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Comparison of Alternative Design Wheelbarrows
for Haulage in Civil Construction Tasks
World Bank Technical Memorandum No. 1, 1975

WORLD BANK STUDY OF THE SUBSTITUTION OF LABOR
AND EQUIPMENT IN CIVIL CONSTRUCTION

Technical Memorandum No. 1

Comparison of Alternative Design Wheelbarrows for Haulage
in Civil Construction Tasks

January 1975

A comparison is made of productivity in haulage of different
design of wheelbarrows. Two-wheel and one-wheel barrows, solid tired
vs pneumatic rubber tired barrows, and ball bearing vs bushed bearing
wheels for barrows are investigated. On the basis of 6 weeks of trials,
it is concluded that a light weight, single-wheel barrow with a scooter-
tire and ball-bearing wheels, is the most economical type of wheelbarrow
for earth haulage.

Transport Research Division
Transportation and Urban Projects Department

Preface

This is one of a series of papers prepared in the course of the Study of the Substitution of Labor and Equipment in Civil Construction. The paper is prepared with the objective of generating discussion on the results of the study as and when they are available. The conclusions of this paper, therefore, must be considered tentative and subject to revision in light of further field work and analysis. It is hoped that engineers would find these results useful in planning and executing labor-intensive civil construction projects. Comments are solicited from all interested persons.

The paper is based on the field work in India undertaken by Scott Wilson Kirkpatrick and Partners (consultants) in collaboration with the Border Roads Organization and the Ministry of Shipping and Transport (Roads Wing). The study is directed by Inder K. Sud of the World Bank. Mary Bullington contributed to the analysis of this paper. Financial support for the study is being provided by the World Bank and the Governments of Canada, Denmark, Federal Republic of Germany, Finland, Japan, Norway, Sweden, United Kingdom and the United States.

I. INTRODUCTION

1.   In earlier times in western countries wheelbarrows have been a common mode of mass haulage in labor-intensive construction works and this suggests that in the present day there might be significant use for well designed and constructed wheelbarrows (or carts) under the right circumstances. Observations of traditional haulage methods in both India and Indonesia suggest that indeed wheelbarrows could raise labor productivity significantly. While headbaskets (or shoulder yokes) are the most common modes of haulage observed, wheelbarrows are used on a few construction sites. However, little attention is given to the design of the wheelbarrows which could have an important bearing on productivity. Design factors which affect the performance of a wheelbarrow are: its weight, size, handle positioning, size and number of wheels, and the type of tires. In India an experiment was undertaken to investigate the efficiency of different designs of wheelbarrows.

2.   Seven different types of wheelbarrows were considered, including two types specifically designed for the study. After a preliminary assessment, four of these were evaluated more fully in trials over a period of six weeks. The paper summarizes the experiment and its results.

3.   The general scope of the experiments was to use two types of Indian two-wheel barrows and two experimental one-wheel barrows to carry loose earth over similar (30 m) haul routes with rising, level and falling gradients, a range of loads being carried in each barrow type. The four objectives of the experiments were:

(a)   to investigate, qualitatively, various aspects of wheelbarrow geometry and construction;

(b)   to quantify the performance of different barrows;

(c)   to investigate the relation between load carried and productivity; and

(d)   to assess the suitability of different barrows for various possible applications, particularly haulage of earth or similar homogenous loose materials.

II. WHEELBARROW TYPES

4.   Two barrows of two-wheel type and two single-wheel barrows were tested in the experiment.

Two-Wheel Barrows

5.   Conventional Indian wheelbarrows are generally of two-wheel type with heavy cast-iron wheels and solid rubber tires. The body is parallel sided, with a struck volume of approximately $0.075m^3$. Frames are generally of welded wrought iron tube, angle iron or steel strip construction. On sites where these barrows

were observed in use, a frequent cause of failure was observed to be poor welding and overstressing of the frame at critical points, such as the handles or axle supports. Bodies are of very heavy construction and generally outlast all other parts of the barrow, especially the wheel bearings which are subjected to very rapid wear, being plain unbushed cast iron on steel. Tire rubber is of low quality with a tendency to disintegerate rather than wear evenly.

6.   While it was intended to test the conventional Indian wheelbarrows in the experiment, it was realized that major improvements in performance (and life) can be obtained by some minor modifications in these wheelbarrows. Therefore, two modified barrows of conventional Indian design were tested instead. These wheelbarrows are shown in Figure 1 and described below.[1]

    i)   A modified two-wheel Indian barrow with lighter wheels of pressed steel construction and ball bearings. Roll-over bars were provided at the front to facilitate tipping (see Figure 1-a). The weight saved in the wheels was partly lost by the addition of roll-over bars. The cost of the barrow was US$41. This wheelbarrow design was designated as Typce C.

    ii)   A conventional Indian design wheelbarrow except that brass bushes were specified (Figure 1-b). The wheels supplied were of the plain bearing, cast iron variety, with excessive slack even when new. The cost of the barrow was US$21. Many failures of tires and frame were experienced in the period of 6 weeks the barrows were in use. This wheelbarrow design was designated as Type D.

One-Wheel Barrows

7.   Two one-wheel barrows were specially designed for the experiment. The starting point for the designs of the one-wheel barrows was the traditional British general purpose wheelbarrow. For the Ir lian situation it was thought necessary to reduce the body capacity to allow for the smaller physical stature of the operatives, and hence two different sizes were planned in order to obtain some information on this point. Ball bearings were used and pneumatic-tired wheel of increased size employed, since the barrows were intended to be suitable for earthmoving on relatively longer hauls and possibly rougher surfaces than a general purpose barrow. The barrows were designed to be as light as possible, but non-availability of steel tubing prevented this aim being fully achieved. The two barrows were designated as Type E and Type G and are shown in Figure 2 and described below.[2]

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[1] Detailed dimensions of a conventional two-wheel Indian barrow are given in Appendix I. The two-wheel barrows used in the experiment were generally of similar dimensions.

