**Vision of the institute**

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

**Mission of the institute**

To keep pace with advancements in knowledge and make the students competitive and capable at the global level.

To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations to shine as torch bearer of tomorrow’s society.

To strive to attain ever-higher benchmarks of educational excellence.

**Vision of the Department**

The department will be recognised for its value based teaching, associated activities pertaining to research and entrepreneurship.

**Mission of the Department**

* To provide quality education through faculty and state of art infrastructure
* To identify the current problems in society pertaining to Civil Engineering disciplines and to address them effectively and efficiently
* To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society

**PEO’s**

**Graduates who complete their UG through our institute will be,**

**PEO 1**- Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, water resource engineering by using technical, communication and management skills.

**PEO 2**- Engaged in higher studies and research activities in various civil engineering fields and life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities.

**PEO 3**- Serve in a leadership position in any professional or community organization or local or state engineering board

**PEO 4**- Registered as professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

**PSO’s**

**PSO 1** – To apply science, mathematics and mechanics to solve problems in engineering realm

**PSO 2** – To analyse the techniques, skills and modern engineering tools necessary for engineering practices

PSO 3 – To develop ability to function as a leader and a team player in multidisciplinary teams

**PSO 4** – To recognize of the need for and an ability to engage in research and life-long learning for developing sustainable construction practices

**PSO 5** – To design and conduct experiments as well as to analyse and interpret data

**Unit – 2**

**Collection and Transportation**

**Structure**

2.0 Introduction

2.1 Objectives

2.2 Systems of Collection

2.3 Collection Equipment

2.4 Garbage chutes

2.5 Transfer station

2.6 Route optimization techniques

2.7 Assignment questions

2.8 Outcomes

2.9 Further Reading

**2.0 Introduction**

Waste collection is a part of the process of [waste management](https://en.wikipedia.org/wiki/Waste_management). It is the transfer of [solid waste](https://en.wikipedia.org/wiki/Solid_waste) from the point of use and disposal to the point of [treatment](https://en.wikipedia.org/wiki/List_of_waste_treatment_technologies) or [landfill](https://en.wikipedia.org/wiki/Landfill). Waste collection also includes the [curb side collection](https://en.wikipedia.org/wiki/Curbside_collection) of [recyclable](https://en.wikipedia.org/wiki/Recyclable_waste) materials that technically are not [waste](https://en.wikipedia.org/wiki/Waste), as part of a municipal [landfill diversion](https://en.wikipedia.org/wiki/Landfill_diversion) program.

**2.1 Objectives**

1. Discuss the various components of a waste collection system;
2. Explain the characteristics of waste containers relative to their use;
3. State the purpose of a transfer station;
4. Evaluate how a collection system is planned and implemented;
5. Collect and maintain the required data for record keeping and inventory control;

**General Issues in Collection and Transport:**

* Poor garbage storage/discharge. For example, garbage temporarily discharged at the roadside or in public bins must be re-loaded again into collection vehicles.
* Inappropriate waste transfer from handcarts to tractor-trailers. Typically, handcarts discharge their loads onto the ground, meaning it must be re-loaded into the trailer.
* Collection costs are high and service levels are low.
* Inappropriate waste transfer from hand tractors to four-wheel tractors. Garbage in two-wheel tractors must be emptied manually onto the ground. This garbage must then be re-loaded into a trailer.
* Poor labour management and supervision.
* Inadequate cooperation from citizens with the collection schedules and methods.
* Inappropriate type and size of collection vehicles.
* Non-rational routes for collection service.
* Failure to optimize vehicle productivity by selecting the appropriate crew size and shift duration.
* Inadequate container capacity at the communal collection points.
* Long vehicle down-times from poor equipment maintenance/repair.

**2.2 Systems of Collection:**

**(i) Collection points:** These affect such collection system components as crew size and storage, which ultimately control the cost of collection. The collection points depend on locality and may be residential, commercial or industrial.

**(ii) Collection frequency:** Climatic conditions and requirements of a locality as well as containers and costs determine the collection frequency.

