Chapter B-5

Performance of JCB and tipper combination

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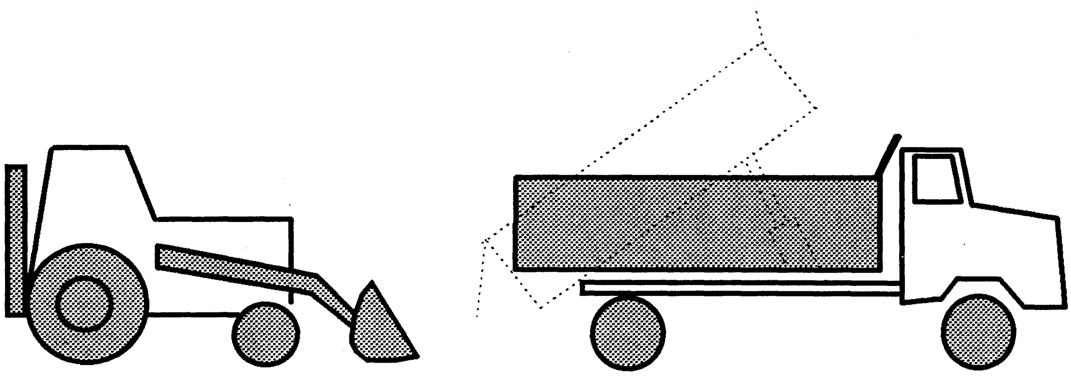
B-5.1 INTRODUCTION

In Ahmedabad, a variety of types of vehicles are used to collect solid waste from different situations. JCB payloaders (as shown in sketch form in figure B-5.1) are used to remove wastes from open storage points. They load the wastes into open tipper trucks, which transport the wastes to the disposal site, and unload in a short time because of their tipping bodies.

A time and motion study (or work study) was carried out for this system, operating in the South Zone of Ahmedabad in 1994. The purpose of this study was to evaluate the efficiency of the system and level of utilisation of the vehicles and manpower, and to look for ways of improving the efficiency. This study is different from the studies in other chapters in that it concerns a group of vehicles of two different types working together. Costs were not calculated in this case, but the data presented here would be useful in estimating the costs of the present system and the impact on the costs of suggested improvements.

Ahmedabad Municipal Corporation owned five JCB payloaders, out of which three were in daily use, operating three shifts per day. The timings of the shifts were 7 am to 3 pm, 2 pm to 10 pm, and 9 pm to 5 am. Each payloader worked with four tipper trucks. Drivers reported to the vehicle workshop, and drove their vehicles to the zonal office where a cleaner or assistant was allocated to each vehicle.



a) JCB payloader *b) Tipper truck*

Figure B-5.1 Conceptual illustration of payloader and tipper

Payloaders are usually used for removing wastes from transfer stations and big vats (enclosures), and for clearing up backlogs of large quantities of waste, because they are most suited to removing large quantities from one place in a short time. (Such large open dumps of waste are not to be encouraged from a sanitation or aesthetic point of view, because wind, animals and rag-pickers scatter the waste, and the piles encourage rat and fly breeding.) If the system is to work efficiently, the number of trucks must be carefully matched to the quantity of waste and the time needed to take the waste to the disposal site, unload and return. Both payloaders and tippers need a higher level of maintenance than simple open trucks.

B-5.2 TIME AND MOTION STUDY OBSERVATIONS

The operation of the vehicles was followed for one shift, the times loading, travelling and unloading were noted, the distance travelled by the payloader was measured, and the loads were estimated or measured. The data collected are shown in tables B-5.1 and B-5.2.

Table B-5.1 Time and motion study of JCB Payloader

JCB Payloader No. 1792 72 HP Bucket capacity $1 m^3$ Loading height 3.33 m
1st shift - 7 am to 3 pm. Diesel issued 38.8 litres

Time	Distance meter [km]	Location / station	Tipper reg. No.	Loading time [min]	Approx. load [tons]	Notes / remarks
7.35	1118	Garage	9000 6530 6538 6546			Start from the garage
7.45	1119	South zone office	9000 6530 6538 6546			Provide cleaner to payloader and one S.S.I. No written allotment of area was given. It took only 5 minutes
7.55	1120	Chowpatti	6546 6530 6538 9000	1	0.5	
8.00	1121	Zoo garden	6546 6530 6538 9000	6 6 7 9	0.5 1.5 1.0 1.0	Attended after 3 days. Garden refuse only. All refuse vehicles left for disposal site with loads of 1 to 1.5 tons.
			6530 6546 9000	6 6 6	1 1 0.5 - 0.8	Buckets were not full. After this JCB operator had a tea break as there were no trucks.
10.10	1122	open air	6530	4	2	Refuse
10.25	1123	Macchi Pire	6546 9000	5	1.5	Tipper 9000 reported at 10.30 but there was no garbage.
10.40	1124	Bhalikia	9000	7	2	Bucket not full
11.00	1127	Uttamnagar	6530	7	3	6530 reported at 11.08, i.e. 8 minutes after payloader. 8899 reported instead of 6538, which went to carry debris. There was a good vat, but there was no waste inside it.
11.27	1128	Basant-nagar	8899	7	1.5	Dry leaves. This point had not been attended for 7 days
11.37	1128	Millatnagar 1st point	6546 9000	5	1.25	6545 arrived 8 minutes after JCB. 6545 left for garage because of brake failure
		Millatnagar 2nd point	9000	6	2.5	Rubbish and refuse
12.00	1138	Pragati-nagar	9000 6530	5 9	1.5 3.5	Refuse 6530 was taken to the municipal weighbridge at 1.45 pm. Weight of load 3035 kg.