[2] Detailed dimensions of the two one-wheel barrows are given in Appendix II.

a) Two-Wheel Barrow with Light Wheels of Pressed Steel Construction
   and Ball Bearings (Type C)

b) Two-Wheel Barrow with Plain Bearing Cast Iron Wheels and Brass
    Bushes (Type D)

Figure 1. Modified Conventional Two-Wheel Indian Barrows Used in the
           Experiment
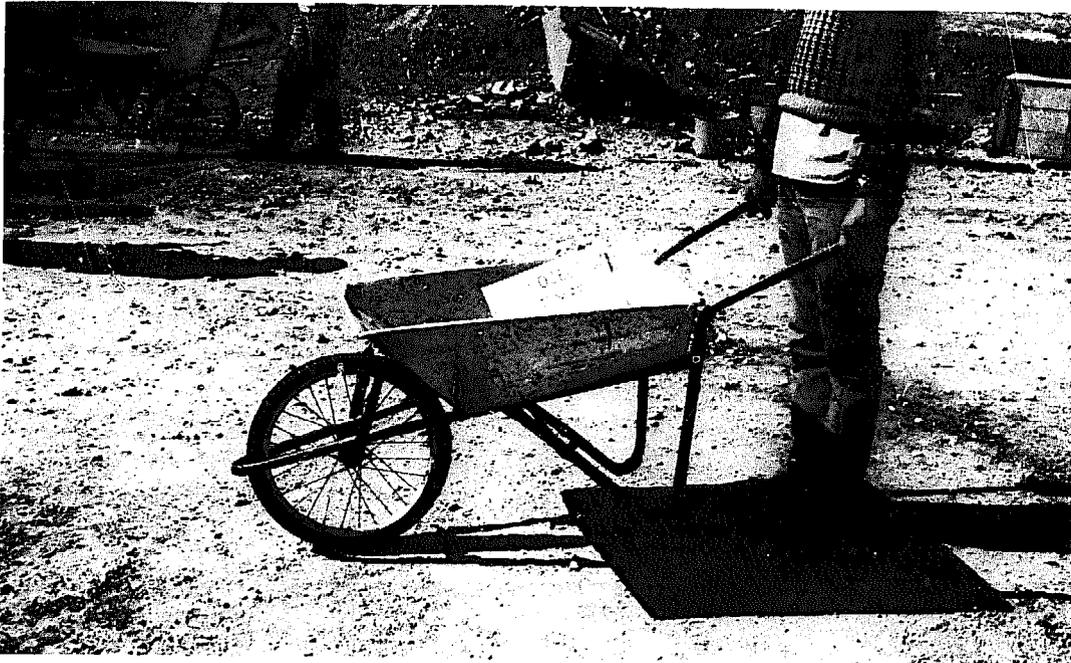
a) One-Wheel Barrow with Light Wrought Iron Tube Frame and a Pneumatic Tired Cycle Wheel (Type E)

b) One-Wheel Barrow of Stronger Construction and a Pneumatic Scooter Tired Wheel (Type G)

Figure 2. One-Wheel Barrows Designed for the Experiment

i) The Type E barrow was a light, small (0.05m^3) barrow based on a garden wheelbarrow design, modified by alterations to the frame details and substitution of a 40 cm diameter pneumatic-tired cycle wheel. As steel tube was not available, a heavier guage of wrought-iron tube was used, adding 2 kg to the weight of the frame. The rivetting of the body and top-edge reinforcement were unsatisfactory. It was also found that the quality of wheels and tires were inadequate for their purpose and the expected life of these barrows was a few months. The cost of each barrow was approximately U.S.$23.

ii) The Type G barrow was of larger capacity (0.065m^3) and stronger construction than the cycle-wheel barrow. They were well made, and had a robust scooter wheel with ball-bearing axle, but the frame dimensions (particularly handle width) as constructed were not as designed. The narrow handle spacing probably affected adversely the performance of the Type G barrow in the experimental work. Cost of this barrow was U.S.$41.

III. EXPERIMENTAL PROCEDURE

8.   A site was selected where two haul routes on a hard smooth earth surface could be established, one having a uniform 4% gradient and the other being level. A quantity of earth was excavated and a stockpile of this loose material established at one end of the haul route in use. Four or five locally employed laborers, depending on availability, were detailed to work on the experiment. Generally, two were occupied in loading, one or two in hauling and one assisted with weighing the wheelbarrows loads, density measurement, etc. After an initial period where investigations of the task from a work-study approach were carried out, a methodology was established whereby the various parameters within the control of the experiment were treated as follows:

Constant Factors:

Haul Length	30 m
Condition of Haul Route	Fair
Material Type & Density	Loose Earth
Method of Payment	Daily Paid

Controlled Variables:

Barrow Type	4 Types used
Gradient	+ 4%, 0 or -4%
Load Carried	60-150 Kg

Uncontrolled Variables:

Labor	Different proficiency

9.   The method of working was normally to move the stockpile of loose earth from one end of the haul route to the other using a particular barrow and carrying a certain load. The stockpile was then moved back again, when the barrow type or load could be changed, as necessary, to build up a set of observations for each barrow type and for varying load and gradient. In this way two to four sets of observations were obtained each day. The laborers undertook different activities on successive days. The individual laborers detailed for the study varied to some extent. A fairly wide cross section of labor was involved in the experiment over the six-week period. It was not thought feasible to pay the workers by any incentive system because of the continually varying nature of the work.

10.   Observations were taken of the times for hauling loaded, unloading, and hauling empty. The barrows were weighed empty and the weight of the contents were weighed at intervals to control and record the average load. The loading element was also timed on some occasions; however, it should be noted that the wait-while-loading time is not really relevant to a working cycle on actual construction where spare barrows would normally be employed for optimum output.

IV. RESULTS OF THE EXPERIMENT

11.   The detailed results of the experiments are summarized in Appendix III. Figures 3-5 have been prepared from these results with the intention of showing the relative performance of the different barrow types in terms of haulage output.

12.   After the experimental field work had started it was observed that variation in performance due to the differing work capacity of the individual laborers was an important factor. This meant that a much larger (than planned) number of observations would be required to achieve statistically reliable results if barrow type, gradient and load were all treated as variables. Sufficient time was not available for these extra observations and, therefore, the data obtained was less than complete for statistical reliability. However, it is hoped that the observations made have been interpreted satisfactorily using judgement in selecting 'representative' observations or more particularly omitting unrepresentative ones.