In hot and humid climates, for example, solid wastes must be collected at least twice a week.

For instance, while sealed or closed containers allow collection frequency up to three days, open and unsealed containers may require daily collection.

Collection efficiency largely depends on the demography of the area (such as income groups, community, etc.), where collection takes place.

**(iii) Storage containers:** Proper container selection can save collection energy, increase the speed of collection and reduce crew size.

Most importantly, containers should be functional for the amount and type of materials and collection vehicles used. Containers should also be durable, easy to handle, and economical, as well as resistant to corrosion, weather and animals.

While evaluating residential waste containers, consider the following:

* Efficiency, i.e., the containers should help maximise the overall collection efficiency.
* Convenience, i.e., the containers must be easily manageable both for residents and collection crew.
* Compatibility, i.e., the containers must be compatible with collection equipment.
* Public health and safety, i.e., the containers should be securely covered and stored.
* Ownership, i.e., the municipal ownership must guarantee compatibility with collection equipment.

(iv) **Collection crew:** The optimum crew size for a community depends on labour and equipment costs, collection methods and route characteristics.

The size of the collection crew also depends on the size and type of collection vehicle used, space between the houses, waste generation rate and collection frequency.

(v) **Collection route:** Proper planning of collection route also helps conserve energy and minimise working hours and vehicle fuel consumption.

It is necessary therefore to develop detailed route configurations and collection schedules for the selected collection system. The size of each route depends on the amount of waste collected per stop, distance between stops, loading time and traffic conditions.

Barriers, such as railroad, embankments, rivers and roads with heavy traffic, can be considered to divide route territories.

(vi) **Transfer station:** A transfer station is an intermediate station between final disposal option and collection point in order to increase the efficiency of the system, as collection vehicles and crew remain closer to routes.

In some instances, the transfer station serves as a pre-processing point, where wastes are dewatered, scooped or compressed. A centralised sorting and recovery of recyclable materials are also carried out at transfer stations.

**2.3 Collection Equipment:**

**Container system:**

**(1) Hauled Container Systems:**

The container is sited at a location. In accordance with some cycle, the container is picked up and hauled off to the disposal area where the container is emptied and returned to the original location. The truck had no container; the container is carried by the truck. A variation is start with an empty container.

**Advantages:**

* Useful when the generation rate is high and the containers are large.
* May eliminate spillage associated with multiple smaller containers.
* Flexible. Need more capacity, use a larger container.

**Disadvantage:**

* If the containers are not filled, low utilization rate.

**Types:**

* Hoist truck - similar to an emergency truck, but dumpsters are picked up or hoisted, smaller volumes, and bulky items.
* Tilt frame - assembly on truck allows sliding of large containers on and off the truck.
* Trash trailer - The slider assembly is not part of the truck, but part of the trailer

**Stationary container system:**

The waste container remains in the vicinity of where the waste is generated. The waste is unloaded into a bigger truck. A large container is an integral part of the truck. When fully loaded from multiple waste containers, the truck travels to and from the landfill as opposed to the waste container.

**Advantage:**

* The vehicle does not travel to the disposal area until it is full yielding higher utilization rates.

**Disadvantage:**

* The system is not flexible in terms of picking up bulky goods.
* Wastes e.g. demolition that makes damage the relatively delicate mechanisms.
* Large volume generations may not have room for storing large containers

**Types:**

* Manually loaded. Small containers. Residential pickup.
* Mechanically loaded. Larger containers. Wheeled residential pickup and commercial pickup
* Almost all contain internal compaction equipment

**Communal containers:**

* The use of communal containers is largely dependent on local culture, tradition and attitudes towards waste. Communal containers may be fixed on the ground (stationary) or movable (hauled).
* Movable containers are provided with hoists and tails compatible with lifting mechanism of collection vehicles and such containers have capacities of 1 – 4 m3.
* Residential and commercial areas in India, the communal containers are often made of concrete.
* In areas with very high waste generation rates, i.e., rates exceeding two truckloads daily, such as wet markets, large commercial centres and large business establishments, roll-on-roll or hoisted communal containers with capacities of 12 – 20 m3 and a strong superstructure with wheels are used.

