ARE WE AWARE OF THE EXTENT OF WASTAGE ON OUR BUILDING CONSTRUCTION SITES ?

by
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Abstract

Wastage to a certain extent is inevitable on building sites and this is generally recognised by everybody in the construction industry. However, there is considerable evidence to indicate that wastage of materials and labour on our construction sites is beyond acceptable limits.

Through details on site studies carried out on 5 building sites, causes of material wastage were identified and wastage of all key materials corresponding to various categories and conditions were quantified. The study was also extended to investigate the efficiency of human resources on sites.

It was found that a considerable amount of material wastage and idling of human resources on building sites can be eliminated by proper management throughout the project.

Finally, recommendations were developed to cut down wastage on building sites with particular emphasis on material and labour wastage.

1.0 Introduction

Any practitioner in the construction industry will undoubtedly agree that wastage on building construction sites cannot be totally eliminated. Any attempt to reduce wastage beyond reasonable limits will always become uneconomical.

However, experience on our building sites suggests that wastage of resources is beyond acceptable limits. Any attempt to reduce this unacceptable wastage will increase productivity saving a considerable amount of money spent on resources like labour and materials.

To study this problem of wastage on Sri Lankan building sites, a comprehensive research programme was implemented with the following objectives.

1. To identify major causes of wastage on building sites.

2. To quantify them under various conditions and categories.

3. To develop and recommend methods to reduce these wastages.

The methodology adopted to achieve the aforementioned objectives included a questionnaire survey among a representative sample of contractors, field interviews and on-site data collection.

Contractors' views on material wastage, wastage of manpower, wastage arising from construction plant, wastage due to inappropriate construction methods, poor planning, lack of cost control and poor communication were presented in a previous research paper by Jayawardane (Jayawardane 1992a). Contractors views on causes of wastage, suggestions for improvement, difficulties for further improvement, support required from various bodies were also presented in the same paper.

This paper presents the results of an on-site survey carried out specifically to achieve the second and third objectives mentioned above.

2.0 Wastage of Construction Materials

2.1 Methodology adopted for data collection

In addition to the questionnaire survey described in the previous paper, it was originally thought that quantification of material wastage using case studies can be carried out by comparing the quantities of material used on site

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according to measured bill items with the requirement given in the standard norms. This was justifiable since similar studies have been carried out in other countries (Skoyles et al 1974). In fact, one live project was studied in this way.

However, it was very difficult to do this because of lack of accurate data. Inaccuracy or unavailability of norms given in standards made it even more difficult to quantify wastage this way. Consequently, wastage was observed on day-to-day basis on live projects for a period of about 2-3 weeks to identify causes and to quantify wastage.

Collection of data from four sites was thought to be just sufficient for the purpose. These four sites were selected from Grade 1 and 2 contractors of the National Registry covering both public and private contractors. One additional site of a Grade 3 contractor was also studied for the purpose of comparison.

Four Technical Assistants were engaged on each site to collect data on material wastage at different stages of material flow. All other necessary information such as specific nature of sites, management habits, working habits and other problems at site were also recorded, by ensuring that the data collection team developed an informal friendship with supervisors and workmen to obtain a true picture of the site. Informal discussions were also held with supervisors and workmen to gather further information on wastage and to clarify doubtful situations.

2.2 Procedure adopted for quantification of material wastage

The steps adopted in analysing field data collected on material wastage are as follows.

1. All possible variables/factors which might affect wastage of different materials were identified together with different treatment levels for qualitative variables as shown in Table 1.