13.   Bearing in mind the limitations of the data, there appears to be a consistent pattern of outputs for the various barrow types; for example, see Figures 3-5. For any given load, higher outputs were obtained with one-wheel barrows than with two-wheel ones, regardless of gradient. Further, the wheelbarrow types substantially showed the same order of relative performance regardless of gradient; for example, considering a net load of 100 kg and alloting the output of the 'conventional' two-wheel barrow (Type D) a value of unity, the output performance of the barrows can be rated as shown in Table 1.
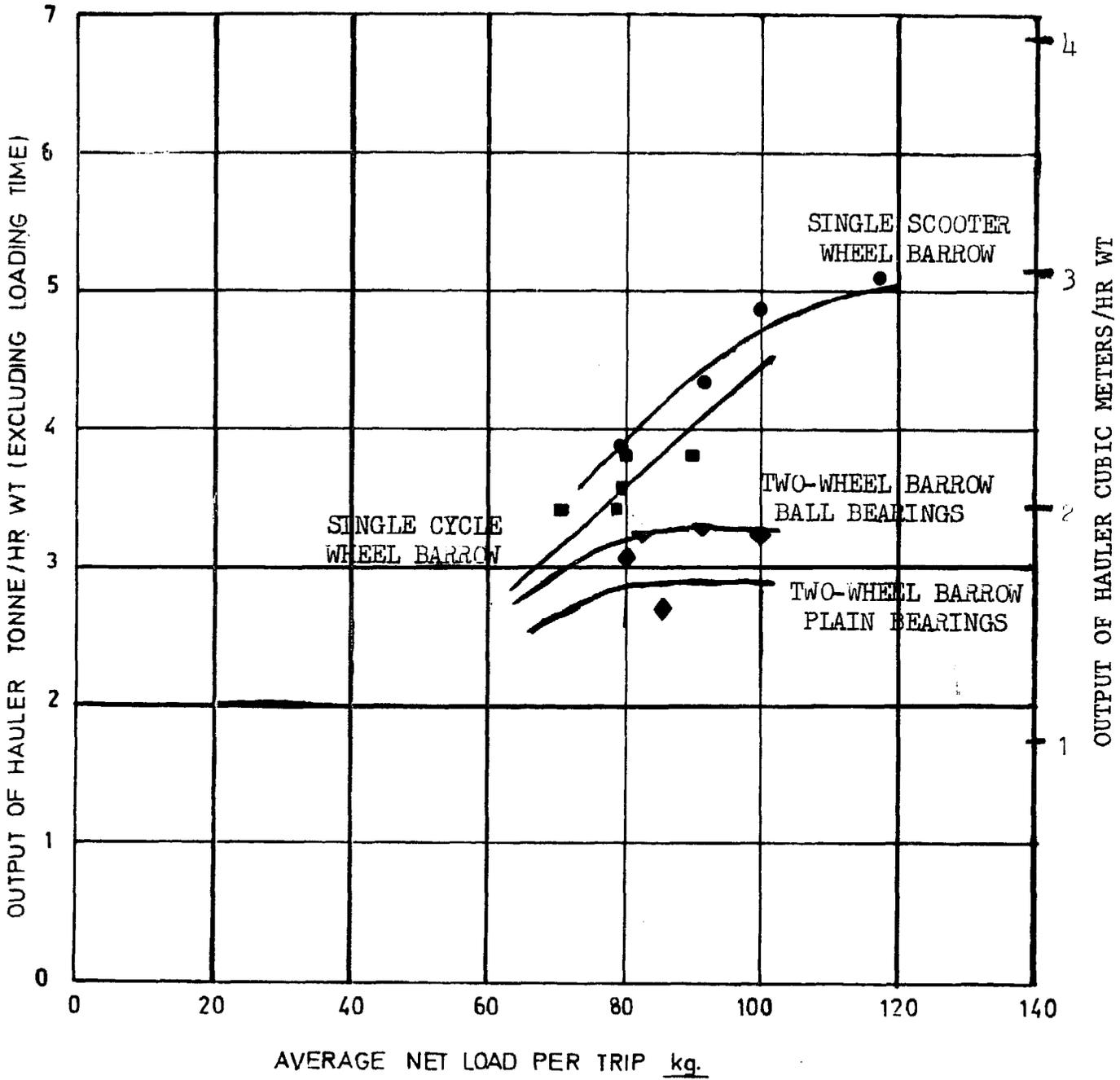
KEY ▼ = TYPE C   ◆ = TYPE D   ■ = TYPE E   ● = TYPE G

Figure 3. Haulage Output with Different Wheelbarrows Smooth Hard Earth Surface, 4% Up Gradient

Figure 4. Haulage Output with Different Wheelbarrows Smooth Hard Earth Surface, Level

Figure 5. Haulage Output with Different Wheelbarrows Smooth Hard Earth Surface, 4% Down Gradient

Table 1. Relative Output Performance for Four Types of Wheelbarrow

Barrow Type	Description	Relative output performance (100 kg load)		
		4% up gradient	Level	4% down gradient
D	Two-wheel, plain bearing	1.0	1.0	1.0
C	Two-wheel, ball bearing	1.15	1.2	1.1
G	Single scooter wheel	1.6	1.3	1.25
E	Single cycle wheel	1.55	1.4	1.3

It must be emphasised that these figures have been obtained by omitting from the graphs results having large scatter from what is judged to be the underlying pattern. However, it may be that by chance a consistent deviation from the probable 'mean' has occurred where, for example, on 4% up gradients the Type G barrow performance is better than the Type E barrow, since there is no obvious reason why this should be the case and the lighter Type E barrow is superior on level and down gradients, up to the loads permitted by its smaller capacity. The performance figures should therefore be regarded as providing a general rather than precise indication of the comparative outputs obtainable.

14.   A measure of whether the increased output of the single-wheel barrows is significant in practice can be obtained by considering the comparative cost of haulage. Naturally the barrows with bearings and pneumatic tires are more expensive, but their lives should be longer to compensate. Using an unskilled labor wage of U.S.$0.07 per hour the following comparison was obtained.

Table 2. Cost of Haulage for 30 m Lead Using Wheelbarrows

Barrow Type	Cost on site (US.$)	Repairs etc.allow (U.S.$)	Expected life (Hours,WT)	Cost per hour (U.S.$)	Haulage cost for 30 m lead (U.S.$ per tonne)	Remarks
C	41	20	2,000	0.03	0.025	Well made, 1 yr life assumed
D	21	20	1,000	0.04	0.032	Poor design and construction, 6 months life assumed
G	41	20	2,000	0.03	0.021	Robust design, 1 yr life assumed
E	23	20	500	0.08	0.031	Light construction and unreliable wheel, 3 months life assumed

Thus the very light cycle-wheel barrow, the most efficient machine in simple productivity terms, has no advantage in cost terms because of its short life. However, the more robust scooter-wheel design has the same order of advantage on cost basis as on productivity basis.

