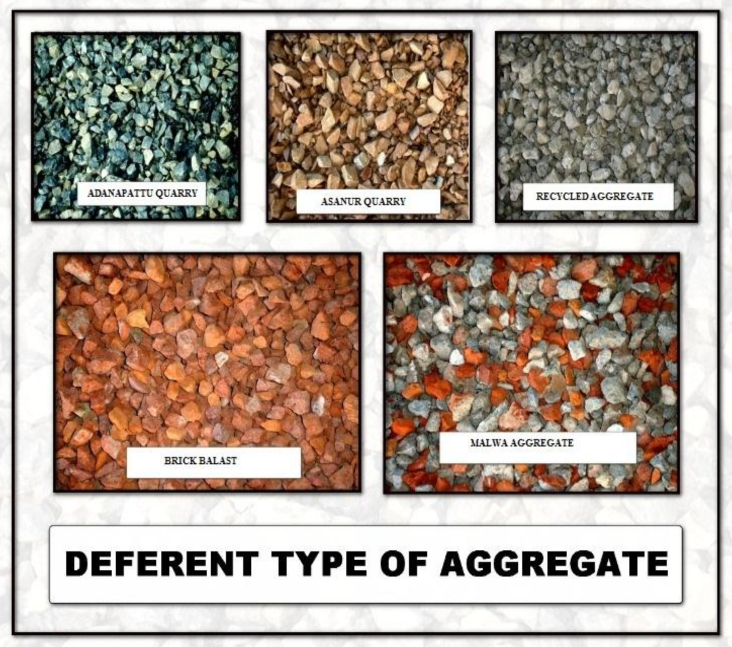

Figure 3- Typical Shape & Color of Different Source of Aggregate.

Typical photograph of these five type of aggregates are shown in Figure 3. All these materials have been tested for their physical properties like aggregate impact value, specific gravity, water absorption, bulk density etc. Physical properties of these materials are given in table 1. A plot of specific gravity of these five type of aggregate is shown in figure 4. It shows that specific gravity of MALWA aggregate is about 72% of fresh Adanapattu aggregate which is not very low.

The MALWA, Brick bates & concrete debris were collected from different sources and broken into the pieces of approximately 20 & 10 mm size with the help of hammer. On large scale this can be broken by Crushers. The foreign matter was sorted out from the Solid waste. Further, Aggregate pieces were mechanically sieved through IS sieve of 26.5 mm and 4.75 mm to remove higher & finer particles. The fine particles separated out can go back to river bed in the same trucks which bring river sand.

TABLE – 1 PHYSICAL PROPERTIES OF MATERIALS USED IN CONCRETE MIX

Description of Material	Material Source	Specific Gravity	Water Absorption (%)	AIV (%)	Average FM 20 mm	10 mm	Bulk Density (gm/cc)
Fresh Aggregate	Adanapattu	2.78	0.31	13	7.2	6.37	1.65
Local Aggregate	Asanur	2.5	1.53	24	6.99	6.77	1.23

Recovered Concrete Aggregate (RCA)	Waste concrete	2.37	4.58	24.34	7.71	6.47	1.09
Brick Aggregate	Brick kiln	1.84	12.5	42.7	7.14	6.27	0.92
Malwa Aggregate	Dismantled House	1.98	10.47	39.35	7.28	6.28	1.05
Sand	M- Sand	2.78	2.26	-	2.85 (Zone II)		1.65

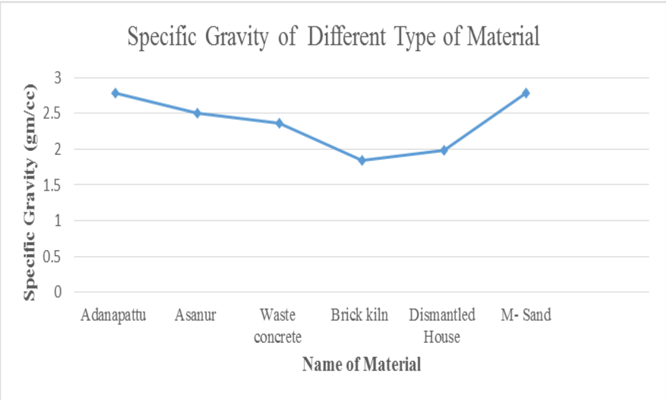

Figure 4- Variation of Specific gravity of Materials

a) Concrete Mixes:

To see the possibility of the use of MALWA in construction Industry, experimental investigations are carried out in laboratory to evaluate the Strength, permeability etc. The Concrete mix parameters of MALWA and recycled Concrete aggregate along with other materials were determined for the concrete mix of M20. The properties of conventional aggregates used in the normal concrete and design mix with recycled aggregates are the main parameters to compare about the usefulness of these aggregates from strength consideration.