* Different treatment levels identified for the qualitative variables shown in Table 1 are as follows.
* Degree of supervision (1-effective, 2-average, 3-poor)
* Concern of labour (1-highly motivated, 2-averagely motivated, 3-poorly motivated)
* Sub-contract (1-direct labour, 2-sub-contract)
* Mode of transport(1-pan, 2-wheel barrow, 3-manual, 4-hoist)
* Type of work:
  (a) mortar/concrete (1-half brick work, 2-full brick work, 3-plastering, 4-rendering, 5-column/beam concreting,6-slab concreting)
  (b)formwork and steel (1-slab, 2-column, 3-beam, 4-stair case)
  (c)Timber (1-door window frames, 2-sashes, 3-roof)
* Size of brick (1-standard, 2-8"x3.5"x1.5", 3-7.5"x3.5"x2", 4-8.25"x3.25"x2", 5-7.75"x3.75"x1.75", 6-7.5"x3.5"x2")
* Experience of workers (1-experienced, 2-inexperienced)
* Storage (1-good, 2-poor)
* Site space (1-more than enough, 2-just sufficient, 3-restricted)
* Material reconciliation (1-Yes, 2-No)
* Material quality (1-good, 2-average, 3-poor)
* Age of material (1-new, 2-old)
* Diameter of bars (1-binding wires, 2-6mm , 3-10mm , 4-12mm , 5-16mm , 6-20mm , 7-25mm)

2. Percentages of wastage observed during different stages of material flow, from the point of material delivery at site to its ultimate use, were calculated corresponding to each material type. The following stages were thus considered.

* Cement : a) wastage during storage
  b) wastage during handling & transport
* Sand : a) wastage during storage
  b) wastage during handling & transport
* Metal : a) wastage during storage
  b) wastage during handling & transport
* Mortar : a) wastage during transport
  b) wastage during placing
  c) wastage due to excess volume thrown away
  d) wastage due to excess used
* Concrete : Same as mortar
* Steel : a) wastage during cutting
  b) wastage during (storage/use/handling)
* Bricks : a) wastage during transport/handling
  b) wastage during laying
* Formwork : a) wastage during erection
  b) wastage during striking
  c) wastage during storage

3. All the percentages, variables/factors were compiled into tabular form suitable for detailed statistical analysis.

4. A detailed statistical analysis was carried out for significant factor identification using SPSS statistical package.

5. Percentages of wastage observed for different materials were separately calculated based on the significant factors identified in the previous step.

2.3 Results obtained for material wastage

It was thought appropriate to provide detailed results for one material for ease of understanding and to provide the other results in a summary form. As an example, let us consider wastage of sand during storage. The experimental factors used for this analysis were: degree of supervision, concern of labour, quantity available; effectiveness of storage; and limitations of space. Out of these, none of the factors were found to be statistically significant. Thus, all the data were grouped together. The frequency histogram and the corresponding statistics are shown in Figure 1.

Causes of this wastage according to the priority order were found to be:

(a) gradual spreading of sand from uncovered edges of the sand pile during usage, rain and pedestrian and vehicular traffic near the stock pile.

(b) Poor storage areas where sand is sunk into the ground due to soft ground conditions.

Similarly, sand wastage during handling and transport was investigated. In this case also none of the variables tested were found to be statistically significant. The corresponding frequency histogram and statistics are shown in Figure 2.

The main cause of wastage of sand during handling and transport was the careless handling and transport either by shovel, pans, wheel barrows, or dumpers from the stockpile to the mixer and also improper feeding into the mixer.

Since there were no significant factors affecting sand wastage during all stages of storage, handling and transport, all cases were combined. The corresponding frequency histogram and statistics are shown in Figure 3.

Similar procedure was adopted to identify major causes and quantify wastage of all important materials at various stages of material flow. The results are summarised in Table 2.

3.0 Wastage of Human Resources

Clearly, another equally important area of construction wastage is the waste of human resources. Although a detailed study was not carried out to identify the exact causes of human wastage, a study was carried out to find out:

(a) effectiveness of management and supervision in deploying sufficient and well co-ordinated work to the workmen;

(b) various relaxation and idling pattern of workers when work is available to them;

(c) extent of effective use of human resources in ordinary construction sites.

3.1 Methodology adopted for data collection

Activity Sampling field count method was used for data collection. Field count observations at 15 minute interval were obtained on all people working on the site under study. A special activity sampling study sheet was prepared for this purpose.