15.   It is clear that in a cyclical activity, such as hauling, output is dependent on the load carried each trip and if a greater load can be carried without a more than proportional loss of speed, then a higher output is obtained. One aim, therefore, of presenting the haulage data in the form of Figures 3-5 was to find whether an optimum load could be determined for the different barrow types on different gradients. In fact an optimum is not indicated by the graphs for haulage on level and falling routes, but there is a fairly clear indication that for a 4% up gradient a point of diminishing return has been reached at a weight of barrow plus load of approximately 150 kg. The corresponding net loads (payloads) being 120 kg for the Type G scooter-wheel barrow and 105 kg for the two-wheel barrows. The tabulated data confirms that two attempts to carry 120 kg in the two-wheel barrows were unsuccessful on the up gradient. Because its body could only hold a maximum of 100 kg of soil, the optimum load could not be reached with the light weight cycle-wheel barrow (Type E).

16.   To make some assessment of the effect of gradient the results have been averaged for all loads and are presented in Figure 6 to show the speed of hauling loaded and hauling empty in the cases of the barrows Type D and Type G. On down-grade the loaded speeds are similar, on level and up-grade the Type G scooter-wheel barrow shows a marked improvement, viz. 48 m/min. compared with 29 m/minute. The empty speeds are about the same, or slightly higher for the one-wheel barrow. It is interesting that the unloading time for the one-wheel barrow is consistently shorter than the two-wheel unloading time (averaging one third less), although the laborers were of the opinion that one-wheel barrows were awkward to unload in comparison with the two-wheel variety. The stop-watch shows the contrary, and the explanation is probably the unfamiliar technique called for from workers new to this type of barrow.

17.   To summarize the findings briefly, the two-wheel barrows show a small but reasonably consistent difference in performance. The superior quality Type C with ball bearings was marginally better as tested and would clearly have a longer life in service and show cost benefits over the cheaper short-lived Type D whose perfor- mance could be expected to deteriorate markedly in service. The one-wheel barrows were capable of distinctly higher outputs than the two-wheel variety, but the concept of a very light-weight barrow (Type E), although offering the maximum in output terms, does not seem practical as it demands a very high standard of manufac- turing to give a reasonable life span. The more robust Type G design appears to offer worthwhile savings in haulage costs due to its longer expected life and higher output.

V. CONCLUSIONS

18.   The design of wheelbarrows (as well as of other tools) has a significant influence on the productivity of labor. Unfortunately, not sufficient attention is given to the design and quality aspects of tools used in labor-intensive projects. The experiment in this paper has demonstrated that with improvements in design and quality of wheelbarrows at marginal additional costs, productivity rates can be increased. A single wheel, scooter tired wheelbarrow is shown to be the most efficient (and economical) type of wheelbarrow.
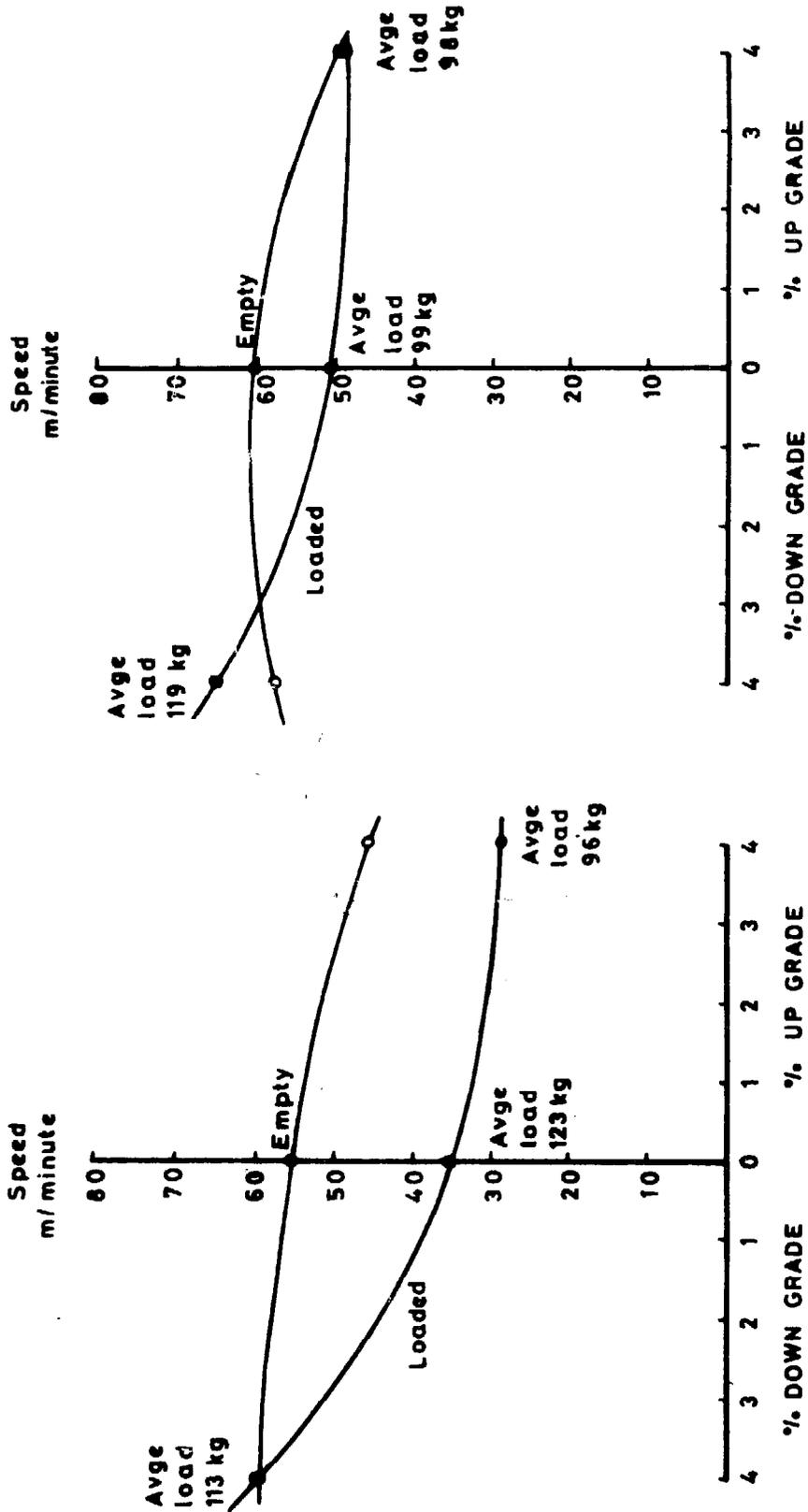
Figure 6. Speeds Loaded and Empty vs Gradient Averaged Over all Load
(30 m Haul Length and Haul Route Condition Fair)

