Chapter A-1

Primary collection equipment

A-1.1 INTRODUCTION

This chapter is about brooms, handcarts and containers. These items are so simple and commonplace that an engineer or manager might consider it a waste of his or her precious time to bother with such details. Fortunately, municipal engineers in some of India's largest cities have realised the importance of these items. Their importance stems from the large numbers of people that are using this type of equipment, and the great difference it can make to a task to have tools that are appropriate and efficient. A small increase in efficiency, leading to a small financial saving, can be very significant if multiplied by the number of sweepers employed in a large city (which may be several thousands). For example, in 1993 Mumbai had nearly four thousand sweepers' beats (each with two sweepers) and spent Rs 3 crores (approximately $1 million) on primary collection tools. The total length of all the streets in Mumbai requiring sweeping was estimated to be 1525 km. Mumbai uses 25 tons of brooms each year.

Handcarts (or wheelbarrows) are an indispensable tool for street sweeping and waste collection in most countries of the world, yet often their design is very inadequate. A new design of cart was introduced into Ahmedabad in the 1980s in an attempt to improve the efficiency of primary collection operations. The success of this new design is assessed.

It is much more expensive to sweep up ten kilograms of waste that has been scattered on a street than to pick up a container into which ten kilograms of waste have been placed by residents. In an effort to improve the efficiency of primary collection operations, Ahmedabad Municipal Corporation developed a system that used small community containers, at very convenient locations, so that residents could place their waste directly into these bins rather than walking a long distance to a large container, or depositing their waste on the street. This new system had a number of interesting innovations and implementation techniques, and these are discussed in the last section of this chapter.

A-1.2 SWEEPERS' TOOLS IN MUMBAI

with S A Bargir

a) Brooms

There are two types of brooms - bunch brooms and stock brooms. They are sketched in figure A-1.1.

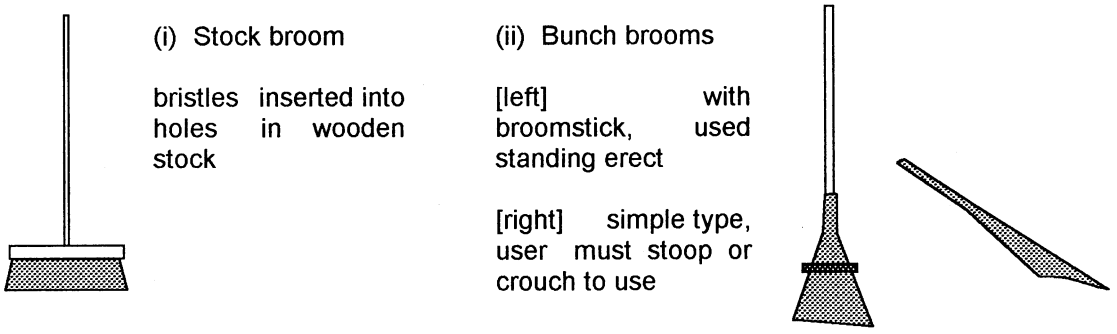


Figure A-1.1 Types of handbrooms

The advantages and disadvantages of these types of brooms are listed in table A-1.1

Table A-1.1 Advantages and disadvantages of different types of brooms

Advantages	Disadvantages
Stock broom	
◊ Can be made wide so that it can sweep a large area in one stroke;	♦ Wide brooms are heavy and so tiring to use;
◊ If bristles are stiff they are good for dislodging material that is adhering to the road surface;	♦ Wide brooms should be reinforced with diagonal stays to prevent the connection between the stock and the stick being broken.
Bunch broom with broomstick	
◊ Cheap and easy to repair	♦ Only a small area is swept with each stroke.
Simple bunch broom	
◊ Very cheap	♦ The user must bend down or crouch so that his/her face is nearer to the ground and the dust that is stirred up by the sweeping.
◊ Can be used to flick light litter on sandy surfaces without collecting all the sand	

In Mumbai the bunch broom with a broomstick was in widespread use. A modification was proposed to enable sweepers to loosen hard materials that were adhering to the road surface - a blade made of steel plate was attached to the top of the broomstick as shown in figure A-1.2; the broom could be inverted to use the blade.