3.2 Results obtained for human resource wastage

It was identified that the best way to fulfil the above objectives is to draw bar diagrams for every site during various times of the day representing (a) percentage of workers who are active, (b) percentage of workers who are idle when work is available, and (c) percentage of workers who are idle due to lack of work. To this end, all observations taken at a specific time of a day were combined and averaged corresponding to the above three categories. Different sites were treated separately to avoid influence due to large number of site specific variables involved. A typical set of histograms drawn for one site is shown in Figures 4a, 4b and 4c.

Summary results of human resource usage at different sites are shown in Table 3 and weighted mean values of wastage of human resources are shown in Table 4. The results clearly indicate that a considerable attention is needed by the management to increase effective use of human resources on construction sites.

4.0 Concluding Remarks and Recommendations

The results shown in Table 2 for wastage of materials and Table 3 and 4 for wastage of human resources clearly provide an alarming signal on the effective use of these valuable resources in our construction sites at present. An urgent attention is required to reduce this unacceptable wastage and thereby to increase productivity. Some recommendations that can be made towards this endeavor are given below.

1. Proper material reconciliation systems must be introduced for all key materials and reconciliation be done every day. These reconciliation forms should be developed by the ICTAD and made available for the contractors similar to the other forms and formats developed in 1991(Karunaratna et al 1991). (see also 6 below).

2. All existing work norms and BSRs; which have a wide variability, redundant items and unavailability of necessary items; must be reinvestigated and amended. This should be carried out by ICTAD based on good sample projects using systematic work study. Updated documents should be made available to all organisations to be used as guidelines.

3. Construction management tools such as materials management, project control, project monitoring, financial management, general site management, work study, personnel management should be introduced to all management and supervisory staff through short courses. This should be done by ICTAD/CHPB as at present. ACCSL may act as the link to identify priority areas and personnel.

4. ACCSL in collaboration with ICTAD/CHPB should develop a construction manual as a ready reckoner for managerial and supervisory staff covering all the areas mentioned in 3 above and should be popularised and made available to all contractors registered under ICTAD. Action must be taken to encourage these contractors to use these guide lines.

5. Strict supervision should be extended for sub-contractors and the issue of materials to them must be strictly controlled and monitored. Payments shall be tied-up to the extent of material used to control excessive use and wastage as was done in 1985 at SEC when labour contracting was introduced. Casual subcontracting should be avoided as far as possible since this encourages wastage on sites.

6. Since subcontracting system is unavoidable and the main organisation cannot be expected to recruit all staff on a permanent basis, the subcontracting system must be properly developed to reduce the existing shortcomings such as excessive wastage, poor quality, and other management and contractual difficulties.

7. SLSI should establish acceptable standards for all construction materials. ICTAD should take action to stop flooding the market with substandard and low quality materials both locally produced and imported and to provide necessary specifications to parties concerned.

8. A licensing system for all skilled workers should be introduced. The necessary training for these workers may be given either by apprentice type of training or by various training institutes. The trade tests shall be carried out by ICTAD in collaboration with NAITA under the umbrella of Tertiary and Vocational Education Commission (TVEC). Tradesmen who do not possess such a certificate shall not be allowed to practice, except as trainees, on construction sites. Action must be taken to properly recognise such qualified people and attract trainees to follow the courses by gradually upgrading their social status.

9. Workers should be educated at site on proper personal and site management, and make them aware of the advantages of good practices and disadvantages of bad practices. An effective communication system such as posters and sign boards at sites would be useful for this purpose. Any benefits should be shared among everyone concerned to build up the team spirit and to motivate workmen.

10. Significant wastage of constituent materials, particularly cement occur due to incorrect proportioning of concrete mix. Mix designs must be encouraged to select the best ratio rather than adopting traditional ratios.

11. Research should be carried out to investigate the overall economy due to various sizes of bricks for different type of structures. (Some research on this has already been carried out at Moratuwa (Weerathunga et al 1992). If economical the current standard size can be changed. The size thus obtained and the brick quality must be maintained by every producer. This should be achieved by forming a Brick Manufacturers' Association under ICTAD. This can be done without affecting the current employment pattern of the brick manufacturing industry.

