IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN : 2278-1684, p-ISSN : 2320–334X
PP 52-61
www.iosrjournals.org

Waste Minimization at construction site

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Abstract: *Construction waste results from the construction of buildings ,roadways ,bridges ,and other man made. It is estimated that construction industry in India generates about 10-12 million tons of waste annually. The projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55000 million cu.m. An additional ,750 million cu .m. aggregate would be required for achieving the targets of the road sector .Recycling of the aggregate material from construction waste might reduce the demand – supply gap in this sector. While retrievable items such as bricks, wood, metal ,tiles are recycled ,the concrete and masonry waste ,accounting for more than 50 % of the waste from the construction activities ,are not being currently recycled in India. In this research work one case study is taken .In that case study for estimation of different types of construction waste in field. A survey of generation of construction waste in construction of residential houses is done .The observations and results obtained from the survey of the construction waste are presented in the tabular and graphical forms.*

I. Introduction

1.1 General

Construction waste is generated whenever construction activity takes place, such as building roads, bridges, fly over, subway ,remodeling and so on . It consists mostly of inert and non- biodegradable Materials such as concrete, plaster, metal, wood, plastics. These wastes are heavy ,having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container .It is not uncommon to see huge piles of such waste ,which is heavy as well stacked on roads especially in large projects ,resulting in traffic congestion and disruption. Waste from small generators such as individual house construction find its way into the nearby municipal waste heavy quality for further treatment such as to make for energy recovery. In many cases, it finds it way into surface drains ,choking them .It constitutes about 10-20% of the municipal solid waste (excluding large construction projects).It is estimated that the construction industry in India generates about 10-12 million tons of waste . The projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55000 million cu.m. An additional ,750 million cu .m. aggregate would be required for achieving the targets of the road sector .Recycling of the aggregate material from construction waste might reduce the demand – supply gap in this sector. While retrievable items such as bricks,wood,metal ,tiles are recycled ,the concrete and masonry waste ,accounting for more than 50 % of the waste from the construction activities ,are not being currently recycled in India.

1.2 Significance Of The Issue Of Construction Waste

It is essential to prepare a waste management hierarchy ,which emphasizes waste prevention or reduction in re-use ,re use in recycling or recovery including the use of waste as a source of energy and the final disposal of all these via landfill or incineration without energy recovery.The hierarchy is generally summarized as :

- Prevention or reduction
- Re-use
- Recycling or materials recovery
- Energy recovery
- Disposal in a safe manner

Aims & Objective of the study:

1. Identifying the origin and destination of the construction waste
2. Identifying the uantities of hazardous waste and other waste parts for which a separate collection would be appropriate.
3. Examine possibilities and practical measures that can be applied to prevent construction waste going to land fills.

II. Overview of research work

In this research work survey for the g generation of construction waste in construction of residential houses as done. The survey of about 55 houses were constructed in the last 2 years .The construction of these houses was supervised by qualified engineers .The owners of houses and consulting engineers were requested to provide the financial record for purchase of various construction materials .Some of them did not co-operated ,some who refused and did not maintain them properly .Out of 55 house owners who were surveyed, 22 house owners have maintained the record of purchases of materials and they agreed to furnish the information . The actual measurement of the selected 22 houses were conducted and quantities of materials such as sand, aggregate, bricks ,cement, flooring, and steel (as per design) w ere estimated. These estimated quantities of different materials were compared with the purchased quantities of the construction materials and the quantities of construction waste for all 22 houses in the study.

III. Methodology to estimate construction waste:

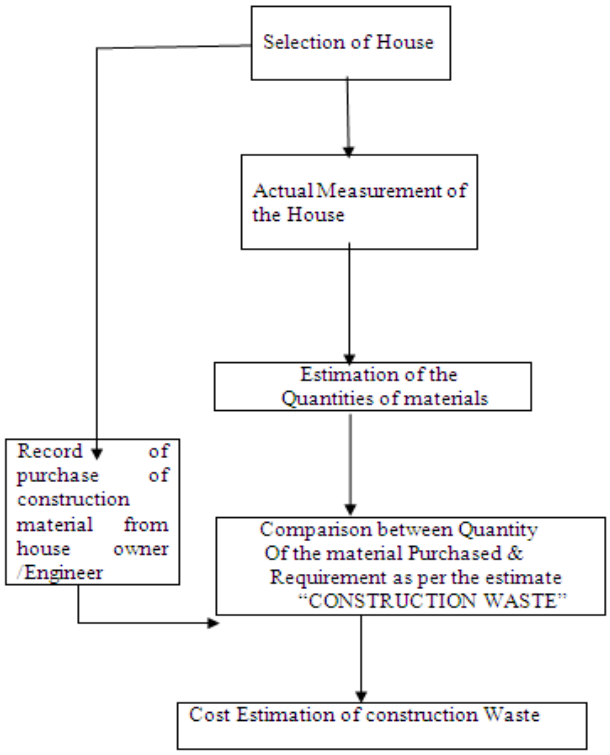
Around 50 houses were surveyed and the owners of houses were interviewed. The house owner who have maintained the record of the quantities of the material purchased and expenditure were selected for study .Out of 50 house owner s initially interviewed only 22 house owners have fulfilled the selection criteria and shown their co-operation in providing the information ,thus only those houses were selected for study.