Notes: Loads were estimated from experience.

Total estimated load	26 tons
Time taken	4 hr 25 min.
Number of trips	15
Average load per trip	1.7 tons

Table B-5.2 Time and motion study of tipper 6530

Conventional tipper Registration number 6530 110 HP Wheelbase 4470 mm
Cargo body capacity 6.4 m3 Loading height 1817 mm
Gross vehicle weight [GVW] 15244 kg Tare weight 6945 kg Payload capacity 8299 kg

Vehicle out from garage 7.35 am Issue of diesel fuel is typically 45 litres
Reporting to South Zone office 7.45 am
Departure from South Zone office 7.50 am

Trip	Location	Loading point		Disposal site		Load	Payload
no.		Arrival	Departure	Arrival	Departure	carried [kg]	utilised [%]
1	Chowpatti	7.55	7.57	There was no solid waste			
1	Zoo garden	8.00	8.12	8.37	8.47	1500	18
2	Zoo garden	9.12	9.18	9.41	9.51	1000	12
3	Open air	10.13	10.17	10.38	10.48	2000	24
4	Uttamnagar	11.08	11.20	11.38	11.48	3000	36
5	Pragatinagar	12.06	12.15	1.05	1.10	3035 *	37

Notes: * This load was measured on a weighbridge. The other loads were estimated. [The load for trip no. 5 was estimated to be 3.5 tons.]
The average payload utilisation capacity was 25.3%

At some loading points there was little or no waste, so time was wasted travelling to that site, often by several vehicles. The trucks were generally not full when they went to the disposal site, so the cost per ton was increased since the time and fuel for a trip were spent on a relatively small quantity of waste. The trucks were designed to carry a weight of over eight tons, but the average of the actual loads was less than two tons, and only 25% of the load carrying capacity of truck 6530 was used during the shift that was studied.

The average loading time of the payloader was observed to be about one minute per cycle - a cycle includes loading the bucket, moving between the waste and the tipper, and discharging the bucket.

B-5.3 ANALYSIS OF RESULTS

The working time can be divided into categories:

◊ Actual productive time - This is the time when the person or equipment is operating and achieving the desired purpose - in this case moving waste.

◊ Productive idle time is the time spent unavoidably and necessarily, but without working towards achieving the desired objective. For example, when the payloader is loading a truck, the truck is waiting, and as far as the truck is concerned this is productive idle time. Another example is the time spent reporting to the zonal office.

◊ Non-productive idle time is time lost to tea breaks, because of lateness etc.

Table B-5.3 is used to calculate the time utilisation of the payloader. It shows that not all of the required data were collected; as a result some values were estimated. This example illustrates the need to practice collecting work study (or time and motion) data, since it is sometimes difficult to know in advance what data will be needed and how they can be measured, so it is generally advisable to regard the first observation as a trial and aim to start using the data collected on the second observation. It is seen from the table that the actual loading time is 21% of the total shift, that waiting time is estimated to be 36% and that non-productive idle time, according to the guessed values, was 26% of the official shift time, because of a delayed start and an early return. If more trucks were available, or if the trucks were able to carry more, the productive idle time (waiting) could have been reduced.