Cement used in investigations confirms to various properties given in IS: 12269-1999 and having Compressive Strength of 53 MPa at 28 days. Fresh coarse aggregates from Adanapattu & Asanur Quarry are conforming to IS: 383 specifications. Fine aggregate is from river bed. Water used is from deep bore well, which is potable quality and free from impurities. Using these 5 types of aggregate given in table 1, several concrete mixes were prepared in the grade equivalent to M20 by conventional design method (IS Code Method). Following combination of concrete mixes were made.

1. Concrete mixes with the basic five aggregates given in table 1.
2. Five combination of Recycled Concrete Aggregate (RCA) with fresh ADANAPATTU aggregate in the combination of 0, 30, 50, 70 and 100% of fresh aggregate.
3. Five combination of MALWA Aggregate with fresh ADANAPATTU aggregate in the combination of 0, 30, 50, 70 and 100% of fresh aggregate.

All these materials were taken for a smaller batch and weighed as per design requirement given in tables 2, 3 & 4. These tables also give the quantity of other materials used for M 20 grade concrete. Materials were mixed in laboratory mixture. 12 cubes (150 x 150 x 150 mm size) were cast for each mix. In addition 3 Cylinders each of size 150 mm diameter and 160 and 300mm height were cast for determining permeability and elastic modulus of concrete in all these cases. Cubes & cylinders were cured in curing tank. The cubes were tested on 7, 28, 60 & 90 days. Each cube was also weighed and concrete density was calculated.

TABLE - 2 Design Mix Proportion for Equivalent to M-20 gradeConcrete For Five Different Aggregates

Material	Units	Fresh Adanapattu	Fresh Asanur	RCA	Brick	MALWA
		TM - 2	TM - 1	TM - 3	TM - 5	TM - 4
Cement	Kg	350	350	350	350	350
20 mm	Kg	443	577	562	291	286
10 mm	Kg	646	395	359	424	480
Sand	Kg	702	702	702	702	702
Water	Kg	210	210	210	210	210
W/C Ratio	%	0.60	0.60	0.60	0.60	0.60

TABLE - 3 Design Mix Proportion for Equivalent to M-20 grade Concrete For Fresh Adanapattu & RCA in different proportions

Material	Units	Fresh Adanapattu (100%)	Fresh 70% RCA - 30%	Fresh 50% RCA - 50%	Fresh 30% RCA- 70%	RCA (100%)
		TM - 2	TM - 7	TM - 6	TM - 8	TM - 3
Cement	Kg	350	350	350	350	350
20 mm (Adanapattu)	Kg	443	406	221	221	-
20 mm (RCA)	Kg	-	187	187	343	562
10mm (Adanapattu)	Kg	646	332	332	129	-
10mm (RCA)	Kg	-	109	265	281	359
Sand	Kg	702	702	702	702	702
Water	Kg	210	210	210	210	210
W/C Ratio	%	0.60	0.60	0.60	0.60	0.60

TABLE - 4 Design Mix proportion for Equivalent to M-20 grade Concrete For Fresh Adanapattu & MALWA in different proportions						
Material	**Units**	**Fresh Adanapattu (100%)**	**Fresh Adanapattu -70% MALWA - 30%**	**Fresh Adanapattu -50% MALWA - 50%**	**Fresh Adanapattu -30% MALWA - 70%**	**MALWA (100 %)**
		TM - 2	**TM - 11**	**TM - 9**	**TM - 10**	**TM - 4**
Cement	Kg	350	350	350	350	350
20 mm (Adanapattu)	Kg	443	419	299	179	-
20 mm (Malwa)	Kg	-	125	208	292	286
10mm (Adanapattu)	Kg	646	343	245	148	-
10mm (Malwa)	Kg	-	103	171	239	480
Sand	Kg	702	702	702	702	702
Water	Kg	210	210	210	210	210
W/C Ratio	%	0.60	0.60	0.60	0.60	0.60

C) Discussion of Results:

The details of the investigation are summarized and discussed in the following heads.