**Collection vehicles**

* The collection vehicle selected must be appropriate to the terrain, type and density of waste generation points, the way it travels and type and kind of material.
* It also depends upon strength, stature and capability of the crew that will work with it. The collection vehicle may be small and simple or large, complex and energy intensive. A description of some vehicle types follows:

(i) **Small-scale collection and muscle-powered vehicles:**

The handcart which is pushed by the operator as he walks along.

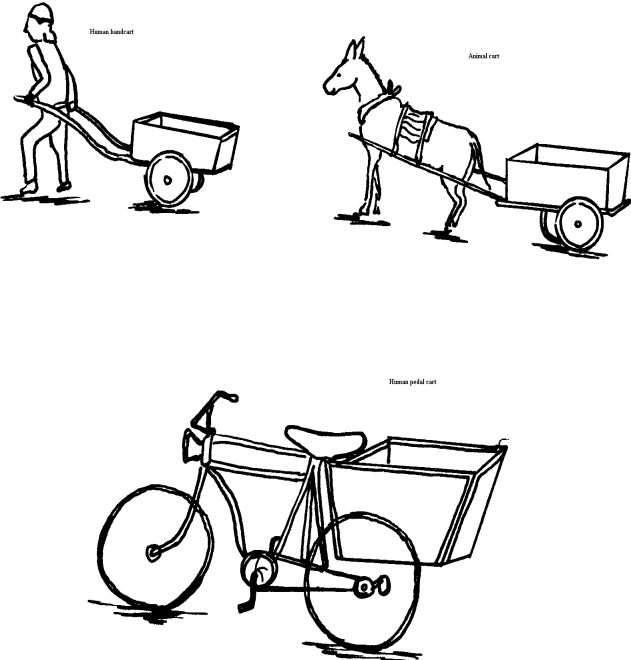
* Very limited capacity in terms of volume and capacity
* Carries 0.25 to 1 m3 with a maximum range of 1 km
* Very cheap
* Operated by one person

The pedal tricycle with a tray or box in front of or behind the operator.

* Loads up to 1.5 m3.
* Range greater because of higher speed when empty
* Lifetime about 2 years
* No negative impact on environment

Animal-drawn cats, often pulled by donkeys.

* Common around the world
* Carry up to 1.5 m3 and range of up to 7 km.
* Cost of feeding and caring for animals added factor



(ii) **Non-compactor trucks:**

Non-compactor trucks are efficient and cost effective in small cities and in areas where wastes tend to be very dense and have little potential for compaction.

When these trucks are used for waste collection, they need a dumping system to easily discharge the waste. Trucks with capacities of 10 – 12 m3 are effective, if the distance between the disposal site and the collection area is less than 15 km.

(iii) **Compactor truck:**

Compaction vehicles are more common these days, generally having capacities of 12 – 15 m3 due to limitations imposed by narrow roads. Although the capacity of a compaction vehicle, is similar to that of a dump truck, the weight of solid wastes collected per trip is 2 to 2.5 times larger since the wastes are hydraulically compacted.

A wide variety of trucks are used for collection. Factors to consider in selecting include:

* The weight of waste that the truck can actually carry
* Cost of purchase and operation, including fuel and maintenance
* Delays in obtaining spare parts
* Suitability of the vehicle for the local roads considering width, congestion, and surface conditions
* Ease of loading and unloading

**2.4 Garbage chutes:**

Garbage chutes are common in high rise apartment buildings and are used to collect all the building’s garbage in one place. Often the bottom end of chute is placed directly above a large waste container. This makes garbage collection more efficient.