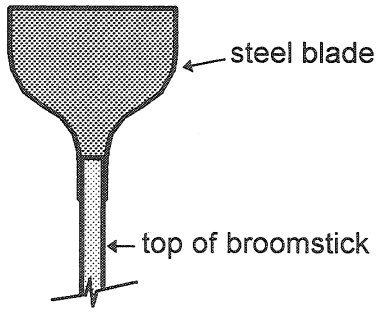


Figure A-1.2 Scraper blade on broom

Though the blade was useful in dislodging adhering deposits, it was not popular with the sweeping staff because the blade was at head height when the broom was being used normally for sweeping, and the blade was sharp - and therefore dangerous - and dirty.

The simple, short bunch broom was in widespread use in many Indian cities, but not Mumbai. Because the user must bend down to use it, back pain may result from prolonged use. The sweeper is also closer to the dust that is being stirred up and so may be more at risk from Tuberculosis and other respiratory infections than a sweeper who has an erect posture. It also appears degrading - and perhaps dangerous - to be stooping or crouching in a crowded street. See figure A-1.3

Figure A-1.3 Sweeper using simple bunch broom - note her stooped position

b) Sweepers' bins

In Mumbai sweepers were working in pairs - one would sweep and the other would load the sweepings into baskets or bins (known locally as *handbarrows*) to carry them to the nearest container or storage point. Until 1991 these baskets were made of cane, brought from Assam, but disturbances in that State prevented the continued supply of cane for these baskets. An alternative was sought. Bamboo seemed to be a suitable alternative, and the cost of bamboo baskets was found to be considerably less that the cost of the cane baskets - Rs 30 for a bamboo basket as compared with Rs 200 for a cane basket. Was the crisis in cane supply a blessing in disguise, introducing the cheaper alternative of bamboo? This question is answered in table A-1.3.

Municipal engineers looked at other alternatives. (it is always good to review as wide a range of options as possible before coming to a decision.) One possibility was the use of fibre-reinforced plastic (also known as fibreglass). Such bins could easily be made locally, to any convenient size and shape. They can also be repaired without special equipment. Moulded plastic was also seen as an option, but since polymers such as polyethylene have value as secondary materials in the recycling industry, it was decided that non-recyclable materials should be used to reduce the risk of theft. Fibre-reinforced plastic bins were costed at Rs 650 each. Were they a reasonable alternative? Table A-1.3 provides the answer.

Some basic information about these three types is given in table A-1.2.

Table A-1.2 General description of alternative containers for sweepers

	Cane basket	Bamboo basket	FRP bin
Plan cross section shape	circular	circular	square
Top dimension (diameter or side) mm	440	450	450
Bottom dimension mm	380	350	300
Height mm	360	350	500
Weight kg	4	1.5	4
Capacity litres	50	50	70
Unit cost Rs	200	30	650

Table A-1.3 Cost comparison for alternative containers for sweepers

The cost for the whole of Mumbai for one year's operation is estimated.
There were 3766 beats in Mumbai, and since each beat required two containers, the total number required is in the region of 7600.

	Cane basket	Bamboo basket	FRP bin
Average useful life L days	30	7	270
Number required for one year = 365/L x 7600	92,500	3,96,300	10,300
Total cost Crores of Rs	1.85	1.19	0.67
Annual saving over cane baskets Rs	-	66,00,000	1,18,00,000
Savings as percent	-	36%	64%

If the savings are accurately estimated in table A-1.3, there is clear evidence of the value of investigating even simple items. The item with the highest unit cost appears to be very significantly cheaper for the city. The savings are many times the annual salaries of the engineers required to collect the data so it is financially worthwhile for engineers to spend their time on such matters. It is necessary to check the accuracy of the data - particularly the actual useful service lives. A factor that has not been considered in this simple analysis is the cost of administration and logistics of the

provision of the bamboo baskets - organising the supply, storage and distribution of these short-lived items would add to the expense and inconvenience of using this type of container.

More recently moulded plastic bins have replaced the FRP type. They are made from LLDP (Linear low-density polyethylene), were lasting up to two months longer than the FRP bins, and cost a little less (Rs 542 each). The problem of losing the bins to recycling was tackled by requiring that sweepers who wished to have a new bin should "trade in" the old bin.

Figure A-1.4 shows some of these alternatives.

Figure A-1.4 Containers used by sweepers (On the right is a bamboo basket; next to it is a damaged FRP bin, and next to that is a new design of plastic bin.)

In addition to a broom, two containers and a handcart, each pair was provided with two squares of plastic (polypropylene) sheet 200mm x 200mm, for picking up light waste that had been swept into a pile. These sheets were not often employed; most sweepers seemed to use pieces of plywood or card - perhaps the plastic squares were recycled or used for another purpose in the home.