The methodology for survey and the estimation of construction waste is shown in the following steps-

1. The actual measurement of the house was undertaken and the quantities of different materials such as cement ,sand, aggregate, bricks ,tiles and steel required was calculated.
2. The actual quantities of cement ,sand ,aggregate, bricks, tiles and steel purchased for the construction was taken from the records of the house owner.
3. The difference between the quantity purchased and quantity required is termed as construction waste .
4. The cost of the construction waste can be estimated on the basis of existing schedule.

   The generation of construction wastes depend upon various factors , some of prominent factors are skill of person supervising the work , financial conditions of owner and duration of the execution of the work. The houses which were selected for the study belong to the owners in the middle income group ,supervised by a professional engineer and completed in one stretch .Hence it is assumed that in all houses the conditions which might affect the generation of the construction waste were constant.

   The flow chart mentioning the overall procedure is shown if fig. 1



5. Field survey of construction waste :
The actual measurement of the 22 houses was undertaken and the quantities of construction Material which were actually consumed was calculated as per the standard practice.The construction materials viz cement ,sand ,aggregate ,bricks,MS bars,internal & external flooring was considered for study.The rates of the materials which were taken for the estimation of the cost are given in table NO.1

Table No.1 – Rates of the materials considered for study (Market rate)

Sr.No.	Items	Unit	Rate(Rs)
1	Cement	Bag	230.00
2	Sand	100 Cft(Brass)	800.00
3	Aggregate	100 Cft(Brass)	1000.00
4	Bricks		
	Cut Size(CS)	1000 Nos	1750.00
	Full Size(FS)	1000 Nos	2200.00
	Double Size(DS)	1000 Nos	3800.00
5	MS Bars	Quintal (100 Kg)	3600.00
6	Internal Flooring		
	Marble	100 Sqft(Brass)	2800.00
	Spartek	100 Sq ft(Brass)	3000.00
	Mosaic	100 Sq ft(Brass)	1000.00
7	External Flooring		
	Shahbad	100 Sqft(Brass)	2000.00

The invisible items were measured on the basis of the construction record (measurement book) of the consultant .The quantities of the construction materials which were consumed as calculated on the basis of measured items are shown in table No. 2

Table No.2 –" Quantities of the construction materials Consumed as Calculated on the Basis of Measured items"

H No.	**Plot Area**	**Built up Area**	**Cement**	**Sand**	**Sand**	**Aggregate**	**Aggregate**	**BrickWork**	**Type of brick**	**Bricks**	**Bricks**	**MSbar**	**Internal Flooring**	**Internal Flooring**	**External Flooring**	**External Flooring**
	Sq.m.	**Sq. m.**	**bags**	**Cu m.**	**Brass(100 cu f)**	**Cu m.**	**Brass(100 Cu m)**	**Cu m**		**No, /cu m**	**Number**	**Quintel**	**Sq m**	**Brass (100 Sq ft)**	**Sq m**	**Brass (100 sqft)**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	200.00	109.25	661	89.83	31.70	46.76	16.50	112.12	FS	509	57071	32.93	97.00	10.44	8.24	0.89
2	180.00	47.43	304	34.11	12.04	26.38	9.31	28.25	CS	627	17711	21.08	45.36	4.88	0.00	0.50
3	296.25	82.80	508	61.90	21.84	41.66	14.70	57.02	CS	627	35750	30.89	67.13	7.22	7.57	0.81
4	191.25	84.38	542	68.26	24.09	43.70	15.42	72.32	CS	627	45345	19.59	62.13	6.68	5.28	0.57
5	174.50	84.38	531	71.36	25.18	41.54	14.66	94.00	FS	509	47846	23.21	56.57	6.09	5.52	0.59
6	206.12	93.75	555	94.56	33.37	31.60	11.15	127.52	FS	509	64908	22.45	67.97	7.31	10.75	1.16
7	139.29	80.85	520	91.46	32.27	19.18	6.77	44.44	CS	627	27864	9.59	56.35	6.06	18.17	1.95
8	192.00	51.75	353	44.52	15.71	27.60	9.74	67.33	CS	627	42216	18.50	46.64	5.02	2.52	0.27
9	191.20	51.63	369	47.82	16.87	28.25	9.97	51.68	CS	627	32403	13.01	41.66	4.48	4.72	0.51
10	160.00	148.08	772	93.49	82.99	22.12	7.81	110.66	FS	509	56324	25.18	121.88	13.11	29.16	3.14
11	153.30	148.08	545	100.18	35.35	17.70	6.25	95.84	FS	509	48783	19.87	120.65	12.98	10.03	1.08
12	175.00	84.14	608	110.07	38.84	21.83	7.70	59.78	CS	627	37481	12.53	65.16	7.01	21.67	2.33