Table B-5.3 Time utilisation of payloader

(Based on data in table B-5.1. Time intervals in minutes)

Time			Activity / location	Actual productive time	Productive idle time		Non-productive idle time
Start	Finish	Interval			Travel	Waiting	
7.00	7.35	35	Delay in starting shift				35
7.35	7.45	10	Travel to Zone Office		10		
7.45	7.50	5	Office administration			5	
7.50	7.55	5	Travel to Chowpatti		5		
7.55	8.00	5	At Chowpatti *	1	4		
8.00	10.10	130	At zoo garden	46	4	80	
10.10	10.25	15	Open air	4	4	7	
10.25	10.40	15	At Macchi Pire	5	4	6	
10.40	11.00	20	At Bhalikia	7	12	1	
11.00	11.27	27	At Uttamnagar	7	4	16	
11.27	11.37	10	At Basantnagar	7		3	
11.37	12.00	23	At Millatnagar I and II	11	12		
12.00	15.00	180	At Pragatinagar, and returning to garage	14	20 **	56	90 **
			TOTALS	**102**	**79**	**174**	**125**
			PERCENTAGES	**21**	**17**	**36**	**26**

Notes * Unless otherwise recorded, the travelling time is estimated as 4 minutes for 1 km (that is, a speed of 15 km/h)

** Insufficient data were collected, so these values are guesstimates.

Table B-5.4 Time utilisation of tipper 6530

(Data taken from table B-5.2. All times are in minutes)

Trip	Location / activity	Productive idle time		Actual productive time - travel and unloading			Non-productive
No.		loading	other	to disposal	unloading	returning	idle time
	Delay in start						35
	Garage to Chowpatti		20				
1	Chowpatti		5				
1	Zoo garden	6	6	25	10	25	
2	Zoo garden	6		23	10	22	
3	Open air	4		21	10	20	
4	Uttamnagar	7	5	18	10	18	
5	Pragatinagar	9		20 (1)	5	20 (2)	
	Weighing, returning		80 (3)				40
	TOTALS	**32**	**116**	**107**	**45**	**105**	**75**
	PERCENTAGES	**7**	**24**	**22**	**9**	**22**	**16**

Notes: (1) 50 minutes elapsed between leaving Pragatinagar and arriving at the disposal site. It is assumed that this time was taken to go to the weighbridge and weigh the full vehicle

(2) It is assumed that 50 minutes were needed to weigh the empty vehicle and return to the collecting area, and that, as before 20 minutes were for the usual journey to the disposal site and 30 minutes for weighing.

(3) This time interval comprises two periods of 30 minutes for weighing and 20 minutes for returning to the garage via the zone office

The results for the tipper truck show that 53% of the shift was actual productive time (travelling and unloading), and this could have been higher if the truck had not been weighed, or could have been weighed at a more convenient location. These results depend on assumptions to cover missing data. The non-productive idle time is less than for the payloader, probably because of the extra requirement to weigh the truck on this occasion, which prevented the driver from returning to the garage at the normal time.

B-5.4 DISCUSSION

It must be remembered that people usually work differently when they are being observed, and that taking one of the trucks for weighing may have disrupted the normal working pattern.

As is usually the case with open trucks, the load that could be carried was restricted by the volume of the body (6.4 m^3), not the load that the chassis could carry (8299 kg). The key factor is the density of the waste. Some of the waste mentioned in table B-5.1 probably had a very low density (perhaps 75 kg/m^3 - especially the dry leaves, and probably the garden waste). On the other hand, some of the domestic waste that was collected may have been wet and partially decomposed, with a density of 600 kg/m^3 - eight times as much.

The following calculations illustrate the effect of volume utilisation and body size, and point the way to a possible improvement in the system.

Present body volume		6.4 m^3
Weight of full load if density is 500 kg/m^3	= 64 x 500 =	3200 kg
Average load (table B-5.1)		1730 kg
Average current body utilisation	= 1730 / 3200 =	54%

If the utilisation rate of the existing trucks could be increased, it might be possible to operate with three tippers to every payloader, instead of the current four. Having a smaller number of tippers in the team might result in longer waiting times for the payloader - for example if three trucks are quickly filled and despatched to the disposal site, there would be a longer interval between the filling of the third and the return of the first than if there were four trucks. However, counteracting this effect, it would take slightly longer to load the same waste into fewer trucks because more care should be taken to fill all of the body, rather than just dumping a few bucket loads into the middle of the truck. Utilising the capacity of the trucks more fully would also mean that a tipper that was not quite full would need to go with the payloader to the next site in order to be completely filled - not a problem if the distance were small, but a significant delay over a longer distance because of the slow speed of the payloader.

A further increase in the utilisation of the payload capacity of the tippers could be achieved if the body size were doubled to 12.8 m^3, as the following calculation shows

Payload capacity of existing vehicle		8299 kg
Average load (table B-5.1)		1730 kg
Current payload utilisation	1730 / 8299 =	21%
If body volume 12.8 m^3 and refuse density 500 kg/ m^3, maximum payload would be	12.8 x 500 =	6400 kg
New payload utilisation would be	6400 / 8299 =	77%

The body volume could be doubled by raising the sides by 600 mm. The loading height would then be (1817 + 600 =) 2417 mm, which is still comfortably less than the height to which the payloader is able to load - 3330 mm. Raising the sides might add one ton to the weight of the body, but the weight of the refuse and the extensions to the sides would add up to only 7400 kg, which is less than the payload of 8299 kg for which the chassis and tipping mechanism are designed.