Appendix 1 - References

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Appendix 2 - Abbreviations

ACCSL- Association of Construction Contractors in Sri Lanka
CHPB- Centre for Housing Planing and Building
ICTAD- Institute for Construction Training and Development
SEC - State Engineering Corporation
SLSI - Sri Lanka Standards Institution
NAITA - National Apprenticeship and Industrial Training Authority
TVEC - Tertiary and Vocational Education Commission

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Table 1 - Possible variables affecting material wastage

Material & mode of waste (When expressed as %) \ variables/Factors	Degree of Supervision	Concern of Labour	Sub-contract	Distance to work place	Mode of Transport	Type of Work	Size of Bricks	Output/Quantity	Experience of Workers	Distance to Mixer	Storage	Site Space	Material Reconciliation	Material Quality	Age of Material	Ø of Bars
1. Storage waste(cement)	*	*	*								*		*		*	
2. Handling waste(cement)	*	*	*					*	*				*			
3. Storage waste(sand)	*	*						*			*	*				
4. Handling waste(sand)	*	*	*		*			*	*	*		*				
5. Storage waste(metal)	*	*						*			*	*				
6. Handling waste(metal)	*	*	*		*			*	*	*		*				
7. Transport waste(mortar)	*	*	*	*	*			*	*				*			
8. During placing(mortar)	*	*	*			*			*				*			
9. Excess thrown away(mortar)	*	*	*										*			
10. Excess used(mortar)	*	*	*			*	*		*				*			
11. Transport waste(concrete)	*	*	*	*	*				*							
12. During placing(concrete)	*	*	*			*			*							
13. Excess thrown away(concrete)	*	*	*										*			
14. Excess used (concrete)	*	*	*			*			*				*			
15. Transport waste(bricks/blocks)	*	*	*	*	*	*	*	*	*		*			*		
16. Laying waste(bricks)	*	*	*			*	*		*					*		
17. Formwork	*	*	*			*			*		*			*		
18. Timber	*	*	*			*			*		*			*		
19. Reinforcement	*	*	*			*			*				*			*

Table 2 - Summary results of wastage observed during wastage field data analysis

Material	Stage	Significant variables	Mean Wastage %	Stand. Deviation %	Range %	Skewness	Main Causes
1. Cement (powder form)	(a) Storage	-	-	-	-	-	Note: No wastage was observed during 153 cases out of 156 observations, thus considered unimportant.
	(b) Handling & transport	-	2.90	6.49	0 - 53.10	4.14	Careless handling, unacceptable breaking of bags using shovels etc., taking out cement using shovels.
2. Sand (before mixing)	(a) Storage	-	4.71	9.00	0 - 44.60	2.28	Gradual spreading of sand from uncovered edges during usage, rain and by pedestrian & vehicular traffic near stock pile. Poor storage areas on soft ground.
	(b) Handling & transport	-	4.63	6.70	0 - 50.00	3.00	Careless handling and transport by shovel, pan, wheel barrow or dumper from stock pile to mixer and during feeding to mixer.
	(c) Combined	-	9.34	9.05	0 - 50	1.88	The above causes. Sand is also wasted due to inefficient sieving of wet sand which is not included here.
3. Metal (before mixing)	(a) Storage	-	1.46	4.61	0 - 20	3.48	Similar to case (a) of sand above
	(b) Handling & transport	-	3.47	4.85	0 - 23.1	2.62	Similar to case (b) of sand above
	(c) Combined	-	4.93	5.86	0 - 23.1	1.87	Same as (a) and (b)

Table 2 - Continued.....