13	312.00	92.59	709	98.46	34.74	32.37	11.42	98.27	DS	255	25059	33.63	84.18	9.06	18.22	1.96
14	435.00	131.40	590	76,89	27.13	47.57	16.79	99.60	FS	509	50696	99.80	57.43	6.18	70.81	7.62
15	218.62	95.99	537	63.79	22.51	41.49	14.64	113.64	FS	509	57841	32.89	67.41	7.25	36.82	3.96
16	174.50	84.38	538	63.09	22.26	43.26	15.27	96.95	FS	509	49348	41.74	63.65	6.85	5.11	0.55
17	243.45	68.63	450	55.41	19.55	37.03	13.07	48.19	CS	627	30213	21.46	49.92	5.37	12.18	1.31
18	286.75	69.53	538	66.22	23.37	43.82	15.46	62.61	CS	627	39254	26.96	50.09	5.39	19.56	2.10
19	300.00	176.06	864	105.44	37.21	72.54	25.60	166.36	DS	255	42422	40.71	142.5	15.33	21.86	2.35
20	250.50	189.85	977	125.42	44.26	76.91	27.14	130.73	FS	509	66542	44.84	141.10	15.18	41.92	4.51
21	214.60	93.16	487	71.72	25.31	47.86	16.89	29.80	CS	627	18685	29.80	72.14	7.76	45.21	4.86
22	463.00	87.37	593	110.33	38.93	19.59	6.91	161.29	DS	255	41129	15.50	62.66	6.74	16.15	1.74

The actual quantities of construction materials which were purchased,are obtained from owner's purchase record.The quantities are shown in Table No 3

Table No.3 –" Quantities of construction materials purchased"

H No.	Plot Area	Built UP Area	Cement	Sand	Aggregate	Type of brick	Bricks	MS Bar	Type of Internal Flooring	Internal Flooring	Type of External Flooring	External Flooring
	Sq.m.	Sq.m.	Bags	No.of Tractors	No.of Tractors		Number	Quintal		Brass(100 sqft)		Brass(100 sqft)
1	2	3	4	5	6	7	8	9	10	11	12	13
1	200.00	109.25	690.00	31.00	15.00	FS	62000	34.50	MAR	11,00	SHBD	1.00
2	180.00	47.43	312.00	15.00	9.50	CS	21000	21.25	MOS	5.50	SHBD	0.60
3	296.25	82.80	522.00	21.00	14.50	CS	41000	31.00	MAR	8.00	SHBD	1.00
4	191.25	84.38	564.00	26.00	14.00	CS	51000	19.75	MAR	7.50	SHBD	0.75
5	174.50	84.38	545.00	26.00	13.50	FS	55000	23.50	MAR	6.50	SHBD	0.75
6	206.12	93.75	578.00	36.00	9.00	FS	70000	22.75	SPT	7.70	SHBD	1.25
7	139.29	80.85	534.00	33.00	8.00	CS	33000	9.75	SPT	6.50	SHBD	2.25
8	192.00	51.75	401.00	17.00	9.00	CS	50000	18.60	MAR	5.20	SHBD	0.50
9	191.20	51.63	398.00	18.00	9.00	CS	39000	13.10	MOS	4.50	SHBD	0.60
10	160.00	148.08	810.00	32.00	8.50	FS	61000	25.25	SPT	13.50	SHBD	3.25
11	153.30	148.08	565.00	36.00	6.00	FS	54000	20.00	SPT	13.00	SHBD	1.25
12	175.00	84.14	645.00	40.00	8.00	CS	44000	12.75	MAR	7.90	SHBD	2.50
13	312.00	92.59	715.00	32.00	12.50	DS	28000	33.75	SPT	9.50	SHBD	2.00
14	435.00	131.40	620.00	27.00	16.50	FS	55000	100.00	MOS	6.50	SHBD	8.00
15	218.62	95.99	550.00	24.00	12.50	FS	65000	33.00	SPT	7.70	SHBD	4.25
16	174.50	84.38	545.00	23.00	15.00	FS	55000	42.00	MOS	7.00	SHBD	0.75

17	243.45	68.63	475.00	20.00	12.00	CS	36000	21.50	MOS	5.50	SHBD	1.50
18	286.75	69.53	560.00	26.00	13.50	CS	47000	27.00	MOS	5.50	SHBD	2.25
19	300.00	176.06	890.00	38.00	23.00	DS	47000	41.00	SPT	16.50	SHBD	2.50
20	250.50	189.85	990.00	44.00	24.50	FS	80000	45.00	SPT	15.50	SHBD	4.75
21	214.60	93.16	500.00	26.00	15.00	CS	22000	30.00	MAR	8.25	SHBD	5.00
22	463.00	87.37	610.00	39.00	7.00	DS	48000	15.50	MOS	7.00	SHBD	1.75

The quantities of construction wastes was estimated as the difference of the quantities of the different construction material purchased and the actual quantities of construction material consumed . The quantities of the construction waste are shown in table No 4;