If the sides are raised, it is important to modify the tailgate so that it does not trap the waste when the body is being tipped, as shown in figure B-5.2. The hinge should be fixed at the highest point of the body, above the height of the top if the waste.

If the capacity of the tippers is increased in this way, two trucks can have the carrying capacity of four, so it may be possible to reduce the number of tippers working with a payloader from four to two, or otherwise it might be possible to greatly increase the productivity of one payloader, if the trucks it loads can carry much more at one time.

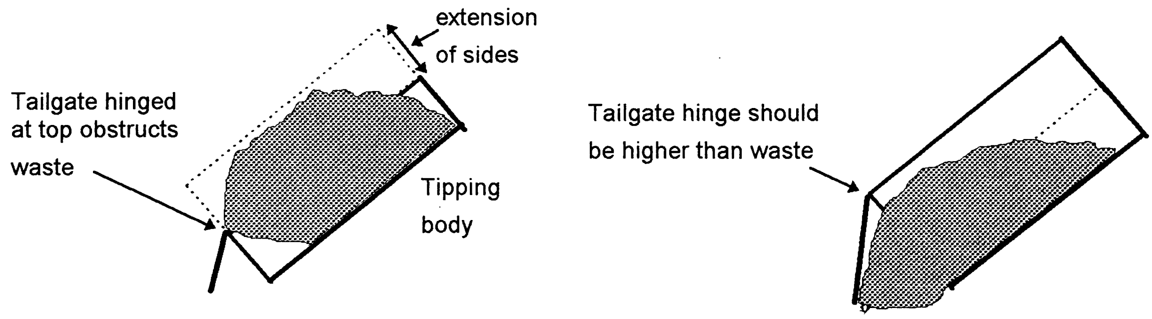


Figure B-5.2 Obstruction to unloading caused by top-hinged tailgate

At some storage points, the accumulated amount of waste was very small. (For example, the record in table B-5.1 shows that, before this study, one point had not been attended for seven days, and another for three days.) It is not economical for the payloader to go to a collection point where there is very little waste, so either money is wasted in sending the payloader to move a small quantity of waste, or the collection point is not visited for some time until a larger amount of waste has accumulated. If the waste is dry or inert, such a delay may be acceptable, though it may have unacceptable aesthetic or nuisance effects. On the other hand, if the waste contains wet or biodegradable material, there may be serious odour problems and a high degree of fly breeding if the waste is left for several days. A better solution for such places would be to use another storage and transport system, such as a hook lift container or something smaller, according to the volumes of waste generated. Payloaders should only be used where the rate of waste production is very large.

Although it may be possible to design a theoretical model for such a system to ensure high actual productive times for both payloader and tipper, in practice is it very difficult because of the daily variations in the volumes of waste at the different collection points.. Ideally the payloader should just have finished loading the last of the trucks on their first trip (for example) when the first of the tippers returns for loading for its second trip. In practice, either the payloader must wait for the tippers or some of the tippers must wait their turn while others are being loaded. However a good supervisor can achieve a satisfactory level of performance, particularly if he is able to direct the trucks to the next rendezvous with the payloader, as they travel back from the disposal site. The best way of doing this is to have two-way radio communication with the tipper drivers. In a situation where the drivers do as many trips as they can in a day, such a system could pay for itself (in terms of reduced operating costs) in a short time, but if the drivers do only a fixed number of trips in a shift (because of labour union agreements, for example) then the investment in two-way radios may not be worthwhile. A compromise arrangement might be for the supervisor to have a mobile phone with which he could relay instructions to the drivers via the gatekeeper at the disposal site. In many parts of the world, all refuse collection trucks are fitted with either radios or mobile phones in order to maximise utilisation and efficiency, and minimise the effects of breakdowns and unusual surges in waste quantities.

The unit costs for this system are likely to be comparatively low, because large quantities of wastes can be handled quickly and the labour requirement is low. To operate efficiently, this system requires large quantities of waste to be collected at a small number of sites, and this can lead to waste being left to accumulate for a few days, causing a number of sanitary and environmental problems. Such a system requires that waste be collected from a relatively large population, and this normally means bringing the waste a long distance - too far for householders to bring themselves, but reasonable if a tricycle or handcart primary collection service is provided. This method falls between the situation when a hook-lift container system is appropriate, (for which the accumulated volumes of waste are smaller), and the transfer station concept described in chapter A-3, which would be best suited to larger daily quantities.

The bucket of a payloader cannot be expected to pick up all the waste and leave the site clean. It is easy for the bucket to damage masonry walls if the operator tries to clean into the corners. A sweeper should always work in conjunction with a payloader in order to ensure that all the waste is removed each time, and that the collection point is left in a clean and orderly condition.