Material	Stage	Significant variables	Mean wastage %	Stand. Deviation %	Range %	Skewness	Main Causes
4. Mortar	(a) Transport	Mode of transport					
		(a) pans	2.67	4.16	0-22.1	3.15	Usage of old & unusable pans, overfilling, segregation.
		(b) Wheelbarrow	5.20	4.43	0.2-24.9	1.77	Use of old and damaged wheel barrows. Spilling
		(c) Shovel	4.68	2.25	1.3-8.3	0.10	& waste due to careless throwing by shovel
	(b) During placing	Subcontract or not					
		(a) Direct labour	6.00	4.90	0-23.9	1.28	Inefficient supervision, carelessness.
		(b) Subcontract	8.26	8.12	0-44.3	2.11	Inefficient supervision, carelessness.
	(c) Excess thrown away	Subcontract or not					
		(a) Direct labour	3.54	5.03	0-24.9	2.41	Inefficient supervision.
		(b) Subcontract	5.76	6.23	0-28.3	1.84	Inefficient supervision.
	(d) Excess used	Type of work					
		(a) 9" brick wall	8.58	14.76	0-57.4	1.57	Excessive bed thickness, smaller bricks.
		(b) Plastering	17.48	21.43	0-75.2	1.09	Excessive thickness due to nonverticality & unevenness of walls.
		(c) Rendering	25.70	17.41	0-49.2		Proper level is not maintained by hard core filling.

Table 2 - Continued.....

Material	Stage	Significant variables	Mean wastage%	Stand. Deviation%	Range%	Skewness	Main Causes
5. Concrete	(a) Transport	-	2.64	2.76	0-10.2	1.46	Usage of old unsuitable pans and wheel barrows, carelessness of workers.
	(b) Placing	-	2.17	2.67	0-9.1	1.63	Inefficient supervision, carelessness
	(c) Excess thrown away	-	3.46	5.89	0-23.2	2.21	Inefficient supervision
	(d) Excess used	Degree of supervision & work type (a) Slab concreting, effective supervision	3.18	6.36	0-15.9	2.25	Excess thickness
		(b) Slab concreting average supervision	4.59	6.96	0-16.0	1.15	Excess thickness, poor supervision
		(c) Cloumn/beam poor supervision	4.18	9.35	0-20.9	2.23	
		(d) Slab concreting poor supervision	21.7	12.55	0-40.7	0.25	Excess thickness, poor supervision.
6. Bricks	(a) Transport & handling	-	4.29	6.35	0-52.6	4.95	Poor quality, careless handling during loading & unloading, throwing of bricks, unsuitable lifting methods.
	(b) Laying	-	1.83	3.31	0-20.8	3.34	Breakage of good bricks when bats are needed.
	(c) Combined wastage	-	6.12	6.84	0-52.6	3.82	Same as above

Table 2 - Continued.....

Material	Stage	Significant variables	Mean wastage %	Stand. Deviation %	Range %	Skewness	Main Causes
7. Formwork	(a) Cutting & fabrication	-	6 -35	more than 50% of time wastage > 10%, more than 20% of time wastage > 20%			
	(b) Storage and handling	-	0-300				Refabrication when old ones can be used.
	(c) Careless striking	-	0 - 55				Poor supervision and poor fixing of shuttering making difficult to remove.
8. Structural timber			15-20				
9. Steel	-	-	10-50	7.37	0 - 35.2	1.89	Inefficient supervision

Table 3 - Summary results of human resource usage at sites

Site Number	% Active		% Idle with work		%Idle without work	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Site 1	14.5	88.0	6.0	76.0	3.5	17.5
Site 2	52.0	84.5	8.5	22.0	5.5	28.5
Site 3	45.0	93.0	2.5	45.0	2.0	26.8
Site 4	56.0	84.0	4.0	26.0	6.0	25.0
Site 5	40.0	100.0	5.0	58.0	0.5	33.5

Table 4 - Percentage wastage of human resources

Site number	Percentage idle		
	% Idle with work	% Idle without work	Total % idle
Site 1	23.04	9.63	32.67
Site 2	16.26	13.86	30.12
Site 3	13.32	10.72	24.04
Site 4	11.94	9.87	21.81
Site 5	14.48	7.39	21.87