DIMENSIONS OF A CONVENTIONAL INDIAN TWO-WHEEL BARROW

148

93

55

59

48
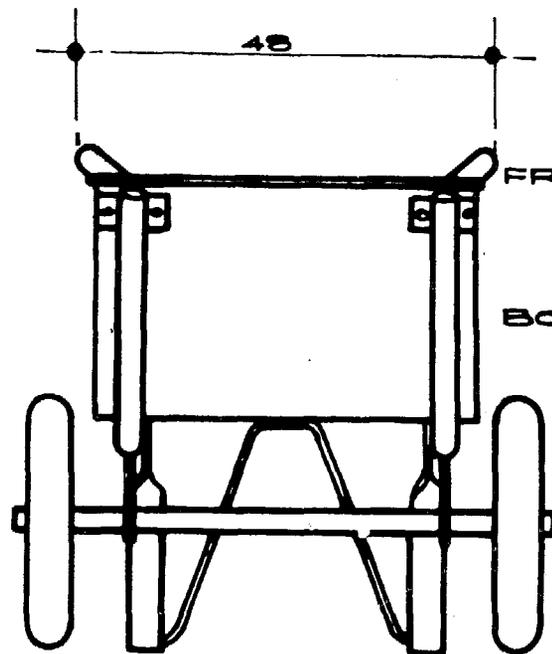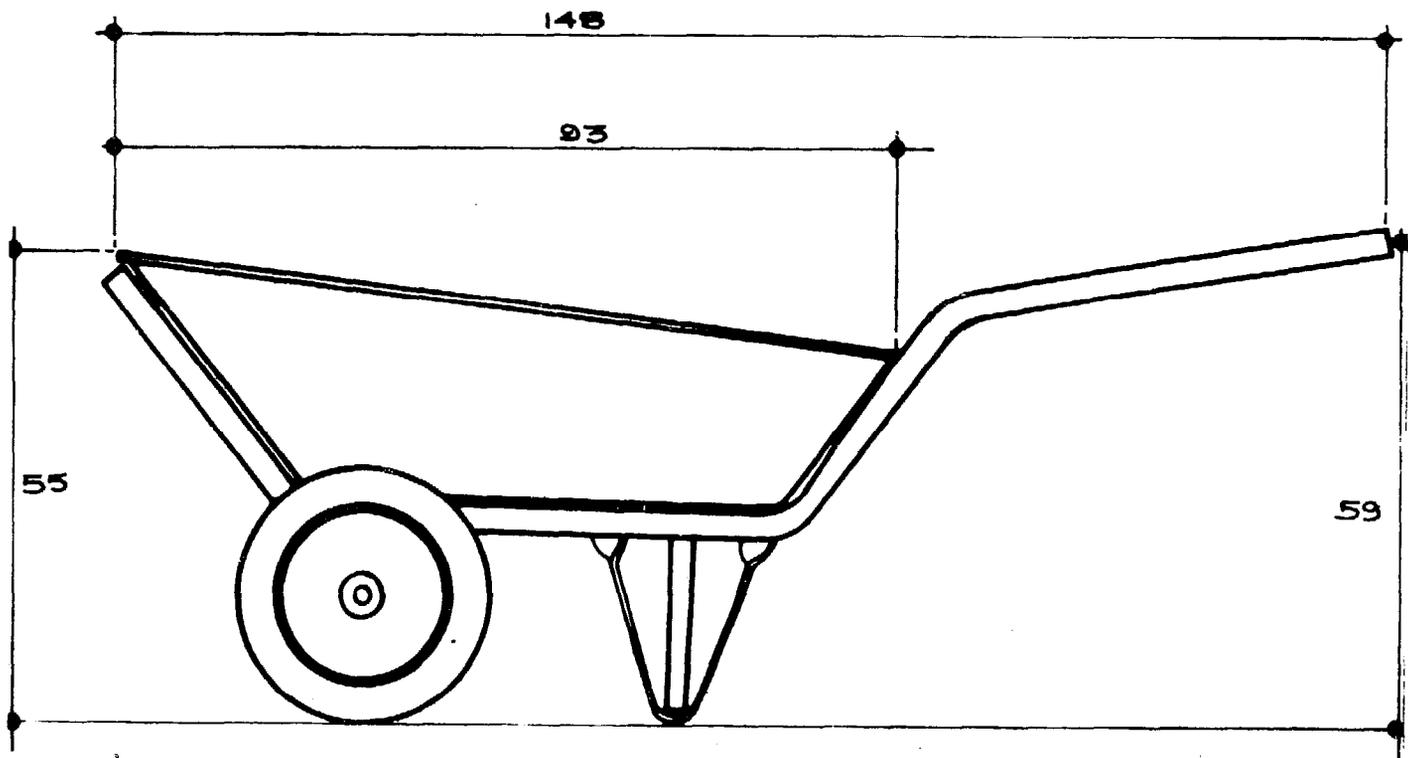
FRAME TUBES 3·2 dia x 14g.

BODY 10g steel sheet.

WHEELS 30 dia. cast iron, tyre solid rubber width 5·5 with plain bearings.

Notes. WEIGHT 45 kg. CAPACITY ·075 m³ NOMINAL.

DIMENSIONS IN CENTIMETRES.   SCALE 1·10

DETAILED DIMENSIONS OF EXPERIMENTAL LIGHTWEIGHT ONE-WHEELBARROW (TYPE E)