Table No 4: Quantities of the construction waste

H. No.	Plot Area	Built up Area	Cement Qty (waste)	Sand Qty(waste)	Aggregate Qty(waste)	Type of brick	Brick Qty(waste)	MS Bar Qty(waste)	Type	Internal Flooring Qty(waste)	Type	External Flooring Qty(waste)
	Sqm	sqm	Bags	Brass(100 Cuf)	Brass(100 Cuf)		Number	Quintal		Brass(100 Sqft)		Brass(100 sqft)
1	2	3	4	5	6	7	8	9	10	11	12	13
1	200.00	109.25	29.00	7.05	2.25	FS	4929	1.57	MAR	0.56	SHBD	0.11
2	180.00	47.43	8.00	6.71	2.57	CS	3289	0.17	MOS	0.62	SHBD	0.10
3	296.25	82.80	14.00	4.41	3.42	CS	5250	0.11	MAR	0.78	SHBD	0.19
4	191.25	84.38	22.00	8.41	2.08	CS	5655	O.16	MAR	0.82	SHBD	0.18
5	174.50	84.38	14.00	7.32	2.22	FS	7154	0.29	MAR	0.49	SHBD	0.16
6	206.12	93.75	23.00	11.63	0.10	FS	5092	0.30	SPT	0.39	SHBD	0.09
7	139.29	80.85	14.00	8.98	3.23	CS	5136	0.16	SPT	0.44	SHBD	0.30
8	192.00	51.75	48.00	5.54	1.51	CS	7784	0.10	MAR	0.18	SHBD	0.23
9	191.20	51.63	29.00	5.63	1.28	CS	6597	0.09	MOS	0.02	SHBD	0.09
10	160.00	148.08	38.00	7.01	2.82	FS	4676	0.07	SPT	0.39	SHBD	0.11
11	153.30	148.08	20.00	9.65	1.88	FS	5217	0.13	SPT	0.02	SHBD	0.17
12	175.00	84.14	37.00	11.16	2.30	CS	6519	0.22	MAR	0.89	SHBD	0.17
13	312.00	92.59	6.00	5.26	4.20	DS	2941	0.08	SPT	0.44	SHBD	0.04
14	435.00	131.40	30.00	6.62	3.84	FS	4304	0.20	MOS	0.32	SHBD	0.38
15	218.62	95.99	13.00	7.49	0.98	FS	7159	0.11	SPT	0.45	SHBD	0.29
16	174.50	84.38	7.00	6.49	3.48	FS	5652	0.26	MOS	0.15	SHBD	0.20
17	243.45	68.63	25.00	5.45	1.93	CS	5787	0.04	MOS	0.13	SHBD	0.19
18	286.75	69.53	22.00	9.13	1.41	CS	7746	0.04	MOS	0.11	SHBD	0.15
19	300.00	176.06	26.00	10.29	3.15	DS	4578	0.29	SPT	0.17	SHBD	0.15
20	250.50	189.85	13.00	10.74	3.49	FS	13458	0.16	SPT	0.32	SHBD	0.24
21	214.60	93.16	13.00	7.19	1.86	CS	3315	0.20	MAR	0.49	SHBD	0.14
22	463.00	87.37	17.00	9.82	1.84	DS	6871	0.00	MOS	0.26	SHBD	0.01

IV. Analysis Of Data – Construction Waste

The scatter diagram for the cost of the waste construction materials versus built up areas are plotted and are shown in fig A.1 to A.8

Figure A.1 - "% of Cost of Construction Waste vs Constructed Area"

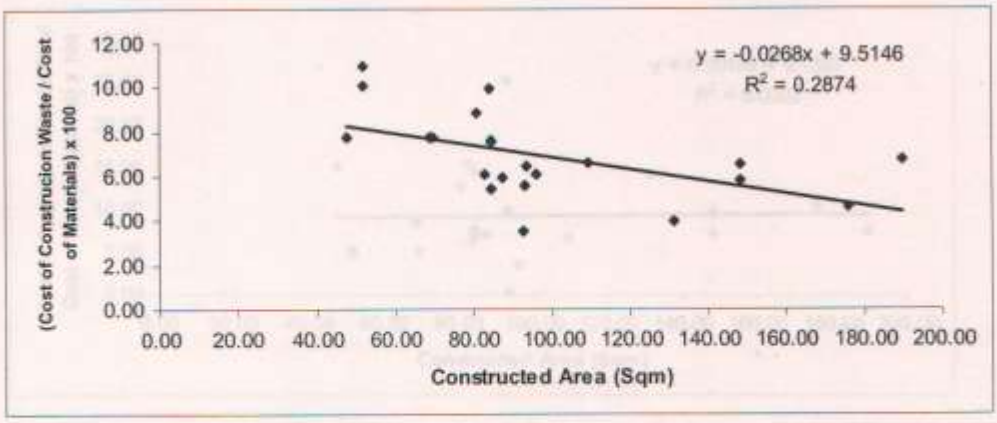


Figure A.2 - "% of Cost of Cement Waste vs Constructed Area"