1. Mix Reology
2. Compressive .Strength.
3. Density Of Concrete.
4. Fracture Mechanism at Failure.
5. Permeability of concrete.

Detailed discussions are given below under above heads.

1. Mix Reology:

Various observations mix Reology and general behavior for each mix was observed. Fresh concrete mix in general and in slump cone has been carefully examined. The mix was found to be cohesive texture in all the cases. To get workable mix a slight adjustment in water cement ratio was made. No admixture was used in any mix to be consistent. A typical shape of the mix in slump cone is shown in figure 5. No bleeding, segregation or shearing of slump cone was observed. It was seen that concrete behaves very much like normal concrete with true slump.

Figure 5- Typical shape of Slump cone

The retention of workability / slump was also recorded for 60 minutes. The details of observations for three broad classifications are given in tables 5, 6 & 7. Variation in slump value for 5 basic materials initially and after 60 minutes is shown in figure 6. It is seen, that even after 60 minutes the concrete remains workable for Recycled aggregates including MALWA.

TABLE - 5 Mix Reology for 5 types of Aggregates						
	Units	**Fresh Adanapattu**	**Fresh Asanur**	**RCA**	**BRICK**	**MALWA**
		TM - 2	**TM - 1**	**TM - 3**	**TM - 5**	**TM - 4**
Initial Slump	mm	200	200	170	150	160
Initial Temperature	⁰C	26.1	18.2	26.8	23.8	25.2
Ambient Temp	⁰C	29.4	24.3	29.1	26.5	28.2
Slump After 1 hour	mm	129	120	70	35	55
Bleeding		No	No	No	No	No
Segregation		No	No	No	No	No
Type Of Slump		True	True	True	True	True

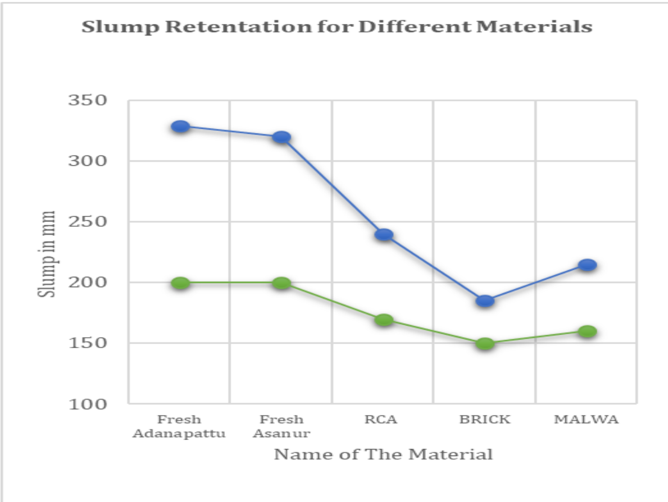

Figure 6 - Value of slump for 5 basic materials

TABLE - 6 Mix Reology for Different combinations of Adanapattu & RCA

	Units	Fresh Adanapattu 100%	Fresh 70% RCA - 30%	Fresh 50% RCA - 50%	Fresh 30% RCA- 70%	RCA - 100%
		TM - 2	TM - 7	TM - 6	TM - 8	TM - 3
Initial Slump	mm	200	200	185	200	170
Initial Temperature	⁰C	26.1	27.9	23.3	20.4	26.8
Ambient Temp	⁰C	29.4	26.1	25.7	24.7	29.1
Slump After 1 hour	mm	129	110	100	90	55
Bleeding		No	No	No	No	No
Segregation		No	No	No	No	No
Type Of Slump		True	True	True	True	True