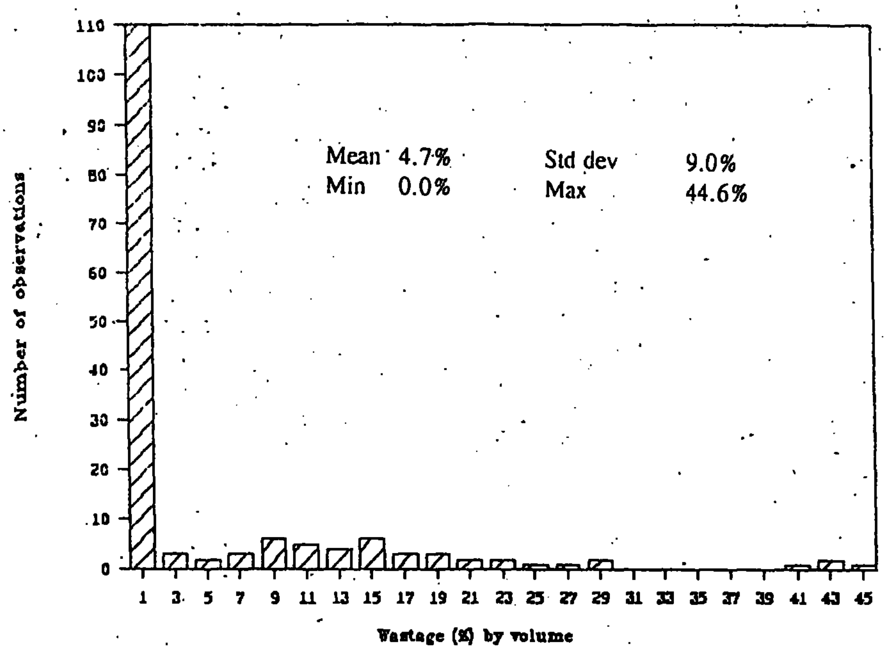

Figure 1 - Frequency histogram and statistics for sand wastage during storage

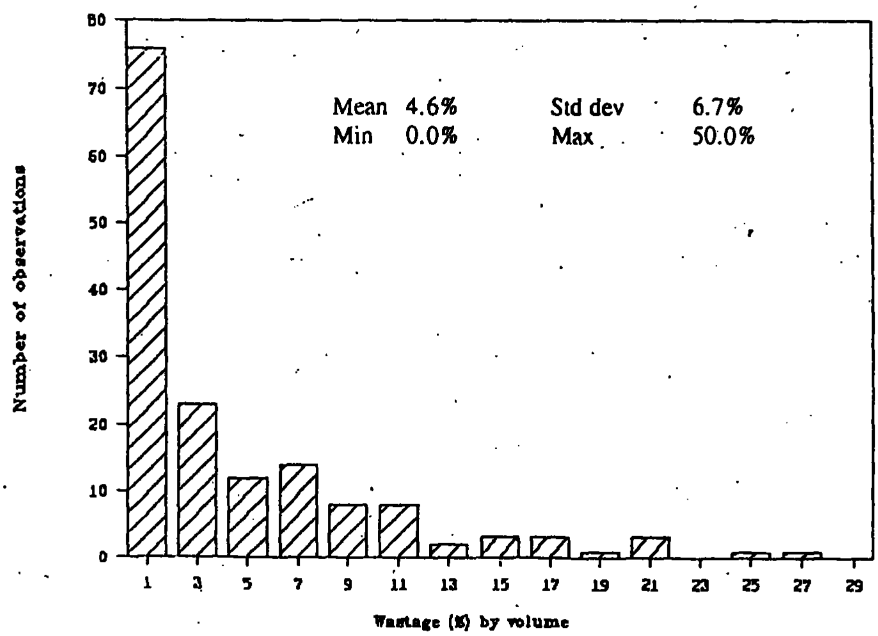

Figure 2 - Frequency histogram and statistics for sand wastage during handling and transport