Mechanical sweepers on truck chassis were tried in 1980. They drew fierce opposition from the labour unions who saw them as a threat to jobs, and it was difficult to get the spare parts from abroad. It is certainly advantageous for the nation if more jobs can be provided by employing manual sweepers, rather than cutting the workforce with mechanical sweepers, provided that the cost of the manual method does not become excessive.

In conclusion, the advice of an engineer involved in the provision of equipment for street sweepers is:

- ◊ Keep the systems and tools simple;
- ◊ Use materials and tools that are available locally and without interruption;
- ◊ Train and motivate the staff to use the tools in a proper manner;
- ◊ Preventive maintenance is better than waiting for failures

This advice is often applied to larger and more sophisticated equipment - it is important to realise that it applies to simple street-sweeping equipment also. Perhaps a further recommendation could be added to this list:

◊ Consider a range of alternatives and collect data about each in order to find the most economical and appropriate solutions.

A-1.3 SIX-BIN HANDCARTS IN AHMEDABAD

Handcarts or wheelbarrows are a very important item in solid waste management systems, especially where labour-intensive methods are used and the gradients of the streets are slight. They can be found in almost every country in the world, used by street sweepers and for primary refuse collection. Yet it is amazing how often the carts have been poorly designed. Why have handcarts been neglected by engineers? The answer may lie in the fact that trained engineers may think that their skills should not be used on such simple vehicles, that decision-makers do not want engineers' time to be spent on such things, and that professionals are not prepared to learn from the experience of uneducated manual labourers - a design is rarely adequate at the first attempt; designs should be tested under normal working conditions and refined, in consultation with those who use them. Whatever the reason, it is a fact that there is much room for improvement in the design of most handcarts.

This section describes a handcart that is the exception - it has been designed with considerable thought, and is a much more suitable tool than most types of handcart that can be found around the world. It was observed in operation in Ahmedabad and Rajkot in Gujarat State. It will be referred to as the "six-bin handcart" and can be seen on the cover and in photograph 2. Before this design is discussed, some general points will be made about the design of handcarts, to set the scene for the review of this particular type.

a) Criteria for the design of handcarts

◊ ***How much can it carry?*** In many situations the operator of a handcart wants to carry as large a load as possible. If (s)he is required to move the material some distance - say, over 500 metres - it will be preferable to minimise the unproductive travelling time by maximising the load, so that the journey is made as few times as possible. (If the containers into which the waste is to be put are close together, this argument may not apply since the journey to the unloading point is insignificant.) A simple test of this fact is to observe how labourers use their carts - usually they keep piling waste onto their carts until they are overloaded, indicating that the labourers regard the capacity of the cart as insufficient.

A labourer can push at least 150 kg of waste in a well designed and maintained cart on a reasonable level surface (based on the author's observations in Iran and Chad). If the density of the waste is known, it is possible to calculate the volume of waste that weighs 150 kg. This should be the target capacity for a cart which is to be used for primary collection from houses. If a cart is to be used for street sweeping it may be appropriate for the capacity to be less because:

(i) the waste takes more time to collect than if it is picked up directly from households and so it may not be possible to collect 150 kg during the day's work, and

(ii) there may be community storage containers at frequent intervals so that it is not necessary to carry the waste over a long distance

◊ ***How is the waste transferred?*** Too often one sees labourers tipping the contents of their carts onto the ground and then scooping the waste up into the container or vehicle that will take the waste to the disposal site. (This is shown in photograph 1) This practice is inefficient (wasting time), unhealthy (forcing the labourer to touch or have close contact with the waste), and polluting (often some of the waste is left on the ground or is scattered by the wind). There are two simple ways of avoiding this problem -

⇒ One solution is to have a split level site so that waste can be tipped directly from the cart into the bulk container. An example of such as system is described in chapter A-3. If it is decided to build a ramp for handcarts, one must consider the slope of the ramp - a gentle slope requires considerable space and a steep slope greatly reduces the weight that can be carried in the handcart.

⇒ Another solution is to containerise the refuse in a number of bins that are small enough so that they can be lifted and tipped into the bulk container or transport vehicle, as shown in photograph 2. The maximum weight that can be lifted in this way depends on the strength of the labourer, the convenience of the lifting position, and the height to which the container must be lifted. If there are six containers on a cart, and the weight of refuse collected is 150 kg, then the labourer must be required to lift in each bin 150 / 6 = 25 kg of waste, to which must be added the weight of the container. (This assumes that the weight of refuse in each container is equal, which is unlikely.) If lifting of loads of up to 35 kg is not acceptable, it is necessary to either reduce the total load carried on each trip (increasing unproductive travelling time), or increase the number of containers to eight - unless there is always someone at the unloading point who can help with the lifting and emptying of the containers.