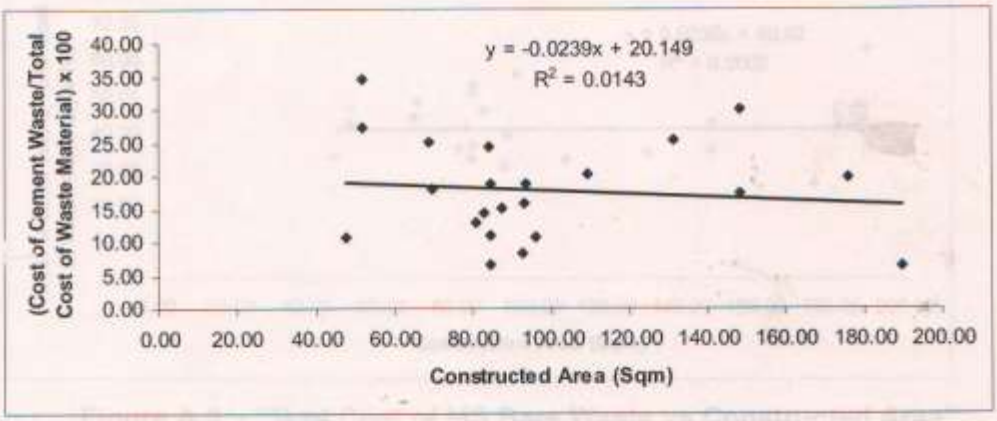
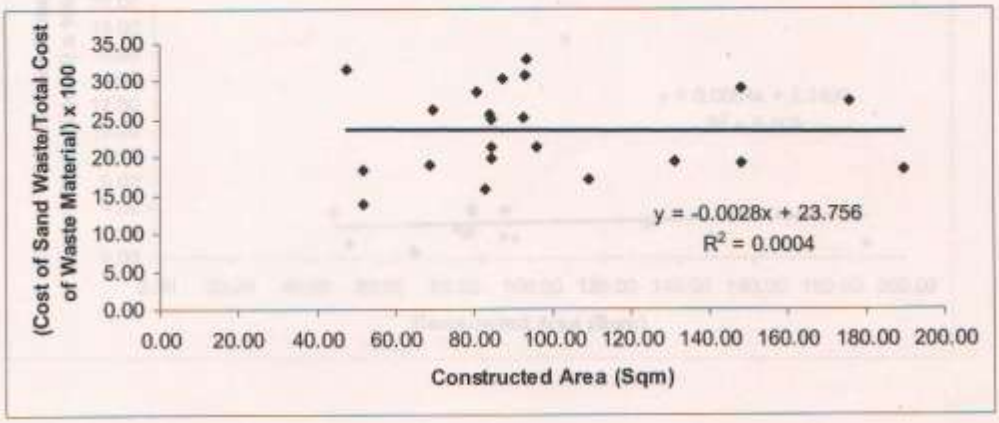


Figure A.3 - "% of Cost of Sand Waste Waste vs Constructed Area"



The % of cost of the different types of the construction waste with respect to the total cost of the construction waste and the total cost of the construction material was calculated

Figure A.4 - "% of Cost of Aggregate Waste vs Constructed Area"

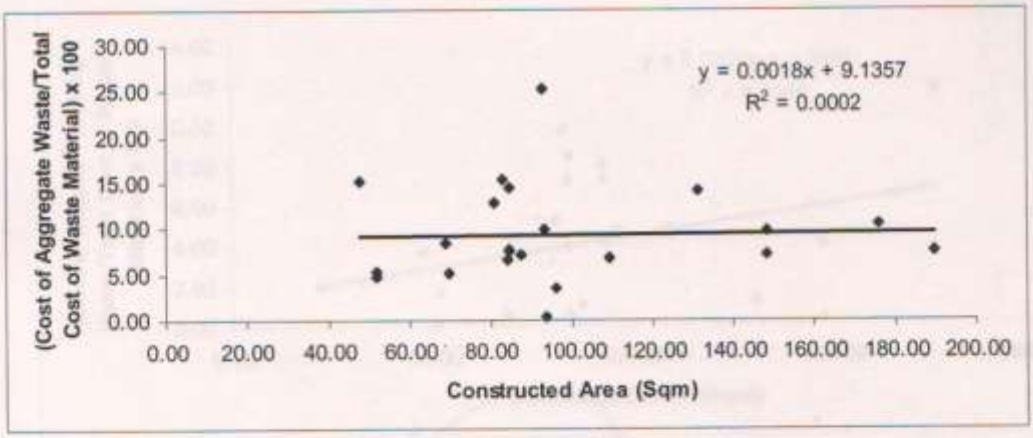


Figure A.5 - "% of Cost of Brick Waste vs Constructed Area"