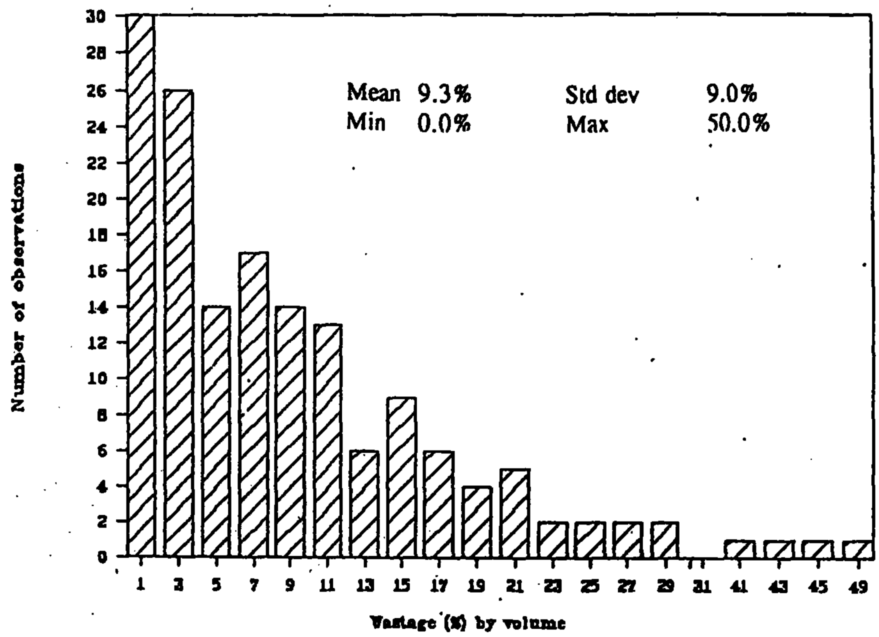

Figure 3 - Combined frequency histogram and statistics for wastage of sand

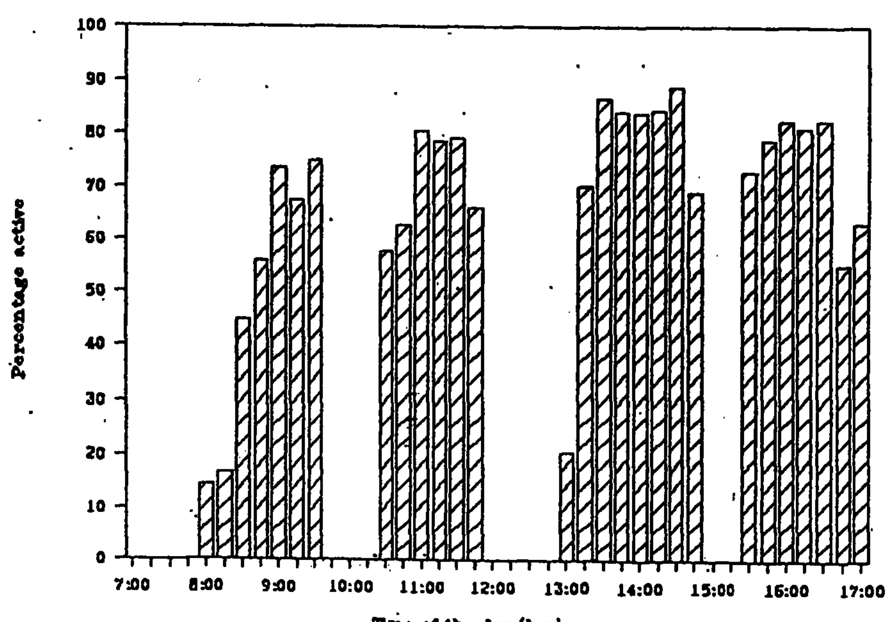

Figure 4a - Histogram representing percentage of workers (active)