◊ ***General design features*** If the cart is to carry a number of bins, the size on the shape of the bins should be such that the cart is not too wide or long so that manoeuvring it is not difficult. The plan dimensions of the bins should be large enough that big items of waste cannot bridge across the rim and prevent the efficient utilisation of the bin's capacity. Bins that are rectangular in plan may be difficult to pack if the dimensions of large items in the waste are larger than the smaller horizontal dimension of the bin. Square and rectangular bins may be easily deformed and develop dangerous jagged projections at the corners. Bins that are circular in plan do not fit together well - considerable space is lost between the bins, requiring a larger cart and providing more opportunity for waste to fall between the containers.

The pushing handle should be at a convenient height and orientation so that the necessary horizontal force can be provided easily, the labourer's back can be straight, and any lifting is convenient.

◊ ***Wheels*** The wheels of a cart are of great importance. Several features should be considered:

⇒ Number If the cart has only two wheels, the operator is always required to apply a lifting force, adding to the fatigue and perhaps causing back injuries. Therefore at least three wheels are required, but it must be possible to tilt the cart so that only two wheels are in contact with the ground in order to turn the cart. This can be done by having one axle close to the centre of gravity so that the cart can be tilted by lifting or applying body weight. Carts that have three or more wheels may roll by themselves if left on sloping ground, but this is not generally a problem. The advantages of having four wheels are that the cart is more stable and that a wheel can be carried over a hole in the road surface, rather than going down into it.

⇒ Size Large wheels are better on rough surfaces, and, with poor bearings, cause less rolling resistance. On the other hand, large wheels are heavier and more expensive, and may obstruct the removal of containers.

⇒ Contact surface A wide rim is necessary on soft ground. A soft contact surface - such as a pneumatic tyre or solid rubber tyre - reduces the difficulty of pushing on stony or rough ground, but maintenance is considerably more. Manus Coffey recommends the bead section of vehicle tyres because they are made from good quality rubber, and are easy to obtain in good condition from scrapped tyres.

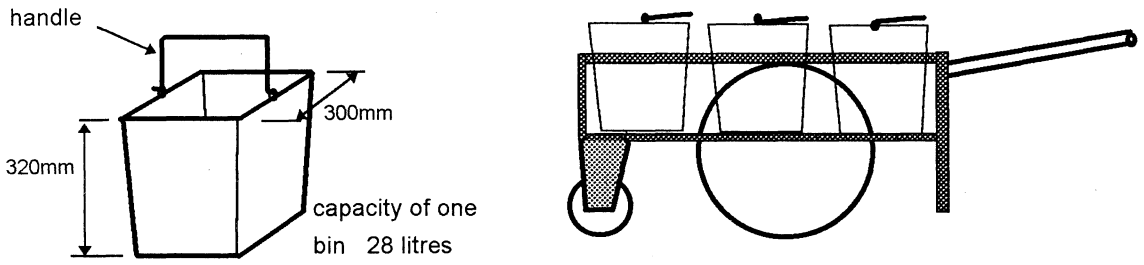
⇒ Bearings Simple journal bearings are rarely lubricated as they should be, so one often sees severely worn wheels at strange angles because of wear between the shaft and the hub. Ball or roller bearings are more expensive and must be protected from dust, and should always be specified for the wheels that carry the main load.

⇒ Durability Bicycle wheels are generally not strong enough for this kind of duty. Motorcycle wheels have proved well suited, but they are likely to be expensive. Prototypes should be thoroughly tested before being implemented on a large scale.

b) General description of six-bin handcart

This design represents a major step forward in handcart design in India. They were designed in 1988 and 5000 were supplied to Ahmedabad Municipal Corporation. The most common previous design had a capacity of only 125 litres and had two large steel wheels. Waste was transferred by tipping it onto the ground or road. The capacity of the new handcart is 6 x 28 = 170 litres, and waste can be transferred directly into large containers without tipping it onto the ground. In 1994 the cost of a six-bin handcart (with its bins) was estimated to be Rs 2000, which is about twice the cost of the previous

type. The life of the handcarts appeared to be more than five years, and the life of a container was said to be about two years.
If the density of the waste is 400 kg/m^3, the payload of the handcart is
0.17 x 400 = 68 kg.