135

66

52

56

57

52
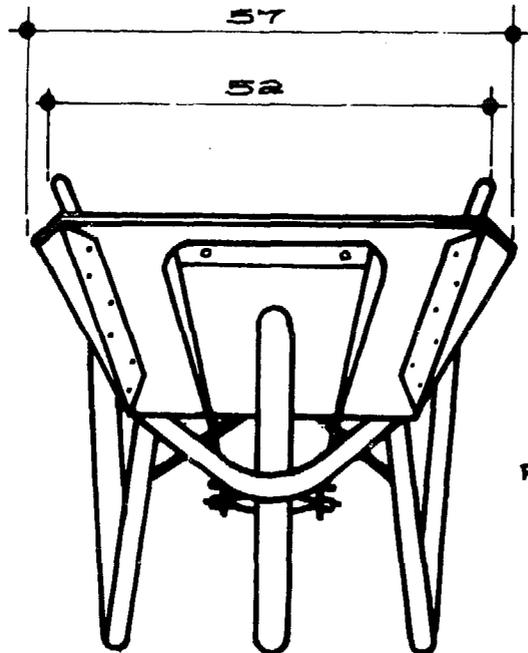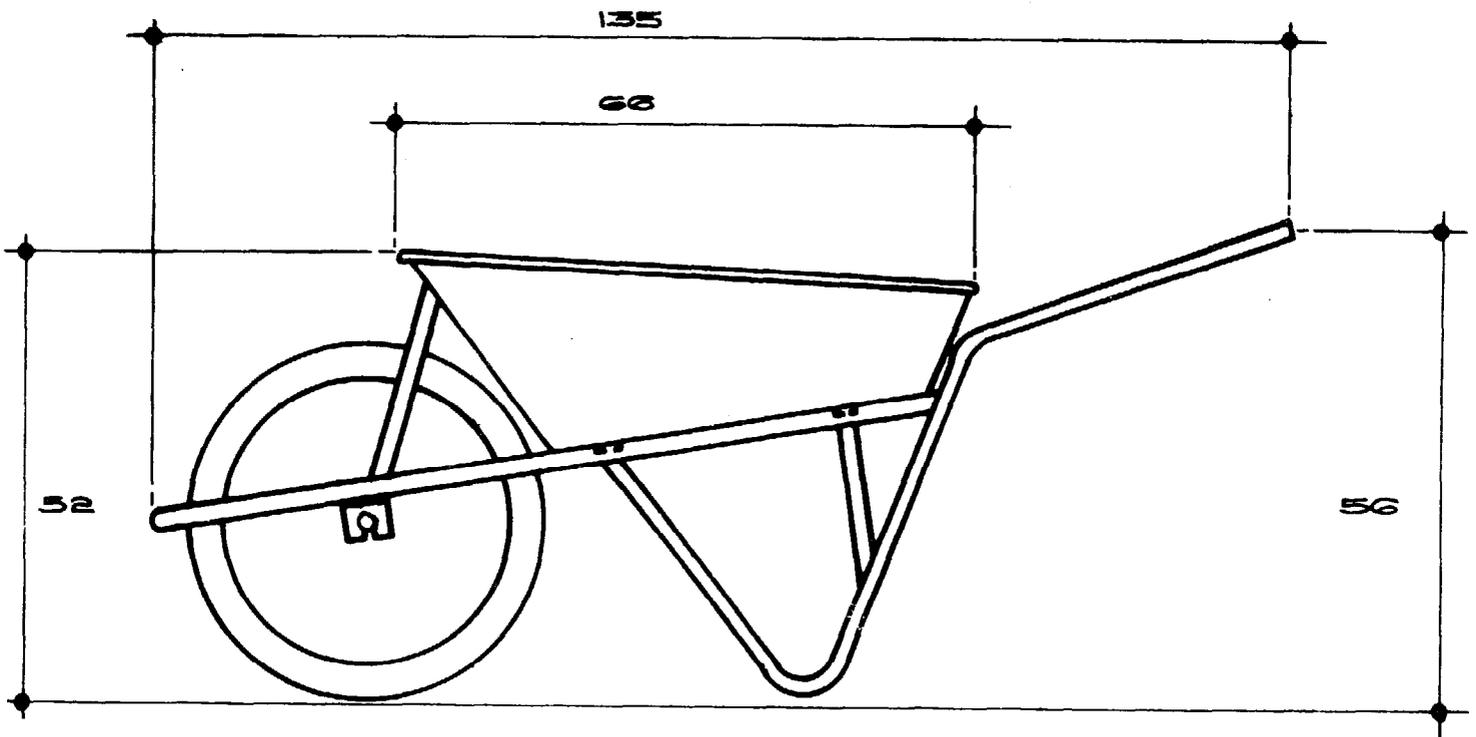
BODY 24g. galvanised sheet

FRAME TUBES 2 dia.
16g. thickness

WHEEL 40 dia, 3·5 tyre width (cycle wheel) with ball bearings

Notes. WEIGHT 10kg. CAPACITY 0·05 m³ nominal.
Dimensions in cms

SCALE 1·10

DETAILED DIMENSIONS OF ONE-WHEEL SCOOTER TIRED EXPERIMENTAL WHEELBARROW (TYPE G)

149

76

55

62

61

58

BODY 18g. steel sheet

FRAME TUBES 3.5 dia.