Garbage chutes used in apartment buildings are available in diameter 12-36 inch. The most common chute diameter is 34 inch. Garbage chutes man be round, square or rectangle at the top or/and the bottom. All the available chutes can be furnished with suitable intake chute either at the bottom or at the site or used for installation on various floor levels. Draft baffles at intake doors, door locks, sprinklers, disinfection systems, sound insulations and roof vents are among the many accessories available. Use of disinfecting and sanitizing unit is recommended because cleanliness of chute and absence of odours generally depend to a large extent on their use. In designing garbage chutes for high rise buildings one must consider variation in the rate at which solid waste is discharged.

In determining the size of chute it is common to assume

* Bulk density of waste to be 90 kg/m3
* Per capita waste generation as 0.5 kg / capita / day

**2.5 Transfer station:**

Transfer station is a centralised facility, where waste is unloaded from smaller collection vehicles and re-loaded into large vehicles for transport to a disposal or processing site. This transfer of waste is frequently accompanied by removal, separation or handling of waste.

Also, the use of transfer station proves reasonable, when there is a need for vehicles servicing a collection route to travel shorter distances, unload and return quickly to their primary task of collecting the waste. Limitations in hauling solid wastes are the main factors to be considered, while evaluating the use of transfer stations.

These include the additional capital costs of purchasing trailers, building transfer stations and the extra time, labour and energy required for transferring wastes from collection truck to transfer trailer.

Consider the following factors that affect the selection of a transfer station:

* Types of waste received.
* Processes required in recovering material from wastes.
* Types of collection vehicles using the facility.
* Types of transfer vehicles that can be accommodated at the disposal facilities.
* Site topography and access.

**Types of transfer stations:**

Transfer stations are used to accomplish transfer of solid wastes from collection and other small vehicles to larger transport equipment. Depending on the method used to load the transport vehicles, transfer stations may be classified into three general types:

1. Direct load
2. Storage load
3. Combined direct and storage discharge.
4. **Direct-Load Transfer Stations:**

At direct-load transfer stations, the wastes in the collection vehicles are emptied directly into the vehicle to be used to transport them to a place of final disposition. In some cases, the wastes may be emptied onto an unloading platform and then pushed into the transfer vehicles, after recyclable materials have been removed.

1. **Storage-Load Transfer Station:**

In the storage-load transfer station, wastes are emptied directly into a storage pit from which they are loaded into transport vehicles by various types of auxiliary equipment.

The difference between a direct-load and a storage-load transfer station is that the latter is designed with a capacity to store waste (typically one to three days).

1. **Combined direct and storage discharge:**

Combined direct-load and discharge-load transfer stations have also been developed Transfer stations may also be classified with respect to throughput capacity (the amount of material that can be transferred and hauled) as follows: small, less than 100 tons/day; medium, between 100 and 500 tons/day; and large, more than 500 tons/day.

**Capacity:**

A transfer station should have enough capacity to manage and handle the wastes at the facility throughout its operating life. While selecting the design capacity of a transfer station, consider trade-offs between the capital costs associated with the station and equipment and the operational costs. Designers should also plan adequate space for waste storage and, if necessary, waste processing. Transfer stations are usually designed to have 1.5 – 2 days of storage capacity.

When planning the unloading area, designers should allow adequate space for vehicle and equipment manoeuvring.

To minimise the space required, the facility should be designed such that the collection vehicle backs into the unloading position. Adequate space should also be available for offices, employee facilities, and other facility-related activities.

Following factors should be considered in determining capacity of a transfer facility include:

* Capacity of collection vehicles using the facility
* Desired number of days of storage space on floor
* Time required to unload collection vehicles
* Number of vehicles that will use the station and their expected days and hours of arrival
* Waste sorting or processing to be accomplished at the facility
* Transfer trailer capacity
* Hours of station operation
* Availability of transfer trailers waiting for loading
* Time required attaching and disconnecting trailers from tractors or compactors.