(a) detail of bin

(b) outline concept of cart

Figure A-1.5 Sketch of six-bin handcart used in Ahmedabad

Table A-1.4 Specification of six-bin handcart

	Large wheels	Small wheel
Diameter mm	500	200
Width mm	40	60
Construction	Steel, 6 spokes	Plastic
Bearing	Ball bearing	Journal
Length of tray mm	970	
Width of tray mm	695	

c) Observations of the six-bin handcart in operation

based on information collected by N H Waghela, R Ramanathan
Dr T M Shantaram, R C Chavan and Dr D C Bhandari

The operation of the six-bin handcarts was studied in Ahmedabad - observations of the operation and condition of the carts were recorded and the operators were asked for their opinions and experiences.

The investigators monitored operations at one bulk container (capacity 10m^3). Most of the sweepers were using the six-bin handcarts and took three to four minutes to transfer their loads to the container. One lady had lost her cart and was bringing waste to the container in a basket. Others did not have all their bins. One sweeper was using the old type of cart, and spent eight minutes transferring the load to the container, having first tipped that waste onto the road.

Some of the incoming bins were weighed. When the sweepers were coming in with the first loads the weights of the bins with their contents were 9.2, 8.9, 11.7, 10.7, 10.5, 10.1, 10.2, and 11.2 kg.
The average full weight was therefore 10.3 kg
An empty bin weighed 5.0 kg.
The net weight of waste was therefore 5.3 kg.
The estimate of the density of the waste from these figures is therefore 5.3 / 0.028 = 190 kg/m^3
The total load carried by the handcart can be estimated as 6 x 5.3 = 32 kg.

The weights recorded when the sweepers returned with their second loads were 6.5, 7.5, 7.5, 7.2, and 6.0 kg. (It was conjectured that the weights were less because the sweepers had wanted to fill their bins quickly to finish the morning's work. Apparently the sweepers were expected to make two trips during the morning shift [06.30 to 11.00].) The estimated load per trip dropped to 12 kg.

In addition to these operational points, fourteen handcarts were observed to monitor their condition. The results are shown in table A-1.5.

Table A-1.5 Observations of the condition of the handcarts

Number of handcarts in sample	14
Number of handcarts without a front wheel	3
Number of handcarts with a broken handlebar	3
Number of bins that were missing	20
so number of bins in sample = (14 x 6) - 20	64
Number of bins without floors [or bottoms]	25

It was also observed that all the handcarts had heaps of waste piled over the tops of the bins, and that ten of them had gunny (sacking) or a net of nylon string tied onto the handlebar frame, to increase the capacity of the carts.

In discussion with the sweepers, the following facts emerged:

- ◊ Several complained about the difficulty of pushing the carts when the front wheel was missing or when the handlebar frame was broken; female staff said this was particularly a problem when they were pregnant or had recently been sterilised. (The problem with the handlebar frame was that welds would break.)
- ◊ No repairs or replacements had been carried out since the introduction of the carts five years before;
- ◊ It was not possible to transfer the waste directly into the bulk container when the bottom of the bin had been lost because of corrosion, or when the handles were missing;
- ◊ Sweepers had hurt themselves when their carts had stopped suddenly when the front wheel hit an obstruction or hole;
- ◊ Eleven out of 14 said that they did not favour having larger carts or larger bins.

It was common practice to thread a chain through the handles of the bins and padlock it so that the bins and cart were not stolen when they were parked overnight near the sweeping area. (The lock and chain were provided by the Municipal Corporation. If a bin were stolen, a sweeper was required to pay Rs 114 for the new one. The investigators were told that damaged bins could be exchanged for good ones, but the number of bins without floors suggested that such exchanges were not always possible. Often handles would be damaged, especially during the rainy season when the waste was much heavier.

Comments

- ♦ The apparent density of the waste is lower than expected. In fact, the use of small containers highlights the wide variation in the densities of wastes, from very low density materials such as leaves and paper to high density construction debris, or wet, partially decomposed organic material. A bin that is sufficiently large to be very heavy when full of construction debris can easily be filled by a kilogram of leaves. In addition, the particle size of the waste becomes important, because a few sticks or twigs can prevent most of the capacity of a small bin from being used. Wastes may not fill the corners of square containers.
- ♦ Maintenance of the handcarts and bins is shown to be of considerable importance. The fact that the carts are still operational after five years testifies to the general quality of their design and construction, but certain features should be designed or fabricated differently - for example the handlebar frame. The reasons why the front wheels failed should be investigated. Materials other than steel should be investigated for the containers, because of the problems caused by corrosion of the floors. However even the best-designed products need maintenance, and provisions should be made for repairing or replacing defective components.
- ♦ The observations that bins were generally overfilled and that sweepers had found a way of increasing the capacity of their carts suggest that a larger capacity would be appropriate. When

asked directly about larger carts the sweepers may have opposed them because of fears that more work would have been required with larger carts.