12g. thickness
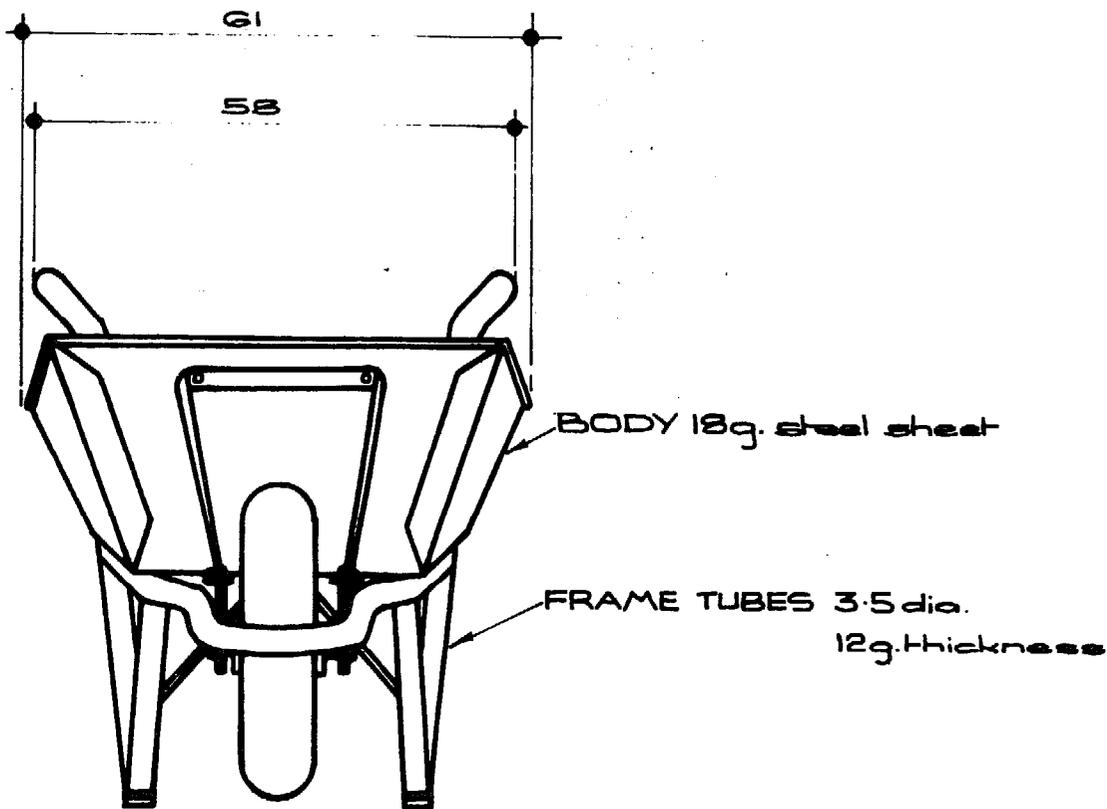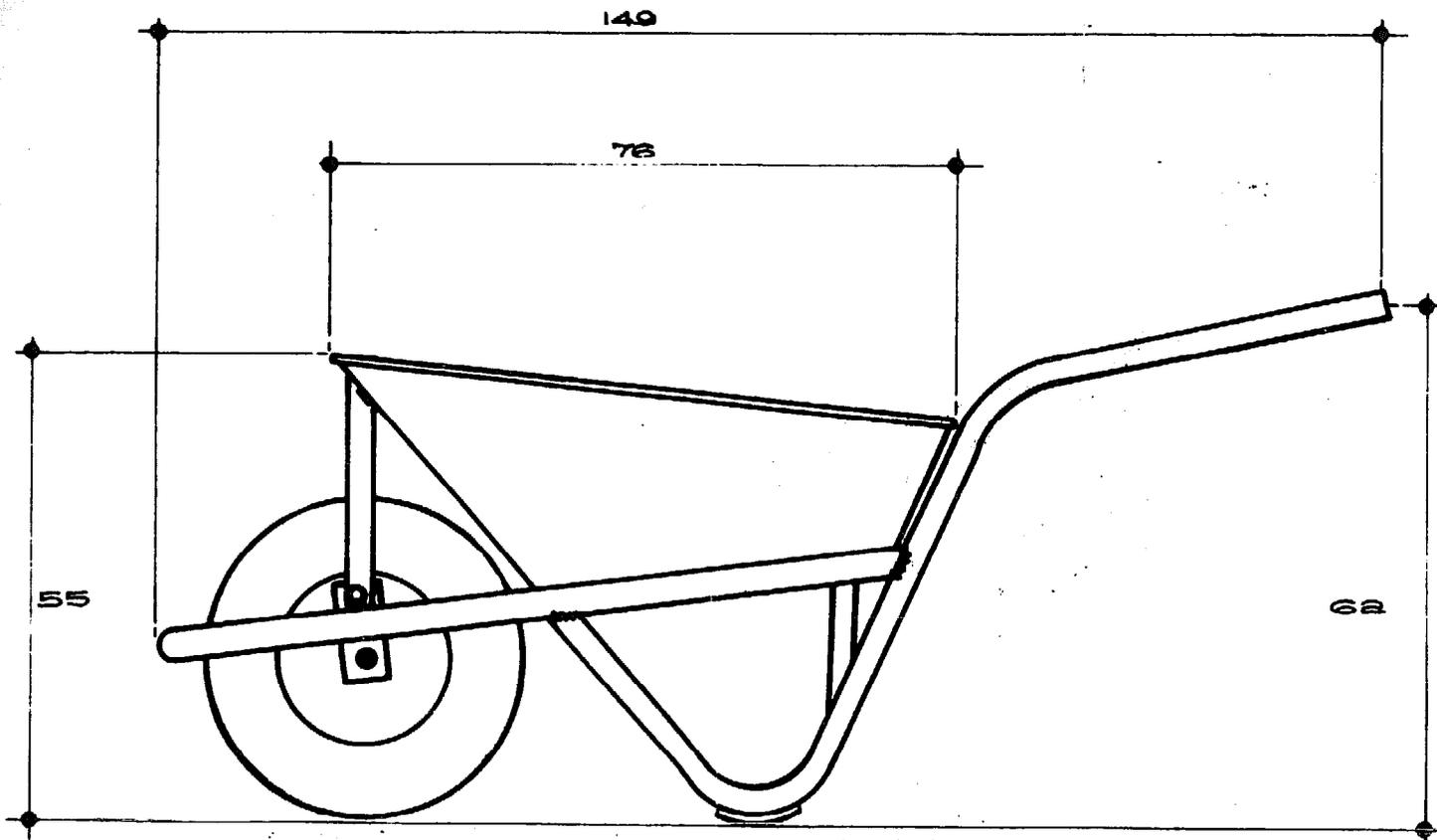
WHEEL 38 dia. 9 tyre width (scooter wheel) with ball bearings.

Dimensions in cms.

Notes. WEIGHT 30kg., CAPACITY 0.065 m³ nominal   SCALE · 1 10

WHEELBARROW EXPERIMENT - Summary of Observations
Haul Length-30m; Rise-1.2m; Haul Route Condition-Fair

DATE	BARROW TYPE	AVERAGE LOAD ** Kg.	CYCLE ELEMENT MEAN TIMES (WT)					No. OF CYCLES MEASURED	No. OF LOADERS + SHOVELS	No. OF HAULERS + BARROWS
			HAULING LOADED mins.	UNLOAD mins	HAULING EMPTY mins.	AWAIT LOADING mins.	ACTUAL LOADING mins.			
5·3·74	C	79	0·52	0·21	0·57	0·11	0·73	10	2	1
1·2·74		83	0·83	0·23	0·49	0·09	0·80	6	2	1
30·1·74		80	0·97	0·31	0·52	0·09	0·81	21	2	1
31·1·74		91	0·90	0·36	0·41	0·08	0·61	5	2	1
8·2·74		100	0·55	0·27	0·46	—	—	40	-	1
5·3·74		100	1·09	0·21	0·57	0·18	1·14	10	2	1
5·3·74		120	4·28*	0·32	0·63	0·20	1·09	8	2	1
2·2·74	D	80	0·91	0·40	0·46	—	—	21	-	2
28·1·74		85	0·92	0·42	0·56	0·22	0·66	20	2	2
8·2·74		100	0·59	0·24	0·49	—	—	40	-	-
6·3·74		100	1·89	0·26	0·66	0·17	1·08	10	2	1
2·2·74		100	1·01	0·45	0·47	—	—	50	-	2
6·3·74		119	4·33*	0·32	0·68	0·25	1·31	5	2	1
4·3·74	E	70	0·60	0·12	0·52	0·10	0·70	10	2	1
1·2·74		77	0·50	0·17	0·40	0·12	0·59	6	2	1
4·2·74		79	0·55	0·35	0·51	0·15	0·71	15	2	1
5·2·74		80	0·58	0·23	0·54	—	—	50	-	1
4·3·74		80	0·62	0·13	0·54	0·11	0·79	10	2	1
4·3·74		90	0·65	0·16	0·60	0·14	0·72	13	2	1
6·2·74		100	0·64	0·21	0·61	—	—	40	-	2
5·3·74	G	79	0·57	0·19	0·48	0·08	0·72	10	2	1
13·2·74		92	0·59	0·20	0·49	0·44	0·87	20	2	2
6·2·74		100	0·74	0·34	0·61	—	—	40	-	2
8·2·74		100	0·54	0·21	0·48	—	—	40	-	1
6·3·74		117	0·57	0·28	0·53	0·14	1·19	10	2	1