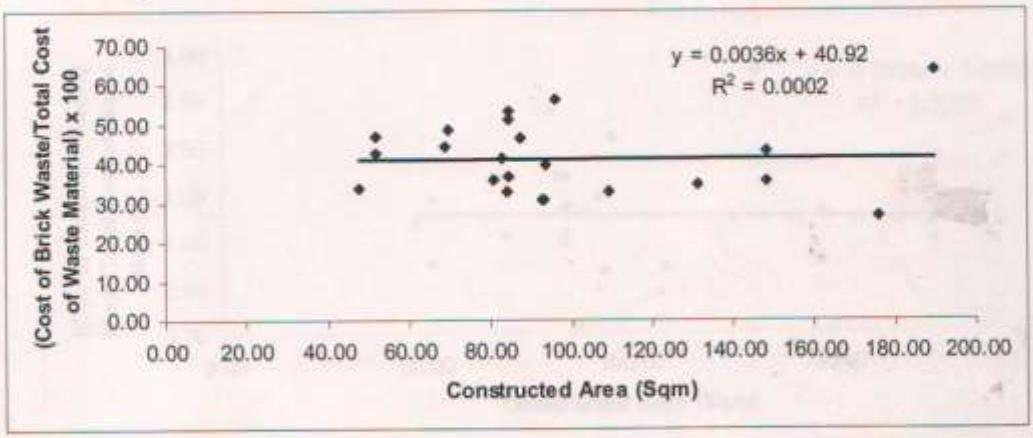
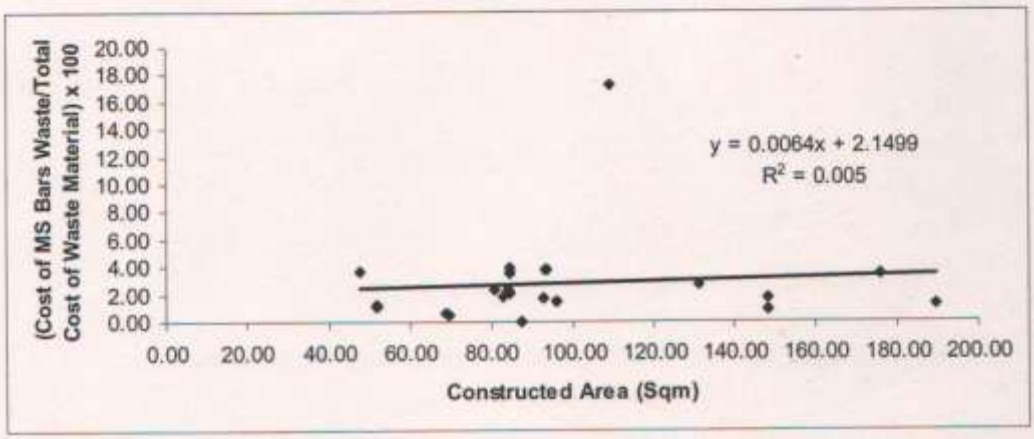


Figure A.6 - "% of Cost of MS Bars Waste vs Constructed Area"



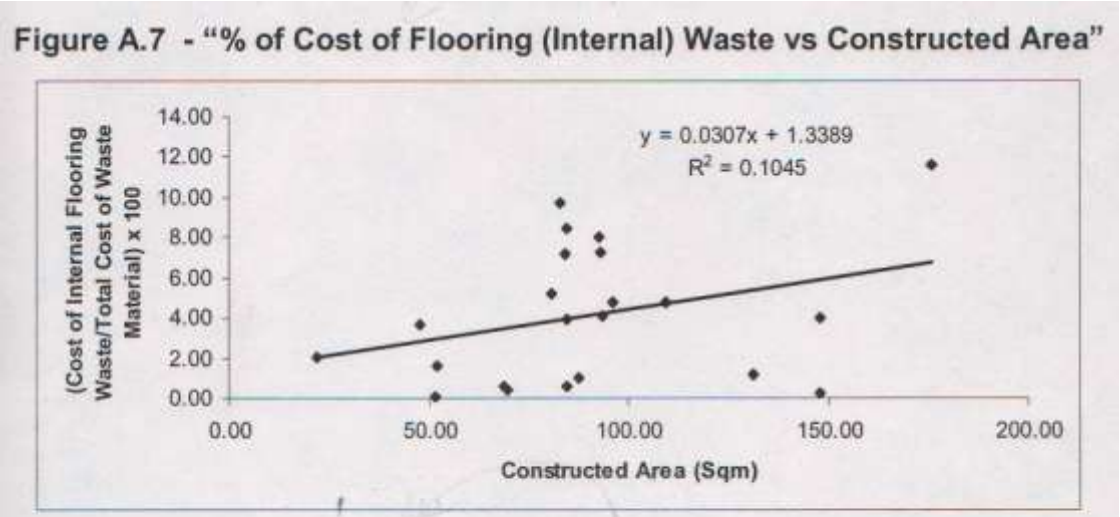


Figure A.7 - "% of Cost of Flooring (Internal) Waste vs Constructed Area"