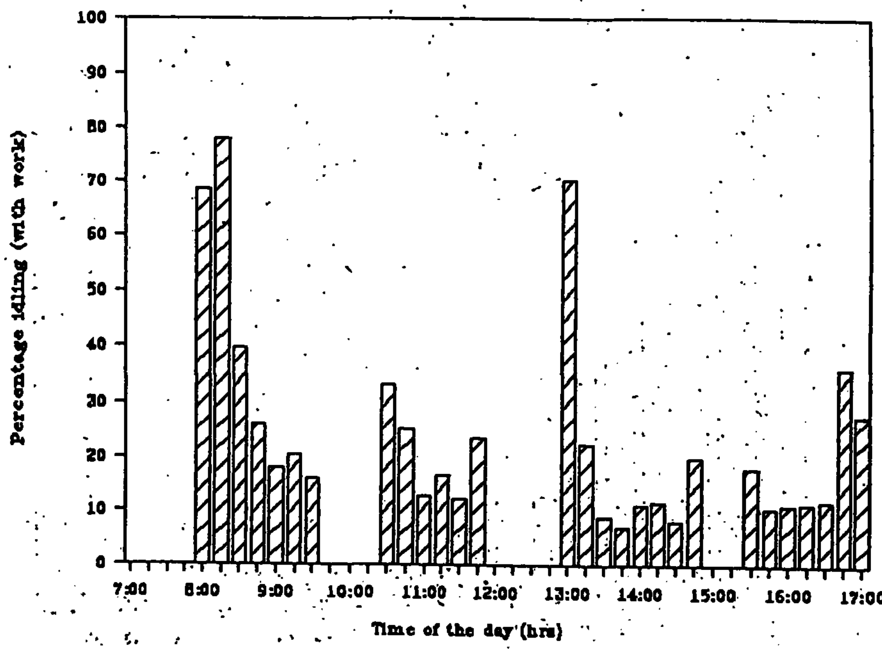

Figure 4b - Histogram representing percentage of workers (idle when work is available)

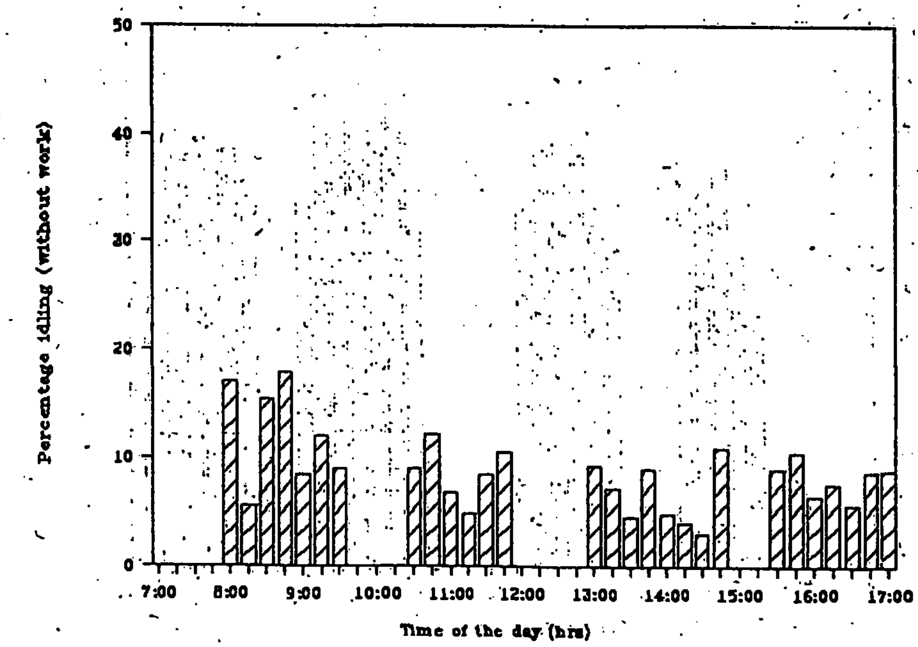

Figure 4c - Histogram representing percentage of workers (idle when work is not available)