A-1.4 INTERCHANGEABLE COMMUNITY BINS IN AHMEDABAD

with Dr P K Makwana, Dr D Bhandari and Dr T M Shantaram

a) Introduction

In the late 1980s, solid waste management in Ahmedabad benefited from vigorous leadership (particularly from Mr P U Asnani) and support from the World Bank. A key objective in many of the initiatives was to reduce double handling of waste (that is, once it has been put into a container it should not be deposited again on the ground for a second loading, but should be transferred directly only into a vehicle or larger containers until it reaches the disposal site). Double handling is both inefficient and unhygienic. The six-bin handcarts that have already been mentioned are one result of the developments of this period, since waste can be transferred directly into a $10m^3$ container without it coming into contact with the ground. Another development of this kind is a system of small community bins that were introduced on a trial basis. This system - which can be characterised as primary collection from community bins using specially designed trucks - will be briefly described in this section, and some lessons that might be drawn from this trial will be suggested.

The basic equipment is shown in figure A-1.6. The photograph shows the purpose-built truck which can carry 44 rectangular community bins like that shown in the right foreground. A sample bin was measured and found to be 335 mm deep, 630 mm long and 350 mm wide, giving a capacity of about 75 litres. (The capacity of the bins was normally quoted as being 80 litres, so perhaps the sample bin that was measured was smaller than most of the others.) The system concept was that the bins were distributed on the basis of one container to every 25 families, they were exchanged every day for an empty bin, and the loaded bins were carried on the special truck to a large hook-lift container, into which the contents were tipped. The benefit of exchanging containers rather than emptying them was that no dust or litter were spread in the residential area, as they might be if the waste were transferred at the container location.

Figure A-1.6 The Ahmedabad exchangeable community bin system

The scheme was started in 1988-9, when 2500 bins and 12 trucks were purchased. The trucks were to make two trips in an 8 hour shift, and the crew of each truck was one driver and two labourers. Each container was to be exchanged daily. The containers were painted in the distinctive colours of the Corporation - yellow and saffron stripes.

b) Lessons from experience

The experiences with this system can be divided into two phases.

Problems of Phase I

- ◊ The community was not motivated to make the system function effectively. The system was new to the community and no family took an interest in the scheme. Domestic waste was thrown on the ground as before.
- ◊ Lack of co-operation. No one was responsible for taking care of the community bins so they were moved, stolen, or misused.
- ◊ No replacement procedure The community bins were placed according to the wishes of junior municipal officers and politicians, without considering the local conditions. The bins were not replaced once they disappeared or were damaged. This led to underutilisation of the vehicles, so that they were used with community bins for other purposes, such as transport for supervisors.
- ◊ Misuse by street sweepers The street sweepers found the community bins convenient for depositing street sweepings in order to avoid carting their loads to container sites.
- ◊ Misuse by residents The containers were designed for typical household refuse. However, in addition to kitchen and paper wastes, households also produce heavy wastes like soil and building rubble when alterations are being made to the fabric of the houses, and if there are gardens there are likely to be large quantities of low-density wastes such as leaves and tree cuttings. Construction debris adds greatly to the weight of the contents of a bin, such that a labourer might be unwilling or unable to lift it, and the garden residues from one household would be enough to fill the whole bin - which was intended for 25 households. Often construction debris and garden waste would be left beside the bins because there was no simple way of collecting them.
- ◊ Complaints The bins became an eyesore along the road sides. Residents moved the bins away from their homes. The community bins became storage sites for additional waste, and cows and other animals scattered the contents. Damaged bins were abandoned for long periods of time.

Phase 2 Implementing solutions

The problems that arose in the first phase called for an alternative strategy which would develop a more positive and co-operative attitude amongst the community.