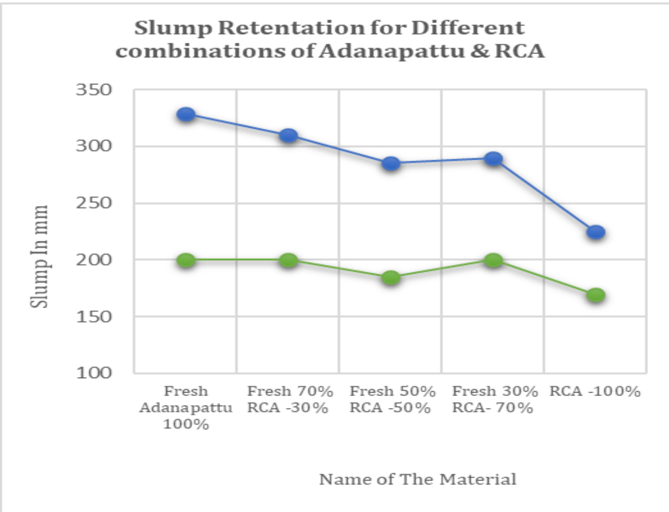

Figure 7 - Value of slump for for Different combinations of Adanapattu & RCA

TABLE -7 Mix Reology for Different combinations of Adanapattu & MALWA

	Units	Fresh Adanapattu 100%	Fresh 70% MALWA 30%	Fresh 50% MALWA 50%	Fresh 30% MALWA 70%	MALWA 100%
		TM - 2	TM - 11	TM - 9	TM - 10	TM - 4
Initial Slump	mm	200	200	180	200	160
Initial Temperature	⁰C	26.1	22.3	19.8	20.2	25.2
Ambient Temp	⁰C	29.4	24.6	24.5	24.3	28.2
Slump After 1hour	mm	129	120	90	80	55
Bleeding		No	No	No	No	No
Segregation		No	No	No	No	No
Type Of Slump		True	True	True	True	True

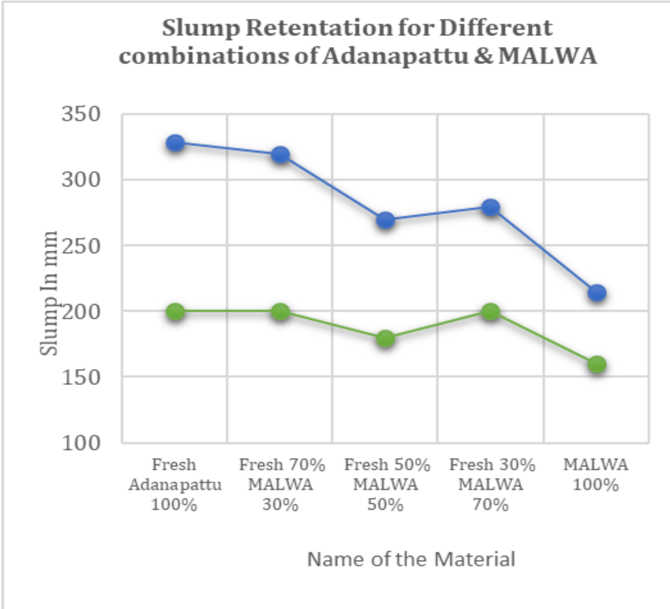

Figure 8 - Value of slump for 5 Different combinations of combinations of Adanapattu & MALWA

2) Compressive Strength:

After curing the Concrete Cubes were tested after 7, 28, 60 & 90 days. Compressive strength in each case is summarized in Tables 8, 9 & 10 and shown in figures 7, 8 & 9 for different cases. It is seen that all the concrete Mixes attain more than Design Compressive strength ie 20 MPa. It is also seen that there is considerable gain in strength even after 28 days. Figures show that Compressive strength of fresh and recycled concrete aggregate (RCA) (100%) is similar. However, strength with Brick and MALWA Aggregate is minimum. It is seen that even the MALWA and recycled aggregate attains full design strength and it gains strength even after 28 days.

TABLE- 8 Compressive Strength With 5 types of aggregate

	Units	Fresh Adanapattu	Fresh Asanur	RCA	Brick	MALWA
		TM - 2	TM - 1	TM - 3	TM - 5	TM - 4
Average 7 day Strength	MPa	30.08	28.75	30.11	26.53	24.59
Average 28 day Strength	MPa	41.88	30.85	38.48	30.49	32.12

Average 60 day strength	MPa	46.09	36.47	45.53	34.31	37.76
Average 90 day strength	MPa	49.82	39.09	48.2	38.49	39.56
Avg. Weight of cubes	Kg	8.467	7.776	8.01	7.426	7.61
Density of concrete	g/cc	2.509	2.304	2.373	2.200	2.255
Impermeability Coeff. (10-04) (as defined)	-	5.09	3.28	3.03	2.97	1.71