The advantages of having a transfer station are:

* The small dumper placer vehicles need not have to travel long distances up to the landfill site which on an average are located at 20 to 25Km away from the center of the city. This saves travel time and the fleet can be better utilized for making extra trips resulting in effective cleaning and sweeping.
* There is saving on the consumption of the fuel and as such the cost of the garbage transport is minimized.
* The wear and tear of the tyres and other components of vehicles are minimized by avoiding long trips and adverse conditions at landfill sites.
* There will be less traffic at landfill site thereby facilitating proper spreading of garbage and giving a better look at these sites.

**Bailing and Compacting:**

Bailing and compaction systems shall be designed, constructed, and operated so as to:

* Be surrounded by a fence, trees or natural features so as to control access and be screened from the view of immediately adjacent neighbours, unless the tipping floor is fully enclosed by a building.
* Be sturdy and constructed of easily cleanable materials.
* Be free of potential rat harbourages, and provide effective means to control insects, birds and other vermin
* Be adequately screened to prevent blowing of litter and to provide effective means to control litter
* Provide protection of the tipping floor from wind, rain or snow other than below grade bins or detachable containers
* Have an adequate buffer zone around the operating area to minimize noise and dust nuisances, and for transfer stations.
* Provide all-weather approach roads, exit roads, and all other vehicular areas;
* Provide pollution control measures to protect surface and ground water, including runoff collection and discharge.
* Provide pollution control measures to protect air quality including a prohibition against all burning and the development of odour and dust control plans to be made a part of the plan
* Prohibit scavenging

**2.6 Route optimization techniques:**

Efficient routing and re-routing of solid waste collection vehicles can help decrease costs by reducing the labour expended for collection. Routing procedures usually consist of the following two separate components:

(i) **Macro-routing:**

Macro-routing, also referred to as route-balancing, consists of dividing the total collection area into routes, sized in such a way as to represent a day’s collection for each crew. The size of each route depends on the amount of waste collected per stop, distance between stops, loading time and traffic conditions. Barriers, such as railroad embankments, rivers and roads with heavy competing traffic, can be used to divide route territories. As much as possible, the size and shape of route areas should be balanced within the limits imposed by such barriers.

(ii) **Micro-routing:**

Using the results of the macro-routing analysis, micro-routing can define the specific path that each crew and collection vehicle will take each collection day. Results of micro-routing analyses can then be used to readjust macro-routing decisions. Micro-routing analyses should also include input and review from experienced collection drivers.

**Routes should design using the following rules:**

* Routes should not be overlapped. Each route should be compact, consisting of street segments clustered in the same geographical area.
* Total collection plus hauling time should be reasonably constant for each route in the community.
* The collection route should be started as close to the garage or motor pool as possible, taking into account heavily travelled and one-way streets.
* Heavily travelled streets should not be visited during rush hours.
* In the case of one-way streets, it is best to start the route near the upper end of the street, working down it through the looping process.
* Higher elevations should be at the start of the route.
* For collection from one side of the street at a time, it is generally best to route with many anti-clockwise turns around blocks.
* For collection from both sides of the street at the same time, it is generally best to route with long, straight paths across the grid before looping anti-clockwise.

**2.7 Recommended Questions**

1. Explain hauled container system and stationary container system
2. Explain different types of transfer stations
3. Explain the following: a) Hauled container system

b) Stationary container system

1. An area consisting of 400 houses contributes solid waste. Estimate the solid waste generation rate, if the observation is a local transfer station and period of generation is one week. The waste is carried out in two types of vehicles Viz, compactor trucks and flat bed trucks.

**2.8 Outcomes**

1. Understand health and environmental issues related to solid waste management
2. Apply steps in solid waste management-waste reduction at source, collection techniques

**2.9 Further Reading**

1. http://www.defence.gov.au/jlc/Documents/DSCC/ADF%20Health%20Manual%20Vol%2020,%20part8,%20chp3.pdf
2. http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap4.pdf
3. http://inspire.redlands.edu/cgi/viewcontent.cgi?article=1203&context=gis\_gradproj
4. https://journal.gnest.org/sites/default/files/Journal%20Papers/6-11\_APAYDIN\_388\_9-1.pdf