- ♦ Participation of NGOs An NGO which was engaged in some welfare projects for rag-pickers and segregation of recyclable waste joined with the Municipal Corporation in its efforts to improve the use of the bins. Bank union volunteers joined the NGO and selected an area in which to support the introduction of community bins.
- ♦ Community education The NGOs actively moved into the chosen community, identified the leaders in the societies and flats, and explained the advantages of community bins and encouraged groups to take care of them.
- ♦ Interaction between the community and the Municipal Corporation Municipal Corporation officers, NGO representatives and community leaders met and decided on the number of bins and identified the sites where they would be kept. Accordingly, the bins were provided in the project area. The bins were placed at all the identified places, a route was finalised for the collection vehicle, and an adequate number of bins were kept reserved for immediate replacement. of damaged or missing bins.
- ♦ Supervision Community leaders, NGOs and the sanitary supervisors constantly monitored the work on a day-to-day basis during the initial stages, and later the sanitary staff continued to check almost daily and NGOs monitored operations at regular intervals. Complaints were attended to as a priority and resolved within 24 to 48 hours.
- ♦ Extra loads As there was no provision for the disposal of debris and bulky waste, trucks or skips were sometimes deployed. No street sweeper was allowed to dispose of street waste in the community bins.

- ♦ Recycling The NGO managed to get big plastic bags as a donation from an industrial house. Households were urged to segregate all recyclable waste and keep it separately in their house. Another NGO known as SEWA (Self Employed Woman's Association) involved lady rag-pickers from the area who visited the houses to collect recyclables twice weekly. These workers were given aprons with a badge. The rag pickers were thus identified to the residents so there was no hesitation in allowing them into the premises. In this way the recycling workers obtained clean recyclable material and thereby earned Rs 25 to 40 per day.

This strategy led to responsible behaviour from the community. People were really involved and felt happy to notice a change in their environment. Instead of complaining to the Municipal Corporation, they showered it with compliments.

c) Survey of residents

A brief survey of the opinions and practices of the residents was carried out in an area where the system was still in operation - an area called Pragatinagar. The housing in this area was mostly three-storey buildings erected by the Housing Board, though there were also some individual houses belonging to a higher income group. The results of the survey are given in appendix AA-1.
It is interesting to note (question 2) that children played a relatively minor role in taking household waste to the bin. (Many types of community bin are too high for children to reach comfortably, but these bins were low enough for children to be able to lift any load they could carry into the bin.) Replies to question 3 suggest that the bins were too small to serve 25 households, because they were frequently overflowing. The majority of people interviewed seemed happy with the system (questions 5 and 6, but the easy access for rag-pickers and animals appeared to cause problems (question 7).
It appeared that there were problems during the monsoon in that the collection of rainwater in the bins caused a foul smell and made the emptying of the bins more difficult.

d) Observations and comments

- ◊ The exchange concept is good in that it prevents dust and litter from being scattered in the residential area, and could be developed so that damaged bins could be easily exchanged for good bins at the unloading point. The exchange system could also include the option of washing the containers at the transfer point after they have been emptied. However, a major weakness is that if all the containers are, on average, half full, the load carried by the truck is half, because it goes against the principle of operation to distribute extra waste amongst the containers on the truck. Community bins, especially if they are small, should have a generous safety margin in terms of their capacity to cope with fluctuations in the quantities of waste. (If the containers are bigger and serve a larger number of households, there is more chance that the variations will be averaged out, and that one large quantity from one source will have a proportionately smaller effect.) In addition, if the bins are emptied daily, there should be an allowance for one day's collection being missed - because of a particularly important holiday, a strike or a vehicle failure. If containers are normally emptied daily, and one day is missed, there should be sufficient storage for twice the anticipated volume. The following calculation serves as an example:
  If the estimated volume of waste to be put into a container is 30 litres (based on the number of people and the per capita generation rate);
  - to allow for fluctuations it might be appropriate to provide a 40 litre storage volume,
  - and to allow for the collection being missed one day, (i.e. for storage of two days' waste instead of one) the required volume would be

    $2 \times 40 = 80$ litres
  - Therefore, the average volume carried by the truck on a normal day might be

    $44 \times 30 = 1320$ litres,

  instead of the capacity of

  $44 \times 80 = 3520$ litres

  if the bins were all full.
  - If the density of the waste is 400 kg/m^3 then a typical load on a normal day might be only

    $1320/1000 \times 400 = 528$ kg,

  which very small in comparison with the possible payload of the truck (which is probably considerably more than 3000 kg).
- ◊ The exchange system requires more work of the labourers, since they must lift each full container twice.