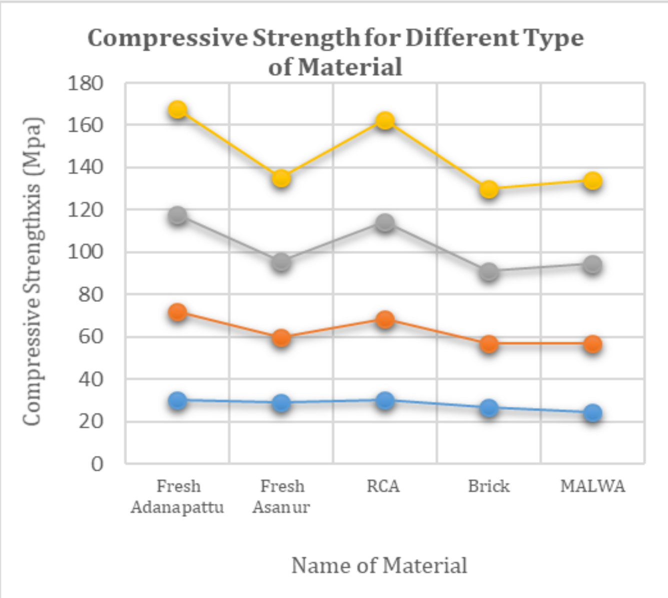

Figure 9 - Compressive Strength of concrete mix for 5 basic aggregates

TABLE – 9 Compressive Strength With Fresh Adanapattu & RCA Aggregates

	Units	Fresh Adanapattu 100%	Fresh 70% RCA - 30%	Fresh 50% RCA - 50%	Fresh 30% RCA-70%	RCA - 100%
		TM - 2	TM - 7	TM - 6	TM - 8	TM - 3
Average 7 day Strength	MPa	30.08	28.14	30.23	29.5	30.11
Average 28 day Strength	MPa	41.88	40.15	40.58	38.32	38.48
Average 60 day strength	MPa	46.09	42.34	44.38	40.38	45.53
Average 90 day strength	MPa	49.82	49.18	48.56	44.42	48.2
Avg. Weight of cubes	Kg	8.467	8.253	8.187	8.116	8.01
Density of concrete	g/cc	2.509	2.445	2.411	2.425	2.373
Impermeability Coeff. (10-04) (as defined)	-	5.09	5.14	5.62	5.65	3.03

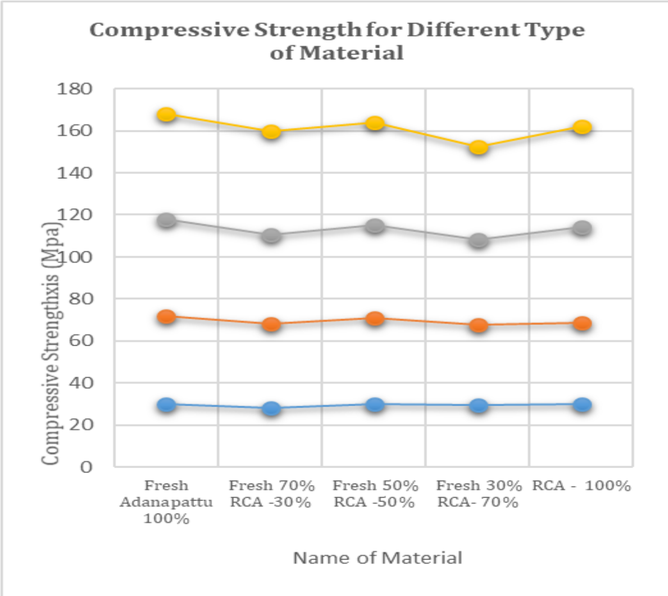

Figure 10 - Compressive Strength of concrete mix with Fresh ADANAPATTU and RCA in different proportions.