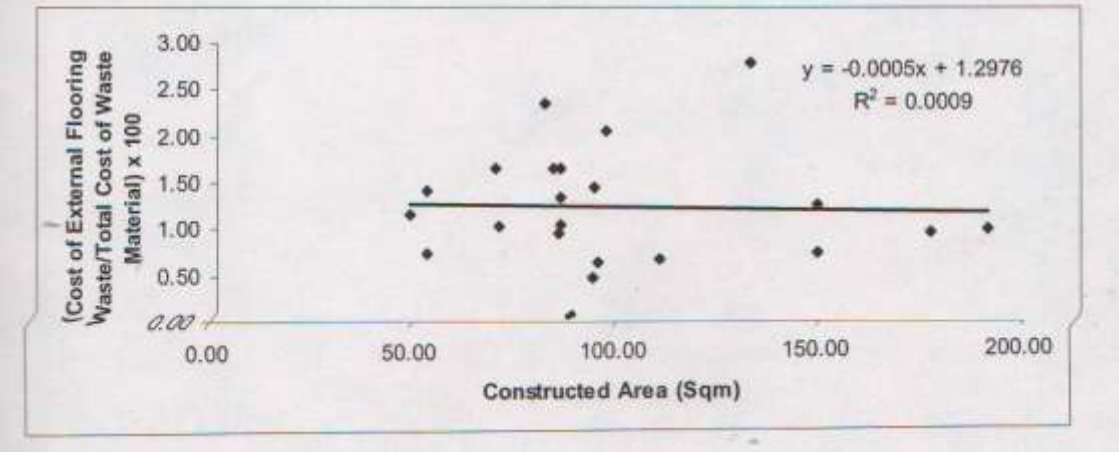


Figure A.8 - "% of Cost of Flooring (External) Waste vs Constructed Area"

and are shown in Table No 6 and fig. 2

Table No 6 – " % of cost of Different Types of Construction Waste w.r.t.Total cost of Waste and Total Cost of Construction Material (Average of 22 Houses Surveyed)"

Table No 6

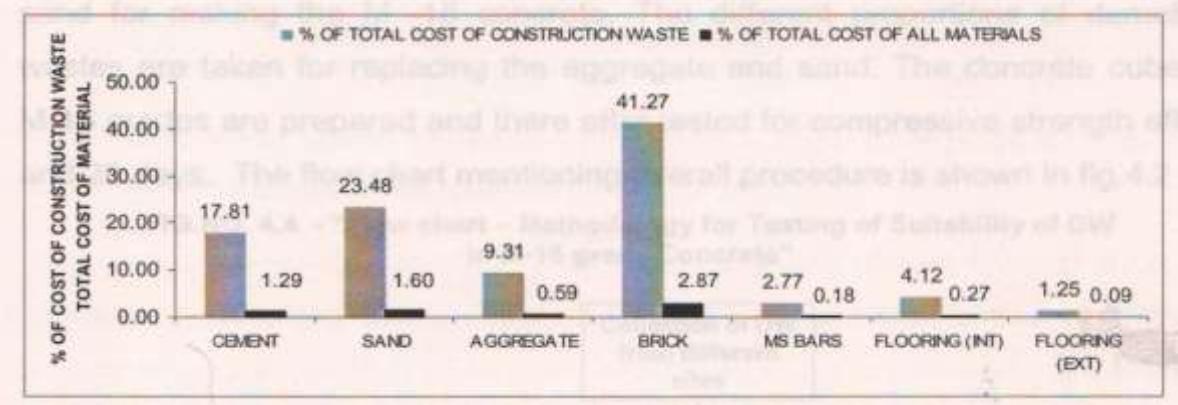
Sr.No.	MATERIAL	% OF Total cost of Waste	% of Total Cost of Material Purchased
1	CEMENT	17.81	1.29
2	SAND	23.48	1.60
3	AGGREGATE	9.31	0.59
4	BRICK	41.27	2.87
5	MS BARS	2.77	0.18
6	FLOORING(INT)	4.12	0.27
7	FLOORING(EXT)	1.25	0.09

V. Result

The scatter diagrams as shown in figures A.1 to A.8 demonstrates that there is no relationship between the constructed area and constructed waste generated.