◊ It was estimated that the life of the bins was two to three years. In addition to rust and impact damage, it was thought that the bins might be have been taken for other uses.

◊ When the collection operation was being observed the bins were not being exchanged. It appeared that the truck crew were obliged to keep their containers in good condition and so they did not want to exchange them and leave their numbered bins to be perhaps damaged or stolen. (The bins on the truck all had the truck's number written on them, suggesting that they should remain with the truck.)

◊ Apparently, the trucks did not report to the local ward office, so the sweeping supervisor did not know when the truck was in his area, making co-ordination difficult.

◊ The bins were generally between 10 and 30 metres from the property boundaries. Residents did not want them closer because they feared contracting an illness if the bins were too close.

◊ It appeared that the bins did not have a sufficient capacity for each to serve 25 households. It would therefore be desirable to provide more bins to the area or increase the size of the bins. (In increasing the size one must always consider the maximum weight that the containers may have when full of dense wet waste, and whether the labourers would be able to load them into the truck.)

◊ The blocks each comprised six flats (or apartments). It is often helpful to design a system to harmonise with the existing social arrangements. For example, if each block of flats had its own servant or sweeper, it might be helpful to allocate a container to each building, and make the servant responsible for keeping the surroundings of the containers clean. It might even be possible to keep a cover on the container, so that the container could be kept within the property boundary. (It is usually pointless to provide a community bin with a lid because very few people take the trouble to use the lid properly, and they may be reluctant to touch a lid that has been used by unknown people and may have been fouled by their waste. It is often different if the responsibility for the container is defined.). So an alternative approach would be to allocate a container to each building - the initial cost would be more, but the life of the container might be longer. If this were done it would be necessary to modify the exchange system. If it is possible to make the residents buy their container, the feeling of ownership and responsibility would be very beneficial in terms of extending the life of the containers.

e) Summary and conclusions

* The Ahmedabad Municipal Corporation is to be congratulated on its efforts to investigate new systems and to involve the community in this system.

* No costing of the operation was conducted by the survey team, so it has not been possible to compare this system with others. Though the exchange system has a number of aesthetic advantages, it is thought that its cost may be high. It is likely that the loads carried by the truck were very low compared with the possible payload of the truck, and increasing this load might reduce the operational cost of the system.

* The volume of waste coming from any particular source can fluctuate significantly from day to day, so a small community bin should be considerably larger than the size estimated from average rates. Consideration should also be given to the management of building debris and bulky and garden waste.

* Experiences in Ahmedabad clearly illustrate the importance of involving the community to the greatest possible extent in the preparations and decisions relating to a new system, and in fostering a sense of responsibility for, and ownership of the containers. A domestic waste collection system should never be seen as purely a matter of technology and municipal management, it should be seen also as a question of the behaviour and attitudes of the beneficiary community, and considerable effort is needed to ensure that this aspect of the system is successful. Neither the engineer or the community worker can solve the problem alone.

APPENDIX AA-1 AHMEDABAD COMMUNITY BIN SYSTEM - RESULTS OF QUESTIONNAIRE SURVEY

A small survey was carried out in an area where the community bins were in use, to gain some understanding of the knowledge, attitudes and practices of the residents with regard to this system of waste collection. Two pairs of investigators asked eight questions at 38 households. The questions and an analysis of the replies are shown below.

1. *Is the solid waste from your house put into a community bin?*	Yes	35	92%
	No	2	5%
	Not aware	1	3%
2. *Who carries the waste from your house to the bin?*	Adult member	17	40%
	Children	3	7%
	Domestic servant	10	24%
[Some households gave more than one answer.]	Hired sweeper	12	29%
3. *How often are the bins full or overflowing?*	Every day	21	55%
	More than twice a week	6	16%
	Occasionally	7	18%
	Not aware	4	11%
4. *How often are the bins emptied in one week?*	Daily	33	87%
	4 to 5 times per week	3	8%
	Not aware	2	5%
5. *Are you happy with the present location of the bins?*	Yes	33	75%
	No	4	9%
	Should be nearer	3	7%
[Some households gave more than one answer.]	Should be further	4	9%
6. *Do you like the present collection system? Please give reasons.*	Yes	36	95%
	No	0	
	No opinion	2	5%
7a. *Do rag pickers cause any problems?*	Yes	28	74%
	No	6	16%
	No reply	4	10%
7b. *Do stray animals cause any problems?*	Yes	33	87%
	No reply	5	13%

8. *Do you have any suggestions for improving the system?*