TABLE – 10 Compressive Strength With Fresh Adanapattu & MALWA Aggregates

	Units	Fresh Adanapattu 100%	Fresh 70% MALWA -30%	Fresh 50% MALWA -50%	Fresh 30% MALWA -70%	MALWA 100%
		TM - 2	TM - 11	TM - 9	TM - 10	TM - 4
Average 7 day Strength	MPa	30.08	28.47	28.27	25.45	24.59
Average 28 day Strength	MPa	41.88	36.18	35.69	33.45	32.12
Average 60 day strength	MPa	46.09	39.73	38.04	37.84	37.76
Average 90 day strength	MPa	49.82	42.78	41.93	40.09	39.56
Avg. Weight of cubes	Kg	8.467	8.17	8.07	7.866	7.61
Density of Concrete	g/cc	2.509	2.421	2.391	2.331	2.255
Impermeability Coeff. (10-04) (as defined)	-	5.09	2.11	1.75	1.84	1.71

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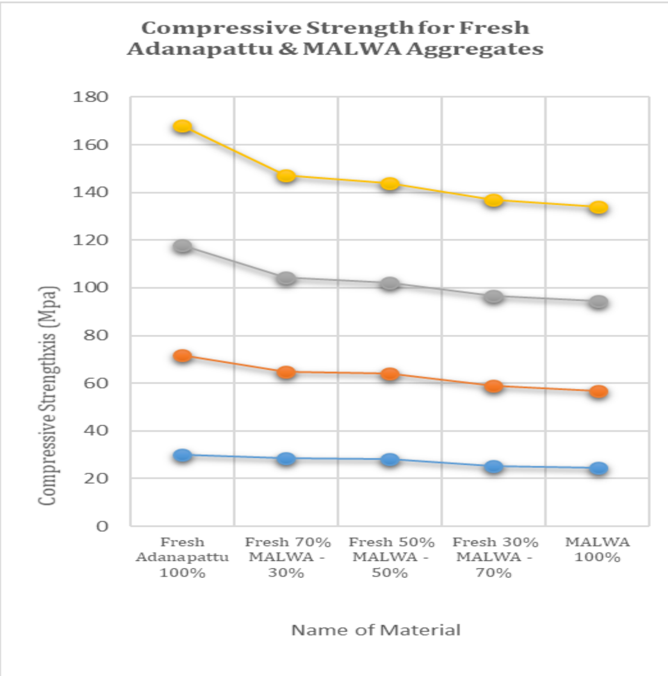

Figure 11 - Compressive Strength of concrete mix withFresh ADANAPATTU and MALWA in different proportions.

It is found that such concrete with recycled aggregate or MALWA can achieve the strength up to 20-25 MPa (equivalent to 1:1-1/2:3 concrete Mix). Such strength is sufficient for normal Construction of Buildings etc.

3) Density of Concrete:

Each cube was weighed and density of concrete was calculated. The variation of density in each case is also given in Tables 8, 9 & 10. It is also shown in figure 10 for five basic aggregates. It is seen that density is maximum when fresh Adanapattu aggregate is used and it is minimum when brick aggregate is used. The maximum density is 2.509 g/cc and minimum is 2.20 g/cc. RCA shows a density of 2.373 g/cc and MALWA aggregate as 2.255 g/cc. It is seen that density with MALWA is about 90% and of RCA is about 95% of fresh aggregate which is quite high.

4) Failure Pattern Of Cubes / Fracture Mechanism At Failure Load:

1. The shape of crushed cubes is shown in figure 11. It is seen that the failure pattern of all Recycled Aggregate is similar as for typical fresh aggregate.

2. It is generally seen that the failure occurs at the interface of aggregate & mortar for fresh Adanapattu & RCA, while as any where for Local, MALWA & Brick Aggregates.

3. Brick Aggregate and Plaster lumps pieces are broken in MALWA & brick aggregates.

Permeability of concrete:

Permeability of concrete is determined using method described in "Specifications for Road & Bridge Works" of Indian Road Congress. For this 3 cylinders, having dimensions of 150mm diameter & 160mm height were cast and cured for 28 days. They were fixed in permeability apparatus shown in figure 12. Water pressure of 7 Kg/cm^2 was applied for 96 hours in the Permeability Apparatus.

Fig.12 - Permeability Apparatus

After 96 hours cylinders were taken out of M/C and split under line load in Compression Testing Machine. The depth of penetration of water in cylinder was observed & measured as well as volume of water lost from original level in the intake tube is recorded. The results are interpreted as:

1. Measure the depth of penetration of water in permeability cylinder at several places and find average depth.

2. Coefficient of impermeability is calculated as volume of water lost in the tube divided by volume of concrete penetrated with water i.e.