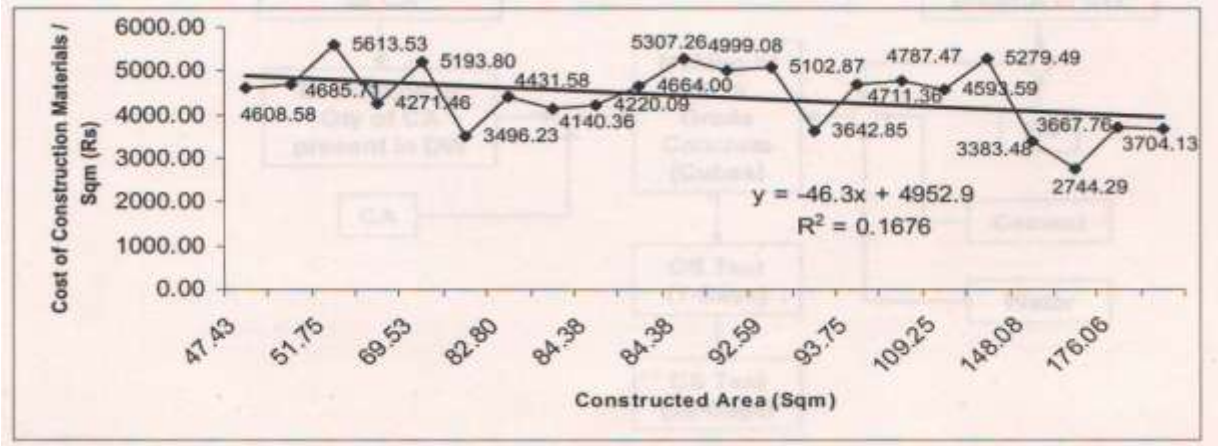
It is clear from fig 2 that brick waste are maximum among all types of construction material studied ,whereas the external flooring are minimum.

Fig No 2 – "% of construction waste versus Total cost of Waste & Total Cost of Construction Material"



The cost of the construction material per sqm of the construction is calculated for all the 22 houses surveyed. The constructed area of the houses varies from 47.43 sqm to 176.06 sqm. A graphical plot of constructed area (sqm) versus cost of construction material per sqm. Is shown in fig 3 .It is evident from fig 3 that the cost of the construction material/sqm decreases slightly with increase in the constructed area which is obvious.

Fig .NO.3 – " Cost of Construction Material per sqm "

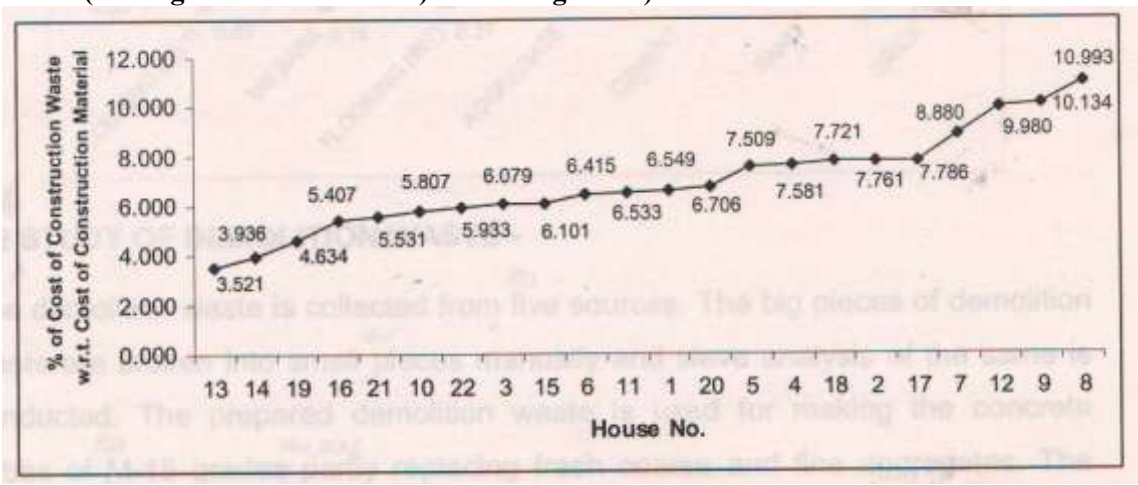


VI. Conclusion

The study of 22 houses was done for the construction waste.The survey data was analysed and the following conclusions were drawn from the analysis –

i. There is no definite relationship between the different construction waste generated and the constructed area .However ,the least cost of the construction waste of the total cost of the construction material is for the house No 13(92.59)is 3.521 % and high as 10.993 % for house No 8(51.75 sqm)

Fig No 4 – " % of Construction Waste Versus Total Cost of Waste & Total Cost of Construction Material (Average of 22 houses data) Ascending order)"



ii. It can be observed from fig 4 that on average the total cost of all the construction wastes ranges from 5.4% - 7.79% of total cost of construction materials.This range can be taken as the best practice range although the number of houses surveyed are too less to make such generalization.

iii. The % cost of the different types construction waste w.r.t. total cost of the construction waste and the total cost of construction material (average of the 22 houses) is shown in fig 5 .It is constructed that the proportion of brick waste is maximum i.e. 41.27% of total cost of construction waste and 2.87% of total cost construction material .The waste of the other construction materials viz. sand ,cement,aggregate,internal flooring,MS bars and External flooring are 23.28%,17.81%,9.31%,4.12%, 2.77%,and 1.25% of the total cost of construction waste and are 1.60%,1.29%,0.59%,0.27%, 0.18% & 0.09%of the total construction material respectively.

Fig No 5- " % of Construction waste Versus Total Cost of Waste & Total Cost of Construction Waste (Average of 22 houses data) (Ascending Order)

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