* These loads too great for continuous operation
** The soil density is 1.65 tonne per cubic meter

WHEELBARROW EXPERIMENT – Summary of Observations

Haul Length-30m; Level; Haul Route Condition – Fair

DATE	BARROW TYPE	AVERAGE LOAD Kg.*	CYCLE ELEMENT MEAN TIMES (WT)					No. OF CYCLES MEASURED	No. OF LOADERS SHOVELS	No. OF HAULERS BARROWS
			HAULING LOADED mins	UNLOAD mins	HAULING EMPTY mins	AWAIT LOADING mins	ACTUAL LOADING mins			
28·2·74	C	64	0·59	0·23	0·52	0·13	0·57	17	2	1
25·2·74		81	0·62	0·24	0·49	0·11	0·73	10	2	1
19·2·74		100	0·59	0·27	0·52	0·14	1·10	12	2	1
22·2·74		120	0·54	0·26	0·60	0·15	1·12	12	2	1
2 3·74		142	0·76	0·35	0·58	0·16	1·43	12	2	1
23·2·74	D	82	0·89	0·26	0·53	0·15	0·75	10	2	1
20·2·74		100	0·84	0·33	0·54	0·11	1·11	12	2	1
2·3·74		115	0·80	0·30	0·53	0·18	1·42	10	2	1
27·2·74		152	0·94	0·32	0·55	0·21	1·47	16	2	1
4·3·74		152	0·76	0·33	0·58	0·13	1·61	10	2	1
1·3·74	E	80	0·49	0·11	0·47	0·09	0·71	21	2	1
18·2·74		90	0·38	0·22	0·48	—	1·09	7	2	2
2·3·74		92	0·53	0·14	0·54	0·13	0·70	12	2	1
26·2·74		98	0·58	0·18	0·54	0·18	0·08	10	2	1
28·2·74	G	63	0·55	0·15	0·44	0·09	0·56	20	2	1
25·2·74		78	0·51	0·16	0·47	0·08	0·56	12	2	1
16·2·74		90	0·69	0·29	0·51	—	1·48	11	2	1
2·3·74		90	0·51	0·23	0·47	0·10	0·72	10	2	1
19·2·74		100	0·60	0·22	0·53	0·12	0·98	12	2	1
26·2·74		109	0·63	0·24	0·47	0·17	0·97	8	2	1
16·2·74		150	0·67	0·33	0·56	—	1·27	21	2	1

*The soil density is 1.65 tonne per cubic meter

WHEELBARROW EXPERIMENT - Summary of Observations

Haul Length-30m; Fall-1.2m; Haul Route Condition - Fair

DATE	BARROW TYPE	AVERAGE LOAD * Kg.	CYCLE ELEMENT MEAN TIMES (WT)					No. OF CYCLES MEASURED	No. OF LOADERS + SHOVELS	No. OF HAULERS + BARROWS
			HAULING LOADED mins.	UNLOAD mins.	HAULING EMPTY mins.	AWAIT LOADING mins.	ACTUAL LOADING mins.			
5-3-74	C	79	0·52	0·21	0·57	0·14	0·77	10	2	1
7-2-74		100	0·47	0·42	0·62	—	—	40	2	1
5-3-74		119	0·54	0·22	0·65	0·20	1·12	10	2	1
29-1-74		157	0·65	0·55	0·71	0·11	1·36	20	2	1
2-2-74	D	100	0·43	0·58	0·72	—	—	50	—	2
7-2-74		100	0·60	0·39	0·66	—	—	40	—	1
4-2-74		120	0·53	0·44	0·56	—	—	50	—	2
23-1-74		150	0·42	0·34	0·58	0·46	1·14	20	2	2
4-3-74	E	80	0·47	0·12	0·57	0·09	0·76	12	2	1
4-3-74		91	0·51	0·16	0·56	0·12	0·70	10	2	1
1-2-74		93	0·36	0·24	0·47	0·14	0·78	10	2	1
25-1-74		95	0·58	0·36	0·67	0·23	0·72	25	2	2
31-1-74		100	0·46	0·53	0·66	0·12	0·72	7	2	1
5-2-74		100	0·47	0·23	0·51	—	—	50	—	1
7-2-74	G	100	0·47	0·34	0·63	—	—	46	—	1
12-2-74		128	0·43	0·26	0·61	0·37	1·04	25	2	2
14-2-74		143	0·48	0·24	0·57	0·09	0·92	25	2	1

* The soil density is 1.65 tonne per cubic meter

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Washington, D.C. 20433,
United States of America

Technical Memoranda published in this series to date are as follows:

Number	Title	Dates	Revisions
1	Comparison of Alternative Design Wheelbarrows for Haulage in Civil Construction Tasks	Jan'75	
2	Increasing Output of Manual Excavation by Work Reorganisation An example of Passing Place Construction on a Mountain Road	Jan'75	
3	Comparison of Different Modes of Haulage in Earthworks	Jan'75	Completely revised and re-issued June 1975
4	Effect of Health and Nutrition Status of Road Construction Workers in Northern India on Productivity	Jan'75	
5	Comparison of Hand Laid and Machine Laid Road Surface	Feb'75	
6	Haulage with life of Materials Lifting Sand by Ropeway	Feb'75	
7	Productivity Rates of Earthmoving Machines	May'75	Supplement issued August '75
8	Collection of Productivity Data from Civil Construction Projects	July'75	
9	Report of First Road Demonstration Project	August'75	
10	A System of Deriving Rental Charges for Construction Equipment	August'75	
11	A Literature Review of the Ergonomics of Labor-Intensive Civil Construction	August'75	

Number	Title	Dates	Revisions
12	Haulage by Headbaskets, Shoulder Yokes and other Manual Load Carrying Methods	October '75	
13	The Use of Wheelbarrows in Civil Construction	October '75	
14	Hardware Research Summary	October '75	
15	The Planning and Control of Production, Productivity and Costs in Civil Construction Projects	October '75	
16	Level Cranes	October '75	
17	Compaction	December '75	
18	Spreading Activities in Civil Construction	December '75	