Impermeability coefficient = vol. of water lost in tube / (Average depth of water penetration in concrete x X-area of cylinder).

A typical split cylinder shape is shown in figure 13. In this

Figure 13 - A typical shape of split cylinder

Figure, the effect of water penetration is shown at top and marked by line. The impermeability of concrete, as defined above, is plotted in figures 14. This shows the changes in coefficient of impermeability or depth of water penetration for five basic aggregates. In the case of brick aggregate it is maximum. For RCA, the value is similar to ADANAPATTU aggregate & MALWA aggregate is more than this.

OBSTACLES IN USE OF MALWA IN CONSTRUCTION

Although, it is environmentally beneficial to use **MALWA & RCA** in construction, however the current legislation and experience are not adequate to support and encourage the use of recycled demolished waste in India. Lack of awareness, guidelines, standards and lack of confidence in Architects, Engineers & user agencies is a major cause for poor utilization of MALWA or Recycled Aggregate in construction. Further, the acceptability of recycled aggregate is impeded for structural applications due to the lack of technical know-how like porosity, effect of sulphate and chloride, impurities and large variation in quality etc. In view of above, there is urgent need to the take following measures:-

- Sensitization/ dissemination or knowledge of demolition waste towards its utilization in construction.
- Preparation and implementation of techno-legal clauses including legislations, guidance,
- Penalties etc. for disposal of construction waste on roads and delineation of dumping areas for pre-selection, treatment & transport of MALWA.
- National level support on research studies on Solid waste disposal & MALWA utilization with different proportions.
- Preparation of techno-financial document, financial support for introducing MALWA in construction including assistance in transportation, establishing recycling plant, RMC Plant etc.
- Formulation of guidelines, specifications and Codal provisions.

ADVANTAGES OF USING MALWA AND RECYCLED AGGREGATE

In brief the following are the main advantages of using MALWA in Construction.

Figure 14 - A typical shape of split cylinder

1. Disposal of MALWA becomes easier.
2. It can generate work for unemployed people like collecting MALWA by Rag pickers etc., and deposit it at Ready Mixed Concrete Batching Plants. A typical Ready Mix Concrete Plant (RMC Plant) is shown in Figure 15.
3. It can keep the roads and streets clean by not dumping MALWA on the road side. This will also minimize the accidents on Roads because of fewer obstructions.
4. RMC Plants will be able to get some raw material free of cost except they may pay little transportation cost.
5. Stone queries or Hillocks will be less affected and hence environment can be preserved. Resulting floods and droughts will be minimized
6. It will save the natural resources like Hillocks, River Pebbles etc from extinction and thus Deforestation of hilly areas will be minimized.
7. Finer material passing through 4.75 mm IS sieve can go back to river beds in the same trucks which bring sand from river bed.
8. We can make concrete blocks, like clay bricks etc out of this type of concrete. By making bricks out of MALWA Concrete, the manufacture of conventional clay bricks can be reduced & hence top Soil, which is suitable for Agriculture, can be conserved.

CONCLUSIONS

Based on the present investigations on MALWA & Recycled Aggregates, the following conclusions are drawn.

- It is possible to produce a good concrete using the MALWA & RECYCLED AGGREGATE with partial modification in water and cement contents for appropriate locations.
- All types of aggregate attain full design Strength. Even Brick aggregate and MALWA also attains full design strength, though its strength is minimum out of various types of Aggregates studied.
- Concrete with MALWA, Brick & RCA absorbs a higher amount of water than Conventional Aggregate.
- Study shows that MALWA & Recycled Aggregate (RCA) can be easily used in construction of buildings, concrete paving blocks & tiles, making similar to Clay Bricks, flooring, approach lanes, sub-base concrete course and in highways for dry lean concrete (DLC) etc.
- Partial or full replacement of coarse aggregates in concrete by recycled aggregates and MALWA generally lowers the compressive strength approximately up to 20 - 30 percent. But it can still be used for concrete up to M25 strength.
- Studies on the Chemical and mechanical properties of the MALWA & RECYCLED Aggregate must be done for variation of proportions and their properties.

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